Geotechnical Investigations and Drainage Planning in Clyde River, Nunavut

Clyde River, NU

Final Report
REV-02

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NUNAMI STANTEC

Sign-off Sheet

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1.0 INTRODUCTION

1.1 GENERAL

In 2018, Nunami Stantec Limited (Nunami Stantec) was contracted by the government of Nunavut (GN) – Department of Community and Government Services (CGS) to complete a desktop terrain analysis and geotechnical review to support the planning of a proposed new subdivision in Clyde River, NU. The study area consisted of a new subdivision referred as: Block 2, Lots 1 to 40, and Roads R24, R25 and R26, (see Plan 3926 in Appendix G). This study area was proposed by the Hamlet in 2009 for further development to accommodate population growth; however, locals had concerns that the land might be unstable and/or too wet for the proposed development.

The initial phase of work was completed in accordance with Stantec's proposal No. 599783 dated May 1, 2017, developed based on the Request for Proposals (RFP) 2017-30, and approved by CGS on June 2, 2017.

On June 29, 2019, CGS requested that Nunami Stantec submit a cost estimate to complete a geotechnical field program and additional drainage planning to complement the findings of the initial scope of work completed in January of 2018. This second phase of work was completed in accordance with the Term of Reference proposed by CGS under the GN Standing Offer Agreement 2014-48.

As instructed in Term of Reference developed by CGS, the methodology and deliverables of the 2018 study would guide the scope of the second phase of work including an updated study area that encompasses the remaining portions of the townsite (including proposed new Block 3 and Block 4), rather than just the initial subdivision. The findings of the second phase of work will be complementary to the existing 2018 study combining the deliverables (e.g., maps) from the 2018 study.

The information contained in the current report, therefore, include a combined summary of objectives, methodology, results as well as recommendations regarding the geotechnical evaluation and drainage planning components in support of future subdivision planning in Clyde River, NU.

1.2 OBJECTIVE

One of the key objectives of the geotechnical evaluation and drainage planning study was to identify potential features, terrain-related constraints and/or geohazards that might negatively affect the development of new subdivisions.

The preliminary study was completed using readily available information relative to the topography, surficial materials, soils conditions present within the study area. Available satellite imagery was used to further assess local terrain conditions. A field reconnaissance was conducted in the fall of 2018. A supplementary field investigation program was completed in Fall 2019. The combined scope of work includes the following main tasks:

- A review and compilation of relevant information and technical documents,

- A desktop terrain assessment including qualitative construction suitability rating,
- A field reconnaissance program to validate and update the finding of the desktop analysis,
- A geotechnical field program including borehole investigations and laboratory analyses,
- An evaluation of existing community drainage infrastructures,
- A summary of factual geotechnical data obtained from the investigation,
- The development of a drainage plan, including instructions and recommendations regarding future land development within the community.

1.3 STUDY AREA

As confirmed through the Terms of Reference for the second phase of work, the updated study area includes the entire townsite of Clyde River and its environs, rather than just the initially proposed Block 2 (Figure 1-1). For description and presentation purpose, the study area was separated in a series of sub-sections identified as blocks or districts.

Figure 1-1 Overview of the Study Area

1.4 PROJECT SETTING

This section provides a general overview of the physiography, geology and glacial history and permafrost conditions associated to the study area.

1.4.1 Physiography

Clyde River (or Kanngiqtugaapik in Inuktitut, which means “nice little inlet”) is located on the east coast of Baffin Island, within the Qikiqtaaluk region of Nunavut. The area is located within the Davis physiographic region of Canada, within the Baffin Coastal Lowlands Ecoregion, which is bordered to the south by Baffin Highlands (Bostock 2014). The hamlet of Clyde River is found on the eastern shore of Baffin Island on the northwest side of Patricia Bay.

1.4.2 Geology

In general terms, the local bedrock comprises relatively hard, light to dark colored, igneous and metamorphic rocks. More precisely, bedrock consists of an Archean-Aphebian crystalline complex with granitic to intermediate gneisses, granitic and charnockitic plutons, early mafic dykes, and metamorphosed supracrustal sequences with associated felsic, mafic, and ultramafic rocks. (Jackson 2000).

1.4.3 Glacial and postglacial history

The overall landscape surrounding Clyde River has undergone extensive glaciation and modification by glaciers. Ice caps and glaciers, U-shaped valley, hanging valleys, cirques and moraine ridges are all remnant of glaciation in the region. During the Late Wisconsinan glaciation, the Fox Dome of the Laurentide Ice Sheet covered Baffin Island. Cold-based, non-erosive ice occupied upland region, while warm-based, erosive ice infilled the coastal forelands and fjords (Irvine 2011). At the end of the last glacial maximum, glaciers had flowed from Clyde Inlet into Patricia Bay towards Baffin Bay. The outlet glacier that was covering the present townsite retreated from the area, influencing the course of the Clyde River (northeast), leaving a series of recessional lateral moraines immediately north of southwest/northeast moraines immediately north of the community.

Throughout the Holocene, moderate to steep slopes have been modified by gravitational and periglacial processes, leaving colluvial deposits along several slopes. Fluvial erosion and deposition have resulted in the development of river terraces, floodplains and fans. Organics have accumulated in poorly drained areas and in topographic low.

1.4.4 Ecoregion

Lands within the Coastal Lowlands Ecoregion are characterized by a sparse vegetation cover of mixed herbs, shrubs and mosses. The area is characterized by a High Arctic ecoclimate; generally humid and cold, and marked by short, cool summers and long winters (Ecological Stratification Working Group 1995; Agriculture and Agri-Food Canada 1999). The mean annual air temperature in Clyde River for the period 1981-2010 was of -12.6°C. Precipitation measured during the same period averaged 63.3 mm year^{-1} of rainfall and 194.7 cm year^{-1} of snowfall. Average thawing and freezing indices are 382°C-days and 4950°C-days, respectively (Environment Canada 2017).

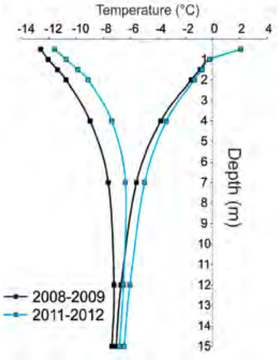
1.4.5 Permafrost

Clyde River is located within the continuous permafrost zone, an area where permafrost is assumed to underlie 90 to 100% of the ground surface (Heginbottom and Radburn 1992). Permafrost likely extends over 500 m below the ground surface in this area. Based on regional permafrost mapping from Heginbottom and Radburn (1992), the ground ice content is generally low in the area (i.e., generally less than 10 % by volume in the first 10 to 20 m of below the ground surface). The presence of ground ice (likely underestimated in the above reference at 10%) creates adverse soil conditions requiring technical solutions to facilitate housing and infrastructure development and/or maintenance.

1.4.6 Ground temperature review

Information on permafrost ground temperature in Clyde River has been published by Nixon (1988) and Ednie and Smith (2010, 2015). Temperature profiles were monitored from 2008 to 2012 in glaciomarine deposits consisting of sands, silts and gravels at depths up to 15 m (Ednie and Smith 2015). Figure 1-2 presents the maximum and minimum annual ground temperature profiles obtained from this location. Mean active layer thickness for the entire data collection period is 0.95 m and average ground temperatures at 15 m depth was of -6.9°C (Ednie & Smith 2015). The temperature profiles show a general warming trend of ground temperature when comparing 2008-2009 to 2011-2012.

Figure 1-2 Annual ground temperature profile for Clyde River[1]



1.5 ADAPTATION TO CLIMATE CHANGE

Permafrost warming can lead to a deepening of the active layer and thawing of permafrost ground ice. The loss of volume caused by the melting of ground ice generates settlement and subsidence. It is recognized that permafrost degradation may adversely affect some building foundations (e.g., settlement and cracking) and provoke some localized settlement and subsidence along roads (Allard et al. 2014). Oswell and Nixon (2014); however, demonstrated that ground temperatures under raised building cool over time and become colder than the ground remote from the building. When long-term climate warming

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[1] Figure present maximum and minimum ground temperatures for the years 2008 to 2012. Figure modified from Ednie & Smith (2015).

is considered, the temperature at depth do warm, but after 20 years of climate warming the ground temperatures are still not warmer than the initial ground temperatures remote from the building.

Assessments of landscape hazards and potential effects of future climate change have been conducted for different communities within Nunavut, including Whale Cove (Allard et al. 2014), Cambridge Bay (Smith & Forbes 2014), Kugluktuk (Smith 2014) and Arviat (Forbes et al. 2014). The community of Clyde River was not covered by these assessments, however, a study by Smith et al. (2012b) did highlight landscape hazards related to the presence of permafrost. Both these types of assessments were made to assist with the development of community planning activities, in the context of climate change. According to Canadian Standards Association (2019), the sensitivity of a proposed site/structure to climate change is governed by the anticipated ground temperature at the end of the service life of the structure and needs to be evaluated. The potential implications of climate change on ground temperature should be evaluated following the guidance provided in the Canadian Standards Association (CSA) document related to infrastructure in permafrost (CSA 2019).

Government of Nunavut (2013) Homeowner’s Guide to Permafrost in Nunavut and Canadian Standards Association (2014), provides key baseline information on permafrost evolution processes, presents different methods to assess permafrost conditions (e.g., signs of shifting, clues for ice-rich permafrost, historical assessment and soil types) and suggests methods to counter permafrost degradation under housing (e.g., build on bedrock and types of foundations to use). These documents should be considered in community drainage system planning.

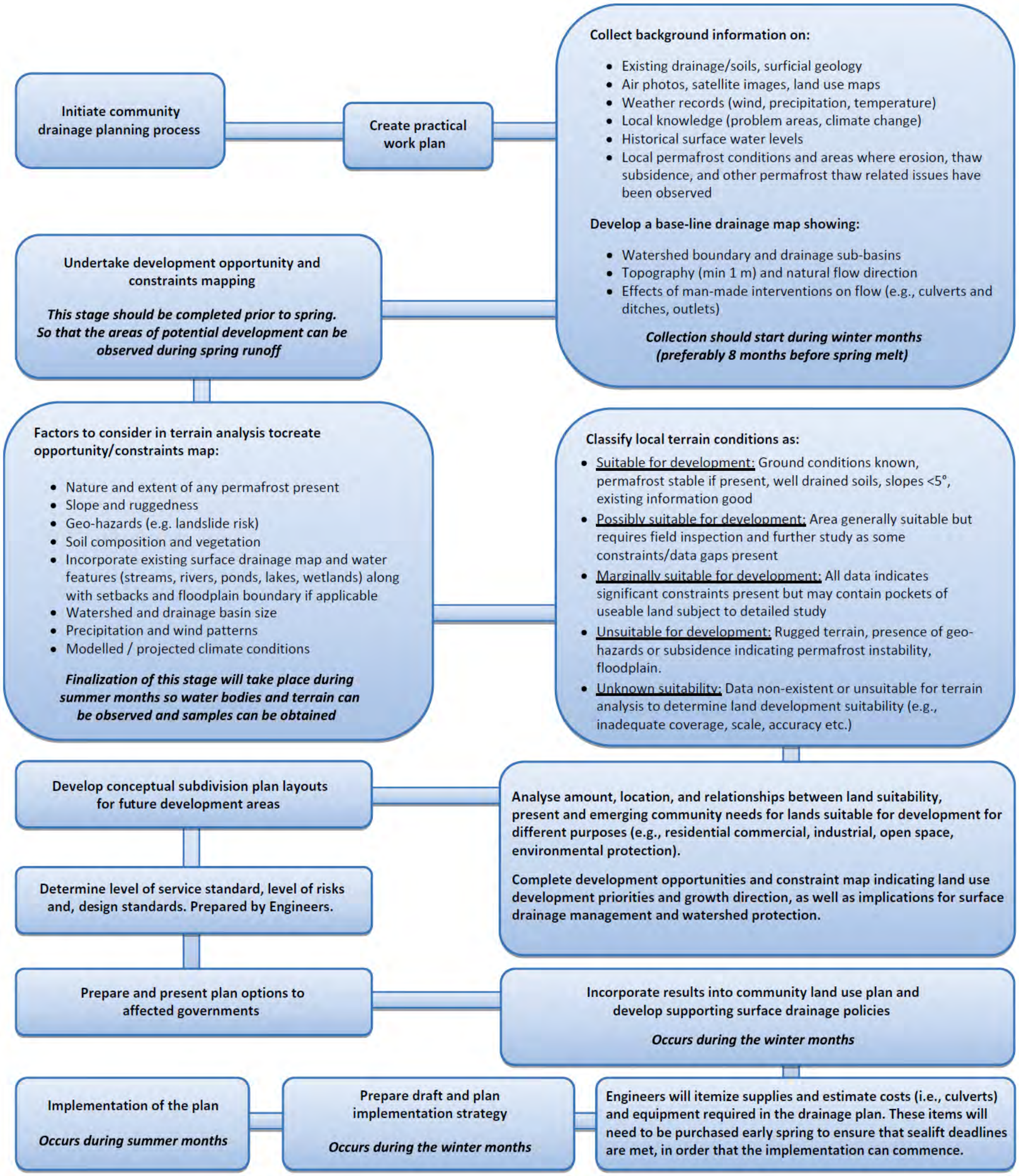
1.6 DRAINAGE ASSESSMENT AND PLANNING

In northern communities, surface drainage issues appearing during the short warm summers and short spring and fall seasons, are a constant challenge. Typical drainage problems are road washouts after extreme rainfall events, drainage ponding, and poorly constructed culverts (Canadian Standards Association 2015). A good drainage plan may prevent these problems. The Canadian Standards Association (2015) provides a typical drainage planning flow chart, Figure 1-3.

A drainage analysis requires compilation of information such as existing surface drainage systems, climate data, site inspection data, bedrock and surficial geology maps, topographic data, permafrost features, hydrologic data (e.g., catchment area and drainage patterns), geotechnical investigation and plans for future development. These data are used to create a baseline drainage map, a terrain constraints map and to identify the potential areas at risk; followed by planning for future drainage infrastructure and/or development relocation.

Spring snowmelt runoff and summer-fall drainage issues and conditions must also be observed before the drainage plan is fully developed (Canadian Standards Association 2015).

Figure 1-3 Drainage planning flow chart



Initiate community drainage planning process

Create practical work plan

Collect background information on:

- Existing drainage/soils, surficial geology
- Air photos, satellite images, land use maps
- Weather records (wind, precipitation, temperature)
- Local knowledge (problem areas, climate change)
- Historical surface water levels
- Local permafrost conditions and areas where erosion, thaw subsidence, and other permafrost thaw related issues have been observed

Develop a base-line drainage map showing:

- Watershed boundary and drainage sub-basins
- Topography (min 1 m) and natural flow direction
- Effects of man-made interventions on flow (e.g., culverts and ditches, outlets)

Collection should start during winter months (preferably 8 months before spring melt)

Undertake development opportunity and constraints mapping

This stage should be completed prior to spring. So that the areas of potential development can be observed during spring runoff

Factors to consider in terrain analysis tocreate opportunity/constraints map:

- Nature and extent of any permafrost present
- Slope and ruggedness
- Geo-hazards (e.g. landslide risk)
- Soil composition and vegetation
- Incorporate existing surface drainage map and water features (streams, rivers, ponds, lakes, wetlands) along with setbacks and floodplain boundary if applicable
- Watershed and drainage basin size
- Precipitation and wind patterns
- Modelled / projected climate conditions

Finalization of this stage will take place during summer months so water bodies and terrain can be observed and samples can be obtained

Classify local terrain conditions as:

- Suitable for development: Ground conditions known, permafrost stable if present, well drained soils, slopes <5°, existing information good
- Possibly suitable for development: Area generally suitable but requires field inspection and further study as some constraints/data gaps present
- Marginally suitable for development: All data indicates significant constraints present but may contain pockets of useable land subject to detailed study
- Unsuitable for development: Rugged terrain, presence of geo-hazards or subsidence indicating permafrost instability, floodplain.
- Unknown suitability: Data non-existent or unsuitable for terrain analysis to determine land development suitability (e.g., inadequate coverage, scale, accuracy etc.)

Analyse amount, location, and relationships between land suitability, present and emerging community needs for lands suitable for development for different purposes (e.g., residential commercial, industrial, open space, environmental protection).

Complete development opportunities and constraint map indicating land use development priorities and growth direction, as well as implications for surface drainage management and watershed protection.

Develop conceptual subdivision plan layouts for future development areas

Determine level of service standard, level of risks and, design standards. Prepared by Engineers.

Prepare and present plan options to affected governments

Incorporate results into community land use plan and develop supporting surface drainage policies

Occurs during the winter months

Engineers will itemize supplies and estimate costs (i.e., culverts) and equipment required in the drainage plan. These items will need to be purchased early spring to ensure that sealift deadlines are met, in order that the implementation can commence.

Prepare draft and plan implementation strategy

Occurs during the winter months

Implementation of the plan

Occurs during summer months

2.0 METHODOLOGY

This section provides baseline information on permafrost and drainage related challenges in northern communities and gives an overview of the methodology applied for the drainage planning and geotechnical investigation tasks.

This methodology includes the following:

- List of relevant background materials used as part of the study
- Desktop terrain assessment
- Qualitative construction suitability rating
- Geotechnical field programs
- Laboratory analyses

2.1 BACKGROUND REVIEW

Background data was collected from a variety of sources including (but not limited to) the following:

- Literature on landscape hazards and potential effects of future climate change in Nunavut (Allard et al. 2014; Forbes et al. 2014; Smith & Forbes 2014; Smith 2014).
- Work on community-based permafrost monitoring (Irvine 2011; Ernie & Smith 2015).
- Digital surficial geology (Smith et al. 2012a) and periglacial and permafrost geology mapping (Smith et al. 2012b).
- 2016 and 2018 satellite imagery and Territorial Digital Elevation Data (DEM)[2].
- 2018 Clyde River vector base data (e.g. parcels, building footprints, hydrology (2010), topography, infrastructures)[3].
- CSA 503-15: Community drainage system planning, design, and maintenance in northern communities (Canadian Standards Association 2015).
- CSA S501-14: Moderating the effects of permafrost degradation on existing building foundations (Canadian Standards Association 2014).
- CSA PLUS 4011-19: Technical guide: Infrastructure in permafrost: A guideline for climate change adaptation. (Canadian Standards Association 2019).

2.2 DESKTOP TERRAIN ASSESSMENT

2.2.1 Surficial geology and permafrost and periglacial features

The existing surficial geology mapping (Smith et al 2012a) and permafrost and periglacial mapping (Smith et al. 2012b) were reviewed and modified to create terrain maps for the study area (see Figures B-1 and B-2 in Appendix B). Desktop mapping was conducted using ESRI ArcGIS® and Global mapper software and was carried out through the interpretation of 2016 and 2018 satellite imagery provided by CGS. No stereo imagery was used in this process. The territorial DEM was then used to create a slope model. The slope model consisted in classifying slope segments in predefined classes (plain to very gentle 0-10 %;

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[2] Satellite imagery and DEM were provided by the Government of Nunavut, Department of Community and Government services.

[3] Provided by the Government of Nunavut, Department of Community and Government services.

gentle, 10-20 %; moderate, 20-50 %; moderately steep, 50-70 %; steep, >70 %). This data was used to create a slope map of the study area at a scale of 1:8,500 (see Figure B-3 in Appendix B). It was found that this three-dimensional representation of the study area provided limited value to the assessment as the DEM data was very coarse. Although the data allowed to identify major slope breaks, the overall poor accuracy of the data limited the identification of microtopographic features (i.e., gullies and rills, ice wedge polygons, drainage flow paths and solifluction lobes).

2.2.2 Drainage site conditions

Watershed and sub-basins were first interpreted using the territorial DEM, then refined using the 2016 satellite images. This task involved setting boundaries between inferred drainage zones to have a map representation of the flow directions. Drainage flow paths were mapped from the interpretation of physical and vegetation indicators visible on the satellite imagery. Flow paths included channelized active flow that occurred during most of the thaw season, and areas with no clear channel where intermittent flow was active during spring snowmelt and after heavy rainfalls.

Potential indicators of the variability of surface drainage are distinct topographic features (e.g. rills, troughs), seepage channels generally matching the slope orientation, standing water areas and distinct vegetation communities growing within or alongside imperfect to poorly drained terrain. Based on these, terrain polygons were drawn and assigned a soil drainage class. Soil drainage classes are relative and qualitative descriptions of the removal of water from a soil in relation to water supply. The drainage classes used in the assessment are derived from the Canadian Soil Information System (CanSIS[4])and consist of the following: Very poor, poor, imperfect, moderately well, well, rapid and very rapid.

2.3 QUALITATIVE CONSTRUCTION SUITABILITY ASSESSMENT

Qualitative construction suitability within the study area is based on the overall site conditions, including the presence/absence of terrain constraints and potential geohazards.

- **Terrain constraints** are naturally occurring features that have the potential to negatively affect the design, construction and maintenance of a community (e.g. slope steepness, drainage conditions, surficial material type, permafrost and periglacial features).
- **Geohazards** are terrain conditions that may lead to localized or widespread damage to property and threaten personal safety. Common examples of geohazards are landslides, gully erosion, ground subsidence and thermokarsting, flooding, thermo-erosion of permafrost.

These features were identified through background data review, desktop mapping and field observations.

The construction suitability classification used for the assessment is based on the standard developed by the Canadian Standards Association for *Community drainage system planning, design, and maintenance in northern communities* (Canadian Standards Association 2015), then adjusted based on characteristics of the study area (Table 2-1).

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[4] http://sis.agr.gc.ca/cansis/nsdb/soil/v1/snt/drainage.html

Table 2-1 Criteria for estimating construction suitability classes

Classes conditions
Terrain suitable for development • Permafrost present with low to moderate volumetric ice content (VIC 0-50 %). • Well-drained to imperfectly drained soils. • Level topography with slopes under 10%. • Inactive to limited periglacial processes. No observed evidence of rapid mass movement.
Terrain potentially suitable for development • Permafrost generally present with low to moderate ice-content; however, may include areas of high ice content (VIC 50-100%). • Permafrost features such as ice wedges may be present. • Imperfectly to poorly drained soils. • Gently sloping topography with slopes between 10 to 20%. • Inactive to limited periglacial processes. No observed evidence of rapid mass movement. • Site is adjacent to an area that may negatively impact the suitability of the site.
Terrain unfavorable for development • Permafrost present with high ice content. • Observed indicators of unstable terrain (e.g., ground settlement, thermokarst development, thermo-erosion, gully erosion, landslide). • Poorly drained to very poorly drained soils. Surface seepage or drainage flow path generally present. • Slopes > 20%. • Thick organic soils. • Snow drifting and/or snow accumulation areas. • Sites with active mass wasting processes. • Areas potentially susceptible to flooding

2.4 FIELD PROGRAMS

2.4.1 Initial field reconnaissance (September 2017)

A field reconnaissance visit was conducted as part of the initial phase of work to confirm the findings of the preliminary mapping and to collect additional data relevant to drainage conditions. The fieldwork was conducted by a field technician from Nunami Stantec between September 18 and 21, 2017.

This field reconnaissance focused on the initial study area (Block 2) and immediate surrounding areas. A series of foot traverses were conducted across the terrain, with stops at selected ground inspection sites, several of which were pre-selected while conducting the mapping exercise. Information recorded during field program included: slope gradient, sediment type, surface expression, sediment texture, soil drainage conditions, presence of seepage pathways and/or catchment areas, permafrost-related features and/or periglacial processes, as well as the characterization of existing drainage infrastructures.

2.4.2 Drainage evaluation program (September 2019)

The purpose of the second field program was to assess the drainage conditions and to evaluate the existing community drainage infrastructures. Fieldwork was conducted by two geomorphologists from Nunami Stantec on September 10 to 11, 2019.

The evaluation program was conducted within the existing townsite and the immediate environs around the townsite[5]. Information recorded during field program included: GPS coordinates, soil drainage conditions, presence of drainage flow paths, permafrost-related features and/or periglacial processes, presence and condition of existing drainage infrastructure.

CAD drawings supporting the drainage planning are presented in Appendix C. An inventory of the existing drainage infrastructures (including existing culverts, berms and ditches) is presented in Appendix D.

2.4.3 Geotechnical investigation program (September 2019)

The geotechnical program was completed between September 12 and 18, 2019 and consisted of drilling 18 separate boreholes. Thirteen boreholes were conducted using a portable two-person mechanical auger operated by Stantec, and five boreholes were conducted using an air-track drill supplied and operated by a drilling subcontractor (Canadrill Ltd). All boreholes were drilled within the extents of the proposed Blocks 2, 3 and 4. More precisely, boreholes advanced with the air-track drill were completed within 100 m from the existing road network. Borehole locations were recorded using a handheld GPS. There locations with reference to the proposed subdivisions are displayed on Figure B-7 (Appendix B).

Portable mechanical auger drilling

Shallow boreholes (BH19-01 to BH19-13) were drilled to depths ranging from 0.74 m to 2.64 m below ground surface (bgs). The equipment used consisted of a two-stroke engine mounted with aluminum drill rod extensions and a diamond carbide core barrel (40 cm-long and 10 cm in diameter), which allows for

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[5] The “immediate environs” refers to land that may be potentially developable for new residential subdivisions around the existing townsite, within a twenty-year planning horizon.

retrieval of undisturbed cores in permafrost soils. The undisturbed core samples were cleaned, photographed, measured and described. Whenever observed in the core samples, the cryostructures were described using nomenclature and classification derived from Pihlainen and Johnston (1963), and Murton and French (1994). The cryostructures classification used is presented in Appendix E.

Air-track drilling

Deeper boreholes (BH19-14 to BH19-18) were drilled to depths of 10 m bgs. The boreholes were advanced by the percussion rotary air blast drilling method, with a 165 mm outside diameter drill bit. Drill cuttings were ejected out of the borehole by compressed air forced out at the drill bit face. Due to the drilling method employed for this investigation, the soil samples observed from each borehole at different depths were highly disturbed. Disturbed soil samples were collected from the drill cuttings at an approximate 1m interval. Finally, a thermistor string was temporarily inserted in BH19-14 so to record temperatures at depths of 1, 2, 4, 6 and 8 m. On completion, the boreholes were backfilled with available drill cuttings.

Laboratory testing

Samples recovered from the site were stored in moisture tight containers and were returned to the Stantec laboratory (Laval, Qc) for detailed classification and testing. Laboratory testing included the following:

- Moisture content (or gravimetric water content) on all samples,
- Grain size analysis (for coarse grained aggregates including sieve > 5 mm) on selected samples,
- Volumetric ice content (VIC) of selected samples using:

$$\mathbf{VIC}\ (\%) = \frac{\mathbf{V_i}}{\mathbf{V_t}}$$

  where V_t is the total volume of the frozen sample (cm^3) and V_i is the volume of ice (cm^3) estimated from weight loss after drying, using the theorical density of ice (0.9175 g cm^{-3}).

- Salinity analysis of the ice and pore water from the permafrost cores BH19-03-DC-03 and BH19-05-DC-05 was measured by BV Laboratory. Salinity was measures in milliSiemens per centimeter (mS cm^{-1}) and results were converted in part per thousand (ppt) using:

$$\mathbf{Salinity}\ (\mathbf{mS\ cm^{-1}}) * \mathbf{0.7} = \mathbf{Salinity}\ (\mathbf{ppt})$$[6]

The test results obtained from the field assessed materials were verified in the Laval laboratory. Borehole records are presented in Appendix E. The results of the laboratory testing are presented in the attached gradation curves and summary tables in Appendix F.

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[6] Conversion factor used in Irvine (2011).

2.5 FINAL MAPPING

Final mapping was conducted using information gathered during the field programs. The following table summarizes the maps presented as part of the assessment (see Appendix B).

Table 2-2 Summary of maps presented as part of the drainage analysis

Figure	Maps	Comments	Mapping scale
B-1	Surficial Geology	Surficial geology overview of Clyde River (modified from Smith et al. 2012a)).	1:8,500
B-2	Permafrost and Periglacial Features	Permafrost and periglacial features (Modified from Smith et al. 2012b).	1:8,500
B-3	Topography and DEM-Derived Slope Classes	Slope mapping of the existing townsite and the immediate environs around the townsite.	1:8,500
B-4	Watershed Boundary and Drainage Sub-basins	Overview of watershed boundary, drainage sub-basins and flow direction of Clyde River.	1:40,000
B-5	Drainage Conditions	Drainage flow path and soil drainage of Clyde River.	1:8,500
B-6	Construction Suitability	Terrain constraint-related hazard assessment mapping of Clyde River.	1:8,500
B-7	Borehole Locations	Location of all boreholes drilled within the extents of the proposed Block 2 and Block 4.	1:4,500

3.0 RESULTS – DESKTOP TERRAIN ASSESSMENT

3.1 SURFICIAL GEOLOGY

Regional, 1:10,000 scale, surficial geology mapping of Clyde River (Smith et al. 2012a) was used as baseline to provide an overview of the surficial materials within the area (see Figure B-1 in Appendix B).

The most common surficial material found within the study area is till, followed by marine colluvium, glaciolacustrine, fluvial and in lesser proportion, organic and glaciofluvial. Anthropogenic, or disturbed materials were also mapped in areas where fill was placed or excavated. Comments on typical drainage conditions (i.e., during the thawing season) of each material types are provided below.

Till (morainal material), deposited directly by glacial ice is the most widely distributed surficial material within the study area. Till deposits found in the general area of Clyde River are described by Smith et al. (2012a) as either: “a till blanket sufficiently thick to obscure the relief of the underlying bedrock, or a morainal complex where thick till comprises morainal ridges and complexes formed during ice-marginal recession”.

Field observations showed that the till is generally composed of medium sand and silt, with variable amount of angular to sub-angular gravel, cobbles and boulders and with occasional clay fractions. Surface seepage, permafrost processes (e.g. ice wedges) and periglacial processes (e.g., solifluction lobes) are occurring in these deposits. Drainage conditions in the till deposits generally range from well to very poorly drained. Till deposits are potentially ice-rich.

Marine deposits (including beaches and terraces) are found at lower elevations along Patricia Bay. The beach materials consist mainly of sand and gravel, and the terraces materials are finer with variable contents of silt, sand and gravel. Drainage conditions of the marine deposits range from well to very poorly drained. Beaches deposits are likely to contain low to moderate ice contents, as marine terraces should be considered as potentially ice-rich.

Colluvial deposits are accumulations of unconsolidated material that result from mass movement events. These materials generally consist of reworked till where the soil properties were modified by geomorphic processes such as active layer detachment and solifluction. The deposit typically contains medium sand and silt, with variable amount of clay and gravel. Drainage of the colluviums range from moderately well to poorly drained. These sediments should be considered as potentially ice-rich, as they contain a high proportion of fine-grained material.

Glaciolacustrine deposits accumulated in glacier-dammed or pro-glacial lakes, and occur mainly within the northern portion of the proposed new subdivision Block 4. The material is generally fine-grained (clay to sandy-silt), however can contain beds of sand and gravel. Drainage generally range from poorly to very poorly drained and organic accumulations occur in the area. Permafrost is likely to present ice-rich conditions.

Alluvial (Fluvial) deposits are the result of transportation and deposition of material by streams and rivers. They occur in the project area as thin veneers (i.e. < 1 m) overlying till. The material consists of sand and gravel, with variable amounts of silt. Drainage conditions within the alluvial deposits varied considerably (from rapidly to very poorly drained). The ice content of these sediments should also be considered variable.

Organic materials consisting mostly of peaty soils were mainly observed as veneers overlying till and marine deposits. No thick organic accumulation (e.g. peatland) was identified within the study area. Organic materials are poorly to very poorly drained. Their capacity to retain high amounts of water generally favors the creation of ice-rich permafrost profiles. The vegetation in the study area (approximately 60% of the ground cover) consist mainly of sedges, lichens, mosses with a few low shrubs. Thick and healthy moss cover is usually a good indicator of an elevated water table within a potential seepage zone.

Glaciofluvial deposits are the result of transportation and deposition of material by glacial meltwater streams. They occur as outwash deposits and terraces and are found towards the airport. These sediments commonly consist of stratified coarse material such as sand, gravel and cobbles, and may include minor silt and clay content. Drainage conditions within glaciofluvial deposits are generally rapidly to poorly drained. The ice content of these sediments should be considered variable.

Anthropogenic deposits were mapped within the limits of the community and mainly include disturbed areas where fill material was placed (e.g., housing areas and roads), as well as the footprints of the various borrow areas. Fill material observed within the community mainly consist of till (medium sand and silt, with variable amount of angular to sub-angular gravel), with minor amount of glaciofluvial sand and gravel. The ice content of anthropogenic deposits is assumed to be low.

3.2 PERMAFROST AND PERIGLACIAL FEATURES

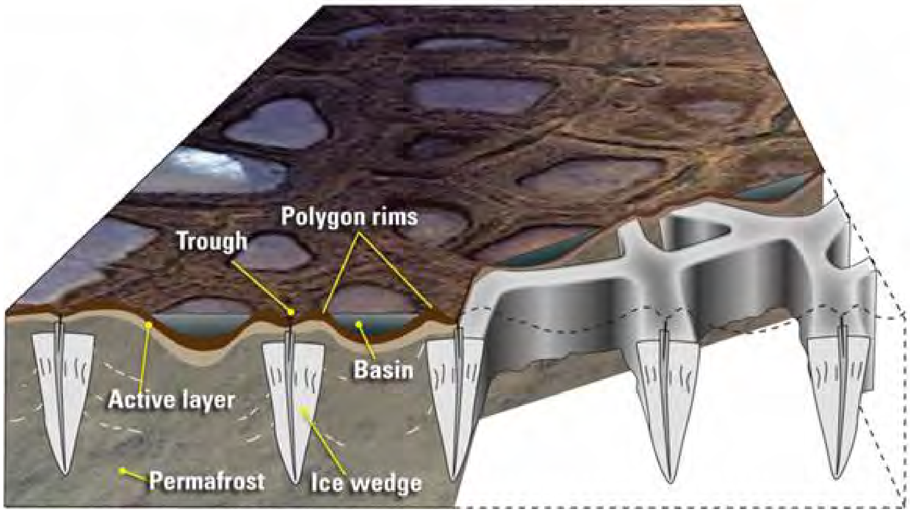
Key baseline information on permafrost and periglacial conditions in Clyde River, is available from a study by Irvine (2011) and mapping by Smith et al. (2012b). Identified features of interest include ice wedge polygons, solifluction lobes and nivation hollows. Patterned grounds that formed from cryoturbation and sorting of the material, also occur across the landscape (e.g., frost boils, sorted circles and sorted stripes.

3.2.1 Ice wedges

Ice wedge polygons are ground ice features widely distributed in permafrost areas. They result from the thermal contraction of permafrost soils, creating cracks that fill with ice formed from snowmelt water. The yearly repetition of this process facilitates the creation of ice wedges that form huge polygonal networks throughout periglacial landscapes (Fortier and Allard 2004). Figure 3-1 presents a schematic illustration of a network of ice wedges. Ice wedge within Clyde River were previously mapped using aerial imagery by Smith et al. (2012b). A map displaying the locations of ice wedges in presented in Appendix B, Figure B-2.

Within the study area, low-centered ice wedge polygons were observed to be dominantly located within marine deposits alongside Patricia Bay as well as low-lying organic veneers overlying lacustrine and/or fine-grained till deposits. More precisely, ice wedges were observed in the following areas: the north and east portion of Block 2 (Lot 1, 2 and 24), the northeast portion of Block 4 (Lots 25 to 32). Some wedges were also observed within the disturbed footprints of former borrow areas, as well as areas surrounding existing buildings. Although land development has already occurred above areas identified as containing ice wedges, presence of this feature should be considered carefully when planning housing and infrastructure development as degradation of these massive ice features may lead to thermo-erosion, thermokarst development, gullying and ground subsidence (Godin et al. 2016).

Figure 3-1 Schematic illustration of a network of ice wedges in permafrost[7]



3.2.2 Solifluction lobes

Solifluction lobes are smooth, lobate periglacial features that formed from the slow downslope movement of surficial materials (soils). Their displacement is typically limited to few centimeters per year, and is often the dominant mechanism of slope modification in periglacial environments (Åkerman 1996). Solifluction lobes are created by three processes: frost creep (downslope movement occurring from freeze-thaw cycles), gelifluction (movement of saturated soil during thawing of frozen substrate) and plug-like flow (soil sliding at the active layer and ice-rich permafrost boundary) (Mackay 1981; Matsuoka 2001; French 2007).

These features were previously mapped by Smith et al. (2012b), as presented in Figure B-2 in Appendix B. Most of their location matches areas characterized by till or colluviated till surfaces (5 to 20% slope) characterized by imperfectly to poorly drained soil conditions. Example of a solifluction observed in the field include the southernmost portion of Block 2 (Lot 21). At this location, a distinct lobe feature resulting from slow mass movement is visible (Figure 3-2). The feature appeared stable and no seepage was identified at this location.

Although a series of solifluction lobes have been identified as part of previous mapping exercises, most of these features appear to present limited constraint related to site development (with the exception of areas where active seepage was identified).

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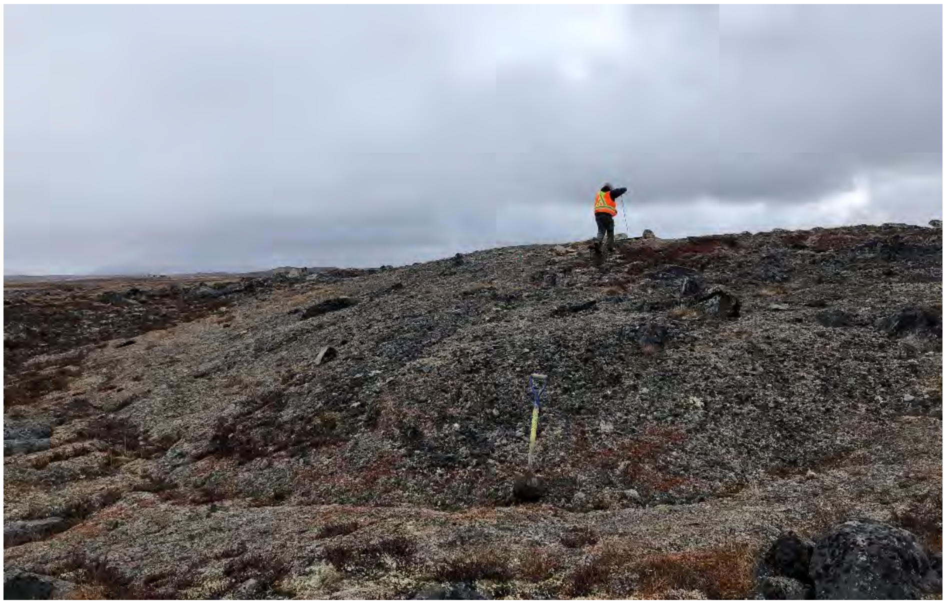
[7] Figure by R. Mitchell/Inkworks for U.S. Fish and Wildlife Service

Figure 3-2 Example of solifluction lobe in Block 2 (Lot 21)



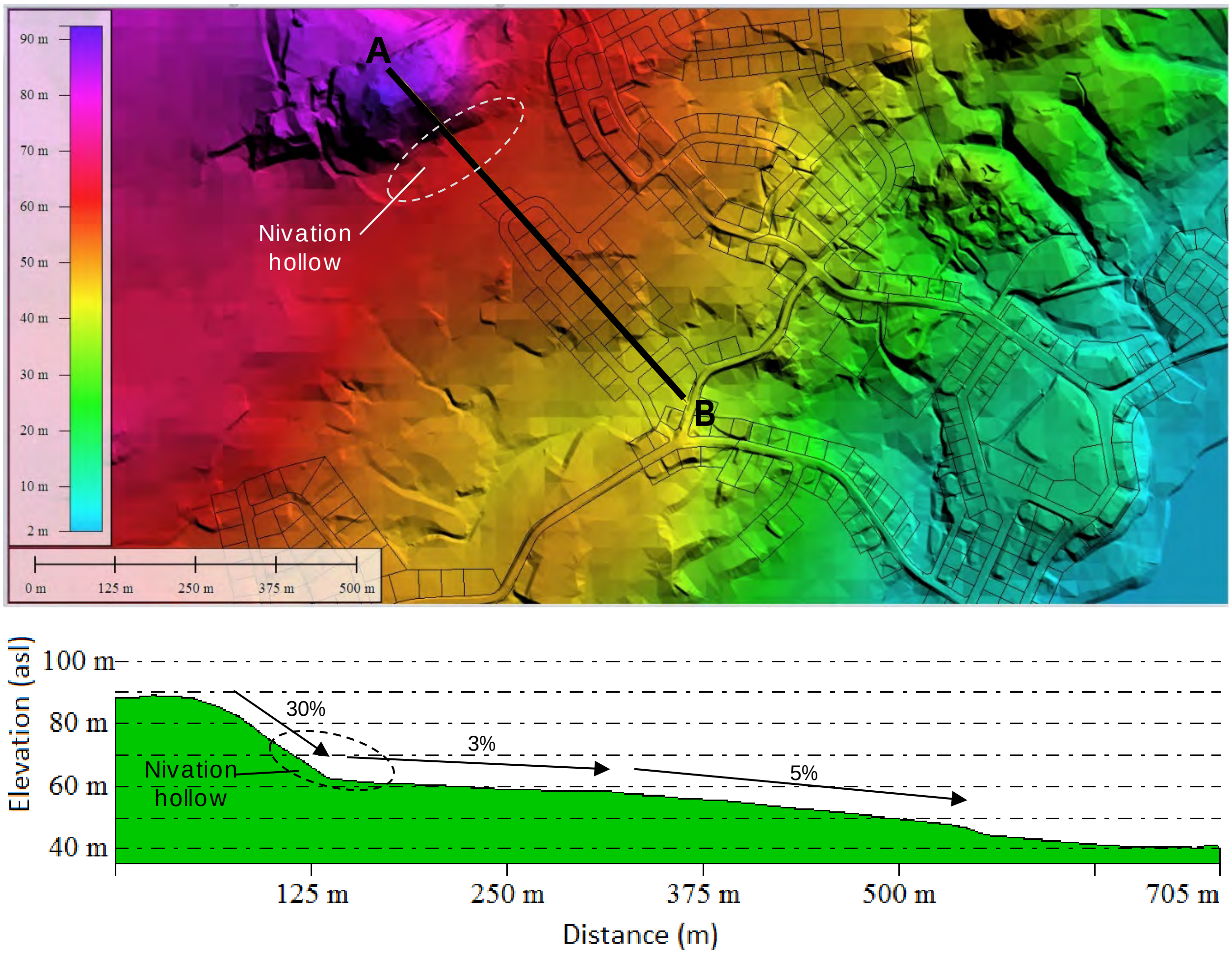
3.2.3 Nivation hollows

Nivation hollows are formed by periglacial weathering where perennial or semi-permanent accumulation of snow patches lead to the formation of shallow depressions. Their presence does impact drainage conditions within the Clyde River area, where the slow melting of persistent snow patches allows for seasonal seepage that extends much later than the regular spring melt period. Even though no perennial snow patches were observed during the September 2019 field program, the review of satellite imagery suggests that late-lying accumulations are present at several locations within the study area.

An example of a nivation hollow was observed immediately north of Block 2, along the base of the moderately steep slope (~ 30%) located below the existing borrow source (Figure 3-3). At this location, late-lying snow patches are often observed late in the thawing season, therefore impacting local drainage conditions. Ice wedges were identified at this location. A schematic representation of the topography in the area is shown in Figure 3-4.

Figure 3-3 Snow patches residues and downslope hydrology

Figure 3-4 Plan view showing DEM and topographic cross-section across Block 2 (vertical exaggeration 1:2)



3.3 ASSESSMENT OF LOCAL DRAINAGE CONDITIONS

3.3.1 Drainage conditions within the developed portions of the community

An overview map of Clyde River incorporating the waterbodies, watersheds, flow directions and main infrastructure footprints was produced at a scale of 1:40,000 and is presented in Appendix B, Figure B-4. A terrain map incorporating the drainage flow paths and soil drainage classes surrounding the study area, was produced at a scale of 1:8,500 and is presented in Appendix B, Figure B-5. Key drainage features were also added to drainage plans presented in Appendix C.

Although no well-defined creek or river flow directly within the developed portion of the community, three main drainage features were observed to impact flow across the study area. These features consist of coalescing flow paths (some poorly-defined), eventually forming poorly developed drainage channels. A first feature drains the upper portions of Block 1 and Block 2 before flowing southerly toward the sealift area. A second feature drains through Block 3 and Block 4, before flowing southeasterly toward the center of the community. A third feature drains the north and northeast portions of the community (active borrow source and Block 4), before flowing southeasterly toward the eastern limit of the community. Imperfect to very poor drainage conditions were observed during the 2019 field investigation. Although the drainage conditions are driven by a series of interconnected factors including (but not limited to) topography and surficial materials, some of these conditions arise from either a lack of drainage infrastructures, inadequate infrastructure maintenance or inadequate construction practices.

Adverse drainage conditions specific to the different community districts are highlighted in Figure 3-5, and are summarized below.

Northern district

- Waterlogged soils and standing water observed within low-lying terrain, including in fill material observed underneath some of the housing units.
- Groundwater seepage and poor drainage in areas adjacent to new infrastructures.

Area surrounding road R5

- Seepage and poor drainage alongside residential lots.

Sealift and Quluaq school districts

- Poor drainage conditions behind housing units.
- Water ponding along stream (culvert C-19 area).
- Gullying and thermo-erosion of ice wedges occur during spring snowmelt season.

Eastern district

- Poor drainage behind housing units.
- Persistent snow patches accumulate above the district and trigger poor drainage conditions.

It is also noted that surface runoff over roads and driveways was also observed throughout the community.

Figure 3-5 Flow paths and drainage features within the community. A) Northern district; B) Area surrounding road R5; C) Sealift and Quluaq school districts; D) Eastern district.

3.3.2 Drainage conditions within Block 1

Only one drainage flow path was identified within Block 1. This flow path drains the northwesternmost portion of the study area (initiating near the current waste disposal site), then flows east and south toward the community. Waterlogged fine-grained soils were observed alongside this flow path. Drawing C-101 (Appendix C) shows that the flow path crosses Lots 5, 6, 11, 18 and 29, as well as proposed road R22 and R23.

3.3.3 Drainage conditions within Block 2

A series of drainage flow paths with significant runoff potential were identified within the general on either side of Block 2 (Figure B-5 Appendix B). Two flow paths are present in the easternmost portion of Block 2 (Lot 20). These flow paths drain a good portion of the terrain found immediately downslope of the borrow source. At least three other flow paths were identified immediately west of Block 2, the closest one being adjacent to Lots 1 and 9 and road R25. These features drain the western portion of the watershed, until merging with the northeasterly flowing stream present south of Block 2. This stream flows within a poorly-defined channel, the width of which can reach up to 40 m wide. Up to 0.5 m deep of water was observed in the stream during the 2019 field program. Drawing C-102 (Appendix C) shows that Lots 17 and 20, as well as proposed road R24 and R26 are crossed by flow paths.

Poor to very poor soil drainage conditions are present within the eastern and northern portion of Block 2 and can lead to the pooling of surface water. The permafrost is partially responsible for this process, by preventing the downward drainage of water below the active layer causing saturation of the active layer and water ponding at the ground surface.

This process was observed at the base of the borrow source slope (i.e., north of Lots 1 and 2), as well as within the southernmost section of Lot 20, alongside the upland side of the road (road section R20). This area was identified as potentially problematic due to the occurrence of seepage runoff and water accumulation mainly during the spring snowmelt season.

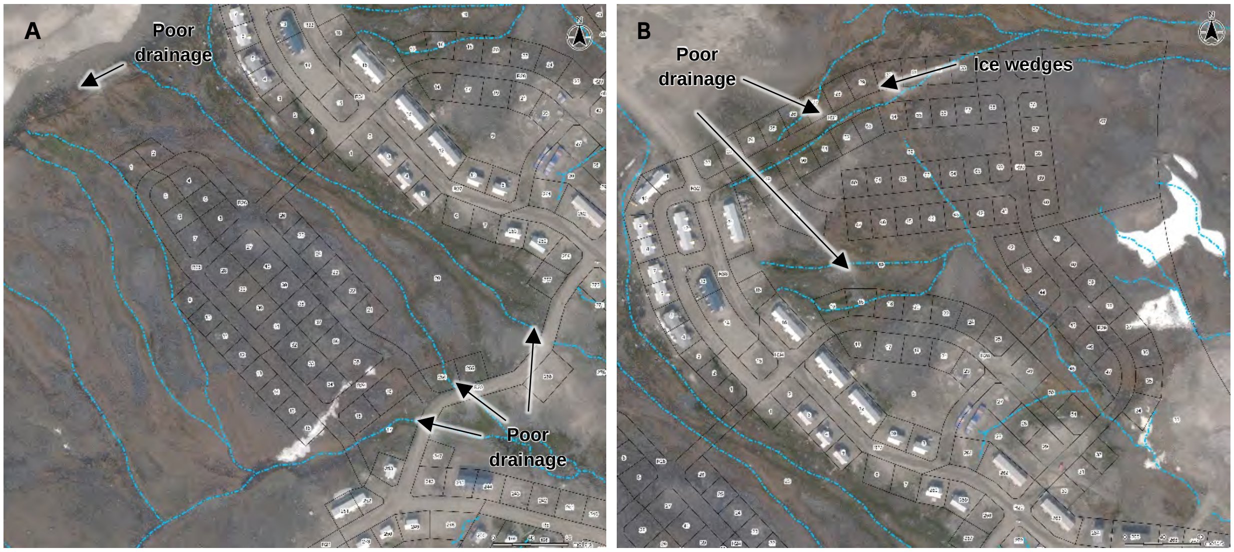
3.3.4 Drainage conditions within Block 3 and Block 4

Drainage flow paths with significant runoff potential were identified within Block 3 and Block 4 (Figure B-5, Appendix B and Drawing C-103 and C-105, Appendix C). Three flow paths were observed within Block 3. Two of these drain the northern community district easterly, and merge with a flow path that drains southerly through the middle of Block 3 and 4. Slopewash and erosion of fill material was observed alongside the staging area used by the Housing Corporation. This erosion was likely triggered by surface seepage runoff during the spring snowmelt season.

Two flow paths were observed within the northernmost portion of Block 4 (surrounding road R31). Adverse drainage conditions in this area were observed in the field (i.e., waterlogged soils and standing water). The presence of standing water within ice wedge throughs was also observed. Note that the shallow active layer depths measured in this area (see section 4.1.6) was observed to influence soil saturation and accumulation of standing water.

Example locations of adverse drainage conditions specific to Blocks 2, 3 and 4 are highlighted in Figure 3-6.

Figure 3-6 Flow paths surrounding Block 2 (A) and Blocks 3 and 4 (B)



3.4 ASSESSMENT OF EXISTING DRAINAGE INFRASTRUCTURES

This section summarizes observations made during the field program regarding existing drainage infrastructures in the developed portions of the community. Missing or required drainage infrastructures related to potential development within Blocks 1 to 4 are also discussed.

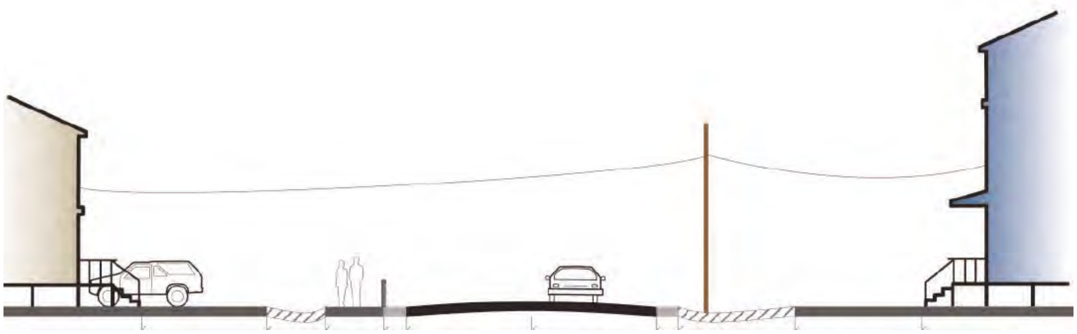
3.4.1 Drainage infrastructures within the developed portions of the community

A total of 42 culverts (C-01 to C-42), 3 berms (B-01 to B-03) and 8 ditches (D-01 to D-08) have been inventoried throughout the study area. Based on field observations several of the existing culverts experienced problems associated to localized deformation, undersizing and/or sedimentation. A few berms observed in the area showed minor issues associated with positioning and water seepage. Finally, shallow swales or a few ditches identified along existing roads experienced issues associated with moderate to inefficient drainage performance.

Observations made as part of the field program helped identify several areas characterized by imperfect to poor drainage conditions (e.g., water ponding and surface runoff was observed at several locations above roads and driveways). Observed conditions are likely to be worse during the spring meltout season.

Improvements of local drainage conditions could be achieved by maintaining, upgrading, repositioning and/or replacing some of the existing infrastructures. Similarly, improvements could be made by adding new infrastructure. This is especially the case with culverts and ditches that were observed to be missing at several locations along the existing roads network. Common practice is to have swales or shallow ditches alongside roads to facilitate drainage runoff and control potential ponding, as illustrated in Figure 3-7. A general guideline on drainage ditches/swales for Local road and collector is provided on CAN/CSA-S503-15 (Community drainage system planning, design, and maintenance in northern communities, CSA 2015).

Figure 3-7 Profile view showing driveways and drainage ditches/swales (modified from CSA 2015)



Refer to the drainage plans presented in Appendix C (Drawings C-100 to C-108) for the location of both existing and required infrastructures including culverts, ditches and berms. Refer to Appendix D for a photographic inventory and summary description of the drainage infrastructures located within the community.

3.4.2 Drainage infrastructures within Block 1

There are currently no drainage infrastructures in Block 1. If going forward with development as proposed through the lot layout presented in the drainage plan (Appendix C), infrastructure including ditches and culverts will be required. The proposed schematics include:

- Required culverts at crossing of major flow paths (C-60 and C-61).
- A ditch or swale on either side of most new roads.

It should be noted that new ditch lines should be built within newly placed fill material rather than on excavated native ground (i.e., where the base of the new ditch matches the native ground surface). This will limit potential permafrost degradation.

3.4.3 Drainage infrastructures within Block 2

Four culverts (C-05 to C-08) currently drain Block 2; with another culvert (C-03) draining the northern district of the community toward Block 2. Overall, the culverts presented moderate issues associated with deformation, fracturing, burial and poor positioning. Culvert C-03 is undersized and its inlet was observed to be blocked.

The proposed schematics for Block 2 include:

- Required culverts at crossing of major flow paths (C-55 to C-59)
- A ditch or swale on either side of new roads
- A ditch or swale in the backyard areas separating Lots 3 to 8 and Lots 27 to 40.

3.4.4 Drainage infrastructures within Blocks 3 and 4

Only a single ditch was observed to facilitate drainage through Block 3 (i.e., south of the yard used by the housing corporation), with currently no drainage infrastructures in proposed Block 4.

Observations summarized as part of the Construction Suitability Assessment (Section 3.5) suggest that modifications of the current roads and lots layout are required in Block 3 and Block 4 so to avoid problematic terrain. For this reason, specific locations of proposed drainage infrastructures are not presented in the drainage plan drawings.

Once the road and lot layout are optimized, special attention should be given to place ditches on either side of proposed roads, with culverts located at road intersections and driveways locations. Culverts will also be required wherever local flow paths have been identified.

4.0 RESULTS - GEOTECHNICAL INVESTIGATION

4.1 SUBSURFACE CONDITIONS

The following sections summarize the geotechnical properties specific to soil investigated in portion of Block 2, Block 3 and Block 4. The overall stratigraphy mainly consisted of a thin layer of organics overlying till or glaciolacustrine materials. The subsurface conditions encountered in boreholes completed in the September 2019 field program are presented in Table 4-1. Refer to Figure B-7 (Appendix B) for a map showing the location of specific boreholes. An overview of that map is presented below.

Figure 4-1 Overview of borehole locations

Table 4-1 Summary of subsurface conditions

Borehole Nº	Stratigraphy (depth below the ground surface, m)										
	Fill	Topsoil	Peat	Silt, sandy, gravelly	Silt and Sand	Sand, silty, gravelly	Silt and Gravel	Sand and Gravel, silty	Gravel, sandy	Cobble / Boulder	Massive Ice*	Active Layer
BH19-01	-	0.0-0.05	-	-	0.05-1.14	1.21-1.69	-	1.69-2.03	-	1.14-1.21	-	0.65
BH19-02	-	-	-	-	-	0.0-1.80	-	-	-	-	-	> 0.60
BH19-03	-	0.0-0.05	-	-	-	0.05-2.00	-	-	-	-	-	0.90
BH19-04	-	-	0.0-0.15 0.20-0.30	0.15-0.20 0.30-0.60	-	-	-	-	-	-	0.60-0.74	0.20
BH19-05	-	-	0.0-0.38 0.56-0.70	-	-	0.38-0.56	-	-	0.70-2.50	-	-	0.25
BH19-06	-	0.0-0.05	-	-	-	0.05-1.90	-	-	-	-	-	1.15
BH19-07	-	-	-	-	-	0.0-2.00	-	-	-	-	-	> 0.70
BH19-08	-	0.0-0.05	-	-	-	-	-	0.05-1.40	-	-	-	> 0.55
BH19-09	-	0.0-0.05	-	-	0.05-1.60	-	-	-	-	-	-	> 0.55
BH19-10	-	-	-	-	-	-	-	-	0.0-1.00	-	-	> 0.55
BH19-11	-	-	0.0-0.10	0.10-0.67	-	0.67-2.13	-	-	-		-	0.35
BH19-12	-	-	0.0-0.10	0.10-1.00	-	-	-	-	-		-	0.90
BH19-13	-	-	0.0-0.10	0.10-0.50	0.50-1.79 1.95-2.25	-	2.25-2.64	-	-	1.79-1.95	-	0.50
BH19-14	-	-	0.0-0.10	-	0.10-5.50	6.00-9.25 9.75-10.00	-	-	-	5.50-6.00 9.25-9.75	-	-
BH19-15	-	-	0.0-0.10	0.10-1.50	1.50-10.00	-	-	-	-	-	-	> 0.50
BH19-16	-	0.0-0.05	-	0.05-1.00 5.00-7.00	7.00-10.00	1.00-5.00	-	-	-	-	-	> 0.50
BH19-17	-	0.0-0.05	-	-	-	0.05-1.00 7.00-10.00	-	1.00-6.50	-	6.50-7.00	-	> 0.50
BH19-18	0.0-0.50	-	-	-	0.50-3.00	3.00-8.50 9.75-10.00	-	-	-	8.50-9.75	-	> 0.50

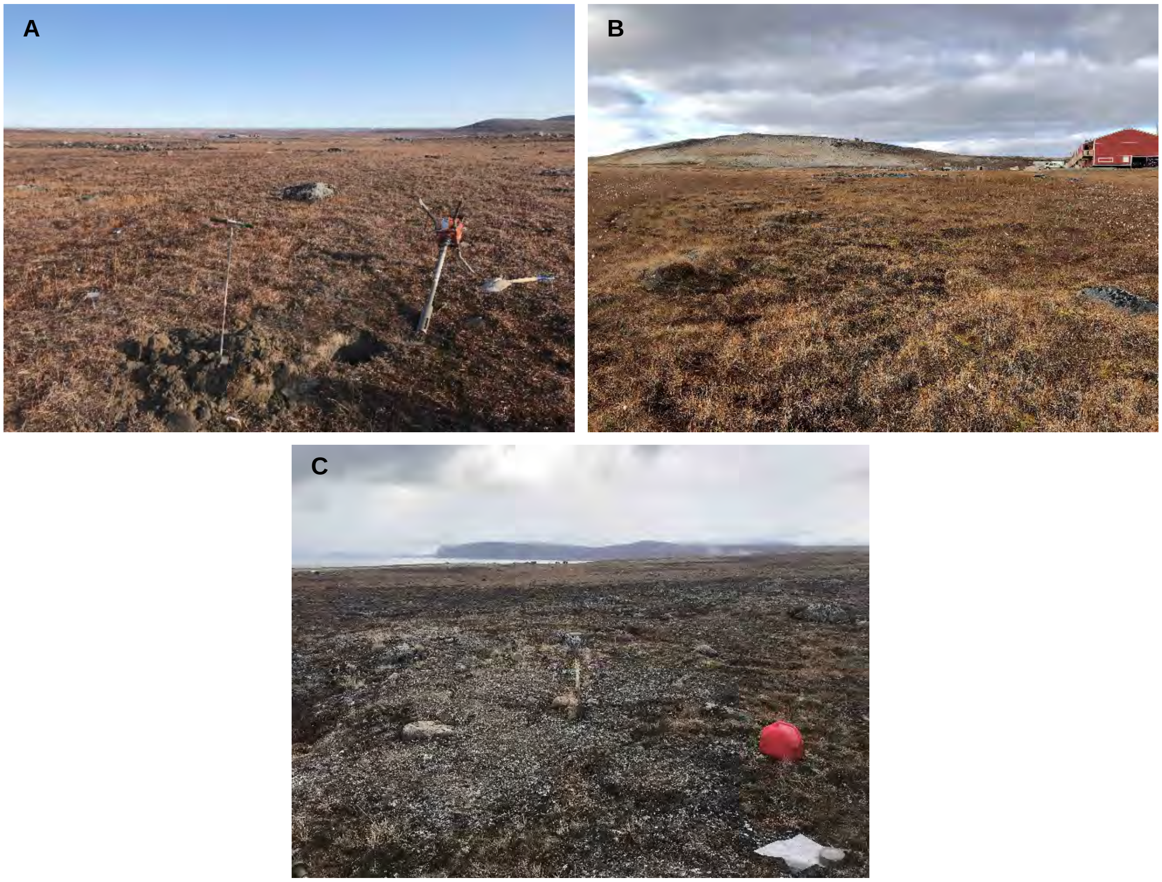
*Massive ice encountered at BH19-04 correspond to an ice-wedge (based on visual assessment of ice structure). Note that only the uppermost portion of the ice-wedge was observed/sampled. Full depth of the ice-wedge is unknown.

4.1.1 Organic

Thin surficial organics were encountered at most borehole locations, with a thickness generally varying between 5 cm and 15 cm. The surficial organic either consisted of a cover of mosses and sod overlying a thin topsoil (in BH19-01, BH19-03, BH19-06, BH19-08, BH19-09, BH19-16 and BH19-17), of peat accumulations (in BH19-04, BH19-05, BH19-11, BH19-12, BH19-13, BH19-14 and BH19-15), or was characterized by a sparse vegetation cover (in BH19-02, BH19-07 and BH19-10).

Organic accumulations characterized by a cover of mosses and sod overlying a thin topsoil were found in moderately well to poorly drained soils and were widespread across Blocks 2, 3 and 4. Peat accumulations were restricted to poorly drained soils and mostly occurred within drainage flow paths. Areas with a sparse vegetation coverage were confined to moderately well drained topographic highs and patterned ground features often occurred in these areas. Refer to Figure 4-2 for an example of the different organic types observed.

Figure 4-2 Surficial organic observed within the study area. A) Mosses and sod overlying topsoil; B) Peat accumulation; C) Sparse vegetation coverage.



4.1.2 Till

Till was found as the dominant material within the study area. Based on field observations and laboratory analysis, the till encountered within Blocks 2, 3 and 4 consist of a diamicton with matrices generally composed of inorganic silt, sand and silt, or sand with variable quantities of gravel and low plastic clay. Those soils are spatially variable in composition, structure and properties, and also include layers with matrices of silt and gravel to gravel. Concentrations of angular to sub-angular cobbles and boulders were observed at the ground surface throughout the study area. The origin of those deposits is assumed to be related to either direct deposition or reworking of the till material by periglacial action and/or washing of fine-grained material by flowing water.

The local subgrade conditions of till deposits are likely to vary significantly with respect to changes in moisture content, especially in areas where imperfect to poor drainage conditions were observed.

4.1.3 Glaciolacustrine

Glaciolacustrine deposits (deposited in a glacier-dammed or pro-glacial lake) were encountered in boreholes BH19-04, BH19-05 and BH19-16. These deposits consist of silty sand (in BH19-04 between 0.30-0.60 m and BH19-16 between 1-5 m), sandy silt (in BH19-16 between 5-7 m) and sandy gravel (in BH19-05 between 0.70-2.5 m)).

Glaciolacustrine deposits were observed to a maximum depth of 7 m (in BH19-16).

The interpretation of the deposit’s origin is based on general landscape, field interpretation, material color and relevant literature available for the area.

4.1.4 Bedrock

Bedrock was not encountered within the limits of the boreholes.

4.1.5 Groundwater

Groundwater seepage was observed in the active layer in BH19-09 (0.30 m) and in BH19-12 (0.10 m). It is noted that saturated soils were observed at the ground surface in BH19-01, BH19-04, BH19-05, BH19-06, BH19-08, BH19-12 and BH19-14. Wet soils were observed in BH19-11, BH19-13 and BH19-15. Groundwater levels should be considered higher along the drainage flow paths.

Note that groundwater levels may fluctuate seasonally and in response to precipitation events. To determine the long-term groundwater conditions at the site, installation of groundwater monitor wells or standpipes would be required. In continuous permafrost terrain, groundwater will be typically restricted to the seasonal active layer.

4.2 PERMAFROST

4.2.1 Active Layer Measurements

Active layer measurements taken on September 12 to 18, 2019, are presented in Table 4-1. Findings are summarized below:

- Measured active layer depths varied in the range of 0.20 m to 1.15 m.
- Thicker active layer depths (> 0.90 m) were recorded at boreholes BH19-03, BH19-06 and BH19-12.
- Thinner active layer depths (0.20 m to 0.65 m) were recorded at boreholes BH19-01, BH19-04, BH19-05, BH19-11 and BH19-13.
- Active layer depths were not recorded at boreholes BH19-02, BH19-07 to BH19-10, and BH19-14 to BH19-18; however, the active layer was at least 0.50 m deep.

Variations in active layer depths are controlled by a series of interconnected factors and site-specific conditions. Seasonal thawing depths were generally observed to be deeper in moderately well to well drained soils located on topographic highs; these areas often present a sparse vegetation coverage. Thinner active layers were measured in imperfectly to poorly drained areas characterized by the presence of peat (with the exception of very poorly drained areas such as the active seepage channels where thick active layer were observed.

4.2.2 Ice Contents

Water contents and VIC values obtained from laboratory testing conducted on samples of permafrost are presented in Table 4-2. VIC calculations were conducted in order to further quantify the presence/absence of ice-rich soils. The values presented correspond to samples obtained from the first two meters of permafrost underlying the active layer (i.e., generally between 0.5 m and 2.5 m bgs). Findings are summarized below:

- Core drilling of near-surface (i.e., < 3 m bgs) permafrost allowed for the assessment of ice content. Elevated ice contents were identified within imperfect to poorly drained soils overlain by organic covers (e.g., drainage flow paths). Topographic highs and moderately well drained soils with sparse vegetation cover presented low to moderate ice contents.

- Measured water contents varied between 12.2% and 236.5%; note that due to destructive sampling method, the water content values of the air-track drill samples are likely underestimated.

- Measured VIC varied between 24.1% and 86.6%.

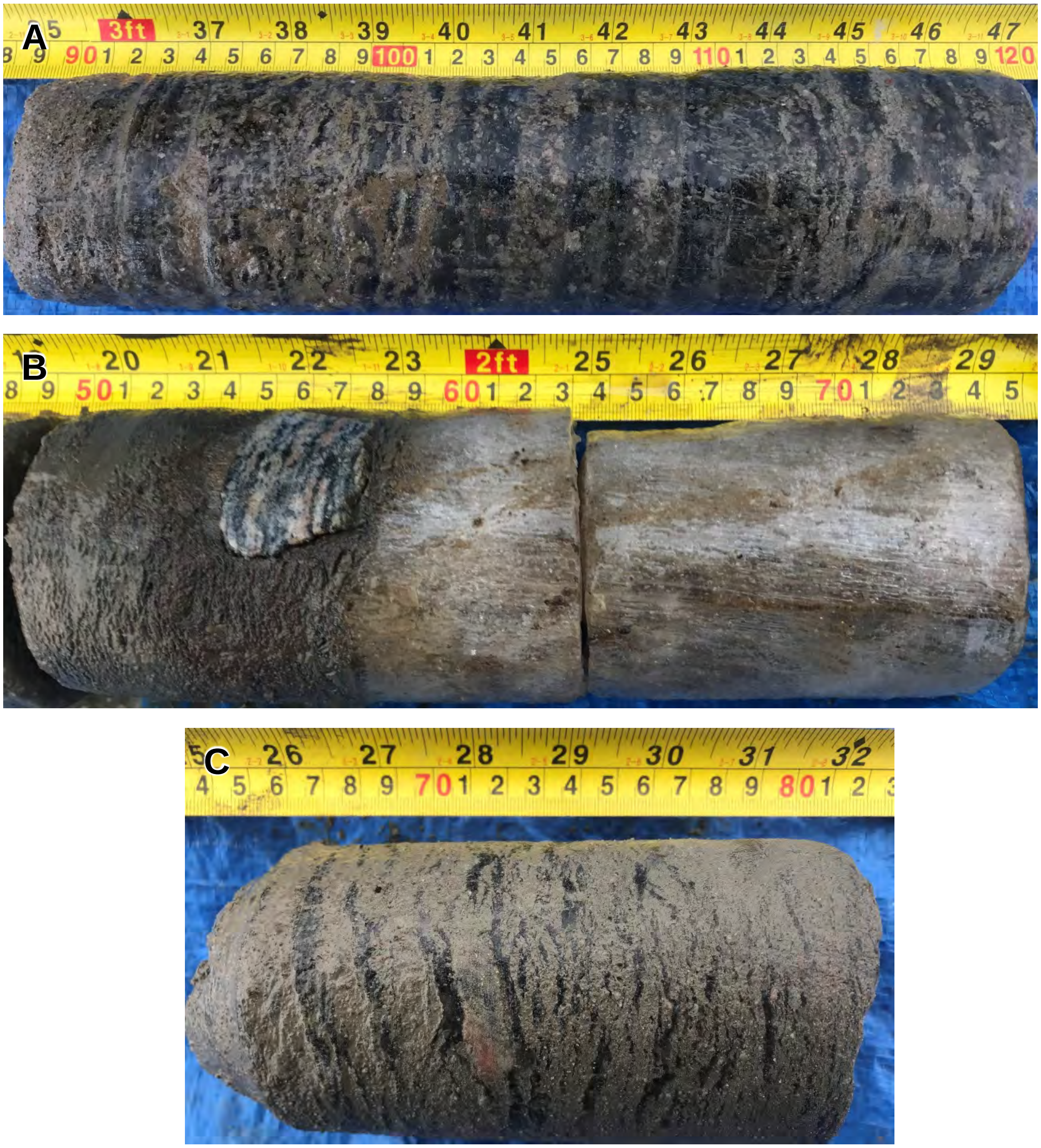
- **Low ice content permafrost** with VIC < 25% and inferred from water contents < 25%, was measure at boreholes BH19-01, BH19-11, BH19-13 and BH19-18.

- **Moderate ice content permafrost** with VIC 25-50% and inferred from water contents 25-50%, was measured at boreholes BH19-02, BH19-03, BH19-04, BH19-05, BH19-09, BH19-11, BH19-13, BH19-16 and BH19-17.

- **High ice content permafrost** with VIC > 50% and inferred from water contents > 50%, was measured at boreholes BH19-01, BH19-03, BH19-05, BH19-06, BH19-11, BH19-13, BH19-014 and BH19-15.
- No ice was identified in boreholes BH19-07, BH19-08, BH19-10 and BH19-12.
- The upper limit of an ice wedge was recorded at a depth of 0.60 m in borehole BH19-04. The occurrence of an ice wedge at that location is based on the visible polygonal pattern in the area as well as the borehole location(the borehole was conducted within the linear trough matching the ice wedge location), as well as the distinctive vertical foliation structure observed in the ice core sample. Note that the overall depth of the wedge is unknown.
- Signs of thaw degradation (tension cracks and localized ground subsidence) were observed surrounding BH19-03. Field observations suggest that the subsidence is related to ground disturbance that occurred in the past (vehicle ruts visible at the ground surface in the area).

Photographs showing examples of core samples with elevated ice content are presented in Figure 4-3.

Figure 4-3 Examples of ice-rich permafrost core samples.



Notes:

A) Layered and suspended cryostructures in till at BH19-03-DC-02 (0.90-1.18 m) with VIC of 77 %.

B) Upper contact with an ice wedge at BH19-04-DC-03 (at 0.60 m); vertical ice foliations were observed in the ice.

C) Lenticular cryostructures in till at BH19-01-DC-02 (0.65-0.80 m) with VIC of 62 %.

Table 4-2 Summary of near-surface permafrost conditions

Borehole Nº	Site Description	Drilling Depth (m)	Active Layer (m)	Near-Surface* Water Content (%)	Near-Surface* VIC (%)	Permafrost Ice Content Class**
BH19-01	Poorly drained soil.	2.03	0.65	12.2 to 65.7	57.1 to 71.5	High
BH19-02	Moderately well drained sorted soil with sparse organic cover.	1.80	> 0.60	50.0	44.6	Moderate
BH19-03	Lower slope position next to apparent ground subsidence with signs of thaw degradation.	2.00	0.90	22.0 to 236.5	34.7 to 77.0	High
BH19-04	Poorly drained peat cover with ice wedge polygonal network observed at the surface.	0.74	0.20	60.7	39.1 to massive (ice wedge)	High
BH19-05	Poorly drained peat cover with ice wedge polygonal network observed at the surface. Borehole adjacent to an ice wedge.	2.50	0.25	36.4 to 216.6	41.8	High
BH19-06	Imperfectly drained soil with thin organic cover.	1.90	1.15	51.5 to 67.3	56.1	High
BH19-07	Moderately well drained soil with sparse organic cover. On a topographic high adjacent to a morainal ridge.	2.00	> 0.70	-	-	Low
BH19-08	Moderately well drained soil.	1.40	> 0.55	-	-	Moderate
BH19-09	Moderately well drained soil. Adjacent to drainage flow path.	1.60	> 0.55	27.3	-	Low
BH19-10	Moderately well drained sorted soil with very sparse organic cover.	1.00	> 0.55	-	-	Low
BH19-11	Poorly drained peat cover.	2.13	0.35	14.3 to 195.4	24.1 to 86.6	High
BH19-12	Poorly drained peat cover. Within a drainage flow path.	1.00	0.90	-	-	High
BH19-13	Poorly drained peat cover.	2.64	0.50	50.0 to 92.8	45.7 to 70.1	High
BH19-14	Poorly drained peat cover.	10.00	-	78.4	-	High
BH19-15	Poorly drained peat cover.	10.00	> 0.50	83.3	-	High
BH19-16	Soft poorly drained soil.	10.00	> 0.50	41.2	-	High
BH19-17	Soft poorly drained soil.	10.00	> 0.50	30.1	-	Moderate
BH19-18	Shallow fill over till.	10.00	> 0.50	24.6	-	Low

*Near-surface refers to the first two meters of permafrost underlying the active layer (i.e., generally between 0.5 m and 2.5 m bgs).

**Permafrost ice content classification is based on the following:

- Low (water content and VIC 0-25%), Moderate (water content and VIC 25-50%), High (water content and VIC > 50%).
- Considers the overall ice content observed or inferred within the first two meters of permafrost underlying the active layer.
- Where no ice content was measured, the ice contents were inferred from site conditions and drillers interpretation of permafrost condition.

4.2.3 Pore water salinity

The presence of pore water salinity can induce freeze point depression. The freezing point depresses approximately 0.28°C for every 5 ppt of salinity. Hence, soils with a pore water salinity of 32 ppt will have an actual freeze/thaw temperature of about -2°C. Different pore water salinity results are available in the literature for permafrost samples obtained in Clyde River. Hivon and Sego (1993) reported values ranging between 0.6 ppt to 44.5 ppt, while Nixon (1988) reported values ranging between 2.0 ppt to 33.0 ppt, with an average of approximately 12.5 ppt. Note that based on information from the National Snow and Ice Data Center, typical salinity of sea water in northern regions is of approximately 32 ppt.

Laboratory testing results of pore water salinity recorded values of 0.066 ppt (in BH19-03) and 0.027 ppt (in BH19-05) (Table 4-3). These values are low when compared to the above cited values and suggest that permafrost sampled at boreholes BH19-03 and BH19-05 (i.e., 25 to 30 m above sea level) correspond to non-saline permafrost.

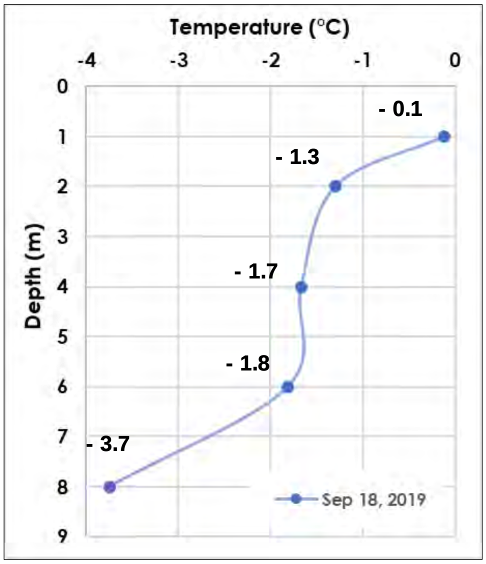
Table 4-3 Pore water salinity results

Sample Nº	Salinity (mS cm^{-1})	Temperature (°C)	Salinity (ppt)
BH19-03-DC-03	0.094	25	0.066
BH19-05-DC-05	0.038	25	0.027

4.2.4 Ground Temperature Profile

Ground temperatures recorded at borehole BH19-14 varied from -0.1°C at 1 m depth to -3.7°C at 8 m depth. Ground temperature profile is presented in Figure 4-4. Note that this temperature profile was obtained within a few hours following borehole drilling and therefore represents local temperature profile with potential impact due to ground disturbance during drilling.

Figure 4-4 Ground temperature profile recorded at borehole BH19-14



5.0 QUALITATIVE CONSTRUCTION SUITABILITY ASSESSMENT

The construction suitability assessment focused primarily on interpreted and/or observed terrain conditions that could adversely affect land development within the study area. Table 5-1, 5-2, 5-3 and 5-4 summarize the identified constraints and potential suitability issues within the proposed subdivisions.

Refer to Figure B-6 (Appendix B) for a map displaying results of the qualitative construction suitability rating throughout the community. Through this assessment, it is important to note that portions of the current townsite are located within areas identified as unfavorable for development. This classification is related to several interrelated criteria, including the local susceptibility to water pooling, the presence of fine-grained marine sand often susceptible to erosion, the overall topography and the occurrence of snow drifting, prolonged summer snowmelt and seepage from late-lying snowpacks, the ground surface displaying earth hummocks and ice wedge polygons (which are indicator of periglacial processes often related to ice-rich permafrost) as well as the expected presence of saline permafrost and the risk of development of thermokarst-related ground subsidence. Note that this classification matches observations reported as part of previously conducted hazard assessment conducted for the area (e.g., Irvine 2011) as well as other (yet) unpublished composite hazard assessment mapping data.

Table 5-1 Block 1 - Construction suitability rating and summary of terrain constraints

Construction suitability ratings	Lots	Constraints	Comments/observations
Suitable for development	1 to 3, 7 to 10, 13 to 16, 19 to 23, 27, 28, 30 to 36	N/A	• Limited to no visible constraints.
Potentially suitable for development	15, 24, 25, 26	GS	• Gently sloping terrain
	4, 12, 17	PD, IC	• Poorly drained soils • Elevated ice contents expected within these lots
Unfavorable for development	5, 6, 11,18, 29	PD, FP, IC	• Development of these lots should be made with consideration to the drainage flow path

Road segments	Constraints	• Comments/observations
R22 and R23 extremities, R21	N/A	• Limited to no visible constraints
R22 and R23 mid-section	PD, FP, IC	• Poorly drained soils • Potential seepage due to late-lying snow accumulation • Planned road at the crossing of a drainage flow path • Potential for elevated ice contents

Terrain constraints are: poorly drained terrain (PD), surface seepage (SS), drainage flow paths (FP) and downslope drainage issues (DD), gentle sloping terrain 10 to 20% (GS), moderate to steep sloping terrain >20% (MSS), may include areas of elevated ice content >50% (IC), observed conditions indicative of unstable terrain (UT), visible feature indicative of ice-rich permafrost such as ice wedges (IW).

Table 5-2 Block 2 - Construction suitability rating and summary of terrain constraints

Construction suitability ratings	Lots	Constraints	Comments/observations
Suitable for development	4 to 10, 13 to 16, 18, 23 to 34, 37 to 40	N/A	• Limited to no visible constraints • Lot 9 should be considered carefully as its westernmost portion is within a poorly drained surface flow path
Potentially suitable for development	11, 12, 22, 36	GS	• Gently sloping terrain
	21	IC	• Imperfectly drained terrain where ice contents are likely elevated • Site adjacent to poorly drained flow path • Likely elevated ice contents • Solifluction lobe visible
Unfavorable for development	1, 2, 3, 19	PD, SS, IC	• Likely high inputs of water from upstream late-lying snow accumulation • Poorly drained soils • Elevated ice contents occur within these lots
	17	PD, SS, FP, DD	• Culverts lack efficient drainage • Western sub-basins drain through this lot
	20	PD, SS, FP, DD	• Poor overall drainage conditions • Seepage and water ponding observed • Culverts lack efficient drainage • Eastern sub-basin drains through this lot
	35	UT, IC	• Indicators of unstable terrain were observed in the southwest portion of the site

Road segments	Constraints	• Comments/observations
R25 and R26 downslope	N/A	• Limited to no visible constraints
R24 to R20	FP	• Planned road crosses a primary drainage flow path
R24 between Lots 19 and 35	PD, IC	• Poorly drained terrain • Elevated ice contents
R25 upslope and R26 to R34	PD, SS, FP, IC	• Planned road at the crossing of a drainage flow path (R26 to R34) • Likely high inputs of water from upstream late-lying snow accumulation • Poorly drained soils • Elevated ice contents
R26 upslope	PD, SS, IC	• Likely high inputs of water from upstream late-lying snow accumulation • Poorly drained soils • Elevated ice contents

Terrain constraints are: poorly drained terrain (PD), surface seepage (SS), drainage flow paths (FP) and downslope drainage issues (DD), gentle sloping terrain 10 to 20% (GS), moderate to steep sloping terrain >20% (MSS), may include areas of elevated ice content >50% (IC), observed conditions indicative of unstable terrain (UT), visible feature indicative of ice-rich permafrost such as ice wedges (IW).

Table 5-3 Block 3 - Construction suitability rating and summary of terrain constraints

Construction suitability ratings	Lots	Constraints	Comments/observations
Suitable for development	9, 17, 19, 20, 21, 23 24, 25, 33, 35, 37, 41 to 47, 49	N/A	• Limited to no visible constraints • Lot 33 is suitable only within a small section adjacent to Lots 35 to 37
Potentially suitable for development	22, 29, 30, 31, 33, 34	GS	• Gently sloping terrain • Ice wedges likely present
Unfavorable for development	38, 39, 40	MSS	• Moderate to steep slopes
	14, 15, 16, 18, 28, 32, 33 (along flow paths), 48, 50, 51	PD, SS, FP, IC	• Likely high inputs of water from upstream late-lying snow accumulation • Poorly drained soils • Elevated ice contents likely occur within these lots • Drainage flow paths through these lots
	26, 27	PD, SS, FP, MSS	• Within a drainage flow path • Steep sloping of the housing corporation yard

Road segments	Constraints	• Comments/observations
R27, R28 western section and R29 northern section	N/A	• Limited to no visible constraints • R29 crosses two areas with moderate to steep terrain
R28 eastern section	PD, SS, FP, MSS	• Within a drainage flow path • Steep sloping of the housing corporation yard
R29 to R20 and R28	PD, SS, FP, IC	• Planned road at the crossing of a primary drainage flow path • Likely high inputs of water from upstream late-lying snow accumulation • Poorly drained soils • Likely contains elevated ice contents

Terrain constraints are: poorly drained terrain (PD), surface seepage (SS), drainage flow paths (FP) and downslope drainage issues (DD), gentle sloping terrain 10 to 20% (GS), moderate to steep sloping terrain >20% (MSS), may include areas of elevated ice content >50% (IC), observed conditions indicative of unstable terrain (UT), visible feature indicative of ice-rich permafrost such as ice wedges (IW).

Table 5-4 Block 4 - Construction suitability rating and summary of terrain constraints

Construction suitability ratings	Lots	Constraints	Comments/observations
Suitable for development	22, 23, 24, 33 to 42, 44 to 46, 48, 49, 52, 53, 55 to 62, 64 to 67	N/A	• Limited to no visible constraints • A narrow drainage flow path crosses Lot 59; however, most of the lot is suitable • Note that minor portions of Lots 49, 52, 53, 67 are considered unfavorable for development.
Potentially suitable for development	-	-	-
Unfavorable for development	25 to 32, 50, 51, 54	PD, SS, FP, IC, IW	• Likely high inputs of water from upstream late-lying snow accumulation • Poorly drained soils • Elevated ice contents occur within these lots • Drainage of northern community district through these lots • Ice wedges polygon confirmed
	47	PD, SS, IC	• Poorly drained terrain • Likely high elevated ice contents
	19, 43, 63	PD, SS, FP, IC	• Likely high inputs of water from upstream late-lying snow accumulation • Poorly drained soils • Likely elevated ice contents • Drainage from the north toward Block 3

Road segments	Constraints	• Comments/observations
R31 eastern and southern sections, R30	N/A	• Limited to no visible constraints
Most of R31	PD, SS, FP, IC, IW	• Likely high inputs of water from upstream late-lying snow accumulation • Poorly drained soils • Elevated ice contents occur within these lots • Drainage of northern community district through these lots • Ice wedges polygonal network occur
R30 between Lots 43 and 63	PD, SS, FP, IC	• Planned road crosses a drainage flow path • Likely high inputs of water from upstream late-lying snow accumulation • Poorly drained soils • Likely contains elevated ice contents

Terrain constraints are: poorly drained terrain (PD), surface seepage (SS), drainage flow paths (FP) and downslope drainage issues (DD), gentle sloping terrain 10 to 20% (GS), moderate to steep sloping terrain >20% (MSS), may include areas of elevated ice content >50% (IC), observed conditions indicative of unstable terrain (UT), visible feature indicative of ice-rich permafrost such as ice wedges (IW).

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 SUMMARY OF KEY FINDINGS

6.1.1 Surficial geology

The most common surficial material present within the study area is till. Soil drainage conditions within the till deposits were observed to range from well drained to poorly drained, with minor areas of very poor drainage (i.e., areas where standing water was present). Geotechnical investigations confirmed the occurrence of ice-rich permafrost, especially in fine-grained soils characterized by imperfect to poor drainage. Other surficial deposits identified within the study area include marine, colluvium, glaciolacustrine, fluvial and in lesser proportion, organic and glaciofluvial.

6.1.2 Soil Drainage

Soil drainage conditions are controlled by multiple interconnected factors, including (but not limited to) topography, local soil properties and permafrost conditions. Observations made as part of the field programs indicated that moderately well to imperfectly drained conditions are predominant within the community. Well drained soils are present; however, limited to elevated areas corresponding to till moraine deposit. Imperfect to poor drainage conditions were observed along drainage flow paths, as well as low-lying areas including surroundings of several residential units. Sectors characterized with very poor drainage included small wetlands and other areas impacted by the accumulation of standing water.

The delayed melting of the active layer in nivation hollows and areas characterized late-lying snow accumulations is believed to impact local drainage conditions in several locations.

6.1.3 Terrain-related constraints

The following terrain-related constraints were identified as presenting challenges related to the planning and construction of future development areas. They consist of:

- **Local drainage conditions.** Areas characterized by poor, to very poor drainage conditions are considered to be the main constraint to the development of the proposed new subdivisions (Blocks 1 to 4). Identification of those areas is essential so that appropriate design can be implemented.

- **Drainage flow paths and surface seepage.** Surface water flow paths and surface seepage were observed within several lots and road segments included in the proposed subdivisions. These conditions will require appropriate drainage management considerations.

- **Permafrost and periglacial processes.** The presence of ice-rich permafrost does represent a constraint to land development within the study area. Note, however, that the risk for thermal degradation and ground subsidence can be reduced or removed through appropriate planning and engineering.

- **Soil surface erosion.** Observations made within the community indicated that moderate to severe surface erosion can occur at along building pads (some old, some recently constructed). Field observations suggest that the erosion process is often related to inappropriate drainage management practices.

6.1.4 Construction suitability

Assessing construction suitability was conducted using a multi-criteria approach. Key drivers influencing suitability of a given location consisted of local terrain conditions, including the overall topography, nature and properties of local surficial materials, drainage conditions as well as the presence of terrain-related constraints and geohazards. Considerations regarding available construction equipment and potential foundations systems were not accounted for.

The overall assessment and resulting construction suitability map (Appendix B, Figure B-6) indicate that it is feasible to proceed with land development within the proposed subdivisions; however, that modifications to the originally proposed development plans should be considered to avoid problematic terrain.

Refer to Table 5-1 to 5-4 for a list of areas or lots for which development plans should be halted or revised. Although those areas were labeled as “unfavorable for development”, it is important to note that adequate level of design, construction techniques and maintenance activities could make them suitable for development. Key areas where residential development plans should be halted or revised include the following:

- **Block 1, Lots 5, 11, 18 and 29** where an easterly-oriented flow path crosses through the proposed layout. No visible issues related to solifluction lobe previously identified by Smith et al. 2012b (see figure B-2).

- **Block 2, Lots 1, 2, 3, 19 and 35** where poor drainage conditions, and/or thaw susceptible permafrost is expected to be present.

- **Block 3, Lots 14, 15, 16, 18, 26, 27, 28, 32, 33, 38, 39, 40, 50 and 51** where overall topography and adverse drainage conditions were identified.

- **Block 4, Lots 25 to 32, 43, 47, 50, 51, 54, 63** where adverse drainage conditions, and/or thaw susceptible permafrost with ice wedges are expected to be present.

As noted above, some level of development could go forward in the above-mentioned areas assuming that appropriate drainage infrastructures, building foundation system and/or mitigations strategies are put in place (e.g., concentrating the flow along alignment matching the boundaries between lots, building thick gravel pads and using deep pile systems instead or screw jacks or aluminum space frame systems). A phased-approach to land development in those areas is recommended (e.g., building pads in year one, then waiting for at least one year for the disturbed materials to progress towards a new thermal stability).

6.2 UPGRADE OF EXISTING DRAINAGE INFRASTRUCTURES

Observation made during the 2017 and 2019 field programs indicated that some of the existing culverts are too small to adequately handle peak water flows. In addition, several culverts were either damaged (i.e., partially crushed) and/or were partially buried by sediment and/or debris. The occurrence of a “perched” culvert, stranded above flow channels, is leading to ponding and localized flooding. Similar observations had already been made by Irvine (2011).

More specifically, the following actions are recommended:

- Addressing problems identified at culverts located along key drainage flow paths should be prioritized so to limit water ponding along road embankments. Culvert diameter of at least 500 mm are generally adequate for cross-road drainages; however, site-specific assessment of peak flow should be conducted during the spring melt season, to confirm the appropriate minimum culvert size. Based on the CSA – Community drainage system planning, design, and maintenance in northern communities (Canadian Standards Association 2015), culverts should be sized to accept design flow at 80% capacity under free flow condition (1:10 year event).
- Numerous culverts were observed to have been damaged by heavy machinery during either road grading or snow plowing activities. Deformed and/or crushed culverts should be replaced, and appropriate soil cover should be used to avoid any future damage
- Raised culvert inlet should be lowered to the elevation of natural flow channels to limit water ponding upstream of the culvert. Rip rap should be placed at raised culvert outlet reduce the potential for erosion.
- A properly designed drainage ditch and/or a positive discharge should be considered at each culvert outlet.

6.3 RECOMMENDATIONS REGARDING FUTURE DEVELOPMENT

Permafrost ground conditions present unique but solvable challenges with regard to land development in the North. Site specific conditions, exacerbated by impacts of changing temperatures and precipitation patterns require adequate planning, design, and maintenance of drainage related infrastructure to ensure that minimal negative impacts and disruption occurs in the future.

Key policy guidance documents have been developed in recent years in relation to reducing the overall vulnerability of infrastructure in northern communities. For the current study, four key documents developed as part of the Northern Infrastructure Standardization Initiative (NISI) provide standards and recommendations regarding proper evaluation, design, construction, operation and maintenance of new and existing infrastructures. They consist of:

- CAN/BNQ 2501-500 Geotechnical Site Investigations for Building Foundations in Permafrost.
- CAN/CSA-S503-15 Community drainage system planning, design, and maintenance in northern communities.

- CSA-S501-14 Moderating the effects of permafrost degradation on existing building foundations.
- CSA PLUS 4011:19 Technical Guide: Infrastructure in permafrost: A guideline for climate change adaptation.

The following sections highlight key recommendations related to the development of new subdivision components in Clyde River (i.e., road access, building pads and drainage infrastructure). The goal is not to summarize the above cited documents, but rather to emphasize on key items that with respect to future development in Clyde River.

6.3.1 Appropriate level of geotechnical investigations

Geotechnical site investigations are essential to ensure that a sufficient level of site-specific information is available to support appropriate design, construction and maintenance of future infrastructures.

6.3.2 Building pads and road embankments

Good gravel sources are sparse in Clyde River. For this reason, new building pads are mostly built of fine-grained till (i.e., sandy silt with variable amounts of gravel and clays) obtained from the borrow source located north of the community. These materials are especially susceptible to freezing and soil surface erosion. Deep rills and gullies are visible in several developed areas throughout the community, often leading to damage to building foundations. Aside from the texture of the material used to build pads, the thickness of the material should also be properly estimated. Thicker pads composed of coarser materials will reduce the potential for permafrost degradation and will drain water more effectively. Side slopes covered with coarse gravel or riprap will reduce erosion and localized sloughing.

Ideally, structural fill consisting of a non-frost susceptible granular fill (i.e., well-graded sand and gravel containing less than 5 to 8 percent fines) should be used as building pad materials. If such material is not readily available, special attention should be given to ensure that the most appropriate building foundation system is selected, therefore accounting for potential ground movement. Effort should be given to grade building pads so that water drains away from the developed lots (i.e. pads will serve as a drainage barrier). Coarse-textured fill should be also placed on lots and roads characterized by imperfect or poor drainage. Slope cuts and/or excavations should be limited to minimize potential permafrost degradation.

6.3.3 New drainage infrastructures

Proper surface water drainage is essential for preserving the stability of new infrastructures. Drainage ditches or swales should not be excavated in ice-rich permafrost without detailed design unless proper measured are implemented in order to control erosion and prevent progressive permafrost degradation. Instead, ditches of swales should be formed within newly placed fill material, where the base of the ditches of swales matches the native ground surface (or above).

Existing preferential drainage flow paths should be maintained to route water away from the development area without causing potential ground disturbance. Berms could be an effective way to direct drainage away from the proposed new lots. Creating a raised barrier with proper surface drainage strategy could convey surface runoff downslope away from newly built roads and building pads. Note that proper design and material selection would be required to avoid any erosion.

Culverts will need to be installed along new road segments and driveways, especially where flow paths have been identified. Design of large culverts will require that the drainage regime be better characterized (e.g., stream discharge assessment will need to be made during peak flows). These observations should be conducted during spring melt.

It is recommended that the culverts be founded on structural backfill placed on native soil. In addition, care should be taken to avoid damage to permafrost during the installation of culverts. Finally, culvert inlets and outlets shall be designed to mitigate erosion of the surrounding area.

6.3.4 Erosion control

Erosion control measures should be included in the design of pads and embankments, especially next to drainage infrastructure (culverts). Materials to consider are geotextiles and riprap armouring. More specifically:

- Riprap (i.e., a blanket revetment constructed of rocks or rubbles) should be used to armor segments of embankment slope located alongside culvert inlets currently present along road segment R26. This material will limit potential erosion of fine fill material. Use of geotextiles or an appropriate filter design is also recommended. Riprap aprons should also be used to mitigate potential erosion at culvert outlets.

- Limiting ground disturbance and potential damage to the native vegetation will minimize soil surface erosion. Maintaining the natural vegetative cover facilitates ground retention and prevents surface erosion.

- Sediment controls should be used to prevent siltation of the culverts leading to improper functioning of the drainage system. The installation of silt traps, re-vegetation (may be inappropriate for this environment), straw mulching and implementation of other erosion control measures are essential.

6.3.5 Inspection and maintenance

A properly maintained and monitored drainage system will ensure a high level of efficiency and durability. To do so:

- Inspection and maintenance personnel should be responsible for maintaining the drainage system.

- The drainage infrastructures should be inspected on a weekly basis during melting season and/or after major rain events.

- Damaged culverts should be immediately repaired or replaced.

- Erosion control measures should be implemented as soon as visible signs of surface erosion are identified.

- The cause of any malfunction of the drainage system should be identified and addressed immediately.
- Blocked culverts should be cleared immediately to restore surface water flow through the culvert.
- During winter, carry out frequent inspections to ensure that the drainage system is not damaged by snow removal or completely blocked by ice. Snow removal personnel should be aware of the location of the drainage infrastructure. Marker poles may be placed to warn operators of the presence of the culvert outlets.

7.0 CLOSURE

Use of this report is subject to the Statement of General Conditions provided in Appendix A. It is the responsibility of the Client within the Statement of General Conditions, and its agents to review the conditions and to notify Nunami Stantec should any of these not be satisfied. The statement of general conditions addresses the following:

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- Standard of care
- Interpretation of site conditions
- Varying or unexpected site conditions
- Planning, design, or construction

We trust that the information contained in this report is adequate for your present purposes. If you have any questions about the contents of the report, or if we can be of any other assistance, please do not hesitate to contact us at your convenience.

Yours very truly,

NUNAMI STANTEC LIMITED

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APPENDIX A

Statement of General Conditions

STATEMENT OF GENERAL CONDITIONS

USE OF THIS REPORT: This report has been prepared for the sole benefit of the Client and may not be used by any third party without the express written consent of Stantec, which may be withheld at Stantec's discretion. Any use which a third party makes of this report is the responsibility of such third party.

BASIS OF THE REPORT: The information, opinions, and/or recommendations made in this report are in accordance with Stantec's present understanding of the specific site and project scope as described by the Client. The contents of this report are applicable only to the site conditions encountered at the time of the investigation or study. If the proposed project differs or is modified from what is described in this report or if the site conditions are altered, this report is no longer valid unless Stantec is engaged by the Client to review and revise the report to reflect the differing or modified project specifics and/or the altered site conditions.

STANDARD OF CARE: Preparation of this report, and all associated work, was carried out in accordance with the reasonable skill and diligence required by customarily accepted professional practices and procedures normally provided in the performance of such services at the time when and the location in which the services were performed. No other warranty is made.

INTERPRETATION OF SITE CONDITIONS: Soil, rock, and/or other material descriptions, and statements regarding their condition, made in this report are based on site conditions encountered by Stantec at the time of the work at specific field observation locations and/or through interpretation of both digital imagery and/or LiDAR data. Classifications and statements of condition have been made based on anticipated behavior of the materials or geomorphic processes and are interpretive in nature; no specific description should be considered exact, but rather should be considered reflective of the anticipated behaviour of materials or geomorphic processes. Extrapolation of in situ conditions can only be made to some limited extent beyond the observed locations. The extent depends on variability of the soil, superficial materials, bedrock, soil moisture and groundwater conditions as influenced by geological processes, construction activity, and land use.

VARYING OR UNEXPECTED CONDITIONS: Should any site or subsurface conditions be encountered that are different from those described in this report, Stantec must be notified immediately to assess if the varying or unexpected conditions are substantial and if reassessments of the report conclusions or recommendations are required. Stantec will not be responsible to any party for damages incurred as a result of failing to notify Stantec that differing site or sub-surface conditions are present.

PLANNING, DESIGN, OR CONSTRUCTION: Development or design plans and specifications should be reviewed by Stantec, sufficiently in advance initiating the next project stage (property acquisition, tender, construction, etc.), to confirm that this report adequately addresses the elaborated project specifics and that the contents of this report have been properly interpreted. Specialty quality assurance services (field observations and testing) during construction are a necessary part of the evaluation of sub-subsurface conditions and site preparation works. Site work relating to the recommendations included in this report should only be carried out in the presence of a qualified engineer or geoscientist; Stantec cannot be responsible for site work carried out without its representative being present.

APPENDIX B

Figures

Notes

1. Coordinate System: NAD 1983 UTM Zone 19N

2. Data Sources: Government of Nunavut, Stantec, Smith et al. 2012

3. Background: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

Legend

🟨 Surficial Geology

☐ Land Parcels

Quaternary Surficial Desposits

A	**Anthropogenic Material**
Lsn	**Snow packs**: Perennial accumulations of wind drifted snow and found in lee side depressions.
	Alluvial Deposits
F	**Alluvial sediments (undifferentiated)**: Sand-silt-gravel 1-5 m thick; Contains both floodplain and terrace deposits that cannot be resolved at scale of mapping.
Ff	**Alluvial fan**: Sand-silt-gravel, with detrital organic layers; formed by steep gradient streams and at the base of debris flows.
Fp	**Alluvial plain**: Sand-silt-gravel 1-5 m thick; deposited within the floodplain bounds; inclined surface.
Ft	**Alluvial terrace**: Sand-silt-gravel 1-5 m thick; marks former floodplain levels, below which the river has incised; flat to gently inclined surfaces, generally situated along lateral margins of the modern river.
	Colluvial Deposits
Ca	**Colluvial apron**: Scree (talus) blocky bedrock debris and unconsolidated materials derived from cliff-fall and slope wash forming debris ramps 1 to 10s of meters thick; blocky debris at angle of repose.
Cls	**Landslide deposits**: Accumulations of unconsolidated materials and bedrock debris derived from active layer detachments, slumps, or debris flows.
	Glaciofluvial Deposits
Gf	**Glaciofluvial sediments (undifferentiated)**: Sand-silt-gravel 1-5 m thick; contains both floodplain and terrace deposits that cannot be resolved at the scale of mapping.
GFp	**Glaciofluvial plain**: Sand-silt-gravel 1-10 m thick; deposited by deglacial rivers across a floodplain.
GFt	**Glaciofluvial terrace**: Sand-silt-gravel 1-10 m thick. Exposures along river cut banks and tributary drainage channels expose sub-surface coarse cobble and gravel material, suitable as granular aggregate material, northwest of Clyde River airport.
	Glaciolacustrine Deposits
GL	**Glaciolacustrine sediments (undifferentiated)**: Massive to current-bedded sand and gravel, 1 to 5 m thick, deposited in a glacier-dammed lake; can infill or drape a landscape.
GMm	**Submarine moraine complex**: Non-sorted sand-silt-gravel-boulder deposited as a grounding-line moraine along the lateral base of a marine-grounded glacier.
	Marine Deposits
Mb	**Marine blanket**: Offshore sand-silt-clay 1-10 thick; often contains shell fragments.
Mr	**Marine beaches**: Raised beach ridges and the modern transgressive beach; typically comprised of sand and gravel, can have a coarse sediment surface washed lag and ice-pushed boulders.
Mt	**Marine terrace**: Flat to gently slope terrain of sand-silt-gravel deposited and reworked in intertidal and estuarine regions during periods of post-glacial isostatic uplift.
	Organic Deposits
O	**Organic material (undifferentiated)**: Accumulations of peat and other organic matter in low-lying, often seasonally wet areas, with thicknesses <0.5 to 2 m.
	Till Deposits
Tb	**Till blanket**: Till sufficiently thick to obscure the relief of underlying bedrock surface; thicknesses >2 m.
Tm	**Moraine complex**: Till forming moraine ridges and morainal complexes. Thick till in discontinuous lateral moraines that formed during ice-marginal recession. Can contain patches of ice-contact stratified drift and outwash.

0 150 300 metres

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1:8,500

N

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Project Location
Clyde River,
Nunavut

Prepared by JH on 2019-10-24
Technical Review by MV on 2019-10-24

Client/Project
Government of Nunavut
Department of Community and
Government Services

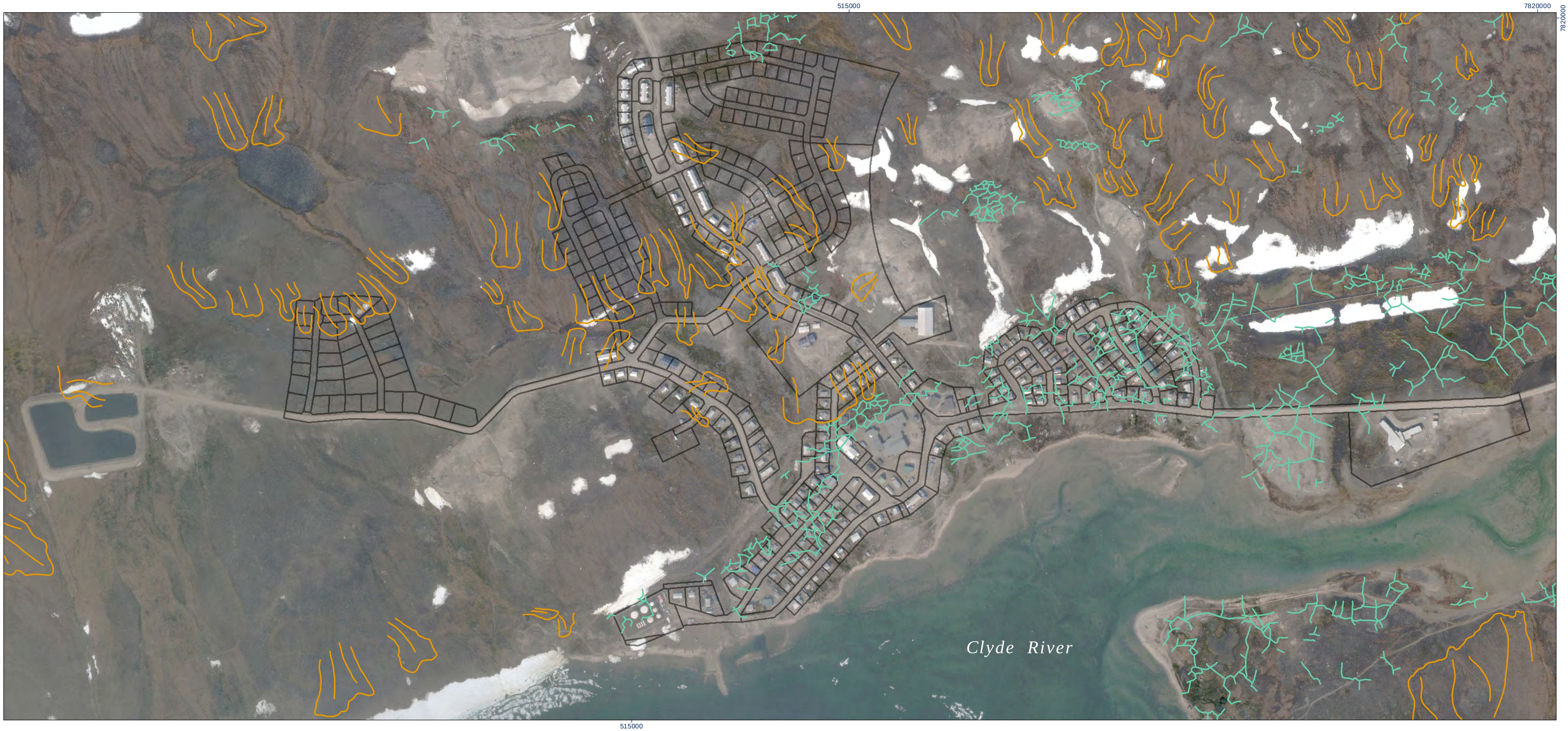
144902893-001 REVB

Figure No.
B-1

Title
Surficial Geology
(Modified from Smith et al. 2012a)

G:_GIS_Project_Folder\144902708_Clyde_River\figures\1114902893_Terrain_Mapping\114902893-001_CR_Surficial_Geology_Overview_REVB.mxd Revised: 2019-10-24 By: JHiebert

G:_GIS_Project_Folder\144902708_Clyde_River\figures\1114902893_Terrain_Mapping\1114902893-004_CR_PMF_Periglacial_REVB.mxd Revised: 2019-10-24 By: JHiebert



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⌇	Solifluction Lobe
⋎	Ice Wedge
▭	Land Parcels

0 150 300 metres

(At original document size of 11x17)
1:8,500

N

Notes
1. Coordinate System: NAD 1983 UTM Zone 19N
2. Data Sources: Government of Nunavut, Stantec
3. Background: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
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Project Location
Clyde River,
Nunavut

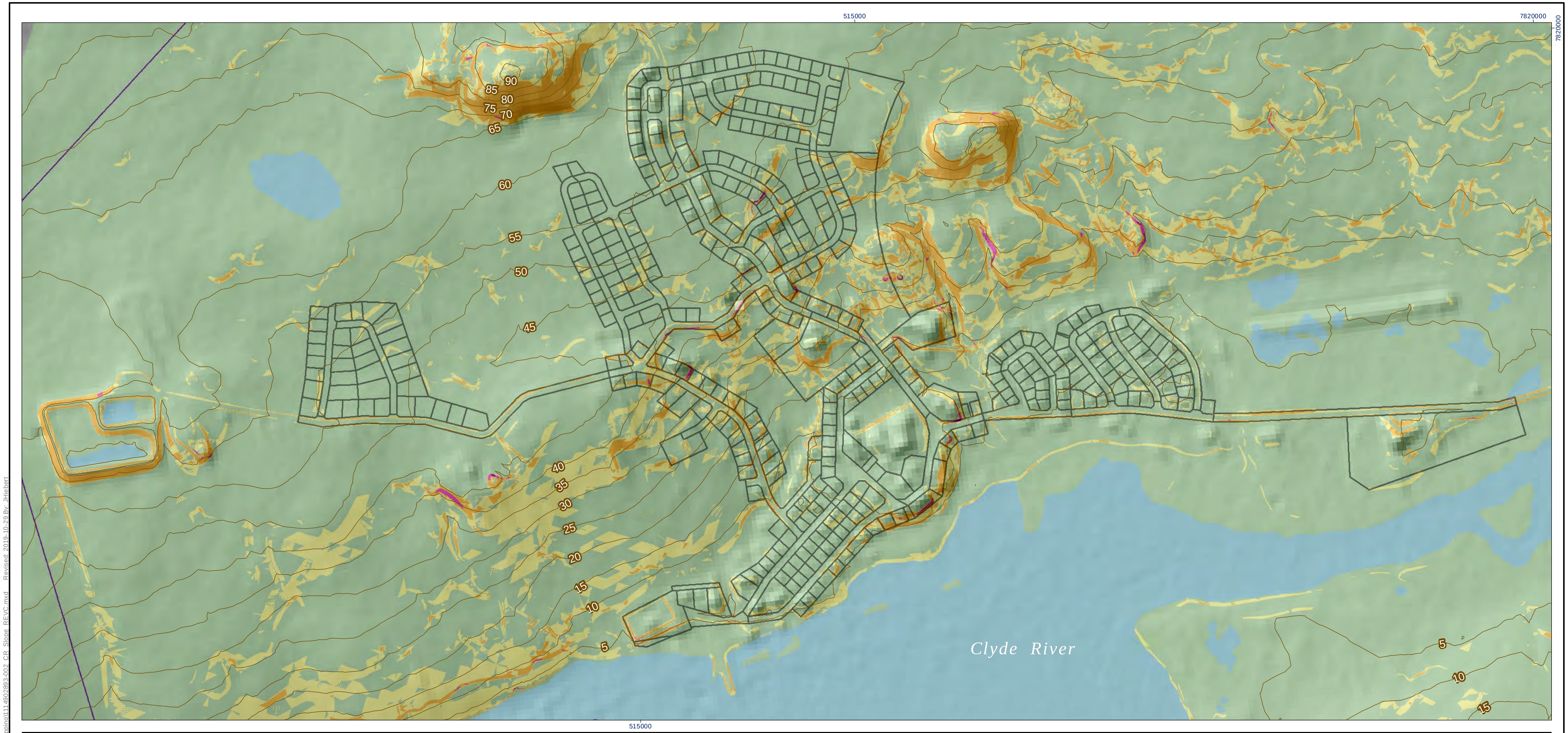
Prepared by JH on 2019-10-24
Technical Review by MV on 2019-10-24

Client/Project
Government of Nunavut
Department of Community and
Government Services

144902893-004 REVB

Figure No.
B-2

Title
Permafrost and Periglacial Features (modified from Smith et al. 2012b)



Legend

— Contours (5m)

☐ Land Parcels

🟦 Waterbodies

Slope steepness (%)

- 🟩 0 - 10
- 🟨 10 - 20
- 🟧 20 - 50
- 🟥 50 - 70
- 🟪 70 - 100

0 150 300 metres

(At original document size of 11x17)
1:8,500

N

Notes
1. Coordinate System: NAD 1983 UTM Zone 19N
2. Data Sources: Government of Nunavut, Stantec, Polar Geospatial Center
3. Background: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
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Project Location
Clyde River,
Nunavut

Prepared by JH on 2019-10-29
Technical Review by MV on 2019-10-29

Client/Project
Government of Nunavut
Department of Community and
Government Services

144902893-002 REVC

Figure No.
B-3

Title
Topography and DEM-Derived Slope Classes

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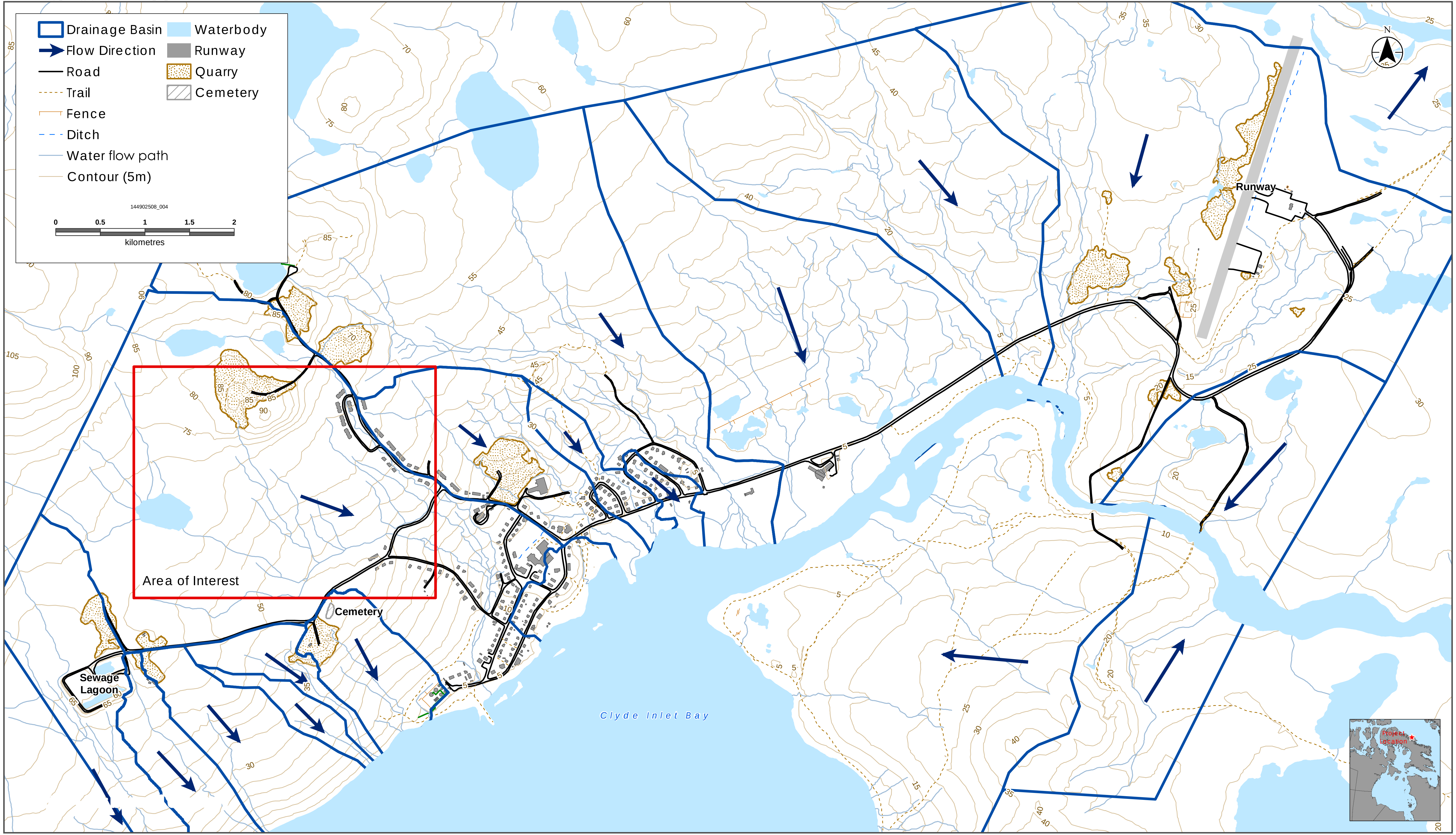

Sources: Base Data - Natural Earth; Thematic Data - ERBC

Stantec

CLYDE RIVER

Watershed Boundary and Drainage Sub-Basins - **Clyde River**

Appendix B, Figure B-4

Legend

🟨	Drainage
- - -	Water Flow Path
☐	Land Parcels

Drainage Classes

Very rapidly	x
Rapidly	r
Well	w
Moderately well	m
Imperfect	i
Poor	p
Very poor	v

0 150 300 metres
(At original document size of 11x17)
1:8,500

N

Notes
1. Coordinate System: NAD 1983 UTM Zone 19N
2. Data Sources: Government of Nunavut, Stantec
3. Background: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
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Project Location
Clyde River,
Nunavut

Prepared by JH on 2019-10-29
Technical Review by MV on 2019-10-29

Client/Project
Government of Nunavut
Department of Community and
Government Services

144902893-003 REVB

Figure No.
B-5

Title
Drainage Conditions

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Legend

⬜ Land Parcels

Suitability Classes

🟩 Terrain Suitable for Development

🟨 Terrain Potentially Suitable for Development

🟥 Terrain Unfavorable for Development

Classes Conditions

Terrain Suitable for Development - Permafrost present with low to moderate volumetric ice content (VIC 0-50 %). - Well-drained to imperfectly drained soils.	- Level topography with slopes under 10%. - Inactive to limited periglacial processes. No observed evidence of rapid mass movement.
Terrain Potentially Suitable for Development - Permafrost generally present low to moderate ice-content; however, may include areas of high ice content (VIC 50-100 %). - Permafrost features such as ice wedges may be present. - Imperfectly to poorly drained soils.	- Gently sloping topography with slopes between 10 to 20%. - Inactive to limited periglacial processes. No observed evidence of rapid mass movement. - Site is adjacent to an area that may negatively impact the suitability of the site.
Terrain Unfavorable for Development - Permafrost present with high ice content. - Observed indicators of unstable terrain (e.g., ground settlement, thermokarst development, thermo-erosion, gully erosion, landslide). - Poorly drained to very poorly drained soils. Surface seepage or drainage flow path generally present.	- Slopes > 20%. - Thick organic soils. - Snow accumulation areas. - Sites with active mass wasting processes. - Areas potentially susceptible to flooding.

0 150 300 metres

(At original document size of 11x17)
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Project Location
Clyde River,
Nunavut

Prepared by JH on 2019-11-27
Technical Review by MV on 2019-11-27

Client/Project
Government of Nunavut
Department of Community and
Government Services

144902893-005 REVE

Figure No.
B-6

Title
Construction Suitability

Notes
1. Coordinate System: NAD 1983 UTM Zone 19N
2. Data Sources: Government of Nunavut, Stantec
3. Background: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
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Legend

◈	Shallow Borehole (0-3m)
◈	Deep Borehole (0-10m)
☐	Land Parcels

0 75 150 metres

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Project Location
Clyde River,
Nunavut

Prepared by JH on 2019-11-12
Technical Review by MV on 2019-11-12

Client/Project
Government of Nunavut
Department of Community and
Government Services

144902893-006 REVC

Figure No.
B-7

Title
Borehole Locations

Notes
1. Coordinate System: NAD 1983 UTM Zone 19N
2. Data Sources: Government of Nunavut, Stantec
3. Background: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
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APPENDIX C

Drainage Plan

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Notes

LOT 24* DENOTES LOTS UNFAVORABLE FOR DEVELOPMENT

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2	----	----	----	----
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GOVERNMENT OF NUNAVUT DEPARTMENT OF COMMUNITY AND GOVERNMENT SEVICES

DRAINAGE PLANNING

CLYDE RIVER

Title
CIVIL
CLYDE RIVER
GENERAL OVERVIEW

Project No.
144902893

Scale
1:3000H
0 30 90 150m

Revision
A/0

Sheet
1 of 9

Drawing No.
C-100

ORIGINAL SHEET - ANSI D

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2019.11.13 1:53:32 PM By: Hodgins, Oliver

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Notes

Legend

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DITCH LINE	→· · ·—	→· · ·—
CULVERT	▬	▨
BERM	▬	
NATURAL DRAINAGE	– – – – –	
GRAVEL ROAD	—	
PARCEL BOUNDARY	—	

LOT 24* DENOTES LOTS NOT RECOMMENDED FOR DEVELOPMENT

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DRAINAGE PLANNING

CLYDE RIVER

Title
CIVIL
DRAINAGE PLAN
BLOCK 1

Project No.
144902893

Scale
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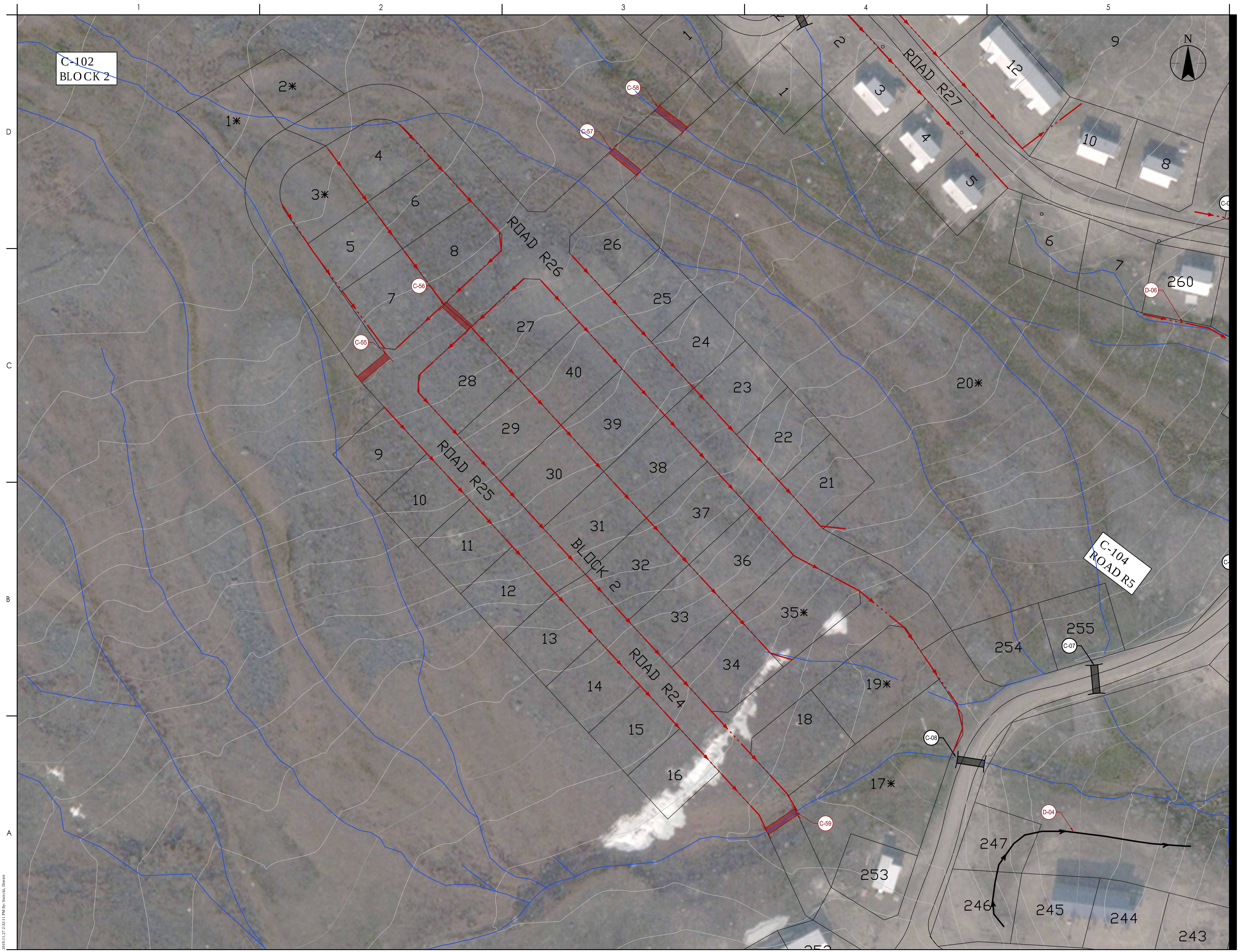
1:75V 0 0.75 2.25 3.75m

Revision
A/0

Sheet
2 of 9

Drawing No.
C-101



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Notes

Legend

	EXISTING	REQUIRED
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NATURAL DRAINAGE	– – – – –	
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LOT 24* DENOTES LOTS UNFAVORABLE FOR DEVELOPMENT

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DRAINAGE PLANNING

CLYDE RIVER

Title
CIVIL
DRAINAGE PLAN
BLOCK 2

Project No.
144902893

Scale
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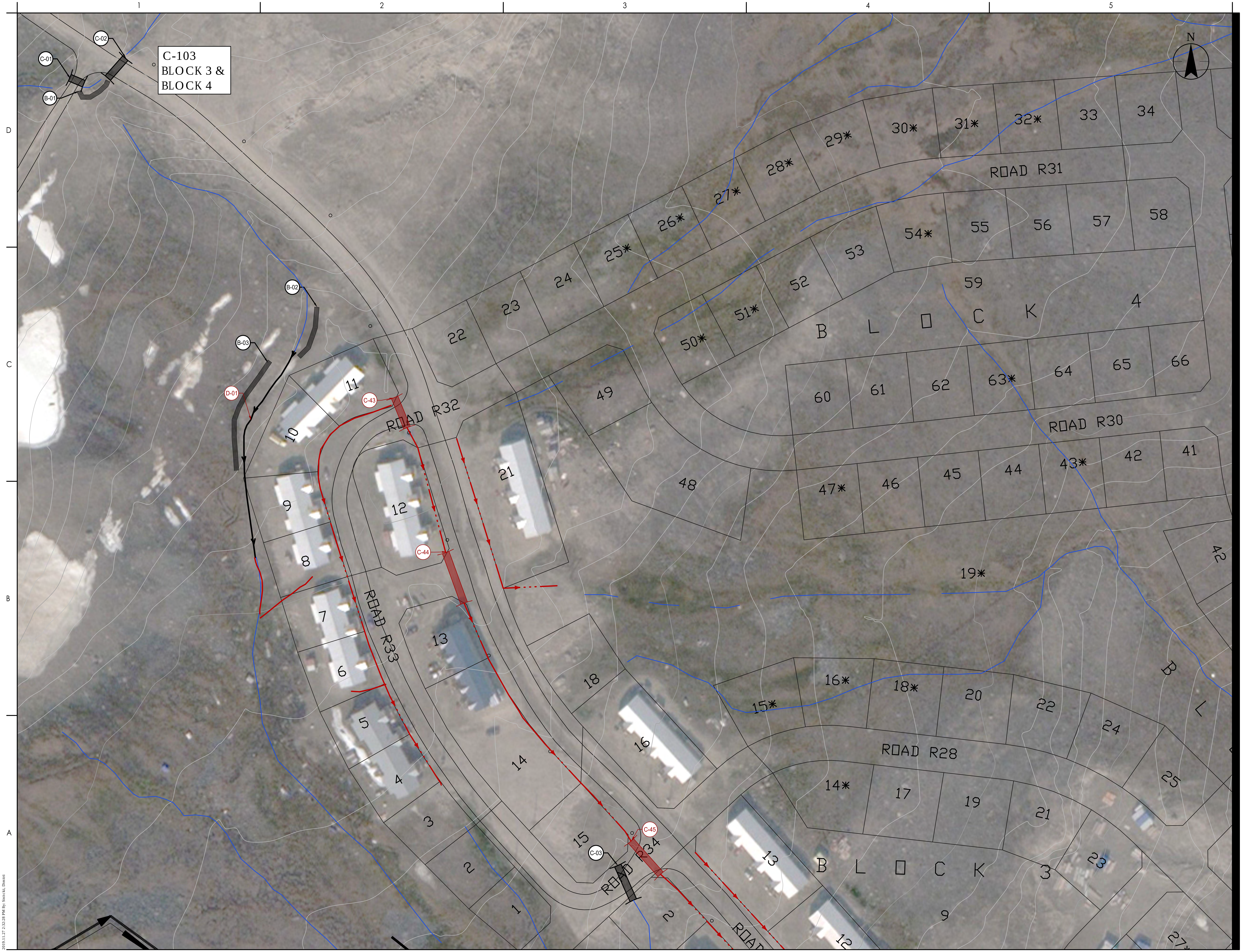
1:75V 0 0.75 2.25 3.75m

Revision
A/0

Sheet
3 of 9

Drawing No.
C-102



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Notes

Legend

	EXISTING	REQUIRED
DITCH LINE	→· · · —	→· · · —
CULVERT	▬	▨
BERM	▬	
NATURAL DRAINAGE	– – – – –	
GRAVEL ROAD	——	
PARCEL BOUNDARY	——	

LOT 24* DENOTES LOTS UNFAVORABLE FOR DEVELOPMENT

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DRAINAGE PLANNING

CLYDE RIVER

Title
CIVIL
DRAINAGE PLAN
BLOCK 3 AND BLOCK 4

Project No.
144902893

Scale
1:750H 0 7.5 22.5 37.5m
1:75V 0 0.75 2.25 3.75m

Revision
A/0

Sheet
4 of 9

Drawing No.
C-103

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2019.11.27 2:32:28 PM By: Sinitckii, Dimitrii

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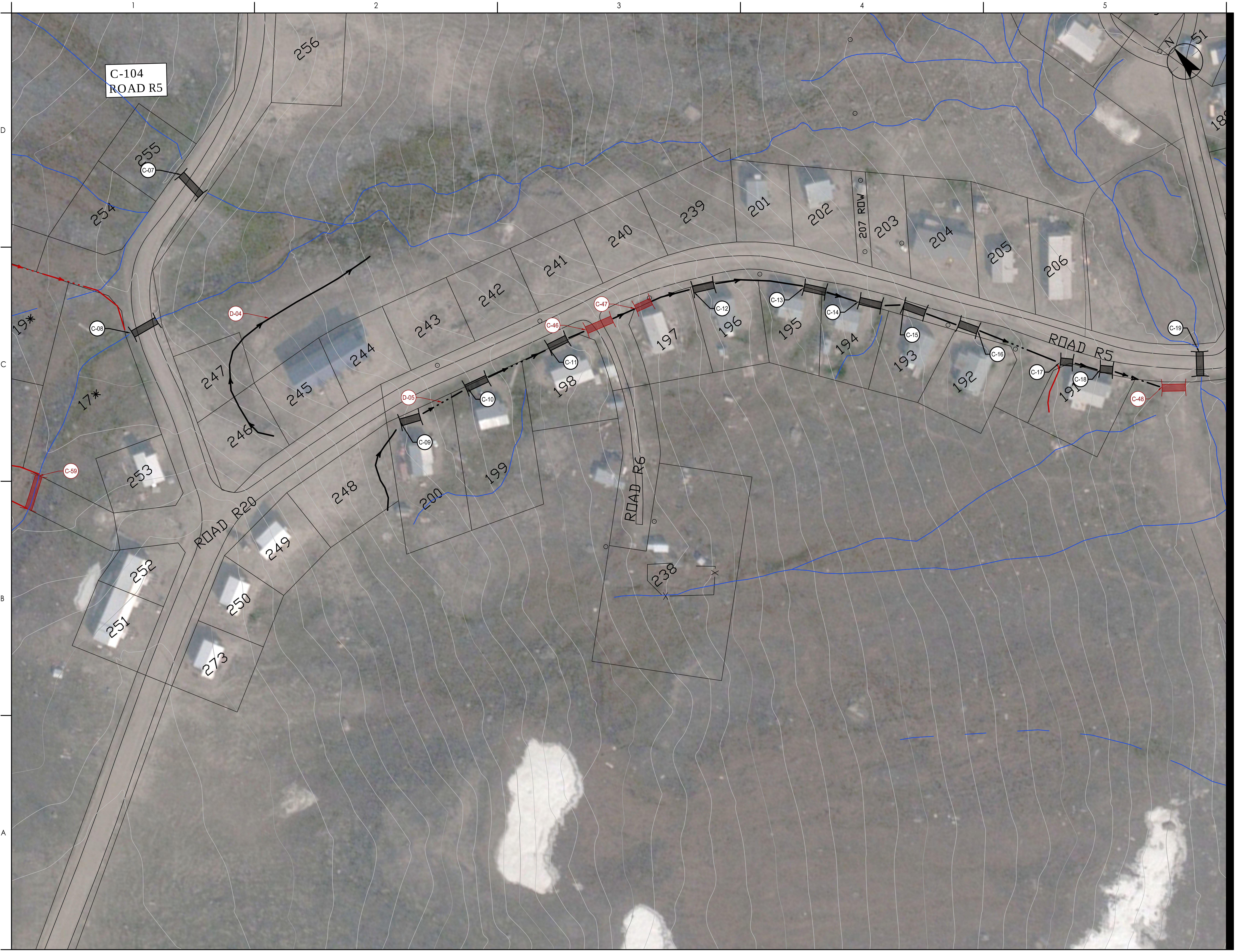

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Notes

Legend

	EXISTING	REQUIRED
DITCH LINE	→ · · · —	→ · · · —
CULVERT	▬	▨
BERM	▬	
NATURAL DRAINAGE	– – – – –	
GRAVEL ROAD	——	
PARCEL BOUNDARY	——	

LOT 24* DENOTES LOTS UNFAVORABLE FOR DEVELOPMENT

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DRAINAGE PLANNING

CLYDE RIVER

Title
CIVIL
DRAINAGE PLAN
ROAD R5

Project No.
144902893

Scale
1:750H 0 7.5 22.5 37.5m
1:75V 0 0.75 2.25 3.75m

Revision
A/0

Sheet
5 of 9

Drawing No.
C-104

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Legend

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DITCH LINE	→· · · —	→· · · —
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BERM	▬	
NATURAL DRAINAGE	– – – – –	
GRAVEL ROAD	——	
PARCEL BOUNDARY	——	

LOT 24* DENOTES LOTS UNFAVORABLE FOR DEVELOPMENT

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DRAINAGE PLANNING

CLYDE RIVER

Title
CIVIL
DRAINAGE PLAN
BLOCK 3

Project No.
144902893

Scale
1:750H 0 7.5 22.5 37.5m
1:75V 0 0.75 2.25 3.75m

Revision
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Sheet
6 of 9

Drawing No.
C-105

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LOT 24* DENOTES LOTS UNFAVORABLE FOR DEVELOPMENT

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DRAINAGE PLANNING

CLYDE RIVER

Title
CIVIL
DRAINAGE PLAN
SEALIFT DISTRICT

Project No.
144902893

Scale
1:750H 0 7.5 22.5 37.5m
1:75V 0 0.75 2.25 3.75m

Revision
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Sheet
7 of 9

Drawing No.
C-106

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CULVERT	▬	▨
BERM	▬	
NATURAL DRAINAGE	- - -	
GRAVEL ROAD	—	
PARCEL BOUNDARY	—	

LOT 24* DENOTES LOTS UNFAVORABLE FOR DEVELOPMENT

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COMMUNITY AND GOVERNMENT SEVICES

DRAINAGE PLANNING

CLYDE RIVER

Title
CIVIL
DRAINAGE PLAN
QULUAQ SCHOOL DISTRICT

Project No.
144902893

Scale
1:750H 0 7.5 22.5 37.5m
1:75V 0 0.75 2.25 3.75m

Revision
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Sheet
8 of 9

Drawing No.
C-107

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2019.11.27 2:34:26 PM By: Sinitckii, Dimitrii

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Notes

Legend

	EXISTING	REQUIRED
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CULVERT	▬	▬
BERM	━	
NATURAL DRAINAGE	– – –	
GRAVEL ROAD	─	
PARCEL BOUNDARY	─	

LOT 24* DENOTES LOTS UNFAVORABLE FOR DEVELOPMENT

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DRAINAGE PLANNING

CLYDE RIVER

Title
CIVIL
DRAINAGE PLAN
EASTERN DISTRICT

Project No.
144902893

Scale
1:750H 0 7.5 22.5 37.5m
1:75V 0 0.75 2.25 3.75m

Revision
A/0

Sheet
9 of 9

Drawing No.
C-108

APPENDIX D

Drainage Infrastructure Inventory

Culvert Inventory

Culvert C-01 and C-02

- Culverts located across access road to existing borrow pit.
- Drainage from the borrow pit area (north of Block 2) toward the southeast (Block 4 area).
- Erosion observed alongside embankment surrounding C-02.
- **Upgrade and maintenance recommended.**

Culvert C-03

- Culvert located across road R34.
- Drainage from lots surrounding road R33 toward Bloc 2, Lot 20.
- Undersized culvert (~130 mm), the west extremity was observed to be buried within roadbed.
- **Culvert should be replaced and repositioned. A swale or shallow ditch would promote faster drainage alongside road R34 in the area.**

Culvert C-04

- Culvert located across access road to Housing Corporation yard.
- Drainage of upstream area toward shallow ditch (draining water eastwardly)
- Undersized culvert (~250 mm), the west end was observed to be buried. The east end was observed to be damaged (likely from grading/snowplowing activities).
- Surface water flow observed over the access road. Likely related to buried culvert inlet.
- **Culvert needs replacement. Swales or ditches would promote faster drainage alongside road R27 and R20.**

Culvert C-05

- Culvert located across road R20.
- Drainage from upstream lots toward the small stream flowing to the sealift district.
- Poorly defined flow path leading to localized water ponding.
- Partial culvert inlet Blockage by silt and sand (~5 %).
- Damaged culvert inlet.
- **Culvert need maintenance or upgrade.**

Culvert C-06

- Culvert located across road R20 (immediately south from Block 2).
- Drainage from Block 2 (Lot 20) toward the stream flowing to the sealift district.
- Poorly defined flow path upstream from culvert.
- Ponding observed around culvert inlet.
- Culvert outlet perched above ground surface (~30 cm). Risk for localized erosion.
- Tension cracks observed alongside embankment.
- **Culvert placement could be optimized to facilitate water flow and limit potential ponding.**

Culvert C-07

- Culvert located across road R20.
- Drainage from Block 2, (Lot 20) toward the stream flowing to the sealift district.
- Poorly defined flow path upstream from culvert.
- Ponding observed around culvert inlet.
- Partial culvert inlet blockage (~80 %).
- Tension cracks observed alongside embankment (upslope embankment).
- **Culvert need maintenance or upgrade to facilitate water flow and limit potential ponding.**

Culvert C-08

- Culvert located across road R20.
- Drainage from sub-basins west of Block 2, toward the stream flowing to the sealift district.
- Crushed culvert inlet and minor erosion noted alongside upslope road embankment.
- Ponding observed around culvert inlet.
- **Culvert need maintenance or replacement. A larger culvert would allow for a more efficient drainage in period of snowmelt or following heavy rainfall events.**
- **Rip-rap required at culvert outlet to minimize potential erosion.**

Culvert C-09 to C-18

- Series of small dimeter culverts (~150 mm) located across driveways along road R5.
- Waterlogged soils and standing water observed in low-lying areas characterized by thin fill (<40 cm) or no fill.
- Localized erosion and sedimentation observed along the road, with some culverts showing partial blockage by sand and silt (e.g., C-17 and C-18).
- Several of the culverts were observed to be crushed, deformed and/or perched.
- **Several culverts need maintenance or replacement. A ditch along the west side of road R5 would allow for more efficient drainage and would limit potential erosion.**

Culvert C-19

- Recently upgraded culvert located across road R5.
- Drainage of the stream flowing westerly toward the sealift district.
- Good overall condition however the culvert was observed to be slightly perched above the ground surface, allowing for ponding upstream from the culvert.
- Possibility that some localized subsidence occurred in the area (thermal degradation).
- **Lowering the culvert would allow for more efficient drainage.**

Culvert C-20

- Culvert located in front of the Municipal Center (east corner).
- Drainage of the pad hosting the Municipal Center, toward the residential lots downslope.
- Good overall condition.
- Minor sedimentation observed within the culvert.
- **Annual maintenance should include cleaning the inlet of loose sand and silt. Some Rip rap should be placed at the outlet to protect then steep embankment from erosion.**

Culvert C-21


- Culvert located across access road to inactive borrow pit.
- Downslope drainage from Blocks 3 and 4 through a major flow path toward Patricia Bay.
- Culvert inlet partially blocked with gravel and cobbles.
- Culvert outlet perched.
- Good overall condition
- **Annual maintenance should include cleaning erodible material and obstructions from the inlet area.**

Culvert C-22


- Culvert located across access road to the community arena.
- Drainage from Blocks 3 and 4 through a major flow path toward Patricia Bay.
- Good overall condition.
- Minor sand and silt sedimentation immediately upstream from the culvert.
- **Annual maintenance should include clearing material within the culvert.**
- **Attention should be given to limit erosion of fine-grained soils in the area (former borrow pit immediately north of the arena).**

Culvert C-23

- Small culvert (~150 mm) located across residential driveway along road R8.
- No swale or ditch confining drainage towards the culvert.
- Partial culvert blockage by sand and silt (>50 %).
- Damage culvert inlet and outlet (likely from grading/snowplowing activities).
- **Culvert requires maintenance or replacement.**
- **Proper ditches or swales required alongside road R8.**

Culvert C-24

- Culvert located across access road leading to the power plant.
- Drainage of a major flow path toward the shoreline area.
- Some sand and gravel accumulation within the culvert. Material observed not to impact water flow.
- Culvert observed to be deformed. Structural integrity of the culvert likely impacted.
- Limited fill cover present above the crest of the culvert (~20 cm).
- **Overall stability of the culvert should be monitored. Replacement might be required.**

Culvert C-25

- Culvert located across road R3.
- Drainage from a small flow path toward Patricia Bay. The flow path was observed to be poorly defined upstream from the culvert.
- Culvert inlet observed to be deformed.
- Sedimentation observed within the culvert (<20% blockage).
- **Deformed culvert inlet should be fixed. Annual maintenance should include clearing material within the culvert.**

Culvert C-26

- Culvert located across road R3.
- Drainage from a small flow path toward Patricia Bay. The flow path was observed to be poorly defined upstream from the culvert.
- Culvert observed to be deformed.
- Sedimentation observed within the culvert (<20% blockage).
- **Deformed culvert inlet should be fixed. Annual maintenance should include clearing material within the culvert.**

Culvert C-27

- Culvert located across road R10.
- Drainage from flow path adjacent to Quluaq school toward ditchline alongside road R10.
- Good overall condition.
- Slightly raised culvert inlet allows for ponding alongside the Quluaq school parking lot.
- **Improved ditch conditions would improve drainage between culverts C-27 and C-29. Ditch upgraded should consist in adding fill on either side of the ditch rather than excavating below natural grade.**

Culvert C-28

- Small culvert (< 150 mm) located across Family Resource Center driveway.
- Drainage alongside road R8 toward road R10.
- Poorly confined flow path feeding the culvert. No swale or ditch observed.
- Sedimentation observed within the culvert (<20% blockage).
- **Ditch required to facilitate drainage alongside road R8 to R10. Existing undersized culvert should be replaced. Extra culverts should be installed wherever cross-ditch access are required.**

Culvert C-29


- Culvert located adjacent to the Health Care Center (alongside road R10).
- Drainage from culvert C-27 toward major flow path to Patricia Bay.
- Missing ditch and unconfined flow upstream from culvert.
- Sedimentation observed within the culvert (<20% blockage).
- Damage culvert inlet and outlet (likely from grading/snowplowing activities).
- **Ditch required to facilitate drainage alongside road R10. The culvert needs to be fixed or replaced so to allow for improved drainage.**

Culvert C-30


- Culvert located across the access road connecting the arena to the eastern community district.
- Drainage from the northeast toward a major flow path to Patricia Bay.
- Poorly confined flow path feeding the culvert. Water ponding observed.
- Culvert fully exposed, with surface water flowing on either side of the culvert.
- Sedimentation observed within the culvert (~10% blockage).
- Undersized culvert (300 mm) for the potential discharge during melting season.
- **Road access should either be fixed or decommissioned. Culvert needs replacement.**

Culvert C-31

- Two culverts side by side located across road R13.
- Drainage of major flow path to Patricia Bay.
- Good overall condition.
- **Adding riprap material below the culvert outlet would minimize potential future erosion.**

Culvert C-32

- Two culverts located across a new access road leading to a borrow pit.
- Drainage of major flow path toward the discharge area located east of the community.
- Poorly defined flow path upstream from the culvert.
- The position of the newly installed culvert is not optimal, which allows from water ponding upstream from the access road. The older culvert is partially crushed, with its inlet and outlet observed to be partially blocked by debris.
- **Road upgrade required. Replacement of damage culvert recommended.**

Culvert C-33

N/A

N/A

- Culvert located across road R14.
- Drainage of minor flow path toward Patricia Bay.
- Poorly defined ditch near culvert inlet – Ditches are absent alongside roads R14 and R15.
- **Ditches should be excavated to the base of the fill material so to allow for improved drainage alongside roads R14 and R15.**

Culvert C-34, C-35 and C-36

- Group of three culverts located across residential driveways and road R14.
- Drainage of runoff water from poorly drained backyard area towards Patricia Bay.
- Poorly defined ditches or swales feeding the culverts.
- Sedimentation observed within the culverts (~30% blockage).
- Damage culvert inlet and outlet (likely from grading/snowplowing activities).
- **Culvert maintenance or replacement required. A ditch should run alongside road R14, with culverts placed at driveway locations.**

Culvert C-37

- Culvert located at the intersection of road R14 to road R16.
- Drainage of runoff water from poorly drained backyard area towards Patricia Bay.
- Poorly defined flow path upstream and downstream from the culvert.
- Sedimentation observed within the culvert (~20% blockage).
- **Culvert maintenance required. A ditch should run alongside the two roads, with culverts placed at driveway locations.**

Culvert C-38

- Culvert located across road R14.
- Drainage of runoff water from poorly drained backyard area towards Patricia
- Poorly defined flow path upstream from the culvert. No ditch or swale observed.
- Sedimentation observed within the culvert (~50% blockage).
- Partially crushed culvert.
- **The flow path leading to the culvert could be improved by adding fill and directing flow into a ditch. Maintenance is required on the culvert to improve water flow.**

Culvert C-39

- Culvert located across road R14.
- Drainage of standing water in low lying area alongside road R14.
- Poorly defined flow path upstream from the culvert. No ditch or swale observed.
- Perched culvert inlet. Damage culvert outlet (likely from grading/snowplowing activities).
- **Adding fill alongside the road would help recontouring the area and form a shallow swale, allowing the water to better drain towards the culvert. Maintenance required on culvert.**

Culvert C-40

- Culvert located across road R17.
- Drainage of side road flow path toward major flow path to Patricia Bay.
- Crushed culvert inlet and outlet with partial culvert blockage by sand and silt.
- **Culvert maintenance or replacement required. A ditch should run alongside road R17, with culverts placed at driveway locations.**

Culvert C-41

- Culvert located across road R17.
- Drainage of low-lying terrain alongside road toward major flow path to Patricia Bay.
- Poorly defined flow path upstream from culvert.
- Crushed and buried culvert inlet and outlet.
- **Culvert maintenance or replacement required. A ditch should run alongside road R17, with culverts placed at driveway locations.**

Culvert C-42

- Culvert located across road R35 to the airport.
- Drainage of major flow path toward Patricia Bay.
- Good overall condition.
- **Annual maintenance recommended.**

Berm Inventory

Berm B-01

- Berm located adjacent to access road to existing borrow pit
- Berm allows to redirect surface water flow from culvert C-01 towards culvert C-02.
- Some seepage observed through the berm.
- **Material should be added to the berm consolidate the berm and limit potential seepage.**

Berm B-02

- Small berm located north of the northern district.
- Berm allows to redirect surface water flow behind the residential units rather than alongside road R27 where no ditch is present.
- Disturbed topography and poor drainage conditions leading to localized ponding.
- **Adding fill and recontouring the poorly drained area would allow for more effective drainage. If required, adding material along the berm would limit potential seepage towards road R27.**

Berm B-03

- Berm form by the placement of excavated material along a drainage ditch (see ditch D-01).
- The berm is located along the same drainage channel then berm B-02 (further downstream) and facilitates drainages away from recently constructed residential units.
- **Maintenance required.**

Ditch / Swale Inventory

Ditch D-01

- Ditch located north of the northern district of the community (flow toward Block 2).
- Poor drainage leads to ponding upstream and downstream.
- Tension cracks observed along the southern section of the ditch.
- **Ditch needs better grading to avoid ponding which could lead to further permafrost degradation and ground subsidence.**

Ditch D-02 and D-03


- Ditch located downslope from the housing corporation yard.
- Ditch feeds into a major drainage flow path downstream.
- Erosion and slope wash observed to have initiated along the edge of the yard.
- **Maintenance required. Adding fill would help confine the flow. Erosion control (e.g., rip rap) should be placed along the short steep slope marking the edge of the pad.**

Ditch D-04


- Poorly defined ditch located across lots 246 and 247 (adjacent to road R20).
- Ditch feeds into a major stream that flows towards the sealift area.
- Poorly contoured portion of the ditch leads to water ponding. Minor erosion observed to initiate along the embankment of road R20.
- **Maintenance required. Ditch needs better grading to avoid ponding and erosion.**

Ditch D-05

- Series of poorly defined ditch segments located alongside road R5.
- The ditch line is discontinuous, which lead to water ponding along several houses and seepage across the road.
- Some erosion and gullying observed.
- **Considerations should be given to add backfill material along the front portion of some of the residential lots in order to recontour low-lying areas and improved overall drainage.**
- **The ditch running along the west side of road R5 should be improved so to further confine water flow following snow melt and heavy rain events.**

Ditch D-06

- Ditch located alongside from Quluaq school (northwest side of the building).
- Drainage from the southwest toward the northeast.
- Excavated material placed north for the ditch is acting as a berm. Water was observed to accumulated upslope from that material.
- **The improvised berm needs to be recontoured to allow for seepage water to cross into the ditch. Adjusting the grade of the ditch line would promote more efficient drainage.**

Ditch D-07

- Ditch located north from Quluaq school.
- Drainage from the southwest and northwest toward the southeast.
- Inadequate slope leading to accumulation of standing water within the ditch.
- **The overall grade of the ditch should be adjusted.**
- **Culvert C-27 located below the area of ponding water should be lowered.**

Ditch D-08

- Poorly defined ditch located alongside the Health Care Center.
- Drainage from culverts C-27 and C-28 toward culvert C-29.
- **Deepening of the ditch line would allow for a more confined flow. General maintenance required.**

APPENDIX E

Borehole Records

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

Rootmat	- vegetation, roots and moss with organic matter and topsoil typically forming a mattress at the ground surface
Topsoil	- mixture of soil and humus capable of supporting vegetative growth
Peat	- mixture of visible and invisible fragments of decayed organic matter
Till	- unstratified glacial deposit which may range from clay to boulders
Fill	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

Desiccated	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
Fissured	- having cracks, and hence a blocky structure
Varved	- composed of regular alternating layers of silt and clay
Stratified	- composed of alternating successions of different soil types, e.g. silt and sand
Layer	- > 75 mm in thickness
Seam	- 2 mm to 75 mm in thickness
Parting	- < 2 mm in thickness

Terminology describing soil types:
The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488) which excludes particles larger than 75 mm. For particles larger than 75 mm, and for defining percent clay fraction in hydrometer results, definitions proposed by Canadian Foundation Engineering Manual, 4th Edition are used. The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):
Terminology describing materials outside the USCS, (e.g. particles larger than 75 mm, visible organic matter, and construction debris) is based upon the proportion of these materials present:

Trace, or occasional	Less than 10%
Some	10-20%
Frequent	> 20%

Terminology describing compactness of cohesionless soils:
The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test (SPT) N-Value - also known as N-Index. The SPT N-Value is described further on page 3. A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
Very Loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

Terminology describing consistency of cohesive soils:
The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests. Consistency may be crudely estimated from SPT N-Value based on the correlation shown in the following table (Terzaghi and Peck, 1967). The correlation to SPT N-Value is used with caution as it is only very approximate.

Consistency	Undrained Shear Strength		Approximate SPT N-Value
	kips/sq.ft.	kPa	
Very Soft	<0.25	<12.5	<2
Soft	0.25 - 0.5	12.5 - 25	2-4
Firm	0.5 - 1.0	25 - 50	4-8
Stiff	1.0 - 2.0	50 – 100	8-15
Very Stiff	2.0 - 4.0	100 - 200	15-30
Hard	>4.0	>200	>30

ROCK DESCRIPTION

Except where specified below, terminology for describing rock is as defined by the International Society for Rock Mechanics (ISRM) 2007 publication "The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974-2006"

Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	*Very Poor Quality*
25-50	*Poor Quality*
50-75	*Fair Quality*
75-90	*Good Quality*
90-100	*Excellent Quality*

Alternate (Colloquial) Rock Mass Quality	
Very Severely Fractured	*Crushed*
Severely Fractured	*Shattered or Very Blocky*
Fractured	*Blocky*
Moderately Jointed	*Sound*
Intact	*Very Sound*

RQD (Rock Quality Designation) denotes the percentage of intact and sound rock retrieved from a borehole of any orientation. All pieces of intact and sound rock core equal to or greater than 100 mm (4 in.) long are summed and divided by the total length of the core run. RQD is determined in accordance with ASTM D6032.

SCR (Solid Core Recovery) denotes the percentage of solid core (cylindrical) retrieved from a borehole of any orientation. All pieces of solid (cylindrical) core are summed and divided by the total length of the core run (It excludes all portions of core pieces that are not fully cylindrical as well as crushed or rubble zones).

Fracture Index (FI) is defined as the number of naturally occurring fractures within a given length of core. The Fracture Index is reported as a simple count of natural occurring fractures.

Terminology describing rock with respect to discontinuity and bedding spacing:

Spacing (mm)	Discontinuities	Bedding
>6000	*Extremely Wide*	-
2000-6000	*Very Wide*	*Very Thick*
600-2000	*Wide*	*Thick*
200-600	*Moderate*	*Medium*
60-200	*Close*	*Thin*
20-60	*Very Close*	*Very Thin*
<20	*Extremely Close*	*Laminated*
<6	-	*Thinly Laminated*

Terminology describing rock strength:

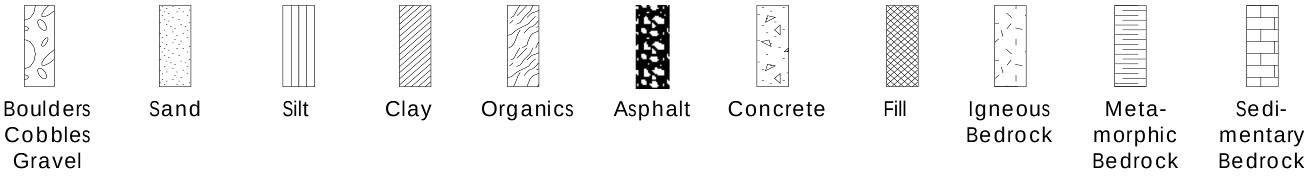
Strength Classification	Grade	Unconfined Compressive Strength (MPa)
Extremely Weak	R0	<1
Very Weak	R1	1 – 5
Weak	R2	5 – 25
Medium Strong	R3	25 – 50
Strong	R4	50 – 100
Very Strong	R5	100 – 250
Extremely Strong	R6	>250

Terminology describing rock weathering:

Term	Symbol	Description
Fresh	W1	No visible signs of rock weathering. Slight discoloration along major discontinuities
Slightly	W2	Discoloration indicates weathering of rock on discontinuity surfaces. All the rock material may be discolored.
Moderately	W3	Less than half the rock is decomposed and/or disintegrated into soil.
Highly	W4	More than half the rock is decomposed and/or disintegrated into soil.
Completely	W5	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil	W6	All the rock converted to soil. Structure and fabric destroyed.

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT

▼	measured in standpipe, piezometer, or well
▽	inferred

RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (63.5 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (300 mm) into the soil. In accordance with ASTM D1586, the N-Value equals the sum of the number of blows (N) required to drive the sampler over the interval of 6 to 18 in. (150 to 450 mm). However, when a 24 in. (610 mm) sampler is used, the number of blows (N) required to drive the sampler over the interval of 12 to 24 in. (300 to 610 mm) may be reported if this value is lower. For split spoon samples where insufficient penetration was achieved and N-Values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N-values corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

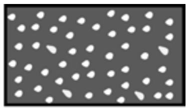
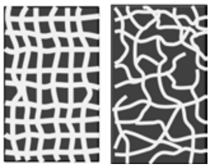
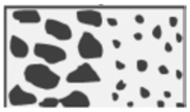
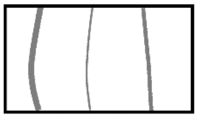
Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to 'A' size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (300 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_u	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer

CRYOSTRUCTURE CLASSIFICATION

Cryostructure*	Equivalent classification**	Description	Illustration***
Structureless no excess ice (Si)	Nbn	-Interstitial pore ice not visible to the unaided eye -Usually ice-poor sediment	
Structureless excess ice (Se)	Nbe	-Interstitial pore ice that is visible to the unaided eye -Usually ice-poor sediment	
Lenticular (Le)	Vs	-Lens-shaped ice in sediment -Thickness: <1 cm -Generally horizontal (parallel to freezing front) -May be straight, wavy, inclined, interlaced -Usually ice-rich sediment	
Layered (La)	Vs	-Continuous band of ice, sediment or a combination of both -Thickness: cm to dm -Usually ice-rich sediment	
Reticulate (Re)	Vr	-Net-like structure of interconnected sub-horizontal ice lenses and sub-vertical ice veins -Usually ice-rich sediment	
Crustal (Cr)	Vc	-Ice coating around rock fragments or aggregates. -Thickness: few millimeters to centimeters thick coating	
Suspended (Sp)	Ice + Soil type	-Suspended aggregates in ice -Usually very ice-rich sediments	
Ice wedge (Iw)	Ice	-Ice with little soil inclusion -Present vertical foliations typical of ice wedge development -May be observed as polygonal ice wedge network across the landscape	

* Adapted from Murton and French (1994).
** From Pihlainen and Johnston (1963).
*** Modified from Stephani et al. (2010).

BOREHOLE REPORT

Project:	**Geotechnical Investigation and Drainage Planning**	Location :	**UTM 19**	Borehole :	**BH19-01**
		X :	**7819055.06**	Page :	**1 of 1**
Project No.:	**144902893**	Y :	**514533.84**	Start date :	**2019-09-12**
Client:	**Government of Nunavut**	Type of borehole :	**Borehole**	Inspector :	**M. Verpaelst**
Site:	**Clyde River, Nunavut**	Equipment :	**STIHL FB200**	Depth :	**2.03 m**
Figure:		Casings :		Elevation :	**m**
		Corer :	**Core diameter: 76**		

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
TW	Thin wall sampler
ST	Shelby tube
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1	2019-09-12	0.65 m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remouded (unfrozen sample)
▨	Intact (thin wall sampler)
■	Lost
◧	Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

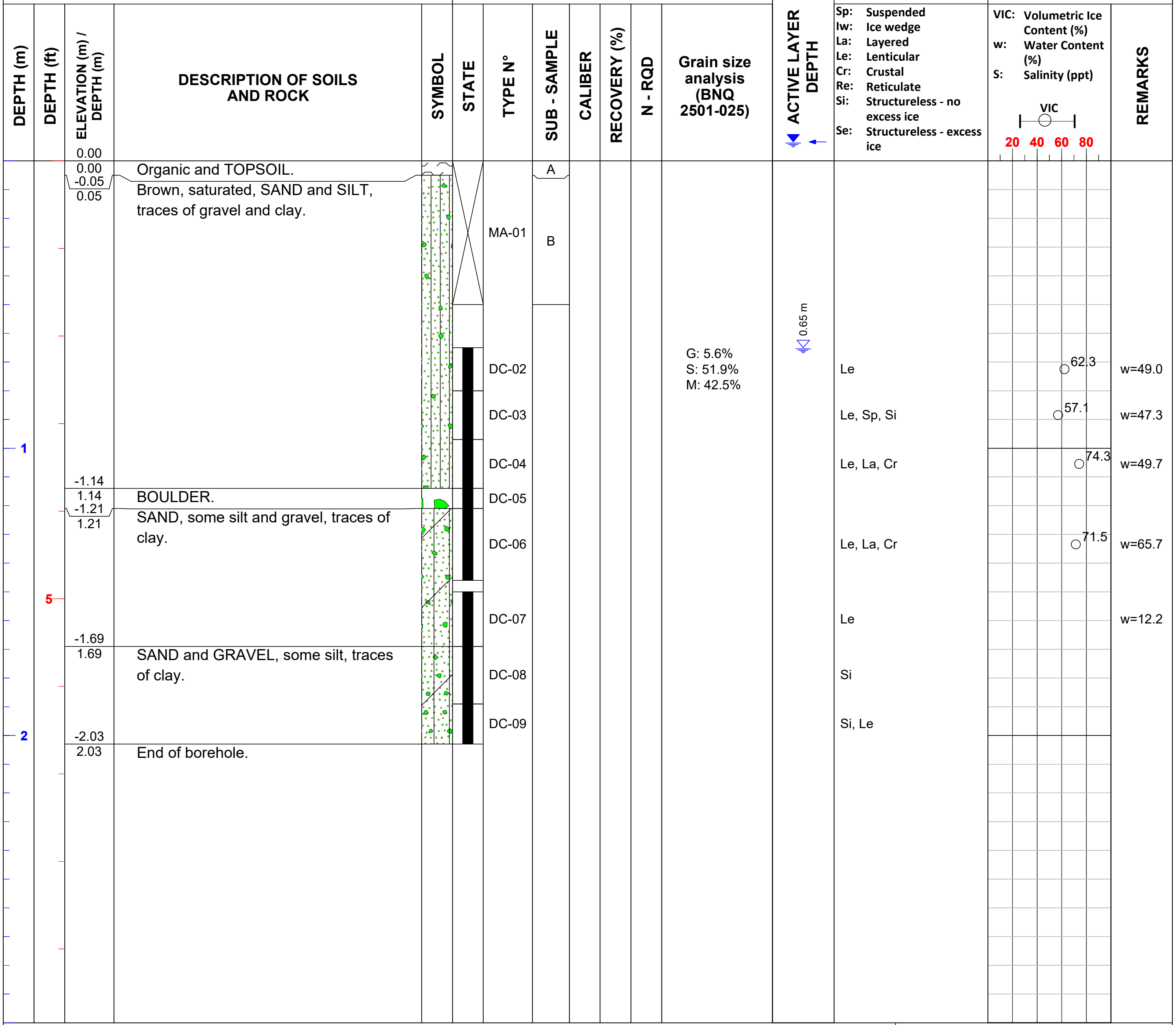
JOINTS SPACING

Very tight	< 20 mm
Tight	20 - 60 mm
Close	60 - 200 mm
Moderately spaced	200 - 600 mm
Spaced	600 - 2000 mm
Very spaced	2000 - 6000 mm
Wide	> 6000 mm

STRATIGRAPHY | SAMPLES | CRYOSTRUCTURES | TESTS

CRYOSTRUCTURES:
- Sp: Suspended
- Iw: Ice wedge
- La: Layered
- Le: Lenticular
- Cr: Crustal
- Re: Reticulate
- Si: Structureless - no excess ice
- Se: Structureless - excess ice

TESTS:
- VIC: Volumetric Ice Content (%)
- w: Water Content (%)
- S: Salinity (ppt)



ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK
0.00 0.00	Organic and TOPSOIL.
-0.05 0.05	Brown, saturated, SAND and SILT, traces of gravel and clay.
-1.14 1.14	BOULDER.
-1.21 1.21	SAND, some silt and gravel, traces of clay.
-1.69 1.69	SAND and GRAVEL, some silt, traces of clay.
-2.03 2.03	End of borehole.

TYPE N°	SUB - SAMPLE	Grain size analysis (BNQ 2501-025)	CRYOSTRUCTURES	VIC	REMARKS
MA-01	A B				
DC-02		G: 5.6% S: 51.9% M: 42.5%	Le	62.3	w=49.0
DC-03			Le, Sp, Si	57.1	w=47.3
DC-04			Le, La, Cr	74.3	w=49.7
DC-05					
DC-06			Le, La, Cr	71.5	w=65.7
DC-07			Le		w=12.2
DC-08			Si		
DC-09			Si, Le		

General remarks: **Location: Bloc 2, Lot 4**

Verified by : **O.Piraux**

Date : **2019-10-24**

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BOREHOLE REPORT

Project:	**Geotechnical Investigation and Drainage Planning**	Location :	**UTM 19**	Borehole :	**BH19-02**
		X :	**514647.35**	Page :	**1 of 1**
Project No.:	**144902893**	Y :	**7819012.63**	Start date :	**2019-09-19**
Client:	**Government of Nunavut**	Type of borehole :	**Borehole**	Inspector :	**M. Verpaelst**
Site:	**Clyde River, Nunavut**	Equipment :	**STIHL FB200**	Depth :	**1.80 m**
Figure:		Casings :		Elevation :	**m**
		Corer :	**Core diameter: 76 mm**		

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
TW	Thin wall sampler
ST	Shelby tube
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remolded (unfrozen sample)
▨	Intact (thin wall sampler)
■	Lost
◧	Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

JOINTS SPACING

Very tight	< 20 mm
Tight	20 - 60 mm
Close	60 - 200 mm
Moderately spaced	200 - 600 mm
Spaced	600 - 2000 mm
Very spaced	2000 - 6000 mm
Wide	> 6000 mm

STRATIGRAPHY

SAMPLES

CRYOSTRUCTURES

Sp: Suspended
Iw: Ice wedge
La: Layered
Le: Lenticular
Cr: Crustal
Re: Reticulate
Si: Structureless - no excess ice
Se: Structureless - excess ice

TESTS

VIC: Volumetric Ice Content (%)
w: Water Content (%)
S: Salinity (ppt)

ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	STATE	TYPE N°	SUB - SAMPLE	CALIBER	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)	ACTIVE LAYER DEPTH	CRYOSTRUCTURES	VIC (20 40 60 80)	REMARKS
0.00 0.00	Brown, humid, gravelly SAND, some silt. - Presence of cobbles and boulders at the surface	☒	MA-01									
-0.60 0.60	- Unfrozen material (may have melted from friction) - Inferred ice-poor permafrost (if present at this depth)	☒	DC-02									
-1.25 1.25		☒	DC-03									
-1.45 1.45	Silty SAND, some gravel, traces of clay.	◧	DC-04					G: 14.2% S: 57.9% M: 28.0%		Le, Cr	44.6	w=50.0
-1.60 1.60	Gravelly SAND, some silt.	◧	DC-05							Le, Cr		
-1.80 1.80	End of borehole.											

General remarks: **Location: Bloc 2, Lot 26**

Verified by : **O.Piraux**

Date : **2019-10-24**

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BOREHOLE REPORT

Project:	**Geotechnical Investigation and Drainage Planning**	Location :	**UTM 19**	Borehole :	**BH19-03**
		X :	**514715.25**	Page :	**1 of 1**
Project No.:	**144902893**	Y :	**7818850.8**	Start date :	**2019-09-13**
Client:	**Government of Nunavut**	Type of borehole :	**Borehole**	Inspector :	**M. Verpaelst**
Site:	**Clyde River, Nunavut**	Equipment :	**Hand-Held Core Drilling Auger**	Depth :	**2.00 m**
Figure:		Casings :		Elevation :	**m**
		Corer :	**Core diameter: 76 mm**		

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
TW	Thin wall sampler
ST	Shelby tube
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1	2019-09-13	0.90 m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded (unfrozen sample)
▨	Intact (thin wall sampler)
■	Lost
◨	Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

JOINTS SPACING

Very tight	< 20 mm
Tight	20 - 60 mm
Close	60 - 200 mm
Moderately spaced	200 - 600 mm
Spaced	600 - 2000 mm
Very spaced	2000 - 6000 mm
Wide	> 6000 mm

STRATIGRAPHY

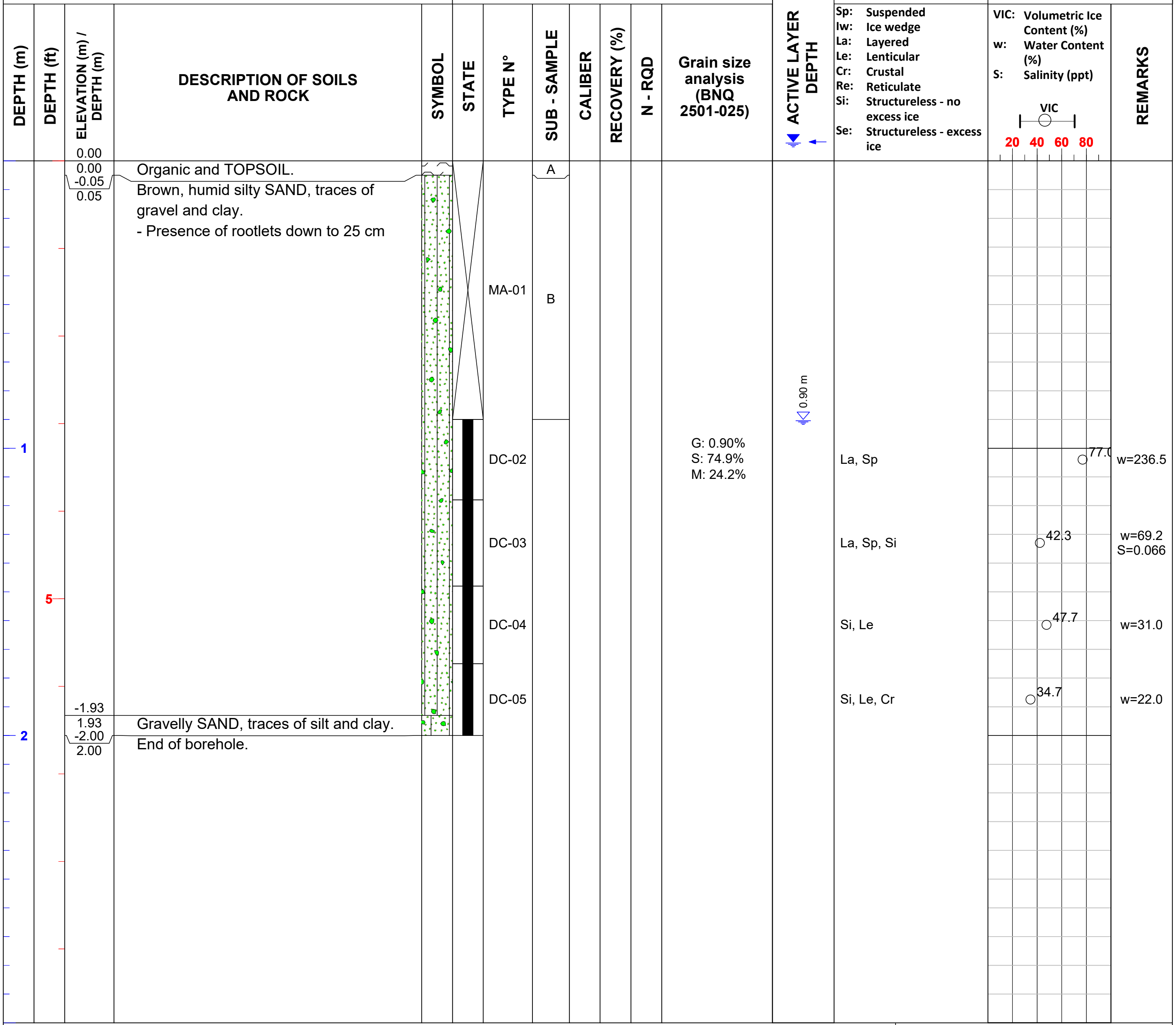
SAMPLES

CRYOSTRUCTURES

Sp:	Suspended
Iw:	Ice wedge
La:	Layered
Le:	Lenticular
Cr:	Crustal
Re:	Reticulate
Si:	Structureless - no excess ice
Se:	Structureless - excess ice

TESTS

VIC:	Volumetric Ice Content (%)
w:	Water Content (%)
S:	Salinity (ppt)



ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	TYPE N°	SUB - SAMPLE	CALIBER	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)	CRYOSTRUCTURES	VIC	REMARKS
0.00 0.00 -0.05 0.05	Organic and TOPSOIL. Brown, humid silty SAND, traces of gravel and clay. - Presence of rootlets down to 25 cm	MA-01	A B							
		DC-02					G: 0.90% S: 74.9% M: 24.2%	La, Sp	77.	w=236.5
		DC-03						La, Sp, Si	42.3	w=69.2 S=0.066
		DC-04						Si, Le	47.7	w=31.0
-1.93 1.93 -2.00 2.00	Gravelly SAND, traces of silt and clay. End of borehole.	DC-05						Si, Le, Cr	34.7	w=22.0

General remarks:

Location: Bloc 2, Lot 35

- Lower slope position, bench-like potentially related to slow mass movement
- Borehole next to apparent ground subsidence
- Signs of thaw degradation (tension cracks and localized ground subsidence)

Verified by : O.Piraux

Date : 2019-10-24

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BOREHOLE REPORT

Project:	**Geotechnical Investigation and Drainage Planning**	Location :	**UTM 19**	Borehole :	**BH19-04**
		X :	**514814.32**	Page :	**1 of 1**
Project No.:	**144902893**	Y :	**7819422.23**	Start date :	**2019-09-13**
Client:	**Government of Nunavut**	Type of borehole :	**Borehole**	Inspector :	**M. Verpaelst**
Site:	**Clyde River, Nunavut**	Equipment :	**STIHL FB200**	Depth :	**0.74 m**
Figure:		Casings :		Elevation :	**m**
		Corer :	**Core diameter: 76 mm**		

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
TW	Thin wall sampler
ST	Shelby tube
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1	2019-09-13	0.20 m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded (unfrozen sample)
▨	Intact (thin wall sampler)
■	Lost
◧	Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

JOINTS SPACING

Very tight	< 20 mm
Tight	20 - 60 mm
Close	60 - 200 mm
Moderately spaced	200 - 600 mm
Spaced	600 - 2000 mm
Very spaced	2000 - 6000 mm
Wide	> 6000 mm

STRATIGRAPHY / SAMPLES / CRYOSTRUCTURES / TESTS

CRYOSTRUCTURES:
Sp: Suspended
Iw: Ice wedge
La: Layered
Le: Lenticular
Cr: Crustal
Re: Reticulate
Si: Structureless - no excess ice
Se: Structureless - excess ice

TESTS:
VIC: Volumetric Ice Content (%)
w: Water Content (%)
S: Salinity (ppt)

DEPTH (m)	DEPTH (ft)	ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	SYMBOL	STATE	TYPE N°	SUB - SAMPLE	CALIBER	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)	ACTIVE LAYER DEPTH	CRYOSTRUCTURES	VIC 20 40 60 80	REMARKS
		0.00													
		0.00 -0.15	Saturated, PEAT.		☒	MA-01	A B					0.20 m			
		0.15 -0.20	Grey, saturated, organic, sandy SILT, traces of clay.		◧	DC-02	A						Le		
		0.20 -0.30	Orange-brown, frozen PEAT.		◧										
		0.30 -0.60	Grey, organic, sandy SILT, some clay, traces of gravel.		◧		B C				G: 5.10% S: 33.4% M: 61.5%		Si Le	39.1	w=60.7
		0.60 -0.74	ICE WEDGE.		◧	DC-03	A B						Le, Cr Iw		
		0.74	End of borehole.												
1															
	5														
2															

General remarks: **Location: Block 4, Lot 29**

Verified by : **O.Piraux**

Date : **2019-10-24**

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BOREHOLE REPORT

Project:	**Geotechnical Investigation and Drainage Planning**	Location :	**UTM 19**	Borehole :	**BH19-05**
		X :	**514814.32**	Page :	**1 of 1**
Project No.:	**144902893**	Y :	**7819422.23**	Start date :	**2019-09-13**
Client:	**Government of Nunavut**	Type of borehole :	**Borehole**	Inspector :	**M. Verpaelst**
Site:	**Clyde River, Nunavut**	Equipment :	**STIHL FB200**	Depth :	**2.50 m**
Figure:		Casings :		Elevation :	**m**
		Corer :	**Core diameter: 76 mm**		

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
TW	Thin wall sampler
ST	Shelby tube
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1	2019-09-13	0.25 m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded (unfrozen sample)
▨	Intact (thin wall sampler)
■	Lost
◧	Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

JOINTS SPACING

Very tight	< 20 mm
Tight	20 - 60 mm
Close	60 - 200 mm
Moderately spaced	200 - 600 mm
Spaced	600 - 2000 mm
Very spaced	2000 - 6000 mm
Wide	> 6000 mm

STRATIGRAPHY

ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK
0.00 0.00	Saturated, PEAT.
-0.25 0.25	Frozen PEAT, traces of sand, silt, and clay.
-0.38 0.38	Dark grey, organic, silty SAND, some gravel, traces of clay.
-0.56 0.56	PEAT, some sand and silt, traces of clay.
-0.70 0.70	Dark grey, sandy GRAVEL, some silt, traces of clay.
-2.50 2.50	End of boehole.

SAMPLES

TYPE N°	SUB - SAMPLE	Grain size analysis (BNQ 2501-025)	CRYOSTRUCTURES	VIC	REMARKS
MA-01					
DC-02	A		Le		
	B		Le		
DC-03	A		Le, Cr		
	B		Le		
DC-04			Le, Sp		
DC-05		G: 63.6% S: 22.2% M: 14.2%	Le, La, Cr	41.8	w=36.4 S=0.027
DC-06			Le, Cr		
DC-07			Le, Cr		
DC-08			Le, Cr		
DC-09	A		Le, Cr		
	B		Sp		
DC-10			Sp		w=216.6

ACTIVE LAYER DEPTH: 0.25 m

CRYOSTRUCTURES

Sp:	Suspended
Iw:	Ice wedge
La:	Layered
Le:	Lenticular
Cr:	Crustal
Re:	Reticulate
Si:	Structureless - no excess ice
Se:	Structureless - excess ice

TESTS

VIC:	Volumetric Ice Content (%)
w:	Water Content (%)
S:	Salinity (ppt)

VIC: 20 40 60 80

General remarks: **Location: Block 4, Lot 29**

Verified by : **O.Piraux**

Date : **2019-10-24**

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BOREHOLE REPORT

Project:	**Geotechnical Investigation and Drainage Planning**	Location :	**UTM 19**	Borehole :	**BH19-06**
		X :	**514830.9**	Page :	**1 of 1**
Project No.:	**144902893**	Y :	**7819322.08**	Start date :	**2019-09-14**
Client:	**Government of Nunavut**	Type of borehole :	**Borehole**	Inspector :	**M. Verpaelst**
Site:	**Clyde River, Nunavut**	Equipment :	**STIHL FB200**	Depth :	**1.90 m**
Figure:		Casings :		Elevation :	**m**
		Corer :	**Core diameter: 76 mm**		

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
TW	Thin wall sampler
ST	Shelby tube
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1	2019-09-14	1.15 m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remodeled (unfrozen sample)
▨	Intact (thin wall sampler)
■	Lost
◧	Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

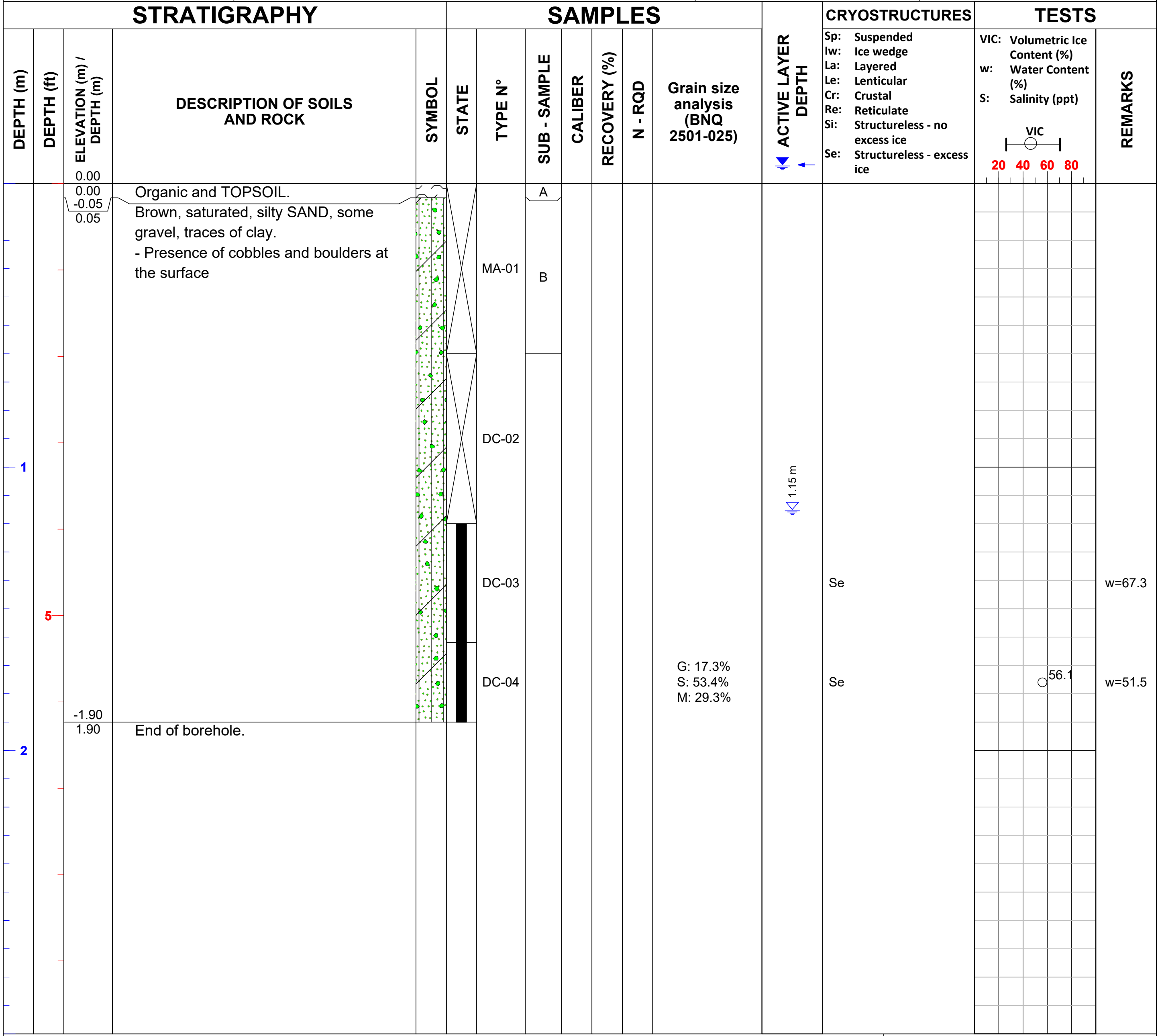
COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

JOINTS SPACING

Very tight	< 20 mm
Tight	20 - 60 mm
Close	60 - 200 mm
Moderately spaced	200 - 600 mm
Spaced	600 - 2000 mm
Very spaced	2000 - 6000 mm
Wide	> 6000 mm



Sp:	Suspended
Iw:	Ice wedge
La:	Layered
Le:	Lenticular
Cr:	Crustal
Re:	Reticulate
Si:	Structureless - no excess ice
Se:	Structureless - excess ice

VIC:	Volumetric Ice Content (%)
w:	Water Content (%)
S:	Salinity (ppt)

ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	TYPE N°	SUB - SAMPLE	Grain size analysis (BNQ 2501-025)	CRYOSTRUCTURES	TESTS	REMARKS
0.00 0.00	Organic and TOPSOIL.		A				
-0.05 0.05	Brown, saturated, silty SAND, some gravel, traces of clay. - Presence of cobbles and boulders at the surface	MA-01	B				
		DC-02					
		DC-03			Se		w=67.3
		DC-04		G: 17.3% S: 53.4% M: 29.3%	Se	56.1	w=51.5
-1.90 1.90	End of borehole.						

General remarks:	**Location: Block 4, Lot 61**	Verified by :	**O.Piraux**
		Date :	**2019-10-24**

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BOREHOLE REPORT

Project:	**Geotechnical Investigation and Drainage Planning**	Location :	**UTM 19**	Borehole :	**BH19-07**
		X :	**514870.22**	Page :	**1 of 1**
Project No.:	**144902893**	Y :	**7819183.82**	Start date :	**2019-09-14**
Client:	**Government of Nunavut**	Type of borehole :	**Borehole**	Inspector :	**M. Verpaelst**
Site:	**Clyde River, Nunavut**	Equipment :	**STIHL FB200**	Depth :	**2.00 m**
Figure:		Casings :		Elevation :	**m**
		Corer :	**Core diameter: 76 mm**		

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
TW	Thin wall sampler
ST	Shelby tube
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remodeled (unfrozen sample)
▨	Intact (thin wall sampler)
■	Lost
◧	Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

JOINTS SPACING

Very tight	< 20 mm
Tight	20 - 60 mm
Close	60 - 200 mm
Moderately spaced	200 - 600 mm
Spaced	600 - 2000 mm
Very spaced	2000 - 6000 mm
Wide	> 6000 mm

STRATIGRAPHY · SAMPLES · CRYOSTRUCTURES · TESTS

CRYOSTRUCTURES

Sp:	Suspended
Iw:	Ice wedge
La:	Layered
Le:	Lenticular
Cr:	Crustal
Re:	Reticulate
Si:	Structureless - no excess ice
Se:	Structureless - excess ice

TESTS

VIC:	Volumetric Ice Content (%)
w:	Water Content (%)
S:	Salinity (ppt)

VIC 20 40 60 80

DEPTH (m)	DEPTH (ft)	ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	STATE	TYPE N°	CRYOSTRUCTURES
		0.00 0.00	Brown, humid, gravelly and silty SAND. - Presence of cobbles and boulders at the surface	☒	MA-01	
				☒	DC-02	
1				☒	DC-03	
		-1.25 1.25	Brown-grey, gravelly SAND, some silt, traces of clay. - Unfrozen material (may have melted from friction) - Inferred ice-poor permafrost (if present at this depth)	☒	DC-04	
	5			☒	DC-05	
		-1.68 1.68	- Limited sample recovery (may have metled from friction)	◧	DC-06	Se
		-1.83 1.83		☒	DC-07	
2		-2.00 2.00	End of borehole.			

General remarks:

Location: Block 4, Lot 20
- Morainal ridge deposit
- Periglacial processes (sorting) observed at the surface

Verified by : **O.Piraux**
Date : **2019-10-24**

BOREHOLE REPORT

Project:	**Geotechnical Investigation and Drainage Planning**	Location :	**UTM 19**	Borehole :	**BH19-08**
		X :	**514644.17**	Page :	**1 of 1**
Project No.:	**144902893**	Y :	**7818824.91**	Start date :	**2019-09-14**
Client:	**Government of Nunavut**	Type of borehole :	**Borehole**	Inspector :	**M. Verpaelst**
Site:	**Clyde River, Nunavut**	Equipment :	**STIHL FB200**	Depth :	**1.40 m**
Figure:		Casings :		Elevation :	**m**
		Corer :	**Core diameter: 76 mm**		

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
TW	Thin wall sampler
ST	Shelby tube
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded (unfrozen sample)
▨	Intact (thin wall sampler)
■	Lost
◧	Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

JOINTS SPACING

Very tight	< 20 mm
Tight	20 - 60 mm
Close	60 - 200 mm
Moderately spaced	200 - 600 mm
Spaced	600 - 2000 mm
Very spaced	2000 - 6000 mm
Wide	> 6000 mm

STRATIGRAPHY

SAMPLES

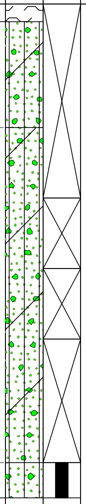
CRYOSTRUCTURES

Sp:	Suspended
Iw:	Ice wedge
La:	Layered
Le:	Lenticular
Cr:	Crustal
Re:	Reticulate
Si:	Structureless - no excess ice
Se:	Structureless - excess ice

TESTS

VIC:	Volumetric Ice Content (%)
w:	Water Content (%)
S:	Salinity (ppt)

VIC 20 40 60 80



DEPTH (m)	DEPTH (ft)	ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	SYMBOL	STATE	TYPE N°	SUB - SAMPLE	CALIBER	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)	ACTIVE LAYER DEPTH	CRYOSTRUCTURES	TESTS	REMARKS
		0.00 0.00	Organic and TOPSOIL.				A								
		-0.05 0.05	Brown, saturated, silty SAND and GRAVEL, traces of clay. - Presence of cobbles and boulders at the surface			MA-01	B								
		-0.35 0.35	- Becoming grey.				C								
						DC-02									
						DC-03									
1						DC-04									
		-1.30 1.30	- Limited sample recovery (may have melted from friction) - Inferred ice-rich			DC-05							Sp		
		-1.40 1.40	End of borehole.												
	5														
2															

General remarks:	**Location: Block 2, Lot 14** **- Lost the borehole**	Verified by :	**O.Piraux**
		Date :	**2019-10-24**

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BOREHOLE REPORT

Project:	**Geotechnical Investigation and Drainage Planning**	Location :	**UTM 19**	Borehole :	**BH19-09**
		X :	**514555.44**	Page :	**1 of 1**
Project No.:	**144902893**	Y :	**7818932.52**	Start date :	**2019-09-15**
Client:	**Government of Nunavut**	Type of borehole :	**Borehole**	Inspector :	**M. Verpaelst**
Site:	**Clyde River, Nunavut**	Equipment :	**STIHL FB200**	Depth :	**1.60 m**
Figure:		Casings :		Elevation :	**m**
		Corer :	**Core diameter: 76 mm**		

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
TW	Thin wall sampler
ST	Shelby tube
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded (unfrozen sample)
▨	Intact (thin wall sampler)
■	Lost
◧	Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

JOINTS SPACING

Very tight	< 20 mm
Tight	20 - 60 mm
Close	60 - 200 mm
Moderately spaced	200 - 600 mm
Spaced	600 - 2000 mm
Very spaced	2000 - 6000 mm
Wide	> 6000 mm

STRATIGRAPHY

SAMPLES

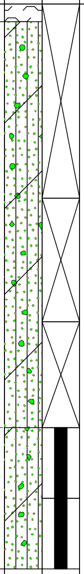
CRYOSTRUCTURES

Sp:	Suspended
Iw:	Ice wedge
La:	Layered
Le:	Lenticular
Cr:	Crustal
Re:	Reticulate
Si:	Structureless - no excess ice
Se:	Structureless - excess ice

TESTS

VIC:	Volumetric Ice Content (%)
w:	Water Content (%)
S:	Salinity (ppt)

VIC 20 40 60 80



DEPTH (m)	DEPTH (ft)	ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	SYMBOL	STATE	TYPE N°	SUB - SAMPLE	CALIBER	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)	ACTIVE LAYER DEPTH	CRYOSTRUCTURES	TESTS	REMARKS
		0.00													
		0.00	TOPSOIL.												
		-0.05 0.05	SILT and SAND, some gravel, traces of clay. - Presence of cobbles and gravel at the surface - Groudwater seepage at 0.30 m			MA-01									
						DC-02									
1						DC-03									
		-1.20 1.20	- Limited sample recovery (may have melted from friction)			DC-04					G: 12.9% S: 39.4% M: 47.7%		Si		w=27.3
	5					DC-05							Se, Le		
		-1.60 1.60	End of borehole.												
2															

General remarks: **Location: Block 2, Lot 9**

Verified by : O.Piraux

Date : 2019-11-04

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BOREHOLE REPORT

Project:	**Geotechnical Investigation and Drainage Planning**	Location :	**UTM 19**	Borehole :	**BH19-10**
		X :	**514690.4**	Page :	**1 of 1**
Project No.:	**144902893**	Y :	**7818966.29**	Start date :	**2019-09-15**
Client:	**Government of Nunavut**	Type of borehole :	**Borehole**	Inspector :	**M. Verpaelst**
Site:	**Clyde River, Nunavut**	Equipment :	**STIHL FB200**	Depth :	**1.00 m**
Figure:		Casings :		Elevation :	**m**
		Corer :	**Core diameter: 76 mm**		

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
TW	Thin wall sampler
ST	Shelby tube
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded (unfrozen sample)
▨	Intact (thin wall sampler)
■	Lost
◧	Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

JOINTS SPACING

Very tight	< 20 mm
Tight	20 - 60 mm
Close	60 - 200 mm
Moderately spaced	200 - 600 mm
Spaced	600 - 2000 mm
Very spaced	2000 - 6000 mm
Wide	> 6000 mm

STRATIGRAPHY

SAMPLES

CRYOSTRUCTURES

Sp:	Suspended
Iw:	Ice wedge
La:	Layered
Le:	Lenticular
Cr:	Crustal
Re:	Reticulate
Si:	Structureless - no excess ice
Se:	Structureless - excess ice

TESTS

VIC:	Volumetric Ice Content (%)
w:	Water Content (%)
S:	Salinity (ppt)

VIC: 20 40 60 80

DEPTH (m)	DEPTH (ft)	ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	SYMBOL	STATE	TYPE N°	SUB - SAMPLE	CALIBER	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)	ACTIVE LAYER DEPTH	CRYOSTRUCTURES	TESTS	REMARKS
		0.00 0.00	Brown, humid, sandy GRAVEL. - Presence of cobbles and boulders at the surface		☒	MA-01									
					☒	DC-02									
					☒	DC-03									
1		-1.00 1.00	End of borehole.												
	5														
2															

General remarks:

Verified by : O.Piraux

Date : 2019-10-24

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BOREHOLE REPORT

Project:	**Geotechnical Investigation and Drainage Planning**	Location :	**UTM 19**	Borehole :	**BH19-11**
		X :	**514775.28**	Page :	**1 of 1**
Project No.:	**144902893**	Y :	**7818848.62**	Start date :	**2019-09-15**
Client:	**Government of Nunavut**	Type of borehole :	**Borehole**	Inspector :	**M. Verpaelst**
Site:	**Clyde River, Nunavut**	Equipment :	**STIHL FB200**	Depth :	**2.13 m**
Figure:		Casings :		Elevation :	**m**
		Corer :	**Core diameter: 76 mm**		

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
TW	Thin wall sampler
ST	Shelby tube
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded (unfrozen sample)
▨	Intact (thin wall sampler)
■	Lost
◧	Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

JOINTS SPACING

Very tight	< 20 mm
Tight	20 - 60 mm
Close	60 - 200 mm
Moderately spaced	200 - 600 mm
Spaced	600 - 2000 mm
Very spaced	2000 - 6000 mm
Wide	> 6000 mm

STRATIGRAPHY · SAMPLES · CRYOSTRUCTURES · TESTS

CRYOSTRUCTURES

Sp:	Suspended
Iw:	Ice wedge
La:	Layered
Le:	Lenticular
Cr:	Crustal
Re:	Reticulate
Si:	Structureless - no excess ice
Se:	Structureless - excess ice

TESTS

VIC:	Volumetric Ice Content (%)
w:	Water Content (%)
S:	Salinity (ppt)

VIC: 20 40 60 80

ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	STATE	TYPE N°	SUB - SAMPLE	Grain size analysis (BNQ 2501-025)	ACTIVE LAYER DEPTH	CRYOSTRUCTURES	VIC	REMARKS
0.00 -0.10 / 0.00	PEAT.	☒	MA-01	A					
0.10	Brown, wet, organic SILT, traces of sand and clay.			B		0.35 m			
		■	DC-02				Le, La	86.6	w=195.4
-0.67 / 0.67	Brown, silty and gravelly SAND, traces of clay.	■	DC-03		G: 31.4% S: 39.3% M: 29.3%		Le, Re, La, Sp	61.7	w=55.4
		■	DC-04				Le, Cr		
		■	DC-05				Le, Cr	24.1	w=14.3
		■	DC-06				Le, Cr, Si	48.5	w=31.2
		■	DC-07				Le, Cr, Si		
-2.13 / 2.13	End of borehole.								

DEPTH (m): 1, 2 — DEPTH (ft): 5

General remarks: **Location: Block 2, adjacent to Lot 19 and R24**

Verified by : **O.Piraux**

Date : **2019-10-24**

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BOREHOLE REPORT

Project:	**Geotechnical Investigation and Drainage Planning**	Location :	**UTM 19**	Borehole :	**BH19-12**
		X :	**514775.28**	Page :	**1 of 1**
Project No.:	**144902893**	Y :	**7818848.62**	Start date :	**2019-09-15**
Client:	**Government of Nunavut**	Type of borehole :	**Borehole**	Inspector :	**M. Verpaelst**
Site:	**Clyde River, Nunavut**	Equipment :	**STIHL FB200**	Depth :	**1.00 m**
Figure:		Casings :		Elevation :	**m**
		Corer :	**Core diameter: 76 mm**		

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
TW	Thin wall sampler
ST	Shelby tube
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1	2019-09-15	0.90 m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded (unfrozen sample)
▨	Intact (thin wall sampler)
■	Lost
◨	Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

JOINTS SPACING

Very tight	< 20 mm
Tight	20 - 60 mm
Close	60 - 200 mm
Moderately spaced	200 - 600 mm
Spaced	600 - 2000 mm
Very spaced	2000 - 6000 mm
Wide	> 6000 mm

STRATIGRAPHY

SAMPLES

CRYOSTRUCTURES

Sp: Suspended
Iw: Ice wedge
La: Layered
Le: Lenticular
Cr: Crustal
Re: Reticulate
Si: Structureless - no excess ice
Se: Structureless - excess ice

TESTS

VIC: Volumetric Ice Content (%)
w: Water Content (%)
S: Salinity (ppt)

VIC
20 40 60 80

DEPTH (m)	DEPTH (ft)	ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	SYMBOL	STATE	TYPE N°	SUB - SAMPLE	CALIBER	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)	ACTIVE LAYER DEPTH	CRYOSTRUCTURES	TESTS	REMARKS
		0.00 0.00	PEAT.		☒	MA-01	A								
		-0.10 0.10	Grey, saturated, gravelly and sandy SILT, traces of clay. - Seepage at 0.10 m		☒		B								
		-0.30 0.30	Grey, sandy SILT, some gravel, traces of clay.		☒	DC-02									
					☒	DC-03									
		-0.90 0.90	- Limited sample recovery (may have melted from friction) - Ice-rich permafrost		◨	DC-04						0.90 m	Sp		
1		-1.00 1.00	End of borehole due to excess water and mud in borehole.												
	5														
2															

General remarks:	**Location: Block 2, R26, within water flow path**	Verified by :	O.Piraux
		Date :	2019-10-24

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BOREHOLE REPORT

Project:	**Geotechnical Investigation and Drainage Planning**	Location :	**UTM 19**	Borehole :	**BH19-13**
		X :	**514681.44**	Page :	**1 of 1**
Project No.:	**144902893**	Y :	**7819076.31**	Start date :	**2019-09-15**
Client:	**Government of Nunavut**	Type of borehole :	**Borehole**	Inspector :	**M. Verpaelst**
Site:	**Clyde River, Nunavut**	Equipment :	**STIHL FB200**	Depth :	**2.64 m**
Figure:		Casings :		Elevation :	**m**
		Corer :	**Core diameter: 76 mm**		

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
TW	Thin wall sampler
ST	Shelby tube
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1	2019-09-15	0.50 m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remodeled (unfrozen sample)
▨	Intact (thin wall sampler)
■	Lost
◧	Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

JOINTS SPACING

Very tight	< 20 mm
Tight	20 - 60 mm
Close	60 - 200 mm
Moderately spaced	200 - 600 mm
Spaced	600 - 2000 mm
Very spaced	2000 - 6000 mm
Wide	> 6000 mm

STRATIGRAPHY · SAMPLES · CRYOSTRUCTURES · TESTS

CRYOSTRUCTURES

Sp:	Suspended
Iw:	Ice wedge
La:	Layered
Le:	Lenticular
Cr:	Crustal
Re:	Reticulate
Si:	Structureless - no excess ice
Se:	Structureless - excess ice

TESTS

VIC:	Volumetric Ice Content (%)
w:	Water Content (%)
S:	Salinity (ppt)

VIC 20 40 60 80

ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	STATE	TYPE N°	SUB - SAMPLE	Grain size analysis (BNQ 2501-025)	ACTIVE LAYER DEPTH	CRYOSTRUCTURES	VIC	REMARKS
0.00 / 0.00	PEAT.	☒	MA-01	A					
-0.10 / 0.10	Brown to grey, wet, gravelly and sandy SILT, traces of clay.	☒		B					
-0.50 / 0.50	Grey, SAND and SILT, some gravel, traces of clay.	■	DC-02			0.50 m	Si, Le		
		■	DC-03				Le, Cr		
		■	DC-04		G: 12.2% S: 46.5% M: 41.3%		Le, La	70.1	w=92.8
		■	DC-05				Le, La, Cr		
-1.38 / 1.38	Boulder, GNEISS.	■	DC-06	A			La		
				B					
-1.52 / 1.52	Grey SAND and SILT, some gravel, traces of clay.	■	DC-07				Le, La	67.3	w=55.5
		■	DC-08	A			Le, La		
-1.79 / 1.79	COBBLES.			B					
-1.95 / 1.95	Grey SAND and SILT, some gravel, traces of clay.	■	DC-09				La, Sp, Le		
-2.25 / 2.25	Sandy SILT and GRAVEL, traces of clay.	■	DC-10				Sp		
		■	DC-11				La, Le	45.7	w=50.0
-2.64 / 2.64	End of borehole.								

DEPTH (m): 1, 2 — DEPTH (ft): 5

General remarks:	**Location: Block 2, East of R26**	Verified by :	**O.Piraux**
		Date :	**2019-10-24**

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BOREHOLE REPORT

Project: **Geotechnical Investigation and Drainage Planning**

Project No.: **144902893**
Client: **Government of Nunavut**
Site: **Clyde River, Nunavut**
Figure:

Location : **UTM 19**
X : **514759.87**
Y : **7818814.28**
Type of borehole : **Borehole**
Equipment : **Air Track Drill**
Casings :
Corer : **Core diameter: 165 mm**

Borehole : **BH19-14**
Page : **1 of 1**
Start date : **2019-09-17**
Inspector : **M. Verpaelst**
Depth : **10.00 m**
Elevation : **m**

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
TW	Thin wall sampler
ST	Shelby tube
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remodeled (unfrozen sample)
▨	Intact (thin wall sampler)
■	Lost
◧	Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

JOINTS SPACING

Very tight	< 20 mm
Tight	20 - 60 mm
Close	60 - 200 mm
Moderately spaced	200 - 600 mm
Spaced	600 - 2000 mm
Very spaced	2000 - 6000 mm
Wide	> 6000 mm

STRATIGRAPHY

SAMPLES

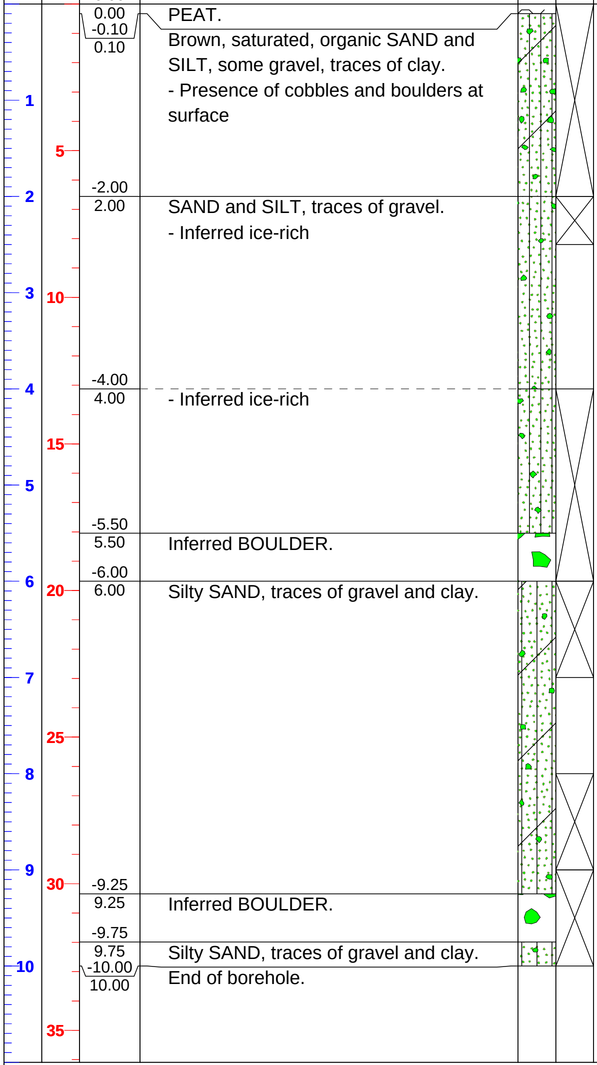
CRYOSTRUCTURES

Sp: Suspended
Iw: Ice wedge
La: Layered
Le: Lenticular
Cr: Crustal
Re: Reticulate
Si: Structureless - no excess ice
Se: Structureless - excess ice

TESTS

VIC: Volumetric Ice Content (%)
w: Water Content (%)
S: Salinity (ppt)

VIC 20 40 60 80



ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	TYPE N°	SUB - SAMPLE	CALIBER	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)	ACTIVE LAYER DEPTH	CRYOSTRUCTURES	TESTS	REMARKS
0.00 0.00	PEAT.										
-0.10 0.10	Brown, saturated, organic SAND and SILT, some gravel, traces of clay. - Presence of cobbles and boulders at surface	AT-01									
-2.00 2.00	SAND and SILT, traces of gravel. - Inferred ice-rich	AT-02					G: 3.40% S: 53.1% M: 43.5%				w=78.4
-4.00 4.00	- Inferred ice-rich	AT-03	A								w=72.4
-5.50 5.50	Inferred BOULDER.		B								
-6.00 6.00	Silty SAND, traces of gravel and clay.	AT-04					G: 4.70% S: 57.6% M: 37.6%				w=29.8
		AT-05									w=13.2
-9.25 9.25	Inferred BOULDER.	AT-06									w=14.1
-9.75 9.75	Silty SAND, traces of gravel and clay.										
-10.00 10.00	End of borehole.										

General remarks: **Location: Block 2, Lot 19**

Verified by : **O.Piraux**

Date : **2019-11-04**

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BOREHOLE REPORT

Project:	**Geotechnical Investigation and Drainage Planning**	Location :	**UTM 19**	Borehole :	**BH19-15**
		X :	**514685.48**	Page :	**1 of 1**
Project No.:	**144902893**	Y :	**7819068.75**	Start date :	**2019-09-18**
Client:	**Government of Nunavut**	Type of borehole :	**Borehole**	Inspector :	**M. Verpaelst**
Site:	**Clyde River, Nunavut**	Equipment :	**Air Track Drill**	Depth :	**10.00 m**
Figure:		Casings :		Elevation :	**m**
		Corer :	**Core diameter: 165 mm**		

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
TW	Thin wall sampler
ST	Shelby tube
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded (unfrozen sample)
▨	Intact (thin wall sampler)
■	Lost
◧	Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

JOINTS SPACING

Very tight	< 20 mm
Tight	20 - 60 mm
Close	60 - 200 mm
Moderately spaced	200 - 600 mm
Spaced	600 - 2000 mm
Very spaced	2000 - 6000 mm
Wide	> 6000 mm

STRATIGRAPHY / SAMPLES / CRYOSTRUCTURES / TESTS

CRYOSTRUCTURES

Sp:	Suspended
Iw:	Ice wedge
La:	Layered
Le:	Lenticular
Cr:	Crustal
Re:	Reticulate
Si:	Structureless - no excess ice
Se:	Structureless - excess ice

TESTS

VIC:	Volumetric Ice Content (%)
w:	Water Content (%)
S:	Salinity (ppt)

VIC: 20 40 60 80

DEPTH (m)	DEPTH (ft)	ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	STATE	TYPE N°	SUB - SAMPLE	CALIBER	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)	ACTIVE LAYER DEPTH	CRYOSTRUCTURES	TESTS	REMARKS
		0.00 0.00	PEAT.	☒	MA-01	A								
		-0.10 0.10	Brown to grey, wet, gravelly and sandy SILT. - Presence of cobbles and boudlers at the surface			B								
1														
	5	-1.50 1.50	SAND and SILT, some gravel, traces of clay. - Inferred ice-rich	☒	AT-02					G: 7.1% S: 50.1% M: 42.8%				w=83.3
2														
3	10			☒	AT-03									w=76.4
4														
5	15			☒	AT-04					G: 1.40% S: 41.7% M: 57.0%				w=31.0
6	20													
7		-7.00 7.00	- Inferred ice-poor	☒	AT-05									w=9.3
8	25													
9	30	-9.00 9.00		☒	AT-06									w=11.8
10		-10.00 10.00	End of borehole.											
	35													

General remarks: **Location: Block 2, East of R26**

Verified by : O.Piraux

Date : 2019-10-24

BOREHOLE REPORT

Project: **Geotechnical Investigation and Drainage Planning**
Project No.: **144902893**
Client: **Government of Nunavut**
Site: **Clyde River, Nunavut**
Figure:

Location : **UTM 19**
X : **514699.1**
Y : **7819356.02**
Type of borehole : **Borehole**
Equipment : **Air Track Drill**
Casings :
Corer : **Core diameter: 165 mm**

Borehole : **BH19-16**
Page : **1 of 1**
Start date : **2019-09-18**
Inspector : **M. Verpaelst**
Depth : **10.00 m**
Elevation : **m**

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
TW	Thin wall sampler
ST	Shelby tube
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remodeled (unfrozen sample)
▨	Intact (thin wall sampler)
■	Lost
◧	Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"
Very loose	0 - 4
Loose	4 - 10
Compact	10 - 30
Dense	30 - 50
Very dense	> 50

CONSISTENCY	Cu OR Su (kPa)
Very soft	< 12
Soft	12 - 25
Firm	25 - 50
Stiff	50 - 100
Very stiff	100 - 200
Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

JOINTS SPACING

Very tight	< 20 mm
Tight	20 - 60 mm
Close	60 - 200 mm
Moderately spaced	200 - 600 mm
Spaced	600 - 2000 mm
Very spaced	2000 - 6000 mm
Wide	> 6000 mm

STRATIGRAPHY

ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK
0.00 0.00	TOPSOIL.
-0.05 0.05	Brown, humid, sandy SILT, some gravel, traces of clay. - Presence of cobbles and boulders at the surface
-1.00 1.00	Silty SAND, some gravel, traces of clay. - Inferred ice-rich
-5.00 5.00	Dark grey, sandy SILT, traces of gravel and clay.
-7.00 7.00	Grey, SILT and SAND, traces of gravel and clay.
-10.00 10.00	End of borehole.

SAMPLES

TYPE N°	Grain size analysis (BNQ 2501-025)	REMARKS
MA-01		
AT-02	G: 16.5% S: 51.5% M: 32.0%	w=41.2
AT-03		w=150.7
AT-04		w=29.3
AT-05		w=24.1
AT-06	G: 0.20% S: 42.3% M: 57.5%	w=13.2

CRYOSTRUCTURES

Sp: Suspended
Iw: Ice wedge
La: Layered
Le: Lenticular
Cr: Crustal
Re: Reticulate
Si: Structureless - no excess ice
Se: Structureless - excess ice

TESTS

VIC: Volumetric Ice Content (%)
w: Water Content (%)
S: Salinity (ppt)

VIC
20 40 60 80

General remarks: **Location: Block 4, Lot 24**

Verified by : **O.Piraux**
Date : **2019-11-04**

Stantec

BOREHOLE REPORT

Project:	**Geotechnical Investigation and Drainage Planning**	Location :	**UTM 19**	Borehole :	**BH19-17**
		X :	**514801.85**	Page :	**1 of 1**
Project No.:	**144902893**	Y :	**7819160.73**	Start date :	**2019-09-18**
Client:	**Government of Nunavut**	Type of borehole :	**Borehole**	Inspector :	**M. Verpaelst**
Site:	**Clyde River, Nunavut**	Equipment :	**Air Track Drill**	Depth :	**10.00 m**
Figure:		Casings :		Elevation :	**m**
		Corer :	**Core diameter: 165 mm**		

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
TW	Thin wall sampler
ST	Shelby tube
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remodeled (unfrozen sample)
▨	Intact (thin wall sampler)
■	Lost
◧	Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

JOINTS SPACING

Very tight	< 20 mm
Tight	20 - 60 mm
Close	60 - 200 mm
Moderately spaced	200 - 600 mm
Spaced	600 - 2000 mm
Very spaced	2000 - 6000 mm
Wide	> 6000 mm

STRATIGRAPHY

SAMPLES

CRYOSTRUCTURES

Sp:	Suspended
Iw:	Ice wedge
La:	Layered
Le:	Lenticular
Cr:	Crustal
Re:	Reticulate
Si:	Structureless - no excess ice
Se:	Structureless - excess ice

TESTS

VIC:	Volumetric Ice Content (%)
w:	Water Content (%)
S:	Salinity (ppt)

VIC

20 40 60 80

DEPTH (m)	DEPTH (ft)	ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK
		0.00	
		0.00 -0.05 0.05	TOPSOIL. Brown, humid SAND, some silt, traces of gravel and clay. - Presence of cobbles and boulders at the surface
1		-1.00 1.00	Grey, silty SAND and GRAVEL, traces of clay. - Inferred ice-rich
	5		
2			
3	10		
4			
	15		
5			
6	20	-6.50 6.50	Inferred BOULDER.
7		-7.00 7.00	Silty SAND, traces of gravel and clay.
	25		
8			
9	30		
10		-10.00 10.00	End of borehole.
	35		

STATE	TYPE N°	SUB - SAMPLE	CALIBER	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)	ACTIVE LAYER DEPTH	CRYOSTRUCTURES	TESTS	REMARKS
☒	MA-01									
☒	AT-02					G: 37.6% S: 39.6% M: 22.8%				w=30.1
☒	AT-03									w=28.5
☒	AT-04									w=29.4
☒	AT-05	A B				G: 3.70% S: 69.6% M: 26.7%				w=10.7
☒	AT-06									w=15.0

General remarks:	**Location: Block 4, Lot 14**	Verified by :	O.Piraux
		Date :	2019-11-04

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Stantec

BOREHOLE REPORT

Project: **Geotechnical Investigation and Drainage Planning**
Project No.: **144902893**
Client: **Government of Nunavut**
Site: **Clyde River, Nunavut**
Figure:

Location : **UTM 19**
X : **514969.77**
Y : **7819137.64**
Type of borehole : **Borehole**
Equipment : **Air Track Drill**
Casings :
Corer : **Core diameter: 165 mm**

Borehole : **BH19-18**
Page : **1 of 1**
Start date : **2019-09-18**
Inspector : **M. Verpaelst**
Depth : **10.00 m**
Elevation : **m**

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
TW	Thin wall sampler
ST	Shelby tube
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remodeled (unfrozen sample)
▨	Intact (thin wall sampler)
■	Lost
◧	Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

JOINTS SPACING

Very tight	< 20 mm
Tight	20 - 60 mm
Close	60 - 200 mm
Moderately spaced	200 - 600 mm
Spaced	600 - 2000 mm
Very spaced	2000 - 6000 mm
Wide	> 6000 mm

STRATIGRAPHY

SAMPLES

CRYOSTRUCTURES

Sp: Suspended
Iw: Ice wedge
La: Layered
Le: Lenticular
Cr: Crustal
Re: Reticulate
Si: Structureless - no excess ice
Se: Structureless - excess ice

TESTS

VIC: Volumetric Ice Content (%)
w: Water Content (%)
S: Salinity (ppt)

VIC 20 40 60 80

DEPTH (m)	DEPTH (ft)	ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	SYMBOL	STATE	TYPE N°	SUB - SAMPLE	CALIBER	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)	ACTIVE LAYER DEPTH	CRYOSTRUCTURES	TESTS	REMARKS
		0.00 0.00	FILL.		☒	MA-01									
		-0.50 0.50	Grey, SILT and SAND, traces of gravel and clay. - Inferred ice-poor		☒	AT-02					G: 0.10% S: 46.4% M: 53.5%				w=24.6
1															
	5														
2															
3	10	-3.00 3.00	Grey SAND, some silt, traces of gravel.		☒	AT-03									w=17.1
4															
	15														
5		-5.00 5.00	Grey, silty SAND, traces of gravel and clay.		☒	AT-04					G: 3.40% S: 62.7% M: 33.9%				w=6.4
6	20														
7					☒	AT-05									w=5.9
	25														
8															
		-8.50 8.50	Inferred BOULDER.		☒	AT-06	A								
9	30						B C								
		-9.75 9.75	Grey, silty SAND, traces of gravel and clay.				D								
10		-10.00 10.00	End of borehole.												
	35														

General remarks: **Location: Block 4, R28**

Verified by : O.Piraux
Date : 2019-10-24

APPENDIX F

Laboratory Analysis

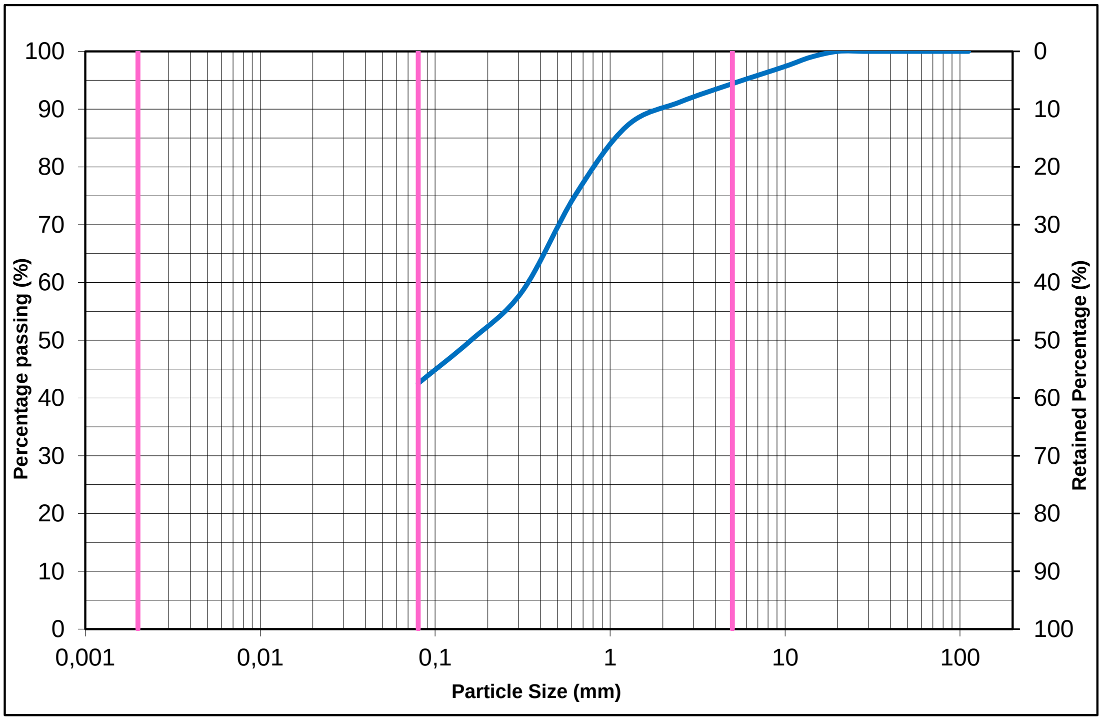
Stantec
2273 Michelin Street,
Laval QC, H7L 5B8

LABORATORY TESTING REPORT

Client :	Government of Nunavut	Sampled by :	MV / OP
Project :	Drainage and Geotechnical assessment Clyde River, NU	Sampling Date :	September 12, 2019
Project No :	144902893.200.205		
Sample No :	BH19-01 DC-02	Material Description :	Sand and fine particles, traces of Gravel
Depth :	0,65 - 0,80m		

Grain Size Analysis (BNQ 2501-025)

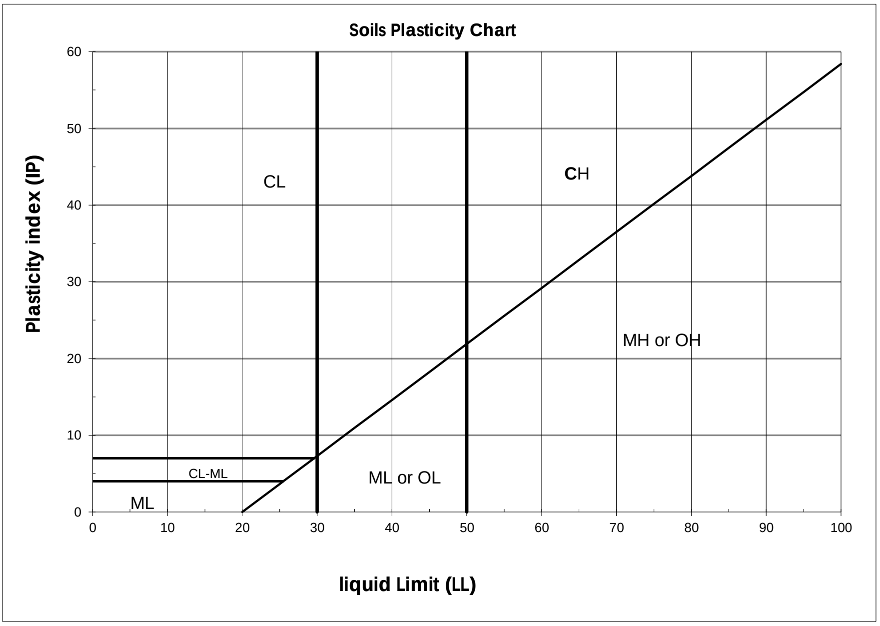
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	100
14,0	99
10,0	97
5,00	94
2,50	91
1,25	87
0,630	75
0,315	58
0,160	50
0,080	42,5



% Gravel : 5,6 % Sand : 51,9 % Fine Particles : 42,5

Other tests

Test / Standard	Results
Water Content (NQ 2560-200) (%)	49,0
VIC (%)	62,3



Remarks :

Prepared by : Benoit Cyr, B. Sc. Geology. **Date :** October 16, 2019

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Laval QC, H7L 5B8

LABORATORY TESTING REPORT

Client : Government of Nunavut

Project : Drainage and Geotechnical assessment
Clyde River, NU

Project No : 144902893.200.205

Sample No : BH19-02 DC-04

Depth : 1,45 - 1,60m

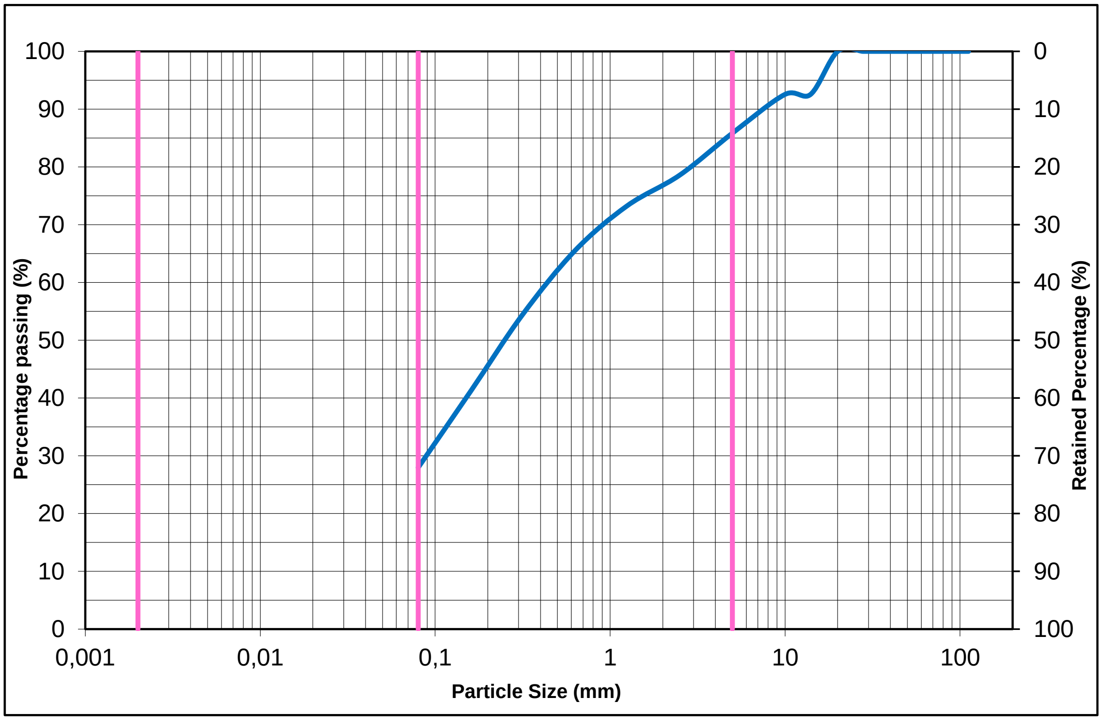
Sampled by : MV / OP

Sampling Date : September 12, 2019

Material Description : Silty Sand, some Gravel

Grain Size Analysis (BNQ 2501-025)

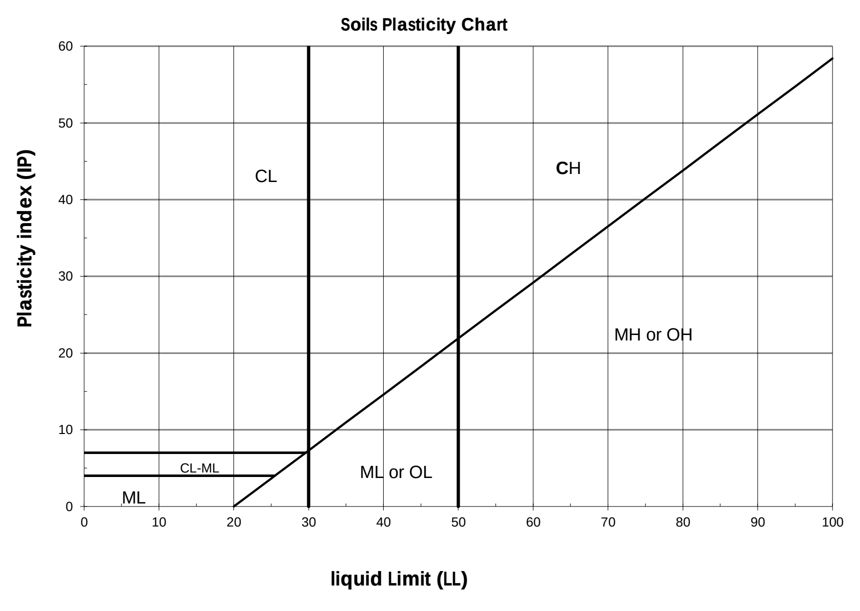
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	100
14,0	93
10,0	93
5,00	86
2,50	79
1,25	73
0,630	66
0,315	54
0,160	41
0,080	28,0



% Gravel : 14,2 % Sand : 57,9 % Fine Particles : 28,0

Other tests

Test / Standard	Results
Water Content (NQ 2560-200) (%)	50,0
VIC (%)	44,6



Remarks :

Prepared by : Benoit Cyr, B. Sc. Geology.

Date : October 16, 2019

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Laval QC, H7L 5B8

LABORATORY TESTING REPORT

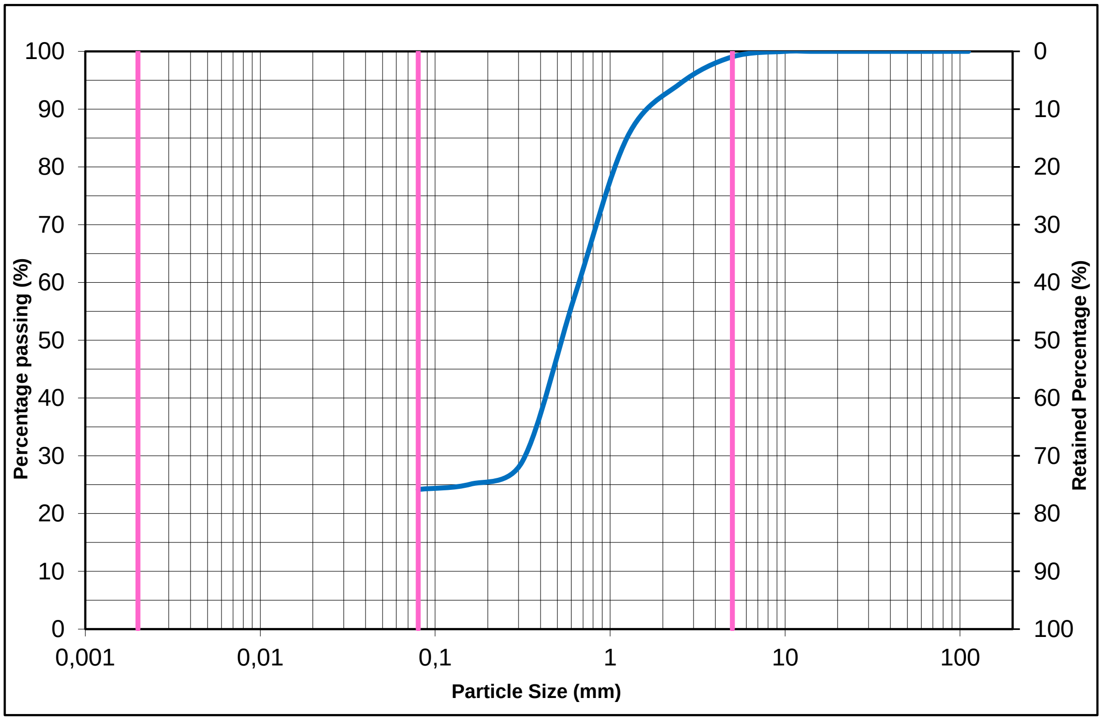
Client : Government of Nunavut
Project : Drainage and Geotechnical assessment
Clyde River, NU
Project No : 144902893.200.205
Sample No : BH19-03 DC-02
Depth : 0,90 - 1,18m

Sampled by : MV / OP
Sampling Date : September 13, 2019

Material Description : Silty Sand, traces of Gravel

Grain Size Analysis (BNQ 2501-025)

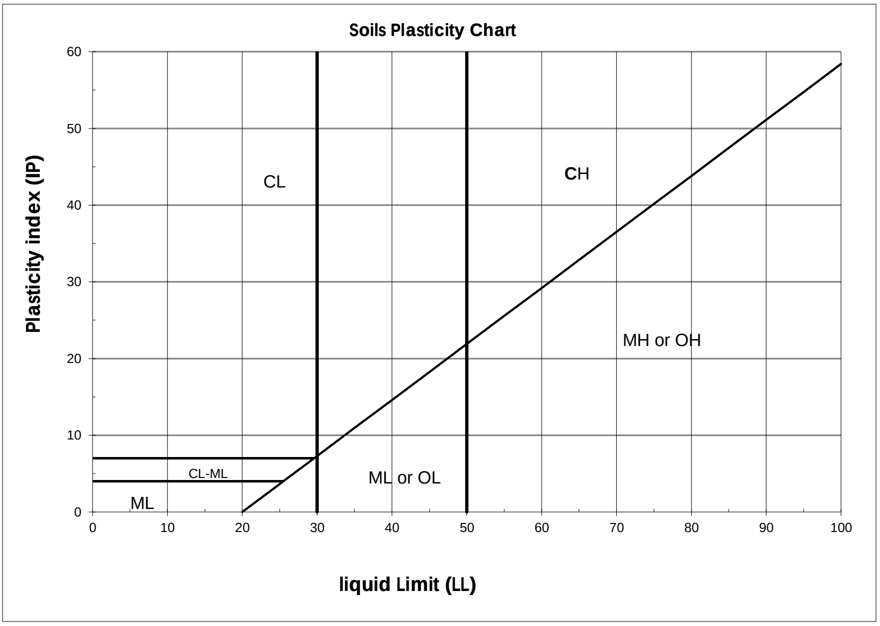
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	100
14,0	100
10,0	100
5,00	99
2,50	94
1,25	85
0,630	58
0,315	29
0,160	25
0,080	24,2



% Gravel : 0,9 % Sand : 74,9 % Fine Particles : 24,2

Other tests

Test / Standard	Results
Water Content (NQ 2560-200) (%)	236,5
VIC (%)	77,0



Remarks :

Prepared by : Benoit Cyr, B. Sc. Geology.

Date : October 16, 2019

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Laval QC, H7L 5B8

LABORATORY TESTING REPORT

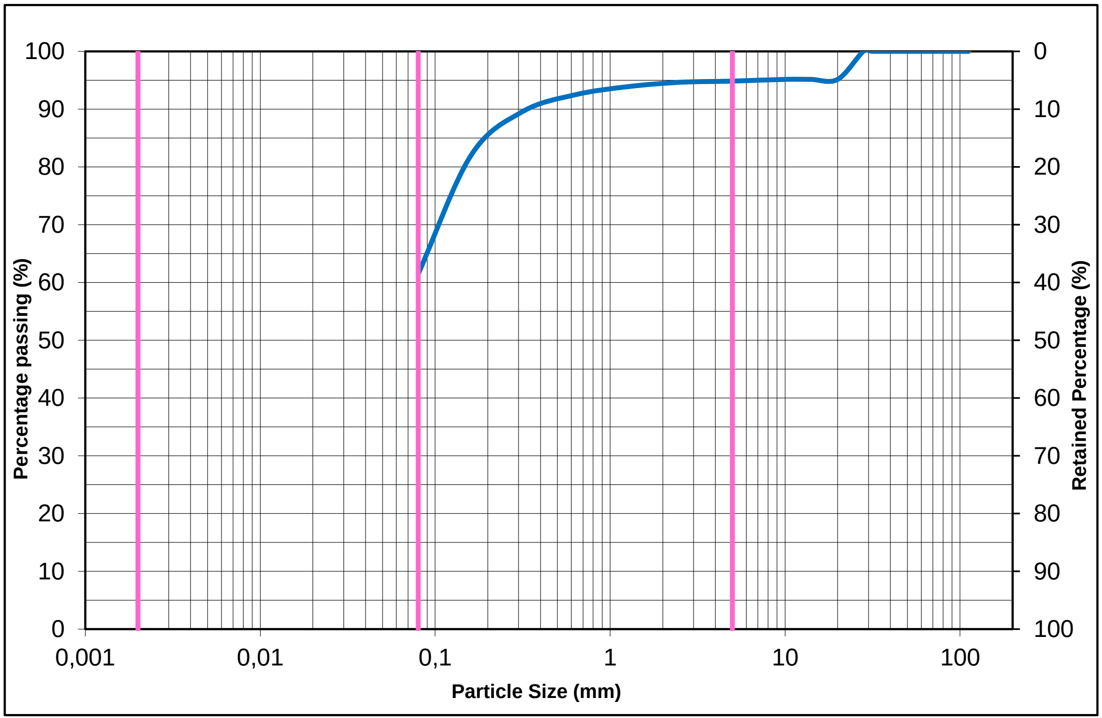
Client : Government of Nunavut
Project : Drainage and Geotechnical assessment
Clyde River, NU
Project No : 144902893.200.205
Sample No : BH19-04 DC-02
Depth : 0,43 - 0,52m

Sampled by : MV / OP
Sampling Date : September 13, 2019

Material Description : Sandy fine particles, traces of Gravel

Grain Size Analysis (BNQ 2501-025)

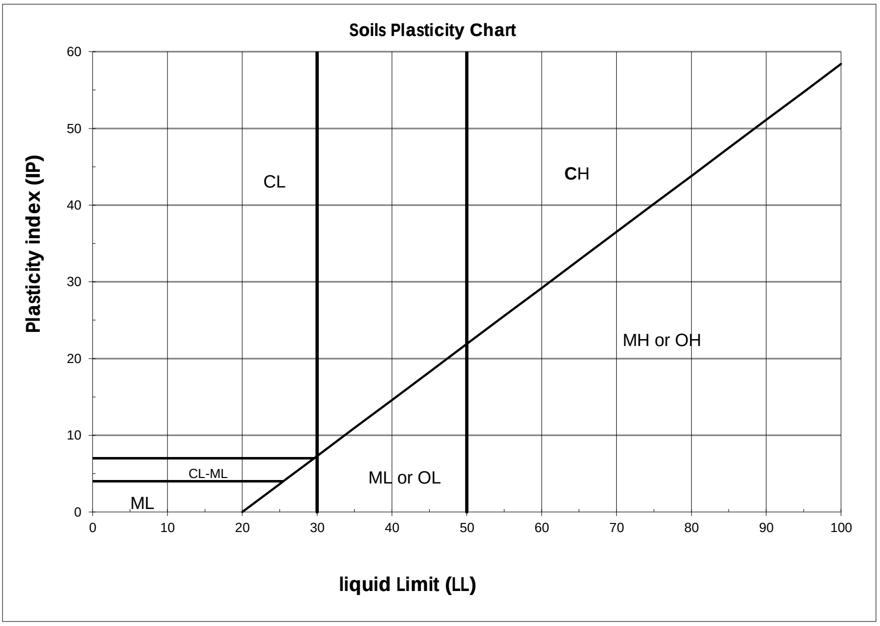
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	95
14,0	95
10,0	95
5,00	95
2,50	95
1,25	94
0,630	92
0,315	90
0,160	82
0,080	61,5



% Gravel : 5,1 % Sand : 33,4 % Fine Particles : 61,5

Other tests

Test / Standard	Results
Water Content (NQ 2560-200) (%)	60,7
VIC (%)	39,1



Remarks :

Prepared by : Benoit Cyr, B. Sc. Geology. **Date :** October 16, 2019

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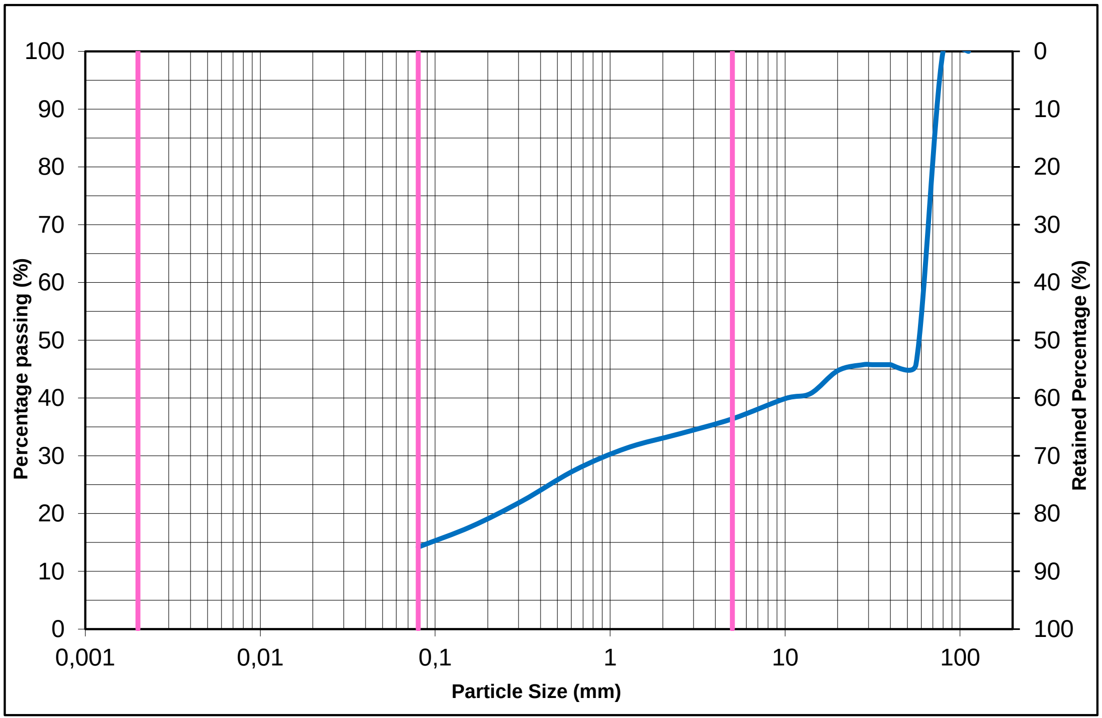
LABORATORY TESTING REPORT

Client :	Government of Nunavut	Sampled by :	MV / OP
Project :	Drainage and Geotechnical assessment Clyde River, NU	Sampling Date :	September 13, 2019
Project No :	144902893.200.205		
Sample No :	BH19-05 DC-05	Material Description :	Sandy Gravel, some fine particles
Depth :	0,88 - 1,18m		

Grain Size Analysis (BNQ 2501-025)

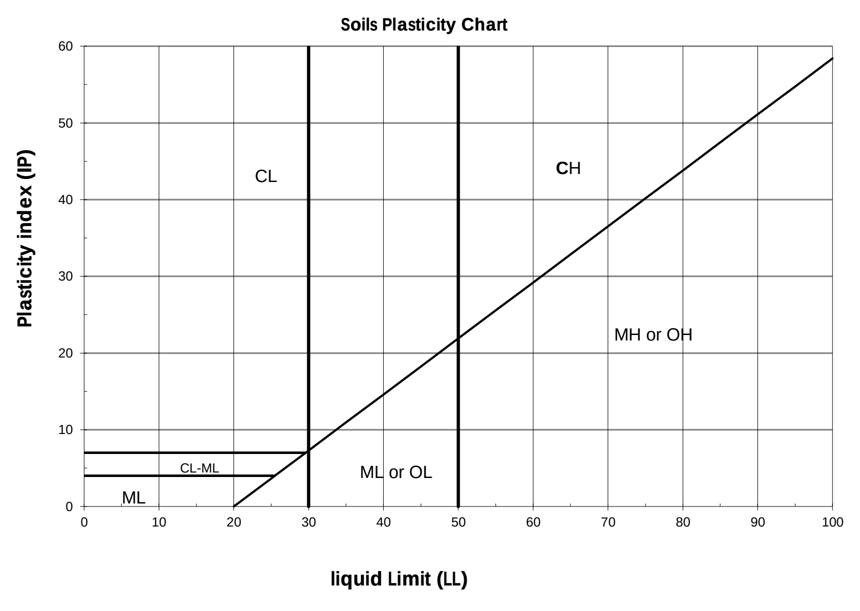
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	46
40,0	46
31,5	46
28,0	46
20,0	45
14,0	41
10,0	40
5,00	36
2,50	34
1,25	31
0,630	28
0,315	22
0,160	18
0,080	14,2



% Gravel : 63,6 % Sand : 22,2 % Fine Particles : 14,2

Other tests

Test / Standard	Results
Water Content (NQ 2560-200) (%)	36,4
VIC (%)	41,8



Remarks :

Prepared by : Benoit C..., B. Sc. Geology.

Date : October 16, 2019

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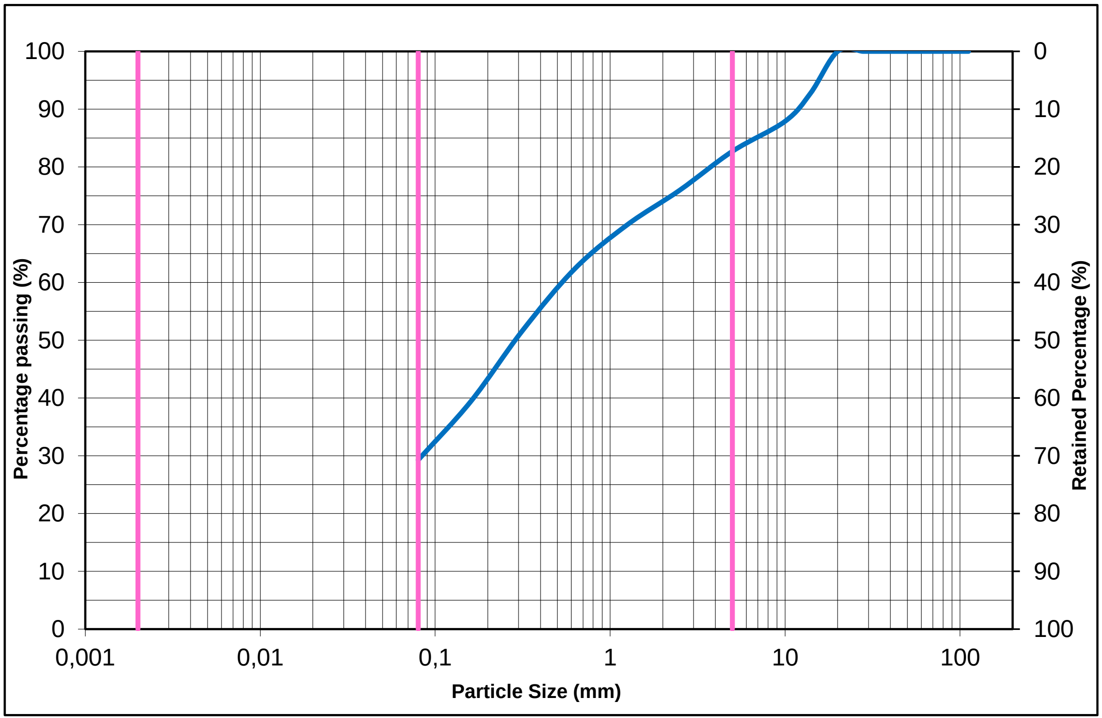
Laval QC, H7L 5B8

LABORATORY TESTING REPORT

Client :	Government of Nunavut	Sampled by :	MV / OP
Project :	Drainage and Geotechnical assessment Clyde River, NU	Sampling Date :	September 14, 2019
Project No :	144902893.200.205		
Sample No :	BH19-06 DC-04	Material Description :	Silty Sand, some Gravel
Depth :	1,79 - 1,90m		

Grain Size Analysis (BNQ 2501-025)

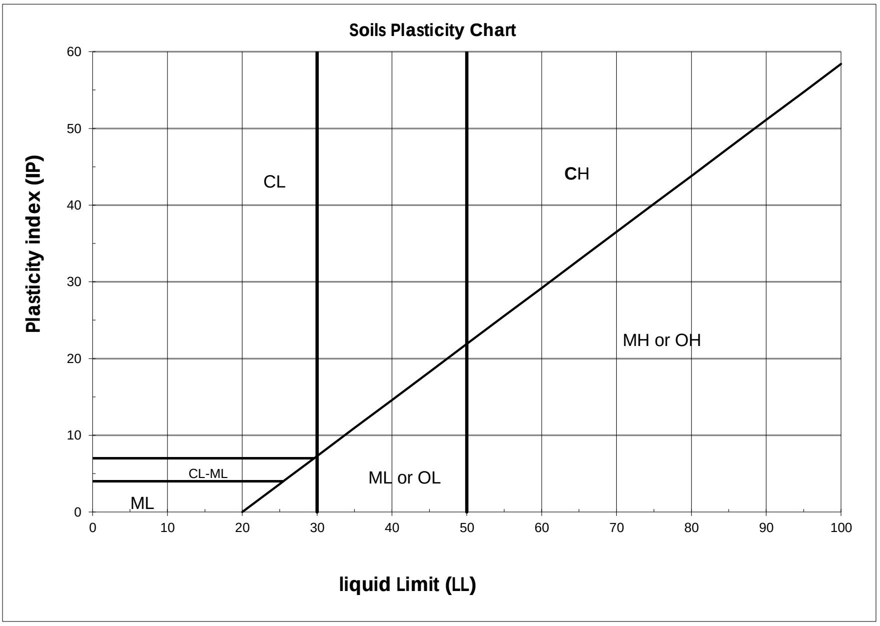
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	100
14,0	93
10,0	88
5,00	83
2,50	76
1,25	70
0,630	62
0,315	52
0,160	39
0,080	29,3



% Gravel : 17,3 % Sand : 53,4 % Fine Particles : 29,3

Other tests

Test / Standard	Results
Water Content (NQ 2560-200) (%)	51,5
VIC (%)	56,1



Remarks :

Prepared by : Benoit Cyr, B. Sc. Geology.

Date : October 16, 2019

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Laval QC, H7L 5B8

LABORATORY TESTING REPORT

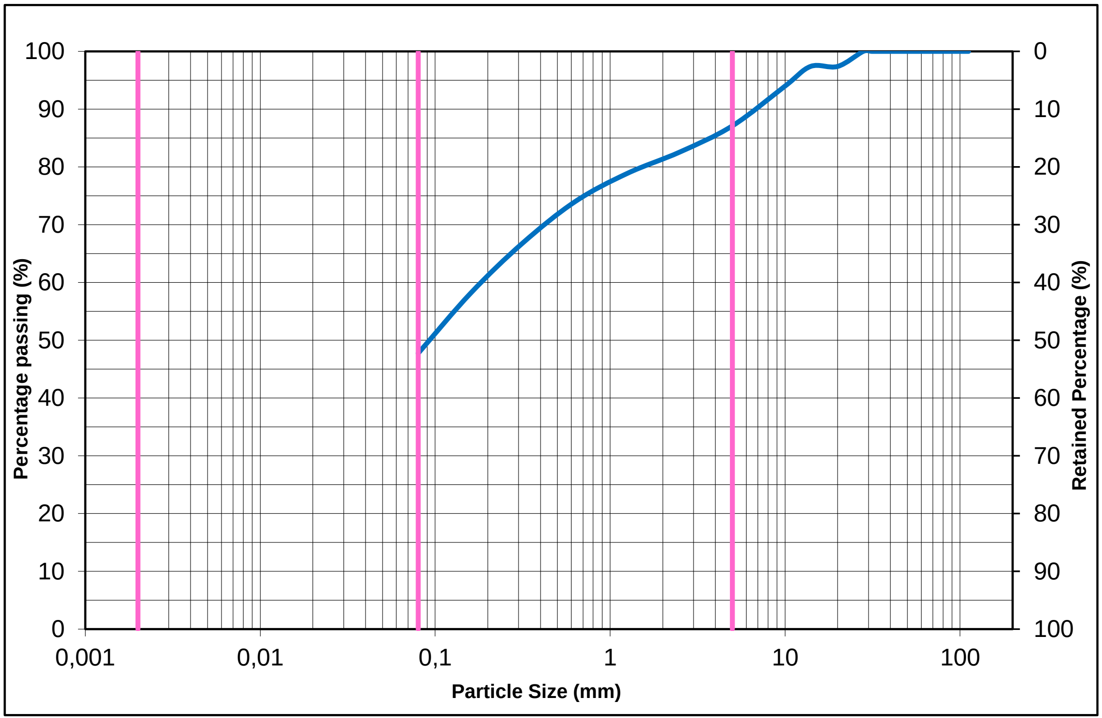
Client : Government of Nunavut
Project : Drainage and Geotechnical assessment
Clyde River, NU
Project No : 144902893.200.205
Sample No : BH19-09 DC-04
Depth : 1,36 - 1,40m

Sampled by : MV / OP
Sampling Date : September 15, 2019

Material Description : Fine particles and Sand, some Gravel

Grain Size Analysis (BNQ 2501-025)

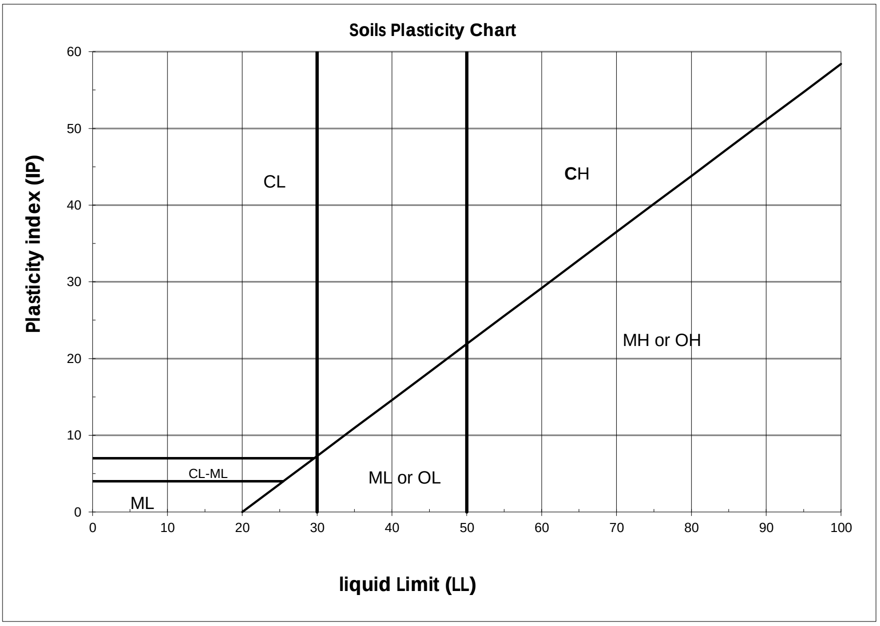
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	97
14,0	97
10,0	94
5,00	87
2,50	83
1,25	79
0,630	74
0,315	67
0,160	58
0,080	47,7



% Gravel : 12,9 % Sand : 39,4 % Fine Particles : 47,7

Other tests

Test / Standard	Results
Water Content (NQ 2560-200) (%)	27,3



Remarks :

Prepared by : Benoit Cyr, B. Sc. Geology.

Date : October 16, 2019

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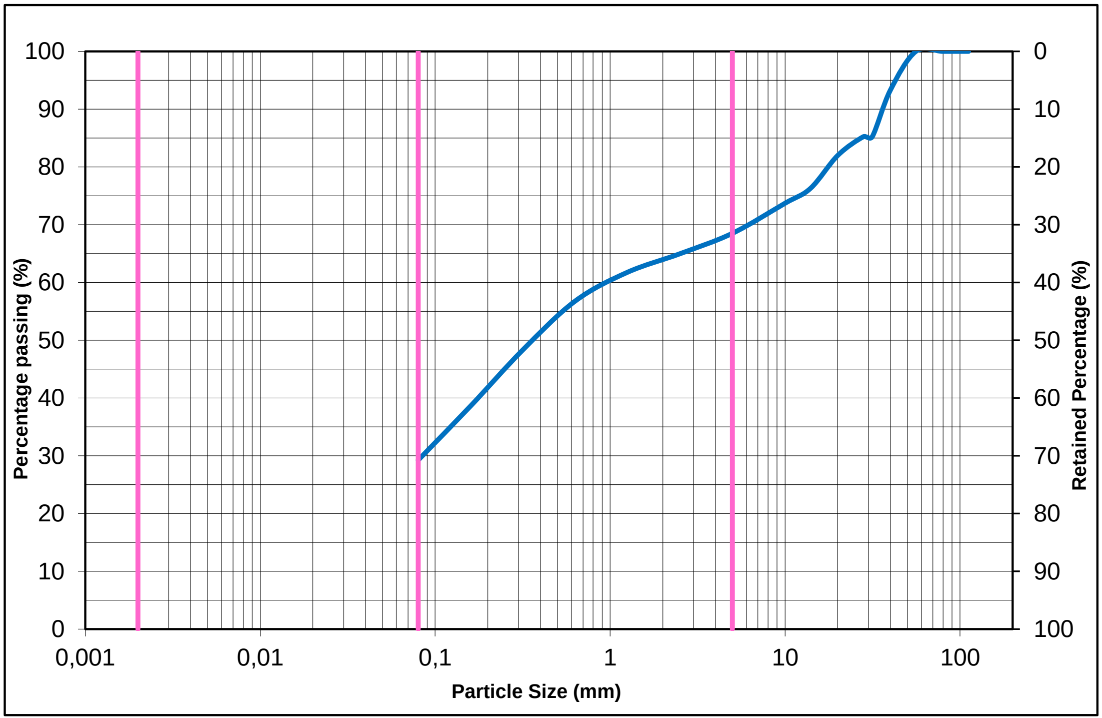
Laval QC, H7L 5B8

LABORATORY TESTING REPORT

Client :	Government of Nunavut	Sampled by :	MV / OP
Project :	Drainage and Geotechnical assessment Clyde River, NU	Sampling Date :	September 15, 2019
Project No :	144902893.200.205		
Sample No :	BH19-11 DC-03	Material Description :	Silty, Gravely Sand
Depth :	0,67 - 1,04m		

Grain Size Analysis (BNQ 2501-025)

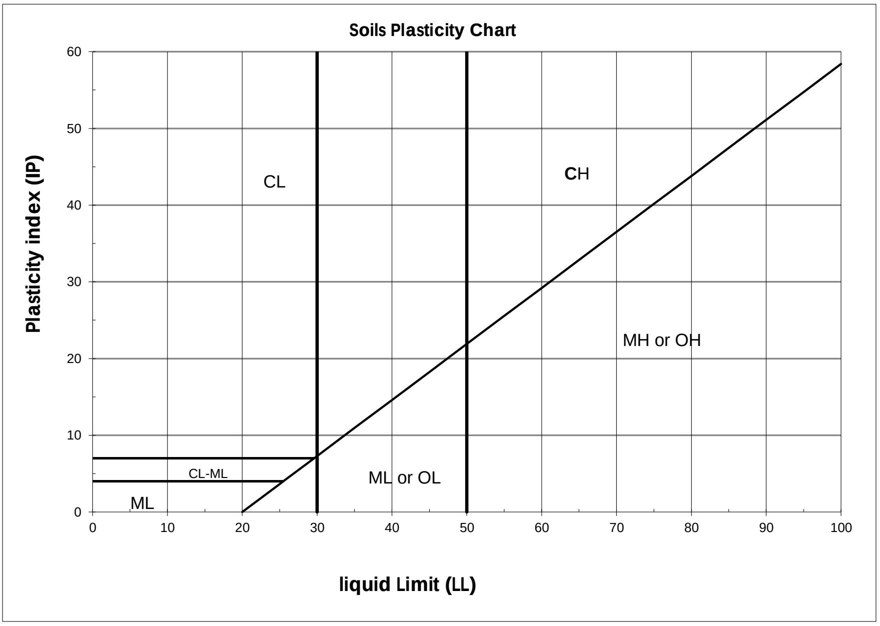
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	93
31,5	85
28,0	85
20,0	82
14,0	76
10,0	74
5,00	69
2,50	65
1,25	62
0,630	57
0,315	48
0,160	39
0,080	29,3



% Gravel : 31,4 % Sand : 39,3 % Fine Particles : 29,3

Other tests

Test / Standard	Results
Water Content (NQ 2560-200) (%)	55,4
VIC (%)	61,7



Remarks :

Prepared by : Benoit Cyr, B. Sc. Geology. **Date :** October 16, 2019

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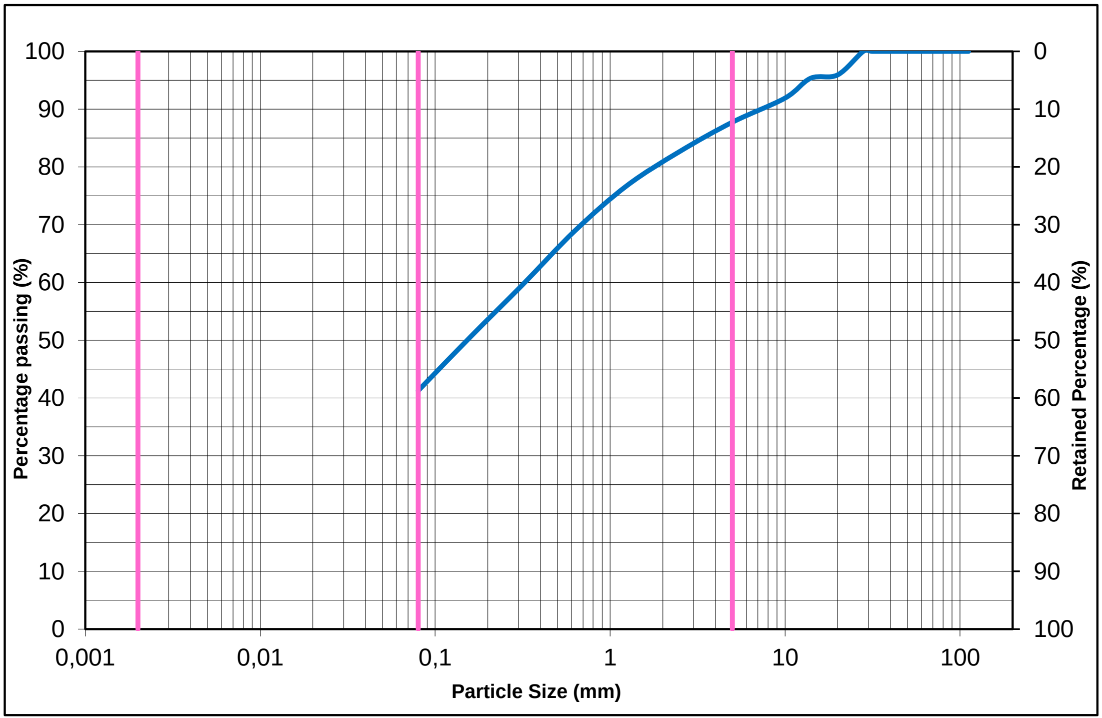
Laval QC, H7L 5B8

LABORATORY TESTING REPORT

Client : Government of Nunavut
Project : Drainage and Geotechnical assessment
Clyde River, NU
Project No : 144902893.200.205
Sample No : BH19-13 DC-04
Depth : 0,80 - 1,00m
Sampled by : MV / OP
Sampling Date : September 15, 2019
Material Description : Sand and fine particles, some Gravel

Grain Size Analysis (BNQ 2501-025)

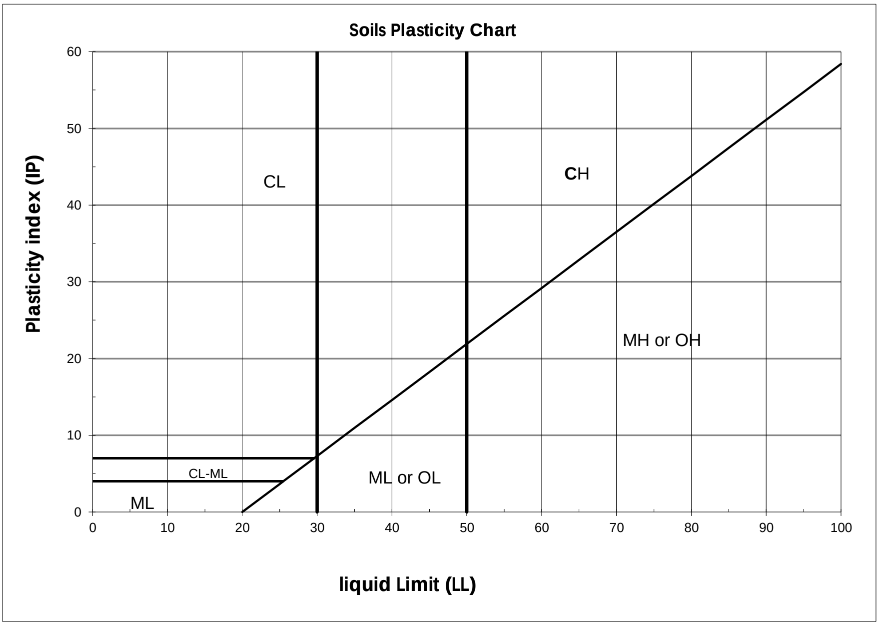
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	96
14,0	95
10,0	92
5,00	88
2,50	83
1,25	77
0,630	69
0,315	60
0,160	51
0,080	41,3



% Gravel : 12,2 % Sand : 46,5 % Fine Particles : 41,3

Other tests

Test / Standard	Results
Water Content (NQ 2560-200) (%)	92,8
VIC (%)	70,1



Remarks :

Prepared by : Benoit Cyr, B. Sc. Geology.

Date : October 16, 2019

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LABORATORY TESTING REPORT

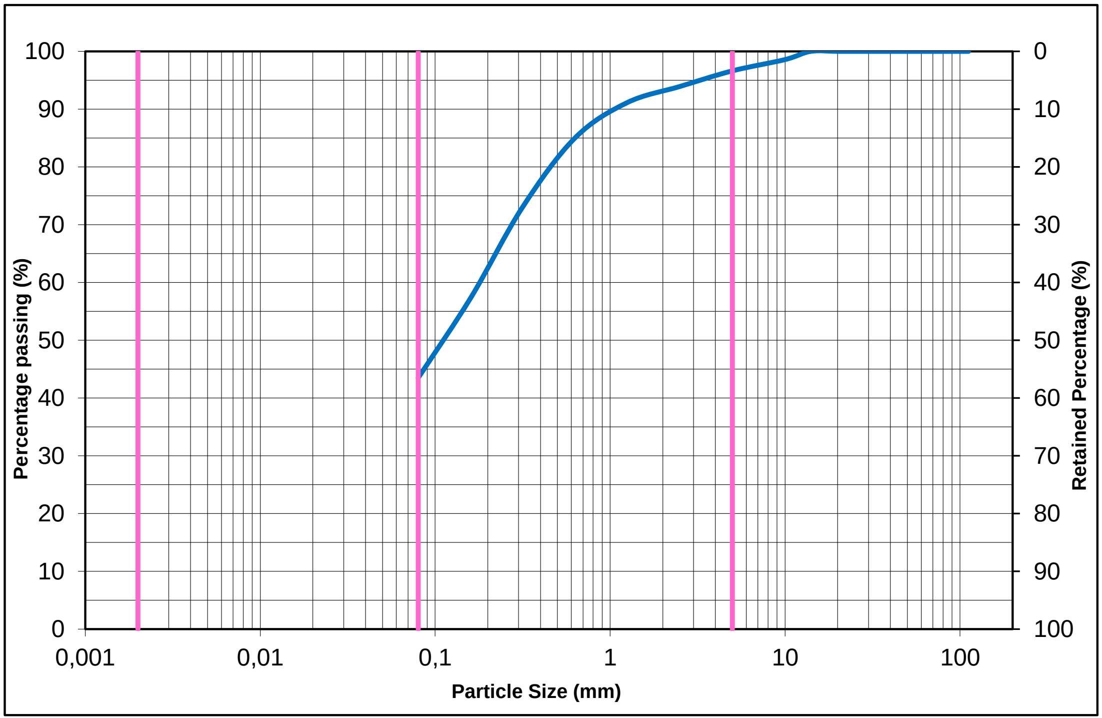
Client : Government of Nunavut
Project : Drainage and Geotechnical assessment
Clyde River, NU
Project No : 144902893.200.205
Sample No : BH19-14 AT-02
Depth : 2,00 - 2,50m

Sampled by : MV / OP
Sampling Date : September 17, 2019

Material Description : Sand and fine particles, traces of Gravel

Grain Size Analysis (BNQ 2501-025)

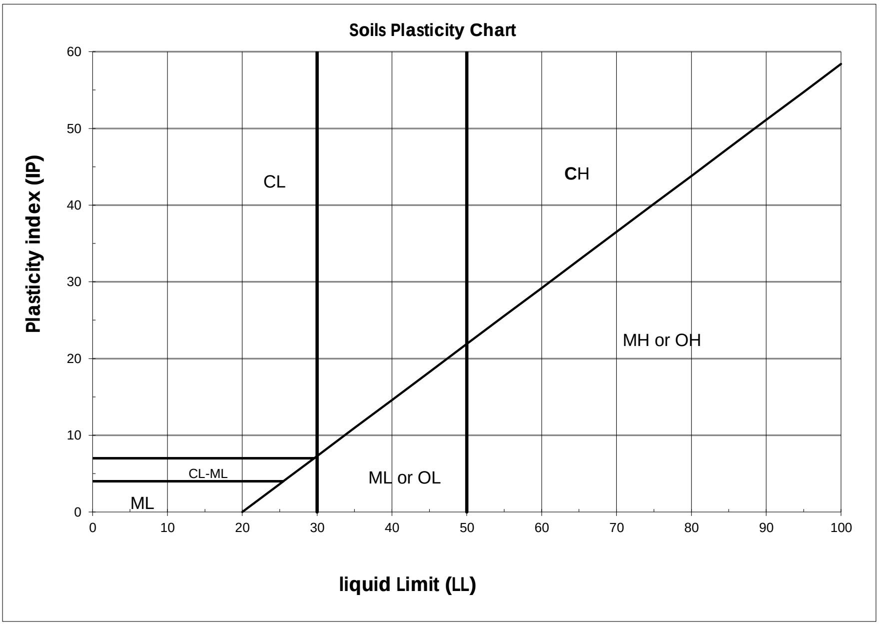
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	100
14,0	100
10,0	99
5,00	97
2,50	94
1,25	91
0,630	85
0,315	73
0,160	57
0,080	43,5



% Gravel : 3,4 % Sand : 53,1 % Fine Particles : 43,5

Other tests

Test / Standard	Results
Water Content (NQ 2560-200) (%)	78,4



Remarks :

Prepared by : Benoit Cyr, B. Sc. Geology.

Date : October 16, 2019

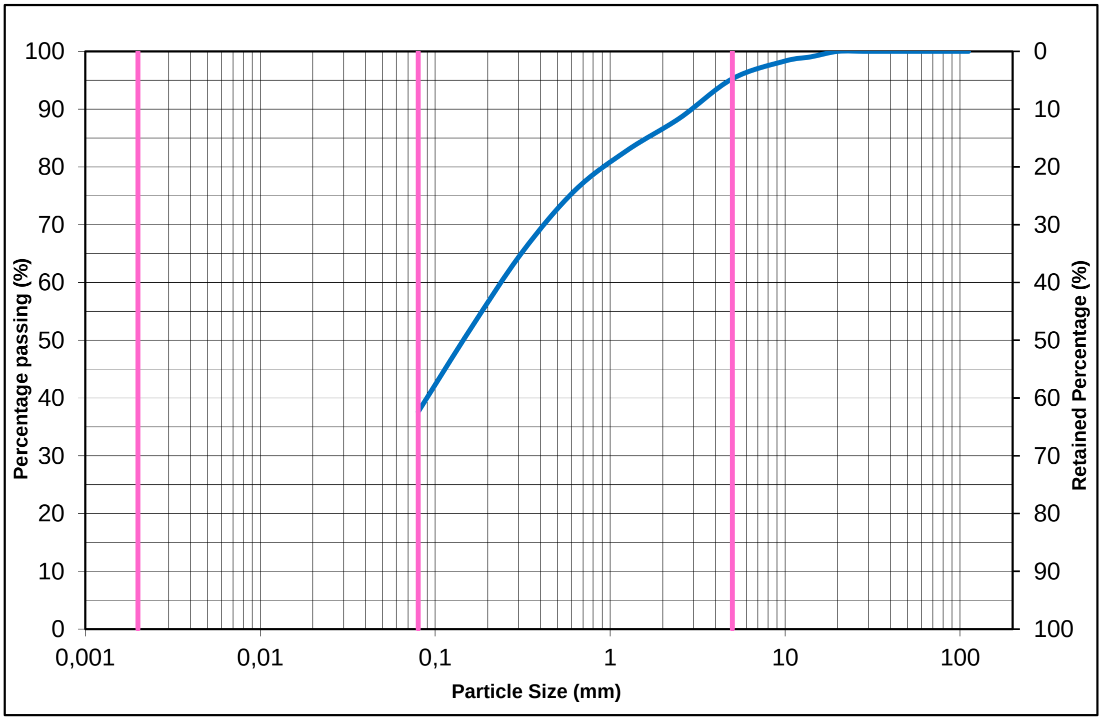
2273 Michelin Street,
Laval QC, H7L 5B8

LABORATORY TESTING REPORT

Client :	Government of Nunavut	Sampled by :	MV / OP
Project :	Drainage and Geotechnical assessment Clyde River, NU	Sampling Date :	September 17, 2019
Project No :	144902893.200.205		
Sample No :	BH19-14 AT-04	Material Description :	Sand and fine particles, traces of Gravel
Depth :	6,00 - 7,00m		

Grain Size Analysis (BNQ 2501-025)

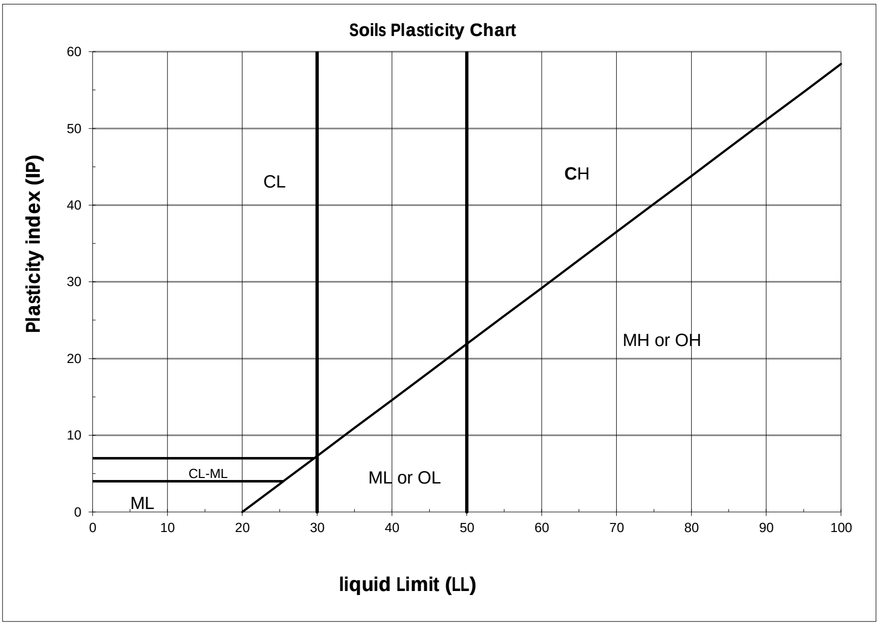
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	100
14,0	99
10,0	98
5,00	95
2,50	88
1,25	83
0,630	76
0,315	65
0,160	52
0,080	37,6



% Gravel : 4,7 % Sand : 57,6 % Fine Particles : 37,6

Other tests

Test / Standard	Results
Water Content (NQ 2560-200) (%)	29,8



Remarks :

Prepared by : Benoit Cyr, B. Sc. Geology. **Date :** October 16, 2019

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Laval QC, H7L 5B8

LABORATORY TESTING REPORT

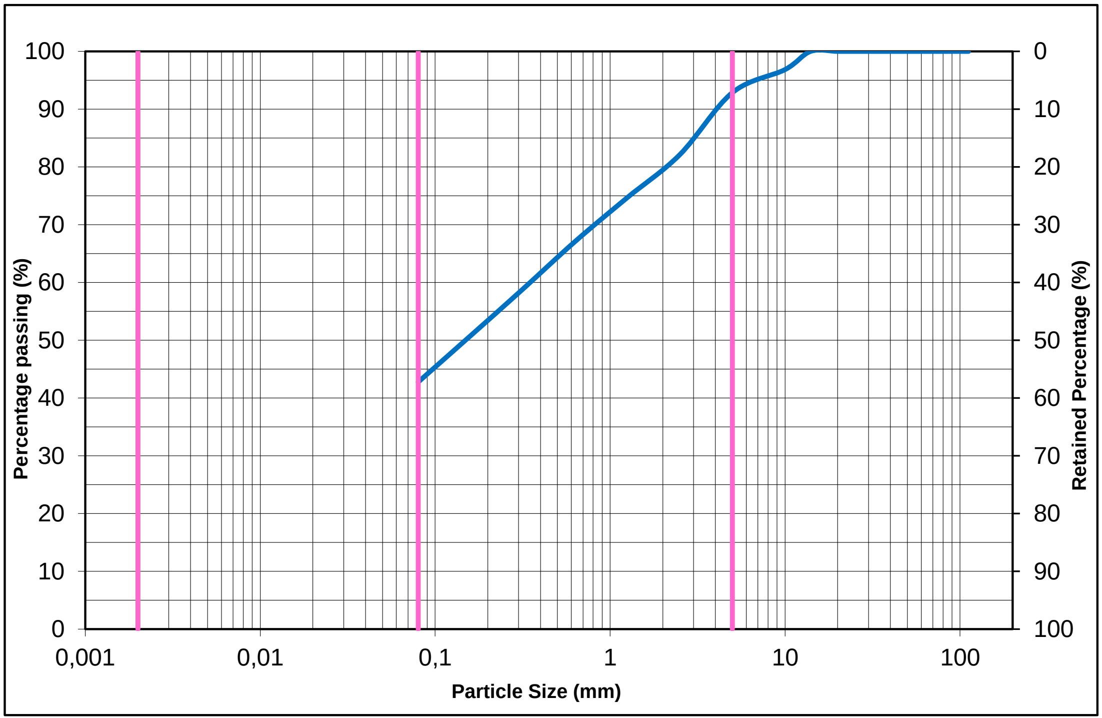
Client : Government of Nunavut
Project : Drainage and Geotechnical assessment
Clyde River, NU
Project No : 144902893.200.205
Sample No : BH19-15 AT-02
Depth : 1,50 - 2,00m

Sampled by : MV / OP
Sampling Date : September 18, 2019

Material Description : Sand and fine particles, traces of Gravel

Grain Size Analysis (BNQ 2501-025)

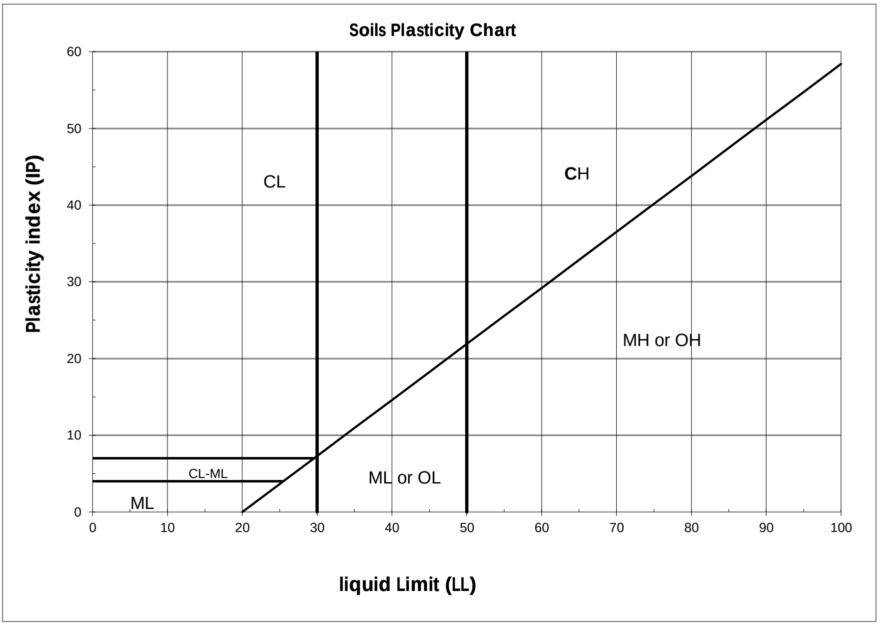
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	100
14,0	100
10,0	97
5,00	93
2,50	82
1,25	75
0,630	67
0,315	59
0,160	51
0,080	42,8



% Gravel : 7,1 % Sand : 50,1 % Fine Particles : 42,8

Other tests

Test / Standard	Results
Water Content (NQ 2560-200) (%)	83,3



Remarks :

Prepared by : Benoit Cyr, B. Sc. Geology.

Date : October 16, 2019

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2273 Michelin Street,
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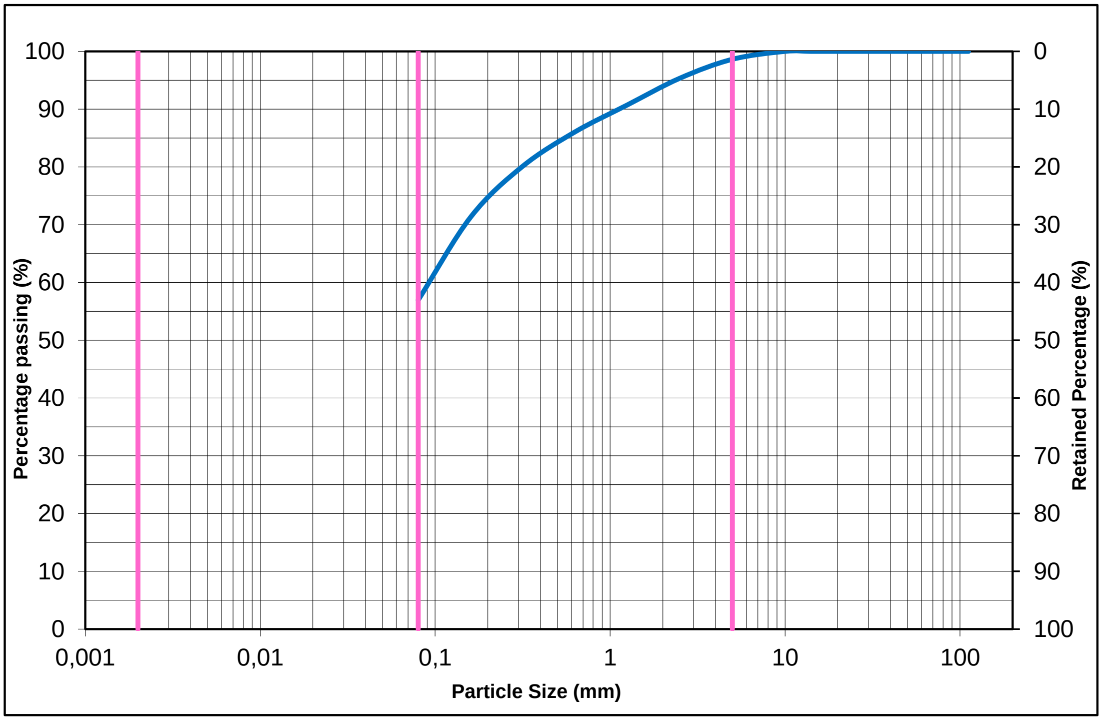
LABORATORY TESTING REPORT

Client :	Government of Nunavut	Sampled by :	MV / OP
Project :	Drainage and Geotechnical assessment Clyde River, NU	Sampling Date :	September 18, 2019
Project No :	144902893.200.205		
Sample No :	BH19-15 AT-04	Material Description :	Fine particles and Sand, traces of Gravel
Depth :	5,00 - 6,00m		

Grain Size Analysis (BNQ 2501-025)

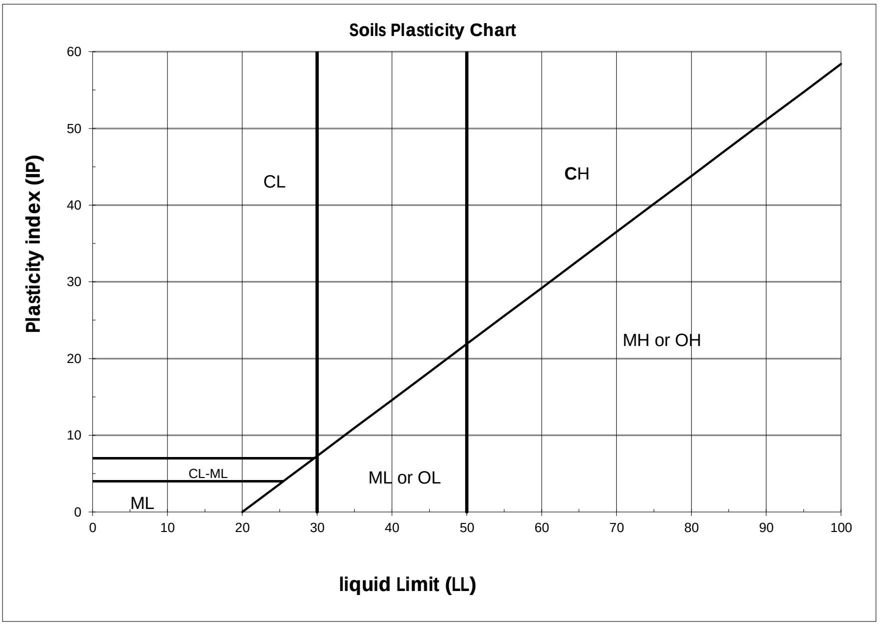
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	100
14,0	100
10,0	100
5,00	99
2,50	95
1,25	91
0,630	86
0,315	80
0,160	71
0,080	57,0



% Gravel : 1,4 % Sand : 41,7 % Fine Particles : 57,0

Other tests

Test / Standard	Results
Water Content (NQ 2560-200) (%)	31,0



Remarks :

Prepared by : Benoit Cyr, B. Sc. Geology.

Date : October 16, 2019

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Laval QC, H7L 5B8

LABORATORY TESTING REPORT

Client : Government of Nunavut

Project : Drainage and Geotechnical assessment
Clyde River, NU

Project No : 144902893.200.205

Sample No : BH19-16 AT-02

Depth : 1,00 - 2,00m

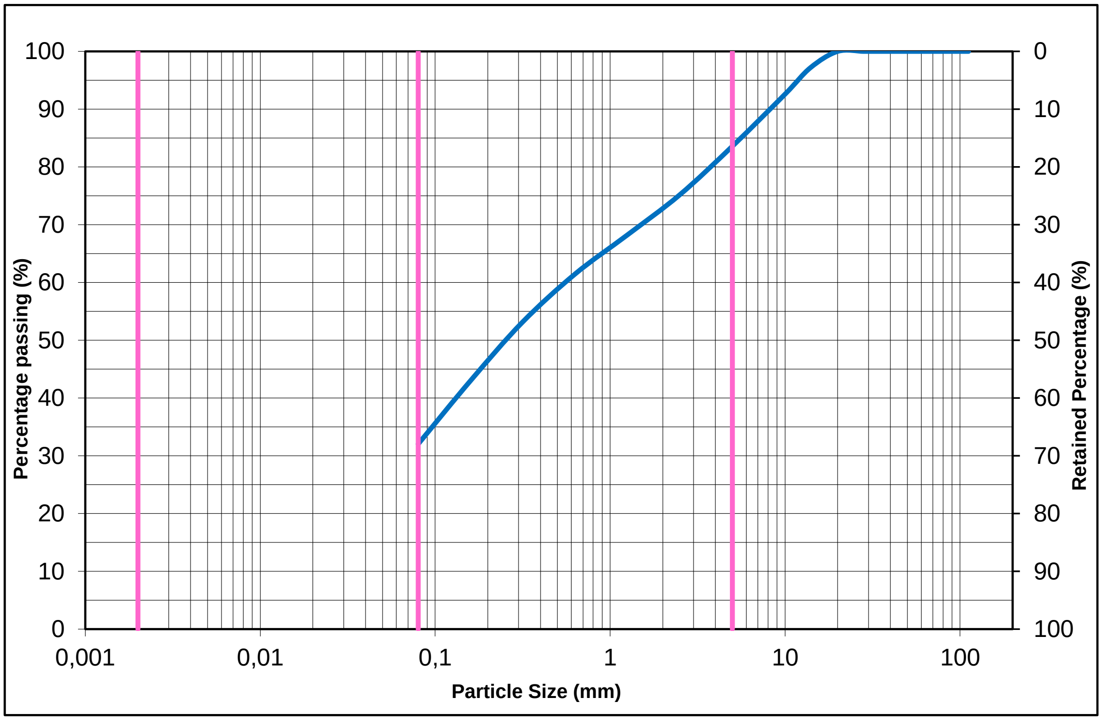
Sampled by : MV / OP

Sampling Date : September 18, 2019

Material Description : Silty Sand, some Gravel

Grain Size Analysis (BNQ 2501-025)

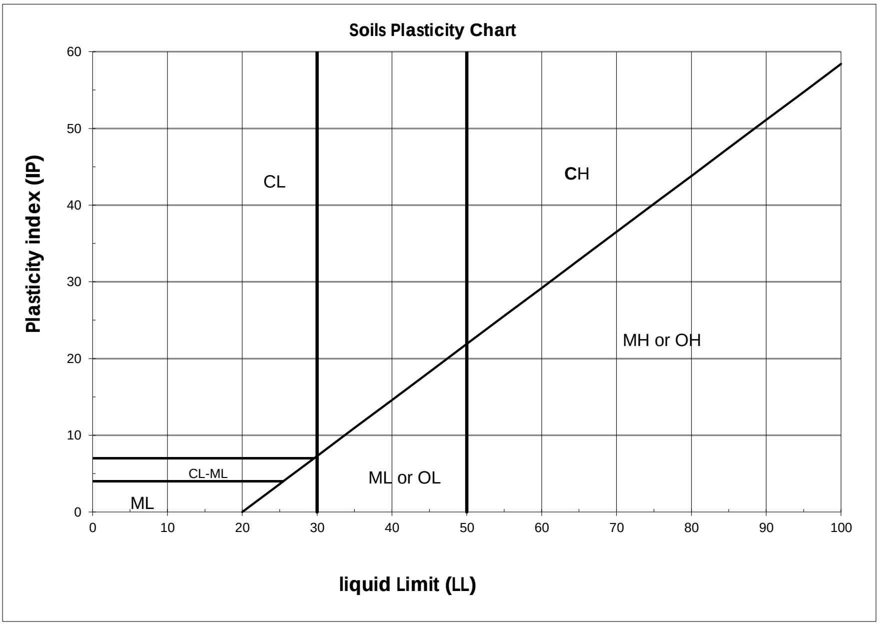
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	100
14,0	97
10,0	93
5,00	84
2,50	75
1,25	68
0,630	61
0,315	53
0,160	43
0,080	32,0



% Gravel : 16,5 % Sand : 51,5 % Fine Particles : 32,0

Other tests

Test / Standard	Results
Water Content (NQ 2560-200) (%)	41,2



Remarks :

Prepared by : Benoit Cyr, B. Sc. Geology.

Date : October 16, 2019

Stantec

2273 Michelin Street,
Laval QC, H7L 5B8

LABORATORY TESTING REPORT

Client : Government of Nunavut

Project : Drainage and Geotechnical assessment
Clyde River, NU

Project No : 144902893.200.205

Sample No : BH19-16 AT-05

Depth : 7,00 - 8,00m

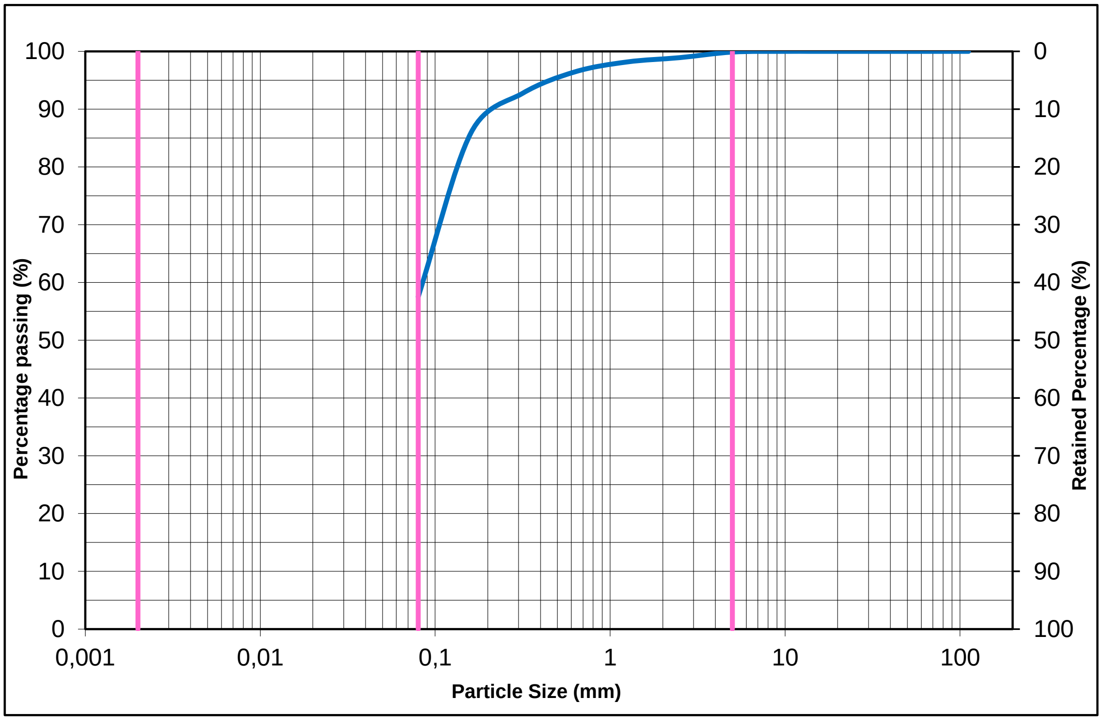
Sampled by : MV / OP

Sampling Date : September 18, 2019

Material Description : Fine particles and Sand, traces of Gravel

Grain Size Analysis (BNQ 2501-025)

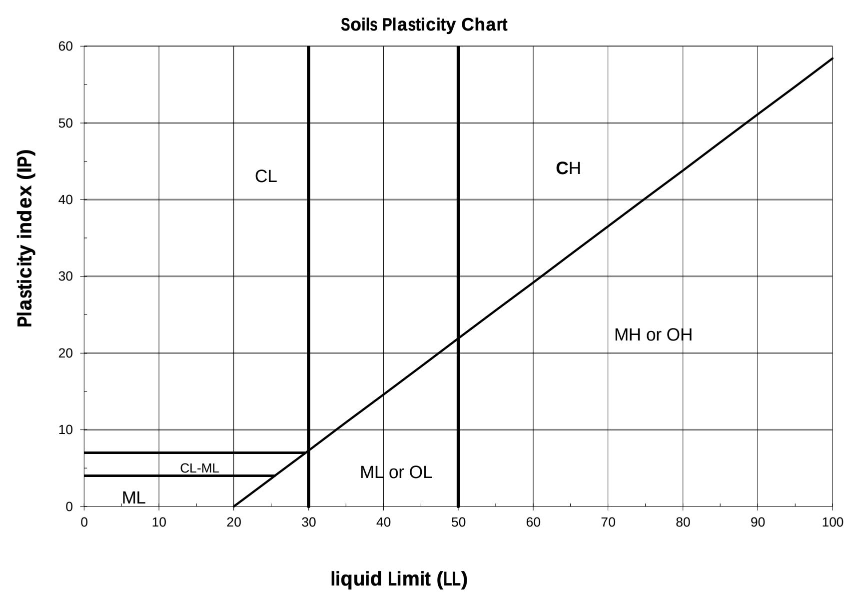
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	100
14,0	100
10,0	100
5,00	100
2,50	99
1,25	98
0,630	96
0,315	93
0,160	86
0,080	57,5



% Gravel : 0,2 % Sand : 42,3 % Fine Particles : 57,5

Other tests

Test / Standard	Results
Water Content (NQ 2560-200) (%)	24,1



Remarks :

Prepared by : Benoit Cyr, B. Sc. Geology.

Date : October 16, 2019

2273 Michelin Street,
Laval QC, H7L 5B8

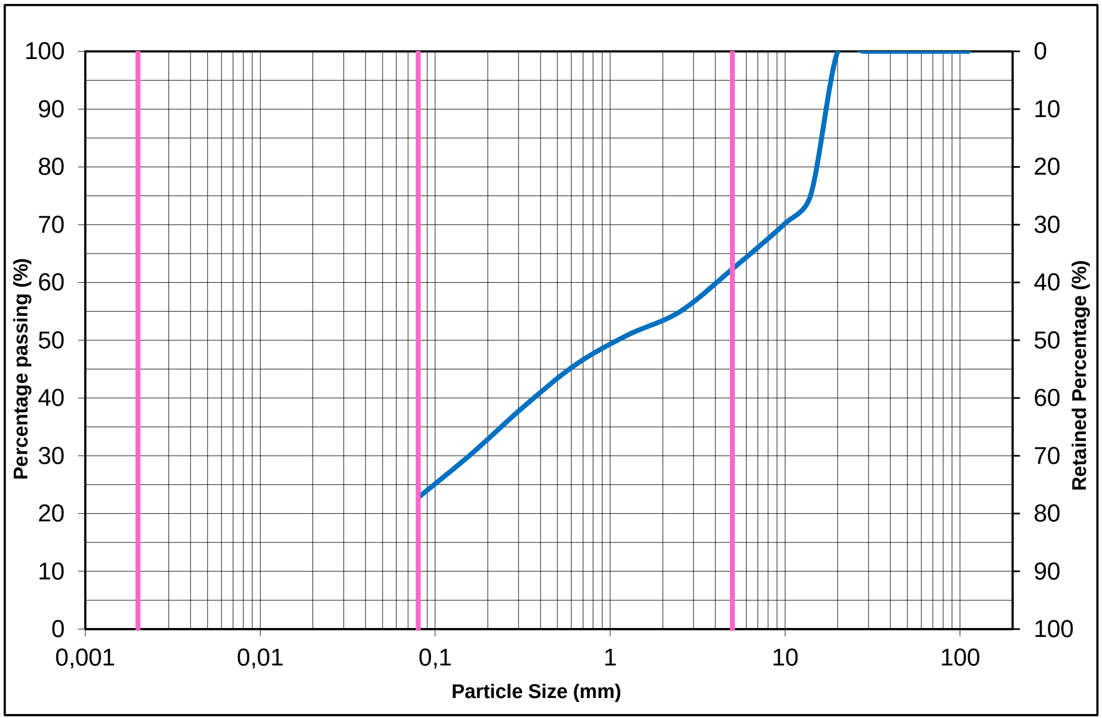
LABORATORY TESTING REPORT

Client : Government of Nunavut
Project : Drainage and Geotechnical assessment
Clyde River, NU
Project No : 144902893.200.205
Sample No : BH19-17 AT-02
Depth : 1,00 - 2,00m

Sampled by : MV / OP
Sampling Date : September 18, 2019
Material Description : Silty Sand and Gravel

Grain Size Analysis (BNQ 2501-025)

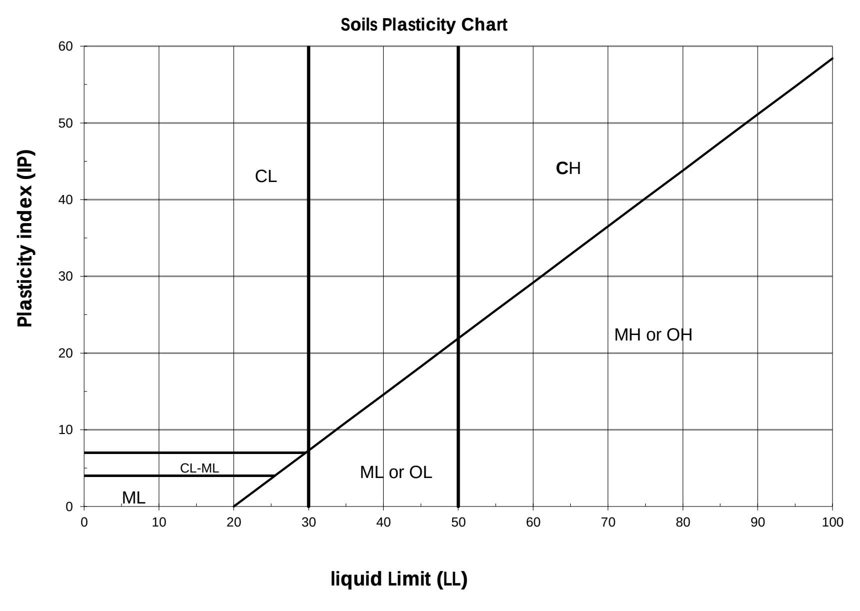
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	100
14,0	75
10,0	70
5,00	62
2,50	55
1,25	51
0,630	46
0,315	38
0,160	30
0,080	22,8



% Gravel : 37,6 % Sand : 39,6 % Fine Particles : 22,8

Other tests

Test / Standard	Results
Water Content (NQ 2560-200) (%)	30,1



Remarks :

Prepared by : Benoit C..., B. Sc. Geology.

Date : October 16, 2019

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2273 Michelin Street,
Laval QC, H7L 5B8

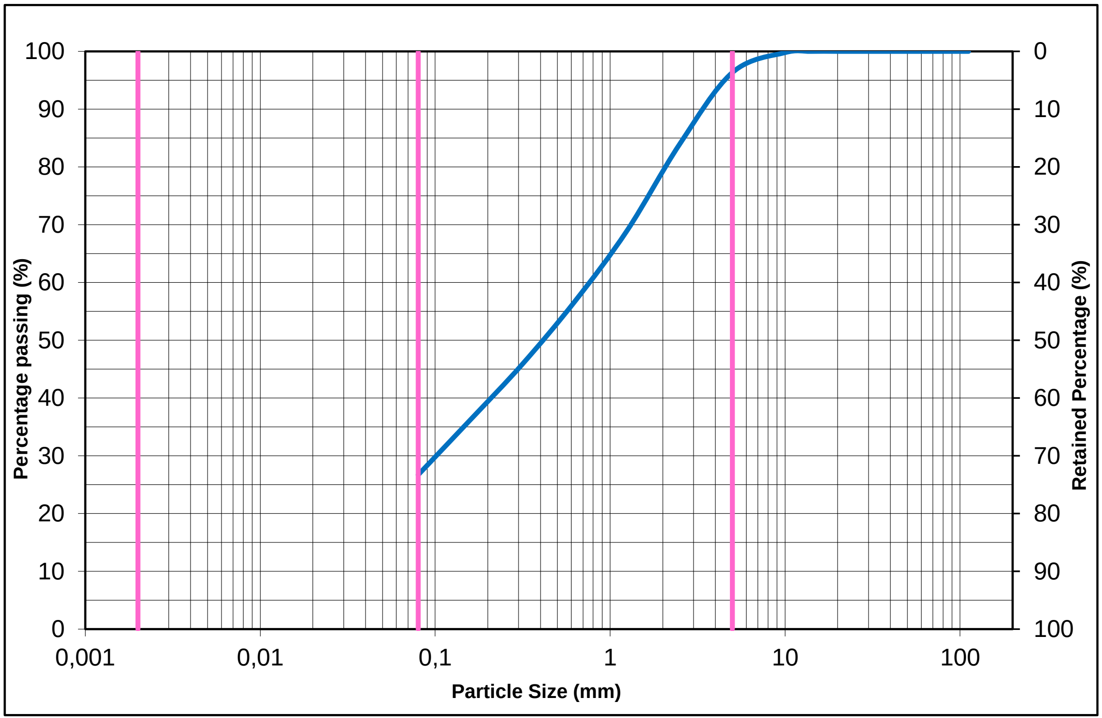
LABORATORY TESTING REPORT

Client : Government of Nunavut
Project : Drainage and Geotechnical assessment
Clyde River, NU
Project No : 144902893.200.205
Sample No : BH19-17 AT-05
Depth : 7,00 - 8,00m

Sampled by : MV / OP
Sampling Date : September 18, 2019
Material Description : Silty Sand, traces of Gravel

Grain Size Analysis (BNQ 2501-025)

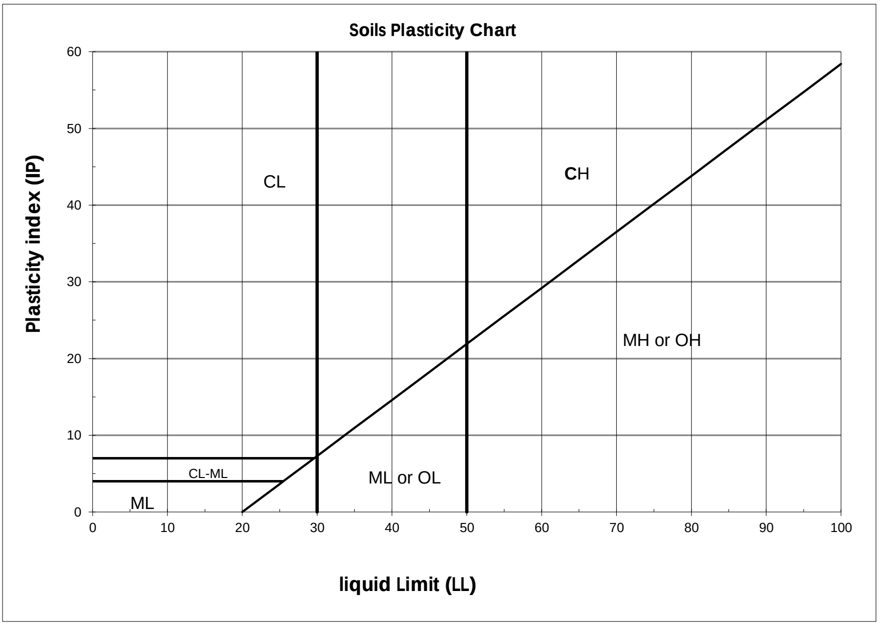
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	100
14,0	100
10,0	100
5,00	96
2,50	84
1,25	69
0,630	57
0,315	46
0,160	36
0,080	26,7



% Gravel : 3,7 % Sand : 69,6 % Fine Particles : 26,7

Other tests

Test / Standard	Results
Water Content (NQ 2560-200) (%)	10,7



Remarks :

Prepared by : Benoit Cyr, B. Sc. Geology.

Date : October 16, 2019

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Laval QC, H7L 5B8

LABORATORY TESTING REPORT

Client : Government of Nunavut

Project : Drainage and Geotechnical assessment
Clyde River, NU

Project No : 144902893.200.205

Sample No : BH19-18 AT-02

Depth : 1,00 - 2,00m

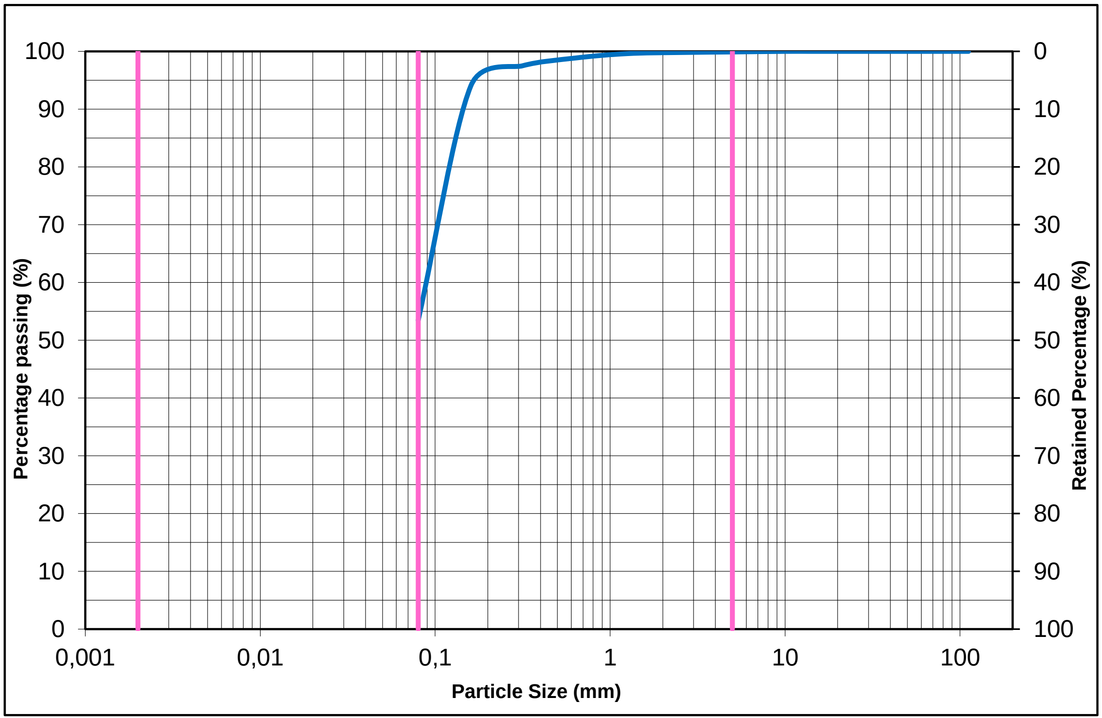
Sampled by : MV / OP

Sampling Date : September 18, 2019

Material Description : Fine particles and Sand,
traces of Gravel

Grain Size Analysis (BNQ 2501-025)

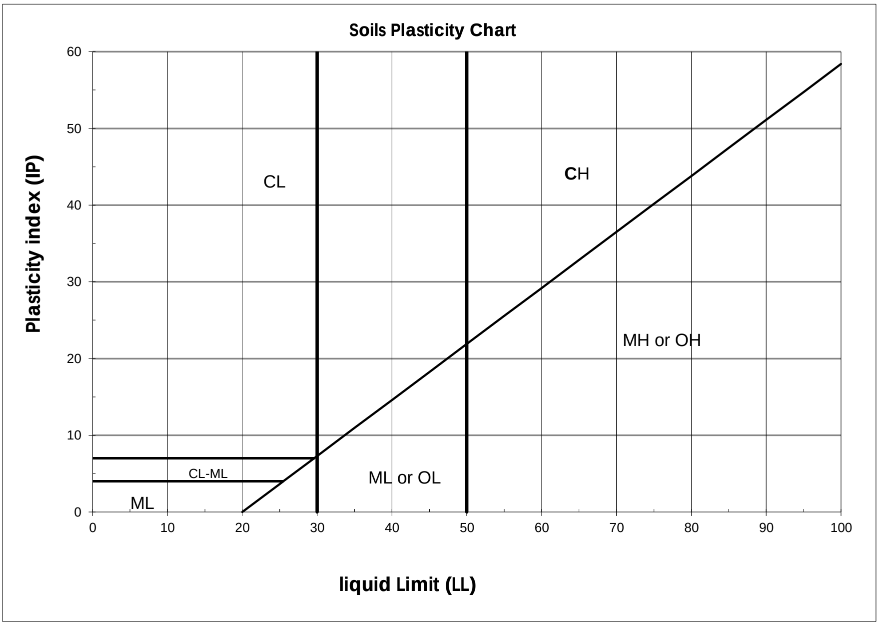
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	100
14,0	100
10,0	100
5,00	100
2,50	100
1,25	100
0,630	99
0,315	97
0,160	94
0,080	53,5



% Gravel : 0,1 % Sand : 46,4 % Fine Particles : 53,5

Other tests

Test / Standard	Results
Water Content (NQ 2560-200) (%)	24,6



Remarks :

Prepared by : Benoit Cyr, B. Sc. Geology.

Date : October 16, 2019

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2273 Michelin Street,
Laval QC, H7L 5B8

LABORATORY TESTING REPORT

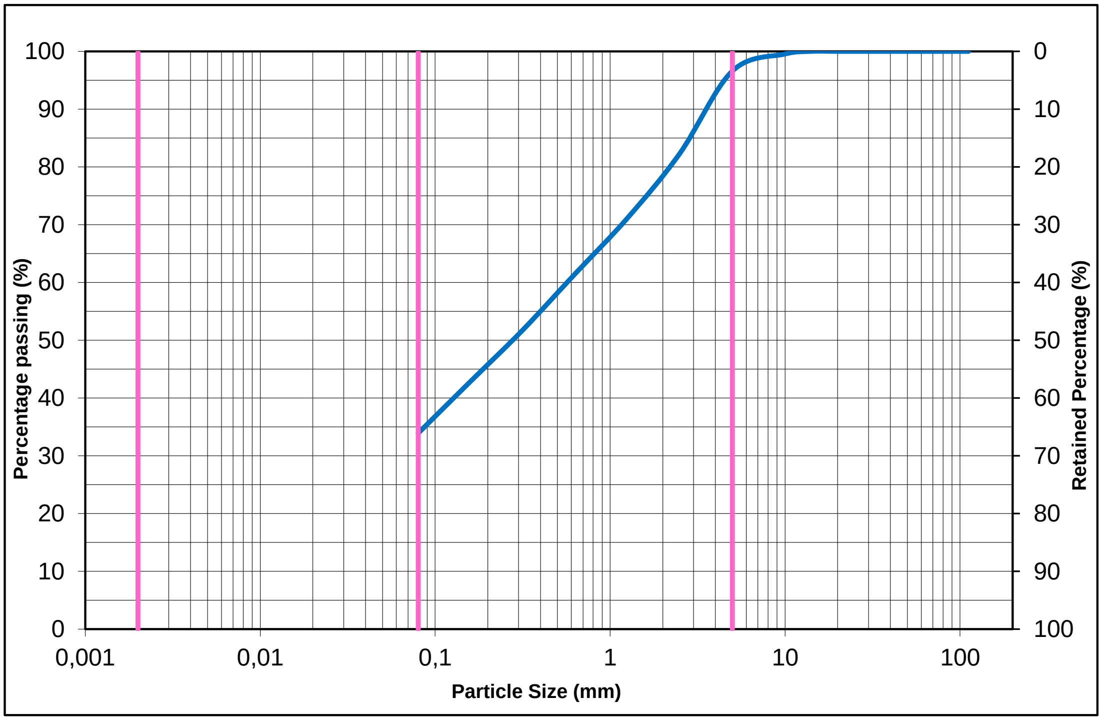
Client : Government of Nunavut
Project : Drainage and Geotechnical assessment
Clyde River, NU
Project No : 144902893.200.205
Sample No : BH19-18 AT-04
Depth : 5,00 - 6,00m

Sampled by : MV / OP
Sampling Date : September 18, 2019

Material Description : Silty Sand, traces of Gravel

Grain Size Analysis (BNQ 2501-025)

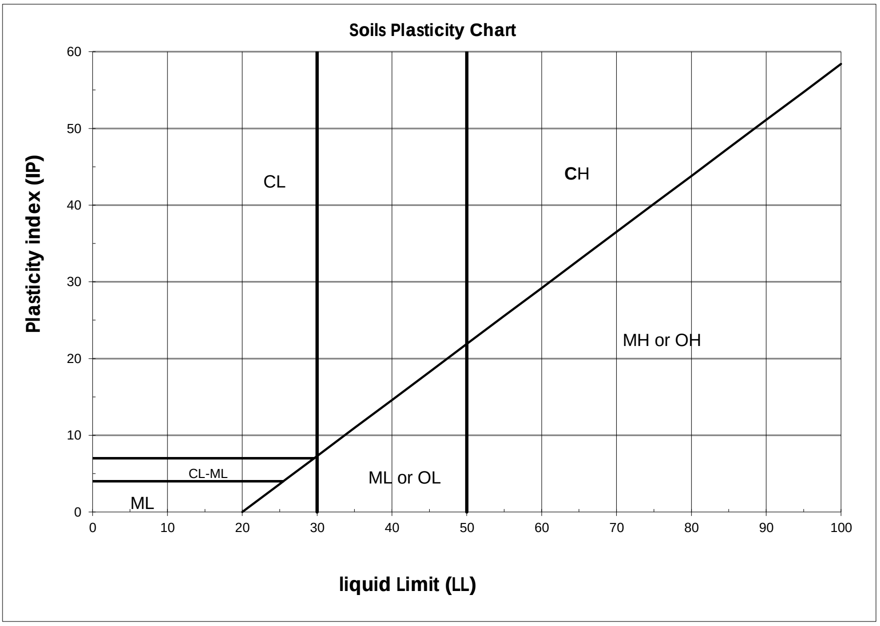
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	100
14,0	100
10,0	100
5,00	97
2,50	82
1,25	71
0,630	61
0,315	52
0,160	43
0,080	33,9



% Gravel : 3,4 % Sand : 62,7 % Fine Particles : 33,9

Other tests

Test / Standard	Results
Water Content (NQ 2560-200) (%)	6,4


Soils Plasticity Chart

Remarks :

Prepared by : Benoit Cyr, B. Sc. Geology.

Date : October 16, 2019

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2273 Michelin Street
Laval QC, H7L 5B8

Determination of Water Content

LC 21-201
BNQ 2501-170

Projet: Clyde River, NU
Project No : 144902893.200.205

Testing date : October 10, 2019
Tested by : B. Cyr

Equipment used : Scale : ☐ LAV-012 ☑ LAV-013 Oven : ☑ LAV-025 ☐ LAV-026 ☐ LAV-090

Water Content (%)							
Borehole No :	BH19-01	BH19-01	BH19-01	BH19-01	BH19-01	BH19-02	BH19-03
Sample No :	DC-02	DC-03	DC-04	DC-06	DC-08	DC-04	DC-02
Depth (m)	0.65-0.80	0.80-0.97	0.97-1.14	1.21-1.46	1.69-1.89	1.45-1.60	0.90-1.18
Water Content (%)	**49,0**	**47,3**	**49,7**	**65,7**	**12,2**	**50,0**	**236,5**
VIC (%)	**62,3**	**57,1**	**74,3**	**71,5**		**44,6**	**77,0**
Borehole No :	BH19-03	BH19-03	BH19-03	BH19-04	BH19-05	BH19-05	BH19-06
Sample No :	DC-03	DC-04	DC-05	DC-02	DC-05	DC-10	DC-03
Depth (m)	1.18-1.48	1.48-1.75	1.75-2.00	0.43-0.52	0.88-1.18	2.27-2.47	1.24-1.30
Water Content (%)	**69,2**	**31,0**	**22,0**	**60,7**	**36,4**	**216,6**	**67,3**
VIC (%)	**42,3**	**47,7**	**34,7**	**39,1**	**41,8**		
Borehole No :	BH19-06	BH19-09	BH19-11	BH19-11	BH19-11	BH19-11	BH19-13
Sample No :	DC-04	DC-04	DC-02	DC-03	DC-05	DC-06	DC-04
Depth (m)	1.79-1.90	1.36-1.40	0.35-0.67	0.67-1.04	1.47-1.65	1.65-1.75	0.80-1.00
Water Content (%)	**51,5**	**27,3**	**195,4**	**55,4**	**14,3**	**31,2**	**92,8**
VIC (%)	**56,1**		**86,6**	**61,7**	**24,1**	**48,5**	**70,1**
Borehole No :	BH19-13	BH19-13	BH19-14	BH19-14	BH19-14	BH19-14	BH19-14
Sample No :	DC-07	DC-11	AT-02	AT-03	AT-04	AT-05	AT-06
Depth (m)	1.56-1.68	2.38-2.64	2.00-2.50	4.00-5.50	6.00-7.00	8.00-9.00	9-00-10.00
Water Content (%)	**55,5**	**50,0**	**78,4**	**72,4**	**29,8**	**13,2**	**14,1**
VIC (%)	**67,3**	**45,7**					
Borehole No :	BH19-15	BH19-15	BH19-15	BH19-15	BH19-15	BH19-16	BH19-16
Sample No :	AT-02	AT-03	AT-04	AT-05	AT-06	AT-02	AT-03
Depth (m)	1.50-2.00	3.00-4.00	5.00-6.00	7.00-8.00	9.00-10.00	1.00-2.00	3.00-4.00
Water Content (%)	**83,3**	**76,4**	**31,0**	**9,3**	**11,8**	**41,2**	**150,7**
VIC (%)							
Borehole No :	BH19-16	BH19-16	BH19-16	BH19-17	BH19-17	BH19-17	BH19-17
Sample No :	AT-04	AT-05	AT-06	AT-02	AT-03	AT-04	AT-05
Depth (m)	5.00-6.00	7.00-8.00	9.00-10.00	1.00-2.00	3.00-4.00	5.00-6.00	7.00-8.00
Water Content (%)	**29,3**	**24,1**	**13,2**	**30,1**	**28,5**	**29,4**	**10,7**
VIC (%)							
Borehole No :	BH19-17	BH19-18	BH19-18	BH19-18	BH19-18		
Sample No :	AT-06	AT-02	AT-03	AT-04	AT-05		
Depth (m)	9.00-10.00	1.00-2.00	3.00-4.00	5.00-6.00	7.00-8.00		
Water Content (%)	**15,0**	**24,6**	**17,1**	**6,4**	**5,9**		
VIC (%)							

Revised by : Benoit Cyr, B. Sc. Geology.

Date : October 15, 2019

C:\Users\becyr\Desktop\dossier terminés\144902708.206.500\144902708.206.500-BH19-01-DC02.xlsx

Votre # du projet: 144902893.200.205
Adresse du site: CLYDE RIVER - DRAINAGE ASSESSMENT
Votre # Bordereau: N/A

Attention: Manuel Verpaelst
STANTEC CONSULTING LTD
MONTREAL
100, boulevard Alexis-Nihon
Suite 110
Ville Saint-Laurent, QC
CANADA H4M 2N6

Date du rapport: 2019/10/21
Rapport: R2509973
Version: 1 - Finale

CERTIFICAT D'ANALYSES

 # DE DOSSIER LAB BV: B951042
Reçu: 2019/10/17, 10:15

Matrice: Eau
Nombre d'échantillons reçus: 2

Analyses	Quantité	Date de l' extraction	Date Analysé	Méthode de laboratoire	Référence Primaire
Salinité	2	N/A	2019/10/17		SM23 2520B m

Remarques:

Laboratoires Bureau Veritas sont certifiés ISO/IEC 17025 pour certains paramètres précis des portées d’accréditation. Sauf indication contraire, les méthodes d’analyses utilisées par Labs BV s’inspirent des méthodes de référence d’organismes provinciaux, fédéraux et américains, tels que le CCME, le MELCC, l’EPA et l’APHA.

Toutes les analyses présentées ont été réalisées conformément aux procédures et aux pratiques relatives à la méthodologie, à l’assurance qualité et au contrôle de la qualité généralement appliqués par les employés de Labs BV (sauf s’il en a été convenu autrement par écrit entre le client et Labs BV). Toutes les données de laboratoire rencontrent les contrôles statistiques et respectent tous les critères de CQ et les critères de performance des méthodes, sauf s’il en a été signalé autrement. Tous les blancs de méthode sont rapportés, toutefois, les données des échantillons correspondants ne sont pas corrigées pour la valeur du blanc, sauf indication contraire. Le cas échéant, sauf indication contraire, l’incertitude de mesure n’a pas été prise en considération lors de la déclaration de la conformité à la norme de référence.

Les responsabilités de Labs BV sont restreintes au coût réel de l’analyse, sauf s’il en a été convenu autrement par écrit. Il n’existe aucune autre garantie, explicite ou implicite. Le client a fait appel à Labs BV pour l’analyse de ses échantillons conformément aux méthodes de référence mentionnées dans ce rapport. L’interprétation et l’utilisation des résultats sont sous l’entière responsabilité du client et ne font pas partie des services offerts par Labs BV, sauf si convenu autrement par écrit. Labs BV ne peut pas garantir l’exactitude des résultats qui dépendent des renseignements fournis par le client ou son représentant.

Les résultats des échantillons solides, sauf les biotes, sont rapportés en fonction de la masse sèche, sauf indication contraire. Les analyses organiques ne sont pas corrigées en fonction de la récupération, sauf pour les méthodes de dilution isotopique.
Les résultats s’appliquent seulement aux échantillons analysés. Si l’échantillonnage n’est pas effectué par Labs BV, les résultats se rapportent aux échantillons fournis pour analyse.
Le présent rapport ne doit pas être reproduit, sinon dans son intégralité, sans le consentement écrit du laboratoire.
Lorsque la méthode de référence comprend un suffixe « m », cela signifie que la méthode d’analyse du laboratoire contient des modifications validées et appliquées afin d’améliorer la performance de la méthode de référence.
Notez: Les données brutes sont utilisées pour le calcul du RPD (% d'écart relatif). L'arrondissement des résultats finaux peut expliquer la variation apparente.

Note : Les paramètres inclus dans le présent certificat sont accrédités par le MELCC, à moins d’indication contraire.

Votre # du projet: 144902893.200.205
Adresse du site: CLYDE RIVER - DRAINAGE ASSESSMENT
Votre # Bordereau: N/A

Attention: Manuel Verpaelst

STANTEC CONSULTING LTD
MONTREAL
100, boulevard Alexis-Nihon
Suite 110
Ville Saint-Laurent, QC
CANADA H4M 2N6

Date du rapport: 2019/10/21
Rapport: R2509973
Version: 1 - Finale

CERTIFICAT D'ANALYSES

 # DE DOSSIER LAB BV: B951042
Reçu: 2019/10/17, 10:15

clé de cryptage

Veuillez adresser toute question concernant ce certificat d'analyse à votre chargé(e) de projets
Kathie Quevillon, B.Sc., Chimiste, Chargée de projets
Courriel: Kathie.QUEVILLON@bvlabs.com
Téléphone (514)448-9001 Ext:7066281
==
Ce rapport a été produit et distribué en utilisant une procédure automatisée sécuritaire.
Lab BV a mis en place des procédures qui protègent contre l'utilisation non autorisée de la signature électronique et emploie les «signataires» requis, conformément à l'ISO/CEI 17025. Veuillez vous référer à la page des signatures de validation pour obtenir les détails des validations pour chaque division.

PARAMÈTRES CONVENTIONNELS (EAU)

ID Lab BV		HD2013	HD2014	
Date d'échantillonnage		2019/09/13	2019/09/13	
	Unités	**BH19-03-DC-03**	**BH19-05-DC-05**	**Lot CQ**
CONVENTIONNELS				
Salinité †	n/a	0.094	0.038	2040016
Température (°C) †	n/a	25	25	2040016

Lot CQ = Lot contrôle qualité
† Accréditation non existante pour ce paramètre

REMARQUES GÉNÉRALES

Contenant non approprié.: HD2013
Salinité: Délai maximum de conservation dépassé sur réception.: HD2013
Contenant non approprié.: HD2014
Salinité: Délai maximum de conservation dépassé sur réception.: HD2014

Les résultats ne se rapportent qu'aux échantillons soumis pour analyse

PAGE DES SIGNATURES DE VALIDATION

Les résultats analytiques ainsi que les données de contrôle-qualité contenus dans ce rapport furent vérifiés et validés par les personnes suivantes:

Caroline Bougie
2007-004

Caroline Bougie

Caroline Bougie, B.Sc. Chimiste

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APPENDIX G

Block 2 – Plan 3926

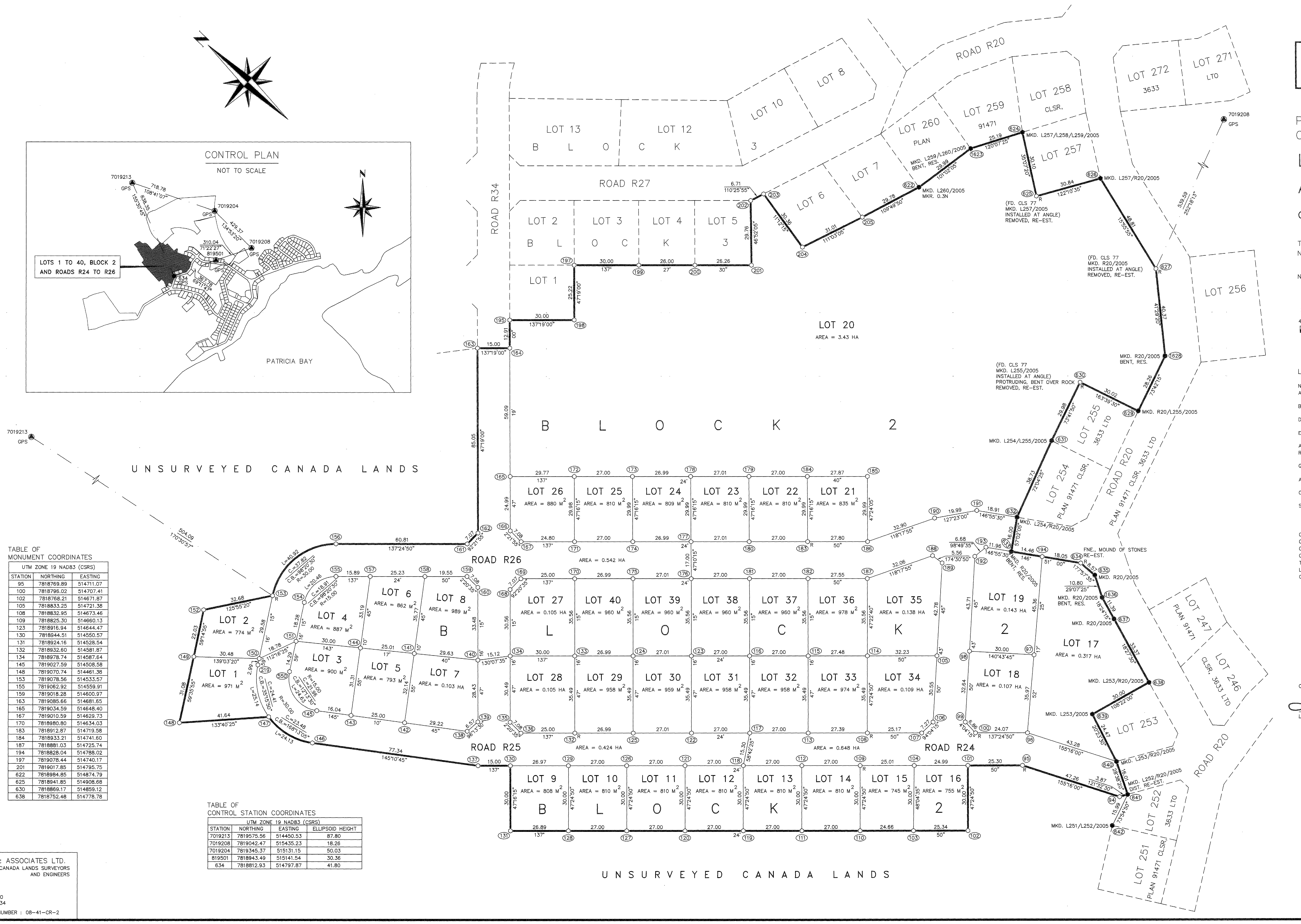

TABLE OF
MONUMENT COORDINATES

UTM ZONE 19 NAD83 (CSRS)		
STATION	NORTHING	EASTING
95	7818769.89	514711.07
100	7818796.02	514707.41
102	7818768.21	514671.87
105	7818833.25	514721.38
108	7818832.95	514673.46
109	7818825.30	514660.13
123	7818916.94	514644.47
130	7818944.51	514550.57
131	7818924.16	514528.54
132	7818932.60	514581.87
134	7818978.74	514587.64
145	7819027.59	514508.58
148	7819070.74	514461.38
153	7819078.56	514533.57
155	7819062.92	514559.91
159	7819018.28	514600.97
163	7819085.66	514681.65
165	7819034.59	514648.40
167	7819010.59	514629.73
170	7818980.80	514634.03
183	7818912.87	514719.58
184	7818933.21	514741.60
187	7818881.03	514725.74
194	7818828.04	514788.02
197	7819078.44	514740.17
201	7819017.85	514795.75
622	7818984.85	514874.79
625	7818941.85	514908.68
630	7818869.17	514859.12
638	7818752.48	514778.78

TABLE OF
CONTROL STATION COORDINATES

UTM ZONE 19 NAD83 (CSRS)			
STATION	NORTHING	EASTING	ELLIPSOID HEIGHT
7019213	7819575.56	514450.53	87.80
7019208	7819042.47	515435.23	18.26
7019204	7819345.37	515131.15	50.03
819501	7818943.49	515141.54	30.36
634	7818812.93	514797.87	41.80

OLLERHEAD & ASSOCIATES LTD.
CANADA LANDS SURVEYORS
AND ENGINEERS
BOX 1169
YELLOWKNIFE, NT
X1A 2N8
PH: (867)873-9690
FAX: (867)669-6334

PROJECT NUMBER : 08-41-CR-2

CANADA LANDS SURVEYS RECORDS
95514
DATE: APRIL 2, 2009

A COPY OF THIS PLAN IS FILED IN THE LAND TITLES OFFICE FOR NUNAVUT AS
3926

PLAN AND FIELD NOTES OF SURVEY OF

LOTS 1 TO 40, BLOCK 2
AND ROADS R24, R25 AND R26

CLYDE RIVER, NUNAVUT

THIS SURVEY WAS EXECUTED DURING THE PERIOD OF AUGUST 28 TO SEPTEMBER 10, 2008 NOT CONTINUOUS, BY LLOYD K. TAYLOR, C.L.S.

NOTE: LANDS DEALT WITH BY THIS PLAN COMPRISE UNSURVEYED CANADA LANDS.

SCALE 1 : 750.

40 20 0 50 100 METRES
30 10

LEGEND

NAD83 (CSRS) CONTROL COORDINATES WERE DERIVED VIA THE CANADIAN REFERENCE SYSTEM PRECISE POINT POSITIONING SERVICE. AVERAGE COMBINED SCALE FACTOR FOR PROJECT AREA IS 0.9995944.

BEARINGS ARE GRID, REFERRED TO THE CENTRAL MERIDIAN OF UTM ZONE 19 (69° WEST LONGITUDE).

DISTANCES SHOWN ARE EXPRESSED IN METRES AND ARE HORIZONTAL AT GENERAL GROUND LEVEL.

ELEVATIONS ARE ELLIPSOIDAL BASED UPON THE NAD83 (CSRS) DATUM.

ALL POSTS PLACED IN THE COURSE OF THIS SURVEY ARE MARKED WITH APPROPRIATE LOT NUMBERS, BLOCK NUMBERS, ROAD NUMBERS, THE YEAR 2008 AND 'R' FOR ROAD WHERE APPLICABLE.

GPS OBSERVATIONS WERE USED TO DERIVE THIS SURVEY.

ALL BOUNDARY DIMENSIONS ARE CALCULATED UNLESS SHOWN OTHERWISE.

COORDINATES FOR ALL BOUNDARY MONUMENTS AND FEATURE TIES ARE SHOWN IN THE SUPPLEMENTARY FIELD NOTES.

SURVEY REPORT AND SUPPLEMENTARY FIELD NOTES FOR THIS SURVEY ARE RECORDED UNDER FIELD BOOK 36765 CLSR.

CONTROL MONUMENT FOUND (80948 CLSR)	▲
C.L.S. '77 POST PLACED	⬡
C.L.S. '77 ROCK POST PLACED	⬡R
C.L.S. '77 POST FOUND	⬢
TRAVERSE LINES	— · —
LANDS DEALT WITH BY THIS PLAN ARE BOUNDED THUS	━━

GPS DENOTES GLOBAL POSITIONING SYSTEM CONTROL MONUMENTS AND CONTROL STATIONS.

CERTIFIED CORRECT

Llyd K Tayl, DATE 11/02/09
LLOYD K. TAYLOR, CANADA LANDS SURVEYOR

Lloyd K. Taylor
No. 1235

SURVEY AND PLAN ARE SATISFACTORY PURSUANT TO SECTION 29, CANADA LANDS SURVEYS ACT

Mar 13, 20 09
DARREN FLYNN
DIRECTOR, COMMUNITY PLANNING AND LANDS
FOR THE GOVERNMENT OF NUNAVUT

DEPARTMENT OF NATURAL RESOURCES
SECTION 29, CANADA LANDS SURVEYS ACT
CONFIRMED

David Rochette Mar. 18, 20 09
DAVID ROCHETTE, C.L.S., Q.L.S.
HEAD, NUNAVUT CLIENT LIAISON UNIT
CANADA CENTRE FOR CADASTRAL MANAGEMENT

REVIEWED BY
CANADA CENTRE FOR CADASTRAL MANAGEMENT
YELLOWKNIFE, NT

ITEM: 2008-20-078
FILE: SM8492-C/6
REVIEWED BY: JdA March 2/09

CANADA LANDS SURVEYS RECORDS 95514