Geotechnical Evaluation and Drainage Planning in Arctic Bay, Nunavut

Arctic Bay, NU

Final Report
REV-02

March 2023

Prepared for:
Government of Nunavut
Department of Community and Government Services

Prepared by:
Nunami Stantec Limited

Project No.: 144902983/144903266

NUNAMI STANTEC

Sign-off Sheet

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Abbreviations

bgs	below ground surface
CGS	Community and Government Services
CSA	Canadian Standards Association
DSM	Digital Surface Model
DTM	Digital Terrain Model
ESWG	Ecological Stratification Working Group
GN	Government of Nunavut
GSC	Geological Survey of Canada
MAAT	mean annual air temperature
MAGT	mean annual ground temperature
NISI	Northern Infrastructure Standardization Initiative
Nunami Stantec	Nunami Stantec Limited

Definitions and Terminology

Active layer – The top layer of ground that is subject to annual freezing and thawing in areas underlain by permafrost (Canadian Standards Association; CSA, 2014).

Catchment – The area which collectively drains to a specified outlet location.

Channel – A natural or apparently natural drainage feature with defined bed and banks and which conveys perennial, intermittent, or ephemeral flow.

Constraint – Naturally occurring features that have the potential to negatively affect the design, construction and maintenance of infrastructures. Examples of terrain constraints include slope steepness, drainage conditions, snow accumulation areas, steep bedrock ridges and ice-rich permafrost.

Cross Culvert – A culvert which conveys flow beneath a travelled road.

Ditch – A constructed or apparently constructed drainage feature with defined bed and banks and which conveys perennial, intermittent, or ephemeral flow.

Drainage flow path – A natural or constructed drainage feature which collects and conveys semi-concentrated flow, but does not have defined bed and banks.

Drainage Pathway – General term to describe drainage direction; includes overland flow, drainage draws, ditches, and channels.

Entrance culvert – A culvert which conveys flow beneath a driveway.

Existing developed areas – Existing built-up areas of Arctic Bay.

Geohazard – Features or terrain conditions having the potential to lead to localized or widespread damage to property and threaten personal safety. Examples of geohazards are ground subsidence related to permafrost thaw degradation, landslide, flooding and shoreline erosion.

Ground ice – A general term referring to all types of ice contained in freezing and frozen ground (National Standard of Canada 2017).

Overland Flow – Surface drainage occurring in a non-channelized, mostly evenly distributed manner over the land.

Permafrost - Defined on the basis of temperature: it is ground (i.e., soil and/or rock) that remains at or below 0 °C for at least two consecutive years (French, 2007).

Planned future subdivisions – Blocks 8, 9, and 10 within the Municipal Reserve (MR) Zones, as outlined and described in the RFP.

Watershed – Analogous to a catchment but often used for larger scale applications and/or referring to a large river or lake (e.g., the Meliadine River watershed).

1 INTRODUCTION

1.1 General

In 2020, Nunami Stantec Limited (Nunami Stantec) was contracted by the government of Nunavut (GN) – Department of Community and Government Services (CGS) to complete a geotechnical evaluation and drainage planning for the Hamlet of Arctic Bay, Nunavut.

This initial phase of work was completed based on Nunami Stantec's proposal No. 599783 dated April 9, 2020, which was filed under GN Standing Offer Agreement 2019-74 (GN contract #239688). A draft report (REV-01) corresponding to this initial phase of work was submitted to CGS on March 2021 (Nunami Stantec 2021). On March 15, 2022, CGS requested that Nunami Stantec submit a cost estimate to complete the above-referenced contract which geotechnical and drainage tasks had not been completed due to COVID-19 travel restrictions. The scope of work for this second phase of work was executed between June and October of 2022.

The current report therefore supersedes the March 2021 REV-01 report, and includes a combined summary of methodology, results and recommendations regarding the geotechnical evaluation and drainage planning completed for the hamlet of Arctic Bay, NU.

1.2 Scope of Work

As instructed in the Terms of Reference developed by CGS and subsequent proposals prepared by Nunami Stantec, the scope of work was twofold and included the following key objectives:

Geotechnical component:

- Conduct a geotechnical evaluation of the existing townsite and future development areas through visual observations and borehole investigations,
- Include assessment and mapping of surficial geology, slopes, drainage, permafrost and periglacial conditions,
- Have due regards for terrain-related constraints and landscape hazards, including the impacts of climate change on permafrost,
- Develop a construction suitability (or development suitability) map categorizing the study area as generally suitable, conditionally suitable or unsuitable for development, and
- Provide recommendations regarding site works and/or preparations required for future developments, especially for areas identified as conditionally suitable for development.

Drainage planning component:

- Evaluate the existing community drainage infrastructure and make specific recommendations regarding how local drainage can be improved,

- Inform on how drainage structures should be designed in future subdivisions,
- Specify recommended guidelines to account for the effects of a changing climate and permafrost regime with regard to drainage management,
- Describe practices for site and community planning that help to maintain the service life of community infrastructure, as well as the natural landscape processes through avoidance, mitigation and drainage system management practices, and
- Provide low cost, practical solutions that can be adapted and implemented given local constraints on capacity and resources.

1.3 Study Area

The Hamlet of Arctic Bay is known to the Inuit as *Ikpiarjuk*, “the pocket”, which refers to the way the community is surrounded on three sides by tall hills. The community faces southeast into Arctic Bay which in turn faces southwest to Adams Sound, off the coast of Admiralty Inlet on northern Baffin Island (Figure 1-1). The area is part of the Qikiqtaaluk region and according to the most recent census count by the Nunavut Bureau of Statistics (2016), the population of Arctic Bay was of 867 as of July 1, 2016 (an increase of 5.5% from the 2011 census).

The study area includes the existing townsite of Arctic Bay (i.e., the main concentrations of buildings) and the immediate environs. In the current context, the “immediate environs” refers to land that may be potentially developable for new subdivisions around the existing townsite within a twenty-year planning horizon. This includes planned future subdivisions (i.e., already surveyed lots) and future growth areas as identified on the Community Plan (No. 144-2011) and Zoning By-law (145-2011) in place for the 2010-2030 period (see Appendix G).

For description purposes, the study area is separated in a series of subdivisions referred as blocks. Of special interest regarding the development of future residential infrastructure are Block 2 to Block 5, as presented on Figure 1-1. Most of Block 1 is already developed and for this reason was targeted as part of the intrusive geotechnical assessment. As of 2022, only the lots within Block 2 and Block 3 have been surveyed.

Service Layer Credits: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

Legend

- Land_Parcels
- 🟥 Areas of Interest for Future Development
- ⊕ Completed Boreholes
- Contours (10m)
- Escarpment

0 250 500 metres

(At original document size of 11x17)
1:10,000

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

Client/Project
144902983-008 REVD

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
1-1

Title
Study Area

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2 METHODOLOGY

2.1 Desktop Terrain Assessment

Conducting a desktop terrain assessment provides key insights regarding overall site conditions, distribution of landforms and surficial materials, as well as natural processes operating a landscape. This assessment was initiated prior to the execution of the field program, which allowed for a more efficient planning and execution of field activities. The information summarized below was then reviewed using field data.

2.1.1 Background Data Review

Information collected through existing reports, historical data and published literature is summarized in the following sections. Key data sources include (but are not limited to) the following:

- Bedrock Geology (Turner and Kamber 2012)
- Surficial geology (Dyke 2000)
- Watershed Study (Land Data Technologies 2007)
- Permafrost, landscape hazards and potential effects of climate change (Ednie and Smith 2010,2011, 2015; Ford et al. 2006a, 2006b, 2008).

Additional reference and guideline documents accounted for as part of the geotechnical evaluation and drainage planning work include the following:

- CAN/BNQ 9701-500/2023 Risk-Based Approach for Community Planning in Northern Regions - Requirements and Guidance (National Standard of Canada 2023).
- CAN/BNQ 2501-500/2017 Geotechnical Site Investigations for Buildings Foundations in permafrost zones (National Standard of Canada 2017).
- CSA S503:20: Community drainage system planning, design, and maintenance in northern communities (CSA 2020).
- CSA S501-14: Moderating the effects of permafrost degradation on existing building foundations (CSA 2014).
- CSA PLUS 4011-19: Technical guide: Infrastructure in permafrost: A guideline for climate change adaptation. (CSA 2019).

2.1.2 Terrain Mapping

The mapping was conducted using ESRI ArcGIS and was carried out through the interpretation of the following data:

- 2006, 2017 and 2021 satellite imagery
- 2017 and 2021 Digital Surface Model (DSM) and Digital Terrain Model (DTM)
- 2022 Building footprint, infrastructure, and transportation vector datasets
- 2017 Hydrology (water bodies and watercourses) vector datasets
- 2017 Contours vector datasets

Drone-based imagery captured as part of the 2022 field program was also used to refine the terrain mapping. Mapping conducted to support the geotechnical investigation and drainage planning included the following:

Topography. Assessing the local topography was completed using the DSM, DTM and 1m contour data. Using this data, the landscape was segmented in predefined slope classes (0-5 %, 5-25 %, 25-50 %, 50-70 %, >70 %). Topographic cross sections of downslope gradients across areas of interest for new development areas were generated.

Watershed and drainage. Watershed and drainage features were first interpreted using the DSM/DTM, then refined using available satellite imagery, drone imagery and field observations. This task involved setting boundaries between inferred drainage zones to develop a map presenting the drainage flow directions. Hydrographic features were delineated from the interpretation of physical and vegetation indicators visible on the satellite imagery. This includes drainage pathways (i.e., general term to describe drainage direction; including overland flow, drainage draws, ditches, and channels) as well drainage draws (i.e., natural or constructed drainage features which collects and conveys semi-concentrated flow, but does not have defined bed and banks).

Surficial Geology. Regional mapping by Dyke (2000) was reviewed and used as a base to create an adapted surficial geology map of the study area. Relatively homogeneous terrain units (or polygons) were delineated on the basis of surficial materials, surface expression and expected depth to bedrock.

Terrain Constraints and Landscape hazards. Special attention was given to identify terrain constraints and landscape hazards (or geohazards) present within the study area, with focus on subject areas for consideration for future development. For this project, terrain constraints are interpreted as naturally occurring features that have the potential to challenge or negatively impact the design, construction and/or maintenance of a community (e.g., slope steepness, drainage conditions, surficial material type, presence of permafrost). In comparison, landscape hazards are terrain conditions that may lead to localized or widespread damage to property and threaten personal safety. Common examples include (but are not limited to) landslides, shoreline erosion and permafrost degradation.

Aside from the study area map (Figure 1-1), terrain figures produced as part of the assessment are presented in Appendix B.

2.2 Field Programs

2.2.1 Geotechnical Investigation Programs

Two field programs (2020 and 2022) were conducted to document terrain and geotechnical site conditions within the hamlet. Both programs focused on undeveloped residential areas located in Blocks 2, 3, 4 and 5 (see Figure 1-1). Municipal and industrial lots were not targeted as part of the drilling program. The initial geotechnical investigation field program was completed between November 14 and 18, 2020. The ground surface was snow-covered during the investigation, therefore observations related to drainage component was postponed to a later visit. This initial field program consisted of drilling boreholes using an air track drill rig which was owned and operated by Kudlik Construction Ltd. of Iqaluit, NU. The boreholes were advanced by percussion rotary air blast drilling method, with an approximate 203 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, the soil samples observed from each borehole were highly disturbed, greatly limiting observations for soil classification and observations related to ground ice.

Drilling locations were selected based on the findings of the desktop terrain assessment. A total of 12 boreholes were drilled to depths ranging from 9.2 m to 10.4 m below ground surface (bgs). Soil cuttings and drill response were used to the extent possible to identify subsurface conditions in general accordance with the procedures outlined in the attached explanatory key: Symbols and Terms Used on Borehole and Test Pit Records with soil descriptions prepared in accordance with ASTM D2487 and D2488. Samples were collected from the disturbed drill cuttings at regular intervals or when changes in the stratigraphy were noted. On completion, the boreholes were backfilled with available drill cuttings. Borehole locations were recorded using a handheld GPS, with corresponding elevations obtained from the DSM. Refer to Table 2-1 for coordinates and elevations of the boreholes.

A second field program was completed between July 16 and 22, 2022. Key tasks of this program included drilling shallow boreholes to further assess soils and near surface permafrost, and conducting visual observations to support the geotechnical assessment. The borehole drilling was limited to two locations within Block 2 (BH22-02 and BH22-03) and one location within Block 3 (BH22-01). The equipment used to drill those shallow boreholes consisted of a two-stroke engine mounted on aluminum drill rod extensions and a diamond carbide core barrel (40 cm-long and 10 cm in diameter).

The 2020 and 2022 borehole locations are tabulated in Table 2-1 and displayed on the figures presented in Appendix B. Boreholes records are presented in Appendix C.

Table 2-1 Borehole Locations and Elevations

Borehole No.	Block/Lot number[2]	Coordinates (UTM 83 Z16) Northing (m)	Coordinates (UTM 83 Z16) Easting (m)	Estimated Ground Surface Elevation[1] (m)	Depth Drilled (m)
BH20-01	Block 3/Lot 23	559308	8104992	52.03	10.2
BH20-02	Block 3/Lot 39	559295	8104833	44.54	10.2
BH20-03	Block 3 / Lot 11	559285	8104650	49.17	9.9
BH20-04a	Block 3 / Lot 6	559362	8104534	45.67	10.4
BH20-05	Block 2 / Lot 49	559588	8104385	30.08	10.2
BH20-06	Block 2 / Lot 64	559568	8104278	30.13	10.0
BH20-07	Block 2 / Lot 55	559640	8104246	23.93	10.1
BH20-08	Block 2 / Lot 14	559605	8104130	34.20	9.2
BH20-09	Block 4 / N.A.	560231	8105710	35.35	9.9
BH20-10	Block 4 / N.A.	560513	8105757	37.05	10.1
BH20-11	Block 5 / N.A.	560765	8105513	18.84	10.1
BH20-12	Block 5 / N.A.	560985	8105320	13.36	10.2
BH22-01	Block 3 / Lot 30	559359	8104619	40	2.1
BH22-02	Block 2 / Lot 52	559601	8104307	29	1.2
BH22-03	Block 2 / Lot 52	559612	8104307	29	0.9

NOTES:
[1] Ground surface elevation estimated from DSM data
[2] Unsurveyed or unlabelled lots are identified as "N.A."

2.2.2 Laboratory Testing

Samples recovered from the site were sealed in moisture tight bags and returned to the Stantec geotechnical laboratory in Edmonton for further visual classification and laboratory testing. Laboratory testing was completed on select samples (2020 program only) and limited to the following:

- Moisture content (or gravimetric water content) on all samples.
- Atterberg Limits on select fine grained samples.
- Grain size analysis (for coarse grained aggregates including sieve > 5 mm) on selected samples.

The results of the laboratory testing are summarized in Section 4. Moisture contents and Atterberg limit results are displayed on the borehole records and gradation curves are presented in Appendix D. No logs were produced for the shallow boreholes conducted as part of the 2022 field visit.

2.2.3 Development Suitability Assessment

The culmination of the geotechnical evaluation consists of a development suitability map, which assigns suitability classes to site-specific conditions. The development suitability classification used for the assessment is based on the recently published *Risk-Based Approach for Community Planning in Northern Regions* (National Standard of Canada 2023), then was adapted to the overall site conditions encountered within the study area. A summary of criteria used for assessing development suitability through the hamlet is presented in Table 2-2. Results of the assessment are summarized in Section 4, with figures presented in Appendix B.

Table 2-2 Criteria used for estimating development suitability.

Classes Conditions[1]
Terrain generally suitable for development (green areas[2]) - Permafrost with low to moderate ground ice content. - Well to moderately well drained soils[3]. - Flat to gently undulating topography (slopes under 10%). - Inactive or limited periglacial processes. No observed evidence of mass movement.
Terrain conditionally suitable for development (yellow areas[2]) - Permafrost with moderate ground ice content, may include areas of high ice content. - Permafrost features such as ice wedges may be present but not readily visible. - Moderately well drained to poorly drained soils[3]. - Drainage pathway visible. - Gently sloping topography (slopes between 10 and 20%). - Site showing limited evidence of past mass movements. - Site is adjacent to an area presenting unsuitable conditions.
Terrain unsuitable for development (red areas[2]) - Permafrost with elevated ground ice content. - Confirmed presence of massive ice. - Observed indicators of unstable terrain (e.g., ground settlement, thermokarst development, thermo-erosion, gully erosion, landslide). - Poorly drained to very poorly drained soils[3]. - Soil surface erosion and gullying. - Slopes > 20%. - Thick organic soils. - Snow drifting and/or snow accumulation areas. - Site showing active evidence of mass movement. - Areas susceptible to flooding.
NOTES: [1] What is considered “generally suitable” for one type of infrastructure or land may be “conditionally suitable” for a different type of infrastructure or land use. The same is applicable to “conditionally suitable” or “unsuitable” classes. [2] Refers to color-coded units displayed on the development suitability map located in Appendix B. [3] Drainage classes derived from the Canadian Soil Information System (Expert Committee on Soils Survey 1982).

2.3 Drainage Assessment and Planning

In northern communities, surface drainage issues during the short summers and spring/fall shoulder seasons are often a challenge. Typical drainage issues include road washouts after extreme rainfall events, water ponding, culverts with reduced capacity, and obstruction/overflow of ditches with poor definition and/or insufficient depth.

The CSA, through the Community Drainage System Planning, Design, and Maintenance in Northern Communities (CSA 2020), indicates that a drainage analysis should have due regard for a number of interconnected factors, including existing surface drainage infrastructure, climate data, site inspection data, bedrock and surficial geology , topographic data, permafrost features, hydrologic data (e.g., catchment area and drainage patterns), geotechnical investigation and available plans for future development. The activities and expectations of the local community, as well as overall public safety, should also be taken into account when performing drainage assessment and planning.

The drainage assessment and planning component of this project generally followed the guidance and protocols from Clause 4 of CSA (2020). As stated in CSA (2020), under ideal circumstances, drainage system planning and design using the CSA (2020) standard is completed in advance of development. The assessment methodology applied to both the existing developed areas and the planned future subdivision is presented below.

2.3.1 Existing Developed Areas

The following was completed during the field inspection:

- Meeting with John Hussey (SAO Hamlet of Arctic Bay) and Sam Willie (Public Works Foreman, Hamlet of Arctic Bay) to identify locations and details of areas which have demonstrated notable drainage issues in the past, and where the Hamlet of Arctic Bay and/or Government of Nunavut (GN) would like specific recommendations for improvement. Within this report, these areas are referred to as “Identified Drainage Problem Areas”, or IDPAs.
- Assessment of factor(s) impacting site conditions at IDPAs.
- Completion of an inventory of culverts, ditches (constructed) and channels (natural) present within the study area, with compilation of the following information:
    - Street that the culvert crosses under
    - Location (northing/easting, referenced to NAD83 UTM Zone 16)
    - Type (entrance or cross culvert)
    - Shape (circular, box)
    - Material (e.g., corrugated steel pipe (CSP))
    - Diameter (in mm)
    - Crushing of culvert ends (yes/no)
    - Infilling of culvert barrel with sediment (depth of sediment in mm)
    - Site photographs including (but not limited to) upstream end of the culvert facing upstream, upstream end of the culvert facing downstream, downstream end of the culvert facing upstream, and downstream end of the culvert facing downstream
    - General observations regarding upstream and downstream ditch and embankment conditions

Using the data collected during the field inspection, the following were measured, calculated, or determined:

- Approximate culvert length (in meters, measured in ESRI ArcGIS from available imagery)

- Culvert condition ratings for five different categories as detailed in Table 2-3. This assessment is based on general assessment methods from CSA (2020) and a modified version of MTO (2013) to suit the project objectives and infrastructure types found in Arctic Bay
- Assignment of a Priority levels for remediation (high, medium, low).

Table 2-3 Culvert Rating Methodology (modified from MTO 2013)

Category	Rating Methodology
Material - Metal Culverts	0 - New condition, may also exhibit slight discoloration of surface, galvanizing partially gone along invert. 1 - Discoloration of surface, galvanizing completely gone along invert but no layers of rust. Minor pinholes in pipe material located at end of pipe but not located beneath roadway. 2 - Layers of rust forming. Sporadic pitting of invert, minor pinholes forming throughout pipe. 3 - Heavy rust, thick scaling throughout pipe. Deep pitting, perforations throughout invert. 4 - Extensive Heavy rust, extensive perforations throughout pipe. End sections corroded away. Bottom portion completely corroded exposing underlying granular. Partially to fully collapsed. Priority levels for remediation: High: 3-4 Medium: None Low: 0-2
Shape	0 - Smooth curvature in barrel. Span dimension within 3% of design. 1 - Smooth curvature in top half of barrel with flattening on bottom portion. Span dimension up to 5% greater than design. 2 - Slight distortion in one location on the top portion. Bottom has slight reverse curvature in one location. Span dimension up to 10% greater than design. Nonsymmetrical shape. 3 - Significant distortion throughout length. Lower 1/3 may be kinked. Span dimension up to 15% greater than design. 4 - Extreme deflection at isolated locations. Flattening at top of arch or crown. Bottom has reverse curvature throughout. Span dimension greater than 15% of design. Extremely non-symmetrical. Priority levels for remediation: High: 3-4 Medium: None Low: 0-2
Capacity	0 - Little to no sediment build-up in pipe. Culvert ends are undamaged. Little to no debris blocking flow. 1 - Minor debris and sediment, less than 30% blockage. Possible infiltration of fine roots. No evidence of flooding of roadway or adjacent land. 2 - Major debris and sediment more than 30% blockage, flooding of roadway and/or adjacent properties. Possible infiltration of tap roots causing major flow restriction. Priority levels for remediation: High: 2 Medium: None Low: 0-1
Erosion and Scour	0 - Embankment, slopes at culvert outlet are intact and stable. 1 - Minor erosion of embankment, slope, or at culvert outlet less than 100mm around ends. Still protected or well vegetated. 2 - Major erosion of slope, embankment, or at culvert outlet greater than 200mm around culvert ends, guardrail displaced / settled, posts loosened / separated from soil. Priority levels for remediation: High: 2 Medium: None Low: 0-1

Category	Rating Methodology
Upstream and Downstream Channel	0 - No evidence of channel bed or bank erosion. Intermittent patches of grass and exposed earth. 1 - Minor channel erosion. Minor damage to channel protection. 2 - Bank protection eroded. Bank protection debris causing blockage and more significant channel erosion. Channel alignment causing scour holes, bank erosion, and is threatening end treatment. Major erosion of channel. Priority levels for remediation: High: 2 Medium: None Low: 0-1

Using the above-listed data, figures presenting existing drainage infrastructure were produced. The figures are accompanied by a detailed culvert inventory (Appendix E) and by text summarizing the general drainage conditions in the developed areas of Arctic Bay.

Based on the general drainage conditions and comparisons to established industry standards, a series of community-wide recommendations were developed to improve the existing drainage system. At IDPAs, specific recommendations were provided to address the specific cause of the drainage issue(s). These recommendations are summarized in tabular format, with figures to assist with their interpretation.

2.3.2 Drainage Planning in Future Subdivisions

Although development may be envisioned in the future within Block 4 and Block 5, the key areas of interest for future developments consist of Block 2 and Block 3, where main access roads have been constructed (but not necessarily completed) and property lots have already been surveyed.

During the field assessment, the preliminary catchments from the desktop terrain mapping were ground-truthed to confirm their locations. Overland drainage pathways and drainage channels/ditches were documented, and existing culverts were identified and characterized using the protocol outlined above.

Surrounding drainage infrastructure were identified to inform inflows to the development block(s), and potential outfall locations from the development block(s) were identified. Low-lying areas prone to seepage, ponding or soil surface erosion, wherever present, were observed to supplement the geotechnical investigation of development suitability.

A proposed conditions drainage plan was developed consisting of general development block grading and overland flow direction, constructed channels/ditches and culverts.

3 SUMMARY OF SITE CONDITIONS

3.1 Regional Setting

Arctic Bay is located on the northeast coast of Baffin Island, within the Qikiqtaaluk region of Nunavut. The area is part of the Davis physiographic region of Canada as described by Bostock (2014). Lands surrounding Arctic Bay are part of the Borden Peninsula ecoregion, which covers north-central Baffin Island and the southwestern coast of Bylot Island. The area is characterized by plateaus and valleys, in places dissected by deep fjords, inlets and bays. The landscape surrounding the community consist of a south-oriented bay (Admiralty Inlet) surrounded by steep escarpment to the north, east and west. Above from the escarpment is a flat to gently undulating bedrock plateau which elevation averages approximately 180m above sea level (asl). The community itself sits at the base of the escarpment slope surrounding the bay, occupying the shoreline area and extending inland to elevations not exceeding 40 m asl.

3.2 Bedrock Geology

Baseline information on bedrock geology is available from maps by the Geological Survey of Canada (GSC) (de Kemp et al. 2006) and technical publications by Jackson and Iannelli (1981), Turner (2009) and Turner and Kamber (2012). The study area is located within the Borden Basin on northern Baffin Island. Bedrock associated to the Borden Basin is Precambrian in age (more precisely Mesoproterozoic; 1,600 to 1,000 million years ago). The community of Arctic Bay is surrounded by bedrock from two distinct formations referred as the Arctic Bay and Society Cliffs Formations.

The Arctic Bay Formation outcrops over most of the southern basin area and consist predominantly of pyritiferous shale with siltstone and quartz arenite interbedded with shale in the lower part of the formation, and siltstone, dolostone and quartz arenite interbedded with shale in the upper part (Jackson and Iannelli, 1981; Turner 2009). The formation was described as 180 m thick at Arctic Bay (although reaching over 600 m throughout most of the region). Fragmented shale bedrock is commonly used as construction material (both for road embankment and building pads) within the hamlet. Exposures of shale bedrock are visible at the quarry site (western part of the hamlet), as well as along an escarpment located behind from the row of houses (north from Road R54).

The overlying Society Cliffs Formation is dominated by gray dolomite. Interbedded with the dolomite are lesser amounts of quartz arenite, arkose, shale, and gypsum (Turner 2009). The formation is exposed above from the hamlet, along the steep escarpment marking the crest of the slope along the eastern part of the hamlet. There is currently no quarry allowing for the extraction of dolomite rocks in Arctic Bay.

Overview pictures of both formations are showed below (Figure 3-1)

A map displaying regional bedrock geology is presented in Figure B-1 (Appendix B).

Figure 3-1 (A) Bedrock of the Arctic Bay Formation and (B) Society Cliffs Formation

3.3 Climate

Climate in Arctic Bay is typical of the high arctic ecoclimate. Summers are relatively short, cool, and moist while winters are long and extremely cold. This ecoclimate is supporting a very sparse vegetative cover of moss and mixed low-growing herbs and shrubs. The vegetation cover is generally higher on wetter sites, along streams, rivers and drainage draws. Regosolic Turbic Cryosols and Regosolic Static Cryosols are the dominant soils types (Ecological Stratification Working Group) (ESWG, 1995).

Historical climate data is available from the Nanisivik airport, located on an exposed plateau (642 m asl) some 20km east from Arctic Bay.

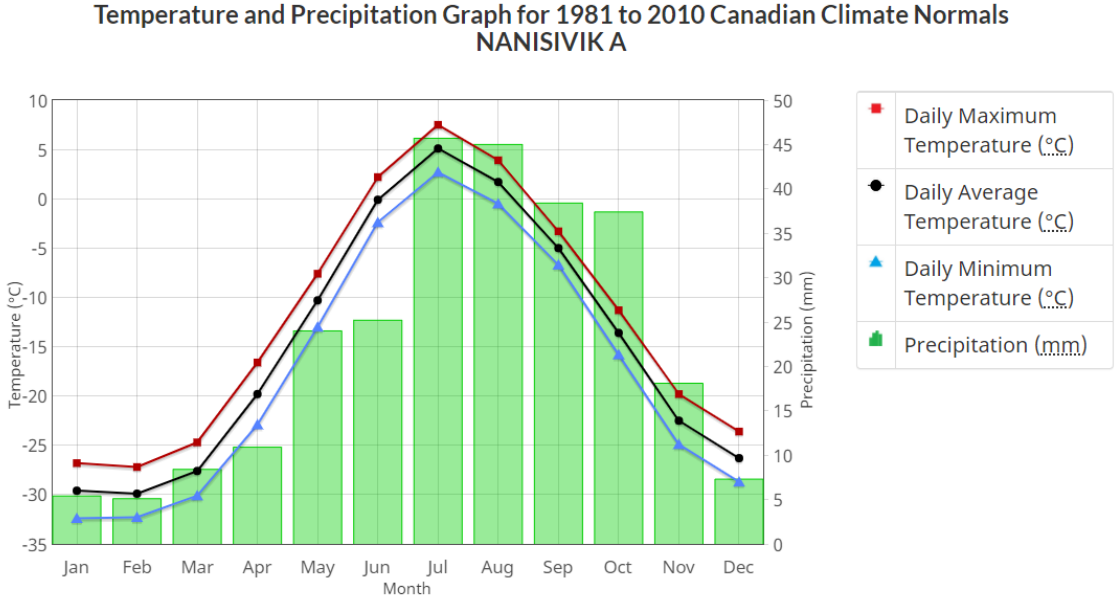

Figure 3-2 shows climate normal for the 1981 to 2010 period. Based on tabulated data available from Environment Canada website[1], the monthly mean, daily maximum and daily minimum temperatures in February were - 29.9°C, -27.2°C, and -32.3°C respectively. Similar temperatures values for the month of July were 5.1°C, 7.5°C, and 2.7°C, respectively. The mean annual air temperature (MAAT) was -14.8°C. Extreme maximum and minimum temperatures were 18.5°C and -53°C. Total annual precipitation was of 270.9 mm, with an annual rainfall volume of 77.3 mm and a snowfall accumulation of 191.3 cm.

In 1999, a weather station was installed at the new airstrip located about 6.5 km southeast of the community at the airport (31 m asl). The MAAT calculated at the Arctic Bay airport station for the 1999-2008 period was of -15.9ºC, and of -12.5ºC for the 2009 to 2019 period (Environment Canada 2020). In 2020, the MAAT was of -12.8ºC. The average daily maximum, mean, and minimum temperatures in February were -30.5°C, -28.9°C, and -38.4°C respectively. The values for the month of July were of 7.8°C, 11.3°C, and 4.3°C respectively. Extreme maximum and minimum temperatures in 2019 were of 17.4°C and -42.0°C respectively. Unfortunately, limited information appears to be available on precipitation from the Arctic Bay airport station.

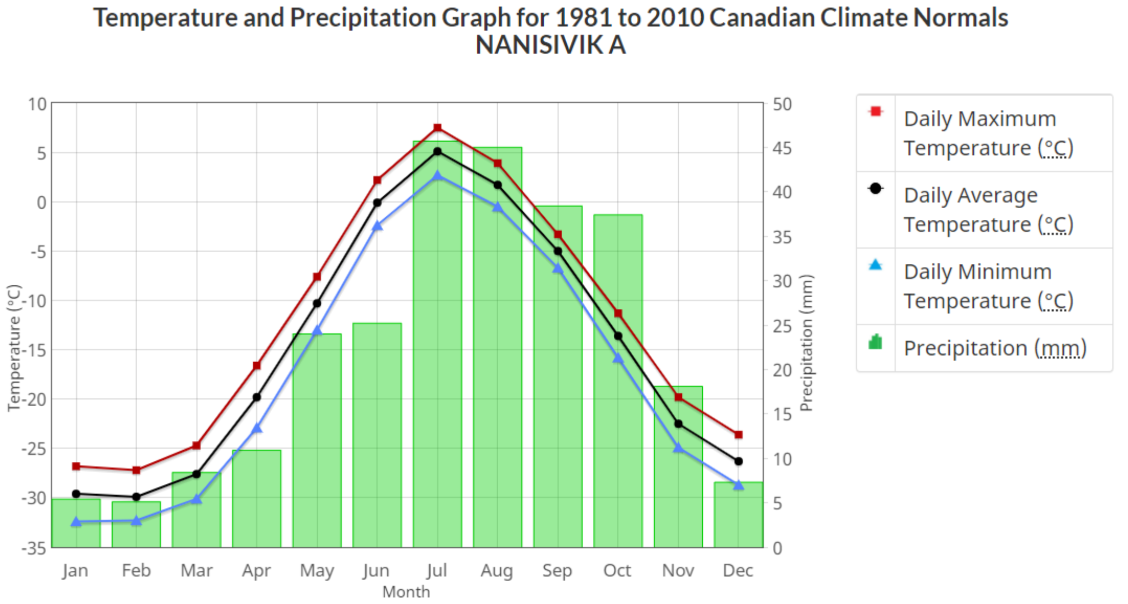

Figure 3-2 Nanisivik Temperature and Precipitation (1981-2010)

SOURCE: Environment Canada

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[1] https://climate.weather.gc.ca/climate_normals

3.4 Topography

Within the developed portion of the community, ground elevations range from sea level along the shoreline, to a maximum of approximately 55m asl along the newly constructed road present in Block 2 (i.e., Road R75). Around the community, the terrain gradually climbs until reaching the undullating plateau overlooking the bay, with elevations averaging 180m asl.

Most of Arctic Bay was developped on south and east facing slopes ranging from near-planar (0-5%) to approximately 15%. Shorth steep slopes, some in excess of 25%, are found locally throughout the community (e.g., alongside building pads, road embankments or road cuts, along the shoreline). Upward from the community, the colluvial and bedrock slope progressively steepens until reaching grades in excess of 70%. Near vertical bedrock escarpments are found near the crest of the escarpment.

The slope gradients observed within the undisturbed terrain matching the proposed new subdivision area of Block 2 and Block 3 mostly average 10 to 15%, with a maximum of approximately 25%. In Block 4 between the community and the industrial area, the slope average 15 to 20%. Figure B-2 (Appendix B) illustrates the dominant slope classes present throughout the hamlet and surrounding areas. Topographic cross sections representative of downslopes gradients across areas of interest for new subdivision areas are also presented.

3.5 Watershed and Drainage

Background information on watersheds is available from data developed by Land Data Technologies (2007). Watershed delineation polygons were reviewed using satellite imagery and topographic data received from CGS. Minor adjustments were made along some of the watershed boundaries. The delineation of waterbodies, watercourses and apparent drainage draws was further refined based on field observations.

A watershed map is presented in Figure B-3 (Appendix B). Drainage characteristics are discussed in Section 5 (Drainage Assessment and Planning).

3.6 Surficial Geology

Regional surficial geology mapping is available for Nunavut (Gilbert et al. 2006). Additional mapping for the Arctic Bay and northwesternmost Baffin region (1:250,000 scale) is available through mapping by Dyke (2000). No large-scale mapping presenting terrain conditions within the community and immediate surrounding area was available for the area. The above-cited maps were used as baseline data in support of additional terrain mapping and was complemented with the interpretation of satellite imagery and topographic data.

The terrain mapping conducted for the project indicates that the most common surficial materials identified within the study area consists primarily of till, weathered bedrock and colluvium, and in lesser proportion, fluvial, organic and glaciofluvial deposits. Marine deposits are expected to be present at low elevations, potentially at depth.

A summary of the surficial materials present within the study area is presented below. Comments on the expected drainage conditions (i.e., during the thawing season) of each material types are provided. Refer to the surficial geology map presented in Figure B-4 (Appendix B) for the distribution of these materials.

Till (morainal material). Till deposits consist of material deposited in subglacial and/or ice marginal environments. Typically, till deposits consist of well to moderately compacted material that is non stratified and contain a heterogeneous mixture of particle size comprised in a matrix of sand, silt and clay. Till deposits documented in the general area of Arctic Bay are classified by Dyke (2000) 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”.

Terrain mapping and field observations conducted as part of the site visit suggest that of the thickness of the till material varies greatly, from a thin veneer (< 1m) along the western portion of the hamlet to a thick blanket several meters thick in the eastern portion. Drainage conditions in till deposits generally range from imperfectly to moderately well drained.

Colluvial deposits consists of accumulations of unconsolidated material that result from mass movement processes. These materials consist predominantly of dolomite bedrock fragments of the Society Clifts Formation, as well as reworked till which position and/or properties have been modified by slow gravitational processes. The blocky, bedrock-derived colluvial deposits are expected to be limited to the moderate to steep slope segments found upward from the developed portion of the community. At lower elevation towards the developed portion of the community, colluvial material, are fine-grained due to the presence of weathered shale along the lower portion of the Arctic Bay Formation. Similarly, colluviated till deposits found around the mid-slope surrounding the community is expected to be fine-grained. Drainage of colluvial deposits is expected to vary depending on the texture of the material; from well to rapidly drained in coarse deposits, to moderate and poorly drained in fine-grained deposits.

Alluvial (Fluvial) deposits are the result of transportation and deposition of material by streams and rivers. Significant fluvial deposits are absent of the study area, with only minor deposits occurring as thin veneers (i.e., < 1 m) overlying till, for example at the bottom of some of the small drainage channels punctuating the developed portion of the community. The material consists of sand and gravel, with variable amounts of silt. Drainage conditions within these deposits varied considerably from rapidly to poorly drained.

Glaciofluvial deposits are the result of transportation and deposition of material by glacial meltwater streams. They occur as outwash deposits and terraces and are mainly 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. Glaciofluvial deposits are generally well drained.

Organic materials are generally found in wetlands and other poor drained areas. Organic-rich soils were primarily observed overlying till in the area identified as Block 2 as well as in the low-lying terrain located downslope from the lagoon 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. Thick and healthy moss cover is usually a good indicator of an elevated water table within a potential seepage zone.

Marine deposits were not delineated on the surficial geology map, nor were encountered as part of the field programs; however, are expected to be found along the low-lying terrain surrounding the bay. This material is typically fine-grained.

3.7 Granular Aggregate and Quarry

The following is a summary of information gathered from background documents, complemented with terrain mapping observations.

- Well-graded sandy gravels associated to fluvial/glaciofluvial deposits in the vicinity of the airport are understood to be the main source of granular aggregate materials for the community. Deltaic and raised beach materials are also found in the area. This material was reported to range from gravel with sand to sand with gravels (minor fines) (Amec 2003). Based on limited indirect evidence such as satellite imagery interpretation and general geological considerations, significant quantities of materials are assumed to be present in the area.
- Mud shale is understood to be available from a quarry located in the western portion of the community (vicinity of Block 2). This material was reported to be relatively soft, can be dug with an excavator when unfrozen and does not require crushing. The material is used for surfacing some of the community roads, including the new access roads located within Block 2 and Block 3.

Photographs of granular aggregate source and quarry are presented in Figure 3-3 below.

Figure 3-3 Granular aggregate (left) and quarry material (right) in Arctic Bay

3.8 Permafrost

Arctic Bay is located within the continuous permafrost zone, an area where permafrost is assumed to underlie 90 to 100% of the ground surface (NRC 2009). Permafrost likely extends several hundred meters below the ground surface in this area. Based on regional permafrost mapping, the ground ice content is generally medium in the area (i.e., 10-20% per volume in the first 10 to 20 m of below the ground surface), including features such as ice wedges and massive ice bodies.

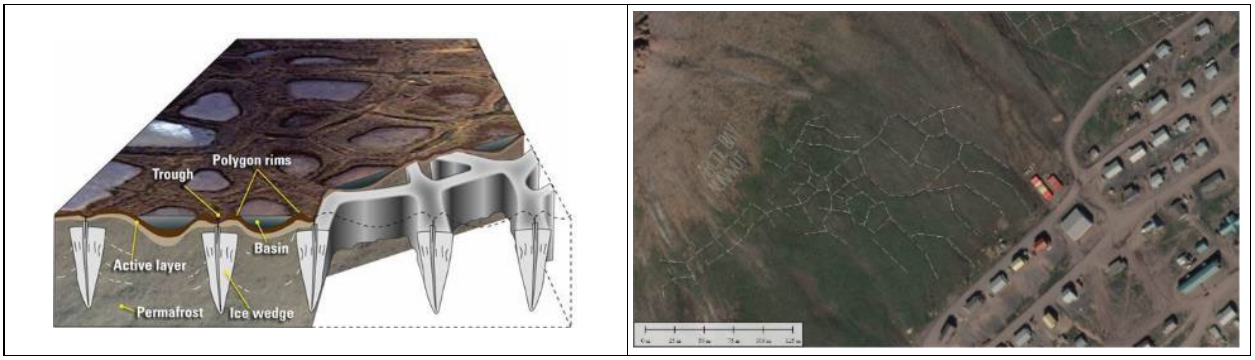
3.8.1 Ground Ice and Patterned Ground

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 (Mackay 1990). The yearly repetition of this process facilitates the creation of ice wedges that form huge polygonal networks throughout periglacial landscapes.

Figure 3-4 presents a schematic illustration of a network of ice wedges.

Networks of ice wedges were identified along the slope marking the perimeter of the developed portion of the community and areas surrounding existing buildings. Wedges are predominant on the hillslope above Block 4 and undeveloped sectors of Blocks 2, 3 and 5. Based on existing literature, hillslope ice wedges can reach several meters in width and depth (Mackay 1995).

The locations of suspected ice wedges are displayed on the landscape hazard and land development suitability map presented on Figure B-5 (Appendix B).

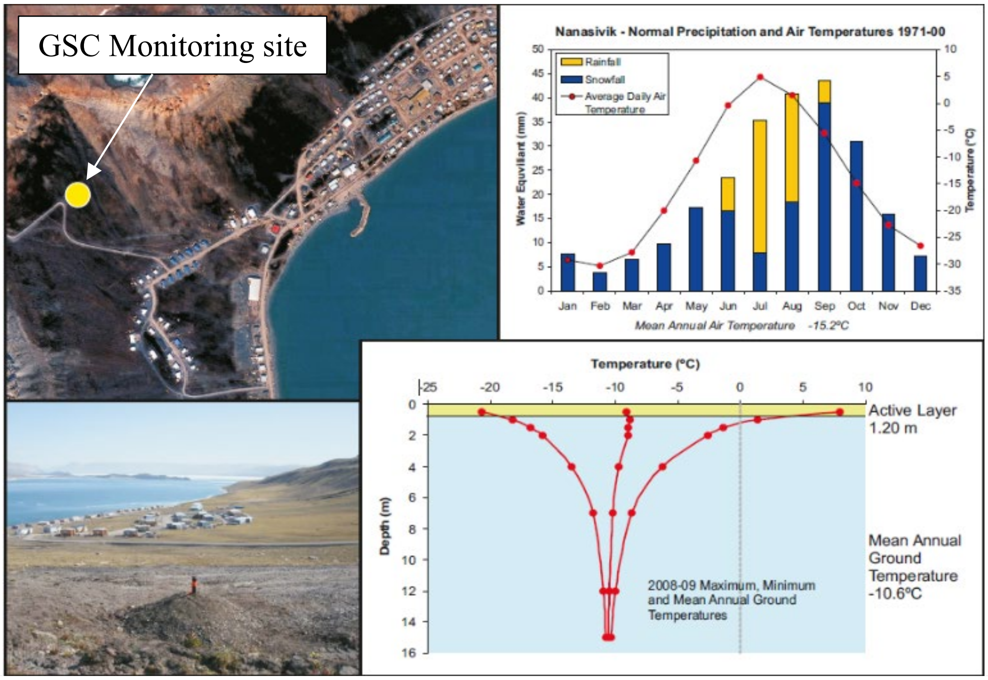


Source: R. Mitchell/Inkworks for U.S. Fish and Wildlife Service

Figure 3-4 Schematic Illustration of a Network of Ice Wedges

3.8.2 Ground temperature

The GSC, through collaboration with CGS and the Nunavut Department of Environment, has developed a ground temperature monitoring network in Nunavut, including in the community of Arctic Bay. Information on local permafrost ground temperature has previously been presented by Ednie and Smith (2010, 2011, 2015) and Smith et al. (2013). The data is associated to an instrumented 15m deep borehole located alongside the access road leading to the Nanisivik mine, approximately halfway between the community and the location of the freshwater intake source (see Figure 3-5). Surficial materials in the area consist of a till blanket overlying shale bedrock. Ground temperature data for the August 2008 to August 2013 period indicate an average active layer thickness of 1.2 m, and an average ground temperature of -10.3°C at a 15 m depth. The mean annual ground temperature (MAGT), which correspond to the depth of zero annual amplitude, is assumed to be slightly colder at -10.6°C. Based on data presented by Ednie and Smith (2015), permafrost temperatures recorded at 15 m depth have increased at an average rate of 0.17°C per year since the beginning of the monitoring program in 2008/2009.



SOURCE: Smith et al. 2013

Figure 3-5 Air and Ground Temperature Data

3.9 Landscape Hazards and Vulnerability to Climate Change

Warming in the Canadian Arctic has remote northern communities facing a number of challenges. These changes are affecting both infrastructure and livelihoods of northern communities. Assessments of landscape hazards and potential effects of climate change in Arctic Bay is available through publications by Ford et al. (2006a,b; 2008).

The findings of the terrain mapping identified four main hazard types: permafrost degradation, slope instability, soil surface erosion and coastal erosion.

3.9.1 Permafrost Degradation

Permafrost is an important component of the Arctic landscape, influencing hydrological systems and ecosystems, which presents challenges to infrastructure development. Melting permafrost can result in changes to ecosystems as well as infrastructure stability. Melting or warming permafrost can lead to slope instabilities, softening foundations under infrastructure and a shortened season for land transportation over winter roadways. The impacts of climate change to permafrost are of concern because of how these changes impact the ability of land to support buildings and infrastructure.

Drivers of permafrost and active layer changes are multiple and often strongly interrelated. Increasing air temperature plays a dominant role in triggering changes in near surface permafrost properties, followed by other climatic factors such as increase rain and snow precipitation. A direct impact of permafrost warming is a deepening of the active layer and thawing of near surface permafrost ground ice. The loss of volume caused by the melting of ground ice then generates differential settlement. Permafrost degradation may adversely affect some building foundations (e.g., settlement and cracking) and cause localized settlement and subsidence along roads. The magnitude of thaw settlement depends on several factors; however, most directly related to the type of soils and ice content of the local permafrost (i.e., the greater the ice content, the greater the extent of degradation and settlement).

3.9.2 Slope Instability

Evidence of slope instabilities are present within the study area, both within the developed portion of the community and along the slopes backing the general bay area. These features include rapid mass movements such as active layer detachments, small debris slides, debris flows and rock falls, as well as slow mass movements such as solifluction or frost creep. While some of these features are expected to be old and inactive (some likely predating the initial establishment of the community), some are recent and are impacting the stability of existing infrastructures (e.g., a small landslide occurred behind the recently built power plant in 2022). Changing conditions triggered by climate change (e.g., increase freeze thaw cycles, increase rainfall or storm events) have the potential to initiate or exacerbate slope instabilities.

Active layer detachments and rockfalls: Active layer detachments consist of shallow translational landslides that develop in thawing soils overlying permafrost. Their development involves a reduction in effective stress and strength at the contact between a thawing overburden and underlying frozen material. Active-layer detachment slides can occur in response to high seasonal air temperature, summer rainfall events, rapid melting of snow cover, as well as a response to surface disturbances (Lewkowicz 1992).

Review of satellite imagery suggest that most landslides affecting unconsolidated sediments in and immediately around Arctic Bay have initiated as active layer detachments, with some features that have developed in a range of morphological types including slides and debris flows.

Landslides that have developed along the mid to upper slopes surrounding the community have an elongated morphology which in places is confined in a well-defined channel. These failures generally show a curved scar at their headwall, a fairly straight channel and a debris fan at their toe. A landslide is visible along the slope backing the Taqqut Inns North hotel. The feature measured 50 m long by 30 m wide for an approximate displaced volume of 200 m^3. The landslide is understood to have occurred sometime between 2006 and 2009 and is suspected to have initiated due to ground disturbance (excavations) along the access road leading to the hotel parking lot.

Fragmental rockfalls are also expected to occur, mainly along the uppermost section of the hillslopes where the accumulation of blocky material was observed from satellite. Comparing the location of these deposits to slope inclination data available from the DEM indicated that the lower limit of the rockfall run-out zone was found to average ~50% slope (~26 degrees), matching theorical relationship between slope angle and rock fall behavior (Hungr and Evans 1988). No rockfall debris were identified within the developed portion of the community, however, the uppermost portion of Block 3 (Figure 3-6) was found to be located within 150 m of slopes segments presenting rockfall hazards. Other shallow landslide deposits are visible above from Block 4.

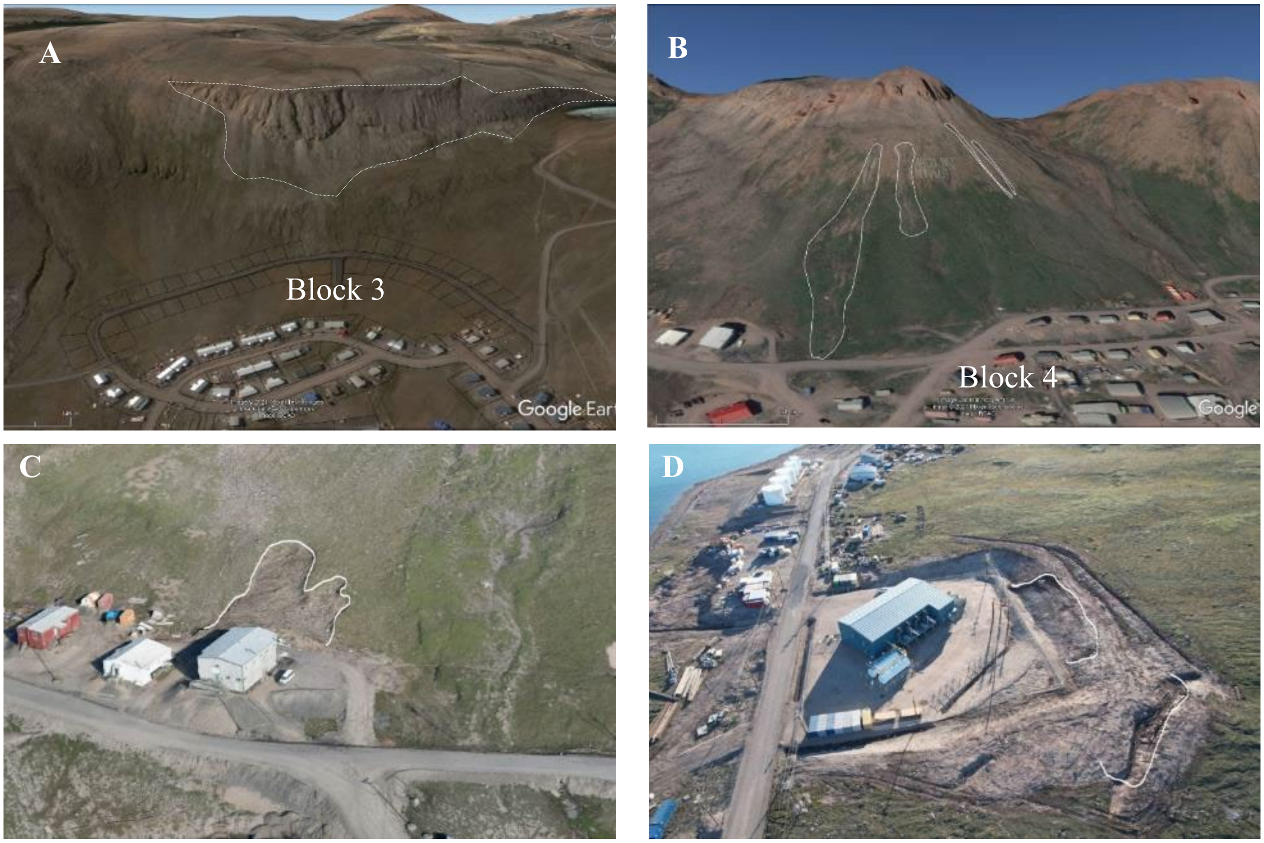


Figure 3-6 (A) Rockfall and (B) Active Layer Detachments upslope from the Community; (C) landslide behind the Taqqut Inns North hotel and (D), unstable terrain behind the power plant

Solifluction (frost creep): Periglacial solifluction is a form of slow mass movement controlled mainly by frost creep which results from combined thaw settlement and sliding on slopes under gravity; it is directly related to the content in segregation ice and to water supply during the thaw (Benedict 1976). Common resulting feature is the formation of solifluction lobes; generally consisting of smooth, elongated to stepped features ranging in size from a few decimeters to a few meters in length and width.

Evidence of solifluction in the Arctic Bay area are present along various slope segments surrounding the community, including upslope from Blocks 2, 3, and 5 (see examples on Figure 3-7). A review of satellite imagery and DSM data suggests that solifluction is predominant along south- to southeast-facing slopes averaging 20%, where surficial materials consist of imperfectly to poorly drained till or colluviated till. Solifluction within the angular colluvial debris present immediately below bedrock escarpments was also noted.

Field observations made in 2022 confirmed the widespread occurrence of solifluction and frost creep within hamlet, both along undisturbed slope segments and areas where development took place.

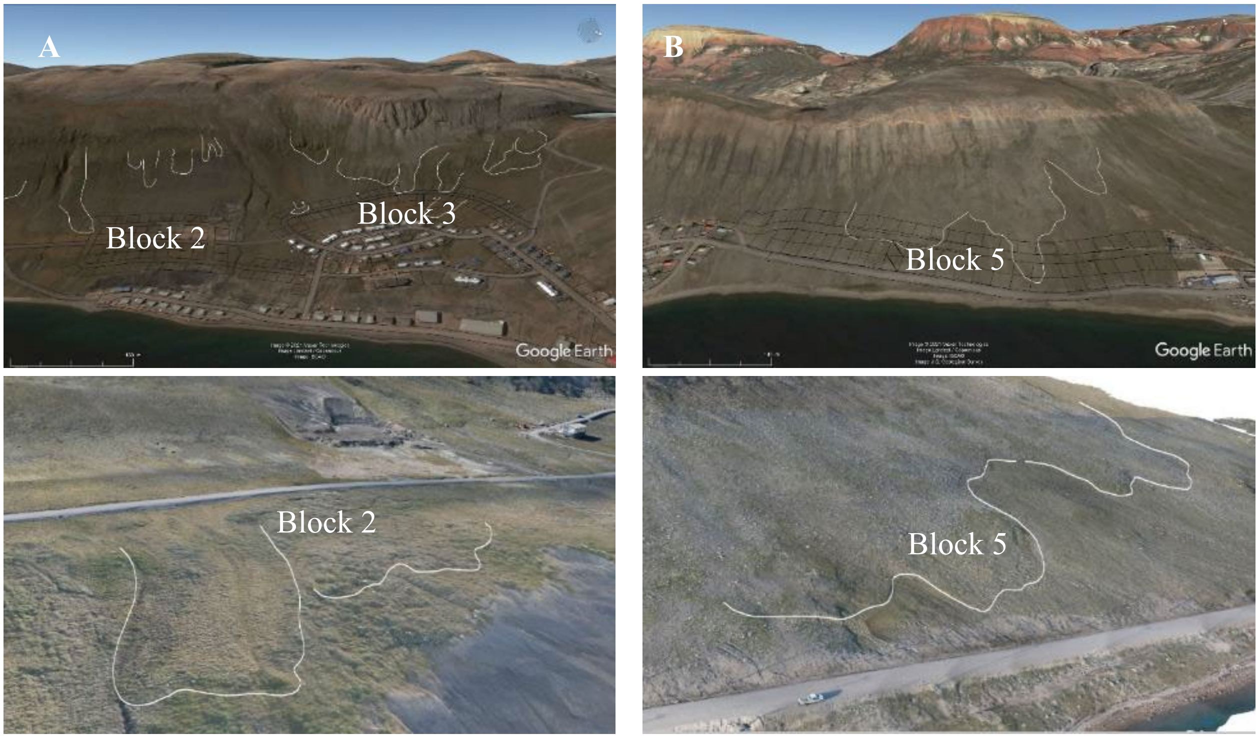


Figure 3-7 Solifluction Lobes Upslope from Blocks 2 and 3 (a), and Block 5 (b)

3.9.3 Soil Surface Erosion

Spring snowmelt runoff and summer-fall drainage issues appear to be a persistent seasonal hazard for the community. Gullies resulting from the incision of running water in both soils and weathered bedrock form a persistent feature in the landscape. The slopes surrounding the bay are punctuated by intermittent streams and other drainage draws directing water towards the sea. In some areas, runoff is concentrated in deep gullies (e.g., between Block 2 and Block 3), or along poorly developed channels and ice wedge troughs (e.g., above from Block 4), delivering discharge flows into the community. Rapid snowmelt and extreme rain events have the potential to overwhelm local drainage infrastructures, causing localize ponding, surface erosion and washouts.

The terrain mapping indicated that gullies are present throughout the study area, both along the moderately to steeply sloping hillsides surrounding Arctic Bay, as well as along gentle slopes present within the developed portion of the community. The two most important gully systems run on either side of Block 2 (Figure 3-8a). Peak drainage discharge and shallow landslides initiating in or entering these gullies may pose a hazard to local infrastructures (including roads, buildings and drainage structures).

Examples of erosion features are provided on Figure 3-8 below.

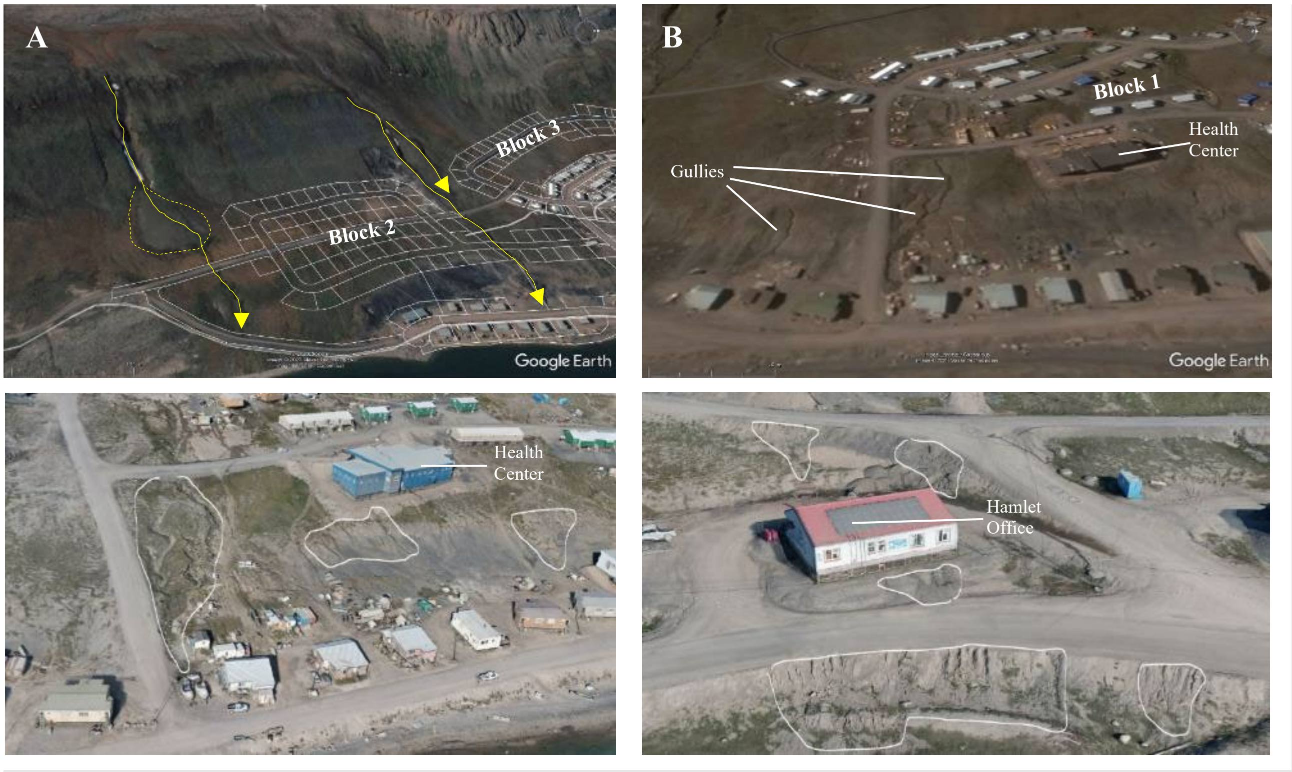


Figure 3-8 Example of areas impacted by seepage, erosion and gullying

4 GEOTECHNICAL INVESTIGATION

4.1 Site Conditions and General Field Observations

Block 2 was accessed via the existing gravel road (R69) connecting the community to the shale quarry and cemetery further north. Lots located on the west (uphill) side of the existing road were observed to have natural grade averaging 5 to 10% slope. Along the uppermost row of lots projected for Block 2, the terrain has an average slope of 15%, then progressively increasing as the terrain climb towards the steep bedrock escarpment surrounding the community. East (downslope) of Road R69, the natural grade was estimated at 10%, until reaching a much steeper cut slope (30 to 45%) assumed related to historical borrow material sourcing and excavation and grading along the edge of the bay (i.e., areas downslope of BH20-05 and BH20-07). Immediately west of lots 25 and 26, the presence of a small rock (shale) quarry was observed. A review of available satellite imagery suggested that material excavations initiated sometime around 2011.

Field observations conducted during snow free conditions in the summer of 2022 showed the soils in the southern portion of Block 2 to be poorly imperfect to poorly drained. Seepage was observed coming from the escarpment area and waterlogged soils, often organic-rich, located to the north of gravel road (Road R69). Discussions with hamlet officials suggested that this section of road has significantly subsided since its construction about ten years ago. Ice wedges and solifluction lobes initially identified as part of the desktop mapping were observed in the field, primarily downslope from Road R69 in the area corresponding to lots 51 to 56. Drainage conveyance issues were observed at existing culverts (see Section 5).

Block 3 is accessible via an existing gravel road (Road R75). This road was built around 2010 using fragmented shale excavated from the nearby quarry. An overhead power line was observed following the north edge of the road. The power poles are supported in rock-filled culverts drilled into the ground. One multi-unit residential building (five-plex) was present across the road from the location of BH20-04a (lot 27 and 28). Significant disturbance of the ground surface (deep wheel ruts) was observed immediately downslope from the five-plex. These ground surface disturbances could cause a deepening of the active layer, which impacts the drainage conditions, and potentially promotes the occurrence of solifluction.

Signs of ground movement were observed around the perimeter of the building, at the contact between the piles and the ground surface, (a void is visible on the downslope side of the pile displayed on Figure 4-1 below).

Figure 4-1 Near-surface ground movement observed at recently installed foundation piles (5-plex, Block 3)

A residential unit built in 2020 was present further south along the same road (lot 43). The five-plex is supported on steel piles, the single unit residential building is supported on screw jacks placed on 8”x8” wood beams. The material used to build the pad was observed to consist of shale rock fill (see Figure 3-1 c and d). Recently placed (< 10 years) fill material was observed to consists predominantly of centimetric-sized, black to grey shale fragments, which weathering of fissile fragments will ultimately leads to the formation of clay-rich soil. This progressive weathering of the shale rock fill is expected generate significant consolidation settlement, especially in the first few years following the construction of road embankment and building pads.

Figure 4-2 Fragmented shale rock used to build pad in newly constructed area of Block 3

Block 4 was accessed via the road marking the outer limit of the existing built-up portion of the community. No permanent structures were observed on the north (upslope) side of the road; however, some smaller storage sheds and containers, as well as boats, snowmobiles, and other vehicles were located within this area at the time of the investigation. The natural grade was estimated at 10% and the boulders were assumed related to the local till and not the result of rockfall from the rock slope located some 250m upslope. The observation of a well-defined network of ice wedges in this area confirmed the findings of the initial desktop terrain mapping.

Block 5 was accessed via the main road (Nanisivik Highway) leading to the industrial areas and airport further to the southeast. The proximity of this road to the edge of the bay (i.e., 20 to 80 m), making those future developments would occur on the upside of the existing road. In Block 5, the overall slope profile along the proposed development area was found to range from 15 to 20 %. Outside of the existing roadway and overhead powerline (southside of the road), no other infrastructure was observed in this area. The distinct profile of low-lying solifluction lobes was observed at the ground surface, further confirming the occurrence of soil creep in the area.

4.2 Subsurface Conditions

Subsurface conditions are summarized based on the results from the field investigation programs. Geotechnical observations and data are shown on the borehole records provided in Appendix C and summarized in the following sections.

4.2.1 Overburden

The dominant stratigraphy encountered at the boreholes consisted of sandy to silty soils overlying weathered shale bedrock. Due to the limitations of the drilling method in winter conditions, limited observations could be made of surficial organic soils, and for this reason their thickness was excluded from the borehole records. The sand soils were generally comprised of brown to reddish brown sand with high fines content (clays and silts) and traces of gravel. At BH20-10 and BH20-12 located in the eastern part of the community in Blocks 4 and 5, the sand was observed to contain a greater proportion of gravels with increasing depth.

Ten (10) of the 15 boreholes terminated in bedrock (i.e., excluding BH20-01, BH20-03, BH20-11, BH20-12 and BH22-01). BH20-01 terminated in a layer of clay with sand and BH20-03 and BH22-01 terminated in a layer of clay containing shale fragments, likely indicative of the presence of weathered shale bedrock at depth.

BH20-11 and BH20-12 terminated in sand and gravel.

Laboratory testing conducted on the samples of the sand material measured natural moisture contents between 4.8 and 35.6%. in 2022, a moisture content up to 63% was measured from sample obtained from BH22-01. Grain size distribution testing was completed on select samples and the results are summarized in Table 4-1.

Table 4-1 Grain Size Distribution

Borehole	Sample	Depth (m)	Description	% Gravel	% Sand	% Silt	% Clay
BH20-02	BS1	1.2	Silty sand, trace clay, trace gravel	6.6	60.4	23.1	9.9
BH20-03	BS1	0.9	Sand, some fine, trace gravel	6.3	73.0	20.7	
BH20-4a	BS1	0.6	Silty sand, some clay, trace gravel	4.3	50.9	26.6	18.2
BH20-10	BS1	0.9	Silty sand, some clay, trave gravel	1.6	52.7	30.9	14.8
BH20-10	BS2	2.4	Gravelly sand, some fines	27.9	54.9	17.2	
BH20-12	BS1	0.9	Silty sand, some clay, trace gravel	8.6	53.0	26.7	11.7

Atterberg Limit testing was carried out on select samples. The results are tabulated in Table 4-2 below.

Table 4-2 Atterberg Limit Test Results

Borehole	Sample	Depth (m)	Moisture Content (%)	Plastic Limit	Liquid Limit	Plasticity Index	Liquidity Index
BH20-01	BS2	1.5	16.9	12	23	11	0.54
BH20-05	BS1	1.2	13.2	17	22	5	0.76
BH20-07	BS1	1.8	10.6	17	23	6	1.06
BH20-09	BS1	0.9	17.0	14	19	5	0.60

In accordance with the Unified Soil Classification System, the samples tested can be classified as Lean Clay (CL) and Clay Silt (CL-ML).

4.2.2 Bedrock

Bedrock was encountered in BH20-02, BH20-04a to BH20-10 and in BH22-02 and BH22-03. In BH20-02 and BH20-04a to BH20-08. The bedrock, generally highly weathered, consisted of a dark brown to black shale and was encountered at depths ranging from 0.9 m to 8.2 m.

In BH20-09 and BH20-10, the bedrock consisted of reddish igneous rock potentially associated to local quartzite deposits as reported in other geological studies available for the area (e.g., EXP 2018). This bedrock was encountered at a depth ranging from 8.2 m to 8.8 m.

The depth to bedrock in Block 2 ranged from 2.4 to 4.3 m, in Block 3 from 0.9 to > 10 m, and in Block 4 from 8.2 to 8.4 m. The depth to bedrock could not be confirmed in Block 5.

4.2.3 Permafrost and Ground-Ice

Ground ice content varied within the samples retrieved but was difficult to quantify as part of the initial 2020 drilling program due to the time of year and the drilling method utilized (i.e., destructive drilling using an air track rig). Confirming the thickness of the active layer as part of this initial program was not possible due to the frozen ground profiles in all boreholes. Approximate amounts of ground ice based on field observations of disturbed samples have been included in the borehole logs.

Key observations regarding permafrost and ground-ice are summarize below.

2020 drilling program:

- At BH20-03, a 3 m layer of ice containing only minor soil inclusions was encountered between 4.6 to 7.6 m bgs. It was not possible to confirm the type of the massive ice (e.g., ice wedge, buried ice or segregation ice).
- At BH20-09, a layer of ice with little to no soil inclusions was encountered between 1.1 and 4.6 m bgs. This borehole matched the location of an ice wedge identified from the terrain analysis.
- Ice content at other borehole locations range from no visible ice to approximately 15% or less (estimated from disturbed soil samples).

2022 drilling program:

- Measured active layer thicknesses were of 1.1 m bgs at BH22-01, 0.8 m bgs at BH22-02 and 0.7 m bgs at BH22-03.
- Ice-rich permafrost was observed at 1.6 m bgs at BH22-01. Visible ice consisted of random or irregularly oriented ice generally less than 2 cm in thickness. A moisture content of 63 % was measured from a sample.
- Attempts at coring ice from ice-wedges located within Block 2 were unsuccessful due to refusal on weathered shale bedrock at shallow depth (i.e., 1.2 m bgs at BH22-02 and 0.9 m bgs at BH22-02). The distinct polygonal features observed at the site; however, is typical of the presence of ice-wedges in the area.

4.2.4 Groundwater

Soils were frozen at the time of the winter 2020 drilling program.

Groundwater seepage was observed as part of 2022 summer program. Water was mainly observed along drainage channels and other poorly defined flow paths present across the landscape. Although groundwater levels were not recorded in the field, these levels are expected to fluctuate within the active layer during the summer thawing season, then be fully frozen during the winter season.

4.3 Permafrost and Climate Change Considerations

The CSA provides guidance for screening the vulnerability of a development to climate change (CSA 2019). Based on future projections of air temperatures derived from climate models under a “high” greenhouse gas scenario, Arctic Bay may experience a change in MAAT of 1.6°C by 2040, and up to 4.3°C by 2070. Acknowledging that observed permafrost warming in communities of the eastern and high Arctic appears consistent with the changes in regional air temperature (Ednie and Smith 2015), it seams reasonable taking the conservative assumption that near-surface ground temperature increases will match MAAT increases (i.e., 1.6°C warmer by 2040).

The overall sensitivity of permafrost can be classified based upon ground material, ice content, and an estimate of the ground temperature (CSA 2019). For the purpose of climate change screening, the CSA developed a permafrost sensitivity ranking based on the following three main factors:

- the likelihood of thaw settlement due to active layer deepening
- the potential for a reduction in bearing strength and creep resistance due to warming of the frozen ground
- the potential for accentuated frost heaving

Because soils in Arctic Bay consists predominantly of sand with high fines content overlying weathered shale bedrock, but also because of the known occurrence of soil containing excess ice at shallow depth, the overall sensitivity of permafrost to climate change within the study area is anticipated to range from moderate to high.

Table 4-3 Projected Seasonal Mean Temperature Change Under a “High” Greenhouse Gas Emission Scenario

Year	Spring	Summer	Autumn	Annual
2011–2040	1.3	0.7	2.3	1.6
2041–2070	3.4	1.9	5.8	4.3
2071–2100	6.3	3.5	9.1	7.6
NOTE: The value displayed in each cell represents the average change in mean seasonal or annual temperature for the specified 30-year period when compared to the average mean seasonal temperature from 1986 to 2015 (Arctic Sector E3).				
SOURCE: modified from CSA 2019				

Another important factor to consider is the intensification of the hydrological cycle triggered by the rise in temperatures. The amount, type, and patterns of rainfall and snow precipitation are expected to change, further contributing to permafrost degradation and adding stress to local infrastructures. The Nunavut Climate Change Center[2] reports that precipitations in the Arctic have increased by approximately 8 % in the last 100 years, with additional increases predicted for the future. Available precipitation data from the Arctic Bay airport station, however, is limited and does not allow to present clear trends. It is reasonable

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[2] https://www.climatechangenunavut.ca/en/understanding-climate-change/climate-change-nunavut

to expect that changing climatic patterns will intensify permafrost degradation, also leading to ground instabilities, local flooding and washouts along roads and access trails.

4.4 Development Suitability Assessment

The qualitative development suitability assessment conducted as part of the project focused on terrain and geotechnical site conditions that could adversely affect land development. Through the assessment, adverse conditions were observed to be associated to the following two main categories:

Terrain and/or geotechnical constraints consisting of naturally occurring features having the potential to negatively affect the design, construction and maintenance of infrastructures. Local examples of terrain or geotechnical constraints include slope steepness, drainage conditions, surface/subsurface material types and the occurrence of ice-rich permafrost.

Landscape hazards consisting of features or conditions having the potential to lead to localized or widespread damage to property and threaten personal safety. Local examples of landscape hazards include landslides, gully erosion, thermokarst and ground subsidence, flooding or shoreline erosion.

Guided by the criteria listed in Table 2-2, the following suitability rating was used to classify the study area:

- ***Terrain suitable for development:*** Based on the findings of the development suitability assessment, short to medium-term developments strategy should focus on terrain identified as suitable for development. It is important to note; however, that there is limited availability of readily available development land where no terrain-related constraints were identified.
- ***Terrain conditionally suitable for development:*** Terrain conditionally suitable for development consist predominantly of areas associated to the presence of drainage anomalies and/or suspected ice-rich terrain. Most recently surveyed lots located within Block 2 and Block 3 are assumed to be conditionally suitable for development. The application of best practices for construction and drainage management will be required. Building and maintaining infrastructures over ice-rich terrain could generate additional cost and involves extra maintenance.
- ***Terrain unsuitable for development:*** The combination of moderately steep to steep topography (i.e., slopes > 20%), the presence of massive ice as well as hazards such as mass movements and surface erosion were the key constraints making some of the local terrain unsuitable for development. Although engineering measures and construction techniques could be applied to address these constraints, avoiding these locations is recommended.

Figure B-5 (Appendix B) presents an overview of the result for the community and immediate surrounding areas. To help interpret the results, Figures B-5.1 to B-5.5 present landscape hazards and drainage features overlaid onto the development suitability polygons.

Wherever development is to occur in areas presenting constraints and hazards, then appropriate design, construction and maintenance guidelines should be applied (see Section 6: Conclusion and Recommendations).

5 DRAINAGE ASSESSMENT AND PLANNING

5.1 Existing Developed Areas

Figure B-3 in Appendix B illustrates the watershed catchment boundaries, drainage channels and flow paths for the overall study area. These features, in addition to existing drainage infrastructure are illustrated in greater detail on the Drainage planning figures presented in Appendix F (Figure F-1 to F-5). Culvert characteristics and photographs are provided in Appendix E.

5.1.1 General Drainage Conditions

Ditches and Channels. Within the developed core of Arctic Bay, ditches and channel are often absent from roadsides, with only the shallow swale marking the edges of the road embankment conveying water. Field observations have shown that most existing roads are build on low embankments, often resulting in the lack of proper ditches on the uphill sides of roads. Sections of roads and ditches were also observed to lack grading, sometime resulting in ponding of surface water.

Figure 5 from CSA (2020) recommends that ditches should be present on both sides of roads to convey roadway drainage coming from the road crest. In some cases, ditching on both sides of the road is not required due to the road layout in relation with the terrain layout. This is reflected in Figure 4 of CSA (2020). At the minimum, it is recommended that roadside ditches be provided on at least one side (uphill) of each road for snow accumulation and conveyance of runoff.

- *Observed drainage deficiency: spatial coverage of the ditch network is insufficient*

The distinction between a ditch/channel and drainage flow path (as defined in the Definitions and Terminology section) can be subjective. This was especially true for Arctic Bay where many of the roadside drainage features are informal (i.e., not intentionally constructed), or have little to no bed or bank definition putting them on the threshold of a ditch/channel.

It is understandable that wide and shallow drainage ditches or swales are important in Arctic Bay to allow for flexible vehicle access to buildings for servicing (e.g., septic pumpouts and water tank filling, snow clearing). However, the non-existent to shallow ditch geometry comes at the expense of reduced capacity for flow conveyance during runoff events in the spring, summer, and fall, as well as increased risk of ditch and culvert icing during the winter and spring melt periods. In addition, the shallow ditch geometry facilitates the driving of vehicles, ATV’s and snowmobiles across the ditches which can:

a. compact snow piled in the ditch (increasing risk of ditch and culvert icing/blockages)
b. alter the ditch geometry (impairing conveyance),
c. crushing of culvert ends (also impairing conveyance), and ultimately
d. generate ponding and spillage across road surfaces.

The recommended ditch dimensions provided by CSA (2020) are 2-4 m width and 0.75 m depth, although ditches should be sized as required to adequately convey the flows they are receiving. The dimensions of ditches were not recorded in Arctic Bay due to time constraints; however, depths of less than 0.50 m were observed in most cases.

- *Observed drainage deficiency: variable and often insufficient ditch depths and width*

Culverts. A total of 65 culverts were inventoried within the hamlet as part of the 2022 field program, including14 culverts located along Airport Road, immediately east of the hamlet. Additional culverts are present outside from the townsite (e.g., roads leading wastewater lagoon or airport area); however, their assessment was not part of the current scope.

A breakdown of the culvert type, material, and sizes is provided in Table 5-1. Of the 65 culverts inventoried as part of the field program, 61 consisted of cross culverts and 4 consisted of entrance culverts. All culverts but one were observed to be circular in shape. Corrugated steel pipe (CSP) was by far the most common culvert material (63 out of 65 culverts or 97 %); however, a few rare smooth walled steel pipes (SWSP) were also observed (2 occurrences). The 500- and 800-mm diameter culverts were the most common size observed (respectively 37% and 38%). Other culvert sizes observed in the field are listed in Table 5-1.

A summary of culvert characteristics, along with site photographs, are provided in Appendix E.

Table 5-1 Summary Characteristics of Culverts in Arctic Bay

Culvert Type	Culvert Material	Culvert Diameter (mm)								Totals	
		150	200	300	350	450	500	600	800		
Cross	CSP	1		3	1	3	22	4	25	59	61
	SWSP		2							2	
Entrance	CSP			1			2	1		4	4
	SWSP									0	
Totals		1	2	4	1	3	24	5	25	65	65

<u>Culvert Condition Ratings: Barrel Material, Shape, Capacity, Erosion and Scour</u>. Table 5-2 provides a summary of culvert condition ratings for the 65 culverts inventoried within the study area. The priority level for remediation is also indicated.

Table 5-2 Summary of Culvert Condition Ratings

Condition Rating	Barrel Material (0-4)		Shape (0-4)		Capacity (0-2)		Erosion and Scour (0-2)		US/DS Channel (0-2)	
0	54	83.1%	49	75.4%	19	29.2%	27	41.5%	42	64.6%
1	11	16.9%	6	9.2%	12	18.5%	15	23.1%	13	20.0%
2	0	0.0%	4	6.2%	34	52.3%	23	35.4%	10	15.4%
3	0	0.0%	1	1.5%						
4	0	0.0%	5	7.7%						
NOTES:										
Priority for remediation (based on Table 2-3)					High	Medium	Low (no highlight)			

Based on the field observations and summary results in presented in Table 5-2, the following drainage deficiencies are noted:

- *Drainage deficiency: 46 of the 65 culverts (70.8%) had either a crushed inlet and/or a crushed outlet. 6 of these culverts (9.2%) showed severe deflection of distortion with a high priority for remediation.*
- *Drainage deficiency: 46 of the 65 culverts (70.8%) are infilled with a high priority for remediation (note that these are not necessarily the same 46 culverts where crushed inlets/outlets were observed).*
- *Drainage deficiency: 23 of the 65 culverts (35.4%) have erosion and scour in the vicinity of the culvert ends with a high priority for remediation.*
- *Drainage deficiency: 10 of the 65 culverts (15.4%) have channel erosion, scour, sedimentation, or other instability upstream or downstream of the culvert that threatens the culvert such that there is a high priority for remediation.*

<u>Culvert Marker Pole</u>. None of the 65 culverts assessed in the field had functional marker poles. The purpose of the marker poles is to identify culvert ends so that drivers and snowplows can avoid the culvert ends, therefore minimizing damage to the culvert ends. The absence of culvert marker poles is considered a key contributing factor to the high rate of culvert end damage.

- *Drainage deficiency: culvert marker poles not present.*

Other general drainage deficiencies.

Other general drainage problems that were observed during the drainage assessment or otherwise expressed to Stantec included:

- *Drainage deficiency: some backyard ponding was observed to be occurring; however, overall was very limited due to natural grades (~8%). Occurrence of ponding is likely worse in spring melt conditions than what was observed in the mid-July field visit.*
- *Drainage deficiency: most driveways are missing entrance culverts; this results in overall poor conveyance and localized blockage of the existing ditch.*
- *Drainage deficiency: drainage monitoring is completed on a response- or incident-basis; a formal drainage monitoring program is not currently in place.*

5.1.2 Community-Wide Drainage Recommendations

Based on the drainage deficiencies noted in Section 5.1.1 above, 10 community-wide drainage recommendations were developed for Arctic Bay (Table 5-3). It is Stantec's opinion that implementation of these drainage recommendations will result in improved drainage conditions within the community.

Table 5-3 Community-Wide Drainage Recommendations

Drainage Deficiency [1]	**Recommended Action(s)**
Variable and often insufficient ditch depths and widths (qualitative observation)	• Improve the geometry of existing drainage ditches. • Where permafrost and soil conditions permit, existing ditches should be improved to meet CSA (2020) guidelines (0.75 m deep, 4 m wide). These recommended dimensions result in side slopes of approximately 2.7:1 (H:V) which should be reasonable for occasional servicing access by vehicles if required, but will also discourage everyday driving over the ditches which should preserve ditch geometry, conveyance capacity, and snow clearing capacity. If the ditching area has space constraints, the width of the ditch may be narrowed to a minimum of 2 m. • Larger ditches may be required if inflows require increased conveyance capacity or if ditch or culvert icing is common in the area. • Due to the fine texture nature of soils in Arctic Bay, larger ditches should be protected using riprap (i.e., angular rocks). • As ditch construction may restrict access to properties, designated site access (driveways) and entrance culverts may need to be installed. Entrance culverts should have the required depth of cover, have marker posts installed, and have culvert end treatments applied to protect the ends from damage. Where warranted and/or practicable, efforts should be made to install SWSP culverts (CSA 2020). Culvert diameter should be equal to or larger than the upstream culverts.
Culverts were observed to have damaged ends, in most cases assumed to be related to snow plowing and/or road grading activities	• Repair the damaged/crushed culvert ends to re-establish hydraulic conveyance capacity of the culvert. • Culverts requiring remediation are identified in the detailed culvert database in Appendix E. • The severity of the damage will determine the required work at each culvert: o Culverts with minor deformation at the ends may be bent back to the intended shape with appropriate tools. o Where i) is not possible, culverts may be repaired by cutting off the damaged portion and either leaving it square (if remaining culvert projects from embankment) or adding a short section of new culvert with an appropriate coupling. Culverts with more substantial end damage may require a portion of the road to be dug up to reach a section of non-crushed culvert prior to coupling with the culvert extension. o For severely damaged culverts where upon further inspection crushing extends through substantial portions of the barrel, complete culvert replacement may be required. o For CSP culverts, the repaired culvert ends should be reinforced with a steel end stiffener (e.g., Figure 5-1 as extracted from CSA 2020) or comparable stiff steel collar. This end treatment will make the culvert ends more resistant to damage in the future. As the hardened end treatments will not deform in the same way as CSP culverts, they pose a potential safety hazard to vehicles or humans who are accustomed to driving over the culvert ends (before or after deformation). The installation of the hardened end treatments should be communicated to the local community in advance of implementation. • Where warranted and/or practicable, efforts should be made to install SWSP culverts (CSA 2020). SWSP culverts are also more resistant to end deformation and do not require end treatments. Multi-level culvert arrangements, as illustrated in Figure 9 of CSA (2020), can be considered if culvert icing is an issue. Culvert diameter should be equal to or larger than the upstream culverts.
Culverts are infilled with a high priority for remediation	• Clean out the sediment inside the culverts to re-establish culvert conveyance capacity. • Culverts requiring cleanouts are identified in the detailed culvert database in Appendix E. • Cleaning out of the culverts can be completed hydraulically with a flusher truck, or potentially with a hose from a fire truck. Manual agitation of the sediment in the culvert with a shovel or pole can help loosen sediment and promote hydraulic flushing. If sediment accumulation is too substantial to flush using these methods, culvert replacement may be considered. • Where warranted and/or practicable, efforts should be made to install SWSP culverts (CSA 2020). • Infilled culverts are often connected to ditches that have also been infilled. It is highly recommended that improvements to the ditch geometry (to match CSA 2020 standards and connecting to the culvert inverts) upstream and downstream of the culvert be completed in tandem with the culvert cleanout.
Culverts showing insufficient depth of cover	• Increase the depth of cover by way of raising the road elevation over the culvert (i.e., by adding road surfacing material), or lowering the culvert. • If the culvert is slated for replacement for any of the culvert condition ratings, complete the replacement with a lowered culvert to meet the depth of cover requirements. Where lowering the culvert is not possible given receiving ditches, SWSP culverts should be installed (CSA 2020). Culvert diameter should be equal to or larger than the upstream culverts. • Road raising may also be performed to achieve the required depth of cover, and can provide the added benefit of providing increased road clearance from ditch bottoms.
Missing culverts and inappropriate culvert sizing	• A few locations were observed to be missing a culvert to ensure appropriate cross drainage. These locations are displayed on the figures presented in Appendix E. • To ensure proper conveyance, culvert diameter should be equal to or larger than the upstream culverts. • Install entrance culverts at all driveways. Where warranted and/or practicable, efforts should be made to install SWSP culverts (CSA 2020). Culvert diameter should be equal to or larger than the upstream culverts.
Erosion and scour in the vicinity of the culvert ends with a high priority for remediation	• Culverts requiring repairs to the embankment or scour/erosion at culvert ends are identified in the detailed culvert database in Appendix E. • It is worth investigating the cause of embankment or outlet erosion/scour prior to implementing a solution. For example, an embankment could be eroding due to flows entering the ditch from road spillage caused by nearby culverts being crushed or infilled. In this case, improving the conveyance of the crushed or infilled culverts may re-establish normal drainage patterns and alleviate the embankment erosion, and simple re-grading/re-dressing of the embankment slope is sufficient. • In other cases, the embankment or outfall erosion/scour may be due to the overall limited length of the culvert, where the culvert ends (or outlets) are too close to the road embankment and causing its erosion. • Other elements contributing to the erosion issues include the quantity of water received, the slope of the culvert, or the slope of the receiving system. In these scenarios, angular rip rap is well suited for stabilization. A layer of non-woven geotextile fabric should be installed beneath the rip rap and keyed into the existing ground at the ends to reduce the winnowing of fines and undermining of the rip rap. Well-graded rip rap gradations (i.e., a range of diameters) should be used where possible to improve stability. The rip rap should be graded to match the culvert invert of the affected end, and should be graded to the receiving system avoiding abrupt changes in channel gradient.

Culvert marker poles not present	• Culvert marker poles should be installed at the upstream and downstream ends of each culvert. • Given the snow ploughing and buildup over the winter in Arctic Bay, it is likely that marker posts may be damaged over the winter each year. The annual inspection, re-securing, or reinstalling of marker posts should be incorporated into the drainage monitoring program (last item in this table).
Backyard ponding	• Connect areas of frequent backyard ponding to the nearest drainage ditch by way of a small ditch (dimensions to suit field conditions and space constraints). In undisturbed vegetated terrain, it may be more appropriate to construct these small, often temporary ditches using hand tools (shovels) as the use of heavy equipment may cause permafrost degradation and further drainage issues. • The small ditch should be installed in a direction which matches the general drainage direction (e.g., overland flow path) to maintain positive drainage.
Emergency flooding equipment and supplies not in reserve	To enable emergency flooding response actions, the Hamlet should retain the following supplies in reserve for emergency use: • Spare culverts of various sizes • Sandbags • Rolls of 6 mil plastic sheeting (for use in sandbag berms) • Typical details for sandbag berms • Gas-powered pumps and hoses for pumps • Rip rap • List of competent individuals and contractors in drainage and civil engineering who can be contacted for emergency technical and construction assistance.
Drainage Monitoring Program not in place	A drainage monitoring program should be developed and implemented. The existing drainage maps and culvert inventory provide the foundation for such a program. The components of a drainage monitoring program are outlined in CSA (2020) Clause 6 and include the following considerations/components: • Able to be executed by local competent individuals (e.g., town foreman or equipment and utility operators familiar with or trained in drainage systems). • Should incorporate risk of failure into project prioritization. • Spring inspection and maintenance involving culvert inspections (following a similar method to that applied in this report) and any urgent actions, ditch and culvert blockage identification and removal, culvert marker post inventory and repair, litter and debris removal, and identification/documentation of ditch and culvert icing issues for future planning purposes. • Summer inspection and maintenance following a similar approach to the spring inspection, but with snow-free conditions for better observation. • Fall construction and repairs, when water levels in northern communities are typically the lowest. • Drainage monitoring in the winter consists mainly of snow management considerations and planning for the spring melt.

Figure 5-1 Culvert End Treatment – Culvert End Stiffener (Figure 17 from CSA 2020)

Figure 17
Example of culvert end treatment
(See Clause 5.6.4.8.)

Note: *This culvert end stiffener detail was developed by the Ministry of Transportation in Saskatchewan (2018). Originally intended for large diameter culverts (1.8 to 2.4 m diameter), a similar detail would also be useful for the smaller diameter culverts commonly seen in the communities. A wider stiffener band could be considered for culvert sections more prone to damage from maintenance equipment or crushing from traffic.*

5.1.3 Identified Drainage Problem Areas (IDPAs)

A total of six IDPAs were identified as part of the drainage assessment. Their numbering was assigned geographically (west to east) and is not indicative of priority level.

Identified issues and recommended actions are provided below. Refer to Figures F-6 to F-11 in Appendix C for a summary of the information presented below.

IDPA #1: Culvert issues and springtime flooding over Road R69

IDPA #1 is located on the southwest portion of Arctic Bay, within the proposed development area of Block 2. The drainage issues are related to the runoff of water along a series of flow paths crossing road R69 (Figure 5-3). In the area, drainage waters originate from the bedrock plateau overlooking the bay area, then flow along the escarpment through poorly defined seepage channels before crossing Road R69. At the crossing of Road R69, the flow of water is generally unconfined (i.e., no well-defined channel, bed and/or banks), often seeping through thawed organic-rich soils overlying the permafrost.

Major integrity issues were observed at culvert AB_56 and culvert AB_159, where AB_56 is showing a buried inlet and both AB_56 and culvert AB_159 showing badly torn outlets. It was also observed that the road was narrow, and that the embankment was low with reference to the surrounding terrain. Soils on the upper side of the road were often waterlogged, suggesting inefficient drainage across the recently built roadway. The outlets of both culverts being ripped and badly torn is likely related to the snow plowing activity (i.e., the grader or snow blade hitting the end of the culverts). An assumption related to the low-lying embankment and buried inlet is that the roadbed appears to have progressively sunk into the soft organic-rich soils, progressively pushing culvert downward, causing infill and blockage. The presence of longitudinal cracks on the shoulder of the road suggests differential settlement underneath the roadsides.

Figure 5-2 IDPA #1: Culvert issues and springtime flooding over Road R6. Example from culvert AB_159

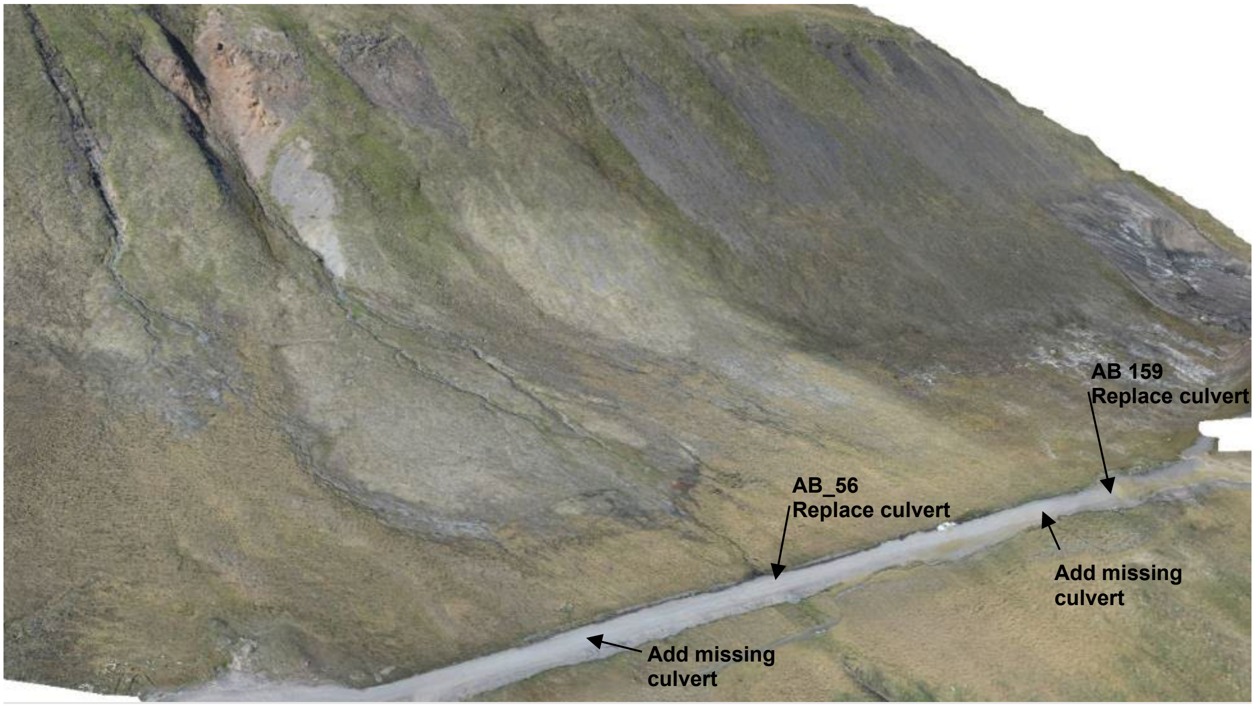

Figure 5-3 IDPA #1

Recommended Actions:

- Excavate and replace culverts AB_56 and AB_159. A minimum culvert diameter of 500 mm is recommended.
- Install additional culverts as suggested on Figure F-6, Appendix F.
- Ensure adequate drainage conveyance alongside the road (uphill side). A shallow swale might be preferred over a ditch.
- Ensure an adequate depth of cover above all culverts across Road R69 (450 mm based on CSA 2020).
- Aside from the required road upgrade (e.g., widening of the embankment), consider raising the road to keep water from spilling over the embankment during high water conditions; alternatively, consider lowering or “sinking” the culverts below the drainage channels.

IDPA #2: Culvert issues and oversteep embankment at Road R71

IDPA #2 is located downslope of Block 2, along Road R71. Along that road, culvert AB_54 was observed have collapsed at its center, blocking water flow and causing piping through the roadbed and localized failure of the roadway embankment. Culvert AB_151 was also observed to have collapsed near its center. Shoreline erosion was observed to occur downslope from culvert AB_151.

Both these culverts are located along a section of road that is steep (up to 18 %), narrow (under 5 m) and showing oversteep embankment side-slopes (in places, up to 70 %). A culvert was also observed to be missing at the base of the slope. This area is known to be impacted by flooding and shoreline erosion.

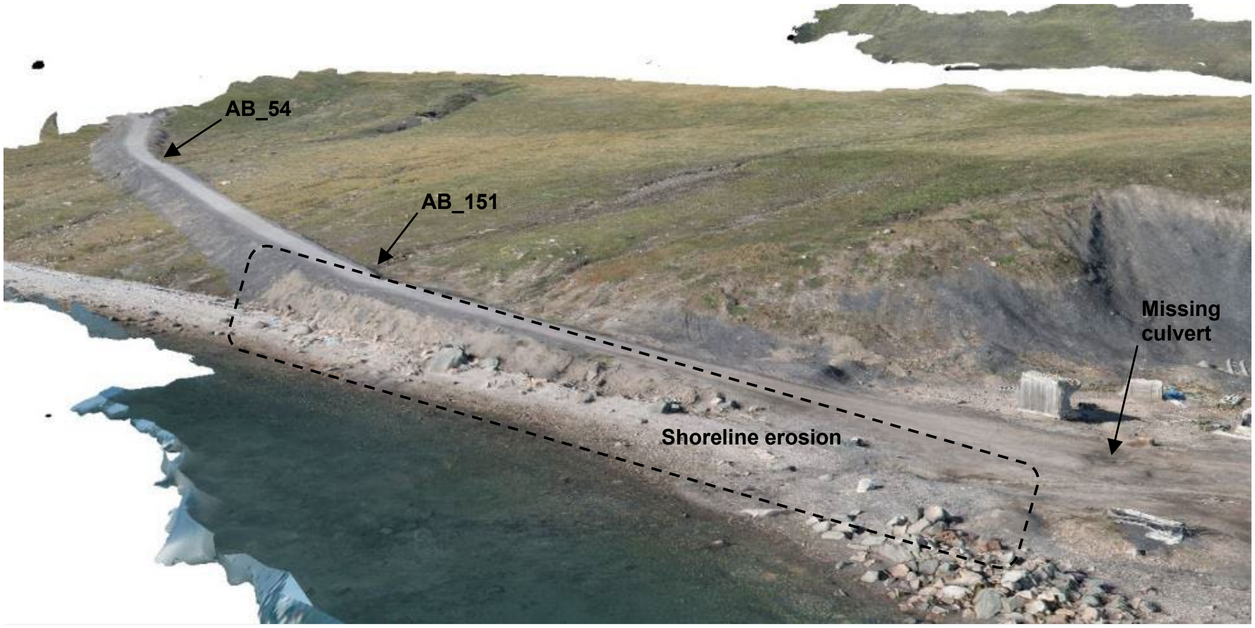

Figure 5-4 IDPA #2

Recommended Actions:

- The preferred option is to deactivate Road R71. This mainly due to the steep overall grade of the road (>15% in some area), narrow road base (< 4 m), oversteep embankment side slopes (in areas >70%), and shoreline erosion issue. Road deactivation requirements would require removing culverts, stabilizing the road prism, limiting access in a clearly visible manner to prevent access by motor vehicles (other than all-terrain vehicles).
- If deactivation is not an option:
- Consider upgrading the road (road grade and width), including protecting the embankment from shoreline erosion.
- Excavate and replace culverts AB_54 and AB_151, making sure that bottom ends are placed at appropriate heights from the ground surface to avoid erosion and embankment stability issues.
- Install additional culvert at crossing of seepage flow paths. The culvert diameter should be equal to, or larger than, the upstream culverts.

IDPA #3: Overflow and erosion

IDPA #3 is located along a major drainage channel originating from the outlet of a small lake approximately 4.3 ha in size and located on the bedrock plateau overlooking the bay area. Downslope from the lake, the channel drains the existing quarry area (northern limit of Block 2), then travels within a "V-shaped" gully before flowing over a near-vertical escarpment, down onto the staging area facing the shoreline and bay area (Road R54 area).

The main issues along this drainage channel include the overflow or cascading waters coming down the short (6 to 8 m) bedrock escarpment as well as the erosion caused along the channel (Figure 5-5). During meetings and discussions with hamlet officials, concerns were expressed regarding the recurrent erosion of fill material within the staging area (especially in the gully channel at the base of the escarpment), and more specifically, the overall hazards presented by the feature to local kids playing in the area.

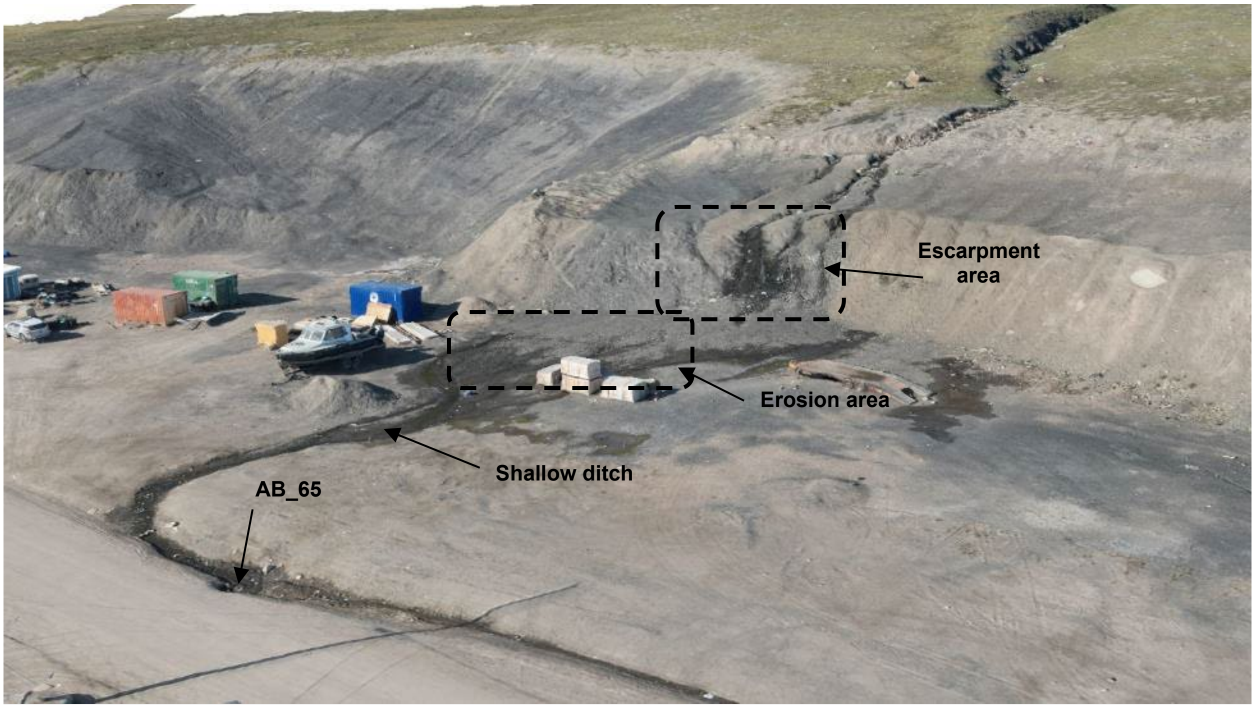

Figure 5-5 IDPA #3. Overview

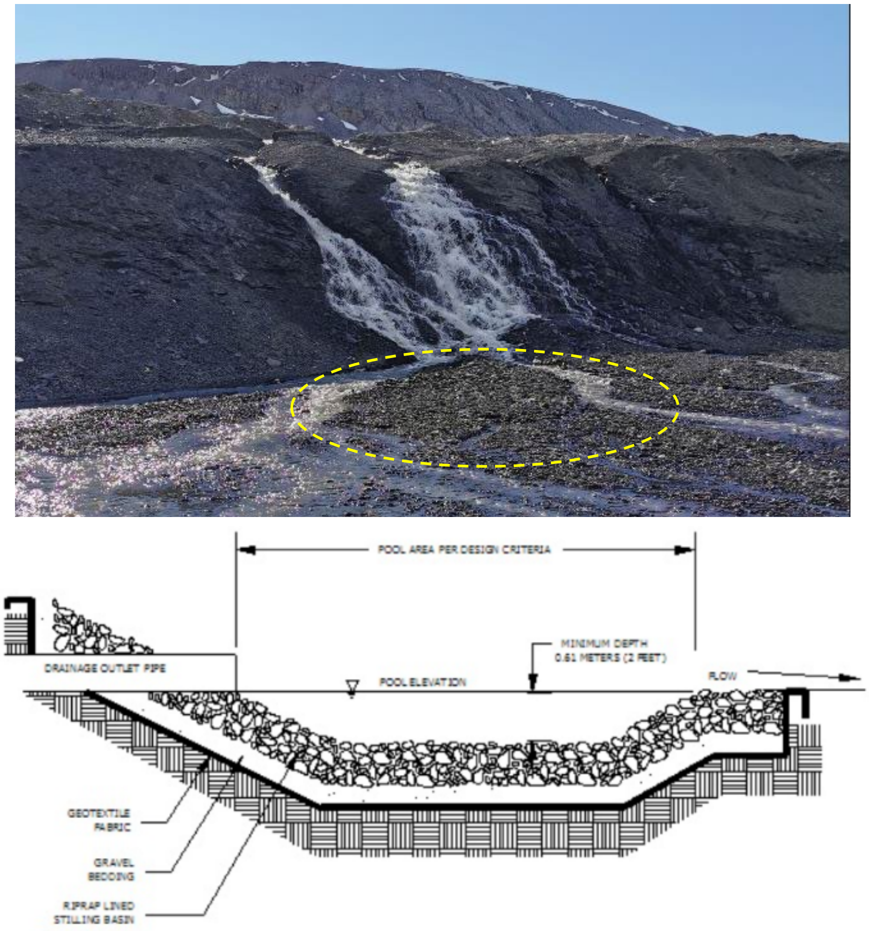

Figure 5-6 IDPA #3. Proposed plunge pool area and schematic example[3]

Recommended Actions:

- Immediately upslope from the escarpment, assess the possibility of concentrating the flow into single channel in order to limit erosion and encroachment.
- At the base of the embankment, excavate a shallow plunge pool to dissipate the energy and limit future erosion. The plunge pool should be lined with angular riprap material. The use of local shale material is not recommended due to the fissile nature of the rock.
- Ensure adequate conveyance downstream from the plunge pool by deepening the ditch leading to culvert AB_65. Conveyance issues observed at culvert AB_65 should be addressed (i.e., crushed inlet and material infill). The use of a larger diameter culvert (800 mm) is recommended.
- To address potential safety hazard during spring freshet peak flow (i.e., until remediation activities are conducted), consider installing temporary fencing and/or a post raising awareness about the hazard.

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[3] https://megamanual.geosyntec.com/npsmanual/outletsedimenttrap.aspx

IDPA #4: Erosion and conveyance issue

IDPA #4 consists of portion of a drainage channel characterized by soil erosion as well as the accumulation of sediments around the inlet of culvert AB_37 (Figure 5-7). The erosion observed at IDPA #4 initiates at the exit of culvert AB_40 (i.e., ~80 m above from AB_35). The outlet of culvert AB_40 was observed to be perched, causing erosion of the fine-grained soils. The erosion was observed to be most severe along the slope segment separating culvert AB-35 from culvert AB_37.

At the approach of Road R55, culvert AB-37 was observed to be partially infilled, apparently caused by the sedimentation of materials eroded upslope along the channel.

Figure 5-7 IDPA #4

Recommended Actions:

- Fix or replace culverts showing issues (crushed inlets, infill, perched outlets) upslope from the area impacted by erosion (see culverts AB_41, AB_160, AB_40 and AB_35 in Appendix E).
- Address the erosion issue at the exit of culvert AB_40 by placing riprap material. The placement of a riprap apron at the base of the embankment, below from the outlet, will serve as an energy dissipator, limiting the erosion of the fine-grained soils found in the area.
- Downstream from culvert AB-35, consideration should be given to addressing the erosion issues observed along the main drainage channel. This could involve applying riprap along the main channel as well as some backfilling/recontouring of older gullies.
- Deepening of the ditch line should be conducted immediately upslope from culvert AB_37. This would involve removing the infill material that has accumulated at the entry of culvert AB_37.

IDPA #5: Hamlet Office area

IDPA #5 consists of the area surrounding the Hamlet Office (Figure 5-8).

The surface water draining across the Hamlet Office lot initiates from the undeveloped terrain backing the community, with a potential input of groundwater from drainage of the small lake located on top the bedrock plateau.

From the Tangmaarvik Hotel (Road R66) to the shoreline area downslope from the Hamlet Office (Road R3), the flow of surface water is conveyed through poorly defined ditches, often overflowing across road surfaces. Around the Hamlet office, runoff water was observed to have caused shallow rills and erosion, especially alongside the road embankments, but also across the parking area and underneath the Hamlet Office building itself. Downslope from the office, the water again overflows on top of the road, causing significant erosion of the road embankment. Culvert AB_181, downslope from the Hamlet Office, was observed to be inefficient, mainly due to its small diameter (200 mm).

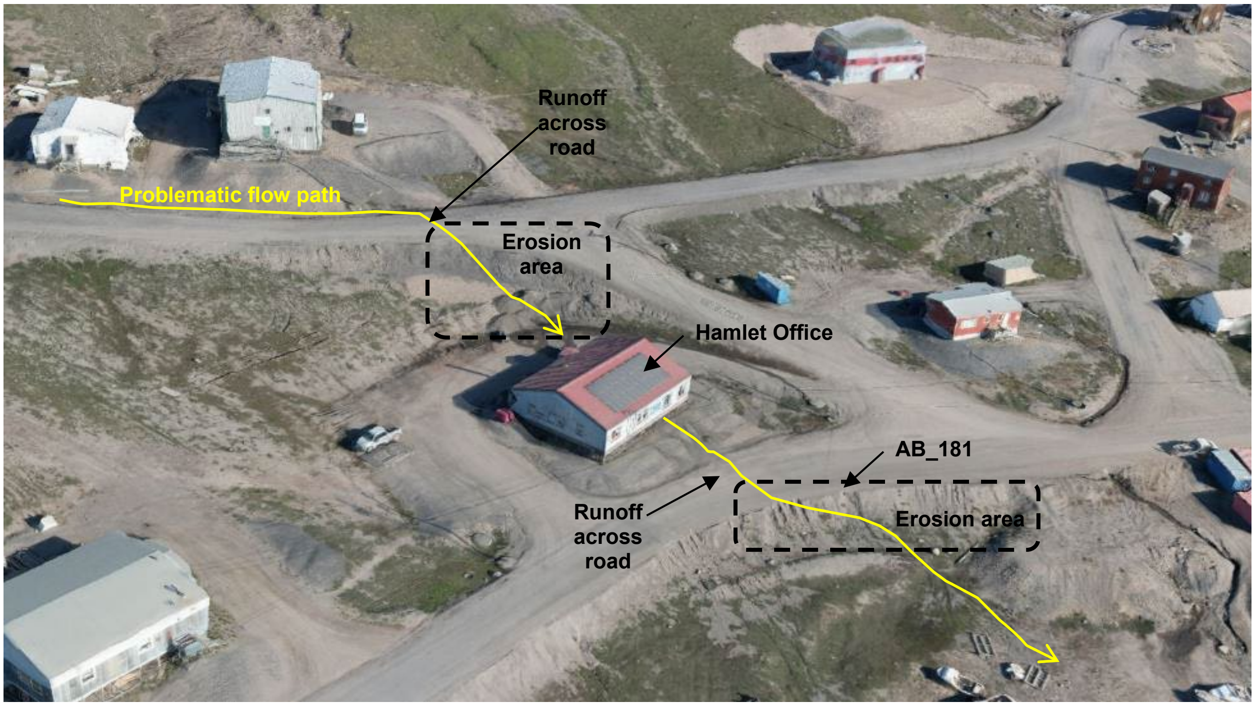

Figure 5-8 IDPA #5. Observed drainage issues

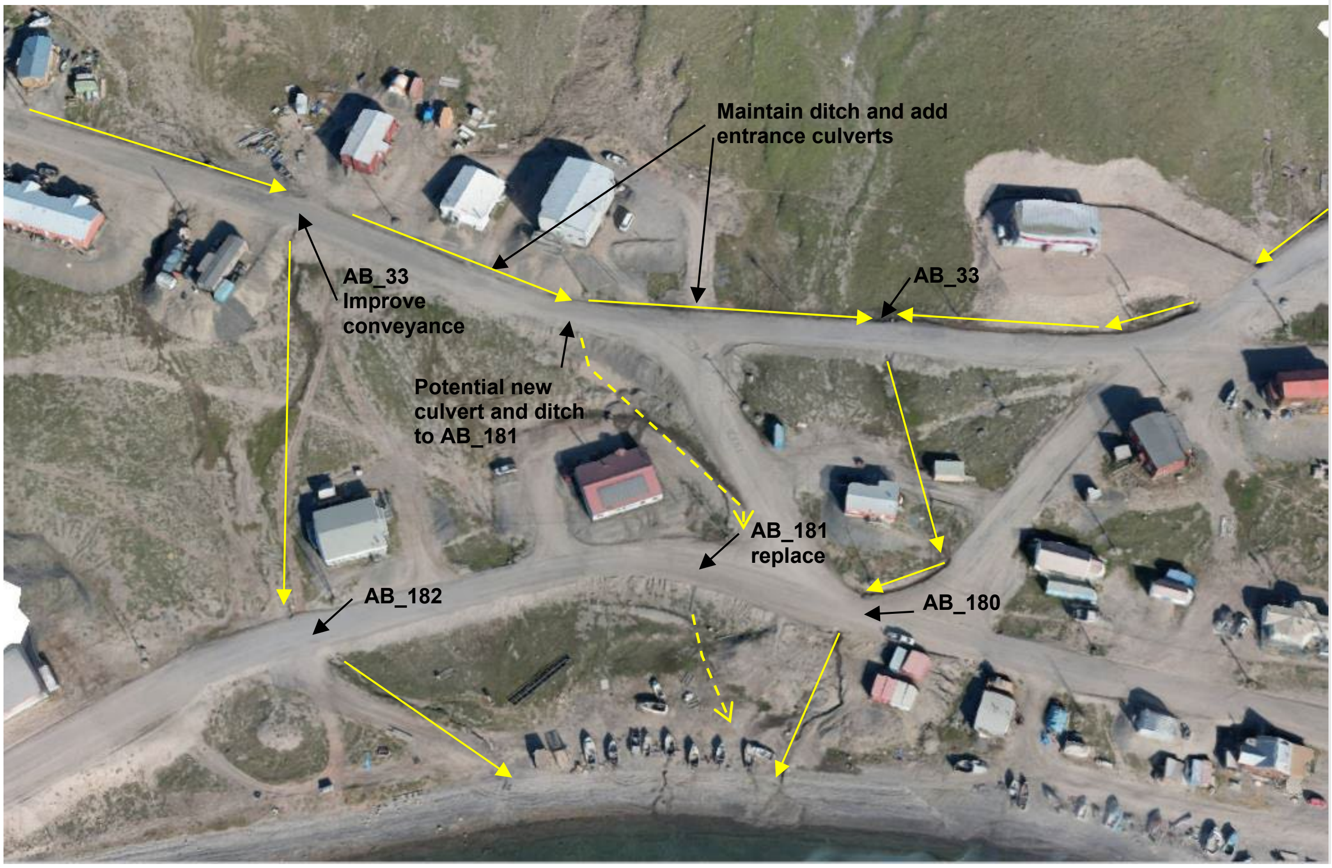

Figure 5-9 IDPA #5. Recommended actions

Recommended Actions:

- The end-goal at IDPA #5 is to reroute drainage water away from the Hamlet Office building.
- Conveyance needs to be improved alongside Road R66 to ensure that maximum drainage flow is directed through culvert AB_33 (and not further down along side Road R66 towards the Tangmaarvik Hotel and Hamlet Office area).
- Entrance culverts are missing to access the Hotel. These culverts are required to ensure conveyance through the existing ditchline, all the way towards culvert AB_28. Routing eastward drainage flow towards culvert AB_33 and westward flow towards culvert AB-28 should significantly decrease the seepage observed immediately upslope from the hamlet office.
- If active seepage is still taking place from the hotel, downslope towards the Hamlet Office, a new culvert and ditch might need to be installed. This ditch would then connect to culvert AB_181, which also need to be replaced.
- Downslope from culvert AB_28, special attention is required to address conveyance issues observed at culvert AB_179 and culvert AB_180. This includes cleaning the culverts from infill materials and addressing erosion and stability issues alongside the road embankment.

IDPA #6: CO-OP store area

IDPA #6 consists of the area surrounding the CO-OP store. The Hamlet expressed that the area surrounding the CO-OP is periodically subject to surface runoff and ponding, likely due to the limited capacity of existing culverts and general lack of a well-defined ditch network to convey runoff water downslope towards the bay.

Culvert AB_25 is located across Road R13 and receives runoff water originating from the upper portion of the slope surrounding the bay area. The inlet of that 800 mm diameter culvert was not visible and assumed to be fully buried. At its outlet alongside the upper south corner of the CO-OP building, the proximity of the culvert to the building and the lack of well-defined ditch suggests that the area is susceptible to high runoff volumes which likely contribute to the erosion of the fill material alongside the building. The occurrence of rills and shallow gullies at the ground surface alongside the CO-OP building was noted as an indicator of the erosion taking place in the area.

Additional drainage issues were observed along this drainage path further down from the CO-OP store, including erosion along the drainage channel and culvert conveyance issues due to culvert infill and blockage.

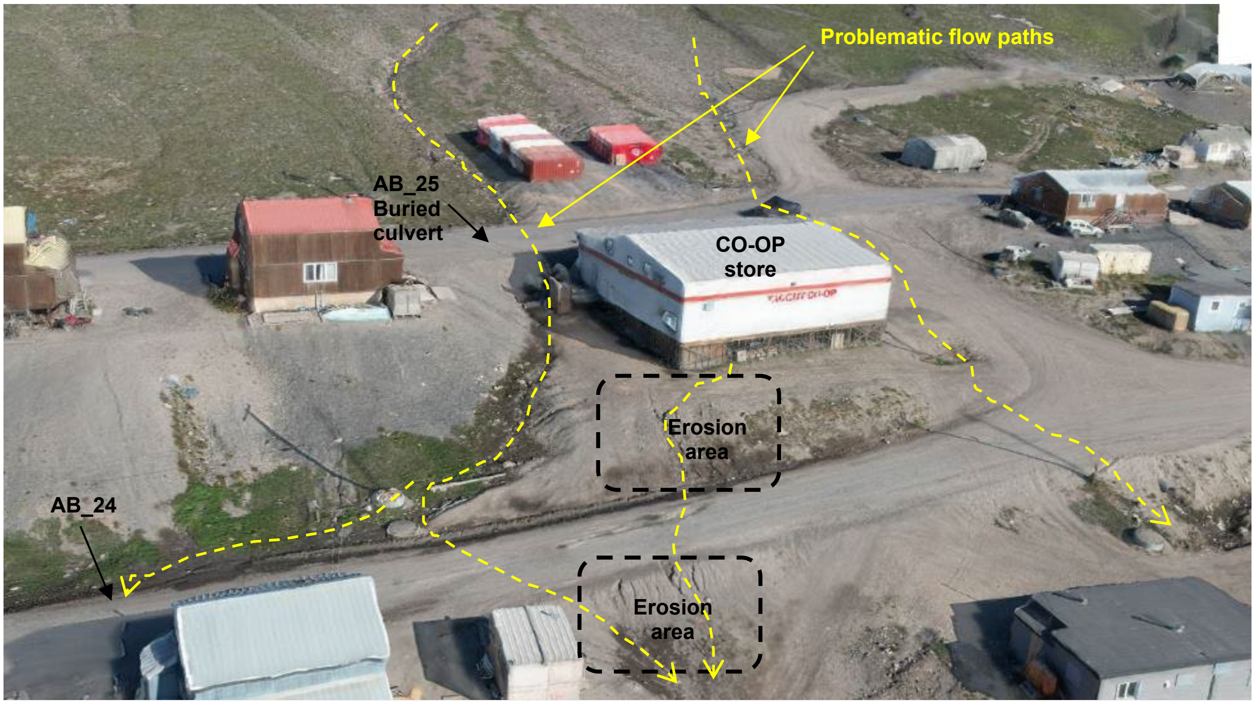

Figure 5-10 IDPA #6

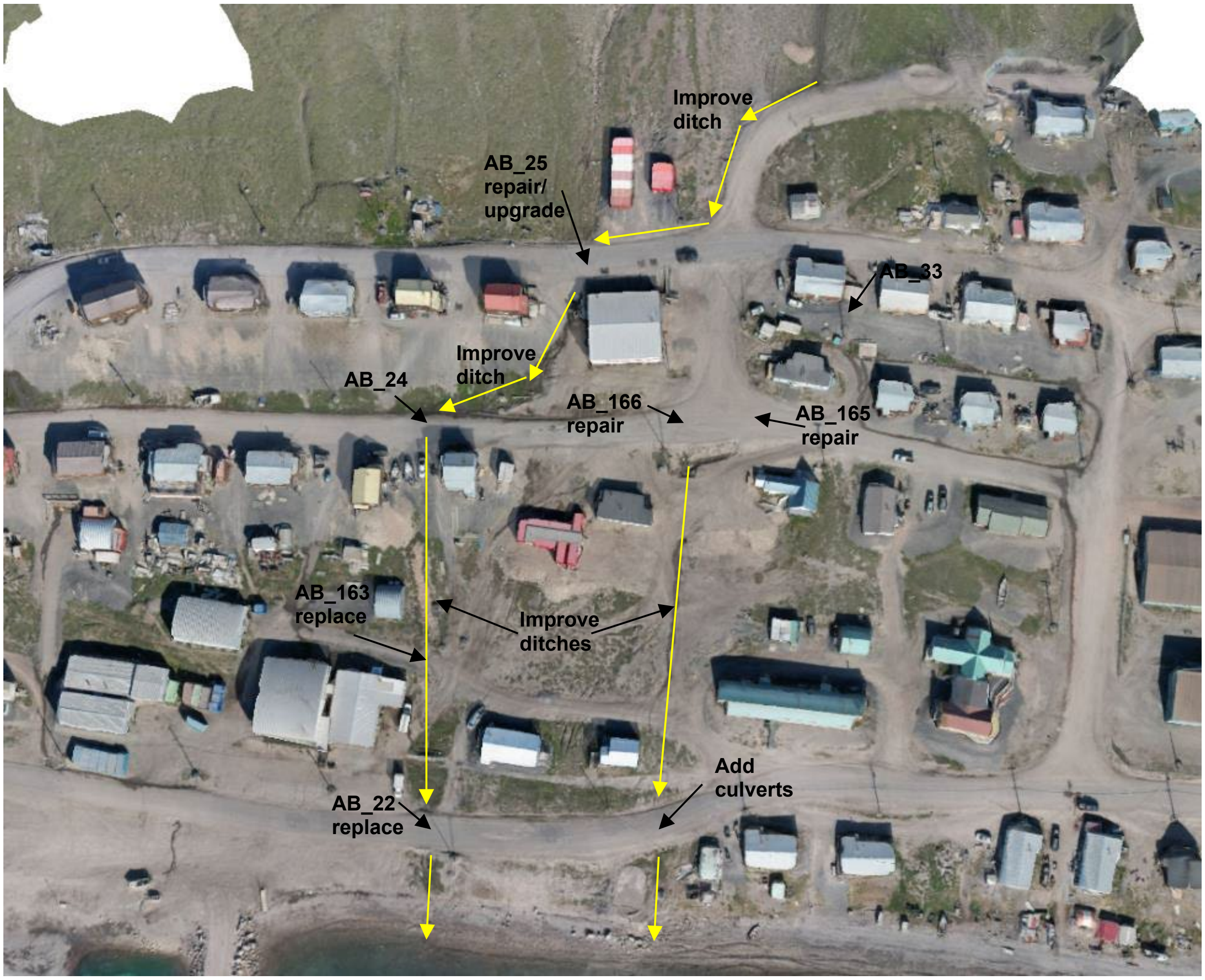

Figure 5-11 IDPA #5. Corrective actions

Recommended Actions:

- Improve conveyance of ditch along the roads immediately above the CO-OP store. This includes installing an entrance culvert across the access leading to the CO-OP shipping container storage area.
- Excavate infill material that is obstructing the entrance of culvert AB_25 (currently fully buried). The use of riprap material might be required the stabilize entrance of the improved ditch upslope from the culvert.
- Add a new 800 mm culvert section (minimum 10m) to the end of culvert AB_25 to bring the culvert outlet away from the CO-OP building (currently less than 3 m separating the culvert outlet from the steps leading to the CO-OP rear entrance).
- Downslope from the upgraded culvert AB_25, improve conveyance by formalizing the ditch line leading to culvert AB_24, then to culvert AB_163 and culvert AB-22. Erosion control using riprap material is recommended.

- Both AB_163 and culvert AB-22 need to be replaced. Ensure appropriate culvert sizing from the top to the bottom of the slope. The use of 800 mm diameter culverts is recommended.
- Upward and east of the CO-OP area, evaluate the option of diverting water east from the CO-OP access road and parking area towards culvert AB_165 (if grade allows), or installing a new culvert to bring water across the parking area towards culvert AB_166.

5.1.4 Drainage Planning - Future Development Areas

The conceptual drainage plans for the future subdivisions identified as Block 2 and Block 3 are presented in Appendix F, Figure F-12 and Figure F-13. The proposed drainage infrastructure presented in these drawings are provided at the conceptual planning level as detailed engineering design has not been completed.

Future engineering and site development works may require amendments to the conceptual drainage plan presented here. Detailed engineering of the site drainage infrastructure, incorporating quantitative analysis of runoff rates, volumes, and conveyance capacities of infrastructure (existing vs. proposed conditions), are recommended to advance conceptual plans to the detailed engineering level.

The conceptual drainage plans for the planned future subdivisions incorporated the following principles in accordance with CSA (2020) and general best management practices for drainage in developed areas:

- Existing drainage directions and boundaries should be preserved as much as practical.
- Road crown should occur in the centre; roadside ditches should be provided on both sides of the road.
- Entrance culverts should be located at the driveway entrance of each lot.
- Where warranted and/or practicable, efforts should be made to install SWSP culverts (CSA 2020).
- Drainage from upstream areas between lots should be avoided where practical.
- All culverts should meet minimum depth of cover requirements.
- Culvert marker poles should be installed on both ends of each culvert.
- Ditch outfalls should be located at an existing drainage feature; stable outlets and tie-ins should be provided.
- Drainage monitoring should be completed to detect drainage issues and inform corrective or adaptive action.

6 CONCLUSION AND RECOMMENDATIONS

6.1 Summary of Key Findings

A summary of key findings and considerations for future development is presented below.

6.1.1 Overburden Soils and Bedrock

- The most common surficial material present within areas of interest for future developments consist of sand till, with varying but relatively high fines (silt/clay) content. The thickness of the till is expected to range locally, from a thin veneer along mid-slope sections to a thick blanket along lower slopes. Colluviated till overlying weathered bedrock, then exposed bedrock surfaces occupies higher and steeper slopes, some located within proximity to the proposed development areas of Block 2 and Block 3.
- Bedrock was encountered in 10 of the 15 boreholes drilled in 2020, at depths ranging from 0.9 m to 8.2 m bgs. Observed bedrock samples consisted predominantly of black weathered shale, although reddish igneous rocks (potentially quartzite) were also encountered. The depth to bedrock was shallower in the western portion of the community, especially within Block 2.

6.1.2 Slope Stability

- Features indicative of slope instabilities are present within the study area, both within the community limits and along the slopes backing the general bay area. They include rapid mass movements such as active layer detachments, debris flows and rock falls, as well as slow mass movements such as solifluction or frost creep. Some of these features are impacting existing infrastructures (e.g., landslide behind the power plant and the Taqqut Inns North hotel, solifluction at the new 5-plex in Block 3). The occurrence of ground instabilities is expected to increase in relation with climate change.

6.1.3 Permafrost

- The hamlet is located within the continuous permafrost zone, where frozen ground is expected to reach several hundred meters in depths.
- Measured active layer was of 1.1 m bgs at BH22-01, 0.8 m bgs at BH22-02 and 0.7 m bgs at BH22-03.
- Permafrost was encountered in all boreholes. The ice content was observed to vary locally, with occurrence of massive ice confirmed at two boreholes. At BH20-03 (in Block 3), a 3.5 m layer of ice was encountered between 4.6 and 7.6 m bgs. At BH20-09, a 3 m layer of ice was encountered at a depth ranging between 1.1 and 4.6 m bgs.
- The presence of ice rich permafrost immediately below the base of the active layer was confirmed within Block 3 (63 % moisture content at 1.5 m bgs at BH22-01). This observation suggests that the

permafrost is thaw sensitive and that a deepening of the active layer is likely to translate into a release of water into the active layer.

- The presence of networks of ice wedge polygons was confirmed as part of mapping, visual field observations and geotechnical drilling. These ice wedges are predominantly located upslope from the area identified as Block 4, and within undeveloped sectors of Blocks 2, 3 and 5.
- Because soils in Arctic Bay consists predominantly of sand with high fines content overlying weathered shale bedrock, but also because of the known occurrence of soil containing massive ice at shallow depth, the overall sensitivity of permafrost to climate change is anticipated to range from moderate to high.

6.1.4 Drainage Conditions

- Features indicative of drainage issues were found throughout the study area and include unconfined seepage flow paths, gullies and rills, as well as poorly drained low-lying terrain.
- A detailed inventory of existing drainage structures (mainly culverts) was conducted. Observed drainage deficiencies include insufficient coverage (and depth) of the ditch network, high proportion of culverts showing crushed ends, infill, and erosion issues.

6.1.5 Aggregate and Borrow Materials

- Shale bedrock and undisturbed till soils may be suitable for selective reuse in future development and general site grading activities; however, would require a geotechnical investigation to further confirm material properties. It should be noted that due to the high fines content, these soils would be considered moisture sensitive, and the suitability for reuse as a select structural fill will be highly influenced by weather and precipitation.
- East of the community towards the airport, vast deposits of fluvial/glaciofluvial materials are present, which could represent valuable granular resource to support future development. Additional investigations of these granular deposits are required to confirm suitability to be used as structural fill.

6.1.6 Development Suitability Assessment

The qualitative development suitability assessment conducted as part of the project focused primarily on terrain and geotechnical site conditions that could adversely affect the design, construction and maintenance of future developments throughout the community. Key factors or variables found to influence local development suitability are related to drainage conditions, topography (slope), the occurrence of geoprocesses (e.g., mass movements), and the presence of ice-rich permafrost.

Key findings of the development suitability assessment include the following:

<u>Terrain suitable for development</u> was identified within Block 1 through Block 5, mainly consisting of already developed lots located on 0 to 10% slope where no drainage anomaly or apparent landscape hazard were observed. Ice-rich permafrost (including massive ice) may locally be present at depth. Appropriate measures to maintain permafrost and manage drainage and are still required.

Terrain conditionally suitable for development was found to consist predominantly of slopes ranging from 10 to 20%, where drainage anomalies and/or suspected ice-rich terrain were identified. Areas showing imperfect to poor drainage conditions or suspected of containing ice-rich soils are also included.

Terrain conditionally suitable for development was identified throughout the study area. This includes most of the terrain located within Block 2 and Block 3.

Terrain unsuitable for development was found to consist predominantly of areas characterized by a combination of moderately steep to steep topography (i.e., slopes > 20%), massive ice, rapid mass movements and surface erosion.

6.2 Geotechnical and Drainage Considerations for Future Developments

Permafrost ground conditions present unique but solvable challenges with regard to land development in Nunavut. Site specific conditions, exacerbated by impacts of changing temperatures and precipitation patterns require adequate planning, design, and maintenance of infrastructures 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 9701-500/2023 Risk-Based Approach for Community Planning in Northern Regions - Requirements and Guidance (National Standard of Canada 2023)
- CAN/BNQ 2501-500/2017 *Geotechnical Site Investigations for Buildings Foundations in permafrost zones* (National Standard of Canada 2017)
- CSA S503:20: *Community drainage system planning, design, and maintenance in northern communities* (CSA 2020)
- CSA S501-14: *Moderating the effects of permafrost degradation on existing building foundations* (CSA 2014)
- CSA PLUS 4011-19: *Technical guide: Infrastructure in permafrost: A guideline for climate change adaptation*. (CSA 2019)

The following sections highlight key recommendations related to the development of new subdivision components in the hamlet of Arctic Bay (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 are especially relevant based on the findings of the current project.

6.2.1 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. The current evaluation should be considered a high-level evaluation to support development suitability from a geotechnical point of view. As the planning of future developments advance, additional site-specific geotechnical investigations should be conducted as they relate to the various stages of land development.

Findings of the geotechnical evaluation indicated that the fine-grained soils encountered as part of the investigation are thaw sensitive, imperfect to poorly drained and are compressible. Both slow and rapid mass movements (solifluction and landslides) are occurring along mid- to upper slopes surrounding the community. Soils containing massive ice were confirmed to be present (including but not limited to ice wedges). These soils are highly thaw sensitive and could exhibit significant settlement (and downslope movement) upon thawing.

Conducting the following investigations prior to developing infrastructures within area identified as conditionally suitable for development is recommended:

- The ground ice content and the temperature of the ground are the main determinants of the load-bearing capacity of the permafrost (CSA 2019). Because the drilling equipment utilized as part of most geotechnical field investigations allowed for a limited characterization of frozen soils, it is recommended that near surface permafrost coring be completed to describe cryostratigraphy (following ASTM D4083) and volumetric ice content. Thermistors should be installed to further assess ground thermal regime.
- The occurrence of solifluction along moderate slopes segments of Block 2, 3 and 5 suggest that freeze/thaw processes are impacting fine-grained soils. The slow downslope movements of soils contained within the active layer could adversely impact existing and/or future development areas. Special attention is required to ensure that the appropriate level of site information is obtained to select and design the appropriate foundation system for future buildings.
- Borehole drilling and slope stability analysis should be performed to assess site conditions along the lower portion of Block 2 (i.e., downslope from BH20-05 and BH20-07). A geotechnical set-back from the crest of the slope should be assessed for development. The geotechnical set-back will typically vary from approximately 1 to 4 times the slope height. (i.e., the area currently corresponding to Block 2, Lots 29 to 34).
- Site-specific geotechnical investigations should be conducted once more specific development plans are available. Confirming that an appropriate level of investigation is achieved will require the consideration of the infrastructure types, then follow the overall recommendations as presented in CAN/BNQ 2501-500/2017 *Geotechnical Site Investigations for Buildings Foundations in permafrost zones* (National Standard of Canada 2017).
- The characteristics of readily available fill materials (mainly shale rock) may impact the design and planning of future infrastructures. Proper assessment of the overall suitability of local borrow materials should be conducted.

6.2.2 Building Pads and Road Embankments

Field observations indicate the weathered shale bedrock obtained from local borrow sources is commonly used as borrow material for fill within de developed portion of the community and the construction and surfacing of local roads. Shale derived fill is susceptible to weathering, degradation from freeze thaw, frost action and soil surface erosion. The use of shale derived fill should be avoided.

Structural fill used for building pads should consists of non-frost susceptible granular fill such as well-graded sand and gravel containing less than 5 to 8 percent fines. Quality borrow materials appear readily available from gravel sources located around the airport area.

The thickness of the pads and road embankments should be designed to reduce permafrost degradation, especially in terrain identified as potentially suitable for development. Generally, pad/embankments approximately 1.2 to 1.8 m thick placed above grade will reduce permafrost degradation. 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. Compaction of the pads in controlled lifts is also key, given the soft and wet subgrade of most native soils, compaction should be limited to static compaction only (i.e., no vibratory compaction).

6.2.3 Site Grading and Drainage

Ice-rich permafrost, including areas of massive ice, were observed in some of the terrain targeted for future developments. Based on current understanding of the constraints associated with these soils, no development should occur within those areas.

Until additional investigations allow for investigation near-surface ground ice, stripping of the surficial topsoil/organic layer should be avoided in areas identified as conditionally suitable for development areas. The organic topsoil reduces heat flow into the ground and helps preserve the subgrade in a frozen state. Proper surface water drainage will be essential to avoid surface erosion and preserve the permafrost. If construction occurs during the thawing season, appropriate drainage management techniques should be in place before spring runoff. The construction of temporary berms is generally preferred over the excavation of drainage ditches or swales.

Building pads should be graded a 2% or more so that water drains away from the lots. Coarse-textured granular fill should be placed on lots and roads characterized by imperfect or poor drainage. Wherever required, slope cuts and/or excavations should be limited to reduce permafrost degradation.

6.2.4 New Drainage Infrastructure

Proper surface water drainage is essential for preserving the stability of infrastructure. Drainage ditches or swales should not be excavated in ice-rich permafrost. Special attention will be required to control and mitigate adverse drainage conditions in areas identified as potentially suitable for development.

Ditches or swales should be formed within newly placed fill material, where the base of the ditches or swales match the native ground surface (or above).

Berms could be an effective way to direct drainage away from the proposed new lots. Adequate design and material selection would be required to avoid any erosion.

Culverts should be installed along new road segments, driveways and where flow paths have been identified. An assessment of the stream discharge should be carried out during peak flows (spring melt) to inform the design and sizing of culverts.

Culverts should be founded on structural fill placed on native soil. Care should be taken to minimize ground disturbance during the installation of culverts. Culvert inlets and outlets should be protected against erosion.

6.2.5 Erosion Control

Erosion control measures should be included in the design of pads and road embankments, especially in terrain conditionally suitable for development where proposed developments might cross natural drainage features such as seepage flow paths. Materials to consider for erosion control include geotextiles and riprap. More specifically:

- Riprap (i.e., a blanket revetment constructed of rocks or rubble) should be used to armor segments of embankment located alongside culvert inlets/outlets. 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 reduce 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, which can cause drainage system to function poorly. The installation of silt traps, re-vegetation (may be inappropriate for this environment), straw mulching and implementation of other erosion control measures are essential.

7 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:

- use of the report
- basis of the report
- 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.

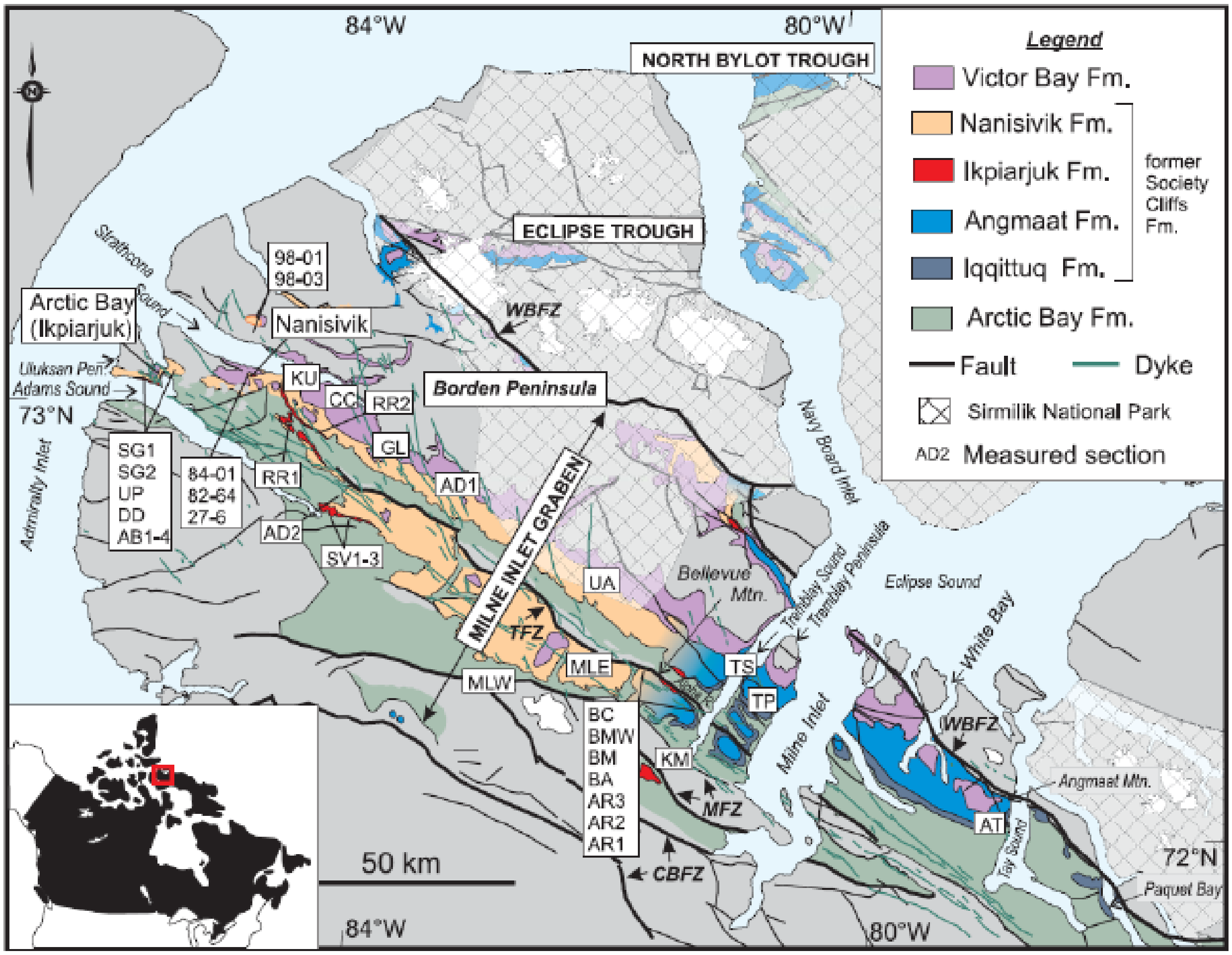
INTERPRETATION OF SITE CONDITIONS: Soil, rock, and/or other material descriptions, and statements regarding their condition, made in this report are based on site conditions encountered by Stantec at the time of the work at specific field observation locations and/or through interpretation of both digital 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

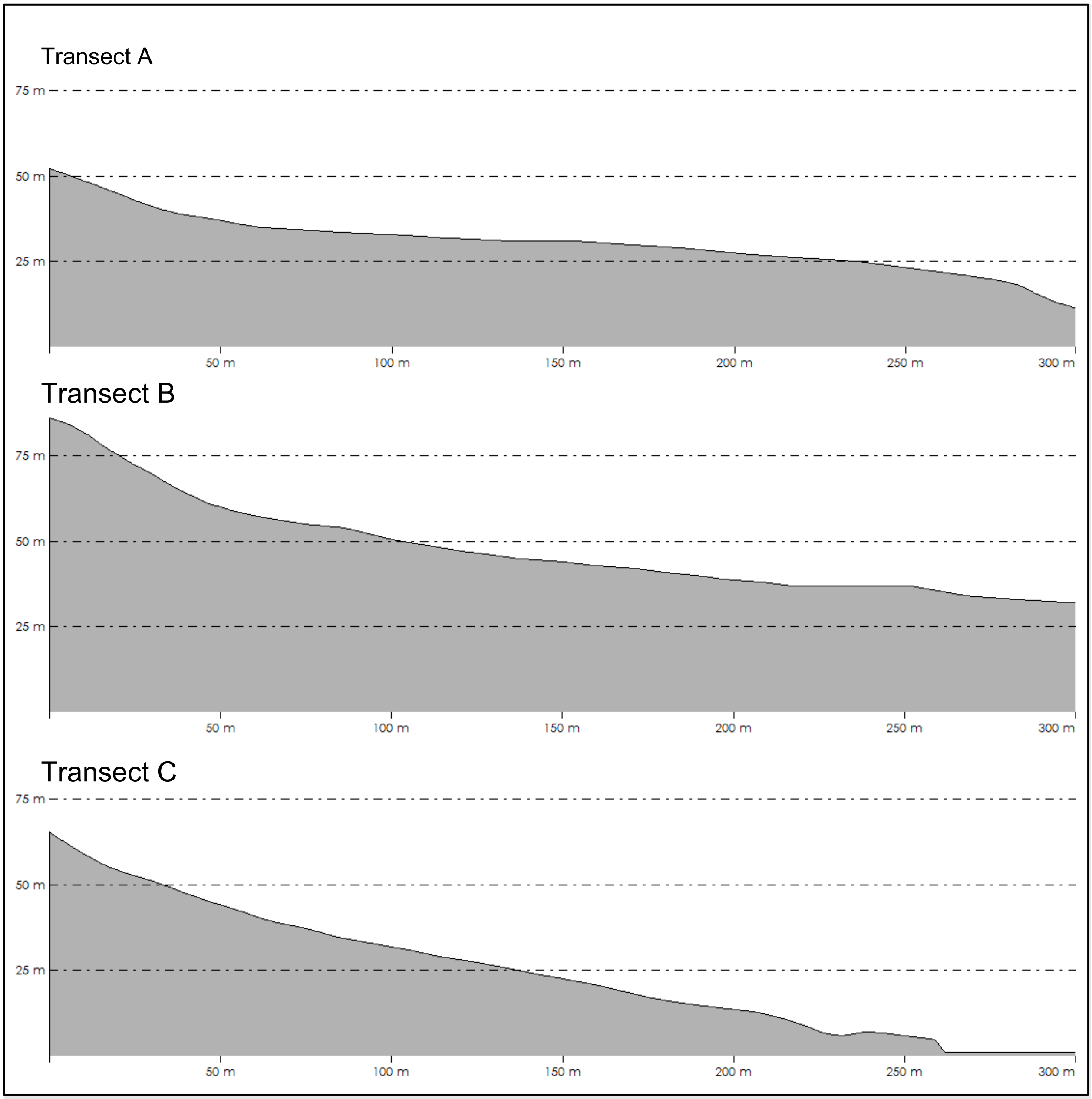
APPENDIX B Terrain Figures

Figure B-1 Regional Bedrock Geology



SOURCE: from Turner 2009

Figure B-2.2 Topographic Cross Sections



Service Layer Credits: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

Legend

- — Land_Parcels
- ⊕ Completed Boreholes
- — Contours (10m)
- ▭ Watershed (ha)
- — Drainage Channel
- ┅ Flow Path

0 250 500 metres

(At original document size of 11x17)
1:10,000

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

Client/Project
144902983-002 REVF

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
B-3

Title
Watersheds and Drainage Features

G:_GIS_Project_Folder\144902983_Arctic_Bay\figures\2023\144902983_002_REVF_ArcticBay_Watersheds.mxd Revised: 2023-03-24 By: JHiebert

Service Layer Credits: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

Legend

- Land Parcels
- Completed Boreholes
- Contours (10m)
- Surficial Geology*

***SURFICIAL GEOLOGY EXPRESSION**

Surficial Material	
Alluvial	A
Colluvium	C
Glaciofluvial	FG
Till (morainal)	T
Organic	O
Bedrock	R

Surface Expression	
Veneer (<1m)	v
Blanket (>1m)	b
Plain (0-5%)	p
Gentle slope (6-26%)	j
Moderate slope (27-49%)	a
Moderately steep slope (50-70%)	k
Steep slope (>70%)	s
Undulating (<27%)	u
Terrace	t

Composite Symbols	
Underlying surface material	[ ]
Delimiter - Component in front of the symbol is more extensive	/
Delimiter - Component in front of the symbol is much more extensive	//

0 250 500
metres

(At original document size of 11x17)
1:10,000

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

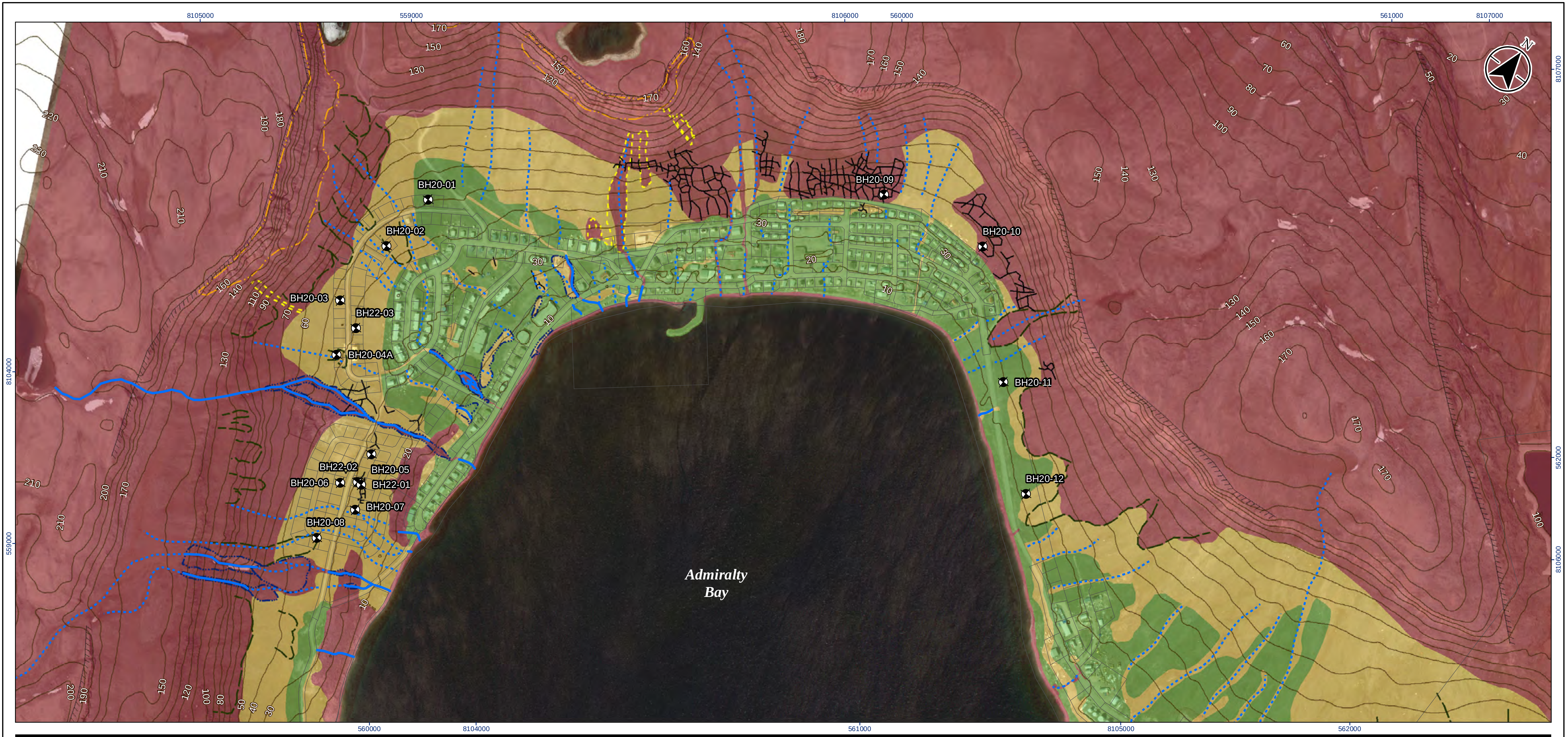
Client/Project
144902983-001 REVG

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
B-4

Title
Surficial Geology

G:_GIS_Project_Folder\144902983_Arctic_Bay\figures\2023\144902983_001_REVG_ArcticBay_Surficial_Geology.mxd Revised: 2023-03-24 By: JHiebert



Service Layer Credits: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

Legend

- Land Parcels
- Completed Boreholes
- Contours (10m)
- Drainage Channel
- Flow Path
- Escarpment

Land Development Suitability

- 🟩 Suitable for Development
- 🟨 Conditionally Suitable for Development
- 🟥 Unsuitable for Development

Landscape Hazards

- Solifluction Lobes
- Ice Wedge
- Active Layer Detachments
- Rockfall
- Erosion / Gullying

0 250 500
metres

(At original document size of 11x17)
1:10,000

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

Client/Project
144902983-003 REVH

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
B-5

Title
Landscape Hazards and Land Development Suitability

G:_GIS_Project_Folder\144902983_Arctic_Bay\figures\2023\144902983_003_REVH_ArcticBay_LandscapeHazard_Construction_Suitability.mxd Revised: 2023-03-24 By: JHiebert

Legend

- Land Parcels
- ⊕ Completed Boreholes
- Gravel Roads
- Contours (10m)
- Drainage Channel
- Flow Path

Land Development Suitability

- 🟩 Suitable for Development
- 🟨 Conditionally Suitable for Development
- 🟥 Unsuitable for Development

Landscape Hazards

- Solifluction Lobe
- Ice Wedge
- Erosion / Gullying

0 50 100 metres

(At original document size of 11x17)
1:2,500

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

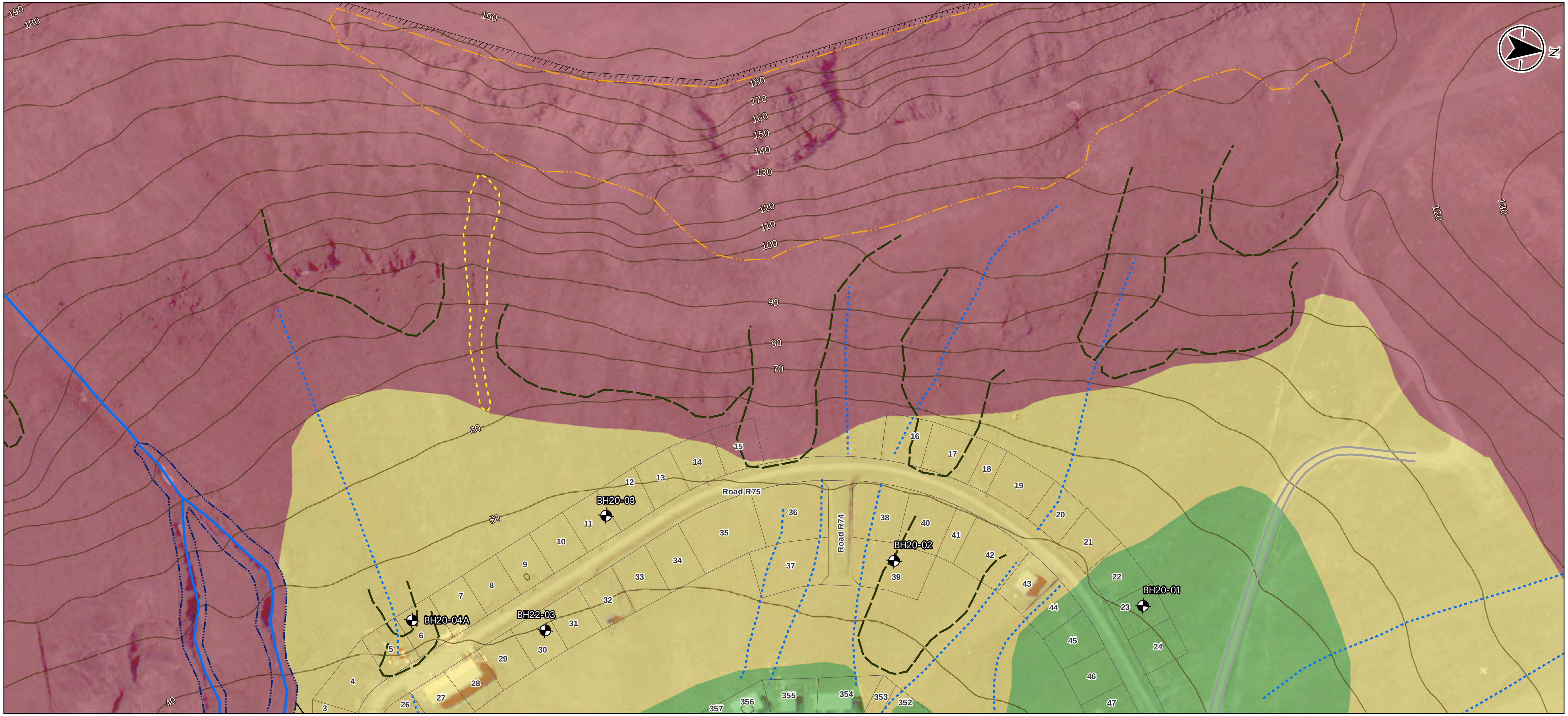
Client/Project
144902983-007 REVH

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
B-5-1

Title
Land Development Suitability and Landscape Hazards

G:_GIS_Project_Folder\144902983_Arctic_Bay\figures\2023\144902983_007_REVH_ArcticBay_LandscapeHazard_Cons_Suitability_Mapbook-.mxd Revised: 2023-03-24 By: JHiebert



Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

Legend

- Land Parcels
- ⊕ Completed Boreholes
- Gravel Roads
- Contours (10m)
- Escarpment
- Drainage Channel
- Flow Path

Land Development Suitability

- 🟩 Suitable for Development
- 🟨 Conditionally Suitable for Development
- 🟥 Unsuitable for Development

Landscape Hazards

- Solifluction Lobe
- Ice Wedge
- Active Layer Detachments
- Rockfall
- Erosion / Gullying

0 50 100 metres
(At original document size of 11x17)
1:2,500

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

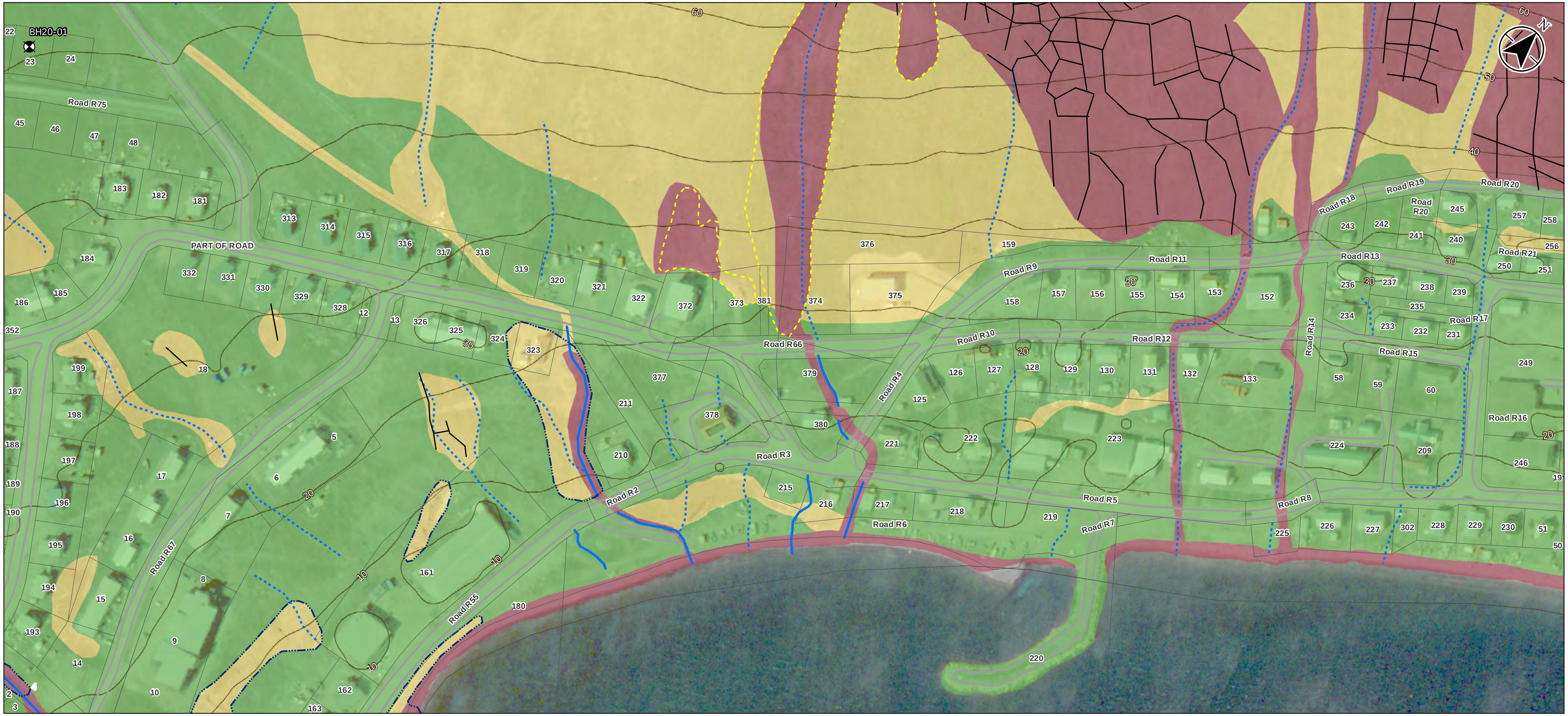
Client/Project
144902983-007 REVH

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
B-5-2

Title
Land Development Suitability and Landscape Hazards

G:_GIS_Project_Folder\144902983_Arctic_Bay\figures\2023\144902983_007_REVH_ArcticBay_LandscapeHazard_Cons_Suitability_Mapbook.mxd Revised: 2023-03-24 By: JHiebert



Legend

— Land Parcels

⌖ Completed Boreholes

— Gravel Roads

— Contours (10m)

— Drainage Channel

⋯ Flow Path

Land Development Suitability

🟩 Suitable for Development

🟨 Conditionally Suitable for Development

🟥 Unsuitable for Development

Landscape Hazards

— Ice Wedge

⬚ Active Layer Detachments

⬚ Erosion / Gullying

0 50 100 metres

(At original document size of 11x17)
1:2,500

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

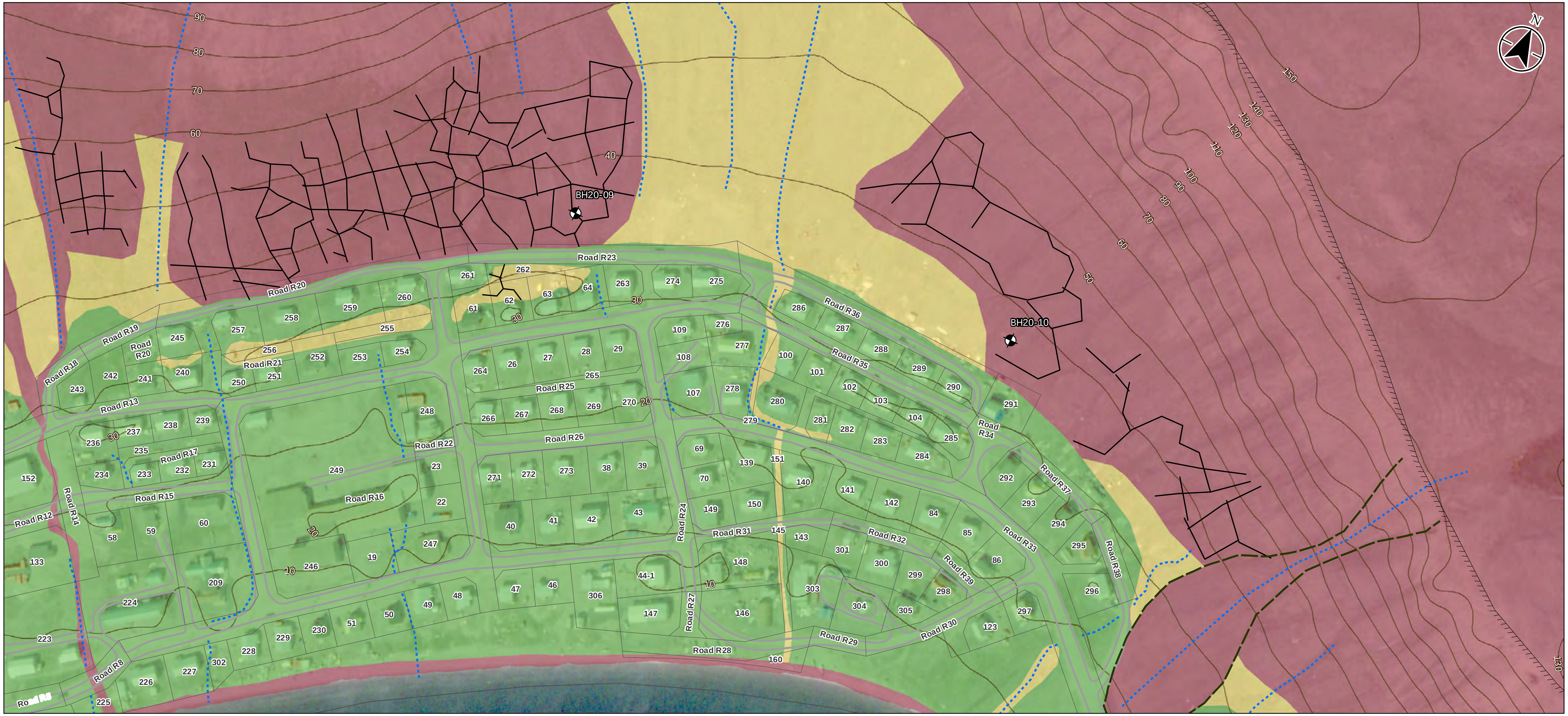
Client/Project
144902983-007 REVH

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
B-5-3

Title
Land Development Suitability and Landscape Hazards

G:_GIS_Project_Folder\144902983_Arctic_Bay\figures\2023\144902983_007_REVH_ArcticBay_LandscapeHazard_Cons_Suitability_Mapbook.mxd Revised: 2023-03-24 By: JHiebert



Legend

Land Parcels

⊕ Completed Boreholes

Gravel Roads

Contours (10m)

Escarpment

Flow Path

Land Development Suitability

🟩 Suitable for Development

🟨 Conditionally Suitable for Development

🟥 Unsuitable for Development

Landscape Hazards

Solifluction Lobe

Ice Wedge

0 50 100 metres

(At original document size of 11x17)
1:2,500

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

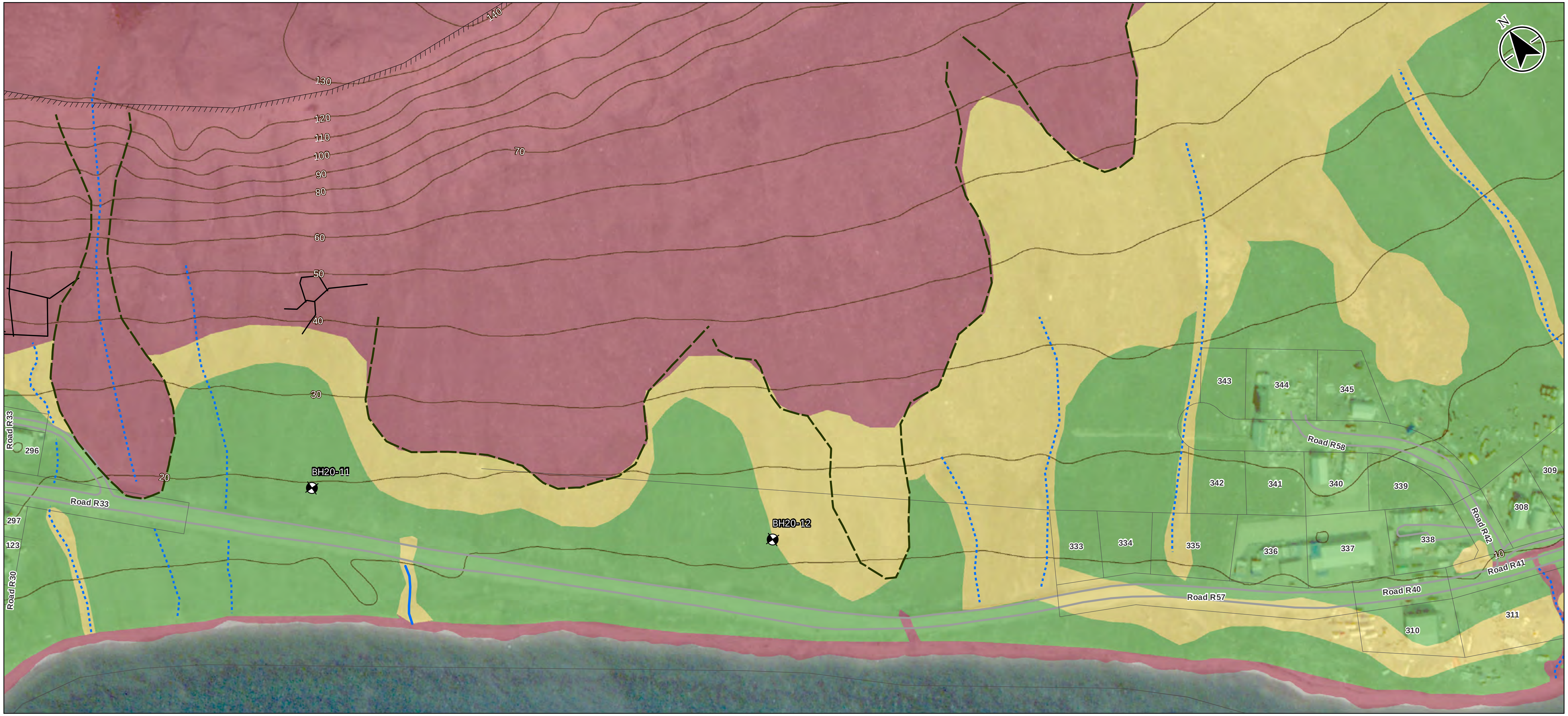
Client/Project
144902983-007 REVH

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
B-5-4

Title
Land Development Suitability and Landscape Hazards

G:_GIS_Project_Folder\144902983_Arctic_Bay\figures\2023\144902983_007_REVH_ArcticBay_LandscapeHazard_Cons_Suitability_Mapbook.mxd Revised: 2023-03-24 By: JHiebert



Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

Legend

— Land Parcels
⊕ Completed Boreholes
— Gravel Roads
— Contours (10m)
⁄⁄⁄⁄ Escarpment
— Drainage Channel
⋯ Flow Path

Land Development Suitability
🟩 Suitable for Development
🟨 Conditionally Suitable for Development
🟥 Unsuitable for Development

Landscape Hazards
– – Solifluction Lobe
— Ice Wedge

0 50 100 metres
(At original document size of 11x17)
1:2,500

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

Client/Project
144902983-007 REVH

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
B-5-5

Title
Land Development Suitability and Landscape Hazards

G:_GIS_Project_Folder\144902983_Arctic_Bay\figures\2023\144902983_007_REVH_ArcticBay_LandscapeHazard_Cons_Suitability_Mapbook-.mxd Revised: 2023-03-24 By: JHiebert

APPENDIX C 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 is in accordance with the Prairie Farm Rehabilitation Association (PFRA) Modified version of the Unified Soil Classification System (USCS) 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. See page 4 for definitions and other details.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris)

Terminology describing materials outside of the PFRA Modified version of 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 2. 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

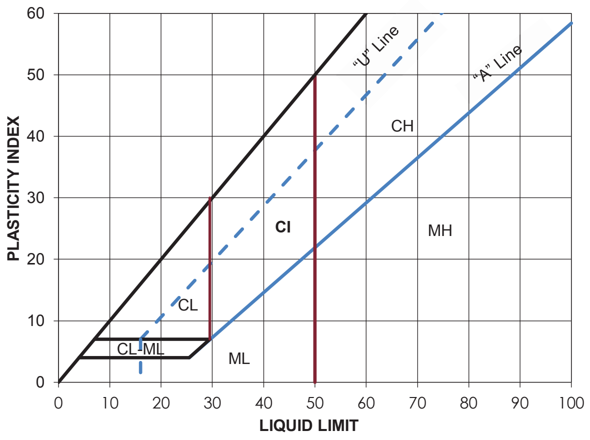
The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests. Consistency may be crudely estimated from SPT N-Value based on the correlation shown in the 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
	kg/cm^2 or 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

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

Major division			Group symbol	Typical description	Laboratory classification criteria	
Coarse grained soils	Gravels (more than half coarse grains larger than 4.75 mm)	Clean gravels (little or no fines)	GW	Well-graded gravels, little or no fines	$C_u = \frac{D_{60}}{D_{10}} > 4;\ C_c = \frac{(D_{30})^2}{D_{10}\ x\ D_{60}} = 1\ to\ 3$	
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines	Not meeting above requirements	
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures	Content of fines exceeds 12%	Atterberg limits below 'A' line or PI less than 4
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits above 'A' line or PI more than 7
	Sands (more than half coarse grains smaller than 4.75 mm)	Clean sands (little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines	$C_u = \frac{D_{60}}{D_{10}} > 6;\ C_c = \frac{(D_{30})^2}{D_{10}\ x\ D_{60}} = 1\ to\ 3$	
			SP	Poorly graded sands, little or no fines	Not meeting above requirements	
		Sands with fines	SM	Silty sands, sand-silt mixtures	Content of fines exceeds 12%	Atterberg limits below 'A' line or PI less than 4
			SC	Clayey sands, sand-clay mixtures		Atterberg limits above 'A' line or PI more than 7
Fine grained soils	Silts (below 'A' line negligible organic content)	$W_L < 50$	ML	Inorganic silts and very fine sands, rock flour, silty sands of slight plasticity	Classification is based upon plasticity chart (see below) **Note:** Whenever the nature of the fine content has not been determined, it is designated by the letter 'F' Example: SF is a mixture of sand with silt or clay	
		$W_L > 50$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils		
	Clays (above 'A' line negligible organic content)	$W_L < 30$	CL	Inorganic clays of low plasticity gravelly, sandy, or silty clays, lean clays		
		$30 < W_L < 50$	CI	Inorganic clays of medium plasticity, silty clays		
		$W_L > 50$	CH	Inorganic clays of high plasticity, fat clays		
	Organic silts & clays (below 'A' line)	$W_L < 50$	OL	Organic silts and organic silty clays of low plasticity		
		$W_L > 50$	OH	Organic clays of high plasticity		
Highly organic soils			Pt	Peat and other highly organic soils	Strong colour or odor, and often fibrous texture	

Note: Boundary classification possessing characteristics of two groups are given group symbols, e.g. GW-GC is a well graded gravel mixture with clay binder between 5% and 12%.



Note: plasticity chart is for soils passing 425 µm sieve

Soil components by particle size distribution

Fraction		Sieve size (mm)		Defining ranges of percentage by weight of minor components	
		Passing	Retained	Percent	Identifier
Gravel	Coarse	75	19	50 – 35	And
	Fine	19	4.75		
Sand	Coarse	4.75	2.00	35 - 20	____y/ey
	Medium	2	0.425		
	Fine	0.425	0.075	20 - 10	Some
Silt (non-plastic) Or Clay (plastic)		0.075		10 – 1	Trace
Oversize materials					
Rounded or sub-rounded cobbles 75 mm to 200 mm Boulders > 200 mm			Angular rock fragments Rocks > 0.75 m^3 in volume		

Note: All sieve sizes are referenced to U.S. standard ASTM E.11 – Alternate equivalent metric sieve sizes in accordance with CGSB Spec. 8-GP-2M to apply when prescribed

NUNAMI STANTEC

BOREHOLE REPORT

Project:	**Geotechnical Evaluation and Drainage planning - Arctic Bay**
Project No.:	**144902983**
Client:	**Government of Nunavut**
Site:	**Arctic Bay, NU**
Figure:	

Location :	**UTM83 zone 16**
X :	**559308**
Y :	**8104992**
Type of borehole :	**Air track**
Equipment :	**Air Track Drill**
Casings :	**mm**
Corer :	**mm**

Borehole :	**BH20-01**
Page :	**1 of 1**
Start date :	**2020-11-16**
Inspector :	**Kudlik Construction Ltd.**
Depth :	**10.20 m**
Elevation :	**52.03 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 (%)

GROUNDWATER

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded
▨	Intact (thin wall sampler)
■	Lost
◧	Core (diamond rock core)

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

SAMPLES

TESTS

GA : grain size analysis
S : sedimentometry
C : consolidation
W : water content
W_L : liquid limit
W_P : plastic limit
Dr : specific gravity
k : permeability
f'c : compressive str.
OM: organic matter
CA : chemical analyses

☒ : N (standard pen.)
▽ : Nc (dyn. pen.)
■ : Cu intact
□ : Cu remoulded
◆ : Su intact
◇ : Su remoulded

W_P W W_L
20 40 60 80

ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	STATE	TYPE N°	TESTS	W
52.03 0.00	Brown CLAY, some sand. - Individual ice inclusions (Vx) (up to 1 mm,<5%)				
		☒	BS-01		13.5
		☒	BS-02	Wl=23%, Wp=12%	16.9
49.90 2.13	Brown, SAND, traces of gravel and clay. - Well bonded, no excess ice (Nbn)				
		☒	BS-03		5.8
45.33 6.71	Brown, CLAY, some sand. - Well bonded, no excess ice (Nbn) - Sand content decreases with depth.				
		☒	BS-04		16.8
		☒	BS-05		20.6
41.83 10.20	End of borehole				

DEPTH (m): 1 2 3 4 5 6 7 8 9 10
DEPTH (ft): 5 10 15 20 25 30 35

General remarks:

Verified by :

Date : 2021-03-22

K:\Styles Stantec\2019\forage_ENG_sobek.sty

NUNAMI STANTEC

BOREHOLE REPORT

Project:	**Geotechnical Evaluation and Drainage planning - Arctic Bay**	Location :	**UTM83 zone 16**	Borehole :	**BH20-02**
		X :	**559295**	Page :	**1 of 1**
Project No.:	**144902983**	Y :	**8104833**	Start date :	**2020-11-15**
Client:	**Government of Nunavut**	Type of borehole :	**Air track**	Inspector :	**Kudlik Construction Ltd.**
Site:	**Arctic Bay, NU**	Equipment :	**Air Track Drill**	Depth :	**10.20 m**
Figure:		Casings :	**mm**	Elevation :	**44.54 m**
		Corer :	**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 (%)

GROUNDWATER ⊽

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remodelled
▨	Intact (thin wall sampler)
■	Lost
◧	Core (diamond rock core)

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 / TESTS

Tests legend:

- GA : grain size analysis
- S : sedimentometry
- C : consolidation
- W : water content
- W_L : liquid limit
- W_P : plastic limit
- Dr : specific gravity
- k : permeability
- f'c : compressive str.
- OM: organic matter
- CA : chemical analyses

Plot legend:

- ☓ : N (standard pen.)
- ▽ : Nc (dyn. pen.)
- ■ : Cu intact
- ☐ : Cu remoulded
- ◆ : Su intact
- ◇ : Su remoulded

W_P W W_L — 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	Standard penetration test BLOWS/150mm	WATER LEVEL / WATER INFLOW	TESTS	W (%)	REMARKS
		44.54 0.00	Brown, silty SAND, traces of clay and gravel, moist.												
					☒	BS-01							GA	16.5	
					☒	BS-02								8.7	
		36.31 8.23	Dark brown-grey, CLAY SHALE. - Very weak and brittle												
		34.34 10.20	End of borehole												

DEPTH (m): 1 2 3 4 5 6 7 8 9 10

DEPTH (ft): 5 10 15 20 25 30 35

General remarks:

Verified by :

Date : 2021-03-22

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NUNAMI STANTEC

BOREHOLE REPORT

Project:	**Geotechnical Evaluation and Drainage planning - Arctic Bay**	Location :	**UTM83 zone 16**	Borehole :	**BH20-03**
		X :	**559285**	Page :	**1 of 1**
Project No.:	**144902983**	Y :	**8104650**	Start date :	**2020-11-15**
Client:	**Government of Nunavut**	Type of borehole :	**Air track**	Inspector :	**Kudlik Construction Ltd.**
Site:	**Arctic Bay, NU**	Equipment :	**Air Track Drill**	Depth :	**9.90 m**
Figure:		Casings :	**mm**	Elevation :	**49.17 m**
		Corer :	**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 (%)

GROUNDWATER ▽

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded
▨	Intact (thin wall sampler)
■	Lost
◧	Core (diamond rock core)

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 / TESTS

TESTS:

GA : grain size analysis
S : sedimentometry
C : consolidation
W : water content
W_L : liquid limit
W_P : plastic limit
Dr : specific gravity
k : permeability
f'c : compressive str.
OM: organic matter
CA : chemical analyses

☒ : N (standard pen.)
▽ : Nc (dyn. pen.)
■ : Cu intact
□ : Cu remoulded
◆ : Su intact
◇ : Su remoulded

ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	SYMBOL	STATE	TYPE N°	SUB - SAMPLE	CALIBER	RECOVERY (%)	N - RQD	Standard penetration test BLOWS/150mm	WATER LEVEL / WATER INFLOW	TESTS	W_P W W_L (20 40 60 80)	REMARKS
49.17 0.00	Brown, SAND, some fines, traces of gravel.		☒	BS-01							GA	○ 11.8	
47.34 1.83	Brown, SHALE FRAGMENTS, traces of sand and gravel.		☒	BS-02								○ 28.2	
44.60 4.57	ICE with soil and gravel inclusions - Soil content increases with depth		☒	BS-03									
41.55 7.62	CLAY, some shale fragments.												
39.27 9.90	End of borehole												

DEPTH (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
DEPTH (ft): 5, 10, 15, 20, 25, 30, 35

General remarks:

Verified by :

Date : 2021-03-22

NUNAMI STANTEC

BOREHOLE REPORT

Project:	**Geotechnical Evaluation and Drainage planning - Arctic Bay**	Location :	**UTM83 zone 16**	Borehole :	**BH20-04A**
		X :	**559362**	Page :	**1 of 1**
Project No.:	**144902983**	Y :	**8104534**	Start date :	**2020-11-15**
Client:	**Government of Nunavut**	Type of borehole :	**Air track**	Inspector :	**Kudlik Construction Ltd.**
Site:	**Arctic Bay, NU**	Equipment :	**Air Track Drill**	Depth :	**10.40 m**
Figure:		Casings :	**mm**	Elevation :	**45.67 m**
		Corer :	**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 (%)

GROUNDWATER ▽

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded
▨	Intact (thin wall sampler)
■	Lost
◧	Core (diamond rock core)

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

TESTS

GA : grain size analysis
S : sedimentometry
C : consolidation
W : water content
W_L : liquid limit
W_P : plastic limit
Dr : specific gravity
k : permeability
f'c : compressive str.
OM: organic matter
CA : chemical analyses

☒ : N (standard pen.)
▽ : Nc (dyn. pen.)
■ : Cu intact
☐ : Cu remoulded
◆ : Su intact
◇ : Su remoulded

W_P W W_L

20 40 60 80

ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	SYMBOL	STATE	TYPE N°	SUB - SAMPLE	CALIBER	RECOVERY (%)	N - RQD	Standard penetration test BLOWS/150mm	WATER LEVEL / WATER INFLOW	TESTS	W_P W W_L	REMARKS
45.67 0.00	Brown, silty SAND, some clay, traces of gravel.		☒	BS-01							GA	○ 9.8	
44.76 0.91	Dark brown-grey, CLAY SHALE. - Very weak and brittle		☒	BS-02									
35.27 10.40	End of borehole												

DEPTH (m)	DEPTH (ft)
1	5
2	
3	10
4	
5	15
6	20
7	
8	25
9	30
10	
	35

General remarks:

Verified by :

Date : 2021-03-22

NUNAMI STANTEC

BOREHOLE REPORT

Project:	**Geotechnical Evaluation and Drainage planning - Arctic Bay**	Location :	**UTM83 zone 16**	Borehole :	**BH20-05**
Project No.:	**144902983**	X :	**559588**	Page :	**1 of 1**
Client:	**Government of Nunavut**	Y :	**8104385**	Start date :	**2020-11-15**
Site:	**Arctic Bay, NU**	Type of borehole :	**Air track**	Inspector :	**Kudlik Construction Ltd.**
Figure:		Equipment :	**Air Track Drill**	Depth :	**10.20 m**
		Casings :	**mm**	Elevation :	**30.08 m**
		Corer :	**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 (%)

GROUNDWATER

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded
▨	Intact (thin wall sampler)
■	Lost
◧	Core (diamond rock core)

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

SAMPLES

TESTS

GA : grain size analysis
S : sedimentometry
C : consolidation
W : water content
W_L : liquid limit
W_P : plastic limit
Dr : specific gravity
k : permeability
f'c : compressive str.
OM: organic matter
CA : chemical analyses

☒ : N (standard pen.)
▽ : Nc (dyn. pen.)
■ : Cu intact
☐ : Cu remoulded
◆ : Su intact
◇ : Su remoulded

W_P W W_L

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	Standard penetration test BLOWS/150mm	WATER LEVEL / WATER INFLOW	TESTS		REMARKS
		30.08 0.00	Brown, CLAY, traces of sand. - Individual ice inclusions (Vx) (<1mm)												
1					☒	BS-01							Wl=22%, Wp=17%	13.2	
2	5														
		27.64 2.44	Dark brown-grey, CLAY SHALE. - Very weak and brittle.		☒	BS-02									
3	10														
4															
5	15														
6	20														
7															
8	25														
9	30		Harder rock, potential boulder.												
10		19.88 10.20	End of borehole												
	35														

General remarks:

Verified by :

Date : 2021-03-22

NUNAMI STANTEC

BOREHOLE REPORT

Project:	Geotechnical Evaluation and Drainage planning - Arctic Bay	Location :	UTM83 zone 16	Borehole :	**BH20-06**
		X :	559568	Page :	1 of 1
Project No.:	144902983	Y :	8104278	Start date :	2020-11-15
Client:	Government of Nunavut	Type of borehole :	Air track	Inspector :	Kudlik Construction Ltd.
Site:	Arctic Bay, NU	Equipment :	Air Track Drill	Depth :	10.00 m
Figure:		Casings :	mm	Elevation :	30.13 m
		Corer :	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 (%)

GROUNDWATER

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded
▨	Intact (thin wall sampler)
■	Lost
◧	Core (diamond rock core)

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

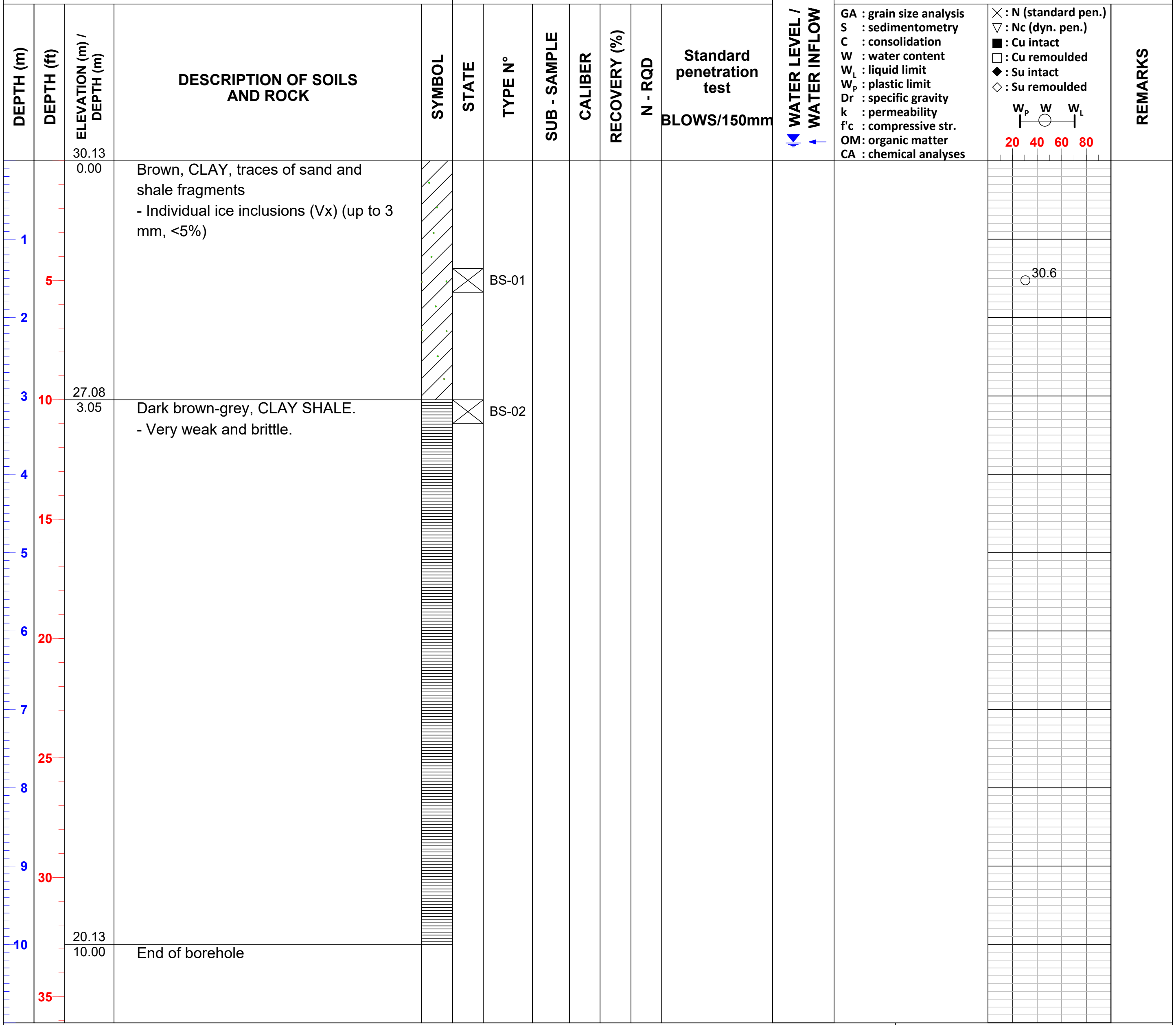
STRATIGRAPHY

SAMPLES

TESTS

GA : grain size analysis
S : sedimentometry
C : consolidation
W : water content
W_L : liquid limit
W_P : plastic limit
Dr : specific gravity
k : permeability
f'c : compressive str.
OM: organic matter
CA : chemical analyses

☒ : N (standard pen.)
▽ : Nc (dyn. pen.)
■ : Cu intact
☐ : Cu remoulded
◆ : Su intact
◇ : Su remoulded



ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	STATE	TYPE N°	TESTS
30.13 0.00	Brown, CLAY, traces of sand and shale fragments - Individual ice inclusions (Vx) (up to 3 mm, <5%)	☒	BS-01	W: 30.6
27.08 3.05	Dark brown-grey, CLAY SHALE. - Very weak and brittle.	☒	BS-02	
20.13 10.00	End of borehole			

General remarks:

Verified by :

Date : 2021-03-22

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NUNAMI STANTEC

BOREHOLE REPORT

Project:	Geotechnical Evaluation and Drainage planning - Arctic Bay	Location :	UTM83 zone 16	Borehole :	BH20-07
Project No.:	144902983	X :	559640	Page :	1 of 1
Client:	Government of Nunavut	Y :	8104246	Start date :	2020-11-15
Site:	Arctic Bay, NU	Type of borehole :	Air track	Inspector :	Kudlik Construction Ltd.
Figure:		Equipment :	Air Track Drill	Depth :	10.10 m
		Casings :	mm	Elevation :	23.93 m
		Corer :	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 (%)

GROUNDWATER

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded
▨	Intact (thin wall sampler)
■	Lost
◧	Core (diamond rock core)

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

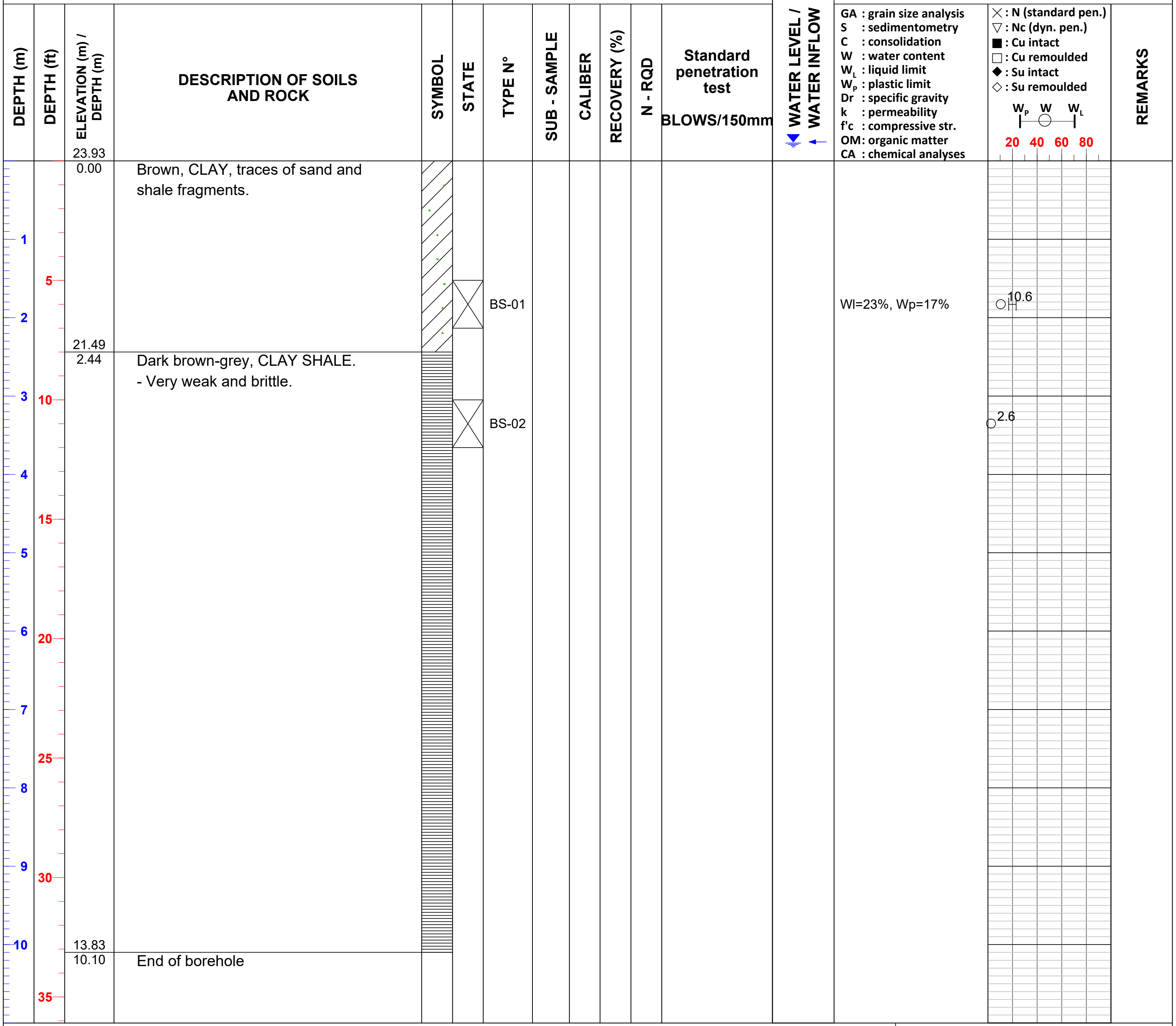
ROCK QUALITY DESIGNATION

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 | TESTS



ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	TYPE N°	SUB - SAMPLE	CALIBER	RECOVERY (%)	N - RQD	Standard penetration test BLOWS/150mm	WATER LEVEL / WATER INFLOW	TESTS	REMARKS
23.93 0.00	Brown, CLAY, traces of sand and shale fragments.	BS-01							Wl=23%, Wp=17%	
21.49 2.44	Dark brown-grey, CLAY SHALE. - Very weak and brittle.	BS-02								
13.83 10.10	End of borehole									

TESTS legend

GA	grain size analysis
S	sedimentometry
C	consolidation
W	water content
W_L	liquid limit
W_P	plastic limit
Dr	specific gravity
k	permeability
f'c	compressive str.
OM	organic matter
CA	chemical analyses

×	N (standard pen.)
▽	Nc (dyn. pen.)
■	Cu intact
□	Cu remoulded
◆	Su intact
◇	Su remoulded

General remarks:

Verified by :

Date : 2021-03-22

NUNAMI STANTEC

BOREHOLE REPORT

Project:	Geotechnical Evaluation and Drainage planning - Arctic Bay	Location :	UTM83 zone 16	Borehole :	BH20-08
Project No.:	144902983	X :	559605	Page :	1 of 1
Client:	Government of Nunavut	Y :	8104130	Start date :	2020-11-15
Site:	Arctic Bay, NU	Type of borehole :	Air track	Inspector :	Kudlik Construction Ltd.
Figure:		Equipment :	Air Track Drill	Depth :	9.20 m
		Casings :	mm	Elevation :	34.20 m
		Corer :	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 (%)

GROUNDWATER ▽

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded
▨	Intact (thin wall sampler)
■	Lost
◧	Core (diamond rock core)

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 %

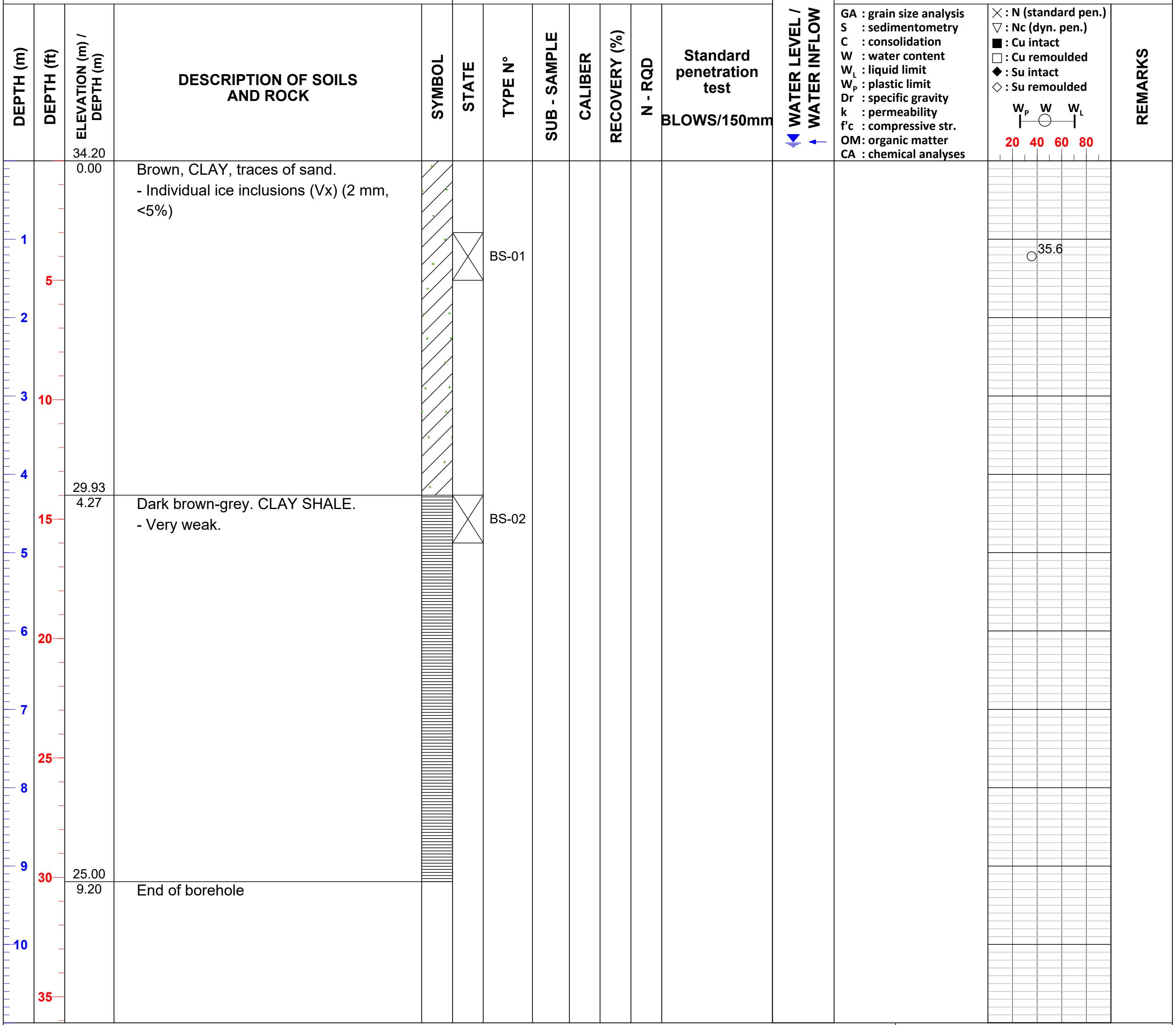
JOINTS SPACING

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

TESTS



ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	TYPE N°
34.20 0.00	Brown, CLAY, traces of sand. - Individual ice inclusions (Vx) (2 mm, <5%)	BS-01
29.93 4.27	Dark brown-grey. CLAY SHALE. - Very weak.	BS-02
25.00 9.20	End of borehole	

GA : grain size analysis
S : sedimentometry
C : consolidation
W : water content
W_L : liquid limit
W_P : plastic limit
Dr : specific gravity
k : permeability
f'c : compressive str.
OM: organic matter
CA : chemical analyses

☒ : N (standard pen.)
▽ : Nc (dyn. pen.)
■ : Cu intact
☐ : Cu remoulded
◆ : Su intact
◇ : Su remoulded

General remarks:

Verified by :

Date : 2021-03-22

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NUNAMI STANTEC

BOREHOLE REPORT

Project:	Geotechnical Evaluation and Drainage planning - Arctic Bay	Location :	UTM83 zone 16	Borehole :	**BH20-09**
		X :	560231	Page :	1 of 1
Project No.:	144902983	Y :	8105710	Start date :	2020-11-16
Client:	Government of Nunavut	Type of borehole :	Air track	Inspector :	Kudlik Construction Ltd.
Site:	Arctic Bay, NU	Equipment :	Air Track Drill	Depth :	9.90 m
Figure:		Casings :	mm	Elevation :	35.35 m
		Corer :	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 (%)

GROUNDWATER

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded
▨	Intact (thin wall sampler)
■	Lost
◧	Core (diamond rock core)

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

TESTS

GA : grain size analysis
S : sedimentometry
C : consolidation
W : water content
W_L : liquid limit
W_P : plastic limit
Dr : specific gravity
k : permeability
f'c : compressive str.
OM: organic matter
CA : chemical analyses

☒ : N (standard pen.)
▽ : Nc (dyn. pen.)
■ : Cu intact
□ : Cu remoulded
◆ : Su intact
◇ : Su remoulded

W_P W W_L

20 40 60 80

ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	STATE	TYPE N°	SUB - SAMPLE	CALIBER	RECOVERY (%)	N - RQD	Standard penetration test BLOWS/150mm	WATER LEVEL / WATER INFLOW	TESTS	W	REMARKS
35.35 0.00	Dark brown, CLAY, traces of sand. - Individual ice inclusions (Vx)											
		☒	BS-01							Wl=19%, Wp=14%	17.0	
34.28 1.07	ICE, without soil inclusions.											
32.91 2.44	ICE, with soil inclusions (5-10%)											
		☒	BS-02									
30.78 4.57	Dark brown, sandy CLAY. - Individual ice inclusions (Vx)											
		☒	BS-03								17.7	
		☒	BS-04								15.4	
26.51 8.84	Red, BEDROCK. - Unconfirmed lithology.											
25.45 9.90	End of borehole											

DEPTH (m): 1 2 3 4 5 6 7 8 9 10

DEPTH (ft): 5 10 15 20 25 30 35

General remarks: **Possible ice wedges around borehole location.**

Verified by :

Date : 2021-03-22

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NUNAMI STANTEC

BOREHOLE REPORT

Project:	**Geotechnical Evaluation and Drainage planning - Arctic Bay**	Location :	**UTM83 zone 16**	Borehole :	**BH20-10**
		X :	**560513**	Page :	**1 of 1**
Project No.:	**144902983**	Y :	**8105757**	Start date :	**2020-11-16**
Client:	**Government of Nunavut**	Type of borehole :	**Air track**	Inspector :	**Kudlik Construction Ltd.**
Site:	**Arctic Bay, NU**	Equipment :	**Air Track Drill**	Depth :	**10.10 m**
Figure:		Casings :	**mm**	Elevation :	**37.05 m**
		Corer :	**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 (%)

GROUNDWATER

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded
▨	Intact (thin wall sampler)
■	Lost
◧	Core (diamond rock core)

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 / TESTS

GA : grain size analysis
S : sedimentometry
C : consolidation
W : water content
W_L : liquid limit
W_P : plastic limit
Dr : specific gravity
k : permeability
f'c : compressive str.
OM: organic matter
CA : chemical analyses

☒ : N (standard pen.)
▽ : Nc (dyn. pen.)
■ : Cu intact
□ : Cu remoulded
◆ : Su intact
◇ : Su remoulded

W_P W W_L — 20 40 60 80

ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	STATE	TYPE N°	SUB - SAMPLE	CALIBER	RECOVERY (%)	N - RQD	Standard penetration test BLOWS/150mm	WATER LEVEL / WATER INFLOW	TESTS	W	REMARKS
37.05 0.00	Brown, silty SAND, some clay, traces of gravel. - Individual ice inclusions (Vx) (<0.5 mm, <5%)	☒	BS-01							GA	8.1	
34.61 2.44	Brown, gravelly SAND, some fines.	☒	BS-02							GA	13.0	
32.48 4.57	Dark brown-black, CLAY. - Well bonded, no excess ice (Nbn)	☒	BS-03								13.1	
29.43 7.62	Dark brown-black, CLAY, some sand and gravel.	☒	BS-04								10.1	
28.82 8.23	Red, BEDROCK. - Unconfirmed lithology.	☒	BS-05									
26.95 10.10	End of borehole											

General remarks:

Verified by :

Date : 2021-03-22

NUNAMI STANTEC

BOREHOLE REPORT

Project:	**Geotechnical Evaluation and Drainage planning - Arctic Bay**	Location :	**UTM83 zone 16**	Borehole :	**BH20-11**
		X :	**560765**	Page :	**1 of 1**
Project No.:	**144902983**	Y :	**8105513**	Start date :	**2020-11-16**
Client:	**Government of Nunavut**	Type of borehole :	**Air track**	Inspector :	**Kudlik Construction Ltd.**
Site:	**Arctic Bay, NU**	Equipment :	**Air Track Drill**	Depth :	**10.10 m**
Figure:		Casings :	**mm**	Elevation :	**18.84 m**
		Corer :	**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 (%)

GROUNDWATER

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded
▨	Intact (thin wall sampler)
■	Lost
◧	Core (diamond rock core)

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

TESTS

GA : grain size analysis
S : sedimentometry
C : consolidation
W : water content
W_L : liquid limit
W_P : plastic limit
Dr : specific gravity
k : permeability
f'c : compressive str.
OM: organic matter
CA : chemical analyses

☒ : N (standard pen.)
▽ : Nc (dyn. pen.)
■ : Cu intact
☐ : Cu remoulded
◆ : Su intact
◇ : Su remoulded

W_P W W_L — 20 40 60 80

ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	STATE	TYPE N°	SUB - SAMPLE	CALIBER	RECOVERY (%)	N - RQD	Standard penetration test BLOWS/150mm	WATER LEVEL / WATER INFLOW	TESTS	W	REMARKS
18.84 0.00	Brown, clayey SAND. - Individual ice inclusions (Vx) (<2%)	☒	BS-01								19.8	
17.01 1.83	Light brown, SAND, traces of gravel. - Individual ice inclusions (Vx) (5-15%)	☒	BS-02								15.2	
14.88 3.96	Light brown, SAND and GRAVEL.	☒	BS-03								4.8	
11.52 7.32	Red brown, SAND and GRAVEL.	☒	BS-04								5.4	
8.74 10.10	End of borehole											

General remarks: **Rock near surface**

Verified by : ____________

Date : **2021-03-22**

NUNAMI STANTEC

BOREHOLE REPORT

Project:	**Geotechnical Evaluation and Drainage planning - Arctic Bay**	Location :	**UTM83 zone 16**	Borehole :	**BH20-12**
		X :	**560985**	Page :	**1 of 1**
Project No.:	**144902983**	Y :	**8105320**	Start date :	**2020-11-16**
Client:	**Government of Nunavut**	Type of borehole :	**Air track**	Inspector :	**Kudlik Construction Ltd.**
Site:	**Arctic Bay, NU**	Equipment :	**Air Track Drill**	Depth :	**10.20 m**
Figure:		Casings :	**mm**	Elevation :	**13.36 m**
		Corer :	**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 (%)

GROUNDWATER ▽

	Date	Depth
Reading 1		m
Reading 2		m

Remarks :

SAMPLE STATE

☒	Remoulded
▨	Intact (thin wall sampler)
■	Lost
◧	Core (diamond rock core)

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 / TESTS

Tests legend:

GA : grain size analysis
S : sedimentometry
C : consolidation
W : water content
W_L : liquid limit
W_P : plastic limit
Dr : specific gravity
k : permeability
f'c : compressive str.
OM: organic matter
CA : chemical analyses

☒ : N (standard pen.)
▽ : Nc (dyn. pen.)
■ : Cu intact
☐ : Cu remoulded
◆ : Su intact
◇ : Su remoulded

W_P W W_L — 20 40 60 80

ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	STATE	TYPE N°	SUB - SAMPLE	CALIBER	RECOVERY (%)	N - RQD	Standard penetration test BLOWS/150mm	WATER LEVEL / WATER INFLOW	TESTS	W	REMARKS
13.36 0.00	Red brown, silty SAND, some clay, traces of gravel.	☒	BS-01							GA	6.6	
11.84 1.52	Red brown, SAND, traces of clay and gravel. - Individual ice inclusions (Vx) (up to 3 mm, 10%)	☒	BS-02								18.0	
	... Ice content decreases with depth to not visible	☒	BS-03								11.0	
7.57 5.79	Red brown, clayey SAND. ...with gravel											
3.16 10.20	End of borehole											

General remarks:

Verified by :

Date : 2021-03-22

APPENDIX D Laboratory Analysis

Stantec

2273 Michelin Street,
Laval QC, H7L 5B8

LABORATORY TESTING REPORT

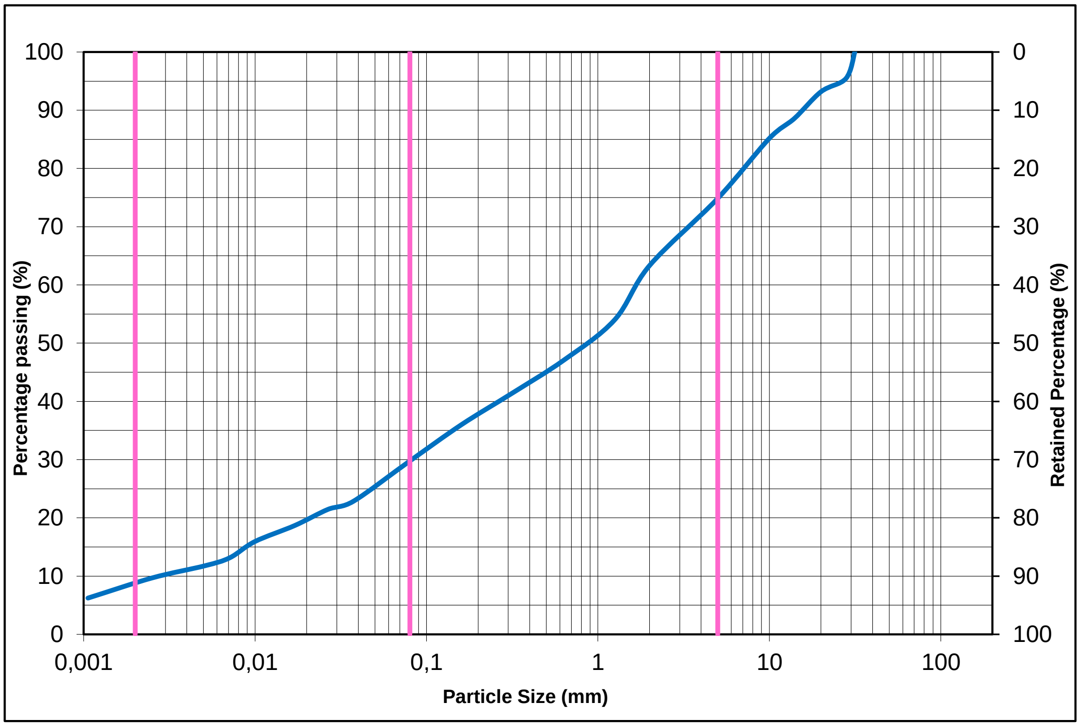
Client : Government of Nunavut
Project : Department of Community and Government Servic
Arctic Bay, NU
Project No : 144903266.200.700
Sample No : BH22-01 DC-03
Depth : 1,30 - 1,60m

Sampled by : Olivier Piraux
Sampling Date : July 19, 2022

Material Description : Silty, Gravely Sand, traces of Clay

Grain Size Analysis (BNQ 2501-025)

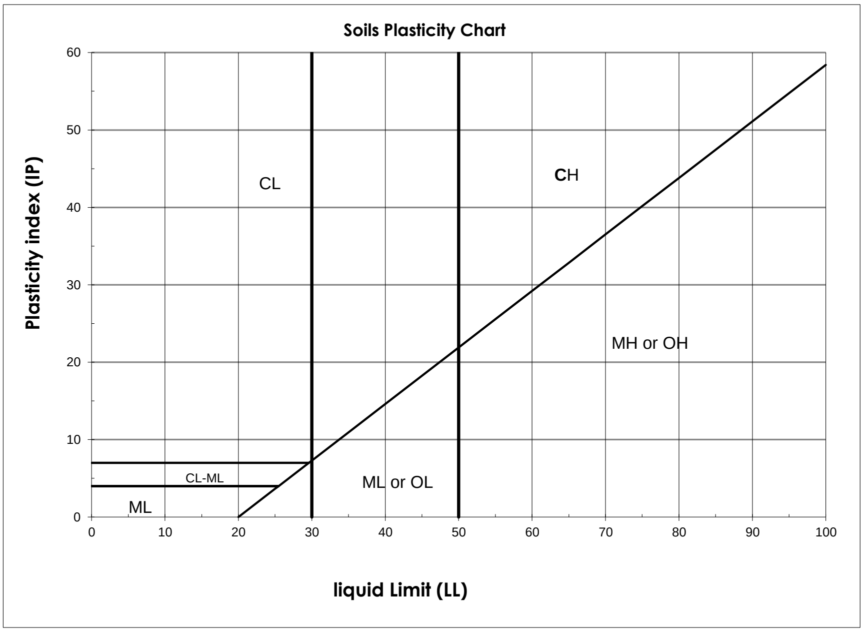
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	95
20,0	93
14,0	89
10,0	85
5,00	75
2,00	63
1,25	54
0,630	47
0,315	41
0,160	36
0,080	29,8



% Gravel: 25,1 % Sand : 45,1 % Silt: 21,3 % Clay: 8,5

Other tests

Test / Standard	Results
Water Content (NQ 2501-170) (%)	15,4



Remarks :

Prepared by : Benoit Cyr, Geo.

Date : August 15, 2022

Stantec
2273 Michelin Street,
Laval QC, H7L 5B8

LABORATORY TESTING REPORT

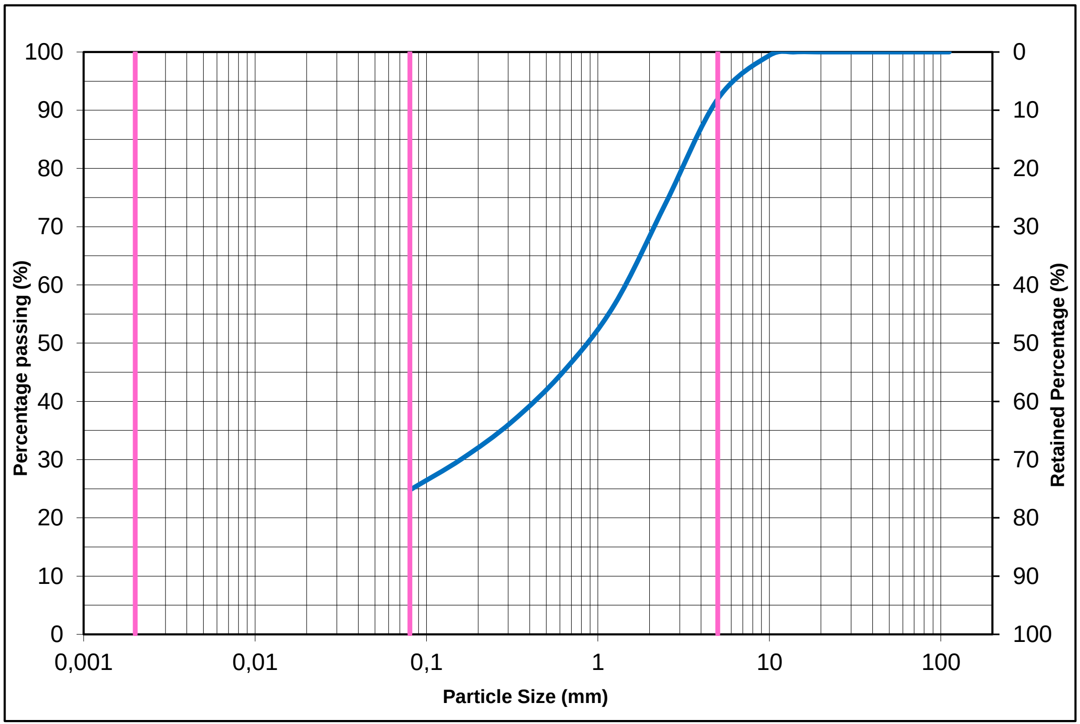
Client : Government of Nunavut
Department of Community and Government Services
Project : Arctic Bay, NU
Project No : 144903266.200.700
Sample No : BH22-02 DC-02
Depth : 1,00 - 1,05m

Sampled by : Olivier Piraux
Sampling Date : July 19, 2022

Material Description : Silty Sand, traces of Gravel

Grain Size Analysis (BNQ 2501-025)

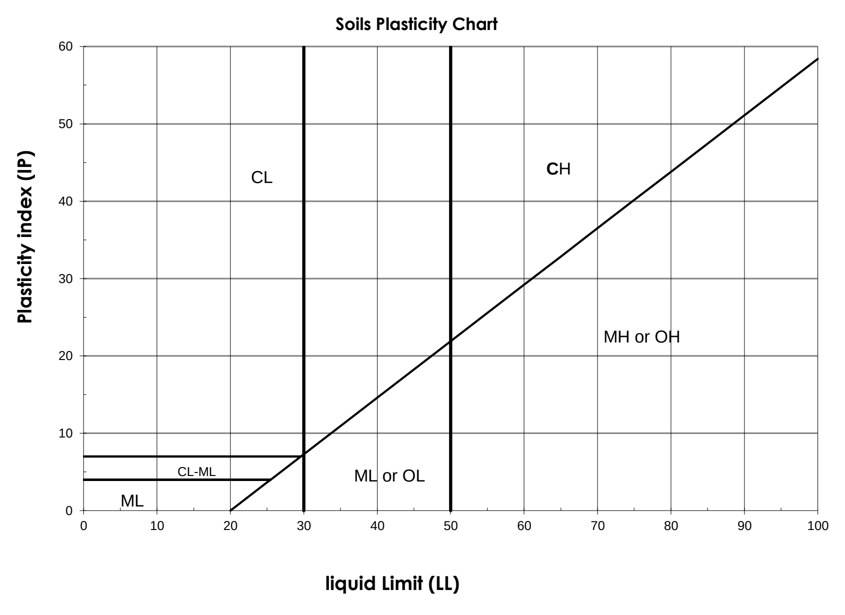
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	100
14,0	100
10,0	99
5,00	92
2,50	74
1,25	57
0,630	45
0,315	37
0,160	30
0,080	24,8



% Gravel : 8,1 % Sand : 67,1 % Fine particles : 24,8

Other tests

Test / Standard	Results
Water Content (NQ 2501-170) (%)	11,0



Remarks :

Prepared by : Benoit Cyr, Geo.

Date : August 15, 2022

2273 Rue Michelin
Laval QC, H7L 5B8

Détermination de la teneur en eau par séchage

LC 21-201
BNQ 2501-170

Projet: Arctic Bay, NU
No de projet: 144903266.200.700

Date de l'essai: 05-08-2022
Réalisé par: B. Cyr

Équipements utilisés : Balance : ☑ LAV-012 ☐ LAV-013 Étuve : ☐ LAV-025 ☐ LAV-026 ☑ LAV-090

Teneur en eau

Forage / tranchée No	BH22-01	BH22-01	BH22-01	BH22-02			
Échantillon	DC-02	DC-03	DC-04	DC-02			
Profondeur (m)	1.10-1.23	1.30-1.60	1.60-1.80	1.00-1.05			
No de la tare							
Masse tare+ échantillon humide (g)	798,3	1144,9	1299,4	481,2			
Masse tare+ échantillon sec (g)	715,7	1013,4	858,8	442,2			
Masse de l'eau (g)	82,6	131,5	440,6	39,0			
Masse de la tare	139,9	159,6	155,1	87,6			
Masse sèche(g)	575,8	853,8	703,7	354,6			
Teneur en eau (%)	**14,3**	**15,4**	**62,6**	**11,0**			
Remarques							

Révisé par : Benoit Cyr, géo.

Date: 15-08-2022

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APPENDIX E Drainage Infrastructure Inventory

Culvert Information		
Culvert ID		AB_2
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		11.5
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Burried
	Downstream	Burried
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Small stream across old road segment. Erosion of the embankment.	

Culvert Location	
Street	R60
Northing (m) [1]	8104975
Easting (m) [1]	562505

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Elevations (masl) [2]

Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)

Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	0	2	0

Recommended Action(s):	Extend inlet/outlet to protect from erosion of the embankment
Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

US, Looking US

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_4
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		11.2
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Good overall condition.	

Culvert Location	
Street	R60
Northing (m) [1]	8105060
Easting (m) [1]	562283

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Elevations (masl) [2]

Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)

Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	0	0	0

Recommended Action(s):	None
Priority:	None

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

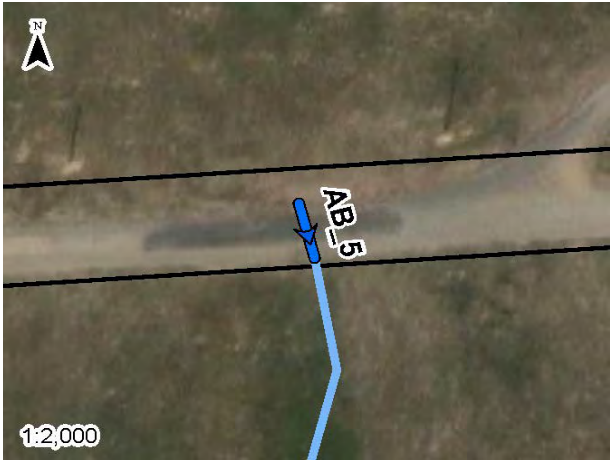
Culvert Information		
Culvert ID		AB_5
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		11.5
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	350
	Downstream	500
Other Comments	Inlet ripped by grader. Outlet no visible. Major erosion draining water coming alongside road to dump.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R60
Northing (m) [1]	8105036
Easting (m) [1]	561937

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	2	0

Recommended Action(s):	Excavate and replace culvert; ensure sufficient depth of cover
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

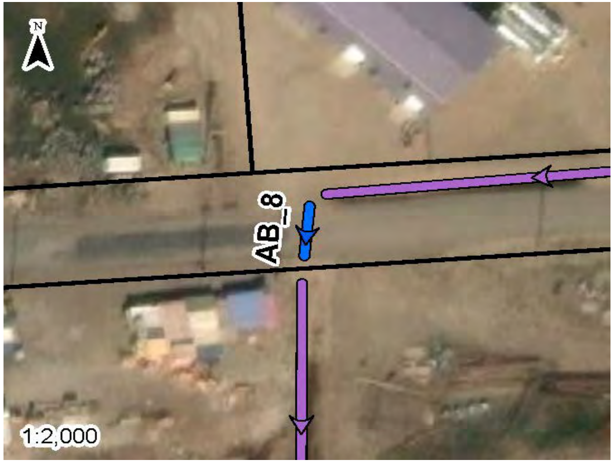
Culvert Information		
Culvert ID		AB_8
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		10.0
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Recently installed. Good example of erosion control (riprap) in well defined drainage ditch.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R60
Northing (m) [1]	8105018
Easting (m) [1]	561668

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	0	0	0

Recommended Action(s):	None
Priority:	None

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_10
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		10.7
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	400
	Downstream	0
Other Comments	Absence of ditch at the inlet cause infill of material in the culvert. Erosion of the embankment causing obstruction at the outlet.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R57
Northing (m) [1]	8105226
Easting (m) [1]	561025

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	2	0

Recommended Action(s):	Clean infill; extend inlet/outlet; erosion control at outlet
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

US, Looking US

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_16
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		9.8
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Burried
Infill Depth (mm)	Upstream	400
	Downstream	0
Other Comments	Inlet is damaged and partially blocked. Outlet extension is detached, likely caused by erosion of the embankment.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R31
Northing (m) [1]	8105587
Easting (m) [1]	560433

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	1	0

Recommended Action(s):	Repair crushed inlet; erosion protection at oulet
Priority:	Low

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_18
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		11.4
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	150
	Downstream	100
Other Comments	Long culvert across road and pad below. Erosion noted at outlet.	

Culvert Location	
Street	R33
Northing (m) [1]	8105639
Easting (m) [1]	560408

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	1	2	0

Recommended Action(s):	Clean inlet area; apply erosion control at outlet
Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_20
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		9.4
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	300
	Downstream	200
Other Comments	Shallow ditch leading to culvert inlet; some sedimentation and ponding.	

Culvert Location	
Street	R34
Northing (m) [1]	8105649
Easting (m) [1]	560415

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	0	0

Recommended Action(s):	Repair crushed inlet/outlet; excate ditch
Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information

Culvert ID		AB_22
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		8.1
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Crushed inlet and perched outlet causing erosion. Culvert appears to be caving in at its center.	

Culvert Location

Street	R5
Northing (m) [1]	8105266
Easting (m) [1]	560041

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Elevations (masl) [2]

Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)

Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	2	0	2	1

Recommended Action(s):	Excavate and replace by 800 mm culvert; apply erosion control at outlet

Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_24
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		11.7
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Culvert in good overall condition; ditch leading to inlet needs improvement.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R12
Northing (m) [1]	8105344
Easting (m) [1]	559965

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
1	0	0	2	2

Recommended Action(s):	Excavate ditch between culverts
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

US, Looking US

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_25
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		11.1
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Burried
	Downstream	Burried
Infill Depth (mm)	Upstream	800
	Downstream	0
Other Comments	Inlet fully burried. Outlet very close to store, without good ditchline conveying water downslope.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R13
Northing (m) [1]	8105411
Easting (m) [1]	559966

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
1	1	2	1	1

Recommended Action(s):	Excavate ditch; apply erosion control
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_28
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		12.1
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Perched outlet, caused by erosion of the embankment.	

Culvert Location	
Street	R66
Northing (m) [1]	8105185
Easting (m) [1]	559800

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	0	2	1

Recommended Action(s):	Apply erosion control at outlet

Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_30
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		9.4
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	No
	Downstream	Yes
Infill Depth (mm)	Upstream	50
	Downstream	0
Other Comments	Signs of previous erosion immediately west and below from outlet. Major flow path identified as problematic.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R5
Northing (m) [1]	8105150
Easting (m) [1]	559880

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	1	2	2

Recommended Action(s):	Apply erosion control at outlet
Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_31
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		15.1
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Perched outlet causing erosion.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R2
Northing (m) [1]	8105026
Easting (m) [1]	559772

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	0	1	1

Recommended Action(s):	Repair crushed inlet; apply erosion control at outlet
Priority:	Low

Upstream View

Upstream Culvert End

Downstream View

US, Looking US

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_33
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		10.9
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Burried
	Downstream	Burried
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	None	

Culvert Elevations (masl)[2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	N.A.
Northing (m)[1]	8105095
Easting (m)[1]	559674

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

N.A

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	0	0	0

Recommended Action(s): N.A.

Priority: None

Upstream View

N.A

Upstream Culvert End

N.A

Downstream View

N.A

Downstream Culvert End

N.A

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_35
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		11.4
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Debris obstructing inlet.	

Culvert Location	
Street	R67
Northing (m) [1]	8104684
Easting (m) [1]	559629

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	0	1	2

Recommended Action(s):	Apply erosion control at outlet and along downstream channel
Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_37
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		10.9
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	350
	Downstream	0
Other Comments	Significant infill at the inlet. Outlet located in an area impacted by shoreline erosion.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

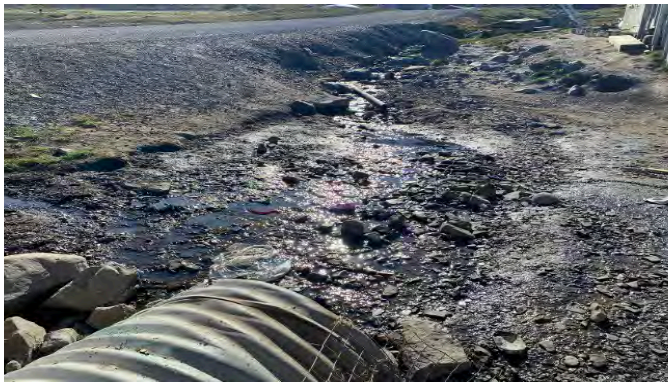
Culvert Location	
Street	R55
Northing (m) [1]	8104675
Easting (m) [1]	559774

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	0	0

Recommended Action(s):	Remove infilled material at inlet. Monitor for shoreline erosion
Priority:	Medium

Upstream View



Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_40
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		17.5
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	150
	Downstream	0
Other Comments	Crushed inlet; shallow depth of cover. Perched outlet causing erosion.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R59
Northing (m) [1]	8104686
Easting (m) [1]	559539

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	1	1	2	2

Recommended Action(s):	Excavate and replace culvert; apply erosion control at outlet
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_41
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		450
Marker Post Present		No
Barrel Length (m)		12.7
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	150
	Downstream	220
Other Comments	Crushed inlet; shallow depth of cover.	

Culvert Location	
Street	R59
Northing (m) [1]	8104646
Easting (m) [1]	559521

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Elevations (masl) [2]

Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)

Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	4	2	0	0

Recommended Action(s):	Excavate and replace culvert

Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_43
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		9.3
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Deformed culvert; appeared to short at the inlet/outlet. Erosion of the embankment.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

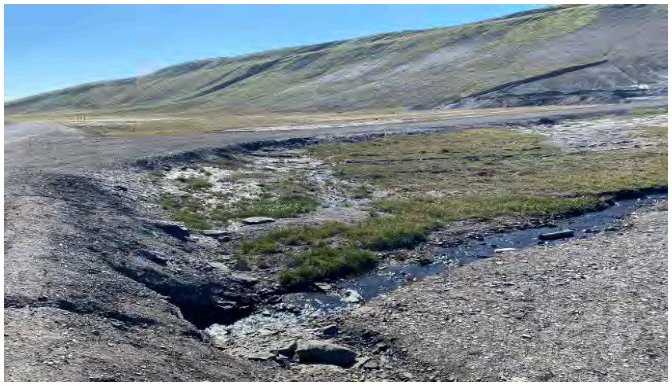
Culvert Location	
Street	R73
Northing (m) [1]	8104456
Easting (m) [1]	559548

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	2	0	1	1

Recommended Action(s):	Extend inlet and outlet, apply erosion control
Priority:	Medium

Upstream View



Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_45
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		600
Marker Post Present		No
Barrel Length (m)		16.6
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	150
	Downstream	150
Other Comments	Crushed inlet/outlet, ripped off by plower/grader. Signs of ponding at outlet.	

Culvert Location	
Street	R33
Northing (m) [1]	8105585
Easting (m) [1]	560657

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	1	0	0

Recommended Action(s):	Repair crushed inlet/outlet; excate ditch in the area

Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_54
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		600
Marker Post Present		No
Barrel Length (m)		5.3
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	400
	Downstream	0
Other Comments	Culvert collapsed and blocked near center of road. Blockage has caused piping and erosion of the embankment.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R71
Northing (m) [1]	8104120
Easting (m) [1]	559795

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	4	2	2	2

Recommended Action(s):	Excavate and replace culvert
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

US, Looking US

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_56
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		450
Marker Post Present		No
Barrel Length (m)		7.8
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	450
	Downstream	450
Other Comments	Buried infill, ripped outlet. Significant seepage area associated to large gully upslope.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R72
Northing (m) [1]	8104076
Easting (m) [1]	559680

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	4	2	1	0

Recommended Action(s):	Excavate and replace by oversize culvert (800 mm); raise road bed
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_61
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		8.4
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Crushed inlet.	

Culvert Location	
Street	R61
Northing (m) [1]	8105031
Easting (m) [1]	561372

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Elevations (masl) [2]

Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)

Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	0	0	0

Recommended Action(s):	Repair crushed inlet and remove debris in the ditch
Priority:	Low

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_65
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		8.6
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Not visible
Infill Depth (mm)	Upstream	650
	Downstream	150
Other Comments	Crushed inlet, infilled by sediment. Outlet impacted by shoreline erosion/wave action. Some infill from wave action.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R54
Northing (m) [1]	8104508
Easting (m) [1]	559771

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	3	2	2	1

Recommended Action(s):	Excavate and replace culvert; shoreline erosion control in the area
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_140
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		9.5
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	No
	Downstream	Yes
Infill Depth (mm)	Upstream	0
	Downstream	150
Other Comments	Inlet is high compared to depth of the ditch. Observed ponding. Crushed outlet and embankment stability issue.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R60
Northing (m) [1]	8104882
Easting (m) [1]	562637

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	1	2	0

Recommended Action(s):	Lower culvert and extend inlet/outlet; erosion control at outlet
Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information

Culvert ID		AB_142
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		10.6
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	300
	Downstream	0
Other Comments	Crushed inlet and sediment infill causing ponding. Erosion of the embankment at the outlet.	

Culvert Elevations (masl) [2]

Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location

Street	R60
Northing (m) [1]	8104823
Easting (m) [1]	562698

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Condition Ratings (MTO 2013)

Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	2	0

Recommended Action(s):	Clean inlet of infill; extend outlet
Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

US, Looking US

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_144
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		12.5
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	50
	Downstream	0
Other Comments	Erosion of the embankment; culvert to short.	

Culvert Location	
Street	R60
Northing (m) [1]	8104707
Easting (m) [1]	562767

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	1	2	0

Recommended Action(s):	Clean inlet of infill; extend outlet; erosion control at outlet
Priority:	Low

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_146
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		7.8
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	100
	Downstream	600
Other Comments	Minor crushing at inlet; outlet has collapsed. Embankment stability issue. Roadside hazard.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R60
Northing (m) [1]	8104598
Easting (m) [1]	562832

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	2	0

Recommended Action(s):	Clean inlet of infill; extend outlet; erosion control at outlet
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_149
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		8.3
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	550
	Downstream	200
Other Comments	Crushed inlet. Infill limited to inlet/outlet areas, from embankment material caving. Embankment erosion at outlet. Roadway hazard.	

Culvert Location	
Street	R60
Northing (m) [1]	8104507
Easting (m) [1]	562880

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Elevations (masl) [2]

Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)

Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	2	0

Recommended Action(s):	Clean infill; extend inlet/outlet; erosion control at outlet
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_151
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		600
Marker Post Present		No
Barrel Length (m)		5.1
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Culvert is crushed at its center, approx. 2m from downstream end. Drains in area impacted by shoreline erosion.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R71
Northing (m) [1]	8104241
Easting (m) [1]	559811

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
1	4	0	0	0

Recommended Action(s):	Excavate and replace culvert
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

US, Looking US

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_153
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		300
Marker Post Present		No
Barrel Length (m)		11.1
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	150
Other Comments	Poorly defined ditch leading to/from inlet. Poorly drained area with seasonnal ponding.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R59
Northing (m) [1]	8104832
Easting (m) [1]	559418

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	0	0

Recommended Action(s):	Clean outlet area
Priority:	Low

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_154
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		10.8
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Deformed culvert, oval 600x950. No visible flow channel up/down from culvert, also no culvert across road immediately below.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	N.A.
Northing (m) [1]	8105045
Easting (m) [1]	559364

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	2	0	0	0

Recommended Action(s):	Repair crushed inlet
Priority:	None

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_155
Type		Entrance
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		600
Marker Post Present		No
Barrel Length (m)		21.4
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	100
Other Comments	Good overall condition except for some riprap material obstructing the inlet/outlet areas. Embankment stability issue at the outlet.	

Culvert Location	
Street	R9
Northing (m) [1]	8105266
Easting (m) [1]	559847

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Elevations (masl) [2]

Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)

Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	1	1	0

Recommended Action(s):	Clean inlet/oulet area

Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_156
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		12.0
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	280
	Downstream	150
Other Comments	Culvert crushed and almost fully blocked. Ditch needs cleanup and deepening. Erosion of embankment at outlet from overflow above road surface.	

Culvert Elevations (masl)[2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R35
Northing (m)[1]	8105702
Easting (m)[1]	560369

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	1	0

Recommended Action(s):	Clean inlet/outlet of infill, excate ditch
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_157
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		450
Marker Post Present		No
Barrel Length (m)		11.0
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	100
	Downstream	0
Other Comments	Two culverts side by side, approx. 2m aside. Old culvert inlet fully buried. New culvert already crushed at inlet.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R36
Northing (m) [1]	8105729
Easting (m) [1]	560365

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	1	1	1

Recommended Action(s):	Repair crushed inlet

Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_158
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		28.9
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Long culvert across road and housing pad. Poorly defined ditch above from inlet. Erosion downslope from outlet.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R11
Northing (m) [1]	8105381
Easting (m) [1]	559944

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
1	0	0	1	1

Recommended Action(s):	Increase depth of ditch leading to next culvert below

Priority:	Low

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

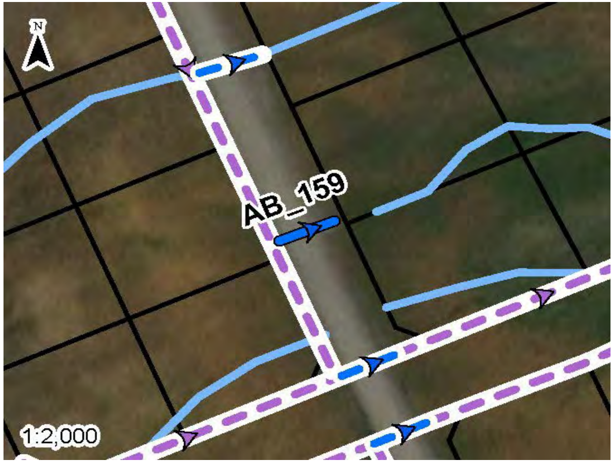
Culvert Information		
Culvert ID		AB_159
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		300
Marker Post Present		No
Barrel Length (m)		11.0
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	100
	Downstream	0
Other Comments	Undersized culvert, crushed and ripped. Erosion of embankment at outlet.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R69
Northing (m) [1]	8104190
Easting (m) [1]	559628

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	4	2	2	2

Recommended Action(s):	Excavate and replace by oversize culvert (800mm); raise road bed
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_160
Type		Entrance
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		300
Marker Post Present		No
Barrel Length (m)		7.4
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	50
	Downstream	50
Other Comments	No ditch conveying water to inlet. Culvert crushed from plowing/grading.	

Culvert Location	
Street	R59
Northing (m) [1]	8104679
Easting (m) [1]	559530

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	1	1	0	0

Recommended Action(s):	Excavate and replace with 500 mm; increase depth of ditch
Priority:	Low

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_161
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		300
Marker Post Present		No
Barrel Length (m)		11.4
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	No
	Downstream	Yes
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Undersized culvert for drainage area above. Crushed outlet and erosion of the embankment.	

Culvert Location	
Street	R67
Northing (m) [1]	8104953
Easting (m) [1]	559586

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	0	0	0

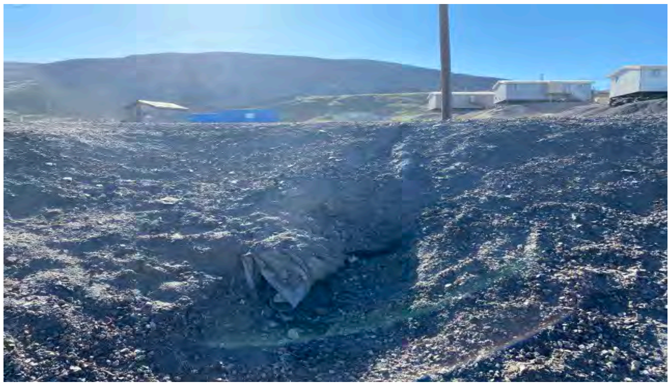
Recommended Action(s):	Excavate and replace by 500 mm culvert
Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End



NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_162
Type		Cross
Shape		Round
Material		SWSP
Diameter or Dimensions (mm)		200
Marker Post Present		No
Barrel Length (m)		9.9
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	120
	Downstream	180
Other Comments	Improvized culvert using metal pipe (foundation pile), poorly placed inlet, with outlet infilled by embankment material.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R5
Northing (m) [1]	8105227
Easting (m) [1]	559986

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	0	0

Recommended Action(s):	Excavate and replace by 500 mm culvert
Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_163
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		5.4
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	500
	Downstream	350
Other Comments	Major drainage path characterized by erosion issues. Existing culvert is fully infilled at the inlet.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	N.A.
Northing (m) [1]	8105303
Easting (m) [1]	560010

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
1	2	2	2	2

Recommended Action(s):	Channel stabilization and erosion control required; replace with 800 mm.

Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_164
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		10.7
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	750
	Downstream	250
Other Comments	Ditchline backfilled with sediments. Culvert is crushed and buried. Outlet too short causing erosion of the embankment.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R16
Northing (m) [1]	8105371
Easting (m) [1]	560136

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	1	0

Recommended Action(s):	Clean inlet or infill; excavate upstream ditch
Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_165
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		19.2
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	350
	Downstream	0
Other Comments	Ditchline backfilled with sediments. Culvert is nearly blocked. Perched outlet causing erosion of the embankment.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R14
Northing (m) [1]	8105412
Easting (m) [1]	560028

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
1	0	2	0	0

Recommended Action(s):	Increase depth of ditch (upstream and downstream); repair culvert inlet
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_166
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		21.8
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Buried
Infill Depth (mm)	Upstream	350
	Downstream	0
Other Comments	No ditch routing water to this culvert. Water comes from seepage above Coop parking lot and from below Coop building.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R12
Northing (m) [1]	8105402
Easting (m) [1]	560015

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
1	1	2	0	0

Recommended Action(s):	Increase depth of ditch (upstream and downstream); repair culvert inlet

Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_167
Type		Entrance
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		23.9
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Buried
	Downstream	Yes
Infill Depth (mm)	Upstream	500
	Downstream	0
Other Comments	Inlet fully buried. Crushed outlet.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R14
Northing (m) [1]	8105388
Easting (m) [1]	560036

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
1	0	2	0	0

Recommended Action(s):	Excavate/unblock inlet area
Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_169
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		17.5
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Crushed inlet. Water flows overtop the road surface, causing erosion problems.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R20
Northing (m) [1]	8105548
Easting (m) [1]	560048

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	0	1	1

Recommended Action(s):	Repair inlet; erosion control at outlet

Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information

Culvert ID		AB_170
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		10.2
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	100
	Downstream	0
Other Comments	Crushed inlet and obstruction by debris in upstream channels; absence of culvert/channel downstream from this location.	

Culvert Elevations (masl) [2]

Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location

Street	R16
Northing (m) [1]	8105581
Easting (m) [1]	560153

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)

Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	1	0	0

Recommended Action(s):	Remove material from inlet/outlet areas; excavate ditch

Priority:	Low

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		#N/A
Type		#N/A
Shape		#N/A
Material		#N/A
Diameter or Dimensions (mm)		#N/A
Marker Post Present		#N/A
Barrel Length (m)		#N/A
Approx. Barrel Slope (%)		#N/A
Approx. Depth of Cover (m)		#N/A
End Crushing	Upstream	#N/A
	Downstream	#N/A
Infill Depth (mm)	Upstream	#N/A
	Downstream	#N/A
Other Comments	#N/A	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
#N/A	#N/A	#N/A	#N/A	#N/A

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	#N/A
Northing (m) [1]	#N/A
Easting (m) [1]	#N/A

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

N.A

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
#N/A	#N/A	#N/A	#N/A	#N/A

Recommended Action(s):	#N/A
Priority:	#N/A

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_172
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		10.9
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	350
	Downstream	300
Other Comments	Flowpath from below the school, surface erosion. No proper conveying of water between culverts along flowpath	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R16
Northing (m) [1]	8105451
Easting (m) [1]	560231

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	0	0

Recommended Action(s):	Remove material from inlet/outlet areas; excavate ditch

Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_173
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		18.0
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	500
	Downstream	100
Other Comments	Buried inlet and outlet areas. ditchline infilled with sediments and road surfacing materials.	

Culvert Location	
Street	R33
Northing (m) [1]	8105618
Easting (m) [1]	560347

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
1	0	2	0	0

Recommended Action(s):	Remove material from inlet/outlet areas; excavate ditch
Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_174
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		9.5
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Burried
	Downstream	Yes
Infill Depth (mm)	Upstream	800
	Downstream	300
Other Comments	Buried inlet. Ditchline backfilled with sediments.	

Culvert Location	
Street	R25
Northing (m) [1]	8105642
Easting (m) [1]	560325

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
1	0	2	0	0

Recommended Action(s):	Remove material from inlet/outlet areas, excavate ditch
Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_175
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		11.9
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	50
	Downstream	0
Other Comments	Signs of recent excavation in the ditch. Loose debris expected to cause future infill of the inlet area.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R28
Northing (m) [1]	8105514
Easting (m) [1]	560447

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	1	0	0

Recommended Action(s):	Clean inlet/outlet if infill, excate ditch
Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_176
Type		Cross
Shape		Round
Material		CSP/SWSP
Diameter or Dimensions (mm)		150
Marker Post Present		No
Barrel Length (m)		8.6
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Undersized culvert, significant seepage areas. Erosion visible along downside of embankment.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R23
Northing (m) [1]	8105692
Easting (m) [1]	560252

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	1	0	0	1

Recommended Action(s):	Excavate and replace with a 500 mm culvert
Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_177
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		24.3
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	300
	Downstream	400
Other Comments	Crushed inlet with significant infill of the ditch. Culvert oriented diagonally across the slope rather than straight downslope.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R16
Northing (m) [1]	8105596
Easting (m) [1]	560189

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
1	0	2	0	0

Recommended Action(s):	Remove material from inlet/outlet areas; excavate ditch
Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_178
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		12.1
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	200
	Downstream	50
Other Comments	Inlet is crushed and full of embankment material. No ditch pass the outlet.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R24
Northing (m) [1]	8105497
Easting (m) [1]	560295

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	1	1	0	0

Recommended Action(s):	Repair crushed inlet, clean outlet area
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information

Culvert ID		AB_179
Type		Entrance
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		8.7
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	250
	Downstream	50
Other Comments	Significant erosion along this flowpath.	

Culvert Location

Street	N.A.
Northing (m) [1]	8105168
Easting (m) [1]	559840

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Elevations (masl) [2]

Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)

Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	2	2

Recommended Action(s):	Clean infill; erosion control and embankment repair
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_180
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		11.7
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	550
	Downstream	350
Other Comments	Long culvert across road and pad below. Erosion noted at outlet.	

Culvert Location	
Street	R3
Northing (m) [1]	8105131
Easting (m) [1]	559851

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	2	2

Recommended Action(s):	Repair/extend inlet and outlet; apply erosion control
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_181
Type		Cross
Shape		Square
Material		SWSP
Diameter or Dimensions (mm)		200
Marker Post Present		No
Barrel Length (m)		12.3
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Improvized culvert. Erosion of embankment at the outlet. Erosion of the roadway embankment in the area.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R3
Northing (m) [1]	8105112
Easting (m) [1]	559816

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	0	2	1

Recommended Action(s):	Excavated and replace by 500 mm culvert
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_182
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		11.0
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Burried
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Deformed culvert (oval shaped,likely related to shipping/transport). Erosion of the embankment at the outlet.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R3
Northing (m) [1]	8105074
Easting (m) [1]	559792

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	0	2	1

Recommended Action(s):	Apply erosion control at outlet
Priority:	Low

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_183
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		12.2
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	550
	Downstream	0
Other Comments	Culvert inlet infilled by embankment material; culvert itself is clean. Erosion at outlet.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R55
Northing (m) [1]	8105003
Easting (m) [1]	559761

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	1	1

Recommended Action(s):	Clean ditchline; repair inlet; apply erosion control at outlet

Priority:	Low

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_184
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		16.4
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	350
	Downstream	0
Other Comments	Burried inlet. Perched outlet. Erosion of oversteep embankment. Shoreline erosion	

Culvert Location	
Street	R55
Northing (m) [1]	8104846
Easting (m) [1]	559751

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Elevations (masl) [2]

Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)

Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	2	2

Recommended Action(s):	Deepen the ditch and clean inlet area; shoreline erosion control
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_185
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		600
Marker Post Present		No
Barrel Length (m)		15.0
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	200
	Downstream	150
Other Comments	Two separate culvert segments. Significant infill.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R59
Northing (m) [1]	8104868
Easting (m) [1]	559439

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	0	0

Recommended Action(s): Clean inlet of infill; excavate ditch

Priority: Low

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_186
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		350
Marker Post Present		No
Barrel Length (m)		9.3
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	300
	Downstream	0
Other Comments	Buried inlet. Very shallow depth of cover (~150 mm) with culvert impacted by grading.	

Culvert Elevations (masl) [2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R57
Northing (m) [1]	8105112
Easting (m) [1]	561217

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	0	0

Recommended Action(s):	Reinstall 500 mm culvert at greater depth
Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information		
Culvert ID		AB_189
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
Barrel Length (m)		12.7
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	Yes
	Downstream	Burried
Infill Depth (mm)	Upstream	150
	Downstream	0
Other Comments	Culvert is 500 mm at inlet, 300 mm at outlet. Cracking alongside the embankment, above from outlet.	

Culvert Elevations (masl)[2]				
Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Location	
Street	R60
Northing (m) [1]	8104421
Easting (m) [1]	562917

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	1	0

Recommended Action(s):	Repair crushed inlet; embankment repair
Priority:	Low

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

Culvert Information

Culvert ID		AB_190
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
Barrel Length (m)		10.9
Approx. Barrel Slope (%)		N.A.
Approx. Depth of Cover (m)		N.A.
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	250
	Downstream	350
Other Comments	Sediments in the ditch. Erosion of the embankment at outlet. Roadway hazard.	

Culvert Location

Street	R60
Northing (m) [1]	8104279
Easting (m) [1]	562971

[1] Precision +/- 3 m; referenced to NAD83 UTM Zone 16 (CSRS)

Culvert Elevations (masl) [2]

Upstream		Downstream		Road Crown
Invert	Obvert	Invert	Obvert	
N.A.	N.A.	N.A.	N.A.	N.A.

[2] Precision +/- 0.03 m; referenced to CLSR (1996) CCM 4, 9, 10, 11, 18

Culvert Condition Ratings (MTO 2013)

Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	1	0

Recommended Action(s):	Clean inlet of infill; extend outlet; apply erosion control at outlet
Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in July of 2022. Current conditions may vary from what is provided on this sheet.

APPENDIX F Drainage Planning Figures

Legend

— Land Parcels
⊕ Completed Boreholes
— Gravel Roads
— Contours (10m)
— Drainage Channel
- - Flow Path
→ Ditch (Proposed)
→ Ditch (Existing)
— Culvert (Proposed)
— Culvert (Existing)

0 50 100 metres

(At original document size of 11x17)
1:2,500

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

G:_GIS_Project_Folder\144902983_Arctic_Bay\figures\2023\144902983_005_REVF_ArcticBay_DrainageDesign_Mapbook.mxd Revised: 2023-03-24 By: JHiebert

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

Client/Project
144902983-005 REVF

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
F-1

Title
Drainage Master Plan

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

Legend

- Land Parcels
- ⊕ Completed Boreholes
- Gravel Roads
- Contours (10m)
- Drainage Channel
- Flow Path
- Ditch (Proposed)
- Culvert (Proposed)
- Culvert (Existing)

0 50 100 metres

(At original document size of 11x17)
1:2,500

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

Client/Project
144902983-005 REVF

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
F-2

Title
Drainage Master Plan

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Legend

Land Parcels

Completed Boreholes

Gravel Roads

Contours (10m)

Drainage Channel

Flow Path

Ditch (Proposed)

Ditch (Existing)

Culvert (Proposed)

Culvert (Existing)

0 50 100
metres

(At original document size of 11x17)
1:2,500

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

Client/Project

144902983-005 REVF

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.

F-3

Title

Drainage Master Plan

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

G:_GIS_Project_Folder\144902983_Arctic_Bay\figures\2023\144902983_005_REVF_ArcticBay_DrainageDesign_Mapbook.mxd Revised: 2023-03-24 By: JHiebert

Legend

- Land Parcels
- Completed Boreholes
- Gravel Roads
- Contours (10m)
- Flow Path
- Ditch (Proposed)
- Ditch (Existing)
- Culvert (Proposed)
- Culvert (Existing)

0 50 100
metres

(At original document size of 11x17)
1:2,500

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

Client/Project
144902983-005 REVF

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
F-4

Title
Drainage Master Plan

G:_GIS_Project_Folder\144902983_Arctic_Bay\figures\2023\144902983_005_REVF_ArcticBay_DrainageDesign_Mapbook.mxd Revised: 2023-03-24 By: JHebert

Legend

- Land Parcels
- Completed Boreholes
- Gravel Roads
- Contours (10m)
- Drainage Channel
- Flow Path
- Ditch (Existing)
- Culvert (Existing)

0 50 100
metres

(At original document size of 11x17)
1:2,500

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

G:_GIS_Project_Folder\144902983_Arctic_Bay\figures\2023\144902983_005_REVF_ArcticBay_DrainageDesign_Mapbook.mxd   Revised: 2023-03-24 By: JHiebert

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

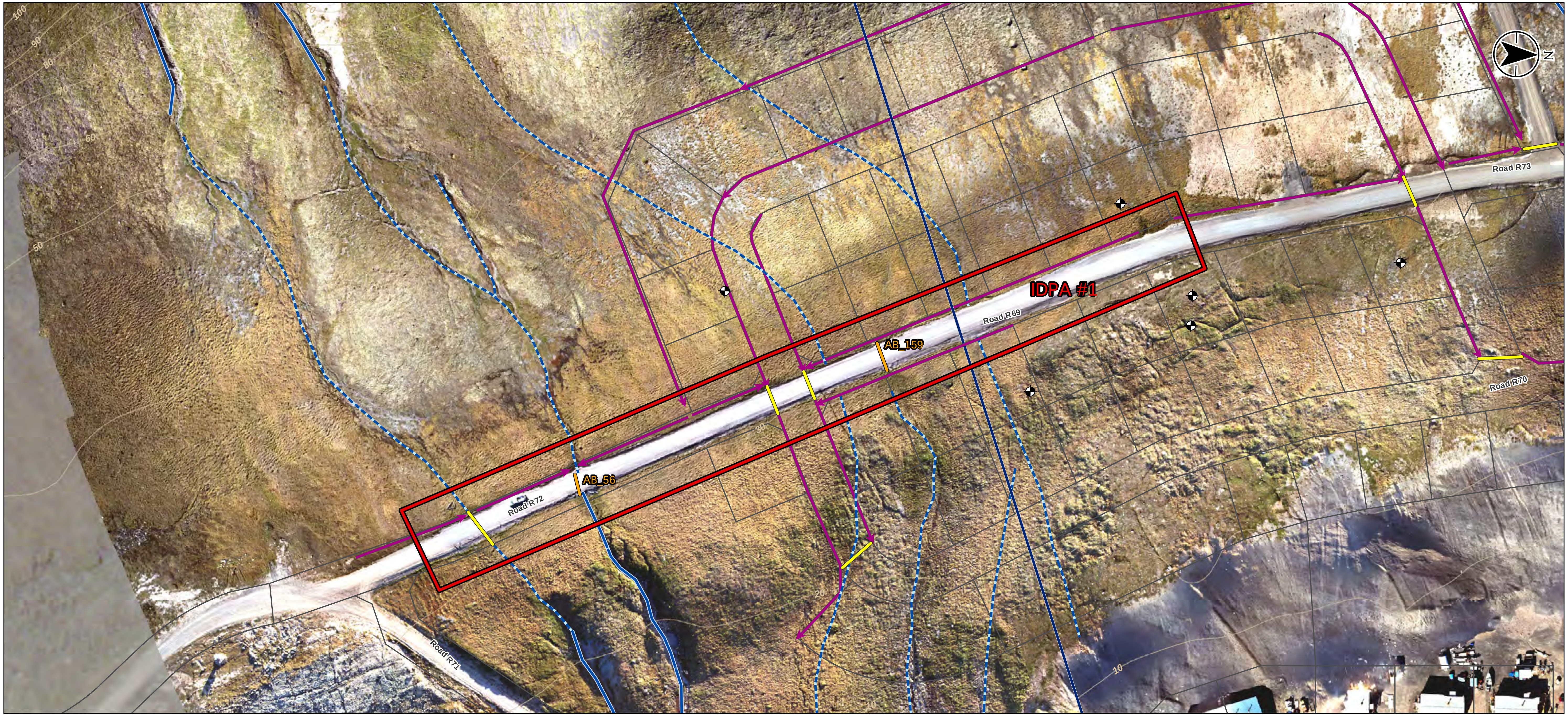
Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

Client/Project
144902983-005 REVF

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
F-5

Title
Drainage Master Plan



Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

Legend

▭	IDPA (Identified Drainge Problem Area)
—	Land Parcels
⊕	Completed Boreholes
—	Contours (10m)
—	Drainage Channel
- - -	Flow Path
→	Ditch (Proposed)
→	Ditch (Existing)
—	Culvert (Proposed)
—	Culvert (Existing)

0 10 20
metres

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

Recommended actions:

- Excavate and replace culverts AB_56 and AB_159
- Minimum diameter of new culverts should be 500 mm
- Install additional culverts as suggested on this figure
- Ensure adequate drainage conveyance alongside the road (uphill side)

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

Client/Project
144902983-009 REVB

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
F-6

Title
Identified Drainage Problem Area (IDPA) #1

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Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

Legend

🟥	IDPA (Identified Drainge Problem Area)
—	Land Parcels
—	Contours (10m)
—	Drainage Channel
- - -	Flow Path
→	Ditch (Proposed)
→	Ditch (Existing)
—	Culvert (Proposed)
—	Culvert (Existing)

0 10 20
metres

(At original document size of 11x17)
1:1,000

Recommended actions:

- The preferred option is to deactivate Road R71.

If deactivation is not an option:

- Consider upgrading the road (road grade and width)
- Excavate and replace culverts AB_54 and AB_151
- Install additional culvert at crossing of seepage flow paths
- Protect the embankment from shoreline erosion

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

Client/Project
144902983-009 REVB

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
F-7

Title
Identified Drainage Problem Area (IDPA) #2

G:_GIS_Project_Folder\144902983_Arctic_Bay\figures\2023\144902983_009_REVB_ArcticBay_Proposed_Conditions_IDPAs.mxd Revised: 2023-03-24 By: JHiebert

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

Legend

🟥	IDPA (Identified Drainge Problem Area)
—	Land Parcels
—	Contours (10m)
—	Drainage Channel
- - -	Flow Path
→	Ditch (Proposed)
→	Ditch (Existing)
—	Culvert (Existing)

0 10 20 metres

(At original document size of 11x17)
1:1,000

Recommended actions:

- Immediately upslope from the escarpment, assess the possibility of concentrating the flow into single channel.
- At the base of the embankment, excavate a shallow plunge pool to dissipate the energy and limit future erosion.
- Ensure adequate conveyance downstream from the plunge pool by deepening the ditch leading to culvert AB_65.
- Conveyance issues observed at culvert AB_65 should be addressed.

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

Client/Project
144902983-009 REVB

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
F-8

Title
Identified Drainage Problem Area (IDPA) #3

G:_GIS_Project_Folder\144902983_Arctic_Bay\figures\2023\144902983_009_REVB_ArcticBay_Proposed_Conditions_IDPAs.mxd Revised: 2023-03-24 By: JHiebert

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

Legend

🟥 IDPA (Identified Drainge Problem Area)
— Land Parcels
— Contours (10m)
— Drainage Channel
- - - Flow Path
→ Ditch (Proposed)
→ Ditch (Existing)
— Culvert (Existing)

0 10 20
metres

(At original document size of 11x17)
1:1,000

Recommended actions:

- Fix or replace culverts showing issues (crushed inlets, infill, perched outlets) upslope from the area impacted by erosion.
- Address the erosion issue at the exit of culvert AB_40 using riprap.
- Address the erosion issues observed along the main drainage channel, downstream from culvert AB-35.
- Remove infill material at the entry of culvert AB_37.

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

Client/Project
144902983-009 REVB

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
F-9

Title
Identified Drainage Problem Area (IDPA) #4

G:_GIS_Project_Folder\144902983_Arctic_Bay\figures\2023\144902983_009_REVB_ArcticBay_Proposed_Conditions_IDPAs.mxd Revised: 2023-03-24 By: JHiebert

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

Legend

- 🟥 IDPA (Identified Drainge Problem Area)
- — Land Parcels
- — Contours (10m)
- — Drainage Channel
- - - Flow Path
- → Ditch (Proposed)
- → Ditch (Existing)
- — Culvert (Existing)

0 10 20
metres

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

Recommended actions:

- Improve conveyance along Road R66 so that maximum drainage flow is directed through culvert AB_33
- Add entrance culverts along access leading to the Hotel
- Route remaining flow towards culvert AB-28
- Downslope from culvert AB_28, address conveyance issues observed at culvert AB_179 and culvert AB_180. This includes cleaning the culverts from infill materials and addressing erosion and stability issues alongside the road embankment.

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

Client/Project
144902983-009 REVB

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
F-10

Title
Identified Drainage Problem Area (IDPA) #5

G:_GIS_Project_Folder\144902983_Arctic_Bay\figures\2023\144902983_009_REVB_ArcticBay_Proposed_Conditions_IDPAs.mxd Revised: 2023-03-24 By: JHiebert

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

Legend

🟥 IDPA (Identified Drainge Problem Area)
— Land Parcels
— Contours (10m)
— Drainage Channel
- - - Flow Path
→ Ditch (Proposed)
→ Ditch (Existing)
— Culvert (Proposed)
— Culvert (Existing)

0 10 20
metres
(At original document size of 11x17)

Recommended actions:

- Improve conveyance of ditch immediately above the CO-OP store
- Install entrance culvert across the access to the CO-OP shipping container area
- Excavate infill material obstructing culvert AB_25 (currently fully buried)
- Add a new 800 mm culvert section to the end of culvert AB_25 to bring the culvert outlet away from the CO-OP building
- Downslope from culvert AB_25, improve conveyance by formalizing the ditch line leading to culvert AB_24, AB_163 and AB-22
- Replace culvert AB_163 and culvert AB-22
- Evaluate the option of diverting water east from the CO-OP access towards culvert AB_165, or installing a new culvert towards culvert AB_166

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

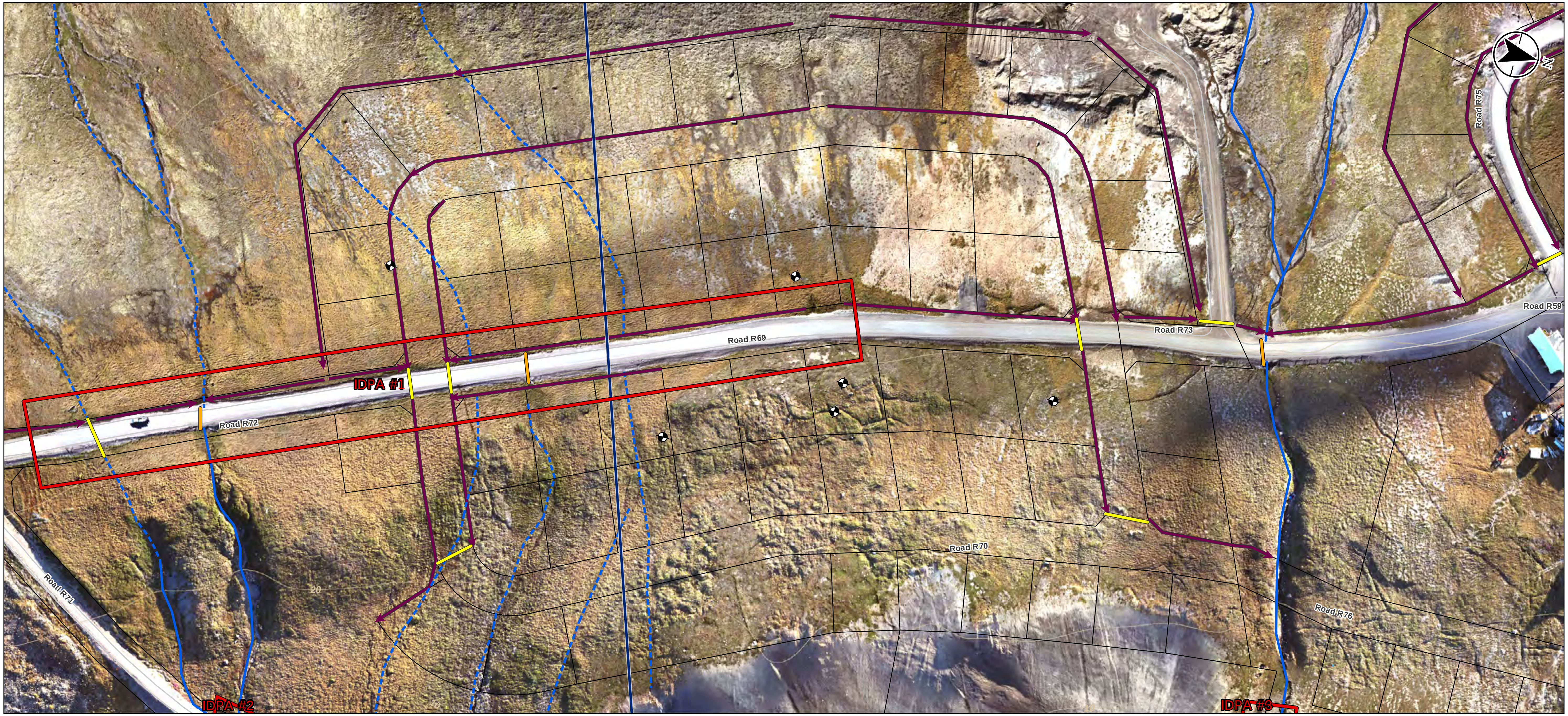
Client/Project
144902983-009 REVB

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
F-11

Title
Identified Drainage Problem Area (IDPA) #6

G:_GIS_Project_Folder\144902983_Arctic_Bay\figures\2023\144902983_009_REVB_ArcticBay_Proposed_Conditions_IDPAs.mxd Revised: 2023-03-24 By: JHiebert



Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

Legend

▭	IDPA (Identified Drainge Problem Area)
—	Land Parcels
⊕	Completed Boreholes
—	Gravel Roads
—	Contours (10m)
—	Drainage Channel
- - -	Flow Path
→	Ditch (Proposed)
→	Ditch (Existing)
▬	Culvert (Proposed)
▬	Culvert (Existing)

0 10 20
metres

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

NUNAMI STANTEC

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

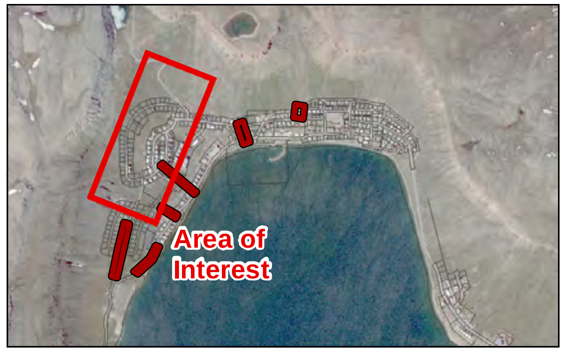
Client/Project
144902983-010 REVB

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
F-12

Title
Proposed Conditions Drainage Plan - Block 2

G:_GIS_Project_Folder\144902983_Arctic_Bay\figures\2023\144902983_010_REVB_ArcticBay_Proposed_Conditions_DrainagePlan_Blocks.mxd Revised: 2023-03-24 By: JHiebert



Legend

- 🟥 IDPA (Identified Drainge Problem Area)
- Land Parcels
- Completed Boreholes
- Gravel Roads
- Contours (10m)
- Drainage Channel
- Flow Path
- Ditch (Proposed)
- Ditch (Existing)
- Culvert (Proposed)
- Culvert (Existing)

0 25 50 metres

(At original document size of 11x17)
1:2,250

Project Location
Arctic Bay,
Nunavut

Prepared by JH on 2023-03-24
Technical Review by OP on 2023-03-24

Client/Project
144902983-010 REVB

Government of Nunavut
Department of Community and Government Services (CGS)

Figure No.
F-13

Title

Proposed Conditions Drainage Plan - Block 3

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Data Sources: GN-CGS, Nunami Stantec (2023)
3. Background: 2021 Imagery

G:_GIS_Project_Folder\144902983_Arctic_Bay\figures\2023\144902983_010_REVB_ArcticBay_Proposed_Conditions_DrainagePlan_Blocks.mxd Revised: 2023-03-24 By: JHiebert

APPENDIX G

Community Plan and Zoning Bylaw

ᐃᒃᐱᐊᕐᔪᒃ

Arctic Bay

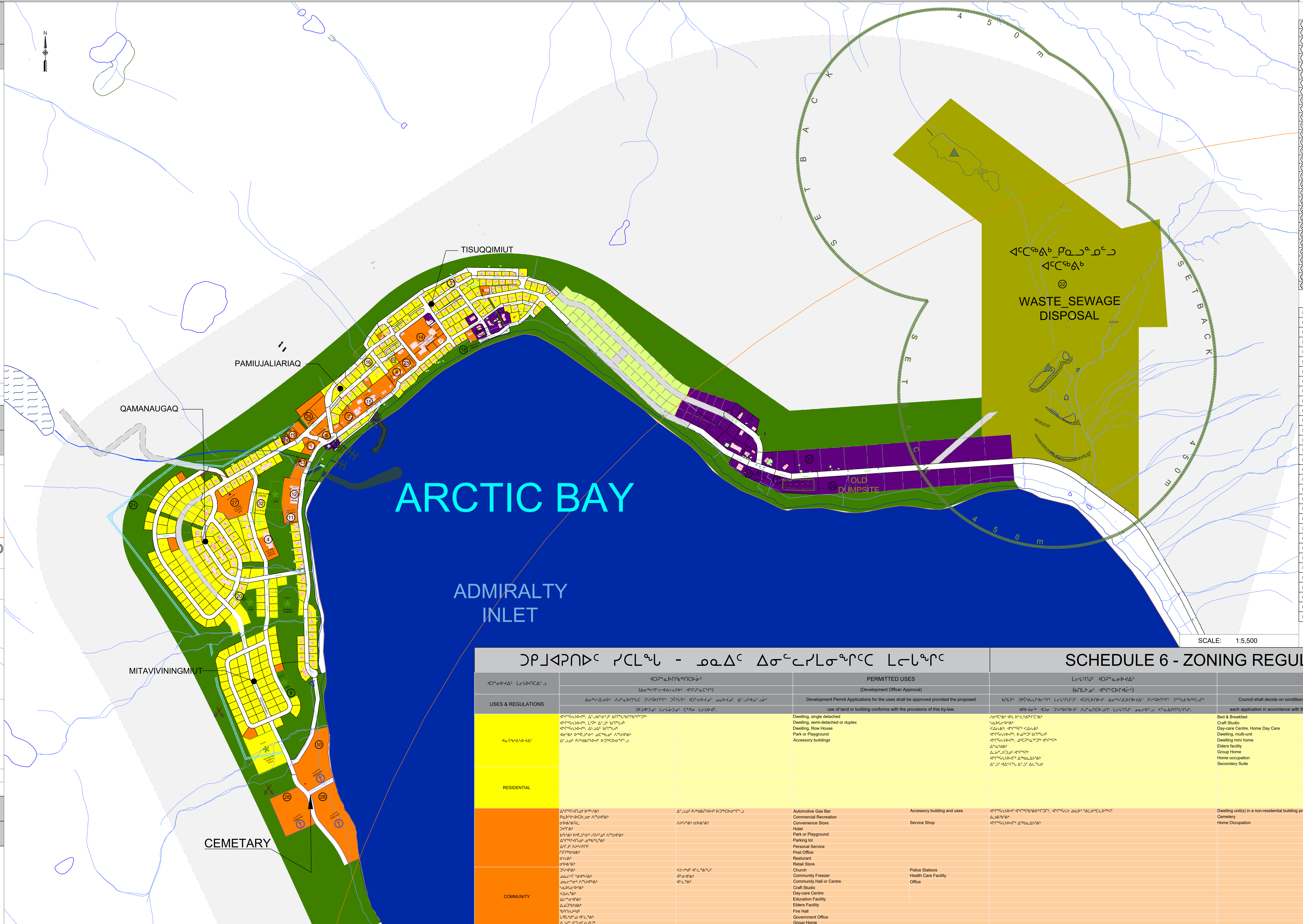
ᐃᒃᐱᐊᕐᔪᒃ
ᓄᓇᓕᐅᑉ ᐸᓐᓇᐃᓯᑎᕐᒐ ᐊᒻᒪᓗ ᓄᓇᐅᑉ ᐋᖅᑭᖅᓯᒪᓂᖏᑦᑕ ᒪᓕᒐᖓ

Arctic Bay
Community Plan & Zoning By-Law
2010-2030

GOVERNMENT OF NUNAVUT
Planning & Lands Division
Baffin

ᑐᑭᓯᒋᑦ 3 - ᓄᓇᓕᖓᓐᓂ ᐸᕐᓇᐅᑎᒎᑦ ᓄᓇᖑᐊᖏᑦ

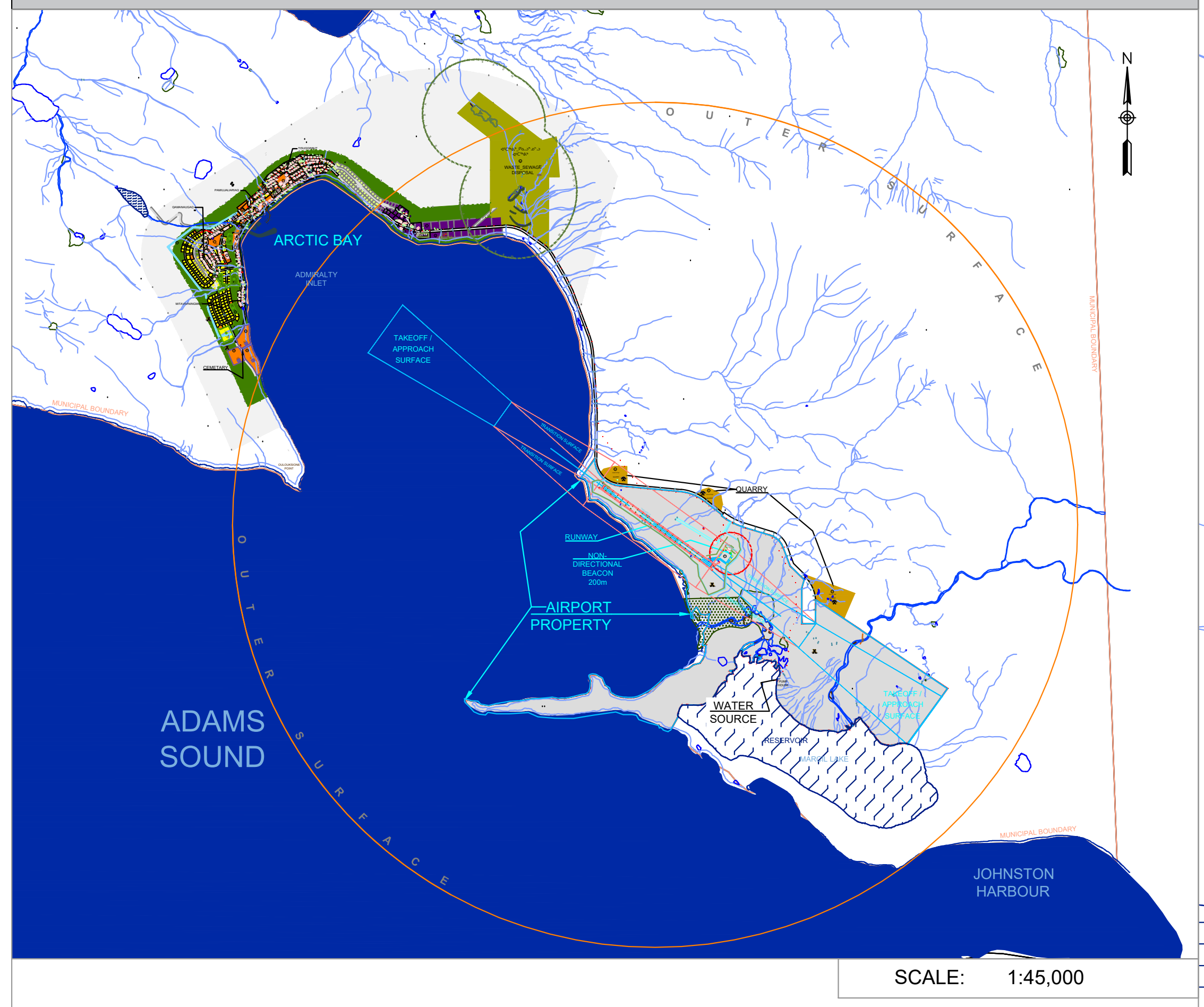
SCHEDULE 3 - COMMUNITY PLAN MAP



①	ᕼᐋᒻᓚᒃᑯᑦ ᐊᓪᓚᕝᕕᖓᑦ	Hamlet Office
②	ᐳᓖᓯᒃᑯᑦ ᐊᓪᓚᕝᕕᖓᑦ	RCMP
③	ᖃᑎᕈᑎᒃᑯᕕᒃ	Fire Station
④	ᐋᓐᓂᐊᕐᕕᒃ	Health Centre
⑤	ᐅᒪᔪᕐᓂᐊᖅᑎᒃᑯᑦ ᐊᓪᓚᕝᕕᖓ	Wildlife Office
⑥	ᐆᒻᒪᖅᑯᑎᓕᕆᔩᒃᑯᑦ	Power Plant
⑦	ᐅᖅᓱᐊᓗᖃᐅᑎᖃᕕᒃ	Tank Farm
⑧	ᐃᒡᓗᓕᕆᔩᒃᑯᑦ	Housing Office
⑨	ᒥᕐᖑᐃᖅᓯᖅᕕᒃ	Park
⑩	ᐃᓗᕕᖅᑲᕕᒃ	Cemetary
⑪	ᓄᓇᓕᖕᓂᒃ ᐱᙳᐊᖅᑲᕕᒃ	Community Hall
⑫	ᓄᓇᓖᑦ ᕼᐋᑭᖅᑲᕕᖓᑦ	Arena
⑬	ᐅᑭᐅᖅᑕᖅᑐᒥᑦ ᓯᓚᑦᑐᖅᓴᕐᕕᒃ	Nunavut Arctic College
⑭	ᐃᓕᓐᓂᐊᕐᕕᒃ	Inuujaq School
⑮	ᓂᐅᕕᕐᕕᒃ	Northern Store
⑯	ᑯᐊᐸᒃᑯᑦ	Taqqut Co-op Store
⑰	ᐅᒥᐊᕐᔪᐊᒃᑯᑦ ᑎᑭᑎᑕᐅᔪᑦ	Sealift Landing Bay
⑱	ᖁᐊᖅᑲᐅᑎ	Community Freezer
⑲	ᑐᔪᕐᒥᕕᒃ	Tangmaarvik Inn
⑳	ᑐᔪᕐᒥᕕᒃ	Kiqqavik Bed & Breakfast
㉑	ᐃᑎᖅᓴᓚᐊᕆᓯᒪᔪᖅ ᓄᓇ	Inceptor Ditch
㉒	ᑭᓈᓗᒃᑲᕝᕕᒃ & ᑭᓈᓗᒡᕕᖕᓄᑦ ᐊᒃᑕᕐᕕᒃ	Sewage Lagoon & Dump Site
㉓	ᐊᒃᑕᕐᕕᑐᖅᑲᖅ	Old Dumpsite
㉔	ᑐᒃᓯᐊᕐᕕᒃ	Full Gospel Church
㉕	ᑐᒃᓯᐊᕐᕕᒃ	Anglican Church
㉖	ᑐᒃᓯᕋᖅᑕᐅᓯᒪᔪᑦ ᓯᕗᓂᑦᓴᖏᓐᓄᑦ ᖃᑎᕈᑎᒃᑯᕕᒃ	New Fire Station
㉗	ᑐᒃᓯᕋᖅᑕᐅᓯᒪᔪᑦ ᓯᕗᓂᑦᓴᖏᓐᓄᑦ ᐃᓕᓐᓂᐊᕐᕕᒃᓴᒧᑦ ᐃᓂᒃᓴᖅ	Proposed Future School Site
㉘	ᑐᒃᓯᕋᖅᑕᐅᓯᒪᔪᖅ ᓯᕗᓂᑦᓴᖏᓐᓄᑦ ᐃᓗᕕᖅᑲᕕᑦᓴᖅ	Proposed Future Cemetery
㉙	ᓄᓇᓕᖕᓂᒃ ᐆᒪᔪᕐᓂᐊᖅᑎᒃᑯᑦ	Hunters & Trappers Association
㉚	ᒥᑦᑕᕐᕕᒃ	Airport
㉛	ᑐᐊᐸᑦᑕᕐᕕᒃ	Quarry
㉜	ᐃᓄᑐᖃᒃᑯᕕᒃ	Elders Center

ᑐᑭᓯᒋᑦ 2 - ᓄᓇᐃᑦ ᐊᑐᖅᑕᐅᓂᖏᓐᓂᑦ ᐊᒻᒪ ᑭᒡᓕᓕᐅᖅᑕᐅᓯᒪᓂᖏᓐᓂᑦ ᓄᓇᖑᐊᖏᑦ

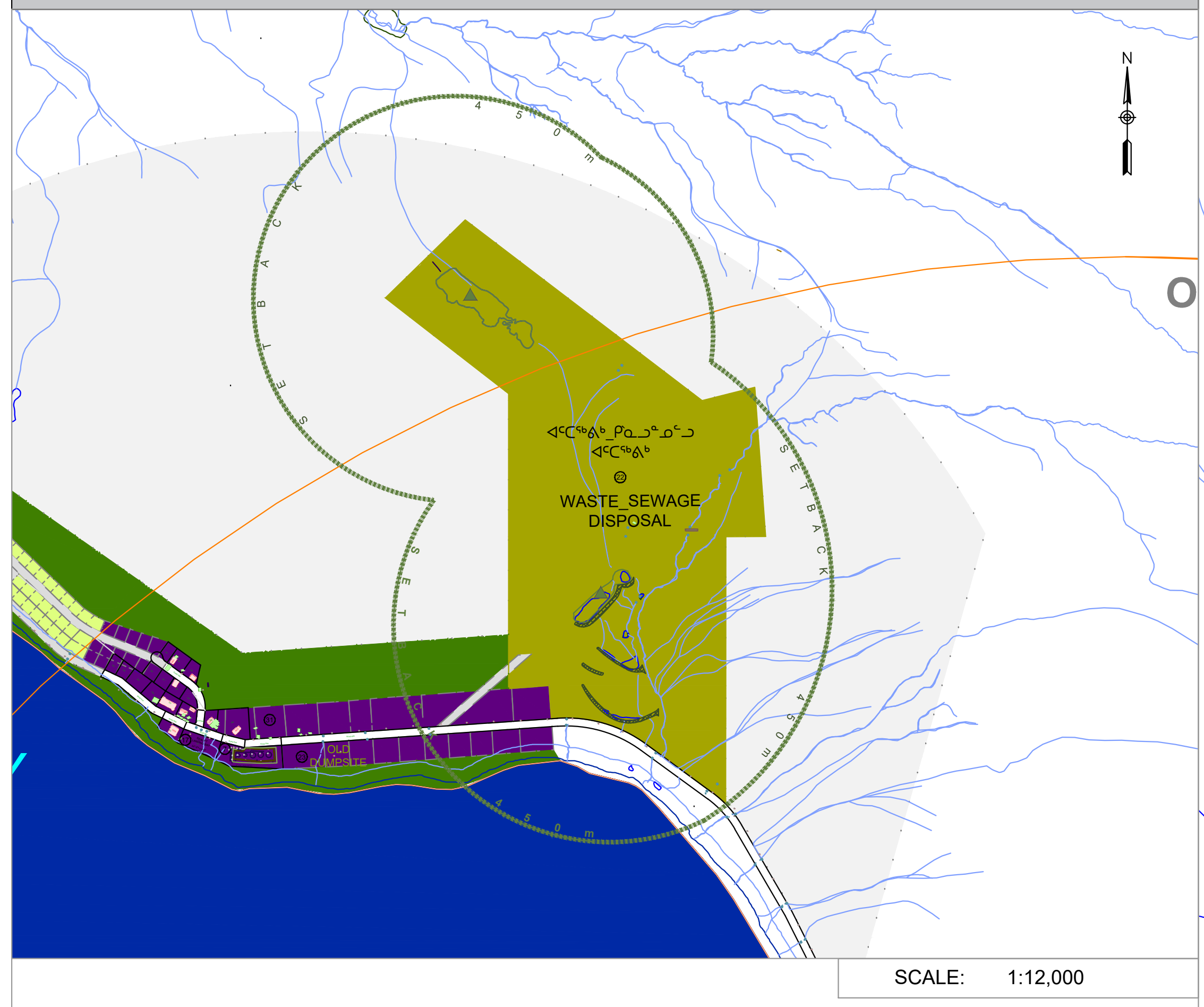
SCHEDULE 2 - GENERAL LAND USE



SCALE: 1:45,000

ᑐᑭᓯᒋᑦ 4 - ᑭᓈᓗᒃᑲᕝᕕᒃ & ᑭᓈᓗᒡᕕᖕᓄᑦ ᐊᒃᑕᕐᕕᒃ

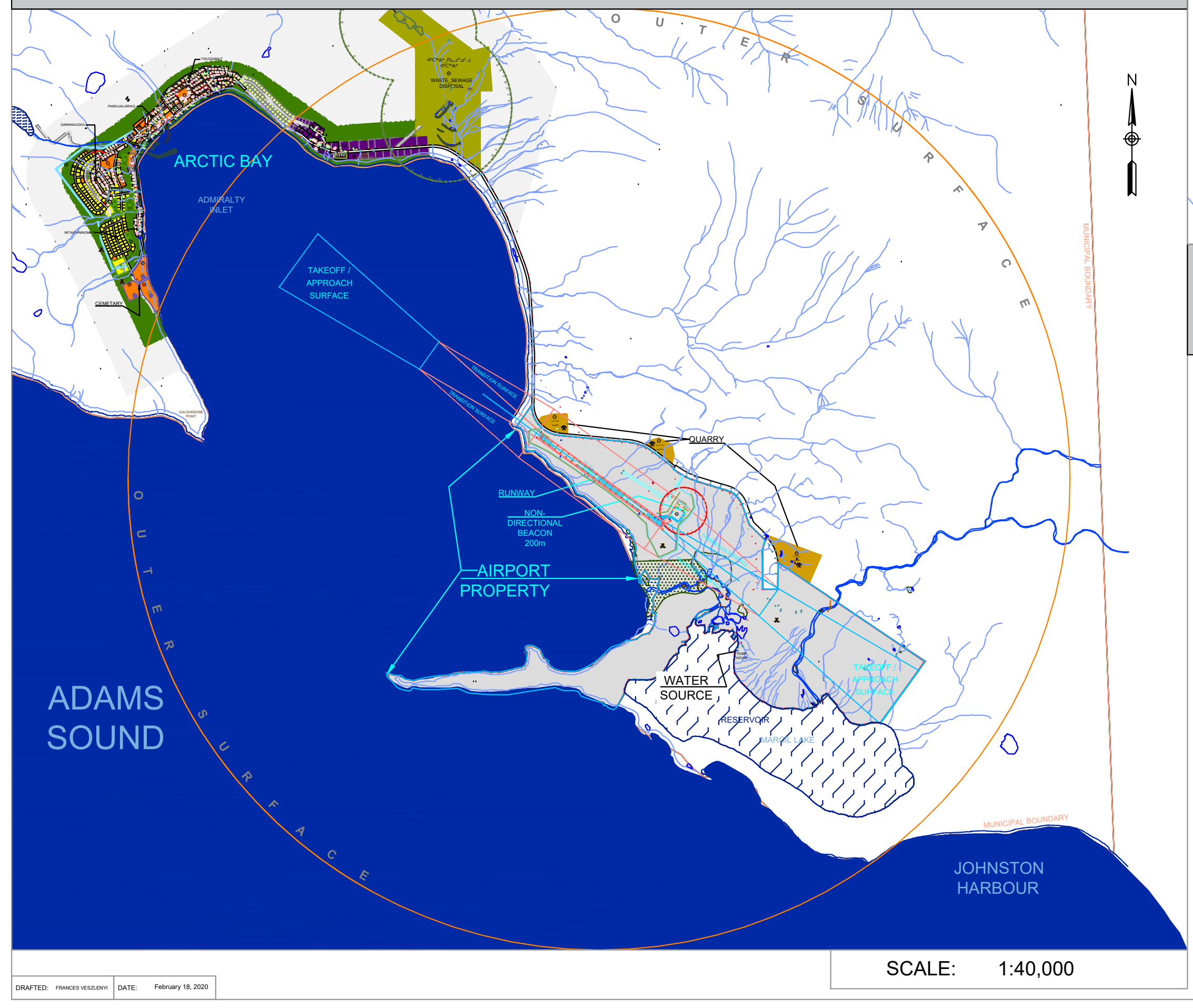
SCHEDULE 4 - SEWAGE LAGOON & DUMP



SCALE: 1:12,000

ᑐᑭᓯᒋᑦ 5 - ᒥᑦᑕᕐᕕᒃ

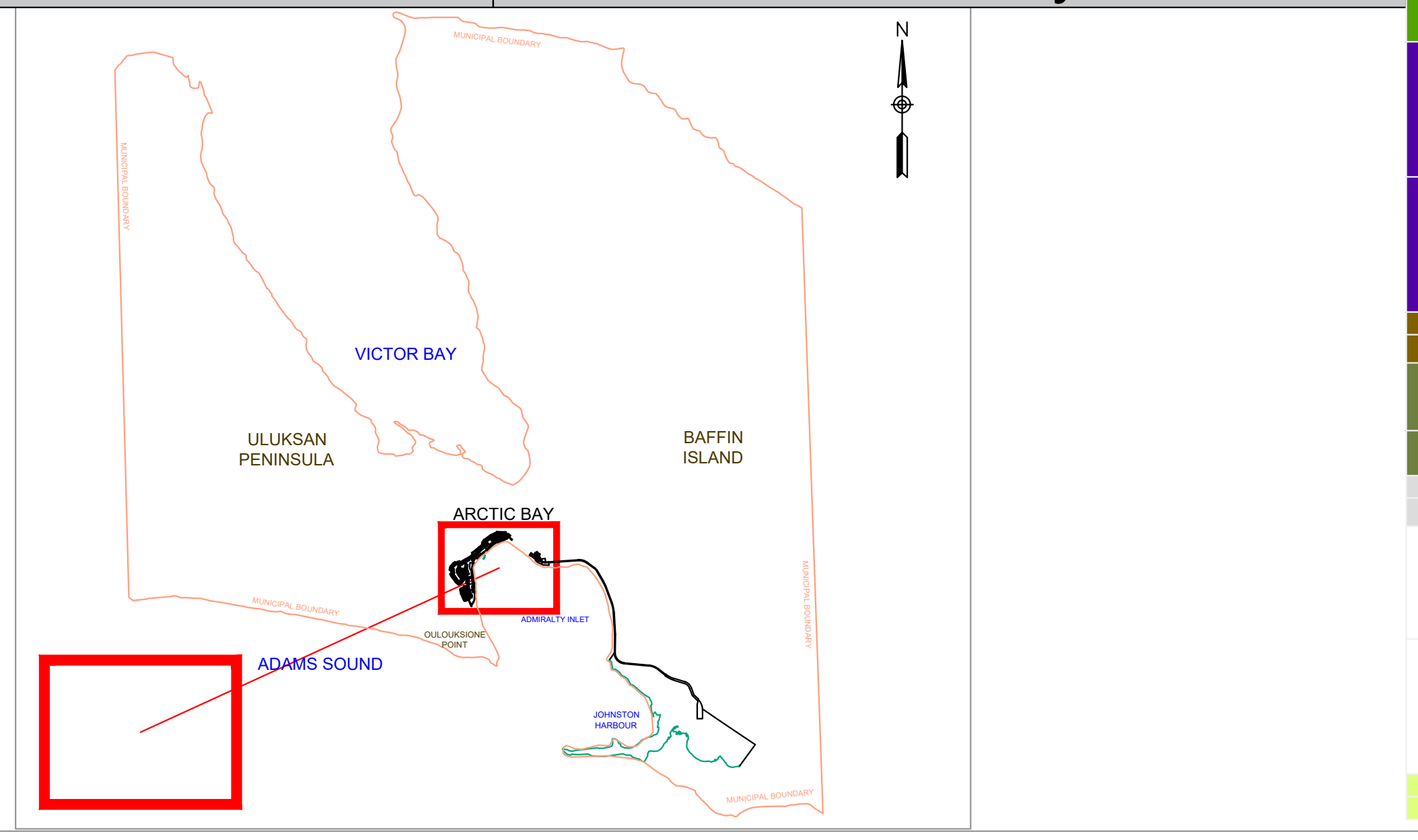
SCHEDULE 5 - AIRPORT MAP



SCALE: 1:40,000

ᑐᑭᓯᒋᑦ 6 - ᓄᓇᓕᖕᒧᑦ ᑭᒡᓕᖓ

Schedule 6 - Municipal Boundary



ᑐᑭᒧᐊᒍᑎᑦ ᓯᑕᒪᖓ - ᓄᓇᐃᑦ ᐃᓂᖓᓯᒪᓂᖏᑦᑕ ᒪᓕᒐᖏᑦ

SCHEDULE 6 - ZONING REGULATIONS

ᐊᑐᖅᑕᐅᓯᐊᑦ ᒪᓕᒐᐅᑎᑕᐃᓪᓗ	ᐊᑐᕈᓐᓇᐅᑎᖃᖅᑎᑕᐅᓂᑦ		PERMITTED USES		ᒪᓕᒋᑎᒍᑦ ᐊᑐᕈᓐᓇᓂᐅᔪᐃᑦ	CONDITIONAL USES
	(ᐃᓂᖅᓯᐅᕙᓪᓕᐊᔪᓕᕆᔨᒃᑯᑦ ᐊᖏᕈᓐᓇᑕᖏᑦ)		(Development Officer Approval)		(ᑲᑎᒪᔨᓄᑦ ᐊᖏᑦᑕᐅᒋᐊᓖᑦ)	(Council Approval)
USES & REGULATIONS	ᐃᓂᖅᓯᒍᒪᓂᐅᑦ ᐱᒍᓐᓇᐅᑎᖓᑕ ᑐᑦᓯᕋᐅᑎᖏᑦ ᑐᕌᖓᑦ ᐊᑐᕐᓂᐅᓯᓄᑦ ᓄᓇᐅᓯᓄᑦ ᐃᓪᓗᕈᐊᓂᓪᓗᓃᑦ ᑐᑭᓯᐊᒃᑐᓄᑦ ᒪᓕᒐᓃᑐᓄᑦ ᑕᐃᕙᓂ ᒪᓕᒐᐅᓯᒥ.		Development Permit Applications for the uses shall be approved provided the proposed use of land or building conforms with the provisions of this by-law.		ᑲᑎᒪᔩᑦ ᑐᑭᑖᒃᑲᐱᓐᓂᐊᓕᖏᑦ ᒪᓕᒋᑎᒍᑦᑐᑦ ᐊᑐᕈᒪᐅᑎᐅᔪᑦ ᐃᓂᖅᓯᒍᒪᐅᑎᐅᔪᐃᑦ ᑐᑦᓯᕋᐅᑎᖏᑦ ᑐᖖᒐᕕᒃᖃᐅᑎᒍᑎᑦ ᐊᑭᐅᔪᖅ ᐊᑐᓂ ᑐᑦᓯᕋᐅᑎᐅᔪᑦ ᐱᒍᓐᓇᑎᑕᐅᒍᑎᑦ ᒪᓕᒋᑎᒍᑦ ᓄᓇᓕᐅᑉ ᐸᓐᓇᐃᓯᑎᕐᒐᑎᒍᑦ.	Council shall decide on conditional use development permit applications based on the merits of each application in accordance with the provisions of this by-law and the polices of the Community Plan.
ᐊᓇᕐᖃᒃᐱᓴᐅᔪᐃᑦ RESIDENTIAL	ᐊᖏᕐᕋᓇᔭᐅᔪᖅ, ᐃᓪᓗᒃᑲᓐᓂᕐᒧᑦ ᑲᑎᙵᕐᖃᑎᖃᖏᑦᑐᖅ		Dwelling, single detached		ᓯᓂᑦᑕᕐᕕᒃ ᐊᒻᒪ ᐅᓪᓛᑯᑦᓱᒥᑕᕐᕕᒃ	Bed & Breakfast
	ᐊᖏᕐᕋᓇᔭᐅᔪᖅ, ᒪᕐᕉᒃ ᐃᓪᓗᒃ ᑲᑎᙵᖕᓂᒃ		Dwelling, semi-detached or duplex		ᓴᓇᐅᒪᓕᐅᕐᕕᒃ	Craft Studio
	ᐊᖏᕐᕋᓇᔭᐅᔪᖅ, ᐃᒡᓗᐃᑦ ᑲᑎᙵᔪᑦ		Dwelling, Row House		ᐸᐃᕆᕕᒃ; ᐊᖏᕐᕋᒥ ᐸᐃᕆᕕᒃ	Day-care Centre, Home Day Care
	ᐊᓂᕐᕕᒃ ᐅᕝᕙᓘᓐᓃᑦ ᓄᑦᑕᖃᓄᑦ ᐱᙳᐊᕐᕕᒃ		Park or Playground		ᐊᖏᕐᕋᓇᔭᐅᔪᖅ, ᐅᓄᖅᑐᑦ ᑲᑎᙵᔪᑦ	Dwelling, multi-unit
	ᐃᓪᓗᓄᑦ ᑭᓱᑯᕕᒋᔭᐅᔪᑦ ᐅᑐᖅᑕᐅᓂᖏᓪᓗ		Accessory buildings		ᐊᖏᕐᕋᓇᔭᐅᔪᖅ, ᓅᑦᑕᕈᓐᓇᖅᑐᖅ ᐊᖏᕐᕋᖅ	Dwelling mini home
					ᐃᓐᓇᒃᑯᕕᒃ	Elders facility
					ᐃᓗᓯᕐᓗᑦᑐᓄᑦ ᐊᖏᕐᕋᖅ	Group Home
					ᐊᖏᕐᕋᓇᔭᐅᔪᒥᒃ ᐃᖅᑲᐃᓯᕕᒃ	Home occupation
					ᐃᓪᓗᑉ ᐊᐃᐸᖓ ᐃᓪᓗᑉ ᐃᓚᖓᓂ	Secondary Suite
COMMUNITY	ᐃᖏᕐᕋᔪᑎᓄᑦ ᐅᖅᓱᕐᕕᒃ	ᐃᓪᓗᓄᑦ ᑭᓱᑯᕕᒋᔭᐅᔪᑦ ᐅᑐᖅᑕᐅᓂᖏᓪᓗ	Automotive Gas Bar	Accessory building and uses	ᐊᖏᕐᕋᓇᔭᐅᔪᑦ ᐊᖏᕐᕋᖅᑲᕐᕕᐅᖏᑦᑐᒥᒃ, ᐊᖏᕐᕋᓇᔭ ᓄᓇᐅᑉ ᖁᓛᓃᑦᑕᓚᐅᖅᐸᑦ	Dwelling unit(s) in a non-residential building provided that the dwelling unit(s) are above ground
	ᑮᓇᐅᔭᓴᐅᑕᐅᓗᓂ ᐱᙳᐊᕐᕕᒃ		Commercial Recreation		ᐃᓗᕕᖅᑲᕕᒃ	Cemetery
	ᓂᐅᕕᕐᕕᑯᓛ	ᐱᓯᖅᓯᕕᒃ ᓂᐅᕕᕐᕕᒃ	Convenience Store	Service Shop	ᐊᖏᕐᕋᓇᔭᐅᔪᒥᒃ ᐃᖅᑲᐃᓯᕕᒃ	Home Occupation
	ᑐᔪᕐᒥᕕᒃ		Hotel			
	ᑳᔮᕕᒃ ᐅᕝᕙᓘᓐᓃᑦ ᓱᕈᓰᓄᑦ ᐱᙳᐊᕐᕕᒃ		Park or Playground			
	ᐃᖏᕐᕋᔪᑎᓄᑦ ᓄᖅᑲᖓᕝᕕᒃ		Parking lot			
	ᐃᒻᒥᒍᑦ ᐱᔨᑦᓯᕋᑎᑦ		Personal Service			
	ᑎᑎᖅᑲᒃᑯᕕᒃ		Post Office			
	ᓂᕆᕕᒃ		Resturant			
	ᓂᐅᕕᕐᕕᒃ		Retail Store			
	ᑐᓱᐊᕐᕕᒃ	ᐸᓖᓯᒃᑯᑦ ᐊᓪᓚᕝᕕᖓᑦ	Church	Police Stations		
	ᓄᓇᓕᒻᒥ ᕿᐊᖅᓱᕕᒃ	ᐋᓐᓂᐊᕐᕕᒃ	Community Freezer	Health Care Facility		
	ᓄᓇᓕᖕᓂᒃ ᐱᙳᐊᖅᑲᕕᒃ	ᐊᓪᓚᕕᒃ	Community Hall or Centre	Office		
	ᓴᓇᐅᒪᓕᐅᕐᕕᒃ		Craft Studio			
	ᐸᐃᕆᕕᒃ		Day-care Centre			
	ᐃᓕᓐᓂᐊᕐᕕᒃ		Education Facility			
	ᐃᓄᑐᖃᒃᑯᕕᒃ		Elders Facility			
	ᖃᑦᑎᕆᔩᑯᑦ		Fire Hall			
	ᒐᕙᒪᒃᑯᓐᓄ ᐊᓪᓚᕕᒃ		Government Office			
	ᐃᓗᓯᕐᓗᑦᑐᓄᑦ ᓇᔪᒐᖅ		Group Home			
ᓄᓇ ᐊᒻᒪᓂᕐᑕᐅᔪᖅ OPEN SPACE	ᐃᑦᑕᕐᓂᓴᑕᓕᒃ		Archaeological site		ᑐᓴᐅᒪᒃᑕᐅᑎᒃᑯᕕᒃ	Communications facility
	ᐊᐳᒻᒧᑦ ᓴᐳᑦᔪᑦ	ᐊᓇᕝᕕᒃ	Snow Fence	Washroom Facility	ᕿᒧᒃᓯᐅᑎᓄᑦ ᕿᓕᒥᒃᑕᕝᕕᒃ	Dog-Team Outdoor Pound
	ᓯᔾᔭᒥ ᐃᓪᓗᑲᓛᑦ	ᐅᒥᐊᖅᑲᕝᕕᒃ	Beach Shacks	Boat Storage	ᐊᐅᓪᓚᕝᕕᑦ	Camp-sites
	ᑐᓚᑦᑕᕝᕕᒃ	ᑳᔮᕕᒃ ᐅᕝᕙᓘᓐᓃᑦ ᓱᕈᓰᓄᑦ ᐱᙳᐊᕐᕕᒃ	Dock	Park or Playground		
	ᓇᓗᓇᐃᒃᑯᑎ ᐃᖅᑲᐅᒪᔾᔪᑎ ᒪᑭᑎᑕᐅᓯᒪᔪᖅ		Monument, Cairn and/or Statue			
	ᓯᓚᒥ ᐱᖁᑎᒃᑯᕕᓚᐅᑲᐅᑎᒃᑐᖅ ᐅᒥᐊᕐᔪᐊᑉ ᐱᖁᑎᖏᑦ ᑎᑭᓯᒪᓂᖓᓂ		Temporary outdoor storage of sealift equipement during sealift			
	ᐃᓪᓗᖃᓛ ᐱᖁᑎᒃᑯᕕᒃ ᐃᓕᖅᑯᓯᖃᕐᓂᖅ ᐱᙳᐊᖅᑐᓄᑦ ᐊᑐᖅᑕᐅᕙᒃᑐᓄ ᓄᓇᖓᓂ		Shed to store equipement for traditional, cultural and recreational activities taking place in the zone			
ᐱᖁᑎᑦᔭᐊᖁᕕᑦ INDUSTRIAL	ᐃᖏᕐᕋᔪᑎᓂᒃ ᓄᓇᓯᐅᑎᓂᒃ ᓴᓇᕕᐅᓂ ᓂᐅᕕᐊᒃᓴᖅᕕᐅᓂ		Automotive Repair, Sales and/or Facility		ᐊᑦᑕᓇᖅᑐᓄᑦ ᐱᖁᑎᒃᑯᕕ	Hazardous goods storage
	ᐃᓪᓗᓴᓄ ᓂᐅᕕᕕ ᐊᒻᒪ ᑳᑐᖅᑕᐅᓯᒪᔪ ᓂᐅᕕᕕᖓ		Building Supply or Contactor's Shop		ᓴᓇᕕᐊᓗ	Manufacturing plant
	ᑳᑐᖅᑕᐅᓯᒪᔪ ᓄᓇᖓ		Contractor's Yard		ᐱᒐᓚᖅᑲᐅᑎ	Outdoor storage
	ᓴᓇᕕᒃ		Craft Studio		ᐃᑯᒪᖅᑯᑎᓕᕆᕕᒃ	Power Plant
	ᐃᓪᓗ ᐱᕈᖅᓯᐊᓄ ᐱᕈᕕ		Greenhouse		ᐃᑯᒪᖅᑯᑎᑦ ᐋᖅᑭᑕᐅᓂᖓ	Utility Installation
	ᐱᒐᓚᖅᑲᐅᑎ		Outdoor Storage		ᐅᐊᑦᑎᔩ ᐸᖅᑭᔩ ᐃᓪᓗᖓ	Caretaker's unit
	ᓱᕈᒃᓯᒪᔪᓂᒃ ᐊᐅᓚᐅᑎᓂᒃᑯ ᓴᓇᕕᒃ		Service and Repair Shop		ᐅᖅᓱᖅᑯᑎᒃᑯᕕᒃ	Tank Farm
	ᐱᒐᓚᖅᑲᕕ		Warehouse			
ᑐᐊᐸᒃᓴᖅᑕᓂᖅ GRANULAR RESOURCE	ᓄᓇᒥᒃ/ᐅᔭᕐᓂᒃ ᐲᔭᐃᓂᖅ		Quarry		ᑐᐊᐸᒃᓴᕐᓂᖅ	Resource Explorations and Development
ᒪᓪᓗᑯᓂᖅ ᐃᒋᑦᑲᕝᕕᖕᓂᖅ WASTE DISPOSAL					ᐊᕐᓯᕝᕕᒃ	Waste Disposal Site
					ᖁᕝᕕᓕᕆᓂᖅ	Sewage Treatment System and/or Lagoon
					ᓴᕕᕋᔭᓄᑦ ᐊᕐᓯᕝᕕᒃ	Metal Dump
ᐃᖏᕐᕋᔾᔪᑎᓕᕆᓂᖅ TRANSPORTATION	ᒥᑦᑕᕐᕕᒃ ᐊᒻᒪ ᒥᑦᑕᕝᕕᖕᒧᑦ ᑐᕌᖓᔪᑦ		Airport and related uses		ᐱᒐᓚᖅᑲᐅᑎ	Outdoor Storage
	ᑐᓴᐅᒪᒃᑕᐅᑎᒃᑯᕕᒃ		Communications facility		ᐱᒐᓚᖅᑲᕕ	Warehouse
ᓄᓇ NUNA	ᐃᑦᑕᕐᓂᓴᑕᓕᒃ		Archaeological Site		ᑐᓴᐅᒪᒃᑕᐅᑎᒃᑯᕕᒃ	Communications Facility
	ᕿᒧᒃᓯᐅᑎᓄᑦ ᕿᓕᒥᒃᑕᕝᕕᒃ		Dog Team Outdoor Pound			
	ᑐᐱᖃᕐᕕᐅᓚᐅᑲᐅᑦ ᐅᕝᕙᓗ ᐊᐅᓪᓚᕝᕕᐅᓚᐅᑲᐅᑦ		Temporary Tenting or Camping		ᓯᔾᔭᒥ ᐃᓪᓗᑲᓛᑦ	Beach shack
					ᐃᓗᕕᖅᑲᕕᒃ	Cemetery
					ᑮᓇᐅᔭᓴᖅᓯᐅᑎᒃ ᐊᖑᓇᓯᖕᓂᖅ	Commercial Harvesting
					ᐊᖑᓇᓱᒃᕕᑦᑐᖃᐃᑦ ᐊᒻᒪ ᐃᖃᓗᓯᐅᕕᑦᑐᖃᐃᑦ ᐃᓪᓗᕆᓛᖅᑐᑦ ᐅᕝᕙᓗᓐᓂᑦ ᐊᐅᓛᕝᕕᐅᔩᑦ	Permanent hunting & fishing cabins or camps
					ᐊᐳᒻᒧᑦ ᓴᐳᑦᔪᑦ	Snow Fence
					ᐳᓚᕋᖅᑎᓄᑦ ᐅᐸᕝᕕᒃ	Tourist Facility
					ᐊᓄᓂᒧᑦ ᐸᐅᑎᑦ ᐃᑯᒪᖅᑯᑎᑖᕈᑎ	Wind Turbine
ᖃᒪᓛᐅᑦ ᓴᓇᕝᕙᓯᒪᔭᖏᑦ MUNICIPAL RESERVE						