BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325

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Document Key

Main Report

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ABBREVIATIONS

the Project	Mary River Project
AEMP	Aquatic Effects Monitoring Plan
ARD	acid rock drainage
AREMA	American Railway Engineering and Maintenance-of-Way Association
Baffinland	Baffinland Iron Mines Corporation
DFO	Fisheries and Oceans Canada
EPP	Environmental Protection Plan
ERP	Early Revenue Phase
FEIS	Final Environmental Impact Statement
Golder	Golder Associates Ltd.
Hatch	Hatch Ltd.
IFC	Issued for Construction
Knight Piésold	Knight Piésold Ltd.
ML	metal leaching
Mtpa	million tonnes per annum
NBRLUP	North Baffin Regional Land Use Plan
NIRB	Nunavut Impact Review Board
NPC	Nunavut Planning Commission
NWB	Nunavut Water Board
OPEP	Oil Pollution Emergency Plan
PAG	Potentially Acid Generating
PWSP	Polishing Waste Stabilization Pond
RBC	Rotating Biological Contactor
ROM	Run of Mine
WRF	waste rock facility
WWTP	wastewater treatment plant

1 – INTRODUCTION

1.1 OVERVIEW

Baffinland Iron Mines Corporation (Baffinland) requires a second amendment to its Type A Water Licence 2AM-MRY1325 (the Licence; Nunavut Water Board (NWB), 2015) to undertake its proposed Phase 2 Proposal at the Mary River Project (the Project). The Mary River Project is an operating iron ore mine located in the Qikiqtani Region of Nunavut (Figure 1.1). Baffinland is the owner and operator of the Project.

The Phase 2 Proposal is described in Section 1.2, and in more detail in the Project Description Technical Supporting Document to which this water licence amendment application is an Appendix. A document map presenting FEIS Amendment No. 2 is included.

This application for a second amendment to the Licence is being submitted to the NWB as part of an Amendment No. 2 to the Final Environmental Impact Statement (FEIS Amendment No. 2) being filed with the Nunavut Impact Review Board (NIRB), so that the Phase 2 Proposal can be evaluated jointly by the NIRB and the NWB in a coordinated process (NIRB and NWB, 2012).

Item 10 of Part B (General Conditions) of the Licence states:

> *The Licensee shall notify the NWB of any major or significant changes in development plans, phase, or conditions associated with the Project, including commencement of the full Operations Phase and other phases associated with the Project, at least sixty (60) days prior to carrying such changes.*

The Phase 2 Proposal represents a significant modification to the Project (Nunavut Planning Commission, 2018).

Also relevant to this application to amend the Licence, Item 12 of Part B (General Conditions) of the Licence states:

> *The Licensee shall, for all Plans submitted under this Licence, include a proposed timetable for implementation. Plans submitted for approval/acceptance, cannot be undertaken without subsequent written Board approval and/or direction. The Board may alter or modify a Plan if necessary to achieve the objectives of the Licence of other regulatory instruments. For plans submitted for Board approval, the Board will notify the Licensee in writing of the Board's approval, rejection or alteration of the Plan. Plans or drawings submitted to the Board for review and/or comments do not necessarily require Board approval prior to implementation; however, the Board may request revisions to those Plans, as required.*

Part G of the Licence (Conditions Applying to Modifications) describes the process to seek and implement modifications to aspects of the Project authorized under the Licence. The Phase 2 Proposal cannot be implemented consistent with the terms of the current Licence (Part G, Item 1). As such, Baffinland is seeking written approval from the Board, in accordance with Part G, Item 2 of the Licence. Part G, Item 3 outlines the information to be provided to the Board when seeking such approval.

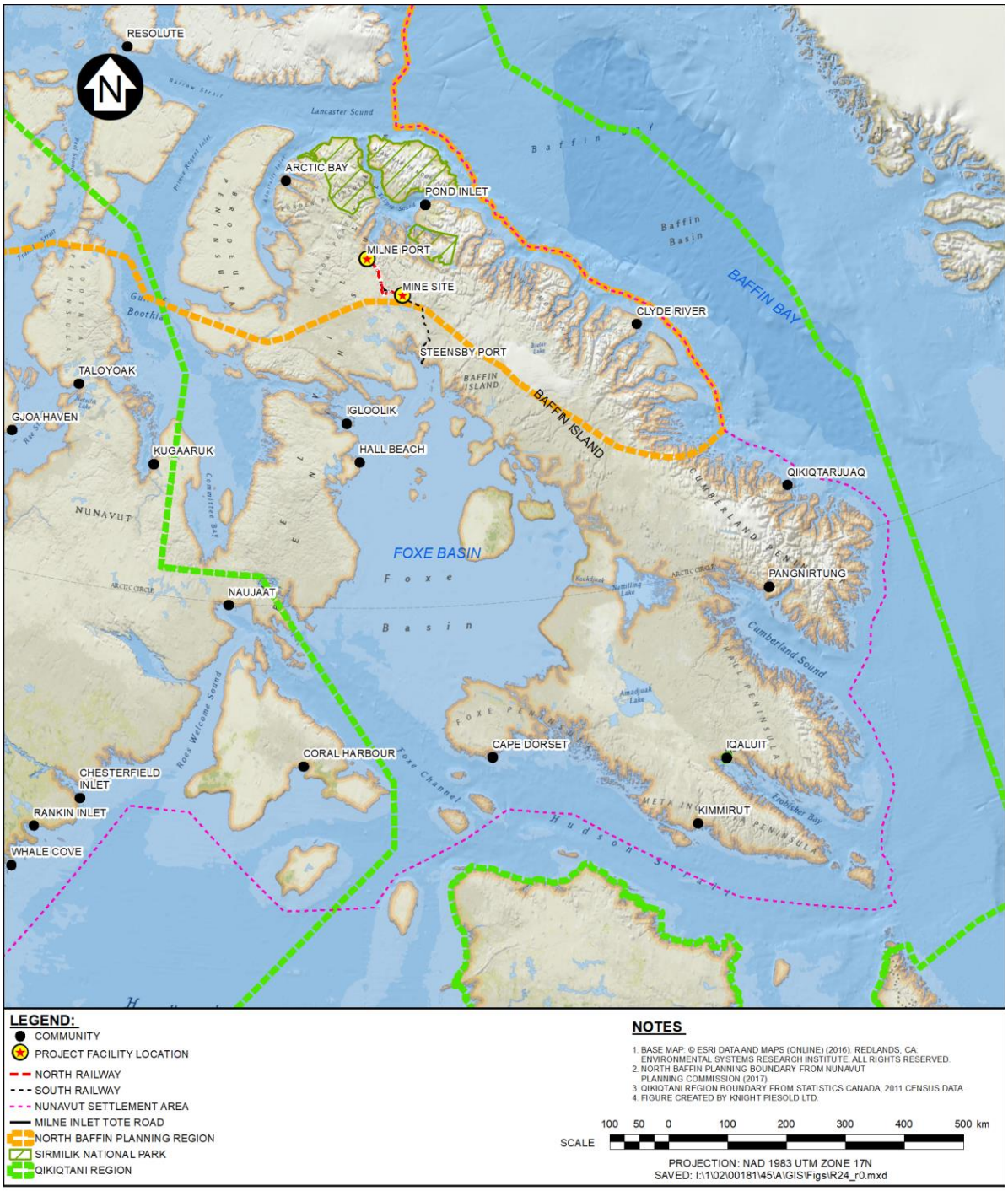

Figure 1.1 Project Location Map

3. Applications for modifications shall contain:

a. A description of the facilities and/or works to be constructed;

b. The proposed location of the structure(s);

c. Identification of any potential impacts to the receiving environment;

d. A description of any monitoring required, including sampling locations, parameters measured and frequencies of sampling;

e. Schedule for construction;

f. Drawings of engineered structures stamped by a Professional Engineer; and

g. Proposed sediment and erosion control measures.

This document describes the activities associated with the Phase 2 Proposal, including required modifications to existing infrastructure currently authorized under the Licence and new infrastructure and/or facilities that are designed to contain, withhold, divert or retain water and/or waste. Information has been provided at a conceptual level for all relevant aspects of the Phase 2 Proposal to support amending the scope of the Licence. In select instances, detailed engineering drawings will be provided to the Board for approval prior to implementation of those same project components, in accordance with the requirements of the current Licence.

1.2 ABOUT THE PHASE 2 PROPOSAL

As part of the regulatory approval process, Baffinland submitted a FEIS to the NIRB, which presented in-depth analyses and evaluation of potential environmental and socioeconomic effects associated with the Project.

In 2012, NIRB issued Project Certificate No 005 which provided approval for Baffinland to mine 18 million tonnes per annum (Mtpa) of iron ore, construct a railway to transport the ore south to a port at Steensby Inlet which operates year-round, and to ship the ore to market. The Project Certificate was subsequently amended to include the mining of an additional 4.2 Mtpa of ore, trucking this amount of ore by an existing road (the Tote Road) north to an existing port at Milne Inlet, and shipping the ore to market during the open water season. The total approved iron ore production was increased to 22.2 Mtpa (4.2 Mtpa transported by road to Milne Port, and 18 Mtpa transported by rail to Steensby Port). This is now considered the Approved Project. The 18 Mtpa Steensby rail project has not yet been constructed, however 4.2 Mtpa of iron ore is being transported north by road to Milne Port currently. Baffinland recently submitted a request for a second amendment to Project Certificate No.005 to allow for a short-term increase in production and transport of ore via road through Milne Port from the current 4.2 Mtpa to 6.0 Mtpa.

The Phase 2 Proposal involves increasing the quantity of ore shipped through Milne Port to 12 Mtpa, via the construction of a new railway running adjacent to the existing Tote Road (called the North Railway; Figure 1.2). The total mine production will increase to 30 Mtpa with 12 Mtpa being transported via the North Railway to Milne Port and 18 Mtpa transported via the South Railway to Steensby Port. Construction on the North Railway is planned to begin in late 2019. Completion of the North Railway is expected in 2020 with transportation of ore to Milne Port by trucks and railway ramping up as mine production increases to 12 Mtpa by 2020. Shipping from Milne Port will also increase to

12 Mtpa by 2020. Construction of the South Railway and Steensby Port will commence in 2021 with commissioning and a gradual increase in mine production to 30 Mtpa by 2024. Shipping of 18 Mtpa from Steensby Port will begin in 2025.

Phase 2 also involves the development of additional infrastructure at Milne Port, including a second ore dock (Figure 1.3). Shipping at Milne Port will continue to occur during the open water season, and may extend into the shoulder periods when the landfast ice is not being used to support travel and harvesting by Inuit. Various upgrades and additional infrastructure will also be required at the Mine Site and along both the north and south transportation corridors to support the increase in production and construction of the two rail lines (Figure 1.4).

Facilities associated with the South Railway and Steensby Port have yet to be built. Issued for Construction (IFC) drawings and other required submissions will be submitted to the Board in accordance with Part B, Item 10 of the Licence, prior to construction of these project components.

1.3 PROPOSED AMENDMENTS TO THE SCOPE OF THE CURRENT LICENCE

The Phase 2 Proposal will involve an increase in the intensity of use of approved activities and an expansion of existing infrastructure. There are no new types of activities associated with the Phase 2 Proposal; for example, the Phase 2 Proposal includes a new North Railway, but the existing licence contemplates the South Railway. With respect to mining, while the annual production rate will increase, there is no change to the mine plan; the same orebody will be mined at a different rate and schedule. As such, the current Licence already contains the mechanisms and provisions to regulate the Phase 2 Proposal, with only modest modifications to the Licence required.

Part A, Item 1 of the current Licence presents a bulleted list describing the scope of the Licence. This scope is presented in Table 1.1 along with proposed modifications that are part of the Phase 2 Proposal.

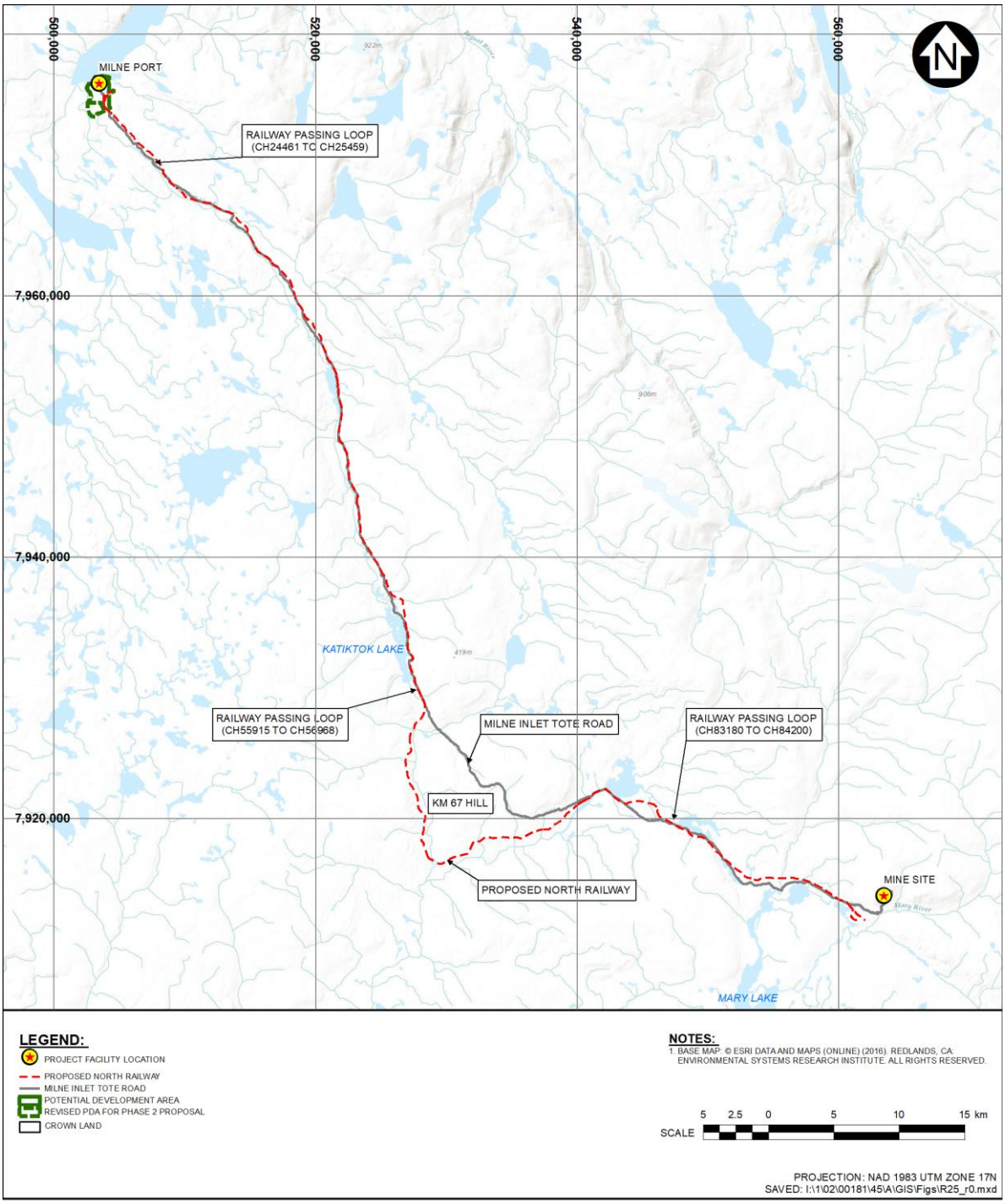

Figure 1.2 North Railway Location

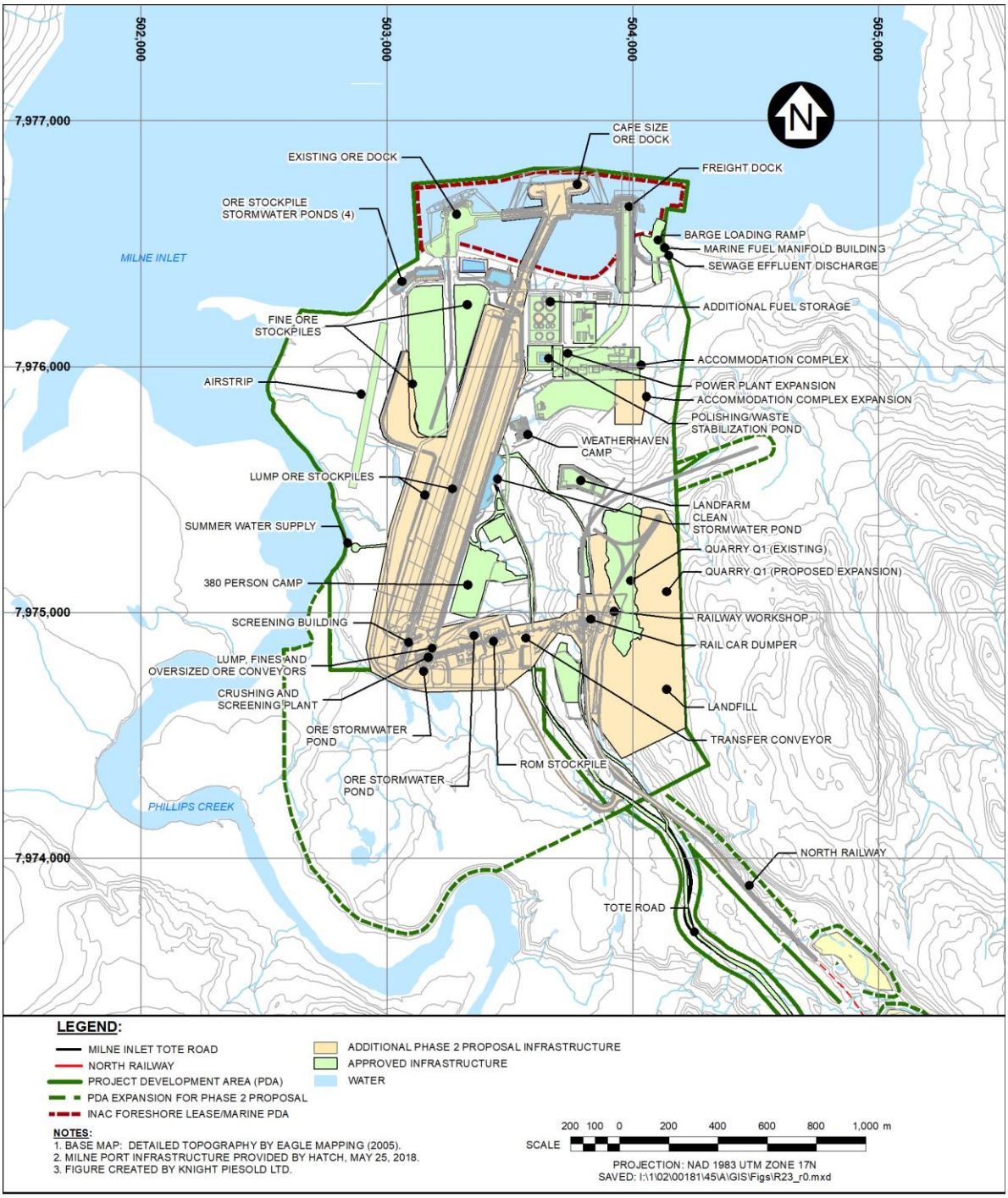

Figure 1.3 Milne Port - Phase 2 Layout

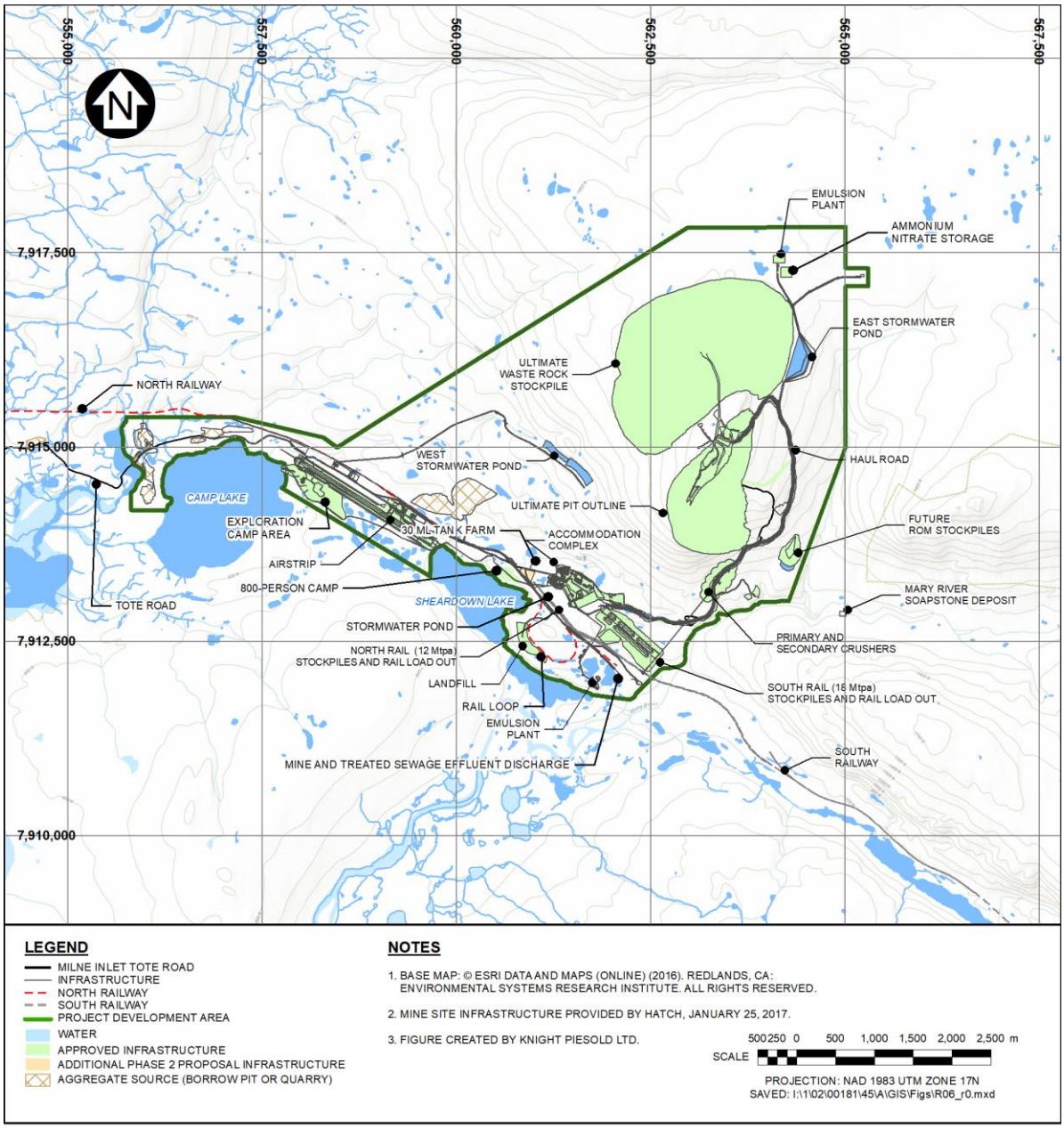

Figure 1.4 Mine Site - Phase 2 Layout

Table 1.1 Proposed Modifications to the Scope of the Current Water Licence

Item No.	Scope of Current Water Licence (NWB, 2015)	Proposed Modifications (Phase 2 Proposal)
1	Water supply for domestic uses and industrial purposes at the Milne Port (Milne Inlet) Site, Mine (Mary River) Site, Steensby Port (Steensby Inlet) Site and the railway camps	No change
2	Site drainage and surface water management for the Milne Port, Mine Site, Steensby Port, and relevant minor project sites	Modifications to site drainage and surface water management at Milne Port and the Mine Site
3	Sewage Treatment Facilities for the Milne Port camp, the Mine Site exploration, construction, and permanent camps; the Steensby Port construction and permanent camps; and the railway camps	No change
4	Oily water treatment facilities for wastewater and oily storm water treatment for maintenance facilities and fuel storage berms at the Milne Port Site, the Mine Site and Steensby Port Site	Additional oily water treatment facilities within the rail maintenance facility proposed at Milne Port
5	Storage and management of hazardous materials at the Milne Port Site and Mine Site	No change
6	Landfarm facilities for the deposition and treatment of hydrocarbon contaminated snow and soil at the Milne Port Site, the Mine Site, and Steensby Port Site	No change
7	Fuel tanks, dispensing storage facilities and associated secondary containment areas or berms for Bulk Fuel Storage Facilities and day tanks at the Milne Port, the Mine Site, and the Steensby Port Site	Bulk fuel storage quantities will increase: two additional 15 ML tanks will be added to the Mine Site tank farm that is being submitted as a notification under the current Licence
8	Containment areas for temporary storage of hazardous/ nonhazardous waste (waste transfer areas) and new product storage for drums and totes at Milne Port, the Mine Site, and Steensby Port	No change
9	Ongoing decommissioning of existing and historic camp infrastructure (Fuel bladder farm and ancillary facilities and more) at the Milne Port Site	No change; historic camp infrastructure and fuel bladder farm have already been decommissioned
10	Explosives storage and explosives manufacturing facilities at the Mine Site and Steensby Port Site	Additional temporary explosives storage facilities will support construction
11	Waste sorting facilities and temporary storage of hazardous wastes at the Mine Site	No change

Item No.	Scope of Current Water Licence (NWB, 2015)	Proposed Modifications (Phase 2 Proposal)
12	Landfills for disposal of solid waste at the Mine Site and Steensby Port Site	A new landfill will be constructed in an exhausted quarry at Milne Port once construction is complete
13	Incinerator Systems for camp and combustible wastes at the Milne Port Site, the Mine Site, Steensby Port Site, and railway construction camps	No change
14	Waste rock stockpile and waste rock pile runoff management at the Mine Site	No change
15	Ore Stockpile runoff management at the Mine Site and Steensby Port Site	Water management facilities at the Mine Site and Milne Port will be upgraded to accommodate expanded ore crushing pads, stockpiling areas and rail loading and offloading facilities. New water management facilities will be constructed at ore staging area at km57 along the North Railway.
16	Secondary Containment for fuel storage and hazardous materials (if any) at each rail camp location	No change
17	Waste disposal facilities for each proposed camp along the railway corridor	All waste generated by mobile camps along the North Railway during its construction will be disposed of in existing waste management facilities
18	Watercourse crossings including pipelines, jetties, bridges; roads associated with channels; and bank alterations, culverts, spurs, erosion control, and artificial accretion	The North Railway will require the installation of bridges and culverts, bank alterations, and erosion control measures
19	Flood control, diversions, alteration of flow or storage by means of dykes or dams	The North Railway will involve infilling of select streams intersected by deep rock cuts. The upstream portion of the infilled streams will be diverted to an adjacent stream.
20	Ongoing inspection and maintenance of all water course crossings and associated infrastructure	No change
21	Tote Road (approximately 100 km all-weather road), which extend from the Mine Site to Milne Port Site in its current form except for routine maintenance and minor upgrades for the transportation of equipment during the Construction Phase of the project	Several sections of the existing Tote Road will be realigned to accommodate the North Railway. Where the North Rail will invariably cross the Tote Road, the road has been realigned to achieve a perpendicular railroad crossing.
22	Ongoing activities in support of engineering and scientific studies for the Project	No change
23	Ongoing maintenance to existing project infrastructure	No change

Item No.	Scope of Current Water Licence (NWB, 2015)	Proposed Modifications (Phase 2 Proposal)
24	299 m^3/day of Water for domestic and industrial purposes during construction activities occurring at Milne Port and related to the Early Revenue Phase (ERP) of the wider Mary River Project including earthworks, laydown areas, concrete and production	No increase in water use is proposed from Milne Port water sources. The Licence currently permits 367.5 m^3/day of water to be used for domestic and industrial purposes during the construction and operation phases.
25	Continued operation of the Matrix Camp (Camp) erected in 2013 for construction activities and expansion of the camp to support additional manpower of up to 350 persons during site preparation work but less than 225 persons during the construction of infrastructure at Milne Port	The number of beds at Milne Port will increase to 1,010 beds during the construction period; reducing to 710 permanent beds during the operation phase.
26	Construction and eventual operation of an additional Waste Stabilization Pond at Milne Inlet (Milne Port)	No change
27	Construction of ore stockpile areas and associated sedimentation ponds, permanent ore dock, ship loading facilities and associated earthworks activities, ore reclaiming conveying equipment, at Milne Inlet (Milne Port)	Additional rail ore unloading, crushing and screening facilities will be constructed; the existing ore stockpile area will be expanded; additional ore reclaiming and conveying equipment, and a second ore dock with its own shiploader will be installed
28	Deposit of Waste during construction activities	No change. Additional construction waste will be generated from an additional construction phase.
29	Water use from specified sources or waterbodies for dust suppression or control along the Tote Road during the Early Revenue Phase	An additional 13 water sources for dust suppression are proposed. The overall daily volume of water for dust suppression will increase from 1,500 to 2,600 m^3/day.
30	Management of ore stockpile runoff at the Milne Port Site	Ore stockpile runoff management facilities will be expanded to accommodate larger ore stockpiles and the relocation of ore crushing and screening operations from the Mine Site to Milne Port
31	Recommissioning of an existing Rotating Biological Contactor (RBC) type Sewage Treatment Plant located at the Milne Port Site	No longer applicable; the RBC Sewage Treatment Plant was decommissioned
32	Construction of an additional Polishing Waste Stabilization Pond (PWSP) to treat off-specification effluent as allowed and described above under the cope of Type B Licence No. 8BC-MRY1416. The PWSP will be of similar capacity and design specifications to the one constructed in 2013.	No change

Item No.	Scope of Current Water Licence (NWB, 2015)	Proposed Modifications (Phase 2 Proposal)
33	Relocation of the treated sewage effluent discharge, from a location north of the old airstrip to north of the Milne Tank Farm	Further relocation of the discharge to an area near the freight dock was approved as part of Modification Request #7. No further modifications are proposed as part of the Phase 2 Proposal.
34	Additional fuel storage to include the installation of two 100,000 L marine diesel tanks	No change
35	Construction of a 4 million tonne ore stockpile pad, associated drainage structures, and two (2) settling or sedimentation ponds	This item overlaps with items 27 and 30 above. The ore stockpile will be expanded to 7.8 Mt. Additional stormwater ponds will collect runoff from the larger stockpile.
36	Construction and operation of an ore dock and ore loading system as allowed under the scope of Licence No. 8BC-MRY1416, and additional ancillary buildings, and maintenance facilities required for the shipment of iron ore	A second ore dock and associated ore loading system will be constructed
37	Tote Road (approximately 100-kilometre, all-weather road), which extends from the Mine Site to the Milne Port Site in its current form except for routine maintenance and minor upgrades being required primarily for the purpose of safety and ensuring compliance with applicable safety regulations under the Mine Health and Safety Act and relevant regulations intended to support the safe transportation of equipment during construction and transportation of ore extracted under the Early Revenue Phase of the Project	This item overlaps with Item 21 above. Modifications to the Tote Road are proposed as described under Item 21.
38	Withdrawal of up to 1,500 m^3/day of water from several specific waterbodies located along the Tote Road, for use in dust suppression or control	This item overlaps with Item 29 above. An additional 13 dust suppression water sources are proposed, and the daily maximum water use will increase to 2,600 m^3/day.
39	Extended use, beyond timeframe previously anticipated, for some infrastructure and/or facilities established for the Project, such as camps, buildings, fuel and transitional fuel storage facilities	No change
40	Use of transitional fuel storage facilities	The bladder tank farms used in exploration no longer store fuel
41	Discharge of treated sewage effluent onto land during the winter months in accordance with the relevant terms and conditions included in the licence	No change

1.4 CONTENTS OF THIS APPLICATION

The following Sections of this Application address the following corresponding Parts of the Licence:

- Section 2 - Part D Conditions Applying to Construction and Operations
- Section 3 - Part E Conditions Applying to Water Use and Management
- Section 4 - Part F Conditions Applying to Waste Disposal and Management
- Section 5 - Part H Conditions Applying to Emergency Response and Contingency Planning
- Section 6 - Part I Conditions Applying to General and Aquatic Effects Monitoring
- Section 7 - Part J (Conditions Applying to Abandonment, Reclamation and Closure) and Part C (Conditions Applying to Security)

Section 8 summarizes the status of management plans required under the Type A Water Licence, while Section 9 describes future submissions to the NWB and associated timeframes. Table 1.2 lists the attachments to this document, which collectively form Baffinland's application for a second amendment to the Licence.

Table 1.2 Attachments to this Application

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14	Compliance Report
15	Corporate and Financial Information
16	Mobile Camps Water and Sewage Tank Design Details
17	Landfarm Manual

1.5 REQUEST UNDER REVIEW

In May 2018, Baffinland submitted a separate Project Proposal to the Nunavut Planning Commission (NPC) requesting a reconsideration of Project Certificate No. 005 to allow the Company to increase the annual production of the current ERP from 4.2 million tonnes per year (Mtpa) to 6.0 Mtpa. On May 18, 2018, the NPC issued a positive conformity determination and referred the proposal to the NIRB for screening. On August 31, 2018, NIRB issued a Reconsideration Report and Recommendations (NIRB, 2018) that rejected the production increase portion of the proposal, but approved Baffinland's plans to construct a 380-person camp and an additional 15 ML fuel tank at Milne Port.

With the NIRB's approval of the camp and fuel tank, Baffinland proposes to submit a modification request to the NWB in the near future to seek approval of these approved elements of the production increase proposal.

2 – CONSTRUCTION AND OPERATIONS (PART D)

2.1 OVERVIEW OF CHANGES

An overview of the Phase 2 Proposal is provided in Section 1.2. The Phase 2 Proposal involves construction of the following additional permanent infrastructure:

Mine Site

- Expanded crusher pad and rail ore loading facilities
- Two additional 15 ML fuel tanks at the Mine Site

Northern Transportation Corridor

- North Railway
- Minor realignments of the Tote Road to accommodate the North Railway
- Quarry development

Milne Port

- Second ore dock
- Larger ore stockpiles
- Shiploading infrastructure
- Additional 380-bed camp at Milne Port

The following features will form part of construction activities for the Phase 2 Proposal:

- Three mobile construction camps
- 36 quarries (32 quarries not previously permitted)

The construction period for Phase 2 will commence in late 2019 and is expected to be completed in 2021.

Baffinland believes that the terms and conditions of the existing Water Licence 2AM-MRY-1325 are satisfactory to cover the scope of proposed amendments under the Phase 2 Proposal.

2.2 APPLICABLE MANAGEMENT PLANS

The following approved management plans relate to the items discussed in this section:

- Borrow Pits and Quarries Management Plan (Baffinland, 2014a)
- Quarry Specific Management Plans (to be developed for quarries prior to their development)
- Phase 1 Waste Rock Management Plan (Baffinland, 2014b)
- Surface Water and Aquatic Ecosystems Management Plan (Baffinland, 2016a)

Any required updates to these plans to account for the Phase 2 Proposal are identified in Section 8. Updates to these plans will be submitted to the NWB for approval in accordance with Items 1 and 2 of Part E of the Licence.

2.3 NORTH RAILWAY

The North Railway connecting the Mine Site and Milne Port is the most substantial infrastructure component associated with the Phase 2 Proposal. The railway will be 110 km in length, and most of

the length the railway embankment will be constructed adjacent to the Tote Road. However, a 20 km section of the railway will deviate from the Tote Road alignment due to steep topography. The construction of the railway is estimated to take two years, with the rail being operational in 2021. The construction of the rail will require multiple laydown sites, mobile construction camps, and quarries for aggregate. The facilities and activities required for the construction and operation of the North Railway include:

- Construction of railway including embankments, signaling equipment and communication towers, water crossings, level crossing with the Tote Road
- Construction and use of multiple laydown areas, shelters and small equipment shops at each laydown
- Use of the ore staging area at km 57 as an intermediate staging area for ore transportation
- Construction and operation three mobile camps
- Exploitation and closure of up to 36 quarries along the North Railway corridor
- Ongoing inspection and maintenance of the railway embankment, railway, signaling and communication equipment
- Transportation of iron ore by trucks and by railway to Milne Port

The ore staging area at km 57 of the North Railway will operate for 1 to 2 years during rail construction. This transfer area will facilitate the movement of ore from haul trucks to railcars. The haul trucks will deliver ore to the ore staging area from the Mine Site via the Tote Road. The ore will be stockpiled at the ore staging area in three 4,150 t stockpiles. The ore will be loaded on railcars using front-end loaders. Once loaded the train will proceed north to Milne Port. Runoff from the stockpiles will be collected and directed to a stormwater pond. Runoff from the ore stockpiles at this facility will be directed to a settling pond. The capacity of this pond is 1,100 m^3. Discharge from the stormwater pond will be monitored to ensure it meets that requirements outline in the current Licence and effluent collected in this pond will be sampled to ensure it meets the mine effluent discharge criteria specified in the Licence before applying the water to the Tote Road as part of dust suppression efforts.

A detailed description of the facilities and activities listed above is provided in Section 3.2 of TSD 2 Project Description.

The following rail design information is provided in Attachment 6:

6.1	North Railway Terrain Analysis
6.2	North Railway Factual Geotechnical Report
6.3	North Railway Geotechnical Embankment Report
6.4	Quarry Geochemical Evaluation
6.5	North Railway Catchment Drawings
6.6	Diagrammatic Conceptual Layout
6.7	North Railway Plan & Profile Drawings
6.8	Km57 Temporary Ore Transfer Area Drawings
6.9	Rail Embankment Drawings

Additionally, detailed layouts of the North Railway are presented in Figure B.4 in Appendix B of TSD 2 Project Description.

2.4 TOTE ROAD REALIGNMENTS AND ACCESS ROADS

In general, the Tote Road alignment will remain unchanged, however some upgrades and minor realignments will be required to facilitate railway crossings. The railway will cross the existing Tote Road at 10 locations. These updates are identified in Section 3.2 of TSD 2 Project Description. The use of the Tote Road as envisioned for the Phase 2 Proposal is detailed in Section 3.1 of the Project Description.

Attachment 7 provides drawings detailing the Tote Road modifications, including:

7.1	Tote Road Relocation Drawings
7.2	Tote Road Rail Crossing Drawings
7.3	Tote Road Typical Drawings

In addition, there are a large number of short access roads that will be constructed as part of the Phase 2 Proposal, summarized as follows:

- **Milne Port** – A 2.7 km access road will be constructed around the circumference of the ore stockpiles along the south and west sides (Figure 1.3).
- **Northern Transportation Corridor** – A number of short access roads up to 500 m in length will be constructed to access quarries and explosives storage areas, and 1.5 km of temporary haul road will be constructed at the km 57 temporary ore transfer area. These access roads are shown on Figure B.4 in Appendix B of TSD 2 Project Description. Additional minor access roads will likely be required to connect the Tote Road to the railway right-of-way during construction.
- **Mine Site** – In addition to minor realignments of the Tote Road, described in Attachment 7, the mine haul road will be extended from the current crusher pad area to the new crusher pad area and rail load-out area servicing the North Railway (Figure B.1 in in Appendix B of TSD 2 Project Description).

Access roads and haul roads will be constructed in accordance with the design criteria presented by Hatch (2018), and the construction methodology described by KP (2018), included as Attachments 5.1 and 5.2, respectively. Crossings associated with these access roads are included in the Tote Road crossing list referenced in Section 2.5.

2.5 WATERCOURSE CROSSINGS AND DIVERSIONS

The construction of the North Railway and the upgrades to Tote Road will result in a number of watercourse crossings. A comprehensive list of watercourse crossings and typicals is provided in Attachment 8; Attachments 8.1 and 8.2 present lists of watercourse crossings proposed along the North Railway and Tote Road / access roads, respectively.

The North Railway will be constructed mostly adjacent to the Tote Road and will cross an estimated 465 watercourse and drainage crossings along the North Railway. The railway will not encroach on any lakes. The majority of crossings (approximately 60%) are confirmed as not fish-bearing. Table 2.1 identifies the fish bearing potential for the North Railway crossings.

Table 2.1 North Railway Crossings and Fish-Bearing Potential

Fish-Bearing Potential	No. of Crossings	Proportion of Total
Certain	65	14%
Probable	36	7%
Potential	42	9%
Unlikely	45	10%
Not fish-bearing	278	60%
Total	**465**	**100%**

Baffinland will conduct field fisheries surveys on the undetermined crossings, to confirm the presence/absence of fish habitat. Further information relating to watercourse crossings is provided in Section 3.2.11 of TSD 2 Project Description. Detailed layouts of the North Railway showing the crossings are presented in Figure B.4 in Appendix B of TSD 2 Project Description.

In areas where the rail alignment is cut into the terrain, it is not feasible to pass streams across the rail alignment. In these 27 locations, the watercourse will be diverted along the rail alignment to an adjacent watercourse. Of the 27 diversions, 23 are considered low risk and the remaining are considered medium or high risk based on the percentage increase of flow in the receiving stream. One of the four streams is a probable fish bearing stream. Baffinland will be implementing mitigation on crossing-by-crossing bases to reduce flow velocities which may include additional culvert barrels, channel widening, construction of habitat features, regarding, and channel stabilization. Details of the hydrologic assessment are provided in Appendix D of TSD 13 Surface Water Assessment.

Four bridges and 417 culverts will be constructed along the North Railway. Bridge spans are based on the existing normal flow riverbank. Attachment 8.3 presents preliminary drawings of the four railway bridges. Bridge designs will be based on the 1:200 year 24-hour storm, sufficiently conservative to account for climate change induced increases in precipitation and runoff (TSD 6 Climate Change Assessment). Temporary cofferdams will be used in the construction of the bridges to isolate areas in which bridge piers will be constructed. Culverts will be installed at other water crossings along the railway. Culverts will be designed in accordance with American Railway Engineering and Maintenance-of-Way Association (AREMA) (2018) guidelines and approved railway design criteria and rationale (provided as Attachment 6.1). Culvert diameters will range from 0.6 m to 1.8 m, and will be covered with a minimum of 1 m of fill. Attachment 8.1 provides a list of the railway crossings, while Attachment 8.3 provides crossing typical drawings.

In order to accommodate the construction of the North Railway, approximately eight culverts will be upgraded along the Tote Road. Details pertaining to the upgrades of these culverts will be explored in the detailed engineering phase. The installations will be consistent with direction previously received from the Fisheries and Oceans Canada (DFO) in the fisheries authorization and the letters of advice. Watercourse crossing for the Tote Road are provided in Attachment 8.2 and typical crossing drawings are provided in Attachment 8.3.

No changes to the Southern Railway watercourse crossings are proposed beyond that presented in the original Type A Water Licence application and addressed in the current scope of the Licence.

2.6 ORE DOCK AND ASSOCIATED INFRASTRUCTURE

Baffinland will construct a second ore dock at Milne Port capable of berthing Cape size ore carriers, as part of the Phase 2 Proposal (Figure 1.3). The dock face will be positioned parallel to the seabed contours. To construct the second ore dock it may be necessary to dredge sediments/soft material on the ocean floor beneath the dock embankment. Localized removal of the upper layer of unsuitable substrate material is anticipated within the confined limits of the sheet pile enclosure. The materials will be transported and disposed with consideration of mitigation design considerations taken to reduce the potential for environmental impacts. The materials may be suctioned and pumped directly to a disposal area located either on land or within a silt curtain confined water lot area, behind the ore dock that will no longer be connected to Milne Inlet. Design shall include consideration of an outlet for stormwater release, if required. Further detail regarding the ore dock, including dock construction methodology is presented in Section 4.2 and Appendix F of TSD 2 Project Description. Information provided is preliminary and is subject to detail design. Once detailed design has been completed, final details will be provided to the NWB.

A second shiploader will be constructed to fill vessels berthing at the new Cape size dock with ore from the lump ore stockpile. A bucket wheel reclaimer will be used to reclaim ore from the stockpile to feed the shiploader. Details regarding the shiploading system are provided in Section 4.3 of TSD 2 Project Description.

The existing ore stockpiles at Milne Port will be expanded and reorganized to accommodate the second dock and shiploader. The fines ore stockpile will be expanded and appropriate water management features included under a separate modification request to be submitted to the NWB in 2018. Ore will arrive from the Mine Site and will undergo secondary ore crushing at Milne Port, where it will be sorted into lump ore and fine ore.

Water management related to the ore stockpiles at Milne Port is discussed in Section 4.4.

2.7 QUARRIES

2.7.1 List of Proposed Quarries

Table 2.2 lists the approved and proposed quarries that may be used to supply aggregate for construction of the Phase 2 Proposal, mainly the North Railway. Quarry locations are shown on Figure 9.1 in Attachment 9.

Table 2.2 Proposed Quarries

Quarry No.	Railway Chainage	Material	Available Volume (m^3)	Approximate Footprint (ha)	UTM Easting	UTM Northing
Q1[1]	CH2000	Granitic Gneiss	400,000	33.6	504013	7974915
PQ1	CH4500 to 6200	Granitic Gneiss	1,110,000	66.7	505953	7972448
Q4	CH7200	Granitic Gneiss	7,687	0.8	507438	7970518
Q6	CH7800	Granitic Gneiss	6,348	0.6	507804	7969988
Q10	CH11800	Granitic Gneiss	14,140	1.4	510638	7967431
Q11	CH14900	Limestone	5,000	0.4	513679	7966223

Quarry No.	Railway Chainage	Material	Available Volume (m^3)	Approximate Footprint (ha)	UTM Easting	UTM Northing
Q13	CH16200	Limestone	118,245	7.9	514295	7965314
PQ2b	CH22000	Limestone	160,000	23.3	517664	7961973
Q16	CH 31700	Limestone	81,717	5.4	521838	7952395
Q19	CH39200	Limestone	28,114	2.8	523024	7945186
PQ4a	CH41600	Limestone	180,000	11.1	523697	7942901
PQ4b	CH42500	Limestone	180,000	12.3	523651	7941894
Q21	CH44600	Limestone	9,000	1.1	524356	7940085
PQ5a	CH45700	Limestone	240,000	18.6	525439	7938839
PQ5b	CH46800	Limestone	500,000	47.2	526119	7937802
Q23	CH48600	Limestone	4,041	0.4	525886	7936586
Q24	CH51250	Limestone	42,412	4.2	527063	7934336
PQ6a	CH56200	Limestone	360,000	26.9	528552	7929763
PQ6b	CH57100	Limestone	300,000	22.4	528993	7928994
Rail Sand Pit	CH58000	Glacial till	TBD2	8.0	528498	7927790
Q27	CH63350	Limestone	136,086	9.1	527208	7923193
PQ9a	CH66000	Limestone	225,000	6.4	527378	7920441
PQ9b	CH66000	Limestone	75,000	2.2	527651	7920425
PQ10a	CH73100	Limestone	180,000	13.5	531568	7917522
PQ10b	CH74200	Limestone	120,000	9.7	531982	7917635
PQ12a	CH84500	Sandstone	240,000	25.8	539072	7921210
PQ12b	CH84500	Sandstone	120,000	20.4	539898	7921837
PQ13	CH85700	Sandstone	180,000	44.7	542676	7923983
PQ14a	CH96700	Sandstone	80,000	4.6	550836	7917829
PQ14b	CH96000	Sandstone	30,000	9.5	550983	7917458
PQ15a	CH101500	Diorite	80,000	8.3	555853	7915626
PQ15b	CH102300	Diorite	45,000	6.1	555270	7915586
QMR2[1]	CH107000	Diorite	250,000	28.0	559982	7914323
Q42	CH109000	Diorite	125,000	6.6	561673	7912667
D1Q1[1]	Deposit No. 1	Granitic Gneiss/schist	275,000	6.7	563055	7914645
D1Q2[1]	Deposit No. 1	Granitic Gneiss/schist	700,000	13.1	563376	7913330

NOTES:

1. EXISTING APPROVED QUARRY WITH AN EXISTING QUARRY MANAGEMENT PLAN.
2. THE RAIL SAND PIT IS EXPECTED TO BE USED DURING RAIL OPERATIONS ONLY, EXTRACTING 5,000 TO 10,000 m^3 OF SAND AND GRAVEL ANNUALLY.

Existing licensed borrow areas between Milne Port and the Mine Site will continue to be used during the life of the Project for various purposes. Aggregate material required for the Tote Road maintenance and upgrades will be extracted from existing quarry sites that have been identified along the Tote Road and new quarry sites along the North Railway depending on proximity to work being completed. One additional borrow area (Rail Sand Pit) is proposed, located at approximately railway chainage km 59.6. Sand will be extracted from this location during the operation phase for rail maintenance. There may be times that sanding of the railway track is required to assist the locomotives with traction when ascending slopes. Between 5,000 to 10,000 m^3 of material may be required annually from this source. Quarry-specific management plans will be submitted to the NWB under the Licence prior to the development of the above-noted quarry and borrow sources.

A total of 79 proposed quarries are also located along the South Railway and at Steensby Port. These quarries are part of the Approved Project, and quarry-specific management plans will be submitted to the NWB under the Licence prior to their development.

2.7.2 ARD/ML Testing

Of the 36 planned quarries to be used to construct the North Railway and other Phase 2 Proposal infrastructure, 24 are located in sedimentary rocks (limestone or sandstone), both of which have a high buffering capacity, and present no Acid Rock Drainage (ARD) risk (Hatch Ltd. (Hatch), 2018; AMEC, 2010). The remaining nine quarries are located in granitic gneiss or diorite, both of which have a low sulphide content, making them unlikely candidates for producing ARD (AMEC, 2010). However, these rock types also have a low neutralization potential, which means that they could produce ARD if the neutralizing materials within them are insufficiently reactive, or depleted at a faster rate than the sulphides. Overall, the ARD potential of the granitic rocks has been assessed to be low (AMEC, 2010; Hatch, 2017).

Results, to date, of geochemical testing for ARD/ML of quarries along the South Railway, indicate that quarry materials have low potential for acid generation and metal leaching (ML) (Baffinland, 2012). The tested and untested quarries will be subject to additional geotechnical and geochemical investigation as the Project proceeds.

Baffinland's Borrow Pits and Quarry Management Plan (Baffinland, 2014a) includes an ARD testing protocol as an appendix. Based on geochemical testing completed to date, as well as established protocols for testing prior to quarrying (applicable also to rock cuts), the risk of these activities generating ARD/ML is low. In the unlikely instance that ARD/ML issues are identified at a quarry, Baffinland will avoid using the quarry.

There may be less flexibility if ARD/ML issues are identified at rock cuts. Options to reroute the railway to avoid an ARD/ML rock cut will be considered. If the railway cannot be realigned to avoid a potential ARD/ML rock cut, other mitigation measures will be evaluated to prevent the release of adverse quality runoff. ARD/ML rock excavated from such areas will not be used as embankment fill, and the rock will be disposed of in a suitable fashion (including possible disposal with PAG waste rock in the waste rock stockpile at the Mine Site). Any exposed faces of ARD/ML rock at such rock cuts will be managed according to site specific conditions. Options may range from do-nothing (if exposed faces are limited and/or runoff from the faces is not of adverse quality) to covering the exposed faces with non-PAG/ML material to placing limestone within seepage paths to increase pH of the runoff and precipitate metals.

2.7.3 Future Quarry-Specific Management Plans

A Borrow Pits and Quarry Management Plan approved under the current Licence identifies its overarching quarry management practices and principles (Baffinland, 2014a). In accordance with Part D, Item 6 of the Licence, Baffinland will submit individual quarry management plan prior to the development of a selected quarry site, provided that the approved Borrow Pits and Quarry Management Plan does not adequately address the development of a given borrow pit or quarry.

2.8 LAYDOWN AREAS

A total of 21 laydown areas will be established to support construction of the Phase 2 Proposal (Table 2.3). This includes 14 laydown areas to be located along the North Railway, 7 laydown areas at Milne Port, and 4 laydown areas at the Mine Site. Several laydown areas at Milne Port and the Mine Site have been previously approved. The laydown areas are shown on Figure 9.2 in Attachment 9.

Table 2.3 Proposed Laydown Areas

Laydown Area	Approximate Location		Area (ha)	Easting	Northing
	Road km	Rail Chainage			
LD-1	Milne Port		3.4	504031.7205	7974597.534
LD-2	km3.7	CH2200	2.6	504048.7622	7974014.558
LD-3	km4.2	CH3000	2.0	504491.5259	7973629.297
LD-4	km5.5	CH4000	2.8	504974.8249	7972675.944
LD-5	km7.0	CH5700	1.5	506327.9788	7971603.115
LD-6	km13.5	CH12000	1.0	510799.1138	7967350.206
LD-7	km23.0	CH21000	1.6	517314.0528	7961896.303
LD-8	km33.5	CH31000	0.6	521690.9776	7953049.867
LD-9	km41.8	CH39500	0.4	522987.3914	7945107.75
LD-10	km46.8	CH44000	1.2	524032.6564	7940558.284
LD-11	km56.8	CH53000	1.0	527217.2405	7932785.764
LD-12	km62.0	CH57800	2.5	528375.0108	7928223.09
LD-13	km78.0	CH84000	2.0	540504.0646	7921426.459
LD-14	km81.0	CH87000	0.3	543185.6927	7921430.623
LD-15	km86.5	CH92000	1.7	547057.519	7919694.509
LD-16	Mine Site		1.5	557978.2855	7914998.395
LD-17	Mine Site		2.3	560009.8703	7913726.444
LD-18	Mine Site		1.7	560829.4248	7913257.917
LD-19	Mine Site		1.9	560909.1397	7913352.577

The laydown areas will be constructed by filling directly over undisturbed ground, including filling in low-lying areas that collect water. The laydown areas will be constructed utilizing blasted rock with

granular topping to a total maximum thickness of 1 m. Fill will be sourced from existing quarries and borrow pits and those proposed under this application (Section 2.7).

2.9 CONSTRUCTION CAMPS

The camps that are currently at Milne Port, along with the construction and operation phase camp occupancies, are presented in Table 2.4.

Table 2.4 Milne Port Camp Occupancies

Camp/Facility	Current	Production Increase	Phase 2 Construction	Phase 2 Operation
Port Site Complex	120	120	330	330
Steensby Camp	54	54		
Matrix Camp	153	153		
Construction Camp			300	
Permanent Camp		380	380	380
Total Beds	327	707	1010	710

As noted in Section 1.5, Baffinland received approval from NIRB to construct the 380 bed camp identified in Table 2.4. A modification request will be submitted in the near future separate from this request for an amendment to the Licence for the Phase 2 Proposal, seeking approval from the NWB for the camp (and fuel tank) under the current Licence.

The camp components at Milne Port associated with the Phase 2 Proposal (this application) include an expansion of the Port Site Complex to 330 beds (210 beds will be relocated from the Mine Site to add to the existing 120 beds), and the additional of a 300-bed construction camp. The total number of beds at Milne Port will peak at 1,010 during construction of the Phase 2 Proposal, and this will be reduced to 710 beds during operation with the removal of the 300-bed construction camp. These changes will allow Baffinland to decommission the temporary 153-bed Matrix camp and the 54-bed Steensby camp early in the construction phase.

Three mobile camps will be used during the construction of the railway. These camps may be located at any or all of the proposed laydown areas throughout the construction phase, so as to accommodate workers closer to the active work front. The three mobile camps will have a combined bed capacity 255 beds. The quantities of water required for these camps is within the allowable water draw from Camp Lake under the current Licence. Water will be trucked from approved domestic water sources to storage tanks, with a daily water supply usage of 76.5 m^3.

The construction workforce at the Mine Site will be accommodated by existing camp facilities (Section 2.10).

Water supply to the camps is discussed in Sections 3.4 and 3.7. Sewage treatment and disposal is discussed in Section 4.7.

2.10 PERMANENT CAMPS

The camps to be added and removed at Milne Port as the result of the Phase 2 Proposal is described in Section 2.9 and in Table 2.4. At the end of the construction phase, two camps will remain: the 380-bed camp to be constructed at Milne Port through a modification request under the current Licence, and the Port Site Complex expanded to 330 beds.

An 800-person camp is being constructed at the Mine Site in 2018 through a modification request under the current Licence (the approved capacity of camps at the Mine Site is 1,200 beds). This will meet the needs of the 12 Mtpa North Railway operation.

Water supply to the camps is discussed in Sections 3.4 and 3.7. Sewage treatment and disposal is discussed in Section 4.7.

2.11 SEDIMENT AND EROSION CONTROL MEASURES

Baffinland will implement the water management features to convey water around or through the laydown areas. Sediment and erosion control measures to address sedimentation concerns (check dams, rip-rap, silt fences, etc.) will be implemented during construction in accordance to Baffinland's Environmental Protection Plan (EPP; Baffinland, 2016b) and Surface Water and Aquatic Ecosystems Management Plan (Baffinland, 2016a). No sediment or erosion control measures are expected to be required once construction has been completed.

Similarly, the quarries proposed as part of the Phase 2 Proposal will have plans for ditches, diversions and ponds (as required) in their respective quarry management plans to be submitted to the NWB prior to their development.

3 – WATER USE AND MANAGEMENT (PART E)

3.1 OVERVIEW OF CHANGES

As part of the Phase 2 Proposal, Baffinland has identified the need to increase water takes from three existing sources, as well has identified thirteen additional water source locations (detailed discussed in Sections 3.3 to 3.5). Water management at Milne Port will be updated to account for the larger stockpiles and new crusher at the Port (see Section 3.6).

3.2 APPLICABLE MANAGEMENT PLANS

There are two approved management plans that relate to water use and management:

- Freshwater Supply, Sewage and Wastewater Management Plan (Baffinland, 2018a)
- Surface Water and Aquatic Ecosystems Management Plan (Baffinland, 2016a)

Any required updates to these plans to account for the Phase 2 Proposal are identified in Section 8. Updates to these plans will be submitted to the NWB for approval in accordance with Items 1 and 2 of Part E of the Licence.

3.3 CONSTRUCTION PHASE WATER USE

The Phase 2 Proposal will not require additional sources or changes in the volume of water used for domestic and industrial purposes during the construction phase. Table 3.1 lists the approved construction phase water sources and volumes of water to be used for domestic and industrial purposes.

Table 3.1 Construction Phase Water Sources

Site	Source	Authorized Water Use Volume (m^3/day)
Milne Port (Milne Inlet)	Phillips Creek (summer)	367.5
	km 32 Lake (winter)	
Mine Site (Mary River)	Camp Lake	657.5
Steensby Port (Steensby Inlet)	ST 347 km Lake	435.8
	3 km Lake	
Ravn River	Camp Lake	145.2
Mid-Rail	Nivek Lake (summer)	79.5
	Ravn Camp Lake (winter)	
Cockburn North (Tunnels Camp)	Cockburn Lake	101.4
Cockburn South Camp	Cockburn Lake	111.1

3.4 OPERATION PHASE WATER USE

The Phase 2 Proposal will not require additional sources or changes in the volume of water used for domestic and industrial purposes during the operation phase. Table 3.2 lists the approved operation phase water sources and volumes of water to be used for domestic and industrial purposes.

Table 3.2 Operation Phase Water Sources

Site	Source	Authorized Water Use Volume (m^3/day)
Milne Port	Phillips Creek (summer)	367.5
	km 32 Lake (winter)	367.5
Mine Site (Mary River)	Camp Lake	355.4
Steensby Port	ST 347 km Lake	243.6
	3 km Lake	

Expansions of the potable water treatment plants at Milne Port and the Mine Site will be required over time to meet increased volume requirements (Section 3.7).

3.5 DUST SUPPRESSION WATER USE

Additional dust suppression water sources along the Northern Transportation Corridor are proposed as part of the construction and operation phases of the Phase 2 Proposal. Table 3.3 lists the approved water sources and volumes identified in Table 2-3 of Part E, Item 25 of the Licence, along with the additional water sources and revised daily volumes.

Of the approved water sources, Baffinland proposes to increase the volumes at three sources, CV078, BG50, and BG32. Thirteen new water sources have been identified, of which one (CWP12) will require the restriction of taking water in June and July only during low flow years. An assessment of the new and revised water sources is presented in TSD 13 Surface Water Assessment (Knight Piésold, 2018a). All water intakes will be equipped with fish screens in accordance to DFO's fish screen guideline (DFO, 1995), as described in the Fresh Water Supply, Sewage and Wastewater Management Plan (Baffinland, 2018a).

As a means of reducing water consumption, stormwater collected at the ore staging area will be used for dust suppression provided the effluent is confirmed to meet the mine effluent discharge limits in Table 10 (Part F, Item 24) of the Licence.

Table 3.3 Approved and Proposed Dust Suppression Water Sources

Water Take Station (Source)	Coordinates		Authorized Water Use	Additional Water Use Requested	Revised Maximum Water Use
	Northing (m)	Easting (m)	(m^3/day)	(m^3/day)	(m^3/day)
MP-MRY-2 (Phillips Creek)	7,975,254	502,829	212	-	212
CV128	7,965,895	513,545	579.5	-	579.5
MP-MRY-3 (km32 Lake)	7953,660	521,189	364	-	364
CV099	7,948,820	521,811	110	-	110
CV087	7,941,040	523,704	90	-	90
CV078	7,936,787	525,852	75	15	90
Katiktok Lake	7,934,552	526,600	318	-	318
BG50	7,926,846	529,334	150	65	215
BG32	7,921,622	540,706	120	60	180
CV217	7,922,158	542,219	130	-	130
Muriel Lake	7,921,987	542,508	212	-	212
David Lake	7,919,396	547,885	132	-	132
BG17	7,917,643	550,703	75	-	75
CV223 (Tom River)	7,914,691	555,818	135	-	135
Camp Lake	7,914,684	557,793	86	-	86
CWP1	7,970,914	506,663	-	140	140
CWP2	7,967,146	510,978	-	110	110
CWP3	7,963,947	515,215	-	55	55
CWP4	7,962,497	516,439	-	75	75
CWP5 (km26 Lake)	7,958,592	518,839	-	120	120
CWP6	7,945,826	522,434	-	80	80
CWP7	7,942,153	523,218	-	60	60
CWP8	7,939,580	524,497	-	35	35
CWP9	7,938,445	524,839	-	45	45
CWP10	7,923,139	527,413	-	55	55
CWP11	7,916,686	529,119	-	100	100
CWP12	7,916,606	551,452	-	80	80
CWP3 (Sheardown Lake)	7,913,489	560,288	-	10	10

3.6 SITE WATER MANAGEMENT

Site water management is described below. Further detail on the management of ore stormwater is provided in Section 4.4, and sewage disposal is described in Section 4.7. Existing site drainage plans require alteration to accommodate the additional infrastructure at both the Mine Site and at Milne Port. Water management plans for the Mine Site and Milne Port are presented as Attachments 10.1 and 10.2, respectively.

Water management facilities at the Mine Site will be modified to account for changes to the crusher pad associated with the 12 Mtpa North Rail operation. A new crusher pad will be constructed along with a new stormwater pond. A stream diversion will be required to divert water away from the crusher pad. Fish are not present within the section of stream (referred to as Sheardown Lake Tributary 12 in the FEIS) that will be affected by the diversion. Drawings of the crusher pad and pond are included as Attachment 10.3. The existing crusher pad and stormwater pond will be decommissioned once the new water management features are in place. IFC engineering drawings will be submitted to the NWB at least 60-days prior to construction, in accordance with Part G of the Licence.

Similarly, water management at Milne Port will undergo changes to accommodate larger ore stockpiles and new facilities associated with ore crushing and the North Railway. The Milne Port Water Management Plan presented as Attachment 10.2 contains layouts showing water management features including ditches, diversions and ponds.

No changes are proposed for the final discharge points at both the Mine Site and Milne Port for mine effluent stormwater.

Site water management will also be required at the ore staging area (Section 2.3). A pad will be established upon which ore will be unloaded from haul trucks, temporarily stockpiled, and loaded into rail cars. Runoff from this pad will be directed to a stormwater pond. Effluent from the pond meeting mine effluent discharge criteria will be used for dust suppression, as noted in Section 3.5.

Similarly, the quarries proposed as part of the Phase 2 Proposal (Section 2.6) will have plans for ditches, diversions and ponds (as required) in their respective Quarry Management Plans that will be submitted to the NWB prior to their development.

Best management practices are incorporated into the design of these site drainage features in accordance to Part F, Item 27 of the Licence.

3.7 WATER SUPPLY INFRASTRUCTURE

Water for domestic and industrial use at Milne Port will continue to be drawn from the same summer and winter sources with no change in the maximum daily volume, as described in Section 3.3 (construction phase) and Section 3.4 (operation phase). Baffinland will build a new water treatment plant at Milne Port for the new 380-person camp under a separate modification request, as described in Section 1.5.

As part of the Phase 2 Proposal and this application, the existing water treatment plant servicing the Port Site Complex will be upgraded or replaced to accommodate the increase in the number of beds from 120 to 330 persons. Details on this component will be submitted to the NWB in the future (Section 9).

As described in Sections 2.9 and 2.10, an 800-bed camp and related water supply facilities are being constructed at the Mine Site in 2018 as part of the Approved Project. No additional water supply infrastructure at the Mine Site is required as part of this application.

Water and sewage process flow diagrams for the Mine Site and Milne Port are included as Attachments 11.2 and 11.4, respectively.

3.8 UPDATED BLOCK FLOW DIAGRAMS

Updated area water balances block flow diagrams for the Mine Site, Milne Port and the temporary ore transfer area are included as Attachments 11.1, 11.3 and 11.5, respectively. Updates to these diagrams will be completed and submitted annually for information to the NWB as part of the annual report in accordance with Part E, Item 10 of the Licence.

4 – WASTE DISPOSAL AND MANAGEMENT (PART F)

4.1 OVERVIEW OF CHANGES

An expansion of current solid waste management facilities will not be required for the Phase 2 Proposal, however a new landfill will be constructed at Milne Port following construction.

Details regarding the proposed changes are provided below.

4.2 APPLICABLE MANAGEMENT PLANS

Four approved management plans relate to waste disposal and management:

- Waste Management Plan (Baffinland, 2018b)
- Phase 1 Waste Rock Management Plan (Baffinland, 2014b)
- Life of Mine Waste Rock Management Plan (Baffinland, 2014c)
- Hazardous Materials and Waste Management Plan (Baffinland, 2017a)

Any required updates to these plans to account for the Phase 2 Proposal are identified in Section 8. Updates to these plans will be submitted to the NWB for approval in accordance with Items 1 and 2 of Part E of the licence.

4.3 WASTE ROCK

Waste rock management is described in a Phase 1 Waste Rock Management Plan (Baffinland, 2014b) and a Life-of-Mine Waste Rock Management Plan (Baffinland, 2014c). The Phase 1 Waste Rock Management Plan addresses the first four years of mining (2015 to 2018) during execution of the ERP. A revised Phase 1 Waste Rock Management Plan is under development, and is expected to be implemented starting in April 2019.

Since mid-2017, Baffinland has identified water quality issues associated with the waste rock facility (WRF). This issue is being addressed as part of current operations under the conditions of the Licence, including the implementation of an Interim Waste Rock Management Plan over the short-term (Golder, 2018a).

The production of waste rock will be accelerated with the development of Phase 2. The Key Facts table (Appendix C of TSD 2 Project Description) provides an updated waste rock production schedule. The revised Phase 1 Waste Rock Management Plan will address both the water quality issues addressed by the Interim Waste Rock Management Plan and the higher production rate associated with the Phase 2 Proposal.

4.4 ORE STOCKPILE STORMWATER

Larger stockpiles and rail loading/unloading facilities at both the Mine Site and Milne Port will necessitate additional water management features to be installed. Table 4.1 below identifies the new infrastructure in relation SNP monitoring stations and proposed changes for the Phase 2 Proposal. A discussion of Milne Port, the Mine Site and the ore staging area is provided below.

Table 4.1 Proposed Changes to Existing Mine Effluent Discharges

SNP Station	Description	Status and Proposed Changes for Phase 2 Proposal
Mine Site		
MS-06	Ore stockpile (crusher pad) pond stormwater	Operational; new stormwater pond will replace new pond, with no changes to final discharge point
MS-07	Run of Mine (ROM) Ore Stockpile Pond Stormwater	Not yet constructed; no changes proposed
MS-08	Waste Rock Stockpile West Pond	Operational, but discharges to the Mary River as the east pond intended
MS-09	Waste Rock Stockpile East Pond	Not yet constructed; no changes proposed
Milne Port		
MP-05	Milne Port Ore Stockpile Sedimentation Pond - East (Stormwater Pond No. 2)	Operational; a second adjacent pond will be constructed in 2018 as part of ongoing operations under a separate modification to the current water Licence 2AM-MRY-1325
MP-06	Milne Port Ore Stockpile Sedimentation Pond - West (Stormwater Pond No. 1)	Operational; a second adjacent pond will be constructed in 2018 as part of ongoing operations under a separate modification to the current water Licence 2AM-MRY-1325
(new)	Stormwater Pond No. 3	New pond to collect runoff from a new ore fines stockpile. Final discharge will be to Milne Inlet via Stormwater Ponds 1/1a or 2/2a, or for use in dust suppression on roads.
(new)	Stormwater Pond No.4	New pond to collect runoff from a new crusher feed stockpile. Final discharge will be to Milne Inlet via Stormwater Ponds 1/1a or 2/2a, or for use in dust suppression on roads.
(new)	Lump ore stockpile perimeter ditching East	New pond to collect runoff along the east perimeter of the lump ore stockpile. Final discharge will be to Milne Inlet via Stormwater Ponds 1/1a or 2/2a, or for use in dust suppression on roads.
(new)	Lump ore stockpile perimeter ditching West	New pond to collect runoff along the west perimeter of the lump ore stockpile. Final discharge will be to Milne Inlet via Stormwater Ponds 1/1a or 2/2a, or for use in dust suppression on roads.
Northern Transportation Corridor		
(new)	Ore Staging Area Stormwater Pond	New pond to collect runoff from the ore staging area for a period of 1 to 2 years during rail construction/commissioning. Final discharge will be to use the effluent for dust suppression on Tote Road.

At Milne Port, the two stormwater ponds (stormwater ponds No. 1 and 2) collecting runoff from the ore stockpile area will be insufficient to contain a larger volume of runoff. Ditching along the east and west perimeter of the lump ore stockpile will contain runoff from the lump ore stockpile. The perimeter ditching will have sumps and the effluent will be discharged by pumping at the current effluent

discharge point at Milne Inlet, provided it meets discharge criteria. Two other ponds (stormwater ponds No. 3 and 4) will be constructed near the crusher feed stockpile and the fines stockpile and will discharge to Milne Inlet via the existing final discharge point associated with the existing stormwater ponds.

At the Mine Site, current road haul stockpiles will be expanded for the North Railway adjacent to the present location and will have a new stacking conveyor and rail loading facility. The surface area of the mine site ore stockpile area will increase by approximately 40% to support the Phase 2 Proposal. Hence, the quantity of runoff from the stockpile and crusher pad area will increase by approximately the same proportion. A new stormwater pond for the primary crushing pad will be constructed. A new stormwater discharge pipeline will be installed to join the new stormwater pond to the combined stormwater and sewage outfall. No change to the final discharge point is proposed. Once the North Railway crusher pad and pond are operational, the existing crusher pad and stormwater pond associated with the ERP operation will be decommissioned.

The ore staging area at km 57 of the North Railway will operate for 1 to 2 years during rail construction. Runoff from the ore stockpiles at this facility will be directed to a settling pond. The capacity of this pond is 1,100 m^3. Effluent collected in this pond will be sampled to ensure it meets discharge criteria before applying the water to the Tote Road as part of dust suppression efforts.

4.5 WASTE GENERATION AND SOLID WASTE MANAGEMENT FACILITIES

Baffinland currently maintains a landfill at the Mine Site and incinerators at both the Mine Site and Milne Port. Table 4.2 identifies the existing solid waste management facilities, and modifications or additions required for the Phase 2 Proposal.

During construction, most waste generated by the mobile rail construction camps will be non-hazardous and combustible, and, will be directed to one of the existing incinerators at the closer of Milne Port or the Mine Site. Waste will be collected from the camps regularly so as to not accumulate significant volumes of waste that may attract wildlife. Non-hazardous waste not suitable for incineration generated by the mobile camps will be directed to the landfill at the Mine Site, as the new landfill at Milne Port will not be constructed right away.

Table 4.2 Modifications and Additions to Existing Solid Waste Management Facilities

Location/Facility	Modification or Addition
Milne Port	
Incinerator	No modification required
Landfill (new)	A landfill will be constructed within the boundaries of Quarry Q1 at Milne Port following construction of the Phase 2 Proposal
Northern Transportation Corridor	
Mobile construction camps	All solid wastes will be transported to existing facilities at the Mine Site or Milne Port for disposal
Mine Site	
Incinerator	No modification required
Landfill	No change; in 2018 the existing landfill will be reaching its initial design capacity, and a modification request is being submitted to the NWB for the staged expansion to the landfill. This proposed expansion will be sufficient to accommodate the Phase 2 Proposal.

The facilities for the storage of hazardous waste will remain unchanged. Any hazardous wastes generated at the camps will be transported to existing hazardous waste storage facilities at Milne Port or the Mine Site. Hazardous waste will be shipped off site for disposal at licenced facilities. Handling, storage and transportation of these wastes will be in accordance with the Transportation of Dangerous Goods Regulations (Transport Canada, 2017).

The expected volumes of waste generated including disposal method, are provided in Table 4.3.

Table 4.3 Projected Waste Quantities

Project Site	Type of Waste	Disposal Method	Volume
Mine Site	Treated sewage	Discharge to tundra	360 m^3/day
	Combustible non-hazardous waste	Incineration	1457 m^3/year
	Non-combustible non-hazardous waste	Landfill	7,500 m^3/year
Milne Port	Treated sewage	Discharge to Milne Inlet	240 m^3/day
	Combustible non-hazardous waste	Incineration	603 m^3/year
	Non-combustible non-hazardous waste	Landfill	7,500 m^3/year
	Hazardous waste	Storage and disposal at licenced facility	240 m^3/year
	Hazardous waste and tires	Shipped off site	510 m^3/year
Mobile Camps	Treated sewage	Stored and trucked to Mine Site or Milne Port WWTP	76.5 m^3/day
	Combustible non-hazardous waste	Trucked to Mine Site or Milne Port Incinerator	192 m^3/year

As with its current operations Baffinland will continue to make efforts to minimize waste by reusing and repurposing equipment and materials when possible.

4.6 OILY WATER TREATMENT FACILITY

Baffinland operates oily water treatment units as part of the truck wash facilities located within the maintenance facilities at both the Mine Site and Milne Port.

A railway maintenance facility will be added at Milne Port and at the ore staging area located at km 57. The facilities will be consistent with the design of oily water treatment facilities at the Mine Site. The oily treatment facility will collect oily water from the workshops and areas that may have come into contact with grease, oil or fuel. Discharges from the oily water treatment facility will meet effluent quality limits prescribed in the Licence in Table 6 (Part F, Item 20).

4.7 SEWAGE DISPOSAL

One sewage treatment plant currently operates at Milne Port. Baffinland will construct a second sewage treatment facility to accommodate the permanent 380-person permanent camp described in Section 2.10. The facility has a capacity for treating effluent of 600 persons based on conservative daily use rates. The 380-person camp (and associated water and sewage infrastructure is now part of the Approved Project (Section 1.5), and therefore Baffinland will submit a modification request to the NWB for this component in the near future.

As part of the Phase 2 Proposal and this application, a third sewage treatment plant is proposed to service the larger Port Site Complex. Details on this component will be submitted to the NWB in the future (Section 9).

Treated effluent will be monitored to ensure it meets applicable discharge criteria as specified in the Licence Part 5, Item 18, Table 5 prior to discharge. Treated sewage effluent will continue to be discharged to Milne Inlet from the same final discharge point shown on Figure B.5 in Appendix B of TSD 2 Project Description.

For its current operations, Baffinland recently submitted a modification request under the Licence for a new 800-person camp and new sewage treatment plant. These facilities are part of the Approved Project will be constructed in 2018 at the location shown on Figure 1.4. Treated sewage effluent from the camp will continue to be land discharged at the same location, reporting to Mary River. The existing treated sewage effluent pipeline and outfall is shown in Figure B.1 in Appendix B of TSD 2 Project Description. A new sewage discharge line will also be installed in 2018 under a separate modification request.

Similarly, the existing and planned sewage treatment plants at both Milne Port and the Mine Site will have sufficient capacity to treat the sewage from the mobile camps. The mobile camps will generate an estimated 76.5 m^3 of sewage per day. Sewage will be held in holding tanks and then transported by truck to one of the sewage treatment plants at Milne Port or at the Mine Site. Waste will be trucked regularly to the incinerator at either Milne Port or the Mine Site. Water and sewage holding tank details are provided in Attachment 16.

Water and sewage process flow diagrams for the Mine Site and Milne Port are included as Attachments 11.2 and 11.4, respectively.

4.8 LANDFILL AT MILNE PORT

The proposed landfill at Milne Port will be constructed within the exhausted Quarry Q1 following construction, as shown on Figure 1.3. The Milne Port landfill will be designed based on the design of the existing landfill at the Mine Site (Knight Piésold, 2008) and consistent with the *Guidelines for the Planning, Design, Operations and Maintenance of Modified Solid Waste Sites in the Northwest Territories* (Ferguson, Simek Clark, 2003). As with the existing landfill at the Mine Site, the new landfill at Milne Port will only receive non-hazardous waste that cannot be incinerated. The area method will be used for waste disposal wherein a low height berm will be constructed along up to two sides of the landfill site (or alternatively against a quarry face), and then waste will be disposed of against the berms and directly onto the ground downstream of the berms. Sand and gravel will be used as the cover material. In order to achieve permafrost encapsulation in the landfill following closure, the final cover will be thicker than the active layer. Appropriate surface water, erosion and sediment control measures will be implemented during operations. The landfill is not expected to significantly change the quality of surface waters in the area due to the inert nature of the waste and small landfill footprint. Because the landfill will be positioned within a rock quarry, no groundwater monitoring is proposed.

A design report which includes an operations and maintenance manual will be submitted to the NWB in June 2020 in accordance with Part G of the Water Licence.

4.9 RAIL CONSTRUCTION SOIL SPOILS

The railway will be constructed using a combination of cut and fill, with material gained from cuts filling the lower lying areas along the alignment. The majority of cuts will be into rock, to minimize cuts in soils, particularly ice-rich soils, to avoid inducing thermal changes and causing geotechnical instability issues. An estimated 650,000 m^3 of soil spoils will be generated during construction of the North Railway. Approximately half of the material will be unfrozen and excavated, while the other half will be frozen material that will require drilling and blasting before excavation.

The soil spoils will require disposal at locations and in a manner that does not result in runoff of sediment-laden water. To reduce the potential for sediment runoff into water bodies and to ensure long-term stability of these materials the following disposal criteria will be applied:

- Soil spoils will be placed in exhausted quarries and borrow pits along the Tote Road as a preferred option. Quarries and borrow areas represent an existing disturbed footprint with limited future use, and therefore make ideal disposal sites, provided they are not planned for use as explosive storage areas during construction.
- Other disposal sites will be identified near to the construction activity. Local depressions or low-relief areas will be selected as opposed to slopes where material can run-off.
- In all instances, as a standard condition of land-use approvals, disposed overburden materials will be placed >33 m from a surface water body.
- Disposal locations will be approved by the appropriate construction personnel (i.e., engineer, construction superintendent or foreman) who have been given such authority, to avoid unauthorized and indiscriminate disposal.
- Disposal locations will be well removed from the railway embankment.
- The stockpile will be designed with a minimal slope that is physically stable.
- Overburden spoils in construction will not be re-used without prior approval by the supervising engineer.

- Overburden soils will be transported directly to the disposal site, without short-term storage and re-handling.

Sediment and erosion control measures will be implemented as identified in the Surface Water and Aquatic Ecosystems Management Plan to prevent runoff of sediment and to possibly divert runoff away from the disposed material.

5 – EMERGENCY RESPONSE AND CONTINGENCY PLANNING (PART H)

5.1 OVERVIEW OF CHANGES

Changes to the Project relevant to emergency response and contingency planning include the addition of two 15 ML fuel tanks to the planned Mine Site fuel farm that will be constructed under the current Licence. A number of temporary explosives storage facilities will also be placed at key locations along the North Railway.

5.2 APPLICABLE MANAGEMENT PLANS

The following management plans relate to emergency response and spill contingency measures:

- Spill Contingency Plan (Baffinland, 2017b)
- Emergency Response Plan (Baffinland, 2018c)
- Oil Pollution Emergency Plan (OPEP) (Baffinland, 2017c)
- Railway Emergency Response Plan (Baffinland, 2018d)

The first two plans are regulated under the Licence. Any required updates to these plans to account for the Phase 2 Proposal are identified in Section 8. Updates to these plans will be submitted to the NWB for approval with the next annual report following amendment of the licence in accordance with Item 1 of Part H of the Licence. A Railway Emergency Response Plan was recently prepared by Baffinland for the North Railway.

5.3 FUEL TANKS

As mentioned in Section 1.5, Baffinland is seeking a short-term increase in production in 2018 and 2019 (to 6 Mtpa) leading up to the Phase 2 Proposal. To this end, a 15 ML fuel tank at Milne Port is included in the scope of the Project Proposal currently under review by the NIRB. If the Project Proposal conforms to the North Baffin Regional Land Use Plan (NBRLUP) and NIRB approves the activity by amending the Project Certificate, then Baffinland will submit a modification request as part of the production increase proposal to construct a 15 ML tank.

Under the current Licence, Baffinland will be installing a fuel tank farm and a 15 ML tank at the Mine Site. The fuel tank farm will be built to accommodate an additional two 15 ML fuel tanks. As part of the Phase 2 Proposal Baffinland will install the remaining two 15 ML fuel tanks, bringing the Mine Site fuel storage capacity to 45 ML. Details regarding the expansion of Mine Site fuel storage is provided in Section 2.8 of the Project Description. Drawings for the Mine Site tank farm and fuel tank details are also provided in Attachment 13.

Mobile fuel trucks will supply fuel to the construction camps along the northern transportation corridor. Mobile double-walled fuel tanks will also be positioned at laydown areas or near construction work fronts during rail construction.

5.4 EXPLOSIVES MANUFACTURING AND STORAGE

Phase 2 requires the expansion of ammonium nitrate storage and explosives magazine storage facilities to support rail construction. Temporary storage of magazines will be required at three locations along the northern transportation corridor. This includes magazine storage facilities at km 13, km 52.4, and km 59.3. Existing magazine storage facilities are located at km 7 and km 63.

A heating facility for emulsion trucks will also be constructed south of Milne Port. The heating facility does not include a wash bay, therefore there is no anticipated contact with water and the trucks while within the building.

6 – GENERAL AND AQUATIC EFFECTS MONITORING (PART I)

6.1 APPLICABLE MANAGEMENT PLANS

The following management plans relate to monitoring:

- Aquatic Effects Monitoring Plan (AEMP; Baffinland, 2015)
- Environmental Protection Plan (EPP; Baffinland, 2016b)
- Surface Water Sampling Program - Quality Assurance and Quality Control Plan (Baffinland, 2016c)

The AEMP is designed to monitor the aquatic ecosystem in the immediate area of the Mine Site that may be affected by multiple stressors (i.e., effluent discharges, dust deposition, sedimentation). The Phase 2 Proposal does not meaningfully change the footprint and hence the potentially affected aquatic receiving environment. Therefore, the AEMP is expected to be adequate as is to continue to monitor the effects of the Project on the aquatic environment. Required updates to these management plans are noted in Section 8.

6.2 POTENTIAL NEW MONITORING STATIONS

Baffinland has identified that changes will be required to Part I of the Licence and its accompanying Schedule I as a result of the Phase 2 Proposal. Table 6.1 identifies the new infrastructure for which Baffinland anticipates monitoring stations may be required in an amended Licence. These additional stations would need to be incorporated into Tables 13 to 15 in Schedule I.

Not included in Table 6.1 are monitoring stations that will need to be established downgradient of the various new quarries. These monitoring stations will be identified in future quarry-specific management plans developed and filed with the NWB in accordance with Part D, Item 6.

In accordance with Part I, Item 6, Baffinland will confirm the locations of newly proposed monitoring stations through GPS coordinates with an inspector. Signs will also be posted to identify the new monitoring stations in accordance with Part I, Item 9 of the Licence.

Table 6.1 Proposed Additional Monitoring Stations

Location	Description	Project Phases	Monitoring Parameters	Frequency
Milne Port				
1	Milne Port Ore Stockpile Stormwater Pond No. 3	Construction Operation Closure	Groups 1 and 7	Daily Monthly
			Group 3	Annually
2	Milne Port Ore Stockpile Stormwater Pond No. 4	Construction Operation Closure	Groups 1 and 7	Monthly during summer
			Group 3	Annually
3	Milne Port Landfill, Downstream Surface Water Drainage	Construction Operation Closure	Groups 1 and 6	Daily Monthly
4	Lump Ore Stockpile Perimeter Ditching East	Construction Operation Closure	Groups 1 and 7	Monthly during summer
			Groups 3	Annually
5	Lump Ore Stockpile Perimeter Ditching West	Construction Operation Closure	Groups 1 and 7	Monthly during summer
			Group 3	Annually
North Railway				
6	Ore Staging Area Stormwater Pond	Construction	Groups 1 and 7	Monthly during summer
			Group 3	Annually

7 – ABANDONMENT, RECLAMATION AND CLOSURE (PART J)

7.1 OVERVIEW OF CHANGES

The Phase 2 Proposal involves the construction and operation of additional infrastructure that will require incorporation into the next revision to the Interim Closure and Reclamation Plan. The reclamation security estimate will also increase once the additional project components have been constructed.

7.2 INTERIM CLOSURE AND RECLAMATION PLAN

Baffinland will submit a revised version of the Interim Closure and Reclamation Plan within 60 days following approval of the requested water licence amendment, in accordance to Part J, Item 2 of the Licence.

7.3 SECURITY

In accordance to Part C of the Licence, Baffinland will update the security requirements for the Project annually, with necessary adjustments accounted for in the results of the Annual Security Review process. The annual review process has been established by the NWB in recognition of the phased approach adopted by Baffinland for the implementation of the Mary River Project.

8 – ENVIRONMENTAL MANAGEMENT PLANS

Table 8.1 identifies the existing Environmental Management Plans currently required under the Licence. The table also identifies whether updates to the Environmental Management Plans will be required for the Phase 2 Proposal. The Interim Closure and Reclamation Plan is not identified in Table 8.1 as that plan is discussed in Section 7.2.

Table 8.1 Status of Management Plans Required under the Type A Water Licence

Type A Water Licence Requirement	Plan (Document No.)	Version	Required Updates for Phase 2 Proposal
Part B, Item 14a Part H, Items 1, 6, 7 and 9	Emergency Response Plan (BAF-PH1-840-P16-0002)	February 2016	Update site layouts in Appendix B
Part B, Item 14b Part H, Items 1, 6, 7 and 9	Spill Contingency Plan (BAF-PH1-830-P16-0036)	March 2016	Add the location and details of new fuel storage and new spill response equipment
Part B, Item 14c Part E, Item 2	Surface Water, Aquatic Ecosystem Management Plan (BAF-PH1-830-P16-0026)	March 2016	Update to reflect changes in water management associated with ore and product stockpiles and disposal of soil spoils from rail construction
Part B, Item 14d Part E, Item 1	Fresh Water Supply, Sewage, and Wastewater Management Plan (BAF-PH1-830-P16-0010)	March 2016	Update to reflect changes in water management associated with ore and product stockpiles; water supply and sewage treatment to mobile construction camps; and the addition of dust suppression water sources within the Northern Transportation Corridor.
Part B, Item 14e Part F, Item 1	Waste Management Plan (BAF-PH1-830-P16-0028)	March 2016	Update to incorporate new landfill proposed at Milne Port
Part B, Item 14s Part D, Item 5h Part F, Item 2	Phase 1 Waste Rock Management Plan (BAF-PH1-830-P16-0029)	April 2014	Update the waste rock production schedule
Part B, Item 14f Part F, Item 2	Life of Mine Waste Rock Management Plan (BAF-PH1-830-P16-0031)	April 2014	No update required
Part B, Item 14q Part F, Item 4	Hazardous Materials and Hazardous Waste Management Plan (BAF-PH1-830-P16-0011)	March 2016	Update with Phase 2 layouts and revised quantities of explosives and ammonium nitrate.
Part B, Item 14i Part D, Item 5a	Borrow Pits and Quarry Management Plan (BAF-PH1-830-P16-0004)	March 2014	Update table and figure with new quarries

Type A Water Licence Requirement	Plan (Document No.)	Version	Required Updates for Phase 2 Proposal
Part E, Item 24	Blasting Management Plan (see Note 1)	April 2013	To be updated or new plan developed that addresses blasting associated with rail construction
Part I, Item 2	Aquatic Effects Monitoring Plan (BAF-PH1-830-P16-0039)	March 2015	No update required
Part I, Item 3	Environmental Protection Plan (BAF-PH1-830-P16-0008)	August 2016	Update to include rail construction and rail watercourse crossing installation
Part I, Item 16	Surface Water Sampling Program - Quality Assurance and Quality Control Plan (BAF-PHI-830-P16-0001)	March 2016	No update required
Individual Quarry Management Plans			
	Borrow Source Management Plan - km 2 (BAF-PH1-830-P16-0030)	October 2014	No update required
	Borrow Source Management Plan - km 97 (BAF-PH1-830-P16-0032)	October 2014	No update required
	Borrow Source Management Plan - km 104 (BAF-PH1-830-P16-0035)	March 2014	No update required
	Quarry Management Plan D1Q1 (H349000-4200-07-245-0001)	October 2013	No update required
	Quarry Management Plan D1Q2 (H349000-4200-07-245-0002)	October 2013	No update required
Part B, Item 14j Part D, Item 5b	Quarry Management Plan Q1 (H349000-1000-07-126-0013)	March 2013	No update required
	Quarry Management Plan Q11 (H349000-3000-07-245-0002)	October 2013	No update required
	Quarry Management Plan Q19 (H349000-3000-07-245-0003)	October 2013	No update required
	Quarry Management Plan Q7 (H349000-3000-07-245-0001)	October 2013	No update required
Part B, Item 14k Part D, Item 5c	Quarry Management Plan QMR2 (BAF-PH1-830-P16-0040)	September 2014	Update required to expand quarry boundaries
Part B, Item 14l Part D, Item 5d	Quarry Management Plan – Quarry QS2	January 2012	No update required
Part B, Item 14m Part D, Item 5e	Quarry Management Plan - Quarry Q7 + 500	January 2012	No update required

Type A Water Licence Requirement	Plan (Document No.)	Version	Required Updates for Phase 2 Proposal
Part B, Item 14n Part D, Item 5f	Quarry Management Plan - Quarry Q133 +500	January 2012	No update required
Part B, Item 14o Part D, Item 5g	Quarry Management Plan - Quarry Q77 +200	February 2012	No update required

NOTES:

1. PART D, ITEM 6 REQUIRES BAFFINLAND TO SUBMIT FOR REVIEW AN ADDENDUM TO THE BORROW PIT AND QUARRY MANAGEMENT PLAN, OR TO SITE-SPECIFIC QUARRY MANAGEMENT PLANS IF NOT ADEQUATELY ADDRESSED BY THE BORROW PIT AND QUARRY MANAGEMENT PLAN. *"THE LICENSEE SHALL SUBMIT TO THE BOARD FOR REVIEW, AN ADDENDUM TO THE PLAN REFERRED TO IN PART D, ITEM 6A FOR ANY QUARRY SITE SELECTED FOR FUTURE DEVELOPMENT THAT THE PLAN DOES NOT ADEQUATELY ADDRESS. IF THE CONTENT OF THE EXISTING QUARRY PLAN REFERRED TO UNDER PART D, ITEM 6A, DOES NOT ADEQUATELY ADDRESS THE PROPOSED ACTIVITIES FOR THE MANAGEMENT REQUIREMENTS OF THE SELECTED QUARRY SITE, THE LICENSEE SHALL SUBMIT TO THE BOARD FOR APPROVAL, A SITE-SPECIFIC QUARRY MANAGEMENT PLAN."*

Items 1 and 2 of Part E and Item 1 of Part H of the Licence specify the requirements for filing updates to the management plans with upcoming annual reports. Baffinland will provide all updated management plans following the scheduled technical meeting, which should occur by February 28, 2018, and may provide interim updated management plans before February 28, 2018 as necessary to support the technical review. TSD 28 Management and Monitoring Plans provides a detailed description of the proposed edits to the management plans prescribed by both the Water Licence and by NIRB (2015).

Although not prescribed by the current Licence, the Snow Management Plan is an important plan that identifies measures to mitigate the release of sediment to watercourses from meltwater originating from snow piles. This plan will be updated to identify revised snow stockpile locations based on site layout changes arising from the Phase 2 Proposal.

Two new biophysical management plans will be required for the Phase 2 Proposal, and therefore have been included in the Addendum to the FEIS:

- **Offsetting Plan for the Serious Harm to Fish - Railway (TSD 15; Knight Piésold, 2018b) -** Construction of the North Railway will involve the installation of new watercourse crossings, and stream diversions that result from rock cuts along the alignment, which will result in serious harm to fish and fish habitat.
- **Offsetting Plan for the Serious Harm to Fish - Second Ore Dock (TSD 23; Golder, 2018b) -** Construction of the second ore dock at Milne Port will require a conceptual offsetting plan to be submitted with this Addendum to the FEIS.

9 – FUTURE SUBMISSIONS TO THE NWB

Table 9.1 lists the future submissions to the NWB in support of this application for an amendment to the Licence amendment, and when these submissions will be provided.

Table 9.1 Timelines for Future Submissions to the NWB

Project Component	Additional Information	Timeline
Milne Port Landfill	Construction plan and schedule, design report with IFC drawings and operation and maintenance manual	June 2020
Milne Port Water Treatment Plant Expansion	Engineering details and operation and maintenance plans	60 days prior to construction (Part D, Item 2)
Milne Port Sewage Treatment Plant (No. 3)	Engineering details and operation and maintenance plans	60 days prior to construction (Part D, Item 2)
Milne Port Ore Stockpiles and Stormwater Ponds	IFC drawings	60 days prior to construction (Part D, Item 2)
km 57 Ore Staging Area and Stormwater Pond	IFC drawings	60 days prior to construction (Part D, Item 2)
New and Modified Quarries	New and/or updated quarry-specific management plans	Prior to quarry development
Construction Plan and Schedule	Construction plan and construction schedule for water works (SIG Table 5, Item 46d)	60 days prior to construction
Environmental Management System	Updates to reflect changes as a result of the Phase 2 Proposal, as described in TSD 28 Management and Monitoring Plans	See Section 8

10 – REFERENCES

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11 – CERTIFICATION

This report was prepared and reviewed by the undersigned.

Prepared: For

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Project Scientist

Reviewed:

Richard Cook, P.Geo. (Ltd.)
Specialist Environmental Scientist | Associate

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Approval that this document adheres to Knight Piésold Quality Systems: D.G.

ATTACHMENT 1

EXECUTIVE SUMMARY

Mary River Project – Phase 2 Proposal

Water Licence Application Executive Summary

Location of the Undertaking

The Mary River Project is an operating iron ore mine located on northern Baffin Island, in the Qikiqtani Region of Nunavut (Figure 1). Baffinland Iron Mines Corporation (Baffinland) is the owner and operator of the Project. Baffinland is planning to initiate an expansion of its Mary River Project, termed the Phase 2 Proposal. The Phase 2 Proposal will involve an increase in the mine production rate at the Mine, the construction of a North Railway located adjacent the Milne Inlet Tote Road (collectively referred to as the Northern Transportation Corridor), and additional ore handling facilities and docking at Milne Port (Figure 2). There will also be an associated increase in shipping activities.

To be able to undertake its Phase 2 Proposal, Baffinland requires an amendment to its Type A Water Licence 2AM-MRY1325 (the Licence; Nunavut Water Board 2015). This application for an amendment to the Licence is being submitted to the Nunavut Water Board (NWB or Board) as part of an amendment to the Final Environmental Impact Statement being filed with the Nunavut Impact Review Board (NIRB), so that the Phase 2 Proposal can be evaluated jointly by the NIRB and the NWB in a coordinated process (NIRB and NWB, 2012).

Description of the Undertaking

The Phase 2 Proposal involves increasing the quantity of ore shipped through Milne Port to 12 Mtpa, via the construction of a new railway running mostly adjacent to the existing Tote Road (called the North Railway; Figure 2). Total mine production will eventually increase to 30 Mtpa to accommodate 12 Mtpa being transported via the North Railway to Milne Port and the approved 18 Mtpa transported via the South Railway to Steensby Port. Construction on the North Railway is planned to begin in late 2019. Completion of construction of the North Railway is expected by 2021 with some temporary commissioning activities commencing in 2020 with transportation of ore to Milne Port facilitated by a combination of trucks and railway. As a result, shipping from Milne Port will also increase to 12 Mtpa by 2020. Construction of the South Railway and Steensby Port will commence in 2021 with commissioning and a gradual increase to 18 Mtpa from Steensby Port will begin in 2025.

Phase 2 also involves the development of additional infrastructure at Milne Port, including a second ore dock (Figure 3). Shipping at Milne Port will continue to occur during the open water season, and may extend into the shoulder periods when the landfast ice is not being used to support travel and harvesting by Inuit, approximately July 1 to November 15.

Various upgrades and additional infrastructure will also be required at the Mine Site and along both the north and south transportation corridors to support the increase in production and construction of the two rail lines (Figure 4).

Facilities associated with the South Railway and Steensby Port have yet to be built. IFC drawings and other required submissions will be submitted to the Board in accordance with Part B, Item 10 of the Licence, prior to construction of these project components.

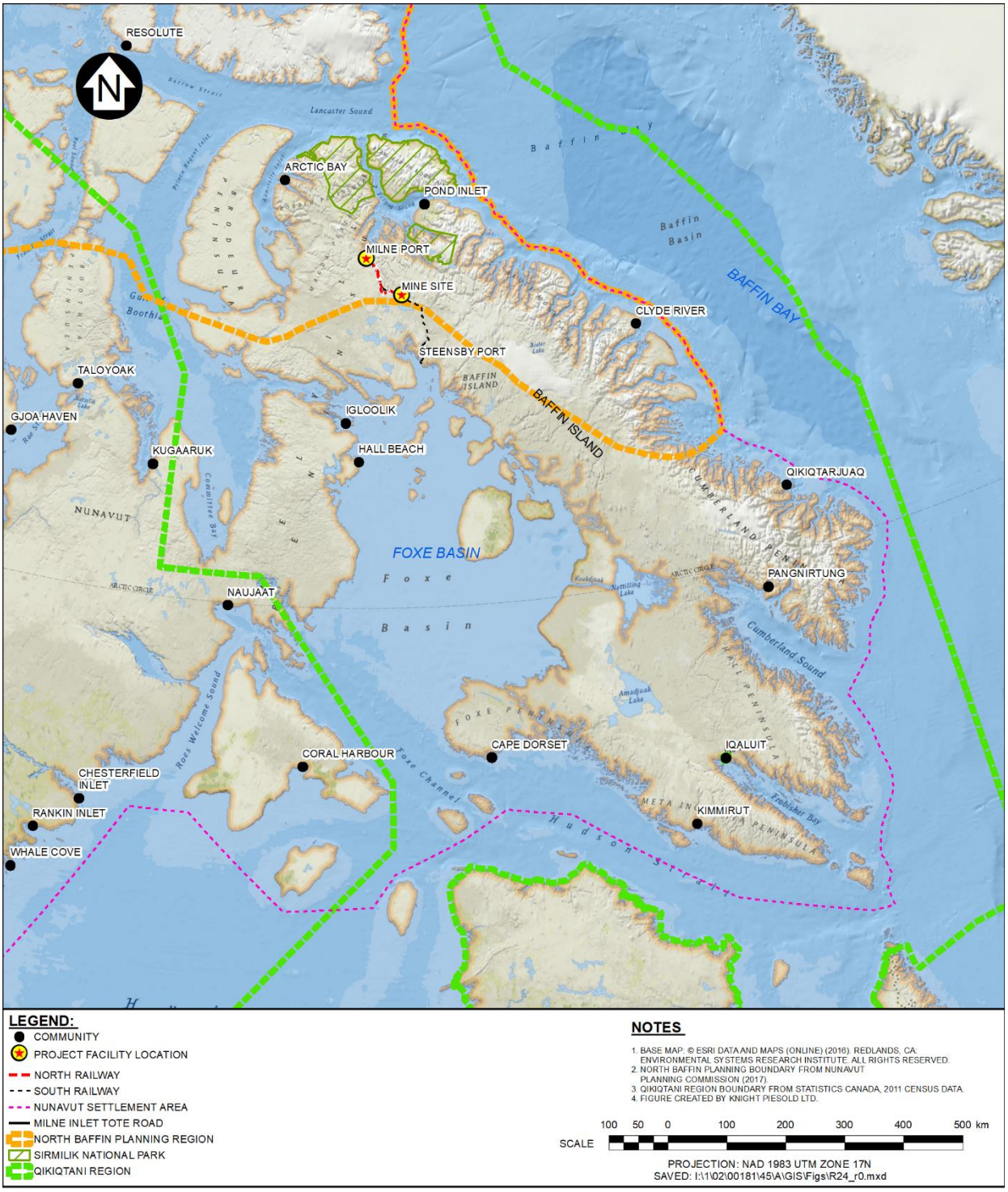

Figure 1 Project Location Map

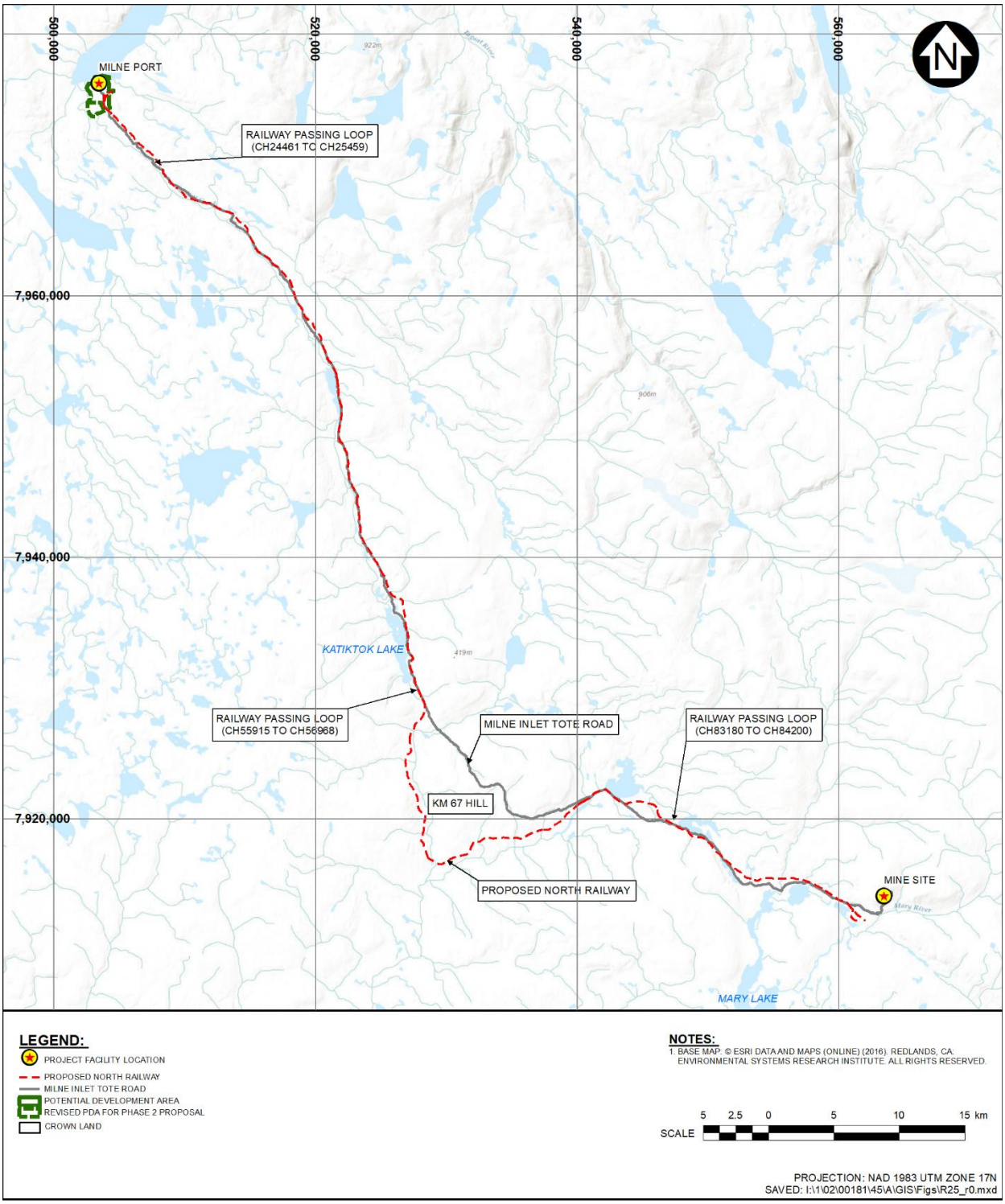

Figure 2 Phase 2 Proposal Project Areas

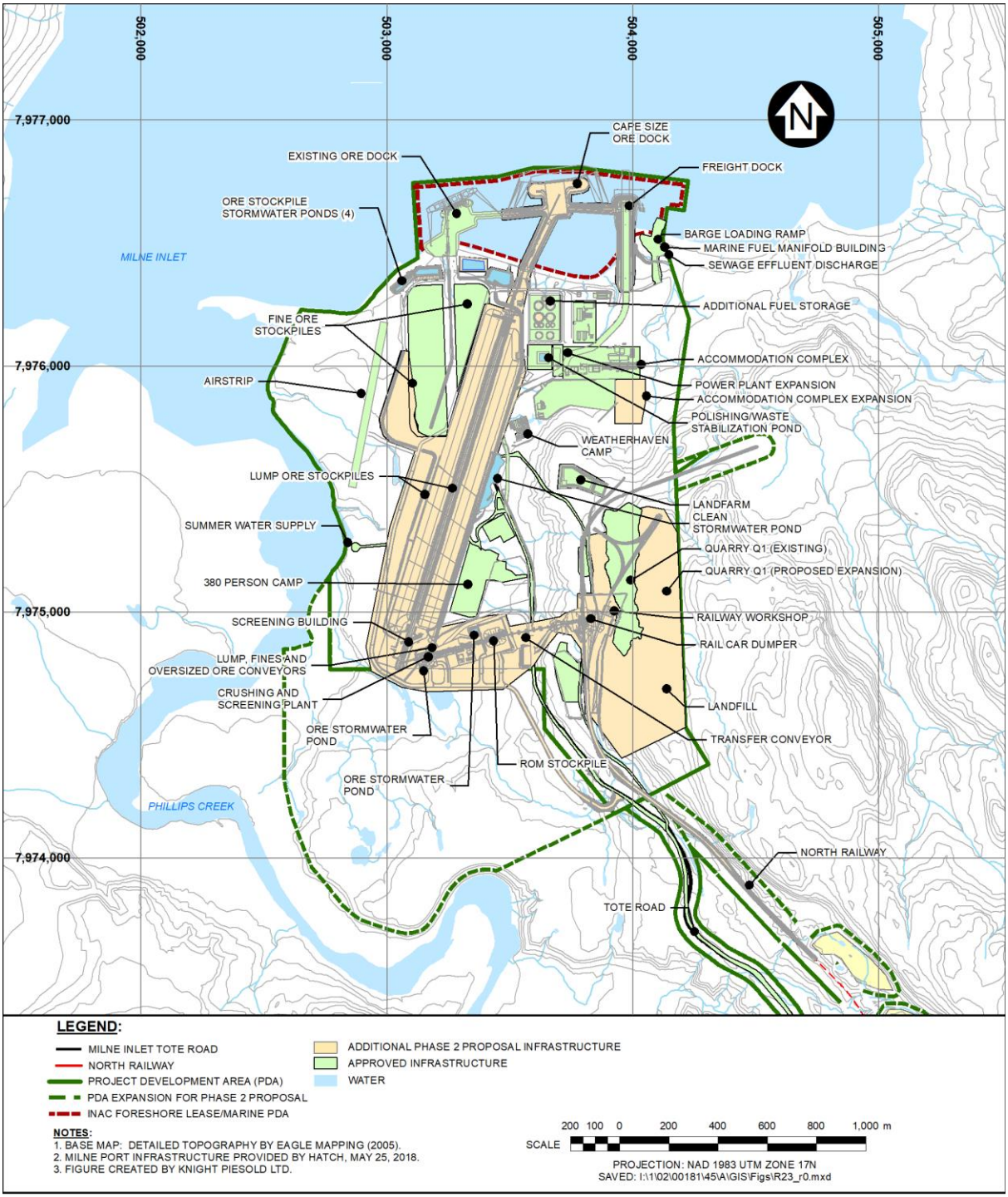

Figure 3 **Milne Port – Phase 2 Proposal Layout**

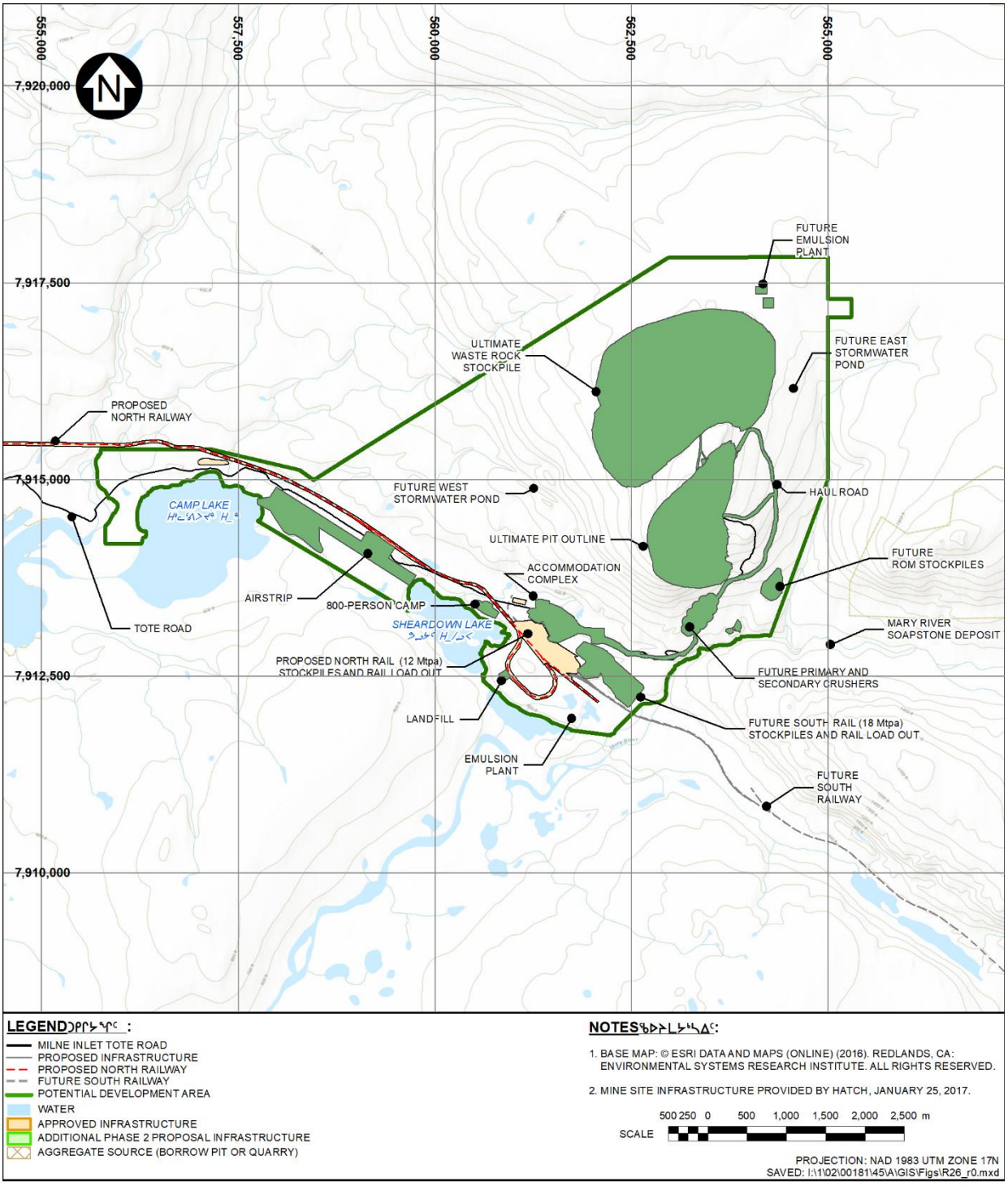

Figure 4 **Mine Site – Phase 2 Proposal Layout**

Water Use

The Phase 2 Proposal will not require increases to daily water withdrawal limits for domestic and industrial water use at Milne Port's two water supplies (Phillips Creek in summer and km32 Lake in winter). There will not be any changes to the Mine Site water supply (Camp Lake). There will be no changes to the water withdrawal volumes from Phillips Creek and Camp Lake for dust suppression.

Along the Northern Transportation Corridor, the existing 12 dust suppression water sources (including Phillips Creek and Camp Lake) will continue to be used, and an additional 13 water sources have been identified along this corridor for use in dust suppression. The total daily water withdrawal for dust suppression changes from 1,500 m^3/day from 12 stations to 2,600 m^3/day from 25 stations.

Waste Disposal

Existing solid waste management and disposal facilities will continue to be used during the Phase 2 Proposal, in accordance with Baffinland's Waste Management Plan. This includes incinerators at Milne Port and the Mine Site, a landfill at the Mine Site, and hazardous waste storage facilities at both sites. These existing facilities will be adequate to support construction of the additional infrastructure associated with the Phase 2 Proposal (mainly the North Railway), including temporary mobile camps established along the North Railway.

Additional waste disposal activities/infrastructure will include:

- Milne Port landfill – A landfill will be constructed within an expanded Quarry Q1 following completion of construction activities
- Milne Port additional settling ponds – Perimeter ditching, with sumps, along the lump ore stockpile and two additional ponds at the rail unloading and crusher area facilities at Milne Port will be constructed to manage runoff. The final discharge point for all stormwater will continue to be the marine environment of Milne Inlet.
- Mine Site Ore Stockpiling and Rail Loading Facilities – Secondary crushing will be relocated indoors at Milne Port; the existing crusher pad, ore stockpile and settling pond will be modified and expanded to accommodate the increased volume of ore destined for Milne Port.
- Temporary Ore Transfer Area – The Phase 2 Proposal will involve establishing a temporary ore transfer area at km56.8, to be used for 1-2 years during the construction phase. The North Railway from Milne Port to km56.8 will be commissioned early, and haul trucks will deliver up to 12 Mtpa of ore to the ore transfer area to be loaded into the railway for delivery to Milne Port. Runoff from temporary stockpiles will be collected in a settling pond. The settling pond will be emptied using a vacuum truck and will be transferred to Milne Port settling ponds.

Other Persons or Properties Affected by the Undertaking

There are no persons occupying the general area, though the area has been and continues to be used by local communities, mainly Pond Inlet. Baffinland has undertaken numerous public meetings and community workshops with the five potentially affected North Baffin communities of Arctic Bay, Clyde River, Hall Beach, Igloolik and Pond Inlet since the Phase 2 Proposal was announced in October 2014.

Predicted Environmental Impacts of the Undertaking and Proposed Mitigation Measures

The Phase 2 Proposal will result in a higher maximum production rate at the Mine Site, the construction

and operation of the North Railway, construction and operation of a second ore dock at Milne Port, and increased open water shipping from Milne Port that may extend into the shoulder season in some years.

None of the activities presented by the Phase 2 Proposal are new, and as such, many of the mitigation measures being implemented for the Approved Project and described in Baffinland's management plans remain relevant. The incremental effects of the Phase 2 Proposal are summarized below:

- **Climate Change** – Implementing the Phase 2 Proposal will reduce life of mine GHG emissions by approximately 10% in comparison to the Approved Project
- **Air Quality** – Despite an increase in the production rate at the Mine Site from 22.2 Mtpa to 30 Mtpa, particulate matter emissions and dust deposition will be reduced overall. This is due to additional mitigation with secondary crushing moving indoors at the Port. Particulate matter emissions and dust deposition along the Northern Transportation Corridor will increase temporarily during construction due to truck haulage of ore at an increased rate (6 to 12 Mtpa) concurrent with rail construction. Following the construction phase, dust emissions will be substantially reduced by using rail to haul ore to the port. The concentrations of air quality contaminants at Milne Port will increase, but will not be significant.
- **Noise** – Noise levels will temporarily increase at all project sites during the construction phase, and will remain slightly higher than levels from the Approved Project during the operation phase.
- **Landforms, Soil and Permafrost** – Construction of the North Railway will have minor effects to important landforms, crossing one esker feature. Rail construction has the potential to disrupt permafrost conditions, and the railway design incorporates a number of design mitigation measures to minimize these effects and the consequent effects of ground instability on the railway.
- **Surface Water** – The Phase 2 Proposal will involve minor changes to water quantity (flow) resulting from rail construction and the installation of stream diversions. These effects were reviewed and where meaningful increases in flow will occur (mainly from diverting the upstream portion of a stream affected by a rock cut on the railway into an adjacent stream), mitigation measures such as channel improvements or bank armouring will be in place to ensure the receiving stream can handle the increased flows. No changes to the mine plan or waste rock disposal plan will occur as a result of the Phase 2 Proposal. The effects of increased dust deposition at Milne Port on water quality was assessed to be not significant. Other water quality effects, such as construction of the railway and the installation of crossings, will be managed using standard mitigation measures (i.e., sediment and erosion control measures) described in Baffinland's existing management plans.
- **Freshwater Biota** – The railway will involve the installation of a large number of culverts and bridges in streams, infilling of streams affected by rock cuts, and encroachment on several ponds or small lakes. A portion of these interactions will occur in waters supporting fish. The railway has been routed to minimize impacts on fish and fish habitat. Other standard mitigation measures have been identified to minimize impacts, and an offsetting plan developed to compensate for serious harm to fish habitat. Baffinland will be seeking an authorization under the Fisheries Act from Fisheries and Oceans Canada.
- **Vegetation** - The Phase 2 Proposal involves an expansion at Milne Port and the creation of the North Railway resulting in additional loss of terrestrial habitat. However, the total area affected

is a small proportion of the available habitat and activities will be planned and conducted to reduce the footprint of the Phase 2 Proposal to only that which is necessary. Changes to culturally valued vegetation as a result of the Phase 2 Proposal are predicted to be negligible as the abundance of indicator species (blueberry) is very low in the area. Fugitive dust emissions due to the transport of ore will increase temporarily along the Tote Road during construction, however once the North Railway is operational, the level of traffic on the road will decrease substantially compared to current operation and construction, as will the corresponding fugitive dust emissions along the road.

- **Terrestrial Wildlife** - Construction, operation and closure activities of the Phase 2 Proposal have the potential to impact distribution and abundance of wildlife in the RSA. Habitat can be impacted through direct loss within the footprint of the Phase 2 Proposal or through indirect loss from project activities that create sensory disturbances that reduces the effectiveness (usefulness) of adjacent habitats. Traditional movement patterns can be altered by Phase 2 Proposal related infrastructure or activities that act as a barrier or filter to movement. Wildlife mortality may increase as a direct result of collisions, or indirectly through increased harvesting access. Also, effluent, dust and air emissions released into the environment have the potential to be absorbed, ingested or inhaled by wildlife, which may have an impact on the health of individual animals and, consequently, wildlife abundance. Baffinland has implemented a Project-wide wildlife policy that has resulted in no direct mortality of caribou.
- **Marine Environment** - The expanded Project footprint in the marine environment will result in the potential loss of productive fish habitat. Other potential effects of the Project on marine water and sediment quality, marine fish habitat, and Arctic char health may result from port construction, vessel traffic, ballast water discharge, which could introduce invasive species to the marine environment, as well as wastewater discharges, ore dust deposition, and underwater noise. Proposed mitigation for potential effects includes implementation of management plans, such as the Shipping and Wildlife Management Plan, the Emergency Response and Spill Contingency Plan, Environmental Protection and Monitoring Plans, and the Surface Water and Aquatic Ecosystem Management Plan. Habitat loss will be compensated through the creation of new habitat, as required by the Fisheries Act.
- **Marine Wildlife** – Potential Project effects on marine mammals include loss of habitat due to port expansion, disturbance and, hearing impairment, and auditory masking from underwater noise generated by shipping and port construction (i.e., pile driving), and potential injury or mortality to marine mammals from ship strikes along the shipping corridor. Mitigation measures have been incorporated into dock design to reduce loss and/or alteration of marine mammal habitat, including reducing the overall subtidal footprint of the dock. Disturbance effects from ship noise will be reduced through reductions in ship speed, which reduces the overall noise output generated by ship propulsion. Noise will also be reduced by requiring vessels to maintain a constant course and speed when in transit and reduce idling when docked at Milne Port. These measures will also help reduce ship strikes.
- **Land Use and Other Socio-economic Effects** - The Phase 2 Proposal is predicted to have both positive and adverse effects on LSA communities with respect to the socio-economic environment. Positive residual effect on labour force capacity, and adverse residual effect on competition for skilled workers are anticipated to arise from Project employment opportunities. Adverse effects were also predicted for human health and well-being, particularly, community

social stability due to absence from the community during work rotation arising primarily from the new incomes the Project brings and challenges fly-in/fly-out employment can present. Activities associated with the Phase 2 Proposal have the potential to adversely interact with culture, resources and land use, including Inuit access to and availability of resources and land. Baffinland looks to boost its efforts on the recruitment, retention, and training of its Inuit workforce through the implementation of provisions in the Inuit Impact Benefits Agreement (IIBA) such as the development of an Inuit Human Resource Strategy (IHRS) and Inuit Procurement and Contracting Strategy (IPCS), and the Q-STEP training program. Baffinland has implemented an Employee and Family Assistance Program (EFAP) for permanent employees and their dependents who may require family-related, parenting, or other forms of personal counselling and assistance.

Water Rights

Most of the Phase 2 Proposal infrastructure is located in Inuit Owned Land. Baffinland has an existing Water Compensation Agreement with the Qikiqtani Inuit Association.

The Phase 2 Proposal is not expected to significantly affect the flow or quality of water flowing through Inuit Owned Lands. Any claims that may arise as a result of the Phase 2 Proposal will be subject to the existing Water Compensation Agreement.

Proposed Phase 2 Proposal Schedule

Table 1 presents the development schedule for the Phase 2 Proposal. Baffinland aims to initiate construction in late 2019, and aims to start operating the North Railway in 2021. Construction of the South Railway is planned to commence the same year and the combined production and transportation of iron ore will reach 30 Mtpa by 2025. The mine will operate through 2035; the mine operating life continues to be 21 years. Mine closure and reclamation activities will be undertaken in the three years following (2036 to 2038).

Table 1 Phase 2 Proposal Schedule

Area	***2018***	***2019-2020***	***2021***	***2022-2023***	***2024***	***2025-2035***
Mine	5.5 Mtpa	6 Mtpa	12 Mtpa	12 Mtpa	21 Mtpa	30 Mtpa
Tote Road/Trucking	5.5 Mtpa	6 Mtpa	12 Mtpa*	NA	NA	NA
North Rail	NA	NA	12 Mtpa*	12 Mtpa	12 Mtpa	12 Mtpa
South Rail	NA	NA	NA	NA	9 Mtpa	18 Mtpa
Milne Port	5.5 Mtpa	6 Mtpa	12 Mtpa	12 Mtpa	12 Mtpa	12 Mtpa
South/Steensby Port	NA	NA	NA	NA	9 Mtpa	18 Mtpa

NA = not applicable

* = 12 Mtpa transported by truck from Mine Site to km 56, and by rail from km 56 to Milne Port in 2021

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ᐃᒥᕐ ᒧᑦ ᓚᐄᓴᓐᓯᒧᑦ ᐅᒃ ᑑᑎᖓᓐᓂ ᐅᓂᒃ ᑳᖓᔪ ᕚᓕᖅᑎᐅᔭᓄᑦ

ᐃᓂᒋᔭᖓ ᐱᓕᕆᓂᐅᔭᓄᑦ

ᑖᓐᓇ ᓄᓘᔮᓐᓂ ᓴᓇᕝᕙᐅᔭᖅ ᐊᐅᓚᑕᐅᔭᖅ ᐅᔭᕋᓐᓂᐊᕐ ᕝᕕᒃ ᓴᕝᕙᕋᔭᒃᓴᓄᑦ ᐃᓂᖃᖅᑐᖅ ᕿᑭᖅᑖᓗᑉ ᐅᐊᖕᓇᖓᓂᑦ, ᕿᑭᖅᑕᓂ ᓄᓇᕐᑎᖓᓂ ᓄᓇᕗᒥᑦ (ᑕᑯᓐᓇᒐᒃᓴᖅ 1). ᐹᓐᓃᓐ ᑰᑦ ᓴᕝᕙᕋᔭᒃᓴᓕᕆᔩᑦ ᑎᒥᖁᑎᒋᔭᖓᑦ (ᐹᓐᓃᓐ) ᓇᖏᓂᖅᑎᐅᕗᖅ ᐊᐅᓚᑦᑎᔨ ᐅᓪᓗᓂᓗ ᓴᓇᕝᕙᐅᔭᒥᒃ. ᐹᓐᓃᓐ ᑰᑦ ᐸᕐᓈᕆᔭᖃᕐᒪᑕ ᐱᒋᐊᕋᓱᖕᓂᕐᒥᒃ ᐊᖏᕐᓕᒋᐊᕆᓂᕐᒥᒃ ᐊᐅᓚᑦᑎᒋᓂᒃ ᓄᓘᔮᓐᓂᑦ ᐅᔭᕋᓐᓂᐊᖅᑕᖏᓐᓂᑦ, ᑕᐃᒪᖅᑕᐅᔭᖅ ᐱᓕᕆᐊᑉ ᒪᕐᕈᑦ ᓕᖅᑕᖏᓐᓂᒃ ᐅᒃ ᑑᑎᖓ ᑖᓐᓇ ᐱᓕᕆᐊᑉ ᒪᕐᕈᑦ ᓕᖅᑕᖏᓐᓂᒃ ᐅᒃ ᑑᑎᖓᐃᓚᖅᑯᑦ ᓂᐊᖅᑐᖅ ᐊᖏᕐ ᓕᒋ ᐊᕆᓂᕐᒥᒃ ᐅᔭᕋᓐᓂᐊᖅᑕᖏᓐ ᓂᒃ ᐅᔭᕋᓂᐊᕝᕕᖕᓂ, ᓴᓇᓂᕐᒥᒃ ᐅᐊᖕᓇᖓᑦ ᓄᓇᓯ ᐅᑎᑯᑖᑉ ᐊᖅᑯᑖᓴᓂᕋᖕᖓᑦ ᕿᓚᒻᒥᐊᓄᑦ ᐅᓯᑲᖅᑕᕝᕙᐅᑉ ᐊᖅᑯᑖᑕᑕ (ᖃᐅᔮᒪᔭ ᐅᓯᖒᖅ ᑕᐃᒍᖅᑕᐅᓪ ᓗᓂ ᐅᐊᖕᓇᖓᑦ ᐅᓯᑲᖅᑕᕆᓂᓪ ᒧᑦ ᐊᖅᑯᑖ), ᐊᒻᒪᓗ ᖃᒃ ᑲᓐᓂᐊᒍᑦ ᓴᕝᕙᕋᔭᒃᓴᓕᕆᕝᕕᓴᑦ ᐱᖁᑎᔾ ᔪᐊᑦ ᑐᓚᒃ ᓯᒪᕝᕕᒃ ᓴᕐ ᓗ ᐅᒥᐊᕐ ᔪᐊᓄᑦ ᕿᒻᒥᑕᐅᒥᐊᕐ ᔪᐊᓕᕆᕝᕕᖕᓂ (ᑕᑯᓐᓇᒐᒃᓴᖅ 2). ᐃᓚᒋᔭᒃᑯᑦ ᓂᐊᕐ ᒥᔭᖅ ᐊᒃ ᑐᐊᔭᒥᒃ ᐊᖏᕐ ᓕᒋᐊᕆᓂᕐᒥᒃ ᐅᒥᐊᕐ ᔪᐊᒃ ᑯᑦ ᐅᓯᑲᖅᑕᖅᑕᐅᔭᓂᒃ.

ᑕᐃᒪ ᓕ ᐱᓕᕆᔭᓐ ᓇᕐᑰ ᓗᒋᑦ ᓴᓇᔭᒪᔭᖕᖏ ᐃᓗᐊᓃᑦ ᑐᑦ ᐱᓕᕆᐊᑉ ᒪᕐᕈᑦ ᓕᖅᑕᖓᓐᓂᑦ ᑐᒃ ᓯᕋᐅᑦ, ᐹᓐᓃᓐ ᑰᑦ ᐱᔭᕆᐊᖅᑐᑦ ᐋᖅᑭᒋᐊᕈᑎᒥᒃ ᐃᓗᐊᓄᑦ ᐃᓚᖓᑕ "A" ᐃᒥᕐ ᒧᑦ ᓚᐃᓴᓐᓯᖓᓐᓂᑦ 2AM-MRY1325 (ᑖᓐᓇ ᓚᐃᓴᓐᓯᖕᖑᖅ ᓄᓇᕗᒥ ᐃᒥᓕᕆᔩᒃ ᑯᑦ ᑲᑎᒪᔨᖏᑦ 2015). ᐅᓇ ᐅᒃ ᑑᑎᖓᐊᖅᑭᒋᐊᕈᑖᓄᑦ ᓚᐃᓴᓐᓯᐊᓄᑦ ᑐᓂᔭ ᐅᓕᖅᐳᖅ ᑖᒃ ᑯᓄᖕᒐᓄᓇᕗᒥ ᐃᒪᓕᕆᔩᒃ ᑯᑦ ᑲᑎᒪᔩᖏᑦ (NWB ᑎᒥᖕᒑᑲᑎᒪᔩᖏᑦ ᒍᓐ ᓃᑦ) ᐃᓚᒋ ᓗᒍ ᐋᖅᑭᒋᐊᕐᑎ ᓈᓴᐅᑎᓕᒃ 3 ᑖᒃ ᓯᒧᖕᒋᖕᒍᓕ ᓕᖅᐹᖅ ᐊᕙᑎᒧᑦ ᐊᒃ ᑐᐃᓂᖃᕈᑖᓄᑦ ᐅᓂᒃ ᑳᖏᓄᑦ (FEIS ᐋᖅᑭᒋᐊᕈᑖ ᓇᐃᓴᐅᑎᓕᒃ 3) ᐸᐃᑉ ᐸᑎᒧᑦ ᑐᓂᔭᐅᔭᖅ ᓄᓇᕗᒥ ᐊᕙᑎᓕᕆᔩᒃ ᑯᑦ ᑲᑎᒪᔩᖏᓐᓂᑦ (NIRB), ᐱᓗᒍ ᑖᓐᓇ ᐱᓕᕆᐊᑉ ᒪᕐᕈᑦ ᓕᖅᑕᖓᓐᓂᑦ ᑐᒃ ᓯᕋᐅᑎᖕᒋᕿᒥᕐ ᕈᔭ ᐅᖅᑯᓗᒍ ᑕᒪ ᐃᓐᓄᑦ ᑲᑐᔾ ᔭᐅᓗᓂ ᑎᒥᖏᓐᓂᑦ ᐊᕙᑎᓕᕆᔩᒃ ᑯᑦ (NIRB) ᐊᒻᒪᓗ ᐃᒪᓕᕆᔩᒃ ᑯᑦ (NWBᔭ ᑲᑐᔾ ᔭᐅᔭᒥᒃ ᐊᐅᓚᓂᖅᑯᓗᑎᒃ (NIRB ᐊᒻᒪᓗ NWB, 2012).

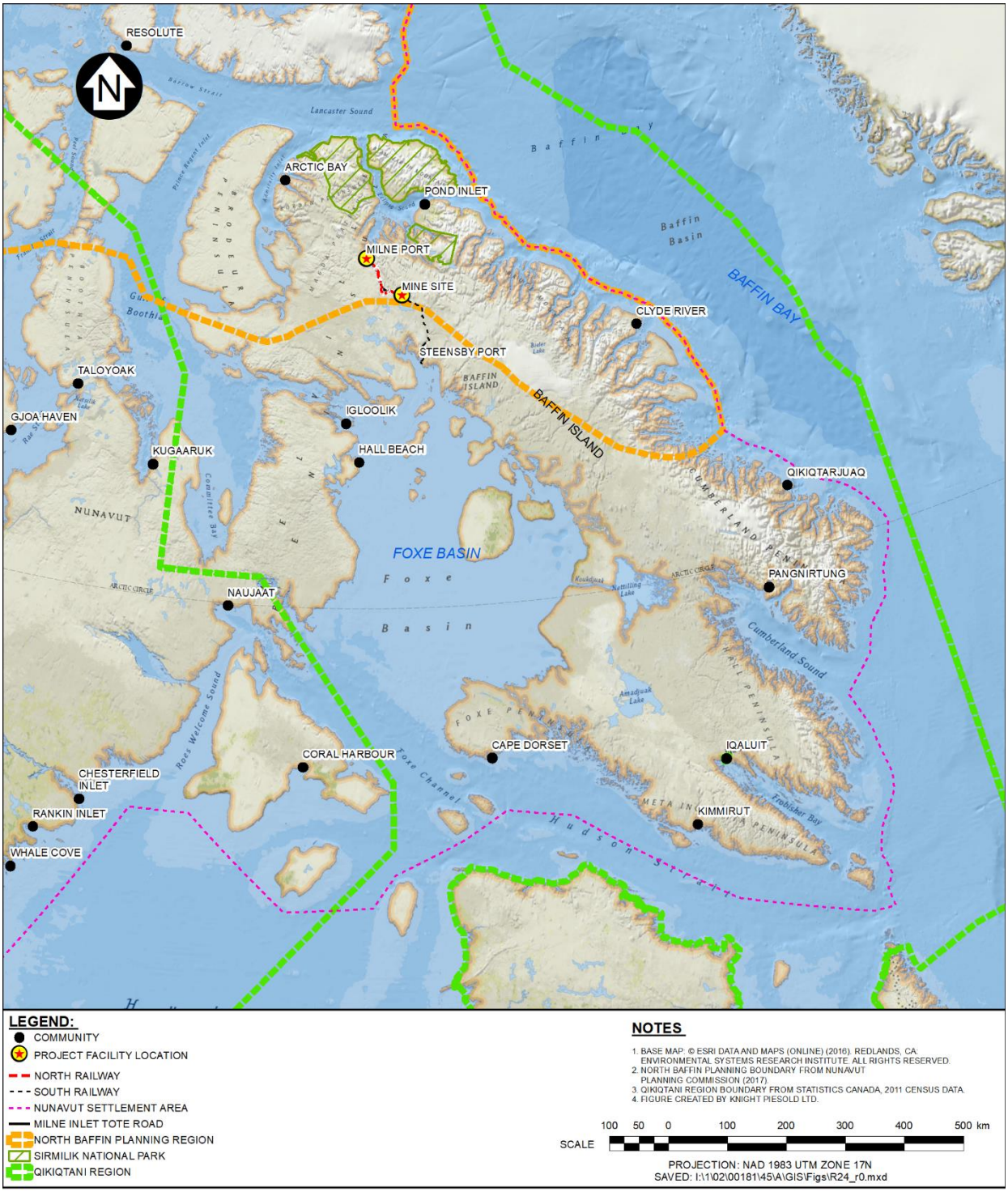
ᐅᓂᒃ ᑳᖏᔭ ᐅᓂᖕᒑᐱᓕᕆᓂᐅᔭᓄᑦ

ᐱᓕᕆᐊᑉ ᒪᕐᕈᑦ ᓕᖅᑕᖓᓐᓂᑦ ᐅᒃ ᑑᑎᖓᐃᓚᖅᑯᖅᑐᖅ ᐊᖑᕆ ᐊᕆᓂᕐ ᒥᒃ ᐊᒃ ᑎᒋ ᐊᓂᐊᑕᓴᕝᕙᕋᔭᒃᓴᐸ ᐅᓯᑲᖅᑕᖅᑕᐅᔫᖅ ᐊᖅᑯᑖᒧᑦ ᕿᒻᒥᑕᐅᒥᐊᕐ ᔪᐊᓕᕆᕝᕕᖕᓂᑦ ᑎᑭᓪᓗᒍ 12 ᒥᓕᐊᓐ ᑕᓐᓂᑦ ᐊᕐ ᕼᐅᒃ ᑖᕐ, ᐊᑐᕐ ᓂᐊᕐ ᓗᑎᒃ ᓴᓇᔭᐅᔭᒃ ᓴᓖᒧᑦ ᓄᑖᒥᒃ ᓄᓇᓯ ᐅᑎᑯᑖᑉ ᐊᖅᑯᑖᓂᒃ ᓴᓇᔭ ᐅᓇᔭᖅᑐᖅ ᓴᓕᐊᖕᒋ ᓇᐸᓗᓪ ᓗᒍ ᐅᓯᑲᖅᑕᕈᑖᑕ ᐊᖅᑯᑖᒧᑦ (ᐅᓪ ᓗᒥ ᑕᐃᔭᖅ ᐅᐊᖕᓈᒧᑦ ᓄᓇᓯ ᐅᑎᑯᑖᖅᕙᒃ; ᑕᑯᓐᓇᒐᒃᓴᖅ 2). ᑲᑎᓪᓖᓪ ᓗᒍ ᐅᔭᕋᓐᓂᐊᖅᑐᓄᑦ ᓴᖅᑭᑕᐅᕙᓪ ᓕᐊᔭᖅ ᖁᑦ ᑎᒃ ᓯᒋᐊᕐ ᓗᓂ ᑎᑭᓪᓗᒍ 30 ᒥᓕᐊᓐ ᑕᓐᓂᑦ ᐊᕐ ᕼᐅᒃ ᑖᕐ ᑖᓐᓇ 12 ᒥᓕᐊᓐ ᑕᓐᓂᑦ ᐊᕐ ᕼᐅᒃ ᑖᕐ ᐅᓯᑲᖅᑕᖅᑕᐅᕙᓪ ᓗᓂ ᐊᑐᕐ ᓗᒍ ᑖᓐᓇ ᐅᐊᖕᓈᒧᑦ ᓄᓇᓯ ᐅᑎᑯᑖᖅᕙᒃ ᑕᑉ ᐱᑯᖕᒑᖕᕿᒻᒥᑕᐅᒥᐊᕐ ᔪᐊᓕᕆᕝᕕᖕᒑᒻᒪᓗ 18 ᒥᓕᐊᓐ ᑕᓐᓂᑦ ᐊᕐ ᕼᐅᒃ ᑖᕐ ᐅᓯᑲᖅᑕᖅᑕᐅᓗᑎᒃ ᐊᑐᕐ ᓗᒍ ᓂᒋᖕᒑᓄᓇᓯ ᐅᑎᑯᑖᖅᕙᒃ ᑕᑲ ᓄᖕᒑᐃᒃ ᐱᑭᑦ ᑐᐊᔾ ᔩᑉ ᐅᒥᐊᕐ ᔪᐊᓕᕆᕝᕕᖕᒑ ᓴᓇᔭ ᐅᓂᖕᒑᑖᔅ ᓯᒪ ᐅᐊᖕᓈᒧᑦ ᓄᓇᓯ ᐅᑎᑯᑖᖅᕙᒃ ᐸᕐ ᓈᕆᔭ ᐅᓯᒪᕚᖅ ᐱᒋᐊᕋᔭᕐ ᓗᓂ ᐃᓱᓕᔾᔨᒋᐊᕈᓂ ᐊᕐ ᕼᐅᒍ 2019. ᐱᔭᕇᖅᑕᐅᓂᖕᒑᓴᓇᔭ ᐅᕙᓪ ᓕᐊᓂᖕᒑᐅᐊᖕᓈᒧᑦ ᓄᓇᓯ ᐅᑎᑯᑖᖅᕙᒃ ᓂᕈᐅᒋᔭᖅ ᐱᔭᕇᕋᔭᖅᓱᓂ 2021 ᐃᓗᐊᒍ ᐊᑐᑲ ᐃᓐ ᓇᕈᑎᒧᑦ ᐱᓕᕆᐊᒃ ᓴᑦ ᑲᔭᓯ ᓗᑎᒃ ᐊᕐ ᕼᐅᒐᓂᒃ 2020 ᐅᓯᑲᖅᑕᖅᑕᐅᓗᓂ ᓴᕝᕙᕋᔭᒃᓴᖅ ᑕᑉ ᐱᑯᖕᒑᖕᕿᒻᒥᑕᐅᒥᐊᕐ ᔪᐊᓕᕆᕝᕕᖕᓂᑦ ᑕᒪ ᐃᑎᒧᑦ ᓄᓇᓯ ᐅᑎᒃ ᑯᑦ ᓄᓇᓯ ᐅᑎᑯᑖᒃ ᑯᓪᓗ ᐅᓯᑲᖅᑕᖅᑕᐅᓗᑎᒃ. ᑕᐃᒪ ᐃᓐ ᓂᑯᐊᓄᑦ, ᐅᓯᑲᖅᑕᐃᓂᖅ ᑕᕝᕙᕗᖕᒍ ᕿᒻᒥᑕᐅᒥᐊᕐ ᔪᐊᓕᕆᕝᕕᖕᒑᖑᕆᐊᕐ ᒥᓗᓂ 12 ᒥᓕᐊᓐ ᑕᓐᓂᑦ ᐊᕐ ᕼᐅᒃ ᑖᕐ ᐱᒋ ᐊᕈᓂ 2020−ᒥᑦ. ᓴᓇᔭ ᐅᓂᖕᒑᓂᒋᖕᒑᓄᓇᓯ ᐅᑎᑯᑖᖅᕙᒃ ᐊᒻᒪᓗ ᐃᒃ ᐱᑭᑦ ᑐᐊᔾ ᔩᑉ ᐅᒥᐊᕐ ᔪᐊᓕᕆᕝᕕᖕᒑᐱᒋ ᐊᕋᔭᖅᓱᓂ ᐊᕐ ᕼᐅᒐᓂ 2021 ᐱᔭᕇᖅᓯᑎᑕᐅᓗᓂ ᖁᑦ ᑎᒃ ᓯᒻᒥ ᓕᐊᔭᕐᒥᒡ ᓗ ᐊᖏᕐ ᓕᒋ ᐊᕆᓃᑦ ᓕᐊᓂᖅ ᐅᔭᕋᓐᓂᐊᖅᑕᐅᔪᑦ ᓴᕝᕙᕋᔭᒃᓴᖅ ᑎᑭᓪᓗᒍ 30 ᒥᓕᐊᓐ ᑕᓐᓂᑦ ᐊᕐ ᕼᐅᒃ ᑖᕐ ᑎᑭᒃ ᑯᓂ 2024. ᐅᓯᑲᖅᑕᐃᓂᖅ 18 ᒥᓕᐊᓐ ᑕᓐᓂᑦ ᐊᕐ ᕼᐅᒃ ᑖᕐ ᐃᒃ ᐱᑭᑦ ᑐᐊᔾ ᔭᐊᑉ ᐅᒥᐊᕐ ᔪᐊᓕᕆᕝᕕᖕᒑᐱᒋ ᐊᕋᔭᖅᓱᓂ ᐊᕐ ᕼᐅᒐᒧᑦ 2025.

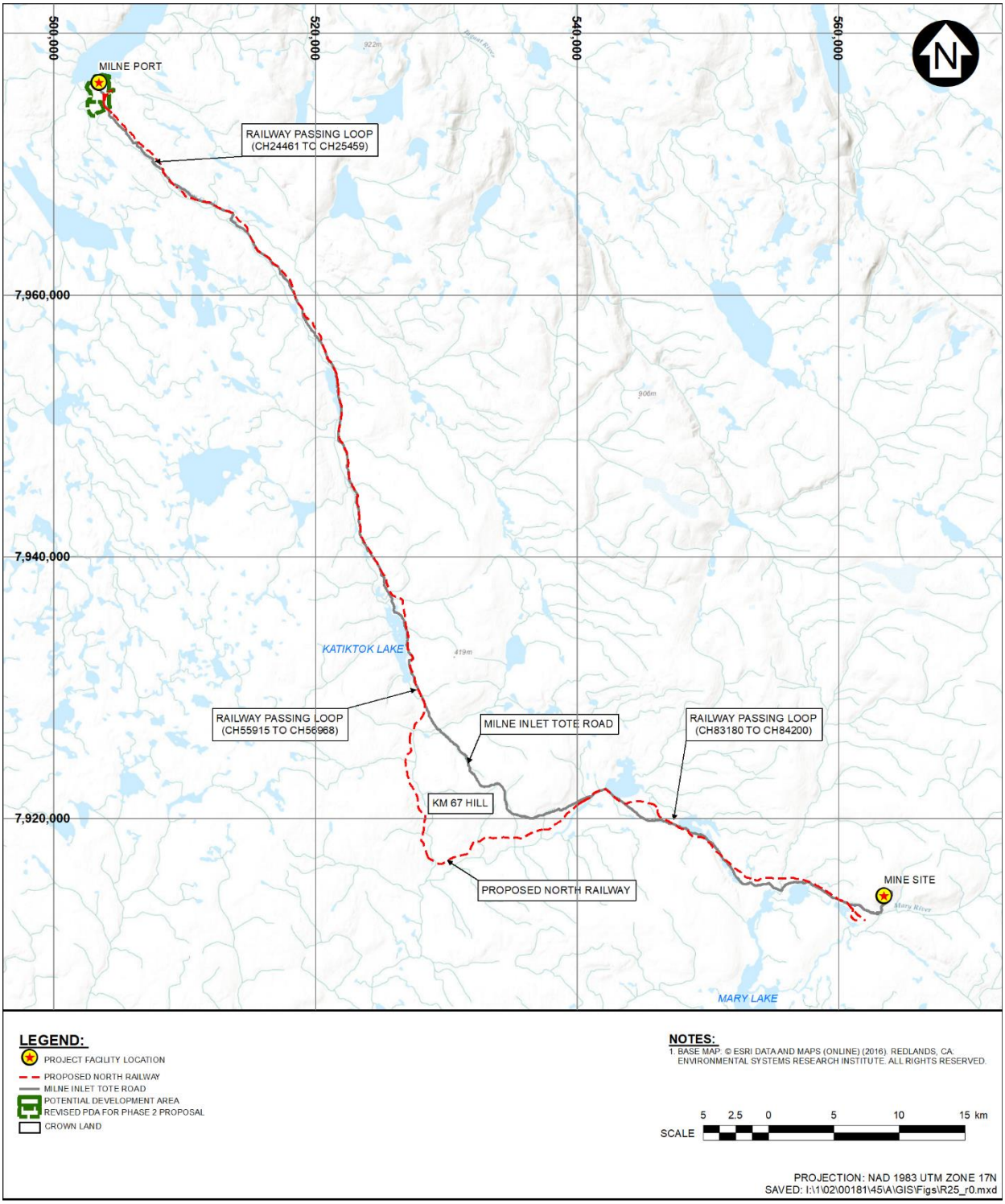
ᐱᓕᕆᐊᑉ ᒪᕐᕈᑦ ᓕᖅᑕᖕᖑᐃᓚᖅᑲᕆᕗᖅ ᓴᓇᒃ ᑲᓐᓂᕐ ᓂᕐᒥᒃ ᐱᖁᑎᔾ ᔪᐊᓂᒃ ᕿᒻᒥᑕᐅᒥᐊᕐ ᔪᐊᓕᕆᕝᕕᖕᒑ, ᐃᓚᐊᖅᓱᓂ ᑭᖑᓕᕐ ᒥᒃ ᓴᕝᕙᕋᔭᒃᓴᓕᕆᕝᕕᖕᒥᒃ (ᑕᑯᓐᓇᒐᕐᓴᖅ 3). ᐅᓯᑲᖅᑕᐃᔪᑦ ᕿᒻᒥᑕᐅᒥᐊᕐ ᔪᐊᓕᕆᕝᕕᖕᒑᑲᔫᓐᓇᖅᑕᕐᓗᑎᒃ ᐊᐅᔭᒃ ᑯᑦ ᓯᑯᖅᐳᓐ ᓃᕐᖑᖅ, ᐱᒋ ᐊᖅᓵᓕᖅᑕᖅᐳᓐ ᓇᕐᓗᑎᒃ ᓯᑯᐃᔭᕈᑎᖕᒑᑦ ᑐᕙᖕᖓᓇᔭᖅᑕᐅᔭᓐ ᓃᕐᖑᖅ ᐃᓄᖕᓄᑦ ᐊᐅᓚᓂᖅᑐᓄᑦ ᐊᖕᒍᓇᓯᒃ ᑐᓄᓗ, ᐃᒻᒪᖄᔭᓚᐃ 1 ᑎᑭᓪᓗᒍ ᓄᕙᐱᕆ 15.

ᐊᑦ ᓯᒦᖅ ᑐᑦ ᓄᑖᖑᕆᐊᕈᑎᑦ ᐱᖁᑎᕐ ᔭᐊᓗ ᐊᑐᕆᐊᖅᑲᕆᓪᓗᑦ ᐅᔭᕋᓐᓂᐊᕐ ᕝᕕᖕᒥᑦ ᑕᒪ ᐃᑎᒍᓗ ᐅᐊᖕᓈᑕ ᓂᒋ ᐊᑕᓗ ᐅᓯᑲᖅᑕᐃᕝᕕᑦ ᓯᓗᖕᒍᕐᒍᑦ ᐃᑲᔭᐃᔾ ᔭᑎᒃ ᓴᑦ ᐊᖑᕆ ᐊᕆᓂᕐ ᒥᒃ ᐅᔭᕋᓐᓂᐊᕐ ᓂᖕᒋᖕᓄᑦ ᓴᓇᔭ ᐅᓂᖕᒋᓄᓗ ᒪᕐ ᕈᒃ ᓄᓇᓯ ᐅᑎᑯᑖᑉ ᐊᖅᑯᑎᖕᒋ (ᑕᑯᓐᓇᒐᒃᓴᖅ 4).

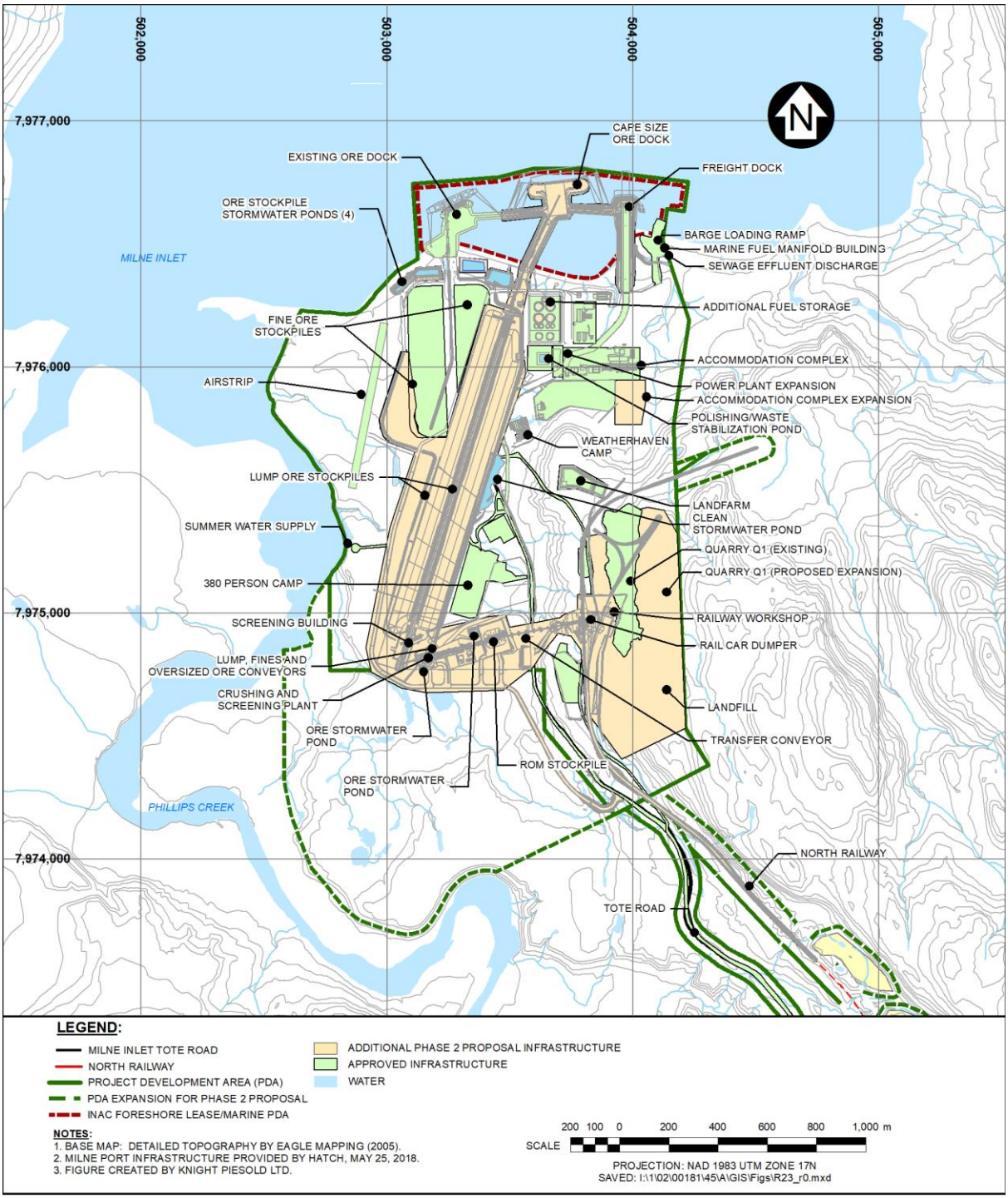
ᐱᖁᑎᔾ ᔭᐊᑦ ᐊᒃ ᑐᐊᓂᖅᑐᑦ ᑖᒃ ᓯᒧᖕᒋᓂᒋᖕᒑᓄᓇᓯ ᐅᑎᑯᑖᖅᕙᒃ ᐊᒻᒪ ᐃᒃ ᐱᑭᑦ ᑐᖅ ᔭᐊᑉ ᐅᒥᐊᕐ ᔪᐊᓕᕆᕝᕕᖕᓚᓯᓕ ᓴᓇᓯᒪᖕᕆᓛᑦ. ᑖᒃ ᑯᐊ IFC ᑎᑎᕋᐅᔭᒐᖕᒋ ᑐᓂᔭ ᕆᐊᓕᕚᓪ ᓗ ᑲᑎᒪᔩᓄᑦ ᑐᓂᔭ ᐅᓂᐊᖅᑐᑦ ᒪᓕᓪ ᓗᒍ ᐃᓚᖕᒐᐱ, ᑎᑎᕋᖕᒐ10 ᓚᐃᓴᓐᓯᐅᑉ, ᓯᕗᓂᐊᒍᑦ ᓴᓇᔭ ᐅᒥ ᐊᓚᐅᖅᑎᓐ ᓇᒥᑦ ᐅᔭᕋᓐᓂᐊᕝᕕᐅᑉ ᐃᓚᒋᖅᓯ ᐅᑎᒋᔭᖕᒋᓄᑦ.



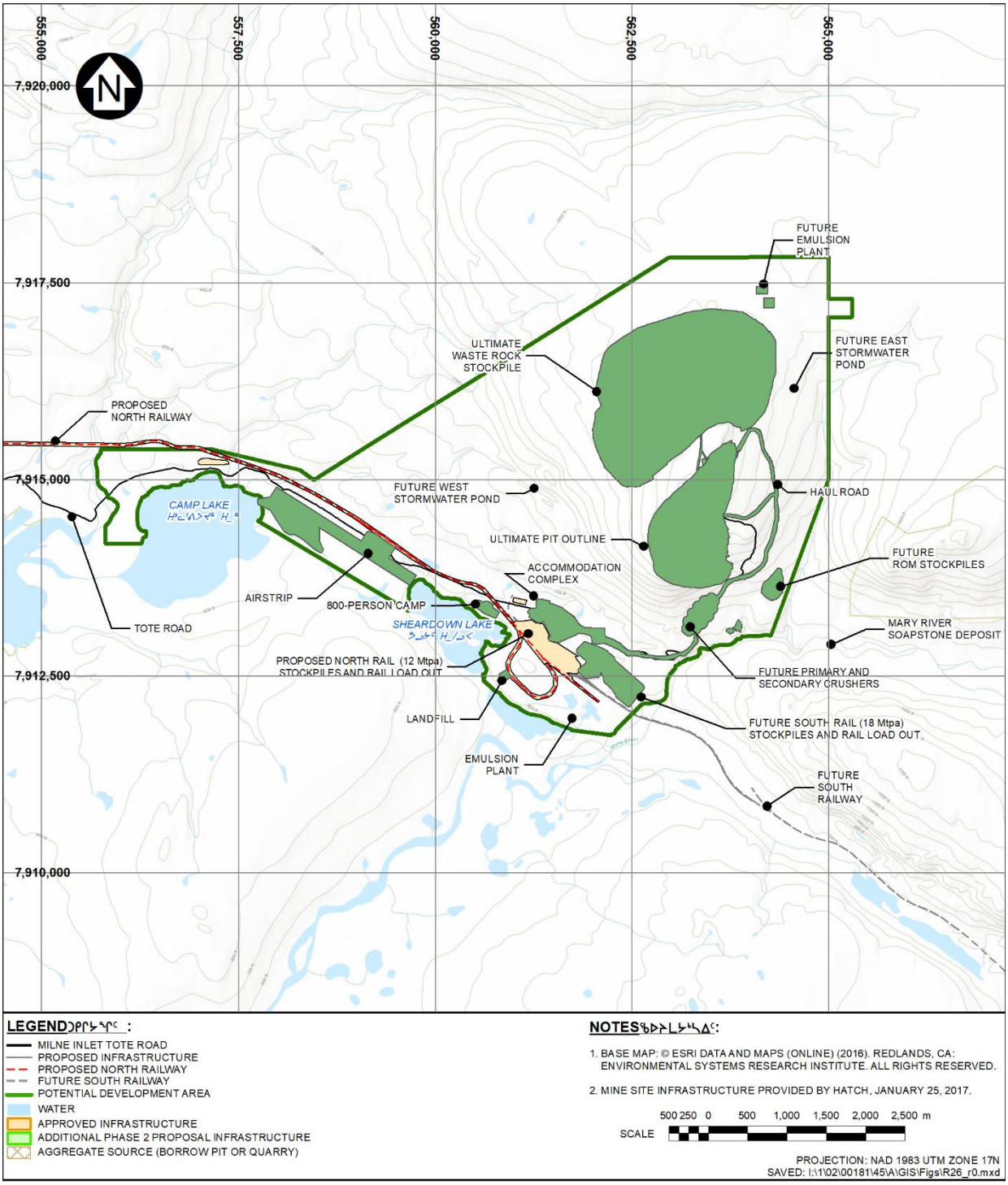
ᑕᑯᓪ ᓇᒃᑲᓪ ᓴᖅ 1 ᐅᕗᖅᕿᓂᐊᖅᑐᑦ ᐃᓂᒋᔭᖅᑕᑦ ᓄᓇᖃᖅᖢᖅ



ᑕᑯᓗ ᓇᒃᑲᓐᓂᕐᒧᑦ ᒪᓕᒐᓱᐃᓐᓇᖅᑐᑦ ᐅᑦ ᑐᑭᓯᒪᔪᑦ ᐃᓄᓐᓂᒃ ᐱᐅᓯᖅᓯᒪᓂᖅ ᐃᓕᓴᕐᕕᑦ ᓄᓇᕗᑦ



ᑕᑯᓛᓂᑦ ᓇᒃᑲᓐᓂᖅ 3 ᖁᕝᕙᓚᑕ ᐅᒥᐊᓂ ᓴᐊᓕᓐᓇᓵᓂᖅ ᐃᓐᓇᕐᓂᐊᓕᖅᑐᑦ ᓴᓇᔨᓛᒥ ᐅᓂᒃ ᑐᑭᓯᓇᖅᑕᒥᓂᒃ ᐅᓂᒃ ᑐᑎᒍᓯᒪᔪᖅ ᐊᖏᖅᑐᓂᒃ ᐅᑎᓪᓗᒥ ᐊᖏᖅᑐᓂᒃ ᑭᓇᐅᔭᖅᑐᓂᒃ



ᑕᑯᓵ ᓇᒃᑲ ᓴᖅ 4 ᐅᖃᕐᖓᓂᕐᒥᐅᑦ ᐃᐅᓪᓗᒥᒃ ᐱᓕᕆᔨᖅᑕᐅᓂᒃ ᓴᓇᔨᓂᒃ ᐅᐱᒍᓐᓇᖅᑐᑦ ᐅᐱᒋᔭᐅᓂᒃᑯᑦ ᐅᖃᖅᑐᒥᐅᑦ ᐊᑐᐃᓐᓇᖅᑐᑦ ᐅᐱ ᑐᑭᓯᒪᔭᒃᑯᑦ

ᐃᒥᕐᒥᒃ ᐊᑐᕐᓂᕗᑦ

ᐱᓕᕆᐊᑉ ᒪᕐᕈᐸᓕᒃᑕᖕᖏᓐᓂᑦ ᑐᒃ ᓯᕋᐅᑎ ᓴᖅᑮᔭᖕᖏ ᑐᖅ ᐊᖕᖏ ᓕᒋᐊᕆᓂᕐᒥᒃ ᖃᐅᑕᒫᑦ ᐃᒥᕐᒧᑦ ᐊᑐᓲᖕᖏᓐᓂᑦ ᐃᓄᖕᖏᓐᓂᑦ ᓴᓇᔭᓄᓐᓄ ᐃᒥᖅᑐᕈᑖᑕ ᕿᙵᖕᔮᓕᒪᕐ ᕉᖕᓂ ᐃᒥᖅᑕᕐ ᕙᖕᖏ ᓂᒃ (ᕿᙵᖕᔮᑕ ᑰᖕᖑᐊᐅᔭᒃ ᑯᑦ ᐊᒻ ᒪᓗ ᑭᒌᒥᑕ 32 ᑕᓯᖕᖑᐅᑭᒃ ᑯᑦ).
ᐊᔩᔾ ᔨᖅᑐᖅᐹ ᔫᖕᖏ ᑐᖅ ᓄᑦᔫᓂ ᐅᔭᕋᖕᓂᐊᕐ ᕙᐅᑉ ᐃᒥᖅᑕᕐ ᕙᖕᓂᑦ (ᓇᔪᒐᐅᑉ ᑕᓯᖕᖑ). ᓱᕐᕋᔾ ᔫᖕᖏ ᑐᑦ ᐃᒥᖅᑕᕐ ᓂᕆᔫᕗᑦ ᑕᒪ ᐃᓐ ᓂᒃ ᑰᖕᖏ ᓄᑦᔫᓐᓄ ᑕᓯᖕᖏᓐᓂᑦ ᐳᔩᖅᑎᑦ ᑎᑦ ᑕᐃᓕᒪᔾ ᔪᑎᖕᖏᓐᓂᑦ.

ᑕᖅ ᕚᓇ ᐅᐊᖕ ᓈᑕ ᐅᓯ ᑲᖅᑕᐃᖅ ᕙᐅᑉ ᐊᖅᑯᑎᖕᖏ, ᐊᑐᕇᖅᑐᑦ 12 ᐳᔩᖅᑎᑦ ᑎᑦ ᑕᐃᓕᒪᔾ ᔪᑎᖕᖏᓐᓂᑦ ᐃᒥᖅᑕᕐ ᕙᖕᖏ (ᐱᖃᓯ ᐅᑎᔪᖅ ᕿᙵᖕᔮᑕ ᑰᖕᖑᓄᑦᔫᓐ ᓄ ᑕᓯᖕᖑ) ᐊᑐᖅᑕᐅᖕᖏ ᓇᓐ ᓄᑎᒃ, ᖄᒃ ᑲᓐ ᓂᐊᒎᓐ ᓄ 13 ᐃᒥᖅᑕᕐ ᕙᒃ ᑲᓐ ᓂᒃ ᓴᑦ ᐊᖅᑯᑎᖕᖓᑦ ᓇᓄᓇᐃᖅᓯᒪᕗᑦ ᐊᑐᕈᒪᔭᑦ ᐳᔩᖅᑎᑦ ᑎᑦ ᑕᐃᓕᒪᔾ ᔪᑎᖕᖏᓐᓂᑦ. ᑲᑎᓕᒫᕐ ᓅᒍ ᖃᐅᑕᒫᑦ ᐃᒥᖅᑕᖅᑕᐅᔪᑦ ᐳᔩᖅᑎᑦ ᑎᑦ ᑕᐃᓕᒪᔾ ᔪᑎᖕᖏᓐᓂᑦ ᐊᓯᔾ ᔨᕋᔭᖅᑐᖅ 1,500 ᒦᑕ^3/ᖃᐅᑕᒫᑦ ᑖᒃ ᑯᓇᖓ 12 ᐃᒥᖅᑕᕐ ᕙᓂᒃ ᐅᕝᕙ2,600 ᒦᑕ^3/ᖃᐅᑕᒫᑦ ᑖᒃ ᑯᓇᖓ 25 ᐃᒥᖅᑕᕐ ᕙᖕᓂᑦ.

ᐊᒃ ᑕᑯᑦ ᐃᒋᑕᐅᓂᖕᖏ

ᐊᑐᕇᖅᑐᑦ ᐊᒃ ᑕᑯᓄᑦ ᑲᒪᒋᔾ ᔪᑎᕗᑦ ᐃᒋᑕᐅᕐ ᕙᖕᖏᓐᓄ ᐱᖁᑎᕐ ᔪᐊᑦ ᐊᑐᐃᓐ ᓇᕋᔭᖅᑐᑦ ᑕᖅ ᕚᓇ ᐱᓕᕆᐊᑉ ᒪᕐᕈᐸᓕᒃᑕᓄᑦ ᐅᒃ ᑑᑎᖕᖓᑦ, ᒪᓕᒃ ᓄᒍ ᐹᕝᕙ ᓵᓐ ᑯᑦ ᐊᒃ ᑕᑯᓄᑦ ᑲᒪᔾ ᔪᑎᓄᑦ ᐸᕐ ᓇᐅᑎᖑᖅ. ᐃᓚᖅᑲᖅᑐᑦ ᐃᑯᐊᓪ ᓚᐅᑎᓂᒃ ᕿᙵᖕᔮᑕ ᐅᒥᐊᔾ ᔪᐊᓕᕆᕐ ᕙᖕᖏ ᐊᒻ ᒪ ᓄᑦᔫᐸ ᐅᔭᕋᖕᓂᐊᕐ ᕙᖕᖏ, ᐊᒃ ᑕᕐ ᕙᖕᖓᑕᐃᑲᓂ ᓄᑦᔫᐸ ᐅᔭᕋᖕᓂᐊᕐ ᕙᖕᖏ, ᐊᒻ ᒪ ᐅᓄᕆᐊᓇᖅᑐᑦ ᐃᒋᑕᐅᔫᑦ ᑐᖅᑯᐃᕐ ᕙᖕᖏᒃ ᑕᒪ ᐃᓐ ᓂᒃ ᓄᓇᖕᖏᒃ. ᐊᑐᕇᖅᑕᕗᑦ ᐱᖁᑎᔾ ᔪᐊᑦ ᓈᒻ ᒪᒃ ᑲᔭᖅᑐᑦ ᓴᓇᔭᐅᑎᓐ ᓄᒍ ᖄᒃ ᑲᓐ ᓂᐊᒍᑦ ᐱᖁᑎᕐ ᔪᐊᒃ ᑲᓐ ᓂᒃ ᓴᑦ ᐊᒃ ᑐᐊᓂᖅᑲᖅᑐᑦ ᑖᔅ ᓯᒨᖑᐱᓕᕆᐊᑉ ᒪᕐᕈᐸᓕᒃᑕᖕᑕ ᐅᒃ ᑑᑎᖕᖓᑦ (ᐱᓗᐊᖅᑐᒥᒃ ᐅᐊᖕ ᓈᒍᑦ ᓄᓇᓯ ᐅᑎᑯᑖᖅᑲ ᕙᒃ), ᐱᖃᓯ ᐅᑎᓐ ᓄᒋᑦ ᐊᑐᑲ ᐃᓐ ᓇᖅᑲᑦ ᑕᕋᔭᖅᑐᑦ ᓅᒃ ᑕᖅᑐᑦ ᑕᖕ ᒫᕐ ᕚᑦ ᓴᓂᕌᒍᑦ ᐅᐊᖕ ᓈᒍᑦ ᓄᓇᓯ ᐅᑎᑯᑖᖅᑲ ᕙᒃ ᓴᖕᖢ.

ᖄᕐ ᑲᓐ ᓂᐊᒍᑦ ᐊᒃ ᑕᑯᓄᑦ ᐱᓕᕆᐊᑦ / ᐱᖁᑎᔾ ᔪᐊᑦ ᐃᓚᖅᑲᕋᔭᖅᑐᑦ ᐅᑯᓂᖕᖑ:

- ᕿᙵᖕᔮᑕ ᐅᒥᐊᔾ ᔪᐊᓕᕆᕐ ᕙᖕᖏ ᐊᒃ ᑕᕐ ᕙᖕᖑ– ᐊᒃ ᑕᕐ ᕙᒃ ᓴᓇᔭ ᐅᓂᐊᖅᑐᖅ ᐃᓗᐊᓄᑦ ᐊᖕᕆᓕᒋ ᐊᕆᓯᒪᔩᑉ ᑐᐊᐸᒃ ᑕᕐ ᕙᒃ Q1 ᑭᖑᓂᐊᓄᑦ ᐱᔭᕇᖅᑕᐅᓯᒪᓕᕈᑎᒃ ᓴᓇᔭ ᐅᕝᕙᓕ ᓕᐊᓂᖕᖏᓐᓂᑦ ᐱᓕᕆᐊᖑᔪᑦ
- ᕿᙵᖕᔮᑕ ᐅᒥᐊᕐ ᔪᐊᓕᕆᕐ ᕙᖕᖏ ᐃᓚᔭᑦ ᑕᓰᑦ ᑭᕙᕐ ᕙᓕᐊᑦ – ᐊᕙᑖᒍᑦ ᐃᓗᑐᔪᓕᐅᕐ ᓗᒍ, ᐃᒪ ᐃᔭ ᐃᔾ ᔪᑎᖃᕐ ᓗᑎᒃ, ᓴᓂᕌᑕ ᓴᕙᕋᔭᒃ ᓴᑦ ᑐᐊᐸᔫᑦ ᑐᖅᑯᐃᕙᖕᖏᒪᕐ ᕉᓪ ᓗ ᑕᓰᒃ ᓄᓇᓯ ᐅᑎᑯᑖᑉ ᐅᓯ ᖕᕆᐊᕐ ᕙᖕᖏ ᓯᖃᓕᕙᐅᓪ ᓗ ᓄᓇᖕᖢ ᐱᖁᑎᕐ ᔪᐊᖃᕐ ᕙᐊ ᕿᙵᖕᔮᑕ ᐅᒥᐊᕐ ᔪᐊᓕᕆᕐ ᕙᖕᖏ ᐊᑐᕐ ᓄᒋᑦ ᒪᖁᖕᒍᑦ ᓇᒃ ᓴᒐᐅᓖᑦ ᓄᖅᑲᖕᖑᓐ ᓇᓯ ᓄᒋᑦ. ᑭᖑᓪ ᓕᖅᐹᖅ ᑯᕙᕐ ᕙᒃ ᓴᖅ ᑕᒪ ᐃᓐ ᓄᑦ ᓯᓚᐳᔪᖕ ᒍᑦ ᐃᓪ ᒥᕈᑕᐅᔪᓄᑦ ᓯᓕᑕᓇᐅᑉ ᐃᒪᖕᖒᖕᖑᕝᖅ ᕿᙵᖕᔮᓂ.
- ᐅᔭᕋᓂᐊᕙᐅᑉ ᓴᕙᕋᔭᒃ ᓴᓄᑦ ᑐᖅᑯᐃᕙᖕᖑᓄᓇᓯ ᐅᑎᑯᑖᓐ ᓄ ᐅᓯᓕᖅᓯᐃᕙᖕᖏ ᐱᖁᑎᕐ ᔪᐊᓄᑦ – ᑭᖑᓂᐊᓄᑦ ᓯᖃᓕᕆᓃᑦ ᓅᑕᐅᓗᑎᒃ ᐃᓪ ᓘᑉ ᐃᓗᐊᓄᑦ ᕿᙵᖕᔮᑕ ᐅᒥᐊᔾ ᔪᐊᓕᕆᕐ ᕙᖕᖏ; ᐊᑐᖅᐅᔪᖅ ᐅᓐ ᓄᒥ ᓯᖃᓕᕆᕙᐅᑉ ᑐᖖᕙᖕᖑ ᓴᕙᕋᔭᒃ ᓴᓄᑦ ᑐᖅᑯᐃᕙᖕᖑ ᑭᕙᑦ ᑕᕝᕙᐊᓗ ᑕᓯᖅ ᐋᖅᑭᒋ ᐊᖅᑕᐅᓗᑎᒃ ᐊᖕᕆᓕᒋ ᐊᓐ ᓄᒋ ᓐᓄᑦ ᑕᒪᒃ ᑮᔭᓇ ᓇᕐᔪᓐ ᓄᒋᑦ ᐊᖕᕆᓕᒋ ᐊᕆᔭᒧᑦ ᓴᕙᕋᔭᒃ ᓴᑦ ᐅᓯᑲᖅᑕᖅᑕᑦ ᕿᙵᖕᔮᑕ ᐅᒥᐊᕐ ᔪᐊᓕᕆᕐ ᕙᖕᖏᓐᓂᑦ.
- ᐊᑐᖅᑕᐅᓚᐅᕋᒃ ᑐᑦ ᓴᕙᕋᔭᒃ ᓴᓄᑦ ᓅᑦ ᑎᓇᕝᕙᒃ ᓄᓇᖕᖑ– ᐱᓕᕆᐊᑉ ᒪᕐᕈᐸᓕᒃᑕᖕᖏᓐᓂᑦ ᐅᒃ ᑑᑎ ᐃᓚᖃᕐ ᓂᐊᖅᑐᖅ ᓴᖅᑮᓂᕐ ᒥᒃ ᐊᑐᓚᒃ ᓴᒥᒃ ᓅᑎᓇᕝᕙᒃ ᓴᒥᒃ ᓴᕙᕋᔭᒃ ᓴᓂᒃ ᑭᒌᒥᑕ 56.8, ᐊᑐᕐ ᓄᑎᒃ ᐊᕐ ᕌᒍᖕᖏᑦ 1-2 ᓴᓇᔭ ᐅᕙᓕ ᓕᐊᑎᓕ ᓄᒍ. ᑖᓐ ᓇ ᐅᐊᖕ ᓈᑕ ᓄᓇᓯ ᐅᑎᑯᑖᖅᑲ ᕙᖕᖑᕿᙵᖕᔮᑕ ᐅᒥᐊᕐ ᔪᐊᓕᕆᕐ ᕙᖕᖏ ᑎᑭᓕ ᓄᒍ ᑭᒌᒥᑕ 56.8 ᐱᒋ ᐊᖅᓵ ᓕᓯᔭ ᐅᓚᔭᖅᑐᖅ, ᐅᓯᑲᖅᑕᐅᑏᑦ ᓄᓇᓯ ᐅᑎᕐ ᔪᐊᑦ ᐅᓯ ᓄᑎᒃ 12 ᒥᓕᐋ ᑕᓐ ᓂᒃ ᐊᕐ ᕌᒍᑖᖅ ᑕᖅ ᕗᖓ ᓅᑎᓇᕝᕙᖕ ᒍᑦ ᓴᕙᕋᔭᒃ ᓴᓄᑦ ᓄᓇᓯ ᐅᑎᑯᑖᒍᑦ ᐅᓯᓕᖅᓯᓗᑦ ᐅᓯᔭ ᐅᓂᐊᕐ ᓄᑎᒃ ᕿᙵᖕᔮᑕ ᐅᒥᐊᔾ ᔪᐊᓕᕆᕐ ᕙᖕᖏᓐᓂᑦ. ᐊᑐᓚᐅᕋᒃ ᑐᑦ ᑐᖅᑯᐃᕙᑦ ᒪᕐᖑᒍᑦ ᑰᓚᖅᑕᖕᖏ ᑲᑎᖅᓯᐊᖑᓄᑎᒃ ᑭᕙᕙᖕ ᒍᑦ ᑕᓯᕐ ᒍᑦ. ᐃᒪ ᐃᔭᖅᑕᐅᖅᑲᑦ ᑕᖅᑐᑦ ᒥᓐ ᓄᐊᕈᑎᒍᑦ ᓄᓇᓯ ᐅᑎᒍᑦ ᓅᑕᐅᖅᑲᑦ ᑕᕐ ᓄᑎᒃ ᑕᐸ ᐱᑯᖑᕿᙵᖕᔮᑕ ᐅᒥᐊᔾ ᔪᐊᓕᕆᕐ ᕙᖕᖑ ᑭᕙᕙᓕᐊᒍᑦ ᑕᓯᖕᖏᓐᓂᑦ.

ᐊᓯᖕᖏ ᑭᒃ ᑯᑐᐃᓐ ᓇᐃᑦ ᓄᓇᐅᔪᓐ ᓄ ᐊᒃ ᑐᖅᑕᐅᔪᑦ ᓴᓇᔭᐅᔪᒪᔪᒍᑦ

ᐃᓄᒃᑯᖕᖏ ᑐᖅ ᓴᓇᔭ ᐅᕙᐅᑉ ᓄᓇᖕᖓᑦ, ᑭᓯᐊᓂ ᓄᓇᖕᖑᑕᐃᒪᖓ ᐅᓐ ᓄᒥ ᓄ ᐊᑐᖅᑕᐅᔫᖅ ᓄᓇᓕᖕᒥ ᐅᑦ ᐃᓄᖕᖏᓐᓂᑦ, ᐱᓗᐊᖅᑐᒥᒃ ᒥᑦ ᑎᒪ ᑕᓕᖕᒥ ᐅᓄᑦ. ᐹᕝᕙ ᓵᓐ ᑯᑦ ᐅᓄᖅᓯᐃᖅᒍᑎᒃ ᑭᒃ ᑯᓕᒫ ᓂᒃ ᑲᑎᒪᑎᑦ ᑎᓯᒪᕗᑦ ᓄᓇᓕᖕ ᓂᓐ ᓄ ᑲᑎᒪᑎᑦ ᑎᓐᓂᑦ ᐃᓕᓐ ᓂᐊᕈᑎᐅᔪᑦ ᑖᓕ ᓕᒪᑦ ᓄᓇᓖᑦ ᐅᐊᖕ ᓇᖕᖏ ᕿᕿᖅᑖᓗᒃ ᐃᒃ ᐱᐊᔾ ᔪᒃ, ᑲᖕᖑᖅᑐᓗᒃ ᐱᒃ, ᓴᓂᕋᔭᒃ, ᐃᒡ ᓗᓕᒃ ᐊᒻ ᒪᓗ ᒥᑦ ᑎᒪ ᑕᓕᒃ ᑕᐃᒪᖓ ᐱᓕᕆᐊᑉ ᒪᕐᕈᐸᓕᒃᑕᖕᖏᓐᓂᑦ ᐅᒃ ᑑᑎᖕᖓᐅᖅᑲᐅᔪᐅᖕᒪᑦ ᐊᑐᐱᓇ 2014 ᐃᓗᐊᓂ.

ᓇᓚᐅᑦ ᑖᒐᑦ ᐊᕙᑎᒧᑦ ᐊᒃ ᑐᐃᓂᐅᓂᐊᖅᑐᑦ ᓴᓇᔭᐅᔪᒪᔪᒧᑦ ᐊᒻ ᒪᓗ ᐊᑐᖅᑕᐅᔪᒪᔪᑦ ᓱᕋᐃᓗᐊᖅᑕᐃᓕᓂᕐ ᒧᑦ ᐊᐅᓚᑦ ᑎᔾ ᔪᑎᒃ ᓴᖏ

ᐱᓕᕆᐊᑉ ᒪᕐᕈᐸᓕᒃᑕᖕᖏᓐᓂᑦ ᐅᒃ ᑑᑎᖕᖑᓴᖅᑮᑦ ᑎᓂᐊᖅᐳᖅ ᐊᖕᖏᓂᖅᓴᒥᒃ ᖁᑦ ᑎᓛᖅ ᐅᔭᕋᖕᓂᐊᖅᑕᖕᖓ ᓈᓵ ᐅᑎᖕᖏᓐᓂᒃ ᓄᑦᔫᓐ ᐅᔭᕋᖕᓂᐊᕐ ᕙᖕᖏ, ᓴᓇᔭ ᐅᓂᖕᖑᐊᐅᓚᑕᐅᓂᖕᖏᓐᓄ ᐅᐊᖕ ᓈᑕ ᓄᓇᓯ ᐅᑎᑯᑖᖅᑲ ᕙᖕᖑ ᓴᓇᔭ ᐅᓂᖕᖑᐊᐅᓚᑕᐅᓂᖕᖏᓐᓄ ᑭᖑᓪ ᓕᖅ ᓴᕙᕋᔭᒃ ᓴᓄᑦ ᐅᓯᓕᖅᓯᐃᕙᒃ ᕿᙵᖕᔮᑕ ᐅᒥᐊᔾ ᔪᐊᓕᕆᕐ ᕙᖕᖏ, ᐊᒻ ᒪ ᐊᑯᓂᐅᓕᕆᐊᕋᔭᖅᑐᑦ ᐊᐅᔭᒃ ᑯᑦ ᐅᒥᐊᔾ ᔪᐊᒃ ᑯᑦ ᐅᓯᑲᖅᑕᖅᑕᑦ ᕿᙵᖕᔮᓂ ᐱᓇᓱᐊᕈᓯᓐ ᓄᑦ ᑭᖑᕝᕙᖕᖓᓂᓯ ᑯᓇᓱᓐ ᓂᖕᖑᐃᓚᓐ ᓂᒃ ᑯᑦ ᐊᕐ ᕌᒍᓂ.

ᐱᓕᕆᐊᒃ ᓴᓕᒫᑦ ᐅᓂᒃ ᑳᓇᔭ ᐅᔪᑦ ᐃᓗᐊᓄᑦ ᐱᓕᕆᐊᑉ ᒪᕐᕈᐸᓕᒃᑕᖕᖓ ᐅᒃ ᑑᑎᖕᖓ ᓄᑖᖑᕐᖏ ᒪᑕ, ᑕᐃᒪ ᐃᓪ ᒪᓕᓗ, ᐅᓄᕌᑦ ᓱᕋᐃᓗᐊᖅᑕᐃᓕᒪᓂᕐ ᒧᑦ ᑲᒪᒋᔭᐅᑉ ᔪᑎᖕᖑ ᐊᑐᓕᖅᑎᑕᐅᕙᓕᐊᔪᑦ ᐅᔭᕋᖕᓂᐊᕐ ᕙᖕ ᒧᑦ ᐅᓂᒃ ᑳᓇᔭ ᐅᔪᓕ ᓄ ᐃᓗᐊᓄᑦ ᐹᕝᕙ ᓵᓐ ᑯᑦ ᐊᐅᓚᑦ ᑎᓂᕐ ᒧᑦ ᐸᕐ ᓇᐅᑎᖕᖏᑦ ᓯᓕ ᐋᑐᑎᖃᖅᐳᑦ. ᖁᑦ ᑎᒋ ᐊᖅᓯ ᐊᖅᓯ ᐊᕐ ᔪᒃ ᑐᑦ ᐊᒃ ᑐᐃᓂᖕᖏ ᑖᔅ ᓯᒪᐅᑉ ᐱᓕᕆᐊᑉ ᒪᕐᕈᐸᓕᒃᑕᖕᖏᓐᓂᑦ ᐅᒃ ᑑᑎᖕᖑᑕ ᐅᓂᒃ ᑳᓇᔭ ᐅᕗᑦ ᐊᑖᓂ:

- **ᓯᓚᐅᑉ ᐊᔾᔫᒋᔪᓐᓈᕐᓂᖓ** – ᐊᑐᓕᖅᑎᑦ ᑎᓂᖅ ᐱᓕᕆᐊᑉ ᒪᕐᕈᒋᓕᖅᑕᖕᒪᑦ ᐅᒃᑑᑎᖕᒐ ᐅᔭᕋᖕᓂᐊᕐᕕᐅᑉ ᓴᖅᑮᓇᔭᖅᑕᖕᒋᓂᒃ ᐊᖅᐸᓯᒥ ᐊᖅᑎᑦ ᑎᓇᔭᖅᑐᖅ ᓯᓚᒧᑦ ᐊᓂᐊᔭ ᓇᓲᖕᒋᓂᒃ ᐃᒻᒪᖃ 10% ᓴᓂᓕᓇᓗᒥᑦ ᐊᖕᒥᖅᓯᒪᔭᑦ ᐅᔭᕋᖕᓂᐊᖅᑐᑦ ᐊᑐᕋᔭᖅᑕᖕᒋᓐᑦ.
- **ᐊᓂᖅᓵᓚᑦ ᑕ ᐱᐅᓂᖕᒐ** – ᐊᖕᒋ ᓕᒋ ᐊᕐ ᓂᐊᕋᓗᐊᖅᑎᓪᓗᒍ ᐅᔭᕋᖕᓂᐊᖅᑕᐅᔪᖅ ᑕᕝᕙᖕᖓ 22.2 ᒥᓕᐊᓐ ᑕᓐᓂᒃ ᐊᕐᓵᒍᓕᓚᒧᑦ ᑎᑭᓪᓗᒍ 30 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᓵᒍᓕᓚᒧᑦ, ᓯᖃᓕᔭᑦ ᐊᓂᐊᔪᑦ ᐳᔪᕈᖅᑐᓪᓗ ᑲᓚᔫᑦ ᐊᒃ ᐸᓇᐊᖕᒍᕋᔭᖅᑐᑦ. ᑕᒪᓐᓇ ᐱᓗᐊᖅᑐᖅ ᖄᒃ ᑲᓐᓂᐊᒍᑦ ᓱᕋᐃᓗᐊᖅᑕᐅᓕᒪᔾᔪᑏᑦ ᑭᖑᓂᐊᒍᑦ ᓯᖃᓕᔭ ᐅᓂᐊ ᐃᓪᓘᑉ ᐃᓗᐊᓄᑦ ᓅᑕᐅᓂᖕᒪᑦ ᕿᑭᖅᑖᓂ. ᓯᖃᓕᔭᑦ ᐱᒃ ᓯᓚᔭᖕᖑ ᐳᔪᕈᖅᑐᓪᓗ ᐳᔫᖅᑕᐃᓕᒪᔾᔪᑎᖕᖑ ᕿᑭᖅᑖᓄᑦ ᐊᖅᑯᑕᖅᑯᓂ ᐊᖕᒍᓕᒥ ᐊᕌᕐᔪᒃ ᑲᔭᖅᑐᑦ ᓴᓇᔭᐅᑎᓪᓗᒍ ᐱᓪᓗᒍ ᓄᓇᓯᐅᑎᕐᔪᐊᑦ ᐅᓯᑲᖅᑕᐃᓂᖕᖑ ᓴᕕᕋᔭᒃ ᓴᒥᒃ ᐅᓄᕐᓂᖅᓴᒃᑯᑦ (6–ᒥ 12–ᒧ ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᓵᒍᑖᓪᓗᑦ) ᒪᓕᒃ ᑲᔭᖅᑐᖅ ᓄᓇᓯᐅᑎᑯᑖᑉ ᐱᔭᓇᖅᑕᐅᕙᓪᓕᐊᓂᖕᒪᑦ. ᓴᓇᔭ ᐅᔭ ᓇᕈᓂ, ᐳᔫᓕᖅᑭᖕᖑᓂᖕᖑ ᓄᖅᑲᖕᖑᕚᓪᓕᕋᔭᖅᐳᖅ ᓄᓇᓯᐅᑎᑯᑖᒃ ᐅᓯᑲᖅᑕᐃᓕᕈᓂ ᐅᒥ ᐊᔾ ᔪᐊᓕᓇᖏ ᕕᖕᖑᒧᑦ. ᐊᓂᖅᓵᓚᑦ ᑎᓐᓂ ᐳᔪᕐᓗᐃᑦ ᖁᖓᔾᔭᓂ ᐅᒥ ᐊᔾ ᔪᐊᓕᓇᖏ ᕕᖕᖑᒥ ᐊᖕᒋᓕᒋ ᐊᕋᔭᖅᑑᓚᓗᐊᖅ ᑭᓯ ᐊᓂ ᐊᖕᖏᓐ ᔫᖕᖑᑐᑦ.
- **ᓂᐹᕿᔭᖕᖑᓂᖅ** – ᓂᐱᖃᓐᓂᖕᒐᑦ ᖁᖕᖏᓯᓐᓂᖕᖑ ᓂᐱᖅᑯᖅᑐᓂᖅᓴ ᐅᑲ ᐃᓐᓇᕋᔭᖅᑐᖅ ᓴᓇᔭᐅᑎᓪᓗᒍ ᑕᒪ ᐃᑎᒍᑦ ᐅᔭᕋᖕᓂᐊᕐᕕᐅᑉ ᓄᓇᖕᖑᒍᑦ ᖁᑦᑎᖕᓂᖅᓴ ᐅᕋᕐᔪᑉᓗᑎᒃ ᓇᓗᓇᐃᖅᓯᒪᔪᓂᒃ ᐃᓗᐊᒍᑦ ᐊᖕᒥᖅᓯᒪᔭᑦ ᐅᔭᕋᖕᓂᐊᖅᑐᒃ ᓴᑦ ᐊᐅᓚᑦ ᑎᑎᓪᓗᒋᑦ ᐅᔭᕋᓂᐊᕐᓂᖕᒥᑦ.
- **ᓄᓇᒥᔭᖕᖑ, ᐃᔾᔪᖕᖓᐊᓪ ᒪᓗ ᖁᐊᖕᖑᐃᓐᓇᓘᖅ ᐃᑭᐊᖕᒐ** – ᓴᓇᔭ ᐅᕙᓪᓕᐊᓂᖕᒐᑖᓐ ᓇ ᐅᐊᖕ ᓈᑕ ᓄᓇᓯᐅᑎᑯᑖᖅᑲᑦ ᕕᒃ ᓴᖅᑮᔪᖅ ᒥᑭᑦ ᑐᓂᒃ ᐊᒃ ᑐᐃᓂᖅᑲᕈᑎᓂᒃ ᐊᑑᑎᔪᓄᑦ ᓄᓇᒥᔭᖕᖑᑕ ᐃᓕᖅᑯᓯᖕᒋᓐᑦ, ᐃᑳᑦ ᓂᐊᑦ ᒪᑦ ᓇᖅᓴᒃᑯᑦ. ᓄᓇᓯᐅᑎᑯᑖᑉ ᐊᖅᑯᑖᑕ ᓴᓇᔭ ᐅᓂᖕᒐᓴᖅᑮᔪᓐᓇᖅᑐᖅ ᐃᑭᐊᖕᒐᑕ ᖁᐊᖕᖑᐃᓐᓇᓘ ᖑᓂᐊᓂᒃ, ᓴᓇᔭ ᐅᓯᒪᓂᖕᒐᐊᖅᑯᑖᑕ ᓄᓇᓯᐅᑎᑯᑖᑉ ᐃᓚᓕᐅᔾᔫᓯᒪᔪᖅ ᖃᔾᓯᒐᓚᖕᖑᓂᒃ ᓱᕋᐃᑦᑕᐃᓕᒪᓂᑦᒧᑦ ᐊᑐᐅᔪᒃ ᓴᓂᒃ ᐊᓪᒪᓗ ᐊᒃ ᑐᐃᓗᐊᕐᑯᓇᒍ ᓄᓇᐅᑉ ᐊᕙᑖᓂᒃ ᓄᓇᓯᐅᑎᑯᑖᑉ ᐊᖅᑯᑖ ᑐᕝᕕᖅᑲᐃᓐᓇᕐᑯᓪᓗᒍ.
- **ᑕᓇᐅᖕᖑᒋᒥᑐᑦ ᐃᒪ ᐃᑦ** – ᐱᓕᕆᐊᑉ ᒪᕐᕈᒋᓕᖅᑕᖕᒪᑦ ᐅᒃᑑᑎᖕᒐᐃᓚᖅᑲᕐᓂᐊᓇᕗᖅ ᐊᓯᔾᔫᓚᓵᖕᓂᐊᖅᑐᖅ ᐃᒪ ᐅᑉ ᐱᐅᓂᖕᒪᑦ (ᑰᓐ ᓂᖕᒐ) ᓴᖅᑭᑦ ᑐᑦ ᓄᓇᓯᐅᑎᑯᑖᑉ ᐊᖅᑯᓯ ᐅᖅᑕᐅᓂᖕᒪᑦ ᐋᖅᑭᒃ ᓯᐃᓂᖕᒋ ᓄᑦ ᑯᑉ ᑯᓪ ᕕᖕᖓᓐ ᓴᖕᖑᐃᖅᑎᑦ ᑎᔾ ᔪᑎᓂᓪ ᓗ. ᑖᒃ ᑯᐊ ᐊᒃ ᑐᐃᓂᑦ ᕿᒥᕐ ᕈᔭ ᐅᓪ ᓗᑎᒃ ᓇᐅᒃ ᑯᓖᖅ ᑰᖕᖑᓂᖕᖓᐊᒃ ᑐᖅᑕᐅᓂᐊᕈᓂ (ᐱᓗᐊᖅᑐᒥᒃ ᓴᓇᔭ ᐅᔫᑉ ᖁᓛᒍᑦ ᑯᒃ ᑐᖅᖃᖅᑐᒥᒃ ᓴᓂᖕᖓ ᖕᖓᒃ ᑕᐅᓂᐊᕈᓂ ᐅᔭᕋᒃᑯᑦ ᑯᕈᖃᖅᑐᒥᒃ ᓄᓇᓯᐅᑎᑯᑖᑉ ᐊᖅᑯᓯ ᐅᖅᑕᐅᑎᓪᓗᒍ ᓴᓂᕋᒎᓕᖅᓗᓂ), ᓯᕋᐃᓗᐊᖅᑕᐃᓕᒪᓂᖅᒧᑦ ᑲᒪᔾᔪᑎᑦ ᓲᓗᑯᑉ ᓯᓇᖅᔪᖅᓂᒃ ᐱᐅᓯᒥᐊᓇᓃᑦ ᖃᑐᓂᐅᓗᓃᓐᓂᑦ ᓄᖕᖑᔾᔭ ᐃᒃ ᑯᓯ ᖅᑕᐅᓂᖕᒪᑦ ᓴᓇᔭ ᐅᓂᐊᓂᒃ ᓴᓂᖅ ᖕᖓ ᑕᖅ ᑰᖕᖑᑐᒧᑦ ᓯᕋᐃᓗᐊᕐᑯᓇᒍ ᐃᒪᖃᖅᓂᖅᓴ ᐅᓕᖅᓂᖕᒪᑦ. ᐊᓯᔾᔫᔪᖃᔾᔫᓇᓂ ᐅᔭᕋᖕᓂᐊᖅᓂᖅᒧᑦ ᐸᖅᓇᐅᑎᖕᒪᑦ ᓴᕕᕋᔭᒃ ᓴᖃᖕᖑᑐᑦ ᐅᔭᕋᑦ ᓴᓂᖅ ᖕᖓᒃ ᑕᐅᓂᖕᖑᓐᑦ ᐸᖅᓇᐅᑎᖕᖑᓐᑦ ᐱᓪᓗᒍ ᑖᓐᓇ ᐱᓕᕆᐊᑉ ᒪᕐᕈᒋᓕᖅᑕᖕᒪᑦ ᐅᒃᑑᑎᖕᒐ ᐊᒃ ᑐᐃᓂᖅᑲᖅᓂᖕᖑ ᐳᔫᕆᓂᖅ ᑎᓗᑦ ᑎᑭᑉ ᐸᓪᓕᐊᓇᔭᖅᑐᖅ ᕿᓐᖒᖅᑕ ᐅᒥ ᐊᔾ ᔪᐊᓕᓇᖏ ᕕᖕᖑᑕ ᐊᖕᖓᑖᒍᑦ ᐃᒪ ᖕᖓᑕ ᐃᒥᑦ ᑎᐊᖕᖓᐅᑎᓂᖕᒋᓐ ᐊᖕᖏᔾᔫ ᓴᕋᓯᒥᔭ ᐅᓇᓂ. ᐊᓯᖕᖑ ᐃᒥᖅᒧᑦ ᐊᒃ ᑐᐃᔪᑦ, ᓘᖅᓗ ᓴᓇᔭ ᐅᓂᐊ ᐊᖅᑯᑖ ᐃᓕᐅᕋᖅᑕᐅᓂᖕᖑᓗ ᐃᑳᖕᖓ ᕕᒃ ᓴᑎᔭᖕᖑ, ᑲᒪᔾᔪᐅᓇᔭᖅᑯᓂᒃ ᐊᑐᖅᓗᓂᒃ ᐊᑐᖅᑕᐅᓚᔪᒃ ᑐᓂᒃ ᓯᕋᐃᓗᐊᖅᑕᐃᓕᒪᔾᔪᑏᑦ (ᓘᓪᓗ, ᓴᖅ ᖕᖓᐅᔪᑦ ᓯᐅᖅᑲᑦ ᓄᖕᖑᔾᔭ ᐃᑦ ᑕᐃᓕᔾᔪᑏᓪᓗ ᑲᒪᔾᔪᑎᖕᖑ) ᐅᓂᒃ ᑳᑎᔭ ᐅᓯᒪᔪᑦ ᐹᖕᖓ ᓛᓐᑯᑦ ᐊᑐᓅᖅᑕᖕᖑᓂ ᑲᒪᔾᔭ ᐅᓂᖕᖑᓐᑦ ᐸᖅᓇᐅᑎᖕᖑᓐᑦ.
- **ᐃᒪᑦ ᑎᐊᖕᖓᐅᑉ ᐆᒪᔪᖕᖑ** – ᓄᓇᓯᐅᑎᑯᑖᑉ ᐊᖅᑯᑖ ᐃᓚᖅᑲᖅᑐᖅ ᐋᖅᑭᒃ ᓯᐃᓂᖕᒋᓂᒃ ᖃᔾᓯᒐᓚᖕᖑᓂᒃ ᓯᓪᓗᓕᐊᑦ ᑰᖕᖓᕕᓂᒃ ᐊᓪᒪᓗ ᐃᑳᖕᖓ ᕖᑦ ᑰᕈᒐᒍᒃᑯᑦ, ᑰᕈᕕᓐᓂᑦ ᓯᒥᒃ ᑕᐅᓂᖕᖑ ᐅᔭᕋᓂᒃ ᖄᖅᑎᓇᑎᓪᓗᒥᑦ, ᐊᓪᒪᓗ ᖃᓂᓈᓇᔭᖃᖅᓐᓃᑦ ᑕᓯᕐᓄᑦ ᑕᓯᕋᒍᓄᑦ ᓗ. ᐃᓚᖕᖑ ᐃᒥᖅ ᔫᖕᖑᓂᖕᖑ ᐱᓕᕆᐊᑦ ᐃᖃᓗᖃᖅᑐᓐᓃᑦ ᑐᑦ. ᓄᓇᓯᐅᑎᑯᑖᑉ ᐊᖅᑯᑖ ᐃᓂᓕᐅᕆᔭ ᐅᓯᒪᕚᖅ ᐊᒃ ᑐᐃᓂᐊ ᐊᒃ ᐸᓯᒌᒥᒃ ᐊᒃ ᑐᐃᖅᑐᓗᒍ ᐃᖃᓗᖕᖑᓇᖅᓂᖕᒋᓐᓗ. ᐊᓯᖕᖑ ᐊᑐᖅᑕᐅᓚᔪᑦ ᑐᑦ ᓯᕋᐃᓗᐊᖅᑕᐃᓯᒪᓂᖅᒧᑦ ᑲᒪᔭᐅᔭᐅᔪᑎᑦ ᓇᓗᓇᐃᖅᓯᒪᔪᒥᓐ ᐊᒃ ᑐᐃᓗᐊᕐᑯᓇᖕᖑ, ᑭᖑᕝᕖᔾᔪᑎᒃ ᓴᖕᖑᒋᓐ ᐸᖅᓇᐅᑎᒥᒃ ᓴᖅᑮᓯᒪᕗᒍᑦ ᐊᖕᖑᕐᒥᒃ ᓯᕋᐃᓂᑦ ᑎᓐᓄᑦ ᑭᖕᖑᕝᕕᐅᑎᒃ ᓴᖕᒋᓄᑦ ᐃᖃᓗᐃᑦ ᓇᔪᖕᒋᓄᑦ. ᐹᖕᖓ ᓛᓐᑯᑦ ᐱᓇᓯᖕᖑᓂᐊᖅᑐᑦ ᐊᖕᒥᖅᑕᐅᔾᔪᑎᒥᒃ ᒪᓕᒃᓗᒍ ᐃᖃᓗᓕᓇᓂᖅᒧᑦ ᐊᓪᒪᓗ ᐃᒪᖅᒥᐅᑕᓕᓇᕐᔪᐊᒃᑯᑦ ᑲᓇᑕᒥ ᒪᓕᒐᖕᖑᓂᒃ.
- **ᐱᕈᖅᑐᑦ** - ᐱᓕᕆᐊᑉ ᒪᕐᕈᒋᓕᖅᑕᖕᒪᑦ ᐅᒃᑑᑎᖕᒐᐃᓚᖅᑲᖅᑎᖕᖑᓐ ᐊᖕᒋᓕᒋ ᐊᓇᓂᕐ ᒥᒃ ᖁᐊᖕᖑᐃᑦ ᐅᒥ ᐊᔾ ᔪᐊᓕᓇᖏ ᕕᖕᖑᓂ ᓴᓇᔭ ᐅᓂᖕᖑᐅᐊᖕ ᓈᑕ ᓄᓇᓯᐅᑎᑯᑖᖅᑲᑦ ᕕᐊᓂᒃ ᓴᖅᑭᑦ ᑐᑦ ᖄᒃ ᑲᓐᓂᐊᒍᑦ ᐊᓯ ᐅᔫ ᓂᕐ ᒥᒃ ᓄᓇᓂᒃ ᓇᔪᖅᑕᐅᔫᓂᒃ.
ᑭᓯ ᐊᓂᓕ, ᑖᓐ ᓇ ᑲᑎᓚᒍ
ᓄᓇᖕᖓᐊᒃ ᑐᖅᑕᐅᔪᖅ ᒥᑭᑦ ᑑᓪ ᒪᑦ ᐊᑐᐃᓐ ᓇᐅᓘᑉ ᓇᔪᓚᓇᔭᒃ ᓴᖕᖑ ᓄᓇᖕᖑᒋ ᓂᒃ ᐱᓕᕆᓂᕗᑦ ᐸᕐ ᓈᓂᓯᒪᔭᕗᑦ ᐊᑐᓐ ᓂᐊᖅᓗᑎᒃ ᐃᓕᖅᑯᓯᖅ ᓂᕐ ᒥᒃ ᒥᑭᖏᒥᒃ ᓄᓇᒥᒃ ᐊᒃ ᑐᐃᓇᓯᒃ ᓗᑎᒃ ᐊᒃ ᑐᖅᑕᖅ ᐱᓕᕆᐊᑉ ᒪᕐᕈᒋᓕᖅᑕᖕᒪᑦ ᐅᒃᑑᑎᖕᖑᓐᑦ ᐊᑐᓇᐊᖅᑕᖅ ᑐᑐᐊᑦ ᓄᓇᖕᖑᒋᓐᑦ. ᐊᓯᔾ ᔫᓇᓂᑦ ᐃᓄᐃᑦ ᐱᐅᓯᖕᖑᒋᓐ ᐊᓐ ᓂᓇᔭ ᐅᔪᑦ ᐱᕈᖅᑐᓐ ᐱᓕᕆᐊᑉ ᒪᕐᕈᒋᓕᖅᑕᖕᒪᑦ ᐅᒃᑑᑎᖕᒪᑦ ᐱᓕᕆᐊᑉ ᒪᕐᕈᒋᓕᖅᑕᖕᒪᑦ ᐅᒃᑑᑎᖕᒪᑦ ᐱᓪ ᓗᒍ ᓂᓇᐅᒥᔭ ᐅᕗᖅ ᐃᓯᒪᓗᖕ ᓇᖕᖑᓂᖕᖑ ᓂᒃ ᐱᑕᖃᓗᐊᖕᖑᓂᖕᒪᑦ ᐃᕈᖅᑐᓂᒃ (ᑭᒍᑕᖕᖓ ᓇᐅᓂᒃ) ᑕᐃᑲᓂ. ᑎᒃ ᑕᐅᕙᑦ ᐳᔪᕐ ᓗᐃᑦ ᐅᓯᑲᖅᑕᐃᓂᖕᖑᓐ ᓴᕕᕋᔭᒃ ᓴᓂᒃ ᐊᖕᒋᓕᒋ ᐊᕋᔭ ᐃᒃ ᑲᔭᖅᑐᖅ ᖁᐊᖕᖑᐃᓐᓇᓂᒃ ᐊᖅᑯᑐᑦ ᓴᓇᔭ ᐅᓕᖅᑎᓪ ᓗᒍ, ᑭᓯ ᐊᓂ ᐅᐊᖕ ᓈᑕ ᓄᓇᓯᐅᑎᑯᑖᖅᑲᑦ ᕕᖕᖑᐊᑐᓕᕈᓂ, ᐅᓄᕐ ᓂᖅ ᐃᖕᖓ ᕋᔭᒃ ᑐᑦ ᐊᖅᑯᑎᒃ ᑯᑦ ᐊᒃ ᐸᓯᒥᐊᓕᓇᒃ ᑲᔭᕐ ᓚᑦ ᓴᓂᕋᒎᑦ ᐅᓕᒧᑦ ᐊᓚᑦ ᑑᑉ ᓴᓇᔭ ᐅᓂᐊᒍᓕ, ᒪᓕᒃ ᑲᔭᓂᓕ ᓗᓂ ᐊᒃ ᓴᓗᐊᓄᑦ ᐳᔪᕐ ᓗᓗᐊᖕᒍᕐᓗᖅ.
- **ᓄᓇᐅᑉ ᓂᕐ ᔪᑎᖕᖑ** - ᓴᓇᔭ ᐅᓂᖕᒐ ᐊᐅᓚᑕᐅᓂᖕᒐᓚᑐᔭ ᐅᓂᐊᓄᑦ ᓗ ᐱᓕᕆᐊᑉ ᒪᕐᕈᒋᓕᖅᑕᖕᒪᑦ ᐅᒃᑑᑎᖕᖑᑕ ᓴᖅᑮᔪᓐ ᓇᖅᑐᖅ ᐊᒃ ᑐᐃᓂᕐ ᒥᒃ ᐊᓯ ᖕᖓᖅᓯᒪᓂᖕᖑᓂᑦ ᐅᓄᓐ ᓂᖕᖑᓂᑦ ᓗ ᓂᔾ ᔪᑏᑦ ᐃᓗᐊᓃᑦ ᑐᑦ ᓴᓇᕙᐅᔫᑉ. ᓇᔪᓚ ᓇᔫ ᐅᔫᖅ
ᐊᒃ ᑐᖅᑕᐅᔪᓐ ᓇᖅᑐᖅ ᐊᓯ ᐅᔫ ᔭ ᐅᓕᓪ ᑖᒃ ᓗᓂ ᐃᓗᐊᓃᒃ ᑯᓂ ᓴᓇᕙᐅᔫᑉ ᓄᓇᖕᖑᓂ ᐱᓕᕆᐊᑉ ᒪᕐᕈᒋᓕᖅᑕᖕᒪᑦ ᐅᒃᑑᑎᖕᖑᑕ ᐅᖕᖓ ᖁᓛᓐ ᓂᓐ ᐊᒃ ᑐᐊᓕᖕᖑᓐ ᑲᓗᐊᑦ ᓗᓂ ᐊᓯ ᐅᔫ ᔭ ᐅᓗᓂ ᐱᓕᕆᓂᐅᔪᑦ ᐱᔾ ᔪᒥᓕᒃ ᓗᒥᑦ ᐃᒃ ᐱᒥᔭ ᐅᔪᖅ ᓇᖅᑐᖅ ᒪᓕᒃ ᓗᒥᑦ ᐊᑐᖅᑕᐅᔪᖅ ᓇᖅᑐᖅ (ᐊᑑᑎᖃᖅ ᓂᖅ ᓗᒃ) ᐊᒃ ᑐᐊᔪᓄᑦ ᓄᓇᓄᑦ ᐱᓕᕆᖕᖓᐅᔪᓂᑦ. ᐃᓕᖅᑯᓯᒥᒍᑦ ᓇᕈᖅ ᓂᐊᕐᓂᖕᒋᓐ ᐊᓯ ᐊᒃ ᑕᐅᔪᑦ ᐱᓕᕆᐊᑉ ᒪᕐᕈᒋᓕᖅᑕᖕᒪᑦ ᐅᒃᑑᑎᖕᖑᑕ ᐱᖁᑎᔾ ᔪᐊᖕᒋᓐᑦ ᐱᓕᕆᓂᖅ ᓄᓐ ᔫᓐ ᓂᑦ ᐊᒃ ᑐᐊᔪᑦ ᓯᒥᒃ ᑎᑎᒍᑎᒃ ᑐᖅᑕᖅ ᑕᕈ ᑕᐅᒍᑎᓐ ᔫᓐ ᓂᑦ ᓇᕈᖅ ᓂᐊᑕᓂ ᔾ ᔪᑏᑦ. ᑐᖁᑦ ᑎᖅᑲᑦ ᑕᖅ ᓂᖕᖑ ᐅᓄᕐᓯᒥ ᐊᑐᐃᓐ ᓇᓇᐊᓖᑦ ᑐᓗᖅ ᑕᐅᖅᑲᑦ ᑕᖅ ᓗᑎᒃ, ᐅᖕ ᖕᖓᐅᔫᓐ ᓂᑦ ᐊᖕᖑᓇᓯᒃ ᑎᓄᑦ ᐅᐸᒃ ᑕᐅᔪᖅ ᓇᓕᕈᑎᒃ ᓇᔪᓚ ᓇᓯᓪ ᖕᖑ.
ᐊᓪ ᒪᑦ ᑕᐅᖅ, ᑭᓈᓗᐃᑦ, ᐳᔪᕐ ᓗᐃᑦ ᓯᓚᒧᓕᓗ ᐳᔫᖅ ᑕᐅᔪᑦ ᓴᖅᑮᔪᓐ ᓇᕐ ᒪᑕ ᐱᕈᖅᑐᓂᑦ ᐱᔭ ᐅᓗᑎᒃ, ᓂᔾ ᔪᑎᓂᑦ ᐃᔭ ᐅᓗᑎᒃ ᐊᓂᖅᓵᖅ ᑕᐅᓗᑎᓪ ᓄᓐ ᓂᑦ, ᑕᒪᒃ ᑯᐊ ᐊᒃ ᑐᐃᓂᖅᑲᖅᓇᖅᑐᑦ ᖃᓄᐃᖕᖑ ᑎᐊᑦ ᓂᖕᖑ ᓂᑦ ᔪᐃᓐ ᓂᑦ ᐊᑐᓂ ᐊᓪ ᒪᓗ,

ᑕᐃᒪ ᐃᓐ ᓂᖕᒥᓂᑦ, ᓂᑦ ᔪᑏᑦ ᐅᓄᓐ ᓂᖏᕈᓯᖕᖑᖅ. ᐸᕝᕙ ᓛᓐ ᑯᑦ ᐊᑐᓕᖅᑎᑦ ᑎᓯᒪᕗᑦ ᐅᔭᕆᖕᓂᐊᕐ ᕕᐅᑉ −ᐃᓚᓕᒫᖏᓂᑦ ᐊᑐᐊᒐᕐᒥᒃ ᐅᓪᓗᒥᒧᑦ ᑐᒃ ᑐᓂᒃ ᑐᓗᖅᑕᐅᔪᖅᑲᓚᐅᖅᓯᒪᓇᓂ.

- **ᑕᕆᐅᑉ ᐊᕙᑎᖓ** ᐊᖏᕐᒥ ᐊᖅᑑᑉ ᐅᔭᕆᖕᓂᐊᕐ ᕕᐅᑉ ᐊᑐᖅᑕᖕᒐᓄᓇ ᑕᕆᐅᑉ ᐊᕙᑎᖕᓂᓴᖅᑮ ᑐᐃᓐ ᓇᓇᐊᓕᒃ ᐊᓯ ᐅᔮ ᓂᕐ ᒥᒃ ᐃᖃᓗᖃᑦ ᑎᐊᕐ ᓂᐅᔪᓂᒃ ᓇᔪᒐᐅᔪᓂᒃ ᐃᒪᖏᓂᒃ. ᐊᓯᖕᖏ ᑕᑯᕐ ᓴᕈᑐᐃᓐ ᓇᓇᐊᓖᑦ ᐊᒃ ᑐᐃᓃᑦ ᐅᔭᕆᖕᓂᐊᖅᑐᓂᑦ ᑕᕆᐅᑉ ᐃᒪᖕᒥᓂᑦ ᐃᓱᕐ ᓂᐊᑕ ᐱᐅᓂᖏᓂᑦ, ᑕᕆᐅᑉ ᐃᖃᓗᖕᑕ ᓇᔪᒐᖏᓂᑦ, ᐊᓪ ᓚᓗ ᑕᕆᐅᕐ ᒥᐅᑕᑦ ᐃᖃᓗᖕᑕᑦ ᖃᓄᐃᖕᖏ ᑎᐊᕐ ᓂᖕᖏ ᐱᐅᔪᓐ ᓃᑐᐃᓐ ᓇᓇᐊᓖᑦ ᐱᓪ ᓗᒍ ᐅᒥᐊᕐ ᐊᓕᓇᕝ ᕖᖕᒥ ᓴᓇᓂᖕᖑ ᓄᑦ, ᐅᒥᐊᑦ ᔪᐊᑦ ᐃᖕᖏ ᕋᔭᖕ ᓂᖏᓄᑦ, ᐅᒥᐊᕐ ᔪᐊᑦ ᐃᒃ ᑕᕐᑯᑎᖕᖃ ᐃᒥᑕᑯᕖᔭ ᐅᖅᑳᑦ ᑕᕐ ᓂᖕᒥᓄᑦ, ᑕᕆᐅᑉ ᐊᕙᑎᖕᒥᓄᑦ ᓄᑖᓂᒃ ᐆᒪᔪᕋᓛᓂᒃ ᓴᖅᑮ ᑐᐃᓐ ᓇᓇᐊᓖᑦ, ᐊᓪ ᓚᓗ ᐊᑐᓈᖅᓯᒪᔪᑦ ᐃᒪᕈᔪᐃᑦ ᑯᕖᔭᐅᓂᖏᓄᑦ, ᓴᕖᕋᔭᒃ ᓴᐅᑉ ᐳᔪᕐ ᓗᖕᑕᑭᕖᕙ ᕕᑦ ᔭᖏᓄᑦ, ᐃᒪᕐ ᒥᓪ ᓗᓂᐱᖅ ᑯᖅᑐᓂᐊᓄᑦ.
ᐊᑐᕈᒪᔭᑦ ᓯᕋᐃᓗᐊᖅᑕᐃᓕᒪᓂᕐ ᒧᑦ ᓴᖅᑭᑐᐃᓐ ᓇᓇᐊᓕᓐ ᓄᑦ ᐊᒃ ᑐᐃᓂᕐ ᓄᑦ ᐃᓚᖕᖅᑐᑦ ᐊᑐᓕᖅᑎᑦ ᑎᓂᕐ ᒥᒃ ᑲᒪᒋᔭᖕᕐ ᓂᕐ ᒧᑦ ᐸᕐ ᓇᐅᑎᓂᒃ, ᓅᕐ ᓗ, ᐅᓯᑲᖅᑕᐃᔪᓄᑦ ᓂᕐ ᔪᑎᓄᓪ ᓗᑲᒪᒋᔭᐅᑦ ᔪᑎᖕᒐᕐ ᓇᐅᑏᖅ, ᑐᐊᕖᕐ ᓇᖅᑐᒃ ᑯᑦ ᐅᐸᒍᑎᓂᖅ ᐊᓪ ᓚᓗ ᑯᕖᔪᖅᑳᓪ ᓚᖕᓂᖅᐸᑦ ᐸᕐ ᓇᐅᑎᖕᖏ, ᐊᕙᑎᒧᑦ ᓴᐳᒥᕐ ᔪᑎᑦ ᐅᔾ ᔨᖅᓅᑎᐅᔪᓄᓪ ᓗᐸᕐ ᓇᐅᑏᑦ, ᑕᕆᐅᖕᖔᕐᒧᒥᒃ ᐃᒪᖅᖅᑐᑦ ᐃᒪᕐ ᒥᐅᑕᑦ ᓇᔪᑲᑎᔭᖕᖏᓄᑦ ᐊᐅᓚᑦ ᑎᑦ ᔪᑏᑦ ᐸᕐ ᓇᐅᑎᖕᖏ. ᓇᔪᑲᑎᔭᓄᑦ ᓯᕋᐃᓃᑦ ᐅᑎᖅᑎᑕᐅᓇᓯᒃ ᑲᔭᖅᑐᑦ ᓴᓇᔭᐅᓗᑎᒃ ᓄᑖᖕᖑᔪᑦ ᓇᔪᑲᑎᔭᒃ ᓴᐅᓰᑦ ᐊᓯᐊᒍᑦ, ᐊᑐᖅᑯᔭ ᐅᓯᒪᔪᑦ ᐃᖃᓗᓕᕆᓇᑦ ᓯᕐᖁᔭ ᑎᔭ ᖕᓚᑦ.

- **ᑕᕆᐅᑉ ᐆᒪᔪᖏ** – ᓴᖅᑭᑐᐃᓐ ᓇᓇᐊᓖᑦ ᐊᒃ ᑐᐃᓃᑦ ᐱᓕᕆᔪᖅᖅᑎᓪ ᓗᒍ ᐳᐃᔾ ᓄᑦ ᐃᓚᖅᖅᐳᑦ ᐊᓯ ᐅᔾ ᓂᖕᑕ ᓇᔪᒐᕆᔾᖕ ᓂᒃ ᐱᓪ ᓗᒍ ᐅᒥᐊᔾ ᔪᐊᖅᑲᕐ ᕕᒃ ᐊᖏᕐᒥ ᐊᖅᑕᐅᓂᖕᖑ ᐸᒡ ᕕᓴ ᐃᓂᖕᖏ ᐊᓪ ᓚᓗ ᑑᓵᑦ ᑎᐊᕿᓐ ᓃᑦ ᓂᖕᖏ, ᐊᓪ ᓚᓗ ᓂᐱᓄᑦ ᐃᒃ ᐱᖕ ᓂᐊᔪᓐ ᓇᐅᑎᖕᖏ ᓯᒥᑦ ᑕᐅᓂᖕᖏ ᐅᒥᐊᑦ ᔪᐊᐸ ᓂᐱᖕᖑ ᓄᑦ ᓴᓇᔪᓕᖅᑎᔪᓄᓪ ᓗᐅᒥᐊᖅ ᔪᐊᓕᖅᑎᖁ ᕕᖕᒥᑦ (ᓄᕐ ᓗ, ᐃᖅᑲᖕᒥᓄᑦ ᑐᖖᕕᓕᐅᖅᑐᑦ), ᐊᓪ ᓚᓗ ᓴᖅᑭᑦ ᑐᓐ ᓇᖅᑐᑦ ᐃᑭᓕᖅᓯᔪᑦ ᑐᕐᑯᑦ ᑎᓃᓪ ᔫᓐ ᓃᑦ ᑕᕆᐅᑉ ᐳᐃᔾ ᖕᖏ ᓄᑦ ᐅᒥᐊᔾ ᔪᐊᓄᑦ ᐊᖅᑯᑖᒍᑦ. ᓯᕋᐃᓗᐊᖅᑕᐃᓕᒪᔾ ᔪᑏᑦ ᐃᓚᓕᐅᑎᔭ ᐅᓯᒪᕗᑦ ᑭᓴᖅᓯᒪᖕ ᕕᐊᑕᓴᓇᔭ ᐅᒪᓂᐊ ᐊᓯ ᐅᔾ ᑦ ᑕᐃᓕᒪᓕᕐ ᒥᒃ ᐃᓯᒪᓯᒪᓪ ᓗᓂᒃ ᒥᑭᓪ ᓕᕆᐊᕐᑯ ᓗᒍ ᐊᓪ ᓚᓗ/ᐅᖕ ᕝᕚᓐ ᓃᑦ ᐊᓯᕈᐃᓃᑦ ᑕᕆᐅᑉ ᐳᐃᔾ ᖕᖑ ᓇᔪᒐᖕᖏ ᓂᒃ, ᐱᖃᓯ ᐅᑎᓪ ᓗᒍ ᑎᓐ ᓂᖕᖑᐅᓕᓐ ᓂᖕᒐᓇᔪᖅᑕᐅᔪᓐ ᓇᓐ ᓂᖕᒐᑐᓕᖅᓯᒪᖕ ᕕᐅᑉ ᒥᑭᓛᖕᑎᓐ ᓇᔪᒃ ᕞᓗ. ᐸᒡ ᕕᓴ ᐃᓃᑦ ᐅᒥᐊᔾ ᔪᐊᐸ ᓂᐱᖕᖑ ᓄᑦ ᐊᒃ ᐸᓯᑭᐊᓃᑦ ᐅᒥᐊᔾ ᔪᐊᑦ ᓱᒃ ᑲᐃᓵᖅ ᓗᑎᒃ, ᐊᐅᕋᐅᔭᐅᑉ ᑲᐃᕙᑕᖕᖓᔪᖕ ᓂᖕᖓ ᓂᐱᖅᑲᓗᐊᕋ ᓗᒍᓐ ᓃᖅ ᓗᓂ. ᓂᐸᓐᓇᔭ ᓗᐊᖅᑕᐃᓕᒪᓂᕐ ᒥᒃ ᐊᑐᕋᓯᒃ ᑲᔭᓇᕗᑦ ᐅᒥᐊᔾ ᔪᐊᑦ ᒪᓕᕐᑯᔭ ᐅᓗᑎᒃ ᐊᖅᑯᓯᐊᓄᑦ ᓯᒃ ᑲᓴᕐᑯᔭ ᐅᓂᕐ ᔫᓗ ᐃᖕᖏ ᕋᑎᓕ ᓗᕆᑦ ᑭᓴᖅᓯᒪᑎᓕ ᕆᓕᓗ ᐊᐅᓚᐅᑎᖕᖏ ᓂᐱᖅᑲᓗᐃᓐ ᓇᖅᑎᑕᐅᓇᑎᒃ ᑕᑉ ᐱᑲᓂ ᖀᖕᖔᑕ ᐅᒥᐊᔾ ᔪᐊᓕᖅᑲᕐ ᕕᖕᖓ. ᑕᒃ ᑯᐊ ᐊᑐᖅᑕᕗᑦ ᐅᓄᖕᖏ ᓂᖅᓴᐅᑎᑦ ᑎᔪᓐ ᓇᖅᑐᑦ ᐅᒥᐊᔾ ᔪᐊᓄᑦ ᑐᓗᖅᑕᐅᔪᓂᒃ.

- **ᓄᓇᐅᑉ ᐊᑐᖅᑕᐅᓂᖕᖑᐊᓪ ᓚᓗ ᐊᓯᖕᖏ ᐃᓅᖃᑎᒌᑦ −ᑮ ᓇᐅᔭ ᓕᐅᕋᓯ ᐊᕈᑎᑦ ᐊᒃ ᑐᐃᓂᖕᖏ** - ᐱᓕᕆᐊᑉ ᒪᕐ ᕈᕆ ᓕᖅᑕᖕᒥᓄᑦ ᐅᒃ ᑑᑎᖕᖑᓇᓚᐅᑦ ᑖᖅᑕᖅ ᐱᑕᖅᑲᕐ ᓂᐊᕐ ᓂᖕᓂᒃ ᑕᒪ ᐃᓐ ᓂᒃ ᐱᐅᔪᓂᒃ ᐱᐅᖕᖏ ᑐᓂᑉ ᓗ ᐊᒃ ᑐᐃᓂᐅᔪᓂᒃ ᑖᒃ ᑯᓇᓂ ᓄᓇᓕᐅᔪᓂᑦ ᓇᓗᓇᐃᖅᓯᒪᔭᓂᒃ ᐱᓪ ᓗᒍ ᐃᓅᖃᑎᒌᑦ −ᑮ ᓇᐅᔭ ᓕᐅᕋᓯ ᐊᕈᑏᑦ ᐊᕙᑎᕆ ᔨᖕᖏ ᓄᑦ. ᐱᐅᓂᖕᖏ ᐊᒃ ᑐᐃᓃᑦ ᓴᓇᔾ ᑕᖅᑲᐅᓕᕈᓐ ᓇᕐ ᓂᖕᖑ ᐊᓪ ᓚ ᐱᐅᖕᖔᑐᑦ ᐱᑉ ᔪᔫᔾ ᔪᐊᖅᑐᓂᒃ ᐃᖅᑲᓇᐃᔭᖅᑎᓪ ᓚᓐ ᓂᒃ ᐱᑕᖅᑲᓕᖅ ᓂᐊᕋᓯᕆᔭᐅᔪᖅ ᐱᓕᕆᑎᓪ ᓗᕆᑦ ᐃᖅᑲᓇᐃᔭᖅᑐᓕᕆᓂᖅ ᔪᑦ. ᐱᐅᖕᖔᑐᑦ ᐊᒃ ᑐᐃᓂᖕᖏ ᓂᕆᐅᕆᔭᐅᕆᕗᑦ ᐃᓅᑉ ᖃᓄᐃᖕᖑ ᓂᐊᑕ

ᐃᓅᓯ ᖃᑦ ᑎᐊᕐ ᓂᖕᖑ ᓄᓪ ᓗ, ᐱᓗᐊᖅᑐᒥᒃ, ᓄᓇᓖᑦ ᐃᓅᖃᑎᒌᑦ ᖃᓄᐃᖕᖕᖏ ᓂᖕᖏ ᕿᒪ ᐃᓯ ᒪᓂᖕᒋᓄᑦ ᓴᓇᔭᖅᑐᖅᓯᒪᓗᑎᒃ ᓄᑦᔫᓐ ᓂ ᐱᓗᐊᖅᑐᒥᓪ ᓗ ᓄᑖᖕᖑᔪᖕ ᓂᒃ ᑮ ᓇᐅᔭ ᓕᐊᓂᒃ ᓴᖅᑮᔭ ᖏᓄᑦ ᐊᓪ ᓚᓗ ᐃᓗᐊᖕᖏᕆᐅᕈᑎᔪᑦ ᖃᖕᖓᑦ ᔫᒃ ᑯᑦ ᑎᑭᑦ ᑐᑦ/ ᐊᐅᓛᖅᑐᑦ ᐃᖅᑲᓇᐃᔭᕐ ᓂᖕᖏ ᓴᖅᑭᔫ ᖏᓄᑦ. ᐱᓕᕆᐊᑦ ᐱᓕᕆᐊᑉ ᒪᕐ ᕈᕆ ᓕᖅᑕᖕᒐ ᓄᑦ ᐅᒃ ᑑᑎᖕᖑᓄᑦ ᐱᑕᖅᑲᕐ ᓇᕐ ᓇᕗᑦ ᐱᐅᖕᖏ ᑐᒥᒃ ᐊᒃ ᑐᐃᓂᖅᑲᕐ ᓂᕐ ᒥᒃ ᐱᖅᑯᓯᖕᖏ ᑎᒍᑦ, ᓯᓇᒃ ᑯᑖᖕᖏ ᑎᒍᑦ, ᓄᓇᒥᒡ ᓗ ᐊᑐᕐ ᓂᖕᖏ ᑎᒍᑦ, ᐱᖅᑯᓯᐅᑎᓪ ᓗᒍ ᐃᓄᐃᑦ ᐃᓯᕐ ᓂᖕᖏ ᐊᑐᐃᓐ ᓇᐅᓂᖕᖏᑕᓗ ᓯᓇᒃ ᑯᑖ ᓄᓇᕐ ᑯᑎᖕᖓ ᓂ. ᐸᕝᕙ ᓛᓐ ᑯᑦ ᐱᕆ ᐊᓪ ᓚᒃ ᑲᓐ ᓂᕈᒪᕗᑦ ᕿᓂᕐ ᓂᕐ ᒥᒃ ᐃᖅᑲᓇᐃᔭᖅᑎᒃ ᓴᓂᒃ, ᐃᖅᑲᓇᐃᔭᖅᑎᓄᑦ ᓄᖅᑲᕈᑕᐅᕙ ᑯᑦ, ᐱᓪ ᒪᒃ ᓴᐃᓃᒃ ᐃᓄᖕ ᓂᒃ ᓴᓇᔭᐅᔪᓂᒃ ᐊᑐᓕᖅᑎᑦ ᑎᓗᑎᒃ ᐃᓄᐃᑦ ᐊᒃ ᑐᖅᑕᐅᓂᖕᖏᓄᑦ ᐱᕚᓕᐅᑎᖕᖏᓄᑦ ᐊᖕᖑᑎᖕᖑ ᓂᒃ (IIBA) ᓃᕐ ᓗ ᐋᖅᑭᒃ ᓯᐃᓗᑎᒃ ᐃᓅᓐ ᓄ ᐃᖅᑲᓇᐃᔭᖅᑐᓕᖅᓂᐅᑉ ᐊᑐᒐᒃ ᓴᖕ ᓂ (IHRS) ᐊᓪ ᓚᓗ ᐃᓄᖕ ᓂᒃ ᓂᐅᕕᕐ ᕕᖅᑲᕐ ᓂᒧᑦ ᑳᓐ ᑐᕋᒃ ᓂᑯᑦ ᐊᑐᖅᑕᐅᔫᒃ ᓴᓕᐊᖕᒐ(IPCS), ᐊᓪ ᓚᓗ ᑖᓐ ᓇ Q-STEP ᐱᓕᕐ ᒪᒃ ᓴᐃᓂᕐ ᒧᑦ ᐃᓕᓐ ᓂᐊᕈᑖᓂᒃ. ᐸᕝᕙ ᓛᓐ ᑯᑦ ᓴᖅᑭᑎᑦ ᑎᓯᒪᔪᕗᑦ ᐃᖅᑲᓇᐃᔭᖅᑎᓄᑦ ᐊᓪ ᓚᓗ ᐃᓕᓯᔭᖕᖏ ᓄᑦ ᐃᖅᑲᔪᖅᑕᐅᖕ ᕕᖕᒥᒃ ᐅᖃᓚᖅᑎᖅᑯᒪᒃ ᐸᑕ (EFAP) ᐃᖅᑲᓇᐃᔭᖅᑎᓪ ᓚᖕᖏᓄᑦ ᖃᓐᖏᑎᖕᖑ ᐸᖅᑭᔭᕆᔭᖕᖏ ᐃᑲᔪᖅᑕᐅᔭ ᕆᐊᓖᑦ ᖃᓐᖏᑎᒌᓄᑦ −ᐊᒃ ᑐᐊᔪᓄᑦ, ᕿᑐᖕᖑᖅᑲᐅᓯ ᕆᓂᕐ ᒧᑦ, ᐊᓯᖏᓐ ᓗ ᐃᓅᓯ ᓕᓂᔭ ᐅᓂᕐ ᒧᑦ ᐊᓪ ᓚᓗ ᐃᑲᔪᖅᑕᔭ ᕆᐊᖅᑲᕐ ᓂᕐ ᒧᑦ.

ᐃᒥᕐ ᒧᑦ ᐱᔪᓐ ᓇᐅᑎᓖᑦ

ᐊᖏᖕᖑᔪᖅ ᑕᒪᓐ ᓇ ᐱᓕᕆᐊᑉ ᒪᕐ ᕈᕆ ᓕᖅᑕᖕᒥᓄᑦ ᐅᒃ ᑑᑎᖕᖑᐱᕐ ᑯᑎᑦ ᔪᐊᖕᖏ ᐃᓂᖅᖅᑐᑦ ᐃᓄᐃᑦ ᓇᖕᒥᓂᕆᔾᖕᑕ ᓄᓇᖕᖏ ᓂᒃ. ᐸᕝᕙ ᓛᓐ ᑯᑦ ᐅᓪ ᓗᒥ ᐃᒥᕐ ᒧᑦ ᑭᖕᖑᕝ ᕕᐅᑎᒥᒃ ᐊᖕᖑᑎᖅᖅᑐᑦ ᕿᑭᖅᑕᓂ ᐃᓄᐃᑦ ᑲᑐᑦ ᔨᖅᑎᕆᖕᖏ ᓂᒃ.

ᐱᓕᕆᐊᑉ ᒪᕐ ᕈᕆ ᓕᖅᑕᖕᒥᓄᑦ ᐅᒃ ᑑᑎᖕᖑᓂᕆᔪᕆᔭᐅᖕᖏᖅ ᐊᖕᖎ ᐊᓗᖕ ᒥᒃ ᐊᒃ ᑐᐃᓂᐊᕐ ᓂᖕᖑᑰᖕ ᓂᖕᒥᓄᑦ ᐅᕝ ᕙᓘᓐ ᓃᑦ ᐱᐅᓂᖕᖑ ᐃᒥᖕᒥᓄᑦ ᑰᓃᑦ ᐃᓄᐃᑦ ᓇᖕᒥᓂᖕᖑᑕ ᓄᓇᖕᖏᓄᑦ. ᑭᓯᑐᐃᓐ ᓇᐃᑦ ᓴᖅᑭᑦ ᑐᑦ ᑕᕝ ᕙᖕᖔ ᐱᓕᕆᐊᑉ ᒪᕐ ᕈᕆ ᓕᖅᑕᖕᒥᓄᑦ ᐅᒃ ᑑᑎᖕᖑᓂᒃ ᑲᒪᒋᔭᐅᓇᔭᖅᑐᑦ ᒪᓕᒡ ᓗᒋᑦ ᐊᑐᖅᑐᖅ ᐃᒥᕐ ᒧᑦ ᑭᖕᖑᕝ ᕕᐅᑎᓄᑦ ᐊᖕᖑᑎᐊᓄᑦ.

ᐊᑐᕈᒪᔪᖕᖑ ᐱᓕᕆᐊᑉ ᒪᕐ ᕈᕆ ᓕᖅᑕᖕᒥᓄᑦ ᐅᒃ ᑑᑎᖕᖑᓄᑦ ᐅᓪ ᓗᕐᑯᑎᒃ ᓴᖕᖏ

ᕿᒥᕐ ᕈᔭᒃ ᓴᖅ 1 ᓴᖅᑮᕗᖅ ᓴᓇᔭ ᐅᓂᒃ ᓴᖕᖑ ᓄᑦ ᐅᓪ ᓗᕐᑯᑎᒃ ᓴᖕᖏ ᑖᔅ ᓯᒧᖕᖑᐱᓕᕆᐊᑉ ᒪᕐ ᕈᕆ ᓕᖅᑕᖕᒥᓄᑦ ᐅᒃ ᑑᑎᒧᑦ. ᐸᕝᕙ ᓛᓐ ᑯᑦ ᑐᕋᖕᖑ ᖃᖅᑐᑦ ᓴᓇᓯᒪᓕᐊᕐ ᓗᑎᒃ ᐃᓯ ᓕᓕᕈᓂ ᐊᕐ ᕌᒍ 2019 ᐱᓕᕆᔭ ᐅᓯᒪᓕᐊᕐ ᓗᓂᓗ ᑖᓐ ᓇ ᐅᐊᖕ ᓈᑕ ᓄᓇᓯ ᐅᑎᑯᑖᖅᑲᕐ ᕕᖕᒐ2021−ᒥ. ᓴᓇᔭ ᐅᓂᖕᒐᓂᒥᖕᖓ ᓄᓇᓯ ᐅᑎᑯᑖᖅᑲᕐ ᕕᖕᒐᐸᕐ ᓇᒃ ᑕᐅᓯᒪᕗᖅ ᐱᕆᐊᕋᔭᕐ ᔪᓂ ᐊᓪ ᓚᓗ ᑲᑎᓪ ᓗᕆᑦ ᐅᔭᕆᖕᓂᐊᖅᑕᑦ ᐊᓪ ᓚᓗ ᐅᓯ ᖃᖅᑕᖅᑲᑦ ᐊᕐ ᕌᒍᖕᖏ ᑕᕝ ᕙᓂ ᐊᓪ ᓚᓗ ᐅᔭᕆᖕᓂᐊᖅᑐᑦ ᑎᑭ ᐅᑎᕆ ᐊᓯ ᓗᑎᒃ 30 ᒥᓕᐊᓐ ᑕᓐ ᓂᒃ ᐊᕐ ᕌᒍᑕᒫᖅ ᐊᕐ ᕌᒍᐊᒍᑦ 2025. ᐅᔭᕆᖕᓂᐊᕐ ᕕᒃ ᐊᐅᓚᐃᓐ ᓇᕋᔭᖅᑐᖅ ᑎᑭᓐ ᓇᓯᓪ ᓗᒍ ᐊᕐ ᕌᒍᖕᒐ2035; ᐅᔭᕆᖕᓂᐊᕐ ᕕᐅᑉ ᐊᐅᓚᓂᒃ ᓴᖕᖑᓯᓕᑲᔪᓯᓇᔭᖅᑐᖅ

21–ᓄᑦ ᐊᕐᕌᒍᓄᑦ. ᐅᔭᕆᓐᓂᐊᕐᕕᐅᑉ ᒪᑐᔭᐅᓂᒃ ᓴᖓᐅᑎᖅᑎᑦ ᑎᓃᓪᓗ ᓄᓇᐅᑉ ᐃᓕᖅᑯᓯᖕᓄᑦ ᐱᓕᕆᓃᑦ ᑲᔪᓯᐊᕋᔭᖅᑐᑦ ᐊᕐᕌᒍᑦ ᐱᖓᓱᓄᑦ ᑭᖑᓂᐊᒍᑦ (2036 ᑎᑭᓪᓗᒍ 2038).

ᕿᒥᕐᕈᔭᒃᓴᖅ 1 ᐱᓕᕆᐊᑉ ᒪᕐᕈᕆᓕᖅᑕᖓᓄᑦ ᐅᒃ ᑑᑎᖓᐅᓪ ᓗᕐᑯᑎᒃ ᓴᖏᓐ

ᐃᓂᖓ	*2018*	*2019-2020*	*2021*	*2022-2023*	*2024*	*2025-2035*
ᐅᔭᕆᓐᓂᐊᕐ ᕕᖓᓂ	5.5 ᒥᓕᐊᓐ ᑕᓐ ᓂᒃ ᐊᕐᕌᒍᑕᒫᖅ	6 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ	12 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ	12 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ	21 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ	30 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ
ᕿᓐᖑᐊᓄᑦ ᐊᖅᑯᑖ/ᓄᓇᒃ ᑰᕈᑎᒃ ᑯᑦ	5.5 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ	6 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ	12 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ*	ᐱᑕᖃᖕᒋᑦ	ᐱᑕᖃᖕᒋᑦ	ᐱᑕᖃᖕᒋᑦ
ᐅᐊᓐ ᓇᖓᓂ ᓄᓇᓯ ᐅᑎᑯᑖᑉ ᐊᖅᑯᑖ	ᐱᑕᖃᖕᒋᑦ	ᐱᑕᖃᖕᒋᑦ	12 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ*	12 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ	12 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ	12 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ
ᓂᕆ ᐊᓂ ᓄᓇᓯ ᐅᑎᑯᑖᑉ ᐊᖅᑯᑖ	ᐱᑕᖃᖕᒋᑦ	ᐱᑕᖃᖕᒋᑦ	ᐱᑕᖃᖕᒋᑦ	ᐱᑕᖃᖕᒋᑦ	9 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ	18 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ
ᕿᓐᖑᐊᑕ ᐅᒥ ᐊᑦ ᔪᐊᓕᕆᔾ ᕕᖓ	5.5 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ	6 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ	12 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ	12 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ	12 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ	12 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ
ᓂᕆ ᖑᐃᒃ ᐱᑭᑦ ᑐᐊᑦ ᔫᑉ ᐅᒥ ᐊᑦ ᔪᐊᓕᕆᔾ ᕕᖓ	ᐱᑕᖃᖕᒋᑦ	ᐱᑕᖃᖕᒋᑦ	ᐱᑕᖃᖕᒋᑦ	ᐱᑕᖃᖕᒋᑦ	9 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ	18 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ

NA = ᐊᑑᑎᖃᖕᖏᑦᑐᖅ

* = 12 ᒥᓕᐊᓐ ᑕᓐᓄᑦ ᐊᕐᕌᒍᑕᒫᖅ ᐅᓯᒃᑲᖅᑕᖅᑕᐅᔪᑦ ᓄᓇᓯᐅᑎᒃ ᑯᑦ ᐅᔭᕋᓐᓂᐊᕐᕕᒦ ᑭᓚᒥᑕ 56–ᒧᑦ, ᓄᓇᓯᐅᑎᑰᒃ ᑯᑦ ᑭᓚᒥᑕ 56–ᒥ ᕿᓐᖑᐊᑕ ᐅᒥ ᐊᑦ ᔪᐊᓕᕆᔾ ᕕᖓᐊᕐ ᕌᒍᐊᓂ 2021

Projet de la rivière Mary – Proposition de la phase 2

Résumé de la demande de permis d'utilisation d'eau

Lieu de l'entreprise

Le Projet de la rivière Mary est une mine de minerai de fer en activité dans le nord de l'île de Baffin, dans la région de Qikiqtani, au Nunavut (figure 1). Baffinland Iron Mines Corporation (Baffinland) est le propriétaire et l'exploitant du projet. Baffinland prévoit entreprendre une expansion de son projet de la rivière Mary, appelée Proposition de la phase 2. La proposition de la phase 2 comprendra une augmentation du taux de production minière à la mine, la construction d'un chemin de fer du Nord adjacent au chemin Tote de Milne Inlet (collectivement, appelés couloir de transport du Nord) et d'autres installations de manutention du minerai au port de Milne (figure 2). Il y aura également une augmentation associée des activités d'expédition.

Pour être en mesure d'entreprendre sa proposition de la phase 2, Baffinland nécessite une modification à sa licence d'utilisation de l'eau de type A 2AM-MRY1325 (la licence : Office des eaux du Nunavut, 2015). Cette demande de modification à la licence est soumise à l'Office des eaux du Nunavut (OEN ou Office) dans le cadre d'une modification à l'Énoncé final des incidences environnementales (EIE) déposée auprès de la Commission du Nunavut chargée de l'examen des répercussions (CNER), afin que la proposition de la phase 2 puisse être évaluée conjointement par la CNER et l'OEN dans le cadre d'un processus coordonné (CNER et OEN, 2012).

Description de l'entreprise

Cela implique l'augmentation de la quantité de minerai expédiée par le port de Milne à 12 TMPA, par la construction d'un nouveau chemin de fer longeant en grande partie l'actuel chemin Tote (appelé le chemin de fer du nord; figure 2). La production totale de la mine passera à 30 TMPA, dont 12 TMPA seront transportées par le chemin de fer du nord jusqu'au port de Milne et 18 autres autorisées, transportées par le chemin de fer du sud jusqu'au port de Steensby. La construction du chemin de fer du Nord devrait débuter vers la fin de 2019. L'achèvement de la construction du chemin de fer du Nord est prévu pour 2021, avec des activités de mise en service temporaires débutant en 2020. Le transport du minerai vers le port de Milne est facilité par une combinaison de camions et de chemin de fer. L'expédition à partir du port de Milne passera également à 12 TMPA d'ici 2020. La construction du chemin de fer du sud et du port de Steensby débutera en 2021 avec une mise en service et une augmentation progressive de la production minière à 18 TMPA à partir du port de Steensby qui commencera en 2025.

La phase 2 comprend également le développement d'infrastructures additionnelles au port de Milne, y compris un second quai de minerai (figure 3). Les expéditions au port de Milne se maintiendront pendant la saison des eaux libres et pourraient se prolonger pendant les périodes où la glace de rive n'est pas utilisée pour supporter les déplacements et les récoltes des Inuits, du 1er juillet au 15 novembre environ de chaque année.

Diverses améliorations et infrastructures additionnelles seront également nécessaires sur le site minier et le long des corridors de transport nord et sud pour soutenir l'augmentation de la production et de la construction des deux lignes ferroviaires (figure 4).

Les installations associées au chemin de fer du Sud et au port de Steensby n'ont pas encore été construites. Les schémas d'IFC et les autres soumissions exigées seront soumis à l'Office conformément à l'article 10 de la partie B du permis, ce avant la construction de ces composantes du projet.

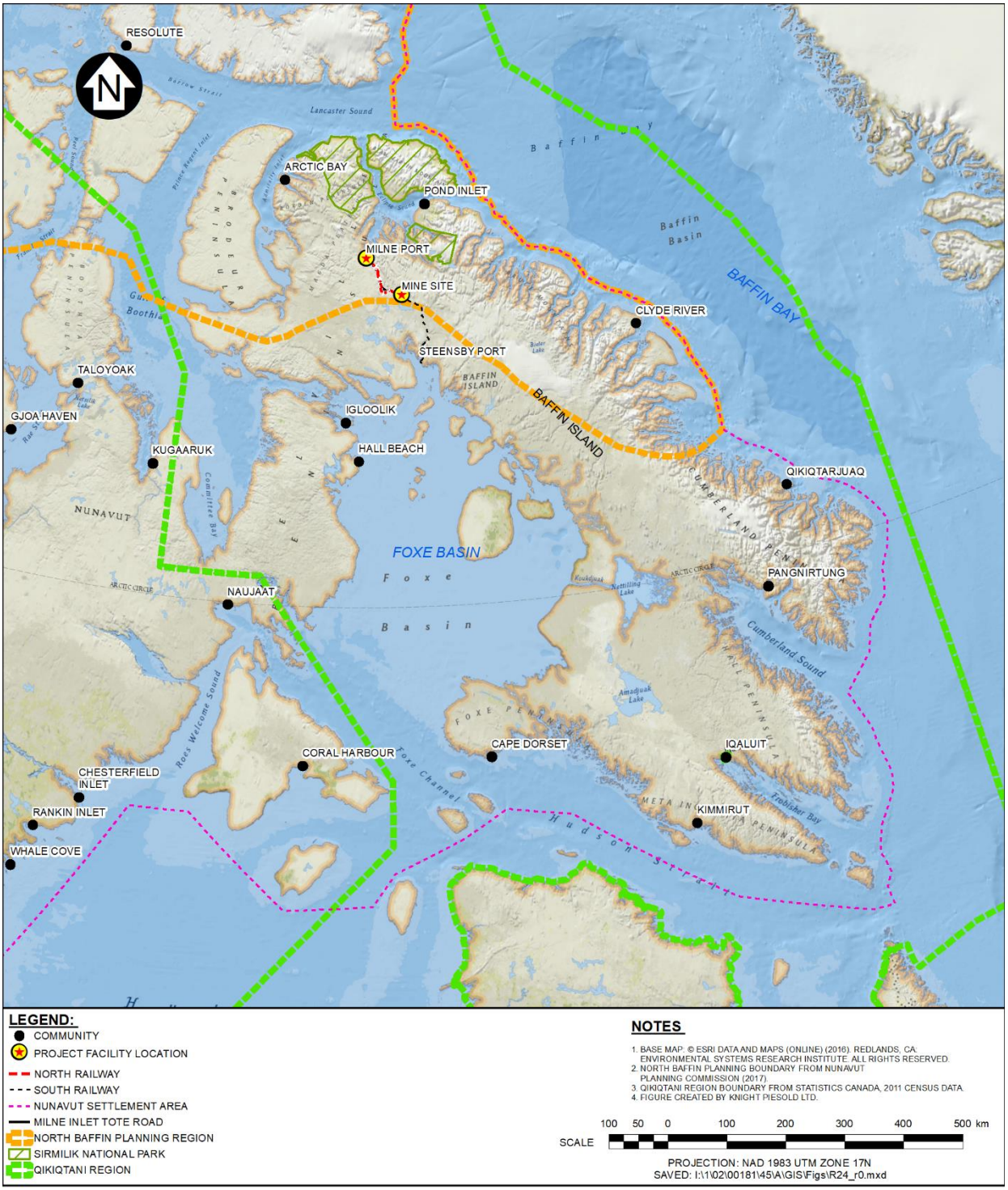


Figure 1 Carte de localisation du projet

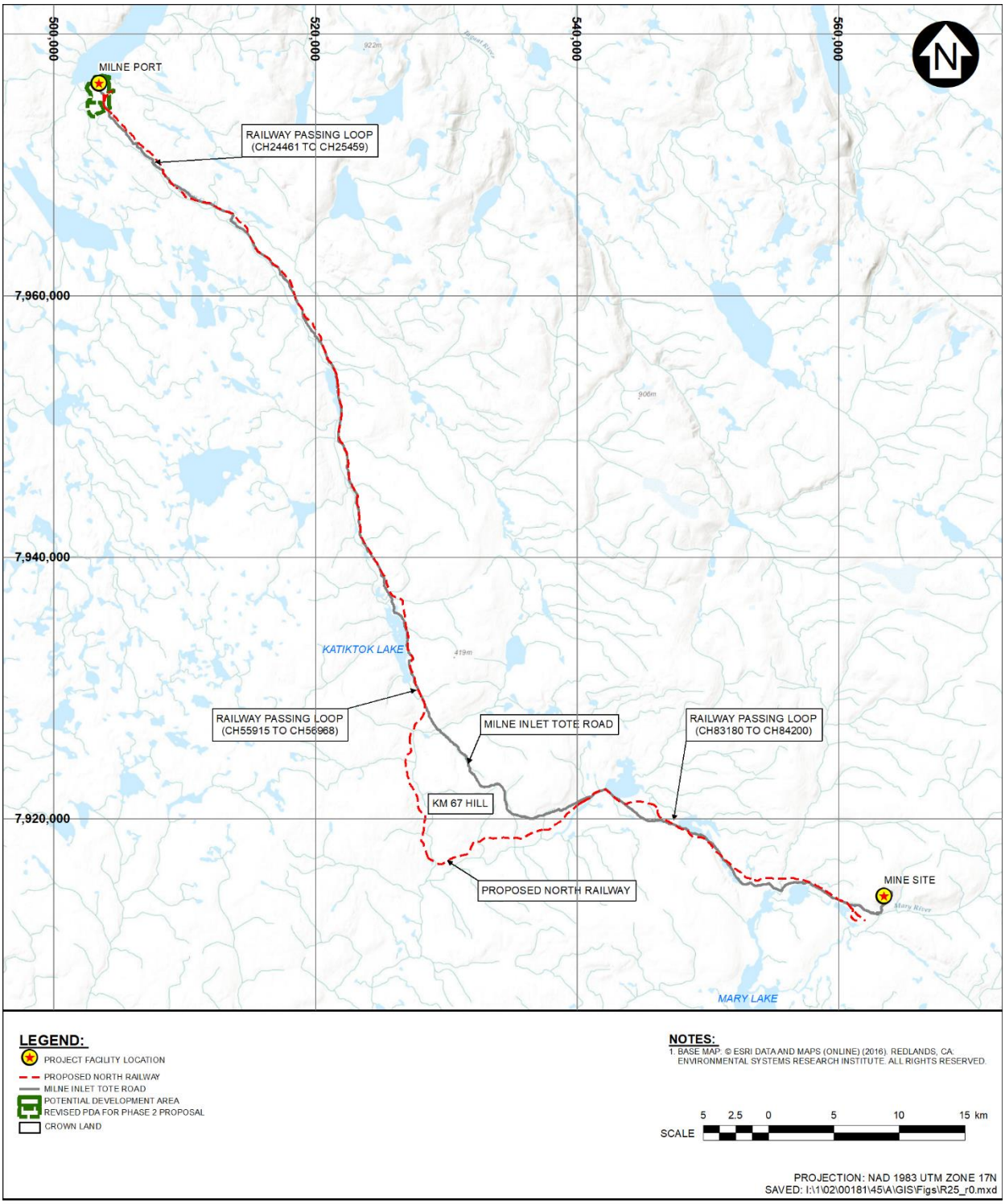


Figure 2 Zones du projet de la Proposition de la phase 2

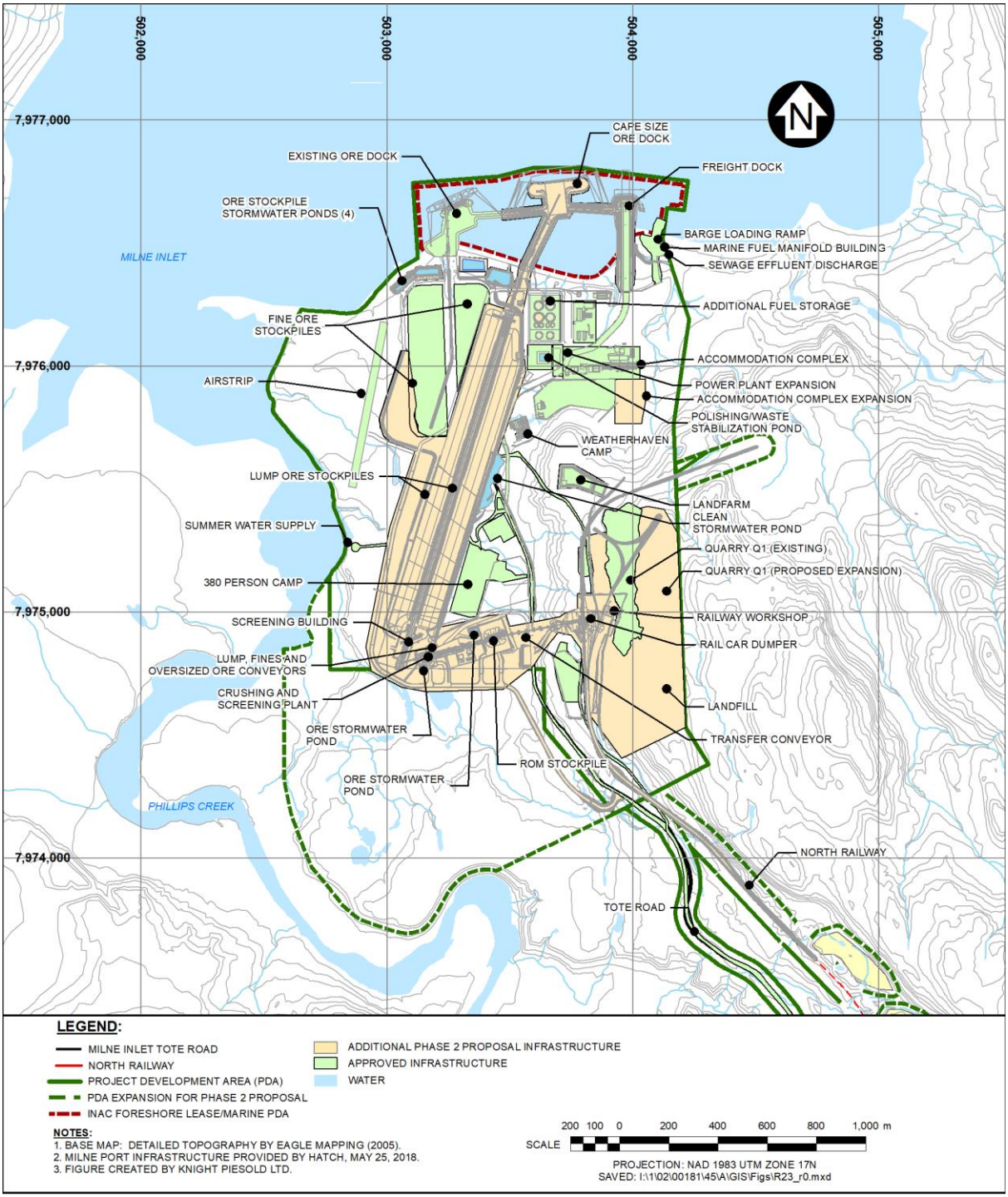


Figure 3 **Port de Milne - Présentation de la proposition de la phase 2**

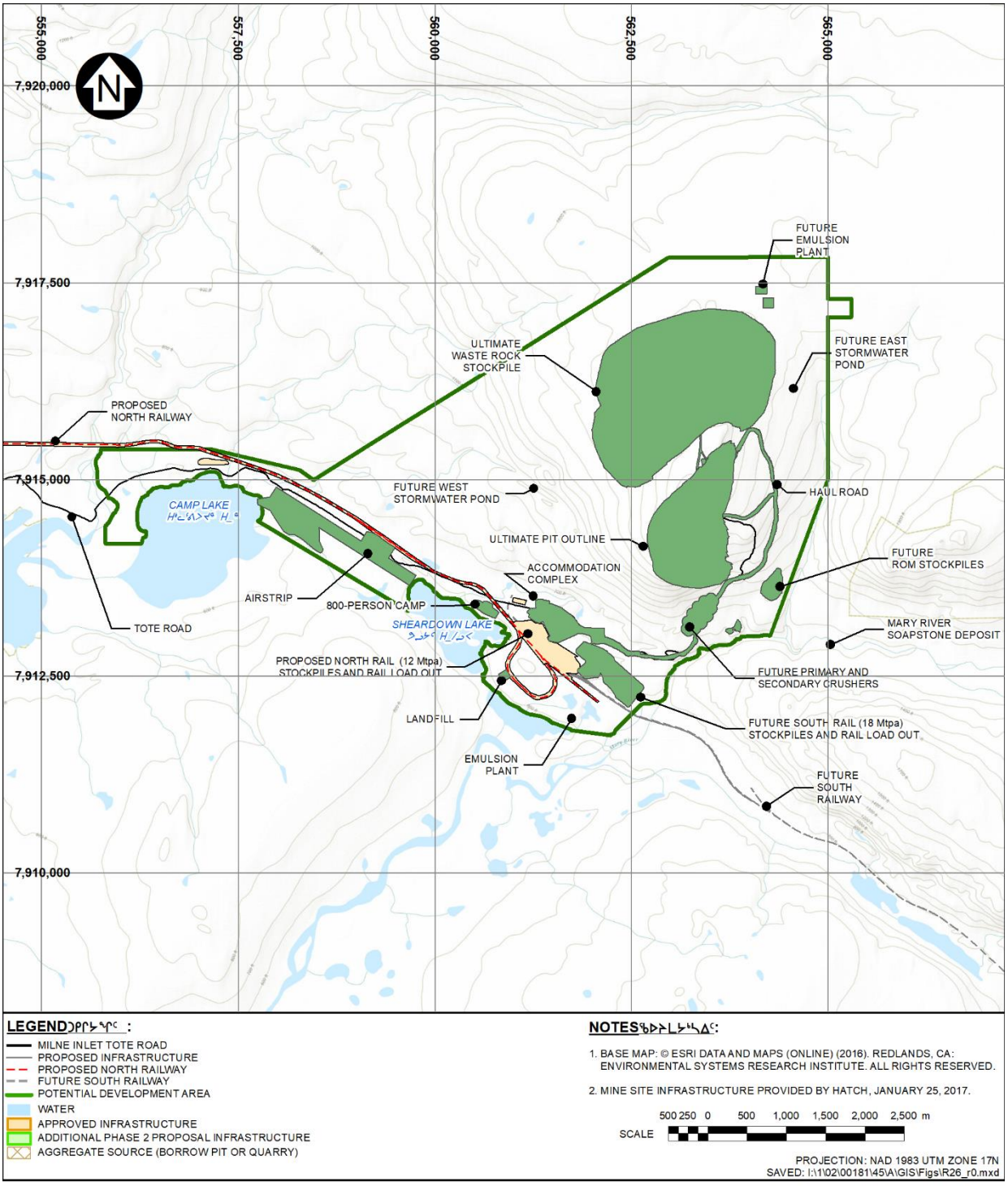


Figure 4 **Site minier - Présentation de la proposition de la phase 2**

Utilisation de l'eau

La proposition de la phase 2 n'exigera pas d'augmentation des limites quotidiennes de prélèvement d'eau pour utilisation domestique et industrielle des deux sources d'approvisionnement en eau du port de Milne (Phillips Creek en été et le lac du km 32 en hiver). Il n'y aura pas de changement à la source d'approvisionnement en eau du site minier (lac Camp). Il n'y aura aucun changement aux volumes de prélèvement d'eau à Phillips Creek et au lac Camp pour la suppression des poussières.

Le long du corridor de transport du Nord, les 12 sources d'eau de suppression des poussières (y compris Phillips Creeks et le lac Camp) continueront d'être utilisées et 13 autres sources d'eau ont été identifiées dans ce corridor pour l'élimination des poussières. Le prélèvement d'eau total quotidien pour l'élimination des poussières passe de 1500 m^3/jour auprès de 12 stations à 2 600 m^3/jour auprès de 25 stations.

Élimination des déchets

Les installations existantes de gestion et d'élimination des déchets solides continueront d'être utilisées pendant la phase 2 de la proposition, conformément au plan de gestion des déchets de Baffinland. Ce plan comprend l'utilisation des incinérateurs du port de Milne et du site minier, une décharge sur le site minier et des installations d'entreposage de déchets dangereux sur les deux sites. Ces installations existantes seront suffisantes pour soutenir la construction des infrastructures additionnelles associées à la proposition de la phase 2 (principalement le chemin de fer du Nord), y compris les camps mobiles temporaires établis le long du chemin de fer du Nord.

Les activités/infrastructures d'élimination des déchets additionnelles comprendront :

- Site d'enfouissement du port de Milne - Un site d'enfouissement sera construit dans une carrière élargie Q1 après l'achèvement des activités de construction.
- Bassins de décantation additionnels au port de Milne - Des fossés périmétriques, avec puisards, le long des tas de minerai en morceaux et deux autres bassins aux installations de déchargement ferroviaire et de concassage du port de Milne seront construits afin de gérer le ruissellement. Le point de rejet final de toutes les eaux pluviales continuera d'être l'environnement marin de Milne Inlet.
- Installations d'entassement de minerai sur le site minier et au site de chargement du chemin de fer - Le concassage secondaire sera relocalisé à l'intérieur du port de Milne; la plate-forme de concassage, le tas de minerai et le bassin de décantation existants seront modifiés et agrandis pour répondre à l'augmentation du volume de minerai destiné au port de Milne.
- Zone de transfert temporaire du minerai - La proposition de la phase 2 comprendra l'établissement d'une zone de transfert temporaire du minerai au km 56,8, qui sera utilisée pendant un à deux ans pendant la phase de construction. Le chemin de fer du nord du port de Milne, au km 56,8, sera mis en service tôt et les camions de transport livreront jusqu'à 12 TMPA de minerai à la zone de transfert du minerai qui sera chargée dans le chemin de fer pour être livrée au port de Milne. Les eaux de ruissellement provenant des tas temporaires seront collectées dans un bassin de décantation. Le bassin de décantation sera vidé à l'aide d'un camion aspirateur et le contenu sera transféré dans les bassins de décantation du port de Milne.

Autres personnes ou biens affectés par l'entreprise

Personne n'occupe la zone générale, bien que la zone ait été et continue d'être utilisée par les communautés locales, principalement Pond Inlet. Baffinland a tenu de nombreuses réunions publiques et ateliers communautaires avec les cinq collectivités potentiellement touchées du nord de Baffin, Arctic Bay, Clyde River, Hall Beach, Igloolik et Pond Inlet depuis l'annonce de la proposition de la phase 2, en octobre 2014.

Impacts environnementaux prévus de l'entreprise et mesures d'atténuation proposées

La proposition de la phase 2 permettra d'augmenter le taux de production maximal au site minier, de construire et d'exploiter le chemin de fer du Nord, de construire et d'exploiter un deuxième quai au port de Milne et d'augmenter la navigation en eau libre au port de Milne de manière à prolonger la saison intermédiaire dans quelques années.

Aucune des activités présentées dans la proposition de la phase 2 n'est nouvelle et, à ce titre, bon nombre des mesures d'atténuation mises en œuvre pour le projet approuvé et décrites dans les plans de gestion de Baffinland demeurent pertinentes. Les effets différentiels de la proposition de la phase 2 sont résumés ci-dessous :

- **Changement climatique** - La mise en œuvre de la proposition de la phase 2 réduira d'environ 10 % la durée de vie des émissions de GES de la mine par rapport au projet approuvé.
- **Qualité de l'air** - Malgré une augmentation du taux de production sur le site minier, passant de 22,2 TMPA à 30 TMPA, les émissions de particules et les dépôts de poussière seront globalement réduits. Cela est dû à la mise en place de mesures d'atténuation additionnelles associées au déplacement des activités de broyage secondaire à l'intérieur du port. Les émissions de particules et les dépôts de poussière le long du corridor de transport du Nord augmenteront temporairement pendant la construction en raison du transport du minerai à un taux accru (de 6 à 12 TMPA) parallèlement à la construction du chemin de fer. Après la phase de construction, les émissions de poussière seront considérablement réduites par l'utilisation du chemin de fer pour transporter le minerai jusqu'au port. Les concentrations de contaminants nuisant à la qualité de l'air au port de Milne augmenteront, mais pas de manière significative.
- **Bruit** - Les niveaux de bruit augmenteront temporairement sur tous les sites du projet pendant la phase de construction et demeureront légèrement supérieurs aux niveaux du projet approuvé pendant la phase d'exploitation.
- **Reliefs, sol et pergélisol** - La construction du chemin de fer du Nord aura des effets mineurs sur les reliefs importants par la traversée d'un esker. La construction des chemins de fer pourrait perturber les conditions du pergélisol; leur conception comprend par conséquent un certain nombre de mesures d'atténuation visant à minimiser ces effets et les conséquences de l'instabilité du sol sur le chemin de fer.
- **Eaux de surface** – La proposition de la phase 2 entraînera des changements mineurs à la quantité d'eau (débit) résultant de la construction du chemin de fer et de l'installation de dérivations de cours d'eau. Ces effets ont été examinés et, dans les endroits où des augmentations significatives du débit se produiront (principalement en détournant la partie amont d'un cours d'eau touché par une coupe de roche dans un cours d'eau adjacent), des mesures d'atténuation telles que l'amélioration des chenaux ou l'armement des rives seront

prises pour s'assurer que le flux de réception peut gérer les flux accrus. Aucun changement au plan de la mine ou au plan d'élimination des stériles n'aura lieu à la suite de la proposition de la phase 2. Les effets de l'augmentation des dépôts de poussière au port de Milne sur la qualité de l'eau ont été jugés non significatifs. Les autres impacts prévus sur la qualité de l'eau, tels que la construction du chemin de fer et l'installation de passages, seront gérés au moyen de mesures d'atténuation normales (c.-à-d. des mesures de contrôle des sédiments et de l'érosion) décrites dans les plans de gestion actuels de Baffinland.

- **Biote d'eau douce** - Le chemin de fer nécessitera l'installation d'un grand nombre de ponceaux et de ponts dans les cours d'eau, le remplissage des cours d'eau touchés par les coupes de roche et l'empiétement sur plusieurs étangs ou petits lacs. Une partie de ces interactions se produiront dans des eaux où vivent des poissons. Le chemin de fer a été aménagé de manière à minimiser les impacts sur le poisson et son habitat. D'autres mesures d'atténuation normales ont été identifiées pour minimiser les impacts, et un plan de compensation a été développé pour compenser les dommages sérieux à l'habitat du poisson. Baffinland demandera une autorisation en vertu de la Loi sur les pêches de Pêches et Océans Canada.
- **Végétation** - La proposition de la phase 2 comprend une expansion au port de Milne et la création du chemin de fer du Nord, entraînant une perte supplémentaire d'habitat terrestre. Cependant, la superficie totale affectée n'est qu'une petite proportion de l'habitat disponible et des activités seront planifiées et menées pour réduire l'empreinte de la proposition de la phase 2 au strict minimum. Les changements à la végétation ayant une valeur culturelle à la suite de la proposition de la phase 2 devraient être négligeables, car l'abondance des espèces indicatrices (bleuets) est très faible dans la région. Les émissions de poussières fugitives dues au transport de minerai augmenteront temporairement le long du chemin Tote pendant la construction, mais une fois le chemin de fer du Nord opérationnel, le niveau de circulation diminuera considérablement par rapport à l'exploitation et à la construction actuelles, tout comme les émissions de poussières fugitives le long de la route.
- **Faune terrestre** - Les activités de construction, d'exploitation et de fermeture de la proposition de la phase 2 pourraient avoir une incidence sur la répartition et l'abondance de la faune dans la ZER. L'habitat peut être affecté par une perte directe dans l'empreinte de la proposition de la phase 2 ou par une perte indirecte causée par les activités du projet qui créent des perturbations sensorielles qui réduisent l'efficacité (l'utilité) des habitats adjacents. Les schémas de mouvement traditionnels peuvent être modifiés par l'infrastructure ou les activités liées à la proposition de la phase 2 qui agissent comme une barrière ou un filtre au mouvement. La mortalité de la faune peut augmenter directement, à la suite de collisions, ou indirectement, en raison d'un accès accru au prélèvement. De plus, les effluents, les poussières et les émissions atmosphériques rejetés dans l'environnement peuvent être absorbés, ingérés ou inhalés par la faune, ce qui peut avoir une incidence sur la santé de chaque animal et, par conséquent, sur l'abondance de la faune. Baffinland a mis en œuvre une politique sur la faune à l'échelle du Projet qui a permis d'éviter toute mortalité directe du caribou.
- **Milieu marin** - L'empreinte élargie du projet dans le milieu marin entraînera la perte potentielle de l'habitat productif du poisson. D'autres impacts potentiels du projet sur la qualité des eaux de mer et des sédiments marins, l'habitat du poisson marin et la santé des ombles chevaliers pourraient résulter de la construction de ports, du trafic maritime, des eaux de ballast, lesquelles pourraient introduire des espèces envahissantes dans le milieu marin, de la décharge

d'eaux usées, du dépôt de minerai et du bruit sous-marin. Les mesures d'atténuation proposées pour contrer de tels impacts comprennent la mise en œuvre de plans de gestion, tels que le plan de gestion de la navigation et de la faune, d'un plan d'intervention d'urgence et de lutte contre les déversements, de plans de protection et de surveillance de l'environnement et d'un plan de gestion des eaux de surface et aquatiques. La perte d'habitat sera compensée par la création d'un nouvel habitat, comme l'exige la Loi sur les pêches.

- **Faune marine** – Les effets du projet reportés dans l'évaluation comprennent la perte d'habitat due à l'expansion des installations portuaires, les perturbations, la déficience auditive et le masquage auditif du bruit sous-marin généré par la navigation et la construction portuaire (c.-à-d. battage de pieux) ainsi que les blessures ou la mortalité potentielles des mammifères marins causées par les collisions avec les navires le long du corridor de navigation. Des mesures d'atténuation ont été incorporées dans la conception des quais pour réduire la perte et/ou l'altération de l'habitat des mammifères marins, y compris la réduction de l'empreinte infratidale du quai. Les effets de perturbations causées par le bruit des navires seront réduits grâce à la réduction de la vitesse du navire, ce qui réduit le bruit global produit par la propulsion du navire. Le bruit sera également réduit en obligeant les navires à maintenir un cap et une vitesse constants lorsqu'ils sont en transit et à réduire la marche au ralenti lorsqu'ils sont amarrés au port de Milne. Ces mesures aideront également à réduire les collisions avec les navires.
- **Utilisation des terres et autres impacts socio-économiques** - On prévoit que la proposition de la phase 2 aura des impacts positifs et négatifs sur les collectivités de la ZEL en ce qui concerne l'environnement socio-économique. Des impacts résiduels positifs sur la capacité de la population active et des impacts résiduels négatifs sur la concurrence pour les travailleurs qualifiés devraient découler des possibilités d'emploi du Projet. Des impacts négatifs ont également été prévus pour la santé et le bien-être, en particulier la stabilité sociale de la communauté due à l'absence de la communauté pendant la rotation de travail, découlant principalement des nouveaux revenus générés par le projet apporte et des défis que pose l'emploi de type volant. Les activités associées à la proposition de la phase 2 peuvent avoir des impacts négatifs sur la culture, les ressources et l'utilisation des terres, y compris l'accès et la disponibilité des ressources et des terres pour les Inuits. Baffinland cherche à accroître ses efforts de recrutement, de maintien en poste et de formation de sa main-d'œuvre inuite en appliquant les dispositions de l'Entente sur les répercussions et les avantages pour les Inuit (ERAI), notamment l'élaboration d'une stratégie de ressources humaines inuites (SRHI) et la mise en œuvre du programme de formation Q-STEP. Baffinland a mis en place un programme d'aide aux employés et aux familles (PAEF) pour les employés permanents et les personnes à leur charge qui peuvent avoir besoin de services de soutien et d'aide personnels liés à la famille et à l'éducation des enfants ou autres formes.

Droits à l'eau

La majeure partie de l'infrastructure de la proposition de la phase 2 est située dans des terres inuites. Baffinland a conclu une entente d'indemnisation pour l'eau avec la Qikiqtani Inuit Association.

La proposition de la phase 2 ne devrait pas avoir d'incidence importante sur le débit ou la qualité de l'eau qui traverse les terres inuites. Toute réclamation qui pourrait découler de la proposition de la phase 2 sera assujettie à l'entente d'indemnisation en matière d'eau existante.

Calendrier avancé pour la proposition de la phase 2

Le tableau 1 présente le calendrier de développement de la proposition de la phase 2. Baffinland vise à lancer la construction à la fin de 2019, et vise à commencer à exploiter le chemin de fer du Nord en 2021. La construction du chemin de fer du Sud est prévue de commencer la même année; l'exploitation et le transport du minerai de fer atteindront un volume de 30 TMPA d'ici 2025. La mine fonctionnera jusqu'en 2035; la durée d'exploitation prévue de la mine demeure toujours 21 ans. Les activités de fermeture et de remise en état des mines seront entreprises dans les trois années qui suivront (de 2036 à 2038).

Tableau 1 Calendrier de la proposition de la phase 2

Région	***2018***	***2019-2020***	***2021***	***2022-2023***	***2024***	***2025-2035***
Mine	5,5 TMPA	6 TMPA	12 TMPA	12 TMPA	21 TMPA	30 TMPA
Chemin Tote/camionnage	5,5 TMPA	6 TMPA	12 TMPA*	S. o.	S. o.	S. o.
Chemin de fer du Nord	S. o.	S. o.	12 TMPA*	12 TMPA	12 TMPA	12 TMPA
Chemin de fer du Sud	S. o.	S. o.	S. o.	S. o.	9 TMPA	18 TMPA
Port de Milne	5,5 TMPA	6 TMPA	12 TMPA	12 TMPA	12 TMPA	12 TMPA
Chemin de fer du Sud/port de Steensby	S. o.	S. o.	S. o.	S. o.	9 TMPA	18 TMPA

S. o. = Sans objet

* = 12 TMPA transportées par camion du site minier au km 56 et par rail du km 56 au port de Milne en 2021

ATTACHMENT 2

APPLICATION FOR WATER LICENCE AMENDMENT

Application for Water Licence Amendment

Document Date: April 2013

Application Submission Date: _____
Month/Day/Year

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OFFICE DES EAUX DU NUNAVUT

DOCUMENT MANAGEMENT

Original Document Date: April 2010

DOCUMENT AMENDMENTS

	Description	Date
(1)	Updated for public distribution as separate document from NWB Guide 7	June 2010
(2)	Updated NWB logos and reformatted table to allow rows to break across page	May 2011
(3)	New NWB logo; request for background information; and change to Block 24	April 2013
(4)		
(5)		
(6)		
(7)		
(8)		
(9)		
(10)		

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OFFICE DES EAUX DU NUNAVUT

APPLICATION FOR WATER LICENCE AMENDMENT

The applicant is referred to the NWB's Guide 7: *Licensee Requirements Following the Issuance of a Water Licence* for more information about this application form.

Where possible, provide background information regarding the original licence application or attach previously submitted information.

EXISTING LICENCE NO: 2AM-MRY1325

1. LICENSEE CONTACT INFORMATION

Is the licensee the same as that referred to on the existing licence?

X Yes ☐ No

If No, a licence assignment must be completed and approved by the NWB. **An amendment will only be issued in the name of the current licensee in the absence of assignment of the licence.**

If the licensee is the same, but the name of the licensee has changed, attach a certificate of name change.

Name:

Address:

Phone: _____
Fax: _____
e-mail: _____

2. LICENSEE REPRESENTATIVE CONTACT INFORMATION – If different from Block 1.

Name:

Address:

Phone: _____
Fax: _____
e-mail: _____

(Attach authorization letter.)

3. NAME OF PROJECT

Has the name of the project changed?

☐ Yes X No

If Yes, indicate the name of the project including the name of the location: _____

4. LOCATION OF UNDERTAKING

Does the proposed amendment change the location of the amended undertaking?

☐ Yes X No

Provide the project extents and camp locations. Identify proposed changes.

Project Extents

NW:	Latitude: (° ’ ” N)	Longitude: (° ’ ” W)
NE:	Latitude: (° ’ ” N)	Longitude: (° ’ ” W)
SE:	Latitude: (° ’ ” N)	Longitude: (° ’ ” W)
SW:	Latitude: (° ’ ” N)	Longitude: (° ’ ” W)

Camp Location(s)

Latitude: (° ’ ” N) Longitude: (° ’ ” W)

5. MAP

Does the proposed amendment change the locations of any of the main components of the undertaking?

☐ Yes X No

Attach a topographical map, indicating the main components of the undertaking. Identify proposed changes.

NTS Map Sheet No.: _____ Map Name: _____ Map Scale: _____

6. NATURE OF INTEREST IN THE LAND

Does the proposed amendment change the nature of the interest in the land?

☐ Yes X No

If Yes, indicate changes. _____

Check any of the following that are applicable to the proposed undertaking (at least one box under the 'Surface' header must be checked).

Sub-surface

☐ Mineral Lease from Nunavut Tunngavik Incorporated (NTI)
Date (expected date) of issuance: _____ Date of expiry: _____

☐ Mineral Lease from Indian and Northern Affairs Canada (INAC)
Date (expected date) of issuance: _____ Date of expiry: _____

Surface

X Crown Land Use Authorization from Indian and Northern Affairs Canada (INAC)
Date (expected date) of issuance: _June 2019___ Date of expiry: _Renew N2014C0013____

☐ Inuit Owned Land (IOL) Authorization from Kitikmeot Inuit Association (KIA)
Date (expected date) of issuance: _____ Date of expiry: _____

☐ IOL Authorization from Kivalliq Inuit Association (KivIA)
Date (expected date) of issuance: _____ Date of expiry: _____

X IOL Authorization from Qikiqtani Inuit Association (QIA)
Date (expected date) of issuance: _2019_____ Date of expiry: _Amend Lease Q13C301__

☐ Commissioner's Land Use Authorization
Date (expected date) of issuance: _____ Date of expiry: _____

☐ Other _____

Date (expected date) of issuance: _____ Date of expiry: _____

Is the name of the entity(s) holding authorizations the same as that considered in the existing water licence?

X Yes ☐ No

If No, a licence assignment must be completed and approved by the NWB.

Name of entity(s) holding authorizations:
_____

7. NUNAVUT PLANNING COMMISSION (NPC) DETERMINATION

Indicate the land use planning area in which the existing project is located.

- [X] North Baffin
- [ ] South Baffin
- [ ] Akunniq
- [ ] Keewatin
- [ ] Sanikiluaq
- [ ] West Kitikmeot

Does the proposed amendment change the land use planning area?

[ ] Yes [X] No

If yes, indicate the land use planning area in which the amended undertaking is located.

- [ ] North Baffin
- [ ] South Baffin
- [ ] Akunniq
- [ ] Keewatin
- [ ] Sanikiluaq
- [ ] West Kitikmeot

Was a land use plan conformity determination required from NPC prior to the issuance of the existing water licence?

[X] Yes [ ] No

If Yes, indicate date issued and attach copy. _____

Does the proposed amendment change the original NPC conformity determination or the need to obtain one?

[ ] Yes [X] No

If Yes, indicate date issued (or expected) and attach a copy. _____
If No, provide written confirmation from NPC confirming that a land use plan conformity review is not required.

8. NUNAVUT IMPACT REVIEW BOARD (NIRB) DETERMINATION

Was a screening determination required from NIRB prior to the issuance of the existing water licence?

[X] Yes [ ] No

If Yes, indicate date issued and attach copy. _____

Does the proposed amendment change the original NIRB screening determination or the need to obtain one?

[X] Yes [ ] No

If Yes, indicate date issued (or expected) and attach a copy. __2019 through coordinated NIRB/NWB Review of Phase 2 Proposal
If No, provide written confirmation from NIRB confirming that a screening determination is not required.

9. DESCRIPTION OF UNDERTAKING

Does the proposed amendment change the description of the undertaking?

☐ Yes X No

List and attach plans and drawings or project proposal. Identify proposed changes.

10. OPTIONS

Does the proposed amendment change any of the alternative methods and locations that were considered to carry out the project?

☐ Yes X No

Provide a brief explanation of the alternative methods or locations that were considered to carry out the project. Identify proposed changes.

All following changes have been proposed under the Amendment No. 2 to the Final Environmental Impact Statement (FEIS Amendment No. 2).

Milne Port
-modifications to site drainage and surface water management
-additional oily water treatment facilities within the proposed rail maintenance facility
-new landfill proposed at Milne Port
-run-off management to include expanded ore crushing pads and stockpiling areas
-expansion of existing ore-stockpiling and related facilities
-construction and operation of a second ore dock

Mine Site
-two additional 15 ML fuel tanks added to the Mine Site tank farm
-run-off management to include expanded ore crushing pads and stockpiling areas

North Rail and Tote Road
-additional railway crossings including bridges, bank alterations, culverts, and erosion control
-minor realignments along the Tote Road, requiring additional culverts
-additional water sources for dust suppression

See the Supplemental Information provided in Appendix D of TSD-2 of the FEIS Addendum for the Phase 2 Proposal.

11. CLASSIFICATION OF PRIMARY UNDERTAKING

Indicate the primary classification of undertaking for the existing licence by checking one of the following boxes:

- ☐ Industrial
- ☐ Agricultural
- X Mining and Milling (includes exploration/drilling/exploration camps)
- ☐ Conservation
- ☐ Municipal (includes camps/lodges)
- ☐ Recreational
- ☐ Power
- ☐ Miscellaneous (describe below): _____

Does the proposed amendment change the classification of primary undertaking?

☐ Yes X No

If Yes, indicate the primary undertaking of the amendment:_____

Information in accordance with applicable Supplemental Information Guidelines (SIG) must be updated and submitted with an Application for Amendment. Indicate which SIG(s) are applicable to your application.

- ☐ Hydrostatic Testing
- ☐ Tannery
- ☐ Tourist / Remote Camp
- ☐ Landfarm & On-Site Storage of Hydrocarbon Contaminated Soil
- ☐ Onshore Oil and Gas Exploration Drilling
- ☐ Mineral Exploration / Remote Camp
- ☐ Advanced Exploration
- X Mine Development
- ☐ Municipal
- X General Water Works
- ☐ Power

12. WATER USE

Indicate, using the boxes below, the types of water use(s) approved in the existing licence.

- X To obtain water for camp/ municipal purposes
- X To obtain water for industrial purposes
- X To divert a watercourse
- X To cross a watercourse
- X To modify the bed or bank of a watercourse
- X To alter the flow of, or store water
- ☐ Flood control
- ☐ Other: _____

Does the proposed amendment change the type(s) of water use(s)?

☐ Yes X No

If Yes, indicate using the boxes below, the proposed change(s) to the type(s) of water use(s) noting any water use(s) that are to be added, continued, or removed.

- ☐ To obtain water for camp/ municipal purposes
- ☐ To obtain water for industrial purposes
- ☐ To divert a watercourse
- ☐ To cross a watercourse
- ☐ To modify the bed or bank of a watercourse
- ☐ To alter the flow of, or store water
- ☐ Flood control
- ☐ Other: _____

13. QUANTITY OF WATER INVOLVED

Does the proposed amendment change the source of water? X Yes ☐ No

Indicate the water source(s). Identify proposed changes:
13 additional proposed water sources along the tote road. See supplemental information in TSD-2, Appendix D.

(show location(s) on map)

Does the proposed amendment change the quality of the water source and/or its available capacity?

☐ Yes X No

No changes to the quality or available capacity of any water sources will occur.

Does the proposed amendment change the overall quantity of water to be used?

X Yes ☐ No

Provide the overall estimated quantity to be used. Identify proposed changes: Increase dust suppression water use by 1100 m^3/day (from 1,500 m^3/day to 2,600 m^3/day).

Does the proposed amendment change the quantity of water to be used from each source?

X Yes ☐ No

Provide the estimated quantity(s) of water to be used from each source. Identify proposed changes. :
Additional water required from previously approved sources:
CV078 – an additional 15 m^3/day is required
BG50 – an additional 60 m^3/day is required
BG32 – an additional 60 m^3/day is required

See supplemental information in TSD-2, Appendix D.

Does the proposed amendment change the quantity of water to be used for each purpose?

X Yes ☐ No

Provide the estimated quantities to be used for each purpose (camp, drilling, etc.). Identify proposed changes.:
Increased dust suppression efforts along the Tote Road and the railway construction right-of-way will require an additional 1100m^3 of water per day.

Does the proposed amendment change the method(s) of extraction? ☐ Yes X No

Describe the method(s) of extraction. Identify proposed changes. :_____

Does the proposed amendment change the quantity(s) of water returned to source(s)?

☐ Yes X No

Estimated quantity(s) of water returned to source(s). Identify proposed changes. : _____ m^3/day

Does the proposed amendment change the quality(s) of water returned to source(s)?

☐ Yes X No

Describe the quality(s) of water(s) returned to source(s). Identify any changes. : _____
_____

14. WASTE

Check the appropriate box(s) to indicate the types of waste(s) approved in the existing licence.

X Sewage
X Solid Waste
X Hazardous
X Bulky Items/Scrap Metal
☐ Animal Waste
☐ Other (describe):_____

X Waste oil
X Greywater
X Sludges
X Contaminated soil and/or water

Does the proposed amendment change the type(s) of waste(s) to be generated or deposited?

☐ Yes X No

If Yes, indicate using the boxes below, the proposed change(s) to the type(s) of waste(s) to be generated and/or deposited noting the addition, removal or continued generation and/or disposal of waste(s).

☐ Sewage
☐ Solid Waste
☐ Hazardous
☐ Bulky Items/Scrap Metal
☐ Animal Waste
☐ Other (describe):_____

☐ Waste oil
☐ Greywater
☐ Sludges
☐ Contaminated soil and/or water

15. QUANTITY AND QUALITY OF WASTE INVOLVED

Does the proposed amendment change the quantity(s) of the types of wastes involved?

X Yes ☐ No

Does the proposed amendment change the composition(s) of the types of wastes involved?

☐ Yes X No

Does the proposed amendment change the method(s) of treatment for the types of waste involved?

☐ Yes X No

Does the proposed amendment change the method(s) of disposal for the types of waste involved?

☐ Yes X No

If Yes to any of the above, describe the proposed changes: The quantity of waste to be generated will

increase. Construction activities, and increased trafficking of ore will result in increased quantities of waste oil and bulky scrap material. However, management and disposal methods will remain unchanged.

For each type of waste indicated in Block 14, describe its composition, quantity in cubic meters/day, method of treatment and method of disposal.

The revised quantities of waste are provided below.

Type of Waste	Composition	Quantity Generated	Treatment Method	Disposal Method
Sewage	Sewage Waste	676.5 m^3/day	Treated in Sewage Treatment Plant	Discharge at current effluent discharge point
Solid Waste	Large bulk items, plastic. non-combustible non-hazardous waste	41.1 m^3/day	Landfill	Landfill
Solid Waste	Combustible Waste, food, rags	6.2 m^3/day	Incineration	Incineration
Hazardous Waste	Paint, aerosol cans, oils, grease	2.1 m^3/day	Storage in lined facility	Shipped off Site and disposed at licenced facility

16. OTHER AUTHORIZATIONS

Does the proposed amendment change the need for other authorizations in addition to the sub-surface and surface land use authorizations provided in Block 6?

X Yes ☐ No

If Yes, indicate any additional authorizations required, which authorizations are no longer required, and which authorizations continue to be required.

For each provide the following:

Authorization: ____IOL Commercial Lease – will need to be amended for the Phase 2 Proposal_____

Administering Agency: _Qikiqtani Inuit Association_____

Project Activity: __Construction of the North Railway; possibly other changes within Commercial Lease Boundary
Date (expected date) of issuance: __2019_____ Date of expiry: _TBD_____

17. PREDICTED ENVIRONMENTAL IMPACTS OF UNDERTAKING AND PROPOSED MITIGATION MEASURES

Does the proposed amendment change the predicted environmental impacts of the undertaking or the mitigation measures?

☐ Yes X No

Describe direct, indirect, and cumulative impacts related to water and waste. Identify any changes.
See FEIS Addendum for the Phase 2 Proposal.

18. WATER RIGHTS OF EXISTING AND OTHER WATER USERS

Was compensation paid and/or an agreement(s) for compensation been entered into with any existing or other users of water during consideration of the existing licence?

X Yes ☐ No

Baffinland has a Water Compensation Agreement in place with the Qikiqtani Inuit Association.

If Yes, provide the names, addresses and the nature of water use by those persons or properties.

Does the proposed amendment adversely affect any known persons or property including those that hold licences for water use in precedence to the application, domestic users, in-stream users, authorized waste depositors, owners of property, occupiers of property, and/or holders of outfitting concessions, registered trapline holders, and holders of other rights of a similar nature?

☐ Yes X No

If Yes, provide the names, addresses and the nature of water use of those persons or properties.

Advise the Board if compensation has been paid and/or an agreement(s) for compensation has been reached with any existing or other water users with respect to the proposed amendment.

Baffinland has a Water Compensation Agreement in place with the Qikiqtani Inuit Association.

19. INUIT WATER RIGHTS

Was compensation paid/ or an agreement(s) for compensation been entered into with any Designated Inuit Organization (DIO) during consideration of the existing licence?

X Yes ☐ No

If Yes, which DIO(s): Qikiktani Inuit Association (QIA)

Does the proposed amendment substantially affect the quality, quantity or flow of waters flowing through Inuit Owned Land (IOL)?

☐ Yes X No

If Yes, advise the Board if negotiations have commenced or an agreement to pay compensation for any loss or damage has been reached with one or more DIO(s) with respect to the proposed amendment.

20. CONSULTATION - Provide a summary of any consultation meetings including when the meetings were held, where and with whom. Include a list of concerns expressed and measures to address concerns.

Summary of public consultation presented in the FEIS Addendum for the Phase 2 Proposal.

21. SECURITY INFORMATION

Does the proposed amendment change the financial security assessment?

X Yes ☐ No

Does the proposed amendment change the estimate of the total financial security for final reclamation?

X Yes ☐ No

Provide an estimate of the total financial security for final reclamation equal to the total outstanding reclamation liability for land and water combined sufficient to cover the highest liability over the life of the undertaking. Estimates of reclamation costs must be based on the cost of having the necessary reclamation work done by a third party contractor if the operator defaults. The estimate must also include contingency factors appropriate to the particular work to be undertaken. Identify any changes in the financial security assessment resulting from the proposed amendment.

An updated reclamation cost estimate to be submitted to the NWB and the QIA as part of the annual security review.

Where applicable, the financial security assessment should be prepared in a manner consistent with the principals respecting mine site reclamation and implementation found in the *Mine Site Reclamation Policy for Nunavut,* Indian and Northern Affairs Canada, 2002.

22. FINANCIAL INFORMATION

Is the statement of financial security the same as that considered in the existing water licence?

X Yes ☐ No

Provide an updated statement of financial security. Please see Attachment 15.1. Baffinland is not an entity that publically discloses audited financial statements

If the applicant is a business entity, please answer the questions below:

Is the list of the officers of the company the same as those considered in the existing water licence?

X Yes ☐ No

Provide a list of the officers of the company. Please see Attachment 15.2

Is the Certificate of Incorporation or evidence of registration of the company name the same?

X Yes ☐ No

Attach a copy of the Certificate of Incorporation or evidence of registration of the company name. Please see Attachment 15.2

23. STUDIES UNDERTAKEN TO DATE

List and attach updated studies, reports, research etc.

See FEIS Addendum for the Phase 2 Proposal, and supplemental information in TSD-2, Appendix D.

Provide a compliance assessment and status report including a response to any inspector's reports. The licensee must contact the NWB for licence specific direction in completing the assessment and report.

Please see Attachment 14 of Appendix D. Baffinland has initiated discussions with the NWB to confirm the approach to the Summary of Compliance Report is adequate.

If in non-compliance, a licence may not be issued until compliance is achieved. If in non-compliance, attach plans/reports for consideration. Application will not be processed if significant issues of non-compliance exist.

24. PROPOSED TIME SCHEDULE

When are proposed amendments scheduled to be undertaken: _____

Does the proposed amendment change the time schedule considered in the existing licence for any phase of development?

☐ Yes X No

Indicate the start and completion dates for each applicable phase of development (construction, operation, closure, and post closure). Identify proposed changes.

Construction
Proposed Start Date: 09/2019 (month/year) Proposed Completion Date: 12/2021 (month/year)

Operation
Proposed Start Date: Currently operating (month/year) Proposed Completion Date: 12/2035 (month/year)

Closure
Proposed Start Date: 01/2036 (month/year) Proposed Completion Date: 12/2038 (month/year)

Post - Closure
Proposed Start Date: 01/2039 (month/year) Proposed Completion Date: 10/2041 (month/year)

For each applicable phase of development indicate which season(s) activities occur.

Construction
☐ Winter ☐ Spring ☐ Summer ☐ Fall X All season

Operation
☐ Winter ☐ Spring ☐ Summer ☐ Fall X All season

Closure
☐ Winter ☐ Spring ☐ Summer ☐ Fall X All season

Post - Closure
☐ Winter ☐ Spring X Summer ☐ Fall ☐ All season

25. PROPOSED TERM OF LICENCE

On what date does the existing licence expire? June 10, 2025

Is the Licensee applying for a combined renewal and amendment of the existing licence?

☐ Yes X No

If Yes, indicate the proposed term of the renewal (maximum of 25 years): _____

Requested date of renewal issuance: _____ (month/year) Requested Expiry Date: _____ (month/year)

(The requested date of renewal issuance must be at least three (3) months from the date of application for a type B water licence and at least one (1) year from the date of application for a type A water licence, to allow for processing of the water licence application. These timeframes are approximate and do not account for the time to complete any pre-licensing land use planning or development impact requirements, time for the applicant to prepare and submit a water licence application in accordance with any project specific guidelines issued by the NWB, or the time for the applicant to respond to requests for additional information. See the NWB's *Guide 5: Processing Water Licence Applications* for more information)

26. ANNUAL REPORTING

Will the proposed amendment change the content of annual reports or the annual report template?

☐ Yes X No

If Yes, provide details regarding the content of annual reports and a proposed outline or template of the annual report.

27. CHECKLIST

The following must be included with the application for Amendment for the water licensing process to begin.

Completed Application for Water Licence Amendment form.

☑ Yes ☐ No If no, date expected _____

Information addressing Supplement Information Guideline (SIG), where applicable (see Block 11)

☑ Yes ☐ No If no, date expected _____

Compliance Assessment / Status Report (see Block 23).

☑ Yes ☐ No If no, date expected _____

Indication of Renewal Requirement (see Block 26)

☑ Yes ☐ No If no, date expected _____

English Summary of Amendment Application.

☑ Yes ☐ No If no, date expected _____

Inuktitut and/or Inuinnaqtun Summary of Amendment Application.

☑ Yes ☐ No If no, date expected _____

Application fee of $30.00 CDN (Payee Receiver General for Canada).

☑ Yes ☐ No If no, date expected _____

Water Use Fee Deposit of $30.00 CDN (Payee Receiver General for Canada). The actual water use fee will be calculated by the NWB based upon the amount of water authorized for use in accordance with the Regulations at the time of issuance of the licence.

☑ Yes ☐ No If no, date expected _____

28. SIGNATURE

Megan Lord-Hoyle	Director, Corporate Sustainability	Megan Lord-Hoyle	September 26, 2018
Name (Print)	**Title (Print)**	**Signature**	**Date**

ATTACHMENT 3

WATER LICENCE CONCORDANCE TABLES

3.1 Document Key
3.2 SIG Concordance

ATTACHMENT 3.1

DOCUMENT KEY

ATTACHMENT 3.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT – PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325
DOCUMENT KEY

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Attachments		Document Title, Author, Date	Electronic File Name	Electronic Files	
No.	**Attachment Title**			**Part**	**Pages**
n/a	**Main Report**	Application to Amend Type A Water Licence 2AM-MRY1325; Knight Piésold Ltd., Sept 26, 2018	180926-2AM-MRY1325-Applic-Part-1-Main-Report	**1**	Pages 1 to 56
1	**Executive Summary**	Executive Summary (English, Inuktitut, French), Baffinland, June 30, 2018	180926-2AM-MRY1325-Applic-Part-2	**2**	Pages 1 to 29
2	**Application for Water Licence Amendment**	Nunavut Water Board, Application for Water Licence Amendment, Baffinland, September 26, 2018			Pages 30 to 46
3	**Supplemental Information Guidelines Concordance Tables**				
3.1	Document Key	Document Key, Knight Piésold Ltd., September 26, 2018	180926-2AM-MRY1325-Applic-Part-3		Pages 1 to 8
3.2	SIG Concordance	Miscellaneous Supplemental Information Guidelines, Baffinland, September 26, 2018		**3**	Pages 9 to 36
4	**Nunavut Planning Commission's Conformity Determination**				
4.1	NPC Conformity Letter	NPC File No 148420 [Mary River Phase 2 Expansion Project], Nunavut Planning Commission, May 29, 2018	180926-2AM-MRY1325-Applic-Part-4	**4**	Pages 1 to 6
4.2	NIRB Review Process Letter	Re: Nunavut Impact Review Board Process Guidance—Mary River Modification Applications – Phase 2 Development Proposal and Production Increase Proposal, Nunavut Impact Review Board, June 11, 2018			Pages 7 to 21
5	**Design Criteria**				
5.1	Civil Design Philosophy	Mary River Expansion Project – Design Criteria: Civil Design Philosophy, Hatch, March 12, 2018	180926-2AM-MRY1325-Applic-Part-5	**5**	Pages 1 to 45
5.2	Rail Design Criteria	Mary River Expansion Project – Railway Design Criteria and Design Rational, Baffinland/Hatch, Nov 28, 2017			Pages 46 to 116
6	**Railway Design Information**				
6.1	North Railway Terrain Analysis	Site Assessment of North Railway Alignment, Baffinland/Hatch, Oct 4, 2017	180926-2AM-MRY1325-Applic-Part-6a	**6a**	Pages 1 to 74
6.2	North Railway Geotechnical Reports	2016-2017-2018 Rail Geotechnical Investigation Factual Data Report, Baffinland/Hatch, May 22, 2018	180926-2AM-MRY1325-Applic-Part-6b	**6b**	Pages 1 to 673

ATTACHMENT 3.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT – PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325
DOCUMENT KEY

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Attachments		Document Title, Author, Date	Electronic File Name	Electronic Files	
No.	**Attachment Title**			**Part**	**Pages**
6.3		Preliminary Geotechnical Recommendation for Railway Embankment (Between Milne Inlet and Mine Site), Baffinland/Hatch, January 10, 2017	180926-2AM-MRY1325-Applic-Part-6c	**6c**	Pages 1 to 24
6.4	Quarry Geochemical Evaluation	Geotechnical Investigations - Acid Rock Drainage Assessment Memo, Hatch, September 11, 2017	180926-2AM-MRY1325-Applic-Part-6d	**6d**	Pages 1 to 8
6.5	North Railway Catchment Drawings	Rail Site Drainage Catchments Drawings, Hatch, April 25, 2018	180926-2AM-MRY1325-Applic-Part-6e	**6e**	Pages 1 to 4
6.6	Diagrammatic Conceptual Layout	Site Plan Diagrammatic Layout - Milne Port to Mine Site Drawing, Hatch, March 21, 2018			Pages 5 to 6
6.7	North Railway Plan & Profile Drawings	Drawings by Hatch, February 10, 2017: Site Plan – Plan and Longitudinal Section … CH. 070km to CH. 37.000km … CH. 37.250km to CH. 74km … CH. 74.250km to CH. 109.680km			Pages 7 to 10
6.8	Km57 Temporary Ore Transfer Area Drawings	Drawings by Hatch, May 8, 2018: Rail Site (56 km) Rail Temporary Loading Facility Rail Site (56 km) Rail Temporary Loadout Cross-section			Pages 11 to 13
6.9	Rail Embankment Drawings	Rail Site – Standard Drawing – Typical Cross Section Drawings, Hatch, March 19, 2018 Rail Site - Standard Drawing – Typical Cut-Off Drain Detail Drawing, Hatch, March 21, 2018			Pages 14 to 19

ATTACHMENT 3.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT – PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325
DOCUMENT KEY

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Attachments		Document Title, Author, Date	Electronic File Name	Electronic Files	
No.	**Attachment Title**			**Part**	**Pages**
7	**Tote Road Realignment Drawings**				
7.1	Tote Road Relocation Drawings	Drawings by Hatch, April 25, 2018: Tote Road – Road Relocation at CH. 29+500 – Layout, Longitudinal and Cross Sections Drawing … at CH. 31+200 … at CH. 84+500 – 85+900	180926-2AM-MRY1325-Applic-Part-7	**7**	Pages 1 to-5
		Rail Site (56km) – Haul Road Layout and Profile 0.000km to 0.800km			Page 6
		Rail Site (56km) – Haul Road Layout and Profile – 0.800km to 1.350km, Hatch May 8, 2018			Page 7
		Mine Site – Tote Road Re-Alignment – Plan and Profile Hatch, December 18, 2017			Pages 8 to 9
		Mine Site – Tote Road & Railroad Crossing – Layout Plan and Details Drawing, Hatch, January 26, 2018			Page 10
7.2	Tote Road Rail Crossing Drawings	Drawings Prepared by Hatch, April 25, 2018: Tote Road – Layout and Longitudinal Section – Grade Crossing at CH. 9+450 …at CH. 12+530 …at CH. 55+445 …at CH. 87+345 …at CH. 91+750 …at CH. 96+585			Pages 11 to 17
7.3	Tote Road Typical Drawings	Mine Site – Haul, Primary and Secondary Roads – Typical Cross Sections Drawing, Hatch, January 26, 2018			Pages 18 to 19
		Tote Road – Standard Drawing – Typical Haul Road Cross Section Drawing, Hatch, April 25, 2018			Page 20

ATTACHMENT 3.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT – PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325
DOCUMENT KEY

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Attachments		Document Title, Author, Date	Electronic File Name	Electronic Files	
No.	**Attachment Title**			**Part**	**Pages**
8	**Watercourse Crossings List and Engineering Drawings**				
8.1	North Railway Crossing List	Table 8.1 - North Railway Culvert Crossings, Bridges, Cuts, Diversions, and Encroachments on Waterbodies and Fish Habitat, Baffinland	180926-2AM-MRY1325-Applic-Part-8	**8**	Pages 1 to 10
8.2	Tote Road Crossing List	Table 8.2 – Tote Road Crossing List, Baffinland			Pages 11 to 12
8.3	North Railway Bridge Drawings	Drawings Prepared by Hatch, April 25, 2018: Rail Site – Bridge General Layout – BR-102-1 Rail Site – Bridge General Layout – BR-15-1 Rail Site – Bridge General Layout – BR-70-1 Rail Site – Bridge General Layout – BR-86-1 Rail Site – Standard Drawing – Typical Cross Section – Multiple Barrel Pipe Culvert Standard Drawing – Typical Cross Section – Single Barrel Pipe Culvert			Pages 13 to 19
9	**Quarry and Laydown Location Figures**				
9.1	Proposed Quarry Locations	Figure 9.1 – Proposed Quarry Locations, Knight Piésold Ltd., July 31, 2018	180926-2AM-MRY1325-Applic-Part-9	**9**	Pages 1 to 3
9.2	Proposed Laydown Area Locations	Figure 9.2- Proposed Laydown Area Locations, Knight Piésold Ltd., July 31, 2018			Pages 4 to 5
10	**Water Management Plans**				
10.1	Mine Site Water Management Plan	Mine Site Surface Water Management Plan and Drawing, Hatch, September 11, 2018	180626-2AM-MRY1325-Applic-Part-10	**10**	Pages 1 to 21
10.2	Milne Port Water Management Plan	Port Surface Water Management Plan and Drawing, Hatch, August 24, 2018			Pages 22 to 75
10.3	Mine Site Crusher Pad Drawings	Drawings Prepared by Hatch, August 3, 2018: Mine Site Crusher Pad Drainage Plan Mine Site Crusher Pad Layout Plan Mine Site Crusher Pad Cross Sections Mine Site Crusher Pad Crusher Ramp & Walls Setting Out Mine Site Crusher Pad Settling Pond Details Mine Site Crusher Pad Settling Pond Plan and Profiles			Pages 76 to 82

ATTACHMENT 3.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT – PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325
DOCUMENT KEY

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Attachments		Document Title, Author, Date	Electronic File Name	Electronic Files	
No.	**Attachment Title**			**Part**	**Pages**
11	**Updated Block Flow Diagrams**				
11.1	Mine Site Water Balance	Mine Site – Area Water Balance – Block Flow Diagram, Hatch, September 12, 2018	180926-2AM-MRY1325-Applic-Part-11	**11**	Pages 1 to 3
11.2	Mine Site Water and Sewage Process Flow Diagram	Mine Site – Water and Sewage – Process Flow Diagram, Hatch, August 7, 2018			Pages 4 to 5
11.3	Port Site Water Balance	Port Site – Area Water Balance – Block Flow Diagram, Hatch, September 12, 2018			Pages 6 to 7
11.4	Port Site Water and Sewage Process Flow Diagram	Port Site – Water and Sewage – Process Flow Diagram, Hatch, August 7, 2018			Page 8 to 9
11.5	Ore Staging Water Balance	Ore Staging Rail Site – Area Water Balance – Block Flow Diagram, Hatch, September 12, 2018			Pages 10 to 11
12	**Mine and Port Site Geotechnical Reports**				
12.1	Mine Site Factual Geotechnical Report	2018 Mine Site Geotechnical Investigation Report, Hatch, 2018	180926-2AM-MRY1325-Applic-Part-12a	**12a**	Pages 1 to 157
12.2	Port Site Geotechnical Recommendations	Preliminary Geotechnical Recommendation for Infrastructures at Milne Inlet, Baffinland/Hatch, Jan 10, 2017			Pages 158 to 171
12.3	Ore Dock Factual Geotechnical Report	2017 Milne Port Ore Dock No. 2 Geotechnical Factual Data Report, Baffinland/Hatch, October 03, 2017	180926-2AM-MRY1325-Applic-Part-12b	**12b**	Pages 1 to 287
12.4	Ore Dock Geophysics Report	Geophysical Seismic Survey for a Proposed Fixed Dock, Mary River Project, Milne Inlet, Nunavut, Geophysics GPR International Inc., February 2014			Pages 288 to 319

ATTACHMENT 3.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT – PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325
DOCUMENT KEY

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Attachments		Document Title, Author, Date	Electronic File Name	Electronic Files	
No.	**Attachment Title**			**Part**	**Pages**
13	**Fuel Tank Farm Drawings**	Mine Site – Fuel System – 15,000,000L Arctic Diesel Tank, Hatch, July 25, 2018	180926-2AM-MRY1325-Applic-Part-13	**13**	Pages 1 to 6
		Mine Site – Tank Farm Grading – Plan, Hatch, July 25, 2018			
		Mine Site – Fuel System – Typical Vertical Tank Details, Hatch, July 25, 2018			
		Mine Site – Tank Farm – Operating Procedures Signage, Hatch, July 25, 2018			
		Mine Site – Tank Farm – TK-005 Arctic Diesel Tank Signage, Hatch, July 25, 2018			
14	**Compliance Report**	Table 14.1 - Compliance Assessment for Licence No. 2AM-MRY1325, Knight Piésold Ltd. Sept 26, 2018 Table 14.2 – Status of Resolution of Non-Compliance Items, Knight Piésold Ltd. Sept 26, 2018	180926-2AM-MRY1325-Applic-Part-14	**14**	Pages 1 to 16
15	**Corporate and Financial Information**				
15.1	Articles of Amalgamation	Ontario Corporation Number 1904371 - Articles of Amalgamation	180926-2AM-MRY1325-Applic-Part-15	**15**	Pages 1 to 23
15.2	Baffinland Officers	Baffinland Iron Mines Corporation – Officers, Baffinland, August 1, 2018			Pages 24 to 25
16	**Mobile Camp Water and Sewage Tank Design Details**	Operation & Maintenance Manual 1704962 – Horizon North Wastewater Storage Tanks, Newterra, No Date Cross Section, Alantra, June 2018 Electrical Layout, Alantra, June 2018 Floor Plan, Alantra, June 2018 Siding Plan, Alantra, June 2019	180926-2AM-MRY1325-Applic-Part-16	**16**	Pages 1 to 77
17	**Landfarm Manual**	Landfarm Operation Maintenance and Monitoring Manual BAF-PH1-320-T07-0005 Rev.0, Baffinland, March 18, 2015	180926-2AM-MRY1325-Applic-Part-17	**17**	Pages 1 to 18

ATTACHMENT 3.2

SIG CONCORDANCE

TABLE 1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325

ATTACHMENT 3.2 - SUPPLEMENTAL INFORMATION GUIDELINES (SIG) CONCORDANCE
MINIMUM APPLICATION REQUIREMENTS

Section Title	Section No.	Information Requirement General Water Works	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	NWB Concordance Assessment
Minimum Application Requirements	**1**	General Water Licence Application Form (see the NWB's *Guide 4: Completing and Submitting a Water Licence Application for a New Licence*) or Application for Water Licence Amendment Form, if appropriate (see NWB's *Guide 7: Licensee Requirements Following the Issuance of a Water Licence*).	**1**	General Water Licence Application Form (see the NWB's *Guide 4: Completing and Submitting a Water Licence Application for a New Licence*) or Application for Water Licence Amendment Form, if appropriate (see NWB's *Guide 7: Licensee Requirements Following the Issuance of a Water Licence*).	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-2		
	2	Information required to satisfy the requirements of the SIG including plans, reports and designs.	**2**	Information required to satisfy the requirements of the SIG including plans, reports and designs.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report to 180926-2AM-MRY1325-Applic-Part-17	All	
	3	Executive summary in English.	**3**	Executive summary in English.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-2	Attachment 1	
	4	Translated executive summary in appropriate language and dialect.	**4**	Translated executive summary in appropriate language and dialect.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-2	Attachment 1	
	5	Application fee.	**5**	Application fee.	**Y**				Fee payments will be mailed to NWB in Gjoa Haven separately.	
	6	Water use fee.	**6**	Water use fee.	**Y**					
	7	A table indicating concordance of the application and supporting documents to the Guidelines. These generic Guidelines are provided in excel as a tool for applicants to provide the necessary concordance table.	**7**	A table indicating concordance of the application and supporting documents to the Guidelines. These generic Guidelines are provided in excel as a tool for applicants to provide the necessary concordance table.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-3	Attachment 3.2	

TABLE 2

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325

ATTACHMENT 3.2 - SUPPLEMENTAL INFORMATION GUIDELINES (SIG) CONCORDANCE
GENERAL WATER LICENCE APPLICATION

Section Title	Section No.	Information Requirement General Water Works	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment
Applicant	**1**	Provide the full name of the applicant and contact person including contact information (position, phone number, address, fax number and email address).	**1**	Provide the full name of the applicant and contact person including contact information (position, phone number, address, fax number and email address).	**Y**		See Doc Key (Att. 3.1)		Att. No. 2 (s. 1)		
Applicant Representative	**2**	Provide the name and contact information of any party submitting the application on behalf of the applicant (including position, phone number, address, fax number and email address).	**2**	Provide the name and contact information of any party submitting the application on behalf of the applicant (including position, phone number, address, fax number and email address).	**N/A**	Not a third party submission					
	3	Provide a signed letter authorizing a party to be the applicant's representative in the licensing process.	**3**	Provide a signed letter authorizing a party to be the applicant's representative in the licensing process.	**N/A**	Not a third party submission					
Project Name	**4**	Provide the name of the project.	**4**	Provide the name of the project.	**Y**		See Doc Key (Att. 3.1)		Att. No. 2 (s. 3)		
Location of Undertaking	**5**	Provide coordinates of the project extents.	**5**	Provide coordinates of the project extents taking into account the Local Project Area (LPA) and the Regional Project Area (RPA), where applicable.	**N/A**	Project coordinates have not changed.					
		Provide location by Latitude and Longitude.		Provide location by Latitude and Longitude.							
		Provide location by UTM coordinates, if available.		Provide location by UTM coordinates, if available.							
				Provide the distances to the nearest communities.							
	6	Indicate whether the drainage basin, in which the project is located, is shared with any other jurisdiction. If applicable, indicate which jurisdiction.	**6**	Indicate whether the drainage basin, in which the project is located, is shared with any other jurisdiction. If applicable, indicate which jurisdiction.	**N/A**	Entirely within Nunavut.					
Map	**7**	Provide a map at a 1:50,000 scale based on the National Topographic Series indicating the location of the undertaking, watercourses and the location of waste deposits. Additional maps at various scales may be provided if those maps will provide additional information or clarification. All maps must indicate the scale, map sheet number, and the location of north.	**7**	Provide a map at a 1:50,000 scale based on the National Topographic Series indicating the location of the undertaking, watercourses and the location of waste deposits. Additional maps at various scales may be provided if those maps will provide additional information or clarification. All additional maps must indicate the scale, map sheet number, and location of north.	**Y**		See Doc Key (Att. 3.1)		Att. No. 6.6 and 10		
Nature of Interest in the Land	**8**	Provide the nature of the interest in the land associated with the proposed undertaking, including:	**8**	Provide the nature of the interest in the land associated with the proposed undertaking, including:	**Y**		See Doc Key (Att. 3.1)		Att. No. 2 (s. 6)		
		Sub-surface leases from Nunavut Tunngavik Incorporated (NTI) and/or Indian and Northern Affairs Canada (INAC) as well as surface authorizations from INAC for crown land use, a Designated Inuit Organization (DIO) for Inuit Owned Land (IOL) use, or the Government of Nunavut for Commissioner's land use. Provide the permit or licence numbers.		Sub-surface leases from Nunavut Tunngavik Incorporated (NTI) and/or Indian and Northern Affairs Canada (INAC) as well as surface authorizations from INAC for crown land use, a Designated Inuit Organization (DIO) for Inuit Owned Land (IOL) use, or the Government of Nunavut for Commissioner's land use. Provide the permit or licence numbers.	**Y**		See Doc Key (Att. 3.1)		Att. No. 2 (s. 6)		
		The date or expected date of issuance of any authorization and the date of expiry.		The date or expected date of issuance of any authorization and the date of expiry.	**Y**		See Doc Key (Att. 3.1)		Att. No. 2 (s. 6)		
	9	Indicate whether the applicant is the name of the entity holding the authorization for the interest in the land and if not, provide the name of the entity holding the authorization.	**9**	Indicate whether the applicant is the name of the entity holding the authorization for the interest in the land and if not, provide the name of the entity holding the authorization.	**Y**		See Doc Key (Att. 3.1)		Att. No. 2 (s. 6)		
NPC Determination	**10**	Provide written confirmation from the NPC confirming that NPC's requirements under the NLCA regarding land use plan conformity (Article 11 of the NLCA) have been addressed.	**10**	Provide written confirmation from the NPC confirming that NPC's requirements under the NLCA regarding land use plan conformity (Article 11 of the NLCA) have been addressed.	**Y**		See Doc Key (Att. 3.1)		Att. No. 4.1		
NIRB Determination	**11**	Provide written confirmation from the NIRB confirming that NIRB's requirements under the NLCA regarding development impact assessment (Article 12 of the NLCA) have been or are in the process of being addressed. Documentation may include:	**11**	Provide written confirmation from the NIRB confirming that NIRB's requirements under the NLCA regarding development impact assessment (Article 12 of the NLCA) have been or are in the process of being addressed. Documentation may include:	**Y**		See Doc Key (Att. 3.1)		Att. No. 4.2		
		Written confirmation from NIRB that the project proposal does not require screening;		Written confirmation from NIRB that the project proposal does not require screening;							
		NIRB's screening determination;		NIRB's screening determination;							
		If a review is required, NIRB's recommendation to the Minister regarding the type of review;		If a review is required, NIRB's recommendation to the Minister regarding the type of review;							
		If a review is required, the Minister's written decision regarding the review of the development proposal;		If a review is required, the Minister's written decision regarding the review of the development proposal;							
		If a review is required, NIRB's project certificate;		If a review is required, NIRB's project certificate;							
	12	Provide a list of activities requested for exception in accordance with NLCA s. 12.10.2;	**12**	List of activities requested for exception in accordance with NLCA s. 12.10.2;	**N/A**	None requested					
	13	Indicate whether any Type B water licence application is for an activity to be considered for interim, short term approval in accordance with NLCA s. 13.5.5.	**13**	Indicate whether any Type B water licence application is for an activity to be considered for interim, short term approval in accordance with NLCA s. 13.5.5.	**N/A**	Baffinland is seeking a modification to its existing Type A Water Licence					

Section Title	Section No.	Information Requirement General Water Works	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment
Description of Undertaking	**14**	Provide a complete description of the undertaking with detailed site plan(s) of all infrastructure. Differentiate any temporary components from permanent components. Consider the following in providing the description:	**14**	See section 4 of this SIG for specific requirements. (Section 4.0 Project Description	**Y**		TSD-2 Project Description, Baffinland, Sept, 2018	08MN053_TSD-02_Project-Description_Rev_1	All		
	a	Camp (see the NWB's SIG for Tourist / Remote Camps (R1));			**Y**		Same as above	Same as above	Sections 2.5, 2.11, 4.6		
	b	Transportation access routes;			**Y**		Same as above	Same as above	Section 3		
	c	Fuel and chemical storage;			**Y**		Same as above	Same as above	Sections 2.9, 4.8		
	d	Quarries / borrow pits;			**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 2.7; Attachment 9		
	e	Existing on site infrastructure;			**Y**		TSD-2 Project Description, Baffinland, Sept 2018	08MN053_TSD-02_Project-Description	Sections 2, 3, 4		
	f	Water intake			**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Sections 2.9, 2.10, 3		
	g	Water storage			**Y**		Same as above	Same as above	Sections 2.9, 2.10, 3		
	h	Water distribution			**Y**		Same as above	Same as above	Section 2.9, 2.10, 3		
	i	Bridges			**Y**		Same as above	Same as above	Section 2.5, Attachment 8		
	j	Culverts			**Y**		Same as above	Same as above	Section 2.5, Attachment 8		
	k	Pipelines			**Y**		Same as above	Same as above	Section 4.7		
	l	Channel / bank alterations			**Y**		Same as above	Same as above	Section 2.5; Attachment 8		
	m	Spurs			**N/A**						
	n	Erosion control			**Y**		Same as above	Same as above	Section 2.11		
	o	Artificial accretion			**N/A**						
	p	Ditches			**Y**		Same as above	Same as above	Attachment 10		
	q	Dikes			**Y**		Same as above	Same as above	Section 2.5		
	r	Dams			**Y**		Same as above	Same as above	Sections 2.5 and 2.11; Attachement 10		
	s	Spillways			**Y**		Same as above	Same as above	Section 4.4		
	t	Berms			**Y**		Same as above	Same as above	Attachment 10		
	u	Cofferdams			**Y**		Same as above	Same as above	Section 2.5		
Other Applicable Supplemental Information Guidelines	**15**	Indicate whether any other Supplemental Information Guidelines apply to the undertaking including the following:	**15**	Indicate whether any other Supplemental Information Guidelines apply to the undertaking including the following:							
	a	Hydrostatic testing		Hydrostatic testing	**N/A**	No hydrostatic testing is proposed					
	b	Tannery		Tannery	**N/A**	No tannery is proposed					
	c	Tourist / remote camp		Tourist / remote camp	**N/A**	This is an operating project					
	d	Landfarm and on-site storage of hydrocarbon contaminated soil		Landfarm and on-site storage of hydrocarbon contaminated soil	**N/A**	No modifications are proposed					
	e	Onshore oil and gas exploration drilling		Onshore oil and gas exploration drilling	**N/A**	No onshore oil and gas exploration drilling is proposed					
	f	Mineral exploration/ remote camp		Mineral exploration/ remote camp	**N/A**	This is an operating project					
	g	Advanced exploration		Advanced exploration	**N/A**	This is an operating project					
	h	Mine development		Mine development	**Y**	The Mine Development SIG has been used					
	i	Municipal		Municipal	**N/A**	This is a mining project					
	j	General Water Works		General Water Works	**Y**	The General Water Works SIG has been used					
	l	Power		Power	**N/A**						
Options	**16**	Provide a brief explanation of the alternative methods or locations that were considered to carry out the project.	**16**	Provide a brief explanation of the alternative methods or locations that were considered to carry out the project.	**Y**		TSD-01 Alternatives Analysis, Baffinland, August, 2018	08MN053_TSD-01_Alternatives-Analysis	All		

Section Title	Section No.	Information Requirement General Water Works	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment
Water Use	**17**	See section 5 of this SIG for specific requirements	**17**	See section 6 of this SIG for specific requirements							
Water Use: Quality and Quantity	**18**	See section 5 of this SIG for specific requirements	**18**	See section 6 of this SIG for specific requirements							
Waste Disposal	**19**	Provide a detailed description of all types of waste and all forms of waste disposal including: (see the NWB definition of Waste in the NWB *Guide 2: Terminology and Definitions*)	**19**	See section 7 of this SIG for specific requirements	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report 180926-2AM-MRY1325-Applic-Part-2	Section 4; Attachment 2, Section 14		
	a	Dredged material			**Y**		TSD-2 Project Description, Baffinland, Sept, 2018	08MN053_TSD-02_Project-Description_Rev_1	Section 4.2		
	b	Hazardous waste including waste oil			**Y**		See Document Key (Attachment 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Sections 4.5 and 4.6		
							Hazardous Materials & Waste Manegement Plan, Baffinland, 2017	http://www.baffinland.com/downloadocs/baf-ph1-830-p16-0011-r5---hazardous-materials-and-waste-management_2017-01-18-06.pdf			
	c	Discharge from dewatered areas			**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 2.5		
Waste Disposal: Quality and Quantity	**20**	For each type of waste, provide the composition, chemical characteristics and quantity generated. Also provide the location, rate, timing, frequency and duration of the deposit.	**20**	See section 7 of this SIG for specific requirements	**Y**		Same as above	Same as above	Section 4.4		
							See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-2	Attachment 2 (s. 15)		
	21	For each type of waste, provide the proposed methods and processes for collecting, storing, treating and discharging the waste. Indicate the capacity of these facilities.			**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 4.4		
							See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-2	Attachment 2 (s. 15)		
	22	Provide a description of any measures to minimize the production of wastes.			**Y**		Waste Management Plan, Baffinland, 2018	http://www.baffinland.com/downloadocs/baf-ph1-830-p16-0028-r6---waste-management-plan_2018-15-12-52.pdf	Section 3.4		
Other Authorizations	**23**	Provide a list of any authorizations required in relation to the project in addition to the water licence. For each additional authorization required for the project, provide the name of the authorization, the administering agency, the project activity requiring the authorization, the date or expected date of issuance and the date of expiry. Provide a description of how those authorizations may affect the NWB's water licensing process.	**21**	Provide a list of any authorizations required in relation to the project in addition to the water licence. For each additional authorization required for the project, provide the name of the authorization, the administering agency, the project activity requiring the authorization, the date or expected date of issuance and the date of expiry. Provide a description of how those authorizations may affect the NWB's water licensing process.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 1.5		
			22	Indicate whether an authorization has been obtained or sought from the Department of Fisheries and Oceans for dewatering or using any waterbodies for containment of waste	**N/A**	No waterbodies will be dewatered for waste containment					
	24	Provide formal applications to the Navigable Waters Protection Program (NWPP) for any works if applicable.	**23**	Provide formal applications to the Navigable Waters Protection Program (NWPP) for any works.	**Y**					Upon completion of NIRB reconsideration	
	25	Provide a timetable for filing the appropriate plans and procedures required by government parties.	**24**	Provide a timetable for filing the appropriate plans and procedures required by government parties.	**Y**						
	26	Indicate whether the applicant / licensee holds any existing water licences. If applicable, provide the licence number and expiry date of any existing water licences.	**25**	Indicate whether the applicant/ licensee holds any existing water licences. If applicable, provide the licence number and expiry date of any existing water licences.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-2	Attachment 2 (s. 1)		

Section Title	Section No.	Information Requirement General Water Works	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment
Predicted Environmental Effect and Proposed mitigation measures	**27**	Identify the potential effect of water use and waste disposal on the following components:	**26**	Identify the potential effect of water use and waste disposal on the following components:							
		Groundwater and Surface Water including:		Groundwater and Surface Water including:	**Y**		TSD-13 Surface Water Assessment, Knight Piesold Ltd., August 2018	08MN053_TSD-13_Surface-Water	All		
		changes in flow (including seasonal rate of flow)		changes in flow (including seasonal rate of flow)							
		quantity		quantity							
		quality		quality							
		Land including:		Land including:	**Y**		TSD-08 Landforms, Soils and Permafrost Assessment, Knight Piesold, July 2018	08MN053_TSD-08_Landforms-Soil-and-Permafrost	All		
		geologic structure change		geologic structure change							
		soil contamination		soil contamination							
		compaction, settling and erosion		compaction, settling and erosion							
		alteration of the permafrost regime		alteration of the permafrost regime							
		riparian zone loss		riparian zone loss	**N/A**	No riparian zone loss aniticipated from water use and waste disposal.					
		Vegetation including:		Vegetation including:	**Y**		TSD-09 Vegetation Baseline and Impact Assessment, EDI, July 2018	08MN053_TSD-09_Vegetation-Baseline-and-Impact-Assessment_Rev_1	All		
		species composition and abundance		species composition and abundance							
		non-native species introduction		non-native species introduction							
		accumulation of toxins and heavy metals (in relation to remediation objectives for closure)		accumulation of toxins and heavy metals (in relation to remediation objectives for closure)							
		Aquatic Ecosystems including:		Aquatic Ecosystems including:	**Y**		TSD-14 Freshwater Fisheries Assessment, North South Consultants, Sept 2018	08MN053_TSD-14-Freshwater-Biota-Habitat_Rev_1	All		
		fish		fish							
		benthic invertebrates		benthic invertebrates							
		plankton		plankton							
	28	Identify effects separately for each project phase.	**27**	Identify effects separately for each project phase.	**Y**		Phase 2 Proposal - Addendum to the Final Environmental Impact Statement, Baffinland, Sept 2018	08MN053_mrp2_eis_Rev_1	Section 10		
	29	Provide a description of the methods used to predict effects.	**28**	Provide a description of the methods used to predict effects.	**Y**		Same as above	Same as above	Section 9		
	30	Provide a cumulative effects assement of the project's water use and waste disposal activities in combination with other past, present and reasonably forseeable projects in the same drainage basin.	**29**	Provide a cumulative effects assessment of the project's water use and waste disposal activities in relation to other activities in the same drainage basin.	**Y**		TSD-27 Cumulative Environmental Effects and Transboundary Effects, Baffinland, Sept 2018	08MN053_TSD-27_Cumulative-Transboundary_Rev_1	Section 1		
	31	Identify effects that may arise from accidental events or malfunctions.	**30**	Identify effects arising from accidental events or malfunctions.	**Y**		Phase 2 Proposal - Addendum to the Final Environmental Impact Statement, Baffinland, Sept 2018	08MN053_mrp2_eis_Rev_1	Section 10.2		
	32	Provide a description of all proposed mitigation, management and monitoring programs to mitigate adverse impacts.	**31**	Provide a description of all proposed mitigation, management and monitoring programs to mitigate adverse impacts.	**Y**		TSD-28 Mitigation and Monitoring Plans	08MN053_TSD-28_Mitigation-Monitoring	All		
	33	Provide a description of the measures to be taken to mitigate impacts on historical resources or traditional uses of water and procedures to be followed should artifacts be discovered.	**32**	Provide a description of the measures to be taken to mitigate impacts on historical resources or traditional uses of water and procedures to be followed should artifacts be discovered.	**Y**		TSD-25 Socio-Economic Assessment, Baffinland, Sept 2018	08MN053_TSD-25_Socio-economic-Assessment_Rev_1	Section 9		
	34	If applicable, provide a description of any potential transboundary effects.	**33**	If applicable, provide a description of any potential transboundary effects.	**Y**		TSD-27 Cumulative Environmental Effects and Transboundary Effects, Baffinland, Sept 2018	08MN053_TSD-27_Cumulative-Transboundary_Rev_1	Section 2		
	35	See sections 4, 5 and 6 of this SIG for additional information requirements	**34**	See sections 5, 6, 7, and 8 of this SIG for additional information requirements							

Section Title	Section No.	Information Requirement General Water Works	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment
Existing and Other User Water Rights	**36**	Provide the names, addresses, and nature of use for any known persons or properties that may be adversely affected by the proposed undertaking, including those that that hold licences for water use in precedent to the application, domestic users, in-stream users, authorized waste depositors, owners of property, occupiers of property, and/or holders of outfitting concessions, registered trapline holders, and holders of other rights of a similar nature.	**35**	Provide the names, addresses, and nature of use for any known persons or properties that may be adversely affected by the proposed undertaking, including those that that hold licences for water use in precedent to the application, domestic users, in-stream users, authorized waste depositors, owners of property, occupiers of property, and/or holders of outfitting concessions, registered trapline holders, and holders of other rights of a similar nature.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-2	Attachment 2 (s. 18)		
	37	Provide a description of any potential effects of the project on the persons or properties identified in item 36 of this section.	**36**	Provide a description of any potential effects of the project on the persons or properties identified in item 35 of this section.	**Y**		TSD-25 Socio-Economic Assessment, Baffinland, Sept 2018	08MN053_TSD-25_Socio-economic-Assessment_Rev_1	Section 9		
	38	Provide a description of the measures incorporated into the project design to mitigate effects of the project on the persons or properties identified in item 36 of this section.	**37**	Provide a description of the measures incorporated into the project design to mitigate effects of the project on the persons or properties identified in item 35 of this section.	**Y**		Same as above	Same as above	Same as above		
	39	Indicate whether compensation has been paid and/or agreement(s) for compensation have been reached with any existing or other users.	**38**	Indicate whether compensation has been paid and/or agreement(s) for compensation have been reached with any existing or other users.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-2	Attachment 2 (s. 19)		
Inuit Water Rights	**40**	Provide a description of any potential effects of the project on the quality, quantity, or flow of waters flowing through Inuit Owned Land (IOL).	**39**	Provide a description of any potential effects of the project on the quality, quantity, or flow of waters flowing through Inuit Owned Land (IOL).	**Y**		TSD-13 Surface Water Assessment, Knight Piesold Ltd., August 2018	08MN053_TSD-13_Surface-Water_Rev_1	All		
	41	Provide a description of the measures incorporated into the project design to mitigate effects of the project on the quality, quantity, or flow of waters flowing through IOL.	**40**	Provide a description of the measures incorporated into the project design to mitigate effects of the project on the quality, quantity, or flow of waters flowing through IOL.	**Y**		Same as above	Same as above	Same as above		
	42	Indicate wheter an agreement to pay compensation for any loss or damage has been reached with one or more Designated Inuit Organization (DIO); or if the parties have been unable to reach an agreement on compensation	**41**	Indicate wheter an agreement to pay compensation for any loss or damage has been reached with one or more Designated Inuit Organization (DIO); or if the parties have been unable to reach an agreement on compensation	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-2	Attachment 2 (s. 19)		
Consultation	**43**	Provide a summary of any consultation meetings including when the meetings were held, where and with whom.	**42**	Provide a summary of any consultation meetings including when the meetings were held, where and with whom.	**Y**		TSD-04 Public Consultation, Baffinland, Sept 2018	08MN053_TSD-04_Public-Consultation_Rev_1	Sections 3, 4		
	44	Provide a summary of the results of consultation meetings including a list of concerns expressed and measures proposed to address concerns.	**43**	Provide a summary of the results of consultation meetings including a list of concerns expressed and measures proposed to address concerns.	**Y**		Same as above	Same as above	Same as above		
Security	**45**	Provide a financial security assessment that includes the following:	**44**	Provide a financial security assessment that is prepared in a manner consistent with principals respecting mine site reclamation and implementation found in the *Mine Site Reclamation Policy for Nunavut* , Indian and Northern Affairs Canada, 2002. The financial security assessment must include:	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 7		
		An estimate of the total financial security for final reclamation equal to the total outstanding reclamation liability for land and water combined sufficient to cover the highest liability over the life of the undertaking;		An estimate of the total financial security for final reclamation equal to the total outstanding reclamation liability for land and water combined sufficient to cover the highest liability over the life of the undertaking;	**Y**		Same as above	Same as above	Same as above		
		The cost of having the necessary reclamation work done by a third-party contractor if the operator defaults;		The cost of having the necessary reclamation work done by a third-party contractor if the operator defaults;	**Y**		Same as above	Same as above	Same as above		
		Contingency factors appropriate to the particular work to be undertaken.		Contingency factors appropriate to the particular work to be undertaken.	**Y**		Same as above	Same as above	Same as above		

Section Title	Section No.	Information Requirement General Water Works	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment
Abandonment and Restoration	**46**	Provide plans for the abandonment and restoration of facilities.	**45**	Provide plans for the abandonment and restoration of the project. Plans must address all phases of the project including construction, operation, care & maintenance, final closure and post closure. Detail the costs to carry out the plan, and a proposal for financial assistance which covers the costs to carry out the plan.	**Y**		Same as above	Same as above	Same as above		
			46	Provide a description of all remediation plans and remediation objectives. Discuss the results of any human health and ecological risk assessment used to establish remediation objectives.	**Y**		Same as above	Same as above	Same as above		
	47	Provide a list and description of any existing abandoned or restored site facilities.	**47**	Provide a list and description of any existing abandoned or restored site facilities.	**Y**		Same as above	Same as above	Same as above		
			48	Provide details regarding the timing of the removal of any dewatering dikes (if applicable) and the implications of this	**Y**		Same as above	Same as above	Same as above		
			49	Provide detailed information regarding the method used to remove/breach any dewatering dykes (if applicable),	**Y**		Same as above	Same as above	Same as above		
Financial Information	**48**	Provide a statement of financial responsibility.	**50**	Provide a statement of financial responsibility.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-15	Attachment 15.1		
	49	If the applicant is an entity for which audited financial statements are issued, a copy of the most recent audited financial statements must be attached to the statement of financial responsibility.	**51**	If the applicant is an entity for which audited financial statements are issued, a copy of the most recent audited financial statements must be attached to the statement of financial responsibility.	**N/A**	Baffinland is not an entity that publiclly discloses audited financial statements.	NWB is aware of Baffinland's current financial security established for the Project				
	50	Provide the name of the corporation, limited company or other business entity, with a list of the officers of the company and a copy of the Certificate of Incorporation or evidence of registration of the company name.	**52**	Provide the name of the corporation, limited company or other business entity, with a list of the officers of the company and a copy of the Certificate of Incorporation or evidence of registration of the company name.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-15	Attachment 15.2		
Studies and Designs	**51**	Provide a list of studies, reports and plans relevant to the application that have been undertaken to date including:	**53**	Provide a list of studies, reports and plans relevant to the application that have been undertaken to date including:							
		Design rational, design requirements, design criteria, design parameters, design standards/analysis/method;	**a**	Design rational, design requirements, design criteria, design parameters, design standards/analysis/method;	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-5	Attachment 5		
		Design assumptions and the limitations associated with such design assumptions;	**b**	Design assumptions and the limitations associated with such design assumptions;	**Y**		Same as above	Same as above	Attachments 5 to 13, 16, 17		
		The inclusion of clear, definable engineering qualifiers with all design drawings and reports;	**c**	The inclusion of clear, definable engineering qualifiers with all design drawings and reports;	**Y**		Same as above	Same as above	Attachments 5 to 13, 16, 17		
		Site specific data and analysis to support the design and management decisions made;		Site specific data and analysis to support the design and management decisions made;	**Y**		Same as above	Same as above	Same as above		
		Materials that appropriately delineate the particulars of a design or plan.		Materials that appropriately delineate the particulars of a design or plan.	**Y**		Same as above	Same as above	Same as above		

Section Title	Section No.	Information Requirement General Water Works	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment
Studies and Designs	**52**	Provide construction methods and procedures regarding how infrastructure will be put in place on-site.	**54**	Provide construction methods and procedures regarding how infrastructure will be put in place on-site.	**Y**		TSD-2 Project Description, Baffinland, Sept, 2018	08MN053_TSD-02_Project-Description_Rev_1	Section 2, 3, 4 and 5		
	53	Provide a timetable for submission of preliminary and final-for-construction engineered designs (note: for construction designs are required for NWB approvals).	**55**	Provide a timetable for submission of preliminary and final-for-construction engineered designs (note: for construction designs are required for NWB approvals).	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 9		
	54	See sections 4 and 5 of this SIG for additional information requirements.	**56**	See sections 5, 6 and 7 of this SIG for additional information requirements							
Proposed Time Schedule	**55**	Provide the proposed start and completion dates for each phase of development (construction, operation, closure) and any anticipated periods of seasonal shut down.	**57**	Provide the proposed start and completion dates for each phase of development (construction, operation, closure and post closure) and any anticipated periods of seasonal shut down.	**Y**		TSD-2 Project Description, Baffinland, Sept, 2018	08MN053_TSD-02_Project-Description_Rev_1	Section 1.2.5		
Proposed Term of Licence	**56**	Provide a proposed term of licence including the expected date of licence issuance and the expected date of licence expiry.	**58**	Provide a proposed term of licence including the expected date of licence issuance and the expected date of licence expiry.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-2	Attachment 2 (s. 25)		
Annual Reporting	**57**	Provide detailed information regarding the content of annual reports and a proposed outline or template of the annual report. The annual report should include the following:	**59**	Provide detailed information regarding the content of annual reports and a proposed outline or template of the annual report. The annual report should include the following:	**N/A**	Baffinland currently submits annual reports to the NWB. Please see the 2017 Annual Report for required information.					
		Water related monitoring results;		Water related monitoring results;							
		Comparison of water quality and quantity monitoring data with the water quality and quantity predictions presented in the application;		Comparison of water quality and quantity monitoring data with the water quality and quantity predictions presented in the application;							
		A description of how any conditions in the NIRB screening decision related to the NWB mandate have been implemented;		A description of how the conditions in the NIRB project certificate related to the NWB mandate have been implemented;							
		Project changes under adaptive management;		Project changes under adaptive management;							
		Any actions taken in response to direction provided by the Inspector.		Any actions taken in response to direction provided by the Inspector.							
Renewals and Amendments	**58**	If the application is for a renewal or amendment of an existing licence provide the water licence number and the date of water licence expiry.	**60**	If the application is for a renewal or amendment of an existing licence provide the water licence number and the date of water licence expiry.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-2	Attachment 2 (s. 25)		
	59	If the application is for a renewal or amendment of an existing licence, provide a compliance assessment/status report. This report must document the status of compliance for each condition of the existing water licence taking into consideration inspector dialogues and inspector directions, responses to inspector dialogues and inspector directions, spills that may have occurred, and any reporting requirements. The report must indicate when facilities were inspected by regulatory agencies and list any spills that may have occured including a description, location shown on a map, and the action taken to address the affected area.	**61**	If the application is for a renewal or amendment of an existing licence, provide a compliance assessment/status report. This report must document the status of compliance for each condition of the existing water licence taking into consideration inspector dialogues and inspector directions, responses to inspector dialogues and inspector directions, spills that may have occurred, and any reporting requirements. The report must indicate when facilities were inspected by regulatory agencies and list any spills that may have occured including a description, location shown on a map, and the action taken to address the affected area.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-14	Attachment 14		

TABLE 3

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325

ATTACHMENT 3.2 - SUPPLEMENTAL INFORMATION GUIDELINES (SIG) CONCORDANCE
PROJECT DESCRIPTION

Section Title	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment	NIRB Guideline Section No.
Description of Undertaking	**1**	Provide a complete description of the undertaking with detailed site plan(s) of all project infrastructure for the Local Project Area (LPA) and/or the Regional Project Area (RPA), where applicable. Include maps and/or aerial photos with scales that allow the determination of distances between the objects depicted. Differentiate any temporary components from permanent components. Consider the following in providing the description:	**Y**		TSD-2 Project Description, Baffinland, Sept, 2018	08MN053_TSD-02_Project-Description_Rev_1	All			
	a	Raw water intake;	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 3			
	b	Water storage and treatment facilities including distribution systems;			TSD-2 Project Description, Baffinland, Sept, 2018	08MN053_TSD-02_Project-Description_Rev_1	Section 2.5, 4.6			
			Y		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Sections 2.6, 2.8, 3.7, 4.6, 4.7			
	c	Existing water bodies/courses and any changes to these water bodies/courses that may have or may occur as a result of water use or waste disposal facilities. Provide an outline of the drainage basin and drainage patterns within the RPA;	**Y**		TSD-13 Surface Water Assessment, Knight Piesold, August 2018	TSD-13-Surface-Water_Rev_1	Section 2			
	d	Location of receiving water bodies and drainage pathways;	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report 180926-2AM-MRY1325-Applic-Part-10	Section 3.6; Attachment 10			
	e	Transportation access routes and details of water course crossings;	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report 180926-2AM-MRY1325-Applic-Part-8	Section 2.5; Attachment 8			
	f	Locations of environmental monitoring sites;	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 6			
	g	Traditional water use and land use areas that may be impacted by the project;	**Y**		TSD-25 Socio-Economic Assessment, Baffinland, August 2018	08MN053_TSD-25_Socio-economic-Assessment_Rev_1	Section 9			
	h	Sewage treatment facilities;	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 4.7			
	i	Wastewater treatment area and discharge outlet locations;	**Y**		Same as above	Same as above	Sections 4.4, 4.6, 4.7			
	j	Solid waste disposal areas and drainage patterns;	**Y**		Same as above	Same as above	Section 4.8			
	k	Incinerators	**N/A**	No modification are proposed in support of the Phase 2 Proposal	Waste Management Plan, Baffinland, 2018	http://www.baffinland.com/downloadocs/baf-ph1-830-p16-0028-r6---waste-management-plan_2018-15-12-52.pdf				
	l	Landfarm (see the NWB's SIG for Landfarm and on-site storage of hydrocarbon contaminated soil (I3));	**N/A**	No modification are proposed in support of the Phase 2 Proposal	Hazardous Materials and Hazardous Waste Management Plan, Baffinland, 2018	http://www.baffinland.com/downloadocs/baf-ph1-830-p16-0011-r5---hazardous-materials-and-waste-management_2017-01-18-06.pdf				
	m	Waste rock piles (PAG and non-PAG);	**N/A**	No modification are proposed in support of the	Life of Mine Waste Rock Management Plan, Baffinland, 2014	http://www.baffinland.com/downloadocs/life-of-mine-waste-rock-management-plan_2017-11-36-42.pdf				

Section Title	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment	NIRB Guideline Section No.
			NA	support of the Phase 2 Proposal	Phase 1 Waste Rock Management Plan, Baffinland, 2014	http://www.baffinland.com/downloadocs/baf-ph1-830-p16-0029-r0---phase-1-waste-rock-management-plan_2017-01-32-01.pdf				

Section Title	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment	NIRB Guideline Section No.
Description of Undertaking	**n**	Stockpiles;	**Y**		TSD-2 Project Description, Baffinland, Sept, 2018	08MN053_TSD-02_Project-Description_Rev_1	Section 2.2; 4.4			
	o	Mill or processing plant;	**Y**		Same as above	Same as above	Section 2.3; 4.4			
	p	Tailings containment areas;	**N/A**	No tailings generated						
	q	Laydown areas;	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 2.8			
	r	Quarries;	**Y**		Same as above	Same as above	Section 2.7			
	s	Hazardous waste disposal area;	**Y**		TSD-2 Project Description, Baffinland, Sept, 2018	08MN053_TSD-02_Project-Description_Rev_1	Section 2.10, 4.9.2			
	t	Waste discharge distribution lines;	**Y**		TSD-2 Project Description, Baffinland, Sept, 2018	08MN053_TSD-02_Project-Description_Rev_1	App. A and B (figures)			
					See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Sections 3.6, 4.4, 4.7			
	u	Fuel and chemical storage;	**Y**		TSD-2 Project Description, Baffinland, Sept, 2018	08MN053_TSD-02_Project-Description_Rev_1	Section 2.9; 4.8			
					See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 5.3			
	v	Explosives manufacturing and storage;	**Y**		TSD-2 Project Description, Baffinland, Sept, 2018	08MN053_TSD-02_Project-Description_Rev_1	Section 2.9.2			
					See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 5.4			
	w	Abandoned and/or restored facilities;	**N/A**	There are no abandoned facilities						
	x	Existing on site infrastructure;	**Y**		TSD-2 Project Description, Baffinland, Sept, 2018	08MN053_TSD-02_Project-Description_Rev_1	All			
	y	Others:	**N/A**	All relevant information in TSD-02 Project Description	TSD-2 Project Description, Baffinland, Sept, 2018	08MN053_TSD-02_Project-Description_Rev_1	All			
Mine Plan	**2**	Provide a Mine Plan Overview including:								
		Description of the location, physical nature, geology and minerology of the ore deposit and host rock. (See section 5 items 19-23)	**N/A**	No change to ore body						
		Mine development plan and methods	**N/A**	No change to mine plan	TSD-2 Project Description, Baffinland, Sept, 2018	08MN053_TSD-02_Project-Description_Rev_1	Section 2.1			
		Exploration operations	**Y**		Same as above	Same as above	Section 9.0			
		Description of earthworks for mine development	**N/A**	No change to mine plan	TSD-2 Project Description, Baffinland, Sept, 2018	08MN053_TSD-02_Project-Description_Rev_1	Section 2.1			
		Milling or processing plant operations including:	**Y**	No milling or processing will occur; only crushing and screening	TSD-2 Project Description, Baffinland, Sept, 2018	08MN053_TSD-02_Project-Description_Rev_1	Sections 2.2, 4.3, 4.4 and 4.5			
		A copy of the mill or processing plant flow sheet. Indicate the points of addition of the various reagents (chemicals) that will be used.								
		The capacity of the mill								
		If applicable, indicate whether the (proposed) milling circuit is in whole or in part based on autogenous grinding.								
		Predicted rate of production.								
		Expected life of the mine.	**Y**		TSD-2 Project Description, Baffinland, Sept, 2018	08MN053_TSD-02_Project-Description_Rev_1	Section 1.2.5			
		Camp and mine site population projections for each phase of the project.	**Y**		TSD-2 Project Description, Baffinland, Sept, 2018	08MN053_TSD-02_Project-Description_Rev_1	Section 2.5, 4.6			

TABLE 4

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325

ATTACHMENT 3.2 - SUPPLEMENTAL INFORMATION GUIDELINES (SIG) CONCORDANCE
BASELINE INFORMATION

Section Title	Section No.	Information Requirement General Water Works	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment
Environmental Setting	**1**	Provide a description of the site using current detailed topographic survey maps and/or aerial photos where applicable. Maps, diagrams, and aerial photos must include accurate scales that allow the determination of distances between the objects depicted.	**1**	Provide a description of the regional and local setting using maps and/or aerial photos with scales that allow the determination of distances between the objects depicted.	**Y**		TSD-2 Project Description, Baffinland, Sept, 2018	08MN053_TSD-02_Project-Description_Rev_1	Section 1; Figures 1.1, 1.2, 1.3, 1.4		
	2	Provide a description of the site history if it has been used in the past.	**2**	Provide a brief history of the property development which took place before the present company gained control of the site. Include shafts, adits, mills, waste dumps, chemical storage areas, tailings disposal areas, and effluent discharge locations. Make references to a detailed map.	**N/A**	The NWB is familiar with the operating history of the Project					
	3	Provide a description of the site conditions, including:	**3**	Provide a description of the site conditions, including:							
	a	location	**a**	location	**Y**		FEIS, Baffinland, 2012	Volume 3	Volume 3, Section 1		
	b	topography	**b**	topography	**Y**		FEIS, Baffinland, 2012	Volume 6	Volume 6, Section 2		
							TSD-08 Landforms, Soil and Permafrost Assessment, Knight Piésold, July 2018	08MN053_TSD-08_Landforms-Soil-and-Permafrost_Rev_1	Section 2.1		
	c	geologic conditions	**c**	geologic conditions	**Y**		FEIS, Baffinland, 2012	Volume 6	Volume 6, Section 2		
							TSD-08 Landforms, Soil and Permafrost Assessment, Knight Piésold, July 2018	08MN053_TSD-08_Landforms-Soil-and-Permafrost_Rev_1	Section 2.1		
	d	hydrologic characteristics	**d**	hydrologic characteristics	**Y**		FEIS, Baffinland, 2012	Volume 7	Volume 7, Section 2		
							TSD-13 Surface Water Assessment, Knight Piésold, Aug 2018	08MN053_TSD-13_Surface-Water_Rev_1	Section 2; Appendix B		
		climate conditions and trends		climate conditions and predicted future climate trends	**Y**		TSD-06 Climate Change Assessment, Baffinland, August 2018	08MN053_TSD-06 _Climate-Change-Assessment_Rev_1	Section 3.4, 3.5, 3.6, 3.7 and 3.8		
	f	seismicity	**f**	seismicity	**Y**		FEIS, Baffinland, 2012	Volume 6 Terrestrial Environment	Section 2		
		permafrost conditions	**g**	permafrost conditions	**Y**		FEIS, Baffinland, 2012	Volume 6	Volume 6, Section 2		
							TSD-08 Landforms, Soil and Permafrost Assessment, Knight Piesold, July 2018	08MN053_TSD-08_Landforms-Soil-and-Permafrost_Rev_1	Section 2.1		
							TSD-06 Climate Change Assessment, Baffinland, August 2018	08MN053_TSD-06 _Climate-Change-Assessment_Rev_1	Section 3.5		
	4	Provide a description of the surface water regime and drainage area. Outline the drainage basin on an attached map.	**4**	Provide a description of the regional and local surface water regime and drainage area and outline the drainage basin on an attached map.	**Y**		FEIS, Baffinland, 2012	Volume 7	Volume 7, Sections 2 and 3		
							TSD-13 Surface Water Assessment, Knight Piesold, July 2018	TSD-13 Surface Water Assessment	Section 2, 3		
			5	Provide a description of the groundwater regime.			FEIS, Baffinland, 2012	Volume 7	Volume 7, Sections 2 and 3		
			6	Provide baseline data and an evaluation of baseline data describing surface and groundwater quality in the project area (physical, chemical, and biological characteristics).	**Y**		FEIS, Baffinland, 2012	Volume 7	Volume 7, Section 3		
							TSD-13 Surface Water Assessment, Knight Piesold, Aug 2018	08MN053_TSD-13_Surface-Water_Rev_1	Section 3		
	5	Provide a description of the usual break-up and freeze-up periods.	**7**	Provide a description of the usual break-up and freeze-up periods.	**Y**		FEIS, Baffinland, 2012	Volume 7 Volume 8	Volume 7, Section 2 Volume 8, Section 2		
	6	Provide a description of streambed material, streambank material, and streambank vegetation.	**8**	Provide a description of streambed material, streambank material, and streambank vegetation,	**N/A**	A high number of crossings are proposed with the Phase 2 Proposal. The crossings are typical of those already in use by Baffinland.					
	7	Indicate the slope of the banks of any water course affected by the application	**9**	Indicate the slope of the banks of any water course affected by the application							
	8	Provide a decription of the meander pattern for any channel affected by the application	**10**	Provide a decription of the meander pattern for any channel affected by the application							
	9	Provide the following streamflow data in cubic metres per second for each watercourse included in the application:	**11**	Provide the following streamflow data in cubic metres per second for each watercourse included in the application:	**Y**		TSD-13 Surface Water Assessment, Knight Piesold, Aug 2018	08MN053_TSD-13_Surface-Water_Rev_1	Appendix C		
		mean annual flow;		mean annual flow;							
		mean summer flow;		mean summer flow;							
		minimum summer flow;		minimum summer flow;							
		minimum annual flow;		minimum annual flow;							
		mean annual flood;		mean annual flood;							
		maximum summer flood;		maximum summer flood;							
		mean summer flood;		mean summer flood;							

Section Title	Section No.	Information Requirement General Water Works	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment
Environmental Setting	**10**	Provide bathymetric information for water bodies affected by the application.	**12**	Provide bathymetric information for water bodies affected by the application.	**N/A**	No new waterbodies affected by the application					
	11	Provide a description of the ground condition for design and engineering of earthwork infrastructure (if applicable, provide test pit/ drill hole logs and laboratory test results).	**13**	Provide a description of the ground condition for design and engineering of earthwork infrastructure, including (if applicable, provide test pit/ drill hole logs and laboratory test	**Y**		FEIS, Baffinland, 2012 See Doc Key (Att. 3.1)	Volume 6 180926-2AM-MRY1325-Applic-Part-6b 180926-2AM-MRY1325-Applic-Part-8	Volume 6, Section 2 Att. 6.2 and Att. 8		
			a	Interim and permanent waste rock facilities	**N/A**	Existing waste rock facilities will be used					
			b	Tailings containment area	**N/A**	The Project does not generate tailings					
			c	Landfills	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 4.8		
			d	Landfarms	**N/A**	No new landfarms proposed	Same as above	180926-2AM-MRY1325-Applic-Part-17	All		
			e	Fuel and chemical storage facilities	**Y**		Same as above	180926-2AM-MRY1325-Applic-Part-1-Main-Report 180926-2AM-MRY1325-Applic-Part-12a 180926-2AM-MRY1325-Applic-Part-13	Section 5.3, Attachments 12.1 and 13		
			f	Explosives management areas and facilities	**Y**		Same as above	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 5.4		
			g	Roads	**Y**		Same as above	180926-2AM-MRY1325-Applic-Part-1-Main-Report 180926-2AM-MRY1325-Applic-Part-6a 180926-2AM-MRY1325-Applic-Part-6b 180926-2AM-MRY1325-Applic-Part-6c 180926-2AM-MRY1325-Applic-Part-7	Section 2.4 and Attachments 6.1, 6.2, 6.3 and 7		
			h	Quarries or borrow pits	**Y**		Same as above	180926-2AM-MRY1325-Applic-Part-1-Main-Report 180926-2AM-MRY1325-Applic-Part-6d	Section 2.7, Attachment 6.4		
			i	Hazardous waste facilities	**Y**		Same as above	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 4.5		
			j	Wastewater treatment facilities	**Y**		Same as above	180926-2AM-MRY1325-Applic-Part-1-Main-Report 180926-2AM-MRY1325-Applic-Part-11 180926-2AM-MRY1325-Applic-Part-16	Section 4.7, Attachments 11 and 16		
			k	Ore stockpiles	**N/A**	New ore stockpile in an area of known geotechnical					
			l	Overburden piles	**N/A**	No changes to waste rock (including overburden)					
			m	Dewatering dikes	**N/A**	No dewatering dykes					
			14	Provide results of any assessment of the permeability of any faults and taliks beneath water bodies.	**N/A**	No project activities within water bodies with taliks					
	12	Provide a description of the historical uses of the waters affected by the project.	**15**	Provide a description of the historical uses of the waters affected by the project.	**Y**		FEIS, Baffinland, 2012	ftp://ftp.nwb-oen.ca/registry/2%20MINING%20MILLING/2A/2AM%20-%20Mining/2AM-MRY1325%20BIMC/1%20APPLICATION/Final%20Environmental%20Impact%20Statement/Volume%2004/.	Volume 4, Section 10 and Appendix 4C		
	13	Provide a description of any traditional uses of water in the project area.	**16**	Provide a description of any traditional uses of water in the project area.	**Y**		Same as above	Same as above	Same as above		
	14	Indicate whether fish, shellfish, or other wildlife are present and harvested in or near the project area and, if applicable, indicate the species harvested and the level of harvest.	**17**	Indicate whether fish, shellfish, or other wildlife are present and harvested in or near discharge areas and, if applicable, indicate the species harvested and the level of harvest.	**Y**		Same as above	Same as above	Same as above		
	15	Provide a description of the results of any consultation with Elders regarding the collection of baseline data.	**18**	Provide a description of the results of any consultation with Elders regarding the collection of baseline data.	**Y**		TSD-04 Public Consultation, Baffinland, Sept 2018	08MN053_TSD-04_Public-Consultation_Rev_1	Section 3, 4		

Section Title	Section No.	Information Requirement General Water Works	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment
Geology and Mineralogy			**19**	Provide a description of the physical nature of the mineralization, including known dimensions and approximate shape		Project is an already operating mine, mining the current Deposit No. 1					
			20	Provide a description of the host rock in the general vicinity of the mineralization (from the surface to the mineralized zone)							
			21	Provide a geological description of the mineralized zone. (If possible, include the percentage of metals)							
			22	Provide a description of the geochemical tests which have been (or will be) performed on the ore, host rock, and waste rock to determine their relative acid generation and contaminant leaching potential. Outline methods used (or to be used) and provide test results in an attached report (ie. static test, kinetic tests).	**N/A**						
			23	Provide an estimate of the percentage of sulphide in the mineralization including:							
				Pyrite							
				Pyrrhotite							
				Pyrite / Pyrrhotite mixture							
				Arsenopyrite							
	16	Provide a description of the geochemical tests which have been (or will be) performed on quarrry or borrow material to determine the relative acid generation and contaminant leaching potential. Outline methods used (or to be used) and provide test results in an attached report (ie. static test, kinetic tests).	**24**	Provide a description of the geochemical tests which have been (or will be) performed on quarrry or borrow material to determine the relative acid generation and contaminant leaching potential. Outline methods used (or to be used) and provide test results in an attached report (ie. static test, kinetic tests).	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 2.7		
Fisheries	**17**	The applicant is advised to consult with DFO regarding fish and fish habitat related issues and to visit DFO's website at http://www.dfo-mpo.gc.ca/habitat/habitat-eng.htm. Indicate whether the applicant has consulted with DFO and provide the results of any consultation.	**25**	The applicant is advised to consult with DFO regarding fish and fish habitat related issues and to visit DFO's website at http://www.dfo-mpo.gc.ca/habitat/habitat-eng.htm. Indicate whether the applicant has consulted with DFO and provide the results of any consultation.	**Y**		TSD-04 Public Consultation, Baffinland, Sept 2018	08MN053_TSD-04_Public-Consultation_Rev_1	Section 3.4		
	18	If applicable, provide baseline data and an evaluation of baseline data describing fish and fish habitat in the project area	**26**	If applicable, provide baseline data and an evaluation of baseline data describing fish and fish habitat in the project area.	**Y**		FEIS, Baffinland, 2012	Volume 7	Volume 7, Appendix 7C		
	19	If applicable, provide a fisheries assessment including:	**27**	If applicable, provide a fisheries assessment including:							
		Detailed area description (including photographic record);		Detailed area description (including photographic record);							
		Description of fish habitat (including river or lake bottom substrates such as silt, sand, or cobble);		Description of fish habitat (including river or lake bottom substrates such as silt, sand, or cobble);							
		Presence of sensitive habitats (spawning, migration corridors etc.);		Presence of sensitive habitats (spawning, migration corridors etc.);	**Y**		TSD-14 Freshwater Biota and Habitat Assessment, North/South Consultants, Sept 2018	08MN053_TSD-14-Freshwater-Biota-Habitat_Rev_1	All		
		Description of aquatic and riparian vegetation;		Description of aquatic and riparian vegetation;							
		Fish community and lifestage present;		Fish community and lifestage present;							
		Depth and width of watercourse;		Depth and width of watercourse;							
		Max/min water flows, currents, tides;		Max/min water flows, currents, tides;							
		Turbidity and sediment loads (total suspended solids);		Turbidity and sediment loads (total suspended solids);							
		Sport, commercial, subsistence fishery present.		Sport, commercial, subsistence fishery present.							

Section Title	Section No.	Information Requirement General Water Works	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment
Studies	**20**	Provide a list of baseline studies, reports and plans relevant to the application that have been undertaken to date or are being planned including:	**28**	Provide a list of baseline studies, reports and plans relevant to the application that have been undertaken to date including:							
		Geotechnical studies;		Geotechnical studies;	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-6a 180926-2AM-MRY1325-Applic-Part-6b 180926-2AM-MRY1325-Applic-Part-6c 180926-2AM-MRY1325-Applic-Part-12a 180926-2AM-MRY1325-Applic-Part-12b	Attachments 6.1, 6.2, 6.3, 12		
		Geochemical studies;		Geochemical studies;	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-6d	Attachment 6.4		
		Water quality studies;		Water quality studies;	**Y**		TSD-13 Surface Water Assessment, Knight Piesold, Aug 2018	08MN053_TSD-13_Surface-Water_Rev_1	Section 3		
		Hydrological and hydrogeological studies;		Hydrological and hydrogeological studies;	**Y**		TSD-13 Surface Water Assessment, Knight Piesold, Aug 2018	08MN053_TSD-13_Surface-Water_Rev_1	Appendix B		
		Traditional use studies;		Traditional use studies;	**Y**		TSD-03 Phase 2 Workshops Report, Jason Prno Consulting Services Ltd., January 2017	08MN053_TSD-03_Phase-2-Community-Workshops-rpt_Rev_1	All		
	f	Aquatic studies;	**f**	Aquatic studies;	**Y**		TSD-14 Freshwater Biota and Habitat Assessment, North/South Consultants, Sept 2018	08MN053_TSD-14-Freshwater-Biota-Habitat_Rev_1	All		
							TSD-15 Freshwater Fish Habitat Offsetting Plan, Knight Piesold, June 2018	08MN053_TSD-15_Conceptual-Freshwater-Offsetting-Plan_Rev_1	All		
		Meteorological studies;		Meteorological studies;	**Y**		TSD-07 Atmospheric Assessments, Knight Piesold, Aug 2018	08MN053_TSD-07_Atmospheric_Assessments_Rev_1	All		

TABLE 5

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325

ATTACHMENT 3.2 - SUPPLEMENTAL INFORMATION GUIDELINES (SIG) CONCORDANCE
WATER USE

Section Title	Section No.	Information Requirement General Water Works	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment
Water Use	**1**	Provide a detailed description of all types of water uses incuding: (See the NWB definition of "use" in the NWB Guide 2: Terminology and Definitions)	**1**	Provide a detailed description of all types of water uses including: (See the NWB definition of "use" in the NWB Guide 2: Terminology and Definitions). Categorize water consumption use(s) as either mining/industrial use and/or domestic use.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 3		
		Obtain water for domestic purposes	**a**	Obtain water for domestic purposes	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Sections 3.3 to 3.5		
		Obtain water for industrial purposes	**b**	Obtain water for industrial purposes: - drilling - mill or processing plant - concrete production - explosives manufacture - ice road construction - other	**Y**		Same as above	Same as above	Same as above		
		To cross a water course	**c**	To cross a water course	**Y**		Same as above	Same as above	Section 2.5		
		To alter the flow of water, or store water	**d**	To alter the flow of water, or store water	**Y**		Same as above	Same as above	Sections 2.5 and 4.4		
		Flood control	**e**	Flood control	**N/A**	No flood control measures to be used.					
		To divert a watercourse	**f**	To divert a watercourse	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 2.5		
		To modify the bed or bank of a watercourse		To modify the bed or bank of a watercourse	**Y**		Same as above	Same as above	Same as above		
		Others:		Others:	**N/A**	No other water uses are contemplated.					
Water Use: Quality and Quantity Water Intake ****Identify uses as either domestic or industrial****	**2**	Provide the name of the primary water source(s) as well as the name of any alternative water source(s).	**2**	Provide the name of the primary water source(s) as well as the name of any alternative water source(s).	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 3		
	3	Provide a description of the source(s) of water and the location of the water source(s) as shown on a map.	**3**	Provide a description of the source(s) of water and the location of the water source(s) as shown on a map.	**Y**		Same as above	Same as above	Same as above		
	4	Indicate the type of water source(s) as lake, river, well, or other type.	**4**	Indicate the type of water source(s) as lake, river, well, or other type.	**Y**		Same as above	Same as above	Same as above		
	5	Provide a description of the quality of the water from the source(s) for each season (summer, fall, winter, spring).	**5**	Provide a description of the quality of the water from the source(s) for each season (summer, fall, winter, spring).	**Y**		Same as above	Same as above	Same as above		
	6	Provide the capacity of the water source(s).	**6**	Provide the capacity of the water source(s).	**Y**		Same as above	Same as above	Same as above		
	7	Provide the acquisition rate in cubic metres per day and cubic metres per year from each water source.	**7**	Provide the acquisition rate in cubic metres per day and cubic metres per year from each water source.	**Y**		Same as above	Same as above	Same as above		
	8	Provide a description of the water intake method(s) including the intake facility, the operating capacity of the pump used, the details of any screening to exclude fish, and the distance the pump will be placed from the ordinary high water mark of the watercourse.	**8**	Provide a description of the water intake method(s) including the intake facility, the operating capacity of the pump used, the details of any screening to exclude fish, and the distance the pump will be placed from the ordinary high water mark of the watercourse.	**Y**		Same as above	Same as above	Same as above		
	9	Provide a description of the general condition of any existing water intake facility. Rate the condition of the facility as satisfactory or unsatisfactory and explain the rating.	**9**	Provide a description of the general condition of any existing water intake facility. Rate the condition of the facility as satisfactory or unsatisfactory and explain the rating.	**Y**		Same as above	Same as above	Same as above		
	10	Indicate whether water is drawn from the source(s) intermittently or continuously and if intermittently indicate during what months it is drawn and for what period it is drawn (days/weeks/months).	**10**	Indicate whether water is drawn from the source(s) intermittently or continuously and if intermittently indicate during what months it is drawn and for what period it is drawn (days/weeks/months).	**Y**		Same as above	Same as above	Same as above		
	11	Indicate the amount of water to be returned to the source(s).	**11**	Indicate the amount of water to be returned to the source.	**Y**		Same as above	Same as above	Same as above		
	12	Provide a description of the methods to ensure water returned to any source is of an acceptable quality.	**12**	Provide a description of the methods to ensure water returned to any source is of an acceptable quality.	**Y**		Same as above	Same as above	Same as above		
	13	Provide a description of any hydrostatic testing programs, including water sources, and treatment/disposal requirements. If applicable, refer to the NWB's SIG for Hydrostatic Testing.	**13**	Provide a description of any hydrostatic testing programs, including water sources, and treatment/disposal requirements. If applicable, refer to the NWB's SIG for Hydrostatic Testing.	**N/A**	Fuel tanks will be weld-tested using other methods					
			14	Indicate the quantities of water required for ice road construction and provide a description of the methods of ice road construction.	**N/A**	No ice roads will be constructed.					
	14	Provide a description of any measures to reduce water consumption.	**15**	Provide a description of any measures to reduce water consumption.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 3.5		

Section Title	Section No.	Information Requirement General Water Works	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment
Water Storage	**15**	Provide a description of any water storage facilities including the type (reservoir/pond, storage tank), location, design, and the water storage volume in cubic meters.	**16**	Provide a description of any water storage facilities including the type (reservoir/pond, storage tank), location, design, and the water storage volume in cubic meters.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 3.7		
	16	If the water storage facility is a reservoir, indicate whether the reservoir is lined, the type of liner and when it was or will be installed.	**17**	If the water storage facility is a reservoir, indicate whether the reservoir is lined, the type of liner and when it was or will be installed.	**N/A**	No reservoir for water storage.					
	17	Indicate whether a storage reservoir is created in a natural channel. If applicable, provide plan and profile drawings of the reservoir including the size of the drainage basin upstream of the reservoir, topographical plan showing the drainage area boundary, number of hectares flooded, surface area of the reservoir at full capacity, storage capacity, and details of shoreline protection.	**18**	Indicate whether a storage reservoir is created in a natural channel. If applicable, provide plan and profile drawings of the reservoir including the size of the drainage basin upstream of the reservoir, topographical plan showing the drainage area boundary, number of hectares flooded, surface area of the reservoir at full capacity, storage capacity, and details of shoreline protection.							
	18	Provide a plan showing representative cross sections of the reservoir.	**19**	Provide a plan showing representative cross sections of the reservoir.							
	19	Provide a description of the general condition of any existing water storage facility and provide an explanation if it is unsatisfactory.	**20**	Provide a description of the general condition of any existing water storage facility and provide an explanation if it is unsatisfactory.	**N/A**	Current water storage facilities are being maintained and used during operations.					
Water Distribution	**20**	Provide a description of water distribution systems (ie. piped water, trucked) including the number of people on each system.	**21**	Provide a description of water distribution systems (ie. piped water, trucked).	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Sections 2.9 and 3.7		
	21	For each phase of development, calculate the total water consumed per day (L/day) by multiplying the estimated number of persons on the system by the estimated average water consumption (Litres/ capita/day). Calculate the total water consumed for each individual distribution system if more than one is used (ie. piped water, trucked water).			**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Sections 3.3, 3.4 and 3.5		
	22	Provide a description of the general condition of any existing water distribution system and provide an explanation if it is unsatisfactory.	**22**	Provide a description of the general condition of any existing water distribution system and provide an explanation if it is unsatisfactory.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 3.5		
Watercourse Crossings	**23**	Provide a description of any watercourse crossings including pipelines, bridges, culverts or roads and its purpose.	**23**	Provide a description of any watercourse crossings including pipelines, bridges, culverts or roads and its purpose.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report 180926-2AM-MRY1325-Applic-Part-8	Section 2.5, Attachment 8		
	24	Indicate whether a temporary detour road is required to construct the watercourse crossing. If applicable, provide a schematic drawing that shows the location of the proposed detour road, any watercourse crossings to be constructed to facilitate the detour road, and the type of crossing.			**N/A**	No detour roads required.					
	25	Provide a plan of any watercourse crossing showing cross section and elevations	**24**	Provide a plan of any watercourse crossing showing cross section and elevations	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report 180926-2AM-MRY1325-Applic-Part-8	Section 2.5, Attachment 8		
Watercourse Trainings	**26**	Provide a description of any watercourse trainings including channel and bank alterations, culverts, spurs, erosion control, and artificial accretion, and its purpose.	**25**	Provide a description of any watercourse trainings including channel and bank alterations, culverts, spurs, erosion control, and artificial accretion, and its purpose.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report 180926-2AM-MRY1325-Applic-Part-8	Section 2.5, Attachment 8		
Flood Control	**27**	Provide a description of any flood control structures and its purpose.	**26**	Provide a description of any flood control structures and its purpose.	**N/A**	No flood control measures to be used.					
Diversions	**28**	Provide a description of any diversions including ditches and dikes, and its purpose.	**27**	Provide a description of any diversions including ditches and dikes and its purpose.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report 180926-2AM-MRY1325-Applic-Part-10	Section 3.6, Attachment 10		
Alterations in flow	**29**	Provide a description of any activities or structures that could alter the flow of a watercourse including dams, spillways, berms, cofferdams, and dikes, and its purpose.	**28**	Provide a description of any activities or structures that could alter the flow of a watercourse including dams, spillways, berms, cofferdams, and dikes, and its purpose.	**Y**		Same as above	Same as above	Same as above		
	30	Indicate whether the natural storage capacity or water level of any lake or pond will be altered.	**29**	Indicate whether the natural storage capacity or water level of any lake or pond will be altered.	**Y**		TSD-13 Surface Water Assessment, Knight Piesold, Aug 2018	08MN053_TSD-13_Surface-Water_Rev_1	Section 2		
	31	If the alteration involves a dam, provide a plan showing the length, height, cross section and elevations of the dam and the location and preliminary designs of spillways, canals, sluice pipes, and any other outlet work.	**30**	If the alteration involves a dam, provide a plan showing the length, height, cross section and elevations of the dam and the location and preliminary designs of spillways, canals, sluice pipes, and any other outlet work.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report 180926-2AM-MRY1325-Applic-Part-10	Section 3.6, Attachment 10		
Dewatering	**32**	Provide a description of dewatering programs, if planned, including estimated quantities, qualities, dewatering flow rates, methods and schedule of withdrawl, end use or discharge location.	**31**	Provide a description of dewatering programs, if planned, including estimated quantities, qualities, dewatering flow rates, methods and schedule of withdrawl, end use or discharge location.	**N/A**	No dewatering programs are planned.					
			32	Provide an estimate of the quality and flow of groundwater that will flow into any open pits.	**N/A**	No change from current Licence.					
Identification	**33**	Indicate whether there are any signs identifying past or present water intake, storage, distribution systems and/or waterwork structures presently in the project area.	**33**	Indicate whether there are any signs identifying past or present water intake, storage, distribution systems and/or waterwork structures presently in the project area.	**N/A**	Area is currently an operating mine.					

Section Title	Section No.	Information Requirement General Water Works	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment
Modifications	**34**	Indicate whether any changes are planned for the water intake, storage, distribution systems and/or waterwork structures. If applicable, see item 35 of this section.	**34**	Indicate whether any changes are planned for the water intake, storage, distribution systems and/or waterwork structures. If applicable, see item 35 of this section.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 3.7		
Proposed Water works	**35**	For each proposed water work component provide design plans. Design plans shall consider the following:	**35**	For each water work component provide the design plans stamped for construction. Design plans shall consider the following:	**Y**					Detailed information will be provided to the NWB prior to starting construction activities.	
		Name of the water body(s) affected.		Name of the water body(s) affected.							
		Site photos, site map, or air photos of the location.		Site photos, site map, or air photos of the location.							
		Description of the existing condition of the site (see section 4)		Description of the existing condition of the site (see Section 5)							
		Indicate whether any structures will be placed in water on a temporary, seasonal or permanent basis and provide a description of when and how the structure will be removed.		Indicate whether any structure will be placed in water on a temporary, seasonal or permanent basis and provide a description of when and how the structure will be removed.							
		The design flood flow in cubic metres per second and its return period for the type of structure proposed.		The design flood flow in cubic metres per second and its return period for the type of structure proposed.							
		An explanation of the rationale for the selected design flow flood and its return period.		An explanation of the rationale for the selected design flow flood and its return period.							
		Design drawings in plan and profile, drawn to scale, including all relevant dimensions.		Design drawings in plan and profile, drawn to scale, including all relevant dimensions.							
		Detaills of design parameters including seismic design criteria if applicable.		Detaills of design parameters including seismic design criteria if applicable.							
		In water work timing restriction for fisheries.		In water work timing restriction for fisheries.							
		Start and completion dates for construction.		Start and completion dates for construction.							
		Construction schedule and sequence taking into account any timing restrictions.		Construction schedule and sequence taking into account any timing restrictions.							
		Construction methods.		Construction methods.							
		Equipment to be used.		Equipment to be used.							
		A description of the source, type, and composition of material used in construction.		A description of the source, type, and composition of material used in construction.							
		The quantity of material to be either placed into or removed from the watercourse.		The quantity of material to be either placed into or removed from the watercourse.							
		Sedimentation and erosion control measures.		Sedimentation and erosion control measures.							
		Construction monitoring plans.		Construction monitoring plans.							
		Construction quality assurance and quality control measures.		Construction quality assurance and quality control measures.							
		Assessment of impacts to fish and fish habitat (see item 46 of this Section).		Assessment of impacts to fish and fish habitat (see item 44 of this Section).							
		Bank stabilization measures (including the size range of material if applicable).		Bank stabilization measures (including the size range of material if applicable).							
		Operation and maintenance plans including instrumentation, monitoring and inspection requirements		Operation and maintenance plans including instrumentation, monitoring and inspection requirements.							
		Contingency plans		Contingency plans.							
		Re-vegetation plans		Re-vegetation plans							
		Proposed post construction monitoring (photos taken of the site before construction, during construction, and after construction; photos should be taken from the same reference point for easy comparison)		Proposed post construction monitoring (photos taken of the site before construction, during construction, and after construction; photos should be taken from the same reference point for easy comparison)							
		Abandonment and restoration plans (see items 46 and 47 of Section 3).		Abandonment and restoration plans (see items 45-49 of Section 3).							
	36	Final plans and drawings for construction must be stamped by a Professional Engineer licensed to practice in Nunavut. (See Section 7 of the NWB's Guide 4: Completing and Submitting a Water Licence Application for more information regarding design drawings).	**36**	Final plans and drawings for construction must be stamped by a Professional Engineer licensed to practice in Nunavut. (See Section 7 of the NWB's Guide 4: Completing and Submitting a Water Licence Application for more information regarding design drawings).							
	37	If geotextile is used or a similar material to prevent the transport of sediment into a watercourse, provide the technical specifications for the proposed material as well as the location, extent and placement method for the material.	**37**	If geotextile is used or a similar material to prevent the transport of sediment into a watercourse, provide the technical specifications for the proposed material as well as the location, extent and placement method for the material.	**Y**					Detailed information will be provided to the NWB prior to starting construction activities.	
	38	If rip rap is used or a similar material for erosion protection, provide information regarding the minimum and maximum sizes of the material and the gradation between those limits. Indicate the quantity to be used and its source.	**38**	If rip rap is used or a similar material for erosion protection, provide information regarding the minimum and maximum sizes of the material and the gradation between those limits. Indicate the quantity to be used and its source.							

Section Title	Section No.	Information Requirement General Water Works	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment
Predicted Environmental Effects and Proposed mitigation measures	**39**	Provide a description of the effects of water usage on the river or lake from which water will be drawn, including potential for drawdown.	**39**	Provide a description of the effects of water usage on the source from which water will be drawn including the potential for drawdown.	**Y**		TSD-13 Surface Water Assessment, Knight Piesold, Aug 2018	08MN053_TSD-13_Surface-Water_Rev_1	All		
	40	Provide a description of any expected changes in surface water flow or storage including changes downstream of the project.	**40**	Provide a description of any expected changes in surface water flow or storage including changes downstream of the project.	**Y**		Same as above	Same as above	Same as above		
	41	If the cross-section of any watercourse is changed, provide a description of the change and its effect on the flow capacity of the channel.	**41**	If the cross-section of any watercourse is changed, provide a description of the change and its effect on the flow capacity of the channel.	**Y**		Same as above	Same as above	Same as above		
	42	If the course of any channel is changed, provide a description of measures to maintain stream bed and bank stability.	**42**	If the course of any channel is changed, provide a description of measures to maintain stream bed and bank stability.	**Y**		Same as above	Same as above	Same as above		
	43	Provide a description of measures of preventing surface water from coming into contact with waste and measures of managing surface water that does come into contact with waste (surface water management plan).	**43**	Provide a description of measures of preventing surface water from coming into contact with waste and measures of managing surface water that does come into contact with waste (surface water management plan).	**Y**		Same as above	Same as above	Same as above		
	44	Provide a description of measures of preventing groundwater from coming into contact with waste and measures of managing groundwater that does come into contact with waste (groundwater management plan).	**44**	Provide a description of measures of preventing groundwater from coming into contact with waste and measures of managing groundwater that does come into contact with waste (groundwater management plan).	**Y**		Same as above	Same as above	Same as above		
Fisheries	**45**	If applicable, provide a description of any potential impacts to fish and/or fish habitat. (Indirect effects may include project effects, water quality, or aquatic organisms. Direct effects may include degradation or alteration of fish habitat). The applicant is advised to consult with DFO regarding fish and fish habitat related issues and to visit DFO's website at http://www.dfo-mpo.gc.ca/habitat/habitat-eng.htm.	**45**	If applicable, provide a description of any potential impacts to fish and/or fish habitat. (Indirect effects may include project effects, water quality, or aquatic organisms. Direct effects may include degradation or alteration of fish habitat). The applicant is advised to consult with DFO regarding fish and fish habitat related issues and to visit DFO's website at http://www.dfo-mpo.gc.ca/habitat/habitat-eng.htm.	**Y**		TSD-14 Freshwater Biota and Habitat Assessment, North/South Consultants, Sept 2018	08MN053_TSD-14-Freshwater-Biota-Habitat_Rev_1	All		
		Potential effects on fish or fish habitat;		Potential effects on fish or fish habitat;							
		The area in square metres to be impacted;		The area in square metres to be impacted;							
		Measures to avoid sensitive periods and habitat areas (i.e., spawning beds, migration corridors);		Measures to avoid sensitive periods and habitat areas (i.e., spawning beds, migration corridors);							
		Measures to avoid physical impacts on habitat;		Measures to avoid physical impacts on habitat;							
		Measures to maintain flows and fish passage;		Measures to maintain flows and fish passage;							
		Measures to avoid sedimentation;		Measures to avoid sedimentation;							
		Measures to avoid spills;		Measures to avoid spills;							
		Detailed habitat no-net-loss plan and site restoration plan;		Detailed habitat no-net-loss plan and site restoration plan;	**Y**		TSD-15 Conceptual Freshwater Offsetting Plan, Knight Piésold, June 2018	08MN053_TSD-15_Conceptual-Freshwater-Offsetting-Plan_Rev_1	All		
Studies	**46**	Provide a list of studies, reports and plans relevant to the application that have been undertaken to date, or are being planned including:	**46**	Provide a list of studies, reports and plans relevant to the application that have been undertaken to date, including:							
		Options analysis;		Options analysis;	**Y**		TSD-01 Alternatives Analysis, Baffinland, August, 2018	08MN053_TSD-01_Alternatives-Analysis	All		
		Water management plan including water balance analysis;		Water management plan including water balance analysis;	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-10	Attachment 10		
		Fisheries assessment;		Fisheries assessment;	**Y**		TSD-14 Freshwater Biota and Habitat Assessment, North/South Consultants, Sept 2018	08MN053_TSD-14-Freshwater-Biota-Habitat_Rev_1	All		
		Construction plan and construction schedule for water works;		Construction plan and construction schedule for water works;	**Y**					Detailed construction information will be made available to the NWB 30 days prior to construction as per water licence.	
		Implementation schedule for construction of works.		Implementation schedule for construction of works.							
		Construction quality assurance and quality control plans;		Construction quality assurance and quality control plans;	**N/A**	Remains unchanged from the Type A Water Licence Application					
		Operation and maintenance plan;		Operation and maintenance plan;	**N/A**	The mine is operational; a large number of operation and maintenance plans are under implementation.					
		Preliminary abandonment and reclamation plans for existing and proposed facilities;		Preliminary abandonment and reclamation plans for existing and proposed facilities;	**N/A**	Intermin Closure Plan has already been filed with the Minister. This will be updated to reflect the Phase 2 Proposal.					
		Final abandonment and reclamation plans for facilities to be closed;		Final abandonment and reclamation plans for facilities to be closed;	**N/A**	Same as above					
		Monitoring plans (See Section 8).		Monitoring plans (See Section 8).	**N/A**	See Table 7					

TABLE 6

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325

ATTACHMENT 3.2 - SUPPLEMENTAL INFORMATION GUIDELINES (SIG) CONCORDANCE
WASTE DISPOSAL

Section Title	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment	NIRB Guideline Section No.
Waste Disposal	**1**	Provide a detailed description of all types of waste and all forms of waste disposal including: (see the NWB definition of Waste in the NWB *Guide 2: Terminology and Definitions*)	**Y**							
		Sewage	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 4			
		Grey water	**Y**							
		Solid waste	**Y**							
		Sludge	**Y**							
		Hazardous waste including waste oil	**Y**							
		Contaminated soil, snow, ice and/or water	**Y**							
		Bulky items/ scap metal	**Y**							
		Mill or processing plant waste	**N/A**	No milling or processing						
		Mine water	**Y**		FEIS, Baffinland, 2012	Volume 7	Volume 7, Section 3			
		Dredged material	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 2.6			
		Discharge from dewatered areas	**N/A**							
		Other: (describe)	**N/A**							
Waste Disposal: Quality and Quantity	**2**	For each type of waste, provide the composition, chemical characteristics and quantity generated. Also provide the location, rate, timing, frequency and duration of the deposit.	**Y**		Same as above	Same as above	Section 4			
	3	For each type of waste, provide the proposed methods and processes for collecting, storing, treating and discharging the waste. Indicate the capacity of these facilities.	**Y**		Same as above	Same as above	Section 4			
	4	Provide a description of any measures to minimize the production of wastes.	**Y**		Same as above	Same as above	Section 4			
Identification	**5**	Indicate whether there are signs identifying any past or present wastewater disposal sites, solid waste disposal sites, or any other waste disposal sites presently in the project area.	**N/A**	The area is a current operating mine						
Modifications	**6**	Indicate whether any changes are planned for the wastewater, solid waste, or any other waste facilities. If applicable, see item 7 of this Section.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 4			
Proposed waste facilities	**7**	For each proposed waste facility provide design plans. The designs shall consider the following:	**Y**		Milne Port Landfill Design and Operation Report			To be provided following construction of the Phase 2 Proposal, approx. June 2020.		
	a	Site photos, site map, or air photos of the site.								
	b	Description of the existing condition of the site (see Section 5).								
	c	A description of the types of waste entering the facility (if applicable, provide a description of the source, type, and quantity of the waste);								
	d	The concentration of waste entering the facility;								
	e	The geochemical characterization of waste entering the facility, where applicable (ie. tailings solids);								
	f	Distance of the facility from watercourses and fish bearing waters.								
	g	All sources of seepage encountered near watercourse and fish bearing waters as well as the volumes (m3/day) and direction of any seepage;								
	h	Existing and proposed drainage modifications.								
	i	Details of retaining structures.								
	j	Level of treatment (primary, secondary or tertiary).								
	k	By products of treatment which may require further treatment, characterization, handling and disposal.								
	l	Capacity and retention time of the facility;								
	m	Identification of final discharge point (last point of control).								
	n	Method and type of discharge (seasonal, annual, continuous) including details of all decant, siphon mechanisms etc.								
	o	Estimated rates for discharge.								
	p	Restrictions on discharge.								
	q	Discharge effluent criteria proposed;								
	r	Receiving water quality objectives.								
	s	Capacity of the receiving environment;								
	t	Details regarding direction and path of wastewater flow from the area or infrastructure.								

Proposed waste facilities	**u**	Design drawings in plan and profile, drawn to scale, including all relevant dimensions.	**Y**		Milne Port Landfill Design and Operation Report			To be provided following construction of the Phase 2 Proposal, approx. June 2020.		
	v	Details of design parameters including seismic design if applicable.								
	w	Start and completion dates for construction.								
	x	Construction schedule and sequence taking into account any timing restrictions.								
	y	Construction methods.								
	z	Equipment to be used.								
	aa	A description of the source, type, and composition of the material to be used in construction.								
	bb	Construction monitoring plans.								
	cc	Construction quality assurance and quality control measures.								
	dd	Operation and maintenance plans.								
	ee	Contingency plans.								
	ff	Abandonment and restoration plans (see items 45-49 of Section 3).								
	8	Final plans and drawings for construction must be stamped by a Professional Engineer licensed to practice in Nunavut. (See Section 7 of the NWB's *Guide 4: Completing and Submitting a Water Licence Application* for more information regarding design drawings).								
	9	Provide an assessment of alternatives for any proposed tailings containment facility.	**N/A**	No tailing produced						
	10	Provide a description of the general condition of any existing waste facilities and provide an explanation if it is unsatisfactory.	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 4			
Predicted Environmental Effects and Proposed mitigation measures	**11**	Provide detailed treatment plans for discharges from any tailings containment area, attenuation pond, reclaim pond, sewage disposal area, sumps or dewatered area. Water treatment plans should include estimates of treatment efficiency for each parameter of concern and a description of pH adjustment methods.	**Y**		Same as above	Same as above	Section 4.7			
	12	Clearly outline proposed discharge criteria, how the criteria were developed, standards to be applied, and how these criteria will be used to prevent ecological effects in the receiving environment.	**N/A**	Discharge criteria are stipulated in Type A Water Licence 2AM-MRY1325 and will be adhered to.						
	13	If waste is expected to infiltrate into the ground, provide a description of the sub-surface soil compositions and provide information on groundwater elevations for the project area. Also provide the proximity between the proposed waste disposal system and the groundwater elevation.	**N/A**	Waste is not expected to inflitrate into the ground.						
	14	Provide a discussion of the consequences of long-term stratification in any pit lakes and associated contingency plans.	**N/A**	Addressed in the Interim Closure and Reclamation Plan						
	15	Provide detailed contingency plans for the treatment of turbid water during dewatering activities and/or increased suspended solids during any rewatering activities.	**Y**		Surface Water and Aquatic Ecosystem Management Plan, Rev 4, Baffinland, March 2016	http://www.baffinland.com/downloadocs/surface-water-and-aquatic-ecosystem-management-plan_2017-11-40-00.pdf	Section 4			

Operations and Maintenance	**16**	Provide operation and maintenance plans for any tailings containment areas.	**N/A**	No tailings produced						
	17	If the project includes sewage and/or solid waste disposal, provide an Operations and Maintenance Manual in accordance with the "Guidelines for the Preparation of an Operations and Maintenance Manual for Sewage and Solid Waste Disposal Facilities in the Northwest Territories, 1996".	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Section 4.8	Jun-2020		
Hazardous Materials	**18**	Provide a description of the type and quantities of drill additives, mill reagents, petroleum products, chemicals and/or hazardous materials on site. (MSDS sheets are not required to be submitted as part of the water licence application).	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-1-Main-Report	Appendix C			
	19	Provide details regarding the handling and storage of hazardous or potentially hazardous materials.	**Y**		Same as above	Same as above	Section 5			
Emergency Response and Spill Contingency	**20**	Provide designs for the fuel tank farm facilities including a description of the nearest water bodies. Provide an evaluation of impacts and mitigation measures in case of a fuel spill.	**Y**		Same as above	180926-2AM-MRY1325-Applic-Part-1-Main-Report 180926-2AM-MRY1325-Applic-Part-13	Section 5; Attachment 13			
	21	Provide an Emergency Response and Spill Contingency Plan (ERSCP) that includes mechanisms and processes for addressing potential or actual failure of structures, response equipment and material storage, and programs for providing appropriate training to workers. The plan shall address all licensed facilities.	**Y**		TSD-28 Mitigation and Monitoring Plans	TSD-28-Mitigation--Monitoring	Section 1.5			
	22	Plan(s) shall address phases of the project including construction, operation, and care & maintenance.	**Y**		Same as above	Same as above	Section 5			
	23	Provide an explanation of how the applicant will ensure project contractors meet the applicant's due diligence standards with respect to oil and hazardous material spill prevention, preparedness, response, and restoration.	**N/A**	Provided in existing Spill Contingency Plan and Oil Pollution Emergency Plan (OPEP)						
Studies	**24**	Provide a list of studies, reports and plans relevant to the application that have been undertaken to date including design and management decisions. Studies, reports and plans may include:								
		Options analysis.	**Y**		TSD-01 Alternatives Analysis, Baffinland, Sept 2018	TSD-01-Alternatives-Analysis_Rev_1	All			
		Geotechnical and geothermal assessment;	**Y**		See Doc Key (Att. 3.1)	180926-2AM-MRY1325-Applic-Part-6a 180926-2AM-MRY1325-Applic-Part-6b 180926-2AM-MRY1325-Applic-Part-6c 180926-2AM-MRY1325-Applic-Part-12a 180926-2AM-MRY1325-Applic-Part-12b	Attachments 6.1, 6.2, 6.3, 12			
		Water quality modeling;	**Y**		TSD-13 Surface Water Assessment, Knight Piesold, August 2018	TSD-13-Surface-Water_Rev_1	Section 3			
		Snow drift assessments;	**N/A**	Not completed						
		Permafrost protection;			TSD-08 Landforms, Soil and Permafrost Assessment,	08MN053_TSD-08_Landforms-Soil-and-Permafrost_Rev_1	All			
		Mine waste and water management; Landfill management; Landfarm management; Quarry Management; Incineration management; Hazardous waste management; Operation and maintenance plan; Inspection plan (see Section 8);	**Y**		TSD-28 Mitigation and Monitoring Plans	TSD-28-Mitigation--Monitoring	All	Baffinland will update its current Environmental Management System and applicable management plans to reflect the requested amendment changes.		
		Tailings monitoring (see Section 8);	**N/A**	No tailings generated						
		Mine site water quality monitoring (see Section 8); Receiving water quality monitoring (see Section 8); Aquatic effects monitoring (see Section 8); Geotechnical and structural monitoring (see Section 8); Quality assurance and quality control plan; Spill contingency and emergency response plans; Preliminary abandonment and reclamation plans for existing and proposed facilities; Final abandonment and reclamation plans for facilities to be closed; Remediation plans for waste disposal infrastructure;	**Y**		TSD-28 Mitigation and Monitoring Plans	TSD-28-Mitigation--Monitoring		Baffinland will update its current Environmental Management System and applicable management plans to reflect the requested amendment changes.		
		Human health and ecological risk assessment for establishment of remediation objectives for closure;	**Y**		TSD-11 Country Foods Risk Assessment	08MN053_TSD-11_Evaluation-of-Exposure-Selected-VECs_Rev_1	All			
		Construction plan and construction schedule for waste management infrastructure; Implementation schedule for construction of works, submission of studies and mitigation plans for operations and closure;	**Y**					To be provided to the NWB prior to construction in accordance with the Licence 2AM-MRY1325.		

TABLE 7

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325

ATTACHMENT 3.2 - SUPPLEMENTAL INFORMATION GUIDELINES (SIG) CONCORDANCE
MONITORING

Section Title	Section No.	Information Requirement General Water Works	Section No.	Information Requirement Mine Development	Indicate whether Information Requirement is applicable by inserting ' Y ' or ' NA '	If 'NA' provide justification	Insert Title, Author and Date of Document where information is provided	Insert electronic file name of document where information is provided	Insert Section of document where information is provided	If information is not available at the time of application, indicate when the information will be made available	NWB Concordance Assessment
Monitoring	**1**	Provide a Monitoring Plan including a description of the methods, procedures, standards, and schedules proposed. Monitoring may be required for water use, effluent, surface and/or groundwater water quality, quantity, or flow; ground temperature; ground settlement; etc.	**1**	Provide a Monitoring Plan including a description of the methods, procedures, standards, and schedules proposed. Monitoring may be required for water use; effluent, surface and/or groundwater water quality, quantity, or flow; ground temperature; ground settlement; etc. The Monitoring Plan must consider the life of the project, temporary closure and permanent closure.	**Y**		Surface Water and Aquatic Ecosystems Management Plan, Baffinland, 2016	http://www.baffinland.com/downloadocs/surface-water-and-aquatic-ecosystem-management-plan_2017-11-40-00.pdf	Section 9		
							Aquatlic Effects Monitoring Plan, Baffinland, April 8, 2016	ftp://ftp.nwb-oen.ca/registry/2%20MINING%20MILLING/2A/2AM%20-%20Mining/2AM-MRY1325%20BIMC/3%20TECH/9%20MONITORING%20(I)/AEMP/2016%20AEMP/	Tables 3.1, 3.2, 4.1; Figures 3-1, 3-2, 3-3, 3-4, 4-1, 4-2, 4-3, 4-4, 4-5		
							Fresh Water Supply, Sewage, and Wastewater Management Plan, Baffinland, March 29, 2018	http://www.baffinland.com/downloadocs/baf-ph1-830-p16-0010-r5---fwswmp_2018-15-11-48.pdf	Section 11		
	2	Indicate who is responsible for sampling including that person's position, contact information and level of training.	**2**	Indicate who is responsible for sampling including that person's position, contact information and level of training.	**Y**		Connor Devereaux Position: Environmental Superintendent				
	3	Indicate the name and contact information of the certified laboratory performing the analysis of samples.	**3**	Indicate the name and contact information of the certified laboratory performing the analysis of samples.	**Y**		ALS Environmental Laboratory in Waterloo, Ontario.	https://www.alsglobal.com/ca/locations/americas/north-america/canada/ontario/waterloo-environmental			
	4	Provide an Inspection Plan including a description of the methods, procedures, standards, and schedules proposed. Inspections may be required for engineered facilities related to the management of water and waste as well as spills.	**4**	Provide an Inspection Plan including a description of the methods, procedures, standards, and schedules proposed. Inspections may be required for engineered facilities related to the management of water and waste as well as spills. The Inspection Plan must consider the life of the project, temporary closure and permanent closure.	**Y**		Environmental Protection Plan, Baffinland, Aug 30, 2016	http://www.baffinland.com/downloadocs/baf-ph1-830-p16-0008-r1---environment-protection-plan_2017-01-05-29.pdf	All		
			5	Provide a summary table of all monitoring commitments that details all monitoring locations. The table should include parameter(s), location, frequency, and mining phase, along with, cross-referencing to sub-documents where detailed information is provided. Where appropriate, a map detailing the location of monitoring sites is to be provided.			Aquatlic Effects Monitoring Plan, Baffinland, April 8, 2016	ftp://ftp.nwb-oen.ca/registry/2%20MINING%20MILLING/2A/2AM%20-%20Mining/2AM-MRY1325%20BIMC/3%20TECH/9%20MONITORING%20(I)/AEMP/2016%20AEMP/	Tables 3.1, 3.2, 4.1; Figures 3-1, 3-2, 3-3, 3-4, 4-1, 4-2, 4-3, 4-4, 4-5		
	6	Provide a summary table that details the monitoring plan. The table should include stations numbers, location, parameter(s) and frequency. Provide a map detailing the location of monitoring sites.	**6**	Provide a summary table of the expected quality and quantity of waters, over time in all sumps, monitoring stations, and discharge points, along with i) if applicable, adaptive management criteria to benchmark if mitigation/contingency are to be implemented, ii) if applicable, water quality criteria, and iii) management action.			Same as above	Same as above	Tables 5.1 and 5.2		
			7	Provide a monitoring plan for incinerator emissions (including, but not limited to, stack testing and annual reporting).	**Y**		Air Quality and Noise Abatement Management Plan, Baffinland, March 14, 2016	http://www.baffinland.com/downloadocs/baf-ph1-830-p16-0002-r6---air-quality-and-noise-abatement-management-plan_2017-01-09-42.pdf	Section 5.2.2		
	5	Provide a Quality Assurance/ Quality Control (QA/QC) Plan that addresses both field sampling and laboratory analyses.	**8**	Provide a Quality Assurance/ Quality Control (QA/QC) Plan that addresses both field sampling and laboratory analyses.			Surface Water Sampling Program – Quality Assurance and Quality Control Plan, Baffinland, Jan 15, 2014	ftp://ftp.nwb-oen.ca/registry/2%20MINING%20MILLING/2A/2AM%20-%20Mining/2AM-MRY1325%20BIMC/3%20TECH/9%20MONITORING%20(I)/I%2016/140115%202AM-MRY1325%20BAF%20PH1%20830%20245%200001%20Part1-IAAE.pdf			

ATTACHMENT 4

REGULATORY CORRESPONDENCE

4.1 NPC Conformity Letter
4.2 NIRB Review Process Letter

ATTACHMENT 4.1

NPC CONFORMITY LETTER

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Nunavunmi Parnaiyiit
Nunavut Planning Commission
Commission d'Aménagement du Nunavut

May 29, 2018

NPC File No: 148420

Natasha Lear
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Dear Ms. Lear, Ms. McCaie, Mr. Kharatyan, Mr. Gillis, Mr Williamson Bathory, Ms. Pirie-Dominix, Ms. Williston and Ms. D'Amours-Gauthier, Ms. Chisholm, Mr. Johnstone, Mr. Kunuk, Mr. Stubbing, Ms .Robinson, Mr. Chapple, Ms. Vaillancourt, and Ms. Lord-Hoyle:

RE: NPC File No 148420 [Mary River Phase 2 Expansion Project]

- ***Associated NPC File Nos:***
  148193 [Mary River Project Land, Freshwater, and Marine Based Monitoring Program];
  148423 [Mary River 2017 Winter Sealift]; and
  148841 [Production Increase, Fuel Tank and Milne Port Accommodations - Project Modification to Project Certificate No. 005 - 08MN053]
- ***Location:*** *North Baffin Region [Near the community of Pond Inlet]*

The following works and activities have been proposed in the above-noted project proposal:

1. Increase in iron ore production and transportation from 4.2 Million tonnes per year under the Early Revenue Phase of the Mary River Project to 12 Million tonnes per year via the northern transportation corridor.

2. Construction and operation of a 110 km railway within the Mary River Transportation Corridor between the mine site and Milne Port, generally following the existing Tote Road. Once the railway is in place the Tote Road will remain operational, but its use by Baffinland will drop substantially and will be limited to moving personnel and key goods.
3. Expansion and improvement of the Milne Port facilities. A second ore dock to accommodate Cape sized vessels; a second ship loader, railway unloading and maintenance facilities, and additional support infrastructure will be developed in addition to an enclosed crushing facility.
4. Modification of the shipping season. The ore shipping season is proposed to be from July 01 to November 15, but would be adapted annually in consultation with the Pond Inlet Hunters and Trapper Organization (HTO) based on ice conditions and thickness. It is noted that winter sealift is not included in this proposal, because on October 24, 2017, due to concerns expressed by the communities regarding ice breaking, the proponent has removed the winter sealift component from the original application.
5. Expansion of the existing accommodation camp at the Mine site.

A complete description of the project proposal reviewed by the NPC can be accessed online using the link below.

The Nunavut Planning Commission (NPC) has completed its review of the above noted project proposal. *It should be noted that the development of the Mary River Transportation Corridor to include a railway required an amendment to the North Baffin Regional Land Use Plan (NBRLUP), which was publically reviewed by the NPC and approved as Amendment No. 3 to the NBRLUP by the Federal Minister of Crown-Indigenous Relations and Northern Affairs, the Territorial Minister of Environment, and the President of Nunavut Tunngavik Incorporated and came into effect on May 8, 2018.*

The NPC previously reviewed some of the works and activities associated with the current proposal, including mining and trucking iron ore, the development of the Milne Port facilities and the construction of camp facilities (conformity determination was issued on April 30, 2008, August 12, 2011, February 8, 2016, January 26, 2017 and on May 18, 2018). These conformity determinations still apply. In addition, associated activities were previously reviewed by the Nunavut Impact Review Board (NIRB FILE NO.: 08MN053 & 17UN012).

The NPC has determined that the above-noted project proposal is a significant modification to the project because it requires the reconsideration and revision of reconsideration of terms and conditions in the project certificate No. 005, as well as an amendment to the Type A Water License 2AM-MRY 1325 . It conforms to the NBRLUP. The proponent has undertaken to comply with the applicable conformity requirements of Appendix C, H, I and P of the NBRLUP.

The above-noted project proposal requires screening by the NIRB under section 12.4.3 of the Nunavut Agreement as amended because it is for a component or activity that was not part of the original or previously amended proposal and its inclusion is a significant modification of the project. By way of this letter, the NPC is forwarding the project proposal with this determination to the NIRB for screening. Project materials, including the applicable conformity requirements, are available at the following address:
http://lupit.nunavut.ca/portal/project-dashboard.php?appid=148420&sessionid=

The regulatory authorities to which this letter is addressed are responsible under the Nunavut Planning and Project Assessment Act (NUPPAA) to implement any of the applicable requirements by incorporating the requirements directly, or otherwise ensuring that they must be met, in the terms and conditions of any authorizations issued.

This conformity determination applies only to the above noted project proposal as submitted. Proponents may not carry out projects and regulatory authorities may not issue licenses, permits and other authorizations in respect of projects if a review by the NPC is required. Regulatory authorities may consult with the NPC to obtain recommendations on their duties to implement the existing land use plans prior to issuing licenses, permits and other authorizations under subsection 69(6) of the NUPPAA.

My office would be pleased to discuss how best to implement the applicable requirements and to review any draft authorizations that regulatory authorities wish to provide for that purpose. If you have any questions, please do not hesitate to contact me at (867) 979-3444.

Sincerely,

Goump Djalogue, MCIP |RPP
Senior Planner,
Nunavut Planning Commission

ATTACHMENT 4.2

NIRB REVIEW PROCESS LETTER

NIRB File No.: 08MN053
NWB File No.: 2AM-MRY1325 - Amendment No. 1/G1

June 11, 2018

Megan Lord-Hoyle
Director, Sustainable Development
Baffinland Iron Mines Corporation
2275 Upper Middle Road East
Oakville, ON L6H 0C3

Sent via email: megan.lord-hoyle@baffinland.com

Re: Nunavut Impact Review Board Process Guidance—Mary River Modification Applications – Phase 2 Development Proposal and Production Increase Proposal

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Dear Megan Lord-Hoyle:

This correspondence is intended to provide procedural guidance in respect of next steps in the Nunavut Impact Review Board's (NIRB or Board) consideration of two (2) applications from Baffinland Iron Mines Corporation (Baffinland) that seek to modify aspects of the original Mary River Project Proposal, NIRB Project Certificate No.: 005 (as amended). The NIRB notes that these two recently-referred applications differ markedly in terms of the scale and scope of changes requested, and also in terms of the land use conformity assessment processes that preceded the referral of the modification applications to the NIRB for assessment. However, as these applications are now being considered by the NIRB at the same time the NIRB has chosen to provide guidance for both applications in this correspondence, rather than issue separate application-specific correspondence.

By way of background, the NIRB has provided abbreviated summaries of the applications in the text that follows. However, to understand the full context of each application specifically, parties should consult the NIRB's public registry at www.nirb.ca by using any of the following search criteria:

- Project Name: Mary River Project
- NIRB File No.: 08MN053
- Application No.: 123910

To directly access any documentation cited in this correspondence, choose the "search documents" option on the NIRB's online public registry and search for the public registry identification numbers included here as footnotes.

BACKGROUND

Original Mary River Project

The original Mary River Project as approved by the NIRB in 2012,[1] and operated by Baffinland, involves the development of an open pit iron ore mine on northern Baffin Island, with associated infrastructure that includes the use of an existing Tote Road between Milne Inlet and a mine site at Mary River, ports at Milne Inlet and Steensby Inlet, and a railway connecting the mine site to the Steensby Port. As originally proposed, iron ore would be transported from the mine site via a railway to be constructed by Baffinland to the port at Steensby Inlet. The original Mary River Project proposed year-round shipping using custom designed ice-breaking ore carriers through Foxe Basin and Hudson Strait to markets in Europe. Following issuance Mary River Project Certificate No. 005 on December 28, 2012, significant elements of the original Mary River Project were *not* constructed following approval, including: the port at Steensby Inlet, the railway from the mine site to Steensby Inlet, and the fleet of purpose-built ice-breaking ore carriers.

Early Revenue Phase

Immediately following approval of the original Mary River Project and issuance of Mary River Project Certificate No. 005, in January 2013, Baffinland applied for a modification to the approved Mary River Project, seeking to amend specific project components and activities to support limited mining activity to commence prior to the construction of the railway and full facilities at the Steensby Port. Specifically, Baffinland proposed to use the Milne Inlet Tote Road to transport a smaller volume of ore to Milne Inlet for shipment during the open water season only, with the railway and Steensby Port development to be delayed until shipments through Milne Inlet had generated revenue to support subsequent development (the Early Revenue Phase Proposal). Following the NIRB's assessment of the Early Revenue Phase Proposal, including conducting a Public Hearing, on March 17, 2014 the NIRB recommended that the Early Revenue Phase Proposal should be allowed to proceed with amendments to the terms and conditions of Mary River Project Certificate No. 005.[2] Following acceptance of the Board's recommendations by the responsible Ministers, Mary River Project Certificate No. 005 was subsequently amended and re-issued on May 28, 2014.

Phase 2 Development

Soon after receiving approval for the Early Revenue Phase Proposal, on October 29, 2014 Baffinland submitted the "Phase 2 Development Proposal" for the Mary River Iron Mine to the Nunavut Planning Commission (NPC) for consideration;[3] the NIRB subsequently received the Phase 2 Development Proposal for assessment on July 13, 2015. The Phase 2 Development

[1] Public Registry ID: 286425
[2] Public Registry ID: 291199
[3] Public Registry ID: 291213 & 291214

Proposal included construction of the following activities *in addition to* the activities associated with the original Mary River Project and the Early Revenue Phase Proposal:

- Changing marine transport of ore from year round shipping to shipping six months of the year (July 01 to December 31), with a focus on shipping ore primarily during the open water season;
- Associated changes at the Milne Port site to maximize shipping during the open water season which would include increases to the size of the proposed second ore dock and ship loader to accommodate cape-sized vessels;
- Reducing the amount of proposed fuel storage at the Milne Port site; and
- The installation of an enclosed ore crushing facility at the Milne Port site.

During the NIRB's consideration of the Phase 2 Development Proposal, the scope of the application was modified by Baffinland to include a proposed northern rail component between the existing Mary River Mine site and the existing facilities at the Milne Inlet Port site. This significant modification resulted in the proposal being referred back to the Nunavut Planning Commission (NPC) for further consideration and processing against the requirements of the North Baffin Regional Land Use Plan on December 19, 2016. The Phase 2 Development Proposal was formally referred back to the NIRB for assessment by the NPC recently on May 29, 2018. As briefly summarized by the NPC in its May 29, 2018 referral to the NIRB,[4] the current scope of the Phase 2 Development Proposal includes the following works and activities:

1. Increase in iron ore production and transportation from 4.2 Million tonnes per year under the Early Revenue Phase of the Mary River Project to 12 Million tonnes per year via the northern transportation corridor.
2. Construction and operation of a 110 km railway within the Mary River Transportation Corridor between the mine site and Milne Port, generally following the existing Tote Road. Once the railway is in place the Tote Road will remain operational, but its use by Baffinland will drop substantially and will be limited to moving personnel and key goods.
3. Expansion and improvement of the Milne Port facilities. A second ore dock to accommodate cape-sized vessels; a second ship loader, railway unloading and maintenance facilities, and additional support infrastructure will be developed in addition to an enclosed crushing facility.
4. Modification of the shipping season. The ore shipping season is proposed to be from July 1 to November 15, but would be adapted annually in consultation with the Pond Inlet Hunters and Trapper Organization (HTO) based on ice conditions and thickness. It is noted that winter sealift is not included in this proposal, because on October 24, 2017, due to concerns expressed by the communities regarding ice breaking, the proponent has removed the winter sealift component from the original application.
5. Expansion of the existing accommodation camp at the Mine site.

[4] Public Registry ID: 318134

The next steps for this assessment include the required submission of a Final Environmental Impact Statement Addendum (FEIS Addendum) in accordance with EIS Guidelines issued by the NIRB on October 6, 2015,[5] to be discussed in more detail later in this correspondence.

Further Interim Development

While the consideration of the Phase 2 Development Proposal remained ongoing, on November 8, 2017 Baffinland submitted a "Tote Road, Camp, and Fuel Upgrade" proposal to the NIRB for consideration.[6] The scope of this proposal included proposed upgrades to the existing Tote Road to address road safety and operational issues, addition of a 15 ML fuel tank to the existing Fuel Storage Facility at Milne Port and the installation of a new 280-person accommodations camp at the Milne Inlet Port. Following a cursory review of the associated documentation, the NIRB determined that Baffinland had not demonstrated that the proposed activities were separate and distinct from the Phase 2 Development Proposal. On November 17, 2017 the NIRB issued correspondence directing Baffinland to modify and resubmit its proposal once it was able to demonstrate that the proposed activities were independent of and not integrally linked to the Phase 2 Development Proposal, and further noted that sufficient supporting information would be required to assess those proposed works not previously considered by the NIRB.

Related Ongoing Monitoring

On December 8, 2017, the NIRB received correspondence from Baffinland which provided notice that it anticipated Baffinland's 2017 road haulage operations would meet and potentially exceed (by 5-7%) the 4.2Mt/a limit established by Term and Condition 179(b) of the Mary River Project Certificate No. 005.[7] On December 12, 2017 the NIRB acknowledged receipt of the update provided by Baffinland and noted that additional reporting would be required from the Proponent once finalized haulage numbers for 2017 became available and an analysis of potential ecosystemic and socio-economic effects associated with the exceedance from predicted/permitted levels of road haulage activities could be completed. The Board further encouraged the Proponent to bring forward an application for a formal reconsideration of Term and Condition 179(b) of the Mary River Project Certificate should Baffinland identify any challenges with complying in future. Baffinland later confirmed the actual 2017 ore haulage total was 4.54 Mt, representing an approximately 7.5% exceedance.

Production Increase Proposal

On April 30, 2018 Baffinland submitted to the NPC and the NIRB, the "Production Increase, Fuel Storage and Milne Port Accommodations Modification Proposal" (Production Increase Proposal).[8] The proposed modifications involve an increase from the current limit of 4.2 Mt/a that can be trucked from the mine site on the Milne Inlet Tote Road and shipped from Milne Inlet Port to 6 Mt/a and include addition of a 15 ML diesel fuel tank to the existing Fuel Storage Facility at Milne Port (consistent with the 2017 "Tote Road, Camp, and Fuel Upgrade" proposal) and the installation of a new 380-person accommodations camp at the Milne Inlet Port (further increased from the 2017 "Tote Road, Camp, and Fuel Upgrade" proposal). Baffinland is now

[5] Public Registry ID: 317361
[6] Public Registry ID: 314260
[7] Public Registry ID: 314492
[8] Public Registry ID: 318142 , 318143, 318141 , 318140

requesting that the NIRB reconsider Conditions 179(a)[9] and 179(b)[10] of Mary River Project Certificate No. 005 and amend these items to accommodate the proposed project changes, independent of the Board's consideration of the activities associated with the Phase 2 Development Proposal.

THE NIRB'S PROCESS FOR ASSESSING THE PHASE 2 DEVELOPMENT PROPOSAL

In general, where an approved project is already governed by the terms and conditions of a NIRB Project Certificate, to determine the process and procedure guiding NIRB's assessment of any modification proposal the Board must consider the following questions:

- Is the proposed modification included within the scope of the original project as previously assessed by the NIRB?
- Is the proposed modification consistent with the terms and conditions of the existing NIRB Project Certificate, or are changes to the Project Certificate necessary to reflect the modification?
- Does the proposed modification constitute a significant modification to the original project that is integrally-linked to the original project (or project as subsequently modified by any modification proposals that have been assessed and approved by the NIRB, such as the amendment to Project Certificate No. 005 to reflect the Early Revenue Phase Proposal)?
- Does the proposed modification constitute a significant modification to the original project that is not integrally-linked to the original project, and that has sufficient scope to be assessed as an independent project proposal?

In respect of Baffinland's Phase 2 Development Proposal, the NIRB has concluded the following:

- Baffinland's Phase 2 Development Proposal constitutes both a significant modification to the original project and a significant modification to the original scope of the Phase 2 Development Proposal received in 2014;[11]
- Baffinland's Phase 2 Development Proposal is integrally-linked to the Original Mary River Project (as amended to reflect the Early Revenue Phase Proposal); and
- If the Board determines that the proposed modifications are acceptable, amendments to the existing terms and conditions of the Mary River NIRB Project Certificate No. 005 may be necessary to reflect the potential for ecosystemic and socio-economic impacts resulting from the proposed modifications.

---

[9] For each year after the Proponent commences shipping ore via Milne Inlet under the Early Revenue Phase Proposal, the Proponent shall include in the Annual Report to the NIRB, a summary of the total amount of ore shipped via Milne Inlet for the previous calendar year.

[10] In any given calendar year, the total volume of ore transported by truck on the Milne Inlet Tote Road shall not exceed 4.2 million tonnes.

[11] Public Registry ID: 306281

In terms of the process governing the Board's assessment of the Phase 2 Development Proposal, the Board concluded in 2014, and reaffirmed in 2016, that, given the integral link between the original Mary River Project and the changes proposed in the Phase 2 Development Proposal, it was appropriate for the NIRB to conduct the assessment of potential impacts as a reconsideration of the existing terms and conditions of Project Certificate No. 005 under Article 12, Section 12.8.2 of the *Nunavut Agreement.* In addition, as previously indicated by the NIRB,[12] due to the addition of the northern rail line to the original Phase 2 Development Proposal in 2016, the NIRB's reconsideration of the revised Phase 2 Development Proposal will be conducted under both the *Nunavut Agreement* and relevant reconsideration provisions of the *NuPPAA* (s. 112*)* as required under the transition provisions of the *NuPPAA* (s. 235).

The NIRB recognizes that on March 10, 2016, the Qikiqtani Inuit Association (QIA) filed correspondence with the Board requesting clarification about the NIRB's processing of Baffinland's Phase 2 Development Proposal as a reconsideration of the existing Project Certificate under Article 12, Section 12.8.2 of the *Nunavut Agreement* rather than as a separate project proposal under Article 12, Section 12.8.3 of the *Nunavut Agreement.* Specifically, the QIA posed the following question:

> *QIA requests clarification from* [sic the NIRB] *as to whether, in the Board's opinion, the modified Project Proposal should undergo an assessment as prescribed by NUPPAA and the NLCA, or if the Board will again, at the request of the Proponent, forgo screening and review to instead reconsider the terms and conditions of the Project Certificate? To be clear, QIA would advocate for the former.*[13]

As noted recently by the NIRB during the Board's consideration of a significant modification to the existing Meliadine Gold Mine Project (NIRB File No. 11MN034), the NIRB rejects the notion that the only mechanism for the NIRB to assess the potential ecosystemic and socio-economic effects of a modification proposal is to conduct a separate screening and review of the modification proposal. The Board's views were stated as follows:

> *Although not expressly stated, the Federal Response appears to suggest that the only mechanism for the NIRB to assess the potential ecosystemic and socio-economic impacts of a modification proposal is to undertake a separate screening of the modification proposal. The NIRB does not agree with that premise.*
>
> *In the Board's view, conducting the assessment of a proposed modification as a separate screening may be appropriate in circumstances where the modification proposal is sufficiently separate and distinct from the original previously-assessed project and may be considered as a separate but related project. Examples of this approach include the NIRB's assessment of the*

[12] Public Registry ID: 306281
[13] Public Registry ID: 301457

> *mining of a new deposit proposed in Agnico Eagle's Whale Tail Pit Project (NIRB File No.:16MN056) and also the proposed mining of a new deposit proposed in TMAC's Phase 2 Hope Bay Belt Project (NIRB File No.: 12MN001).*
>
> *In contrast, where a modification proposal is considered to be within the scope of the assessment of the original project, is integrally-linked to the original project and is not sufficient in scope to be assessed as a stand alone project, the NIRB has clearly rejected the notion that the only mechanism for assessing such modification proposals is for the Board to conduct a separate screening. As illustrated in several reconsiderations of Project Certificate terms and conditions conducted by the NIRB to date under Article 12, Section 12.8.2 of the Nunavut Agreement, the Board's reconsideration must necessarily include an assessment of the potential for the proposed modification to result in changes to the ecosystemic and socioeconomic effects previously assessed for the original project, and the assessment required by the NIRB during a reconsideration is no less rigorous than a screening (and in some cases, even a full environmental review).* [footnotes in the original omitted][14]

Consistent with this approach, and recognizing that the Board has concluded that Baffinland's Phase 2 Development Proposal currently under assessment is integrally-linked to the previously-approved Mary River Project (as modified under the Early Revenue Phase), in the NIRB's view it is appropriate to conduct the assessment of the Phase 2 Development Proposal as a reconsideration of the terms and conditions of Project Certificate No. 005.

Now that the Phase 2 Development Proposal has again been referred to the NIRB for assessment, the next step in the Board's reconsideration process is submission of a Final Environmental Impact Statement Addendum (FEIS Addendum) by Baffinland to support the public review process. The Board previously issued the enclosed *Guidelines to the Preparation of an Environmental Impact Statement for Baffinland's Iron Mines Corporation's Mary River Project (NIRB File No.: 08MN053), Amended Version for the Phase 2 Development Proposal* (the *Amended Guidelines*) to Baffinland to guide its preparation of the required FEIS Addendum; the NIRB has reviewed the *Amended Guidelines* to determine whether, with the addition of the northern rail line to the scope of the Phase 2 Development Proposal, revisions are required. The NIRB has concluded that to reflect the addition of the northern rail line, the *Amended Guidelines* should be updated to add the specific rail line assessment (as found in the EIS Guidelines governing the Board's assessment of the Original Mary River Project Proposal). Other than this addition to the *Amended Guidelines*, no further revisions are required, and Baffinland is advised to prepare the FEIS Addendum assessing the potential ecosystemic and socio-economic effects of the Phase 2 Development Proposal in accordance with the EIS Guidelines.

Following the receipt of Baffinland's FEIS Addendum, the NIRB will conduct an internal conformity review of the submission to determine whether it adequately addresses the

[14] Public Registry ID: 316766

requirements of the *Amended Guidelines*. The Board trusts that the Proponent will find sufficient direction in the *Amended Guidelines* to complete the FEIS Addendum as required to support a thorough public technical review; the Board respectfully requests that Baffinland provide an anticipated date of submission for its FEIS Addendum following its review of the enclosed *Amended Guidelines*.

Once the NIRB determine the FEIS Addendum conforms with the EIS Guidelines, the Board will accept the submission and may initiate the NIRB's standard 90 day public review of the FEIS Addendum consisting of an initial 30 day information request period followed by a 60 day technical review period, as well as the facilitation of public information sessions in the potentially affected communities. It should be noted that, recognizing the capacity limits and potential for confusion of reviewers, the NIRB and the public if the NIRB's consideration of the Production Increase Proposal is overlapping with the Board's reconsideration of the Phase 2 Project Proposal, the Board may delay initiating the public review process for the FEIS Addendum until the NIRB has closed the record on the Board's consideration of the Production Increase Proposal.

In any event, during the NIRB's public information sessions and public review process for the Phase 2 Project Proposal, the NIRB will also solicit public input into the need/utility of scheduling of a meeting of technical experts (i.e., Technical Meeting) to address technical issues arising from the proposed modification and/or the information contained in the FEIS Addendum, as well as inviting discussion about the most appropriate format for a public hearing (written, teleconference or in person) in support of the Phase 2 Project Proposal reconsideration process.

THE NIRB'S PROCESS FOR ASSESSING THE PRODUCTION INCREASE PROPOSAL

To select the most appropriate process to assess the potential ecosystemic and socio-economic effects of Baffinland's "Production Increase, Fuel Storage and Milne Port Accommodations Modification Proposal" (Production Increase Proposal), the Board has considered the following questions:

1. Is the Production Increase Proposal included within the scope of the previously assessed Mary River Project (including as modified by the Early Revenue Phase Project Proposal)?
2. Is the proposed modification consistent with the terms and conditions of the existing NIRB Project Certificate, or are changes to the Project Certificate necessary to reflect the modification?
3. Is the Production Increase Proposal integrally-linked to the Mary River Project, and/or should the modification proposal be characterized as within the scope of the Phase 2 Development Proposal currently being assessed by the Board?
4. If the Production Increase Proposal is integrally linked to the Mary River Project, do the proposed modifications warrant reconsideration of the terms and conditions in Project Certificate No. 005?

Having now reviewed the Production Increase Proposal and the recent June 5, 2018 correspondence from Baffinland, the Board has determined that the proposed activities were *not* included within the scope of the previously assessed Original Mary River Project (including as modified by the Early Revenue Phase Project Proposal). The activities comprising the Production Increase Proposal *are* integrally-linked to the approved Original Mary River Project but *are not* within the scope of the Phase 2 Development Proposal.

In considering the significance of modifications associated with the three main components of the Production Increase Proposal, it is the NIRB's understanding that the proposed fuel tank farm upgrade and the proposed Milne Inlet camp upgrade would require only modifications, not amendments under the existing Type "A" Water Licence (2AM-MRY1325). The Board further recognizes that the proposed increase from the current limit of 4.2 Mt/a to 6 Mt/a of ore that can be trucked from the mine site on the Milne Inlet Tote Road and shipped from Milne Inlet Port is explicitly incompatible with Conditions 179(a) and 179(b) of Mary River Project Certificate No. 005 which would require amendments, if the Board were to approve the modifications proposed in the Production Increase Proposal. On these bases, the Board has decided the modifications proposed in the Production Increase Proposal require assessment through a formal reconsideration of these specific Project Certificate terms and conditions.

Further, the Board's previous assessment of the Early Revenue Phase Proposal and results from the NIRB's ongoing monitoring program for the Original Mary River Project clearly indicate that public concern already exists associated with dust generation from the ore haulage on the Milne Inlet Tote Road and with shipping-related impacts to marine wildlife and Inuit harvesting in the Milne Inlet area. Consequently, it is reasonable for the NIRB to expect that significant public concern is likely to be associated with the proposed increase to ore transport under the Production Increase Proposal and that these concerns will need to be addressed during the NIRB's assessment of this modification proposal.

As indicated in Baffinland's June 6, 2018 correspondence to the NIRB,[15] the Board has considerable discretion in the form of public engagement undertaken as part of a reconsideration of Project Certificate terms and conditions. The public engagement undertaken by a project proponent or other parties is, however, not a direct substitute for the requirement for the Board to create opportunities for the public to meaningfully participate directly within the NIRB's tailored reconsideration assessment processes.

In terms of the specific public engagement associated with the reconsideration process for this file, the NIRB acknowledges the following:

- The NIRB agrees that the need for flexibility, efficiency and coordination must be considered by the Board when establishing applicable processes;
- The Board will investigate the feasibility of having a staff person attend the QIA-led engagement sessions planned for July in Pond Inlet as set out in Baffinland's June 6, 2018 correspondence. Further, the NIRB may undertake its own directed engagement

[15] Public Registry ID: 318065

with the community in coordination with these sessions, depending upon factors such as the availability of time and resources, and the support of the community;

- The Board will consider the engagement undertaken by Baffinland and QIA (and NIRB staff) as planned in July to provide subsequent additional direction to Baffinland, intervenors and communities regarding whether an in-person Public Hearing will be required by the Board to consider the Production Increase Proposal.
- There are a number of specific points where additional information is required to be submitted so that the application for the Production Increase Proposal can be accepted as a completed FEIS Addendum to support the next steps in the reconsideration process – **Appendix A** of this correspondence sets out these information requirements in detail
- As noted above, recognizing the limited capacity of reviewers, the community, etc. the Board will not commence the public technical review of the FEIS Addendum for the Phase 2 Development Proposal until the record is closed for the NIRB's assessment of the Production Increase Proposal.

CONCLUSION

As noted above, the NIRB respectfully requests that Baffinland provide its anticipated date of submission for the FEIS Addendum required to support the assessment of the Phase 2 Development Proposal as soon as practicable.

With respect to next steps associated with the NIRB's processing of the Production Increase Proposal, the NIRB will await Baffinland's submission of the additional information set out in **Appendix A** required for the application to be considered by the Board as a FEIS Addendum required to support the assessment. Upon receipt of the required information, the NIRB will initiate a public technical review of the proposal and will provide additional details regarding the associated assessment process and timelines at that time.

Should you have any questions or require clarification in relation to the NIRB's approach to processing these modification proposals, please contact the undersigned directly at (867) 983-4608 or rbarry@nirb.ca. If you have any questions related to the NIRB's monitoring program for the Mary River Project, please contact the NIRB's Monitoring Officer for the Mary River Project, Solomon Amuno at (867) 983-4603 or samuno@nirb.ca.

Sincerely,

Ryan Barry

Ryan Barry
Executive Director
Nunavut Impact Review Board

cc: William Napier, Baffinland Iron Mine Corporation
Lou Kamermans, Baffinland Iron Mine Corporation
Karén Kharatyan, Nunavut Water Board
Mary River Distribution List

Attached: Appendix A – Information Required to Support Assessment of the Production Increase Proposal

Enclosed (1): Updated Guidelines to Baffinland for the Preparation of a Final Environmental Impact Statement Addendum for the Phase 2 Project Proposal (October 6, 2015)

APPENDIX A: INFORMATION REQUIRED TO SUPPORT ASSESSMENT OF THE PRODUCTION INCREASE PROPOSAL

The Nunavut Impact Review Board (NIRB) has identified the following listing of information as required to supplement Baffinland Iron Mines Corporation's (Baffinland) "Production Increase, Fuel Storage and Milne Port Accommodations Modification Proposal" (Production Increase Proposal) for the application to be considered by the Board as a Final Environmental Impact Statement Addendum (FEIS Addendum) capable of supporting a public technical review. In all cases the NIRB expects updated impact predictions to be provided for the proposed project components and activities to reflect the contributions of the additional activities described in the Production Increase Proposal to the effects of the approved Project with discussion of whether predictions and associated monitoring, mitigation and residual effects for air quality and local climate conditions remain consistent with the analysis provided in the FEIS and FEIS Addendum previously supplied for the Mary River Project Proposal and the associated Early Revenue Phase (ERP) Proposal. The Proponent is further encouraged to demonstrate how its monitoring results and experiences gained in operating the approved Project to date have informed its development of the Production Increase Proposal. While the FEIS Addendum may include specific references to information already posted to the NIRB's public registry, specific public registry identification numbers must be provided, with clear reference to the applicable pages within the document to be referenced. Where substantive revisions or updates to existing management plans have been prepared to specifically support activities outline in the Proposal, they should be provided for review with the FEIS Addendum.

The FEIS Addendum must address the following specific points:

1. How public consultation and Inuit Qaujimaningit/Qaujimajatuqangit, local knowledge and community knowledge have influenced the planning and design of the proposed activities and associated management plan updates.
2. Clarification regarding rationale for excluding upgrades to the Milne Inlet Tote Road from the scope of the Production Increase Proposal, identified in previous submissions as necessary to address road safety and operational issues.
3. Identification of the extent to which Baffinland's Environmental Management Plans, including the Air Quality Management Plan, Oil Pollution Emergency Plan (OPEP), Fuel and Spill Contingency Plan, and Decommissioning and Reclamation Plan would require updates or revisions to address prevention/mitigation of additional dust/GHG emission loading into the environment.
4. Description of how additional sewage and solid wastes materials generated from the proposed new camp facility at Milne Inlet would be managed, with information regarding the location of the sewage management facility, the number and type of trucks to be used for sewage haulage, frequency of sewage collection from the proposed facility, and use of the landfill.
5. Discussion of the anticipated timelines to provide respective regulatory authorities with engineering design and drawings, specifications and engineering analysis to support the design of the proposed camp facility at Milne Inlet and associated infrastructure.

6. Discussion of the environmental implications of sourcing granular resource materials from quarry (Q1) for the new camp facility:
    - Information on the quantity and quality estimates of granular resources from Q1 with discussion of how acid drainage and metal leaching potential of the granular materials have been taken into consideration to avoid any potential ecological risk; and
    - Discussion of how activities within quarry Q1 would be managed to avoid or minimize the creation of pits and depressions to the degree practicable to reduce the potential for standing water.
7. Operational plans and mitigation strategies intended to address potential interactions of proposed activities with traditional hunting activities and potential impacts from increased truck haulage and shipping activities, including:
    - Discussion of the potential impacts to, and interactions with, Inuit harvesting in the port area and along the shipping route;
    - Assessment of potential contaminant loading in sea water and ice from dust plumes deposition at the port site;
    - Discussion of the potential interactions, accidental injuries and mortality of marine mammals directly or indirectly from additional shipping (open water and ice breaking shipping) activities, in particular those marine mammals, which congregate around the proposed northern shipping route;
    - Potential social-economic impacts from increased shipping levels, taking into account any impacts on marine species on which local residents rely on as food sources; and
    - Discussion of proposed safety measures, including considerations for hiring personnel with local knowledge of the marine areas to act as ship-board monitors along the shipping route (Milne Inlet-Eclipse/Baffin Bay) and details regarding the proposed procedures for accident, malfunction and incident management and reporting associated with increased shipping activities.
8. Discussion of proposed management plans for accommodating additional volumes of materials at waste rock facilities, with a discussion of contingency measures that would be employed should the designed facility not be adequate to accommodate the amounts of waste rock generated.
9. Discussion of how the proponent intends to comply with the oil handling facilities standards (TP 12402E), with clarification regarding whether the proposed additional fuel capacity would be expected to increase the minimum size of an oil pollution incident or spill size, beyond what was previously assessed for the approved Project.
10. Discussion of the environmental implications of increased fuel consumption for the Project, should the proposed activities be approved to proceed.
11. Information regarding the adequacy of the current emergency response procedures to address all potential accidents, spills, and or malfunctions associated with the proposed increase in capacity at the fuel storage facility at Milne Inlet. Clarification

should also be provided regarding what protection measures and best management practices would be employed for the construction and containment of additional fuel tanks and storage area to prevent any damage to the surrounding environment.

ATTACHMENT 5

DESIGN CRITERIA

5.1 Civil Design Philosophy
5.2 Rail Design Criteria

ATTACHMENT 5.1

CIVIL DESIGN PHILOSOPHY

Civil Design Philosophy

2018-03-12	2	Approved for Use	F Hugo	A Grobbelaar	D Stanger	T Atiba
2017-08-01	1	Approved for Use	F Hugo	A Grobbelaar	N Mason	M Weaver
2017-03-23	0	Approved for Use	F Hugo	A Grobbelaar	J Cleland	M Weaver
Date	**Rev.**	**Status**	**Prepared By**	**Checked By**	**Approved By**	**Approved By**
			HATCH			**Client**

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Appendix A: Typical Layer Works

Appendix B: Document No. H349000-1000-10-122-0001 Civil Design Criteria

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1. Introduction

This document establishes the Employers requirements for civil design and engineering for the Mary River Expansion Project.

This document is intended to address the key criteria required for the design of site infrastructure at Milne Inlet and the Mine Site.

2. Units and Coordinate System

2.1 The International System of Units (SI units and prefixes) shall be used for all design calculations and on all drawings.

2.2 The grid coordinates shall be based on: projection – Universal Transverse Mercator (UTM) Zone 17 and horizontal datum – NAD 83 Canadian Spatial Reference System (CSRS).

2.3 Vertical datum shall based on the Canadian Geodetic Vertical Datum of 1928 (CGVD28).

3. References

3.1 Codes, Regulations and Standards

3.1.1 Unless specifically stated otherwise, civil design shall be based on the applicable sections of the latest revisions of the following codes, specifications, standards, regulations and other reference documents. In addition, the design must comply with all laws or regulations of federal and Nunavut territorial authorities.

3.2 General

3.2.1 All applicable federal, territorial (Nunavut) and local laws and regulations:

- OHSA Occupational Health and Safety Act
- CSA Canadian Standards Association
- MHSA Mine Health and Safety Act (Nunavut – S.N.W.T. 1994)
- OHSR Occupational Health and Safety Regulations
- NBCC National Building Code of Canada (2010)
- ASTM American Society for Testing and Materials
- ASCE American Society of Civil Engineers
- NFPA National Fire Protection Association
- NRC Natural Resources Canada – Explosives Safety and Security Branch

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3.3 Roads

- TAC Transportation Association of Canada – Geometric Design Guide for Canadian Roads
- AASHTO American Association of State Highway and Transportation Officials
- USBM Design of Surface Mine Haulage Roads – A Manual (US Department of the Interior, Bureau of Mines)
- MSHA Haul Road Inspection Handbook – MSHA Document Number PH99-I-4
- MTO Ministry of Transportation, Ontario – Ontario Traffic Manual.

3.4 Stormwater Management

- MOE Ministry of the Environment – Stormwater Management Planning and Design Manual
- MTO Ministry of Transportation, Ontario – Drainage Manual
- CDA Canadian Dam Association – Dam Safety Guidelines

3.5 Reference Documents

Reference will be made to/contents have been used as general guidance from the following documents, articulated during the previous phases of the project, during the development of these criteria:

- H337697-0000-10-122-0001: Stormwater Management and Drainage System Design
- H337697-6170-10-122-0001: Milne Port Drainage System and Stormwater Management Ponds
- H337697-6170-10-122-0002: Mine Site Drainage System, Stormwater and Sediment Management
- H337697-0000-15-124-0004: Geotechnical Data Report – Infrastructure
- Standard Specification S311213: Quarried Fill Materials
- Standard Specification S003120: Site Conditions
- NB 102-181/30-7: Baseline Hydrology Report, Knight Piesold, Jan 04, 2012
- Updated Design Peak Flow Assessment. Knight Piesold, 2016
- BIM - Early Revenue Phase Tote Road Design Criteria
- H349000-1000-10-122-0001: Civil Design Criteria
- Final Environmental Impact Statement (FEIS), Mary River Project, February 2012
- Nunavut Impact Review Board (NIRB) Project Certificate (No.:005), December 28, 2012
- H349000-2133-10-220-0001: Runoff Coefficient for the Milne Port Ore Stockpile Pad, Project Memo
- H349000-1000-10-220-0001: Stormwater Sedimentation Pond Design Criteria, Project Memo

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- E349000-1000-00-124-0005: Design Brief – Milne Inlet Landfarm, November 2012, EBA File E14101174.
- H353004-00000-228-066-0001: Mary River – Snowmelt + Rainfall Frequency Analysis. 2

4. Site Development

Site development refers to construction of civil infrastructure to support construction and operation of facilities. The following sections list the site development activities and establish criteria that shall be adhered to when carrying out site development design works.

All site development including toe lines of pads and roads shall be designed and positioned so that it is not closer than 31m from the edge of a stream or waterbody. The edge of a stream or water body shall be defined by using the existing surface obtained from the 1m density lidar survey (2016). 2

4.1 Site Preparation

4.1.1 Temporary drainage systems shall be provided at construction areas prior to construction activities taking place as required to control surface runoff.

4.1.2 During the summer months, wetlands or areas with standing water shall be drained and the drying of such shall be promoted prior to construction. Watercourses shall be re-routed with the use of cut-off ditches, or re-aligned engineered channels.

4.1.3 Waste material shall be stockpiled in designated areas with the appropriate erosion and sedimentation control measures in place.

4.2 Earthworks

4.2.1 Earthworks is defined as the activity of moving soil and/or rock. Earth-moving activities are required to obtain the required design elevations of the ground surface. Earthworks includes cut (if required) and fill for roads, buildings and equipment pads, utility berms, foundation excavation, and construction of ditches, diversion channels and berms, dikes, etc. Earthworks shall be carried out in accordance with the following general guidelines:

- Existing unsuitable soils shall be removed and replaced with suitable material to be decided by the Resident Engineer
- Fill materials shall be placed and roller compacted over the proof-rolled subgrade to achieve adequate bearing capacities, as required for specific construction activities
- Rocks/boulders and similar objects adjacent to areas which shall undergo excavation must be removed or secured, if they potentially endanger workers/machinery.

4.2.2 Table 4-1 provides the minimum slope ratios that shall be used in permanent cuts/excavations or fills/embankments. It must be noted that specific studies must be carried out by geotechnical engineers, if these slopes are to be modified with the aim of lowering costs of cut and/or fill.

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Table 4-1: Minimum Slope Ratios

Type of Earthworks	Layer	Ratio H:V
Permanent unsupported cuts	Overburden (ice-rich)	2:1
	Overburden (non-ice-rich)	1.5:1
	Rock (less than 4m)	1:8
Permanent fills (on natural, firm ground)	Granular fill	1.5:1
	Base and Subbase	1.5:1
	Rock fill	1.5:1
	Frozen Permafrost (During winter)	1:8

Notes:
1. The maximum heights and ratios shall be determined considering slopes with typical geometry and no surcharge.
2. The above-listed parameters serve as minimum requirements, and shall be updated/modified based on confirmation/update of the site-specific conditions and/or geotechnical recommendations, or as per BIM's directions.
3. Any geometry and load condition not covered by the table above shall be reviewed by the geotechnical engineer.
4. The granular fill is assumed to be in a drained condition.
5. If the total fill height is greater than 2 m, geotechnical stability analysis and benching requirements shall be considered on a case-specific basis.
6. For overburden cut/fill heights of greater than 5 m, 1.5 m wide benching with minimum 2% cross slope shall be provided.
7. The absolute minimum fill slope for granular material is 1.5H:1V. However, the desirable slope is 2H:1V.
8. The absolute minimum fill slope for rock fill material is 1.25H:1V. However, the desirable slope is 1.5H:1V.
9. For the haul road, the fill side slopes shall be 2H:1V, depending on the site conditions and slope stability.
10. Stability assessments of some cut and fill slopes may be required.
11. For rock cut heights greater than 4 m, 1H:4V slope shall be used with 2 m wide benching and minimum 2% cross slope at every 6 m.

4.2.3 Pits, trenches and similar which will later be stabilized by backfill shall be excavated at a safe slope as determined by the field engineer. Slope ratios listed in Table 4-1 shall be used for planning purposes. Slope ratio of 1:8 shall be used for planning purposes for frozen permafrost ground excavated and backfilled during winter.

4.2.4 In general, cut activities in permafrost shall be avoided/minimized. However, cut may be required to reduce large fills and high embankments that may affect/endanger slope stability. In addition, within areas where the cut materials can be reused as fill, the suitability of performing cuts in the native soil shall be reviewed by BIM and the geotechnical engineer for requirements of soil treatment/improvement, including geogrids and geotextiles, prior to implementation into the final design.

4.3 Site Grading

4.3.1 If applicable, finish grade elevations for roads and yards shall be set a minimum of 100 mm below the finish floor elevation of buildings/sheltered areas, with local ramps provided at doorways, as required.

4.3.2 Finish grading and yard grading shall be set to slope away from planned structures at a minimum of 0.5% to 2%, and drain to a storm drainage collection system. For very long-run and localized areas, the slope shall be reduced or increased, depending on the existing ground slope and the grading around the buildings and facilities.

4.3.3 Site grading shall produce a useable and easily maintainable ground surface, not subject to flooding or erosion. The rough grades and finish grades shall adhere to the following:

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- Final road and site grades shall ensure suitable pedestrian and vehicular access to buildings and facilitate adequate drainage of the site
- Building floor elevations shall be established such that the ground floor of the buildings will not be subject to flooding in the event that the storm drainage system fails
- Elevations of buildings/sheltered areas shall be established to permit gravity connections into sanitary sewers if possible, to avoid the need for pumps.

4.4 Infrastructure Facilities, Pads and Laydown Areas

4.4.1 Temporary/permanent equipment and construction material laydown areas shall be provided as per the applicable Contract Drawings. The sizes of the footprints shall be optimized to keep disturbed areas to a minimum and still provide enough room for storage of material/equipment and circulation of mobile cranes/vehicles.

4.4.2 The subgrades shall be prepared via cut/fill activities prior to pavement installation/placement. The following material shall be used:

- Type 12 (ROQ 600mm minus).

4.4.3 In general, following attainment of the subgrade, the pavement shall be laid on top, with the following minimum thicknesses/material types for infrastructure facility pads and other areas:

- 300 mm, Type 8 (150 mm minus) base △2
- 100 mm, Type 5 (32 mm minus) wearing surface course. △2

4.4.4 Temporary construction pads shall be constructed with:

- Minimum 300mm fill Type 8 for fill depth <600mm or Type 12 for fill depth>600mm
- 100 mm, Type 5 (32 mm minus).

4.4.5 Depending upon the area and specific requirements such as insulation for permafrost protection, the minimum pavement thicknesses and placement of wearing courses may differ from the above-listed.

4.4.6 Sub-grade insulation shall be installed under the footprint of all slab-on-grade and similar buildings to reduce heat transfer into the underlying permafrost. Sub-grade insulation shall comply with geotechnical recommendations. △2

4.4.7 Refer to Appendix A for typical layer works.

4.5 Milne Port Stockpile Area

4.5.1 The lump ore stockpile (Stockpile No. 2) shall be situated on an earthworks platform that shall be used as a laydown area before the stockpile becomes operational. The laydown area shall be designed to be a minimum of 300mm below the reclaim level. △2

4.5.2 The fine ore stockpile (Stockpile No. 1) shall be situated on the existing stockpile area. Additional earthworks will be constructed where required to ensure that there is sufficient area for the stockpile placement. △2

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4.6 Milne Port Design High Tide

4.6.1 The design High Tide levels for the Project shall be as follows:

- The Higher High Water Level (HHWL) for large tides at the Milne Port is +2.3 m above Chart Datum (CD) which corresponds to +1.1 m above Mean Sea Level (MSL)
- The Highest Astronomical Tide (HAT) at the Milne Port is +2.4m above CD which corresponds to +1.2 m above MSL
- The Lower Low Water Level (LLWL) for large tides at the Milne Port is +0.0 m above CD which corresponds to -1.2 m below MSL.

4.7 Retaining Walls

4.7.1 Retaining walls and structures shall be designed based on site-specific conditions. Lateral pressure coefficients for design of retaining walls shall be as per the geotechnical recommendation.

4.7.2 Retaining walls shall be avoided to the greatest extent possible. Concrete, gabion walls, crib walls, reinforced earth and/or other systems of retaining structures shall be used, if required.

4.8 Erosion and Sediment Control

4.8.1 Erosion and sediment control measures shall be installed as required, in and around the project sites to minimize sediment transport off the site.

4.8.2 Control measures shall be designed to:

- Minimize the size of disturbed areas
- Remove sediments from on-site runoffs prior to the runoff leaving the sites
- Prevent sediments from off-site runoffs flowing across disturbed areas
- Reduce runoff velocity flowing across the site
- Meet local requirements for erosion and sediment control plans as defined in the FEIS.

4.8.3 A minimum set back of 31 m from fish-bearing streams and lakes or water bodies shall be provided. Any exception to this shall be consulted with and approved by the Project's environmental team. △2

4.9 Quarry Blasting

4.9.1 The minimum distance that dwelling units (living quarters) shall be positioned away from the quarry will be 600m. △2

4.9.2 The minimum distance that roads, rail lines and project working areas shall be positioned away from the quarry is 300m. △2

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5. Road Design

5.1 General

5.1.1 The access roads at the two project sites may be temporary or permanent. An access road is defined as temporary if it will be used only during the construction period including site predevelopment or site capturing. Permanent roads are defined as roads that are requried for operarations. Permanant roads may be primary secondary or tertiary depending on frequency and type of traffic.

5.1.2 The design and construction of mine haul roads, access and internal site roads at the project sites shall provide a safe environment for construction, operations and maintenance personnel, and shall facilitate the mining operations, ore transport and port operations in an efficient manner. In addition, the design shall comply with the relevant standards, guidelines, acts, approvals, permits, and other contractual environmental requirements of Baffinland as defined in Section 3 of this document.

5.2 Road Category

5.2.1 For the purposes of this design criteria, the roads are classified in three categories:

- **Mine Haul Roads –** The purpose of this type of road is for the mining operation at the mine site – hauling of ore from the open pit to the crusher pad and for maintenance purposes, from the crusher pad to the maintenance building. The mine haul road shall be segregated from the other project roads for safety considerations, and shall comply with the applicable Nunavut MHSA.
- **Primary Roads –** These roads provide two-way access. Frequent traffic is expected.
- **Secondary Roads –** These roads provide two-way access to various facilities/areas within each site, where light vehicles will travel in both directions. They are expected to be used daily.
- **Tertiary Roads –** These roads are generally single lane width and are used in areas where traffic is infrequent / rare.
- **Temporary Roads –** These roads provide access for construction only and are not required for ongoing operation.

5.2.2 Special purpose roads, such as for module transport, may be required and will be determined on a case by case basis.

5.3 Design Vehicle

5.3.1 The following design vehicles shall be utilized for the design of the associated project roadways:

- CAT 793F Haul Truck for the Mine Haul Road
- Other types of design vehicles have been used for the remainder of the Project roadways and a fire truck has been considered as the minimum design vehicle for fire access routes.

△2

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5.4 Geometric Design Criteria

5.4.1 All roads shall be designed as gravel roads and shall accommodate the design vehicle specified in Section 5.3 of this document. The roads' geometric design parameters are specified below:

Table 5-1: Road Geometric Design Criteria

Road Type	Mine Haul Road	Primary Road	Secondary Road	Tertiary & Temporary Roads
Number of Lanes	2	2	2	1
Design Speed (km/h)	50	60	40	40
Posted Speed (km/h)	40	50	30	30
Total Road Width (m)	25	10	6	4
Minimum Horizontal Curve C/L Radius (m)	100	35	35	35
Minimum Intersection Inner Radius (m)	30	15	15	15
Minimum Cross Slope (%)	3	2	2	2
Maximum Grade (%)	10	10	10	10
Minimum K Value (Vertical Sag Curve)	12	8	8	8
Minimum K Value (Vertical Crest Curve)	16	4	4	4
Maximum Super-elevation (%)	4	4	4	4
Minimum Vertical Clearance	9	7	5	5

Notes:
1. The road design parameters are based on the desirable design speeds. Specific parameters such as the minimum turn radii may be modified for some areas locally on a case-by-case basis, via adjustment of the design speeds.
2. The Haul Road width shall be based on the Nunavut Mine Health and Safety Act which requires a minimum travel width three times the width of the widest haulage vehicle for dual lane traffic and two times the width of the widest haulage vehicle for single lane traffic.
3. Shoulder barriers (safety berms or guardrails) for the Haul Road shall be based on the Nunavut Mine Health and Safety Act which requires shoulder barriers of at least ¾ the height of the largest tire of any vehicle using the road and shall be provided along the edge of the haul road wherever a drop-off greater than 3.0m exists. For CAT 777G, the shoulder barrier (safety berm or guardrail) height shall be 2.0 m based on standard tire 27.00 R49 (E4).
4. Total road width includes shoulder width and snow allowance but doesn't include the safety berm width for the haul road.
5. Widening shall be provided in roadway curves as necessary.
6. Need for geotextiles or geogrids shall be considered on a case-specific basis.
7. For the Tote Road design criteria, refer to H349000-3100-10-122-0001.
8. Provide safety stations, emergency ramps or escape lanes in accordance with the local and mine safety requirements. Hatch will only provide two escape ramps at the most critical locations as per BIM's instruction. Escape ramp design shall be carried out as per the USBM manual.
9. For cut/fill heights of greater than 5 m, provide 1.5 m wide benching with minimum 2% cross slope at every 5 m.
10. The ramp leading down to the sea lift from the laydown area at the Milne Port shall have a maximum grade of 8%.
11. The maximum grade for ramps to the buildings is 6%.
12. Fill toe key shall be provided in areas where the existing ground is steeper than 3H:1V away from the road.
13. Design speeds may be reduced locally if needed.

5.4.2 The following general rules shall apply to the geometric design of the project roads:

- Roadway grades shall not exceed the maximum grades specified in Table 5-1 except for short ramps which shall be considered on a case-specific basis
- Signage shall be provided for speed and caution at steep horizontal and/or vertical curves, and where the design criteria can't be met

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- Traffic signs and shoulder barriers (safety berms or guardrails), shall be placed at the outer edges of the roads, as required.

5.5 Pavement Thickness

5.5.1 For the project internal site roads, the subgrades shall be prepared via cut/fill activities prior to pavement installation/placement. Type 12 Run-of-Quarry and/or suitable earth fill material shall be used for subgrade where appropriate and approved by the Engineer. Otherwise type 8 (150mm minus) shall be used. The voids of each layer of Type 12 material shall be filled with rock fragments prior to placement of the next layer.

5.5.2 Pavement thickness for each road type shall comply with Table 5-2.

Table 5-2: Pavement Thickness

Road Type	Primary / Secondary Roads	Tertiary & Temporary Roads
Base (Type 8) note: refer to 5.5.4 below	300 mm	300 mm
Surface (Type 5)	100 mm	100 mm

5.5.3 Pavement details for mine haul road to be confirmed.

5.5.4 Sub-base fill shall be placed as required to achieve specified sub-base elevations with minimum thickness as specified and:

- For sub-base fill depth >600mm Type 12 shall be used. Where no base is placed over the Type 12 the top of Type 12 material shall be chinked with smaller rock fragments and compacted to minimize infiltration of Surface Type 5 material △2
- For sub-base fill depth <600mm Type 8 material shall be used. △2

5.5.5 Pavement thickness for special purpose roads shall be determined on a case by case basis.

5.5.6 Refer to Appendix A for typical layer works.

5.5.7 Design Vehicles, Traffic Volume and Load

5.5.7.1 Vehicle types have been selected for the project roads based on the expected usage and transportation requirements of the area (Section 5.3).

5.5.7.2 All pavement, slabs, bridges, trenches, trench covers and underground installations accessible to trucks shall be designed to withstand the load associated with an HS 20-44 wheel load or its equivalent, as defined by the American Association of State Highway and Transportation Officials (AASHTO) under Standard Specification for highway bridges. However, within areas of special equipment operation, this shall be considered as per the actual vehicle loading.

5.6 Parking

5.6.1 Parking areas shall be designed to accommodate their intended use. In general, all parking areas shall be surfaced with granular materials.

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5.6.2 Vehicle parking area design shall adhere to the following:

- The area shall be graded to direct stormwater away from the parking
- Alignment and gradients shall be coordinated with the grading plans to control drainage
- Walking distance from parking areas shall be kept to a minimum
- Barrier-free parking spaces as well as walkways shall be provided according to the applicable regulations
- Designated turnaround areas shall be provided at dead ends
- Parking lot design criteria shall be as shown in Table 5-3.

Table 5-3: Parking Lot Design Criteria

Topic	Criteria
Gradient	Maximum 5% Minimum 0.5% Optimum 2%
Cross Slope	Maximum 5% Minimum 2% Optimum 3%
Pavement Structure	300 mm Type 8 (150 mm minus) subbase 100 mm Type 5 (32 mm minus) base/wearing surface course
Parking Stall Dimensions	Driving Lane • Width 7.5 m Standard • Depth 6 m • Width 2.75 m Barrier-free • Depth 6 m • Width 3.5 m • Access Aisle Width 1.5 m

5.7 Signage

5.7.1 Traffic control signs and road edge markers shall be provided as required to ensure safe movement in and about the site.

5.7.2 Direction and information signs for both vehicle and pedestrian traffic shall be provided for parking areas, restricted areas, shipping and receiving.

5.7.3 Primary identification signs shall be free-standing and sited according to the applicable standards as listed in Section 3.3.

5.7.4 Other signs shall be free-standing, fence-mounted or wall-mounted.

5.7.5 Security signs shall be provided at the sites and along the site property boundaries.

5.7.6 Signs for the site access roads shall be compliant with the local traffic regulations.

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5.7.7 Signs shall be lighted, if deemed necessary.

5.7.8 All signs and pavement markings (if applicable) shall be well maintained during the construction and operational periods.

5.8 Bollards

5.8.1 Concrete blocks and /or tires shall be provided where required to protect buildings and hazardous areas.

5.8.2 Where available, tires must be used. If tires are not available, concrete blocks must be placed be placed based on the engineer's recommendations.

5.9 Shoulder Barriers (Safety Berms/Guardrails)

5.9.1 Shoulder barriers (earth safety berms or guardrails) shall be provided in accordance with the Nunavut Mines Health and Safety Act.

5.9.2 Barriers shall be provided where a 3.0 m or more drop-off exists at the edge of vehicular areas including roads, pads, lay down areas and similar.

5.9.3 Height of barrier shall be minimum 0.75 times the maximum wheel diameter of traffic expected to operate in the area, including:

- For areas where heavy mining equipment travels barrier height shall be minimum 2.7m high (based on CAT793 F tire, 40.00R57)
- For general vehicular areas barrier height shall be minimum 1.0m high (based on typical transport, vac and tanker trucks used on site).

5.9.4 Safety berms side slopes shall be 1H:1V.

5.9.5 Discontinuous openings shall be provided in berms at maximum 25 m spacing for drainage and snow clearance, with openings smaller than half the blade width of vehicles constructing or maintaining the berms.

5.9.6 Runaway vehicle collision berms or escape lanes shall be provided in accordance with industry requirements as described in the Nunavut MHSA.

5.10 Utility Berms

5.10.1 Utility berms may travel along the project roadways to the greatest extent possible, shall be of trapezoidal cross-sections. Berms with power cables shall be minimum 0.6 m high from the road edge or the existing ground, and shall have maximum fill side slopes of 1.5H:1V, as validated by the geotechnical engineer. They shall be constructed with the use of 300 mm of granular Type 8 (150 mm minus) and 50 mm of granular Type 5 (32 mm minus) material. Berms for pipes may be level with adjacent roads or pipe may be placed directly on existing grade without berm construction where risk of damage is low.

The top width of utility berms will depend on the pipe and cable duct sizes. Utility berms shall cross roadway intersections through utility sleeves. After crossing the intersections, they shall resume the alignments within the utility berms.

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6. Stormwater Management System

6.1 Allowance for Snow Melt Runoff Volume

2

An investigation into Snowmelt was done as per *H353004-00000-228-066-0001: Snowmelt+ Rainfall Frequency Analysis*. It was found that the combination of rainfall and snowmelt in the start of spring has a lower impact on the size of stormwater infrastructure than rainfall during the middle of the wet season (at higher intensities and total precipitation). For this reason, only the runoff methods as specified in the *Baseline Hydrology Report, January 4. North Bay, Ontario. Ref. No. NB102-181/30-7, Rev 1* and updated in *VA16-01950 on 13 December 2016* by Knight Piésold Consulting will be used for designing stormwater infrastructure.

6.2 Internal Surface Drainage

6.2.1 Internal surface drainage areas are defined as areas where the catchment consists out of areas where the natural surface has been disturbed through excavation, mining activity or bulk earthworks such as the construction of pads and roads. The general criteria for the site internal storm water management systems are described below. 2

- All interior site grading and roads shall be designed to provide continuous overland flow without erosion to a drainage ditch system
- All drainage ditches should be of trapezoidal cross sections, where possible
- Ditches shall be designed to convey a 1 in 25 year flood event
- Provision must be made to ensure that there is a safe flow path for events up to the 1 in 100 year event, such that the runoff will not flood key mining areas, cause significant erosion, pick up excessive contaminants or cause other significant problems
- Ditch freeboard, minimum depth, minimum width, side slope, longitudinal slope and maximum permissible velocities shall be as per Table 6-1
- For supercritical flow conditions, the ditches shall be designed to maintain the energy line within the ditch or 300mm freeboard, whichever is higher 2

  Minimum set back distance of structures from top of drainage ditch slopes shall be 3 m
- Roof and yard drainage shall be collected in open ditches
- Appropriately sized rip rap shall be provided at locations throughout the stormwater drainage system which are susceptible to erosion, including ditch sections subject to high-velocities (greater than 1.5 m/s), sections of super critical flow, ditch outlets, storm sewers outfalls, and culverts inlets and outlets
- If the ditch is in rock, no rip rap is required
- Energy dissipaters shall be used where the flow velocities may reach values high enough to cause severe erosion or hydraulic jumps.

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6.3 External Surface Drainage

External surface drainage areas are defined as areas where the catchment consists of undisturbed areas where the environment is mostly in its natural state. Criteria for drainage of the external areas are as follows: 2

- Runoff from undisturbed areas surrounding the mine site shall be collected in perimeter ditches and diverted around and/or through the site perimeter
- To the extent possible, these perimeter ditches shall be designed to discharge at locations that best retain the characteristics of the existing (i.e., pre-development) natural drainage patterns
- Diversion ditches shall be designed to convey the 1 in 100 year flood event 2
- Ditch freeboard, minimum depth, minimum width, side slope, longitudinal slope and maximum permissible velocities shall be as per Table 6-1
- For supercritical flow conditions, the ditches shall be designed to maintain the energy line within the ditch. 2

6.4 Peak Flow Estimation

For flow estimation refer to *NB 102-181/30-7: Baseline Hydrology Report, Knight Piesold, Jan 04, 2012* and updated in *VA16-01950 on 13 December 2016.* 2

6.5 Rainfall Intensity

Rainfall intensities must be based on *NB 102-181/30-7: Baseline Hydrology Report, Knight Piesold, Jan 04, 2012* and updated in *VA16-01950 on 13 December 2016.* 2

6.6 Sedimentation Ponds / Pollution Control Ponds

The design of the sedimentation ponds shall be based on the Civil Design Criteria Document No. H349000-1000-10-122-0001 (Appendix B) that was used for a previous phase of Mary River Mine with the following exception: 2

- Runoff coefficient to estimate runoff shall be 0.9. 2
- Ponds shall be operated as empty to ensure enough capacity is available to accommodate the design volumes. Failure to empty the ponds will result in overflow occurring and the prescribed TSS will not be achieved. 2
- All sedimentation ponds shall be lined with appropriate impermeable geomembrane material. Geomembrane material shall be exposed (not covered with granular material) except where the material will be anchored. 2
- It is assumed that all runoff captured by the sedimentation ponds are non-acid generating and can be discharged to the environment once the TSS levels are within the acceptable range. 2

6.7 Stockpile Footprint

The following sections will cover runoff that can be expected from the Stockpile No. 1 and No. 2 areas. 2

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6.7.1 *Stockpile No.1 Runoff*

2

Runoff from Stockpile No.1 would drain towards the existing sedimentation pond to the North West of the stockpile. The existing pond size will be determined from survey information and evaluated to determine if it meets the required design criteria as stated in Section 6.6.

6.7.2 *Stockpile No.2 Runoff*

2

The entire stockpile area would be surrounded by adequately sized berms to prevent any water from discharging into the natural environment from the stockpiles. Water shall be tested for the required TSS before pumping into the natural environment.

6.8 Culverts, Roadside Ditches and Berms

6.8.1 Drainage ditches and culverts shall be designed for return periods as prescribed in Section 6.2 and Section 0 with peak flows calculated as per Section 6.4. such that the inlet headwater level does not exceed the bottom of the road subbase. Their analysis and design shall consider design flow, culvert size and material, entrance structure layout, outlet structure layout and erosion protection.

6.8.2 Drainage ditch design shall also be subject to the criteria stated in Table 6-1.

Table 6-1: Drainage Ditch and Culvert Design Criteria

Maximum permissible flow velocity in ditch without rip rap (m/s)		1.5
Minimum ditch and culvert slope (%)		0.2
Ditch side slopes (H: V)	Rock	1:4
	Soil	2:1
Minimum culvert diameter (mm)		600
Berm Side Slopes (H:V)		2:1
Berm Top Width (mm)		500
Ditch and Berm Freeboard Requirement of Sub-Critical Flow (mm)		300

6.8.3 Loading over culverts and pipes shall be in accordance with AASHTO HS 20-44, except for areas of special equipment operation, which shall consider actual vehicle loading. The minimum cover for culverts shall be 600 mm, or as required by the differing specific design vehicle.

6.8.4 Fish-bearing culverts shall be minimum 1,000 mm diameter and only one pipe shall be embedded by 10% of the pipe diameter.

6.8.5 All culverts shall be Corrugated Steel Pipe (CSP).

6.8.6 Apply Manning's n values as per the following:

- n = 0.025 for gravel ditches
- n = 0.040 for rip rap ditches
- n = 0.024 for all CSP pipe. 0.

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6.9 Drainage Interceptor/Collector Berms

6.9.1 Drainage berms diverting overland flow from the waste rock drainage area to the sedimentation ponds shall detail as per Table 6-1 above and 0.5 m top width.

6.9.2 Rip rap and other energy dissipation measures shall be provided to protect against erosion.

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Appendix A: Typical Layer Works

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Item	Sub-Base	Base	Surface	Comments
Rail Embankment	Type 12	Type 22 (-50)	Ballast	Refer to rail design for additional details
	>550 mm	150 mm	*per rail detail*	
Construction Laydown Pad	Type 12*	-	Type 5 (-32)	
	>300 mm	-	100 mm	
General Operations Areas and Pads for Equipment / Structures (unheated)	Type 12*	Type 8 (-150)	Type 5 (-32)	Pads constructed directly on excavated rock do not require sub-base fill
	-	300 mm	100 mm	
Slab-on-Grade Building on Permafrost	Type 12*	Type 8 (-150)	Type 5 (-32)	Styrofoam insulation installed in the Base fill (500mm below finished grade), total thickness with insulation 650mm.
	-	300 mm	500 mm	
Stacker/Reclaimer Berm	Type 8 (-150)	Type 22 (-50)	Ballast	To be confirmed by Geotechnical based on updated borehole data and final design for S/R equipment
	>1.85m	150 mm	*per S/R rail detail*	
Ore Stockpile Pads (where developed pad required)	Type 12*	-	Iron Ore **	Primary crusher feed area, rail loading stockpile area, fines intermediate pile, and fines stockpile area (existing SL pile)
	-	-	200 mm	
Road - Primary / Secondary	Type 12*	Type 8 (-150)	Type 5 (-32)	
	-	300 mm	100 mm	
Road - Tertiary / Temporary	Type 12*	-	Type 5 (-32)	
	>300 mm	-	100 mm	
HME Operating Roads / Areas	Type 12*	-	-	Sub-base and surface requirements for Mine Haul Road / HME operating areas to be confirmed
	-	-	-	
Heavy Module Transport Road	Type 12	Type 8 (-150)	Type 5 (-32)	Design and requirements to be confirmed based on final module transport equipment and loads
	>600 mm	300 mm	100 mm	
Mine Haul Road	Type 12	Type 8 (-150)	Type 5 (-32)	This pavement design is applicable to the CAT 793
	800 mm	600 mm	200 mm	

Notes:

1. Sub-Grad fill depth as required to achieve final grad. Use Type 8 instead of Type 12 for depth <600mm.

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2. Iron ore used to surface stockpile pads may be on-spec or off-spec as supplied by BIM operations.
3. Material Types:
   a. Type 12 – ROQ nominally, <600mm (maximum permitted 1000mm)
   b. Type 8 – Jaw crushed or similar, <150mm
   c. Typed 5 – Crushed Aggregate, <32mm
   d. Type 22 – Rail sub-ballast, <50mm

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Appendix B:
Document No. H349000-1000-10-122-0001
Civil Design Criteria

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Civil

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1. Introduction

- The Mary River project site is located in northern Baffin Island, in Nunavut Territory of the Canadian Arctic. The Project currently consists of activities which entail mining high grade iron ore, at a production rate of 3.5 million tonnes per annum, stockpiling it throughout the year at the Milne Port, and shipping the material during the summer months. Development of this Project includes the infrastructure construction and operational activities associated with the Milne Port and Mine Site areas along with upgrading the 100 km Tote Road connecting the two sites. All associated project infrastructure shall be based on a 5 year design life, with the exception of the laydown areas, for which a 1 year design life shall be considered. 1
- The purpose of this document is to provide the necessary information required for the design of infrastructure at the two project sites (Milne Port and Mine Site). The works covered by this criteria include earthworks, site grading, internal roads, stormwater drainage system and the earthworks for service utilities, to be implemented at the project sites. The design criteria proposed in this document shall be treated as minimum requirements for the intended infrastructure design. Refer to Section 2 of this document for a list of other design criteria and technical design documents from the pertinent disciplines. Where a conflict between the various design criteria occurs, the most stringent shall apply.
- This document is intended to address the key criteria required for the design of site infrastructure.

1.1 Safety

The consideration of personnel safety in all stages of the design, construction and operation is paramount. Prime consideration shall be given to safety and reliability to:

- Maximize health and safety for all personnel.
- Minimize environmental impacts.
- Maximize the security of equipment.

2. Other Project Design Criteria

2.1 This design criteria document shall be read in conjunction with other documents which may already exist or will be developed as the project proceeds. These documents include the following:

- Tote Road Design Criteria (H349000-3100-10-122-0001).
- Structural Design Criteria (H349000-1000-35-122-0001).
- ~~Foundation Design Criteria (H349000-1000-35-122-0002).~~ 1
- Aerodrome Design Criteria (H349000-1000-00-109-0001).
- Layout Design Criteria (H349000-1000-50-122-00030. 1
- Foundation Design Basis (H349000-1000-30-109-0001) – For Non-Process buildings. 1

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3. Units and Coordinate System

3.1 The International System of Units (SI units and prefixes) shall be used for all design calculations and on all drawings.

3.2 The grid coordinates shall be based on: projection - Universal Transverse Mercator (UTM) Zone 17 and horizontal datum - NAD 83 Canadian Spatial Reference System (CSRS).

3.3 Vertical datum shall based on the Canadian Geodetic Vertical Datum of 1928 (CGVD28).

4. References

4.1 Codes, Regulations and Standards

4.1.1 Unless specifically stated otherwise, civil design shall be based on the applicable sections of the latest revisions of the following codes, specifications, standards, regulations and other reference documents. In addition, the design must comply with all laws or regulations of federal and Nunavut territorial authorities.

4.2 General

4.2.1 All applicable federal, territorial (Nunavut) and local laws and regulations.

- OHSA Occupational Health and Safety Act
- CSA Canadian Standards Association
- MHSA Mine Health and Safety Act (Nunavut – S.N.W.T. 1994)
- OHSR Occupational Health and Safety Regulations
- NBCC National Building Code of Canada (2010)
- ASTM American Society for Testing and Materials
- ASCE American Society of Civil Engineers
- NFPA National Fire Protection Association
- NRC Natural Resources Canada – Explosives Safety and Security Branch 1

4.3 Roads

- TAC Transportation Association of Canada – Geometric Design Guide for Canadian Roads
- AASHTO American Association of State Highway and Transportation Officials
- USBM Design of Surface Mine Haulage Roads – A Manual (US Department of the Interior, Bureau of Mines)
- MSHA Haul Road Inspection Handbook – MSHA Document Number PH99-I-4
- MTO Ministry of Transportation, Ontario – Ontario Traffic Manual 1

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4.4 Stormwater Management

- MOE Ministry of the Environment - Stormwater Management Planning and Design Manual
- MTO Ministry of Transportation, Ontario – Drainage Manual
- CDA Canadian Dam Association – Dam Safety Guidelines △1

4.5 Reference Documents

Reference will be made to/contents have been used from the following documents, articulated during the previous phases of the project, during the development of these criteria:

- H337697-0000-10-122-0001: Stormwater Management and Drainage System Design.
- H337697-6170-10-122-0001: Milne Port Drainage System and Stormwater Management Ponds.
- H337697-6170-10-122-0002: Mine Site Drainage System, Stormwater and Sediment Management.
- H337697-0000-15-124-0004: Geotechnical Data Report – Infrastructure.
- Standard Specification S311213: Quarried Fill Materials.
- Standard Specification S003120: Site Conditions.
- NB 102-181/30-7: Baseline Hydrology Report, Knight Piesold, Jan 04, 2012.
- BIM - Early Revenue Phase Mine Haul Road Design Criteria.
- BIM - Early Revenue Phase Tote Road Design Criteria.
- H349000-3000-00-124-0001: NB102-00181 Bulk Sampling Program – Road Upgrade Design Summary.
- Final Environmental Impact Statement (FEIS), Mary River Project, February 2012.
- Nunavut Impact Review Board (NIRB) Project Certificate (No.:005), Dec 28, 2012.
- H349000-4221-10-220-0001: Number of Runaway Truck Arresting Provisions for the Mine Haul Road, Project Memo. △1
- H349000-2133-10-220-0001: Runoff Coefficient for the Milne Port Ore Stockpile Pad, Project Memo. △1
- H349000-1000-15-122-0001: Geotechnical Design Criteria △1
- H349000-1000-10-220-0001: Stormwater Sedimentation Pond Design Criteria, Project Memo. △1
- E349000-1000-00-124-0005: Design Brief – Milne Inlet Landfarm, November 2012, EBA File E14101174. △1

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5. Site Development

Site development refers to construction of civil infrastructure to support construction and operation of facilities. The following sections list the site development activities and establish criteria that shall be adhered to when carrying out site development design works.

5.1 Site Preparation

5.1.1 Construction areas shall be cleared of vegetation, and temporary drainage systems shall be provided prior to construction activities taking place within the proposed areas for the new site facilities.

5.1.2 Topsoil and/or existing roots shall be removed to a minimum depth of 150 mm, if required, from all areas where buildings, roads, yards and services are to be constructed, and shall be stockpiled in designated areas. Disposal options shall include on-site reuse, development of a designated stockpile area for disposal, or removal by truck to off-site areas, as instructed by the Company.

5.1.3 During the summer months, wetlands or areas with standing water shall be drained and the drying of such shall be promoted prior to construction. Watercourses shall be re-routed with the use of cut-off ditches, or re-aligned engineered channels.

5.1.4 Waste material shall be stockpiled in designated areas with the appropriate erosion and sedimentation control measures in place. 1

5.2 Earthworks

5.2.1 Earthworks is defined as the activity of moving soil and/or rock. Earth-moving activities are required in order to obtain the required design elevations of the ground surface. Earthworks includes cut (if required) and fill for roads, buildings and equipment pads, utility berms, foundation excavation, and construction of ditches, diversion channels and berms, dikes, etc. Earthworks shall be carried out in accordance with the following general guidelines: 1

- Existing unsuitable soils shall be removed and replaced with suitable material.
- Fill materials shall be placed and compacted over the proof-rolled subgrade in order to achieve adequate bearing capacities, as required for specific construction activities.
- Rocks/boulders and similar objects adjacent to areas which shall undergo excavation must be removed or secured, if they potentially endanger workers/machinery.
- The following criteria shall be used to determine the suitability of the soil for fill:
  - Satisfactory soil: ASTM D 2487 Soil Classification Groups GW, GP, GM, SW, SP, and, SM, or a combination of these groups; non ice-rich, free of debris, waste, vegetation and other deleterious matter. 1
  - Unsatisfactory soil: According to ASTM D 2487 Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH and PT; according to AASHTO M145 Soil Classification Groups A-2-6, A-2-7, A-4, A-5, A-6 and A-7 or a combination of these groups. Also, ice-rich soils or soils containing traces of contamination and/or organic materials. 1
  - Water shall be diverted away from excavations, so it does not saturate the side slopes.

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- If pipes are located in the vicinity of the slopes, erosion control measures shall be in place as mitigation for eventual leaks.
- No loads, including excavated material, traffic of vehicles or heavy machinery shall be allowed near the crest of the slopes (at a distance equal to the height of the excavation) if the slope-support solutions did not take such loads into account.
- Dust control measures shall be in place.
- For delineation of the project development boundaries, the minimum setback from freshwater aquatic environments, including fish-bearing streams and water bodies shall be as per NIRB Project Certification No.005. In general, a minimum 5 m set back shall be provided for non fish-bearing water bodies and streams, due to the potential risks of erosion and slope stability.
- Culvert installation in fish-bearing streams shall follow DFO guidelines.

5.2.2 Table 5-1 provides the minimum slope ratios that shall be used in cuts/excavations or fills/embankments. It must be noted that specific studies must be carried out by geotechnical engineers, if these slopes are to be modified with the aim of lowering costs of cut and/or fill.

Table 5-1: Minimum Slope Ratios

Type of Earthworks	Layer	Ratio H:V	
Permanent unsupported cuts	Overburden (ice-rich)	2:1	1
	Overburden (non ice-rich)	1.5:1	1
	Rock (less than 4m)	1:8	1
Permanent fills (on natural, firm ground)	Granular fill	1.5:1	
	Base and Subbase	1.5:1	
	Rock fill	1.5:1	1

Notes:
1. The maximum heights and ratios shall be determined considering slopes with typical geometry and no surcharge.
2. The above-listed parameters serve as minimum requirements, and shall be updated/modified based on confirmation/update of the site-specific conditions and/or geotechnical recommendations, or as per BIM's directions.
3. Any geometry and load condition not covered by the table above shall be reviewed by the geotechnical engineer.
4. The granular fill is assumed to be in a drained condition.
5. If the total fill height is greater than 2 m, geotechnical stability analysis and benching requirements shall be considered on a case-specific basis. 1
6. For overburden cut/fill heights of greater than 5 m, 1.5 m wide benching with minimum 2% cross slope shall be provided. 1
7. The absolute minimum fill slope for granular material is 1.5H:1V. However, the desirable slope is 2H:1V.
8. The absolute minimum fill slope for rock fill material is 1.25H:1V. However, the desirable slope is 1.5H:1V.
9. For the haul road, the fill side slopes shall be 2H:1V, depending on the site conditions and slope stability.
10. Stability assessments of some cut and fill slopes may be required. 1
11. For rock cut heights greater than 4 m, 1H:4V slope shall be used with 2 m wide benching and minimum 2% cross slope at every 6 m.

5.2.3 In general, cut activities in permafrost shall be avoided/minimized. However, cut may be required to reduce large fills and high embankments that may affect/endanger slope stability. In addition, within areas where the cut materials can be reused as fill, the suitability of performing cuts in the native soil shall be reviewed by BIM and the geotechnical engineer for requirements of soil treatment/improvement, including geogrids and geotextiles, prior to implementation into the final design. 1

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5.3 Backfilling

5.3.1 The gradation of fill material shall be within the Type 5 (32 mm minus) gradation limit for finish grading, within the Type 8 (150 mm minus) and/or suitable earth fill material gradation limit for rough grading, and Type 12 (600 mm minus) and/or suitable earth fill material gradation limit for the rest of the mass backfill. The surface voids of each layer of Type 12 (i.e. Run-of-Quarry material) shall be filled with rock fragments prior to the next layer being placed. 1

5.4 Site Grading

5.4.1 If applicable, finish grade elevations for roads and yards shall be set a minimum of 100 mm below the finish floor elevation of buildings/sheltered areas, with local ramps provided at doorways, as required. 1

5.4.2 Finish grading and yard grading shall be set to slope away from planned structures at a minimum of 0.5% to 2%, and drain to a storm drainage collection system. For very long-run and localized areas, the slope shall be reduced or increased, depending on the existing ground slope and the grading around the buildings and facilities.

5.4.3 Site grading shall produce a useable and easily maintainable ground surface, not subject to flooding or erosion. The rough grades and finish grades shall adhere to the following:

- Final road and site grades shall ensure suitable pedestrian and vehicular access to buildings and facilitate adequate drainage of the site.
- Building floor elevations shall be established such that the ground floor of the buildings will not be subject to flooding in the event that the storm drainage system fails.
- Elevations of buildings/sheltered areas shall be established to permit gravity connections into sanitary sewers if possible, to avoid the need for pumps.

5.5 Infrastructure Facilities, Laydown and Ore Stockpile Areas

5.5.1 Temporary/permanent equipment and construction material laydown areas shall be provided as per the applicable Contract Drawings. The sizes of the footprints shall be optimized to keep disturbed areas to a minimum and still provide enough room for storage of material/equipment and circulation of mobile cranes/vehicles.

5.5.2 The subgrades shall be prepared via cut/fill activities prior to pavement installation/placement. If the height of the subgrade fill is less than 600 mm, Type 8 (150 mm minus) fill shall be used. If the height of the subgrade fill is greater than 600 mm, Type 12 Run-of-Quarry (600 mm minus) and/or suitable earth fill material shall be used. The voids of each layer of Type 12 shall be filled with rock fragments prior to placement of the next layer. 1

5.5.3 In general, following attainment of the subgrade, the pavement shall be laid on top, with the following minimum thicknesses/material types for infrastructure facility pads and other areas:

- 300 mm, Type 8 (150 mm minus) subbase.
- 100 mm, Type 5 (32 mm minus) base/wearing surface course. 1

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5.5.4 Depending upon the area and specific requirements such as insulation for permafrost protection, the minimum pavement thicknesses and placement of wearing courses may differ from the above-listed.

5.5.5 There shall be no insulation under “fold-away” and “fabric” buildings constructed on non-frost susceptible ground material (typical for Milne Port). 1

5.5.6 Insulation shall be provided under “fold-away” and “fabric” buildings constructed on frost susceptible ground material (typical for Mine Site). 1

5.5.7 Frost susceptible and ice-rich soils shall be excavated to the extent required and backfilled with Type 12 Run-of-Quarry (600 mm minus). Non-frost susceptible soils with no visible ice shall not be excavated. 1

5.6 Landfarm

~~5.6.1~~ ~~Both the Milne Port and Mine Site landfarms shall be designed as per the criteria listed in Section 3.2 of Annex 5 in the FEIS, Attachment 5: Waste Management Plan for Construction Operation, and Closure; Appendix 10D-4.~~ 1

~~5.6.2~~ ~~The overall geometry as well as the liner details shall be as per Figure 3, “Hydrocarbon Impacted Soils Storage and Landfarm Facility – Preliminary Design of Landfarm Facility” contained within Attachment 5.~~ 1

5.6.3 EBA Engineering Consultants Ltd. has already carried out the design for the Milne Port Landfarm. 1

5.6.4 Milne Port and Mine Site Hazardous Waste Containment designs shall be carried out as per environmental requirements. They shall be lined, and shall contain sumps. 1

5.7 Milne Port Design High Tide

5.7.1 The design High Tide levels for the Project shall be as follow: 1

- The Higher High Water Level (HHWL) for large tides at the Milne Port is +2.3 m above Chart Datum (CD) which corresponds to +1.1 m above Mean Sea Level (MSL). 1
- The Highest Astronomical Tide (HAT) at the Milne Port is +2.4m above CD which corresponds to +1.2 m above MSL. 1
- The Lower Low Water Level (LLWL) for large tides at the Milne Port is +0.0 m above CD which corresponds to -1.2 m below MSL. 1

5.7.2 The toe of ramp and earthworks pad leading down to the sea lift from the laydown area, including the designated turnaround area at the beach within the Milne Port shall have a design elevation greater than +1.2 m above MSL. 1

5.7.3 Landing pad elevation at the beach shall be minimum 7’ (2.15 m) above the average between the HHWL and LLWL (i.e. +3.3 m above CD which corresponds to +2.1 m above MSL). 1

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5.8 Retaining Walls

5.8.1 Retaining walls and structures shall be designed based on site-specific conditions. Lateral pressure coefficients for design of retaining walls shall be as per the geotechnical recommendation.

5.8.2 Retailing walls shall be avoided to the greatest extent possible. Concrete, gabion walls, crib walls, reinforced earth and/or other systems of retaining structures shall be used, if required.

5.9 Erosion and Sediment Control

5.9.1 Erosion and sediment control measures shall be installed as required, in and around the project sites in order to minimize sediment transport off the site.

5.9.2 Control measures shall be designed to:

- Minimize the size of disturbed areas.
- Remove sediments from on-site runoffs prior to the runoff leaving the sites.
- Prevent sediments from off-site runoffs flowing across disturbed areas.
- Reduce runoff velocity flowing across the site.
- Meet local requirements for erosion and sediment control plans as defined in the FEIS.

5.9.3 A minimum set back of 30 m from fish-bearing streams and lakes or water bodies shall be provided. Any exception to this shall be consulted with and approved by the Project's environmental team. 1

5.10 Construction and Permanent Fencing

5.10.1 Chain link fence, where required, shall be galvanized, with a minimum height of 1.8 m.

5.10.2 Two strands of barbed wire shall be bracketed off the top of the fence for safety reasons, where required by the Company.

5.10.3 Fencing within the sites shall be provided as required and as directed by the Company.

5.11 Explosives Magazine Pads and Earth Barricades 1

5.11.1 Explosives magazine pads shall be designed as per the criteria in Section 5.5 of this document. 1

5.11.2 Geometry of the Explosives Magazine Earth Barricades shall be designed in accordance with the Quantity-Distance Principles Manual from the Natural Resources Canada, Explosives Safety and Security Branch. 1

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6. Road Design

6.1 General

6.1.1 The access roads at the two project sites may be temporary or permanent. An access road is defined as temporary if it will be used only during the construction period, including site predevelopment or site capturing. If an access road will be used during the operational period as well, it is defined as permanent. A 100 km roadway provides access from the Mine Site to the Milne Port (Tote Road), the design criteria for which is included in a separate document. In addition, there is a mine haul road along with internal site roads at the Mine Site, and internal site roads only within the Milne Port, in order to accomodate the mining operations.

6.1.2 The design and construction of mine haul roads, access and internal site roads at the project sites shall provide a safe environment for construction, operations and maintenance personnel, and shall facilitate the mining operations, ore transport and port operations in an efficient manner. In addition, the design shall comply with the relevant standards, guidelines, acts, approvals, permits, and other contractual environmental requirements of Baffinland as defined in Section 2 of this document.

6.2 Road Category

6.2.1 For the purposes of this design criteria, the roads are classified in three categories:

- **Mine Haul Roads -** The purpose of this type of road is for the mining operation at the mine site - hauling of ore from the open pit to the crusher pad and for maintenance purposes, from the crusher pad to the maintenance building. The mine haul road shall be segregated from the other project roads for safety considerations, and shall comply with the applicable Nunavut MHSA.
- **Permanent Access and Internal Site Roads –** These roads provide two way access to and link the various facilities/areas within each site, where B-Trains will travel in both directions.
- **Facility Service Roads –** These roads provide two way access to various facilities/areas within each site, where light vehicles will travel in both directions.
- **Tote Road –** 100 km road providing access from the Mine Site to the Milne Port.

6.3 Design Vehicle

6.3.1 The following design vehicles shall be utilized for the design of the associated project roadways:

- CAT 777G Haul Truck for the Mine Haul Road.
- B-Train (12 axle) for Permanent Access Roads and Internal Plant Roads (150 metric tonnes payload) that need to be utilized by the Tote Road trucks. 1
- CAT 740B for Waste Rock Drainage Pond/Berm. 1
- Other types of design vehicles have been used for the remainder of the Project roadways and a fire truck has been considered as the minimum design vehicle for fire access routes. 1

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6.4 Geometric Design Criteria

6.4.1 All roads shall be designed as gravel roads and shall accommodate the design vehicle specified in Section 6.3 of this document. The roads' geometric design parameters are specified below.

Table 6-1: Geometric Design Criteria

Road Type	Permanent Internal Plant Road	Infrastructure Facility Service Road	Haul Road – Open Pit to Crusher Pad	Waste Rock Dump Road	Haul Road Switchback	Truck Escape Ramps
Number of Lanes	2	2	2	1	2	1
Design Speed (km/h)	30	30	50	30	30	90
Posted Speed (km/h)	20	20	40	20	20	-
Total Road Width (m)	9.2	8 or 6	20	13	20	9
Minimum Horizontal Curve C/L Radius (m)	35	35	100	50	35	280
Minimum Intersection Inner Radius (m)	15	15	30	30	30	-
Minimum Cross Slope (%)	2	2	3	3	3	3
Maximum Grade (%)	10	10	10	10	8	20
Minimum K Value (Vertical Sag Curve)	8	8	12	8	8	3
Minimum K Value (Vertical Crest Curve)	4	4	16	4	4	-
Maximum Super-elevation (%)	4	4	4	4	4	6
Minimum Vertical Clearance	7	5	9	9	9	-

Notes:
1. The road design parameters are based on the desirable design speeds. Specific parameters such as the minimum turn radii may be modified for some areas locally on a case-by-case basis, via adjustment of the design speeds.
2. The Haul Road width shall be based on the Nunavut Mine Health and Safety Act which requires a minimum travel width three times the width of the widest haulage vehicle for dual lane traffic and two times the width of the widest haulage vehicle for single lane traffic.
3. Shoulder barriers (safety berms or guardrails) for the Haul Road shall be based on the Nunavut Mine Health and Safety Act which requires shoulder barriers of at least ¾ the height of the largest tire of any vehicle using the road and shall be provided along the edge of the haul road wherever a drop-off greater than 3.0m exists. For CAT 777G, the shoulder barrier (safety berm or guardrail) height shall be 2.0 m based on standard tire 27.00 R49 (E4).
4. Total road width includes shoulder width and snow allowance but doesn't include the safety berm width for the haul road.
5. ~~For the single lane Haul Road from the crusher pad to the maintenance building, pullouts shall be provided at every 100m.~~
6. Widening shall be provided in roadway curves as necessary.
7. Need for geotextiles or geogrids shall be considered on a case-specific basis.
8. For the Tote Road design criteria, refer to H349000-3100-10-122-0001.
9. Provide safety stations, emergency ramps or escape lanes in accordance with the local and mine safety requirements. Hatch will only provide two escape ramps at the most critical locations as per BIM's instruction. Escape ramp design shall be carried out as per the USBM manual.
10. For cut/fill heights of greater than 5 m, provide 1.5 m wide benching with minimum 2% cross slope at every 5 m.
11. The ramp leading down to the sea lift from the laydown area at the Milne Port shall have a maximum grade of 8%.
12. The maximum grade for ramps to the buildings is 6%.
13. Fill toe key shall be provided in areas where the existing ground is steeper than 3H:1V away from the road.
14. Design speeds may be reduced locally if needed.

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6.4.2 The following general rules shall apply to the geometric design of the project roads:

- Roadway grades shall not exceed the maximum grades specified in Table 6-1, except for short ramps which shall be considered on a case-specific basis.
- Signage shall be provided for speed and caution at steep horizontal and/or vertical curves, and where the design criteria can't be met.
- Light poles, traffic signs and shoulder barriers (safety berms or guardrails), shall be placed at the outer edges of the roads, as required.

6.5 Pavement Design

6.5.1 The design of pavement structures requires information such as the expected pavement service life, design vehicle traffic volume, loads, and geotechnical information such as soil type and California Bearing Ratio (CBR).

6.6 Pavement Thickness

6.6.1 For the project internal site roads, the subgrades shall be prepared via cut/fill activities prior to pavement installation/placement. If the height of the subgrade fill is less than 600 mm, Type 8 (150 mm minus) material shall be used. If the height of the subgrade fill is greater than 600 mm, Type 12 Run-of-Quarry and/or suitable earth fill material shall be used. The voids of each layer of Type 12 material shall be filled with rock fragments prior to placement of the next layer. 1

6.6.2 The following minimum internal site road pavement thicknesses shall be used throughout the project:

- 300 mm, Type 8 (150 mm minus) subbase.
- 100 mm, Type 5 (32 mm minus) base/surface course for low speed light vehicle traffic roads and low speed B-Train traffic roads. 1
- 200 mm, Type 5 (32 mm minus) base/surface course for medium to high speed B-Train traffic roads. 1

6.6.3 The following minimum haul road pavement thicknesses shall be used throughout the project:

- 300 mm, Type 8 (150 mm minus) subbase.
- 300 mm, Type 8 (150 mm minus) base.
- 200 mm, Type 5 (32 mm minus) base/surface course. 1
- ~~900 mm, Type 12 Run-of-Mine structural subgrade (varies depending on the actual site conditions).~~ 1

6.6.4 The ramp and earthworks pad leading down to the sea lift from the laydown area, including the designated turnaround area at the beach within the Milne Port shall contain the following pavement thickness:

- 300 mm, Type 8 (150 mm minus) subbase.
- 200 mm, Type 5 (32 mm minus) base/surface course. 1
- ~~100 mm Type 3 (19 mm minus) wearing course.~~ 1

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6.6.5 Pavement Service Life

6.6.5.1 The service life of the site pavements, prior to any structural rehabilitation work being required, shall be 5 years, unless noted otherwise for specific items.

6.6.6 Design Vehicles, Traffic Volume and Load

6.6.6.1 Vehicle types have been selected for the project roads based on the expected usage and transportation requirements of the area (Section 6.3).

6.6.6.2 All pavement, slabs, bridges, trenches, trench covers and underground installations accessible to trucks shall be designed to withstand the load associated with an HS 20-44 wheel load or its equivalent, as defined by the American Association of State Highway and Transportation Officials (AASHTO) under Standard Specification for highway bridges. However, within areas of special equipment operation, this shall be considered as per the actual vehicle loading.

6.7 Parking

6.7.1 Parking areas shall be designed to accommodate their intended use. In general, all parking areas shall be surfaced with granular materials.

6.7.2 Vehicle parking area design shall adhere to the following:

- The area shall be graded to direct stormwater away from the parking. 1
- Alignment and gradients shall be coordinated with the grading plans to control drainage.
- Walking distance from parking areas shall be kept to a minimum.
- Barrier-free parking spaces as well as walkways shall be provided according to the applicable regulations.
- Designated turnaround areas shall be provided at dead ends.
- Parking lot design criteria shall be as shown in Table 6-2.

Table 6-2: Parking Lot Design Criteria

Topic	Criteria
Gradient	Maximum 5% Minimum 0.5% Optimum 2%
Cross Slope	Maximum 5% Minimum 2% Optimum 3%
Pavement Structure	300 mm Type 8 (150 mm minus) subbase 100 mm Type 5 (32 mm minus) base/wearing surface course 1 ~~50mm wearing course~~ 1
Parking Stall Dimensions	Driving Lane • Width 7.5 m Standard

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Topic	Criteria
	• Depth 6 m • Width 2.75 m Barrier-free • Depth 6 m • Width 3.5 m • Access Aisle Width 1.5 m

6.8 Signage

6.8.1 Traffic control signs and road edge markers shall be provided as required to ensure safe movement in and about the site.

6.8.2 Direction and information signs for both vehicle and pedestrian traffic shall be provided for parking areas, restricted areas, shipping and receiving.

6.8.3 Primary identification signs shall be free-standing and sited according to the applicable standards as listed in Section 4.3.

6.8.4 Other signs shall be free-standing, fence-mounted or wall-mounted.

6.8.5 Security signs shall be provided at the sites and along the site property boundaries.

6.8.6 Signs for the site access roads shall be compliant with the local traffic regulations.

6.8.7 Signs shall be lighted, if deemed necessary.

6.8.8 All signs and pavement markings (if applicable) shall be well maintained during the construction and operational periods.

6.9 Bollards

6.9.1 Bollards, if required, shall be provided at building entrances and around hazardous areas such as tanks and transformers. Bollards shall be 1.2 m high, 150 mm diameter schedule 40 CS pipes. 1

6.9.2 Bollards shall be filled with concrete.

6.9.3 Bollards shall be painted and coated such that they provide clear reflection off of vehicle headlights.

6.10 Shoulder Barriers (Safety Berms/Guardrails)

6.10.1 Shoulder barriers (earth safety berms or guardrails) shall be provided where a 3.0 m or more drop-off exists at the edge of roads. 1

~~6.10.2~~ ~~Shoulder barriers shall be installed where the horizontal distance from the edge of a travelled lane to an obstruction is less than 1.0 m~~ 1

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6.10.3 Earth/safety berms for the Mine Haul Road from the open pit to the crusher pad and from the crusher pad to the maintenance building shall have heights of 2.0 m, and side slopes of 1H:1V. 1

6.10.4 Safety berms for the internal roads shall have heights of 1.0 m and side slopes of 1H:1V. 1

6.10.5 Discontinuous openings shall be provided in berms at maximum 25 m spacing for drainage and snow clearance, with openings smaller than half the blade width of vehicles constructing or maintaining the berms. 1

6.10.6 Runaway vehicle collision berms or escape lanes shall be provided in accordance with industry requirements as described in the Nunavut MHSA.

6.11 Utility Berms

6.11.1 Utility Berms shall travel along the project roadways to the greatest extent possible, shall be of trapezoidal cross-sections, shall be minimum 0.6 m high from the road edge or the existing ground, and shall have maximum fill side slopes of 1.5H:1V, as validated by the geotechnical engineer. They shall be constructed with the use of 300 mm of granular Type 8 (150 mm minus) and 100 mm of granular Type 5 (32 mm minus) material. If the height of the subgrade fill is less than 600 mm, Type 8 (150 mm minus) fill shall be used. If the height of the subgrade fill is greater than 600 mm, Type 12 Run-of-Quarry and/or suitable earth fill material shall be used. The voids of each layer of Type 12 material shall be filled prior to placement of the next layer. The top width of utility berms will depend on the pipe and cable duct sizes. Utility berms shall cross roadway intersections through utility sleeves. After crossing the intersections, they shall resume the alignments within the utility berms. 1

7. Stormwater Management System

7.1 Internal Surface Drainage

7.1.1 The general criteria for the site internal stormwater management system are described below.

- All interior site grading and roads shall be designed to provide continuous overland flow without erosion to a drainage ditch system.
- All drainage ditches should be of trapezoidal cross sections, where possible. 1
- Ditches shall be designed to convey a 1 in 25 year flood event.
- Provision must be made to ensure that there is a safe flow path for events up to the 1 in 100 year event, such that the runoff will not flood key mining areas, cause significant erosion, pick up excessive contaminants or cause other significant problems.
- Ditch freeboard, minimum depth, minimum width, side slope, longitudinal slope and maximum permissible velocities shall be as per Table 7-2.
- Minimum set back distance of structures from top of drainage ditch slopes shall be 3 m.
- Roof and yard drainage shall be collected in open ditches.

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- Rip rap shall be provided at locations throughout the storm drainage system which are susceptible to erosion, including ditch sections subject to high-velocities (greater than 1.5 m/s), sections of super critical flow, ditch outlets, storm sewers outfalls, and culverts inlets and outlets.
- If the ditch is in rock, no rip rap is required.
- Energy dissipaters shall be used where the flow velocities may reach values high enough to cause severe erosion or hydraulic jumps.

7.2 External Surface Drainage

Criteria for drainage of the external area are as follow:

- Runoff from undisturbed areas surrounding the mine site shall be collected in perimeter ditches and diverted around and/or through the site perimeter.
- To the extent possible, these perimeter ditches shall be designed to discharge at locations that best retain the characteristics of the existing (i.e. pre-development) natural drainage patterns.
- Diversion ditches shall be designed to convey the 1 in 100 year flood event.
- Ditch freeboard, minimum depth, minimum width, side slope, longitudinal slope and maximum permissible velocities shall be as per Table 7-2.

7.2.1 Peak Flow Estimation

- **For catchment areas greater than 0.5 km^2:** 1

Runoff peak flow estimation shall be based on the following equations developed by Knight Piésold Consulting:

$Q_2 = 1.1\ A^{0.79}$

$Q_5 = 1.7\ A^{0.77}$

$Q_{10} = 2.0\ A^{0.76}$

$Q_{25} = 2.6\ A^{0.75}$

$Q_{100} = 3.5\ A^{0.73}$

$Q_{200} = 3.9\ A^{0.73}$

Where:

Q=peak flow instantaneous flow in m^3/s

A = drainage area in km^2 (0.5 km^2 $\leq$ A $\leq$ 1000 km^2)

- **For catchment areas less than 0.5 km^2:** 1

The Rational Method shall be used for peak flow estimation, as follows:

Q = 0.28 CIA

Where:

Q = peak instantaneous flow in m^3/s

A = drainage area in km^2

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C = runoff coefficient = 0.90 (for all drainage areas except the Milne Port Ore Stockpile footprint, for which C = 0.0, as per BIM's instructions). 1

I = rainfall intensity corresponding to the time of concentration (mm/hr), estimated using Table 7-1 below.

- Time of Concentration shall be computed with the modified Kirpich equation:

$T_c = 0.06628 (L^{0.77}/S^{0.385})$

Where:

T_c = time of concentration (hours)

L = main channel length (km)

S = main channel slope (m/m)

Minimum T_c = 10 min

7.3 Rainfall Intensity

7.3.1 Table 7-1 displays the Intensity-Duration-Frequency data which shall be used for peak flow runoff approximation, developed by Knight Piesold consulting:

Table 7-1: Rainfall Intensity (mm/h)

Duration	2 yrs	5 yrs	10 yrs	15 yrs	20 yrs	25 yrs	50 yrs	100 yrs	200 yrs
5 min	9.5	12.0	14.0	15.1	15.9	16.5	18.3	20.1	22.0
10 min	7.2	9.0	10.5	11.3	11.9	12.4	13.7	15.1	16.5
15 min	6.0	7.5	8.7	9.4	9.9	10.3	11.4	12.6	13.7
30 min	5.0	6.3	7.3	7.9	8.3	8.6	9.5	10.5	11.4
1 hr	4.0	5.2	6.1	6.6	7.0	7.3	8.1	9.0	9.9
2 hr	3.0	3.9	4.6	5.0	5.2	5.5	6.1	6.8	7.4
6 hr	2.0	2.7	3.3	3.6	3.9	4.0	4.6	5.1	5.7
12 hr	1.3	1.8	2.2	2.4	2.6	2.7	3.1	3.4	3.8
24 hr	1.0	1.4	1.7	1.9	2.0	2.1	2.4	2.7	3.0

7.3.2 Figure 7-1 displays the 200 year design storm distribution:

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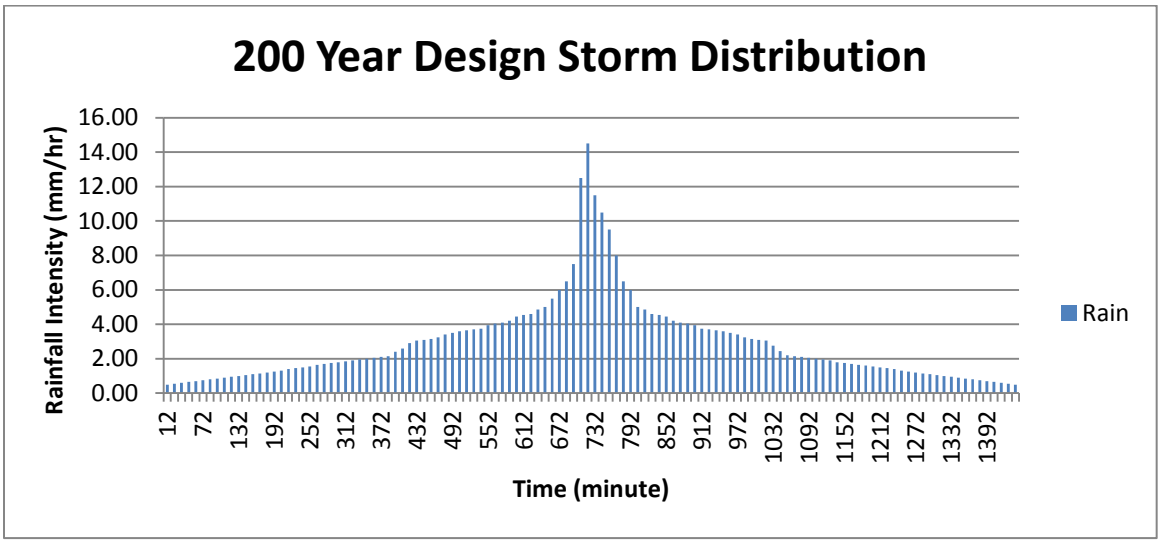

Figure 7-1: 200 Year Storm Distribution

7.3.3 The 200 year 24-hour balanced storm depth is 71 mm.

7.4 Sedimentation Ponds

7.4.1 Sedimentation ponds shall only be provided at the Milne Port Ore Stockpile area, Mine Site Crushing and Screening area and the Mine Site Waste Rock Drainage area. For all other areas, including infrastructure facility pads, laydown areas and roads, the water is considered to be clean and no sedimentation ponds shall be provided. 1

7.4.2 The general design criteria for the project sedimentation ponds are as follow:

- Ponds shall be sized based on 1 in 10 year, 24 hour design storm volumes. 1
- Runoff coefficient to estimate runoff shall be 0.9 for all drainage areas except the Milne Port Ore Stockpile footprint, for which the runoff coefficient shall be 0.0 as per BIM's instructions. 1
- Sedimentation shall be for Total Suspended Solids (TSS) ≤ 30 mg/l for a single sample and TSS ≤ 15 mg/l for the monthly average.
- Sedimentation ponds shall contain emergency overflow weirs of sufficient capacity to safely convey a 1 in 200 year return period storm event or the Probable Maximum Flood (PMF), maximum wind-induced waves, or unexpected operational difficulties. 1
- Emergency overflow weirs shall be designed to handle applicable design storms, such that the pond high water level does not increase past the set freeboard elevation. 1
- Emergency overflow weirs shall be designed as broad-crested weirs with rip rap. 1
- Gabion mattresses shall be provided at the downstream locations of emergency overflow weirs as energy dissipation measures to protect against erosion. 1
- The following broad-crested weir capacity flow equation shall be used for sizing the Project emergency overflow weirs:

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$Q = CLH^{3/2}$ Where:

Q = Peak instantaneous flow (m^3/s)

C = Weir discharge coefficient

L = Width of weir (m)

H = Depth of flow (m), measured 2.5H upstream of the weir discharge point

- Deep sedimentation ponds shall be avoided as much as possible. Sedimentation pond depths shall be kept to less than 5 m, to avoid non-compliant TSS removal/efficiency and other safety concerns.
- Berm/embankment side slopes for the ponds shall be 3H:1V.
- Mine Site Ore Crushing and Screening and Waste Rock Drainage sedimentation ponds shall be lined and the discharge from the ponds shall be controlled.
- Milne Port Ore Stockpile pond(s) can be lined/unlined and depending on its impact to the environment and permafrost as well as geotechnical stability, the discharge from the pond(s) can be controlled/uncontrolled.
- Ponds with storage volumes greater than 30,000 m3 and heights exceeding 2.5 m shall be classified as dams and shall meet the dam safety requirements as per the Canadian Dam Association's Dam Safety Guidelines (CDA 2007).

7.5 Off-Spec and Treated Effluent Ponds

7.5.1 The off-spec effluent pond at the Milne Port shall be sized based on the storage requirements specified in the event that the sewage treatment plant does not meet effluent discharge criteria and/or the system halts operations due to technical difficulties.

7.5.2 The treated effluent pond at the Mine Site shall be sized based on the requirements for 10 months storage of treated sewage generated at the Mine Site during the period in which the body of water receiving the discharge (i.e. Mary River) is frozen.

7.5.3 The ponds shall have minimum freeboards of 0.3 m.

7.5.4 The ponds shall have side slopes of not steeper than 3H:1V.

7.5.5 The effluent ponds shall be lined.

7.6 Culverts and Roadside Ditches

7.6.1 Drainage ditches and culverts for all internal/access roadways and vehicle access points shall be designed to convey the runoff peak flow from a 1 in 25 year return period storm, such that the inlet headwater level does not exceed the bottom of the road subbase. Their analysis and design shall consider design flow, culvert size and material, entrance structure layout, outlet structure layout and erosion protection.

7.6.2 Drainage ditch design shall also be subject to the criteria stated in Table 7-2.

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Table 7-2: Drainage Ditch and Culvert Design Criteria

Maximum permissible flow velocity in ditch without rip rap (m/s)		1.5
Minimum ditch and culvert slope (%)		0.3
Minimum freeboard for ditch (mm)		300
Minimum ditch depth for internal roads and other areas (mm)		300
Minimum ditch bottom width for internal roads and other areas (mm)		500
Minimum rock ditch depth for haul road (mm)		500
Minimum ditch bottom width for haul road (mm)		1000
Ditch side slopes (H:V)	Rock	1:4
	Soil	2:1
Minimum culvert diameter (mm)		500

~~7.6.3~~ ~~All culverts shall have 50 mm diameter steam pipes welded at the top inner sides for prevention of water from freezing.~~

7.6.4 Loading over culverts and pipes shall be in accordance with AASHTO HS 20-44, except for areas of special equipment operation, which shall consider actual vehicle loading. The minimum cover for culverts shall be 600 mm, or as required by the differing specific design vehicle.

7.6.5 Fish-bearing culverts shall be minimum 1,000 mm diameter and only one pipe shall be embedded by 10% of the pipe diameter.

7.6.6 All culverts shall be Corrugated Steel Pipe (CSP).

7.6.7 Apply Manning's n values as per the following:

- n = 0.025 for gravel ditches
- n = 0.040 for rip rap ditches
- n = 0.024 for all CSP pipe.

7.7 Drainage Interceptor/Collector Berms

7.7.1 Drainage berms diverting overland flow from the waste rock drainage area to the sedimentation ponds shall be a minimum of 1.0 m high with 1.5H:1V side slopes and 0.5 m top width.

7.7.2 Rip rap and other energy dissipation measures shall be provided to protect against erosion.

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ATTACHMENT 5.2

RAIL DESIGN CRITERIA

Mary River Expansion Project

Railway Design Criteria and Design Rational

2017-11-28	0	Approved for Use	A. Aquil	F. van Biljon	F. van Biljon	F. Pittman
Date	**Rev.**	**Status**	**Prepared By**	**Checked By**	**Approved By**	**Approved By**
			HATCH			**Client**

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1. General

1.1 Introduction

1.1.1 This revised document incorporates the adjustments made to the rail and embankment designs subsequent to the value improvement processes (VIP) workshop conducted on the outcomes of the initial pre-feasibility capital requirements for the project and should be read with document H352034-300-200-210-0001 – Rev. 0 as initial baseline for design.

1.1.2 It outlines the adjusted Design Criteria that govern the design for the Railway between the Iron Ore Mine at Mary River and Milne Port to the North and inclusive of the loading, discharging and maintenance facilities and rail infrastructure at each end. This project is specifically associated with the optimization of the Expansion Study – Stage II rail studies for Baffinland Expansion 12 million tonnes per annum (Mtpa) Mine Option.

1.1.3 The design codes and standards referenced in this document, engineering and other work done on the Steensby Project, the Tote Road, the Concept Scoping Studies for the rail line to Milne Port and the twice a day optimization progress calls with BIM, subsequent to the pre-feasibility VIP workshop, guided the optimization measures for the railway system's capital requirements.

1.2 Jurisdictional Authority

1.2.1 The railway will be operated and maintained by Baffinland Iron Mines (BIM) during the life of the mine as a private, dedicated railway system.

1.3 Project Scope Definition

1.3.1 The Mary River Expansion Study – Stage II Phase has been planned as a means to further develop the Mary River deposit and in an effort to curb high operating cost of the Tote road operation.

1.3.2 The adjusted aligned 110 km standard gauge rail line and railway system will be designed to allow year round railing of iron ore from Mary River Mine to Milne Port using the rolling stock and support equipment that will be able to remain functional in these extreme conditions in a sustainable manner.

1.3.3 Due to the unknowns regarding train operations in extreme weather for the site, provision has been made for the loss of 21 operating days per calendar year in designing train plans and operating plans and considering capacity issues.

1.4 Project Objectives

1.4.1 The objective of the project is to provide a reliable, all-season transport system to move 12 million tonnes per annum (Mtpa) of iron ore from the Mary River mine site to Milne Port, considering potential upgrades in future to exploit the full potential of the mine and the logistics chain. In an effort to optimize the capital requirements, the transport system will initially not make provision for the transportation of fuel, supplies, equipment and waste.

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1.5 Project Language

1.5.1 The project language will be Canadian English.

1.6 Rail Classification

1.6.1 The railway system is classified as a standard gauge heavy haul system for permitting purposes, although other traffic might be operated on the line in future, the traffic allowed for in this optimized Mary River Expansion Study – Stage II, will be iron ore operating unit trains.

1.7 Design Context

1.7.1 The Rail Design Criteria will be based in general on AREMA but also following a “best practices” approach based on the Consultant’s experience in rail design to incorporate other applicable codes and practises as well as on instruction from the client, BIM and their officials, inside the best practise approach for safe and optimized rail system operations. Section 2 to follow provides a representation of the codes, standards and practises consulted and applied in the design process.

1.8 Scope

1.8.1 The criteria in this document apply to the civil engineering and operational design of the railway system between Mary River Mine and Milne Port including all relevant and related infrastructure, equipment and facilities at the end points and potentially on route.

1.8.2 It includes an occupancy control system and the existing telecommunications back bone. The Tote road is supported by full coverage communications by microwave towers as back bone and repeaters along the road for full coverage. The Mary River Expansion Study – Stage II will need to assess if more repeaters are required for the rail route deviations, considering fiber optic connections between towers and repeaters as enhancement of the backbone, especially deviation 8 around km 67 hill, to support full rail coverage for crew to control room communications and uninterrupted support for the radio distributed power (RDP) for the locomotives on the ore unit trains.

1.9 Safety

1.9.1 The consideration of personnel safety in all stages of the design, construction and operation is paramount. Prime consideration will be given to safety and reliability to:

- Maximize health and safety for all personnel using the railway system and other systems adjoining and running in parallel to the railway system.
- Minimize environmental impacts during the design process to assist in construction and operation.
- Maximize the security of equipment.
- Maximize continuity and sustainability of service (i.e. minimize time any element in the rail system is out of service).
- Special attention is required by BIM to formalize operating rules regarding the access to failed trains for inspection and repairs, as the optimized design does not allow for shoulders on the sub-ballast layer that can serve as footpath for personnel.

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- Ensuring safe layout and user rules for crossings at grade.

1.10 Units of Measure

1.10.1 The International System (SI) will be used as the project standard.

1.11 Limits of Project

1.11.1 The project limits of the rail system are from the Milne Port off-loading area and port yard facilities to Mary River Mine Site loading facilities, dead-end spur.

1.11.2 This includes construction of refuges for Hi-Rail on-track maintenance equipment, crossings and wayside condition monitoring equipment.

1.12 Assumptions and Exclusions

1.12.1 The design criteria for the standard gauge rail are based on the following assumptions:

- The primary usage of this railway is for transporting of primary crushed iron ore from the mine site loading facility to an off-loading facility above the stockyard for the crusher at Milne Port. Although other commodities will potentially be transported between the mine and port in future after further upgrades, such other usage is not considered for the optimization of the pre-feasibility design.
- The operating speed for all trains, loaded or empty, will be 60 km/h in both directions. The design speed will be 75 km/h. Operating speeds are unlikely to be adjusted upwards in future. The geometric design criteria for safe operation is based on these operational requirements and loading factors. Where these geometric design criteria cannot be met, due to site conditions imposed by impacts of permafrost, topography and cost, minimum acceptable geometric design criteria and mitigating operating rules like speed restrictions will be proposed.
- The typical heavy haul Diesel Electric Locomotives (3,280kW) that will be used on the line will have 33 tonnes axle loads (TAL), whilst the typical standard gauge gondola ore cars will have a practical capacity to carry 108 tonnes iron ore with a tare weight of 22 metric tonnes or 32.5 TAL.
- The railway will be operated and maintained by BIM as a privately owned railway system.
- The train operating plan, crew strategy and related functions are covered in Section 4.
- Rolling Stock and facilities are covered under Sections 9 and 10.

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2. References, Acronyms, Design Codes, Standards and Regulations

2.1 Unless specifically stated elsewhere, the rail will be designed in accordance with this criteria read along with applicable sections of the latest revisions of the codes, specifications and standards listed alphabetically below. If there is any conflict between this criteria and other relevant design standards, the discrepancies will be assessed and recommended to include practical best practice for the extreme weather conditions and experienced based best practice on a case by case basis.

- AASHTO - American Association of State Highway and Transportation Officials.
- ACI - American Concrete Institute.
- All applicable federal, territorial and local laws and regulations.
- AREMA - American Railway Engineering and Maintenance-of-Way Association, Manual of Recommended Practice.
- AREMA - Communications and Signals Manual of Recommended Practice.
- ASTM - American Standards for Testing and Materials.
- AWS - American Welding Society.
- CAN/CSA-S6 Canadian Highway Bridge Design Code.
- CENELEC - European Committee for Electrotechnical Standardisation, Standards for Railway Signalling.
- CSA - Canadian Standards Association.
- *Developing and Managing Transportation Infrastructure in Permafrost Regions, TAC-ATC; 2010.*
- Fisheries Act (Canada).
- FRA - Federal Railway Administration (USA).
- IEC - International Electrotechnical Commission.
- ISO - International Standards Organization.
- Northern Land Use Guidelines: Access Roads and Trails, Indian and Northern affairs Canada; Volume 5; 2010.
- Ontario MoE, Stormwater Management Planning and Design Manual, 2003. 2.1.2 In addition, the design must comply with all laws and regulations of local authorities; in the event of conflicting requirements, the most stringent will govern as confirmed with the Engineer. TSB Transportation Safety Board (Canada).
- RTC – Rail Traffic Controller (modeling software).
- UFC - Unified Facilities Criteria, Subarctic Construction.
- USACE - United States Army Corp of Engineers Mine Health and Safety Act.

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2.2 Other Regulations

2.2.1 All applicable federal, provincial and local laws and regulations apply to the Mary River Expansion Study – Stage II:

- INAC - Indian and Northern Affairs Canada.
- OSHA - Occupational Safety and Health Administration.
- OSHR - Occupational Health and Safety Regulations.
- NBCC - National Building Code of Canada.
- NFPA - National Fire Protection Association.
- CFEM - Canadian Foundation Engineering Manual.
- MNR - Ontario Ministry of Natural Resources.
- MOE - Ontario Ministry of the Environment.
- MSHA - Mine Safety and Health Administration Handbook Number PH99-I-4.

2.3 Other Project Design Criteria

2.3.1 This Design Criteria must be read in conjunction with other documents which may already exist or will be developed as the project proceeds. These documents include the following:

- Canarail: Railway Design Brief Report dated November 2011 to Baffinland Iron Mines Corporation, Steensby Project, Revised Feasibility Study.
- Hatch: Baffinland Iron Mines Corporation - Mary River Project, Optimization Study Report 28 March 2012.
- Sub-sections of design criteria and specifications, linked to these two studies as well as that of the Tote road.
- Minimum standards, like the lack of ballast shoulders or the lack of benches on high embankments, have been applied after a project optimization process was completed. So although this configuration is structurally sound it is not a conventional design approach.

2.4 Reference Documents

2.4.1 Reference will be made to the following documents when reading these criteria:

- Baffinland Rail Scoping Study.
- H353004-00000-200-078-0008, the standard specification for Site Data, dated 2016-12-14.
- NB102-00181/39-A.01, Updated Design Peak Flow Assessment, by Knight and Piésold dated, 2016-12-13.
- H352034-3000-228-030-0001, the Project Hydrology Review Memo on the assessment of the Tote road Hydrology, dated 2016-08-18.

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- H353004-00000-200-024-0001, Hydraulic Design of Drainage Structures, dated 2017-02-02
- H352034-3000-224-030-0003, Rail Tie Type Trade-off for Extreme Cold Weather Heavy Haul Operations.

3. Site Conditions

3.1 The standard gauge rail line follows the Tote road alignment between Mary River Mine and the Milne Port to a large extent with 10 pertinent deviations of which deviation 8 around/over the hill at 67 km is the most challenging due to the nature of the topography and the non-cohesive sands and sand and gravel of the undulated hills.

3.2 Site conditions are referenced from document H353004-00000-200-078-0008, the standard specification for Site Data, dated 2016-12-14.

3.3 Refer to the Site Conditions Specification for design temperatures, design wind parameters, seismic parameters, hydrology and snow load design parameters.

4. Operations

The operating requirements dictate the design parameters and criteria for the track, supporting infrastructure and systems that need to be developed inside the environmental and other constraints to support a sustainable operating model irrespective of the optimizing measures taken.

Operating conditions are extreme for equipment, infrastructure and personnel. Consensus has been reached that an initial reasonable operating plan needs to be adapted now with the view to exploit the learning curve of operations experience and the behaviour of the optimized infrastructure to consider adjustment for better efficiencies.

4.1 Traffic

4.1.1 The primary usage of this railway is for transporting of primary crushed iron ore from the mine site loading facility to an off-loading facility above the stockyard for the crusher at Milne Port. Other commodities initially considered for transportation by rail between the mine and port, will continue to be road transported over the Tote.

4.1.2 The ore trains will be unit trains dedicated to ore traffic configured to remain as a complete train-set throughout the operation cycle with at least one locomotive at each end. Trains will only be uncoupled for other than daily provisioning for planned or emergency maintenance purposes on cars or locomotives. “Not-to-go” (bad order cars) will be replaced as required, mainly port side. Train sets and locomotives need to be turned at the portside triangle on a frequency to be determined to ensure even wheel wear.

4.1.3 The railway will transport 12Mtpa of dry primary crushed iron ore equivalent to approximately 12.24Mtpa of wet iron ore (2% moisture content).

4.1.4 The mixed other traffic will be road transported over the Tote road during at least the first 5 years of operation, when further upgrading of the rail line can potentially be considered.

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4.2 Axle Load

4.2.1 The typical heavy haul Diesel Electric Locomotives (3,280 kW) that will be used on the line will have 33 tonnes axle load (TAL), whilst the ore cars to be procured will have capacity to carry 108 metric tonnes iron ore with a tare weight of 22 tonnes or 32.5 TAL. During the ramp-up phase cars can be loaded to a payload of 98 tonnes per car or 30 TAL while the track and formation settles in after which full capacity loading will be considered and authorised.

4.2.2 The system and support infrastructure will be designed for 32.5 TAL.

4.3 Speed

4.3.1 The operating speed for all trains, loaded or empty, will be 60 km/h in both directions. The design speed will be 75 km/h. The design speed has basically the purpose to calculate dynamic forces for bridge structures and other support infrastructure as well as rail superstructure on the main line.

4.3.2 Higher operating speeds are not recommended due to the very small impact faster running times will have on the total cycle time. RTC modelling indicated that a 10 minute saving on running time applies at 65 km/h relative to 60 km/h for the loaded train as an example, as the loaded train can't maintain 60 km/h or 65 km/h continuously over the whole line due to the topography and the alignment. Higher speeds increase the maintenance effort on the track exponentially, so the higher speed value trade-off is debateable, whilst terminal dwell time makes up the largest part of the cycle time in any way.

4.3.3 The geometric design criteria for safe operation is based on these operational requirements and loading factors. Where these geometric design criteria cannot be met, due to site conditions imposed by impacts of permafrost, topography and cost of earthworks, minimum acceptable geometric design criteria and mitigating operating rules like speed restrictions are proposed.

4.3.4 During the spring/summer thaw period there is a possibility that temporary speed restrictions might be imposed over sections of the line if the effects of the permafrost prove to be a concern. This will be determined by intensified track and substructure inspection and monitoring on a daily basis or even on a train by train basis where the maintenance engineer can decide to what speed the operating speed could be reduced or even to suspend operations for a determined period.

4.4 Ore Trains

4.4.1 The ore train configuration and recommendations are presented in the revised static evaluation combined with the Rail Traffic Controller (RTC) dynamic simulation report H352034-3000-200-230-0001.

4.4.2 A specific train configuration is recommended for the optimized alignment and facilities as a workable and sustainable solution. This configuration, as do all the others analyzed, requires a passing loop close to the middle of the line and a departure siding at each terminal.

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4.4.3 Operate 2 train sets of 80 cars and 2 locomotives. Required car fleet is 168 ore cars and 5 Locomotives (1 spare/exchange locomotive and 8 cars) (3,280 kW). One locomotive at each end of the train.

4.4.4 It is assumed that BIM will start off operating shorter trains during the ramp-up period to solve all operating challenges, potential distributed power test trains, crew training and to allow for ballast and formation consolidation before the full train configuration is implemented.

4.5 Design Train Length

- The train design length is 900 m (80 x 10.56 (including stretch) + 2 x 22.7).

4.6 Other Trains

4.6.1 Only ore trains are considered for the optimized rail system proposed and other trains will only be considered during potential future upgrading phases.

4.7 Passing Tracks and Tracks at Terminals

4.7.1 *Passing Loops*

4.7.1.1 The RTC modeling concluded the location of a passing loop close to the 56 km chainage, based on running times of the loaded and empty trains.

4.7.1.2 The mid-way passing loop could be fit between 55,886 km and 56,947 km, providing a clearance of 900 m, fit for maximum 80 car train length. The switches need to be installed on tangent track and not inside vertical curves.

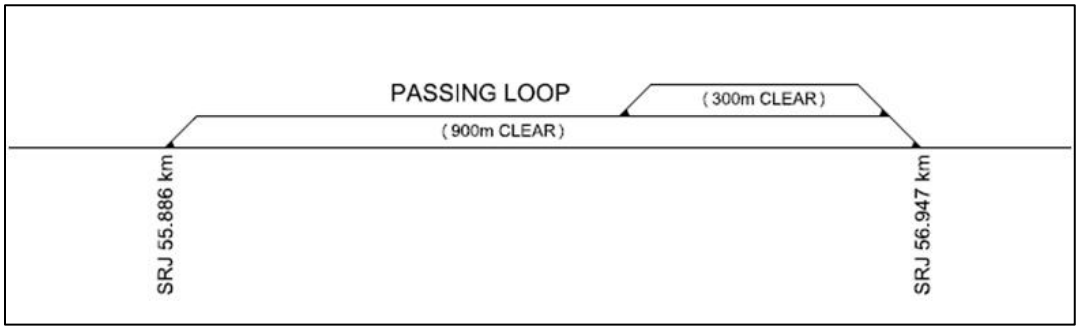

Figure 4-1: Midway Passing Loop and Backtrack

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4.7.2 *Mine Side Track Layout*

4.7.2.1 The Mine side track facilities have been rationalized and are represented in Figure 4-2 below:

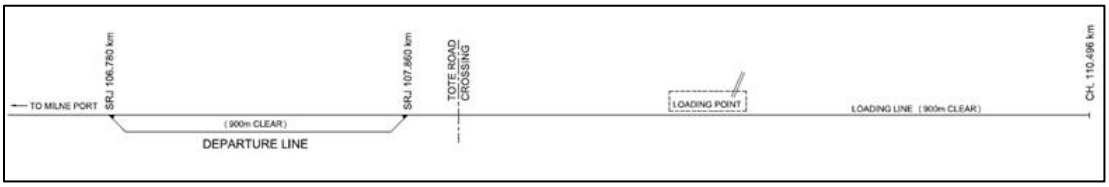

Figure 4-2: Mine Track Diagram

4.7.2.2 The mainline runs past the front-end loader loading bank into a dead-end.

4.7.2.3 A siding of 900m clearance is also required, located in the vicinity where the freight siding was recommended initially.

4.7.2.4 The loading bank operations are based on 3 front-end loaders in the Static and Dynamic analysis.

4.7.3 *Port Side Track Layout*

4.7.3.1 The port side terminal and yard layout have been optimized and is presented in Figure 4-3 below:

4.7.3.2 The mainline will run straight into the elevated area adjacent to the quarry (Q1), through the off-loading facility into a dead-end. Clearances on both sides of the dumper must allow for 900m maximum train lengths, incorporating the tippler run-around section for empty train returns. The run-around section will tie back to the mainline in front of the dumper but will also run straight into a departure siding with 900 m clearance to allow a newly arrived loaded train to position in front of the tippler with an empty train waiting in the siding for inspection before departure back to the mine and for shunting movements if bad order cars need to be exchanged etc. Daily service and provisioning will be done by mobile units to the stationary train on the departure siding in order to enable the locomotives to be provisioned while still coupled to the empty cars.

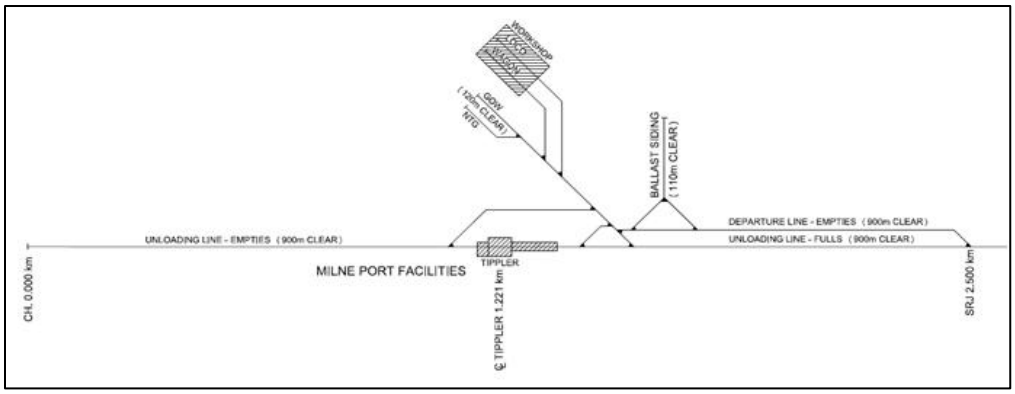

Figure 4-3: Port Side Track Diagram

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4.7.3.3 An additional gather will tie onto the departure siding with four spurs that will go into the Locomotive and car maintenance facilities, for bad-order cars and good order cars for car exchange. Space for a second potential future line adjacent to the dumper empty car spur is provided as a shunting spur that could take a full train length for shunting and operational flexibility in future.

4.7.3.4 Provision for a ballast siding into the quarry area has been allowed for with another connection back to the departures siding that could serve as a triangle for cars and locomotives to be rotated for change of direction of travel and in support of wheel wear management.

4.7.3.5 The cycle time through the port terminal, including all these activities, has the most prominent impact on the train plan.

4.8 Hi-Rail Refuges

4.8.1 Track maintenance personnel and on-track maintenance machinery, must clear the line to let trains pass to minimize train operations interference and delays.

4.8.2 All track-bound equipment use the passing loop back track or the sidings at the terminals for this purpose. However, vehicles used for regular inspection and daily light maintenance are utility vehicles equipped with road/rail functionality, or referred to as “Hi-Rail” equipment.

4.8.3 These vehicles can clear the track at any location provided with a level surface at rail level of approximately 4 m wide, typically at level-crossings or purpose made refuges.

4.8.4 The locations for such refuges or level crossings should be carefully planned with the rail operations and maintenance contractor and will typically be at not more than 10 km intervals where geometric conditions are practical and safe and can coincide with normal level crossings at grade such as the access roads or track maintenance access roads as well as the Tote Road level crossings.

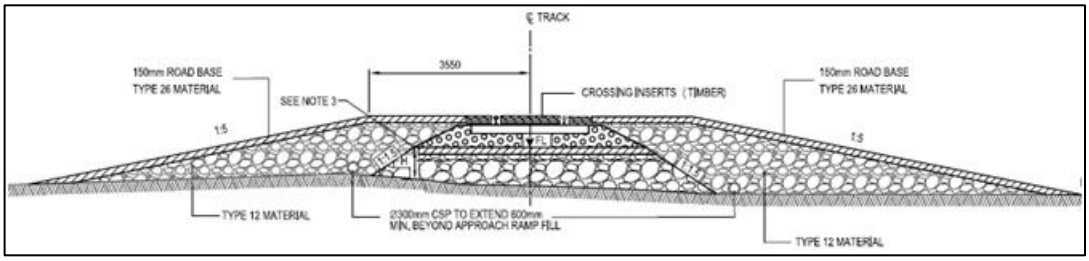

Figure 4-4: Typical Arrangement for Level Crossing

5. Rail Alignment

5.1 General

5.1.1 The design criteria relevant to the rail alignment has been based on design criteria related to heavy haul railway operations and support infrastructure.

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5.1.2 The basic objective is to have the gradients as flat as possible and the radii as large as possible. In some locations this is not possible due to the topography and the geotechnical considerations.

5.1.3 The emphasis for the optimizing actions was on an alignment that promotes operational safety and low maintenance, applying minimum design standards for optimizing purposes. The design speed is 75 km/h for both loaded and unloaded trains and the operating speed is 60 km/h. The commonly used design standard for North America heavy haul industrial track design and upgrades forms the basis of the design standards followed, unless alternative standards are specifically referenced.

5.2 Horizontal Alignment

5.2.1 The rail will predominantly be on an embankment of Type 12 rock fill between 700 mm and 1500 mm thick, above the natural ground level (NGL), measured on the high end of the cross fall under the ballast toe. The 1500 mm thick section had been designed for ice rich soil sections on the alignment.

5.2.2 Unevenness or cross fall in the NGL will be smoothed out with more run of quarry backfill Type 12 of varying thickness.

5.2.3 There will be no benches between topside of the embankment to the toe of the rock fill. There is no shoulder on the sub ballast layer and the ballast shoulder will vary from 300 mm to 600 mm depending on the curve radius for lateral support for the continuously welded track on steel ties.

5.2.4 On these curves where the outside leg of the track gets super elevated the top of formation or top of sub-ballast is widened from the standard 2624 mm to accommodate the wider ballast shoulder as well as the effect of the super elevation.

5.2.5 *Tote Road Interface*

5.2.5.1 Road accidents on the Tote Road should be prevented from having an impact on rail operations and vice versa.

5.2.5.2 For the optimized preliminary design the rail centerline will be off-set at 15 m from the Tote road centerline where the track and the road are at the same grade. Where the track embankment height increases or where the track is lower than the road, each case should be evaluated on its merits to determine the off-set of the embankment toes or cut-line of cuttings to maintain a safety barrier in which safety measures can be installed to keep impact between the two modes isolated.

5.2.5.3 For each locations where the rail alignment interferes with the existing road alignment, more detailed analysis need to be performed to determine whether the rail alignment can be adjusted or whether the road will have to be diverted.

5.2.6 *Curve Radius*

5.2.6.1 The approach for a heavy haul line, or any rail line for that matter, is to install the largest radii possible while still balancing the required earthworks and other design and cost parameters.

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Large curves (or straight track) are better for rail/wheel interaction than small radii curves and therefore better for maintenance purposes.

5.2.6.2 The design brief from BIM for the Mary River Expansion Study – Stage II phase railway, was initially that the horizontal alignment should stay alongside the Tote road and as far as possible inside the previously demarcated areas in which the development was scoped for permitting purposes. This brief was still respected during the optimization efforts except for locations where rock is present for cut to fill and where obvious geometric optimizing opportunities can be exploited.

5.2.6.3 The approach is therefore to design for a nominal radius of 500 m as the rule and an absolute minimum of 230 m as an exception for horizontal curves. (60 km/h speed restriction will apply to curves with radii of 230 m, coinciding with the operating speed). The RTC simulation model outputs will be analysed to consider the speed profile and energy consumption in order to adjust the alignment to exploit further optimization opportunities during the Expansion Study – Stage II phase.

5.2.7 *Spiral Curves (Transitioned Curves)*

5.2.7.1 Spiral lengths of horizontal curves (transition curves from tangent track to circular track) are calculated for each radii according to the AREMA manual for spirals and a design speed of 75 km/h, as follows:

Spiral Length (m)	Curve Radii Range (m)
300	230 to 249
270	250 to 274
240	275 to 299
210	300 to 399
180	400 to 424
150	425 to 549
120	550 to 699

5.2.7.2 In areas with difficult topographical challenges and constraints AREMA allows spiral lengths to be compromised to the following:

Spiral Length(m)	Curve Radii Range(m)
150	230 to 274
120	275 to 324
90	325 to 474
60	475 to 949
30	>950

5.2.7.3 These spirals are normally staked in 30 m stations for construction purposes, hence the lengths of multiples of 30.

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5.2.7.4 As AREMA bases these calculations amongst others on “passenger comfort” it was already recommended for the pre-feasibility design to follow the adaption of constant transitional curve lengths according to the South African standard for heavy haul rail lines analyzed and proven to be effective over many years for track maintenance and rolling stock behavior purposes. This approach is applied for the optimizing efforts for the rail alignment.

- Spiral Length = 60 m for curve radius R ≤ 300 m.
- Spiral Length = 80 m for curve radius R > 300 m.

5.2.7.5 These spirals are staked in 20 m stations for construction purposes in preparing and shaping the sub-grade, formation and track.

5.2.8 *Minimal Tangent Length*

5.2.8.1 Minimum tangent track between spirals of reverse curves is 20 m in order for the bogies of one car to settle and to prevent them from being on cant applied in opposite grades. Transition curves can be butted in compounded and circular curves on running lines.

5.2.8.2 No spirals are required in yard track.

5.2.8.3 Apply the full applicable super elevation (cant) over the length of the spirals on both ends of the circular curve in order to have the full and constant cant on the circular section of the curve. Cant will be applied for 60 km/h operating speed and less cant based on the actual speed profile, for curves where the train goes slower due to gradients or speed restrictions.

5.3 Vertical Alignment

5.3.1 *Curve Lengths*

5.3.1.1 Vertical curvature will be applied between different grades at a rate of change not more than 0.040m/20m/20m (K=100).

5.3.1.2 Vertical curves are to be avoided in horizontal curves, however if it cannot be avoided and any other design criteria is compromised, vertical curves can be fitted to the circular sections of horizontal curves.

5.3.2 *Ruling Gradient*

5.3.2.1 A ruling grade of 1.5% (1 to 66.7 – 1:66.7) facing loaded ore trains will be designed for. Grades on curves must be compensated to allow for an equivalent lesser gradient in curves.

5.3.2.2 Exceptional Grades: A ruling grade of 3.0% (1:33) facing empty ore trains or loaded general freight- and mixed trains (Fuel, material and equipment) will be designed for as an absolute maximum and as an exception, for grades on inclines/declines less than an ore train length. Grades on curves will be compensated to allow for an equivalent lesser gradient in curves.

5.3.2.3 Exceptional Grades occur at only 3 locations over the entire 110 km mainline or approximately 3 km out of 110 km. The steepest grade in 2 of these locations is compensated to 1:35 due to the horizontal curves of radius 700 m in these same sections.

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5.3.2.4 A ruling grade of 2% (1:50) facing empty ore trains or loaded general freight- and mixed trains (Fuel, material and equipment) will be designed for, for grades on inclines/declines more than an ore train length. Where the fill requirements can be enhanced and where the preceding grade is not steeper than 1% (1:100) a grade of 2.2% (1:45) will be allowed for sections longer than an ore train as an absolute maximum.

5.3.2.5 Grades on curves must be compensated to allow for an equivalent lesser gradient in curves in order to compensate for the higher rolling resistance of rail/wheel interaction through curves in relation to the radius of any specific curve.

5.3.2.6 The relatively steep gradients are necessary to adjust to the very challenging topography in the relevant corridor footprint and an effort to minimize the need for extensive excavations in the extreme permafrost conditions of Baffin Island and also to prevent extensive new permitting applications and environmental impact.

5.3.2.7 These gradients fall outside the relevant “range” of gradients normally associated with heavy haul rail operations (refer to Project Benchmarking Memo H352034-3000-224-030-0001), but has been thoroughly analyzed with our in-house traction and adhesion tools to prove sustainability with the optimized alignment as base. Further compromise of gradients to optimize earthworks is not recommended.

5.3.2.8 Allow in general one vertical grade direction change over one ore train length of track and as an exception 2 grade direction changes over one ore train length of track in places where the other vertical- and civil design criteria will be compromised if this exception is not allowed for.

5.3.2.9 The train design length of 900m now makes provision for the maximum number of 80 cars per train with 2 locomotives on RDP.

5.3.2.10 The optimized design based on the pre-feasibility design length of 775 m has not been compromised, as the grade changes per grade allowed also accommodates the 900 m design length.

5.3.2.11 Gradients in other locations:

- Gradients in passing tracks: 0-0.25%.
- Gradients in yard tracks: 0-0.125%.
- Unloading facilities: 0-0.1%.
- Loading facilities and attended trains: 0 – 0.25%

5.3.3 *Grade Compensation*

5.3.3.1 The measure of elevation for a ruling grade (1:X) = (20/X)m per 20 m of track; the reduction in elevation for a curve of radius (R) and a ruling grade (1:X) = (14/R)m/20m; so the measure of elevation for compensated ruling grade = ((20/X)-(14/R))m/20m.
Therefore compensated equivalent ruling grade in such a curve = 1: 20/((20/X)-(14/R)).

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6. Geotechnical Recommendation and Earthworks

Report number H352034-3000-229-230-0001, a summary of the preliminary geotechnical recommendations for the railway embankment design, based on the existing Tote Road geotechnical investigation data, as part of the Mary River Expansion Study – Stage II, served as basis for the preliminary earthworks design criteria for the purpose of the estimation of earthworks quantities for the Mary River Expansion Study – Stage II. These recommendations had been revised for the optimizing exercise subsequent to another site assessment by Hatch that coincided with the VIP workshop. Further optimization and detailing can be considered for the feasibility study as geotechnical drilling and testing are currently conducted on the optimized alignment footprint.

The following paragraphs provide a record of optimizing decisions related to the earthworks.

6.1 Geotechnical Data

6.1.1 The site assessment report and various daily calls are referenced and linked to the cross sections for embankments and excavation on/in ice rich soils, rock and rock plates.

6.2 Embankment Stability

6.2.1 *Sub-grade Properties*

As part of the Tote road upgrade project in 2007/2008, Knight Piesold identified four categories of frost/thaw susceptibility to delineate the road bed foundations and the foundation conditions along the Tote Road.

These views were further enhanced by the site visit and assessment by Hatch and the following typical cross sections were recommended and applied for the MTO's to specific sections on the optimized alignment:

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6.2.2 *Recommended Cross Sections for Embankments*

Two standard embankment sections were introduced as per the schematic in Figure 6-1

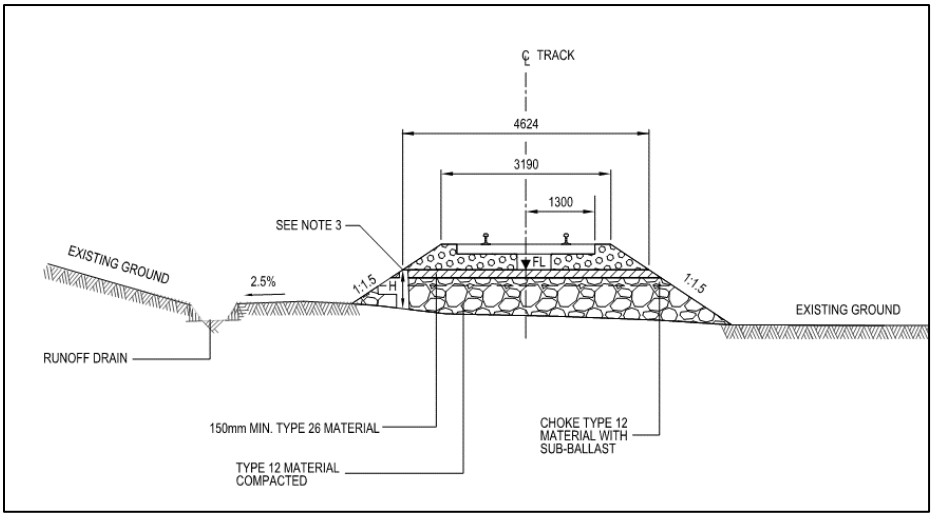

Figure 6-1: Typical Cross Section Embankments

The following observations apply:

6.2.2.1 For radii (R) > 800 m and tangent track the top of formation is 4624 mm, which is the top of sub ballast and base of ballast, therefore no sub ballast shoulder;

6.2.2.2 For 400 m < R ≤ 800 m the top of formation is 4900 mm, which is the top of sub ballast and base of ballast, therefore no sub ballast shoulder. The ballast shoulder is increased to 400 mm to the outside rail of the curve and this outside rail is super elevated between 54 mm and 86 mm, hence the top of sub ballast increases from 4624 mm to 4900 mm to the outside of the curve;

6.2.2.3 For R ≤ 400 m the top of formation is 5100 mm, which is the top of sub ballast and base of ballast, therefore no sub ballast shoulder. The ballast shoulder is increased to 600 mm to the outside rail of the curve and this outside rail is super elevated between 108 mm and 173 mm, hence the top of sub ballast increases form 4624 mm to 5100 mm to the outside of the curve;

6.2.2.4 Material Definition:

- Type 12: Minus 1 m run of quarry rock fill.
- Type 25: Minus 75 mm crushed rock for ballast layer.
- Type 26: Minus 50 mm crushed rock for sub ballast layer and to choke top of Type 12 fill.

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6.2.2.5 Minimum Embankment Thickness (H) (Type 12 Plus Sub Ballast):

- Measured under the ballast toe on the high-end of the cross fall.
- H = 700 mm Standard Dimension.
- H = 1500mm on ice rich Permafrost.
- 1800 g/m² non-woven geotextile under Type 12 material on ice rich Silt.

6.2.3 *Recommended Cross Sections for Excavations*

6.2.3.1 Excavation in ice rich permafrost needs to be avoided. In locations where excavation is not avoidable the excavation should be day lighted to the low side of the side slope as illustrated in the schematic in Figure 6-2.

6.2.3.2 In locations where daylighting is not possible the side slope on the other side will be a mirror image of the slope in the figure to a height where it cuts the natural ground level. Snow trap mitigation will need to be detailed for Expansion Study – Stage II phase.

6.2.3.3 The side slopes of 1V:2H of the excavation is covered by a layer of 500 g/m² non-woven geotextile and a 500 mm cover of selected Type 12 material.

6.2.3.4 The layerworks for the embankment is the standard 700 mm under the ballast toe plus 100 mm polystyrene layer for a total of 800 mm from top of sub ballast to top of excavated permafrost.

6.2.3.5 The polystyrene layer is overlain by a 1000 g/m² geotextile for protection.

6.2.3.6 The standard widths of the top of formation apply for tangent track to curves of less than 400m radii i.e 4624, 4900 mm and 5100 mm.

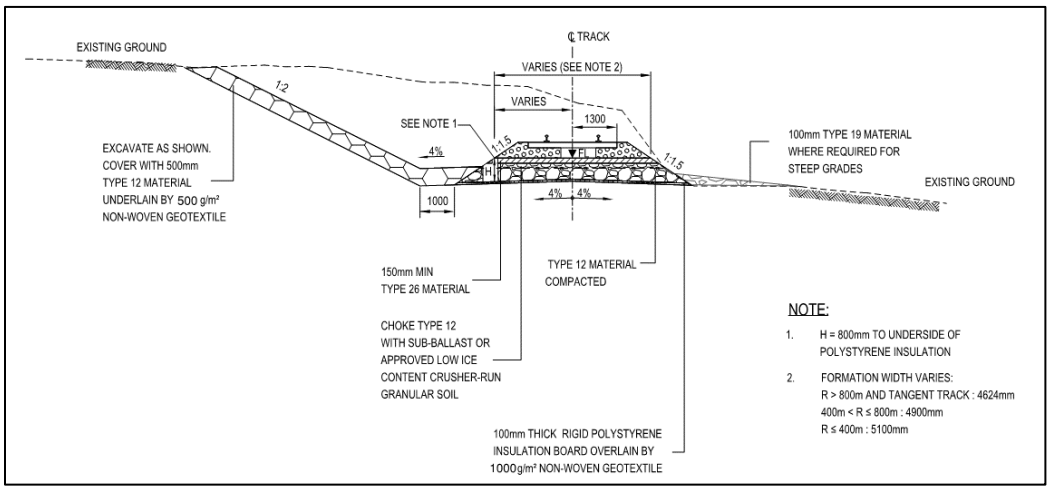

Figure 6-2: Typical Cross Section in Ice Rich Permafrost

6.2.3.7 Excavation in sedimentary bedrock ledges is illustrated in Figure 6-3 below:

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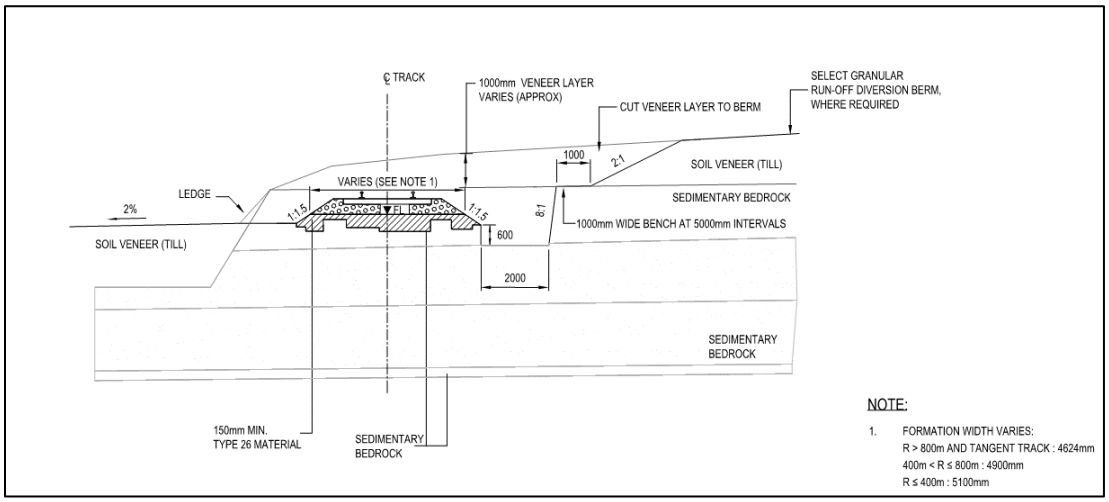

Figure 6-3: Typical Cross Section of Cut in Sedimentary Bedrock Ledges

6.2.3.8 The side slopes of the cut through the sedimentary bedrock is 8V:1H and through the soil veneer (till) 1V:2H.

6.2.3.9 The Type 26 sub ballast thickness is a minimum of 150 mm and the unevenness of the cut in the bedrock is smoothed with sub ballast Type 26.

6.2.3.10 The standard widths of the top of formation apply for tangent track to curves of less than 400m radii i.e 4624, 4900 mm and 5100 mm.

6.2.3.11 Excavation in for cuts in granitic rock is as per Figure 6-4 below:

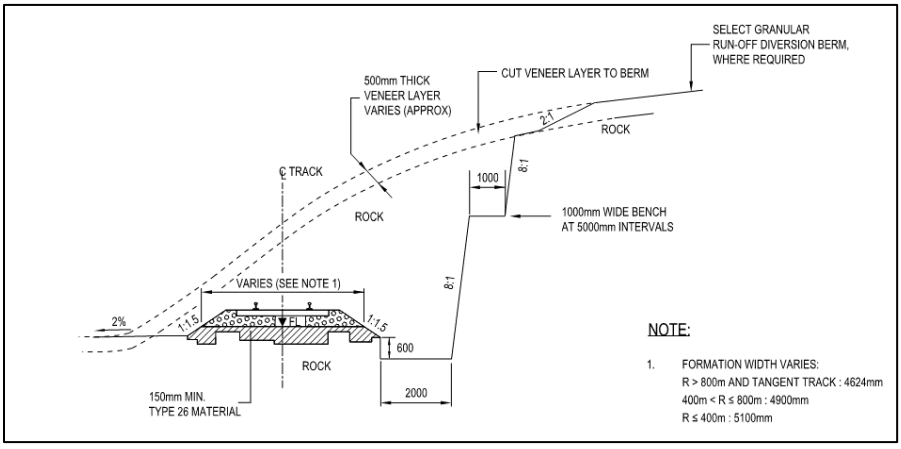

Figure 6-4: Typical Cross Section of Granitic Rock Cut

6.2.3.12 The side slopes of the cut through the granitic rock is 8V:1H and through the soil veneer (till) 1V:2H.

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6.2.3.13 The Type 26 sub ballast thickness is a minimum of 150 mm and the unevenness of the cut in the rock is smoothed with sub ballast Type 26.

6.2.3.14 The standard widths of the top of formation apply for tangent track to curves of less than 400m radii i.e 4624, 4900 mm and 5100 mm.

6.2.3.15 A typcial cut-off drain will be required in some instances where there a stream crossing the rail alignment but where the positioning of a drainage culvert is impossible due to the rail alignment being in a cut and the daylighting of such a culvert is imposiosble or cost prohibitive. The figure below illustrates what this typical detail will entail.

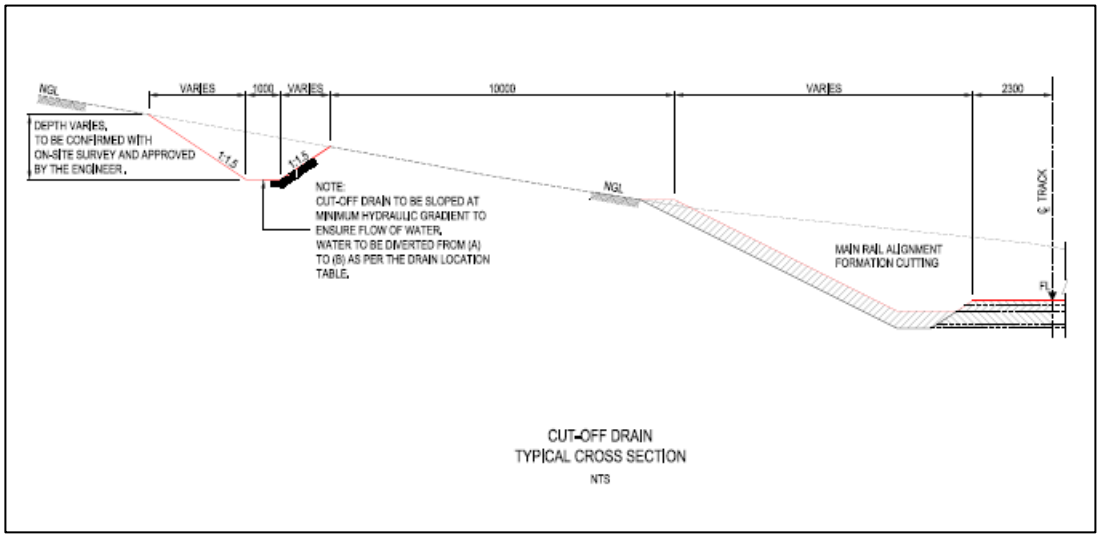

Figure 6-5: Typical Cross for a Cut-off Drain

6.3 Line Sections to Apply Typical Cross Sections

6.3.1 Chainages where to apply the different configurations of the typical cross sections are summarized in Table 6-1 below. The rail chainages in the table offer potential further optimization of better sub grade conditions for the feasibility study and subsequent to the outcome of the geotechnical evaluation currently underway.

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Table 6-1: Type of Embankment Section along the Rail Alignment

Chainage			Embankments	Reference	Excavation	Reference	Remarks Sub grade
From km	To km	Length km	Profile for Layer Works	Embankment Type	Profile for Cut	Cut Type	NS = Non Susceptible PS = Potentially Susceptible MS = Moderately Susceptible HS = Highly Susceptible
0	8.9	8.9	700mm Standard or 150 mm minimum	Figure 6-1	Rock Cut	Figure 6-4	NS
8.9	14.2	5.3	700mm Standard or 150 mm minimum	Figure 6-1	Rock Cut	Figure 6-4	NS
14.2	15.2	1	1500mm Permafrost or 800 mm in cuts	Figure 6-1	Permafrost	Figure 6-2	HS
15.2	30	14.8	700mm Standard or 800 mm in cuts	Figure 6-1	Permafrost	Figure 6-2	PS & NS
30	43	13	700mm Standard or 800 mm in cuts	Figure 6-1	Permafrost	Figure 6-2	PS
43	53	10	700mm Standard or 800 mm in cuts	Figure 6-1	Permafrost	Figure 6-2	NS
53	62	9	700mm Standard or 800 mm in cuts	Figure 6-1	Permafrost	Figure 6-2	PS
62	68	6	700mm Standard or 150 mm minimum	Figure 6-1	Ledge Rock Cut	Figure 6-3	NS
68	76	8	700mm Standard or 800 mm in cuts	Figure 6-1	Permafrost	Figure 6-2	PS
76	80	4	1500mm Permafrost or 800 mm in cuts	Figure 6-1	Permafrost	Figure 6-3	MS
80	86.25	6.25	700mm Standard or 800 mm in cuts	Figure 6-1	Permafrost	Figure 6-2	PS
86.25	87.25	1	1500mm Permafrost or 800 mm in cuts	Figure 6-1	Permafrost	Figure 6-2	MS
87.25	89.5	2.25	700mm Standard or 800 mm in cuts	Figure 6-1	Permafrost	Figure 6-2	PS
89.5	92	2.5	700mm Standard or 150 mm minimum	Figure 6-1	Rock Cut	Figure 6-4	NS
92	95.4	3.4	700mm Standard or 800 mm in cuts	Figure 6-1	Permafrost	Figure 6-2	PS
95.4	95.78	0.38	700mm Standard or 150 mm minimum	Figure 6-1	Rock Cut	Figure 6-4	NS
95.78	100	4.22	700mm Standard or 800 mm in cuts	Figure 6-1	Permafrost	Figure 6-2	PS
100	104	4	700mm Standard or 800 mm in cuts	Figure 6-1	Permafrost	Figure 6-2	NS
104	109	5	700mm Standard or 800 mm in cuts	Figure 6-1	Permafrost	Figure 6-2	PS

Note: [1-] The road foundation classifications are approximate. Foundations Classifications were based on report by Knight Piesold and adjusted to rail chainages and inputs from the Hatch site assessment.

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6.4 Settlement Considerations

6.4.1 Settlement of embankments in permafrost and thaw circumstances offer a challenge in the embankment design process. The requirement is to define settlement allowances during the design process. Careful construction planning to prioritize high embankments to exploit the early settlement under load before the final layer works is one measure to mitigate settlement disruption, as well as strategies to correct settlement during maintenance interventions.

6.4.2 Preloading of the formation will be managed by considering the use of the formation by construction equipment and road vehicles where appropriate.

6.4.3 Table 6-2 provides a summary of the condition of the sub-grade discussed above and linked to certain line sections. It also indicates the estimated settlement considerations linked to these sections.

Table 6-2: Summary of Embankment Recommendation and Estimated Settlement

Embankment Section	Ground Frost/Thaw Susceptibility	Ground Ice Content	Classification	Thaw Settlement Estimate (mm)	Typical Section
Fill Cut	Non Susceptible	Non to low	Segregated ice is not visible by eye[1]	<20	Figure 6-1
	Potentially Susceptible	Low to Mediate	Segregated ice is visible by eye, less than 25 mm (1") in thickness[1]	20-100	
Fill Cut	Moderately Susceptible	Mediate to High	Ice greater than 25 mm (1") thickness[1]	100-300	Figure 6-1
	Highly Susceptible	Very High	Ice greater than 0.3 m [2]	>300	

Notes:[1]- Classification is based on Unified Soil Classification System of Frozen Soils; [2]- Based on Roujanski et. al. (2010).

6.5 Rock Fill Criteria

6.5.1 The geotechnical recommendation is to use rock fill Type 12 for the embankment support under the sub ballast layer for backfill and to smooth the natural ground level (NGL) or to fill where the NGL has a cross fall. Type 26 is the recommended good crushed and graded stone/rock for the sub ballast layer and a choke layer between sub ballast and the Type 12 rock fill. The grading for Type 25, recommended for ballast, is too fine and an alternative grading is provided, more common for use for heavy haul rail lines.

6.5.2 The following is a summary of the gradations for materials to be used for railway embankment fill in Expansion Study – Stage II stage. Types 12 fill is recommended for use as fill material to be placed over the weak native sub-grade to prepare an appropriate foundation for embankment fill construction. The gradation for Type 12 run of quarry fill is shown in Table 6-3.

Table 6-3: Type 12 Fill - Run of Quarry

Nominal Sieve Size (mm)	Percentage Finer Than (By Weight)
1000	100
600	95 - 100

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300	50 - 100
150	0 - 80
19	0 - 30
4.75	0 - 10

6.5.3 Table 6-4 and Table 6-5 summarize materials for ballast and sub-ballast. It should be noted that the grading for ballast had been changed from the Type 25 grading considered by the geotechnical team based on a track design basis. The appropriate “Type” to be confirmed, but ballast is further specified under Section 9.5.1.1.

Table 6-4: Type – Ballast

Nominal Sieve Size (mm)	Percentage Finer Than (By Weight)
73	100
63.0	90 – 100
53.0	40 – 70
37.5	10 – 30
26.5	0 – 5
19.0	0-1
13.2	0

Table 6-5: Type 26 Fill – Sub-ballast

Nominal Sieve Size (mm)	Percentage Finer Than (By Weight)
50	100
13.2	60 – 80
4.75	20 – 45
1.18	0 – 15
0.075	0 – 5

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7. Hydrology

7.1 Introduction

7.1.1 The hydraulic design for culverts and bridge structures for the Tote road was based on 1 in 5 years return flood period, whilst normally 1:50 for culverts and 1:100 return floods and intensities for major structures are considered for railway line designs. For this project the design was for 1:200.

7.1.2 The hydrologic analysis for the Tote road had been reviewed refer to document H352034-3000-228-030-0001 titled the In-Principle Review of Previous Tote Road Hydrology Assessments, dated 2016-08-18.

7.1.3 Baffinland Iron Mine requested Knight Piésold to complete an update of previous studies concerning the design peak flows for the region and to incorporate the most resent stream flow data. Refer to Knight Piésold document number NB102-00181/39-A.01.

7.2 Methodology

7.2.1 *Design Peak Flows*

7.2.1.1 In the Hatch memo referenced in 7.1.3 Hatch raised queries with regard to the method used to derive the design peak flows. Following the updated design peak flows as presented in the report referenced in 7.1.4 the following methodology would be adopted by the project for the design of drainage structures.

7.2.1.2 Drainage structure locations will be identified along the proposed rail alignment, some of these structures will be to facilitate cross-drainage and others will be to perform the function of balancing culverts to balance the water that may collect in a low spot from either side of the rail alignment.

7.2.1.3 Catchments will be delineated by the project for all drainage structures, excluding the rail over river bridges which will be delineated by the responsible engineer to be appointed under procurement package CC003.

7.2.1.4 The delineated catchments will be used in conjunction with the formulas presented as output from 7.1.4 to calculate the associated run-off flows for a 1:200 year flood.

7.2.1.5 The flow volumes calculated in 7.1.5.3 will be used to determine the ultimate sizing of the culvert structure in terms of number and size of barrels.

7.2.1.6 Baffinland Iron Mine supplied information concerning which drainage structures are located in fish bearing streams. BIM will also supply stream flow data for fish bearings streams which, have been monitored on site so as to enable the project to determine the 3-day delay for a 1:10 year flood. This information will then be used to size the drainage structures. It is impossible to have stream flow data for every fish bearing stream. Thus the project will use ratios based on the known flow in monitored stream to scale the flow up or down for other fish bearing streams where no stream flow data is available.

7.2.2 *Flood Return Period*

7.2.3 One in one hundred year return period.

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7.2.4 *Design Velocities*

7.2.5 Velocities of water flow through culverts less than 3 m/s subcritical flow. Normal culvert, embankment and stream side slopes treatment against erosion will be applied.

7.2.6 For velocities determined as more than 3 m/s and less than 5 m/s applicable treatment to normalize the flow will be recommended for erosion protection and/or fish bearing streams.

7.2.7 For flows higher than 5 m/s special treatment must be considered on a case by case approach.

8. Bridge and Culvert Design Criteria

8.1 Introduction

8.1.1 This section describes the design elements and criteria for the railway bridges and major culvert structures that are to be designed and constructed for the Project.

8.1.2 This section will be a live document that will be revised once outstanding information becomes available. The values and information not yet available is highlighted in the relevant sub sections. Additional geotechnical investigations and drilling work as well as bathymetry data will be obtained in the first and second quarter of 2018.

8.2 Title Block

8.2.1 Each structure will be referred to by a prefix of either BR (for bridges) or CV (for culverts), an ID number indicating the kilometer station and a serial number that identifies multiple structures within the same kilometer of track. E.g. BR-68-1, CV-34-3. Zero km is Port Side and 107km Mine Side.

8.2.2 Where a bridge or culvert is located at a kilometer station, the lower km station will be used.

8.3 References for Design Standards

Design	Design Method	Code
Steel Design	Service load design (working stress design)	Chapter 15 of the Manual for Railway Engineering (MRE), as published by the American Railway Engineering and Maintenance-of-Way Association (AREMA).
Concrete Design	Service Load design (working stress design)	Chapter 8 the Manual for Railway Engineering (MRE) as published by the American Railway Engineering and Maintenance-of-Way Association (AREMA)
Prestressed Concrete Design		Part 17 of Chapter 8 of the Manual for Railway Engineering (MRE) as published by the American Railway Engineering and Maintenance-of-Way Association (AREMA).

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Design	Design Method	Code
Seismic design		Chapter 9 the Manual for Railway Engineering (MRE) as published by the American Railway Engineering and Maintenance-of-Way Association (AREMA).

8.3.1 The standards addressed above will be supplemented by the CSA Standard S6 “Canadian Highway Bridge Design Code” (S6). The use of this code and the requirements will be highlighted in the relevant sections below.

8.4 Bridge Geometry

8.4.1 *Design Requirements*

- Number of tracks = 1
- Number of service roads = 0
- Number of walkways = 2 (1 each side of bridge)
- Design life = 20 years

8.4.2 *Datum*

8.4.2.1 The geographical coordinate system used is:

- Name: UTM84-17N
- Description: WGS 1984 UTM, Zone 17 North

8.4.3 *Control Line*

8.4.3.1 The horizontal control line used for the basis of the project is the centre line of track and all transverse dimensions will be taken relative to this control line. The transverse dimension will NOT be taken from the centreline of the structure.

8.4.3.2 The vertical control line used for the basis of the project is the top of the sub-ballast layer.

8.4.4 *Coordinate System*

8.4.4.1 The structures will be dimensioned in ground coordinates and stationing provided in grid coordinates.

8.4.4.2 The conversion between ground and grid coordinates is currently undefined and each structure will be located relative to a single grid point located along the control line at the low station centreline of bearing.

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8.4.5 *Span Lengths*

8.4.5.1 The Span length of a bridge is defined by the distance between the bearing centrelines on the foundations and measured along the control centreline. Span lengths are provided in metres. Standard span lengths has been considered for similar girder type bridges.

8.4.5.2 For fabrication purposes, “Girder Lengths” are specified at temperatures of 20°C.

8.4.5.3 “Span Lengths” are set according to bearings being centred at a temperature of -15°C.

8.4.5.4 As measurements are being taken between foundation units, not along the superstructure, the “Span Lengths” are equally correct at any temperature.

8.4.5.5 The following relationship therefore results:

8.4.5.6 Span Length= Girder Length × (1- (20 + 15) × 12e-6) = 0.99958 × Girder Length.

8.4.5.7 A minimum allowance of 20 mm will be provided on each Girder Length in order to allow for the temperature difference as well as grid to ground conversions.

8.4.6 *Horizontal and Vertical Clearance from Obstructions*

8.4.6.1 For each single track structure, the minimum clear width of the ballast zone is 3.600 m, as measured at the top of concrete/steel deck level. The side walls of the ballast pan will be sloped outwards at a slope of 2V:1H.

8.4.6.2 Minimum clearance box required for trains is as follows:

Width (Horizontal):

- For plan curvature up to 3 degrees (R ≥ 600m): 5715 mm:

  This value is based on the AREMA clearance box width of 5486 mm plus an allowance of 78.2 mm per degree of curvature, in accordance with Table 28-1-1 in Part 1 of Chapter 28 of the 2009 edition of the Manual for Railway Engineering (MRE) as published by the American Railway Engineering and Maintenance-of-Way Association (AREMA), at a maximum curvature of 3 degrees. Structure may intrude into a triangle at the bottom corners. The triangle is 1219.2 mm high by 914 mm wide at the base. See sketch below.

- For tangent track: 5486 mm:

  An allowance is defined by the distance of the obstruction to the curved tangent track. This increase is given per degree of curvature. The allowance will be applied if the tangent track is curved within 24.384 m of the obstruction. At the bottom corner’s, structure may intrude into a triangle that is 1219 mm high by 914 mm wide at the base. This is in accordance with Part 1 of Chapter 28 of the 2009 edition of the Manual for Railway Engineering (MRE) as published by the American Railway Engineering and Maintenance-of-Way Association (AREMA). See sketch below.

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Height (Vertical):

- For plan curvature up to 3 degrees (R ≥ 600 m) and tangent track the height clearance is required to be 7010 mm from top of rail.

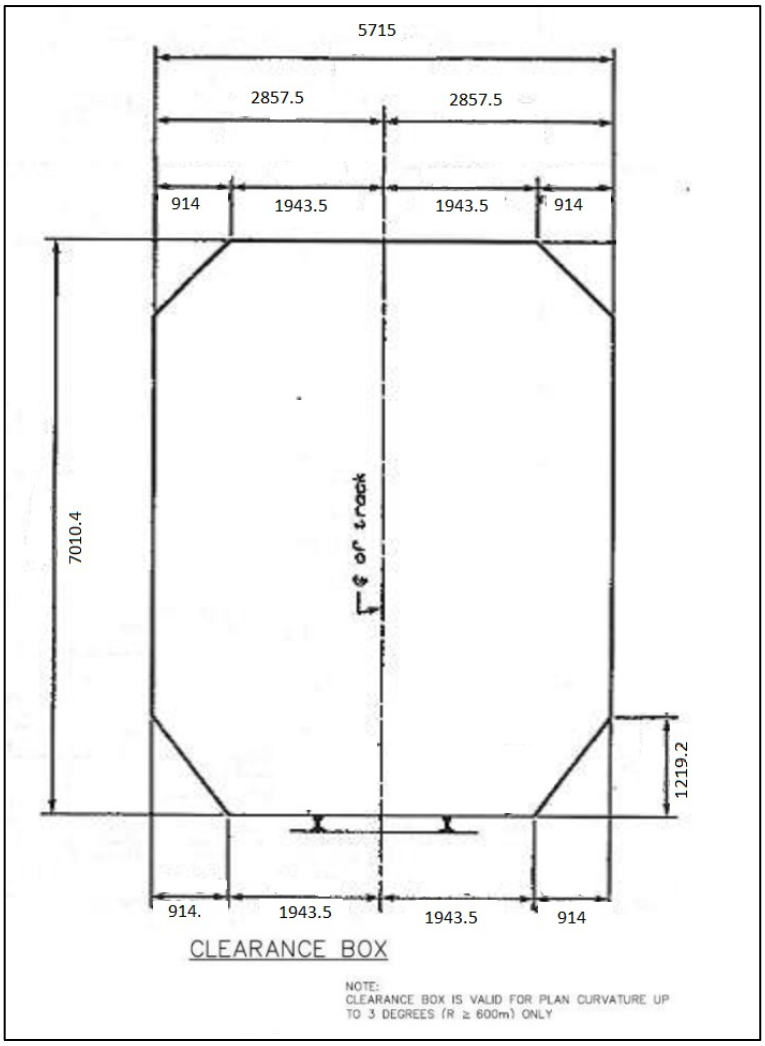

Figure 8-1: Clearance Box for Plan Curvature up to 3 Degrees (R ≥ 600 m)

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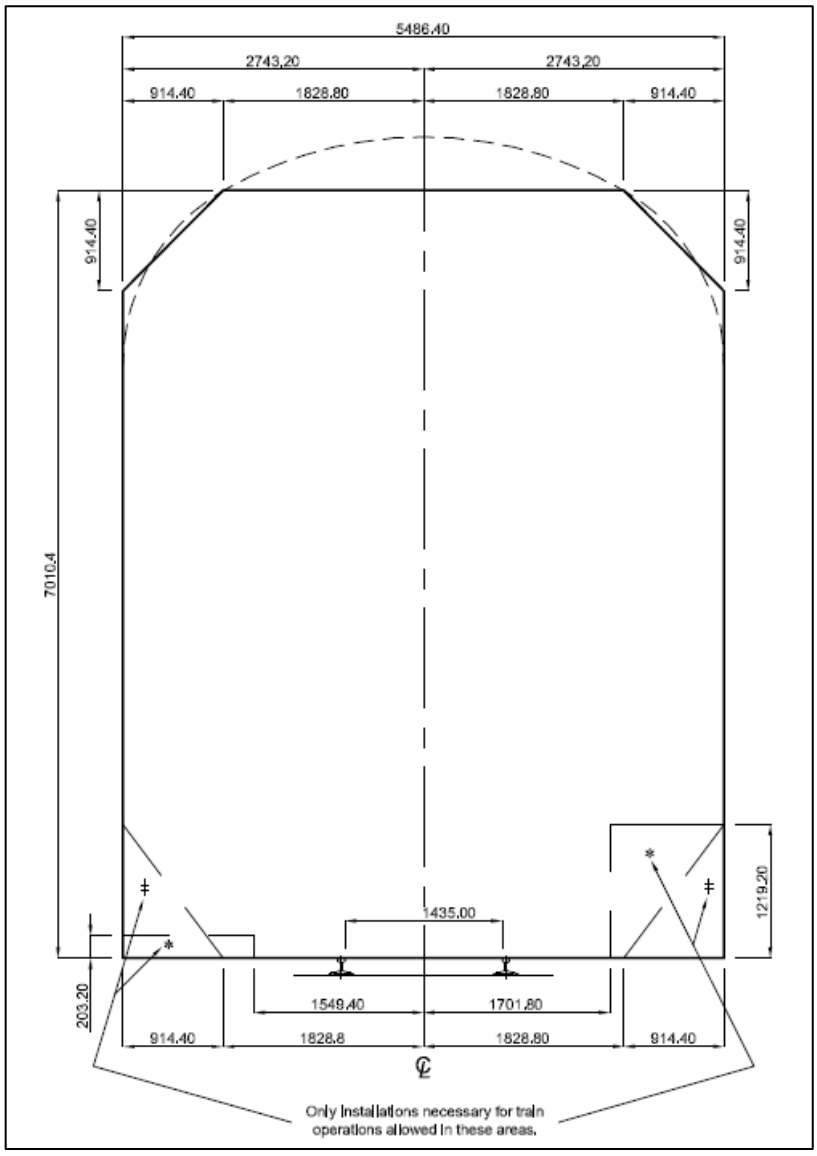

Figure 8-2: Clearance Box for Tangent Track

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8.4.7 *Vertical Clearance of Water Crossings*

8.4.7.1 The freeboard of the bridge is defined as the open space from the soffit of the bridge to the top of the water level at a given flow. The minimum allowable freeboard will be 0.30 meters.

8.4.7.2 For the purpose of this the design the following freeboard must be maintained for water crossings:

- All Streams:
  - 0.30 meters above 1 in 200 year flow elevation (High water level).
  - 0.60 meters above the 1 in 25 years flow elevation.
- Navigable streams only:
  - 1.5 meters above the average annual high water elevation (Normal Water Level), unless noted otherwise.

8.4.8 *Walkways*

8.4.8.1 Where required on bridges for maintenance access, walkways will be provided on both sides of the structures. Walkways will have a minimum width of 700 mm.

8.4.8.2 Guardrails will be provided on the exterior side of the walkway. The guardrails may not be inside of the required clearance box. The guardrail height will be 1050 mm above the walking surface of the walkway.

8.4.8.3 There will be no permanent fixtures inside of the clearance box. Refuge bays will be provided, where pedestrians on the walkway would be located inside the clearance box, at a maximum spacing of 45 meters.

8.4.9 *Fixity*

The fixity on the spans will be as follows:

- One end fixed translationary (X, Y, Z).
- One end will be fixed transversely (Y).

8.5 Bridge Design Parameters and Loading

8.5.1 *Ballasted Deck*

8.5.1.1 Bridges will be assessed on a case by case basis as whether the bridge will have a ballasted deck or open deck.

The criteria basis for this will be:

- Environmental Constraints
- Axle Loading

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- Bridge Strength
- Settlement of piles due to permafrost and alignment of track.

8.5.1.2 Elevations will be set based on an assumed ballast depth of 478 mm below base of rail for wooden ties and the ties will extend as far as the extension of the guardrails, and as such also serve as a transition section between the steel ties on the mainline and the hardwood sleepers on the bridges.

8.5.1.3 For the design of the bridge, the load due to ballast will be based on a depth of 750 mm (approximately 1.5 x design depth from below base of rail), allowance includes for a maintenance tamp. Ballast pans and ballast retaining structures will be designed for a ballast depth of 750 mm.

8.5.1.4 Drainage from the ballast pan will be designed to accommodate and contain any liquid spill that occurs in the vicinity of the bridge. Expansion joints will be designed to contain any liquid spill that occurs in the vicinity of the bridge. The flow of the liquid will be able to be contained.

8.5.2 *Vertical Displacements and Camber*

8.5.2.1 The allowable vertical displacements under live load and impact will be less than:

- Span / 800

8.5.2.2 Spans must be cambered as defined in AREMA Chapter 15 Part 1 Article 1.2.10. All structures must be cambered for dead load. All cambering of spans must be subject to the Contractor's designer's discretion.

8.5.3 *Lateral/Longitudinal Displacements*

8.5.3.1 The allowable lateral displacement within a span shall be less than:

- For tangential track

  $0.028L^2$

- For curved sections

  $0.066L^2$

Where:

The resulting deflection is in mm.

L = span length (m).

The allowable lateral displacement at a pier shall be less than:

- For tangential track

  $0.028D^2$

- For curved sections

  $0.066D^2$

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Where:

The resulting deflection is in mm.

D = sum of the two span lengths adjacent to the pier (m).

The allowable longitudinal displacement of the superstructure shall be less than:

- 50 mm for load combinations including seismic loads
- 28 mm for all other load combinations.

Note: for load combinations including seismic loads, the allowable deflections are for serviceability level.

8.5.4 *Live Load*

8.5.4.1 The defined live load model in MRE Clause 15-1.3.3 is Cooper E-80. For the purposes of the design of the structures for this project, the live load will be based on Cooper E-90 (Cooper E-80 + 12.5%).

8.5.4.2 The impact loading shall be applied in accordance with MRE Clause 15-1.3.3.

8.5.4.3 The alternate live load on the 4 axles shown in MRE Figure 15-1-3 shall also be checked.

8.5.4.4 MRE Clause 15-1.3.4 shall be used to distribute the live loads between the load-carrying members.

8.5.4.5 In accordance with MRE Clause 15-1.3.3 pattern loading will be used on multi span bridges to achieve the greatest live load stress. For single span bridges the greatest live load stress will be determined by applying different scenarios of the Cooper E-100 and alternative live load on 4 axles.

8.5.5 *Centrifugal Force*

8.5.5.1 Centrifugal forces shall be applied in accordance with MRE Clause 15-1.3.6 to structures located on curves.

8.5.5.2 The design speed of 75 km/h shall be assumed when applying the equations.

8.5.6 *Fatigue Stress Cycles*

8.5.6.1 MRE Clause 15-1.3.13 shall be used to design the steel structures for fatigue resistance.

8.5.6.2 All elements shall be designed for more than 2,000,000 stress cycles.

8.5.7 *Braking and Traction Forces*

8.5.7.1 Longitudinal forces shall be determined in accordance with MRE Clause 15-1.3.12.

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8.5.8 *Bearing Friction Forces*

8.5.8.1 The longitudinal forces due to bearing friction will be based on an assumed coefficient of friction of 15%.

8.5.9 *Walkway Loads*

8.5.9.1 For design purposes, any area extending beyond the required clearance box shall be considered to be walkway.

8.5.9.2 Walkway load = 5.0 kPa.

8.5.10 *Snow Loads*

8.5.10.1 The ground snow load in the area is approximately 2.0 kPa in accordance with the 2005 National Building Code of Canada.

8.5.10.2 A snow load of 3 kPa will applied to all structures. The additional 1 kPa is to account for any unforeseen weather and for any uncertainty in the National Building Code of Canada.

8.5.11 *Snow and Walkway Combination*

8.5.11.1 Snow and walkway loading will not be considered to occur simultaneously.

8.5.11.2 Snow and walkway load cases will be considered as follows:

a) 5.0 kPa over the walkway areas (any areas outside the clearance box width) in combination with train loads.

b) 3.0 kPa over the entire width of the bridge, not in combination with train loads.

8.5.11.3 The above indicates that load case a) will govern the design. Thus explicit consideration of snow load is not required.

8.5.12 *Ice Accretion Loads*

8.5.12.1 S6 Figure A.3.1.4 is used for to determine the ice accretion load.

8.5.12.2 The figure indicates that 12 mm of ice thickness is required. A safety of 1.25 is used on the value.

8.5.12.3 Ice thickness = 15 mm.

8.5.12.4 Ice load = 15 mm $\times$ 9.81 kN/m^3 = 0.15 kN/m^2.

8.5.12.5 Ice accretion load will be considered a dead load for the purpose of load combinations.

8.5.13 *Wind Load on Structure*

8.5.13.1 Wing load on structures will be determined in accordance with MRE Clause 15-1.3.8.

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8.5.14 *Wind Load on Live Load*

8.5.14.1 Wind load on live load shall be determined in accordance with MRE Clause 15-1.3.7 (a).

8.6 Other Lateral Forces

Any other additional forces that result from equipment and maintenance shall be determined and applied in accordance with MRE Clause 15-1.3.9.

8.6.1 *Temperature Range*

8.6.1.1 CSA S6 Figure A3.1.1:

- Maximum mean daily temperature = 10°C

8.6.1.2 CSA S6 Figure A3.1.2:

- Minimum mean daily temperature = -35°C

8.6.1.3 Two types of superstructures are provided below in accordance with CSA S6 Clause 3.9.3.

8.6.1.4 Type A: steel or aluminum beam, box, or deck truss systems with steel decks and truss systems that are above the deck.

8.6.1.5 Type B: steel or aluminum beam, box, or deck truss systems with concrete decks.

8.6.1.6 For a Type 'A' superstructure:

- Maximum effective temperature: 10°C + 25°C = 35°C
- Minimum effective temperature: -35°C – 15°C = -50°C

8.6.1.7 CSA S6 Figure A3.1.1:

- Assumed structure depth = 1 m
- Reduction to maximum effective temperature = 3.5°C
- Increase to minimum effective temperature = 5.5°C
- Maximum Temperature = 35°C – 3.5°C = 31.5°C ≈ +35°C
- Minimum Temperature = -50°C + 5.5°C = -44.5°C ≈ -45°C
- Range = 35°C + 45°C = 80°C

8.6.1.8 For a Type 'B' superstructure:

- Maximum effective temperature: 10°C + 20°C = 30°C
- Minimum effective temperature: -35°C – 5°C = -40°C

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8.6.1.9 CSA S6 Figure 3.5:

- Assumed structure depth = 1.5 m
- Reduction to maximum effective temperature = 3.5°C
- Increase to minimum effective temperature = 5.5°C
- Maximum Temperature = 30°C – 3.5°C = 26.5°C ≈ +30°C
- Minimum Temperature = -40°C + 5.5°C = -35.5°C ≈ -35°C
- Range = 30°C + 35°C = 65°C
- The thermal coefficient of steel = 12×10^{-6}/°C
- The thermal coefficient of concrete = 10×10^{-6}/°C

8.6.1.10 The design temperatures above will be used for the structural design of the bridges according to the type classification.

8.6.1.11 The material requirements will be governed by the site Climatic Data. This information indicates that the average temperature is -15ºC and will be used as the temperature that the bearings are centred at.

8.6.2 *Earth Pressure*

8.6.2.1 The active pressure will be determined using the following parameters:

- Unit weight for soil = 20.0 kN/m^3
- 'at rest' coefficient = 0.50

8.6.2.2 The above is to be confirmed with the geotechnical engineer during the project.

8.7 In Stream Ice Loads

8.7.1 The requirement of ice loading on the structure will be determined during the project based on hydrological information.

8.7.2 Where in stream ice loads are required, these shall be determined in accordance with CSA S6 clause 13.2.

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8.8 Stream Forces

8.8.1 Stream forces will be calculated by the following formula:

$P_a = K \times V_a^2$

P_a = average stream pressure (kPa)

V_a = average stream velocity (m/s)

K = drag constant:

= 0.725 for square-ended pier

= 0.360 for semi-circular pier

= 0.400 for a wedge-shaped nose <90°

8.8.2 Forces will be distributed to the pier assuming a triangular pressure distribution of $2P_a$ at water surface and 0 at riverbed.

8.9 Seismic Effects

8.9.1 *General*

8.9.1.1 Seismic analysis will be carried out using a linear elastic analysis. Response spectra will be based on MRE Clause 1.4.4.3.

8.9.1.2 The peak ground acceleration (PGA) proposed value is 0.4g and is to be confirmed from the following website:

http://earthquakescanada.nrcan.gc.ca/hazard/interpolator/

8.9.1.3 MRE Clause 9-1. The Site Coefficient (MRE Clause 9-1.4.4.1) shall be taken as 1.0 for all locations, subject to confirmation by the geotechnical engineers.

8.9.2 *Load Combinations for Structural Check – Concrete Elements*

8.9.2.1 *Service Load Design*

8.9.2.2 The load combinations contained in the table below will be checked. The last column of the table indicates the allowable multiplier to be applied to the working stresses for each combination depending on the specified code.

8.9.2.3 The table below indicates the group loading combination for SERVICE LOAD DESIGN.

8.9.2.4 Groups I-VIII taken directly from MRE Clause 8-2.2.4 Table 8-2-4.

8.9.2.5 Group IX is adapted from a combination specified in MRE Clause 9-1.4.6, this specifies requirements for load factor design (LFD) only. The combination has been determined by comparison with other working stress combinations specified in MRE Chapter 8 and with load combination specified in MRE Clause 8-1.4.6 for steel structures.

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8.9.2.6 Group IX only applies to the “Serviceability” seismic load case. For other seismic load cases, yielding is assumed to occur and these checks not based on material stresses but are based on displacement demands.

Table 8-1: Group Loading Combination – Service Load Design (MRE Clause 8-2.2.4 Table 8-2-4)

Group	D+	LL+I	LL Min	LF	CF	WL	WU	WLL	ICE	EQ	%
I	1	1			1						100
II	1					1					125
III	1	1		1	1	0,5		1			125
IV	1	1			1						125
V	1					1					140
VI	1	1		1	1	0,5		1			140
VII	1	1			1				1		140
VIII	1					1			1		150
IX	1									1	150

Note:
D+ includes D (dead load), E (earth pressure), B (buoyancy) , SF (stream force) and the weight of accreted ice.
LL+I = train loads + impact + 5.0 kPa walkway loads outside of clearance box.
LL Min = Minimum live load per MRE 15-1.3.10 “Stability Check”.
LF = longitudinal force (braking and traction) + bearing friction effects
CF = centrifugal force
WL = wind on loaded structure
WU = wind on unloaded stricture
WLL = wind on live load
ICE = ice loads (down drag and impact – not accretion)
EQ = seismic loads

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8.9.2.7 *Load Factor Design*

- The load combinations contained in the table below will be checked.
- The table below indicates the group loading combination for LOAD FACTOR DESIGN.
- The load factors provided below are only intended for designing structural members by the load factor design concept. The actual loads should not be increased by these factors when designing for foundations, checking foundation stability.

Table 8-2: Group Loading Combination Load Factor Design (MRE Clause 8-2.2.4 Table 8-2-5)

Group	D+	LL+I	LL Min	LF	CF	WL	WU	WLL	ICE	EQ
I	1.4	2.33			1.4					
IA	1.8	1.8			1.8					
II	1.4					1.4				
III	1.4	1,4		1.4	1.4	0.5		1.4		
IV	1.4	1.4			1.4					
V	1.4					1.4				
VI	1.4	1,4		1.4	1.4	0.5		1.4		
VII	1									1
VIII	1.4	1.4							1.4	
IX	1.2					1.2			1.2	

Note:

D+ includes D (dead load), E (earth pressure), B (buoyancy) , SF (stream force) and the weight of accreted ice.

LL+I = train loads + impact + 5.0 kPa walkway loads outside of clearance box.

LL Min = Minimum live load per MRE 15-1.3.10 “Stability Check”.

LF = longitudinal force (braking and traction) + bearing friction effects

CF = centrifugal force

WL = wind on loaded structure

WU = wind on unloaded stricture

WLL = wind on live load

ICE = ice loads (down drag and impact – not accretion)

EQ = seismic loads

8.10 Load Combinations for Structural Check – Steel Elements

8.10.1 *General*

8.10.1.1 The load combinations contained in the table below will be checked.

8.10.1.2 The last column of the table indicates the allowable multiplier to be applied to the working stresses for each combination depending on the specified code.

8.10.1.3 The table below indicates the load combinations with Groups I-III taken from Chapter 15.

8.10.1.4 Group II applies to only to the members which are subjected to wind load only.

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8.10.1.5 Group IX is taken from MRE Chapter 9 with consistency being maintained with the concrete load combination in the previous section with regard to the naming.

8.10.1.6 Group IX applies only to the “Serviceability” seismic load case. For other seismic load cases, yielding is assumed to occur and these checks not based on material stresses but are based on displacement demands.

Table 8-3: Group Loading Combination (MRE Chapter 15)

Group	D+	LL+I	LL Min	LF	CF	WL	WU	WLL	ICE	EQ	%
I	1	1			1						100
IA	1		1		1						100
II							1				100
III	1	1		1	1	1		1	1		125*
IIIA	1						1		1		125*
IX	1									1	150*

*The specified increase in allowable stress shall not be applied to floor beam hangers or bolts.

Notes:

D+ includes D (dead load), E (earth pressure), B (buoyancy) , SF (stream force) and the weight of accreted ice.
LL+I = train loads + impact + 5.0 kPa walkway loads outside of clearance box.
LL Min = Minimum live load per MRE 15-1.3.10 “Stability Check”. Walkway load not included.
LF = longitudinal force (braking and traction) + bearing friction effects
CF = centrifugal force
WL = wind on loaded structure
WU = wind on unloaded structure
WLL = wind on live load
ICE = ice loads (down drag and impact – not accretion)
EQ = seismic loads

8.10.2 *Bearing Replacement*

8.10.2.1 The structure will be designed taking into account the bearing replacement or shimming. Jacking points on the structure will be indicated. This will avoid the future requirements for additional foundations or support frames.

8.10.2.2 The jacking points will be designed for dead load only.

8.10.3 *Utilities*

8.10.3.1 Where required, ducts shall be installed on the bridges for the passage of utilities. Ducts will be surface mounted. The size, location and number of, will be determined during the project.

8.11 Bridge Materials

8.11.1 *Concrete*

8.11.1.1 Cast in-situ concrete will be avoided where possible due to the constraints on construction. However, if the design requirement does not allow for steel or precast concrete, cast insitu shall be used.

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8.11.1.2 The following shall apply:

Cast in-situ Concrete Design: 28-day compressive strength of 35Mpa

Sika Grout Arctic 100 material is to be used or

Air entrapment design is to be used

8.11.1.3 Precast reinforced concrete design: 28-day compressive strength of 45 MPa.

8.11.2 *Concrete Protection for Reinforcement*

8.11.2.1 The minimum clear cover for reinforcement shall be as described below:

- Cast against/permanently exposed to earth: 75 mm
- All other locations: 50 mm

8.11.3 *Structural Steel*

8.11.3.1 All exposed structural steel is to be atmospheric corrosion resistant (weathering steel) Grade 350AT, Category 4 or approved equivalent and shall conform to CSA Standard G40.1.

8.11.4 *Corrosion Allowance*

8.11.4.1 A corrosion allowance of 1.5 mm (1/16'') shall be deducted from the nominal thickness for sheet products only.

8.11.5 *Bolts*

8.11.5.1 All bolts will be 7/8'' diameter (22 mm) type A325 (weathering steel).

8.11.6 *Joints*

8.11.6.1 Integral abutments with no joints will be considered for bridges with spans less than 50 m.

8.11.6.2 Where integral abutment joints are not possible, standard expansion joints will be designed.

8.11.7 *Bearings*

8.11.7.1 Bearings shall be self-lubricating bearings.

8.11.7.2 The coefficient of friction at expansion locations is assumed to be 15% for the design. No additional factor of safety is required on the 15%.

8.11.7.3 The friction forces due to temperature movements are assumed to arise from dead load only. Live load is not included.

8.11.7.4 If self-lubricating spherical bearings are selected then the friction forces will arise as a result of live load rotation.

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8.11.7.5 For multi-span bridges, the worst loading case will arise when a single span is loaded. This is due to the bearings on adjacent span at any pier acting in different directions. For this load case, the 15% coefficient of friction will be used in combination with the total dead load and live load reaction.

8.11.8 *Waterproofing*

8.11.8.1 No waterproofing membrane will be used.

8.11.8.2 For all steel deck plates that are susceptible to crevice corrosion will be galvanised.

8.12 Bridge Geotechnical Parameters

8.12.1 *Ad Freeze Piles*

8.12.1.1 Geotechnical parameters relating to the foundations will be completed when further investigations and details become available.

8.12.1.2 The proposal for the adfreeze piles is to incorporate a welded steel grade beam as a pile cap rather that a concrete pile cap.

8.13 Other Bridge Design Considerations

8.13.1 *Guard Rails*

8.13.1.1 Guard rails shall be provided on all tracks installed on bridges and shall extend 20 m beyond either side of the structure.

8.13.2 *Fish Passage*

8.13.2.1 The bridge crossings will be assessed to determine if the crossing is over a fish habitat. Where bridges are crossing over fish habitats, the environmental recommendations and hydraulic report will provide the requirements.

8.13.3 *Scour Protection*

8.13.3.1 Scour protection will be determined on a case by case basis and will be determined by the hydraulic report.

8.14 Bridge Options

8.14.1 The rail girder bridge that has been considered for the structure:

- Through Plate Girder (TPG)

8.14.2 The rail bridge deck that has been considered for the structure:

- Ballasted Deck that comprises of a concrete deck or steel deck to contain the ballast.

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8.15 Culvert Geometry

- The hydrology in terms of flows, peak flows and intensities for the related catchment areas for each river or stream, the new rail alignment will cross, had been reviewed and determined for 1 in 200 year return periods. This will guide bridge and culvert basic hydraulic sizing and the necessary adjustments (over compensation) to accommodate the uncertainties associated with arctic hydrology and the influence of ice and snow on the hydraulics.
- The Expansion Study – Stage II costing are based on using galvanised corrugated steel pipes pending further investigation to use pre-fabricated concrete box culverts. Pre-fabricated box culverts and culvert bottom slabs are normally up to 3 tonnes per unit, requiring mechanical handling through all the transport mode changes in the logistics chain from manufacturer to installation on site. The trade-off in culvert unit choice can be concluded once the hydraulics had been completed and the material take-off for culverts are detailed, and priced by the contractors during the next phase of the project. It is noted that box culverts are seen as environmentally more friendly bridging fish bearing water ways.

8.15.1 *Dimensions*

8.15.1.1 Culvert diameter or size will be standardized to maximum 4 standard sizes that will either be used as single or multiple culvert combinations for each water way or run-off path where culverts need to be installed. Single pipe culverts will be favored where possible. Dimensions will vary depending on:

- Peak flow volumes.
- The hydraulic gradient of the stream crossing at the track location.
- The proximity to the Tote road culvert in the same stream or run-off path, implying potential downstream mitigating protection of the rail formation for back damming.
- Minimum cover over the culvert and support bedding under the culvert; and
- Fish passage considerations.

8.15.1.2 The four standard sizes ø900 mm, ø1200 mm, ø1500 mm and ø1800 mm will then be installed as single or multiple culverts rounded up to the next full size to determine number of pipes or pre-fabricated units required per location. For grade crossings and caribou crossings ø600 mm will be used to ensure there is drainage underneath crossings of the rail alignment.

8.15.2 *Vertical Clearance*

8.15.2.1 The vertical clearance for culverts shall be determined by considering the 5 dimension drivers above, the upstream storage conditions and the potential damming effect in closer proximity to the Tote road culverts for the water course, by providing mitigating protection for the rail formation on the downstream side with geotextile or anti-seepage walls.

8.15.2.2 The risk of overtopping shall be assessed for the design criteria employed with the purpose to mitigate storm water damage to the rail embankment by anti-seep walls or membranes on both sides or appropriate other measures where required.

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8.16 Culvert Design Rational

8.16.1 *General*

8.16.1.1 Culvert design shall consider the following:

- Prevent water accumulation on the sides of embankments.
- Divert water and ice away from the toe of the embankment.
- Provide cut-off drains or berms for dispersed flow and accumulate through appropriate culvert in the proximity.
- Provide appropriate embankment protection where required.
- The culvert shall be sloped in the direction of flow at the same grade as the water path grade, such that the centre of inlet- and the centre of outlet is as close as possible to the centre of the water path and the direction/orientation of the water path.
- Provide appropriate inlet and outlet protection and treatment, linked to the water flow velocity to prevent piping through the embankment and erosion of the water path sides and the embankment.
- The water shall be channelled with a down chute at such low spots in cuttings into the drop inlet or calming pond.
- Provide culvert barrel treatment, scour holes, wing walls and drop inlets where grades are too steep and water velocity >5 m/s.
- Provide oversized culvert with weirs, cut-off collars both ends and natural stones inside culverts where water velocity <5, but >4 m/s.
- Provide wing walls both ends where water velocity is <4, but >3 m/s.
- Provide basic inlet and outlet protection where water flow velocity is subcritical (<3 m/s).

8.16.2 *Typical Culvert Sections*

8.16.2.1 The culvert dimension considerations in 8.15.1 will guide culvert sizing. Culvert bedding, support, cover and backfill measures are as important. Differential settlement under the embankment weight and train loading as per 8.5.4 and 8.5.5 needs to be prevented. The following Figures provide the basics for culvert configurations and are excerpts of drawings H352034-3000-220-294-0001 and H352034-3000-220-294-0002.

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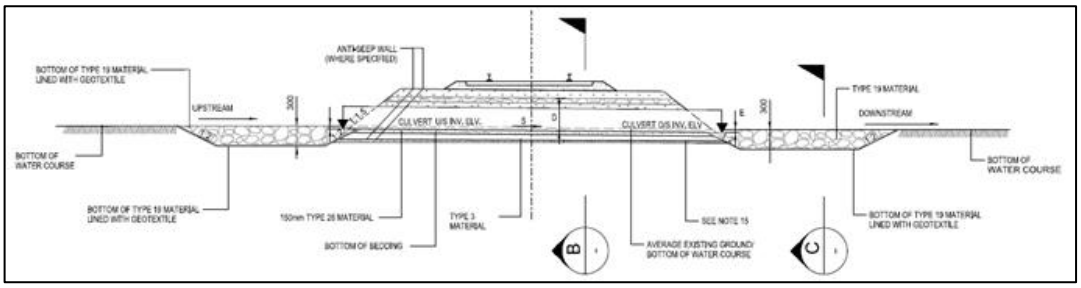

Figure 8-3: Culvert Section with Erosion Protection

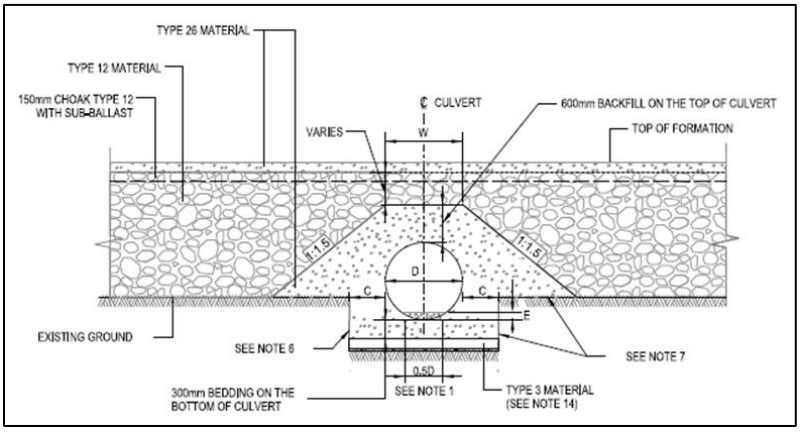

Figure 8-4: Single Pipe Culvert with Minimum Backfill Requirements

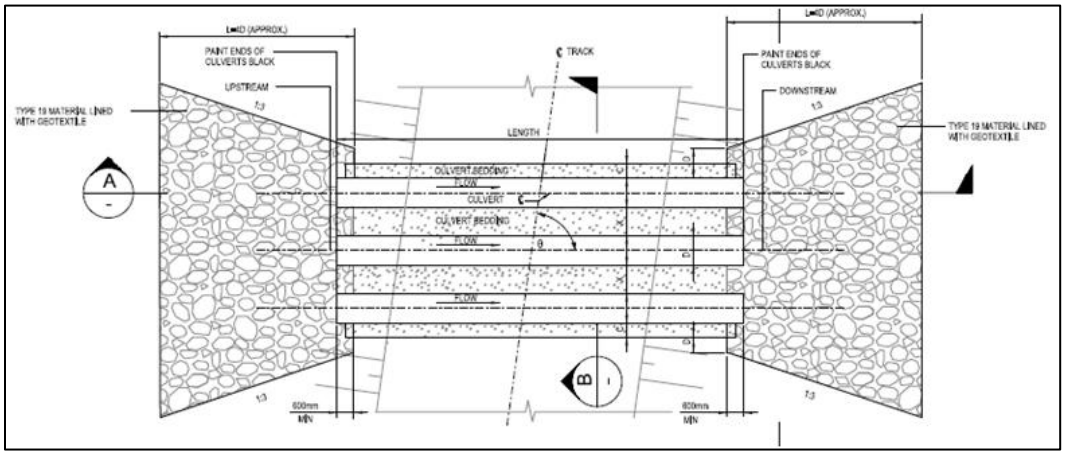

Figure 8-5: Plan – Multiple Pipe Culvert with Erosion Protection

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8.16.3 *Requirements for Fish Bearing Crossings*

8.16.3.1 The following criteria shall apply to fish bearing streams to ensure the protection of fish habitats where culverts need to be installed:

- Identify culverts located in fish bearing crossings.
- Design to assist in minimum disruption of fish migration or movement with reference to over sizing, 20% of diameter below natural stream grade (Figure 8-6), light and appropriate measures to control water velocity through culvert.
- In multiple culvert configurations provide at least in a single culvert the fish passage promoting measures.
- Fish bearing culverts will be assessed on a case by case basis to install appropriate fish passing promoting measures where required.

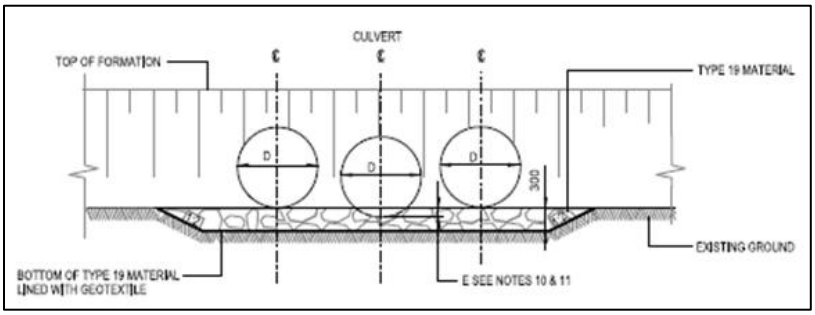

Figure 8-6: Multiple Pipe Culvert with Fish Passing

9. Track

The track design standards have been carried over from document "FULL DESIGN BRIEF 2-04-2012", the Steensby Report, being the property of BIM and reviewed to be a good application of the North American Standards by Consultants experienced in North American and Canadian railway design. A few adjustments have been made which will be highlighted where applicable. Further adaption to minimum standards has been followed to optimize the rail design. A steel tie system will be installed for the optimized approach but the criteria for a wood tie system is included for reference purposes.

9.1 Design Standards

9.1.1 The operating conditions described in Section 4, guide and dictate what standards and procedures is required to provide the infrastructure to support sustainable capacity delivery- and operations for the rail system.

9.1.2 The design of the components is mainly based on AREMA standards and codes of practice and shall conform to CN standards for Class 3 track and the standards and guidelines set forth by the Canadian Transportation Commission (CTC). In the absence of a suitable AREMA standard, other international standards (i.e. UIC, etc.), may be used.

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9.1.3 A full list of all the codes and procedures to consider is provided as Section 2 of this document.

9.2 Track Structure Design Conditions

9.2.1 *Train Loading*

9.2.1.1 The train loadings (design speeds and axle loads) on the track structure associated with the railway are summarized as follows:

Maximum design speed	:	All trains both directions; 75 km/h (loaded and empty)
Annual Traffic	:	Iron Ore Traffic (Dry) 12 Mtpa; (Humid)12.24 Mtpa
Axle Load	:	Ore Train* 32.5 tonnes (all trains)

9.2.2 *Sub-grade Loading*

9.2.2.1 The track structure shall be designed to dissipate train loads through the track structure to produce a maximum loading on the sub-grade of 170 kPa as per Chapter 16 – Section 10.3.2.1 of AREMA.

9.2.3 *Key Track Structure Parameters*

9.2.3.1 The track structure required for the described heavy haul operation can be configured as follows:

- Rail 136 lb RE (67.4 kg/m))
- Welded/jointed sidings. Welded mostly with possible jointed track in yards and
- Ties Timber (178 mm x 229 mm x 2.6 m).
- Tie spacing (mm) 540
- Fastenings Pandrol “e”-clips with 18” Victor tie plates; welded shoulders for steel ties.
- Screw spikes Pandrol “e”-clips with welded rail seat.
- Ballast depth (mm) 300
- Ballast + tie depth (mm) 478
- Ballast shoulder width (mm) tangent/curves 300/350
- Ballast shoulder slope 1V : 1.5H
- Sub-ballast cross-slope 0.00% (Top) 0.00% (Bottom)
- Minimum sub-ballast shoulder width is 0 mm
- Typical cross-sections for main track, siding and yard tracks are shown in the sections below, Figure 9-1 and Figure 9-2 (Drawing H352034-3000-220-294-0003).

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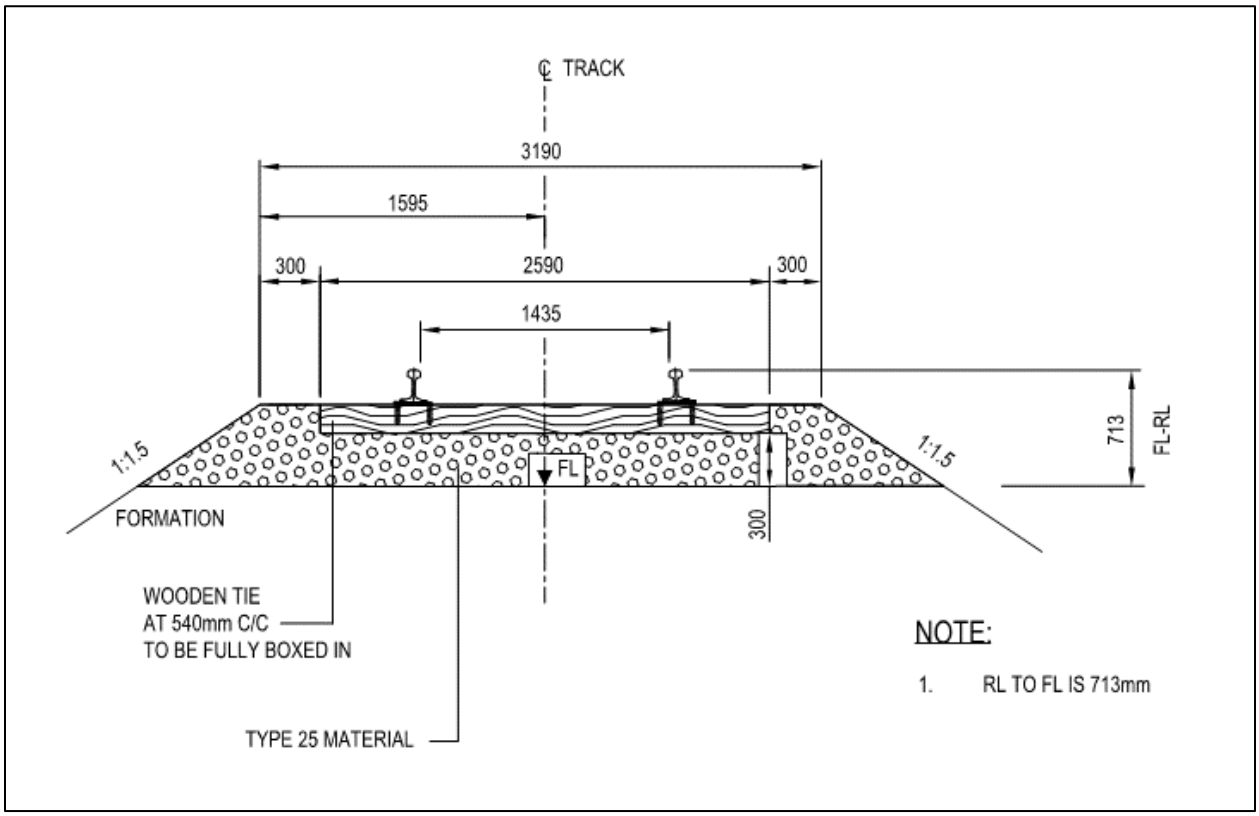

Figure 9-1: Typical Cross Section – Superstructure

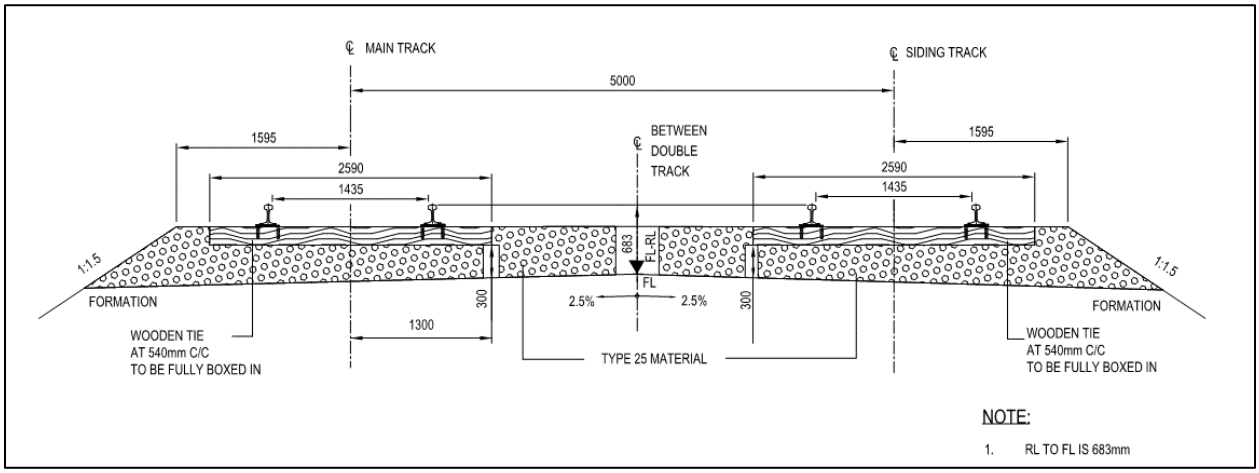

Figure 9-2: Typical Cross Section – Double Track in Sidings – Superstructure

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9.3 Rail

9.3.1 *General*

9.3.1.1 Selection of a rail section for the Baffinland Iron Mines Railway System between Mary River and Milne Port is based on the following criteria:

- Design axle loads.
- Annual tonnage.
- Alignment curvature and gradient.
- Maximum Train design speeds.
- Extreme climate conditions.
- Type of rolling stock.
- Maintenance requirements are somehow compromised with the absence of sub ballast shoulder.
- Ease of welding.

9.3.2 *Rail Dimensions and Tolerances*

9.3.2.1 The rail shall be 136 RE profile for the entire network in accordance with AREMA, Chapter 4.

9.3.2.2 The rail shall be purchased in minimum lengths of 24 m (80 ft.) to support a modular panel installation concept.

9.3.3 *Steel Quality*

9.3.3.1 AREMA, Manual for Railway Engineering, Volume 1, Chapter 4, Sections 2.1.4.1 and 2.1.4.2 list two types of steel, namely, standard chemistry and low alloy chemistry. In addition, the respective tables identify the chemical composition, hardness and tensile properties. With respect to hardness the standard chemistry rail lists two types; standard and high strength rail, while the low alloy chemistry lists three types; standard, intermediate and high.

9.3.3.2 The rail shall be 136RE; AHH grade with minimum yield strength of 130,000 psi, for both mainline track and yard track. The low alloy steel is being recommended on the basis of improved welding characteristics, improved wear characteristics at weld joint areas and superior resistance to wear (longer life).

9.3.3.3 All rails shall be rolled using clean regular carbon steel with an emphasis on the cleanliness of the steel and reduction of inclusions in the rail during the manufacturing process. Premium steel has not been considered due to its predisposition to brittle fracture during extreme cold weather.

9.3.3.4 A major criterion in the selection of a Contractor shall be their ability to roll rails using clean steel and guarantee the durability and cleanliness of the steel in sub -50°C temperatures.

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9.3.4 *Rail End Drilling and Hardening*

9.3.4.1 Rail for use in continuously welded sections shall be supplied undrilled.

9.3.4.2 Rail for use in jointed track shall be drilled to accommodate a 90 mm long, 6-hole joint bar (fishplate). Jointed rail shall only be used in yards and sidings and as such end hardening is not required.

9.4 Ties

9.4.1 *Yards, Mainline and Sidings*

9.4.1.1 All ties shall be untreated hardwood no 1 ties.

9.4.2 *Spacing Tolerance*

9.4.2.1 The tolerance on the tie spacing shall be +/- 10 mm along the mainline and +/- 15 mm in yards and along sidings with no cumulative tolerance over any distance (if in one crib the tie spacing is above the nominal spacing the adjacent crib shall not be above nominal to facilitate continuous action tamping).

9.4.2.2 Tie spacing in the yards and mainline is 540 mm.

9.5 Fastenings

9.5.1 *Steel Ties*

9.5.1.1 Fastenings Pandrol “e”-clips with 18” Victor tie plates (hardwood) for curves with radii <875m with screw spikes.

9.5.1.2 “AREMA” tie plates for curves with radii >875m with cut spikes.

9.6 Ballast

9.6.1 Ballast shall be composed of crushed rock or a material of comparable character and shall be in accordance with AREMA, Chapter 1, Part 2. The ballast material shall be a hard, dense, strong and angular material with a durable particle structure providing sharp corners and cubicle fragments with a minimum of flat and elongated particles. It shall be free from clay, shale or an excess dust or other undesirable substances or materials. The ballast must have high wear and abrasive qualities to withstand the impact of traffic loads and track maintenance by heavy tamping machines without excessive degradation. The ballast must also provide high resistance to temperature change, chemical attack, low absorption properties and should be free of cementing properties.

9.6.2 Testing procedures will be in accordance with the AREMA, Chapter 1, Section 2.8 and conform to ASTM specifications and associated testing procedure, the ballast requirements are prescribed by the code and the Ballast Grading Requirements (AREMA size No. 4) or as in Figure 9-1 below:

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Table 9-1: Ballast Crushed Stone Grading

Nominal Sieve Size (mm)	Percentage Finer Than (By Weight)
73	100
63.0	90 – 100
53.0	40 – 70
37.5	10 – 30
26.5	0 – 5
19.0	0-1
13.2	0

Table 9-2: Ballast Physical Specification

Laboratory Test	Standard	Values
Los Angeles Abrasion Test (LAA)	ASTM C 535-69	< 35% weight loss
Mill Abrasion Test (MA)	Non-standard test	<5% weight loss
LLA + 5(MA)	–	<50%
Degraded Aggregate Cement Value (CV)	Non-standard test	<(1.0 +0.2xMA)
Bulk Specific Gravity	ASTM C127	>2.6
Magnesium soundness test	ASTM C88-76 x 5 cycles	≤8% weight loss
Water Absorption	-	≤1.5%

9.7 Turnouts

9.7.1 *General*

9.7.1.1 Turnout for use on the rail system shall be referred to under the designation relating to the "frog (crossing) number" as described on pages 6-35 and 6-36 in Section 6.5 – Turnouts of the Practical Guide to Railway Engineering, AREMA 2003. Without limiting their completeness, the turnouts shall consist of the following components:

- Switch and crossing assemblies.
- All special and running rails.
- All rail braces, stretcher bars, castings, check rails, other track material, track appurtenances and miscellaneous items required to make the turnout installation complete.
- A complete set of steel turnout ties.

9.7.1.2 The design of the turnouts shall conform to the most recent edition of AREMA Plans and Specifications. They shall be designed to support the operating conditions set forth in the Operating Requirements Section.

9.7.1.3 No. 9 shall conform to the 136 RE rail profile. AREMA standards permit 32 km/h operating speeds through the diverted track for No. 9 lateral turnouts. Operating speed on the mainline is 60 km/h to a maximum of 75km/h as the design speed.

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9.7.2 *Turnout Ties*

9.7.2.1 Track ties for all turnouts within the yard shall be steel ties in accordance with an AREMA No. 9 turnout.

9.7.2.2 Track ties along mainline turnouts shall be steel ties in accordance with an AREMA No. 9 turnout.

9.7.3 *Main Line*

9.7.3.1 The No.9 turnout shall have the geometry conforming to AREMA Plan No. 910-41 with 5,030mm (16 feet 6 inches) straight Samson switch points for standard gauge track. The ties shall be hardwood ties with fastenings designed for this turnout. The tie spacing and lengths shall be in accordance with AREMA specifications.

9.7.4 *Yards and Backtracks*

9.7.4.1 The No. 9 turnout shall have the geometry conforming to AREMA Plan No. 910-41 with 5,030mm (16 feet 6 inches) straight Samson switch points for standard gauge track. The ties shall be hardwood ties and fastenings. The tie spacing and lengths shall be in accordance with AREMA Plan No.912-58 as described in the AREMA, Portfolio of Trackwork Plans for the No. 9 Switches, latest edition.

9.7.5 *Snow Elimination*

9.7.5.1 All mainline and yard turnouts shall be equipped with automatic cold air blowers to ensure that no snow settles between the switch points and the stock rails.

9.8 Joints

9.8.1 *Standard Joint Bars*

9.8.1.1 Joint bars shall be toeless and conform to the profile presented in AREMA, Chapter 4, Part 3, Fig. 4-3-3 for 136RE rail section with the following bolt hole properties:

- Oval shaped with 1-5/16” diameter.
- Track bolts: 1 1/8” x 5 7/8” oval shape.

9.8.1.2 Rail drilling, bar punching and bolts shall be in accordance with AREMA, Chapter 4, Part 3, Table 4-3-1. All nuts and bolts shall be manufactured in accordance with AREMA, Chapter 4, Section 3.5.

9.8.2 *Insulated Joints*

9.8.2.1 Insulated joints are not considered as the signaling and control systems will be radio order controlled for a dark territory systems approach.

9.8.3 *Welded Joints*

9.8.3.1 If the modular installation concept is used the panels will be continuously welded with an on-track butt welding machine. The process shall conform to the requirements of AREMA, Chapter 4, Section 3.1.12. All welds for CWR shall be electric flash-butt welds.

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9.8.3.2 Aluminothermic welds may be used where space does not permit flash-butt welding and for closure welds when de-stressing rails. Aluminothermic rail welds shall be made using full preheat welding kits (molds, charges, etc.), designed for 136RE rail with the metallurgical properties described in the applicable sections

9.9 Other Track Materials

9.9.1 *Guard Rails*

9.9.1.1 Guard rails shall be provided on all tracks installed on bridges and shall extend 20 m beyond either side of the structure. They shall also be provided in locations such as running in close proximity to sensitive water bodies.

9.9.1.2 Guard rails shall be designed in accordance with AREMA, Chapter 7, Section 3.6.2. They shall consist of 2 additional rails located inside the running rails. All guard rails shall be fastened using 12" tie plates for 5 ½" rail base width as per AREMA, Chapter 5, Part 1, Section 1.3, Figure 5-1-4 and standard spikes. It is not required for guard rails to have the same section as the running rails and may be second hand rail with the same base of rail dimension.

9.9.2 *Derails*

9.9.2.1 Derails shall be installed wherever the possibility exists that equipment left standing on tracks, other than main tracks or sidings may be moved by wind, or gravity, or both, so as to obstruct a main track or siding. Derails shall be installed on both ends of tracks where unattended locomotives are regularly stored.

9.9.2.2 The sliding derail shall be the preferred derail, as it provides derailing protection for all types of cars and units that are stored on sidings or backtracks regardless of the grades involved.

9.9.2.3 The model, size and hand of derail shall be selected to match the specific rail section height. A right hand or left hand derail shall be used where derailing protection is required (a right hand derail is one which derails to the right when looking in the direction of the movement to be controlled).

9.9.3 *Stop Blocks (Bumping Posts)*

9.9.3.1 Bumping posts shall be provided at the ends of all dead end tracks. All bumping posts shall be steel fabricated triangle units compatible with 136RE rail sections. In addition, they shall be equipped with a strengthening "middle rail" and a shock-free cushion head.

9.10 Track Signs

9.10.1 The design of the line shall make provision for appropriate way-side signs required for the safe operation of trains. Signs shall be provided for:

- Whistle posts.
- Kilometer and half kilometer point markers.
- Permissible running speeds.

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- Bridge structure and major river identification.
- Station (siding) names.
- Registered clearance and bridge markers.
- Snow and flangers.
- Derails.
- Yard limits.
- Level crossings (Skidoo crossing and animal crossing signs); and
- Other miscellaneous signs required for safe operation.

9.10.2 Way-side signs shall be provided in English and Inuktituk. The design of all signs shall follow the guidelines in AREMA, Chapter 1, Part 7.

9.10.3 Optimization and appropriate elimination of track signs will be pursued further in the feasibility study.

9.11 Crossings

9.11.1 *Crossings and Refuges (Set-offs)*

9.11.1.1 At various locations along the rail line, refuges or set-offs and vehicle crossings are required to accommodate the entrance and exit of track maintenance vehicles. All set-offs shall be constructed using a set of 205 mm (8 in) x 205 mm (8 in) wood planks fastened to the ties using suitable hook bolts. A minimum of 76 mm (3”) shall be maintained between the gauge face of the rail and the nearest wood plank to ensure the wheel flange of rail cars will not be impeded.

9.11.1.2 The track structure shall remain the same as the typical cross-section shown in the cross section drawings and Figure 4-4 in Section 4 above. Road base Type 26 fill material shall be used as an approach material and shall be graded flush with the timber planks between the rails on top of the ties.

9.11.1.3 Where crossings are required in yards, wooden track ties shall be substituted for the ties in the standard yard track structure.

9.11.2 *Animal Crossings*

9.11.2.1 To assist the caribou in crossing over the track the following typical detail illustrates the proposed crossing. A total of 11 crossings has been included in the design and the final locations will be confirmed by BIM.

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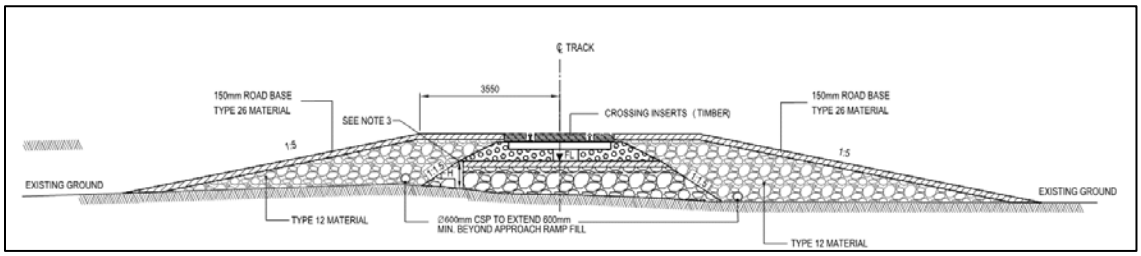

Figure 9-3: Typical Cross Section – Caribou Crossing

9.12 Clearances

9.12.1 *Clearance Diagrams*

9.12.1.1 The clearance enveloped developed is based on Transport Canada's *Standards Respecting Railway Clearances* (TC E-5) and the general clearance envelope outlined in AREMA, Chapter 28, Section 1.2, Figure 28-1-1.

9.12.1.2 The TC E-5 also requires a lateral allowance for track curvature of 25.4 mm per degree of curvature.

Table 9-3: Lateral Clearance Requirements for Curved Track

Curve Radius (m)	Curve Radius (degrees)	Additional Lateral Clearance (mm)
1746	1	25.4
873	2	50.8
582	3	76.2
436	4	101.6
349	5	127
291	6	152.4
249	7	177.8
218	8	203.2

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9.12.2 *Track Spacing*

9.12.2.1 The design of all tracks shall respect the track spacing defined in Table 9-4.

Table 9-4: Track Spacing

Facilities	Minimum Track Spacing - TCE-5(m)	Design Spacing (m)
Tangent Tracks between Mainline and Sidings	4.27	5.00
Yard Tracks	4.11	≥ 5.0 (Purpose made)
Parallel Ladder Tracks	5.49	5.50

9.12.2.2 The minimum distance between track centers shall be increased by 50.8 mm (2”) per degree of curvature. A 5.0 m track spacing shall be used to provide an allowance for curves up to 4 degrees (R=436 m). If a siding curve adjacent to a mainline track exceeds 4 degrees then an additional track spacing of 50.8 mm per degree is required.

9.12.3 *Right-of-Way Fencing*

9.12.3.1 The railway right-of-way shall not be fenced and neither the yards and terminals.

9.13 Track Construction

9.13.1 The specific requirements shall be in accordance with AREMA, Manual of Railway Engineering, Volume 1, Chapter 5, Part 4 and Part 5. These shall be developed and detailed in the specifications. The requirements shall consider the current, most appropriate construction practices and methods that are expected of an international contractor. The use of heavy automatic mechanized machinery will be required. It is expected that bidders will be provided an opportunity to propose alternate methods to construct the track structure that meets the requirements at the most economic cost.

9.14 Track Maintenance

9.14.1 *Track Maintenance Conditions*

9.14.1.1 Sub ballast shoulders have been scaled down to zero for the optimizing exercise. In certain areas particularly with high embankments, long term slow settlement is anticipated due to ice creep. These locations will need to be revisit during the Mary River Expansion Study – Stage II in order to consider wider sub ballast shoulders to suit.

9.14.2 *Maintenance of Way Vehicles*

9.14.2.1 All track maintenance vehicles must be equipped for cold-weather conditions including supplemental heating (portable heaters) and storage for arctic survival equipment. A list of the maintenance of way (MoW) vehicles required is shown in the Operating Plan.

9.14.3 *Maintenance Bases and Sidings*

9.14.3.1 Infrastructure maintenance teams shall be based at both Mary River and Milne Port, the principal shop of MoW equipment shall be in the Consolidated Maintenance Facility at Milne.

9.14.3.2 The main line siding is provided with a back track for MoW use. Siding location will still be confirmed

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10. Rolling Stock

10.1 Locomotives

10.1.1 The locomotives must be diesel-electric locomotives and be able to operate in the harsh and extreme cold environment. Locomotives that are successfully operated under these extreme cold conditions are the EMD SD70 ACEM and the General Electric (GE AC4400) locomotives. The new AC traction motor configuration provides more optimized energy consumption and will be the preferred locomotives for this application.

10.1.2 The locomotives to be standard gauge configuration in order to run on 1435 mm gauge. The locomotives to be equipped with dynamic braking capability as well as distributed power (cable and radio control capability) in order to run multiple locomotives on the train. Each locomotive to be connected with the back to the train and cab facing forward, as there is no balloon at the port or the mine sites for the train to turn around. The locomotives need to be equipped with F-type couplers that can absorb the maximum pull and compression force of 1600 kN. The locomotives to be equipped with airbrake braking system.

10.1.3 The locomotive must have a co-co bogie configuration as the axle loading on the perway will be designed for 32.5 tonnes per axle loading, so typical 198 metric tonnes and 33 tonnes axle loads.

10.1.4 The locomotives must be equipped with an onboard toilet facility.

10.2 Cars

10.2.1 The ore cars to be of standard gauge configuration with 1435 mm gauge and the open top gondola type car that can be tipped by means of a rotary tippler. The cars must be coupled by means of a rotating coupler on each side of the car. This will enable the off-loading of a single car per cycle through the single cell rotary tippler.

10.2.2 The cars must be equipped with an air-brake braking system and the drawbar and coupler configuration must be the F-type coupler.

10.2.3 The ore cars will be designed to accommodate a maximum loaded axle load of 32.4 tonnes per axle and must be equipped with self-steering bogies.

10.2.4 The car must have a tare weight of 22 metric tonnes.

10.2.5 The cars must fit within the minimum rail structure gauge tolerances at a width of 5750 mm. This value is based on the AREMA clearance box width of 5486 mm plus an allowance of 80 mm per degree of track curvature at a maximum curvature of 3 degrees. At the bottom corners, structure may intrude into a triangle that is 1220 mm high by 915 mm wide at the base.

10.2.6 Height: 7010 mm from top of rail.

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10.2.7 The rail structure clearance gauge for both locomotives and cars are indicated by the drawing below:

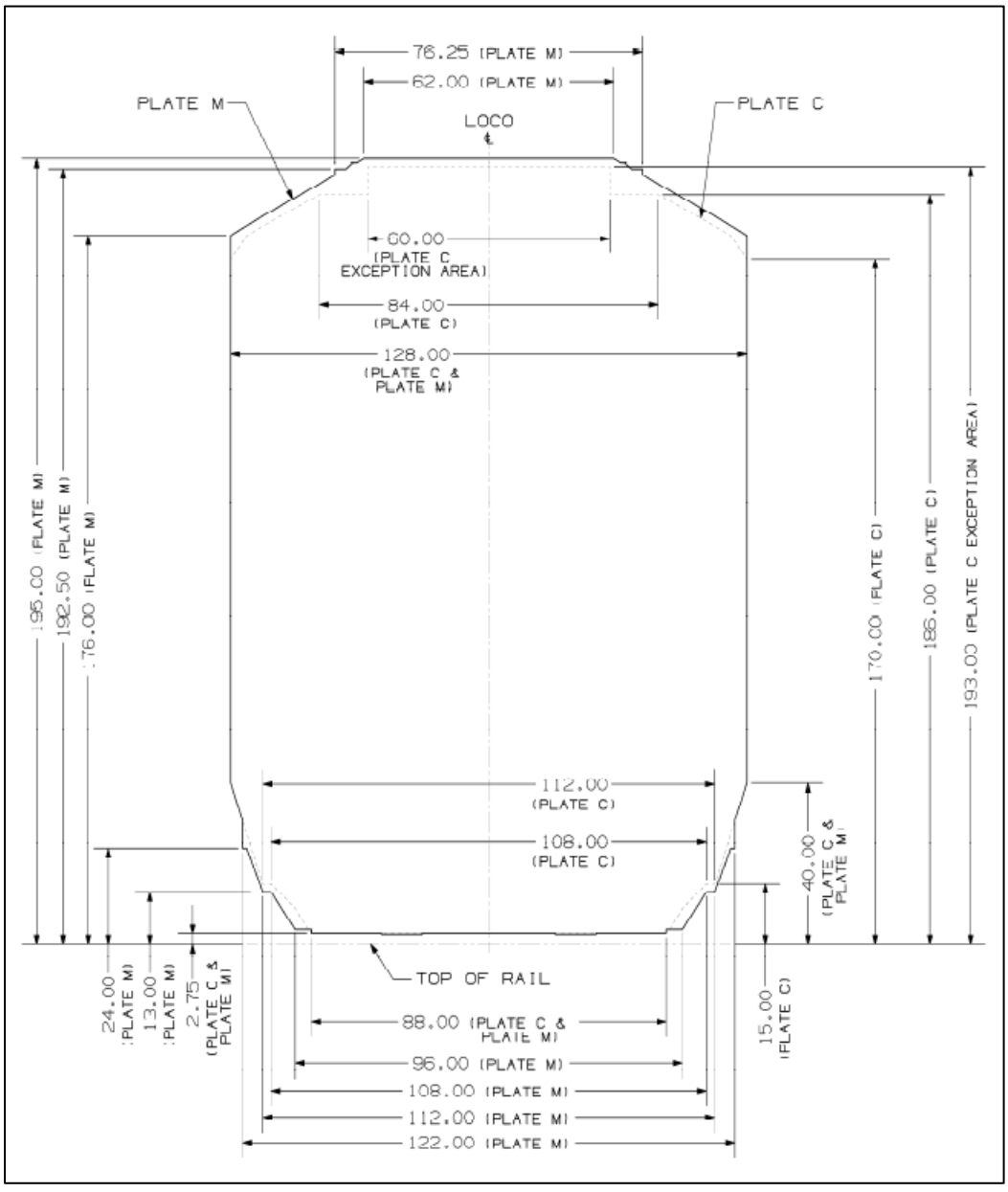

Figure 10-1: Structure Gauge Plate M

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11. Rolling Stock Facilities

11.1 Functional Design Criteria for Diesel-Electric Locomotive Depot

11.1.1 The new locomotive maintenance depot facility will be located at the port of Milne and must be designed to perform all maintenance activities on the diesel-electric locomotives that will be used for the main line operation as well as for the shunt mobile located at the maintenance facility. The original designed facilities have been scaled down on floor space for the optimized operations, office requirements and other amenities have been planned to be modular prefabricated units.

11.2 Main Workshop Facility for Diesel-Electric Locomotives

11.2.1 The facility must provide for minor and major repairs which must include for A, B and C shedding that will include but not be limited to the following activities:

- Unscheduled repairs.
- Scheduled repairs.
- Unscheduled maintenance.
- Scheduled maintenance.
- Component exchange (Blower motors, traction motors, compressors, radiators, turbo charger, alternator, electronic control cards, valves, cables etc.) Repair of these components will be by OEM's).
- Wheel cutting.
- Minor engine repairs.
- Fuelling.
- Sanding.
- Attend to driver trip report faults.
- Oil top-up on sub-systems.
- Electronic cards/modules exchange.
- Toilet servicing.

11.2.2 The locomotive maintenance facility must be fully enclosed in a maintenance building/shed and one locomotive must be able to be serviced in the facility at any given time. The servicing line must be equipped with a pit that will allow maintenance staff to enter underneath the locomotive when stationary on the rail line inside the workshop. Access stairs to be provided at both ends of the pit and adequate lighting to be provided inside the pits.

11.2.3 Mobile scissor jack platforms will be provided to allow maintenance staff to obtain access to both sides of the locomotives and perform maintenance activities. The scissor jack platforms must also be able to lift small components (max. 500 kg) that must be installed on the locomotive. Further consideration to fixed working platforms will be given during the feasibility phase.

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11.2.4 One overhead crane with a capacity of 45 tonnes must be provided to traverse the locomotive area and 10t for the car workshop area and move heavy components within the depot. A forklift with lifting capacity of 15 ton will be used for other lifting activities inside the workshop.

11.2.5 The locomotive inspection platforms and pit areas will be equipped with 380V and 220V power connections as well as compressed air sockets for electrical and pneumatic maintenance tools being used by the maintenance staff.

11.2.6 The pits will be designed to allow for easy construction as well as allow the cleaning of the locomotive below deck equipment and bogies during inspection cycles. The floor design allows for the drainage and collection of effluent from the pit area which will then be treated on site. Adequate light to be provided inside the pits in order for staff to perform inspections. These lights must be waterproof and adhere to IP65 standards.

11.2.7 The locomotive maintenance facility must be able to maintain the dedicated locomotive fleet of 5 mainline diesel-electric locomotives and one shunt mobile.

11.2.8 The facility must have adequate space for storage of locomotive components in the prescribed manner and this facility must form part of the main shed structure.

11.2.9 Office provision must also be made to accommodate the required staff levels at the depot and must link to the main shed structure.

11.2.10 The locomotive daily servicing and provisioning will take place on the departure siding by means of mobile fueling, sanding and maintenance equipment.

11.3 Main Workshop Facility for Iron Ore Cars

11.3.1 The requirement for car maintenance on the dedicated gondola type fleet is that all maintenance activities will be conducted at the new Milne car maintenance depot.

11.3.2 All scheduled and unscheduled work will be conducted at this new facility.

11.3.3 The maintenance cycle of the iron ore car fleet is based on a 2 year lifting cycle which is derived from the annual kilometres travelled and the associated hollow wear on the wheel sets.

11.3.4 Designs of the car maintenance workshop have been scaled down to accommodate two ore cars per cycle in the workshop.

11.3.5 The following ore car maintenance facility functional design criteria was used in the design of the facility:

- Light repairs.
- Scheduled maintenance.
- Unscheduled maintenance.
- The facility must be able to handle two ore cars in the enclosed area.

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- The maintenance facility must be located such that quick turnaround time of cars to be serviced can be achieved.
- Calculations for workshops are based on 365 working days per year.
- Working of day time shifts only.
- Wheel set changes are required at 4 mm hollow wear limit.
- Maintenance on ore car components are based on an exchange principle and sub component repairs are send away for repairs.
- The ore car maintenance facility must be able to maintain the dedicated ore car fleet of 168 cars.
- The facility must be designed to handle the 2, 4, 6, 8 year maintenance cycles for liftings on the cars and equipment must be able to conduct all these scheduled liftings in the depot.
- The depot must be equipped with lifting jacks that can conduct body and bogie lifts inside the main structure of the depot.
- A separate bogie repair area adjacent to the lifting line must be provided to conduct all maintenance on bogie frames, wheels, sub-assemblies, brake systems, couplers, draw gear and body repairs.
- Provision must be made for full brake system testing after the lifting process and must be conducted by means of a single car brake testing system.
- Provision must also be made in the maintenance depot for a wheel lathe that will be required to cut and profile car wheels of the ore car fleet. The locomotive wheel cuts will be performed by means of a portable wheel lathe which will not require a body lift of the locomotive,
- The facility must have adequate space for storage of car components in the prescribed manner and the facility must be linked to the main shed structure.
- Office provision must also be made to accommodate the required staff levels at the depot and must be linked to the man shed structure.
- Provision must be made for store of the following items: oil, rubber pipe, cleaning agents, small parts, coupler and draw gear, bearings, brake valves, knuckles, seals, gas bottles, lubricants and filters and must be linked to the main shed structure.

11.3.6 The following activities will be conducted at the ore car maintenance facility:

- Scheduled repair.
- Unscheduled repair.
- Body repairs.
- Bogie repairs.
- Wheel cutting and re-profiling.
- Bearing replacements.

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- Bogie frame repairs and alignment.
- Draw gear replacement.
- Brake system component replacement.
- Body Painting and Stencilling.

11.4 Rolling Stock Maintenance Facility Stores and Offices

11.4.1 The rolling stock maintenance workshop is designed as a single building that provides space for the locomotive repair and car repair. Stores and offices have been moved adjacent to the workshop in modular format for the optimizing process.

11.4.2 The stores for both locomotive and ore car spares are located on the ground floor of the workshop facility and offices are housed adjacent to the workshop. The stores layout is designed with separate areas for locomotives and cars. Provision must be made for parts received- and dispatch counters with the actual stores located in-between. Space allowance must be made based on the spares requirements of the cars and locomotives.

11.4.3 The bigger component store is equipped with wider doors to allow the delivery and collection of heavy parts by means of a forklift directly from the workshop area. An open area store for larger and heavier components is allowed for. The smaller store areas must be equipped with shelving to increase storage space of the smaller components. The store for small parts provides access for individuals only with no need for access for forklifts.

11.4.4 Allowance must also be made for a dark and ventilated store room required for all the rubber pipes and seals. Provision must also be made for a locomotive battery store with battery recharging equipment and with suitable ventilation.

11.4.5 Provision is made for two compressor rooms that house a compressor for the car brake testing bays and a separate compressor that will supply air to the rest of the car and locomotive workshop areas. A separate gas and cleaning agent store must be provided and these are all situated outside the main building, some 25 m away from the main maintenance building. A run-off water collection treatment facility must be provided for the effluent generated inside the workshop area and must be disposed after treatment.

12. Design Criteria Summary

12.1 This Section is a high level tabular summary of the design criteria covered in the preceding Sections of this design rational for the major elements of the optimized track, supporting infrastructure, operations and rolling stock for the railway between Mary River Mine and Milne Port associated with the Expansion Study – Stage II upgrades.

12.2 The tables also provide cross reference to the section numbers where these criteria are discussed.

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Table 12-1: General Design

Item	Element	Design Criteria	Section
1.	Project Language	Canadian English	1.5
2.	Rail Classification	Standard Gauge- heavy Haul Railway	1.6
3.	Design Context	Mainly AREMA based, and all codes specified	1.7
4.	Units of Measure	International System (SI)	1.10

Table 12-2: Site Conditions

Item	Element	Design Criteria	Section
1.	Site Conditions	Defined Table 3.1	3.2
2.	Design Base	Standard Specification (H349000-S003120)	3.2

Table 12-3: Operations

Item	Element	Design Criteria	Section
1.	Ore Traffic	12 Mtpa (12.24 Mtpa – wet (2%moisture))	4.1.3
2.	Locomotive Axle Load	33 tonnes	4.2
3.	Car Axle Payload - Initially	30 tonnes	4.2
4.	Maximum Car Axle Load	32.5 tonnes	4.2
5.	Train Design Speed	75 km/h	4.3
6.	Operating Speed	60 km/h	4.3
7.	Locomotives per Train	2	4.4.2
8.	Cars per Train	80	4.4.2
9.	Train Design Length (80)	900 m	4.5
12.	Gross Weight Loaded (72)	9750 tonnes	4.5
13.	Gross Weight Empty (72)	1974 tonnes	4.5
14.	Net Weight (72)	7776 tonnes	4.5
15.	Trainloads per day (72)	6 Loads/day	4.5

Table 12-4: Alignment

Item	Element	Design Criteria	Section
	Horizontal Alignment		**5.2**
1.	Minimum off-set from Tote Road	15 m	5.2.1
2.	Curve Radius Target	≥ 1000 m	5.2.2
3.	Curve Radius Minimum Target	500 m	5.2.2
4.	Curve Radius Absolute Minimum	230 m	5.2.2
5.	Transition Curves R > 300 m	80 m	5.2.3
6.	Transition Curves R ≤ 300 m	60 m	5.2.3
7.	Tangent Length between Reverse Curves	20 m	5.2.4
	Vertical Alignment		**5.3**
1.	Vertical Curve rate of Change	0.040 m/20 m/20 m; K=100	5.3.1
2.	Ruling Gradient facing Loaded	1.5% (1:67)	5.3.2
3.	Ruling Gradient facing Empty	2.0% (1:50)	5.3.2
4.	Exceptional facing Empty < 775 m	3.0% (1:33)	5.3.2
5.	Allowed Facing Empty > 775; G>1% to follow	2.2% (1:45)	5.3.2
6.	Grade Compensation for G=1:X in Radius (R)	1: 20/((20/X)-(14/R)).	5.3.3
7.	Gradients in Passing Track	0 to 0.25%	5.3.2.11
8.	Exceptional facing Empty < 775 m	0 to 0.125%	5.5.2.5
9.	Allowed Facing Empty > 775; G>1% to follow	0 to 0.1%	5.5.2.6

Table 12-5: Earthworks

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Item	Element	Design Criteria	Section
	Embankments		**6.2**
1.	Typical Side Slopes	1V:1.5H	6.2.1
2.	Sub Ballast Layer 150 mm	Type 26 Crushed Rock	6.2.2
4.	2nd Layer 550 mm in Non-Susceptible & Potentially Susceptible to Ice soils, choked with Type 26	Type 12 run of quarry rock fill	6.2.2
5.	2nd Layer 1350mm in Moderately Susceptible & Highly Susceptible to Ice soils, choked with Type 26	Type 12 run of quarry rock fill	6.2.2
6.	Geotextile below 1350 mm layer	1800 g/m² Stiff Woven	6.2.2
	Sub-grade Cuttings		**6.2.3**
1.	Cut side slopes in rock	1V:8H	6.2.3
2.	Cut side slopes ice rich soils	1V:2H (for pre feasibility)	6.2.3
3.	Layer Work, Geotextiles and Polystyrene Insulation	Section 6.2.2	6.2.2
4.	Grading Layer Works	Table 6-3 to 6-5	6.5
5.	Recovery of cut frozen ground for fills	Cut to spoil for FS	

Table 12-6: Hydrology

Item	Element	Design Criteria	Section
1.	Design Peak Flows	Extrapolated from Tote study	7.2.1
2.	Flood Return Period	200 years	7.2.2
3.	Design Flows	Q100: V = 3m/sec	7.2.3

Table 12-7: Bridges and Culverts

Item	Element	Design Criteria	Section
1.	The design Criteria for Bridges and Culverts are already in concise summarized format and very comprehensive in the Section indicated		8

Table 12-8: Track

Item	Element	Design Criteria	Section
	Track Superstructure – Rail		**9.3**
1.	Mainline, sidings and yards	136 RE	9.3.2
2.	Mainline Joints	Welded	9.3.2
3.	Yard & Siding Joints	Jointed and Welded	9.3.2
4.	Mainline Ties	Untreated Hardwood Ties	9.4.1
5.	Yard & Siding Ties	Untreated Hardwood Ties	9.4.1
6.	Mainline Tie Spacing	540 mm	9.4.1
7.	Yard & Siding Tie Spacing	540 mm	9.4.3
8.	Curves < R400m Tie Spacing	540 mm	9.4.3
9.	Mainline, sidings and yards Fastenings	Pandrol “e”-clips	9.5.1
10.	Mainline Turnouts	AREMA No. 9	9.7
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	Ballast		**9.6**
1.	Ballast Shoulder General	300 mm	9.6
2.	Ballast Shoulder on outside of Curves < 350m	600 mm if LWR	9.6
3.	Ballast Volume	1600 m³/km	9.6
4.	Sub Ballast Depth	150 mm	9.6
5.	Ballast cover between Sub Ballast & Tie	300 mm	9.6
6.	Ballast +Tie Height	312 mm	9.6
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8.	Ballast Grading & Properties	Table 9-1 and 9-2	9.6

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Table 12-9: Yards and Sidings

Item	Element	Design Criteria	Section
	Milne Tippler Yard		**4.7.3**
1.	Loading Lines	Part of Mainline km's	4.7.3
2.	Departure Loop	900 m	4.7.3
3.	Loco Run-around Loop	347 m	4.7.3
4.	Loco Workshop Spur	390 m	4.7.3
5.	Car Workshop Spur	215 m	4.7.3
6.	Bad Order Car Spur	205 m	4.7.3
7.	Good Order Car Spur	160 m	4.7.3
8.	Quarry Spur and Y	400 m	4.7.3
9.	Cross Over	120 m	4.7.3
	Passing Loop (km's 56.017 to 57.490)		**4.7.1**
1.	Siding	900 m	4.7.1
2.	Back Track	350 m	4.7.1
	Mary River Mine Yard		**4.7.2**
1.	Loading Line right through to Stop Block	Part of Mainline km's	4.7.2
2.	Departure Siding	900 m	4.7.2

Table 12-10: Rolling Stock

Item	Element	Design Criteria	Section
	Locomotives		**10.1**
1.	Fleet Size	4+1 for exchange	4.4.2
2.	Locomotive Type	Diesel Electric	10.1.1
3.	Traction	AC Traction Motors	10.1.1
4.	Horsepower	3,280 kW	10.1.2
5.	Special Specifications	Extreme Cold Weather	10.1.2
6.	Co-Co	6 axles	10.1.3
7.	Minimum Axle load	32 tonnes/axle	10.1.3
8.	Maximum Axle load	33 tonnes/axle	10.1.3
9.	Maximum Length	23 m	10.1.3
10.	Vehicle Gauge	"Plate M" AAR S-2028	10.1.1
11.	Loco Wheel track Gauge	Standard 1,435 mm	10.1.1
	Ore Cars		**10.2**
1.	Fleet Size	180	4.4.2
2.	Car Tare Weight	22 tonnes	10.2.3
3.	Maximum Payload @ 32.5 t/axle	108 tonnes	10.2.3
4.	Coupler to Coupler Length	10.5 m (10.65m incl. Stretch)	10.2.4
5.	Car Width	3.2 m	10.2.4
6.	Maximum Car Height	7.01 m from top of rail	10.2.4

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Table 12-11: Rolling Stock Facilities

Item	Element	Design Criteria	Section
	Locomotive Service (in line servicing in the yards)		**11.2**
1.	• Re-Fueling • Sanding • Provisioning and Hygiene • Lubrication • Daily Service Tasks • Attend to driver trip report faults • Oil top-up on sub-systems • Electronic cards/modules exchange • Windscreen replacement • Windscreen wipers replacement	Mobile equipment & provisioning done on departure siding.	11.2.10
	Locomotive Maintenance Facility		**11.2**
2.	• Unscheduled repairs • Scheduled repairs • Unscheduled maintenance • Scheduled maintenance • Component exchange (Blower motors, traction motors, compressors, radiators, turbo charger, alternator etc.). • Wheel cutting • Engine repairs	1 track extended outside workshop;1 locomotive	11.2.1
	Car Maintenance Facility		**11.3**
3.	• Scheduled repair • Unscheduled repair • Body repairs • Bogie repairs • Wheel cutting and re-profiling • Bearing replacements • Bogie frame repairs • Draw gear replacement • Brake system component replacement • Body Painting and Stencilling.	1 track 2 cars	11.3.6
	Stores and Offices		**11.4**
4.	• Loco and Car shops under one roof • Stores accommodated inside the building and modular offices outside and linked to workshop	2 track bays, parts exchange and repair and other facilities integrated	1.4.1 to 11.4.5

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ATTACHMENT 6

RAILWAY DESIGN INFORMATION

6.1 North Railway Terrain Analysis
6.2 North Railway Geotechnical Investigation Factual Data Report
6.3 North Railway Geotechnical Embankment Report
6.4 Quarry Geochemical Evaluation
6.5 North Railway Catchment Drawings
6.6 Diagrammatic Conceptual Layout
6.7 North Railway Plan & Profile Drawings
6.8 Km57 Temporary Ore Transfer Area Drawings
6.9 Rail Embankment Drawings

ATTACHMENT 6.1

NORTH RAILWAY TERRAIN ANALYSIS

Baffinland Iron Mines Corporation

2

Site Assessment of North Railway Alignment

2

H352034-1000-220-068-0001

			Warren R. Hoyle	Warren R. Hoyle		
2017-10-04	2	Approved for Use	S. Hinchberger	W. Hoyle	S. Heiner	M. Weaver
2017-10-03	1	Approved for Use	S. Hinchberger	W. Hoyle	S. Heiner	M. Weaver
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DATE	**REV.**	**STATUS**	**PREPARED BY**	**CHECKED BY**	**APPROVED BY**	**APPROVED BY**
HATCH						**Client**

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2

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This report contains the expression of the professional opinion of Hatch, based upon information available at the time of preparation. Hatch has conducted this investigation in accordance with the methodology outlined herein. It is important to note that the methods of evaluation employed, while aimed at minimizing the risk of unidentified problems, cannot guarantee their absence. The quality of the information, conclusions and estimates contained herein is consistent with the intended level of accuracy as set out in this report, as well as the circumstances and constraints under which this report was prepared.

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Waiver, Release and Indemnification

To: Hatch Ltd. together with its affiliates, the "Consultant"

Re: Site Assessment of North Railway Alignment, (and together with any subsequent revisions thereof, the "Report") dated April 21, 2017 prepared by the Consultant for Baffinland Iron Mines Corporation (the "Client"), in respect of the drilling, soil and rock sampling along a proposed railway alignment and laboratory testing of samples. 2

The undersigned hereby:

(a) acknowledges that it wishes to receive a copy of the Report from the Client and that a condition precedent to the provision of the Report to the undersigned is that it sign and deliver to the Consultant this Waiver, Release and Indemnification; and

(b) irrevocably and unconditionally:

(i) waives, releases and disclaims any and all suits, actions, proceedings, claims and any other rights (whether in tort, contract or otherwise and whether past, present or future) that it has or may have against or in relation to the Consultant in respect of or in connection with the Report;

(ii) agrees to maintain the Report and the information in the Report strictly confidential and not to provide the Report or any information contained in the Report to any third party without the prior written consent of the Consultant;

(iii) agrees to indemnify, defend and hold harmless the Consultant from and in respect of any suits, actions, proceedings, claims, damages, costs and expenses suffered or incurred by the Consultant and which relate to or result from the use of the Report by the undersigned or the provision by the undersigned of the Report or any of the information set out in the Report to any third party; and

(iv) agrees that the waivers, releases, disclaimers and indemnifications set out above will apply even in the case of the fault, negligence or strict liability of the Consultant and will extend to the officers, directors, employees, agents, representatives, sub consultants and related entities of the Consultant.

Dated: [insert current date]

[INSERT NAME OF REPORT RECIPIENT]

By:_____

Name:

Title:

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1. Introduction

Baffinland Iron Mines Corporation (BIM) operates a Direct Shipping Ore (DSO) Iron Ore mine on Baffin Island, Canada. The current operation (the Mary River Expansion Project) comprises a DSO iron ore mine at Mount (Mnt) Nuluujaak, a camp and associated operating infrastructure located just south of Mnt Nuluujaak, and a port with infrastructure and camp at Milne Inlet. Currently, ore is crushed at the Mary River site, loaded onto B-train haul trucks and transported to the Milne Port on a haul road referred to as the Tote Road. Current production target for this year is 5 Mtpa.

Hatch has been retained by BIM to study the option of a pit-to-port railway for the Mary River Expansion Project. The objective of the study is to expand production to 12 Mtpa and reduce the unit operating cost.

Between September 7 and 14, 2016, Dr. Sean Hinchberger, a Senior Geotechnical Consultant at Hatch, visited the Mary River Expansion Project to inspect the proposed rail alignment and alternatives, identify potential quarry sources for the railway earthworks, and inspect the terrain with attention given to the types of permafrost. This report summarizes the work performed during the site visit as well as the main observations.

2. Methodology

2.1 Geological Review

The following bedrock and surficial soil (geological) maps were reviewed prior to undertaking the site visit. The maps were ‘ground truthed’ during the site visit in order to assess if they are appropriate for use as a basis for the Feasibility Study supplemented with boreholes. Modified versions of the reference maps are attached in Appendix A:

- Little, E.C., Holme, P.J., and Kerr, D.E., 2013. Surficial Geology Icebound Lakes (Southwest) Baffin Island, Nunavut, Geological Survey of Canada Map 74 (preliminary), scale 1:100,000
- Dyke, A.S. 2000, Surficial Geology Phillips Creek, Baffin Island, Nunavut, Geological Survey of Canada, Map 1961A, scale 1:250,000
- Jackson, G.D., Morgan, W.C. and Davidson, A., 1975. Geology Icebound Lake District of Franklin, Geological Survey of Canada, Map 1451A, scale 1:250,000
- Blackadar, R.G. and Davison, W.L., 1968, Geology Phillips Creek District of Franklin, Baffin Island, Geological Survey of Canada, Map 1239A, scale 1:253,440

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2.2 Helicopter Inspections

The author undertook site induction training on September 7, 2016, and developed a work plan on September 8, 2016, with assistance from Jim Mallard and BIM's Exploration and Environmental Teams. The following helicopter assisted inspections were performed in accordance with the work plan:

- September 9, 2016: The author visited a series of locations between Chainage (CH) 10+000 and CH 100+000 on the Tote Road in order to observe and photograph the terrain. The initial inspections confirmed the general accuracy of the geologic maps and enabled the author to identify potential quarry sites considered to be suitable for the railway construction.
- September 11; 2016: The author resumed helicopter inspections on September 11, accompanied by BIM's archeologist (Claude Pinard, Consultant). Potential quarry sites and ice rich permafrost zones were examined as well as the main archeological sites situated adjacent to the Tote Road and Philips Creek. The author gained an understanding of typical archeological constraints, assessed the quarries and obtained rock samples from the quarries for durability and soundness testing.
- September 12, 2016: The remaining quarry sites were inspected, rock sampling was completed, and the rail deviation from CH 60+000 to CH 80+000 was examined.

3. Observations

3.1 Photographic Record

The site visit photographic record is attached in Appendix B. Sixty-three photographs were selected for the record. The photographs are numbered sequentially starting from the north end of the Tote Road near the Milne Port and working south toward the mine site. The photographs were taken using a digital camera equipped with a GPS (Global Positioning System) and their location and view direction are illustrated on the attached Drawing H352035-GEOSKT-229-292-0002; Sheets 1 to 4 (see Appendix B).

Drawing H352035-GEOSKT-229-292-0002 also shows the rail alignment and the terrain types adjacent to the railway as digitized from the surficial geologic maps listed in Section 2.1. Fifteen potential quarry sites were also identified and are labeled PQ01 to PQ15 and plotted on the above noted drawing. The following sections discuss the terrain and potential quarry locations with reference to the photographic record.

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3.2 Terrain Evaluation

3.2.1 CH 0+000 to 10+000

The proposed railway alignment between CH 0+000 and 10+000 is situated mainly on either till (silt, sand and some gravel) or glacial outwash terraces (gravelly sand). Locally, the alignment encroaches on a ridge of granitic bedrock that is oriented parallel to Philips Creek and situated approximately 500 m east of the Tote Road. It was intended to locate the rail at least partially within the granitic ridge in order to provide borrow material for the rail embankment construction. The ridge is ideal for quarry development as described below in Section 4.

Earthwork cuts in this terrain are likely to yield either frozen gravelly sand or good quality rockfill. The frozen gravelly sand will likely be suitable for fill provided that it is passed through a cone crusher after excavation, spread using large dozers (i.e., D8 or larger) and compacted in thin lifts (i.e., 150 mm) to mechanically break down the frozen clumps.

Photograph 1 shows an aerial view of the Tote Road and the granitic ridge between approximately CH 2+500 (foreground) and 10+000 (background). The Tote road is situated on glacial outwash terraces (frozen gravelly sand), which are highly undulating as illustrated by the winding road alignment.

The outwash terraces (gravelly sand) are shown in Photographs 2 and 3 near CH 10+000 (viewing north).

Photographs 4 and 5 show the upstream and downstream reaches of Phillips Creek near the waterfall located at CH 10+800. See also Figure 3-1. These photographs (i.e., 4 and 5) show outcropping granitic bedrock in Phillips Creek and ice rich soils situated immediately east of the creek. Between CH 0+000 and 12+000, similar granitic outcrops occur periodically between Philips Creek and the granitic ridge. Referring to Drawing H352035-GEOSKT-229-292-000, Sheet 1 of 4, there are several pre-existing permitted granitic quarries within this segment of the railway as denoted by the diamond (♦) symbols.

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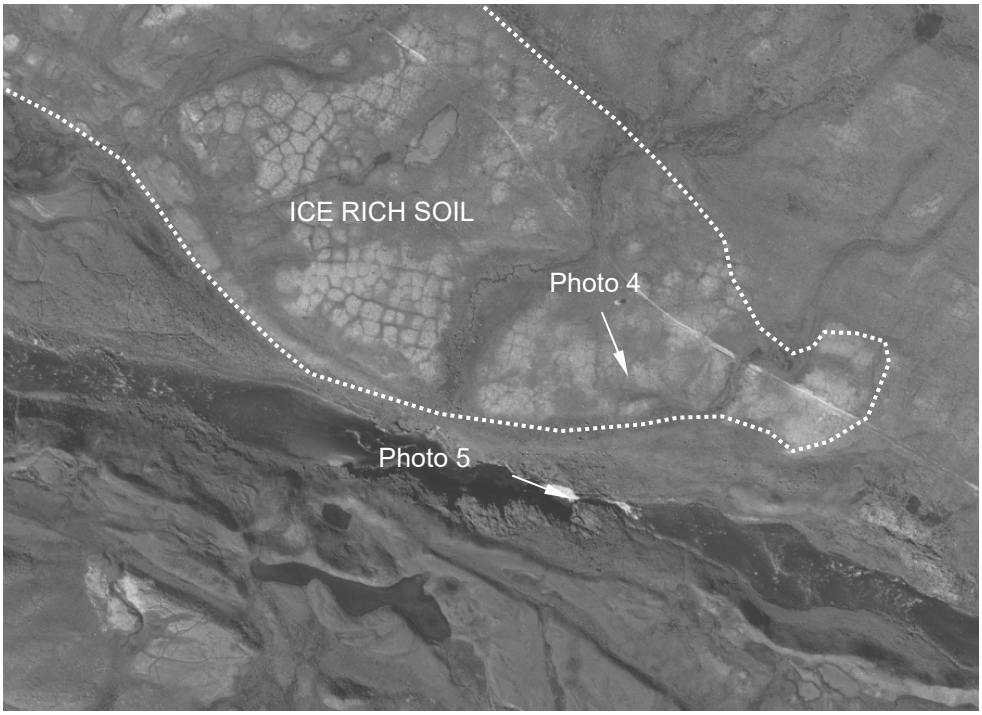

Figure 3-1: Ice Rich Soil Near CH 10+500

3.2.2 CH 10+000 to 46+000

The terrain between CH 10+000 and 46+000 is less undulating compared to CH 0+000 to 10+000. Also, the Phillips Creek valley widens substantially on the east side of the creek as the creek bends southward and diverges from the granitic ridge. Except locally near Philips Creek, the valley comprises a broad till sheet, which slopes gently from east to west. The proposed rail alignment generally follows along the contact between the till sheet (sandy silt with gravel) and glacial outwash deposits (sand and gravelly sand), and as a result, the subgrade conditions alternate between these two domains.

The glacial outwash (mainly sand and gravelly sand) and till can be differentiated by their colour and particle size distributions. The till is damp to wet when thawed, gray and has a silt content that generally ranges between 30 and 50 percent (Note: estimated). The outwash sand is tan coloured and is variable; it generally alternates between relatively clean sand or gravelly sand (0 to 8 percent silt) and silty sand (20 percent silt).

Photographs 6, 7 and 8 show the north approach to Bridge No. 1, Bridge No. 1, and the south approach to Bridge No. 1, respectively. Notably, the terrain is flat with regularly occurring small water bodies, which are usually indicative of ground ice. In this area, the soils comprise mainly sand with trace to some gravel, and variable silt content.

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Photographs 9 to 19 illustrate the two contrasting terrain units that effectively dominate the geology between CH 10+000 and 46+000, i.e., the gray till and tan to reddish brown outwash gravelly sand deposits. Referring to Photograph 10, several ridges occur in the till to the east of the existing Tote Road. These ridges typically indicate the presence of shallow sedimentary bedrock (i.e. limestone beds) located just below the ground surface. The noses of the beds are typically exposed in the occasional creek beds that flow east to west during summer toward Phillips Creek. In some areas, these ridges may be indicative of ground ice as highlighted in Photograph 12.

Photograph 13 shows a typical creek bed. The creek gradient is relatively flat and the flows, when present, are typically along the top of underlying limestone or sandstone beds (i.e. bedrock). Photograph 14 shows a general view of the till plain.

Photographs 15, 17, and 18 all show views of the outwash terrain. As noted above, the surface soils comprise sands and gravelly sands with occasional cobbles.

Photograph 16 shows exposed sedimentary bedrock in the Phillips Creek stream bed. At this location, taking into account the relief and flat lying nature of the bedrock, the depth to bedrock under the Tote Road is in the order of 5 to10 m.

Photograph 19 illustrates the contact between the glacial outwash and till terrain units at CH 46+000. As noted above, these two units can be easily differentiated by their colour and fines content; notably, the till is generally gray and comprises 30 to 50 percent silt particles; whereas, the sand and gravelly sand is tan coloured and relatively clean.

3.2.3 CH 46+000 to 59+200

Between CH 46+000 and 59+000, Tote Road and proposed rail alignment continue to follow the contact between the glacial outwash (gravelly sands) adjacent to associated with Phillips Creek and the glacial till units overlying sedimentary rock located east of the outwash deposits. The terrain is moderately undulating and the predominant soil type is either gravelly sand or sandy silt with gravel.

Over this stretch of the alignment, there is an exposed limestone ridge or mesa running parallel to and approximately 500 m east of the Tote Road. The bedrock ridge occurs between approximately el 750 to el 850 ft and is shown in Photographs 21 (CH 54+200), Photo 22 (CH 57+800) and Photo 26 (CH 52+000 to 58+000). The limestone bed associated with this ridge is more prevalent on the west side of Phillips Creek as shown in Photographs 15, 18, 19, 20 and 24. It is noted that there is possible ground ice at CH 45+000 (see Photograph 20), which is not delineated on the public domain geologic maps for this area. The reader is referred to Appendix C for aerial photographs and an estimate of the extent of ice rich soil.

Lastly, between CH 55+200 and 59+200, Tote Road traverses a flat plain consisting of sand and silty sands deposited in a shallow water proglacial lake environment. Photos 23, 24 and 25 are representative of the terrain at this portion of the alignment.

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Photograph 26 shows a good perspective of the exposed limestone ridge between CH 52+000 and CH 59+200. The ridge is a prime candidate for quarry development.

Photographs 27 to 30, inclusive, show views of Bridge No. 2 and the lake bed deposits located west of the bridge. The primary soil type is silt and sand or silty sand.

3.2.4 CH 59+200 to 70+000

Between CH 59+200 and 70+000, the rail alignment moves from the east side of the Phillips Creek valley to the west side at the headwaters. An unnamed creek enters the valley from the east at CH 59+500 and bends to flow south as shown on Drawing H352034-GEOSKT-229-292-0002, Sheet 3 of 4.

At CH 59+500, the terrain transitions from a relatively flat glacial lacustrine plain to alternating till and glacial fluvial soils overlying limestone bedrock. At the time of the site visit, the proposed rail alignment was situated on the east side of the unnamed creek whereas it has now been located on the west side. Although the following pictures and discussions relate to the terrain on the east side, it is noted that the terrain is similar on both sides of the creek valley.

Photographs 31 and 34 show the exposed dolomitic limestone ridge at CH 64+200 of the rail alignment (Note: East side of the valley). This is the same bedrock unit that is present between CH 42+000 and CH 59+200 on the east and west sides of Phillips Creek and it is prevalent throughout most of the central portion of the rail route. At this location, the bedrock is fairly blocky due to ice jacking and it is covered by a thin discontinuous veneer of glacial till of approximately 1 m thickness or less.

Photographs 32 and 33 show the glacial till blanket in the unnamed creek valley, as well as the lacustrine terrain to the north near the Tote Road Bridge No. 2.

Photographs 35, 36 and 37 show the limestone ridge at CH 66+000 (i.e. between El. 750 ft and 850 ft). Initially, this was thought to be a quarry location for the rail alignment when the alignment was located east of the unnamed creek; however, it is representative of the expected conditions on the west side at PQ09 (See H352034-GEOSKT-229-292-0002, Sheet 3 of 4).

In summary, the author believes that photographs 31, 33, 34, 35, 36 and 37 should be indicative of the conditions at PQ07, PQ08 and PQ09.

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3.2.5 CH 70+000 to 72+600

The proposed railway crosses the unnamed creek from the west side to the east side between CH 70+000 and 72+600. The left bridge approach is situated on a gently sloping till blanket; Photographs 40 and 41 illustrate the till blanket (east side). The terrain transitions to a broad and flat alluvial plain approximately 300 m west of the bridge crossing. The alluvium comprises sand and gravel with cobbles and is illustrated on Photograph 40. Between CH 71+300 and 72+600, the alignment transitions to a glacial lacustrine deposit comprising medium fine sand, which is also shown in Photograph 40. This deposit is wet with numerous small surface water bodies, which again is normally associated with thermal karst and ground ice.

3.2.6 CH 72+000 to 82+000

Between CH 72+000 and 82+000, the railway traverses an extensive till blanket. The till is gray, wet, fine-grained and consists of predominantly silt and sand with some gravel. Locally, there are areas of ground ice as illustrated on H352034-GEOSKT-229-292-0002, Sheet 3 of 4. It is noted that the composition of the till unit is very consistent to that at the north end of the rail near CH 12+000 to CH 82+000; only the moisture content varies and degree of vegetative cover.

The till slopes gently from the north to the south and it is dissected by numerous north-south flowing creeks (summer only). The creeks have eroded through the till to expose the underlying limestone bedrock. Visual examination of some of the creek beds indicates that the till deposit is generally less than 2 m thick.

Photographs 41 to 44 show the general till terrain. Photograph 45 shows the prominent bedrock ridge that is situated about 1.5 km north of the rail and emerges starting at CH 80+000 (see Photograph 45).

The bedrock is very shallow at numerous locations particularly adjacent to the Tote Road. For example, Photograph 47 shows a road cut made in 2016 to reduce grades on the Tote Road. The bedrock at this location is very shallow and the till cover is less than 0.3 m thick. This has been identified as a potential quarry location, See PQ12, as noted in Section 4 of this report.

3.2.7 CH 82+000 to 100+000

Between CH 82+000 and CH 100+000, the terrain alternates between glacial fluvial deposits (gravely sand) and lacustrine deposits (sandy silt and silty sand). The lacustrine is locally ice rich as indicated on drawing H352034-GEOSKT-229-292-0002, Sheet 3 of 4.

Photographs 46, 48, 49, 55, and 56 show the glacial lacustrine terrain, which comprises predominantly flat ice rich sandy silt to silty sand.

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There is an excellent quarry site situated just over 1 km north of the rail alignment and labeled PQ13 on Drawing H352034-GEOSKT-229-292-0002. The potential quarry site is a hill of granitic rock and is shown on Photographs 50 and 52. As an alternate to PQ13, there is also an exposed Diabase Dyke situated another 1.5 km north of PQ13. The dyke is shown in Photographs 51a and b.

Generally, the terrain is flat from about CH 82+000 to CH 95+000; and it becomes more undulating from CH 95+000 to CH 100+000 as the route crosses an esker ridge.

Photographs 57 and 58 show the esker terrain, which consists of mainly gravelly sand.

3.2.8 CH 100+000 to Terminus

The remainder of the route traverses undulating terrain consisting of either a thin veneer of sand and gravel (glacial fluvial) overlying granitic bedrock or exposed granitic rock.

Similar to CH 0+000 to 10+000, it should be appropriate to implement cut-fill construction for this segment of the railway. The cut material is likely to comprise either frozen gravelly sand or sound durable rockfill and the risk of ground ice is judged to be low provided the alignment is not pushed too far north of the Tote Road. The gravelly sand could be used for fill provided that it is passed through a cone crusher and then spread in thin lifts using a large dozer (i.e., D8 or larger) and compacted to break down the frozen pieces.

Photographs 59 and 60 show the Tote Road Bridge No. 4, which is situated on the sand and gravel alluvial plain associated with the unnamed creek.

The rail alignment has been moved north of Bridge No. 4 into the rocky terrain in order to generate rockfill from cut-fill earthworks. Photograph 61 illustrates the predominant terrain for the rail alignment.

4. Quarries

Table 4-1 summarizes the potential quarry sites identified by the author. Fifteen potential quarry sites have been identified that are capable of yielding sufficient quantities of material for rail embankment construction, as discussed below.

Generally, there are three main rock types in which quarries can be developed, notably, granitic rock, medium strong durable limestone and weak limestone or sandstone. The granitic rock and strong durable limestone beds are suitable for run-of-quarry rockfill; the granitic rock is also suitable for ballast. The weak limestone and sandstone bedrock must be treated as a soft rock during fill placement. The quarried materials from the weaker bedrock sources will need to be broken down during borrow and placement by mechanical means as discussed below (i.e., thin lifts and compaction/crushing with large dozers and heavily loaded trucks).

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PQ01: There are three permitted quarries in the granitic ridge located east of Phillips Creek between CH 0+000 and 10+000. Notably, Drawing H352034-GEOSKT-229-292-0002 shows quarries at CH 0+000, 5+800 and 8+300. The granitic rock is ideal for quarry-run rock fill and it will also be acceptable for use as ballast. As discussed above, the rail has been routed immediately adjacent to the granitic ridge in order to create rockfill from cut-fill operations. Additional quarries can be established in the ridge as needed.

PQ2: There is an approximately 1 km long gently sloped possibly granitic rock outcrop situated east of the existing Tote Road between CH 26+000 and 28+000. A quarry at this location should provide suitable rockfill and possibly ballast. Because the majority of the rock is below ground, however, it may be difficult to produce major quantities from this site without impacting a large area.

PQ3: There are shallow limestone beds situated approximately 1.5 km and 3 km east of the Tote Road at approximately CH32+000. Occasionally, the beds are exposed in the creek bottoms that generally flow from southeast to northwest. At the lower elevations (i.e., closer to the Tote Road), the beds were found to consist of soft and weathered sandstone; the beds were harder at higher elevations and comprised mainly limestone. Softer bedrock beds can be utilized for embankment fill provided sufficient mechanical energy is used during borrow and placement to break the rock down.

PQ4 and PQ5: These quarries are located at the north end of the limestone ridge or mesa that runs parallel to the Tote Road from CH 42+000 to CH 58+600 between el 750 ft and el 850 ft. The limestone beds at the north end are less prominent than the ridges further south; however, contractors should be able to develop quarries and produce reasonable quantities of rockfill from these limestone units, if required.

PQ6, PQ7, PQ08, PQ09 and PQ11: All of these potential quarry sites are situated in hard massive limestone bedrock primarily between el 750 ft and el 850 ft. Quarried rock produced from these sources should be suitable for rockfill embankments but is unlikely to be suitable for ballast. The quantity of material available far exceeds the quantities required for construction of the railway. Access is feasible but will need to be planned through areas where the ridge is buried such as shown on Photograph 26. Access roads may require multiple switchbacks due to the grades. Given the difficulty of operating haul trucks on sloping arctic terrain, a conveyor system may be preferred to move the material from the higher elevation quarries to stockpiles adjacent to the Tote Road.

PQ10 and PQ12: These quarry sites consist of shallow limestone beds overlain by less than 2 m of glacial till. The rock at these locations comprises limestone interbedded with weak shale partings and beds. The shale is weaker and friable. Material derived from these sources will be suitable for use as rockfill but it will need to be broken down by mechanical means during exploitation and placement, as discussed above.

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PQ13, PQ14, and PQ15: Most of these potential quarry sites consist of granitic bedrock with a thin veneer of gravelly sand or sand overlying the rock. These quarries should be suitable for producing rockfill as well as ballast and there should be more than enough material to meet the project needs. The overburden thickness at PQ14 is not known and could be too thick to allow easy development. As noted in Section 3, there is a diabase dyke situated 1.5 km north of PQ13 and at PQ15. The diabase is very hard and would be an excellent site for ballast production. The hardness of the diabase will make it difficult to quarry and crush, and given the reasonably good quality of the granitic borrow sources, utilizing the dyke is probably not necessary.

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Table 4-1: List of Potential Quarries

Proposed Quarry	Photograph Reference	Rail Chainage (m)	Rock Type	Overburden (m)	Quality	Description	Development Potential
PQ01	1	0+000 to 11+000	Granitic Gneiss*	0	Good to Excellent	Approx. 10 km long bedrock ridge along east of the existing Tote Road. Suitable ballast material.	Very Good to Excellent
PQ02	None	21+000 to 22+000	Granitic Gneiss*	0.5 to 3	Good to Excellent	An approximately 1 km long possibly granitic rock outcrop gently sloped east of the existing Tote Road between Chainage 26+000 and 28+000. Suitable rockfill and ballast material	Moderate to Good
PQ03	None	32+000 to 36+000	Dolomitic Limestone/ Sandstone	2 to 3 m	Poor to Moderate	Approx. bedrock ridge 2-3 km east of the existing Tote Road. Covered in till veneer but exposed in the creek beds with harder limestone beds at higher elevations.	Poor to Moderate
PQ04	None	42+000	Dolomitic Limestone/ Sandstone	2 to 3	Poor to Moderate	Approx. 1 km long bedrock ridge along east of the existing Tote Road. Covered in till veneer but exposed in the creek beds with harder limestone beds.	Poor to Moderate
PQ05	None	44+000 to 46+000	Dolomitic Limestone	0	Moderate to Good	Approx. 4 km long bedrock ridge east of the existing Tote Road. Large ice jacked blocks.	Moderate to Good
PQ06	21, 26	51+000 to 58+000	Dolomitic Limestone	0	Moderate to Good	Approx. 7 km long bedrock ridge east of the existing Tote Road.	Good to Very Good
PQ07	22,26	58+000	Dolomitic Limestone	0 to 3	Moderate to Good	Outcropping east of the existing Tote Road.	Good to Very Good
PQ08	31	60+000	Dolomitic Limestone	Greater than 3	Moderate to Good	Located west of the existing Tote Road at km 65.	Moderate to Good
PQ09	39**	66+000	Dolomitic Limestone	0 to 3	Good to Excellent	West of the proposed Rail Alignment at the deviation from Tote Road.	Good to Excellent
PQ10	39**	74+000	Dolomitic Limestone	0 to 3	Moderate to Good	North of the proposed Rail Alignment at the deviation from Tote Road.	Poor to Moderate
PQ11	47	84+000	Dolomitic Limestone	0	Moderate to Good	North of the proposed Rail Alignment along the existing Tote Road. Massive cliff with challenging access.	Moderate to Good
PQ12	49	82+000	Dolomitic Limestone	1 to 2	Poor to Moderate	North of the proposed Rail Alignment at the deviation from Tote Road. Veneered Till overburden. Limited vertical development.	Poor to Moderate
PQ13	54 a,b	86+000	Grandiorite*	0 to 2	Very Good to Excellent	Approx. 2 km north of the existing Tote Road/ Rail Alignment.	Very Good to Excellent
PQ14	55**, 65	96+000 to 104+000	Undifferentiated Mafic/Granitic Rock*	1 to 3	Very Good to Excellent	North end of an approx. 8 km long bedrock ridge roughly 1 km north of the existing Tote Road.	Moderate
PQ15	55**, 65	96+000 to 104+000	Diabase*	1 to 3	Very Good to Excellent	South end of an approx. 8 km long bedrock ridge roughly 1 km north of the existing Tote Road; adjacent to the Rail Alignment.	Good to Very Good

* Likely suitable for Ballast
**Photograph is from a nearby similar location and representative of general rock conditions; however, it does not capture the actual location

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5. Aerial Photograph Assessment

The results of aerial photograph analysis are attached in Appendix C. Select stereo pairs were analyzed to evaluate the accuracy of public domain geologic maps (see Appendix A). The results are presented in Appendix C. In general, the analyses confirmed that the terrain assessment summarized on the maps listed in Section 2 and transposed onto Drawing H352034-GEOSKT-229-292-0002 Sheets 1 to 4 are satisfactory. The boundary between the terrain units is approximate and should not be relied on as being highly accurate; however, the overall map boundaries and terrains should be on average representative.

The following summarizes the key findings:

- The number of bedrock outcrops is uncertain between CH 0+000 and 8+000 west of the exposed granitic ridge. The terrain consists of sand and gravel and silty sand and gravel overlying bedrock. Locally, the soil cover has been eroded away to expose the bedrock. The rail alignment may need to be pushed further east to take advantage of the granitic ridge.
- The extent of the ice rich soils is greater than that shown on the public domain maps used to generate Drawings H352034-GEOSKT-229-292-0002 Sheets 1 to 4. Despite this, the rail alignment appears to have avoided the obvious ice rich soil deposits except between CH10+000 and CH 11+00, CH 46+000 and CH 48+500, CH 76+000 and CH 80+000, CH81+500 and CH 83+000 and CH 86+000 and CH 89+000. Cuts should be avoided in these areas or designed with care, supported by borehole investigations.
- Cuts are likely required where the railway traverses across the esker deposit at CH 98+200. Additional boreholes may be required in this area to assess if ground ice exists.
- The extent of outcropping rock between CH100+000 and 105+000 is variable; however, cuts in this section of the alignment should yield mainly granitic rockfill.
- The terrain units and rock types identified on the maps attached in Appendix A are generally confirmed by the site visit and subsequent aerial photograph assessment. Local variations should be expected from these maps but as a whole the maps should serve as a reasonable design basis for the railway supplemented by a geotechnical drilling program.

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Appendix A
Reference Geologic Maps

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SURFICIAL DEPOSITS
QUATERNARY
HOLOCENE

- **Ice:** *glacier*
- **COLLUVIUM:** *block and rubble accumulations, 1-50 m thick*
- Ca — **Talus:** *active block and rubble accumulations as much as 50 m thick forming talus (scree) aprons and fans below cliffs resulting from rock falls and debris flows; commonly crossed by debris flow channels and levées*
- Cr — **Rock glacier debris:** *talus, generally 10-50 m thick, deformed by active flow of interstitial or buried ice to form rock (talus) glaciers with transverse ridges and furrows, and pits, and with steep, unstable sides and fronts*
- **FLUVIAL SEDIMENTS:** *alluvium; gravel and sand, 2-20 m thick*
- Ap — *Alluvial plains; active braided floodplains; includes active proglacial outwash*
- At — *Alluvial terraces*
- Af — *Alluvial fans*
- **MARINE AND GLACIAL MARINE SEDIMENTS:** *gravel, sand, silt, and clay, 1-20 m thick, deposited in deltaic and beach environments during regression of the postglacial sea*
- Mr — **Beach sediments:** *gravel and sand, 1-5 m thick, forming ridges and swales*
- Mt — **Deltaic sediments:** *clay, silt, sand, and gravel, 5-20 m thick, forming coarsening upward sequences under dissected terraces*
- Mv — **Deepwater proglacial silt veneers:** *silt, clay silt, and fine sand with dropstones, 1-2 m thick*
- Mb — **Deepwater proglacial silt blankets:** *silt, clay silt, and fine sand with dropstones and minor gravel, 2-10 m thick*
- **GLACIAL LACUSTRINE SEDIMENTS:** *clay, silt, sand, and gravel deposited in glacier dammed lakes in deepwater and deltaic environments*
- Lt — **Deltaic sediments:** *clay, silt, sand, and gravel, 5-20 m thick, forming coarsening upward sequences under dissected terraces*
- Lv — **Deepwater proglacial silt veneers:** *silt, clay silt, and fine sand with dropstones, 1-2 m thick*
- Lb — **Deepwater proglacial silt blankets:** *silt, clay silt, and fine sand with dropstones, 2-5 m thick*
- **GLACIOFLUVIAL SEDIMENTS:** *gravel and sand, 1-10 m thick, deposited behind, at, and in front of the ice margin*
- Gp,t,f — **Proglacial outwash:** *gravel and sand, 1-10 m thick, forming braided floodplains, Gp; terraces, Gt; and fans, Gf*
- Gr,h — **Ice contact stratified drift:** *gravel and sand, 1-5 m thick, forming eskers, Gr; and kames, Gh*

EARLY HOLOCENE AND WISCONSINAN

- **TILL:** *nonsorted stony muds, 0.5-60 m thick, deposited in subglacial and ice marginal environments; lithic composition generally reflects underlying bedrock*
- Tm — **End moraines:** *5-60 m high, composed of or mantled by till, extensively kettled in places; large features mainly cored by debris-rich relict glacier ice*
- Tv — **Till veneer:** *0.5-2 m thick and discontinuous*
- Tb — **Till blanket:** *2-10 m thick forming an undulating blanket with drumlins and ribbed moraines in places*

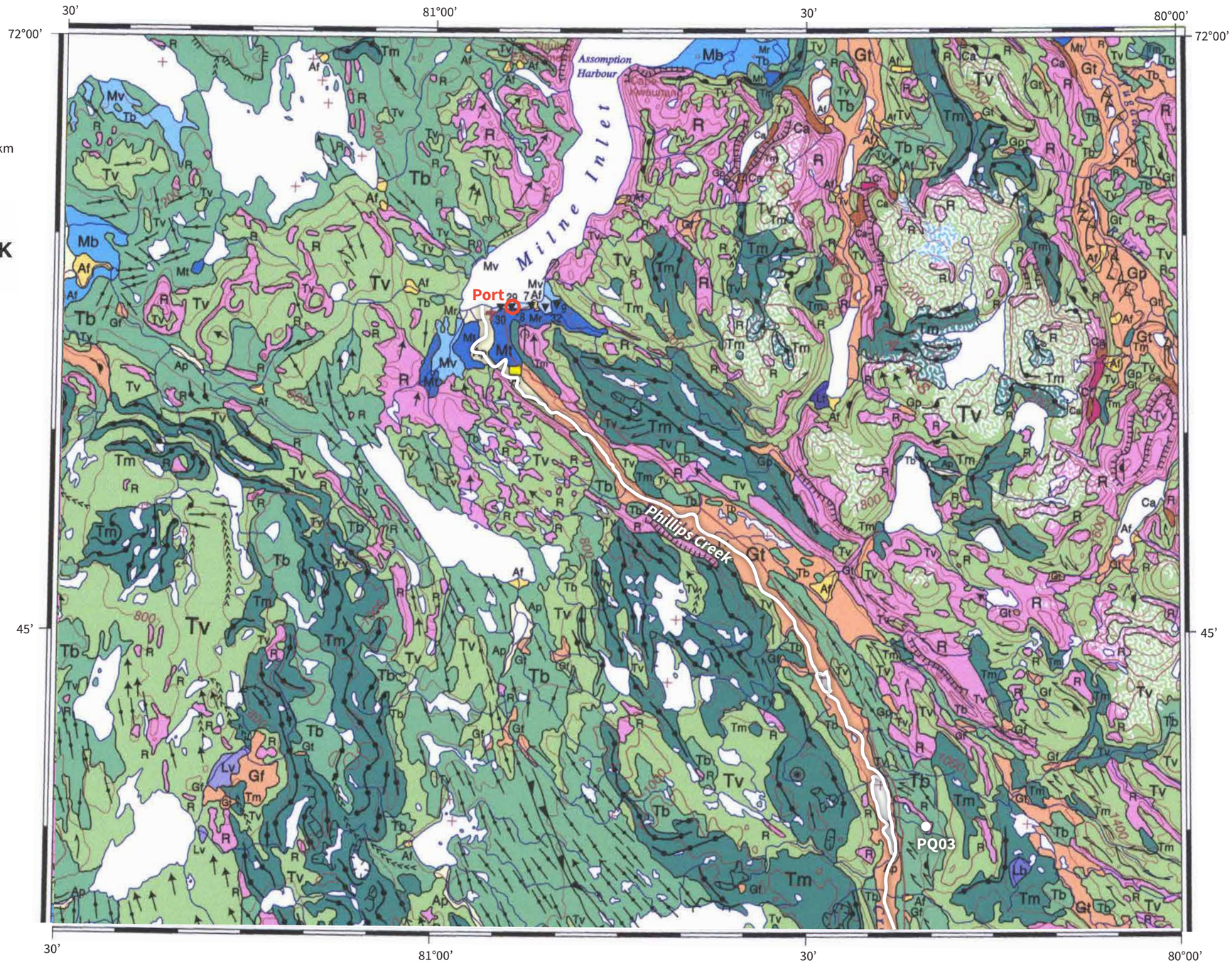
PRE-QUATERNARY

- R — **ROCK:** *rock of various compositions and ages (Jackson and Sangster, 1987) variously modified by glacial erosion during the Quaternary; hilly and hummocky surfaces, ice moulded in places, with lake basins in subglacially scoured regions; smooth surfaces exhibiting little or no sign of glacial erosion in peninsular interiors (Dyke, 1993); cliffs resulting from glacial over-steepening*

0 3 6 km

Modified from

MAP 1961A
SURFICIAL GEOLOGY
PHILLIPS CREEK
BAFFIN ISLAND
NUNAVUT



- Geological boundary
- Areas covered by perennial icefields during the Little Ice Age (indicated by a white pattern)
- Area of active wind erosion; minor attached dunes (indicated by a white pattern)
- Direction of eroding wind
- Small rock glacier
- Pingo
- Kettle (large,small)
- Glacial lake spillway
- Glacial lake ilmit
- Marine limit
- Bouldery ridge; subglacially deformed felsenmeer

- Lateral meltwater channel; barb on upslope side
- Subglacial and proglacial meltwater channel (large, small)
- Esker
- Ice contact face
- Ribbed moraines
- Lateral moraine
- End moraine
- Lateral shear moraine
- Margin of dispersal train; teeth toward axis, steep side of teeth face down ice

- Drumlinoid hill
- Crag and tail
- Ice moulded bedrock
- Striae (ice flow direction known, unknown)
- Cirque
- Cliff in bedrock
- Radiocarbon date (Date / Material / Lab no / Elevation (m))
- Radiocarbon date with field number

Baffinland
12 Mtpa Expansion Project PFS
Surficial Geology - Phillips Creek - Map 1 of 2

HATCH

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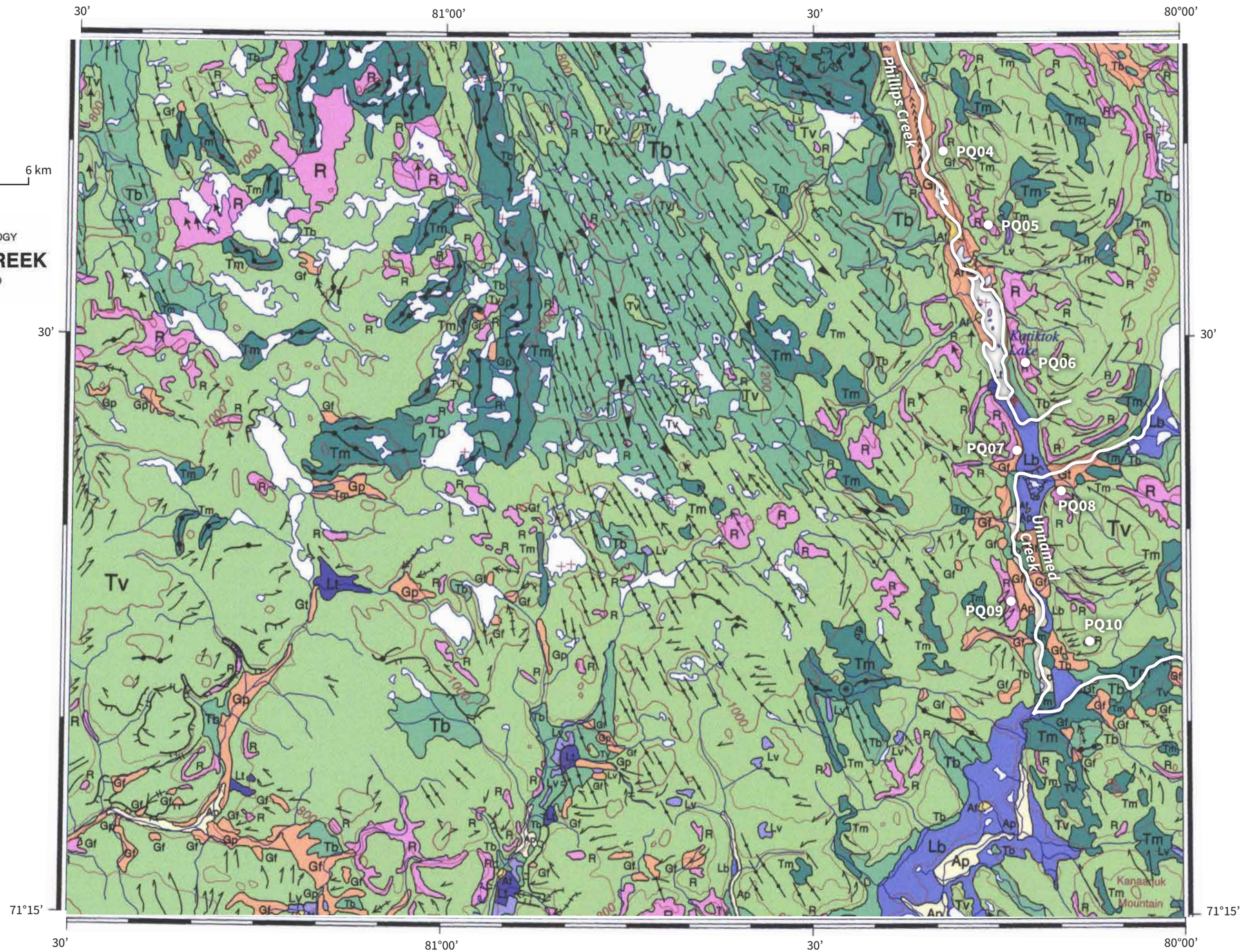
0 3 6 km

Modified from
MAP 1961A
SURFICIAL GEOLOGY

PHILLIPS CREEK

BAFFIN ISLAND
NUNAVUT



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- Radiocarbon date with field number

Baffinland
12 Mtpa Expansion Project PFS

Surficial Geology - Phillips Creek - Map 2 of 2

HATCH

QUATERNARY

SURFICIAL DEPOSITS

HOLOCENE

NONGLACIAL ENVIRONMENTS

ALLUVIAL SEDIMENTS: predominantly composed of sorted and commonly stratified gravel, sand, minor silt and organic detritus deposited by post-glacial fluvial processes; fan deposits may include gravelly diamictons.

Av — **Alluvial veneer:** thin, discontinuous deposit; thickness is less than 1 m.

Ap — **Alluvial floodplain:** typically forms a single level within approximately 1 m of active stream channel; thickness ranges from 1 to 5 m.

At — **Alluvial terrace:** deposits are of floodplain origin and presently are isolated from flooding by stream incision; thickness ranges from less than 1 to 10 m.

Af — **Alluvial fan:** forms fan-shaped landforms with gentle slopes where streams enter larger valleys; thickness can reach up to 10 m.

COLLUVIAL DEPOSITS: mass wasting debris (i.e. deposited by direct gravity-induced movement that may involve water and/or ice); typically unsorted, but may be stratified as a result of gravity induced movement (e.g. debris flows); the character of the deposit depends primarily on its parent material.

Cv — **Colluvial veneer:** thin, discontinuous deposit; thickness is less than 1 m.

Cb — **Colluvial blanket:** a mantle of sediment; thickness is greater than 1 m.

Ca — **Colluvial apron:** forms a slope deposit comprising debris flows, avalanche-dominated fans, and soliflucted sediments derived from bedrock and glacial sediment sources; thickness is up to 10 m, thinning at head and toe of the deposit.

GLACIAL ENVIRONMENT

GLd — **Glaciolacustrine delta:** sediment built-up from flowing glacially derived water entering a glacial lake; the feature may have gently or steeply-dipping fronts; thickness ranges from 3 m to greater than 10 m.

GL — **Undifferentiated glaciolacustrine complex:** consists primarily of glaciolacustrine materials but may contain pockets of till, glaciofluvial, glaciomarine, marine, colluvium and/or alluvium sediments, that are too small to be represented at the scale of mapping; in upper slopes of valleys with cross-valley (DeGeer) moraines, more till is present and is inferred to represent the wasting zone of a paleo-lake; thickness is greater than 1 m.

EARLY HOLOCENE AND PLEISTOCENE

GLACIOFLUVIAL SEDIMENTS: well to poorly stratified gravel, sand and silt; minor diamicton; deposited behind, at, or in front of the ice margin by glacial meltwater.

GFv — **Glaciofluvial veneer:** thin to discontinuous deposit; thickness is less than 1 m.

GFp — **Glaciofluvial plain:** typically forms a single level plain; thickness ranges from 1 m to greater than 5 m.

GFt — **Glaciofluvial terraces:** typically forms terraces separated by scarps; patches of colluvium that are too small to be represented at the scale of mapping may be present along the scarps; thickness ranges from 1 to 20 m.

GFc — **Ice contact glaciofluvial:** kettle and kame topography, including esker ridges; thickness ranges from less than 5 m to greater than 15 m.

GF — **Undifferentiated glaciofluvial complex:** undifferentiated glaciofluvial complex consists primarily of glaciofluvial materials but may contain pockets or till, glaciolacustrine, glaciomarine, marine, colluvium and/or alluvium sediments, that are too small to be represented at the scale mapping; thickness is greater than 1 m.

Tv — **Till veneer:** thin, discontinuous deposit; thickness is less than 1 m.

Tb — **Till blanket:** surface morphology ranges from conforming to underlying bedrock topography to rolling plain masking the underlying topography; may exhibit crag-and-tails and/or flutings; occasionally exhibits roches moutonnées in areas of thin till blankets (e.g., 1 to 2 m); thickness ranges from 1 m to 20 m.

Tm — **Rolling till plain:** surface morphology forms gently rolling plains with 1 to 2 m relief; may exhibit flutings and/or other drumlinoid forms; generally masks underlying topography; thickness is greater than 5 m.

T — **Undifferentiated till complex:** consists primarily of till but may contain pockets of glaciofluvial, glaciolacustrine, glaciomarine, lacustrine, marine, colluvium and/or alluvial sediments that are too small to be represented at the scale of mapping; thickness is greater than 1 m.

PRE-QUATERNARY

BEDROCK

R — **Bedrock:** outcrops of bedrock, may have thin mantle greater than 10 cm of unconsolidated or organic material.

Patterned ground: area exhibits a hexagonal polygon network where polygon diameter ranges from 20 to 50 m; may indicate the presence of buried glacial ice at depth.

NOTES:

Compound units: in areas where the surficial geology types are interspersed in patches or patterns too small to be discerned at the scale of mapping, compound units are used. The dominant component is listed first and separated from the secondary unit by a dot (e.g. Tb.O).

Stratigraphic relationship: where underlying units are known, the unit label shows the surface unit above underlying unit with a single slash (e.g. Tb/R).

Kettle
Geological boundary, defined
Geological boundary, approximate
Beach crest
Drumlinoid (fluting)
Esker ridge (flow direction known)
Esker ridge (flow direction unknown)
Fluted bedrock (ice flow direction known)
Ice-contact terrace scarp
Limit of submergence, marine, defined

Meltwater channel, major (arrow indicates flow direction)
Meltwater channel, minor (flow direction known)
Meltwater channel, minor (flow direction unknown)
Lateral meltwater channel, uphill left
Lateral meltwater channel, uphill right
Moraine ridge, minor
End moraine ridge, major
Lateral moraine ridge, major
Terrace scarp, unspecified
Delta, glaciolacustrine
Station location, ground observation

0 3 6 km

Modified from

CANADIAN GEOSCIENCE MAP 74

SURFICIAL GEOLOGY

ICEBOUND LAKES (SOUTHWEST)

Baffin Island, Nunavut

Baffinland

12 Mtpa Expansion Project PFS

Surficial Geology - Icebound Lakes

HATCH

CENOZOIC

QUATERNARY

Q — Drift and unconsolidated sediments

PALAEOZOIC

ORDOVICIAN AND SILURIAN

LATE MIDDLE ORDOVICIAN TO MIDDLE SILURIAN

OSba — BAILLARGE FORMATION: dolomitic limestone, in part shaly, minor dolomite

ORDOVICIAN

MIDDLE AND (?) LOWER ORDOVICIAN

Osp — SHIP POINT FORMATION: dolomite, in part silty and shaly; dolomitic intraformational conglomerate

CAMBRIAN AND/OR ORDOVICIAN

CAMBRIAN AND/OR EARLY LOWER ORDOVICIAN

ADMIRALTY GROUP

€Oad — GALLERY AND TURNER CLIFFS FORMATIONS UNDIVIDED: quartzose sandstone, minor siltstone, conglomerate, shale; a little breccia; dolomite, shaly, silty, sandy, pure, quartzose sandstone, in part dolomitic; dolomitic intraformational conglomerate; minor siltstone, shale, mostly dolomitic

MIDDLE AND LOWER ORDOVICIAN AND (?) CAMBRIAN

€Oad,sp — Admiralty Group and Ship Point Formations undivided

(?) CAMBRIAN TO MIDDLE SILURIAN

€OS ad,sp,ba — Admiralty Group, Ship Point and Baillarge Formations undivided

PROTEROZOIC

HELIKIAN

Hg — Gabbro dykes

Hab — ARCTIC BAY FORMATION: calcareous shale; dolomite

P — Proterozoic undivided; probably fa

APHEBIAN

A — Granitic and gneissic rocks: fgt, granite, quartz-feldspar gneiss; fmg, migmatite; fbd, banded and fissile gneiss

Geological boundary (defined, approximate, assumed)
Bedding, tops known (inclined)
Foliation (inclined, vertical)
Structural trend (in part from air photographs)
Lineament (from air photographs)
Fault (defined)

Geology of Precambrian rocks by R. G. Blackadar and W. L. Davison, 1963
Geology of Palaeozoic rocks by H. P. Trettin, 1963

Geological cartography by the Geological Survey of Canada, 1967

Horizontal control point
Intermittent stream
Dry river bed with channel
Rapids, falls
Contours (interval 200 feet)

Base-map compiled and drawn by the Surveys and Mapping Branch, 1964

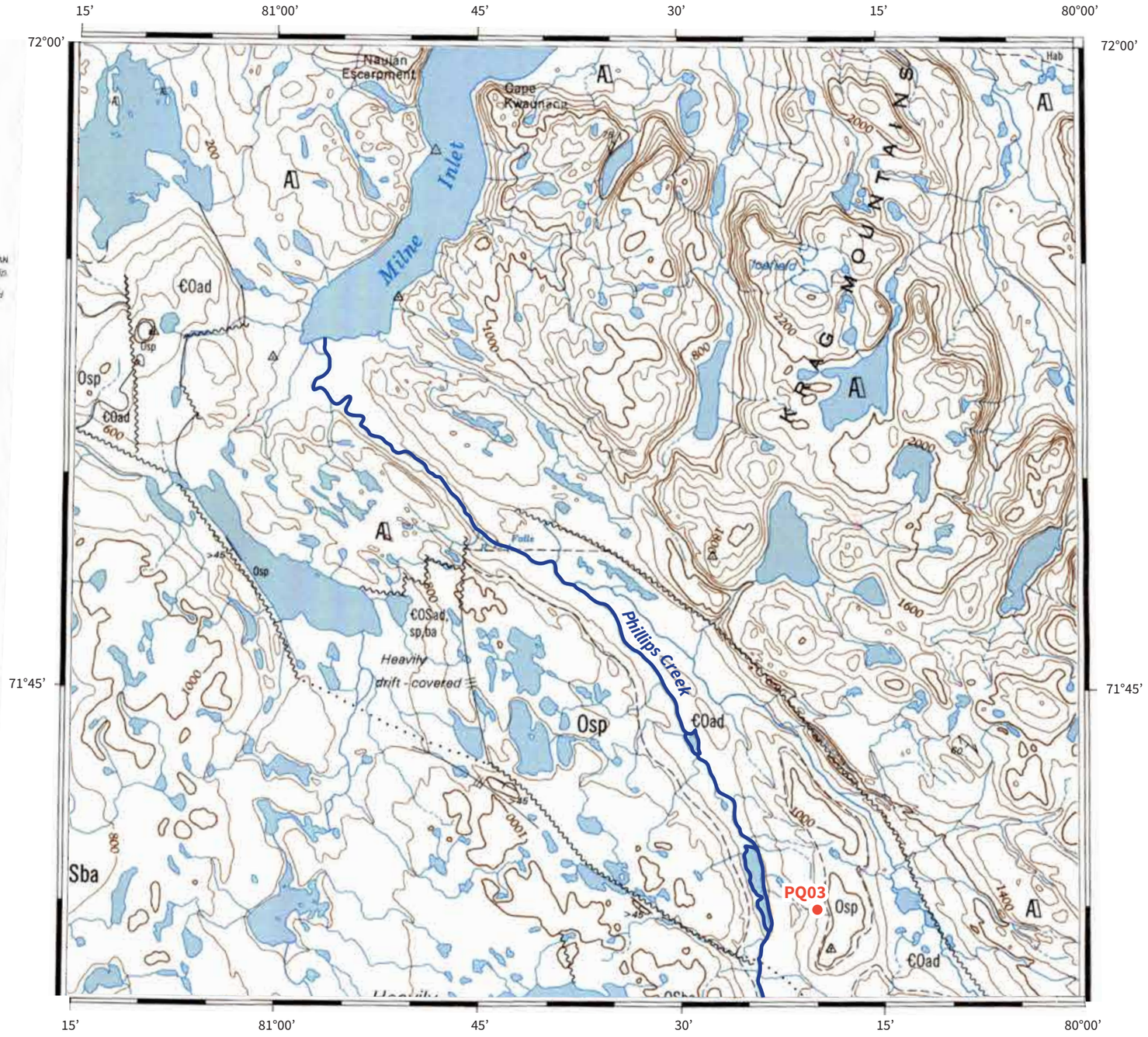
Magnetic declination 1967 varies from 63° 30' westerly at centre of west edge to 65° 30' westerly at centre of east edge. Mean annual change, decreasing 29.5'.

INDEX MAP

0 3 6 km

Modified from

MAP 1239A
GEOLOGY
PHILLIPS CREEK
DISTRICT OF FRANKLIN



Baffinland
12 Mtpa Expansion Project PFS
Geology - Phillips Creek - Map 1 of 2

HATCH

CENOZOIC

QUATERNARY

Q — Drift and unconsolidated sediments

PALAEOZOIC

ORDOVICIAN AND SILURIAN

LATE MIDDLE ORDOVICIAN TO MIDDLE SILURIAN

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MIDDLE AND (?) LOWER ORDOVICIAN

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CAMBRIAN AND/OR ORDOVICIAN

CAMBRIAN AND/OR EARLY LOWER ORDOVICIAN

ADMIRALTY GROUP

€Oad — GALLERY AND TURNER CLIFFS FORMATIONS UNDIVIDED: quartzose sandstone, minor siltstone, conglomerate, shale; a little breccia, dolomite, shaly, silty, sandy; pure quartzose sandstone, in part dolomitic; dolomitic intraformational conglomerate; minor siltstone, shale, mostly dolomitic

MIDDLE AND LOWER ORDOVICIAN AND (?) CAMBRIAN

€Oad,sp — Admiralty Group and Ship Point Formations undivided

(?) CAMBRIAN TO MIDDLE SILURIAN

€OS ad,sp,ba — Admiralty Group, Ship Point and Baillarge Formations undivided

PROTEROZOIC

HELIKIAN

Hg — Gabbro dykes

Hab — ARCTIC BAY FORMATION: calcareous shale; dolomite

APHEBIAN

A — Granitic and gneissic rocks: Ag, granite, quartz-feldspar gneiss; Amg, migmatite; Abd, banded and bi-par. Ai, gneiss

P — Proterozoic undivided; probably fa

Geological boundary (defined, approximate, assumed)
Bedding, tops known (inclined)
Foliation (inclined, vertical)
Structural trend (in part from air photographs)
Lineament (from air photographs)
Fault (defined)

Geology of Precambrian rocks by R. G. Blackadar and W. L. Davison, 1963
Geology of Palaeozoic rocks by H. P. Trettin, 1963

Geological cartography by the Geological Survey of Canada, 1967

Horizontal control point
Intermittent stream
Dry river bed with channel
Rapids, falls
Contours (interval 200 feet)

Base-map compiled and drawn by the Surveys and Mapping Branch, 1964

Magnetic declination 1967 varies from 63° 40' westerly at centre of west edge to 65° 40' westerly at centre of east edge. Mean annual change, decreasing 29.5'

0 3 6 km

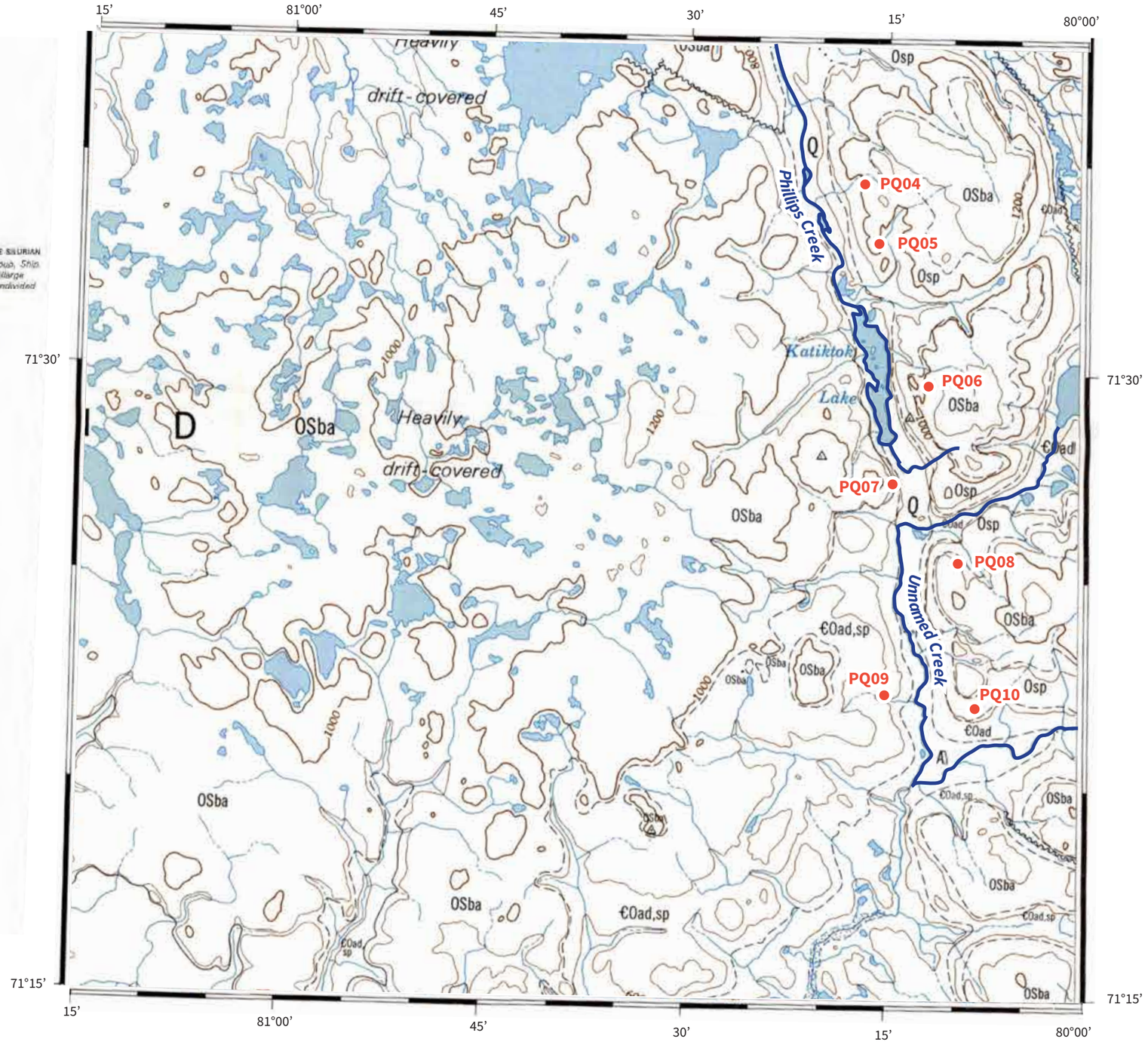
Modified from

MAP 1239A

GEOLOGY

PHILLIPS CREEK

DISTRICT OF FRANKLIN



Baffinland
12 Mtpa Expansion Project PFS
Geology - Phillips Creek - Map 2 of 2

HATCH

Cenozoic

QUATERNARY
PLEISTOCENE-RECENT

Qu — *Chiefly unconsolidated glacial drift, in part reworked by lakes, streams, and frost action; outwash plains (sandurs), bog deposits*

Paleozoic

ORDOVICIAN
BRODEUR GROUP

OBA — *BAILLARGE FORMATION: Member B - limestone and dolomite; light grey, buff, brown, thickly laminated to very thick bedded, microcrystalline; commonly fossiliferous, silty, nodular; minor breccia, chip conglomerate, sandstone, cherty beds. Member A - dark grey shaly carbonate rocks*

CAMBRO-ORDOVICIAN
ADMIRALTY GROUP - SHIP POINT FORMATION

€OTCSP — *TURNER CLIFFS - SHIP POINT FORMATIONS UNDIVIDED: microcrystalline to very finely crystalline dolomite, commonly silty or sandy; very fine- to coarse-grained quartzose and dolomitic and calcareous sandstone; light grey to buff, greyish orange, yellowish brown, white; laminated to thick bedded, massive; minor dolomite conglomerate and chip breccia; fossiliferous; cross-laminations, ripple marks, mudcracks, glauconite, sulphide streaks present locally. Sandstones relatively abundant in lower part*

ADMIRALTY GROUP

€OGA — *GALLERY FORMATION: arkose to orthoquartzite, conglomerate beds and lenses mainly at and near base; minor dolomitic sandstone; ferruginous zones; light grey, pale yellow, light to dusky red, white, brown; very fine- to very coarse-grained, thin- to very thick-bedded; crossbedding common, ripple and sole marks present locally; few worm burrows, quartz clasts predominate in conglomerate, hematite iron ore clasts abundant locally*

Proterozoic

APHEBIAN

Hg — *Massive granite-granodiorite; chiefly pink quartz monzonite; fine- to coarse-grained and pegmatitic; abundant aplite and pegmatite dykes; syenitic dykes and small diatremes locally*

Agp — *Porphyritic quartz monzonite-granodiorite; minor granite, syenite-syenodiorite; light grey, greyish pink to pink, massive to foliated, medium grained; potash feldspar phenocrysts; commonly locally granulated*

Amp — *Porphyroblastic migmatite; commonly of granodioritic composition; abundant schlieren, nebulae, potash feldspar porphyroblasts; medium grained; pinkish grey, light to dark grey, pink; streaky laminated to thin banded, massive*

Amg — *Chiefly banded migmatite; white to light grey granitoid bands alternate with grey to black more mafic bands, some pink to red and reddish black. Bands characterized by diverse composition, origin and geometry. Granitoid bands commonly appear to have been introduced. Derived in part from Mary River Group, and may also include some gneisses basement to this group*

Archean and/or Proterozoic

ARCHEAN AND/OR APHEBIAN
MARY RIVER GROUP (MQ - M)
Undivided Mary River Group: MQ - M, chiefly MS - Mb

M — MS - *Metasediments; chiefly mica-quartz-feldspar schists and gneisses (metashales and metagreywackes), fine- to medium-grained, light to dark grey, very thin bedded to massive. Minor hornblende-, garnet-, alumino-silicate-, pyroxene-, and cordierite-bearing gneisses; bt-par-lit gneiss, quartzite. Local conglomerate, agglomerate*

Mb - *Basic metavolcanic rocks; chiefly massive to pillowed amphibolite (metabasalt ?) and associated pyroclastic rocks; fine- to medium-grained, dark greyish green to black; laminated to massive; minor metamorphosed ultrabasic and anorthositic rocks*

Ma - *Acid metavolcanics; chiefly of quartz latite composition; pale to medium grey, very fine- to fine-grained, indistinctly foliated and layered to massive, commonly with quartz and feldspar phenocrysts. Occurs mainly below the iron-formation*

Am — *Ultrabasic rocks; peridotite, serpentinite, actinolite rock; dark grey, light to dark green, chiefly thick bedded to massive, fine grained to coarse pegmatitic*

MN MG

MN - *Mela-anorthosite, melagabbroic anorthosite, white to light grey and mottled greenish grey and white; fine grained to coarse porphyritic football anorthosite; mostly very thick bedded to massive; minor melagabbro, amphibolite*

MG - *Metagabbro; chiefly amphibolite, fine- to medium-grained, dark greenish grey, foliated to massive*

Mif — *Metamorphosed iron-formation; mainly oxide facies, abundant silicate facies; local carbonate facies, iron ore (magnetite-hematite rock); fine grained, thin laminated to very thin bedded metallic grey, white, buff, brown, reddish*

MQ — *Upper member: quartzite; fine- to coarse-grained, white to pale grey or green; thin bedded to massive, minor meta-arkose, garnet- and mica (locally fuchsite)-bearing rocks*
Lower member: mica-quartz-feldspar schist and paragneiss, rodded-quartz paragneiss, alumino-silicate parsgneisses, minor meta-conglomerate; light to dark grey, fine- to medium-grained, secondary foliation common

gr — *Foliated quartz monzonite-granodiorite, local granite, light pink to light grey, medium grained, massive, minor faint layering; schlieren, mafic lenses, potash feldspar augen. In part younger than Mary River Group.*

mu — *Undifferentiated gneisses, mixed rocks; chiefly undivided Amg, Amp, gr, Amn, Agn; minor supracrustal rocks, veined gneiss, agmatite, gneissic mafic plutonic rocks*

Geological boundary (defined, approximate, assumed, gradational)
Bedding, tops known (horizontal, inclined)
General direction of sedimentary transport indicated by crossbedding
Schistosity, cleavage; ground determinations (inclined)
Gneissosity, general trend, dip unknown
Gneissic layering; mainly ground determinations (horizontal, inclined, vertical, inclination unknown)
Undifferentiated foliation; mainly airborne and airphoto determinations (horizontal, inclined, vertical, inclination unknown)

Linear structures:
Mesoscopic fold axis; hand specimen to large outcrop (horizontal, plunging)
Recumbent fold axis; (plunging)
Rodding; mineral aggregate or segregation, elongated rock fragments (horizontal, plunging)
Mineral lineation; individual crystals (horizontal, plunging)

Fold structure, nature uncertain
Lineament
Fault, solid circle indicates downthrown side (defined, approximate, assumed)
Dyke (defined, approximate-assumed, inferred from aeromagnetic data)
Anticline, arrow indicates direction of plunge (defined-approximate)
Syncline, arrow indicates direction of plunge (defined-approximate)
Antiform (overturned-recumbent)
Synform (upright-inclined)
Glacial striae (direction of ice movement determined, undetermined)
Fossil locality ⑥
Iron-formation (observed - inferred from aeromagnetic data)
Iron-formation; iron ore
Mary River iron deposit ① to ④
Age determination in millions of years (K, potassium-argon; w, whole-rock; a, actinolite; b, biotite; m, muscovite; h, hornblende) • 1965 ± 60
Sample locations of whole-rock Rubidium-Strontium isochron age determinations. See table on map regarding sample combinations in millions of years R(1-9)
Mineral occurrence gn ×
Airstrip (dirt)
Inuit dwelling site (most have square outline)

MINERALS

Asbestos	asb	Molybdenite	mo
Chalcopyrite	cp	Pyrite	py
Galena	gn	Pyrrhotite	po
Graphite	gf	Sphalerite	sp

Geology by G.D. Jackson, 1965, 1967, 1968; W.J. Crawford, 1965, 1968; S.L. Blusson, A. Davidson, W.C. Morgan, 1968; W.L. Davison, 1954; Baffinland Iron Mines Ltd. Co. reports for 1963, 1964

Compilation and interpretation by G.D. Jackson, W.C. Morgan and A. Davidson, completed 1975

Geological cartography by I.A. Coulthart, Geological Survey of Canada

Any revisions or additional geological information known to the user would be welcomed by the Geological Survey of Canada

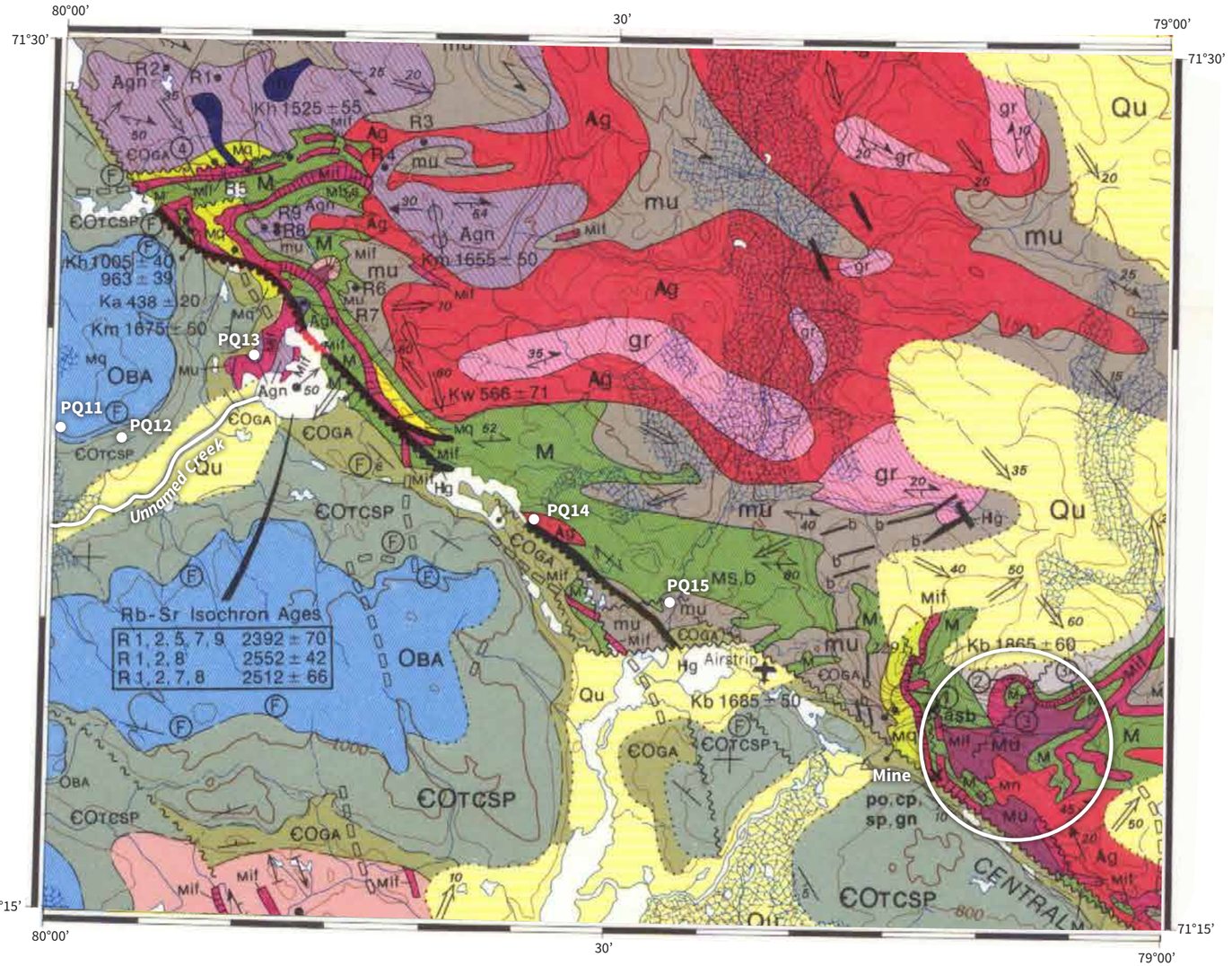
Base-map at the same scale published by the Surveys and Mapping Branch in 1967

Copies of the topographical edition of this map may be obtained from the Canada Map Office, 615 Booth Street, Ottawa, Ontario K1A 0E9

Mean magnetic declination 1977, 63°11.1' West, decreasing 26.6' annually. Readings vary from 61°21.6' in the SE corner to 65°01.8' in the NW corner of the map-area

Elevations in feet above mean sea-level

INDEX MAP



0 3 6 km

Modified from

MAP 1451A
GEOLOGY
ICEBOUND LAKE
DISTRICT OF FRANKLIN

Baffinland
12 Mtpa Expansion Project PFS
Geology - Icebound Lakes

HATCH

Appendix B
Site Photographs

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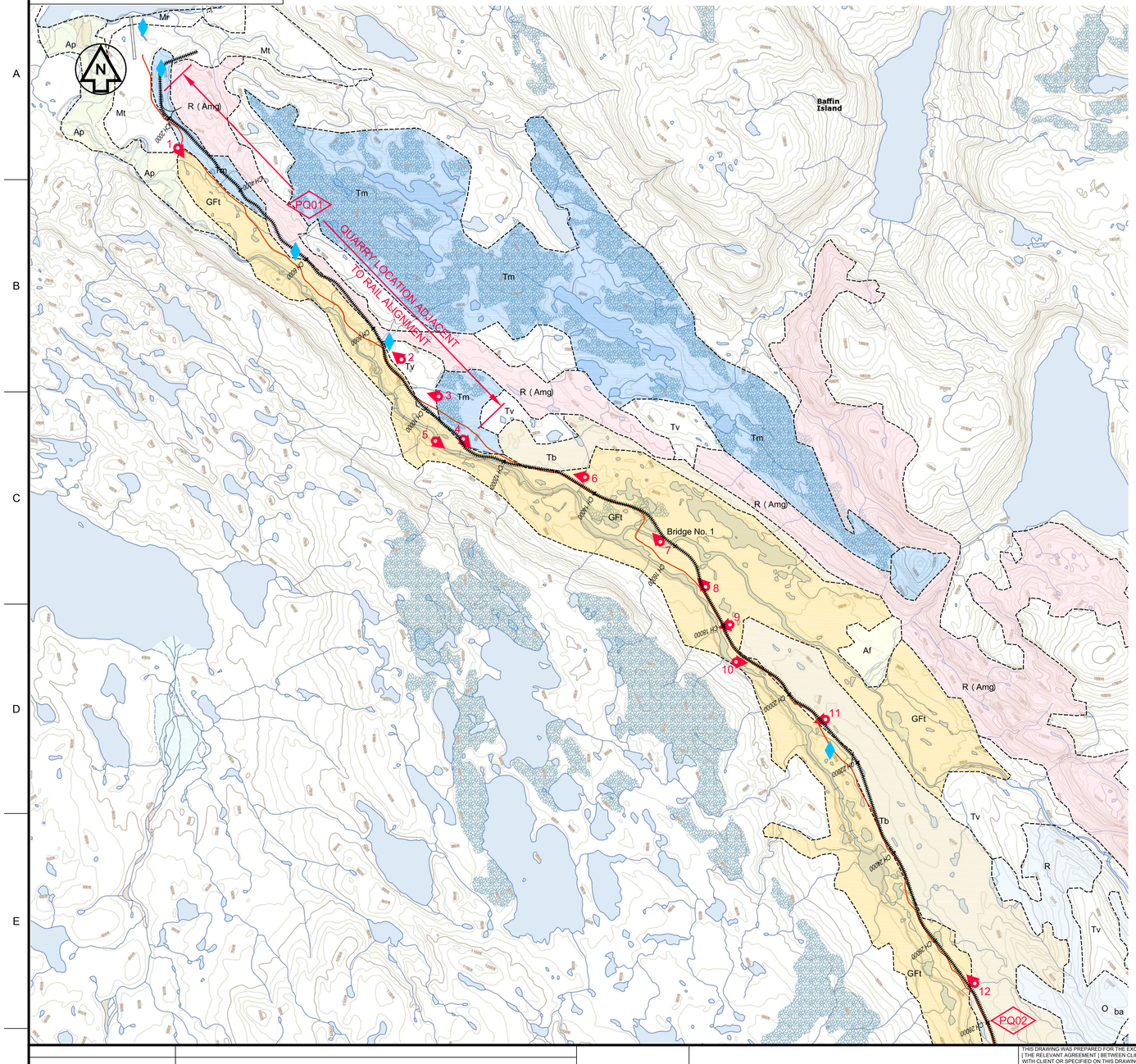

0 1 2 3 4 5 KILOMETRES

SCALE 1:50 000 (B1 SHEET)

NOTE:

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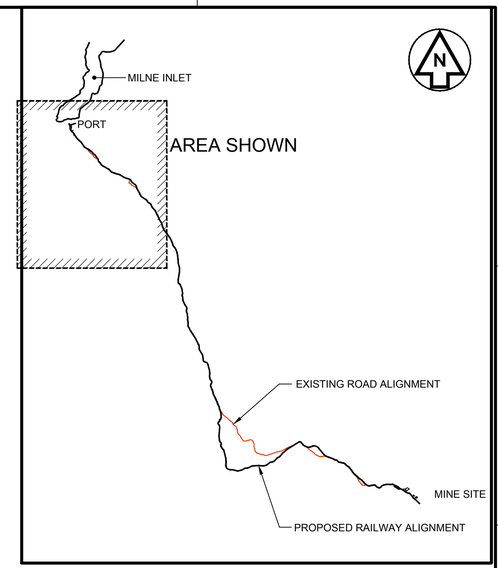
- DYKE, A.S. 2000, SURFICIAL GEOLOGY PHILLIPS CREEK, BAFFIN ISLAND, NUNAVUT, GEOLOGICAL SURVEY OF CANADA, MAP 1961A, SCALE 1:250,000.



KEY PLAN

0 10 20 30 40 50 kilometres

SCALE 1:500 000

LEGEND

- 55 — PHOTOGRAPH LOCATION AND DIRECTION
- PQ02 — POTENTIAL QUARRY
- CURRENT LEASED/PERMITTED QUARRY
- ICE RICH SOIL

UNIT	DESCRIPTION
R (Amg)	UNDIFFERENTIATED GNEISS AND GRANITIC ROCKS
R	SEDIMENTARY ROCK
R,GF	VENEERED ROCK: UNDULATING ROCK COVERED BY A DISCONTINUOUS VENEER OF GLACIAL FLUVIAL SAND AND GRAVEL. NUMEROUS OUTCROPS
A	ALLUVIAL PLANES: ACTIVE BRAIDED FLOODPLAINS INCLUDES ACTIVE PROGLACIAL OUTWASH
Co	COLLUVIUM
L	DEEPWATER PROGLACIAL DEPOSITS: SILT AND CLAYEY SILT BLANKET, WITH FINE SAND WITH ICE RAFTED STONES
Mt	DELTAIC SEDIMENTS: CLAY SILT, SAND AND GRAVEL
Mr	BEACH SEDIMENTS: SAND
GFt,	GLACIOFLUVIAL OUTWASH: TERRACES (t), PLANES (AND FANS (
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Baffinland

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B	PHOTOGRAPH LOCATIONS ADDED	DP	WH	2016-10-15

ROLE	NAME	SIGNATURE	DATE
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DESIGNER	U KHAN	NR	
CHECKER			
DESIGN COORD.	W HOYLE		
RESP. ENG.			
LEAD DISC. ENG.	S HINCHBERGER		
ENG. MANAGER			
PROJ. MANAGER	J CLELAND		

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REFERENCE DRAWINGS

REG. PROFESSIONAL

DRAWING No. | DRAWING TITLE

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PRE FEASIBILITY STUDY

2016 GEOTECHNICAL INVESTIGATIONS
GEOLOGICAL MAPPING
SHEET 1 OF 4

SCALE 1:50,000 OR AS NOTED

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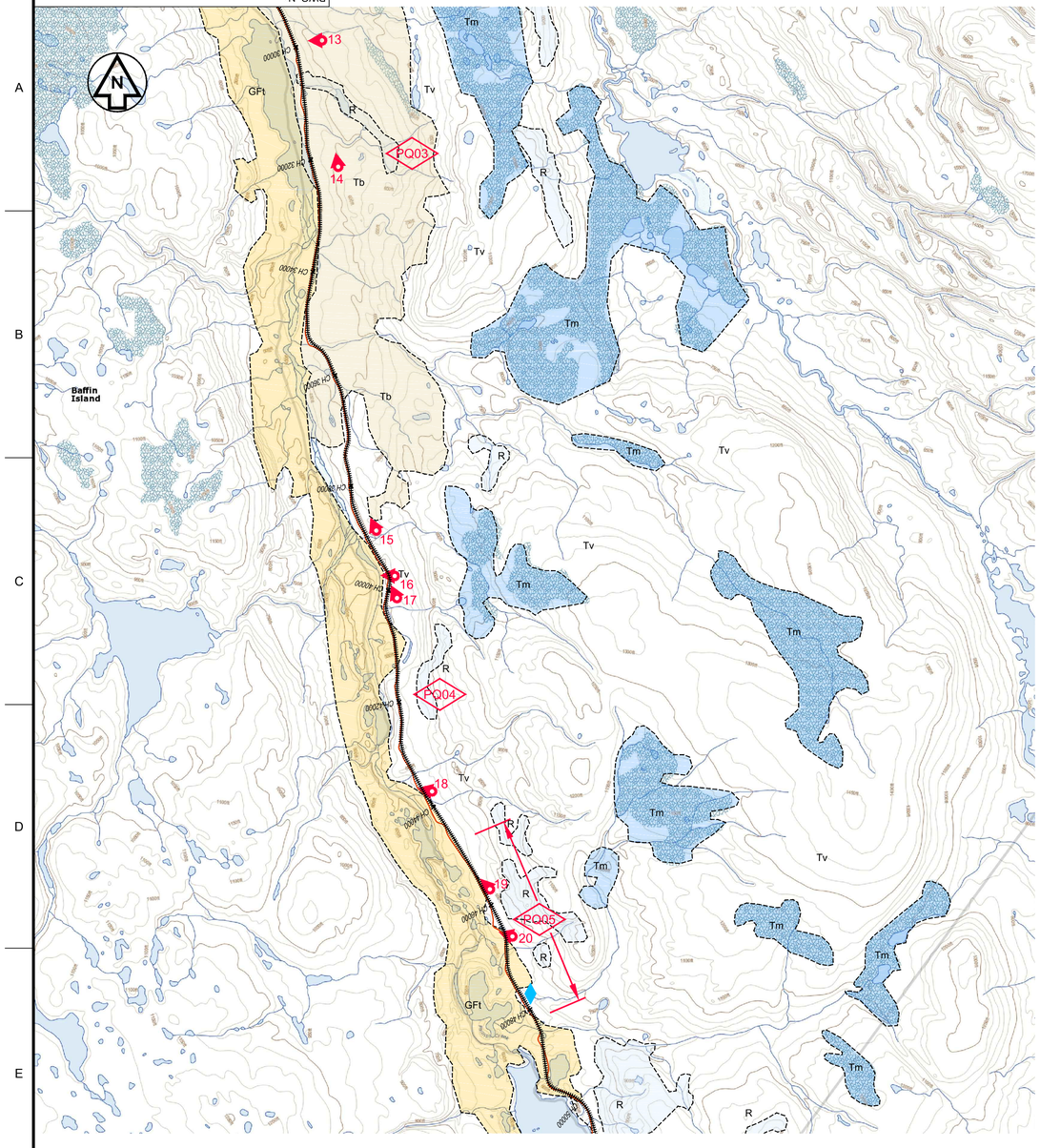

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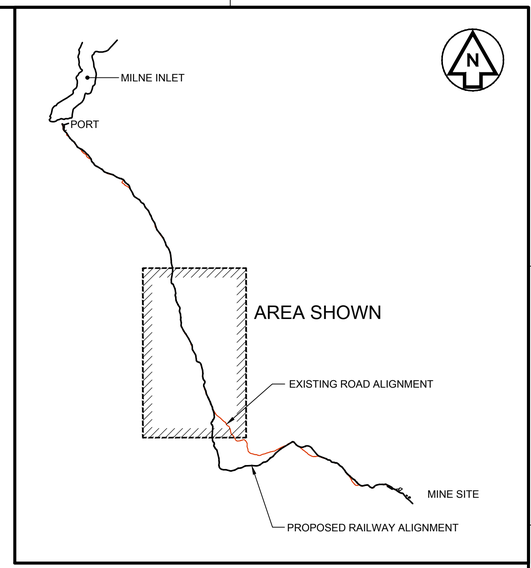

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0 1 2 3 4 5 KILOMETRES

SCALE 1:50 000 (B1 SHEET)

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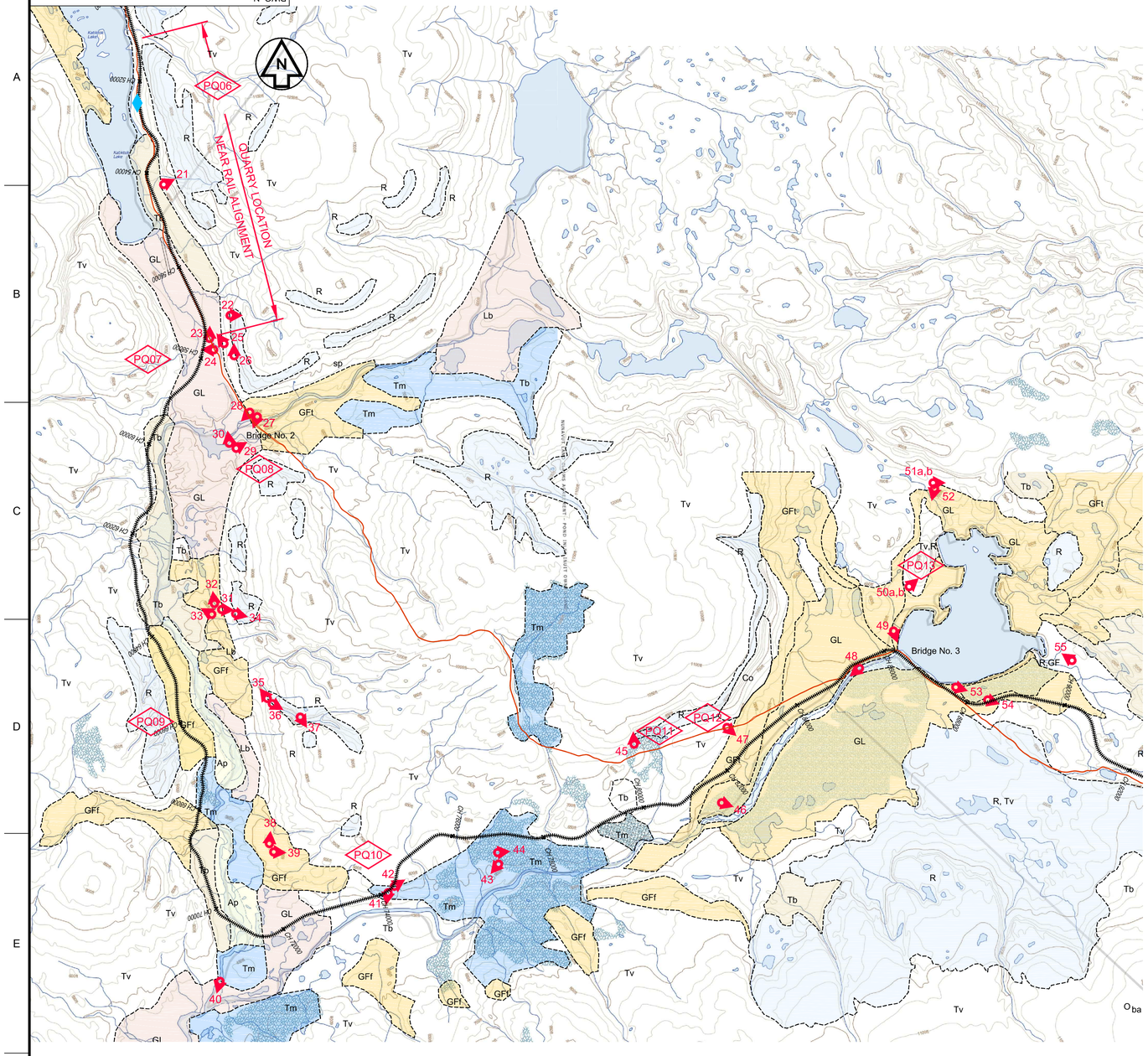

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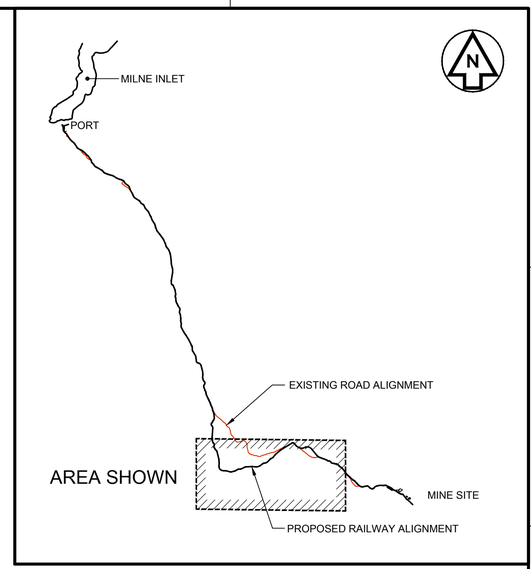

KEY PLAN

0 10 20 30 40 50 kilometres

SCALE 1:500 000

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ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	N DONNELLY	NR	
DESIGNER	U KHAN	NR	
CHECKER			
DESIGN COORD.	W HOYLE		
RESP. ENG.			
LEAD DISC. ENG.	S HINCHBERGER		
ENG. MANAGER			
PROJ. MANAGER	J CLELAND		

DRAWING APPROVAL STATUS: Client Re e

HATCH

Baffinland

BAFFINLAND E PANSION M PA MINE OP ION
PRE FEASIBILITY STUDY

2016 GEOTECHNICAL INVESTIGATIONS
GEOLOGICAL MAPPING
SHEET 3 OF 4

DRAWING No.	DRAWING TITLE
REFERENCE DRAWINGS	

REG. PROFESSIONAL

SCALE 1:50,000 OR AS NOTED

DWG. No. H352034-GEOSKT-229-292-0002

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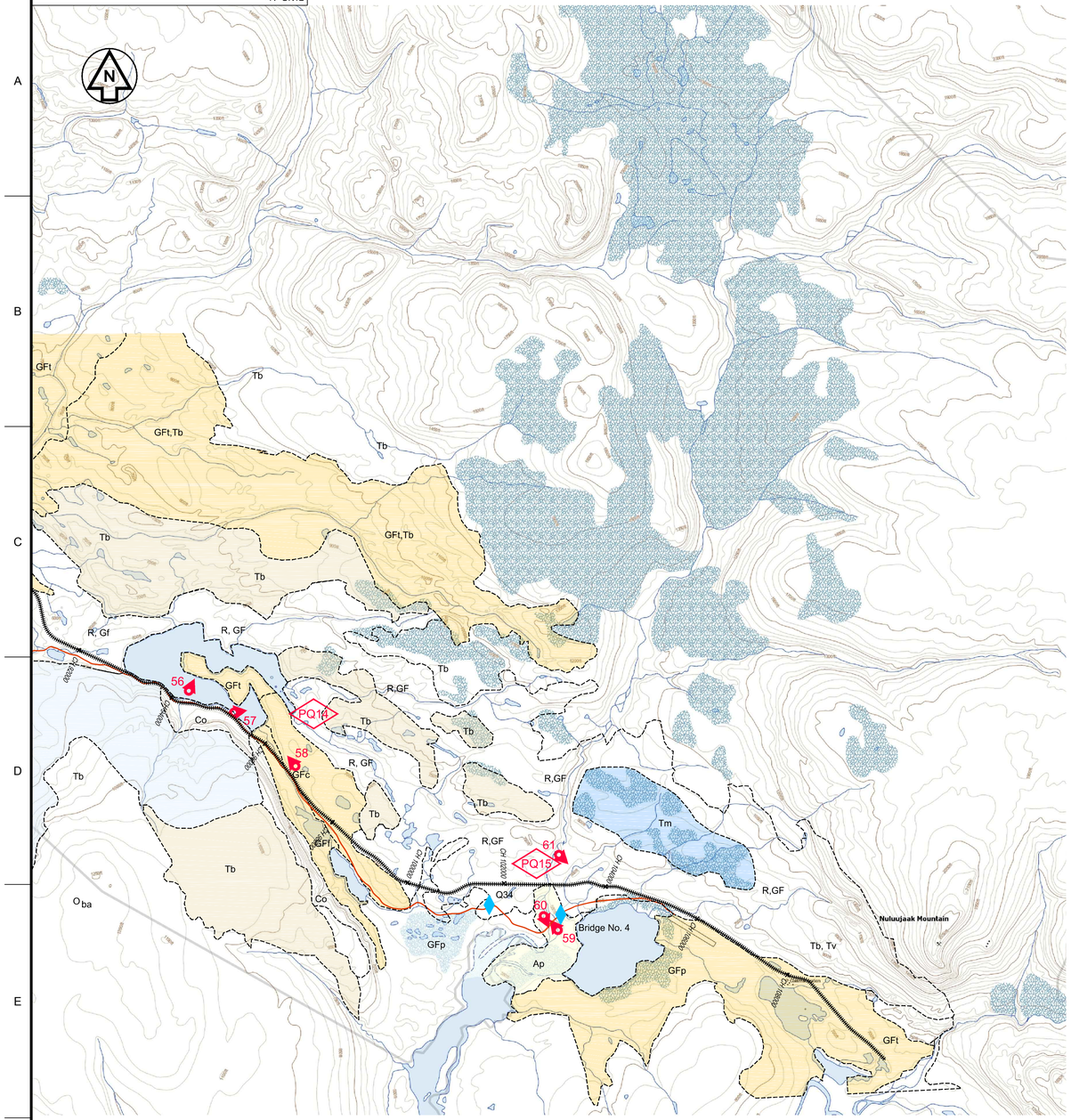
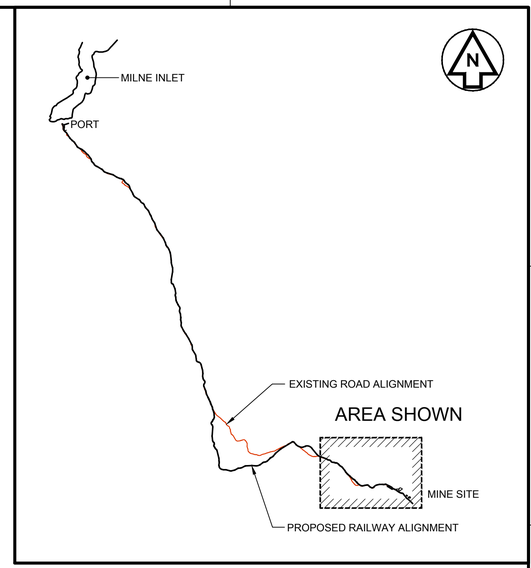


NOTE:

THE TERRAIN UNITS AND BOUNDARIES SHOWN ON THIS DRAWING ARE APPROXIMATE AND ARE BASED ON THE PUBLICALLY AVAILABLE GEOLOGIC MAPS LISTED BELOW. THIS DRAWING IS INTENDED TO ILLUSTRATE GENERAL TRENDS AND IT IS SUITABLE FOR PLANNING PURPOSES FOR PREFEASIBILITY AND FEASIBILITY STUDIES. A SUITABLE GEOTECHNICAL INVESTIGATION PROGRAM SHOULD BE UNDERTAKEN IF UNCERTAINTY IN THE GROUND TYPE AND THE BOUNDARIES BETWEEN UNITS WILL AFFECT DESIGN OR CONSTRUCTION PLANNING. USE OF THIS DRAWING SHOULD TAKE INTO ACCOUNT ITS APPROXIMATE NATURE.

- LITTLE, E.C., HOLME, P.J., AND KERR, D.E., 2013. SURFICIAL GEOLOGY ICEBOUND LAKES (SOUTHWEST) BAFFIN ISLAND, NUNAVUT, GEOLOGICAL SURVEY OF CANADA MAP 74 (PRELIMINARY), SCALE 1:100,000.
- DYKE, A.S. 2000, SURFICIAL GEOLOGY PHILLIPS CREEK, BAFFIN ISLAND, NUNAVUT, GEOLOGICAL SURVEY OF CANADA, MAP 1961A, SCALE 1:250,000.



KEY PLAN

0 10 20 30 40 50 kilometres

SCALE 1:500 000

LEGEND

55 PHOTOGRAPH LOCATION AND DIRECTION

PQ02 POTENTIAL □JARRY

CURRENT LEASED/PERMITTED □JARRY

ICE RICH SOIL

UNIT	DESCRIPTION
R (Am□	UNDIFFERENTIATED GNEISS AND GRANITIC ROCKS
R	SEDIMENTARY ROCK
R,GF	VENEERED ROCK: UNDULATING ROCK COVERED BY A DISCONTINUOUS VENEER OF GLACIAL FLUVIAL SAND AND GRAVEL. NUMEROUS OUTCROPS
A□	ALLUVIAL PLANES: ACTIVE BRAIDED FLOODPLAINS□INCLUDES ACTIVE PROGLACIAL OUTWASH
Co	COLLUVIUM
L□	DEEPWATER PROGLACIAL DEPOSITS: SILT AND CLAYEY SILT BLANKET, WITH FINE SAND WITH ICE RAFTED STONES
Md	DELTAIC SEDIMENTS: CLAY SILT, SAND AND GRAVEL
Mr	BEACH SEDIMENTS: SAND
GFt,□□	GLACIOFLUVIAL OUTWASH: TERRACES (t), PLANES (□ AND FANS (□
GFc	GLACIOFLUVIAL ICE CONTACT DEPOSIT: ESKER
GL	GLACIOLACUSTRINE DEPOSIT: CONTAINS MIXED SAND, AND SILT. INCLUDES BEACH DEPOSITS
T□	TILL BLANKET: 2-10m THICK FORMING AN UNDULATING BLACKET WITH DRUMLINS AND RIBBED MORAINES IN PLACES
T□	TILL VENER: 0.5-2m THICK□DISCONTINUOUS
Tm	GLACIAL END MORAINE: 5-60m HIGH, COMPOSED OF OR MANTLED BY TILL, EXTENSIVELY KETTLED IN PLACES□FLARE FEATURES WITH DEBRIS-RICH RELICT GLACIER ICE
	POTENTIAL □JARRY

0 1 2 3 4 5 KILOMETRES

SCALE 1:50 000 (B1 SHEET)

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D	CLIENT REVIEW	KK	WH	2017-03-17
C	DRILLING PROGRAM STATUS AS OF DECEMBER 09, 2016 (END OF 2016 SEASON)	DP	WH	2016-12-16
B	PHOTOGRAPH LOCATIONS ADDED	DP	WH	2016-10-15

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	N DONNELLY		NR
DESIGNER	U KHAN		NR
CHECKER			
DESIGN COORD.	W HOYLE		
RESP. ENG.			
LEAD DISC. ENG.	S HINCHBERGER		
ENG. MANAGER			
PROJ. MANAGER	J CLELAND		

DRAWING APPROVAL STATUS: Client Re□e□

REFERENCE DRAWINGS

REG. PROFESSIONAL

DRAWING No. | DRAWING TITLE

BAFFINLAND E□ PANSION □ □ M□ PA MINE OP□ ION
PRE FEASIBILITY STUDY

2016 GEOTECHNICAL INVESTIGATIONS
GEOLOGICAL MAPPING
SHEET 4 OF 4

SCALE 1:50,000 OR AS NOTED

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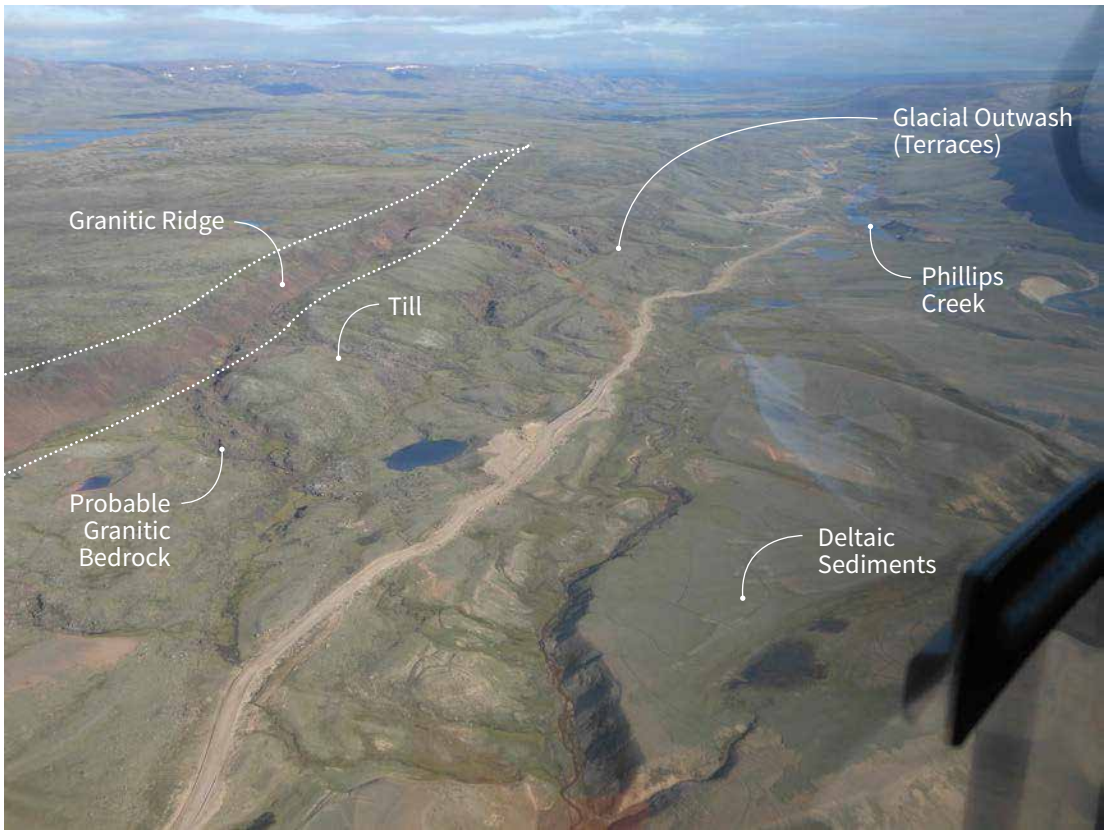

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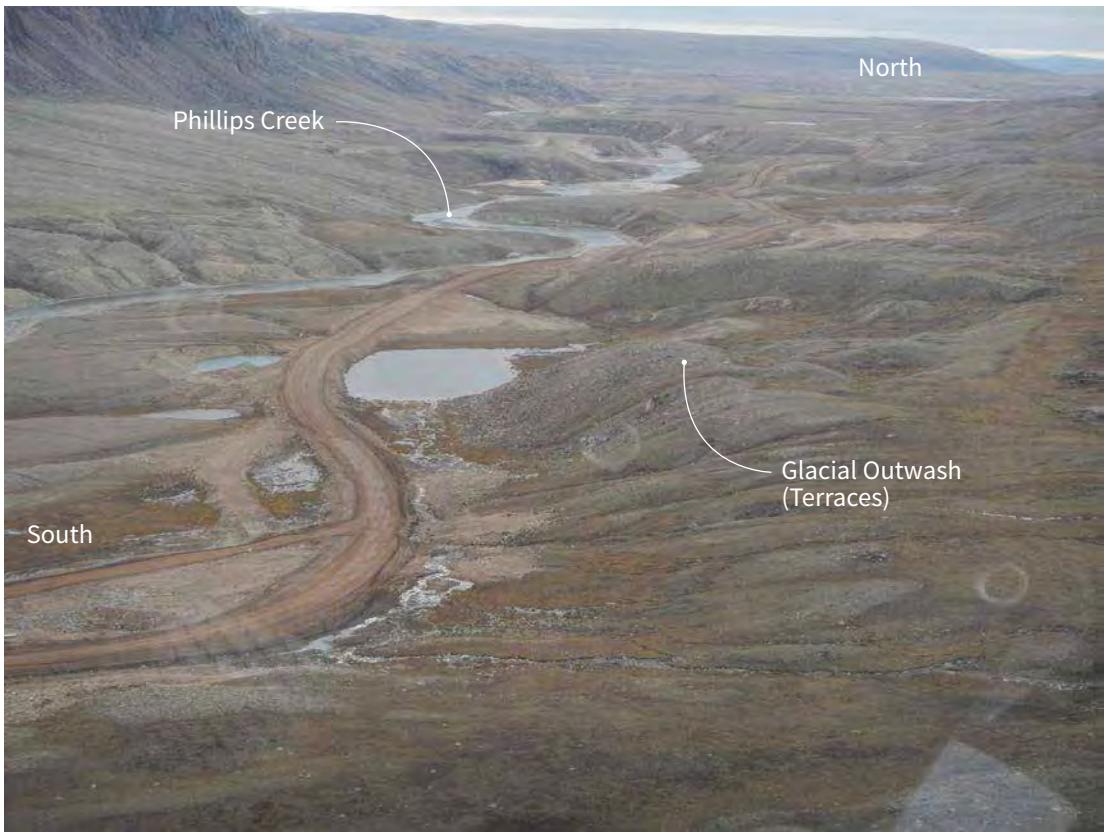

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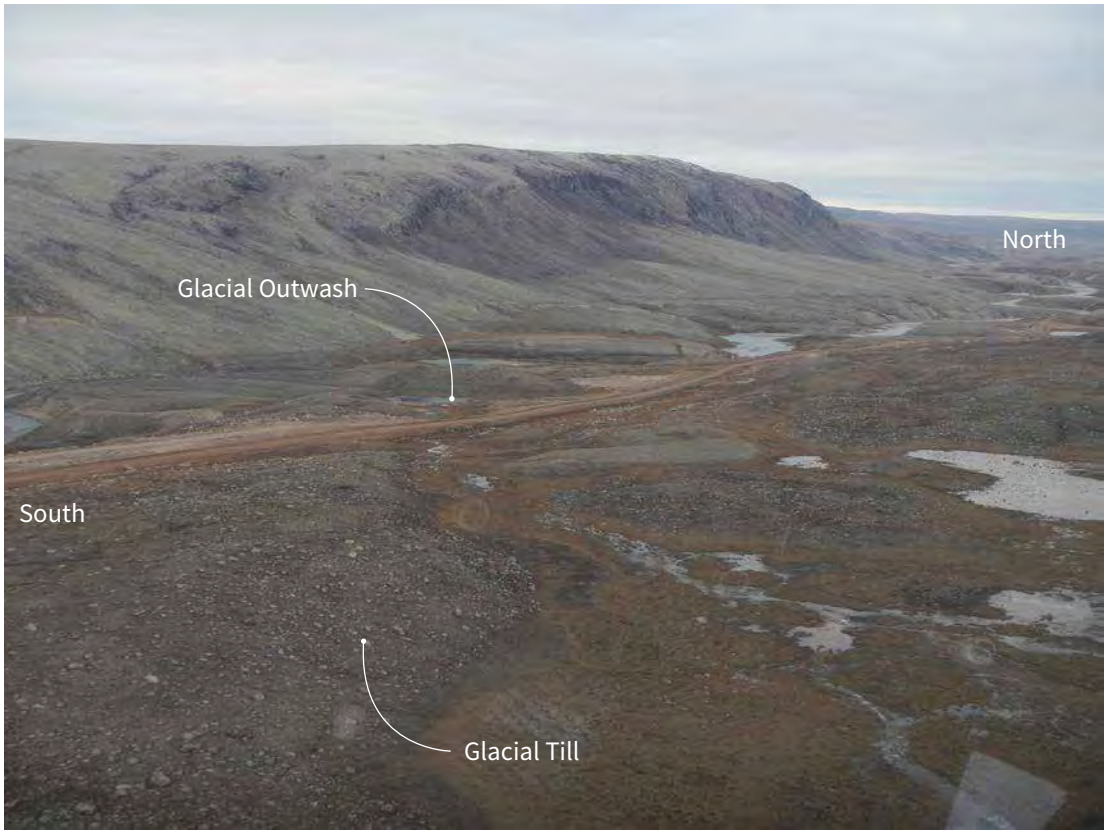

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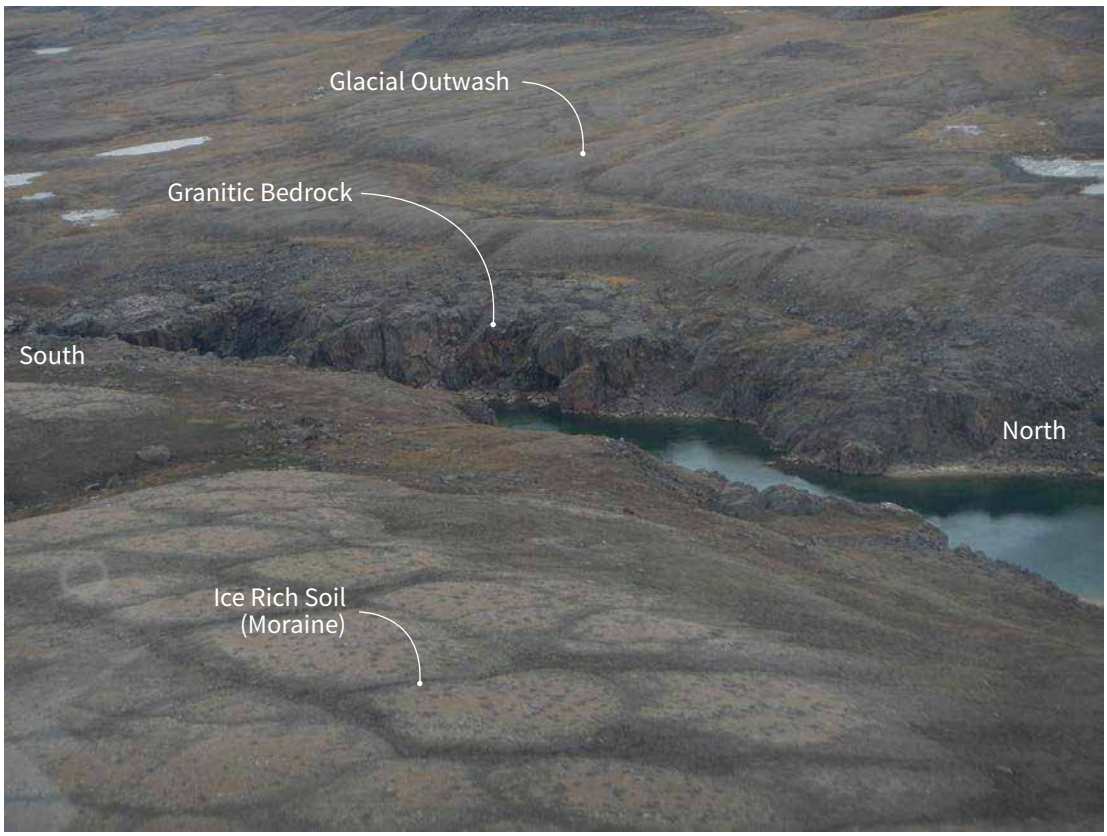

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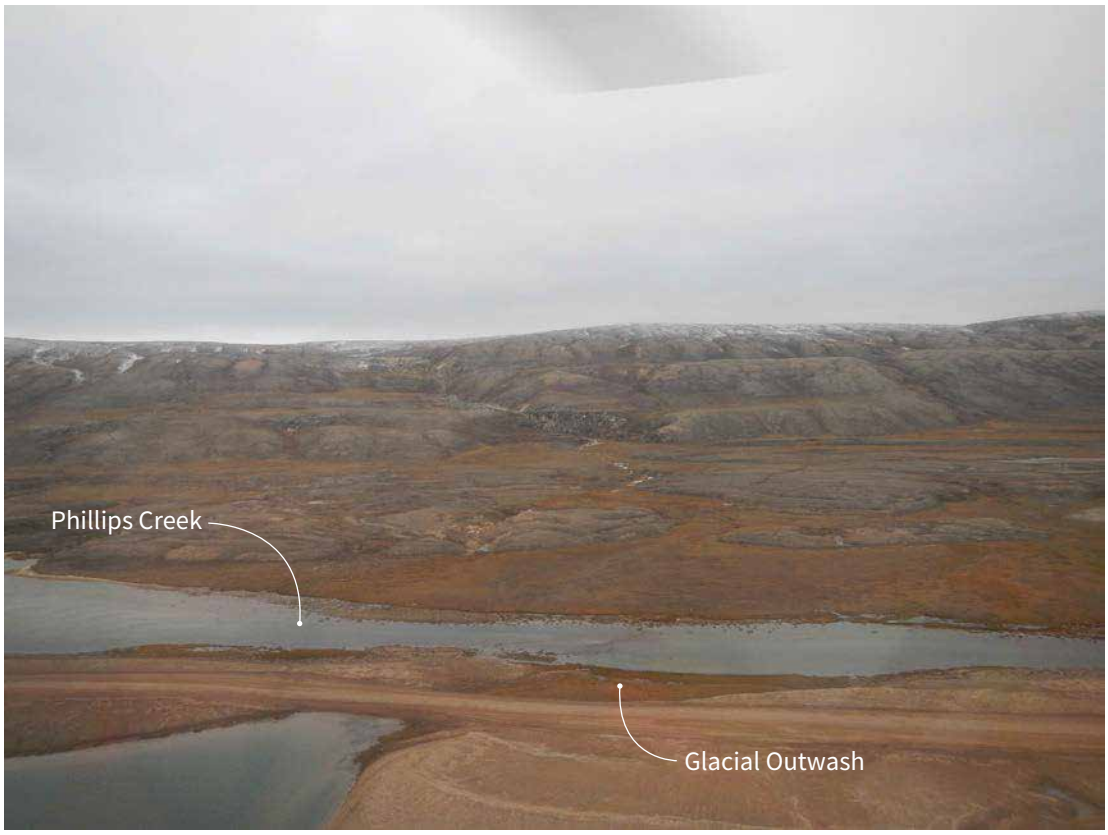
Photo 5

Photo 6

Photo 7

Photo 8



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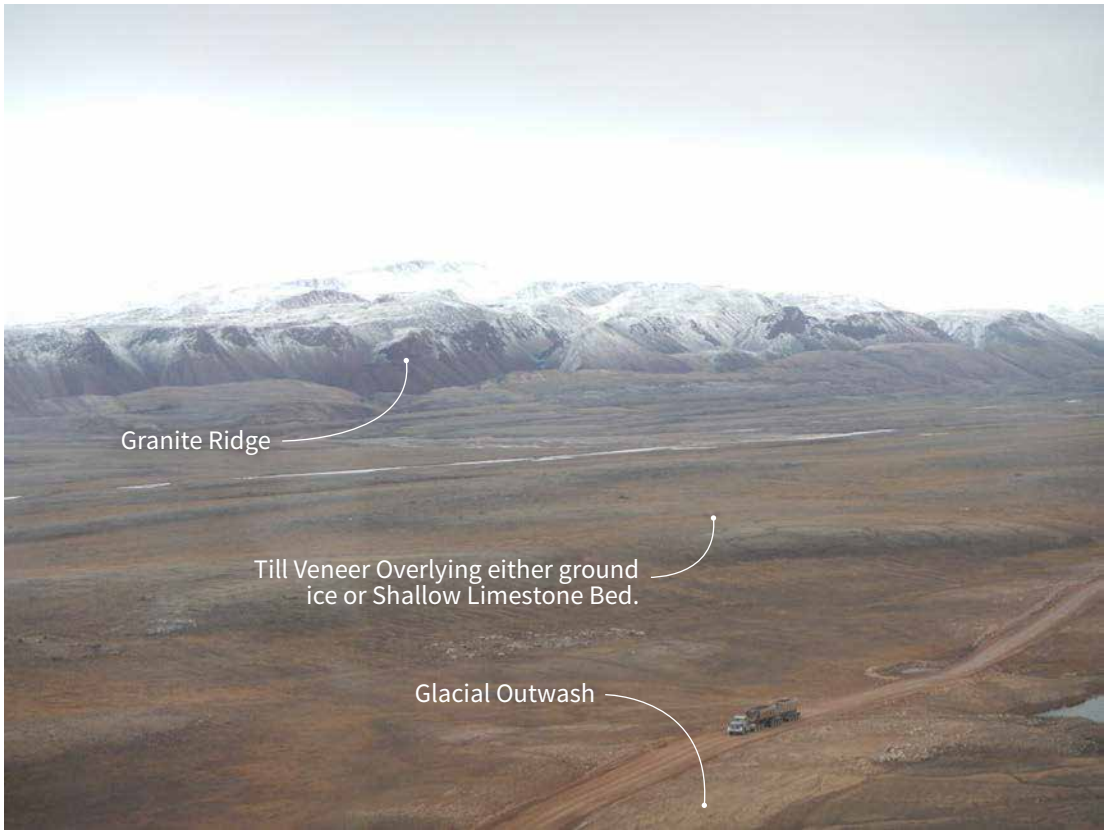

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Photo 11

Photo 12

Photo 13

Photo 14

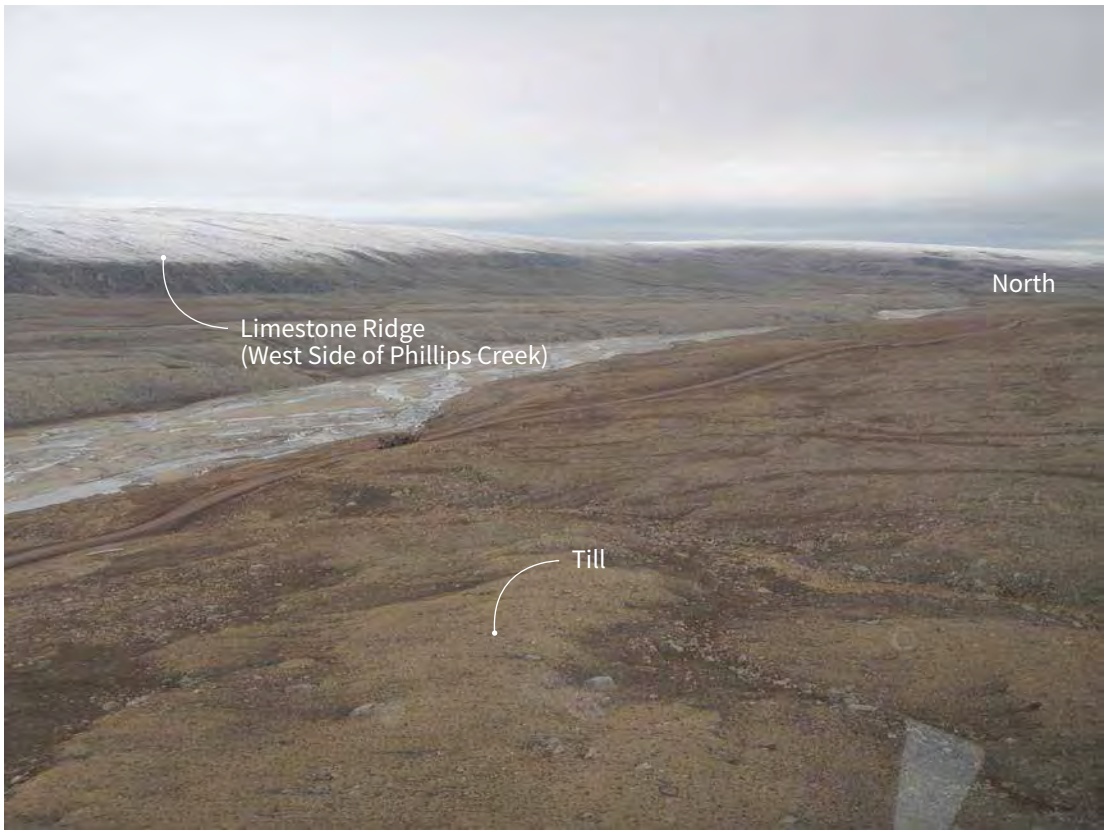

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Photo 16

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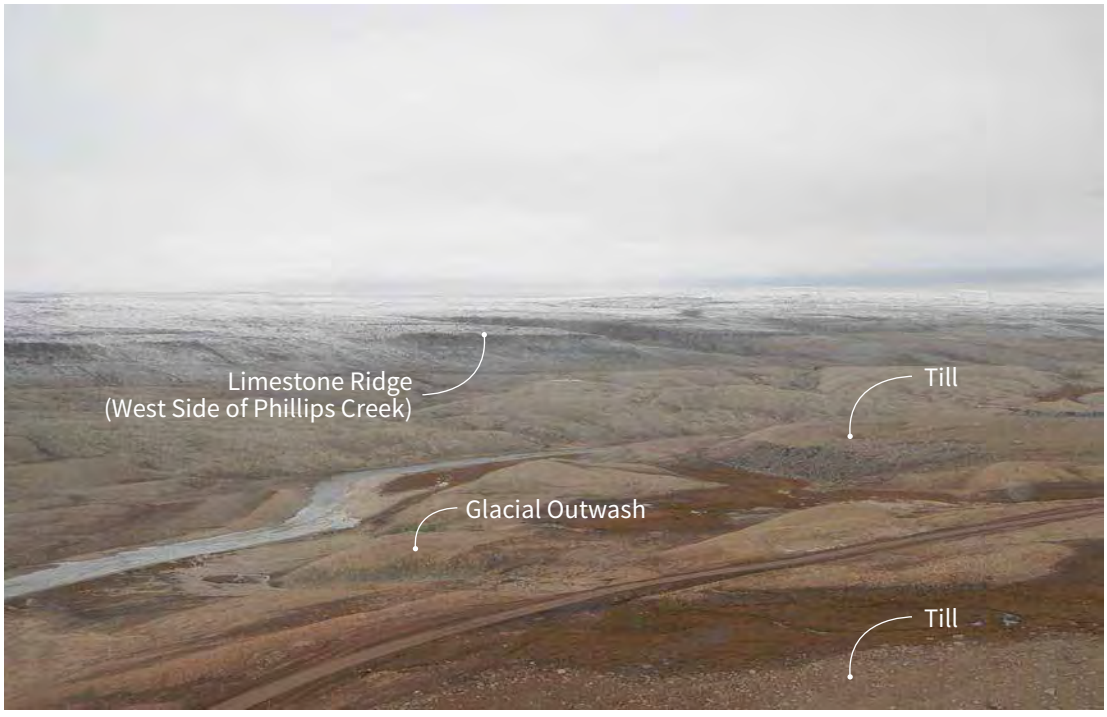

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Photo 19

Photo 20

Photo 21

Photo 22

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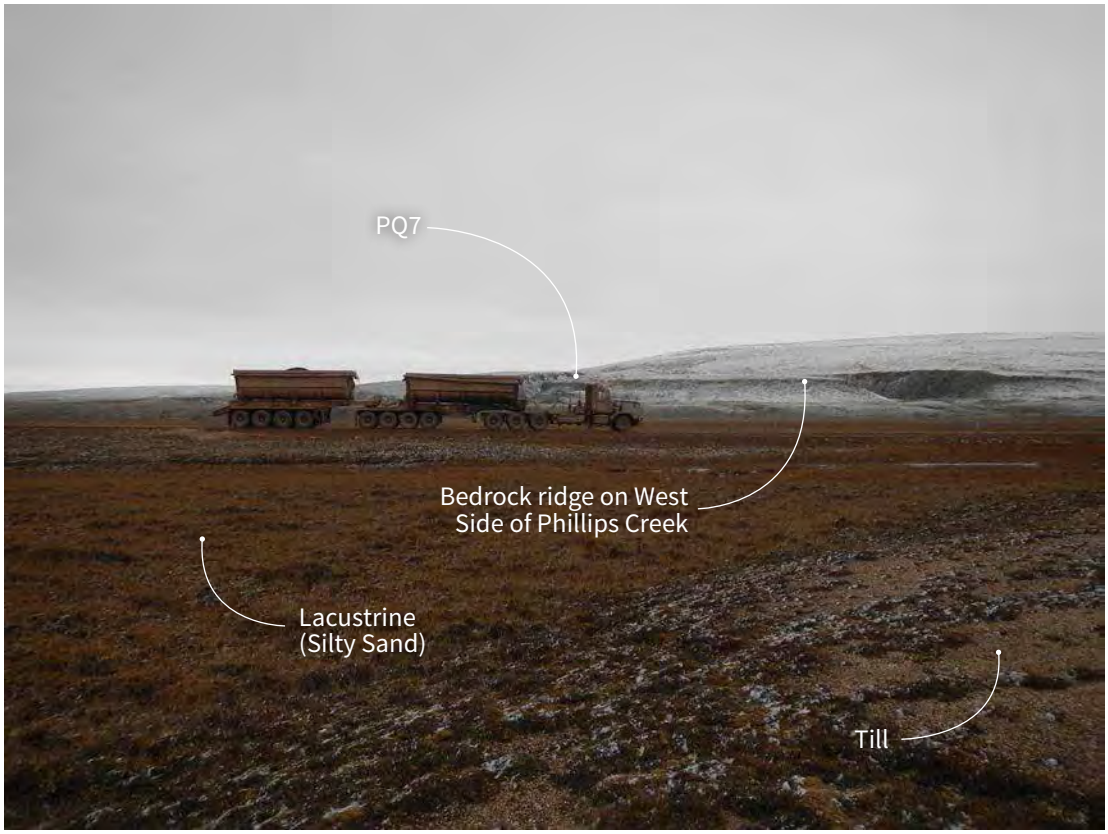


Photo 24

Photo 25

Photo 26

Photo 27

Photo 28

Photo 29

Photo 30

Photo 31

Photo 32

Photo 33

Photo 34

Photo 35

Photo 36

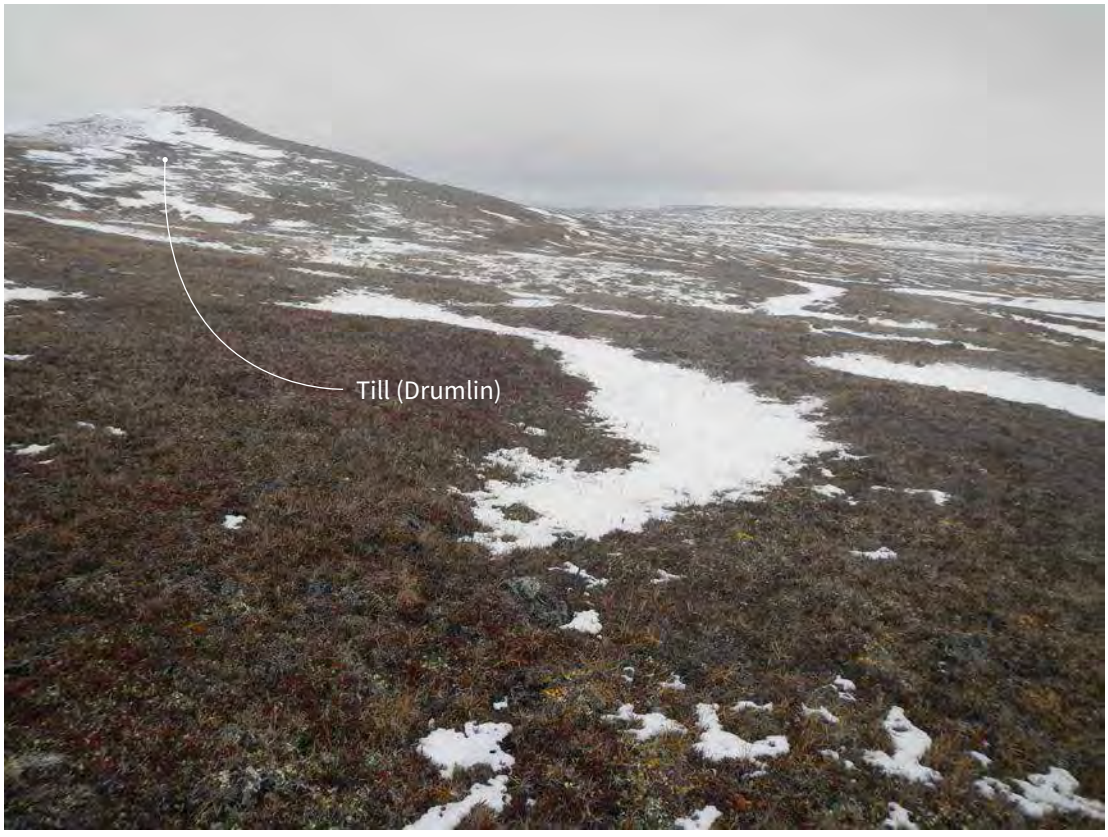
Photo 37

Photo 38

Photo 39

Photo 40

Photo 41



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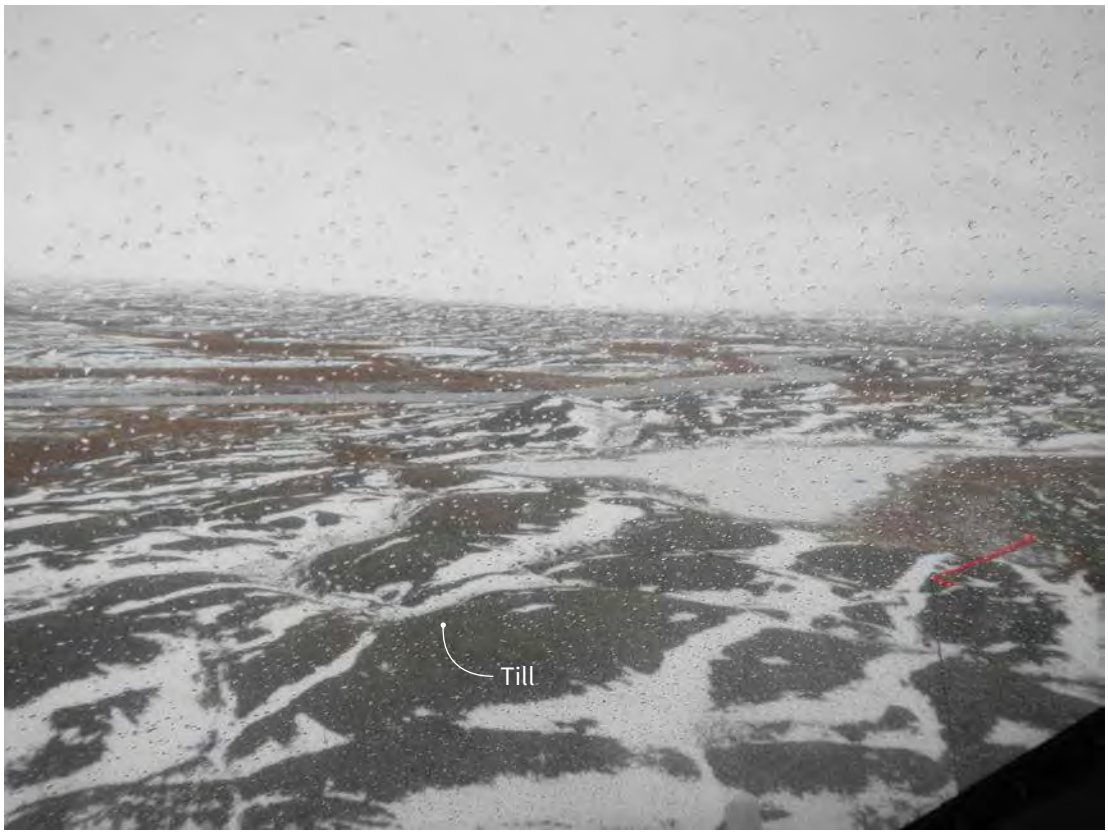

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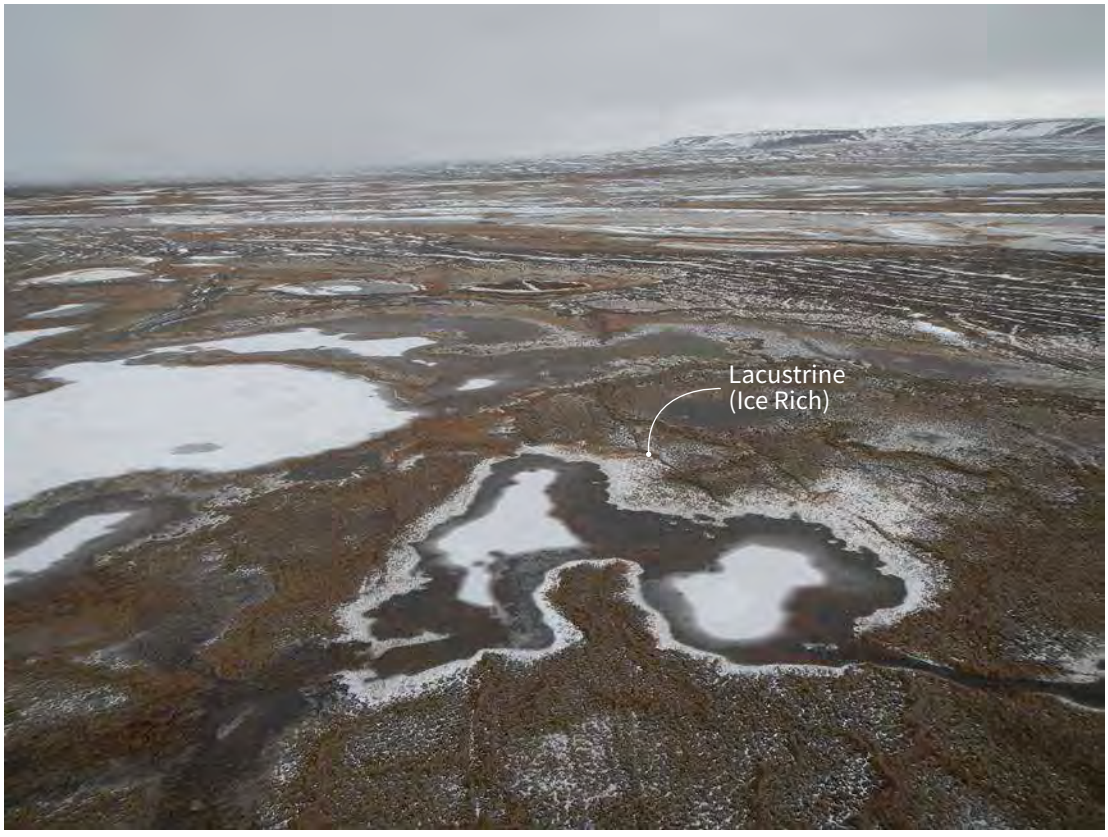

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Photo 47

Photo 48

Photo 49

Photo 50a

Photo 50b

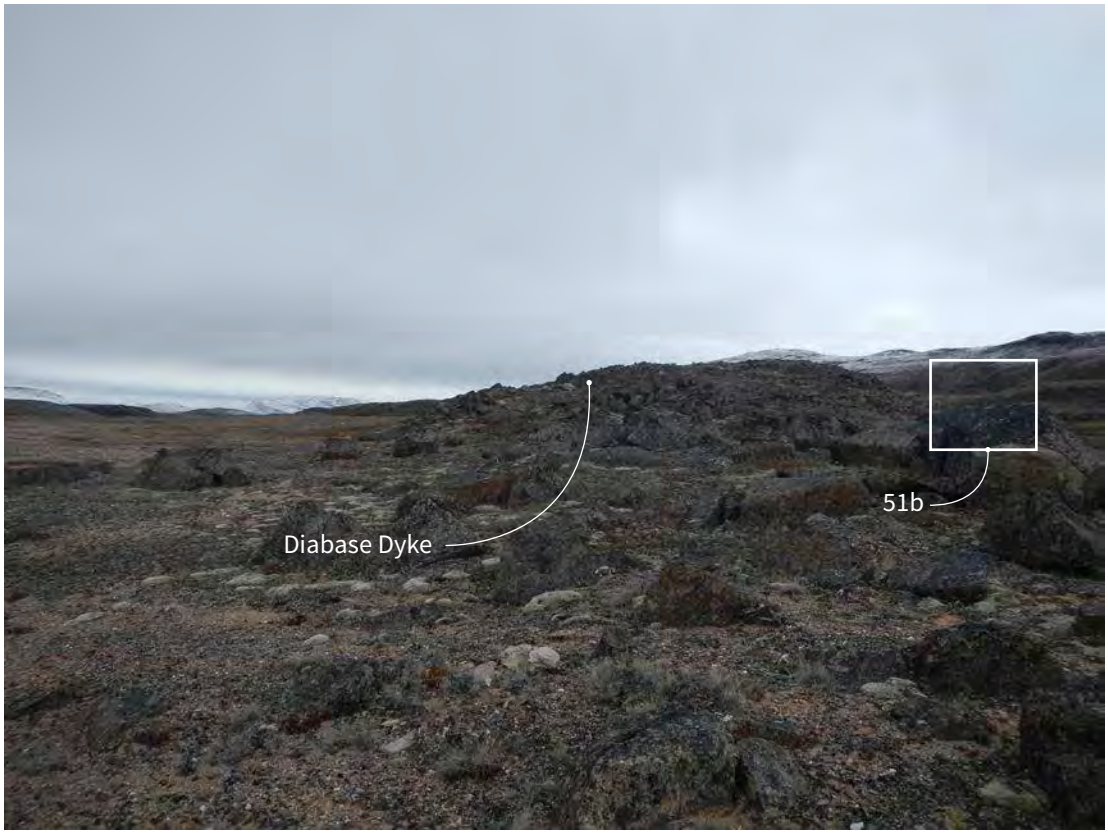

Photo 51a

Photo 51b

Photo 52

Photo 53

Photo 54

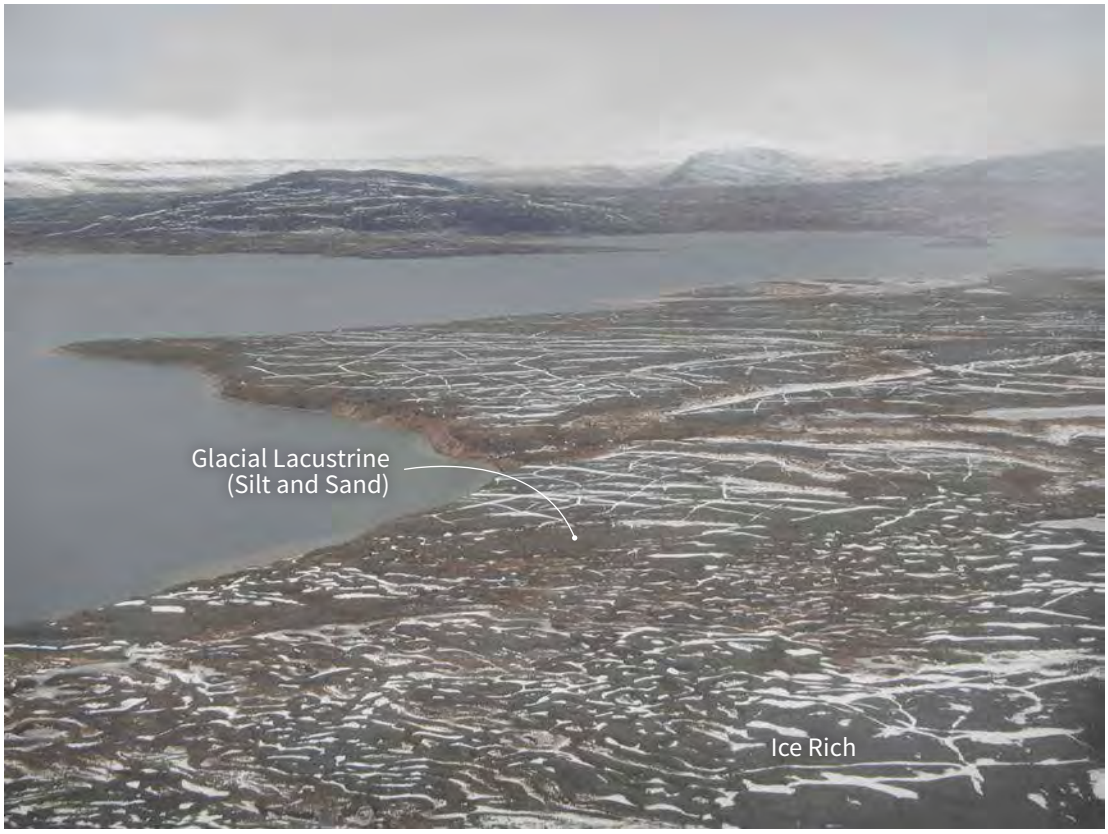

Photo 55

Photo 56

Photo 57

Photo 58

Photo 59

Photo 60

Photo 61

Appendix C
Aerial Photographs

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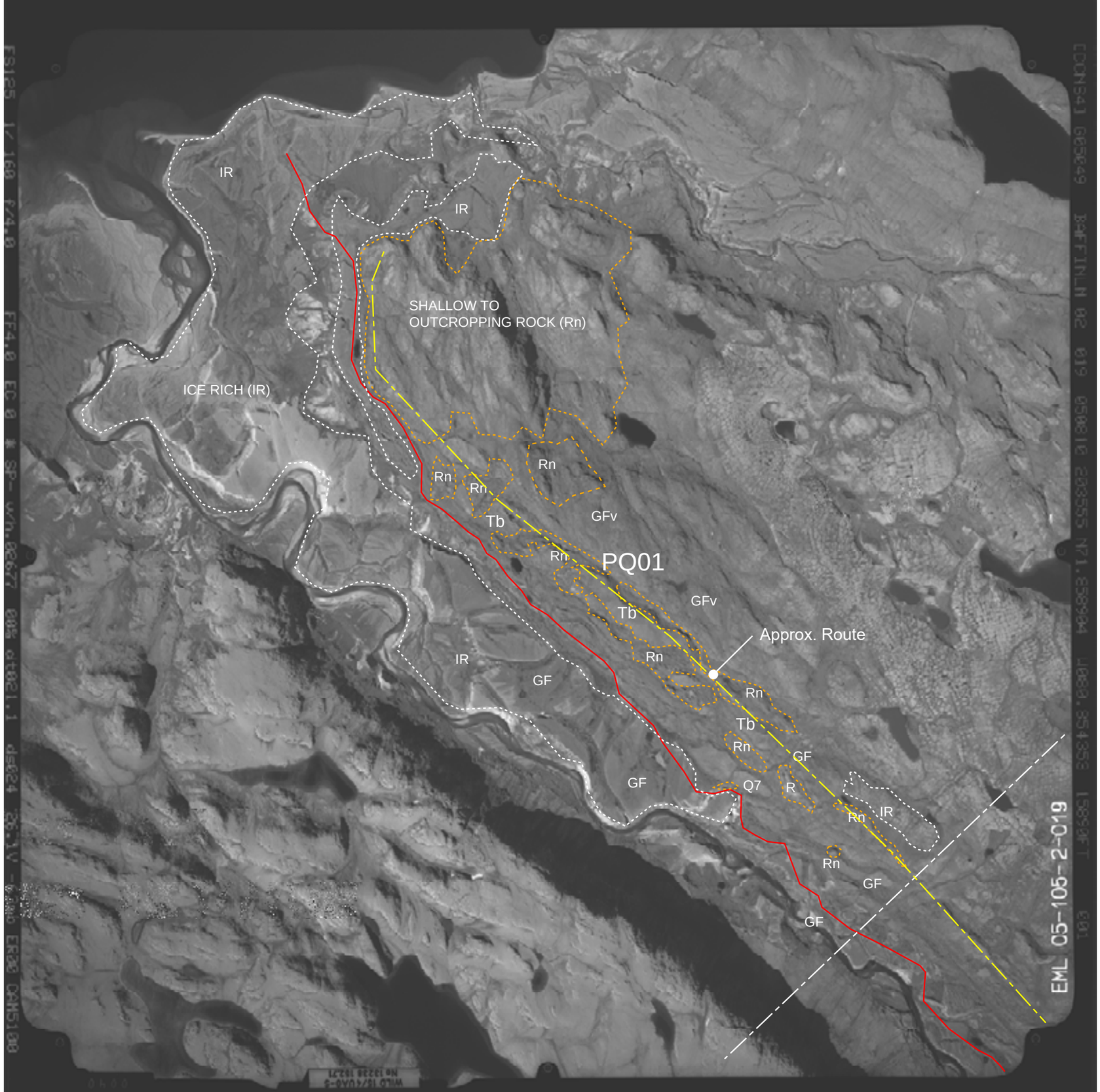
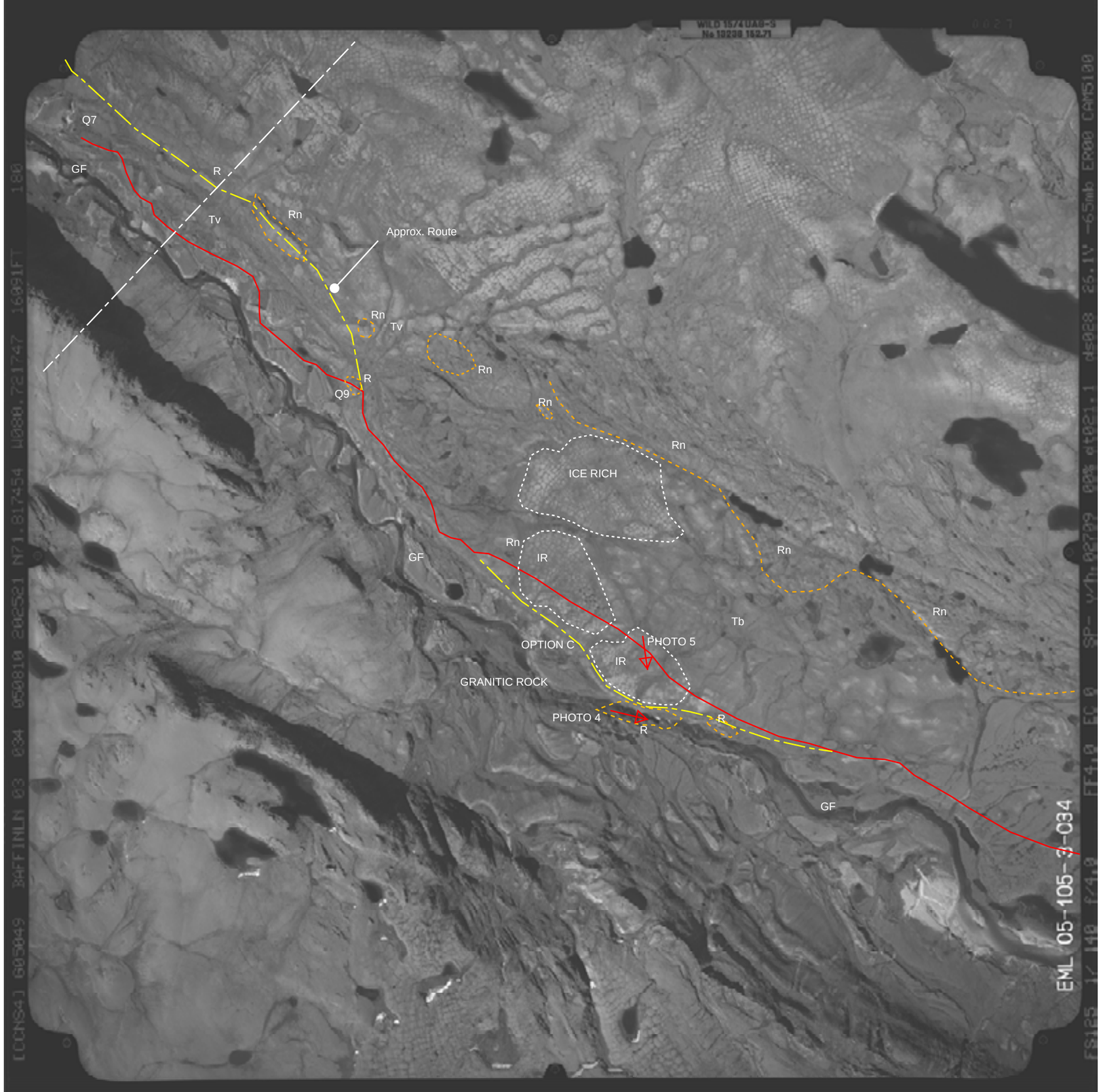


Legend

R - Confirmed or High Probability Rock Outcrop
Rn - Rock knobs, thin soil veneer suspected occasional to frequent outcrops.
GF - Glaciofluvial/fluvial sands and gravels (v-denotes veneer)
Tv - Till Veneer (0-2m thick)
Tb - Till Blanket (>2m thick)
IR - Ice Rich
Al - Alluvium
Tb, Co - Talus over Till

CH0+000 to 8+000



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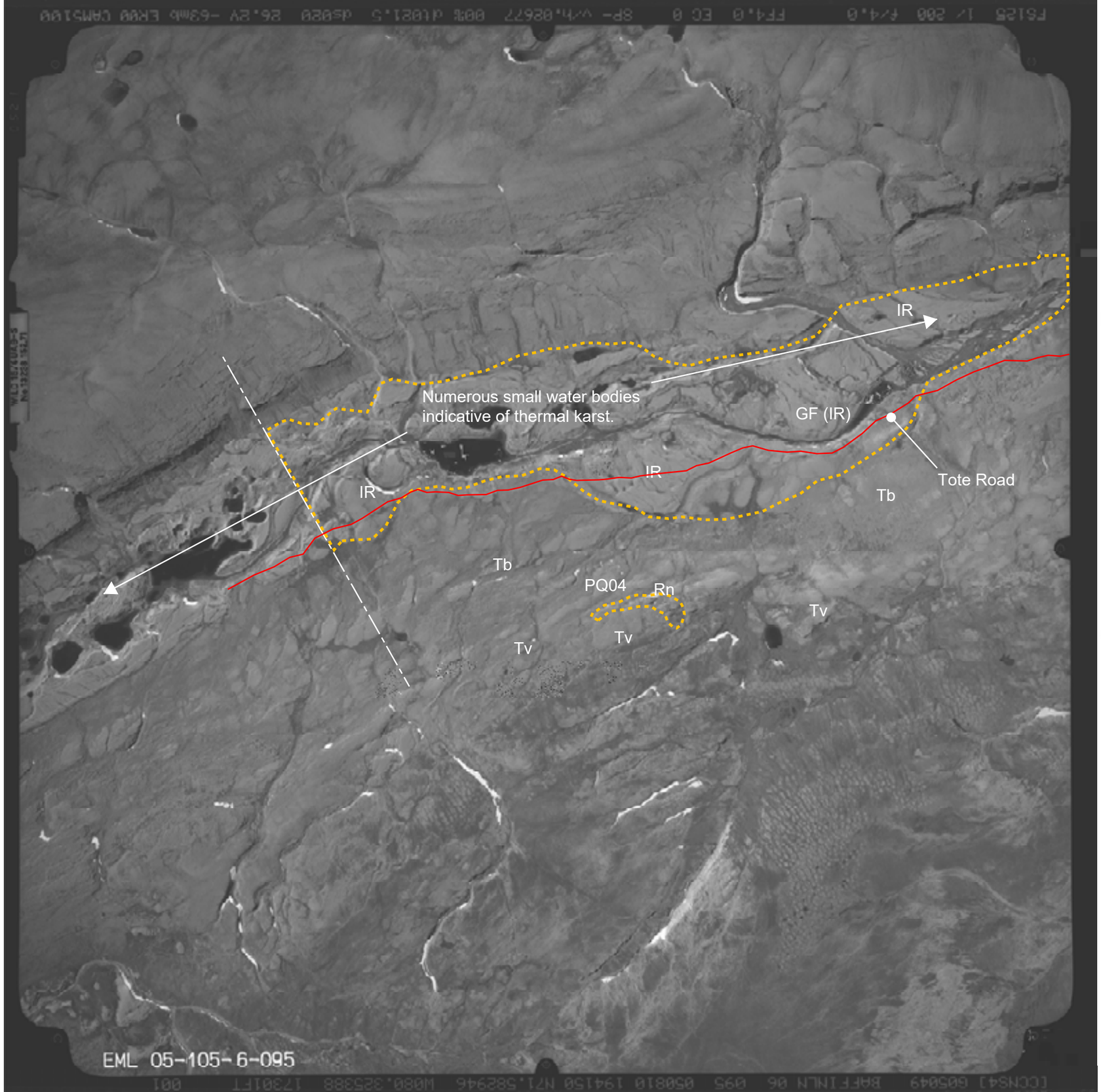
Tb - Till Blanket (>2m thick)
IR - Ice Rich
Al - Alluvium
Tb, Co - Talus over Till

CH 6+000 to CH 14+000



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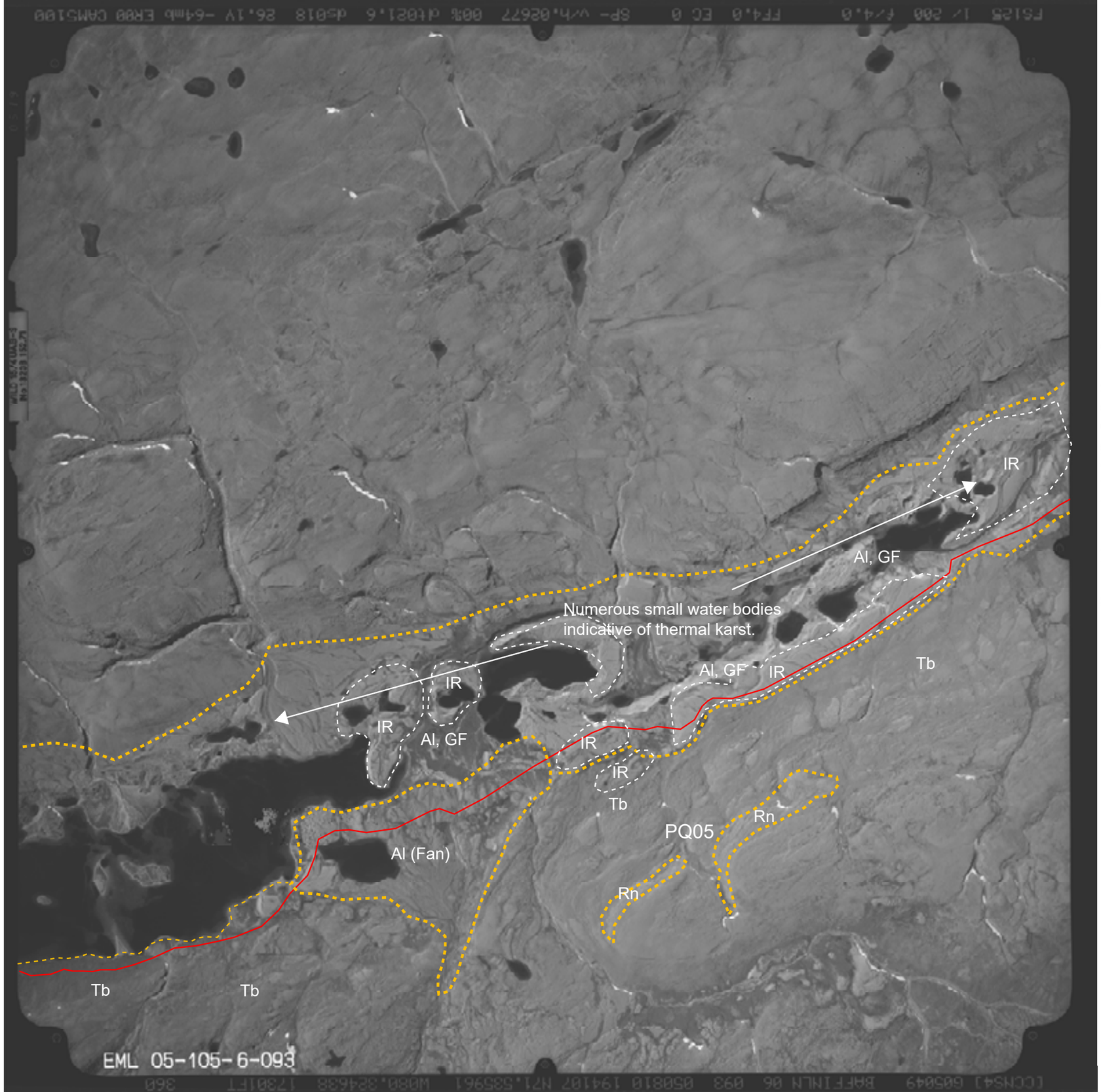
Tb - Till Blanket (>2m thick)
IR - Ice Rich
Al - Alluvium
Tb, Co - Talus over Till

CH 38+000 to 46+000



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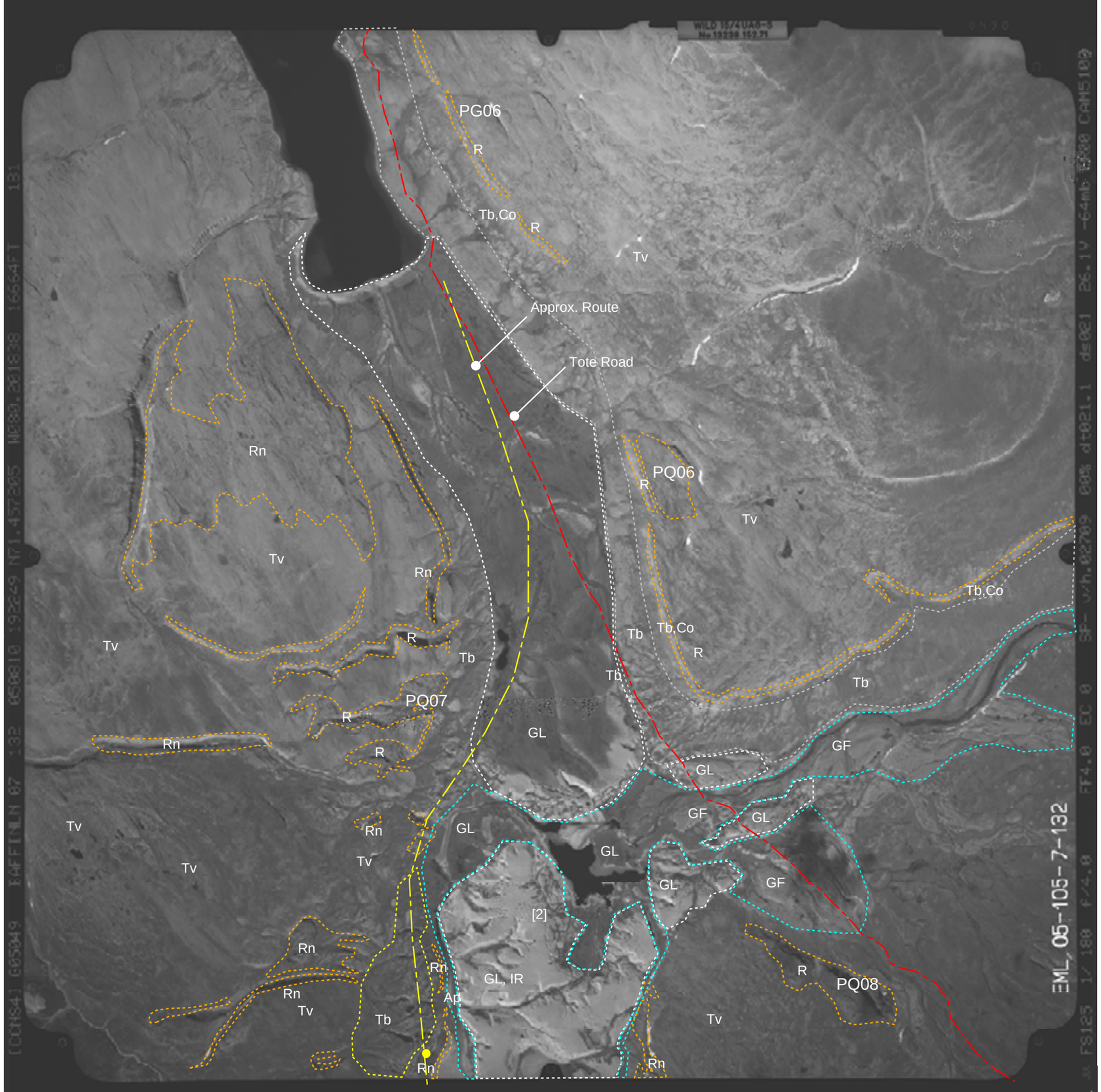
Tb - Till Blanket (>2m thick)
IR - Ice Rich
Al - Alluvium
Tb, Co - Talus over Till

CH 42+500 to 46+000



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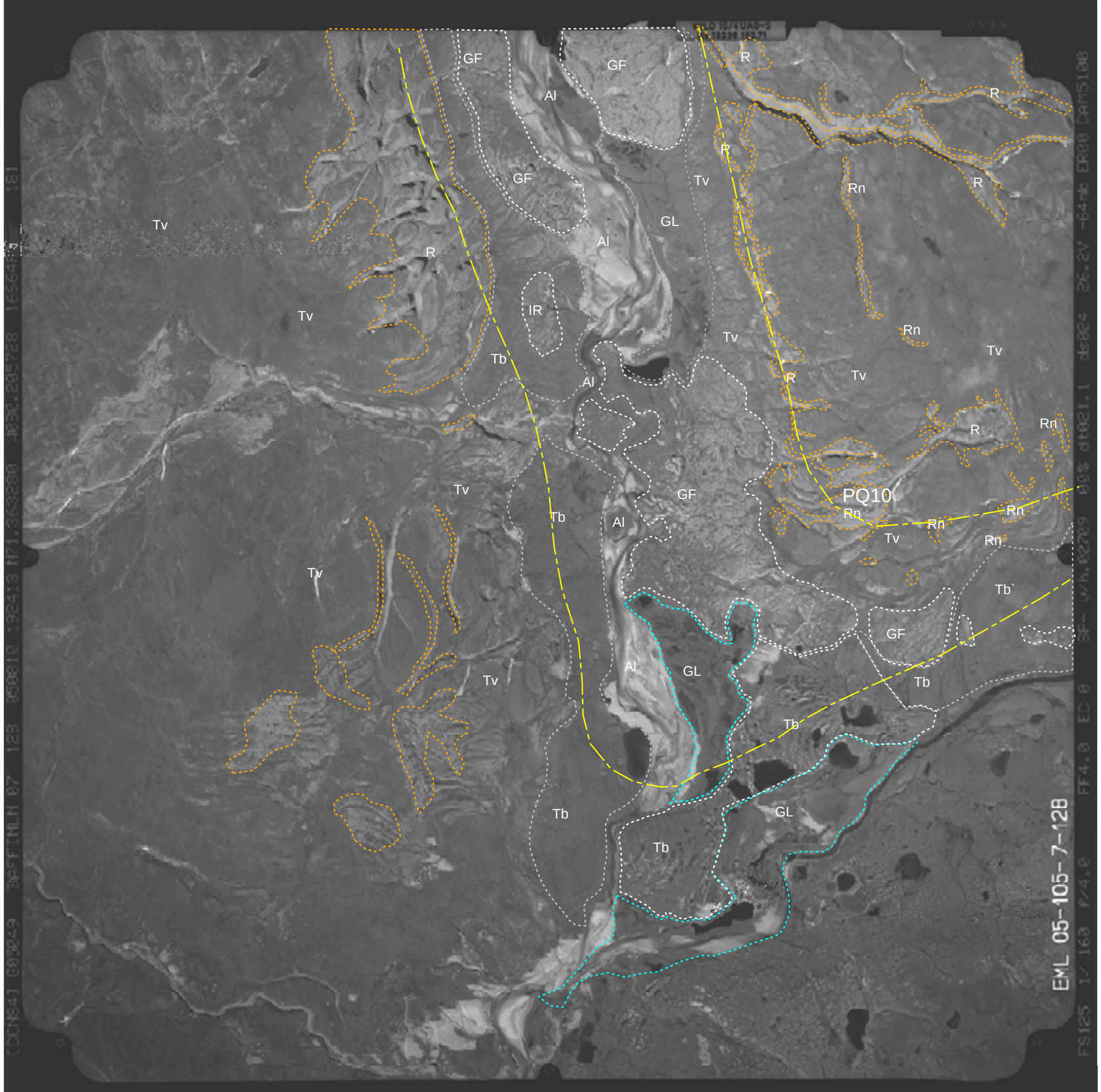
Tb - Till Blanket (>2m thick)
IR - Ice Rich
Al - Alluvium
Tb, Co - Talus over Till

CH 55+000 to CH 62+000



Legend

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IR - Ice Rich
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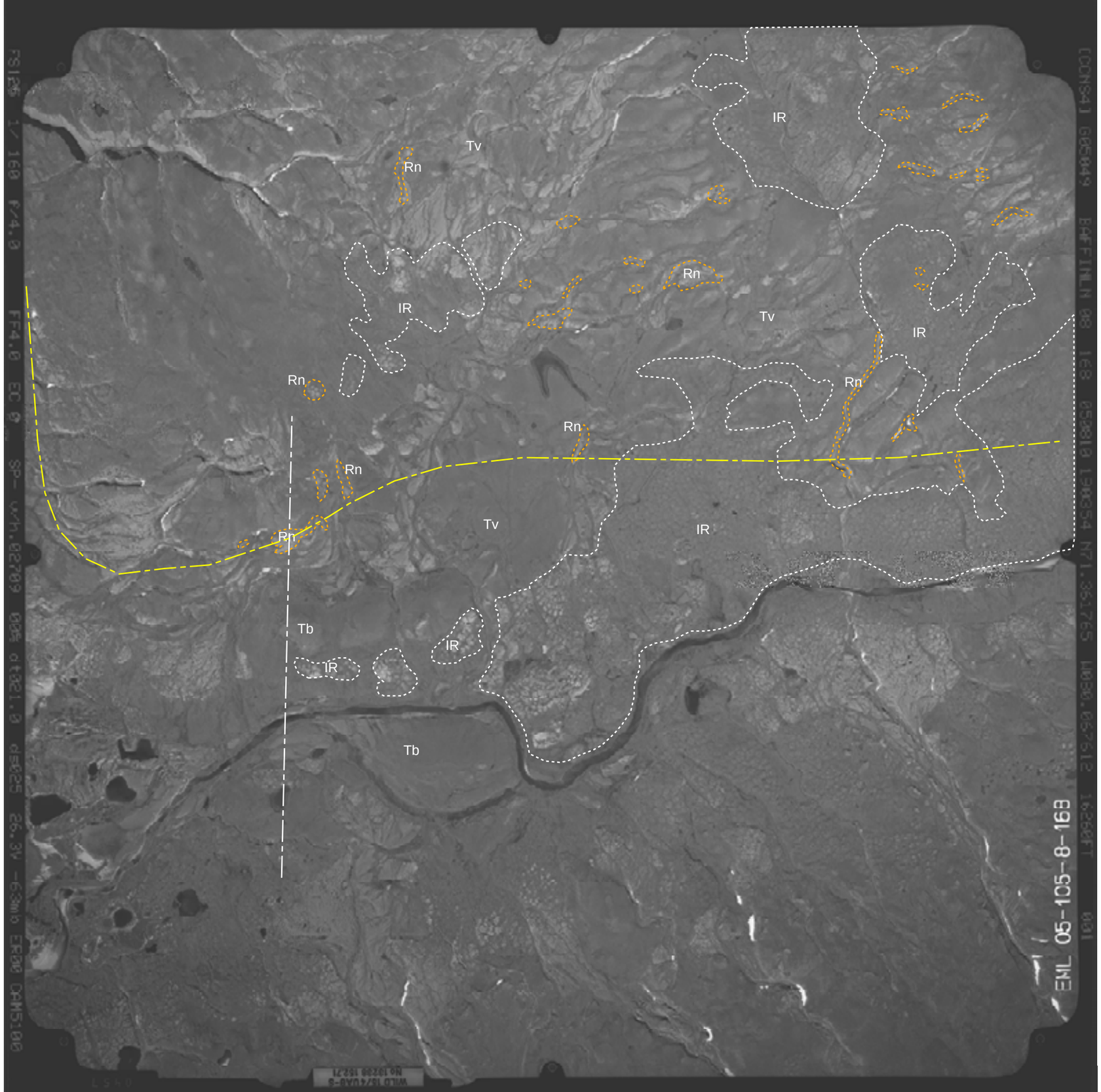
Tb, Co - Talus over Till

CH 64+000 to CH 70+000



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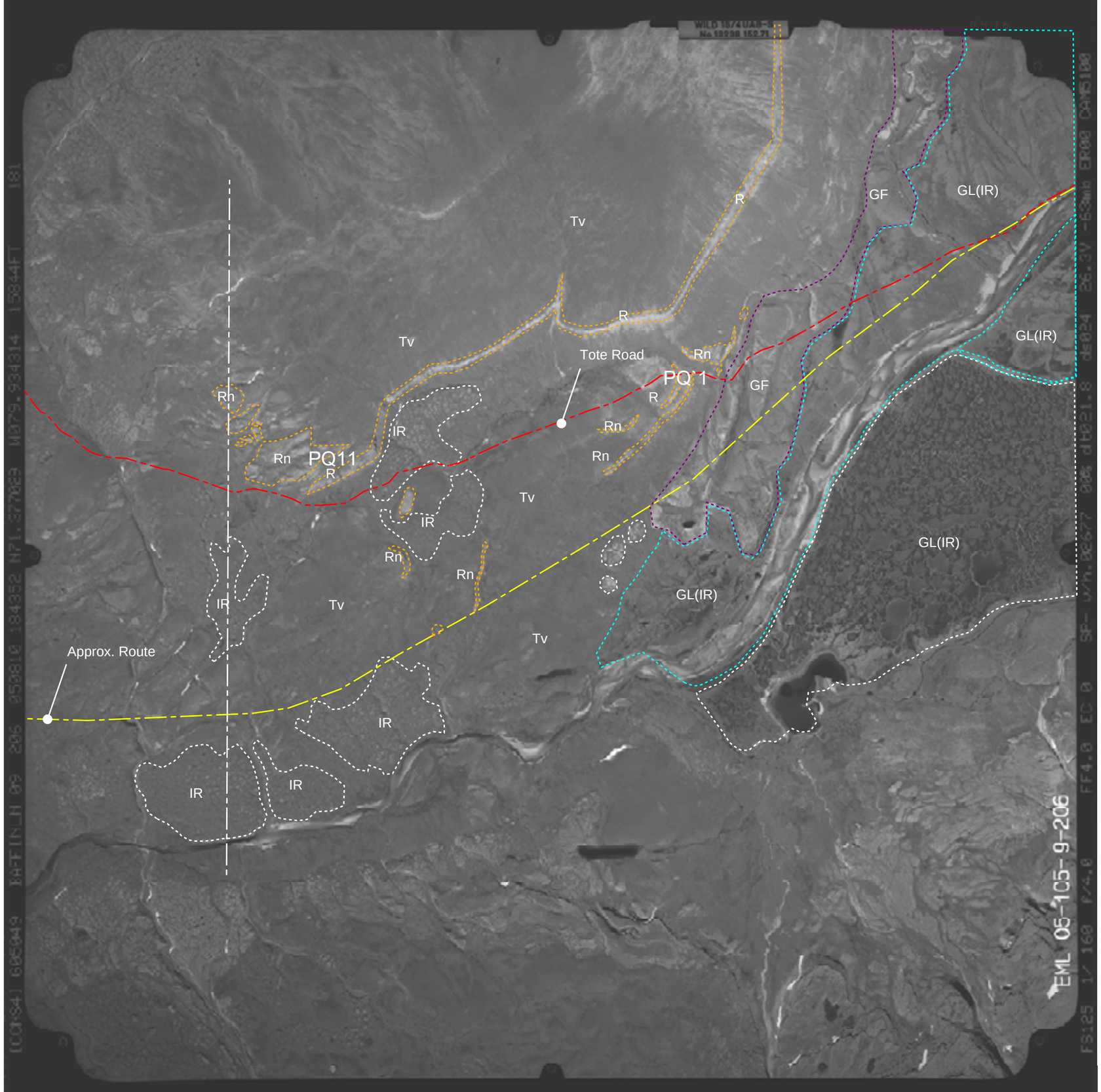
Tb - Till Blanket (>2m thick)
IR - Ice Rich
Al - Alluvium
Tb, Co - Talus over Till

CH 67+000 to CH 76+000



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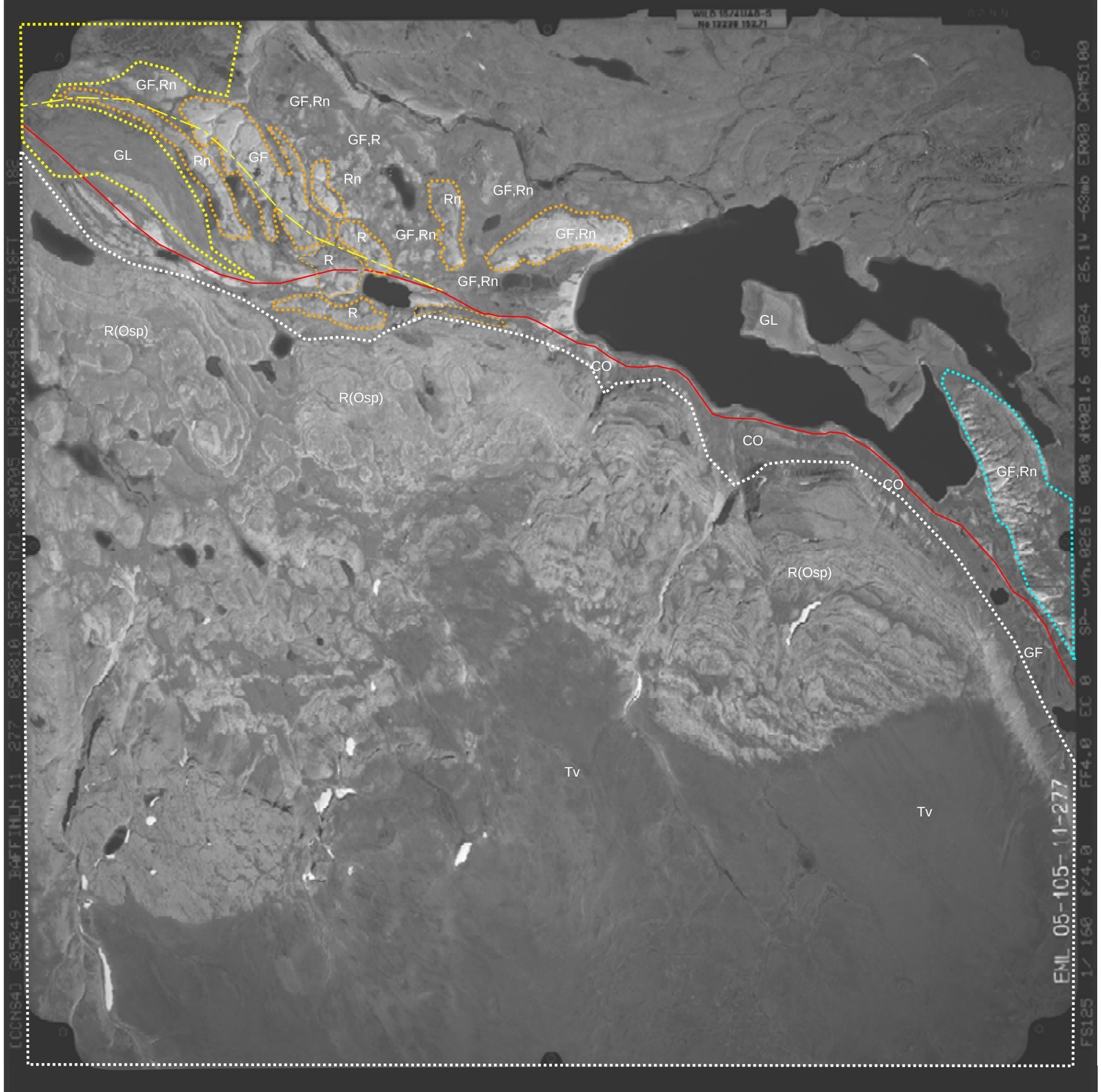
CH 74+000 to CH 81+000



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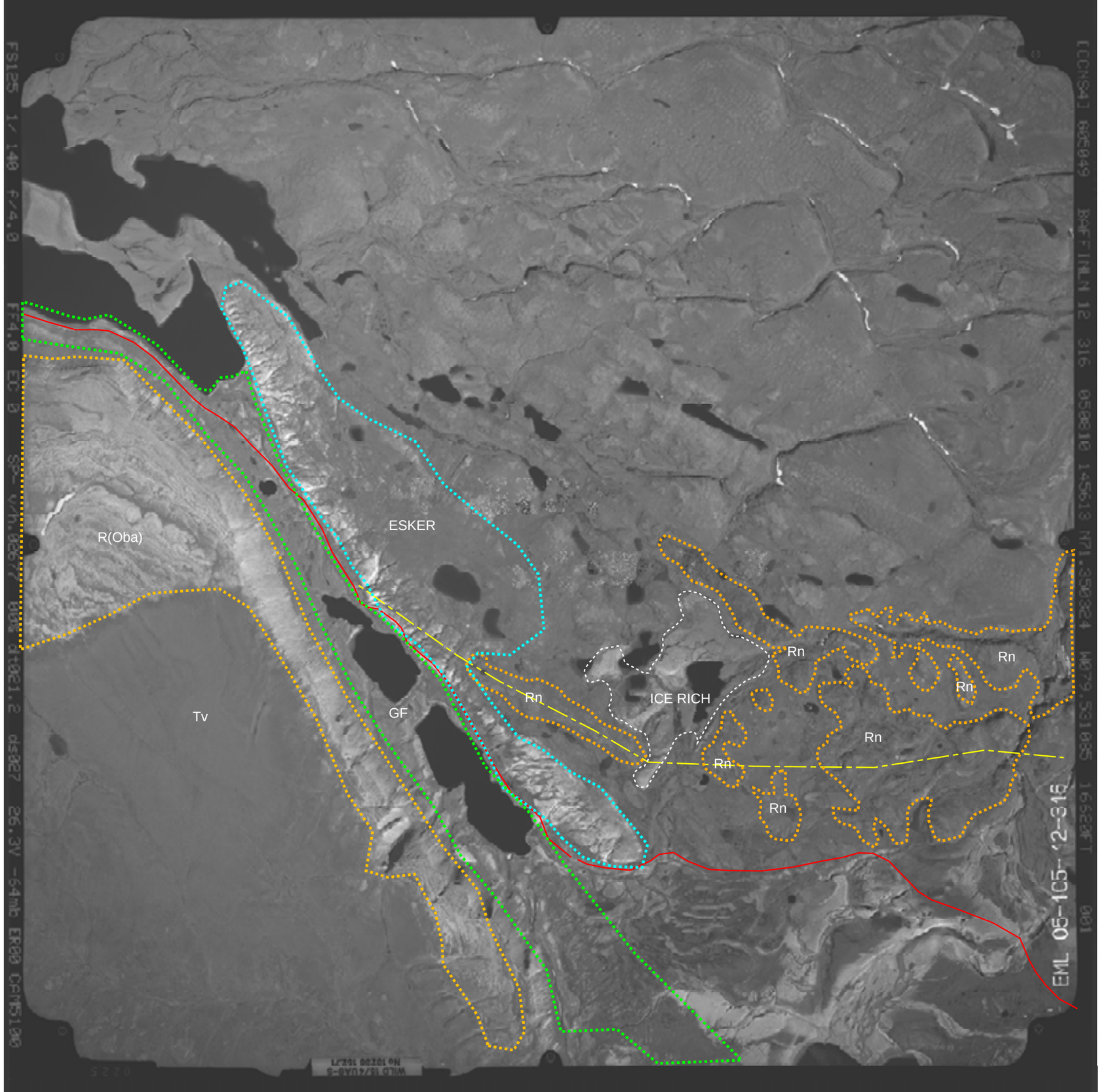
IR - Ice Rich
Al - Alluvium
Tb, Co - Talus over Till

CH 84+000 to CH 94+000



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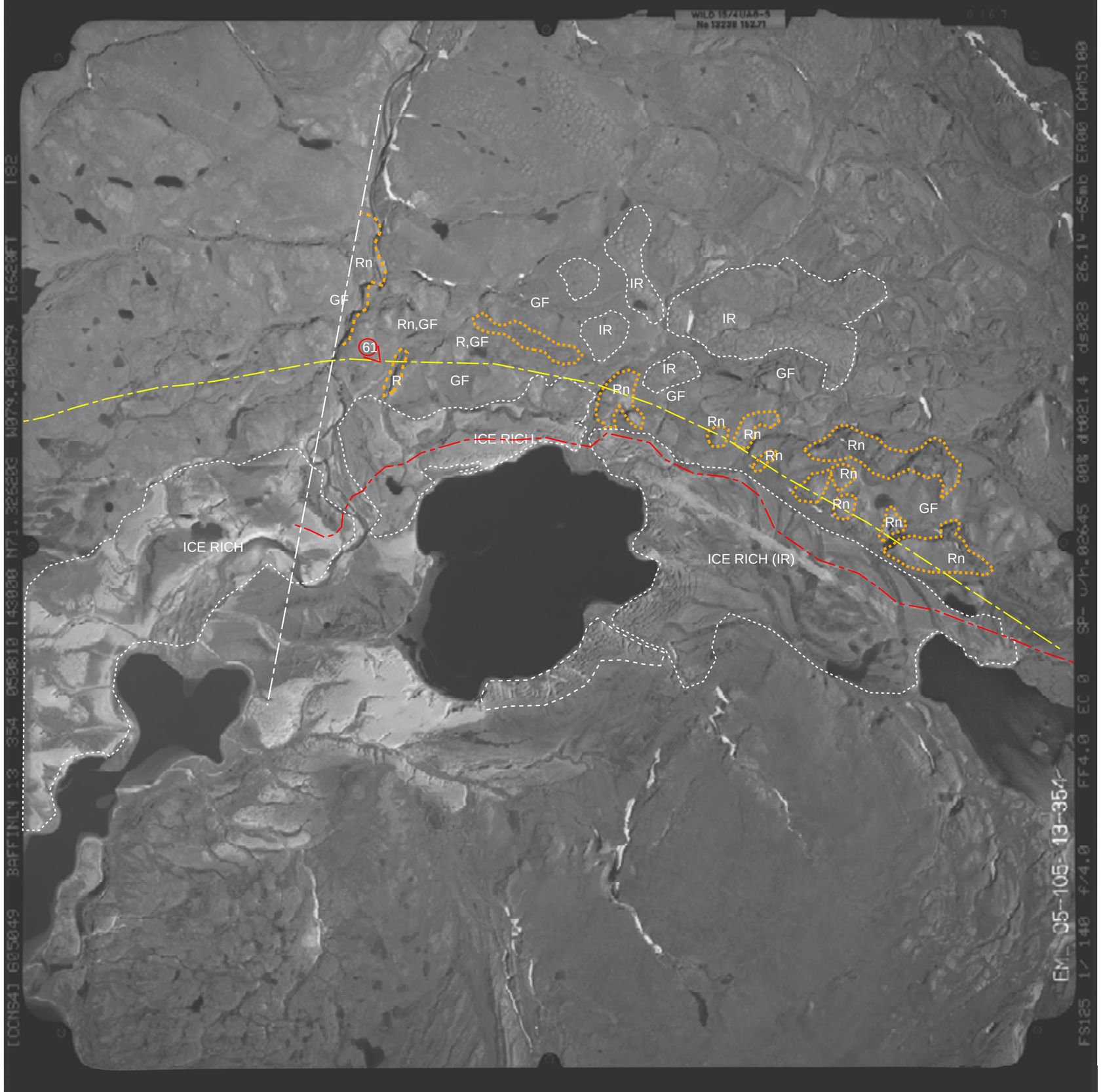
IR - Ice Rich
Al - Alluvium
Tb, Co - Talus over Till

CH 90+500 to CH 96+500



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GF - Glaciofluvial/fluvial sands and gravels (v-denotes veneer)
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Tb - Till Blanket (>2m thick)
IR - Ice Rich
Al - Alluvium
Tb, Co - Talus over Till

CH 96+000 to 105+000

ATTACHMENT 6.2

NORTH RAILWAY FACTUAL GEOTECHNICAL REPORT

Baffinland Iron Mines Corporation
Mary River Expansion Project

2016-2017-2018 Rail Geotechnical Investigation Factual Data Report

			Yang, Michael Digitally signed by Yang, Michael Date: 2018.05.11 12:36:58-04'00'			
2018-09-11	1	Approved for Use	M Yang	W Hoyle	D Stanger	R Stefan
2018-05-22	0	Approved for Use	H Ghiabi	W Hoyle	D Stanger	R Stefan
Date	**Rev.**	**Status**	**Prepared By**	**Checked By**	**Approved By**	**Approved By**
			HATCH			**Client**

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Document Number Explanation

This report was issued for client review as Rev. B on March 13th, 2018 under the following document number: H352034-1000-229-230-0005. Subsequently, there are 2 additional boreholes drilled at each of the three proposed bridges at KM 16, KM 71, and KM 102 in addition to the 3 boreholes drilled for the proposed bridge at KM 86 presented in revision 1. As a result of this additional information, the document number was revised to H353004-10000-229-230-0005. Although the current project number (H353004) was used to report the new data (borehole reports, test reports, etc.), the former project number (H352034) is still shown on the borehole reports/data sheets from previous investigations.

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This report is meant to be read, and sections should not be read or relied upon out of context. While it is believed that the information contained herein is reliable under the conditions and subject to the limitations set forth herein, this Report is based in part on information not within the control of Hatch and Hatch therefore cannot and does not guarantee the accuracy of such information based in whole or in part on information not within the control of Hatch. The comments in it reflect Hatch's professional judgment in light of the information available to it at the time of preparation.

This report contains the expression of the professional opinion of Hatch exercising reasonable care, skill and judgment and based upon information available at the time of preparation. Hatch has conducted this investigation in accordance with the methodology outlined herein. It is important to note that the methods of evaluation employed, while aimed at minimizing the risk of unidentified problems, cannot guarantee their absence. The quality of the information, conclusions and estimates contained herein is consistent with the intended level of accuracy as set out in this report, as well as the circumstances and constraints under which this report was prepared.

Client's Signature:

Name:

Title:

Date:

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Appendix J Geophysics Assessment

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1. Introduction

Baffinland Iron Mines Corporation (BIM) currently operates the Mary River iron ore mine in Nunavut, Canada. BIM plans to increase the production to 12 Mtpa, shipping the output through Milne Port. This will be achieved by upgrading the mine fleet, constructing an approximately 110 km long rail line from the mine site to the port, building a new crushing and screening facility at the port, construction of larger ore stockpiles and building a second ore dock for ship loading.

Hatch Ltd. (Hatch) was retained by BIM to conduct geotechnical drilling investigations for the design of a railway alignment spanning from Milne Port to the Mine Site. The drilling program included three phases; the first phase was executed from September 28 to December 14, 2016, the second phase was executed between April 9, 2017 and May 2, 2017, and the third phase was executed between March 2, 2018 and April 19, 2018.

This report presents (i) sonic borehole data including the visual observations and laboratory test results for particle size distribution and soil behaviour type and (ii) geophysics data including ground-penetrating radar and refractive seismic lines. In addition, sample photographs are appended providing visual records of soil cores.

1.1 Previous Investigations

Geotechnical investigation programs have previously been conducted at the Mary River mine site, Steensby Inlet port structure, the Milne Inlet port site, the Tote Road from the mine site to Milne Port site, along a proposed southern railway alignment from Mary River and Steensby Inlet, as well as offshore investigations at Milne Port.

These previous programs were conducted in 2006, 2007, and 2008 by Knight Piésold Consulting Ltd. (Knight Piésold), in 2010 by AMEC Earth and Environmental (AMEC), and in 2011 and 2013 by Hatch. Select information from those investigations has been incorporated in this report.

1.2 Local Topology and Geology

The approximately 110 km proposed rail line starts at Milne Port (Km 0) and passes through approximately 20 km of Precambrian bedrock terrain, glaciofluvial sand and gravel terraces. Further south, the rail alignment spans across a relatively flat lying ground comprising fine grained glacial till veneer overlying Paleozoic rocks mainly dolomitic limestone units for approximately 60 km. The final stretch of the rail alignment traverses glaciolacustrine and glaciofluvial plains, terraces, eskers and bedrock outcrops ranging from granitic gneiss to sedimentary rocks. For detailed maps showing the geology along the rail alignment please refer to the Site Assessment of North Railway Alignment Report (H352034-1000-220-068-0001).

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2. Geotechnical Investigation

2.1 General

The drilling supervision, field core logging and sampling associated with the railway drilling program was carried out by Hatch. Boart Longyear Ltd. (Boart Longyear) was selected as the drilling contractor. The field program was divided into three phases, the first phase (2016 investigation) was executed from September 28 to December 14, 2016, the second phase (2017 investigation) was executed between April 9 to May 2, 2017, and the third phase (2018 investigation) was executed between March 2, 2018 and April 19, 2018.

A total of 98 boreholes were drilled during the 2016 geotechnical investigation program, ranging from a depth of 1.5 m to 30 m. There were 81 boreholes drilled along the proposed rail alignment, 12 boreholes drilled at the proposed bridge abutments, and 5 boreholes drilled at the proposed quarry locations. These boreholes excluded the ones associated with Milne Port infrastructure.

A total of 14 boreholes were drilled during the early 2017 geotechnical investigation program ranging from a depth of 4.6 m to 25.9 m. Out of these 14 boreholes, 12 boreholes were drilled along the proposed rail alignment, and 2 boreholes were drilled at the proposed bridge abutments.

A total of 3 additional boreholes (BH17-BR86-1, -2, -3) were drilled at the Bridge at Km 86 location during the late 2017 geotechnical investigation program. The boreholes were drilled to a final depth of 39.6 m each.

A total of 6 boreholes were drilled during the 2018 geotechnical investigation program at three proposed bridge abutment locations, excluding boreholes associated with Milne Port Infrastructure. The depths of the boreholes ranged from 11.5 m to 32.5 m.

These boreholes provide data regarding overburden depth, soil type, ground ice and type of bedrock. Approximately 600 samples were collected on site and shipped to the Hatch geotechnical laboratory in Niagara Falls. Representative samples were selected for further laboratory testing.

As part of the 2017 and 2018 drilling program, geophysics work was undertaken along the rail alignment which included refractive seismic surveys and ground-penetrating radar. The geophysics work was undertaken by GPR Geophysics Inc. (GPR Inc.) while field supervision was provided by Hatch.

The focus of this report is the rail alignment portion of the investigation, which includes the boreholes that were drilled along the rail alignment, the bridge abutments and proposed quarry sites, and results from the geophysics surveys that were performed along the rail alignment.

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2.2 Borehole Locations

A summary of the as-drilled borehole locations for the rail alignment, bridge abutments and potential quarries is presented in Table 2-1 through Table 2-3. All coordinates are located within Zone 17 of the Universal Transverse Mercator (UTM) Grid. The coordinates were recorded using a hand-held GPS unit. The horizontal datum for this project is the North American Datum 1983 (NAD 83).

The prefix BH represents Borehole, while 16, 17 and 18 refers to 2016, 2017, and 2018, the year of the investigation. The first letter following the dash symbol (-) categorizes the borehole location as Rail in Fill Sections (R), Rail in Cut sections (C), Bridge Abutment (B) or Quarry (Q).

The borehole locations are provided on the Borehole Location Plan, provided in Appendix A.

Table 2-1: Rail Alignment Borehole Locations

Borehole Number	Easting (m)	Northing (m)	Depth (m)
BH16-R003	504,513	7,975,552	5.5
BH16-R004	507,259	7,970,638	4.5
BH16-R005	509,249	7,968,499	4.5
BH16-R006	508,438	7,969,804	2.9
BH16-R007	510,940	7,967,349	4.5
BH16-R008	512,763	7,966,604	4.5
BH16-R009	514,366	7,965,535	4.5
BH16-R010	515,332	7,963,810	4.5
BH16-R011	516,719	7,962,461	4.0
BH16-R012	516,716	7,962,464	4.0
BH16-R013	518,856	7,959,178	4.0
BH16-R014	519,701	7,957,349	4.5
BH16-R015	520,756	7,955,701	4.5
BH16-R016	521,588	7,953,865	4.5
BH16-R017	521,737	7,952,929	4.5
BH16-R018	521,854	7,951,940	4.5
BH16-R019	521,994	7,950,962	4.5
BH16-R020	521,842	7,949,969	4.5
BH16-R021	521,784	7,948,976	4.5
BH16-R022	522,305	7,948,153	4.5
BH16-R023	522,505	7,947,177	4.0
BH16-R024	522,558	7,946,129	4.5
BH16-R025	522,989	7,945,094	4.5
BH16-R026	523,165	7,944,366	4.5
BH16-R027	523,442	7,942,265	4.5
BH16-R028	524,061	7,940,538	3.6
BH16-R029	525,062	7,938,851	3.0
BH16-R030	525,291	7,937,897	3.6
BH16-R032	525,991	7,936,109	2.7
BH16-R033	526,653	7,935,439	4.2
BH16-R034	527,056	7,933,500	4.5
BH16-R035	527,423	7,932,310	4.5
BH16-R036	527,210	7,931,660	4.5
BH16-R037	527,873	7,929,786	4.5

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Borehole Number	Easting (m)	Northing (m)	Depth (m)
BH16-R038	528,501	7,928,421	4.5
BH16-R039	528,666	7,927,955	4.5
BH16-R040	528,686	7,927,755	4.5
BH16-R041	528,605	7,927,754	1.5
BH16-R042	528,517	7,927,713	4.5
BH16-R043	528,428	7,927,675	9.0
BH16-R044	528,736	7,926,992	4.5
BH16-R045	528,961	7,926,756	4.5
BH16-R046	529,065	7,926,599	4.6
BH16-R053	528,238	7,928,027	6.1
BH16-R067	535,406	7,918,572	4.6
BH16-R068	537,046	7,919,096	4.6
BH16-R069	539,489	7,920,583	4.6
BH16-R070	540,273	7,921,201	4.6
BH16-C006	508,897	7,968,767	3
BH16-C007	517,221	7,962,080	7.6
BH16-C008	520,080	7,956,909	13.7
BH16-C009	522,032	7,948,728	9.1
BH16-C010	522,513	7,946,595	5.5
BH16-C011	525,427	7,937,567	10.6
BH16-C012	526,569	7,935,536	4.6
BH16-C015	536,142	7,918,691	7.6
BH16-C016	536,362	7,918,814	7.6
BH16-C017	538,597	7,919,724	6.1
BH16-C018	546,111	7,920,740	6.1
BH16-C019	546,163	7,920,494	4.5
BH16-C019B	546,214	7,920,455	6
BH16-C020	546,402	7,920,072	10
BH16-C021	546,593	7,919,917	9
BH16-C022	547,077	7,919,746	9.1
BH16-C023	547,304	7,919,643	10.7
BH16-C024	547,530	7,919,537	10.7
BH16-C025	548,370	7,919,181	7.6
BH16-C026	550,262	7,918,123	10.7
BH16-C027	550,416	7,917,928	12.2
BH16-C028	551,403	7,916,768	11.6
BH16-C029	552,569	7,915,813	7.6
BH16-C030	555,337	7,915,646	12.2
BH16-C031	556,864	7,915,216	1.5
BH16-C032	557,282	7,915,265	9.1
BH16-C201	553,750	7,915,276	2.4
BH16-C202	554,531	7,915,452	7.6
BH16-C203	555,007	7,915,451	9.1
BH16-C204	555,659	7,915,432	2.7
BH16-C205	555,883	7,915,449	8.5
BH16-C206	556,059	7,915,442	9.1
BH16-C207	556,679	7,915,415	7.3
BH17-C001	509,861	7,967,883	9.1
BH17-C002	519,513	7,957,644	10.7
BH17-C003	520,091	7,957,302	9.1
BH17-C004	520,484	7,956,357	10.7
BH17-C005	525,227	7,938,527	9.1

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Borehole Number	Easting (m)	Northing (m)	Depth (m)
BH17-C006	527,370	7,932,609	10.7
BH17-C006B	528,253	7,929,081	6.1
BH17-C007	528,564	7,917,138	4.6
BH17-C010	529,961	7,916,702	5.5
BH17-C011	532,072	7,917,478	10.6
BH17-C012	533,228	7,918,553	4.6
BH17-C013	534,196	7,918,569	7.6

Table 2-2: Bridge Abutment Borehole Locations

Borehole Number	Easting (m)	Northing (m)	Depth (m)
BH16-B001	514,191	7,965,675	11.5
BH16-B002	514,290	7,965,604	13.7
BH16-B003	514,357	7,965,533	16.8
BH16-B004	514,367	7,965,540	16.8
BH16-B009	542,204	7,922,291	27.4
BH16-B010	542,208	7,922,304	14.0
BH16-B011	542,365	7,922,121	10.7
BH16-B012	542,376	7,922,131	9.1
BH16-B013	555,619	7,914,671	10.7
BH16-B014	555,599	7,914,683	9.1
BH16-B015	555,824	7,914,884	13.6
BH16-B016	555,830	7,914,892	7.6
BH17-B001	529,031	7,916,747	16.5
BH17-B002	529,323	7,916,577	25.6
BH17-BR86-1	542,257	7,922,182	39.6
BH17-BR86-2	542,269	7,922,172	39.6
BH17-BR86-3	542,304	7,922,142	39.6
BH18-BR15-1	555,758	7,915,441	17.4
BH18-BR15-2	514,211	7,965,645	16.8
BH18-BR70-1	529,143	7,916,680	32.5
BH18-BR70-2	529,107	7,916,700	28.5
BH18-BR102-1	555,758	7,915,441	11.5
BH18-BR102-2	555,697	7,915,443	16.9

Table 2-3: Quarry Borehole Locations

Borehole Number	Easting (m)	Northing (m)	Depth (m)
BH16-Q001	505,308	7,972,797	4.5
BH16-Q7001	529,144	7,927,494	5.0
BH16-Q7002	530,561	7,928,150	6.9
BH16-Q7003	531,053	7,929,065	9.1
BH16-Q7004	529,264	7,927,466	10.6

2.3 Drilling and Sampling Methodology

The geotechnical boreholes were drilled using a BL100 Mini Sonic Drilling rig shown below in Figure 1; manufactured and operated by Boart Longyear. The boreholes were advanced by vibration of the drill string at a high frequency in addition to rotary motion, and pressure by the drilling head. Sonic drilling does not require water at shallow depths in the overburden, and casing was not used for drilling through overburden. Figure 2 shows the equipment used for

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off road transport of personnel and survival shack during the 2017 and 2018 investigations. Other major equipment included generator sets, welding unit, frost fighters and pickup trucks.

Figure 1: Drilling Rig Setup on a Borehole

Figure 2: Survival Shack and Off-Road Transport

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When using sonic drilling in overburden, a 3 m drilling rod was advanced 1.5 m into the ground for each run. The bottom 1.5 m was collected into a 4 inch split PVC pipe as shown in Figure 2. Soil collected above the bottom 1.5 m, if encountered, was disposed to ensure the collected sample was not contaminated by surface soil “fall in” accumulated at the bottom of the drilled hole. Soil sample were photographed in the PVC split. Once the material in the split was photographed and sampled, the splits were secured using caps and aluminum tape, and stored in a shipping container at the Milne Port site.

Bedrock was cored using a HQ-3 triple tube wireline core barrel, which required the use of water and casing. In addition, rock coring required the installation of a high-speed rotary head on the drilling rig every time there was a switch from sonic drilling in soil to rock coring.

The Hatch field supervisor documented the materials encountered, and determined in situ testing and sampling requirements. When ice was encountered in the borehole, it was documented and classified according to ASTM D4083. The description of soils as detailed in the geotechnical borehole reports are based on field visual classification and confirmatory laboratory testing in accordance with the explanatory notes included with these reports.

The detailed geotechnical borehole drilling reports are contained in the attached Appendix B and should be referenced for a complete description of soil materials and the in situ testing and sampling performed. Appendix B also contains a set of explanatory notes detailing terminology used in the borehole reports. Additional observations such as testing and sampling procedures, percent recovery, water loss/gain, and mechanical heating of samples were recorded, along with time of observation. Photographs of samples collected during the drilling investigation are contained in Appendix C. An example of a retrieved sample is shown in Figure 3.

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Figure 3: Sample Collected in a PVC Split Using a Mini Sonic Drilling Rig

2.4 Safety Management Plan

Safety management was a key consideration during the planning process for the geotechnical investigations. A safety management plan was prepared by Hatch and reviewed by BIM and Boart Longyear. A copy of this Plan is provided in Appendix I. A Job Hazard Analysis (JHA) was developed by Hatch and BIM and reviewed by Boart Longyear. This JHA was reviewed periodically and updated according to the work activities. A notification procedure was prepared by BIM specifically for the drilling activities in remote areas. A copy of both the final JHA and the notification procedure is presented in Appendix I.

2.5 Laboratory Testing

2.5.1 Soil Testing

All samples were shipped to the Hatch geotechnical laboratory in Niagara Falls, a Canadian Council of Independent Laboratories (CCIL) certified laboratory (see Appendix G for the certification document). Representative samples were selected for testing including moisture content and particle size distribution in accordance with the standard listed in Table 2-4. Full laboratory test results are presented in Appendix D and laboratory results are summarized in Appendix F. Select laboratory results are also shown on the boreholes in Appendix B.

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Table 2-4: Standards Used for the 2016 and 2017 Geotechnical Investigation

Name	Standard
Standard Test methods for Laboratory Determination of Water Content of Soil and Rock by Mass	ASTM D2216
Standard Test Methods for Particle-Size Distribution of Soils using Sieve Analysis	ASTM D6913
Standard Test method for Particle Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis	ASTM D7928

2.5.2 Rock Testing

The physical testing of bedrock core and rock samples was completed by Amec Foster Wheeler PLC laboratory in Hamilton, Ontario (CCIL certification is shown in Appendix G). Rock testing was completed following the procedures in the Standards listed in Table 2-5.

Table 2-5: Standards for Testing of Coarse Aggregate

Name	Standard
Standard Test Method for Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus	ASTM D6928
Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates	ASTM C136/C136M
Standard Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate	ASTM D7172
Resistance of Unconfined Coarse Aggregate to Freezing and Thawing	ASTM D4992

Samples were collected on site for the granitic gneiss, dolomitic limestone and diabase rock types. Four of the samples were collected for physical testing at the laboratory. The rock type, sample collection method and location of the four tested samples are presented in Table 2-6.

Table 2-6: Rock Type and Location of The Tested Samples

Borehole No.	Laboratory Sample No.	Depth Range (m)	UTM Coordinates		Rock Type	Sample Type
			Easting	Northing		
BH16-Q7004	*NF17-01*	4.6-7.6	529,264	7,927,466	Upper Limestone	Core
BH16-Q7004	*NF17-02*	7.6-10.6	529,264	7,927,466	Lower Limestone	Core
BH16-M007(1)	*NF17-03*	6.1-9.1	503,822	7,974,945	Granitic Gneiss	Core
Lump Sample	*NF17-04*	From Surface	547,599	7,921,210	Diabase	Grabbed Sample

(1) The report for this borehole is presented in Appendix B.

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2.6 Geophysics

GPR Inc. was contracted to undertake a Ground Penetrating Radar (GPR) survey to assess the extent of ground ice in areas that were identified (i) as ice rich or (ii) to have large ice bodies in the 2016, 2017, and 2018 drilling investigation. The survey required towing of a GPR unit (Figure 4) in a line over the area to be surveyed. Readings were recorded using a handheld output device, which can be seen in Figure 5. A detailed description of the GPR survey technique can be found in Appendix J.

Figure 4: Ground Penetrating Radar Survey Unit

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Figure 5: GPR Survey in Progress

Seismic refraction testing was carried out to estimate bedrock depth in areas not accessible by a track mounted drilling rig. A wave was generated by vertically striking a striker plate with a sledgehammer. A line of geophones connected to a data acquisition system was used to record seismic data, shown in Figure 6. A detailed description of the seismic refraction testing can be found in Appendix J.

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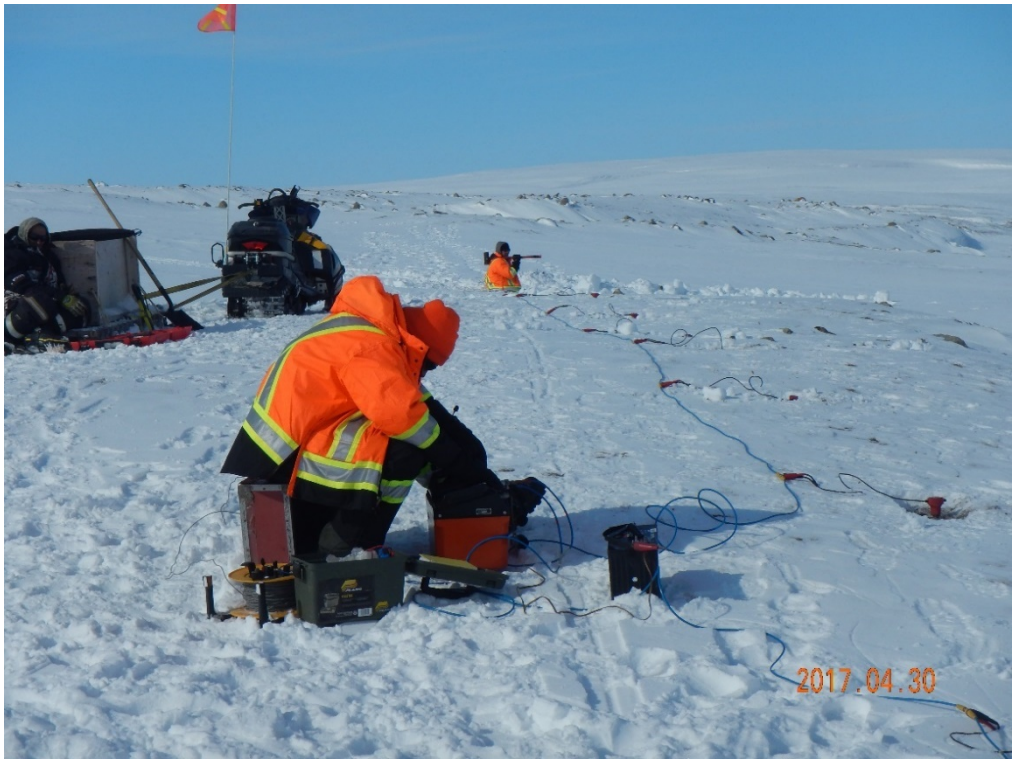

Figure 6: Setup for Seismic Refraction

3. Investigation Results

The sections below include a brief summary of the investigation results. The results of the borehole investigations are presented along the alignment from the Milne Port to the mine site. The boreholes at the bridges and quarry sites are discussed separately.

3.1 Rail Alignment

The following sections contain a summary of the investigation results along the rail alignment grouped by chainage. These observations are a generalization of the borehole findings and the full borehole logs should be consulted to appreciate the full variability of the overburden and bedrock conditions along the alignment. Due to the length of the alignment the investigations are only representative of the conditions in their location and variability may occur between the investigations which have not been considered.

3.1.1 Chainage 0+000 m to 54+000 m

Overburden in this sections of the rail alignment typically consists of sand with silt and/or gravel as secondary components. Layers of gravel or cobbles were encountered in several boreholes in this section. Coarse grain material was often subrounded to rounded, indicating a possible glaciofluvial origin. Layers of coarse grained subangular to angular soil was also encountered and were the most common soil encountered where the rail alignment deviated

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from the Phillips Creek. Large ice lenses were encountered in BH16-C008, BH16-C011 and BH17-C002. These are discussed in more detail in Section 3.6.

Granitic gneiss bedrock outcrops were noted in the investigation area along the first 24 km of the alignment. A typical example of a granitic gneiss outcropping is presented in Figure 7.

Figure 7: Typical Granitic Gneiss Bedrock Outcrop

3.1.2 Chainage 54+000 m to 58+000 m

Boreholes between approximately Chainage 54+000 m and 58+000 m intersected sand or sand with silt from the surface to termination depths, and bedrock was not reached in any of these investigations. An example of the material encountered in this section of the alignment is presented in Figure 8.

Figure 8: Typical Sand Encountered in Boreholes Located between Chainage km 54 and km 58 (BH16-R037)

Dolomitic limestone bedrock outcrops were also noted until km 58. A typical dolomitic limestone outcrop is shown in Figure 9.

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Figure 9: Typical Dolomitic Limestone Outcrop

3.1.3 Chainage 58+000 m to 70+000 m

No boreholes were drilled in this section of the alignment as part of the 2016-17 investigations due to a lack of access to the borehole locations and weather related constraints. Please see Geophysics surveys SL17-D1 through SL17-D7, in Appendix J, for seismic refraction results from this section of the proposed rail alignment.

3.1.4 Chainage 70+000 m to 100+000 m

Typical overburden along this section of the alignment was found to vary from sand to silt and sand, an example is shown in Figure 10. Much of this section of the alignment is mapped as glaciolacustrine or glaciofluvial in origin, which matches the observed materials. Ice lenses were encountered in several boreholes including a 4.6 m thick ice body encountered in BH16-C023 near km 93 of the rail alignment.

Figure 10: Typical soil encountered between Chainage 78+000 m and 90+000 m (BH16-C016)

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3.1.5 Chainage 100+000 m to Terminus

Boreholes in the remaining section of the alignment, intersected materials ranging from silty sand to sand and gravel. These materials often were intersected within the same borehole. This section generally consists of either a thin veneer of sand and gravel (glacial fluvial) overlying granitic bedrock or exposed granitic rock. Inferred bedrock was encountered in all of the investigations in this section. The bedrock in this area is mapped as sedimentary rocks including dolomitic sandstone and undifferentiated gneiss.

3.2 Proposed Bridge Locations

Drilling was completed at four bridge locations along the rail alignment. The bridge abutment boreholes for bridges 1, 3 and 4 were completed during the 2016 investigation; and the bridge 2 boreholes were completed as part of the early 2017 investigation. Three additional holes were drilled for Bridge 3 (KM 86) as part of the geotechnical program completed in late 2017. The approximate chainage for the bridges are as follows:

- Bridge 1: 16+000 m
- Bridge 2: 71+000 m
- Bridge 3: 86+000 m
- Bridge 4: 103+000 m.

3.2.1 Bridge 1

Investigations for the Bridge 1 abutments (BH16-B001 to B004, and BH18-BR15-1 and BH18-BR-15-2) encountered primarily sand and silt. Boulders or cobbles were intersected in all investigations, up to 1.5 m thick in BH16-B001. Bedrock, consisting of granitic gneiss, was reached at depths of 10.7 m and 10.2 m for boreholes BH18-BR15-1 and BH18-BR15-2 respectively. Ice lenses were intersected in three of the four boreholes completed in 2016, up to 3 m thick in BH16-B001.

3.2.2 Bridge 2

The investigations at both abutments of Bridge 2 generally encountered silty, silty sand or sand. A layer of silt with high organic content was encountered between 3.0 and 6.1 m depth in BH17-B002 at the proposed east abutment. An ice layer was encountered from 9.1 m to 10.6 m in BH18-BR70-1. Drilling refusal occurred at a depth of 16.5 m at BH17-B001 and at 25.6 m in BH17-B002. Siltstone to dolomitic limestone bedrock was encountered at depths of 22.9 m and 17.1 m for boreholes BH18-BR70-1 and BH18-BR70-2 respectively.

3.2.3 Bridge 3

Overburden materials encountered at the Bridge 3 abutments generally consisted of well bonded frozen sand. Sand and gravel and silty sand layers were observed in some of the boreholes. BH17-BR86-1, BH17-BR86-2 and BH17-BR86-3 were advanced to a target depth of 39.6 m. A 1m thick layer of ice was encountered from 5 m to 6 m deep at BH17-BR86-1. None of the boreholes drilled at the Bridge at km 86 abutments reach bedrock.

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3.2.4 Bridge 4

The investigations at both abutments of Bridge 4 generally encountered gravel or sand and gravel. The bedrock was outcropped at the surface at the both edges of the river and dips below the surface moving away from the bridge abutments. Granitic gneiss bedrock was encountered at depths of 1.3 m and 9.7 m for boreholes BH18-102-1 and BH18-BR102-2 respectively.

3.3 Proposed Quarry Boreholes

Most quarry location boreholes were not drilled in the 2016 investigation due to weather constraints and challenges associated with access to their locations; however, following several attempts representative samples of the limestone were recovered approximately 3 km east of the rail alignment at Chainage 58+000 m. A sample of the granitic gneiss was collected from the rail unloading area boreholes at Milne Port. Diabase samples were collected from the surface near Chainage 103+000 m during a site visit in September 2016 and tested during this program.

3.3.1 Overburden

Overburden material of thickness ranging from no cover to approximately 5 m was encountered at the quarry locations.

3.3.2 Bedrock

- Extensive granitic gneiss ridge extends from Chainage 0+000 m to 11+000 m, likely continues to approximately Chainage 24+000 m. Possible quarry locations are available along this ridge.
- Extensive dolomitic limestone ridge extends from Chainage 46+000 m to 58+000 m just east of the rail alignment. Possible quarry locations are available along this ridge.
- Other possible quarry locations were observed east of the rail alignment at approximately Chainage 100+000 m (diabase).

3.4 Laboratory Test Results

The results of the classification and moisture content testing have been presented on the borehole logs in Appendix B, at the corresponding sample depths. The full laboratory reports are included in Appendix D with a summary of the classification test results included as Appendix F. During the investigation, samples of typical rock types were collected, at or near potential quarry locations when possible. Laboratory testing was undertaken to determine the suitability of the rock for use as aggregate, including relative density, absorption, abrasion resistance and unconfined freeze thaw loss. A summary of the laboratory test results for the crushed aggregate samples are presented in Table 3-1. Full laboratory test results are presented in Appendix H.

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Table 3-1: Physical Test Results of The Crushed Aggregate Samples

Test Type	Borehole ID: Depth (Lab ID)			
	BH16 – Q7004: 4.6 – 10.6 m	BH16 – Q7004: 4.6 – 10.6 m	BH16 – M007: 6.1 – 9.1 m	Surface Outcrop Sample
	(NF17-01)	(NF17-02)	(NF17-03)	(NF17-04)
Specific Gravity	2.662	2.655	2.618	2.995
Absorption (%)	0.82	0.9	0.37	0.45
Micro-Deval Abrasion (% loss)	10.5	11	4.5	7.9
Unconfined Freeze-Thaw (% loss)	6.7	11.1	1.6	0.8

3.5 Geophysics Results

The GPR investigations were undertaken at fourteen sites along the rail alignment, with seven sites in the deviation area, in order to define ice rich zones. A seismic and georadar survey was undertaken near Chainage 4+500 m of the alignment to determine the depth to bedrock. Seismic surveys were also undertaken at the railway unloading area. The results of the geophysical investigation, including bedrock profiles and ice layer mapping, are presented in Appendix J. Results of the GPR surveys in the ice rich areas are discussed further in Section 3.6.

3.6 Ice Rich Areas

It was found that some of the boreholes drilled during the 2016/2017 rail investigations contained large amounts of ice, and could therefore potentially indicate the presence of large ice bodies. In the area where high ice content were discovered during the borehole investigations, a GPR survey was subsequently used to delineate the subsurface conditions, as presented in Appendix J. Figure 11 is an example of a section of ice core recovered during the borehole investigations.

Figure 11: Ground Ice at Km 47, 1.5 m to 3 m Deep (BH16-C011)

The location of potential ice bodies along the rail alignment may be important for design considerations. Boreholes that contained a significant amount of ice, defined as ice lenses greater than 3 m thick, are shown in Table 3-2.

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Table 3-2: Boreholes With Significant Ice Content

Borehole	Ice Depth from Ground Surface (m)	Investigation Depth (m)	Inferred GPR Ice Thickness* (m)
BH16-C008	3	13.7	>10.7
BH16-C011	1.5	10.7	>9.2
BH16-C023	6.1	10.7	>4.6
BH17-C002	2.7	10.7	>8

* Note: the base of the ice lense/body was not reached in any of these investigations.

The inferred ice thicknesses from the GPR surveys are presented in Appendix J. The GPR surveys of the ice rich areas confirmed the results of the borehole investigation and provide inferred thicknesses and extent of these ice rich areas.

3.7 Georadar Surveys Along the Rail Deviation Area

GPR surveys were conducted at seven sites along the rail deviation area subsequent, and as a separate component, to the 2018 Geotechnical Investigation to determine ice depth, thickness, and extent. The chainage of the survey areas spanned from approximately 59 KM to 69 KM, and 77 KM to 78 KM. Ice chunks and Ice lenses were delineated at depths 4 m to 9 m from the surface. Detailed results and ice thickness maps can be found in Appendix J. It should be noted that no boreholes were drilled in the Georadar survey areas along the rail deviation to verify subsurface ice conditions.

4. Summary of Findings

A variety of soil materials were found along the rail alignment including sand, gravel and lesser amounts of silt during the sonic drilling program. The soils along the alignment were primarily alluvium of glaciofluvial or glaciolacustrine origin, or glacial till or moraine deposits. The boreholes along the alignment have been separated based on the primary soil type encountered as summarized in Table 4-1.

Table 4-1: Primary Materials along Rail Alignment

Approximate Alignment Chainage	Borehole/Geophysics ID	Likely Origin of Primary Soils in Borehole
0+000 m to 17+000 m	BH16-R003	Glaciofluvial Origin
	BH16-R004	
	BH16-R006	
	BH16-C006	
	BH16-R005	
	BH17-C001	
	BH16-R007	
	BH16-R008	
	BH16-B001	
	BH16-B002	
	BH16-B004	
	BH16-R009	
	BH16-B003	

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Approximate Alignment Chainage	Borehole/Geophysics ID	Likely Origin of Primary Soils in Borehole
	BH18-BR15-1	
	BH18-BR15-2	
17+000 m to 25+000 m	BH16-R010	Mix of glaciofluvial and till/moraine
	BH16-R012	
	BH16-R011	
	BH16-C007	
	BH16-R013	
25+000 m to 37+500 m	BH17-C002	Glaciofluvial
	BH17-C003	
	BH16-R014	
	BH16-C008	
	BH17-C004	
	BH16-R015	
	BH16-R016	
	BH16-R017	
	BH16-R018	
	BH16-R019	
	BH16-R020	
	BH16-R021	
	BH16-C009	
	BH16-R022	
	BH16-R023	
37+500 m to 40+000 m	BH16-C010	Mix of glaciofluvial and till/moraine
	BH16-R024	
	BH16-R025	
40+000 m to 54+000 m	BH16-R026	Glaciofluvial
	BH16-R027	
	BH16-R028	
	BH16-R029	
	BH17-C005	
	BH16-R030	
	BH16-C011	
	BH16-R032	
	BH16-C012	
	BH16-R033	
	BH16-R034	
	BH17-C006	
	BH16-R035	
	BH16-R036	
54+000 m to 58+000	BH16-R037	Glaciolacustrine
	BH17-C006B	
	BH16-R038	
	BH16-R053	
	BH16-R039	
	BH16-R040	
	BH16-R041	
	BH16-R042	
	BH16-R043	
	BH16-R044	
	BH16-R045	
	BH16-R046	
58+000 m to 70+000 m	SL17-D6	Till/moraine

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Approximate Alignment Chainage	Borehole/Geophysics ID	Likely Origin of Primary Soils in Borehole
	SL17-D7	
	SL17-D5	
	SL17-D4	
	SL17-D3	
	SL17-D2	
	SL17-D1	
	BH18-BR70-1	
	BH18-BR70-2	
70+000 m to 75+000 m	BH17-C007	Glaciolacustrine
	BH17-B001	
	BH17-B002	
	BH17-C010	
	BH17-C011	
75+000 m to 77+000 m	BH17-C012	Mix of glaciolacustrine and till/moraine deposits
	BH17-C013	
77+000 to 100+000 m	BH16-R067	Glaciolacustrine
	BH16-C015	
	BH16-C016	
	BH16-R068	
	BH16-C017	
	BH16-R069	
	BH16-R070	
	BH16-B009	
	BH16-B010	
	BH16-B011	
	BH16-B012	
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	BH16-C024	
	BH16-C025	
	BH16-C026	
	BH16-C027	
	BH16-C028	
	BH16-C029	
	BH17-BR86-1	
	BH17-BR86-2	
	BH17-BR86-3	
100+000 m to Terminus	BH16-C201	Mix of glaciofluvial and till/moraine deposits
	BH16-C202	
	BH16-C203	
	BH16-C030	
	BH16-B014	
	BH16-B013	
	BH16-C204	
	BH16-B015	
	BH16-B016	
	BH16-C205	

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Approximate Alignment Chainage	Borehole/Geophysics ID	Likely Origin of Primary Soils in Borehole
	BH16-C206	
	BH16-C207	
	BH16-C031	
	BH16-C032	
	BH18-BR102-1	
	BH18-BR102-2	

Bedrock was identified in some boreholes and by refractive seismic methods along the rail alignment. Outcroppings of granitic gneiss, dolomitic limestone and diabase were found along the alignment and may provide borrow materials for the rail construction. Ground ice was noted in a number of the boreholes along the alignment. The following locations were identified as having ground ice significant enough to warrant design consideration and alignment modification, other incidents of ground ice were noted in the borehole reports and may also be encountered between the following investigation locations:

- Some ground ice and individual ice inclusions at the proposed Bridge 1 location at an approximate Chainage at 16+000 m along the proposed rail alignment;
- A large ice body was encountered at the cut location at Chainage 26+700 m on the proposed rail alignment 3 m below the existing ground surface elevation;
- A large ice body was encountered at the cut location at Chainage 47+300 m on the proposed rail alignment at 3 m below the existing ground surface elevation; and
- A large ice body or lenses were encountered at the cut location at Chainage 77+000 m on the proposed rail alignment at approximately 1.5 m to 2.5 m below the existing ground surface elevation;
- Frequent ice inclusions and irregularly oriented excess ice were found at the boreholes drilled between Chainage 92+000 m and 96+000 m of the proposed rail alignment.

A ground-penetrating radar unit was used to confirm and delineate the ice rich areas identified above, with the exception of the previous proposed bridge location at approximately Chainage 92+000 m to 96+000 m.

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Appendix A
Borehole Location Plan

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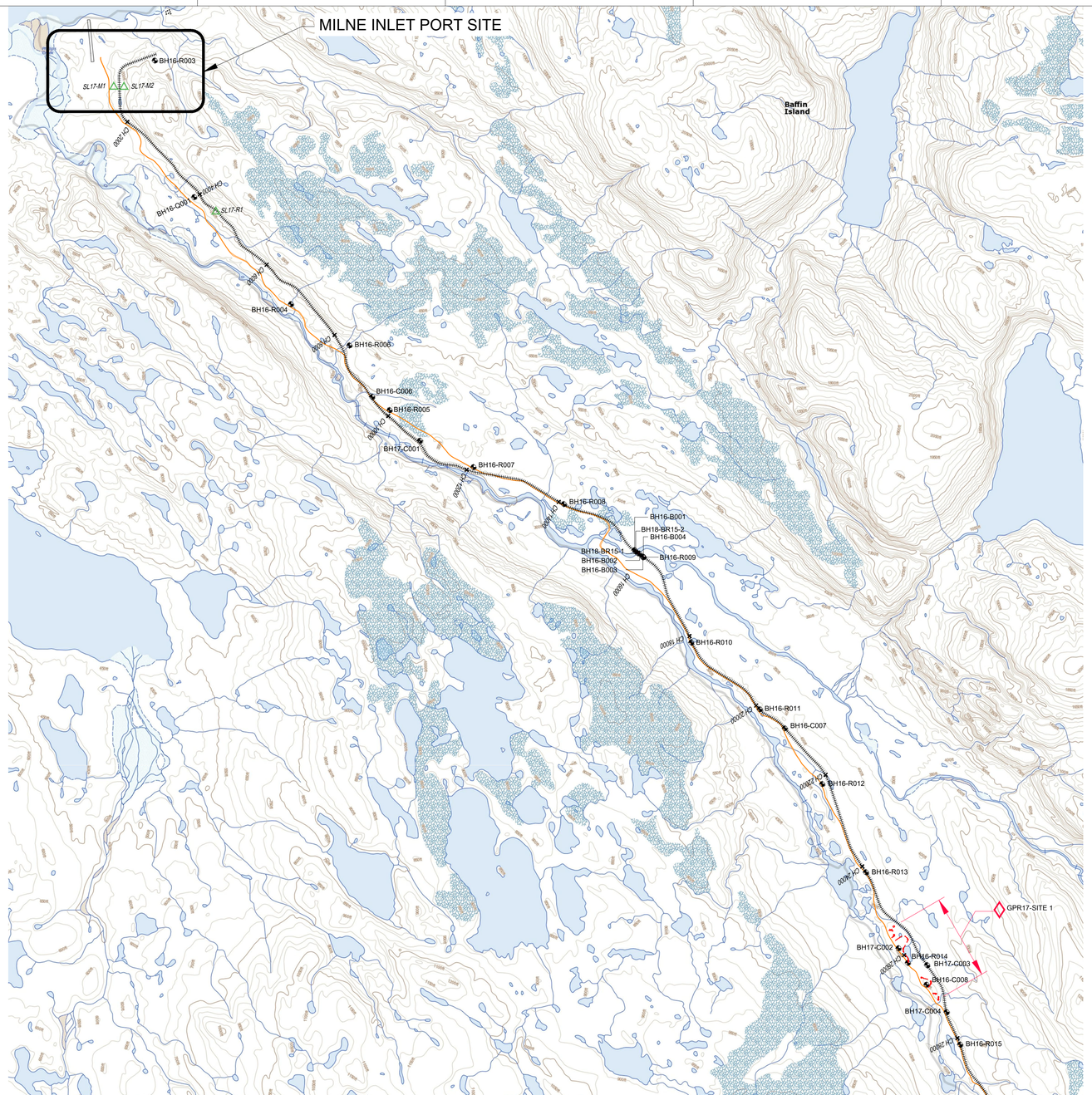

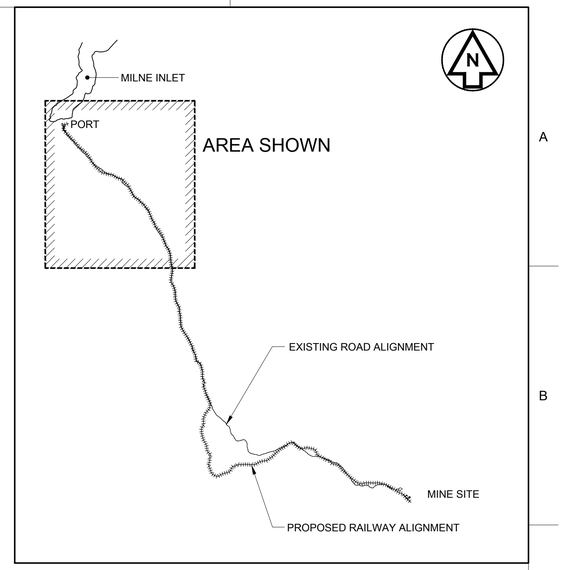

KEY PLAN

0 10 20 30 40 50 kilometres

SCALE 1:500 000

LEGEND

- AS-BUILT BOREHOLE LOCATION
- CHAINAGE POINT ALONG RAIL ALIGNMENT
- SEISMIC LINE LOCATION
- GROUND PENETRATING RADAR SURVEY (GPR) AREA
- PROPOSED RAILWAY
- EXISTING TOTE ROAD

REFERENCES:

FOR SEISMIC AND GROUND PENETRATING RADAR DETAILS SEE GEOPHYSICS GPR INTERNATIONAL INC REPORT

0 1 2 3 4 5 KILOMETRES

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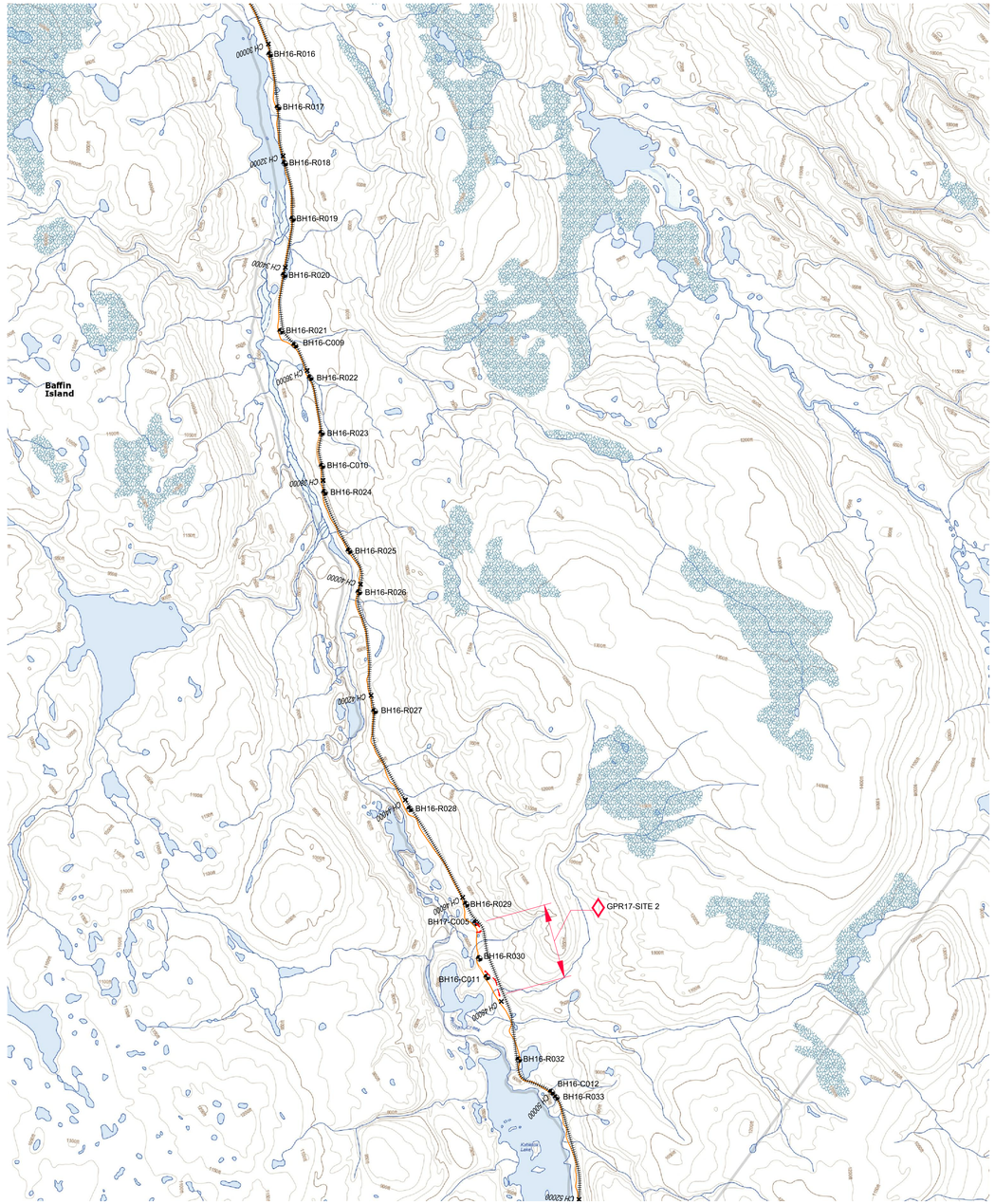

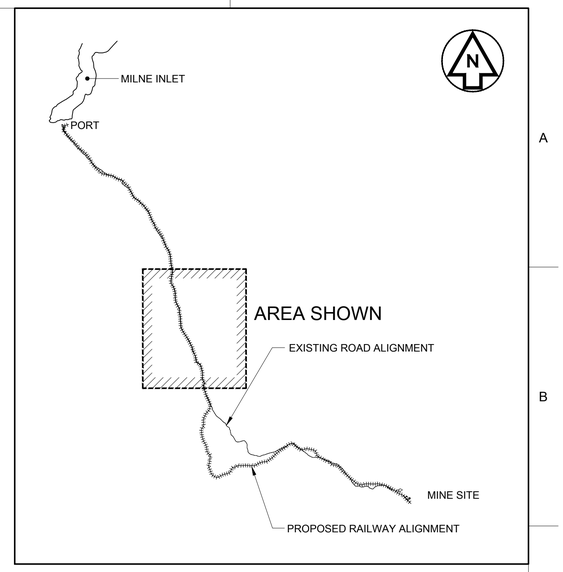

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SCALE 1:500 000

LEGEND

- AS-BUILT BOREHOLE LOCATION
- CHAINAGE POINT ALONG RAIL ALIGNMENT
- SEISMIC LINE LOCATION
- GROUND PENETRATING RADAR SURVEY (GPR) AREA
- PROPOSED RAILWAY
- EXISTING TOTE ROAD

REFERENCES:

FOR SEISMIC AND GROUND PENETRATING RADAR DETAILS SEE GEOPHYSICS GPR INTERNATIONAL INC REPORT

0 1 2 3 4 5 KILOMETRES

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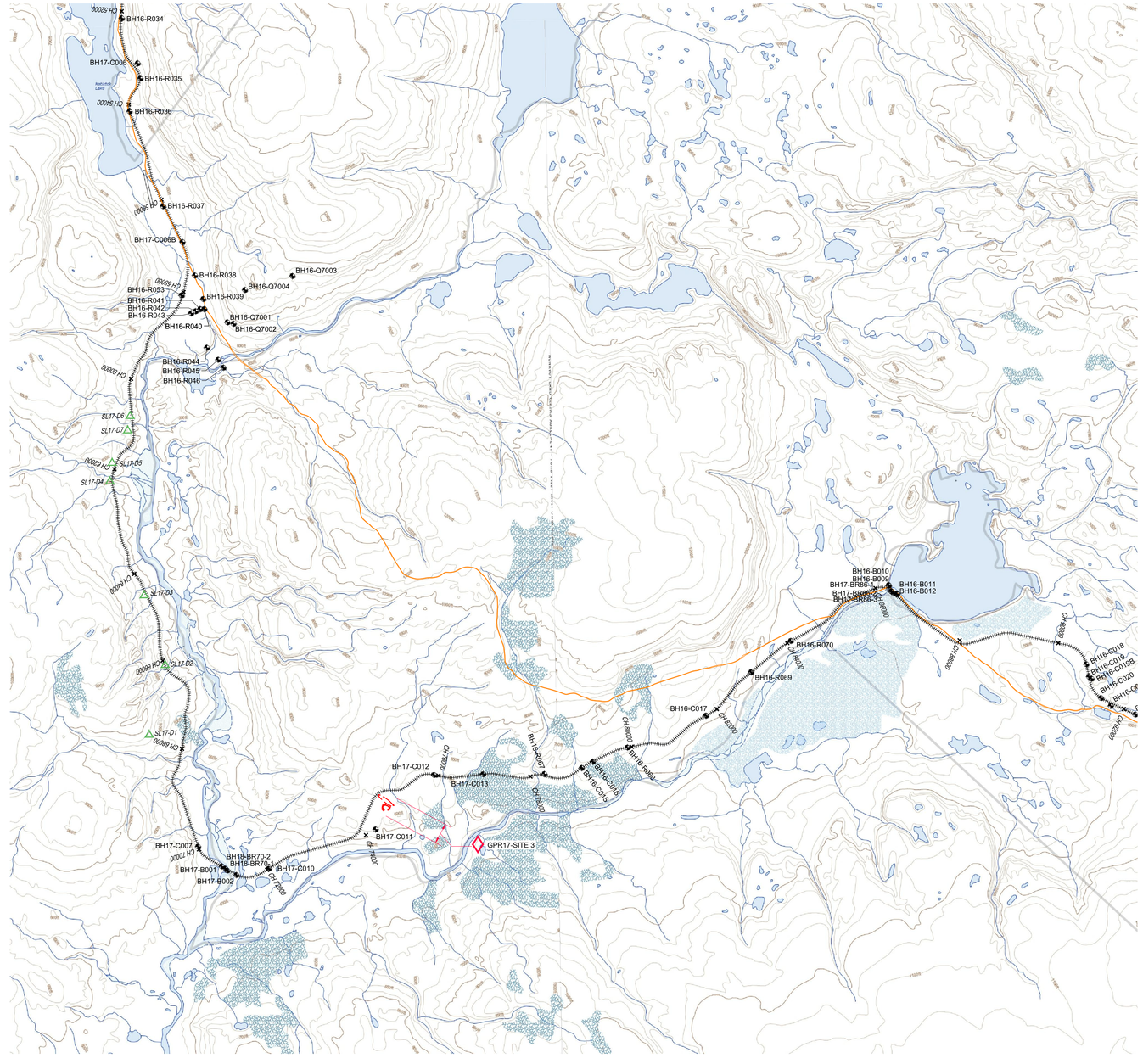

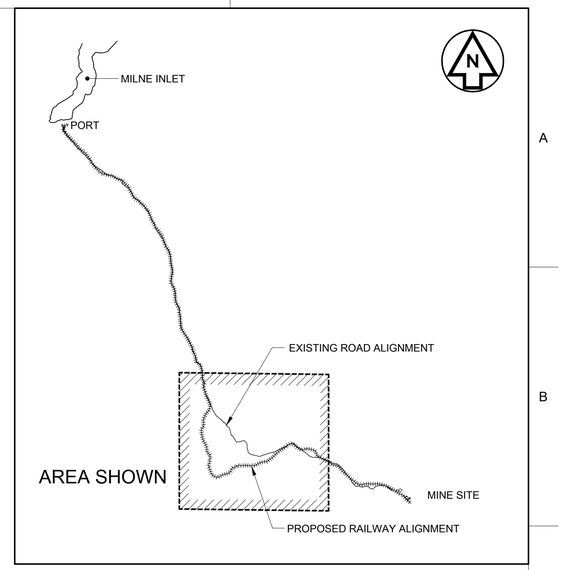

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LEGEND

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- CHAINAGE POINT ALONG RAIL ALIGNMENT
- SEISMIC LINE LOCATION
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REFERENCES:

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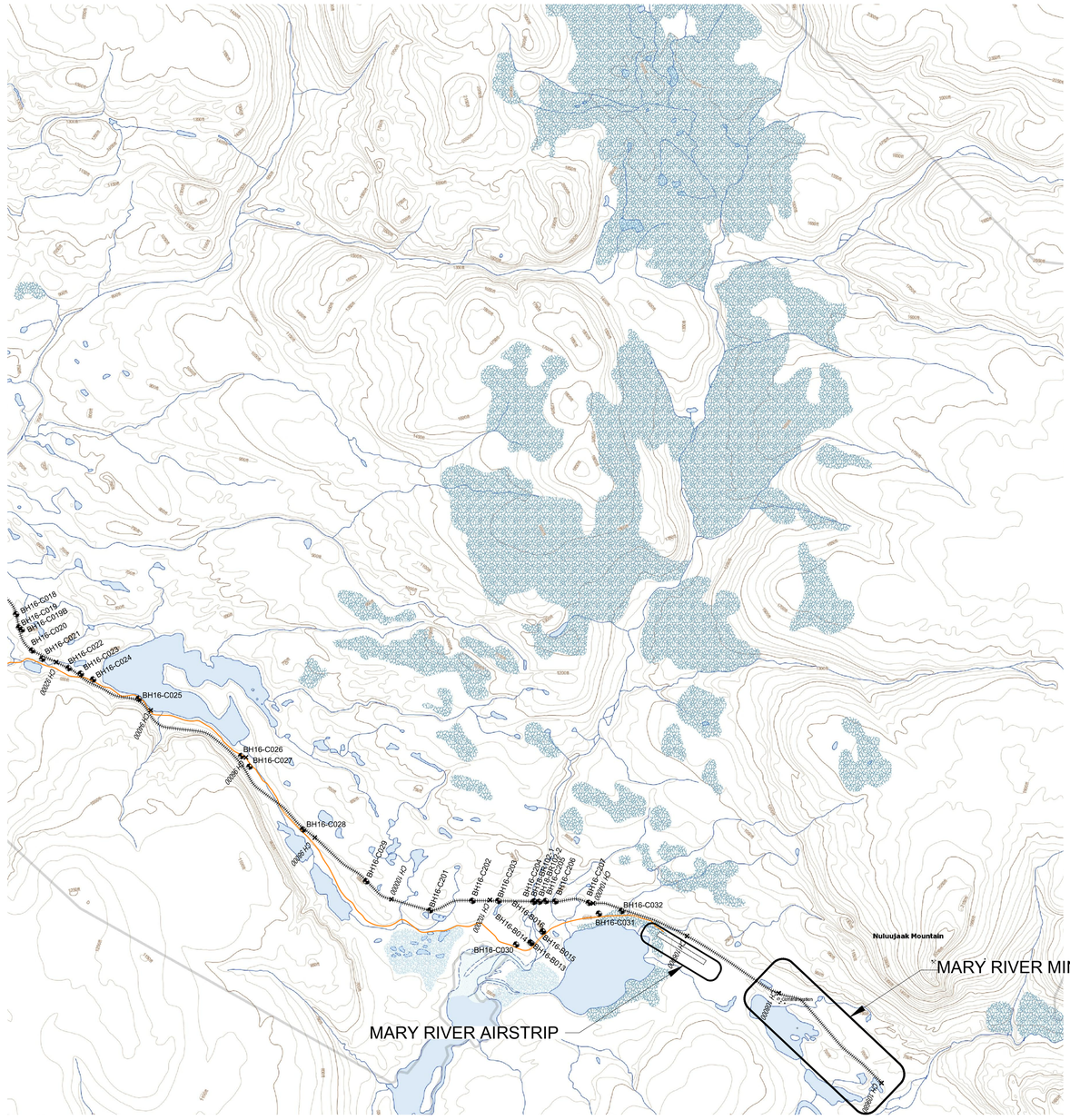

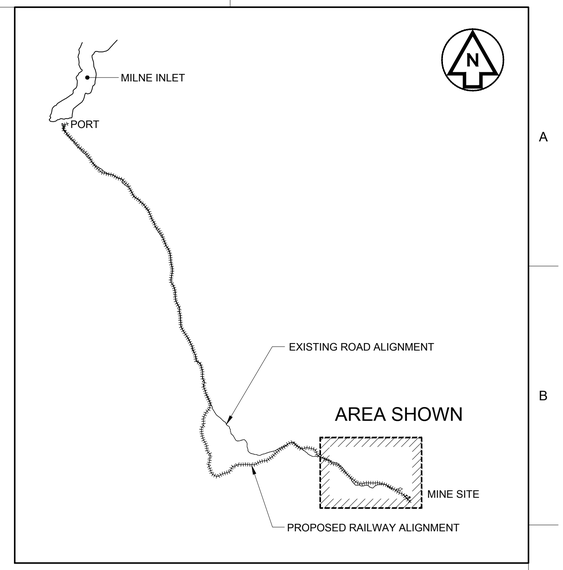

KEY PLAN

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SCALE 1:500 000

LEGEND

- AS-BUILT BOREHOLE LOCATION
- CHAINAGE POINT ALONG RAIL ALIGNMENT
- SEISMIC LINE LOCATION
- GROUND PENETRATING RADAR SURVEY (GPR) AREA
- PROPOSED RAILWAY (ALIGNMENT ADDED IN MARCH 2018)
- EXISTING TOTE ROAD

REFERENCES:

FOR SEISMIC AND GROUND PENETRATING RADAR DETAILS SEE GEOPHYSICS GPR INTERNATIONAL INC REPORT

0 1 2 3 4 5 KILOMETRES

SCALE 1:50 000 (B1 SHEET)

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ENG. MANAGER	F VAN BILJON		20/08/2018
PROJ. MANAGER	S PERRY		20/08/2018

No.	DESCRIPTION	BY	CHK'D	DATE
A	ISSUED WITH GEOTECHNICAL REPORT			20/08/2018

DRAWING APPROVAL STATUS: Record Document

BAFFINLAND IRON ORE MINES LP
MARY RIVER EXPANSION PROJECT

GEOTECHNICAL INVESTIGATIONS
LOCATION PLAN
SHEET 4 OF 4

SCALE 1:500,000 OR AS NOTED

DWG. No. H353004-10000-229-230-0005

REV A

SHEET SIZE: D

REFERENCE DRAWINGS | REG. PROFESSIONAL | REVISIONS

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Appendix B
Borehole Reports

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List of Abbreviations and Terms Used in the Borehole Reports

(Sheet 1)

General

Elevations
Elevations are referenced to datum indicated.

Depth
All depths are given in meters (feet) measured from the ground surface unless otherwise noted.

Sample Recovery
Indicates the length retained in millimeters (inches) in a split spoon sampler or percentage recovery of sample retained in the core barrel sampler.

Sample Number
Samples are numbered consecutively in the order in which they were obtained or attempted in the borehole.

Sample Type
The first letter describes the sampling method and the second, the shipping container.

Sampling Method

A – Split Tube	E – Auger
B – Thin Wall Tube	F – Wash
C – Piston Sampler	G – Shovel Grab Sample
D – Core Barrel	K – Slotted Sampler

Shipping Container

O – Tube	U – Not Recovered
P – Water Content Tin	X – Plastic & PVC Sleeve (Sonic)
Q – Jar	Y – Core Box
S – Plastic Bag	Z – Discarded

Abbreviations
N/A – Not applicable
N/E – Not encountered
N/O – Not observed

Soil

Soil Description, Label and Symbol
Soil description under the "Description" column conforms generally, but not rigorously, to the Unified Soils Classification System. For a given soil unit, defined by depth boundaries, the descriptive text constitutes the definitive soil unit description and takes precedence over both the brief label and the symbol used to graphically represent the soil unit.

Grain Size

Clay		<0.002 mm
Silt	0.002 –	0.075 mm
Sand	0.075 –	4.75 mm
Fine	0.075 –	0.42 mm
Medium	0.42 –	2.00 mm
Course	2.00 –	4.75 mm
Gravel	4.75 –	75 mm
Fine	4.75 –	19.00 mm
Coarse	19.00 –	75.00mm
Cobbles	75 –	300 mm
Boulder		>300 mm

Relative Quantities

Term	*Example*	*(%)*
Trace	Trace sand	1 – 10
Some	Some sand	10 – 20
With (adjective)	With Sand (Sandy)	20 – 35
And	And sand	>35
Noun	Sand	>50

Standard Penetration Test (SPT)
The test is carried out in accordance with ASTM D-1586 and the 'N' value corresponds to the sum of the number of blows required by a 63.5-kg (140-lb) hammer, dropped 760 mm (30 in.), to drive a 50-mm (2-in.) diameter split tube sampler the second and third 150 mm (6 in.) of penetration.

Density (Granular Soils)

	N(SPT)
Very loose	0 – 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very dense	>50

Consistency (Cohesive Soils)

	N(SPT)
Very soft	<2
Soft	2 – 4
Firm	4 – 8
Stiff	8 – 15
Very stiff	15 – 30
Hard	>30

Plasticity/Compressibility

		Liquid Limit (%)
Low plasticity clays	Low compressibility silts	<30
Medium plasticity clays	Medium compressibility silts	30 – 50
High plasticity clays	High compressibility silts	>50

Dilatancy
None - No visible change, during shaking or squeezing
Slow - Water appears slowly on surface of specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid - Water appears quickly on the surface of specimen during shaking and disappears quickly upon squeezing.

Sensitivity

Insensitive	<2
Low	2 – 4
Medium	4 – 8
High	8 – 16
Quick	>16

List of Abbreviations and Terms Used in the Borehole Reports

(Sheet 2)

Rock

Core Recovery
Sum of lengths of rock core recovered from a core run, divided by the length of the core run and expressed as a percentage.

RQD (Rock Quality Designation)
Sum of lengths of hard, sound pieces of rock core equal to or greater than 100 mm from a core run, divided by the length of the core run and expressed as a percentage. Measured along centerline of core. Core fractured by drilling is considered intact. RQD normally quoted for N-size core.

RQD (%) Rock Quality

90	-	100	Excellent
75	-	90	Good
50	-	75	Fair
25	-	50	Poor
0	-	25	Very Poor

Grain Size

Term	*Grain Size*
Very coarse-grained	>60 mm
Coarse-grained	2 mm - 60 mm
Medium-grained	60 μm - 2 mm
Fine-grained	2 μm - 60 μm
Very fine-grained	< 2 μm

Bedding

Term	*Bed Thickness*			
Very thickly bedded		>2 m		>6.50 ft
Thickly bedded	600 mm -	2 m	2.00 -	6.50 ft
Medium bedded	200 mm -	600 mm	0.65 -	2.00 ft
Thinly bedded	60 mm -	200 mm	0.20 -	0.65 ft
Very thinly bedded	20 mm -	60 mm	0.06 -	0.20 ft
Laminated	6 mm -	20 mm	0.02 -	0.06 ft
Thinly laminated		<6 mm		<0.02 ft

Discontinuity Frequency
Expressed as the number of discontinuities per meter or discontinuities per foot. Excludes drill-induced fractures and fragmented zones.

Discontinuity Spacing

Term	*Average Spacing*			
Extremely widely spaced		>6 m		>20.00 ft
Very widely spaced	2 m -	6 m	6.50 -	20.00 ft
Widely spaced	600 mm -	2 m	2.00 -	6.50 ft
Moderately spaced	200 mm -	600 mm	0.65 -	2.00 ft
Closely spaced	60 mm -	200 mm	0.20 -	0.65 ft
Very closely spaced	20 mm -	60 mm	0.06 -	0.20 ft
Extremely closely spaced		<20 mm		<0.06 ft

Note: Excludes drill-induced fractures and fragmented rock.

Broken Zone
Zone of full diameter core of very low RQD which may include some drill-induced fractures.

Fragmented Zone
Zone where core is less than full diameter and RQD = 0.

Strength

Term	*Description*	*Unconfined Compressive Strength (MPa)*	*(psi)*
Extremely weak rock	Indented by thumbnail	0.25 – 1.0	36 – 145
Very weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	1.0 – 5.0	145 – 725
Weak rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	5.0 – 25	725 – 3625
Medium strong rock	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer to facture it	25 – 50	3625 –7250
Strong rock	Specimen requires more than one blow of geological hammer to fracture it	50 – 100	7250 – 14500
Very strong rock	Specimen requires many blows of geological hammer to fracture it	100 – 250	14500 – 36250
Extremely strong rock	Specimen can only be chipped with geological hammer	>250	>36250

Weathering

Term	*Description*
Fresh	No Visible sign of rock material weathering
Faintly weathered	Discoloration on major discontinuity surfaces.
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker than in its fresh condition.
Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones.
Highly weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

BASIS FOR SOIL DESCRIPTION

(Based on AS1726-1993 - Geotechnical Site Investigations, with modifications)

GRAPHIC SYMBOLS FOR SOILS

GRAVEL – poorly graded -

well graded -

SAND – poorly graded -

well graded -

SILT – of low plasticity -

of high plasticity -

CLAY – of low plasticity -

of high plasticity -

ICE -

COBBLES AND BOULDERS -

ORGANIC/ PEATY SOIL -

FILL/ MADE GROUND -

Composite soil types are presented using combined symbols, eg. **Gravelly Sandy CLAY**

GROUNDWATER OBSERVATIONS

Permanent Water Level

Temporary Water Level

Inflow into Pit or Borehole

Outflow/ Water Loss in Borehole

Slow Inflow/ Seepage into Pit or Borehole

SAMPLE TYPES

Disturbed bag sample

Bulk Disturbed (>20kg)

Hollow Stem Auger Core

Auger Flight Cuttings

Standard Penetration Test (SPT), with Disturbed Split-Spoon Sample

SPT (no recovery)

Thin walled "undisturbed" push tube sample eg. U60, U100 etc

Sample attempted with no recovery

HATCHCANADA2015 DRAFT.GLB GrfcText SOIL DESCRIPTION - 3 BAFFINLAND BOREHOLES 2016 - TJ.GPJ <<DrawingFile>> 17/02/2017 15:13

BASIS FOR ROCK DESCRIPTION

(Based on AS1726-1993 - Geotechnical Site Investigations, with modifications)

GRAPHIC SYMBOLS FOR SOILS

GRAVEL – poorly graded -

GRAVEL – well graded -

SAND – poorly graded -

SAND – well graded -

SILT – of low plasticity -

SILT – of high plasticity -

CLAY – of low plasticity -

CLAY – of high plasticity -

FINE GRAINED TAILINGS -

COBBLES AND BOULDERS -

ORGANIC/ PEATY SOIL -

FILL/ MADE GROUND -

Composite soil types are presented using combined symbols, eg. **Gravelly Sandy CLAY**

GRAPHIC SYMBOLS FOR ROCKS

SEDIMENTARY

SHALE

CLAYSTONE

SILTSTONE

SANDSTONE

CONGLOMERATE

BRECCIA

CORE LOSS

CARBONATE

LIMESTONE

Calcareous CLAYSTONE

Calcareous SILTSTONE

CALCARENITE

CALCIRUDITE

CALCRETE

EVAPORITES

GYPSUM

IGNEOUS

COARSE GRAINED

MEDIUM GRAINED

FINE GRAINED

DOLERITE

METAMORPHIC

COARSE GRAINED

MEDIUM GRAINED

FINE GRAINED

Additional rock graphics may be added for specific projects.

GROUNDWATER OBSERVATIONS

Permanent Water Level

Temporary Water Level

Inflow into Pit or Borehole

Outflow/ Water Loss in Borehole

Slow Inflow/ Seepage into Pit or Borehole

SAMPLE TYPES

Disturbed bag sample

Bulk Disturbed (>20kg)

Hollow Stem Auger Core

Auger Flight Cuttings

Standard Penetration Test (SPT), with Disturbed Split-Spoon Sample

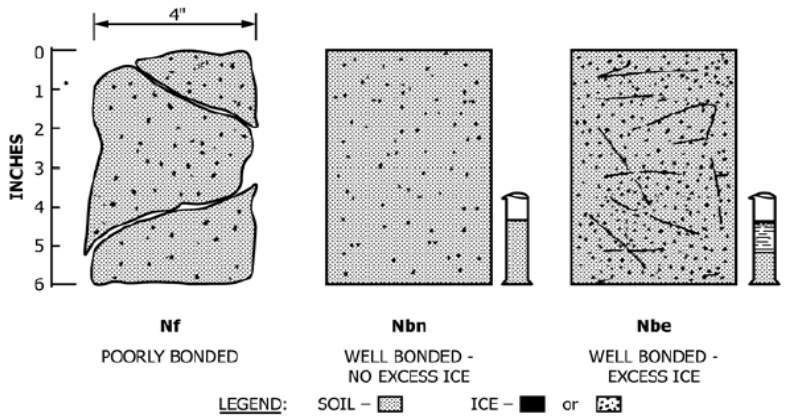
SPT (no recovery)

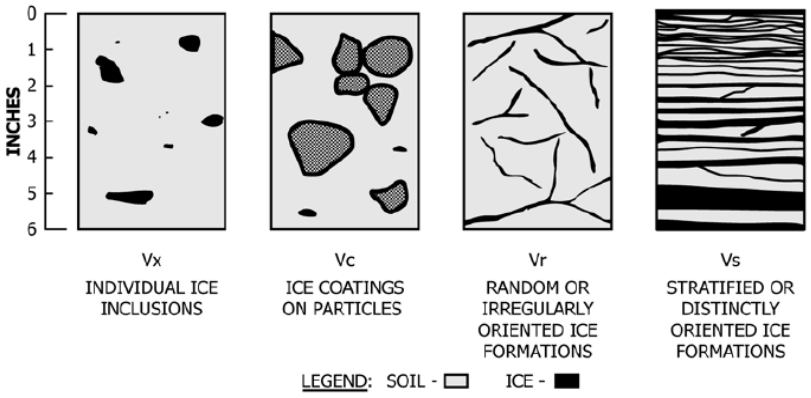
Thin walled "undisturbed" push tube sample eg. U60, U100 etc

Sample attempted with no recovery

HATCH LIBRARY DEVELOPMENT COPY.GLB GrfcText ROCK SYMBOLS GINT LOGS MR 2018 GEOTECHNICAL INVESTIGATION - V7.GPJ <<DrawingFile>> 29/08/2018 12:00

Symbol	Description
Nf	Poorly bonded with no visible excess ice
Nbn	Well bonded with no visible excess ice
Nbe	Well bonded with excess cie
Vx	Individual ice inclusions
Vc	Ice coatings on particles
Vr	Random or Irregularly oriented ice formations
Vs	Stratified or distrinctly oriented ice formations





BOREHOLE REPORT

BH16-B001
Sheet 1 of 2

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 514,191.0 m
Northing: 7,965,675.0 m
Surface Elevation: 78.00 m
Bottom Elevation: 66.50 m
Total Depth: 11.5 m
Logged By: MR
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: Michael Scott
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 12/3/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 / 50 / 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	78.0	0.0	Vibracore	H-Casing		SILT: Organic, fine grained	Vx										
						ICE LENSE, silt inclusions: Grey to dark grey, soft, cloudy texture	ICE										
	77.0	1.0				SILTY SAND, trace GRAVEL, trace COBBLES: Grey to light brown, fine to coarse grained sand, subangular to rounded cobbles	Vc										
	76.0	2.0															
	75.0	3.0					Nbe				9						
	74.0	4.0									19	6	66	29			
	73.0	5.0					Nbn										
	72.0	6.0				BOULDERS: Grey, granitic gneiss and mafic gneiss with pulvurized powder	Nf										
	71.0	7.0															
	70.0	8.0				Sandy SILT, trace COBBLES, trace BOULDERS: Reddish brown, rounded to subrounded cobbles	Nf										
	69.0	9.0															
	68.0	10.0															

Notes:

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BOREHOLE REPORT

BH16-B001

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 514,191.0 m

Northing: 7,965,675.0 m

Surface Elevation: 78.00 m

Bottom Elevation: 66.50 m

Total Depth: 11.5 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 12/3/2016

Driller: Michael Scott

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	67.0	11.0		[11.5]		BOULDERS: Pulverized rock, angular, possible bedrock											
	66.0	12.0				Drilling Refusal. **Drillhole BH16-B001 terminated at 11.5m.**											
	65.0	13.0															
	64.0	14.0															
	63.0	15.0															
	62.0	16.0															
	61.0	17.0															
	60.0	18.0															
	59.0	19.0															
	58.0	20.0															

Notes:

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BOREHOLE REPORT

BH16-B002
Sheet 1 of 2

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 514,290.0 m
Northing: 7,965,604.0 m
Surface Elevation: 78.00 m
Bottom Elevation: 64.90 m
Total Depth: 13.1 m
Logged By: UK
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: E.Beachamp
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 12/2/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	77.0	1.0	Vibracore	H-Casing		SAND: Dark brown to grey, some organics	Nf										
	76.0	2.0				SANDY GRAVEL, some COBBLES: Grey to brown, coarse grained sand, angular gravel	Nf				11						
	75.0	3.0				SAND, some COBBLES, some BOULDERS: Grey, fine grained sand, rounded to subrounded cobbles and boulders	Nf										
	74.0	4.0															
	73.0	5.0				SILTY SAND, some COBBLES, trace GRAVEL: Grey, fine grained sand	Nbn										
	72.0	6.0									14	5	77	19			
	71.0	7.0				SAND, some SILT, trace GRAVEL: Grey	Nf										
						BOULDERS: Granitic, fragmented											
	70.0	8.0				SANDY SILT: Grey, fine grained											
	69.0	9.0				BOULDERS: Granitic gneiss, rock fragments and boulders											
	68.0	10.0				SILTY SAND, some COBBLES, some BOULDERS: Dark grey, fine to coarse grained sand, rounded to subrounded cobbles	Nf										

Notes:

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BOREHOLE REPORT

BH16-B002

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 514,290.0 m

Northing: 7,965,604.0 m

Surface Elevation: 78.00 m

Bottom Elevation: 64.90 m

Total Depth: 13.1 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 12/2/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	67.0	11.0				SILTY SAND, some COBBLES, some BOULDERS: Dark grey, fine to coarse grained sand, rounded to subrounded cobbles *(Continued)*	Nf *(Continued)*										
	66.0	12.0															
	65.0	13.0		[13.1]		SILT, some SAND, trace GRAVEL: Light brown to grey, granular to cohesive, fine to medium grained sand, subangular to angular gravel	Nf										
	64.0	14.0				Drilling Refusal. **Drillhole BH16-B002 terminated at 13.1m.**											
	63.0	15.0															
	62.0	16.0															
	61.0	17.0															
	60.0	18.0															
	59.0	19.0															
	58.0	20.0															

Notes:

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BOREHOLE REPORT

BH16-B003
Sheet 1 of 2

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 514,357.0 m
Northing: 7,965,533.0 m
Surface Elevation: 79.00 m
Bottom Elevation: 63.80 m
Total Depth: 15.2 m
Logged By: MR
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: Michael Scott
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 12/2/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	78.0	1.0	Vibracore	H-Casing		SILTY SAND, with GRAVEL, trace COBBLES: Dark brown to dark grey, Organics, fine to coarse grained sand, subangular gravel	Vc										
	77.0	2.0				GRAVEL, with SAND, some COBBLES, trace SILT: Grey to light brown, fine to coarse grained sand, rounded to subrounded cobbles	Vc				9	24	47	28			
	76.0	3.0				SILTY SAND and GRAVEL: Grey, fine to coarse grained	Nbn										
	75.0	4.0				SAND: Grey, fine to coarse grained sand	Vr										
	74.0	5.0				ICE, silt inclusions: Brown to grey, milky texture											
	73.0	6.0					Vr			>>	100	2	72	26			
	72.0	7.0									23						
	71.0	8.0				SAND, some SILT, trace COBBLES: Reddish brown, rounded to subrounded cobbles	Nf										
	70.0	9.0				SILTY SAND: Grey to brown, fine to coarse grained sand, rounded cobbles											
	69.0	10.0															

Notes:

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BOREHOLE REPORT

BH16-B003

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 514,357.0 m

Northing: 7,965,533.0 m

Surface Elevation: 79.00 m

Bottom Elevation: 63.80 m

Total Depth: 15.2 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 12/2/2016

Driller: Michael Scott

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						BOULDERS: Granitic gneiss											
	68.0	11.0				SILTY SAND, some GRAVEL, some COBBLES: Reddish brown, fine grained sand, angular to subangular gravel	Nf										
	67.0	12.0															
	66.0	13.0															
	65.0	14.0															
	64.0	15.0		[15.2]													
	63.0	16.0				Drilling Refusal. **Drillhole BH16-B003 terminated at 15.2m.**											
	62.0	17.0															
	61.0	18.0															
	60.0	19.0															
	59.0	20.0															

Notes:

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BOREHOLE REPORT

BH16-B004

Sheet 1 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 514,367.0 m

Northing: 7,965,540.0 m

Surface Elevation: 79.00 m

Bottom Elevation: 62.80 m

Total Depth: 16.2 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 12/1/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	78.0	1.0	Vibracore	H-Casing		SAND: Grey, coarse grained sand	Nf										
						0.60 m to 1.50 m: SILT, dark grey to dark brown	Nbn										
	77.0	2.0				SILTY SAND, some GRAVEL: Grey, angular to subangular gravel,	Nf				9						
	76.0	3.0															
	75.0	4.0															
	74.0	5.0				ICE, SILT inclusions: Moderate hardness, greyish color, cloudy texture	ICE										
	73.0	6.0				Sand and SILT, trace GRAVEL: Grey, fine to coarse grained sand	Vr			>>	100	7	54	39			
						BOULDERS: Granitic gneiss											
	72.0	7.0				SAND: Grey, fine to coarse grained	Nbn				19	35	44	21			
	71.0	8.0				SAND: Grey, fine to coarse grained	Nbn										
							Nf										
	70.0	9.0				SILTY SAND: Grey to brown, fine to coarse grained	Nf										
	69.0	10.0															

Notes:

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BOREHOLE REPORT

BH16-B004

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 514,367.0 m

Northing: 7,965,540.0 m

Surface Elevation: 79.00 m

Bottom Elevation: 62.80 m

Total Depth: 16.2 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 12/1/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						ROCK: Granitic gneiss, intact, moderate to high strength											
	68.0	11.0				SILTY SAND, some GRAVEL, trace COBBLES: Brown to reddish brown, fine to coarse grained sand, rounded to subrounded cobbles	Nf											
	67.0	12.0					Vx										
	66.0	13.0															
	65.0	14.0				SAND and SILT, trace COBBLES: Grey to dark grey, fine to medium grained sand, rounded to subrounded cobbles	Vc										
	64.0	15.0															
	63.0	16.0		[16.2]		SAND, some GRAVEL, some COBBLES, trace BOULDERS :Dark grey, fine to coarse grained sand, rounded to subrounded cobbles and boulders	Nf										
	62.0	17.0				Drilling Refusal. **Drillhole BH16-B004 terminated at 16.2m.**											
	61.0	18.0															
	60.0	19.0															
	59.0	20.0															

Notes:

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BOREHOLE REPORT

BH16-B009

Sheet 1 of 3

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 542,204.0 m

Northing: 7,922,291.0 m

Surface Elevation: 143.00 m

Bottom Elevation: 115.60 m

Total Depth: 27.4 m

Logged By: RS/CS

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/7/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	142.0	1.0	Vibracore	H-Casing		SAND: Poorly graded, brown, fine to medium grained	Nf										
	141.0	2.0				1.50 m to 4.00 m: Trace SILT	Nbn										
	140.0	3.0															
	139.0	4.0															
	138.0	5.0															
	137.0	6.0															
	136.0	7.0															
	135.0	8.0															
	134.0	9.0															
	133.0	10.0									22	0	98	2			

Notes:

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HATCH BOREHOLE REPORT

BH16-B009
Sheet 2 of 3

Client: Baffinland Iron Mines
Project No.: H352034
Project: Mary River Expansion Study Stage 2
Datum: NAD83
Location: Proposed Rail Alignment
Platform: Ground

Easting: 542,204.0 m
Northing: 7,922,291.0 m
Surface Elevation: 143.00 m
Bottom Elevation: 115.60 m
Total Depth: 27.4 m
Logged By: RS/CS
Reviewed By: SH/WH

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 11/7/2016
Driller: E.Beachamp
Hole Diameter (mm): 96
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	132.0	11.0				SAND: Poorly graded, brown, fine to medium grained *(Continued)*	Nf *(Continued)*										
	131.0	12.0															
	130.0	13.0															
	129.0	14.0															
	128.0	15.0															
	127.0	16.0															
	126.0	17.0				SAND and GRAVEL: Rounded to subrounded gravel, fine grained sand	Nbn										
	125.0	18.0															
		[18.8]															
	124.0	19.0															
	123.0	20.0															

Notes:

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BOREHOLE REPORT

BH16-B009

Sheet 3 of 3

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 542,204.0 m

Northing: 7,922,291.0 m

Surface Elevation: 143.00 m

Bottom Elevation: 115.60 m

Total Depth: 27.4 m

Logged By: RS/CS

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/7/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	122.0	21.0				SAND and GRAVEL: Rounded to subrounded gravel, fine grained sand *(Continued)*	Nbn *(Continued)*										
	121.0	22.0				SAND: Grey with Brown seams, fine to medium grained sand	Nbn										
	120.0	23.0															
	119.0	24.0															
	118.0	25.0															
	117.0	26.0															
	116.0	27.0															
	115.0	28.0				To Target Depth. **Drillhole BH16-B009 terminated at 27.4m.**											
	114.0	29.0															
	113.0	30.0															

Notes:

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HATCH BOREHOLE REPORT

BH16-B010

Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 542,208.0 m
Northing: 7,922,304.0 m
Surface Elevation: 143.00 m
Bottom Elevation: 133.00 m
Total Depth: 10.0 m
Logged By: CS
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: E.Beachamp
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 11/8/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	142.0	1.0	Vibracore	H-Casing		SAND, trace SILT, trace GRAVEL: Reddish brown, medium to fine grained sand	Nf										
	141.0	2.0					Nbn										
	140.0	3.0									11	5	87	8			
	139.0	4.0				4.20 m: Slight increase in silt content	Nbn										
	138.0	5.0									21	0	98	2			
	137.0	6.0					Nf										
	136.0	7.0				SILTY SAND: Reddish brown to grey, fine to course grained sand	Nbn										
	135.0	8.0															
	134.0	9.0					Nbn										
	133.0	10.0		[10.0]							20	0	61	39			
	132.0	11.0				To Target Depth. **Drillhole BH16-B010 terminated at 10.0m.**											

Notes:

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BOREHOLE REPORT

BH16-B011

Sheet 1 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 542,365.0 m

Northing: 7,922,121.0 m

Surface Elevation: 144.00 m

Bottom Elevation: 133.30 m

Total Depth: 10.7 m

Logged By: RS

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/8/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	143.0	1.0	Vibracore	H-Casing		SAND, trace SILT, trace GRAVEL: Light brown, fine to coarse grained sand	Nf										
	142.0	2.0					Nbn										
	141.0	3.0															
	140.0	4.0					Nbe					0	98	2			
	139.0	5.0					Nbn										
	138.0	6.0															
	137.0	7.0															
	136.0	8.0															
	135.0	9.0									19						
	134.0	10.0															

Notes:

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BOREHOLE REPORT

BH16-B011

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 542,365.0 m

Northing: 7,922,121.0 m

Surface Elevation: 144.00 m

Bottom Elevation: 133.30 m

Total Depth: 10.7 m

Logged By: RS

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/8/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
				[10.7]		SAND, trace SILT, trace GRAVEL: Light brown, fine to coarse grained sand *(Continued)*	Nf *(Continued)*										
	133.0	11.0				To Target Depth. **Drillhole BH16-B011 terminated at 10.7m.**											
	132.0	12.0															
	131.0	13.0															
	130.0	14.0															
	129.0	15.0															
	128.0	16.0															
	127.0	17.0															
	126.0	18.0															
	125.0	19.0															
	124.0	20.0															

Notes:

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BOREHOLE REPORT

BH16-B012

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 542,376.0 m

Northing: 7,922,131.0 m

Surface Elevation: 146.00 m

Bottom Elevation: 136.90 m

Total Depth: 9.1 m

Logged By: RS

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/8/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND and GRAVEL: Fine to coarse grained sand, angular to subangular gravel	Nf										
	145.0	1.0				SAND, trace SILT: Brown, fine to medium grained sand	Nbn										
	144.0	2.0															
Standing Water																	
						SAND and GRAVEL: Brown, rounded to subrounded gravel, up to 30mm	Nf										
	143.0	3.0				SITLY SAND, trace GRAVEL: Grey and brown layers	Nbn				12	4	87	9			
	142.0	4.0	Vibracore	H-Casing													
	141.0	5.0															
	140.0	6.0															
	139.0	7.0															
	138.0	8.0															
	137.0	9.0		[9.1]		To Target Depth. **Drillhole BH16-B012 terminated at 9.1m.**											
	136.0	10.0															

Notes:

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BOREHOLE REPORT

BH16-B013

Sheet 1 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 555,619.0 m

Northing: 7,914,671.0 m

Surface Elevation: 154.80 m

Bottom Elevation: 144.20 m

Total Depth: 10.6 m

Logged By: RS/CS

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/13/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	153.8	1.0	Vibracore	H-Casing		SAND and GRAVEL, some COBBLES: Brown, fine to coarse grained sand, angular gravel	Nf										
	152.8	2.0				1.20 m to 3.00 m: Trace to some silt and cobbles	Nf										
	151.8	3.0				SILTY SAND, some GRAVEL: Grey, angular gravel	Nf										
	150.8	4.0				SAND and SILT: Inferred COBBLES or BOULDERS: Brown, white powder					12	0	53	47			
	149.8	5.0															
	148.8	6.0				INFERRED SANDSTONE: Angular pieces of rock, low to moderate strength											
	147.8	7.0															
	146.8	8.0															
	145.8	9.0				INFERRED SANDSTONE BEDROCK											
	144.8	10.0															

Notes:

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BOREHOLE REPORT

BH16-B013

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 555,619.0 m

Northing: 7,914,671.0 m

Surface Elevation: 154.80 m

Bottom Elevation: 144.20 m

Total Depth: 10.6 m

Logged By: RS/CS

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/13/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
				[10.6]		INFERRED SANDSTONE: Angular pieces of rock, low to moderate strength *(Continued)*											
	143.8	11.0				To Target Depth. **Drillhole BH16-B013 terminated at 10.6m.**											
	142.8	12.0															
	141.8	13.0															
	140.8	14.0															
	139.8	15.0															
	138.8	16.0															
	137.8	17.0															
	136.8	18.0															
	135.8	19.0															
	134.8	20.0															

Notes:

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BOREHOLE REPORT

BH16-B014

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 555,599.0 m

Northing: 7,914,683.0 m

Surface Elevation: 156.00 m

Bottom Elevation: 146.90 m

Total Depth: 9.1 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/28/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	155.0	1.0	Vibracore	H-Casing		SAND and GRAVEL, some COBBLES: Dark grey to brown, medium to coarse grained sand, rounded cobbles 1.50 m to 3.00 m: Trace to some silt	Nf										
	154.0	2.0															
	153.0	3.0				SAND, with GRAVEL, trace COBBLES: Grey, fine to coarse grained sand, angular to subrounded gravel 4.60 m to 7.0 m: Trace to some silt	Nf				12	0	65	35			
	152.0	4.0															
	151.0	5.0															
	150.0	6.0															
	149.0	7.0				SAND with GRAVEL, trace COBBLES: Light grey, white powder, trace cobbles, fine to coarse grained sand, angular gravel 7.90 m: Inferred sandstone bedrock, weak to moderate strength					1	0	63	37			
	148.0	8.0															
	147.0	9.0		[9.1]		To Target Depth. **Drillhole BH16-B014 terminated at 9.1m.**											
	146.0	10.0															

Notes:

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BOREHOLE REPORT

BH16-B015

Sheet 1 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 555,824.0 m

Northing: 7,914,884.0 m

Surface Elevation: 156.00 m

Bottom Elevation: 142.40 m

Total Depth: 13.6 m

Logged By: US

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/14/2016

Driller: Michael Scott

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	155.0	1.0	Vibracore	H-Casing		SILTY SAND, with GRAVEL, with COBBLES: Brown, fine to coarse grained sand, angular to rounded gravel and cobbles, well graded	Nf										
	154.0	2.0								>>	100	17	41	41			
	153.0	3.0															
	152.0	4.0															
	151.0	5.0									11	0	63	37			
	150.0	6.0				6.10 m to 7.60 m: Ice rich soil	Vx										
	149.0	7.0															
	148.0	8.0															
	147.0	9.0															
	146.0	10.0				9.70 m to 10.6 m: Ice rich soil	Vr			>>							

Notes:

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BOREHOLE REPORT

BH16-B015

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 555,824.0 m

Northing: 7,914,884.0 m

Surface Elevation: 156.00 m

Bottom Elevation: 142.40 m

Total Depth: 13.6 m

Logged By: US

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/14/2016

Driller: Michael Scott

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
							Nf *(Continued)*				100	15	66	20			
	145.0	11.0				SANDSTONE: Pulverized sandstone bedrock with some intact sandstone core, grey to white											
	144.0	12.0															
						INFERRED SANDSTONE BEDROCK: bedrock, moderate strength, good quality											
	143.0	13.0															
				[13.6]													
	142.0	14.0				To Target Depth. **Drillhole BH16-B015 terminated at 13.6m.**											
	141.0	15.0															
	140.0	16.0															
	139.0	17.0															
	138.0	18.0															
	137.0	19.0															
	136.0	20.0															

Notes:

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BOREHOLE REPORT

BH16-B016

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 555,830.0 m

Northing: 7,914,892.0 m

Surface Elevation: 153.00 m

Bottom Elevation: 145.40 m

Total Depth: 7.6 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/16/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	152.0	1.0	Vibracore	H-Casing		GRAVEL and SAND, some SILT, trace COBBLES: Light brown to brown, fine to coarse grained sand, rounded to subangular gravel	Nf										
	151.0	2.0															
	150.0	3.0				SAND: Grey to light brown, fine to coarse grained sand 2.80 m to 2.90 m: Ice lense	Nf ICE Vx				15	0	88	12			
	149.0	4.0															
	148.0	5.0					Nf					0	67	33			
	147.0	6.0				5.80 m to 6.10 m: Ice lense	ICE										
						SAND, some GRAVEL, some COBBLES: Light brown to grey	Vx										
	146.0	7.0		[7.6]							7	0	66	34			
	145.0	8.0				To Target Depth. **Drillhole BH16-B016 terminated at 7.6m.**											
	144.0	9.0															
	143.0	10.0															

Notes:

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BOREHOLE REPORT

BH16-C006

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 508,897.0 m

Northing: 7,968,767.0 m

Surface Elevation: 71.75 m

Bottom Elevation: 69.65 m

Total Depth: 2.1 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 12/3/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	70.8	1.0	Vibracore	H-Casing		SAND, some SILT: Dark brown, organic, medium to coarse grained sand	Nf										
						SILTY SAND, with COBBLES, : Grey to white, pulverized rock and angular rock pieces	Nf										
	69.8	2.0		[2.1]		INFERRED BEDROCK: Granitic gneiss											
						Drilling Refusal. **Drillhole BH16-C006 terminated at 2.1m.**											
	68.8	3.0															
	67.8	4.0															
	66.8	5.0															
	65.8	6.0															
	64.8	7.0															
	63.8	8.0															
	62.8	9.0															
	61.8	10.0															

Notes:

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HATCH BOREHOLE REPORT

BH16-C007

Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 517,221.0 m
Northing: 7,962,080.0 m
Surface Elevation: 105.00 m
Bottom Elevation: 97.40 m
Total Depth: 7.6 m
Logged By: MR
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: Michael Scott
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 12/1/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	104.0	1.0	Vibracore	H-Casing		SILTY SAND, trace GRAVEL, trace COBBLES: Light brown, fine to medium grained sand, rounded to subangular gravel	Nf				17						
	103.0	2.0					Vc										
	102.0	3.0					Vx				12	1	73	26			
	101.0	4.0					Nbn										
	100.0	5.0				4.60 m to 4.80 m: Ice lense	ICE										
	99.0	6.0				6.10 m to 7.60 m: Ice rich silty sand	Vx										
	98.0	7.0		[7.6]							39						
	97.0	8.0				To Target Depth. **Drillhole BH16-C007 terminated at 7.6m.**											
	96.0	9.0															
	95.0	10.0															

Notes:

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BOREHOLE REPORT

BH16-C008

Sheet 1 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 520,080.0 m

Northing: 7,956,909.0 m

Surface Elevation: 119.30 m

Bottom Elevation: 105.60 m

Total Depth: 13.7 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/30/2016

Driller: Michael Scott

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	118.3	1.0	Vibracore	H-Casing		GRAVELLY SAND, some COBBLES and SILT: Light brown to grey, fine to coarse grained sand, rounded to subangular gravel	Nf				13						
	117.3	2.0					Vx										
	116.3	3.0				ICE: Grey to white color, weak to moderate strength, cloudy texture, minor silt inclusions	ICE				20						
	115.3	4.0															
	114.3	5.0															
	113.3	6.0															
	112.3	7.0															
	111.3	8.0															
	110.3	9.0															
	109.3	10.0															

Notes:

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BOREHOLE REPORT

BH16-C008

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 520,080.0 m

Northing: 7,956,909.0 m

Surface Elevation: 119.30 m

Bottom Elevation: 105.60 m

Total Depth: 13.7 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/30/2016

Driller: Michael Scott

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	108.3	11.0				ICE: Grey to white color, weak to moderate strength, cloudy texture, minor silt inclusions *(Continued)*	ICE *(Continued)*										
	107.3	12.0															
	106.3	13.0															
		[13.7]															
	105.3	14.0				To Target Depth. **Drillhole BH16-C008 terminated at 13.7m.**											
	104.3	15.0															
	103.3	16.0															
	102.3	17.0															
	101.3	18.0															
	100.3	19.0															
	99.3	20.0															

Notes:

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BOREHOLE REPORT

BH16-C009

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 522,032.0 m

Northing: 7,948,728.0 m

Surface Elevation: 136.50 m

Bottom Elevation: 127.40 m

Total Depth: 9.1 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/28/2016

Driller: Michael Scott

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	135.5	1.0	Vibracore	H-Casing		SILTY SAND, trace GRAVEL: Light brown, fine to medium grained sand, angular to subangular gravel	Nf										
	134.5	2.0															
	133.5	3.0									13	9	61	30			
	132.5	4.0															
	131.5	5.0				SILTY SAND, some GRAVEL: Grey, fine to coarse grained sand, angular to subangular gravel	Nbn										
	130.5	6.0					Nf										
	129.5	7.0				SILTY SAND, with COBBLES, with BOULDERS: Grey, coarse grained sand, angular to subangular gravel	Nf										
	128.5	8.0				SILTY SAND, with COBBLES, with BOULDERS: Grey, coarse grained sand, rounded to subrounded cobblesm possible weathered bedrock												
	127.5	9.0		[9.1]													
	126.5	10.0				To Target Depth. **Drillhole BH16-C009 terminated at 9.1m.**											

Notes:

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BOREHOLE REPORT

BH16-C010

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 522,513.0 m

Northing: 7,946,595.0 m

Surface Elevation: 168.20 m

Bottom Elevation: 162.70 m

Total Depth: 5.5 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/27/2016

Driller: Michael Scott

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	167.2	1.0	Vibracore	H-Casing		SANDY SILT, with GRAVEL, some COBBLES, trace BOULDERS: Brown, fine to coarse grained sand, angular to subangular gravel, rounded to subrounded cobbles and boulders					12						
						ICE LENSE: Clear, no texture											
	166.2	2.0				SANDY SILT, some COBBLES, trace GRAVEL: Subangular to subrounded cobbles											
						Pulvirized ROCK: Possible boulders or bedrock						9	33	58			
	165.2	3.0				3.00 m to 4.00 m: Pulverized rock mixed with water											
	164.2	4.0				WEATHERED ROCK: Dolomitic limestone											
	163.2	5.0		[5.5]													
	162.2	6.0				Drilling Refusal. **Drillhole BH16-C010 terminated at 5.5m.**											
	161.2	7.0															
	160.2	8.0															
	159.2	9.0															
	158.2	10.0															

Notes:

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BOREHOLE REPORT

BH16-C011

Sheet 1 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 525,427.0 m

Northing: 7,937,567.0 m

Surface Elevation: 179.00 m

Bottom Elevation: 168.30 m

Total Depth: 10.7 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/27/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	178.0	1.0	Vibracore	H-Casing		SANDY GRAVEL, with SILT, trace COBBLES: Grey, coarse grained sand, angular to subangular gravel											
						Dolomitic Boulder: White, pulverized											
	177.0	2.0				ICE: No soil inclusions, moderate strength, clear to milky white	ICE			>>	100						
	176.0	3.0				3.00 m to 6.10m: White to milky white, cloudy, weak strength											
	175.0	4.0								>>	100						
	174.0	5.0															
	173.0	6.0				6.10m to 7.60 m: White to clear, candled texture in some parts				>>	100						
	172.0	7.0															
	171.0	8.0				7.60m to 10.60 m: Soft, colourless to milky white, clear to cloudy, sand inclusions				>>	100						
	170.0	9.0								>>	100						
	169.0	10.0								>>							

Notes:

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BOREHOLE REPORT

BH16-C011

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 525,427.0 m

Northing: 7,937,567.0 m

Surface Elevation: 179.00 m

Bottom Elevation: 168.30 m

Total Depth: 10.7 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/27/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
				[10.7]		ICE: No soil inclusions, moderate strength, clear to milky white *(Continued)*	ICE *(Continued)*				100						
	168.0	11.0				To Target Depth. **Drillhole BH16-C011 terminated at 10.7m.**											
	167.0	12.0															
	166.0	13.0															
	165.0	14.0															
	164.0	15.0															
	163.0	16.0															
	162.0	17.0															
	161.0	18.0															
	160.0	19.0															
	159.0	20.0															

Notes:

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BOREHOLE REPORT

BH16-C012
Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion
Location: Tote Road km 53

Project No.: H352034
Datum: NAD83
Platform:

Easting: 526,569.0 m
Northing: 7,935,536.0 m
Surface Elevation: 163.00 m
Bottom Elevation: 158.40 m
Total Depth: 4.6 m
Logged By: MR
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: Michael Scott
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 11/26/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	162.0	1.0	Vibracore	H-Casing		SAND and GRAVEL: Brown to light brown, organics, fine to coarse grained sand, subangular gravel	Nf			0							
						SAND: With GRAVEL, light brown, trace silt, granular, fine to medium grained, subangular to rounded, poorly bonded, no excess ice, (Nf)											
	161.0	2.0				SANDY SILT and GRAVEL: Grey to light grey, fine to coarse grained sand, subangular to rounded gravel	Vx										
	160.0	3.0				BOULDERS: Pulverized, grey to white, and cobbles of limestone, no bedding, angular 2.70 m to 3.00 m: Weathered rock pieces, dolomitic limestone											
	159.0	4.0		[4.6]		SANDY SILT, some GRAVEL: Grey to white to dark grey, pulvirized dolomite, boulders or bedrock, fine to medium grained, strong rock, faintly weathered, weakly jointed											
	158.0	5.0				Drilling Refusal. **Drillhole BH16-C012 terminated at 4.6m.**											
	157.0	6.0															
	156.0	7.0															
	155.0	8.0															
	154.0	9.0															
	153.0	10.0															

Notes:

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BOREHOLE REPORT

BH16-C015

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 536,142.0 m

Northing: 7,918,691.0 m

Surface Elevation: 189.75 m

Bottom Elevation: 182.15 m

Total Depth: 7.6 m

Logged By: UK,MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/24/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	188.8	1.0	Vibracore	H-Casing		SILTY SAND, some GRAVEL, trace COBBLES: Brown to grey, organics, coarse grained sand, angular to sunangular gravel, loose,	Nf				9						
	187.8	2.0				SILTY SAND, with GRAVEL: Grey, fine to coarse grained sand, angular to subangular gravel	Nf										
	186.8	3.0				SILTY SAND, some GRAVEL: Light brown to grey, with gravel and cobbles, medium to coarse grained sand, rounded to subangular gravel	Vx										
	185.8	4.0															
	184.8	5.0															
	183.8	6.0															
	182.8	7.0		[7.6]													
	181.8	8.0				To Target Depth. **Drillhole BH16-C015 terminated at 7.6m.**											
	180.8	9.0															
	179.8	10.0															

Notes:

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HATCH BOREHOLE REPORT

BH16-C016

Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 536,362.0 m
Northing: 7,918,814.0 m
Surface Elevation: 190.10 m
Bottom Elevation: 182.50 m
Total Depth: 7.6 m
Logged By: UK
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: E.Beachamp
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 11/24/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	189.1	1.0	Vibracore	H-Casing		SAND, some SILT: Reddish brown, coarse grained sand, angular gravel	Nbn			●	9						
	188.1	2.0				SANDY SILT, with GRAVEL, trace COBBLES: Light grey, fine grained sand, angular to subangular gravel	Vx			●	9	25	53	22			
	187.1	3.0				SILTY SAND, some GRAVEL: Light brown to grey, fine to coarse grained sand, angular to subangular gravel	Vc			●	8						
	186.1	4.0															
	185.1	5.0				SANDY GRAVEL, with SILT: Light brown to grey, coarse grained sand, angular to subangular gravel	Nbn										
	184.1	6.0															
	183.1	7.0		[7.6]													
	182.1	8.0				To Target Depth. **Drillhole BH16-C016 terminated at 7.6m.**											
	181.1	9.0															
	180.1	10.0															

Notes:

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BOREHOLE REPORT

BH16-C017

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 538,597.0 m

Northing: 7,919,742.0 m

Surface Elevation: 159.90 m

Bottom Elevation: 153.80 m

Total Depth: 6.1 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/23/2016

Driller: Michael Scott

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	158.9	1.0	Vibracore	H-Casing		SAND, some SILT, trace GRAVEL: Brown to light brown, fine to medium grained sand, rounded to subangular gravel	Vx				24	3	74	22			
	157.9	2.0				1.50 m to 3.00 m: Trace cobbles					11						
	156.9	3.0				SAND and GRAVEL, some SILT: Yellowish brown to reddish brown, fine to coarse grained sand, rounded to subangular gravel	Vx										
	155.9	4.0															
	154.9	5.0															
	153.9	6.0		[6.1]							10						
	152.9	7.0				To Target Depth. **Drillhole BH16-C017 terminated at 6.1m.**											
	151.9	8.0															
	150.9	9.0															
	149.9	10.0															

Notes:

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BOREHOLE REPORT

BH16-C018

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 546,111.0 m

Northing: 7,920,740.0 m

Surface Elevation: 160.40 m

Bottom Elevation: 154.30 m

Total Depth: 6.1 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/10/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	159.4	1.0	Vibracore	H-Casing		SAND, some GRAVEL: Grey, 0.075 mm to 25 mm, angular gravel											
	158.4	2.0									9	1	82	17			
	157.4	3.0				INFERRED BEDROCK: Possible Sandstone, greyish white, thinly bedded, 0.075mm, pulverized rock and intact rock, very low strength, weakly cemented											
	156.4	4.0															
	155.4	5.0									3						
	154.4	6.0		[6.1]													
	153.4	7.0				Drilling Refusal. **Drillhole BH16-C018 terminated at 6.1m.**											
	152.4	8.0															
	151.4	9.0															
	150.4	10.0															

Notes:

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BOREHOLE REPORT

BH16-C019

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 546,163.0 m

Northing: 7,920,494.0 m

Surface Elevation: 169.50 m

Bottom Elevation: 165.00 m

Total Depth: 4.5 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/10/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	168.5	1.0	Vibracore	H-Casing		SAND, trace GRAVEL: Brown to reddish brown, medium to coarse grained sand, medium gravel, angular to subangular	Nf										
	167.5	2.0															
	166.5	3.0															
	165.5	4.0		[4.5]													
	164.5	5.0				Drilling Refusal. **Drillhole BH16-C019 terminated at 4.5m.**					8						
	163.5	6.0															
	162.5	7.0															
	161.5	8.0															
	160.5	9.0															
	159.5	10.0															

Notes:

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BOREHOLE REPORT

BH16-C019B

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 546,214.0 m

Northing: 7,920,455.0 m

Surface Elevation: 170.40 m

Bottom Elevation: 164.30 m

Total Depth: 6.1 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/10/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	169.4	1.0	Vibracore	H-Casing		SAND, some GRAVEL: Light brown, medium to coarse grained sand, subangular to rounded gravel	Nf										
	168.4	2.0				SAND: White, fine to medium grained, weakly cemented											
	167.4	3.0															
	166.4	4.0															
	165.4	5.0				4.60 m to 6.10 m: Pulverized with angular pieces of quartz and sandstone observed at 4.6m											
	164.4	6.0		[6.0]							0	0	98	1			
	163.4	7.0				Drilling Refusal. **Drillhole BH16-C019B terminated at 6.1m.**											
	162.4	8.0															
	161.4	9.0															
	160.4	10.0															

Notes:

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HATCH BOREHOLE REPORT

BH16-C020

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 546,402.0 m

Northing: 7,920,072.0 m

Surface Elevation: 166.00 m

Bottom Elevation: 157.00 m

Total Depth: 9.0 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/10/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	165.0	1.0	Vibracore	H-Casing		SAND: Light brown to grey, medium to coarse grained sand, weakly cemented	Nf										
	164.0	2.0									8						
	163.0	3.0					Vr										
	162.0	4.0															
	161.0	5.0					Nf										
	160.0	6.0									8						
	159.0	7.0															
	158.0	8.0															
	157.0	9.0		[9.0]		8.50 m: Weakly cemented sandstone					11						
	156.0	10.0				To Target Depth. **Drillhole BH16-C020 terminated at 9.0m.**											

Notes:

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BOREHOLE REPORT

BH16-C021
Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 546,593.0 m
Northing: 7,919,917.0 m
Surface Elevation: 167.10 m
Bottom Elevation: 158.10 m
Total Depth: 9.0 m
Logged By: MR
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: Samuel Flynn
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 11/9/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	166.1	1.0	Vibracore	H-Casing		SAND: Light brown, medium to coarse grained sand	Nf										
	165.1	2.0				ICE LENSE: Colorless to grey, medium strength, clear to cloudy texture, sand inclusions	Nbe				14						
	164.1	3.0				SAND, some GRAVEL, trace SILT: Grey to light brown, fine to coarse grained sand, subangular to rounded gravel	Nf				12						
	163.1	4.0															
	162.1	5.0				SAND WITH SOME GRAVEL: grey to light brown, trace silt, subangular, fine to coarse grained, subangular to rounded, poorly bonded, no excess ice, (Nf)	Nbn										
	161.1	6.0															
	160.1	7.0				7.00 m: Broken pieces of weak sandstone 7.50 m to 8.70 m: Trace Silt											
	159.1	8.0															
	158.1	9.0		[9.0]		8.70 m: Light grey powder at 8.7m with angular pieces of quartz sandstone, possible bedrock					5	0	67	33			
	157.1	10.0				Drilling Refusal. **Drillhole BH16-C021 terminated at 9.0m.**											

Notes:

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BOREHOLE REPORT

BH16-C022

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 547,077.0 m

Northing: 7,919,746.0 m

Surface Elevation: 163.20 m

Bottom Elevation: 154.10 m

Total Depth: 9.1 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/11/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	163.2	0.0	Vibracore	H-Casing		PEAT, with SAND: Grey, black, fragmented	Nf										
	162.2	1.0				SAND, trace SILT: Grey, medium to coarse grained	Nbn										
	161.2	2.0				1.50 m: Loose, fine to coarse grained, poorly bonded,											
	160.2	3.0				2.60 m: Moderately banded	Nf										
	159.2	4.0					Vx				19	0	98	2			
	158.2	5.0															
	157.2	6.0				6.40 m: Grey to Brown											
	156.2	7.0				7.00 m: Trace cobbles											
	155.2	8.0				ICE LENSE: Grey to blue, Cloudy texture, minor sand and silt inclusions					24						
	154.2	9.0		[9.1]		To Target Depth. **Drillhole BH16-C022 terminated at 9.1m.**											
	153.2	10.0															

Notes:

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BOREHOLE REPORT

BH16-C023
Sheet 1 of 2

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 547,304.0 m
Northing: 7,919,643.0 m
Surface Elevation: 165.90 m
Bottom Elevation: 155.20 m
Total Depth: 10.7 m
Logged By: MR
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: Samuel Flynn
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 11/11/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	164.9	1.0	Vibracore	H-Casing		PEAT, with SAND: Brown to dark grey, medium to coarse grained sand	Nf										
	163.9	2.0				SAND, trace SILT: Dark grey to brown, medium to coarse grained sand	Nbn										
	162.9	3.0				SAND, trace GRAVEL: Grey to light brown, fine to coarse grained sand, subangular to rounded gravel	Nf										
	161.9	4.0									16	0	93	7			
	160.9	5.0				4.60 m to 6.20 m: Light brown, sand and silt, some gravel					17	12	44	45			
	159.9	6.0				ICE: Colorless to white, soft to moderate strength, clear to cloudy texture, minor silt and sand inclusions					15	12	44	45			
	158.9	7.0															
	157.9	8.0															
	156.9	9.0															
	155.9	10.0															

Notes:

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BOREHOLE REPORT

BH16-C023

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 547,304.0 m

Northing: 7,919,643.0 m

Surface Elevation: 165.90 m

Bottom Elevation: 155.20 m

Total Depth: 10.7 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/11/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
				[10.7]		ICE: Colorless to white, soft to moderate strength, clear to cloudy texture, minor silt and sand inclusions *(Continued)*											
	154.9	11.0				To Target Depth. **Drillhole BH16-C023 terminated at 10.7m.**											
	153.9	12.0															
	152.9	13.0															
	151.9	14.0															
	150.9	15.0															
	149.9	16.0															
	148.9	17.0															
	147.9	18.0															
	146.9	19.0															
	145.9	20.0															

Notes:

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BOREHOLE REPORT

BH16-C024

Sheet 1 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 547,530.0 m

Northing: 7,919,537.0 m

Surface Elevation: 165.00 m

Bottom Elevation: 154.30 m

Total Depth: 10.7 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/12/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	164.0	1.0	Vibracore	H-Casing		SAND, trace SILT, trace GRAVEL: Light brown, medium to coarse grained sand, rounded to subangular gravel	Nf										
	163.0	2.0															
	162.0	3.0				3.00 m to 6.00 m: No gravel observed											
	161.0	4.0															
	160.0	5.0									18	0	90	10			
	159.0	6.0				6.10 m to 10.70 m: Light reddish brown sand	Vx										
	158.0	7.0									18						
	157.0	8.0															
	156.0	9.0					Vr										
	155.0	10.0															

Notes:

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BOREHOLE REPORT

BH16-C024

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 547,530.0 m

Northing: 7,919,537.0 m

Surface Elevation: 165.00 m

Bottom Elevation: 154.30 m

Total Depth: 10.7 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/12/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
				[10.7]		SAND, trace SILT, trace GRAVEL: Light brown, medium to coarse grained sand, rounded to subangular gravel *(Continued)*	Nf *(Continued)*				14						
	154.0	11.0				To Target Depth. **Drillhole BH16-C024 terminated at 10.7m.**											
	153.0	12.0															
	152.0	13.0															
	151.0	14.0															
	150.0	15.0															
	149.0	16.0															
	148.0	17.0															
	147.0	18.0															
	146.0	19.0															
	145.0	20.0															

Notes:

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BOREHOLE REPORT

BH16-C025

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 548,370.0 m

Northing: 7,919,181.0 m

Surface Elevation: 163.00 m

Bottom Elevation: 155.40 m

Total Depth: 7.6 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/12/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	162.0	1.0	Vibracore	H-Casing		GRAVELLY SILTY SAND: Brown, fine to coarse grained											
	161.0	2.0															
	160.0	3.0															
	159.0	4.0					Nbn Nf				15	1	89	10			
	158.0	5.0															
	157.0	6.0				ICE: Grey to blue, moderate hardness milky to cloudy texture, sand inclusions 6.10 m to 7.00 m: White to pink, cloudy texture, sand and silt inclusions											
	156.0	7.0		[7.6]		SAND and SILT: LIght brown, fine grained sand	Vx										
	155.0	8.0				To Target Depth. **Drillhole BH16-C025 terminated at 7.6m.**											
	154.0	9.0															
	153.0	10.0															

Notes:

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BOREHOLE REPORT

BH16-C026
Sheet 1 of 2

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 550,262.0 m
Northing: 7,918,123.0 m
Surface Elevation: 170.20 m
Bottom Elevation: 159.50 m
Total Depth: 10.7 m
Logged By: UK
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: E.Beachamp
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 11/12/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	169.2	1.0	Vibracore	H-Casing		SNOW and ROOTLETS											
						SILTY SAND, trace GRAVEL: Dark brown, coarse grained sand	Nf										
	168.2	2.0					Nbn										
	167.2	3.0				SILTY SAND, trace GRAVEL: Brown, fine to medium grained	Nbn										
	166.2	4.0				3.90 m to 4.30 m: Some cobbles and gravel	Nbn				14	6	69	24			
						ICE: Minor silt inclusions	ICE										
	165.2	5.0				SAND and SILT, trace GRAVEL: Brown, fine grained to medium grained sand						2	77	21			
	164.2	6.0				INFERRED BOULDERS											
						SILTY SAND, trace GRAVEL: Grey, fine to coarse grained sand	Nf				19						
	163.2	7.0															
	162.2	8.0									13						
	161.2	9.0															
	160.2	10.0															

Notes:

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BOREHOLE REPORT

BH16-C026

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 550,262.0 m

Northing: 7,918,123.0 m

Surface Elevation: 170.20 m

Bottom Elevation: 159.50 m

Total Depth: 10.7 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/12/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
				[10.7]		SILTY SAND, trace GRAVEL: Grey, fine to coarse grained sand *(Continued)*	Nf *(Continued)*										
	159.2	11.0				To Target Depth. **Drillhole BH16-C026 terminated at 10.7m.**											
	158.2	12.0															
	157.2	13.0															
	156.2	14.0															
	155.2	15.0															
	154.2	16.0															
	153.2	17.0															
	152.2	18.0															
	151.2	19.0															
	150.2	20.0															

Notes:

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BOREHOLE REPORT

BH16-C027
Sheet 1 of 2

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 550,416.0 m
Northing: 7,917,928.0 m
Surface Elevation: 171.00 m
Bottom Elevation: 158.80 m
Total Depth: 12.2 m
Logged By: MR
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: Samuel Flynn
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 11/12/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 / 50 / 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	170.0	1.0	Vibracore	H-Casing		SAND and GRAVEL: Peat, dark grey	Nf										
						SAND and GRAVEL: Dark grey, medium to coarse grained sand, rounded to subrounded gravel	Nf										
						SILTY SAND, trace GRAVEL: Light brown, medium to coarse grained sand, rounded to subangular gravel	Nf										
	169.0	2.0															
	168.0	3.0					Nbn										
	167.0	4.0									10	9	72	20			
	166.0	5.0															
	165.0	6.0				ICE: Grey, low to medium strength, cloudy texture	ICE										
						SILTY SAND, trace GRAVEL: Light brown to grey, fine to coarse grained sand, rounded to subangular gravel	Nf										
	164.0	7.0									16						
						ICE: Grey, low strength, cloudy texture, soil inclusions 7.90 to 12.20 m: Colourless to white, moderate strength, clear to cloudy texture	ICE										
	163.0	8.0															
	162.0	9.0															
	161.0	10.0															

Notes:

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BOREHOLE REPORT

BH16-C027

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 550,416.0 m

Northing: 7,917,928.0 m

Surface Elevation: 171.00 m

Bottom Elevation: 158.80 m

Total Depth: 12.2 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/12/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	160.0	11.0				ICE: Grey, low strength, cloudy texture, soil inclusions *(Continued)*	ICE *(Continued)*										
	159.0	12.0		[12.2]													
						To Target Depth. **Drillhole BH16-C027 terminated at 12.2m.**											
	158.0	13.0															
	157.0	14.0															
	156.0	15.0															
	155.0	16.0															
	154.0	17.0															
	153.0	18.0															
	152.0	19.0															
	151.0	20.0															

Notes:

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BOREHOLE REPORT

BH16-C028

Sheet 1 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 551,403.0 m

Northing: 7,916,768.0 m

Surface Elevation: 189.00 m

Bottom Elevation: 177.40 m

Total Depth: 11.6 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/12/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	188.0	1.0	Vibracore	H-Casing		SAND and GRAVEL, trace COBBLES: Light brown, medium to coarse grained sand, rounded to subangular gravel	Nf										
	187.0	2.0				SAND, with GRAVEL: Grey, fine to coarse grained sand, rounded to subangular gravel	Nf										
	186.0	3.0															
	185.0	4.0															
	184.0	5.0															
	183.0	6.0				SAND, trace SILT: Light grey, fine to course grained sand	Nf										
	182.0	7.0															
	181.0	8.0															
	180.0	9.0									7	0	6	94			
	179.0	10.0				9.40 m to 10.70 m: Some gravel and cobbles					18						

Notes:

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BOREHOLE REPORT

BH16-C028

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 551,403.0 m

Northing: 7,916,768.0 m

Surface Elevation: 189.00 m

Bottom Elevation: 177.40 m

Total Depth: 11.6 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/12/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, trace SILT: Light grey, fine to course grained sand *(Continued)*	Nf *(Continued)*										
	178.0	11.0				SAND, some GRAVEL, trace COBBLES: Reddish brown, fine to coarse grained sand, angular to subrounded gravel	Nf										
						10.80 m: Possible weathered bedrock, pulverized quartz sandstone											
	177.0	12.0		[12.2]		Drilling Refusal.											
						Drillhole BH16-C028 terminated at 11.6m.											
	176.0	13.0															
	175.0	14.0															
	174.0	15.0															
	173.0	16.0															
	172.0	17.0															
	171.0	18.0															
	170.0	19.0															
	169.0	20.0															

Notes:

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HATCH BOREHOLE REPORT

BH16-C029

Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 552,569.0 m
Northing: 7,915,813.0 m
Surface Elevation: 185.25 m
Bottom Elevation: 177.65 m
Total Depth: 7.6 m
Logged By: UK
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: E.Beachamp
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 11/13/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	184.3	1.0	Vibracore	H-Casing		SILTY SAND: Brown to reddish brown, fine grained sand	Nbn										
	183.3	2.0									21	1	75	25			
	182.3	3.0					Nf										
	181.3	4.0				3.70 m to 6.10 m: Low-strength pieces of rock											
	180.3	5.0															
	179.3	6.0															
	178.3	7.0		[7.6]		Reddish brown rocks, narrow bedding, very weak											
	177.3	8.0				To Target Depth. **Drillhole BH16-C029 terminated at 7.6m.**											
	176.3	9.0															
	175.3	10.0															

Notes:

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BOREHOLE REPORT

BH16-C030

Sheet 1 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 555,337.0 m

Northing: 7,914,646.0 m

Surface Elevation: 160.75 m

Bottom Elevation: 148.55 m

Total Depth: 12.2 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/15/2016

Driller: Michael Scott

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	159.8	1.0	Vibracore	H-Casing		SAND, trace GRAVEL: Light brown, medium to coarse grained sand, rounded to subrounded gravel	Nf										
	158.8	2.0				SAND, trace SILT, trace GRAVEL: Light brown, fine to coarse grained sand	Vc				14						
	157.8	3.0															
	156.8	4.0															
	155.8	5.0									19	3	94	3			
	154.8	6.0				ICE and SOIL: White, low strength, cloudy texture, mixed with SILTY SAND											
	153.8	7.0															
	152.8	8.0															
	151.8	9.0															
	150.8	10.0															

Notes:

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BOREHOLE REPORT

BH16-C030

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 555,337.0 m

Northing: 7,914,646.0 m

Surface Elevation: 160.75 m

Bottom Elevation: 148.55 m

Total Depth: 12.2 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/15/2016

Driller: Michael Scott

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	149.8	11.0				ICE and SOIL: White, low strength, cloudy texture, mixed with SILTY SAND *(Continued)*											
	148.8	12.0		[12.2]		To Target Depth. **Drillhole BH16-C030 terminated at 12.2m.**											
	147.8	13.0															
	146.8	14.0															
	145.8	15.0															
	144.8	16.0															
	143.8	17.0															
	142.8	18.0															
	141.8	19.0															
	140.8	20.0															

Notes:

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BOREHOLE REPORT

BH16-C031

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 556,864.0 m

Northing: 7,915,216.0 m

Surface Elevation: 170.00 m

Bottom Elevation: 168.50 m

Total Depth: 1.5 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/15/2016

Driller: Michael Scott

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	169.0	1.0	Vibracore	H-Casing [1.5]		SAND, trace GRAVEL: Brown, fine to coarse grained sand, angular to subangular gravel	Nf										
	168.0	2.0				To Target Depth. **Drillhole BH16-C031 terminated at 1.5m.**											
	167.0	3.0															
	166.0	4.0															
	165.0	5.0															
	164.0	6.0															
	163.0	7.0															
	162.0	8.0															
	161.0	9.0															
	160.0	10.0															

Notes:

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BOREHOLE REPORT

BH16-C032
Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 557,282.0 m
Northing: 7,915,265.0 m
Surface Elevation: 171.00 m
Bottom Elevation: 161.90 m
Total Depth: 9.1 m
Logged By: MR
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: Michael Scott
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 11/15/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	170.0	1.0	Vibracore	H-Casing		PEAT, with SAND and GRAVEL: Brown, medium to coarse grained sand, rounded to subangular gravel	Nf										
	169.0	2.0				SILTY SAND, some GRAVEL: Light brown, medium to coarse grained sand, rounded to subangular gravel	Nf				11	10	71	19			
	168.0	3.0				SILTY SAND and GRAVEL, trace COBBLES: Light brown, medium to coarse grained sand, rounded to subrounded cobbles	Nf										
	167.0	4.0															
	166.0	5.0					Vc										
	165.0	6.0															
	164.0	7.0				ICE and SOIL: Dark grey to light brown, cloudy texture, ice mixed with silty sand	ICE										
	163.0	8.0															
	162.0	9.0		[9.1]		SILTY SAND and GRAVEL, trace COBBLES: Light brown, medium to coarse grained sand, rounded to subrounded cobbles	Vc										
						To Target Depth. **Drillhole BH16-C032 terminated at 9.1m.**											
	161.0	10.0															
	160.0	11.0															

Notes:

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BOREHOLE REPORT

BH16-C201

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 553,750.0 m

Northing: 7,915,276.0 m

Surface Elevation: 178.00 m

Bottom Elevation: 175.60 m

Total Depth: 2.4 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/18/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	177.0	1.0	Vibracore	H-Casing		SAND, some GRAVEL, trace COBBLES: Reddish brown, fine to coarse grained sand, angular to subangular gravel, some silt											
	176.0	2.0		[2.4]		ROCK: Weak to medium strong, sedimentary, grey and white crystals											
	175.0	3.0				To Target Depth. **Drillhole BH16-C201 terminated at 2.4m.**											
	174.0	4.0															
	173.0	5.0															
	172.0	6.0															
	171.0	7.0															
	170.0	8.0															
	169.0	9.0															
	168.0	10.0															

Notes:

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BOREHOLE REPORT

BH16-C202

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 554,531.0 m

Northing: 7,915,452.0 m

Surface Elevation: 174.50 m

Bottom Elevation: 166.90 m

Total Depth: 7.6 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/16/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	174.5	0.0	Vibracore	H-Casing		TOPSOIL, SILTY SAND, with GRAVEL	Nf										
	173.5	1.0				SILTY SAND, with GRAVEL: Light brown, medium to coarse grained sand	Nf										
	172.5	2.0															
	171.5	3.0				Crushed COBBLES and BOULDERS: Grey to pink, fine to coarse grained sand											
	170.5	4.0															
	169.5	5.0				BOULDERS: Grey to light green, granitic gneiss and chloritic schist, medium to coarse grained, very thinly bedded, medium strength, slightly weathered											
	168.5	6.0				INFERRED BEDROCK: Laminated to very thinly bedded, faintly weathered,											
	167.5	7.0		[7.6]													
	166.5	8.0				To Target Depth. **Drillhole BH16-C202 terminated at 7.6m.**											
	165.5	9.0															
	164.5	10.0															

Notes:

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BOREHOLE REPORT

BH16-C203

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 555,007.0 m

Northing: 7,915,451.0 m

Surface Elevation: 177.00 m

Bottom Elevation: 167.90 m

Total Depth: 9.1 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/17/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	176.0	1.0	Vibracore	H-Casing		SILTY SAND, some COBBLES, trace BOULDERS: Grey, fine to coarse grained sand, angular to subangular cobbles	Nf										
	175.0	2.0				SILTY SAND, some GRAVEL: Brown, fine to coarse grained sand	Nf										
	174.0	3.0				SILTY SAND: Brown, fine to medium grained	Nbn										
	173.0	4.0															
	172.0	5.0															
	171.0	6.0				BOULDER: Sandstone, medium grained, medium bedded, weak											
	170.0	7.0				WEATHERED ROCK: Mafic gneiss with crystalline fines observed, shiny face when fracutured, grey and white streaks											
	169.0	8.0				BEDROCK: Gneiss, grey and white bedding layers, approximately 40 mm, thinly bedded,weak to medium quality											
	168.0	9.0		[9.1]													
	167.0	10.0				To Target Depth. **Drillhole BH16-C203 terminated at 9.1m.**											

Notes:

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BOREHOLE REPORT

BH16-C204

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 555,659.0 m

Northing: 7,915,432.0 m

Surface Elevation: 173.00 m

Bottom Elevation: 170.30 m

Total Depth: 2.7 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/16/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	173.0	0.0				PEAT, with SAND and GRAVEL: Brown, fine to coarse grained sand	Nf										
						SAND and GRAVEL, trace COBBLES, trace BOULDERS: Light brown to grey	Nf										
	172.0	1.0	Vibracore	H-Casing													
						SILTY SAND, some GRAVEL, trace COBBLES: Grey, fine to coarse grained sand, rounded to subrounded cobbles	Nf										
	171.0	2.0		[2.7]													
	170.0	3.0															
	169.0	4.0															
	168.0	5.0				INFERRED BEDROCK: Grey, pulverisized boulders of gneiss or Franklin diabase observed, subcohesive, no bedding											
	167.0	6.0															
	166.0	7.0															
	165.0	8.0															
	164.0	9.0				Drilling Refusal. **Drillhole BH16-C204 terminated at 2.7m.**											
	163.0	10.0															

Notes:

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HATCH BOREHOLE REPORT

BH16-C205

Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 555,883.0 m
Northing: 7,915,449.0 m
Surface Elevation: 173.00 m
Bottom Elevation: 164.50 m
Total Depth: 8.5 m
Logged By: UK
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: E.Beachamp
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 11/21/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	172.0	1.0	Vibracore	H-Casing		SAND, with GRAVEL, some COBBLES, trace BOULDERS: Brown, coarse grained sand, rounded to subangular cobbles and gravel											
	171.0	2.0				GRAVELLY SILTY SAND: Brown to grey, coarse grained sand, rounded to subangular gravel											
	170.0	3.0															
	169.0	4.0								●	6	20	47	33			
	168.0	5.0				INFERRED BEDROCK: Granitic, white, crushed and pulverized rock pieces											
	167.0	6.0															
	166.0	7.0															
	165.0	8.0		[8.5]													
	164.0	9.0				Drilling Refusal. **Drillhole BH16-C205 terminated at 8.5m.**											
	163.0	10.0															

Notes:

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BOREHOLE REPORT

BH16-C206

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 556,059.0 m

Northing: 7,915,442.0 m

Surface Elevation: 173.00 m

Bottom Elevation: 163.90 m

Total Depth: 9.1 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/22/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	172.0	1.0	Vibracore	H-Casing		SAND: White to grey, pulverized rock, weak to moderate strength, fine grained	Nf										
	171.0	2.0				SILTY SAND, some GRAVEL: Dark brown, fine to medium grained sand, angular to subangular gravel	Nf										
	170.0	3.0				ICE, with Sandy SILT inclusions: Grey, cohesive, fine grained, hard, cloudy	ICE			>>	53						
	169.0	4.0				SAND and GRAVEL: Reddish brown	Vc										
							Vr				22						
	168.0	5.0				SANDY SILT, trace GRAVEL: Dark grey, find grained sand	Nbn										
	167.0	6.0				BOULDERS: Grey, white to grey, pulverized rock, medium strong											
						SANDY SILT, trace GRAVEL: Dark brown to grey, find grained sand											
	166.0	7.0				INFERRED BEDROCK: Light grey, pulverized rock with intact pieces, medium strong											
	165.0	8.0															
	164.0	9.0		[9.1]													
	163.0	10.0				To Target Depth. **Drillhole BH16-C206 terminated at 9.1m.**											

Notes:

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BOREHOLE REPORT

BH16-C207
Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 556,679.0 m
Northing: 7,915,415.0 m
Surface Elevation: 175.00 m
Bottom Elevation: 167.70 m
Total Depth: 7.3 m
Logged By: MR
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: Samuel Flynn
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 11/21/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 / 50 / 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	174.0	1.0	Vibracore	H-Casing		SAND and GRAVEL, some COBBLES: Brown, medium to coarse grained sand, subangular to rounded gravel and cobbles	Nf										
	173.0	2.0				SAND, some GRAVEL, trace COBBLES: Grey to light yellow, medium to coarse grained sand, rounded to subangular gravel	Vx				12						
	172.0	3.0															
	171.0	4.0															
	170.0	5.0									2						
	169.0	6.0															
	168.0	7.0		[7.3]		INFERRED BEDROCK: Light grey, pulverized rock, with intact pieces of sandstone, medium strong											
	167.0	8.0				Drilling Refusal. **Drillhole BH16-C207 terminated at 7.3m.**											
	166.0	9.0															
	165.0	10.0															

Notes:

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BOREHOLE REPORT

BH16-Q001

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Potential Quarry Location

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 505,308.0 m

Northing: 7,972,797.0 m

Surface Elevation: 68.25 m

Bottom Elevation: 63.65 m

Total Depth: 4.6 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/5/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	67.3	1.0	Vibracore	H-Casing		ORGANICS: Frozen organic soil	Nf										
						SAND, some GRAVEL, trace COBBLES: Medium to coarse grained sand, fine to coarse gravel, light brown, subangular to rounded											
	66.3	2.0				SAND and GRAVEL trace COBBLES: Coarse sand, fine to coarse gravel, light brown to grey, subangular to rounded	Nf										
	65.3	3.0				3.00 m to 4.60 m: Trace COBBLES											
	64.3	4.0		[4.6]													
	63.3	5.0				To Target Depth. **Drillhole BH16-Q001 terminated at 4.6m.**											
	62.3	6.0															
	61.3	7.0															
	60.3	8.0															
	59.3	9.0															
	58.3	10.0															

Notes:

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BOREHOLE REPORT

BH16-Q7001

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Potential Quarry Location

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 529,144.0 m

Northing: 7,927,494.0 m

Surface Elevation: 187.80 m

Bottom Elevation: 184.20 m

Total Depth: 3.6 m

Logged By: CS

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/24/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Water	186.8	1.0	Vibracore	H-Casing		Silty GRAVEL: Light brown, pulverized rock flour (limestone), light grey, subangular to angular limestone, up to 80mm											
	185.8	2.0				SILT, some GRAVEL, trace SAND: Light brown, angular, fine to coarse					11						
	184.8	3.0															
		[3.6]				LIMESTONE: Pulverized, subrounded to round, grey											
	183.8	4.0				To Target Depth. **Drillhole BH16-Q7001 terminated at 3.6m.**											
	182.8	5.0															
	181.8	6.0															
	180.8	7.0															
	179.8	8.0															
	178.8	9.0															
	177.8	10.0															

Notes:

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BOREHOLE REPORT

BH16-Q7002

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Potential Quarry Location

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 530,561.0 m

Northing: 7,928,150.0 m

Surface Elevation: 284.00 m

Bottom Elevation: 277.14 m

Total Depth: 6.9 m

Logged By: RS/CS

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged:

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	283.0	1.0	HQ-3 Coring	Wash Bore C/B & Casing		No recovery											
	282.0	2.0				Silty GRAVEL, some COBBLES: Brown, fine to coarse gravel, subangular to angular											
	281.0	3.0				No recovery											
	280.0	4.0															
	279.0	5.0				LIMESTONE: Grey, fragmented, angular to subangular, limestone bedrock											
	278.0	6.0		[6.9]		Silty GRAVEL, with COBBLES: Light brown, cobbles and gravel are angular to subangular, grey											
	277.0	7.0				To Target Depth. **Drillhole BH16-Q7002 terminated at 6.9m.**											
	276.0	8.0															
	275.0	9.0															
	274.0	10.0															

Notes:

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HATCH BOREHOLE REPORT

BH16-Q7003

Sheet 1 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Potential Quarry Location

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 531,053.0 m

Northing: 7,929,065.0 m

Surface Elevation: 201.00 m

Bottom Elevation: 191.90 m

Total Depth: 9.1 m

Logged By: RS

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/24/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Other Tests
Unobserved due to Permafrost	200.0	1.0	Vibracore	H-Casing		SILT and GRAVEL, trace SAND: Fine grained, angular, beige/grey					
	199.0	2.0				1.50 m to 5.00 m: Visible ice layers, up to 5 mm thick	Vs				
	198.0	3.0									
	197.0	4.0									
	196.0	5.0				SAND: Fine to medium, brown	Nbn				
	195.0	6.0				Gravelly SILT: Well graded, grey					
	194.0	7.0				***Start of Coring at 7.3m.*** ***Continued on Rock Core Log sheet.***					
	193.0	8.0									
	192.0	9.0									
	191.0	10.0									
	190.0	11.0									

Notes:

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BOREHOLE LOG

ROCK CORE FORMAT

BH16-Q7003

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Potential Quarry Location

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 531,053.0 m

Northing: 7,929,065.0 m

Surface Elevation: 201.00 m

Bottom Elevation: 191.90 m

Total Depth: 9.1 m

Logged By: RS

Reviewed By: SH/WH

Contractor: Boart Longyear **Rig Type/ Mounting:** MiniSonic Rig **Bearing:** N/A **Date Logged:** 10/24/2016

Driller: E.Beachamp **Hole Diameter (mm):** 96 **Plunge:** Vertical **Date Checked:** 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Geological Unit	Rock Description ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 [100] 60 20)	RQD %
	200.0	1.0										
	199.0	2.0										
	198.0	3.0										
	197.0	4.0										
	196.0	5.0										
	195.0	6.0										
	194.0	7.0					***Resuming in Rock Core Format 7.3m.***					
	193.0	8.0					LIMESTONE: Bedrock, fragmented / pulverized rock sample					
	192.0	9.0		[9.1]								
	191.0	10.0					To Target Depth. **Drillhole BH16-Q7003 terminated at 9.1m.**					
	190.0	11.0										

Notes:

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BOREHOLE REPORT

BH16-Q7004

Sheet 1 of 3

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Potential Quarry Location

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 529,264.0 m

Northing: 7,927,466.0 m

Surface Elevation: 282.80 m

Bottom Elevation: 272.20 m

Total Depth: 10.6 m

Logged By: RS/CS

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/25/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Other Tests
Unobserved due to Permafrost	281.8	1.0	Vibracore	H-Casing		SILT and GRAVEL: Grey, pulverized limestone					
						No recovery					
	280.8	2.0									
	279.8	3.0									
	278.8	4.0									
		[4.6]				***Start of Coring at 4.6m.*** ***Continued on Rock Core Log sheet.***					
	277.8	5.0									
	276.8	6.0									
	275.8	7.0									
	274.8	8.0									
	273.8	9.0									
	272.8	10.0									

Notes:

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HATCH

BOREHOLE LOG

ROCK CORE FORMAT

BH16-Q7004

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Potential Quarry Location

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 529,264.0 m

Northing: 7,927,466.0 m

Surface Elevation: 282.80 m

Bottom Elevation: 272.20 m

Total Depth: 10.6 m

Logged By: RS/CS

Reviewed By: SH/WH

Contractor: Boart Longyear **Rig Type/ Mounting:** MiniSonic Rig **Bearing:** N/A **Date Logged:** 10/25/2016

Driller: E.Beachamp **Hole Diameter (mm):** 96 **Plunge:** Vertical **Date Checked:** 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Geological Unit	Rock Description ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 60 20) [100]	RQD %
	281.8	1.0										
	280.8	2.0										
	279.8	3.0										
	278.8	4.0					***Resuming in Rock Core Format 4.6m.***					
	277.8	5.0	HQ-3 Coring	HQ			LIMESTONE: Light grey to brown, thickly bedded, weak to medium strong joints, faintly weathered					77
	276.8	6.0					6.00 m to 7.70 m: Medium texture, very thickly bedded, fresh limestone, medium strong					66
	275.8	7.0										
	274.8	8.0					7.70 m to 10.60 m: Weak to medium strong, subhorizontal joints					52
	273.8	9.0										
	272.8	10.0										68

Notes:

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HATCH

BOREHOLE LOG

ROCK CORE FORMAT

BH16-Q7004

Sheet 3 of 3

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Potential Quarry Location

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 529,264.0 m

Northing: 7,927,466.0 m

Surface Elevation: 282.80 m

Bottom Elevation: 272.20 m

Total Depth: 10.6 m

Logged By: RS/CS

Reviewed By: SH/WH

Contractor: Boart Longyear **Rig Type/ Mounting:** MiniSonic Rig **Bearing:** N/A **Date Logged:** 10/25/2016

Driller: E.Beachamp **Hole Diameter (mm):** 96 **Plunge:** Vertical **Date Checked:** 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Geological Unit	Rock Description ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 [100] 60 20)	RQD %
				[10.6]								68
	271.8	11.0					To Target Depth. **Drillhole BH16-Q7004 terminated at 10.6m.**					
	270.8	12.0										
	269.8	13.0										
	268.8	14.0										
	267.8	15.0										
	266.8	16.0										
	265.8	17.0										
	264.8	18.0										
	263.8	19.0										
	262.8	20.0										

Notes:

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BOREHOLE REPORT

BH16-R003

Sheet 1 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 504,513.0 m

Northing: 7,975,552.0 m

Surface Elevation: 61.00 m

Bottom Elevation: 55.40 m

Total Depth: 5.6 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/5/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	60.5	0.5	Vibracore	H-Casing		SAND: Coarse to fine grained, moist	Nf										
	60.0	1.0															
	59.5	1.5				SAND and GRAVEL: Fine to coarse grained sand	Nf										
	59.0	2.0															
	58.5	2.5															
	58.0	3.0				3.00 m to 4.6 m: Trace Cobbles	Nf										
	57.5	3.5															
	57.0	4.0															
	56.5	4.5															
	56.0	5.0															

Notes:

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BOREHOLE REPORT

BH16-R003

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 504,513.0 m

Northing: 7,975,552.0 m

Surface Elevation: 61.00 m

Bottom Elevation: 55.40 m

Total Depth: 5.6 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/5/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	55.5	5.5				SAND and GRAVEL: Fine to coarse grained sand *(Continued)*	Nf *(Continued)*										
		[5.6]				To Target Depth. **Drillhole BH16-R003 terminated at 5.6m.**											
	55.0	6.0															
	54.5	6.5															
	54.0	7.0															
	53.5	7.5															
	53.0	8.0															
	52.5	8.5															
	52.0	9.0															
	51.5	9.5															
	51.0	10.0															

Notes:

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BOREHOLE REPORT

BH16-R004

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 507,259.0 m

Northing: 7,970,638.0 m

Surface Elevation: 43.00 m

Bottom Elevation: 38.43 m

Total Depth: 4.6 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/6/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	42.5	0.5	Vibracore	H-Casing		SAND: Organic, fine to coarse grained											
	42.0	1.0				SAND with GRAVEL: Dark brown, medium to coarse grained sand, Rounded to sub rounded gravel	Nf				30						
	41.5	1.5				SAND, some SILT, trace GRAVEL: Fine to coarse grained sand, rounded to subrounded gravel	Nf										
	41.0	2.0															
	40.5	2.5									10	8	74	18			
	40.0	3.0				SAND and COBBLES, with GRAVEL, some SILT: Light brown to grey, fine to course grained sand, rounded cobbles	Nf										
	39.5	3.5															
	39.0	4.0															
	38.5	4.5		[4.6]													
	38.0	5.0				To Target Depth. **Drillhole BH16-R004 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH16-R005
Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 509,249.0 m
Northing: 7,968,499.0 m
Surface Elevation: 84.00 m
Bottom Elevation: 79.43 m
Total Depth: 4.6 m
Logged By: UK
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: Vance Madden
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 10/6/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	83.5	0.5	Vibracore	H-Casing		SAND and GRAVEL, some SILT: Fine to coarse grained sand, subangular gravel	Nf										
	83.0	1.0									11						
	82.5	1.5				SAND, some SILT, trace GRAVEL: Fine to coarse grained sand, angular to subangular gravel	Nbn										
	82.0	2.0															
	81.5	2.5										4	78	18			
	81.0	3.0					Nf										
	80.5	3.5									10						
	80.0	4.0															
	79.5	4.5		[4.6]		To Target Depth. **Drillhole BH16-R005 terminated at 4.6m.**											
	79.0	5.0															

Notes:

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BOREHOLE REPORT

BH16-R006

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 508,438.0 m

Northing: 7,969,804.0 m

Surface Elevation: 78.75 m

Bottom Elevation: 75.85 m

Total Depth: 2.9 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/6/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	78.3	0.5	Vibracore	H-Casing		SAND: Organic, dark brown	Nf										
	77.8	1.0				SAND and GRAVEL, trace SILT: Coarse grained sand, angular gravel	Nf										
	77.3	1.5					Nbn										
	76.8	2.0					Nf										
	76.3	2.5		[2.9]													
	75.8	3.0				To Target Depth. **Drillhole BH16-R006 terminated at 2.9m.**											
	75.3	3.5															
	74.8	4.0															
	74.3	4.5															
	73.8	5.0															

Notes:

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BOREHOLE REPORT

BH16-R007

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 510,940.0 m

Northing: 7,967,349.0 m

Surface Elevation: 83.00 m

Bottom Elevation: 78.43 m

Total Depth: 4.6 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/6/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	82.5	0.5	Vibracore	H-Casing		SAND, some GRAVEL, some SILT: Reddish brown, fine to coarse grained sand, angular to subangular gravel	Nf										
	82.0	1.0															
	81.5	1.5				SAND, some SILT, trace Gravel: Grey, fine grained to coarse grained sand, angular to subangular gravel	Nbn										
	81.0	2.0															
	80.5	2.5									13	1	87	13			
	80.0	3.0				SAND, with GRAVEL: Grey, fine to coarse grained sand, angular to subanbgular gravel	Nf										
	79.5	3.5				GRAVEL: Coarse, angular to subangular	Nf										
	79.0	4.0									10						
	78.5	4.5		[4.6]		To Target Depth. **Drillhole BH16-R007 terminated at 4.6m.**											
	78.0	5.0															

Notes:

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BOREHOLE REPORT

BH16-R008

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 512,763.0 m

Northing: 7,966,604.0 m

Surface Elevation: 83.50 m

Bottom Elevation: 78.93 m

Total Depth: 4.6 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/7/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	83.0	0.5				SAND with GRAVEL: Medium to coarse grained sand, fine to coarse gravel, light brown, subangular to angular	Nf										
	82.5	1.0															
	82.0	1.5				SAND with GRAVEL, trace COBBLES: Light brown to grey, coarse grained sand, fine to coarse gravel, rounded to subangular gravel	Nf											
	81.5	2.0															
	81.0	2.5															
	80.5	3.0				SAND and GRAVEL, some COBBLES: Light brown, fine to coarse grained sand, fine to coarse gravel, rounded to subrounded	Nf											
	80.0	3.5															
	79.5	4.0															
	79.0	4.5															
	78.5	5.0				To Target Depth. **Drillhole BH16-R008 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH16-R009
Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 514,367.0 m
Northing: 7,965,535.0 m
Surface Elevation: 79.00 m
Bottom Elevation: 74.43 m
Total Depth: 4.6 m
Logged By: MR
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: Samuel Flynn
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 10/8/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 / 50 / 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	79.0	0.0				SAND: Organics, dark brown											
	78.5	0.5				SAND, some GRAVEL: Light brown, fine to coarse grained sand, rounded to subrounded gravel	Nf				23						
	78.0	1.0															
	77.5	1.5				SILTY SANDY GRAVEL, with COBBLES: Medium to coarse grained sand, rounded to subrounded cobbles	Nbn										
	77.0	2.0															
	76.5	2.5															
	76.0	3.0				SILTY SANDY GRAVEL, some COBBLES: Light brown, fine to coarse grained sand, fine to coarse gravel, rounded to subrounded cobbles	Nf										
	75.5	3.5															
	75.0	4.0															
	74.5	4.5															
	74.0	5.0				To Target Depth. **Drillhole BH16-R009 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH16-R010

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 515,332.0 m

Northing: 7,963,810.0 m

Surface Elevation: 80.00 m

Bottom Elevation: 75.43 m

Total Depth: 4.6 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/8/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	79.5	0.5				SAND and GRAVEL: Brown, angular to subangular gravel	Nf										
	79.0	1.0															
	78.5	1.5				1.50 m to 2.50 m: Some silt											
	78.0	2.0															
	77.5	2.5				2.50 m to 4.00 m: Sand with some gravel											
	77.0	3.0															
	76.5	3.5															
	76.0	4.0															
	75.5	4.5				To Target Depth. **Drillhole BH16-R010 terminated at 4.6m.**											
	75.0	5.0															

Notes:

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BOREHOLE REPORT

BH16-R011

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 516,719.0 m

Northing: 7,962,461.0 m

Surface Elevation: 94.70 m

Bottom Elevation: 90.13 m

Total Depth: 4.6 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/8/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	94.2	0.5				SAND and PEAT: Dark brown	Nf										
	93.7	1.0				SAND, some SILT: Brown, fine to coarse grained sand	Nf										
	93.2	1.5															
	92.7	2.0															
	92.2	2.5									19	0	86	14			
	91.7	3.0															
	91.2	3.5															
	90.7	4.0				GRANITE: Pinkish brown, 75 mm, pieces of granite in frozen sand					15						
	90.2	4.5															
	89.7	5.0				Drilling Refusal. **Drillhole BH16-R011 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH16-R012

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 516,716.0 m

Northing: 7,962,464.0 m

Surface Elevation: 106.75 m

Bottom Elevation: 102.75 m

Total Depth: 4.0 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/8/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	106.3	0.5				SAND, some GRAVEL, some COBBLES: Brown, well graded, subangular to angular gravel											
	105.8	1.0				SAND, some SILT, trace GRAVEL: Brown, loose, angular to subangular gravel	Nf										
	105.3	1.5				1.50 m to 3.00 m: Greyish brown, fragmented rock pieces	Nf										
	104.8	2.0															
	104.3	2.5									10	1	81	18			
	103.8	3.0				SAND and GRAVEL: Brown, angular to subangular gravel	Nbn										
	103.3	3.5															
	102.8	4.0				Drilling Refusal. **Drillhole BH16-R012 terminated at 4.0m.**											
	102.3	4.5															
	101.8	5.0															

Notes:

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BOREHOLE REPORT

BH16-R013

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 518,856.0 m

Northing: 7,959,178.0 m

Surface Elevation: 107.00 m

Bottom Elevation: 102.43 m

Total Depth: 4.6 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/8/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	106.5	0.5				SAND, trace GRAVEL: Brown, well graded, angular to subangular gravel											
	106.0	1.0															
	105.5	1.5				SAND, with GRAVEL: Brown, rounded to subangular gravel	Nbn										
	105.0	2.0															
	104.5	2.5				SAND, some SILT: Brown to grey, fine grained sand	Nbn				16	0	85	15			
	104.0	3.0															
	103.5	3.5				Possible GRANITE: Dark grey streaks, dense											
	103.0	4.0									16						
	102.5	4.5															
	102.0	5.0				Drilling Refusal. **Drillhole BH16-R013 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH16-R014

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 519,701.0 m

Northing: 7,957,349.0 m

Surface Elevation: 111.00 m

Bottom Elevation: 106.50 m

Total Depth: 4.5 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/8/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	111.0	0.0				SILTY SAND: Fine grained	Nf										
	110.5	0.5				Silty SAND, with GRAVEL, trace COBBLES: Fine gravel, fine to coarse grained sand	Nf										
	110.0	1.0															
	109.5	1.5				Silty SAND, trace GRAVEL: Subangular to angular gravel, medium to coarse grained sand	Nf										
	109.0	2.0									11	11	69	20			
	108.5	2.5															
	108.0	3.0															
	107.5	3.5															
	107.0	4.0				Sandy GRAVEL, trace COBBLES: Pinkish grey to light brown, coarse grained sand, rounded to subrounded gravel	Nf										
	106.5	4.5				To Target Depth. **Drillhole BH16-R014 terminated at 4.5m.**											
	106.0	5.0															

Notes:

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BOREHOLE REPORT

BH16-R015

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 520,756.0 m

Northing: 7,955,701.0 m

Surface Elevation: 115.00 m

Bottom Elevation: 110.50 m

Total Depth: 4.5 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/8/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	114.5	0.5				GRAVEL with SAND, trace SILT, trace COBBLES: Light brown, fine to coarse gravel, rounded, fine to coarse grained sand	Nf										
	114.0	1.0															
	113.5	1.5				GRAVEL and SAND: Fine to coarse gravel, rounded, fine to medium grained sand, poorly bonded	Nf										
	113.0	2.0															
	112.5	2.5										2	73	24			
	112.0	3.0				SAND with SILT, trace GRAVEL: Light brown, fine to medium grained sand, fine gravel	Nbn										
	111.5	3.5															
	111.0	4.0									13						
	110.5	4.5				To Target Depth. **Drillhole BH16-R015 terminated at 4.5m.**											
	110.0	5.0															

Notes:

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BOREHOLE REPORT

BH16-R016
Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 521,588.0 m
Northing: 7,953,865.0 m
Surface Elevation: 112.00 m
Bottom Elevation: 107.50 m
Total Depth: 4.5 m
Logged By: MR
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: Samuel Flynn
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 10/8/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	111.5	0.5				SAND: Organic, dark grey											
	111.0	1.0				SILTY SAND, trace GRAVEL, trace COBBLES: Light brown, medium to coarse grained sand, fine to coarse gravel, rounded to subrounded	Nf				32						
	110.5	1.5					Nbe										
	110.0	2.0									15	8	55	28			
	109.5	2.5				SAND, with GRAVEL, trace SILT: Fine to coarse grained sand, fine to coarse gravel, rounded	Nbe										
	109.0	3.0															
	108.5	3.5															
	108.0	4.0															
	107.5	4.5				To Target Depth. **Drillhole BH16-R016 terminated at 4.5m.**											
	107.0	5.0															

Notes:

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BOREHOLE REPORT

BH16-R017

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 521,737.0 m

Northing: 7,952,929.0 m

Surface Elevation: 115.00 m

Bottom Elevation: 110.40 m

Total Depth: 4.6 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/9/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost.	114.5	0.5	Vibracore	H-Casing		SILTY SAND and GRAVEL: Brown, fine to coarse grained sand	Nf				29						
	114.0	1.0					Nbn										
	113.5	1.5															
	113.0	2.0															
	112.5	2.5															
	112.0	3.0															
	111.5	3.5															
	111.0	4.0															
	110.5	4.5		[4.6]													
	110.0	5.0				To Target Depth. **Drillhole BH16-R017 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH16-R018
Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 521,854.0 m
Northing: 7,951,940.0 m
Surface Elevation: 113.00 m
Bottom Elevation: 108.40 m
Total Depth: 4.6 m
Logged By: UK
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: Vance Madden
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 10/9/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost.	112.5	0.5	Vibracore	H-Casing		SILTY SAND, some Gravel: Brown, fine gravel, rounded to subangular gravel											
	112.0	1.0															
	111.5	1.5				SILTY SAND with GRAVEL: Grey, fine sand, fine to coarse gravel, rounded to subrounded	Nf										
	111.0	2.0															
	110.5	2.5				2.40 m to 3.00 m: Gravel is fine to coarse, well bonded (Nbn)	Nbn										
	110.0	3.0				3.00 m to 3.90 m: Brown to grey, Subangular gravel, fine to coarse	Nf										
	109.5	3.5															
	109.0	4.0				SILTY SAND and BOULDERS: Crushed, grey with white stratification											
	108.5	4.5		[4.6]													
	108.0	5.0				To Target Depth. **Drillhole BH16-R018 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH16-R019

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 521,994.0 m

Northing: 7,950,962.0 m

Surface Elevation: 112.30 m

Bottom Elevation: 107.70 m

Total Depth: 4.6 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/9/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost.	111.8	0.5	Vibracore	H-Casing		SILTY SAND, with GRAVEL, trace COBBLES: Brown, rounded to subangular gravel, well graded	Nf										
	111.3	1.0				GRAVEL and SAND: Brown, rounded to subround gravel	Nf										
	110.8	1.5				SAND,with GRAVEL, with COBBLES: Brown, rounded to subangular gravel	Nf										
	110.3	2.0															
	109.8	2.5				SILTY SAND with GRAVEL: Brown, rounded to subangular gravel, fragmented rock	Nf										
	109.3	3.0				3.00 m to 4.00 m: Grey	Nbn										
	108.8	3.5															
	108.3	4.0				4.00 m to 4.60 m: Some cobbles	Nf										
	107.8	4.5		[4.6]													
	107.3	5.0				To Target Depth. **Drillhole BH16-R019 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH16-R020

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 521,842.0 m

Northing: 7,949,969.0 m

Surface Elevation: 117.50 m

Bottom Elevation: 112.90 m

Total Depth: 4.6 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/9/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost.	117.0	0.5	Vibracore	H-Casing		SAND and GRAVEL, some SILT, some COBBLES: Brown, angular to subangular gravel	Nf										
	116.5	1.0															
	116.0	1.5				SILTY SAND, with GRAVEL, with COBBLES: White to grey, angular to subangular gravel, crushed rock	Nf										
	115.5	2.0															
	115.0	2.5															
	114.5	3.0				SILT and SAND: Brown to grey, angular to subangular gravel	Nbn										
	114.0	3.5															
	113.5	4.0									20	0	57	43			
	113.0	4.5		[4.6]													
	112.5	5.0				To Target Depth. **Drillhole BH16-R020 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH16-R021

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 521,784.0 m

Northing: 7,948,976.0 m

Surface Elevation: 123.25 m

Bottom Elevation: 118.75 m

Total Depth: 4.5 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/9/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost.	122.8	0.5	Vibracore	H-Casing		SILTY SAND, some GRAVEL, trace COBBLES: Light brown to grey, fine to medium grained sand, fine to coarse gravel, rounded to subangular	Nf										
	122.3	1.0															
	121.8	1.5															
	121.3	2.0				SILTY SAND, some SILT, some GRAVEL, trace COBBLES: Grey to dark grey, angular to subangular gravel, rounded to subrounded cobbles, fine to coarse grained sand	Nf										
	120.8	2.5															
	120.3	3.0				SILTY SAND, some GRAVEL: Light brown to reddish brown, fine to medium grained sand, fine gravel, rounded	Nf										
	119.8	3.5															
	119.3	4.0															
	118.8	4.5		[4.5]		To Target Depth. **Drillhole BH16-R021 terminated at 4.5m.**											
	118.3	5.0															

Notes:

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BOREHOLE REPORT

BH16-R022

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 522,305.0 m

Northing: 7,948,153.0 m

Surface Elevation: 141.40 m

Bottom Elevation: 136.90 m

Total Depth: 4.5 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/9/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost.	140.9	0.5	Vibracore	H-Casing		SILTY SAND and GRAVEL, trace COBBLES: Grey to light brown, angular to subangular gravel, fine to coarse,rounded to subrounded, coarse grained sand	Nf										
	140.4	1.0															
	139.9	1.5															
	139.4	2.0															
	138.9	2.5															
	138.4	3.0				SILT and SAND, some GRAVEL: TILL, grey, fine to coarse grained sand, fine to coarse gravel, rounded to subangular	Nbn										
	137.9	3.5															
	137.4	4.0								●	9	13	44	44			
	136.9	4.5		[4.5]		To Target Depth. **Drillhole BH16-R022 terminated at 4.5m.**											
	136.4	5.0															

Notes:

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BOREHOLE REPORT

BH16-R023

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 522,505.0 m

Northing: 7,947,177.0 m

Surface Elevation: 158.00 m

Bottom Elevation: 154.00 m

Total Depth: 4.0 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/10/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 / 50 / 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	157.5	0.5	Vibracore	H-Casing		SILTY SAND, some GRAVEL: Light brown, fine to medium grained sand, coarse gravel, rounded to subrounded	Nf										
	157.0	1.0				SAND and SILT: Grey, fine to medium grained	Nbn										
	156.5	1.5															
	156.0	2.0										0	61	39			
	155.5	2.5															
	155.0	3.0															
	154.5	3.5															
	154.0	4.0		[4.0]		Drilling Refusal. **Drillhole BH16-R023 terminated at 4.0m.**											
	153.5	4.5															
	153.0	5.0															

Notes:

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BOREHOLE REPORT

BH16-R024

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 522,558.0 m

Northing: 7,946,129.0 m

Surface Elevation: 153.00 m

Bottom Elevation: 148.40 m

Total Depth: 4.6 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/10/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	152.5	0.5	Vibracore	H-Casing		SILTY SAND and GRAVEL: Brown, angular to subangular gravel	Nf										
	152.0	1.0															
	151.5	1.5									9	30	38	32			
	151.0	2.0															
	150.5	2.5															
	150.0	3.0					Nbn				8						
	149.5	3.5															
	149.0	4.0															
	148.5	4.5		[4.6]													
	148.0	5.0				To Target Depth. **Drillhole BH16-R024 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH16-R025

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 522,989.0 m

Northing: 7,945,894.0 m

Surface Elevation: 153.75 m

Bottom Elevation: 149.15 m

Total Depth: 4.6 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/10/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserveddue to Permafrost	153.3	0.5	Vibracore	H-Casing		SANDY SILT, some GRAVEL, trace COBBLES: Grey, angular to subabgular gravel	Nf										
	152.8	1.0									18	13	33	54			
	152.3	1.5					Nbn										
	151.8	2.0															
	151.3	2.5									15	16	43	41			
	150.8	3.0					Vx										
	150.3	3.5															
	149.8	4.0									16						
	149.3	4.5		[4.6]													
	148.8	5.0				To Target Depth. **Drillhole BH16-R025 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH16-R026

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 523,165.0 m

Northing: 7,944,366.0 m

Surface Elevation: 152.00 m

Bottom Elevation: 147.40 m

Total Depth: 4.6 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/10/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	151.5	0.5	Vibracore	H-Casing		SAND with GRAVEL, trace SILT: Grey, granular, organics	Nf										
						SILTY SAND, wtih GRAVEL: Brown, rounded to subangular GRAVEL	Nf										
	151.0	1.0				0.90 m to 3.00 m : Fragmented rock					27						
	150.5	1.5															
	150.0	2.0															
	149.5	2.5															
	149.0	3.0					Nbn										
	148.5	3.5															
	148.0	4.0									8						
	147.5	4.5		[4.6]													
	147.0	5.0				To Target Depth. **Drillhole BH16-R026 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH16-R027
Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 523,442.0 m
Northing: 7,942,265.0 m
Surface Elevation: 171.10 m
Bottom Elevation: 166.50 m
Total Depth: 4.6 m
Logged By: UK
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: Vance Madden
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 10/10/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	170.6	0.5	Vibracore	H-Casing		SAND, with SILT, with COBBLES: Brown, rounded to subrounded cobbles 0.45 m to 1.10 m: Crushed limestone cobbles and boulders	Nf										
	170.1	1.0				SAND and SILT, with GRAVEL: Brown 1.50 m to 3.00 m: Inferred rock/cobbles, fragmented, cobbles rounded to angular	Nf				8	22	43	35			
	169.6	1.5															
	169.1	2.0															
	168.6	2.5															
	168.1	3.0				SILTY SAND, with GRAVEL, with COBBLES: Brown, rounded to subangular gravel	Nbn										
	167.6	3.5															
	167.1	4.0									9						
	166.6	4.5		[4.6]													
	166.1	5.0				To Target Depth. **Drillhole BH16-R027 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH16-R028

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 524,061.0 m

Northing: 7,940,538.0 m

Surface Elevation: 172.30 m

Bottom Elevation: 168.70 m

Total Depth: 3.6 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/10/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	171.8	0.5	Vibracore	H-Casing		SAND and SILT, some GRAVEL: Light grey,fine to coarse grained sand, angular to subangular gravel	Nf				3						
	171.3	1.0				Gravelly Silty SAND: Grey, dark grey mixed, fine to coarse grained sand, fine to coarse gravel, rounded to subrounded	Nf										
	170.8	1.5															
	170.3	2.0															
	169.8	2.5															
	169.3	3.0				SANDY SILT, with GRAVEL, with COBBLES: Fine to medium grained sand, fine to coarse gravel, rounded to subrounded	Nf										
	168.8	3.5		[3.6]													
	168.3	4.0				Drilling Refusal. **Drillhole BH16-R028 terminated at 3.6m.**											
	167.8	4.5															
	167.3	5.0															

Notes:

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BOREHOLE REPORT

BH16-R029

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 525,062.0 m

Northing: 7,938,851.0 m

Surface Elevation: 186.00 m

Bottom Elevation: 183.00 m

Total Depth: 3.0 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/11/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	185.5	0.5	Vibracore	H-Casing		SANDY SILT and GRAVEL, trace COBBLES: Light brown, subangular to angular gravel, fine to coarse sand, fine to coarse gravel	Nf										
	185.0	1.0															
	184.5	1.5				GRAVEL and COBBLES, some SAND: Grey, subgranular to angular gravel, fine to coarse, fine to coarse grained sand	Nf										
	184.0	2.0															
	183.5	2.5															
	183.0	3.0		[3.0]		Drilling Refusal. **Drillhole BH16-R029 terminated at 3.0m.**											
	182.5	3.5															
	182.0	4.0															
	181.5	4.5															
	181.0	5.0															

Notes:

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BOREHOLE REPORT

BH16-R030

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion

Location: Mary River

Project No.: H352034

Datum: NAD83

Platform:

Easting: 525,291.0 m

Northing: 7,937,897.0 m

Surface Elevation: 178.75 m

Bottom Elevation: 175.15 m

Total Depth: 3.6 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/11/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	178.3	0.5	Vibracore	H-Casing		SAND with SILT, with GRAVEL: Brown, angular to subangular gravel	Nf										
	177.8	1.0				SANDY SILT, with GRAVEL, with COBBLES: Grey, angular to subangular gravel	Nf										
	177.3	1.5															
	176.8	2.0				Pulverized rock with fragments of rocks, angular, sharp edges	Nf										
	176.3	2.5									10						
	175.8	3.0															
	175.3	3.5		[3.6]													
	174.8	4.0				Drilling Refusal. **Drillhole BH16-R030 terminated at 3.6m.**											
	174.3	4.5															
	173.8	5.0															

Notes:

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BOREHOLE REPORT

BH16-R032

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 525,991.0 m

Northing: 7,936,109.0 m

Surface Elevation: 168.75 m

Bottom Elevation: 166.05 m

Total Depth: 2.7 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/11/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	168.3	0.5	Vibracore	H-Casing		SILTY SAND, some GRAVEL, some COBBLES: Brown to grey, fine to coarse grained sand											
	167.8	1.0															
	167.3	1.5				LIMESTONE: Pulverized rock, white to grey, angular rock fragments, weak to moderate strength											
	166.8	2.0															
	166.3	2.5		[2.7]													
	165.8	3.0				Drilling Refusal. **Drillhole BH16-R032 terminated at 2.7m.**											
	165.3	3.5															
	164.8	4.0															
	164.3	4.5															
	163.8	5.0															

Notes:

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BOREHOLE REPORT

BH16-R033
Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 526,653.0 m
Northing: 7,935,439.0 m
Surface Elevation: 164.00 m
Bottom Elevation: 159.80 m
Total Depth: 4.2 m
Logged By: UK
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: Vance Madden
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 10/11/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	163.5	0.5	Vibracore	H-Casing		GRAVEL, some SILT, some SAND: Light brown, medium to coarse grained sand, subrounded to rounded gravel	Nf										
	163.0	1.0															
	162.5	1.5				SAND and GRAVEL, with SILT, trace COBBLES: Grey, fine to coarse gravel, fine to coarse grained sand, rounded to subrounded gravel	Nf										
	162.0	2.0															
	161.5	2.5									7						
	161.0	3.0				COBBLES, with GRAVEL, with SAND, trace SILT: Light brown, grey mixed, coarse gravel, angular to subangular, fine to medium grained sand	Nf										
	160.5	3.5															
	160.0	4.0		[4.2]													
	159.5	4.5				To Target Depth. **Drillhole BH16-R033 terminated at 4.2m.**											
	159.0	5.0															

Notes:

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BOREHOLE REPORT

BH16-R034

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 527,056.0 m

Northing: 7,933,500.0 m

Surface Elevation: 175.60 m

Bottom Elevation: 171.10 m

Total Depth: 4.5 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/12/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	175.1	0.5	Vibracore	H-Casing		SAND and GRAVEL, trace silt: Light brown, grey mixed, fine to coarse grained sand, rounded	Nf										
	174.6	1.0															
	174.1	1.5				GRAVELLY SILTY SAND: Light brown, grey mixed, angular to subangular gravel, fine to coarse grained sand	Vx										
	173.6	2.0															
	173.1	2.5									8	27	40	32			
	172.6	3.0															
	172.1	3.5									9						
	171.6	4.0															
	171.1	4.5		[4.5]		To Target Depth. **Drillhole BH16-R034 terminated at 4.5m.**											
	170.6	5.0															

Notes:

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BOREHOLE REPORT

BH16-R035

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 527,423.0 m

Northing: 7,932,310.0 m

Surface Elevation: 186.00 m

Bottom Elevation: 181.40 m

Total Depth: 4.6 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/12/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved	185.5	0.5	Vibracore	H-Casing		SAND, with GRAVEL, with SILT: Grey to brown, angular to subangular gravel	Nf										
	185.0	1.0				GRAVEL, with SAND, with COBBLES: Brown, rounded to subrounded gravel	Nf										
	184.5	1.5				SAND and GRAVEL, some SILT: Grey, fine grained sand	Nf										
	184.0	2.0				GRAVELLY SILTY SAND: Grey	Nbn										
	183.5	2.5										24	42	34			
	183.0	3.0															
	182.5	3.5															
	182.0	4.0				LIMESTONE: Framnebted rock, light grey to white, pulverized, angular, sharp edges											
	181.5	4.5		[4.6]													
	181.0	5.0				To Target Depth. **Drillhole BH16-R035 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH16-R036

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 527,210.0 m

Northing: 7,931,660.0 m

Surface Elevation: 172.00 m

Bottom Elevation: 167.40 m

Total Depth: 4.6 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/12/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	171.5	0.5	Vibracore	H-Casing		Gravelly SAND, some SILT, trace COBBLES: Organic, grey to brown, angular to subangular gravel	Nf										
	171.0	1.0															
	170.5	1.5				SAND and SILT, with GRAVEL trace COBBLES: Brown to grey, angular to subangular gravel	Nf										
	170.0	2.0															
	169.5	2.5									10	23	42	35			
	169.0	3.0				SILT and COBBLES, with SAND: Brown	Nf										
	168.5	3.5															
	168.0	4.0															
	167.5	4.5		[4.6]													
	167.0	5.0				To Target Depth. **Drillhole BH16-R036 terminated at 4.6m.**											

Notes:

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HATCH BOREHOLE REPORT

BH16-R037

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 527,873.0 m

Northing: 7,929,786.0 m

Surface Elevation: 162.25 m

Bottom Elevation: 157.65 m

Total Depth: 4.6 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/12/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	161.8	0.5	Vibracore	H-Casing		SAND, trace SILT: Reddish brown, angular	Nf										
	161.3	1.0															
	160.8	1.5					Nbn										
	160.3	2.0															
	159.8	2.5									20	0	91	9			
	159.3	3.0															
	158.8	3.5															
	158.3	4.0									20						
	157.8	4.5		[4.6]													
	157.3	5.0				To Target Depth. **Drillhole BH16-R037 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH16-R038

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 528,501.0 m

Northing: 7,928,421.0 m

Surface Elevation: 164.00 m

Bottom Elevation: 159.50 m

Total Depth: 4.5 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/12/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	163.5	0.5	Vibracore	H-Casing		SAND, trace SILT, trace GRAVEL: Light brown, reddish brown mixed, medium to coarse grained sand, rounded to subrounded gravel	Nf										
	163.0	1.0															
	162.5	1.5					Vc										
	162.0	2.0									16	2	89	9			
	161.5	2.5															
	161.0	3.0															
	160.5	3.5															
	160.0	4.0									8						
	159.5	4.5		[4.5]		To Target Depth. **Drillhole BH16-R038 terminated at 4.5m.**											
	159.0	5.0															

Notes:

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BOREHOLE REPORT

BH16-R039
Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 528,666.0 m
Northing: 7,927,955.0 m
Surface Elevation: 165.75 m
Bottom Elevation: 161.25 m
Total Depth: 4.5 m
Logged By: MR
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: Samuel Flynn
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 10/12/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 / 50 / 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost.	165.3	0.5	Vibracore	H-Casing		SAND, trace SILT, trace GRAVEL: Light brown, reddish brown mixed, medium to coarse grained sand, rounded to subrounded gravel	Nf										
	164.8	1.0									20	3	94	3			
	164.3	1.5					Nbn										
	163.8	2.0															
	163.3	2.5															
	162.8	3.0															
	162.3	3.5															
	161.8	4.0															
	161.3	4.5		[4.5]		To Target Depth. **Drillhole BH16-R039 terminated at 4.5m.**											
	160.8	5.0															

Notes:

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BOREHOLE REPORT

BH16-R040

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 528,686.0 m

Northing: 7,927,755.0 m

Surface Elevation: 166.00 m

Bottom Elevation: 161.40 m

Total Depth: 4.6 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/13/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost.	165.5	0.5	Vibracore	H-Casing		SAND and SILT, trace GRAVEL: Reddish brown to grey, angular to subangular gravel	Nf										
	165.0	1.0															
	164.5	1.5															
	164.0	2.0															
	163.5	2.5									19						
	163.0	3.0															
	162.5	3.5															
	162.0	4.0															
	161.5	4.5		[4.6]													
	161.0	5.0				To Target Depth. **Drillhole BH16-R040 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH16-R041

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 528,605.0 m

Northing: 7,927,754.0 m

Surface Elevation: 166.00 m

Bottom Elevation: 164.50 m

Total Depth: 1.5 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/14/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost.	165.5	0.5	Vibracore	H-Casing		SAND: Reddish brown, fine to coarse grained sand											
	165.0	1.0															
	164.5	1.5		[1.5]		To Target Depth. **Drillhole BH16-R041 terminated at 1.5m.**											
	164.0	2.0															
	163.5	2.5															
	163.0	3.0															
	162.5	3.5															
	162.0	4.0															
	161.5	4.5															
	161.0	5.0															

Notes:

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BOREHOLE REPORT

BH16-R042

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 528,517.0 m

Northing: 7,927,713.0 m

Surface Elevation: 167.00 m

Bottom Elevation: 162.50 m

Total Depth: 4.5 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/14/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost.	166.5	0.5	Vibracore	H-Casing		SAND, trace GRAVEL: Reddish brown, light brown mixed, medium to coarse grained sand, angular to subangular gravel,	Nf										
	166.0	1.0															
	165.5	1.5															
	165.0	2.0															
	164.5	2.5															
	164.0	3.0				3.30 m to 4.60 m: Trace to some gravel	Nbn										
	163.5	3.5															
	163.0	4.0									15						
	162.5	4.5		[4.5]		To Target Depth. **Drillhole BH16-R042 terminated at 4.5m.**											
	162.0	5.0															

Notes:

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BOREHOLE REPORT

BH16-R043

Sheet 1 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 528,428.0 m

Northing: 7,927,675.0 m

Surface Elevation: 167.00 m

Bottom Elevation: 158.00 m

Total Depth: 9.0 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/13/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost.	166.5	0.5	Vibracore	H-Casing		SAND: Grey to light brown, fine to coarse grained	Nf										
	166.0	1.0															
	165.5	1.5															
	165.0	2.0															
	164.5	2.5															
	164.0	3.0					Vc										
	163.5	3.5															
	163.0	4.0									15						
	162.5	4.5				4.50 m to 7.50m: Trace gravel	Nf										
	162.0	5.0															

Notes:

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BOREHOLE REPORT

BH16-R043

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 528,428.0 m

Northing: 7,927,675.0 m

Surface Elevation: 167.00 m

Bottom Elevation: 158.00 m

Total Depth: 9.0 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/13/2016

Driller: Samuel Flynn

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	161.5	5.5				SAND: Grey to light brown, fine to coarse grained *(Continued)*	Nf *(Continued)*										
	161.0	6.0															
	160.5	6.5															
	160.0	7.0															
	159.5	7.5				7.50 m to 9.00 m: Light brown, fine to medium grained sand, no gravel	Nf										
	159.0	8.0															
	158.5	8.5									7						
	158.0	9.0		[9.0]		To Target Depth. **Drillhole BH16-R043 terminated at 9.0m.**											
	157.5	9.5															
	157.0	10.0															

Notes:

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BOREHOLE REPORT

BH16-R044

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 528,736.0 m

Northing: 7,926,992.0 m

Surface Elevation: 167.00 m

Bottom Elevation: 162.50 m

Total Depth: 4.5 m

Logged By: CS

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/28/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	166.5	0.5	Vibracore	H-Casing		SANDY GRAVEL, trace COBBLES: Light brown, fine to coarse gravel , angular to subangular gravel											
	166.0	1.0															
	165.5	1.5				SAND, some SILT, some GRAVEL: Light brown, rounded to subrounded gravel, medium to coarse grained sand											
	165.0	2.0									11						
	164.5	2.5															
	164.0	3.0															
	163.5	3.5															
	163.0	4.0									16						
	162.5	4.5		[4.5]		To Target Depth. **Drillhole BH16-R044 terminated at 4.5m.**											
	162.0	5.0															

Notes:

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BOREHOLE REPORT

BH16-R045

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 528,961.0 m

Northing: 7,926,756.0 m

Surface Elevation: 138.75 m

Bottom Elevation: 134.25 m

Total Depth: 4.5 m

Logged By: CS

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/28/2016

Driller: Vance Madden

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	138.3	0.5	Vibracore	H-Casing		SAND, some SILT, some GRAVEL, trace COBBLES: Light brown, medium to coarse grained sand											
	137.8	1.0									8						
	137.3	1.5															
	136.8	2.0															
	136.3	2.5															
	135.8	3.0															
	135.3	3.5									21						
	134.8	4.0															
	134.3	4.5		[4.5]		To Target Depth. **Drillhole BH16-R045 terminated at 4.5m.**											
	133.8	5.0															

Notes:

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BOREHOLE REPORT

BH16-R046

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 529,065.0 m

Northing: 7,926,599.0 m

Surface Elevation: 138.20 m

Bottom Elevation: 133.60 m

Total Depth: 4.6 m

Logged By: RS

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/28/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	137.7	0.5	Vibracore	H-Casing		SAND, some GRAVEL, trace SILT: Light brown, subrounded to rounded gravel, medium to coarse grained sand	Nf										
	137.2	1.0				SAND and GRAVEL, trace SILT: Fine to medium grained sand	Nf				6						
	136.7	1.5															
	136.2	2.0				SILT: Organics, peat, dark brown, black, organic odour, frozen	Nbn				40						
	135.7	2.5															
	135.2	3.0				SILTY SAND: Grey, fine to medium grained sand, brown layers	Nbn										
	134.7	3.5															
	134.2	4.0									22						
	133.7	4.5		[4.6]													
	133.2	5.0				To Target Depth. **Drillhole BH16-R046 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH16-R053

Sheet 1 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 528,238.0 m

Northing: 7,928,027.0 m

Surface Elevation: 163.25 m

Bottom Elevation: 157.20 m

Total Depth: 6.1 m

Logged By: RS

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/28/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost	163.25	0.0	Vibracore	H-Casing		SAND, trace SILT, trace GRAVEL: Light grey to brown, medium to coarse grained sand	Nf										
	162.8	0.5															
	162.3	1.0															
	161.8	1.5					Nbn										
	161.3	2.0															
	160.8	2.5															
	160.3	3.0															
	159.8	3.5															
	159.3	4.0															
	158.8	4.5															
	158.3	5.0															

Notes:

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BOREHOLE REPORT

BH16-R053

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 528,238.0 m

Northing: 7,928,027.0 m

Surface Elevation: 163.25 m

Bottom Elevation: 157.20 m

Total Depth: 6.1 m

Logged By: RS

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/28/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, trace SILT, trace GRAVEL: Light grey to brown, medium to coarse grained sand *(Continued)*	Nf *(Continued)*										
	157.8	5.5				5.50 m to 6.10 m: Fine to medium grained sand	Nf				23						
	157.3	6.0		[6.1]													
						To Target Depth. **Drillhole BH16-R053 terminated at 6.1m.**											
	156.8	6.5															
	156.3	7.0															
	155.8	7.5															
	155.3	8.0															
	154.8	8.5															
	154.3	9.0															
	153.8	9.5															
	153.3	10.0															

Notes:

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HATCH BOREHOLE REPORT

BH16-R067

Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 535,406.0 m
Northing: 7,918,572.0 m
Surface Elevation: 189.00 m
Bottom Elevation: 184.40 m
Total Depth: 4.6 m
Logged By: MR
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: Michael Scott
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 11/24/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	188.5	0.5	Vibracore	H-Casing		PEAT, with SAND, with GRAVEL, trace COBBLES: Dark brown to black, Organic, medium to coarse grained sand, rounded to subrounded cobbles	Nf										
	188.0	1.0				SAND, trace GRAVEL, trace COBBLES: Dark grey to dark brown, medium to coarse grained sand, rounded to subrounded cobbles	Nf				16	3	60	37			
	187.5	1.5															
	187.0	2.0															
	186.5	2.5															
	186.0	3.0															
	185.5	3.5															
	185.0	4.0															
	184.5	4.5		[4.6]													
	184.0	5.0				To Target Depth. **Drillhole BH16-R067 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH16-R068
Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 537,046.0 m
Northing: 7,919,096.0 m
Surface Elevation: 183.50 m
Bottom Elevation: 178.90 m
Total Depth: 4.6 m
Logged By: MR
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: Michael Scott
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 11/24/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	183.0	0.5	Vibracore	H-Casing		GRAVELLY SAND, trace SILT: Light brown, fine to coarse grained sand, angular to subangular gravel	Vx										
	182.5	1.0									42						
	182.0	1.5				SAND: Light brown to yellowish grey, fine to medium grained sand	Vx										
	181.5	2.0									15						
	181.0	2.5															
	180.5	3.0				SAND, trace SILT, trace GRAVEL: Dark brown, Organic, fine to medium grained sand	Vx										
	180.0	3.5															
	179.5	4.0															
	179.0	4.5		[4.6]													
	178.5	5.0				To Target Depth. **Drillhole BH16-R068 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH16-R069

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 539,489.0 m

Northing: 7,920,583.0 m

Surface Elevation: 152.00 m

Bottom Elevation: 147.40 m

Total Depth: 4.6 m

Logged By: UK

Reviewed By: SH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 11/23/2016

Driller: E.Beachamp

Hole Diameter (mm): 96

Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	151.5	0.5	Vibracore	H-Casing		Sandy SILT, with GRAVEL, with COBBLES: White to grey, fine grained sand, angular to subangular gravel											
	151.0	1.0									21	19	41	40			
	150.5	1.5															
	150.0	2.0															
	149.5	2.5															
	149.0	3.0															
	148.5	3.5															
	148.0	4.0															
	147.5	4.5		[4.6]													
	147.0	5.0				To Target Depth. **Drillhole BH16-R069 terminated at 4.6m.**											

Notes:

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HATCH BOREHOLE REPORT

BH16-R070

Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 540,273.0 m
Northing: 7,921,201.0 m
Surface Elevation: 146.00 m
Bottom Elevation: 141.40 m
Total Depth: 4.6 m
Logged By: MR
Reviewed By: SH/WH

Contractor: Boart Longyear
Driller: Michael Scott
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 96
Date Logged: 11/23/2016
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to permafrost	146.0	0.0	Vibracore	H-Casing		PEAT, GRAVELLY SAND: Brown, coarse grained sand	Nf										
	145.5	0.5				SAND, trace GRAVEL: Brown to light brown, fine to medium grained sand, angular to subangular gravel	Nf										
	145.0	1.0									8	0	84	16			
	144.5	1.5				1.50 m to 3.00 m: Light brown, some silt	Vx										
	144.0	2.0															
	143.5	2.5															
	143.0	3.0					Nf										
	142.5	3.5															
	142.0	4.0															
	141.5	4.5		[4.6]													
	141.0	5.0				To Target Depth. **Drillhole BH16-R070 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH17-B001

Sheet 1 of 4

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 529,031.0 m

Northing: 7,916,747.0 m

Surface Elevation: 125.00 m

Bottom Elevation: 108.50 m

Total Depth: 16.5 m

Logged By: UK

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/22/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	124.5	0.5	Sonic Drilling	NO CASING		SILTY SAND: Brown, fine grained sand	Nf										
	124.0	1.0															
	123.5	1.5				SAND, trace SILT: Grey, fine grained sand	Nbn										
	123.0	2.0															
	122.5	2.5									26	0	93	7			
	122.0	3.0															
	121.5	3.5															
	121.0	4.0															
	120.5	4.5															
	120.0	5.0		[5.0]		SILT, trace SAND: Black organics, fine grained sand	Nbn										

Notes:

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BOREHOLE REPORT

BH17-B001

Sheet 2 of 4

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 529,031.0 m
Northing: 7,916,747.0 m
Surface Elevation: 125.00 m
Bottom Elevation: 108.50 m
Total Depth: 16.5 m
Logged By: UK
Reviewed By: CH/WH

Contractor: Boart Longyear
Driller: Emile and/or Sam
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 4/22/2017
Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 / 50 / 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	119.5	5.5	Sonic Drilling	NO CASING		SILT, trace SAND: Black organics, fine grained sand *(Continued)*	Nbn *(Continued)*										
	119.0	6.0					Vs				37	0	6	94			
	118.5	6.5															
	118.0	7.0															
	117.5	7.5				SILTY SAND, trace GRAVEL, trace COBBLES: Dark grey, fine to medium grained, well graded sand; multi-coloured, fine to coarse, rounded cobbles	Vx										
	117.0	8.0															
	116.5	8.5				8.80 m: Inferred boulders					10	6	65	29			
	116.0	9.0				SILT with SAND, trace GRAVEL: Dark grey, fine to coarse grained, well graded sand; multi-coloured, fine to coarse, rounded gravel											
	115.5	9.5															
	115.0	10.0		[10.0]													

Notes:

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HATCH BOREHOLE REPORT

BH17-B001

Sheet 3 of 4

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 529,031.0 m
Northing: 7,916,747.0 m
Surface Elevation: 125.00 m
Bottom Elevation: 108.50 m
Total Depth: 16.5 m
Logged By: UK
Reviewed By: CH/WH

Contractor: Boart Longyear
Driller: Emile and/or Sam
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 4/22/2017
Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	114.5	10.5	Sonic Drilling	NO CASING		SILT with SAND, trace GRAVEL: Dark grey, fine to coarse grained, well graded sand; multi-coloured, fine to coarse, rounded gravel *(Continued)*	Vc										
	114.0	11.0				11.00 m to 12.00 m: Large sub-angular cobbles (~ 10 cm) or possible boulders	Vx										
	113.5	11.5									42	7	30	63			
	113.0	12.0					Nf										
						12.20 m: Inferred boulder											
	112.5	12.5															
						12.80 m: Grey, inferred boulder											
	112.0	13.0									12						
	111.5	13.5															
						13.70 m to 16.50 m: Grey, fine grained sand; multi-coloured, fine, rounded gravel											
	111.0	14.0															
	110.5	14.5															
	110.0	15.0		[15.0]													

Notes:

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BOREHOLE REPORT

BH17-B001

Sheet 4 of 4

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 529,031.0 m

Northing: 7,916,747.0 m

Surface Elevation: 125.00 m

Bottom Elevation: 108.50 m

Total Depth: 16.5 m

Logged By: UK

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/22/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	109.5	15.5	Sonic Drilling	NO CASING		SILT with SAND, trace GRAVEL: Dark grey, fine to coarse grained, well graded sand; multi-coloured, fine to coarse, rounded gravel *(Continued)*					12						
	109.0	16.0															
	108.5	16.5		[16.5]		Drilling Refusal. **Drillhole BH17-B001 terminated at 16.5m.**											
	108.0	17.0															
	107.5	17.5															
	107.0	18.0															
	106.5	18.5															
	106.0	19.0															
	105.5	19.5															
	105.0	20.0															

Notes:

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BOREHOLE REPORT

BH17-B002

Sheet 1 of 6

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 529,323.0 m

Northing: 7,916,577.0 m

Surface Elevation: 125.00 m

Bottom Elevation: 99.40 m

Total Depth: 25.6 m

Logged By: AB

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/18/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	125.0	0.0	Sonic Drilling	NO CASING		SAND, some SILT: Brown, medium to fine grained, well graded sand											
	124.5	0.5									19	0	88	12			
	124.0	1.0															
	123.5	1.5															
	123.0	2.0															
	122.5	2.5															
	122.0	3.0				ORGANIC SILT, some SAND: Black, fine grained sand with strong organic odour.	Nbn										
	121.5	3.5									37	0	16	84			
	121.0	4.0					Nbe										
	120.5	4.5					Nbn										
	120.0	5.0		[5.0]			Vx										

Notes:

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BOREHOLE REPORT

BH17-B002
Sheet 2 of 6

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 529,323.0 m
Northing: 7,916,577.0 m
Surface Elevation: 125.00 m
Bottom Elevation: 99.40 m
Total Depth: 25.6 m
Logged By: AB
Reviewed By: CH/WH

Contractor: Boart Longyear
Driller: Emile and/or Sam
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 4/18/2017
Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 / 50 / 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	119.5	5.5	Sonic Drilling	NO CASING		ORGANIC SILT, some SAND: Black, fine grained sand with strong organic odour. *(Continued)*	Nbn *(Continued)*										
	119.0	6.0				SILTY and SAND: Brown, fine to coarse grained, well graded sand	Nf										
	118.5	6.5									24	0	48	52			
	118.0	7.0															
	117.5	7.5															
	117.0	8.0					Nbe										
	116.5	8.5															
	116.0	9.0				9.10 m to 12.20 m: Black, medium to fine grained, well graded sand; multicoloured, rounded to subrounded gravel	Nf										
	115.5	9.5															
	115.0	10.0		[10.0]													

Notes:

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BOREHOLE REPORT

BH17-B002
Sheet 3 of 6

Client: Baffinland Iron Mines
Project No.: H352034
Project: Mary River Expansion Study Stage 2
Datum: NAD83
Location: Proposed Rail Alignment
Platform: Ground

Easting: 529,323.0 m
Northing: 7,916,577.0 m
Surface Elevation: 125.00 m
Bottom Elevation: 99.40 m
Total Depth: 25.6 m
Logged By: AB
Reviewed By: CH/WH

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 4/18/2017
Driller: Emile and/or Sam
Hole Diameter (mm): 100
Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	114.5	10.5	Sonic Drilling	NO CASING		SILTY and SAND: Brown, fine to coarse grained, well graded sand *(Continued)*	Nf *(Continued)*										
	114.0	11.0															
	113.5	11.5								●	9	3	66	32			
	113.0	12.0															
	112.5	12.5				SAND, some SILT, trace to some GRAVEL: Brown, fine to coarse grained, poorly graded sand											
	112.0	13.0															
	111.5	13.5															
	111.0	14.0															
	110.5	14.5															
	110.0	15.0		[15.0]													

Notes:

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HATCH BOREHOLE REPORT

BH17-B002
Sheet 4 of 6

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 529,323.0 m
Northing: 7,916,577.0 m
Surface Elevation: 125.00 m
Bottom Elevation: 99.40 m
Total Depth: 25.6 m
Logged By: AB
Reviewed By: CH/WH

Contractor: Boart Longyear
Driller: Emile and/or Sam
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 4/18/2017
Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	109.5	15.5	Sonic Drilling	NO CASING		SAND, some SILT, trace to some GRAVEL: Brown, fine to coarse grained, poorly graded sand *(Continued)*											
	109.0	16.0									11	10	70	20			
	108.5	16.5															
	108.0	17.0															
	107.5	17.5					Nbe										
	107.0	18.0															
	106.5	18.5				18.60 m to 19.80 m: Some GRAVEL: Multi-coloured, well graded; rounded gravel	Nf				8	15	66	20			
	106.0	19.0															
	105.5	19.5															
	105.0	20.0		[20.0]		19.80 m to 21.30 m: Dark brown, fine to coarse grained, well graded sand; fine	Nf										

Notes:

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BOREHOLE REPORT

BH17-B002
Sheet 5 of 6

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 529,323.0 m
Northing: 7,916,577.0 m
Surface Elevation: 125.00 m
Bottom Elevation: 99.40 m
Total Depth: 25.6 m
Logged By: AB
Reviewed By: CH/WH

Contractor: Boart Longyear
Driller: Emile and/or Sam
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 4/18/2017
Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	104.5	20.5	Sonic Drilling	NO CASING		to coarse gravel SAND, some SILT, trace to some GRAVEL: Brown, fine to coarse grained, poorly graded sand *(Continued)*	Nbn										
	104.0	21.0															
	103.5	21.5				21.30 m to 24.40 m: SILTY SAND, trace GRAVEL: Brown, fine grained sand	Nf										
	103.0	22.0															
	102.5	22.5															
	102.0	23.0															
	101.5	23.5									15	1	72	27			
	101.0	24.0															
	100.5	24.5				Inferred BEDROCK, grey, rock flour, Granitic											
	100.0	25.0		[25.0]													

Notes:

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BOREHOLE REPORT

BH17-B002

Sheet 6 of 6

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 529,323.0 m

Northing: 7,916,577.0 m

Surface Elevation: 125.00 m

Bottom Elevation: 99.40 m

Total Depth: 25.6 m

Logged By: AB

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/18/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	99.5	25.5	Sonic Drilling	NO CASING [25.6]		Inferred BEDROCK, grey, rock flour, Granitic *(Continued)*											
						Drilling Refusal. **Drillhole BH17-B002 terminated at 25.6m.**											
	99.0	26.0															
	98.5	26.5															
	98.0	27.0															
	97.5	27.5															
	97.0	28.0															
	96.5	28.5															
	96.0	29.0															
	95.5	29.5															
	95.0	30.0															

Notes:

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BOREHOLE REPORT

BH17-C001

Sheet 1 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 509,838.0 m

Northing: 7,967,861.0 m

Surface Elevation: 74.00 m

Bottom Elevation: 65.80 m

Total Depth: 8.2 m

Logged By: AB

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/13/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	73.5	0.5	Sonic Drilling	NO CASING		ORGANICS: Brown, fine grained, black mottling											
	73.0	1.0				GRAVELLY SAND, some COBBLES: Grey, well graded, fine grained sand; Coarse, rounded to subrounded gravel											
	72.5	1.5				SAND: Multi-coloured, coarse grained, poorly graded	Nf										
	72.0	2.0				2.10 m: Black mottling											
	71.5	2.5															
	71.0	3.0				SAND and SILT, some GRAVEL: Reddish brown, poorly graded, coarse grained sand; coarse, rounded gravel	Nf			●	7	14	49	37			
	70.5	3.5				3.40 m to 3.70 m: Inferred cobbles											
	70.0	4.0				3.70 m to 6.10 m: Grey, coarse grained, well graded sand; rounded to sub-angular, coarse gravel	Nf										
	69.5	4.5															
	69.0	5.0		[5.0]													

Notes:

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BOREHOLE REPORT

BH17-C001

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 509,838.0 m

Northing: 7,967,861.0 m

Surface Elevation: 74.00 m

Bottom Elevation: 65.80 m

Total Depth: 8.2 m

Logged By: AB

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/13/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	68.5	5.5	Sonic Drilling	NO CASING		SAND and SILT, some GRAVEL: Reddish brown, poorly graded, coarse grained sand; coarse, rounded gravel *(Continued)* 5.20 m to 5.80 m: Inferred cobbles	Nf *(Continued)*										
	68.0	6.0				6.10 m to 7.60 m: No gravel encountered, light brown, fine to coarse grained sand	Nf										
	67.5	6.5															
	67.0	7.0									3	0	48	52			
	66.5	7.5				7.30 m: Inferred cobbles											
	66.0	8.0		[8.2]		7.60 m to 8.20 m: Grey, fine grained Sand; well-graded, rounded gravel											
	65.5	8.5				Drilling Refusal. **Drillhole BH17-C001 terminated at 8.2m.**											
	65.0	9.0															
	64.5	9.5															
	64.0	10.0															

Notes:

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BOREHOLE REPORT

BH17-C002

Sheet 1 of 3

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 519,532.0 m

Northing: 7,957,667.0 m

Surface Elevation: 116.00 m

Bottom Elevation: 105.30 m

Total Depth: 10.7 m

Logged By: UK

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/13/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	115.5	0.5	Sonic Drilling	NO CASING		SAND, trace GRAVEL: Brown, fine to medium grained sand; coarse, rounded gravel	Nf										
	115.0	1.0				COBBLES and BOULDERS, some SAND, trace GRAVEL: White, subangular cobbles; Inferred boulders	Nf										
	114.5	1.5				GRAVELLY SAND, some SILT: Grey, fine to coarse grained sand; coarse gravel	Nf				10	22	59	19			
	114.0	2.0															
	113.5	2.5															
	113.0	3.0				ICE: Clear to cloudy texture 3.00 m to 9.10 m: White cloudy texture	ICE										
	112.5	3.5															
	112.0	4.0															
	111.5	4.5															
	111.0	5.0		[5.0]													

Notes:

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BOREHOLE REPORT

BH17-C002

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 519,532.0 m

Northing: 7,957,667.0 m

Surface Elevation: 116.00 m

Bottom Elevation: 105.30 m

Total Depth: 10.7 m

Logged By: UK

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/13/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	110.5	5.5	Sonic Drilling	NO CASING		ICE: Clear to cloudy texture *(Continued)*	ICE *(Continued)*										
	110.0	6.0															
	109.5	6.5															
	109.0	7.0															
	108.5	7.5															
	108.0	8.0															
	107.5	8.5															
	107.0	9.0				8.80 m to 9.10 m: Ice with silt Inclusions											
	106.5	9.5															
	106.0	10.0		[10.0]													

Notes:

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BOREHOLE REPORT

BH17-C002

Sheet 3 of 3

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 519,532.0 m

Northing: 7,957,667.0 m

Surface Elevation: 116.00 m

Bottom Elevation: 105.30 m

Total Depth: 10.7 m

Logged By: UK

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/13/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	105.5	10.5	Sonic Drilling	NO CASING [10.7]		ICE: Clear to cloudy texture *(Continued)*	ICE *(Continued)*										
	105.0	11.0				To Target Depth. **Drillhole BH17-C002 terminated at 10.7m.**											
	104.5	11.5															
	104.0	12.0															
	103.5	12.5															
	103.0	13.0															
	102.5	13.5															
	102.0	14.0															
	101.5	14.5															
	101.0	15.0															

Notes:

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BOREHOLE REPORT

BH17-C003

Sheet 1 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 520,130.0 m

Northing: 7,957,541.0 m

Surface Elevation: 118.25 m

Bottom Elevation: 109.15 m

Total Depth: 9.1 m

Logged By: UK/AB

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/14/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	118.0	0.0	Sonic Drilling	NO CASING		SILTY SAND: Brown, fine to medium grained sand											
	117.8	0.5				Inferred BOULDERS, GRAVELLY SAND: Brown, coarse grained sand; Fine to coarse, rounded to sub-angular gravel											
	117.3	1.0															
	116.8	1.5															
	116.3	2.0															
	115.8	2.5															
	115.3	3.0				GRAVELLY SILTY SAND: Grey, coarse grained, poorly graded sand; Multi-coloured, coarse, rounded gravel					7	33	46	21			
	114.8	3.5															
	114.3	4.0				4.00 m to 4.60 m: Inferred boulders											
	113.8	4.5															
	113.3	5.0		[5.0]		SILTY SAND, trace GRAVEL: Light brown, well graded sand	Nf										

Notes:

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BOREHOLE REPORT

BH17-C003

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 520,130.0 m

Northing: 7,957,541.0 m

Surface Elevation: 118.25 m

Bottom Elevation: 109.15 m

Total Depth: 9.1 m

Logged By: UK/AB

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/14/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	112.8	5.5	Sonic Drilling	NO CASING		SILTY SAND, trace GRAVEL: Light brown, well graded sand *(Continued)*	Nf *(Continued)*				24	4	73	23			
	112.3	6.0				6.10 m to 9.10 m: Some cobbles, rounded to sub-rounded, multi-coloured, up to 10 cm diamater											
	111.8	6.5															
	111.3	7.0															
	110.8	7.5															
	110.3	8.0				7.90 m: Sand changes from light brown to reddish											
	109.8	8.5															
	109.3	9.0									9	9	57	34			
	108.8	9.5				To Target Depth. **Drillhole BH17-C003 terminated at 9.1m.**											
	108.3	10.0		[10.0]													

Notes:

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BOREHOLE REPORT

BH17-C004

Sheet 1 of 3

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 520,486.0 m

Northing: 7,956,367.0 m

Surface Elevation: 116.30 m

Bottom Elevation: 105.60 m

Total Depth: 10.7 m

Logged By: AB

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/14/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	116.3	0.0	Sonic Drilling	NO CASING		SAND, some SILT, trace GRAVEL: Grey, well graded, sand; Fine to coarse, rounded to sub-rounded gravel											
	115.8	0.5															
	115.3	1.0															
	114.8	1.5				1.80 m to 3.0 m: Some cobbles											
	114.3	2.0															
	113.8	2.5															
	113.3	3.0				SILTY SAND: Light brown, fine to coarse grained, poorly graded sand	Nf										
	112.8	3.5				3.40 m: Inferred boulder											
	112.3	4.0															
	111.8	4.5				4.30 m: Inferred boulder	Vx										
	111.3	5.0		[5.0]													

Notes:

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BOREHOLE REPORT

BH17-C004

Sheet 2 of 3

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 520,486.0 m

Northing: 7,956,367.0 m

Surface Elevation: 116.30 m

Bottom Elevation: 105.60 m

Total Depth: 10.7 m

Logged By: AB

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/14/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 — 50 — 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	110.8	5.5	Sonic Drilling	NO CASING		SILTY SAND: Light brown, fine to coarse grained, poorly graded sand *(Continued)*	Nf *(Continued)*										
	110.3	6.0															
	109.8	6.5															
	109.3	7.0				7.20 m: Inferred Boulder					30	9	75	17			
	108.8	7.5				SILTY SAND, trace GRAVEL: Brown, well graded sand, multi-coloured, fine, rounded to subangular gravel											
	108.3	8.0															
	107.8	8.5															
	107.3	9.0				9.10 m to 9.80 m: Some inferred fragmented cobbles											
	106.8	9.5															
	106.3	10.0		[10.0]							10	8	60	32			

Notes:

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BOREHOLE REPORT

BH17-C004

Sheet 3 of 3

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 520,486.0 m

Northing: 7,956,367.0 m

Surface Elevation: 116.30 m

Bottom Elevation: 105.60 m

Total Depth: 10.7 m

Logged By: AB

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/14/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	105.8	10.5	Sonic Drilling	NO CASING [10.7]		SILTY SAND, trace GRAVEL: Brown, well graded sand, multi-coloured, fine, rounded to subangular gravel *(Continued)*											
	105.3	11.0				To Target Depth. **Drillhole BH17-C004 terminated at 10.7m.**											
	104.8	11.5															
	104.3	12.0															
	103.8	12.5															
	103.3	13.0															
	102.8	13.5															
	102.3	14.0															
	101.8	14.5															
	101.3	15.0															

Notes:

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BOREHOLE REPORT

BH17-C005

Sheet 1 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 525,227.0 m

Northing: 7,938,527.0 m

Surface Elevation: 185.00 m

Bottom Elevation: 175.90 m

Total Depth: 9.1 m

Logged By: UK

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/14/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	184.5	0.5	Sonic Drilling	NO CASING		SILTY SAND: Grey, fine grained, poorly graded	Nf										
	184.0	1.0					Nbn										
	183.5	1.5				ICE and SILTY SAND: Ice rich, grey, poorly graded sand	Vr										
	183.0	2.0															
	182.5	2.5															
	182.0	3.0				SILTY SAND, some GRAVEL: Grey, fine to coarse grained sand; coarse, rounded to subrounded, well graded gravel.	Nf										
	181.5	3.5															
	181.0	4.0															
	180.5	4.5				4.60 m to 6.10 m: Some cobbles, trace boulders	Nbn										
	180.0	5.0		[5.0]													

Notes:

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BOREHOLE REPORT

BH17-C005

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 525,227.0 m

Northing: 7,938,527.0 m

Surface Elevation: 185.00 m

Bottom Elevation: 175.90 m

Total Depth: 9.1 m

Logged By: UK

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/14/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	179.5	5.5	Sonic Drilling	NO CASING		SILTY SAND, some GRAVEL: Grey, fine to coarse grained sand; coarse, rounded to subrounded, well graded gravel. *(Continued)*	Nf *(Continued)*				7	19	57	24			
	179.0	6.0															
	178.5	6.5															
	178.0	7.0															
	177.5	7.5															
	177.0	8.0															
	176.5	8.5				8.50 m to 8.80 m: Some sand	Nbn										
	176.0	9.0															
	175.5	9.5				To Target Depth. **Drillhole BH17-C005 terminated at 9.1m.**											
	175.0	10.0		[10.0]													

Notes:

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BOREHOLE REPORT

BH17-C006

Sheet 1 of 3

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 527,315.0 m

Northing: 7,932,504.0 m

Surface Elevation: 178.60 m

Bottom Elevation: 167.90 m

Total Depth: 10.7 m

Logged By: AB

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/15/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	178.1	0.5	Sonic Drilling	NO CASING		SILTY SAND, inferred BOULDERS: Grey, fine grained, poorly graded sand; grey boulder fragments											
	177.6	1.0															
	177.1	1.5															
	176.6	2.0															
	176.1	2.5															
	175.6	3.0				SAND and SILT, some GRAVEL, ICE Inclusions: Brown sand; multi-coloured, fine, rounded gravel	Vr Vc				14	19	43	38			
	175.1	3.5															
	174.6	4.0															
	174.1	4.5															
	173.6	5.0		[5.0]													

Notes:

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BOREHOLE REPORT

BH17-C006

Sheet 2 of 3

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Proposed Rail Alignment

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 527,315.0 m
Northing: 7,932,504.0 m
Surface Elevation: 178.60 m
Bottom Elevation: 167.90 m
Total Depth: 10.7 m
Logged By: AB
Reviewed By: CH/WH

Contractor: Boart Longyear
Driller: Emile and/or Sam
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 4/15/2017
Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 / 50 / 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	173.1	5.5	Sonic Drilling	NO CASING		SAND and SILT, some GRAVEL, ICE Inclusions: Brown sand; multi-coloured, fine, rounded gravel *(Continued)*	Vr *(Continued)*										
	172.6	6.0					Nbe										
	172.1	6.5															
	171.6	7.0				SILT and SAND, inferred BOULDERS: Light brown silt; fine grained, well graded sand; grey boulder fragments											
	171.1	7.5															
	170.6	8.0				GRAVELLY SAND and SILT, ICE Inclusions: Light brown silt; angular gravel; possible boulders	Vx			●	16	22	42	27			
	170.1	8.5															
	169.6	9.0					Vr										
	169.1	9.5															
	168.6	10.0		[10.0]													

Notes:

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BOREHOLE REPORT

BH17-C006

Sheet 3 of 3

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 527,315.0 m

Northing: 7,932,504.0 m

Surface Elevation: 178.60 m

Bottom Elevation: 167.90 m

Total Depth: 10.7 m

Logged By: AB

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/15/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	168.1	10.5	Sonic Drilling	NO CASING [10.7]		GRAVELLY SAND and SILT, ICE Inclusions: Light brown silt; angular gravel; possible boulders *(Continued)* 10.40 m to 10.70 m: Inferred Boulders	Vx *(Continued)* Vr										
	167.6	11.0				To Target Depth. **Drillhole BH17-C006 terminated at 10.7m.**											
	167.1	11.5															
	166.6	12.0															
	166.1	12.5															
	165.6	13.0															
	165.1	13.5															
	164.6	14.0															
	164.1	14.5															
	163.6	15.0															

Notes:

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BOREHOLE REPORT

BH17-C006B

Sheet 1 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 528,253.0 m

Northing: 7,929,081.0 m

Surface Elevation: 0.00 m

Bottom Elevation: -6.10 m

Total Depth: 6.1 m

Logged By: UK

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/17/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-0.5	0.5	Sonic Drilling	NO CASING		SILTY SAND, some COBBLES: Brown, fine grained sand; rounded to sub-rounded cobbles	Nf										
	-1.0	1.0				SILTY SAND: Reddish brown, fine to medium grained sand	Nf										
	-1.5	1.5															
	-2.0	2.0					Nbn										
	-2.5	2.5															
	-3.0	3.0															
	-3.5	3.5					Nbn										
	-4.0	4.0															
	-4.5	4.5															
	-5.0	5.0		[5.0]													

Notes:

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BOREHOLE REPORT

BH17-C006B

Sheet 2 of 2

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 528,253.0 m

Northing: 7,929,081.0 m

Surface Elevation: 0.00 m

Bottom Elevation: -6.10 m

Total Depth: 6.1 m

Logged By: UK

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/17/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-5.5	5.5	Sonic Drilling	NO CASING		SILTY SAND: Reddish brown, fine to medium grained sand *(Continued)*	Nf *(Continued)*										
	-6.0	6.0		[6.1]													
						To Target Depth. **Drillhole BH17-C006B terminated at 6.1m.**											
	-6.5	6.5															
	-7.0	7.0															
	-7.5	7.5															
	-8.0	8.0															
	-8.5	8.5															
	-9.0	9.0															
	-9.5	9.5															
	-10.0	10.0															

Notes:

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BOREHOLE REPORT

BH17-C007

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 528,564.0 m

Northing: 7,917,138.0 m

Surface Elevation: 132.00 m

Bottom Elevation: 127.40 m

Total Depth: 4.6 m

Logged By: AB

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/22/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	131.5	0.5	Sonic Drilling	NO CASING		ORGANIC SILT, some SAND: Brown sand, dark grey organics, some rootlets											
	131.0	1.0															
	130.5	1.5				SILT and SAND, trace GRAVEL: Light brown, fine to coarse grained, well graded sand	Nbe										
	130.0	2.0															
	129.5	2.5					Vc										
							Vr										
	129.0	3.0															
	128.5	3.5															
	128.0	4.0				3.70 m to 4.60 m: Grey, fine grained	Vs			●	14	10	37	53			
	127.5	4.5		[4.6]													
	127.0	5.0				To Target Depth. **Drillhole BH17-C007 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH17-C010

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 529,961.0 m

Northing: 7,916,702.0 m

Surface Elevation: 0.00 m

Bottom Elevation: -4.60 m

Total Depth: 4.6 m

Logged By: AB

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/20/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-0.5	0.5	Sonic Drilling	NO CASING		SAND, trace SILT, trace GRAVEL: Brown, very dense, fine to coarse grained sand, well graded	Nf										
	-1.0	1.0															
	-1.5	1.5															
	-2.0	2.0					Nbe										
	-2.5	2.5									14	1	88	11			
	-3.0	3.0					Nf										
	-3.5	3.5															
	-4.0	4.0									15	0	90	9			
	-4.5	4.5		[4.6]													
	-5.0	5.0				To Target Depth. **Drillhole BH17-C010 terminated at 4.6m.**											

Notes:

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HATCH BOREHOLE REPORT

BH17-C011

Sheet 1 of 1

Client: Baffinland Iron Mines
Project No.: H352034
Project: Mary River Expansion Study Stage 2
Datum: NAD83
Location: Proposed Rail Alignment
Platform: Ground

Easting: 532,072.0 m
Northing: 7,917,478.0 m
Surface Elevation: 168.00 m
Bottom Elevation: 163.40 m
Total Depth: 4.6 m
Logged By: UK
Reviewed By: CH/WH

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 4/19/2017
Driller: Emile and/or Sam
Hole Diameter (mm): 100
Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	168.0	0.0	Sonic Drilling	NO CASING		SILTY SAND: Dark brown, organic	Nf										
	167.5	0.5				SILTY SAND, trace COBBLES: Brown, fine grained sand, rounded to subrounded cobbles	Nf										
	167.0	1.0															
	166.5	1.5				1.50 m to 3.0 m: No cobbles encountered	Vs										
							Vr										
	166.0	2.0															
	165.5	2.5															
	165.0	3.0															
	164.5	3.5					Nbn										
	164.0	4.0									17	0	76	24			
	163.5	4.5		[4.6]													
	163.0	5.0				To Target Depth. **Drillhole BH17-C011 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH17-C012

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 533,228.0 m

Northing: 7,918,553.0 m

Surface Elevation: 182.66 m

Bottom Elevation: 178.06 m

Total Depth: 4.6 m

Logged By: UK

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/19/2017

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	182.2	0.5	Sonic Drilling	NO CASING		SILTY SAND: Dark grey, fine grained sand	Nf										
	181.7	1.0															
	181.2	1.5					Vx										
	180.7	2.0															
	180.2	2.5				ICE: White, cloudy texture	ICE										
	179.7	3.0				GRAVELLY SILT and SAND: Brown, fine grained sand; coarse, angular to sub-angular gravel	Nf										
	179.2	3.5															
	178.7	4.0									8	25	35	40			
	178.2	4.5		[4.6]													
	177.7	5.0				To Target Depth. **Drillhole BH17-C012 terminated at 4.6m.**											

Notes:

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BOREHOLE REPORT

BH17-C013

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Proposed Rail Alignment

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 534,196.0 m

Northing: 7,918,569.0 m

Surface Elevation: 182.20 m

Bottom Elevation: 177.60 m

Total Depth: 4.6 m

Logged By: UK

Reviewed By: CH/WH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/18/2016

Driller: Emile and/or Sam

Hole Diameter (mm): 100

Date Reviewed: 6/8/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 50 100	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	181.7	0.5	Sonic Drilling	NO CASING		SAND and SILT, some GRAVEL: Brown, fine grained sand; coarse, sub-rounded to rounded gravel	Nf										
	181.2	1.0									14	12	43	46			
	180.7	1.5				ICE and SILTY SAND: Grey, fine grained sand, stratified to irregular oriented ice formation	ICE + SOIL										
	180.2	2.0															
	179.7	2.5															
	179.2	3.0															
	178.7	3.5															
	178.2	4.0															
	177.7	4.5		[4.6]													
	177.2	5.0				To Target Depth. **Drillhole BH17-C013 terminated at 4.6m.**											

Notes:

BAFFINLAND GINT LIBRARY.GLB Log ICE BOREHOLE RAIL ALIGNMENT ALL_WITH ICE LOG_REV 3.GPJ <<DrawingFile>> 13/09/2017 11:26

BOREHOLE REPORT

BH17-BR86-1

Sheet 1 of 4

Client: Baffinland Iron Mines Corporation

Project: Mary River Expansion Project

Location: North West Abutment

Project No.: H353004

Datum: NAD83

Platform: Ground

Easting: 542,257.3 m

Northing: 7,922,181.7 m

Surface Elevation: 142.93 m

Bottom Elevation: 103.33 m

Total Depth: 39.6 m

Logged By: R.S

Reviewed By: H.G

Contractor: Boart Longyear

Driller: Brent McAndrew

Rig Type/ Mounting: MiniSonic Rig

Hole Diameter (mm): 100 mm

Date Logged: 10/1/2017

Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	142.9	0.0				Sandy GRAVEL, trace Silt: Brown.	unfrozen										
	141.9	1.0				SAND, trace Silt: Brown to greyish-brown, medium to fine grained, well graded. Ice poor soil.	Nbn										
	140.9	2.0															
	139.9	3.0															
	138.9	4.0															
	137.9	5.0				ICE	ICE										
	136.9	6.0															
	135.9	7.0				SAND, trace Silt: Alternating layers of grey sand and brown silty sand, poorly graded, medium to fine grained. Ice poor soil.	Nbn										
	134.9	8.0															
	133.9	9.0															
	132.9	10.0															
	131.9	11.0															

Notes: Hole not located directly on abutment.

HATCH LIBRARY V1.01.GLB Log ICE BOREHOLE KM 86 RAIL BRIDGE ABUTMENTS.GPJ <<DrawingFile>> 05/03/2018 16:27

BOREHOLE REPORT

BH17-BR86-1
Sheet 2 of 4

Client: Baffinland Iron Mines Corporation
Project: Mary River Expansion Project
Location: North West Abutment

Project No.: H353004
Datum: NAD83
Platform: Ground

Easting: 542,257.3 m
Northing: 7,922,181.7 m
Surface Elevation: 142.93 m
Bottom Elevation: 103.33 m
Total Depth: 39.6 m
Logged By: R.S
Reviewed By: H.G

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100 mm
Date Logged: 10/1/2017
Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 25 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	130.9	12.0				SAND, trace Silt: Alternating layers of grey sand and brown silty sand, poorly graded, medium to fine grained. Ice poor soil. *(Continued)*	Nbn *(Continued)*										
	129.9	13.0															
	128.9	14.0															
	127.9	15.0															
	126.9	16.0															
	125.9	17.0															
	124.9	18.0															
	123.9	19.0															
	122.9	20.0															
	121.9	21.0															
	120.9	22.0															

Notes: Hole not located directly on abutment.

HATCH LIBRARY V1.01.GLB Log ICE BOREHOLE KM 86 RAIL BRIDGE ABUTMENTS.GPJ <<DrawingFile>> 05/03/2018 16:27

BOREHOLE REPORT

BH17-BR86-1
Sheet 3 of 4

Client: Baffinland Iron Mines Corporation
Project: Mary River Expansion Project
Location: North West Abutment

Project No.: H353004
Datum: NAD83
Platform: Ground

Easting: 542,257.3 m
Northing: 7,922,181.7 m
Surface Elevation: 142.93 m
Bottom Elevation: 103.33 m
Total Depth: 39.6 m
Logged By: R.S
Reviewed By: H.G

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100 mm
Date Logged: 10/1/2017
Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 25 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	119.9	23.0				SAND, trace Silt: Alternating layers of grey sand and brown silty sand, poorly graded, medium to fine grained. Ice poor soil. *(Continued)*	Nbn *(Continued)*										
	118.9	24.0															
	117.9	25.0															
	116.9	26.0															
	115.9	27.0															
	114.9	28.0															
	113.9	29.0				29.30m to 29.4m: Some fine gravel.											
	112.9	30.0															
	111.9	31.0															
	110.9	32.0															
	109.9	33.0															

Notes: Hole not located directly on abutment.

HATCH LIBRARY V1.01.GLB Log ICE BOREHOLE KM 86 RAIL BRIDGE ABUTMENTS.GPJ <<DrawingFile>> 05/03/2018 16:27

BOREHOLE REPORT

BH17-BR86-1
Sheet 4 of 4

Client: Baffinland Iron Mines Corporation
Project No.: H353004
Project: Mary River Expansion Project
Datum: NAD83
Location: North West Abutment
Platform: Ground

Easting: 542,257.3 m
Northing: 7,922,181.7 m
Surface Elevation: 142.93 m
Bottom Elevation: 103.33 m
Total Depth: 39.6 m
Logged By: R.S
Reviewed By: H.G

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 10/1/2017
Driller: Brent McAndrew
Hole Diameter (mm): 100 mm
Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 25 50	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	108.9	34.0				SAND, trace Silt: Alternating layers of grey sand and brown silty sand, poorly graded, medium to fine grained. Ice poor soil. *(Continued)*	Nbn *(Continued)*										
	107.9	35.0				SAND, with SILT: Brown, fine grained. Ice poor soil.	Nbn										
	106.9	36.0															
	105.9	37.0				35.0m to 37.8m: Dark brownish-grey.											
	104.9	38.0															
	103.9	39.0															
	102.9	40.0				To Target Depth. **Drillhole BH17-BR86-1 terminated at 39.6m.**											
	101.9	41.0															
	100.9	42.0															
	99.9	43.0															
	98.9	44.0															

Notes: Hole not located directly on abutment.

HATCH LIBRARY V1.01.GLB Log ICE BOREHOLE KM 86 RAIL BRIDGE ABUTMENTS.GPJ <<DrawingFile>> 05/03/2018 16:27

BOREHOLE REPORT

BH17-BR86-2

Sheet 1 of 4

Client: Baffinland Iron Mines Corporation

Project: Mary River Expansion Project

Location: North West Abutment

Project No.: H353004

Datum: NAD83

Platform: Ground

Easting: 542,268.6 m

Northing: 7,922,171.3 m

Surface Elevation: 142.97 m

Bottom Elevation: 103.37 m

Total Depth: 39.6 m

Logged By: U.K and R.S

Reviewed By: H.G

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/26/2017

Driller: Brent McAndrew

Hole Diameter (mm): 100 mm

Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 25 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	142.0	1.0				Sandy GRAVEL, trace SILT: Brown.	unfrozen										
	142.0	1.0				SAND, trace SILT: Brown and greysish-brown. Ice poor soil.	Nbn				14	25	72	2			
	141.0	2.0									23	0	93	7			
	140.0	3.0									18	0	91	9			
	139.0	4.0															
	138.0	5.0				4.6m to 6.1m: Uniform brown colour, trace multi-coloured fine gravel.					37	4	91	5			
	137.0	6.0															
	136.0	7.0															
	135.0	8.0				SAND, trace to some Silt: Alternating layers of grey sand and brown silty-sand, poorly graded. Ice poor soil.	Nbn										
	134.0	9.0															
	133.0	10.0									22	0	89	11			
	132.0	11.0															

Notes: Hole is directly on North West Abutment.

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BOREHOLE REPORT

BH17-BR86-2
Sheet 2 of 4

Client: Baffinland Iron Mines Corporation
Project: Mary River Expansion Project
Location: North West Abutment

Project No.: H353004
Datum: NAD83
Platform: Ground

Easting: 542,268.6 m
Northing: 7,922,171.3 m
Surface Elevation: 142.97 m
Bottom Elevation: 103.37 m
Total Depth: 39.6 m
Logged By: U.K and R.S
Reviewed By: H.G

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100 mm
Date Logged: 10/26/2017
Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 25 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	131.0	12.0				SAND, trace to some Silt: Alternating layers of grey sand and brown silty-sand, poorly graded. Ice poor soil. *(Continued)*	Nbn *(Continued)*				23						
	130.0	13.0															
	129.0	14.0															
	128.0	15.0															
	127.0	16.0															
	126.0	17.0															
	125.0	18.0															
	124.0	19.0															
	123.0	20.0									22	0	90	10			
	122.0	21.0															
	121.0	22.0															

Notes: Hole is directly on North West Abutment.

HATCH LIBRARY V1.01.GLB Log ICE BOREHOLE KM 86 RAIL BRIDGE ABUTMENTS.GPJ <<DrawingFile>> 05/03/2018 16:27

BOREHOLE REPORT

BH17-BR86-2
Sheet 3 of 4

Client: Baffinland Iron Mines Corporation
Project No.: H353004
Project: Mary River Expansion Project
Datum: NAD83
Location: North West Abutment
Platform: Ground

Easting: 542,268.6 m
Northing: 7,922,171.3 m
Surface Elevation: 142.97 m
Bottom Elevation: 103.37 m
Total Depth: 39.6 m
Logged By: U.K and R.S
Reviewed By: H.G

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 10/26/2017
Driller: Brent McAndrew
Hole Diameter (mm): 100 mm
Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 25 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	120.0	23.0				SAND, trace to some Silt: Alternating layers of grey sand and brown silty-sand, poorly graded. Ice poor soil. *(Continued)*	Nbn *(Continued)*										
	119.0	24.0									25						
	118.0	25.0															
	117.0	26.0															
	116.0	27.0															
	115.0	28.0															
	114.0	29.0															
	113.0	30.0									26						
	112.0	31.0															
	111.0	32.0															
	110.0	33.0															

Notes: Hole is directly on North West Abutment.

HATCH LIBRARY V1.01.GLB Log ICE BOREHOLE KM 86 RAIL BRIDGE ABUTMENTS.GPJ <<DrawingFile>> 05/03/2018 16:27

BOREHOLE REPORT

BH17-BR86-2

Sheet 4 of 4

Client: Baffinland Iron Mines Corporation

Project: Mary River Expansion Project

Location: North West Abutment

Project No.: H353004

Datum: NAD83

Platform: Ground

Easting: 542,268.6 m

Northing: 7,922,171.3 m

Surface Elevation: 142.97 m

Bottom Elevation: 103.37 m

Total Depth: 39.6 m

Logged By: U.K and R.S

Reviewed By: H.G

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/26/2017

Driller: Brent McAndrew

Hole Diameter (mm): 100 mm

Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	109.0	34.0				SAND, trace to some Silt: Alternating layers of grey sand and brown silty-sand, poorly graded. Ice poor soil. *(Continued)*	Nbn *(Continued)*										
	108.0	35.0															
	107.0	36.0															
	106.0	37.0									27						
	105.0	38.0				37.4m to 39.3m: Trace Organics, dark brownish-grey to black, thin lenses of organics.											
	104.0	39.0															
						SAND, and SILT: Brown, fine grained. Ice poor soil.	Nbn				25	0	61	39			
	103.0	40.0				To Target Depth. **Drillhole BH17-BR86-2 terminated at 39.6m.**											
	102.0	41.0															
	101.0	42.0															
	100.0	43.0															
	99.0	44.0															

Notes: Hole is directly on North West Abutment.

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BOREHOLE REPORT

BH17-BR86-3
Sheet 1 of 4

Client: Baffinland Iron Mines Corporation
Project: Mary River Expansion Project
Location: South East Abutment

Project No.: H353004
Datum: NAD83
Platform: Ground

Easting: 542,304.8 m
Northing: 7,922,141.4 m
Surface Elevation: 143.38 m
Bottom Elevation: 103.78 m
Total Depth: 39.6 m
Logged By: U.K
Reviewed By: H.G

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100 mm
Date Logged: 10/22/2017
Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 / 25 / 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	142.4	1.0				SAND with Gravel, trace Silt: Brown.	unfrozen				14	21	69	10			
	141.4	2.0				SAND, trace to some SILT: Brown and greyish- brown, medium to fine grained. Ice poor soil.	Nbn				23	0	93	7			
	140.4	3.0									24	0	94	6			
	139.4	4.0															
	138.4	5.0									25	0	89	11			
	137.4	6.0				6.1m to 9.0m: Colour changes to uniform dark brown.											
	136.4	7.0															
	135.4	8.0									26	0	78	22			
	134.4	9.0															
	133.4	10.0				SAND, trace Silt: Alternating layers of grey sand and brown silty sand, poorly graded, medium to fine. Ice poor soil.	Nbn										
	132.4	11.0															

Notes: Hole is directly on South East Abutment

HATCH LIBRARY V1.01.GLB Log ICE BOREHOLE KM 86 RAIL BRIDGE ABUTMENTS.GPJ <<DrawingFile>> 05/03/2018 16:27

BOREHOLE REPORT

BH17-BR86-3

Sheet 2 of 4

Client: Baffinland Iron Mines Corporation

Project: Mary River Expansion Project

Location: South East Abutment

Project No.: H353004

Datum: NAD83

Platform: Ground

Easting: 542,304.8 m

Northing: 7,922,141.4 m

Surface Elevation: 143.38 m

Bottom Elevation: 103.78 m

Total Depth: 39.6 m

Logged By: U.K

Reviewed By: H.G

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/22/2017

Driller: Brent McAndrew

Hole Diameter (mm): 100 mm

Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 25 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	131.4	12.0				SAND, trace Silt: Alternating layers of grey sand and brown silty sand, poorly graded, medium to fine. Ice poor soil. *(Continued)*	Nbn *(Continued)*				26	0	93	7			
	130.4	13.0															
	129.4	14.0															
	128.4	15.0															
	127.4	16.0				15.2m to 16.8m: Silty sand layers are dark brown.											
	126.4	17.0															
	125.4	18.0															
	124.4	19.0															
	123.4	20.0															
	122.4	21.0															
	121.4	22.0															

Notes: Hole is directly on South East Abutment

HATCH LIBRARY V1.01.GLB Log ICE BOREHOLE KM 86 RAIL BRIDGE ABUTMENTS.GPJ <<DrawingFile>> 05/03/2018 16:27

HATCH BOREHOLE REPORT

BH17-BR86-3

Sheet 3 of 4

Client: Baffinland Iron Mines Corporation

Project: Mary River Expansion Project

Location: South East Abutment

Project No.: H353004

Datum: NAD83

Platform: Ground

Easting: 542,304.8 m

Northing: 7,922,141.4 m

Surface Elevation: 143.38 m

Bottom Elevation: 103.78 m

Total Depth: 39.6 m

Logged By: U.K

Reviewed By: H.G

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/22/2017

Driller: Brent McAndrew

Hole Diameter (mm): 100 mm

Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 25 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	120.4	23.0				SAND, trace Silt: Alternating layers of grey sand and brown silty sand, poorly graded, medium to fine. Ice poor soil. *(Continued)*	Nbn *(Continued)*										
	119.4	24.0				23.0m to 24.5m: Colour changes to dark brown, layers are now brown and dark brown.											
	118.4	25.0															
	117.4	26.0															
	116.4	27.0															
	115.4	28.0				27.4m to 30.5m: Colour changes to grey, layers are now light and dark grey.											
	114.4	29.0															
	113.4	30.0									25	0	92	8			
	112.4	31.0				SAND, trace SILT: Brown to grey. Ice poor soil.	Nbn										
	111.4	32.0															
	110.4	33.0															

Notes: Hole is directly on South East Abutment

HATCH LIBRARY V1.01.GLB Log ICE BOREHOLE KM 86 RAIL BRIDGE ABUTMENTS.GPJ <<DrawingFile>> 05/03/2018 16:27

BOREHOLE REPORT

BH17-BR86-3

Sheet 4 of 4

Client: Baffinland Iron Mines Corporation

Project: Mary River Expansion Project

Location: South East Abutment

Project No.: H353004

Datum: NAD83

Platform: Ground

Easting: 542,304.8 m

Northing: 7,922,141.4 m

Surface Elevation: 143.38 m

Bottom Elevation: 103.78 m

Total Depth: 39.6 m

Logged By: U.K

Reviewed By: H.G

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/22/2017

Driller: Brent McAndrew

Hole Diameter (mm): 100 mm

Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 25 50	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	109.4	34.0				SAND, trace SILT: Brown to grey. Ice poor soil. *(Continued)*	Nbn *(Continued)*										
	108.4	35.0															
	107.4	36.0															
	106.4	37.0															
	105.4	38.0															
	104.4	39.0															
	103.4	40.0				To Target Depth. **Drillhole BH17-BR86-3 terminated at 39.6m.**											
	102.4	41.0															
	101.4	42.0															
	100.4	43.0															
	99.4	44.0															

Notes: Hole is directly on South East Abutment

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BOREHOLE REPORT

BH18-102-1

Sheet 1 of 2

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 102 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 555,763.0 m

Northing: 7,915,435.0 m

Surface Elevation: 168.00 m

Bottom Elevation: 158.35 m

Total Depth: 9.7 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear

Rig Type/ Mounting: Sonic Drill Rig

Date Logged: 4/7/2018

Driller: Brent McAndrew

Hole Diameter (mm): 100

Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 25 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	168.0	0.0				PEAT: Frozen with roots.	Nf										
						GRAVEL: Two boulders.											
	167.0	1.0				GRAVELLY SAND with COBBLES: Brown.											
						Start of Coring at 1.3m. ***Continued on Rock Core Log sheet.***											
	166.0	2.0															
	165.0	3.0															
	164.0	4.0															
	163.0	5.0															
	162.0	6.0															
	161.0	7.0															
	160.0	8.0															
	159.0	9.0															
	158.0	10.0															

Notes:

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BOREHOLE LOG

ROCK CORE FORMAT

BH18-102-1

Sheet 2 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 102 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 555,763.0 m

Northing: 7,915,435.0 m

Surface Elevation: 168.00 m

Bottom Elevation: 158.35 m

Total Depth: 9.7 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear **Rig Type/ Mounting:** Sonic Drill Rig **Bearing:** N/A° **Date Logged:** 4/7/2018

Driller: Brent McAndrew **Hole Diameter (mm):** 100 **Plunge:** ° **Date Checked:**

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description: ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 [100] 60 20)	RQD %	Defect Log	Defect Description: Inclination, type, infill, amount, aperture, planarity, roughness, frequency (Specific / General)
	167.0	1.0					***Resuming in Rock Core Format 1.3m.***							
	166.0	2.0					BEDROCK: Gneiss, red plagioclase feldspar, coarse to very coarse grained, strong to very strong rock, fresh. 1.73 m: One discontinuity angled approx. 30 deg, black coated, 8 mm black alteration zone. 2.09 m - 2.31 m: Fractured area. 2.31 m - 2.91 m: Becoming coarser grained. 3.00 m: Becoming grey with pink (7 mm) veins, medium grained, strong to very strong. 3.53 m - 3.74 m: Black biotite mica, fractured zone, irregularly oriented 0.5 mm - 5 mm crystals. 3.74 m - 4.54 m: Quartzo feldspathic gneiss, grey to pink, very strong to strong. 4.54 m - 4.85 m: Potassium feldspar rich, pink, fractured zone. 4.85 m - 4.96 m: Possibly chloritized, 2 mm vein, medium grained, medium strong. 4.91 m - 4.93 m: Clay vein, weak. 4.96 m - 5.06 m: Some gneissic banding, red/black fine grained, strong. 5.06 m - 5.26 m: Broken core, clay rich vein, fine to medium grained, red/black, chlorite infilled joints. 5.26 m - 6.01 m: Trace potassium feldspar banding, quartz rich, strong grey, fine. 6.06 m - 6.36 m: Quartzo feldspar with black biotite banding, potassium feldspar rich, red, chlorite infilled joints. 6.36 m - 6.59 m: Quartz and feldspar, grey. 8.12 m - 8.26 m: Gneiss, grey pink, strong. 8.26 m - 8.30 m: Possible clay zone,							
	165.0	3.0												
	164.0	4.0												
	163.0	5.0												
	162.0	6.0												
	161.0	7.0												
	160.0	8.0												
	159.0	9.0												
	158.0	10.0												

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

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BOREHOLE LOG

ROCK CORE FORMAT

BH18-102-1

Sheet 3 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 102 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 555,763.0 m

Northing: 7,915,435.0 m

Surface Elevation: 168.00 m

Bottom Elevation: 158.35 m

Total Depth: 9.7 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear **Rig Type/ Mounting:** Sonic Drill Rig **Bearing:** N/A° **Date Logged:** 4/7/2018

Driller: Brent McAndrew **Hole Diameter (mm):** 100 **Plunge:** ° **Date Checked:**

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.	Weathering/ Cementation	Estimated Strength EH VH H M L VL EL	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm 2000 600 200 [100] 60 20	RQD %	Defect Log	Defect Description Inclination, type, infill, amount, aperture, planarity, roughness, frequency Specific / General
	157.0	11.0					possibly chloritized, weak. 8.30 m - 8.61 m: Fine to medium grained, grey. 8.61 m - 8.87 m: Band of quartz to potasium feldspar, coarse grained, pink. Remainder fine to medium grained, grey, possible possible chlorite veins, trace pyrite, black biotite veins.							
	156.0	12.0					To Target Depth. **Drillhole BH18-102-1 terminated at 9.7m.**							
	155.0	13.0												
	154.0	14.0												
	153.0	15.0												
	152.0	16.0												
	151.0	17.0												
	150.0	18.0												
	149.0	19.0												
	148.0	20.0												

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

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BOREHOLE REPORT

BH18-102-2
Sheet 1 of 3

Client: Baffinland Iron Mine
Project No.: H353004
Project: Mary River Expansion Study
Datum: NAD83
Location: Proposed Bridge 102 Abutment
Platform:

Easting: 555,674.0 m
Northing: 7,915,409.0 m
Surface Elevation: 166.00 m
Bottom Elevation: 149.10 m
Total Depth: 16.9 m
Logged By: YF/MY
Reviewed By:

Contractor: Boart Longyear
Rig Type/ Mounting: Sonic Drill Rig
Date Logged: 4/8/2018
Driller: Brent McAndrew
Hole Diameter (mm): 100
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	166.0	0.0				SAND and GRAVEL: Medium grained sand, brown, slightly moist.	Nf inferred										
	165.0	1.0				GRAVELLY SAND, trace BOULDERS: Fine sand, possible boulder dust.	Nf inferred										
	164.0	2.0				GRAVELLY SAND, trace SILT: Medium to coarse grained, brownish grey to brown, subrounded to subangular.	Nf inferred										
	163.0	3.0				3.40 m and 3.70 m: Cobbles						31	69	0			
	162.0	4.0				SAND, some GRAVEL, trace SILT: Medium to fine grained, brownish grey.	Nf inferred										
	161.0	5.0				4.70 m: Inferred boulder. 5.00 m and 5.30 m: Cobble.											
	160.0	6.0				GRAVEL to COBBLES: Mixed igneous / metamorphic, washed. 5.6m: Organic / sulfur layer.											
	159.0	7.0															
	158.0	8.0															
	157.0	9.0				***Start of Coring at 8.7m.*** ***Continued on Rock Core Log sheet.***											
	156.0	10.0															

Notes:

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BOREHOLE LOG

ROCK CORE FORMAT

BH18-102-2

Sheet 2 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 102 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 555,674.0 m

Northing: 7,915,409.0 m

Surface Elevation: 166.00 m

Bottom Elevation: 149.10 m

Total Depth: 16.9 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear **Rig Type/ Mounting:** Sonic Drill Rig **Bearing:** N/A° **Date Logged:** 4/8/2018

Driller: Brent McAndrew **Hole Diameter (mm):** 100 **Plunge:** ° **Date Checked:**

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description (ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.)	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 [100] 60 20)	RQD %	Defect Log	Defect Description (Inclination, type, infill, amount, aperture, planarity, roughness, frequency) Specific / General
	165.0	1.0												
	164.0	2.0												
	163.0	3.0												
	162.0	4.0												
	161.0	5.0												
	160.0	6.0												
	159.0	7.0												
	158.0	8.0					***Resuming in Rock Core Format 8.7m.***							
	157.0	9.0		9 / 135			BEDROCK: Gneiss, visible medium to coarse grains, red, black, and grey, strong to very strong.					77		Fz DI DI 10° Jt Pl Sm 20° Jt Pl Sm Red stains sn
	156.0	10.0										22		Fz

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	DI	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

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BOREHOLE LOG

ROCK CORE FORMAT

BH18-102-2

Sheet 3 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 102 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 555,674.0 m

Northing: 7,915,409.0 m

Surface Elevation: 166.00 m

Bottom Elevation: 149.10 m

Total Depth: 16.9 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear **Rig Type/ Mounting:** Sonic Drill Rig **Bearing:** N/A° **Date Logged:** 4/8/2018

Driller: Brent McAndrew **Hole Diameter (mm):** 100 **Plunge:** ° **Date Checked:**

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description (ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.)	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 [100] 60 20)	RQD %	Defect Log	Defect Description (Inclination, type, infill, amount, aperture, planarity, roughness, frequency) Specific / General
	155.0	11.0		10 / 98			BEDROCK: Gneiss, visible medium to coarse grains, red, black, and grey, strong to very strong. *(Continued)*					22		Cz 90° Jt Pl Sm 40° Jt Cu Sm
				11 / 76			10.90 m: Possible porphyriticm, no gneissic banding.					43		70° Jt Pl Sm Orange stains sn Dl 75° Jt Pl Sm Fz
	154.0	12.0		12 / 115								87		45° Jt Pl Sm Rust staining sn Fz
	153.0	13.0		13 / 115			12.50 m: Two weathered / soft zones / seams at 13.00 m and 13.30 m, 4 mm, one visible joint, non stained.					66		Dl 30° Jt Pl Sm sn 80° Jt Pl Ro cg 50° Jt Pl Sm cg Fz
	152.0	14.0		14 / 91			13.70 m: Minor gneissic banding, becoming iron stained, black, weak.					49		20° Jt Pl Sm 75° Jt Cu Ro Rust stain, silt infill sn Dl 70° Jt Cu Sm Rusty infill sn Fz 80° Jt Pl Sm Rust infill sn Dl 5° Jt Pl Ro Black silty infill cg 75° Jt 80° Jt Pl Sm infill cg 90° Jt Cu Sm 20° Jt Cu Sm Black silt sn Fz
	151.0	15.0		15 / 117								40		
	150.0	16.0		16 / 106			15.70 m: Potassium felspar and quartz rich core, medium grained, red. 16.40 m: Quartz vein, very stained.					24		45° Jt Cu Sm Rusty sn Cz 45° Jt Cu Sm sn 45° Jt Pl Sm infill cg 80° Jt Pl Sm Rusty sn Dl 50° Jt Cu Sm
	149.0	17.0					To Target Depth. **Drillhole BH18-102-2 terminated at 16.9m.**							
	148.0	18.0												
	147.0	19.0												
	146.0	20.0												

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

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BOREHOLE REPORT

BH18-BR15-1

Sheet 1 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Bridge 15 (Kilometer 18)

Project No.: H353004

Datum: NAD83

Platform:

Easting: 555,758.0 m

Northing: 7,915,441.0 m

Surface Elevation: 78.00 m

Bottom Elevation: 60.63 m

Total Depth: 17.4 m

Logged By: MY/PS

Reviewed By:

Contractor: Boart Longyear

Driller: Brent McAndrew

Rig Type/ Mounting: Sonic Drill Rig

Hole Diameter (mm): 100

Date Logged: 3/11/2018

Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	78.0	0.0	Mini Sonic Drilling Rig BL100			SNOW	ICE										
						ICE	ICE										
	77.0	1.0				SILTY SAND, some GRAVEL: fine to medium grained sand, brownish grey.	Nf inferred										
	76.0	2.0					Possible ice feature, all melted.				6	34	44	22			
	75.0	3.0															
	74.0	4.0				4.20 m - 4.30 m: Boulder inferred with silty sand layer.					11	6	57	37			
	73.0	5.0									7						
	72.0	6.0															
	71.0	7.0															
	70.0	8.0				COBBLES and BOULDERS: Cobble at 7.75 m and 8.90 m.											
	69.0	9.0				MUD SLURRY with GRAVEL to COBBLES: Coarse gravel (26 mm).	Nf inferred										
	68.0	10.0															

Notes:

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BOREHOLE REPORT

BH18-BR15-1
Sheet 2 of 3

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Bridge 15 (Kilometer 18)

Project No.: H353004
Datum: NAD83
Platform:

Easting: 555,758.0 m
Northing: 7,915,441.0 m
Surface Elevation: 78.00 m
Bottom Elevation: 60.63 m
Total Depth: 17.4 m
Logged By: MY/PS
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: Sonic Drill Rig
Hole Diameter (mm): 100
Date Logged: 3/11/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						ROCK: 60% mafic, 10-15% red mineral, 10% black elongate, reflective. Refusal on hard rock.											
	67.0	11.0				***Start of Coring at 10.7m.***											
						Continued on Rock Core Log sheet.											
	66.0	12.0															
	65.0	13.0															
	64.0	14.0															
	63.0	15.0															
	62.0	16.0															
	61.0	17.0															
	60.0	18.0															
	59.0	19.0															
	58.0	20.0															

Notes:

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BOREHOLE LOG

ROCK CORE FORMAT

BH18-BR15-1

Sheet 3 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Bridge 15 (Kilometer 18)

Project No.: H353004

Datum: NAD83

Platform:

Easting: 555,758.0 m

Northing: 7,915,441.0 m

Surface Elevation: 78.00 m

Bottom Elevation: 60.63 m

Total Depth: 17.4 m

Logged By: MY/PS

Reviewed By:

Contractor: Boart Longyear **Rig Type/ Mounting:** Sonic Drill Rig **Bearing:** N/A° **Date Logged:** 3/11/2018

Driller: Brent McAndrew **Hole Diameter (mm):** 100 **Plunge:** ° **Date Checked:**

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description: ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 60 20) [100]	RQD %	Defect Log	Defect Description: Inclination, type, infill, amount, aperture, planarity, roughness, frequency (Specific / General)
							Resuming in Rock Core Format 10.7m.							
	67.0	11.0		1 / 130			BEDROCK: Granitic gneiss alternating with mafic bands.					52		Fz 3° Jt Pl Sm 5° Jt Pl Sm
	66.0	12.0		2 / 105								76		Dl 40° Jt Pl Sm 10° Jt Pl Sm cg
	65.0	13.0		3 / 96			12.58 m: Mafic matrix with white minerals peppered throughout, medium grain size.					43		90° Jt Pl Sm 85° Jt Pl Sm 90° Jt Pl Ro 90° Jt Pl Sm 75° Jt Pl Sm Fz 0° Jt Pl Sm Soil cg Cz
	64.0	14.0		4 / 154								92		30° Jt Pl Ro Rust staining sn 80° Jt Pl Ro Rust staining sn 90° Jt Pl Sm 45° Jt Pl Ro Rust sn 30° Jt Pl 30° Jt Pl Sm Darker staining 0° Jt Pl Ro
	63.0	15.0		5 / 101			14.80 m - 15.85 m: Dark mafic to ultramafic matrix, black visable minerals.					86		45° Jt Pl Sm 45° Jt Pl Sm 70° Jt Pl Ro Dl Fz
	62.0	16.0		6 / 99			15.85 m - 15.95 m: Granitic gneiss. 15.95 m - 17.22 m: Mafic matrix.					95		Dl 45° Jt Pl Sm
	61.0	17.0					17.22 m: Mafic matrix with red banding, granitic gneiss.							45° Jt Pl Sm Some staining, infill cg Dl 40° Jt Pl Sm Staining sn
	60.0	18.0					To Target Depth. **Drillhole BH18-BR15-1 terminated at 17.4m.**							
	59.0	19.0												
	58.0	20.0												

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

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HATCH BOREHOLE REPORT

BH18-BR15-2
Sheet 1 of 3

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Bridge 15 (Kilometer 18)

Project No.: H353004
Datum: NAD83
Platform:

Easting: 514,211.0 m
Northing: 7,965,645.0 m
Surface Elevation: 78.00 m
Bottom Elevation: 61.20 m
Total Depth: 16.8 m
Logged By: MY/PS
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: Sonic Drill Rig
Hole Diameter (mm): 100
Date Logged: 3/12/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	78.0	0.0				ICE	ICE										
	77.0	1.0				BOULDERS to COBBLES: Grey with red viens.	Nf										
						SAND, trace SILT: Fine to medium grained, light brown, red, and black.	Nbn - Vx				14	1	85	14			
	76.0	2.0				SANDY SILT: Grey.	Nbn			>>	63	1	45	54			
						SILTY SAND, trace to some GRAVEL: Fine to medium grained, brownish grey.					9	29	39	32			
	75.0	3.0					Nf										
	74.0	4.0				3.90 m: Trace boulders, sub-rounded to rounded gravel and boulders.					11	14	60	26			
	73.0	5.0				5.20 m: Some gravel, trace boulders.	Nf inferred										
	72.0	6.0									5	22	48	30			
	71.0	7.0															
	70.0	8.0	Mini Sonic Drilling Rig BL100			7.80 m: Trace cobbles.											
	69.0	9.0				8.50 m - 8.70 m: Trace boulders, coarsening downwards, sub-angular to sub-rounded.											
	68.0	10.0				9.45 m - 9.80 m: Boulders, dark matrix with granitic crystals.	Nf										

Notes:

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BOREHOLE REPORT

BH18-BR15-2

Sheet 2 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Bridge 15 (Kilometer 18)

Project No.: H353004

Datum: NAD83

Platform:

Easting: 514,211.0 m

Northing: 7,965,645.0 m

Surface Elevation: 78.00 m

Bottom Elevation: 61.20 m

Total Depth: 16.8 m

Logged By: MY/PS

Reviewed By:

Contractor: Boart Longyear

Driller: Brent McAndrew

Rig Type/ Mounting: Sonic Drill Rig

Hole Diameter (mm): 100

Date Logged: 3/12/2018

Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						10.00 m - 10.15 m: Boulders, dark matrix with granitic crystals. ***Start of Coring at 10.2m.*** ***Continued on Rock Core Log sheet.***											
	67.0	11.0															
	66.0	12.0															
	65.0	13.0															
	64.0	14.0															
	63.0	15.0															
	62.0	16.0															
	61.0	17.0															
	60.0	18.0															
	59.0	19.0															
	58.0	20.0															

Notes:

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BOREHOLE LOG

ROCK CORE FORMAT

BH18-BR15-2

Sheet 3 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Bridge 15 (Kilometer 18)

Project No.: H353004

Datum: NAD83

Platform:

Easting: 514,211.0 m

Northing: 7,965,645.0 m

Surface Elevation: 78.00 m

Bottom Elevation: 61.20 m

Total Depth: 16.8 m

Logged By: MY/PS

Reviewed By:

Contractor: Boart Longyear **Rig Type/ Mounting:** Sonic Drill Rig **Bearing:** N/A° **Date Logged:** 3/12/2018

Driller: Brent McAndrew **Hole Diameter (mm):** 100 **Plunge:** ° **Date Checked:**

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description: ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 60 20) [100]	RQD %	Defect Log	Defect Description: Inclination, type, infill, amount, aperture, planarity, roughness, frequency (Specific / General)
							Resuming in Rock Core Format 10.2m.							
	67.0	11.0					BEDROCK: Granitic gneiss, grey matrix with red veins. 10.70 m - 11.10 m: mafic matrix with plagioclase and granitic banding (gneissic banding). Crushed rock, up to 30 cm.							
	66.0	12.0												
	65.0	13.0												
	64.0	14.0					13.70 m - 13.85 m: Pulverized rock.							
	63.0	15.0												
	62.0	16.0					15.50 m: Thicker plagioclase beds, thicker clasts (granite)							
	61.0	17.0					To Target Depth. **Drillhole BH18-BR15-2 terminated at 16.8m.**							
	60.0	18.0												
	59.0	19.0												
	58.0	20.0												

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

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BOREHOLE REPORT

BH18-BR70-1

Sheet 1 of 5

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 70 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 529,138.0 m

Northing: 7,916,667.0 m

Surface Elevation: 124.00 m

Bottom Elevation: 91.50 m

Total Depth: 32.5 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear

Rig Type/ Mounting: Sonic Drill Rig

Date Logged: 4/13/2018

Driller: Brent McAndrew

Hole Diameter (mm): 100

Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	123.0	1.0				SILTY SAND: Greyish brown, fine to medium grained.	Nbn										
	122.0	2.0															
	121.0	3.0				3.00 m: Saline smelling dark organic layer. 3.30 m: Banding of silt. 3.70 m: Organic layer.	Nbn to Vx				22	0	97	3			
	120.0	4.0				4.20 m: Micaceous minerals, organics.	Vs										
	119.0	5.0															
	118.0	6.0					Nbn										
	117.0	7.0									28	0	80	20			
	116.0	8.0				7.60 m: Interbedded silt and organic layers, pungent organics.	Vr to Vx										
	115.0	9.0				ICE and SOIL: Silt, trace sand, grey.	I+S										
	114.0	10.0									36	0	3	97			

Notes:

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BOREHOLE REPORT

BH18-BR70-1
Sheet 2 of 5

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Proposed Bridge 70 Abutment

Project No.: H353004
Datum: NAD83
Platform:

Easting: 529,138.0 m
Northing: 7,916,667.0 m
Surface Elevation: 124.00 m
Bottom Elevation: 91.50 m
Total Depth: 32.5 m
Logged By: YF/MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: Sonic Drill Rig
Hole Diameter (mm): 100
Date Logged: 4/13/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 25 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						ICE and SOIL: Silt, trace sand, grey. *(Continued)*	I+S *(Continued)*										
	113.0	11.0				SILTY SAND: Brownish grey, stratified, possible laminated organics.	Nbn										
						11.30 m - 11.45 m: Clay layers.					19	0	39	61			
	112.0	12.0				11.80 m - 12.00 m: Inferred boulder.											
						12.25 m - 12.30 m: Trace gravel, grey.											
						12.70 m - 13.05 m: Inferred boulder.											
	111.0	13.0				13.30 m: Cobbles.											
	110.0	14.0				SANDY SILT, trace GRAVEL: Grey.	Nbn										
											15	9	51	40			
	109.0	15.0				15.20 m, 16.40 m: Cobbles, greyish brown.											
	108.0	16.0															
											14	19	26	55			
	107.0	17.0															
						17.40 m - 18.00 m: Boulders	Nbn inferred										
	106.0	18.0				SANDY SILT, trace CLAY: Dark grey.	Nbn inferred										
						SILT, trace GRAVEL, trace SAND: Grey, coarse grained sand.	Nbn inferred										
	105.0	19.0															
	104.0	20.0				19.80 m - 21.70 m: Trace to some											

Notes:

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BOREHOLE REPORT

BH18-BR70-1

Sheet 3 of 5

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 70 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 529,138.0 m

Northing: 7,916,667.0 m

Surface Elevation: 124.00 m

Bottom Elevation: 91.50 m

Total Depth: 32.5 m

Logged By: YF/MY

Contractor: Boart Longyear

Rig Type/ Mounting: Sonic Drill Rig

Date Logged: 4/13/2018

Driller: Brent McAndrew

Hole Diameter (mm): 100

Date Reviewed:

Reviewed By:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	103.0	21.0				angular fine to medium gravel, trace cobbles. SILT, trace GRAVEL, trace SAND: Grey, coarse grained sand. *(Continued)*	Nbn inferred *(Continued)*										
	102.0	22.0				21.70 m: Angular gravel in a silt matrix. Inferred as rock flour, cobbles, gravel, boulders, white to grey dust.											
	101.0	23.0				BEDROCK (Inferred): Rock dust.											
	100.0	24.0															
	99.0	25.0															
	98.0	26.0				***Start of Coring at 25.9m.*** ***Continued on Rock Core Log sheet.***											
	97.0	27.0															
	96.0	28.0															
	95.0	29.0															
	94.0	30.0															

Notes:

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BOREHOLE LOG

ROCK CORE FORMAT

BH18-BR70-1

Sheet 4 of 5

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 70 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 529,138.0 m

Northing: 7,916,667.0 m

Surface Elevation: 124.00 m

Bottom Elevation: 91.50 m

Total Depth: 32.5 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear **Rig Type/ Mounting:** Sonic Drill Rig **Bearing:** N/A° **Date Logged:** 4/13/2018

Driller: Brent McAndrew **Hole Diameter (mm):** 100 **Plunge:** ° **Date Checked:**

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description: ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 [100] 60 20)	RQD %	Defect Log	Defect Description: Inclination, type, infill, amount, aperture, planarity, roughness, frequency (Specific / General)
	103.0	21.0												
	102.0	22.0												
	101.0	23.0												
	100.0	24.0												
	99.0	25.0					***Resuming in Rock Core Format 25.9m.***							
	98.0	26.0		18 / 101			BEDROCK: Siltstone to dolomitic limestone, grey with dark grey / black streaks, fine to very fine grained, medium strong rock. 25.98 m - 27.02 m: Silt seams.					64		90° Jt Pl Sm 90° Jt Pl Sm Silt, light brown cg Dl 90° Jt Pl Sm 90° Jt Pl Sm Yellowish brown coating cg 90° Jt Pl Sm Silt cg 90° Jt Pl Sm Some silt cg 90° Jt Pl Sm Silt cg 90° Jt Pl Sm
	97.0	27.0					27.32 m - 27.36 m: Silt seams. 27.40 m - 28.60 m: Irregular black bands, bioturbated with mud seams, strong rock (excepting weak seams).							Sm 90° Jt Pl Sm 90° Jt Pl Sm 90° Jt Pl Sm
	96.0	28.0		19 / 72			27.82 m - 27.83 m: Silt seams.					42		Sm 90° Jt Pl Sm 90° Jt Pl Sm 90° Jt Pl Sm 90° Jt Pl Sm 90° Jt Pl Sm
	95.0	29.0		20 / 86			28.60 m - 29.50 m: No visible mud, but some core loss.					83		Sm 90° Jt Pl Sm 90° Jt Pl Sm Silt cg 90° Jt Pl Sm Silt cg 90° Jt Pl Sm 90° Jt Pl Sm 90° Jt Pl Sm 90° Jt Pl Sm 80° Jt Pl Sm 90° Jt Pl Sm
	94.0	30.0					29.50 m - 31.00 m: Bioturbated, 5 cm mud seam, strong rock.					58		Fz 90° Jt Ir Ro

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

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BOREHOLE LOG

ROCK CORE FORMAT

BH18-BR70-1

Sheet 5 of 5

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 70 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 529,138.0 m

Northing: 7,916,667.0 m

Surface Elevation: 124.00 m

Bottom Elevation: 91.50 m

Total Depth: 32.5 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear **Rig Type/ Mounting:** Sonic Drill Rig **Bearing:** N/A° **Date Logged:** 4/13/2018

Driller: Brent McAndrew **Hole Diameter (mm):** 100 **Plunge:** ° **Date Checked:**

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description (ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.)	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 [100] 60 20)	RQD %	Defect Log	Defect Description (Inclination, type, infill, amount, aperture, planarity, roughness, frequency) Specific / General
	93.0	31.0		21 / 103			BEDROCK: Siltstone to dolomitic limestone, grey with dark grey / black streaks, fine to very fine grained, medium strong rock. *(Continued)*					58		90° Jt Pl Sm Silt cg 90° Jt Pl Sm Sm 90° Jt Ir Ro 90° Jt Pl Sm 90° Jt Pl Sm 90° Jt Pl Sm Silt cg Fz 90° Jt Pl Ro Dl
	92.0	32.0		22 / 103								95		
	91.0	33.0					To Target Depth. **Drillhole BH18-BR70-1 terminated at 32.5m.**							
	90.0	34.0												
	89.0	35.0												
	88.0	36.0												
	87.0	37.0												
	86.0	38.0												
	85.0	39.0												
	84.0	40.0												

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

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BOREHOLE REPORT

BH18-BR70-2

Sheet 1 of 4

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 70 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 529,107.0 m

Northing: 7,916,700.0 m

Surface Elevation: 124.00 m

Bottom Elevation: 95.50 m

Total Depth: 28.5 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear

Rig Type/ Mounting: Sonic Drill Rig

Date Logged: 4/17/2018

Driller: Brent McAndrew

Hole Diameter (mm): 100

Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	124.0	0.0				SAND, trace to some SILT: Light brown, fine to medium grained.	Nbn										
	123.0	1.0									1	38	47	15			
											20	0	86	14			
							Nbe										
	122.0	2.0															
	121.0	3.0															
											15	0	91	9			
	120.0	4.0															
	119.0	5.0															
	118.0	6.0				6.10 m: With fine black organic layers.											
	117.0	7.0				7.00 m - 7.10 m: Silt, some sand.											
						SAND interbedded with SILT.	Nbe										
	116.0	8.0				8.30 m: Becoming finer with depth.	Vr										
	115.0	9.0				ICE: 40% soil	ICE										
						SILT, some CLAY: Dark brown.	Vr - Vs										
	114.0	10.0				9.70 m - 10.10 m: Ice lenses, snow like.					23	0	2	98			

Notes:

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BOREHOLE REPORT

BH18-BR70-2
Sheet 2 of 4

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Proposed Bridge 70 Abutment

Project No.: H353004
Datum: NAD83
Platform:

Easting: 529,107.0 m
Northing: 7,916,700.0 m
Surface Elevation: 124.00 m
Bottom Elevation: 95.50 m
Total Depth: 28.5 m
Logged By: YF/MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: Sonic Drill Rig
Hole Diameter (mm): 100
Date Logged: 4/17/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	113.0	11.0				SILT, some CLAY: Dark brown. *(Continued)* 10.50 m - 10.70 m: Fine to medium sand, trace silt. 10.70 m - 10.75 m: Ice, snow like. 10.75 m: Fine sand, interbedded with darker brown silt.	Vr - Vs *(Continued)* Nbn Vr										
	112.0	12.0				SILTY SAND, trace GRAVEL: Dark brown with layers of yellow, angular gravel. 12.70 m - 12.90 m: White to grey limestone cobbles. 12.90 m: Fine to medium gravel, angular to sub-rounded. 13.60 m - 13.70 m: Becoming darker brown.											
	110.0	14.0				COBBLES: Limestone in possible rock floor. 14.90 m - 15.20 m: Highly disturbed, dark grey wilt wirh angular gravel, inferred rock. 15.20 m - 16.80 m: Potential bedrock surface, grey angular gravel size pieces in majority crushed grey silt sized matrix. 17.10 m: Fractured rock, weathered top layer, 5 mm pockets of silt with 10 cm silt pocket below, very fine grained, laminated to fractured to full of holes. 18.30 m - 18.75 m: Loss of fines. 18.75 m - 19.30 m: Laminated, very fine grained. 19.35 m - 19.60 m: Silt, grey, pieces of rock, likely bedrock, thin horizontal laminations, smooth, horizontal	Nf inferred					0	2	98			
	104.0	20.0															

Notes:

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BOREHOLE REPORT

BH18-BR70-2

Sheet 3 of 4

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 70 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 529,107.0 m

Northing: 7,916,700.0 m

Surface Elevation: 124.00 m

Bottom Elevation: 95.50 m

Total Depth: 28.5 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear

Rig Type/ Mounting: Sonic Drill Rig

Date Logged: 4/17/2018

Driller: Brent McAndrew

Hole Diameter (mm): 100

Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 25 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	103.0	21.0				fractures, silt seams present. COBBLES: Limestone in possible rock floor. *(Continued)* ~~21.20~~ m - 22.10 m: Fractured zone, fresh, strong. ***Start of Coring at 21.3m.*** ***Continued on Rock Core Log sheet.***											
	102.0	22.0															
	101.0	23.0															
	100.0	24.0															
	99.0	25.0															
	98.0	26.0															
	97.0	27.0															
	96.0	28.0															
	95.0	29.0															
	94.0	30.0															

Notes:

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BOREHOLE LOG

ROCK CORE FORMAT

BH18-BR70-2

Sheet 4 of 4

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 70 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 529,107.0 m

Northing: 7,916,700.0 m

Surface Elevation: 124.00 m

Bottom Elevation: 95.50 m

Total Depth: 28.5 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear **Rig Type/ Mounting:** Sonic Drill Rig **Bearing:** N/A° **Date Logged:** 4/17/2018

Driller: Brent McAndrew **Hole Diameter (mm):** 100 **Plunge:** ° **Date Checked:**

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description: ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 [100] 60 20)	RQD %	Defect Log	Defect Description: Inclination, type, infill, amount, aperture, planarity, roughness, frequency (Specific / General)
	103.0	21.0					***Resuming in Rock Core Format 21.3m.***							
	102.0	22.0					BEDROCK: Siltstone to dolomitic limestone. 22.10 m - 24.00 m: Fractured, crystal filled (white, medium grade) voids from 23.30 m, fresh, strong.							
	101.0	23.0												
	100.0	24.0					24.00 m - 25.50 m: Void to 24.40 m, becoming beige 24.50 m - 24.70 m, mottled.							
	99.0	25.0												
	98.0	26.0					25.50 m - 27.00 m: Beige mottled from 25.60 m - 26.00 m, decreasing in beige concentrate after, fresh.							
	97.0	27.0												
	96.0	28.0					27.00 m - 28.50 m: Beige mottled grey mudstone, becoming more banded, strong, fresh, one vein at 28.00 m.							
	95.0	29.0					To Target Depth. **Drillhole BH18-BR70-2 terminated at 28.5m.**							
	94.0	30.0												

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

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Appendix C
Sample Photographs

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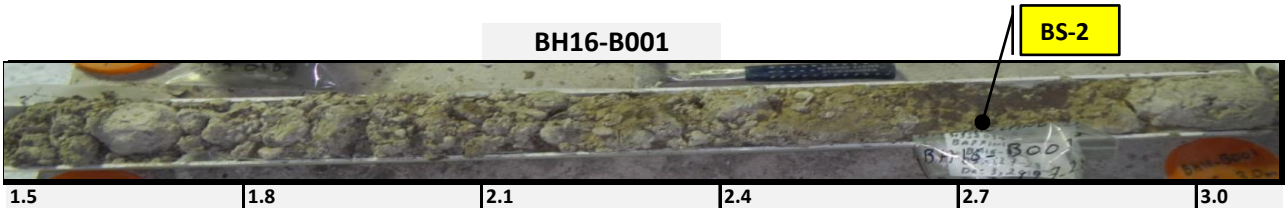
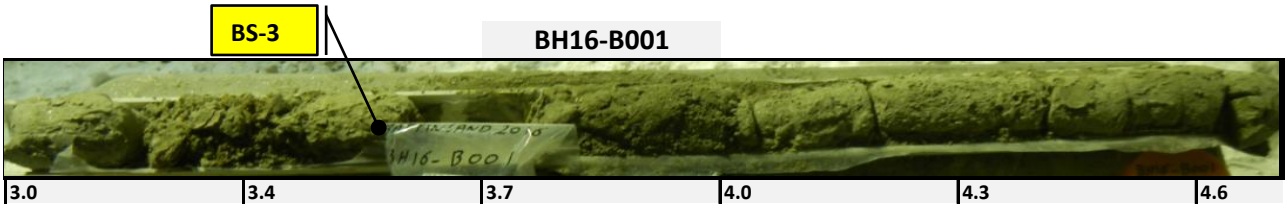
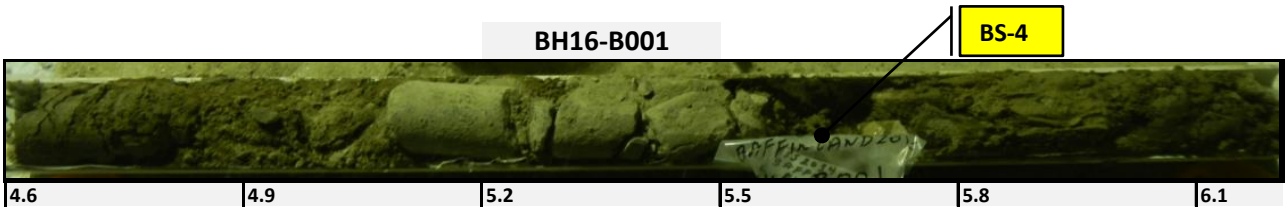
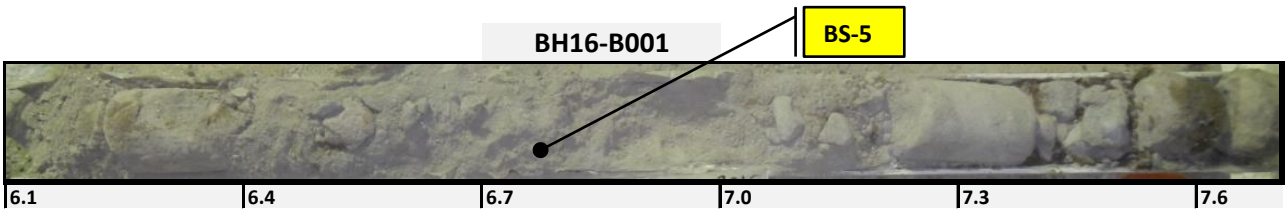
Sample Photographs

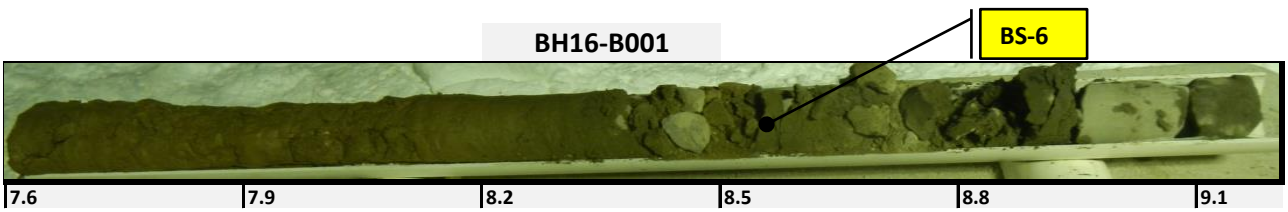
Borehole Name:	BH16-B001	Mary River 12 MTPA Mine Expansion
Location:	17 W 514191 7965675	Pre-feasibility Study
Completion Date:	3/12/2016	Baffinland Iron Mines











BH16-B001

9.1	9.4	9.8	10.1	10.4	10.7

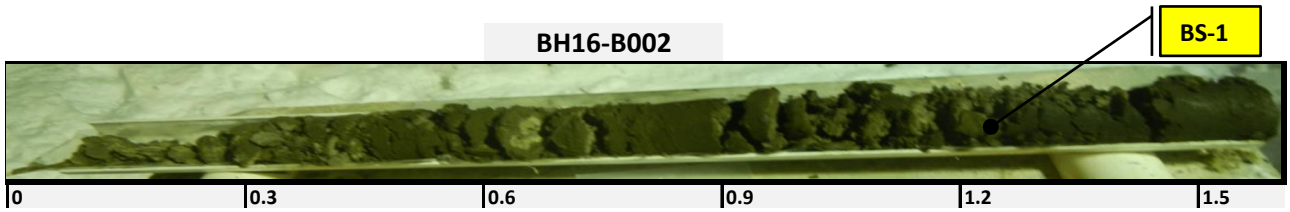
BH16-B001

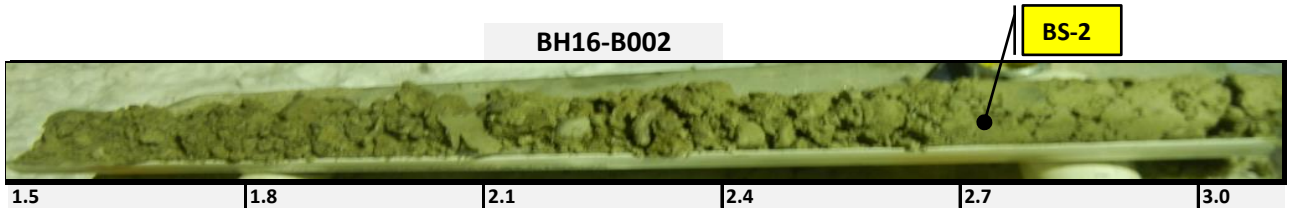
10.7	11.0	11.3	11.6	11.9	12.2

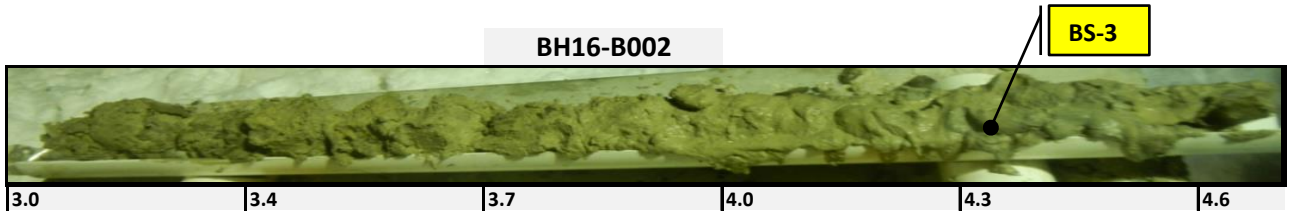
HATCH

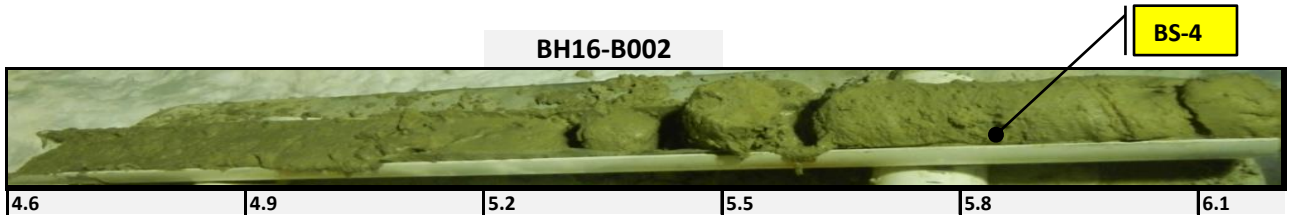
Sample Photographs

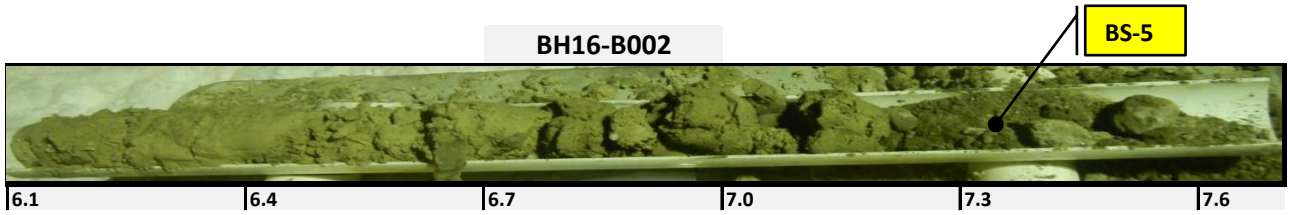
Borehole Name:	BH16-B002	Mary River 12 MTPA Mine Expansion
Location:	17 W 514290 7965604	Pre-feasibility Study
Completion Date:	2/12/2016	Baffinland Iron Mines





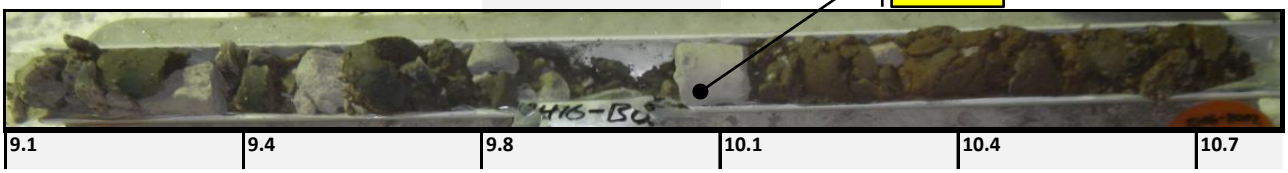






BH16-B002

BS-7

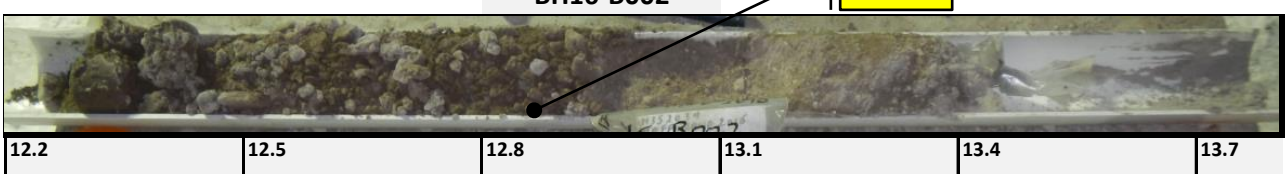


BH16-B002

BS-8

BH16-B002

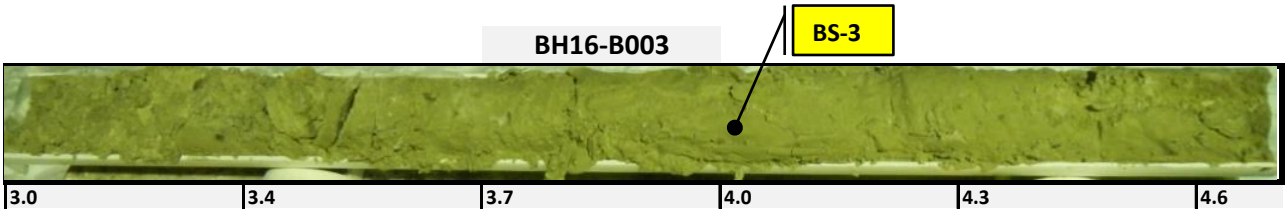
BS-9

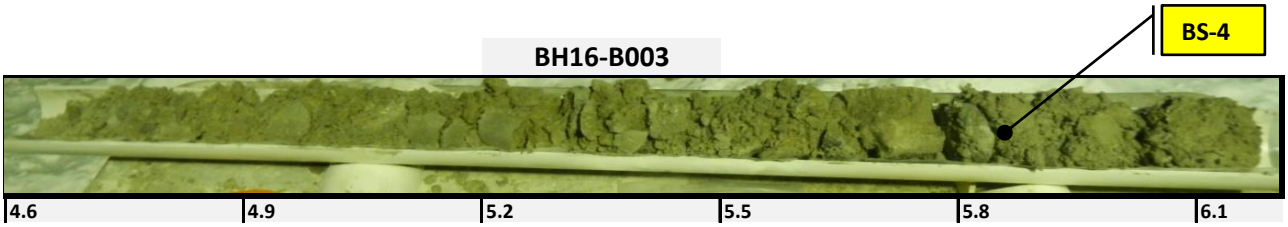


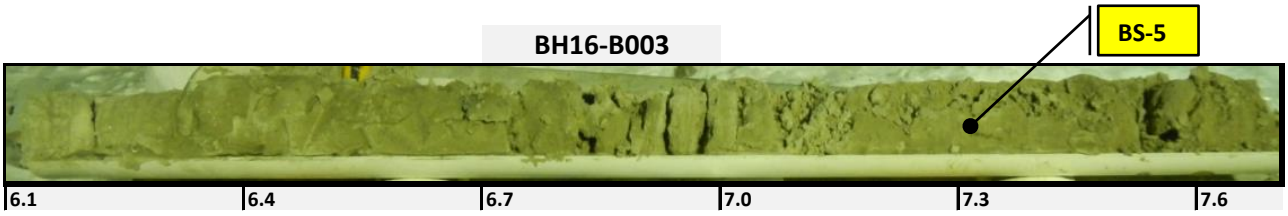
HATCH

Sample Photographs

Borehole Name:	BH16-B003	Mary River 12 MTPA Mine Expansion
Location:	17 W 514357 7965533	Pre-feasibility Study
Completion Date:	2/12/2016	Baffinland Iron Mines







HATCH

BH16-B003

9.1	9.4	9.8	10.1	10.4	10.7

BH16-B003

10.7	11.0	11.3	11.6	11.9	12.2

BH16-B003

12.2	12.5	12.8	13.1	13.4	13.7

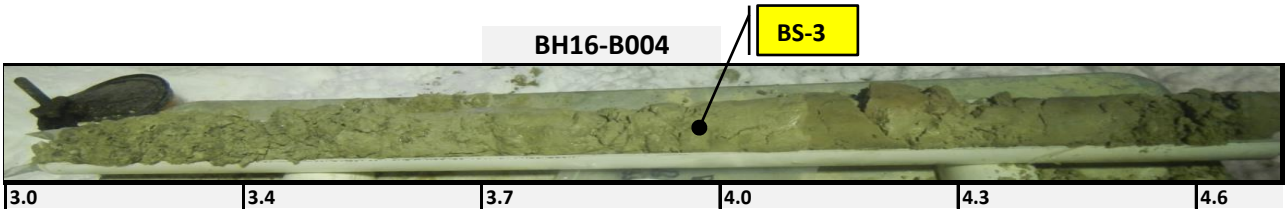
BH16-B003

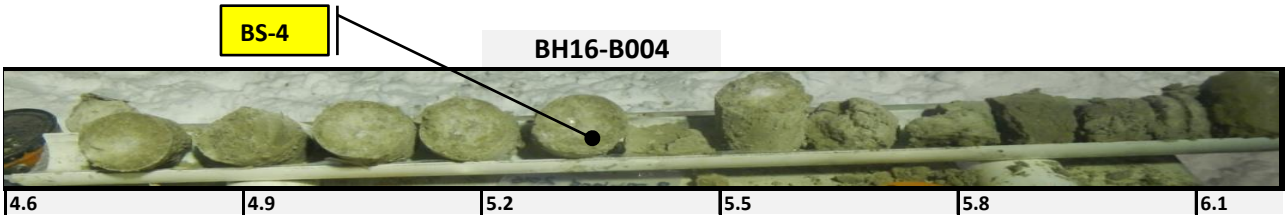
13.7	14.0	14.3	14.6	14.9	15.2

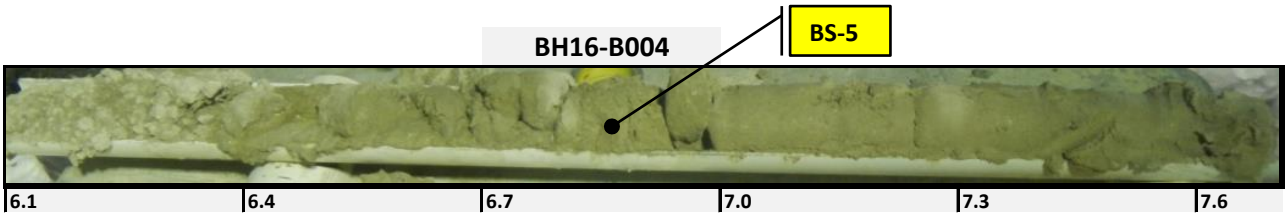
HATCH

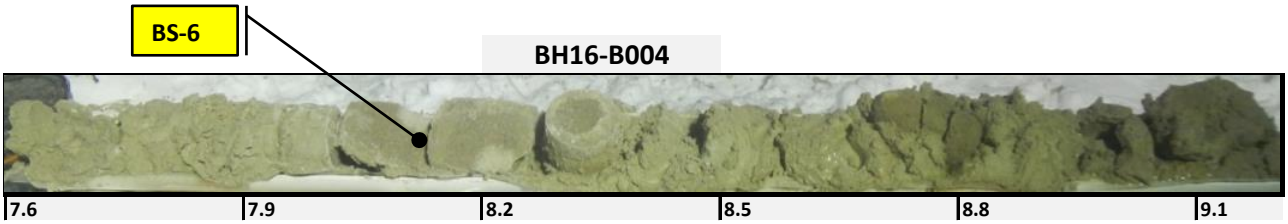
Sample Photographs

Borehole Name:	BH16-B004	Mary River 12 MTPA Mine Expansion
Location:	17 W 514367 7965540	Pre-feasibility Study
Completion Date:	1/12/2016	Baffinland Iron Mines









BS-7

BH16-B004

10.6	10.9	11.2	11.5	11.8	12.1

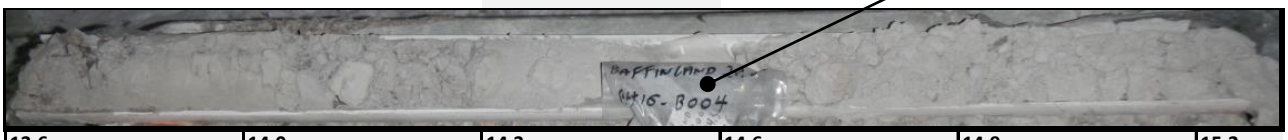
BS-8

BH16-B004

12.1	12.4	12.7	13.0	13.3	13.6

BS-9

BH16-B004



13.6	14.0	14.3	14.6	14.9	15.2

BS-10

BH16-B004

15.2	15.5	15.8	16.1	16.4	16.7

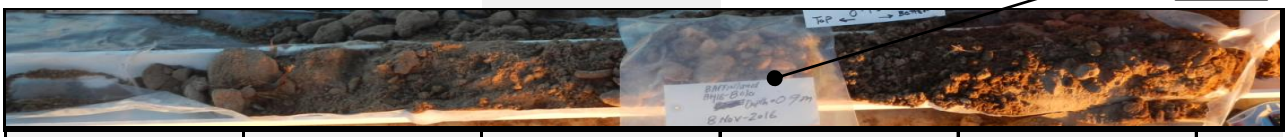
HATCH

Sample Photographs

Borehole Name:	BH16-B010	Mary River 12 MTPA Mine Expansion
Location:	17 W 542208 7922304	Pre-feasibility Study
Completion Date:	08/10/2016	Baffinland Iron Mines

BH16-B010

BS-1



0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-B010

BS-2

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-B010

BS-3

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BS-4

BH16-B010

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BS-5

BH16-B010

6.1 | 6.6 | 7.1 | 7.6 | 8.1 | 8.6

BH16-B010

BS-6

8.6 | 8.9 | 9.2 | 9.5 | 9.8 | 10.1

HATCH

Sample Photographs

Borehole Name:	BH16-B013	Mary River 12 MTPA Mine Expansion
Location:	17 W 555619 7914671	Pre-feasibility Study
Completion Date:	13/11/2016	Baffinland Iron Mines

BH16-B013

Sample photo not taken

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-B013

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

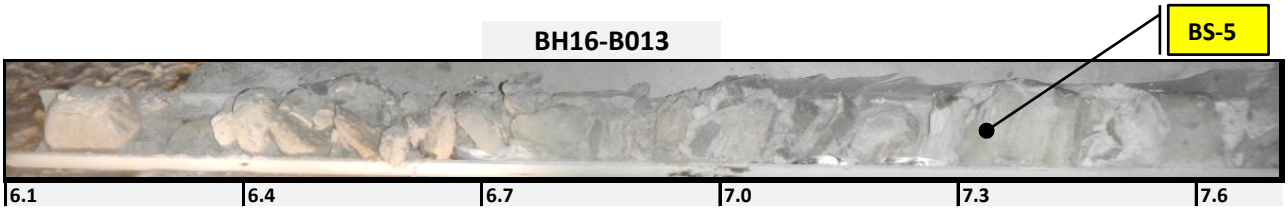
BH16-B013

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH16-B013

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH16-B013



6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

BH16-B013

7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

HATCH

BH16-B013

9.1	9.4	9.8	10.1	10.4	10.7

Sample Photographs

Borehole Name:	BH16-B014	Mary River 12 MTPA Mine Expansion
Location:	17 W 555599 7914683	Pre-feasibility Study
Completion Date:	14/11/2016	Baffinland Iron Mines

BH16-B014

BH16-B014

BH16-B014

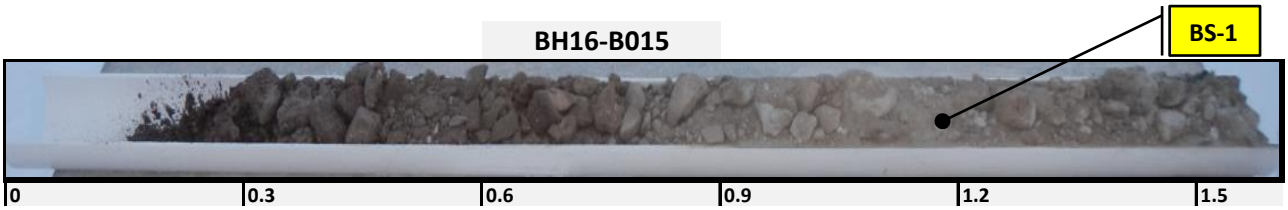
BH16-B014

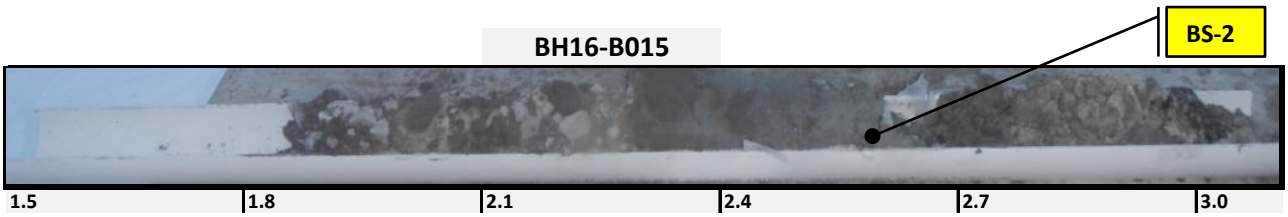
BH16-B014

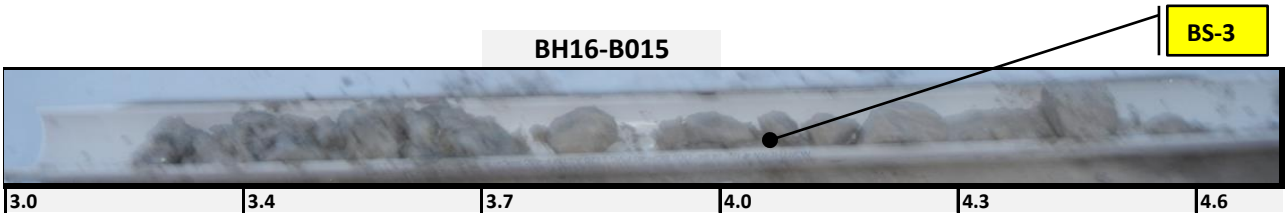
BH16-B014

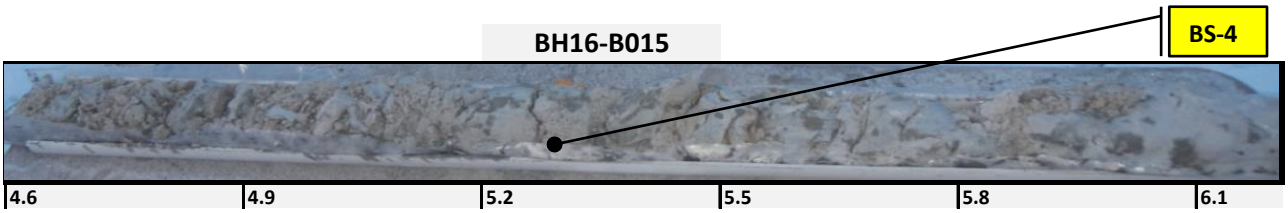
Sample Photographs

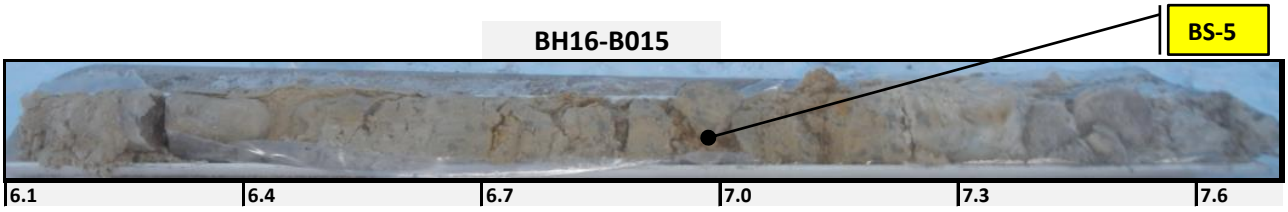
Borehole Name:	BH16-B015	Mary River 12 MTPA Mine Expansion
Location:	17 W 555824 7914884	Pre-feasibility Study
Completion Date:	14/11/2016	Baffinland Iron Mines

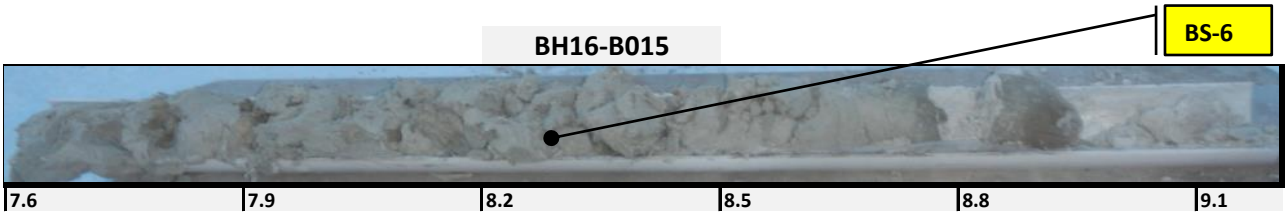












BH16-B015

9.1	9.4	9.8	10.1	10.4	10.7

BH16-B015

10.7	11.0	11.3	11.6	11.9	12.2

BH16-B015

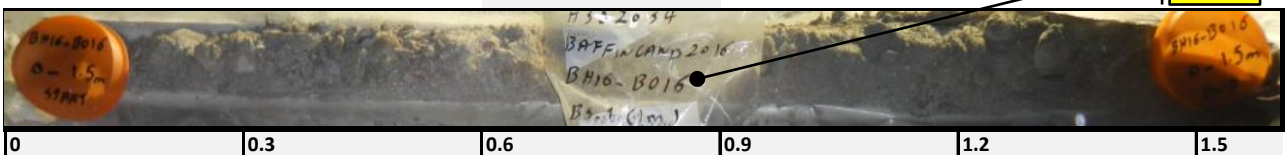
12.2	12.5	12.8	13.1	13.4	13.7

HATCH

Sample Photographs

Borehole Name:	BH16-B016	Mary River 12 MTPA Mine Expansion
Location:	17 W 555830 7914892	Pre-feasibility Study
Completion Date:	14/11/2016	Baffinland Iron Mines

BH16-B016

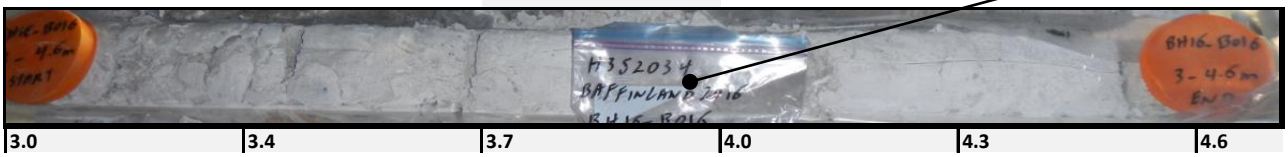


0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-B016

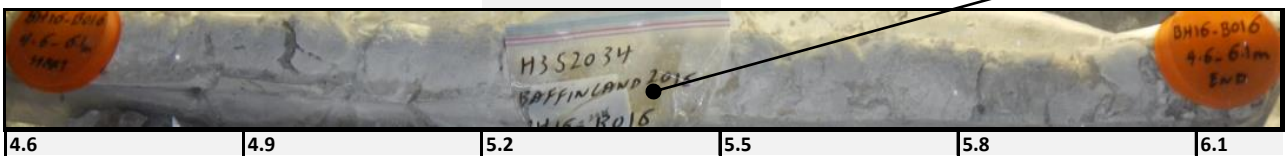
1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-B016



3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH16-B016



4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH16-B016

6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

HATCH

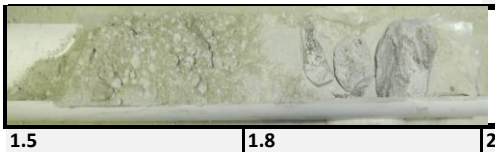
Sample Photographs

Borehole Name:	BH16-C006	Mary River 12 MTPA Mine Expansion
Location:	17 W 508897 7968767	Pre-feasibility Study
Completion Date:	3/12/2016	Baffinland Iron Mines

BH16-C006

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-C006



End of borehole at 2.1m

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

Sample Photographs

Borehole Name:	BH16-C007	Mary River 12 MTPA Mine Expansion
Location:	17 W 517221 7962080	Pre-feasibility Study
Completion Date:	1/12/2016	Baffinland Iron Mines

BH16-C007

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-C007

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-C007

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH16-C007

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH16-C007

6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

HATCH

Sample Photographs

Borehole Name:	BH16-C008	Mary River 12 MTPA Mine Expansion
Location:	17 W 520080 7965909	Pre-feasibility Study
Completion Date:	11/30/2016	Baffinland Iron Mines

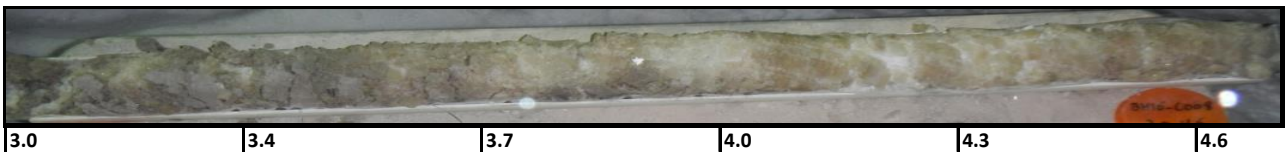
BH16-C008

0	0.3	0.6	0.9	1.2	1.5

BH16-C008

1.5	1.8	2.1	2.4	2.7	3.0

BH16-C008



3.0	3.4	3.7	4.0	4.3	4.6

BH16-C008

4.6	4.9	5.2	5.5	5.8	6.1

BH16-C008

6.1	6.4	6.7	7.0	7.3	7.6

BH16-C008

7.6	7.9	8.2	8.5	8.8	9.1

BH16-C008

9.1	9.4	9.8	10.1	10.4	10.7

BH16-C008

10.7	11.0	11.3	11.6	11.9	12.2

BH16-C008

12.2	12.5	12.8	13.1	13.4	13.7

HATCH

Sample Photographs

Borehole Name:	BH16-C009	Mary River 12 MTPA Mine Expansion
Location:	17 W 522032 7948728	Pre-feasibility Study
Completion Date:	28/11/2016	Baffinland Iron Mines

BH16-C009

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

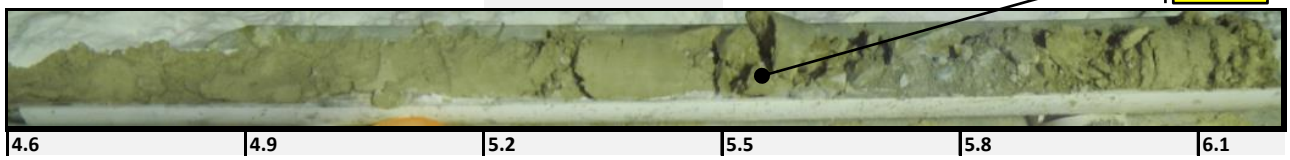
BH16-C009

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-C009

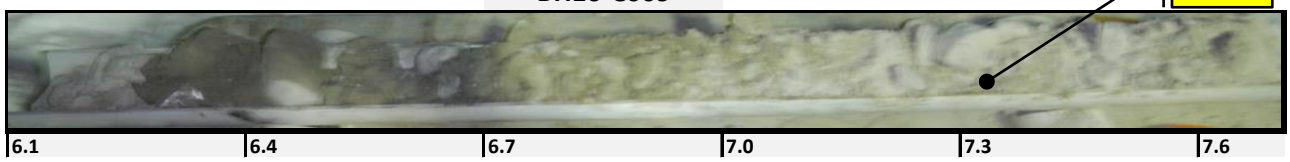
3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH16-C009



4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH16-C009



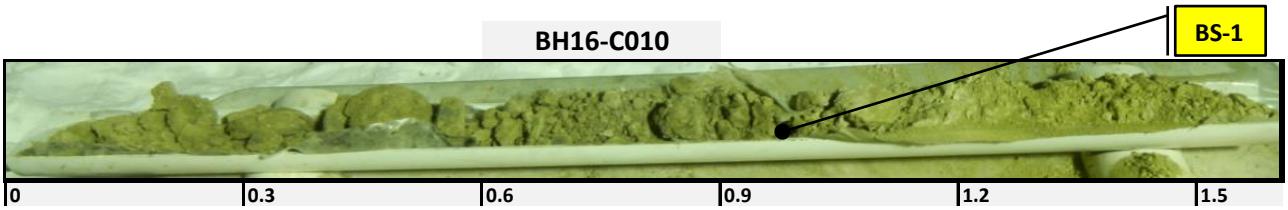
6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

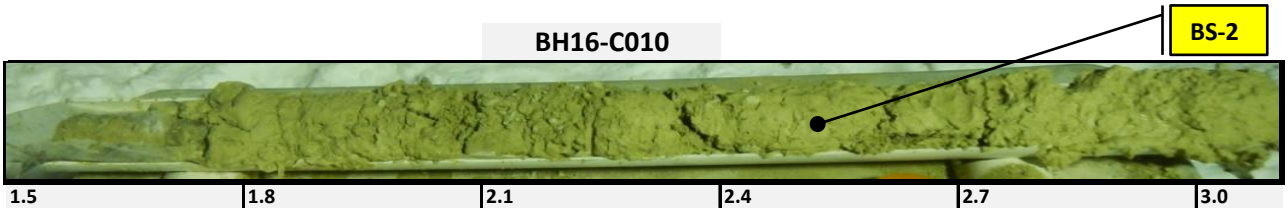
BH16-C009

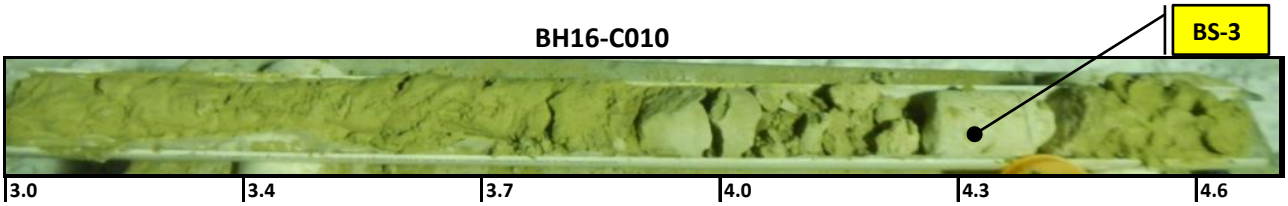
7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

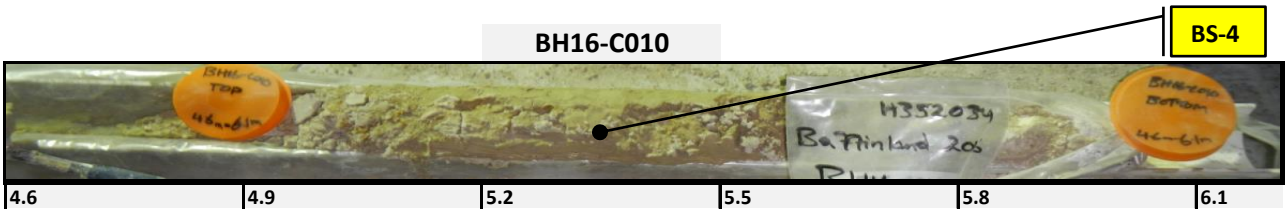
Sample Photographs

Borehole Name:	BH16-C010	Mary River 12 MTPA Mine Expansion
Location:	17 W 522513 7946595	Pre-feasibility Study
Completion Date:	27/11/2016	Baffinland Iron Mines





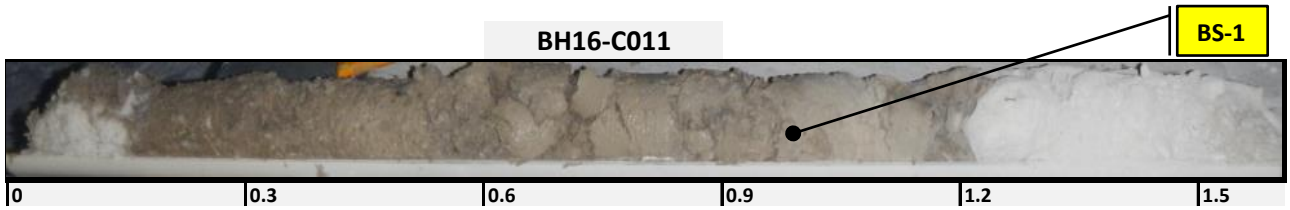




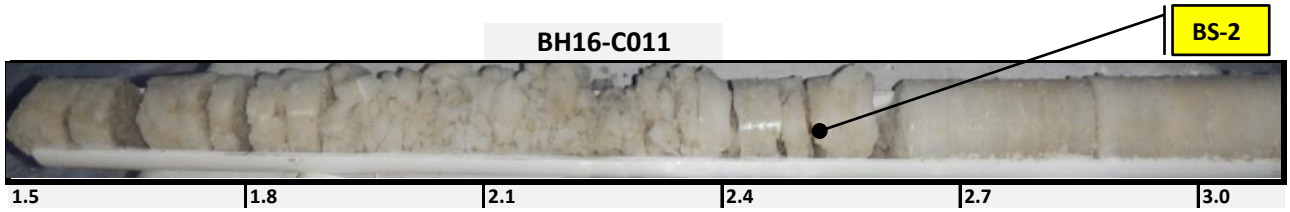
Sample Photographs

Borehole Name:	BH16-C011	Mary River 12 MTPA Mine Expansion
Location:	17 W 525427 7937567	Pre-feasibility Study
Completion Date:	27/11/2016	Baffinland Iron Mines

BH16-C011



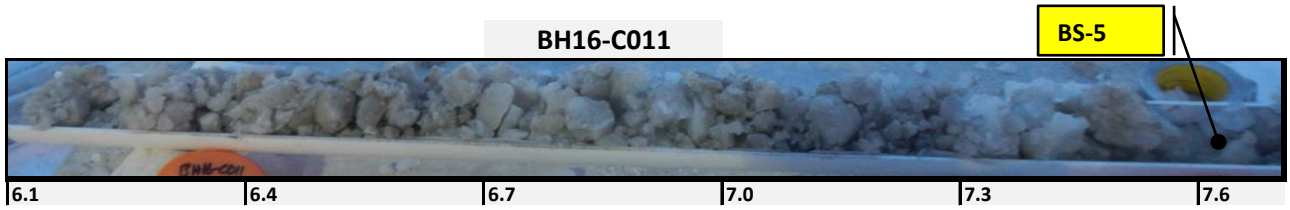
BH16-C011



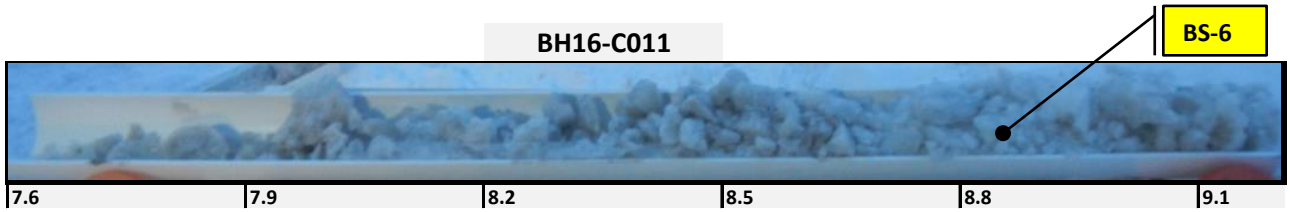
BH16-C011

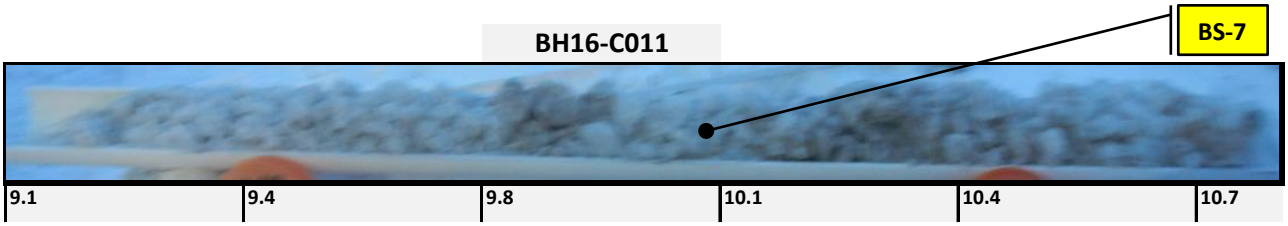
BH16-C011

BH16-C011



BH16-C011




BH16-C011
BS-7
9.1
9.4
9.8
10.1
10.4
10.7

HATCH

Sample Photographs

Borehole Name:	BH16-C015	Mary River 12 MTPA Mine Expansion
Location:	17 W 536142 7918691	Pre-feasibility Study
Completion Date:	24/11/2016	Baffinland Iron Mines

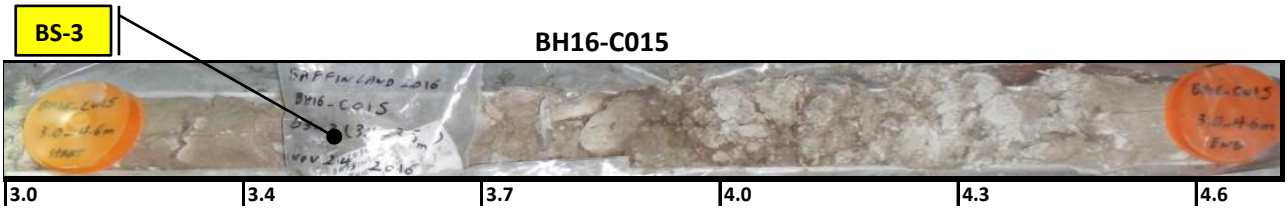
BH16-C015

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-C015

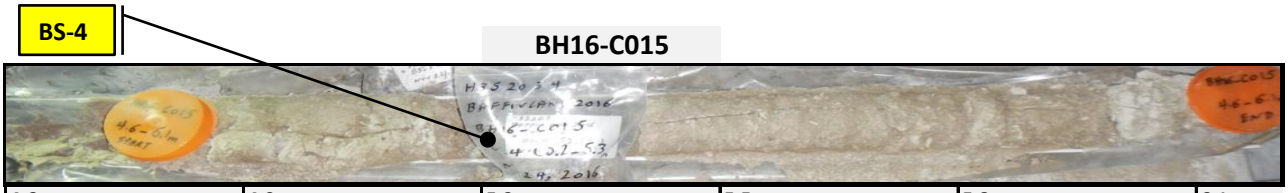
1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-C015



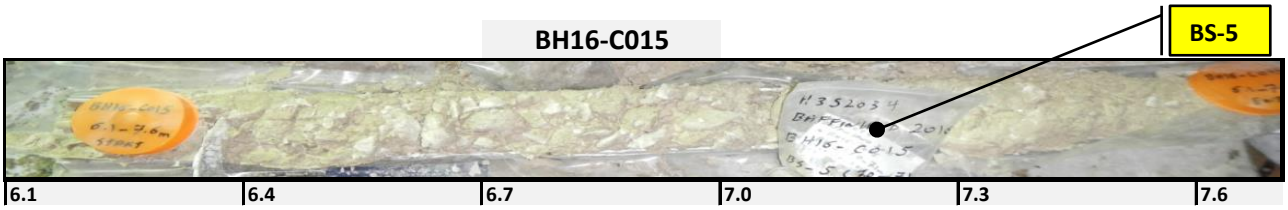
3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH16-C015



4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH16-C015



6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

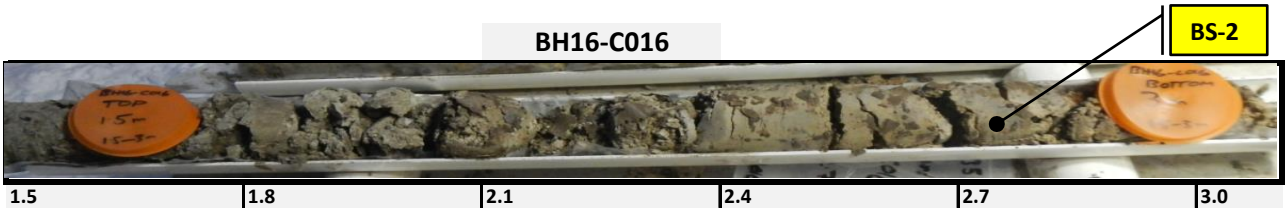
Sample Photographs

Borehole Name:	BH16-C016	Mary River 12 MTPA Mine Expansion
Location:	17 W 536362 7918814	Pre-feasibility Study
Completion Date:	24/11/2016	Baffinland Iron Mines

BH16-C016

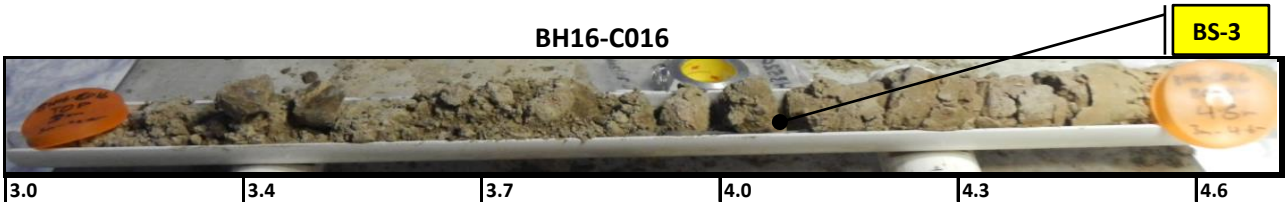
0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-C016



1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-C016

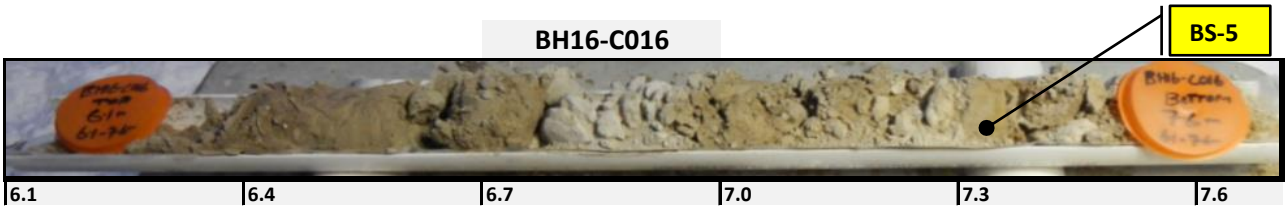


3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH16-C016

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH16-C016



6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

Sample Photographs

Borehole Name:	BH16-C017	Mary River 12 MTPA Mine Expansion
Location:	17 W 538597 7919724	Pre-feasibility Study
Completion Date:	23/11/2016	Baffinland Iron Mines

BH16-C017

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

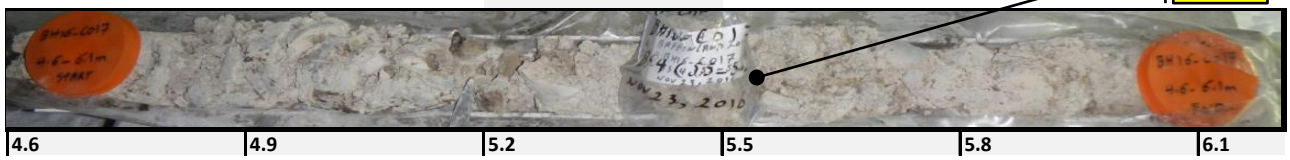
BH16-C017

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-C017

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

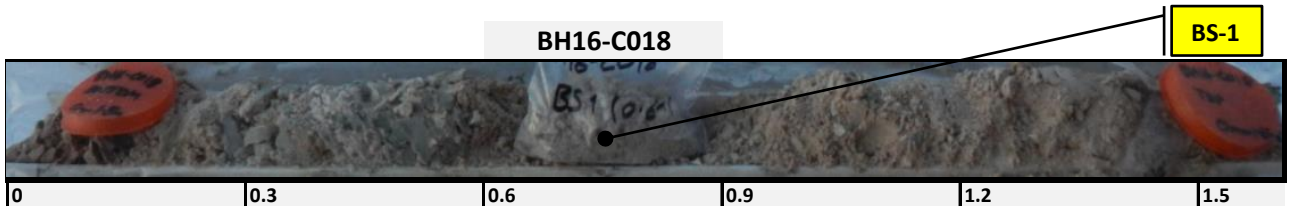
BH16-C017

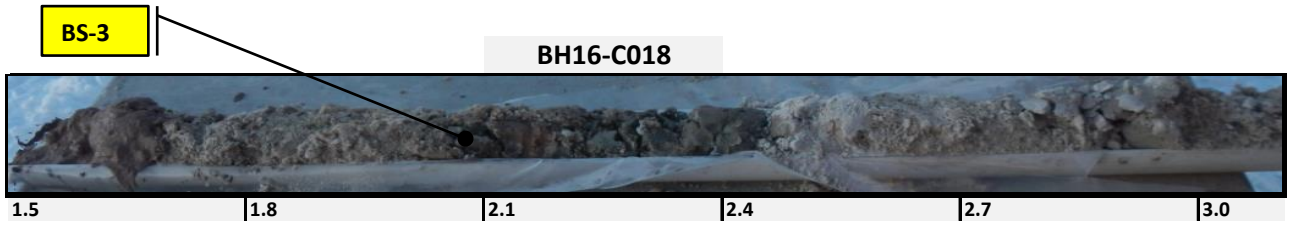


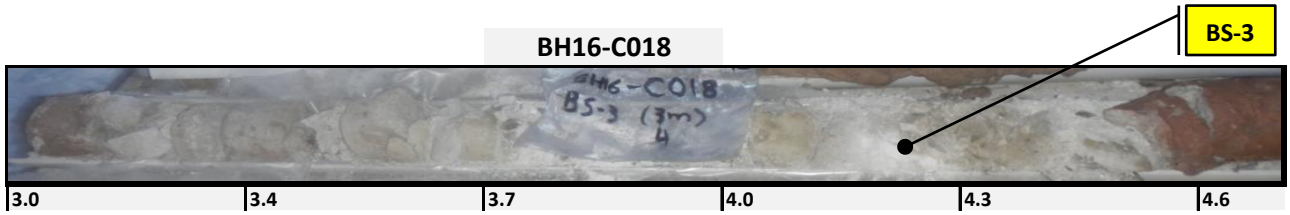
4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

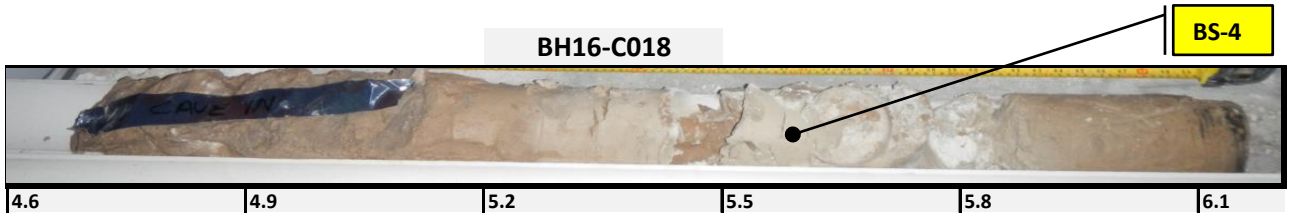
Sample Photographs

Borehole Name:	BH16-C018	Mary River 12 MTPA Mine Expansion
Location:	17 W 546111 7920740	Pre-feasibility Study
Completion Date:	10/11/2016	Baffinland Iron Mines



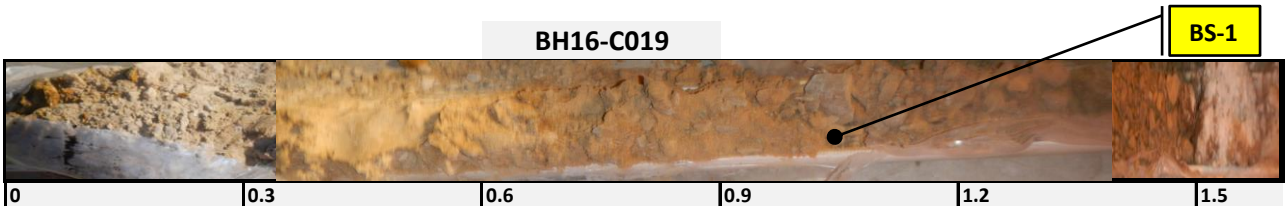


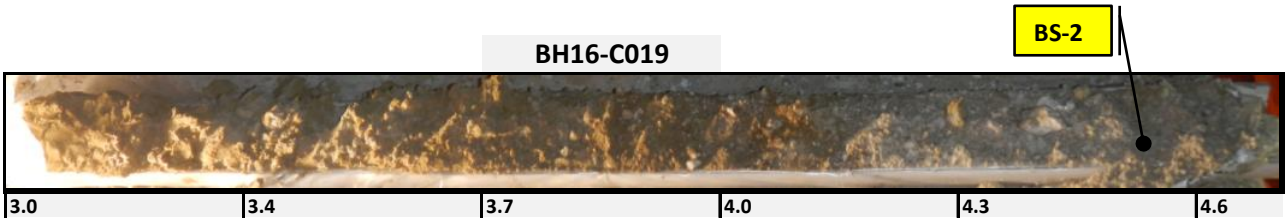




Sample Photographs

Borehole Name:	BH16-C019	Mary River 12 MTPA Mine Expansion
Location:	17 W 546163 7920494	Pre-feasibility Study
Completion Date:	10/11/2016	Baffinland Iron Mines





Sample Photographs

Borehole Name:	BH16-C019B	Mary River 12 MTPA Mine Expansion
Location:	17 W 546214 7920455	Pre-feasibility Study
Completion Date:	11/11/2016	Baffinland Iron Mines

BH16-C019B

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-C019B

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-C019B

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH16-C019B

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

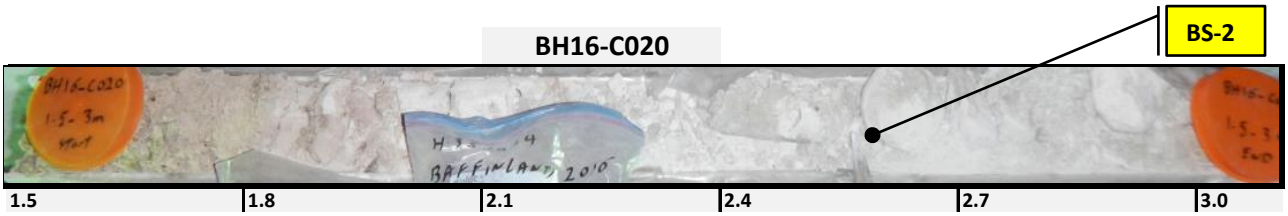
Sample Photographs

Borehole Name:	BH16-C020	Mary River 12 MTPA Mine Expansion
Location:	17 W 546402 7920072	Pre-feasibility Study
Completion Date:	10/11/2016	Baffinland Iron Mines

BH16-C020

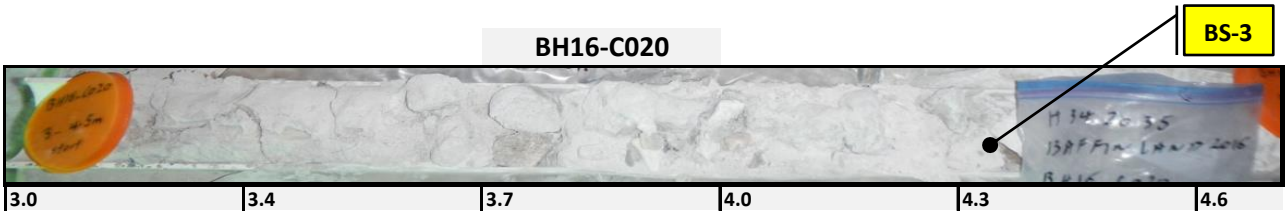
0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-C020



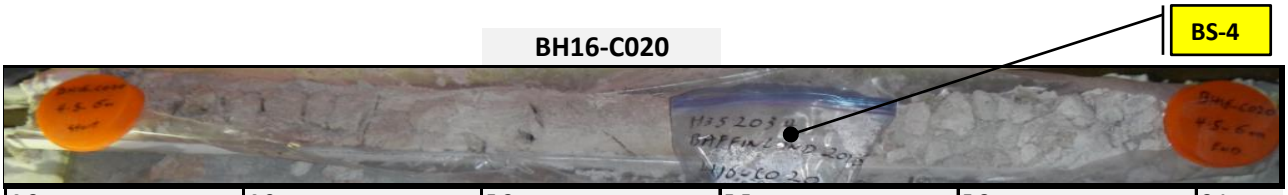
1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-C020



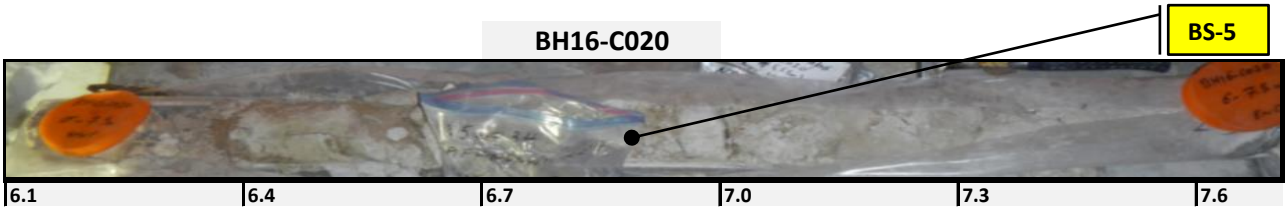
3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH16-C020



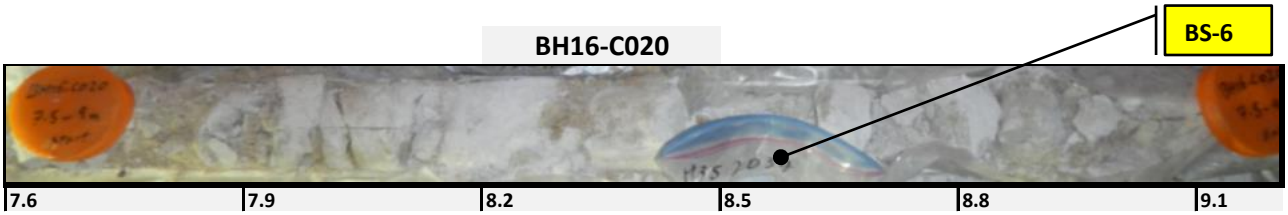
4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH16-C020



6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

BH16-C020



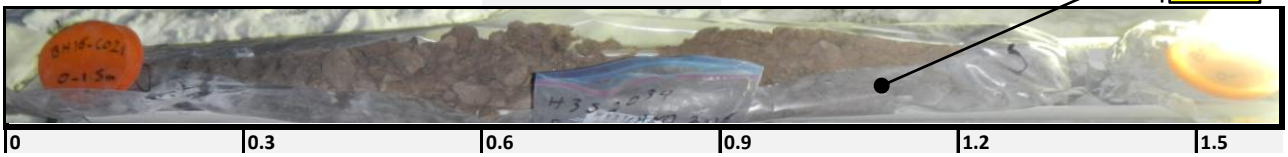
7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

HATCH

Sample Photographs

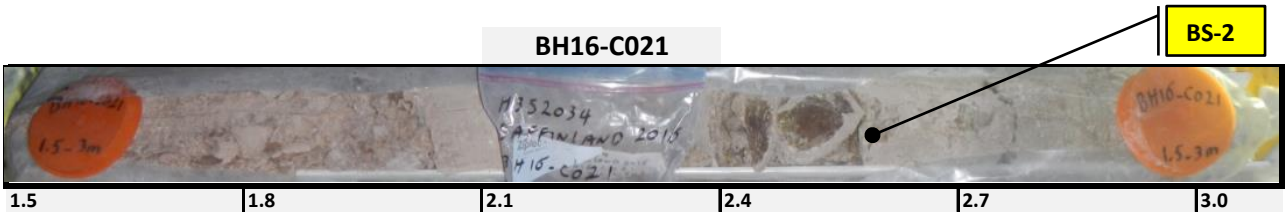
Borehole Name:	BH16-C021	Mary River 12 MTPA Mine Expansion
Location:	17 W 546593 7919917	Pre-feasibility Study
Completion Date:	09/11/2016	Baffinland Iron Mines

BH16-C021



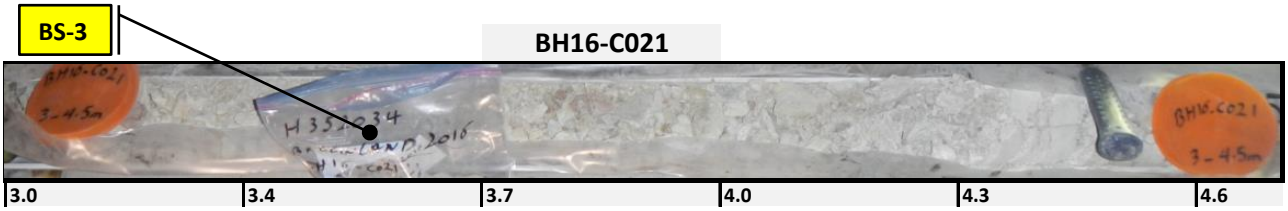
0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-C021



1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-C021



3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

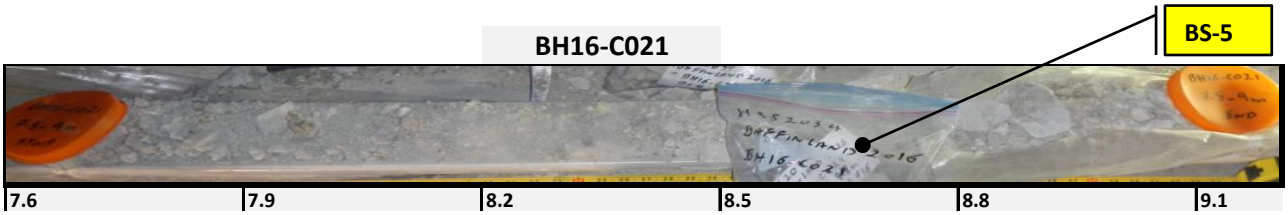
BH16-C021

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH16-C021

6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

BH16-C021



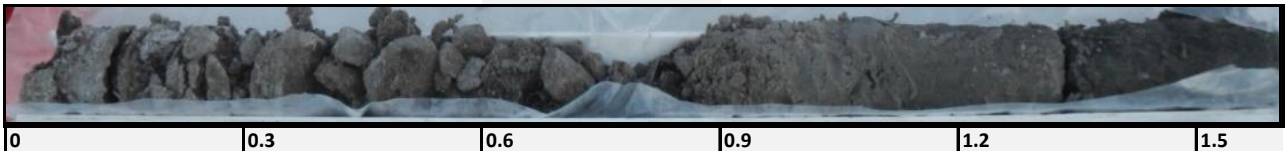
7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

HATCH

Sample Photographs

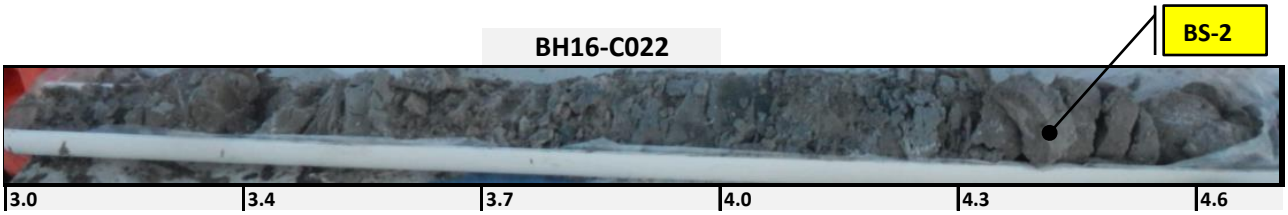
Borehole Name:	BH16-C022	Mary River 12 MTPA Mine Expansion
Location:	17 W 547077 7919746	Pre-feasibility Study
Completion Date:	11/11/2016	Baffinland Iron Mines

BH16-C022



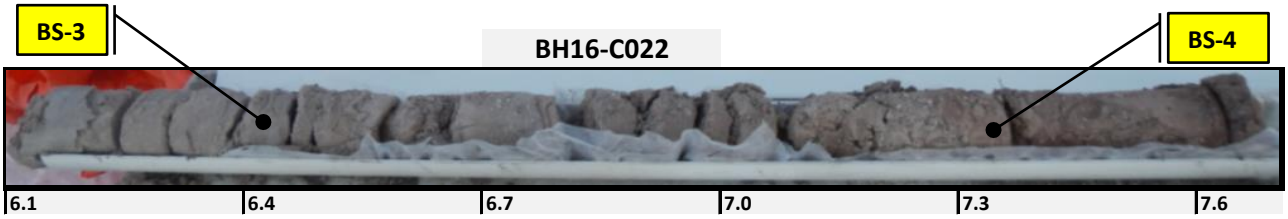
BH16-C022

BH16-C022

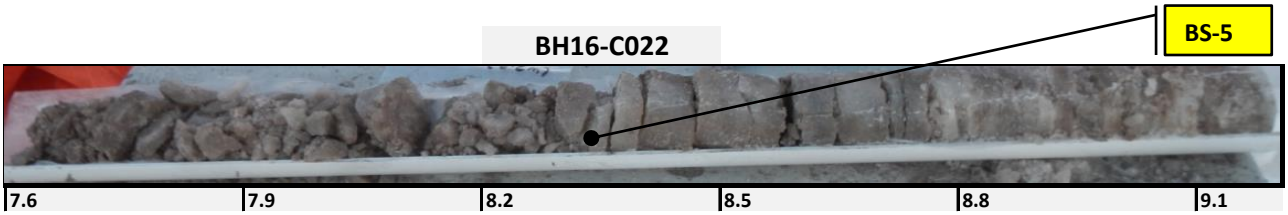


BH16-C022

BH16-C022



BH16-C022



HATCH

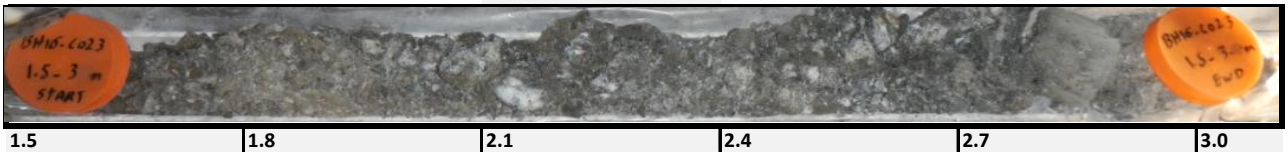
Sample Photographs

Borehole Name:	BH16-C023	Mary River 12 MTPA Mine Expansion
Location:	17 W 547304 7919643	Pre-feasibility Study
Completion Date:	11/11/2016	Baffinland Iron Mines

BH16-C023

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-C023



1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BS-1

BH16-C023

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BS-2

BH16-C023

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BS-3

BH16-C023

6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

BH16-C023

7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

BH16-C023

9.1	9.4	9.8	10.1	10.4	10.7

HATCH

Sample Photographs

Borehole Name:	BH16-C024	Mary River 12 MTPA Mine Expansion
Location:	17 W 547530 7919537	Pre-feasibility Study
Completion Date:	14/11/2016	Baffinland Iron Mines

BH16-C024

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-C024

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BS-1

BH16-C024

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BS-2

BH16-C024

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH16-C024

BS-3

6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

BH16-C024

BS-4

7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

HATCH

BH16-C024

9.1	9.4	9.8	10.1	10.4	10.7

Sample Photographs

Borehole Name:	BH16-C025	Mary River 12 MTPA Mine Expansion
Location:	17 W 548370 7919181	Pre-feasibility Study
Completion Date:	12/11/2016	Baffinland Iron Mines

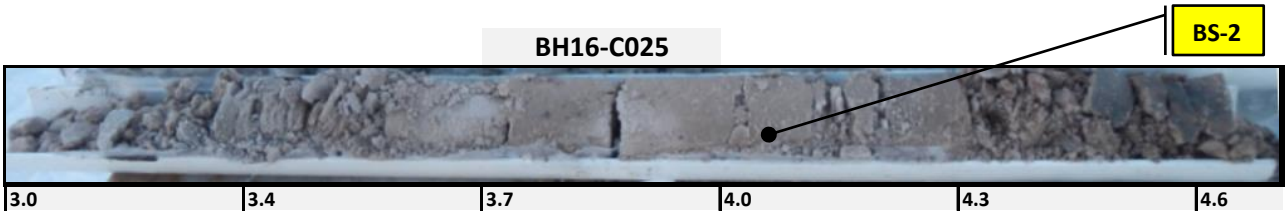
BH16-C025

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-C025

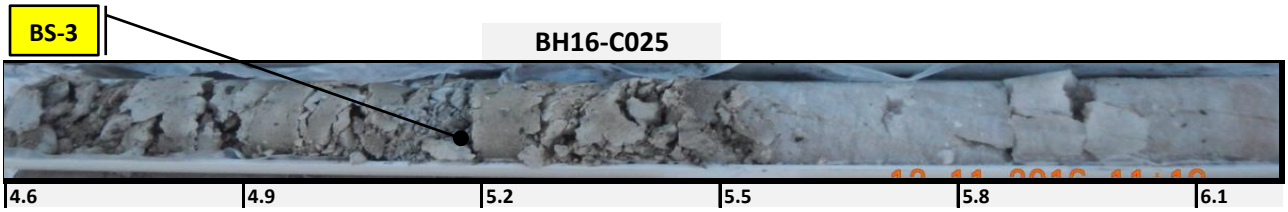
1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-C025



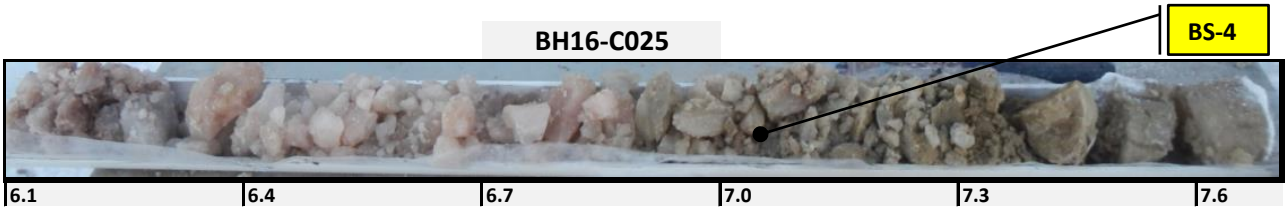
3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH16-C025



4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH16-C025



6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

HATCH

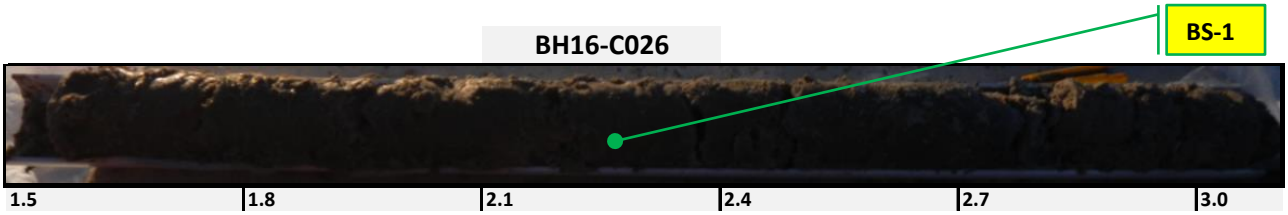
Sample Photographs

Borehole Name:	BH16-C026	Mary River 12 MTPA Mine Expansion
Location:	17 W 550262 7918123	Pre-feasibility Study
Completion Date:	12/11/2016	Baffinland Iron Mines

BH16-C026

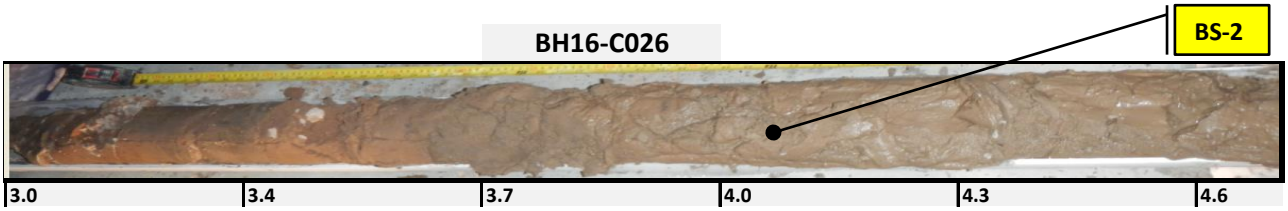
0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-C026



1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-C026



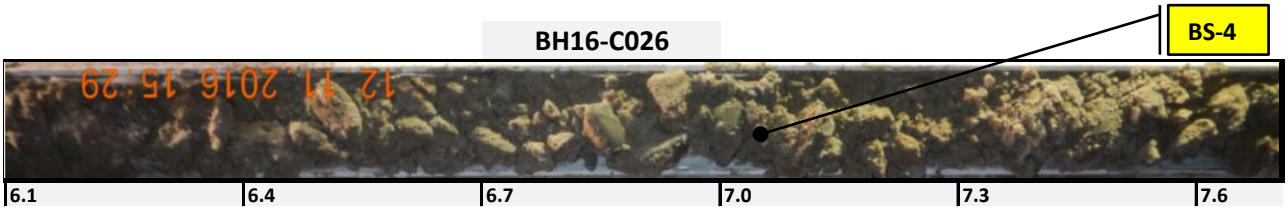
3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH16-C026

Sample photo not taken

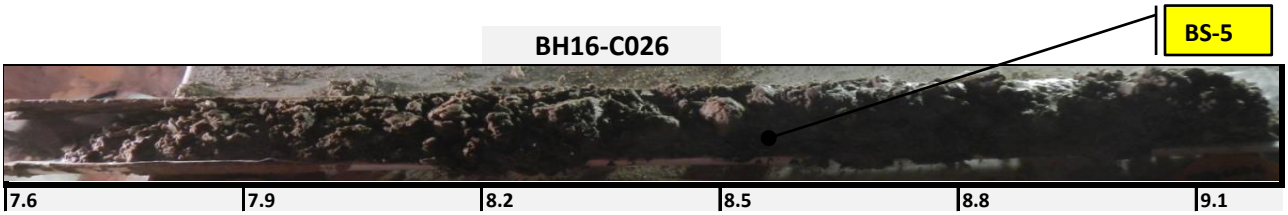
4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH16-C026



6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

BH16-C026



7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

HATCH

BH16-C026

9.1	9.4	9.8	10.1	10.4	10.7

HATCH

Sample Photographs

Borehole Name:	BH16-C027	Mary River 12 MTPA Mine Expansion
Location:	17 W 550416 7917928	Pre-feasibility Study
Completion Date:	12/11/2016	Baffinland Iron Mines

BH16-C027

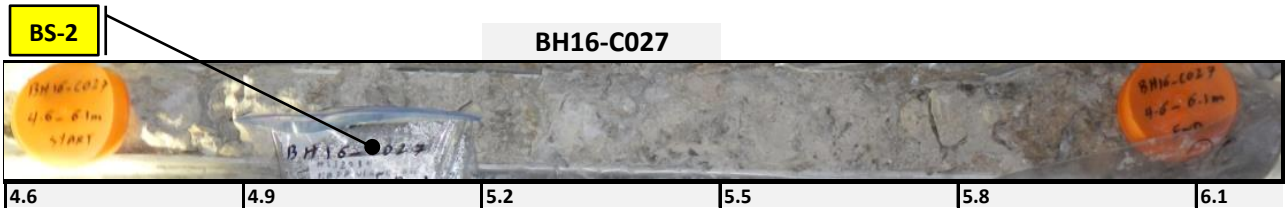
0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-C027

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-C027

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6



4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH16-C027

6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

BH16-C027

7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

BH16-C027

9.1	9.4	9.8	10.1	10.4	10.7

BH16-C027

10.7	11.0	11.3	11.6	11.9	12.2

BH16-C027

Sample photo not taken

12.2	12.5	12.8	13.1	13.4	13.7

BH16-C027

Sample photo not taken

13.7	14.0	14.3	14.6	14.9	15.2

Sample Photographs

Borehole Name:	BH16-C028	Mary River 12 MTPA Mine Expansion
Location:	17 W 551403 7916768	Pre-feasibility Study
Completion Date:	13/11/2016	Baffinland Iron Mines

BH16-C028

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-C028

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-C028

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH16-C028

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BS-1

BH16-C028

6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

BH16-C028

BS-2

7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

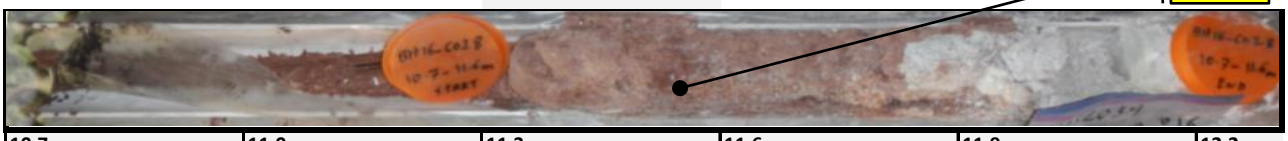
BS-3

BH16-C028

9.1	9.4	9.8	10.1	10.4	10.7

BH16-C028

BS-4

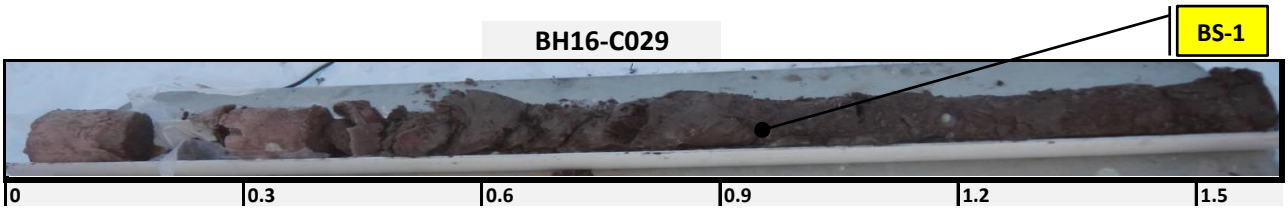


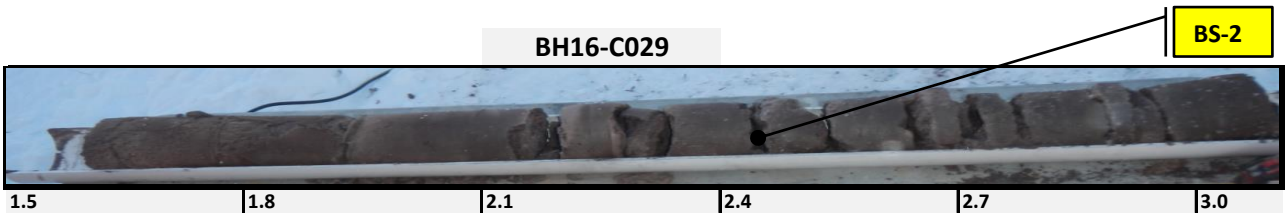
10.7	11.0	11.3	11.6	11.9	12.2

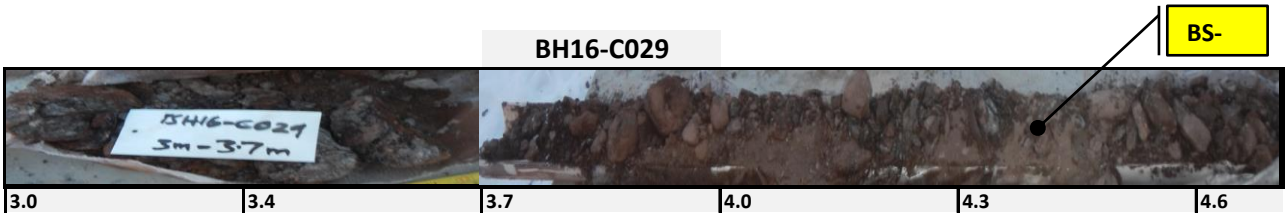
HATCH

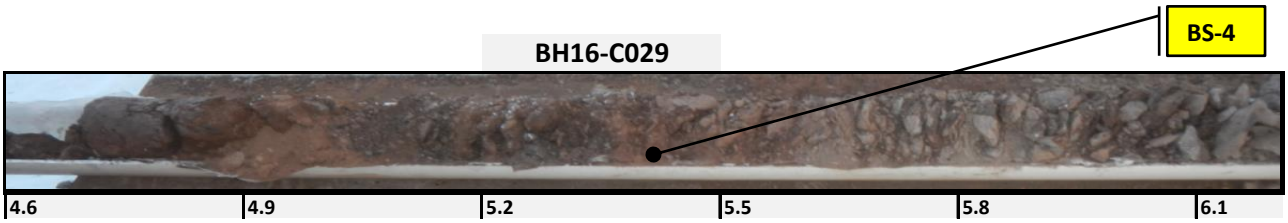
Sample Photographs

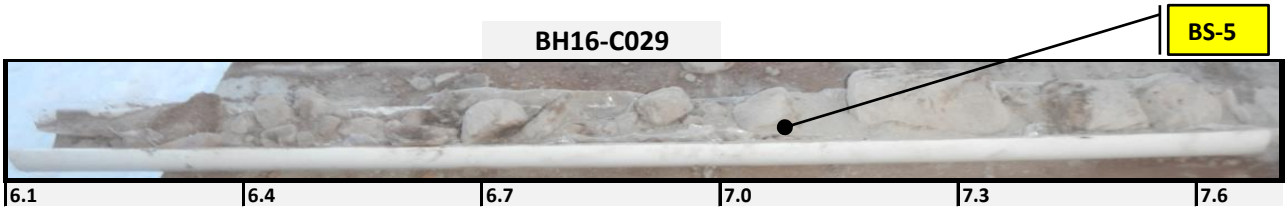
Borehole Name:	BH16-C029	Mary River 12 MTPA Mine Expansion
Location:	17 W 552569 7915813	Pre-feasibility Study
Completion Date:	13/11/2016	Baffinland Iron Mines











HATCH

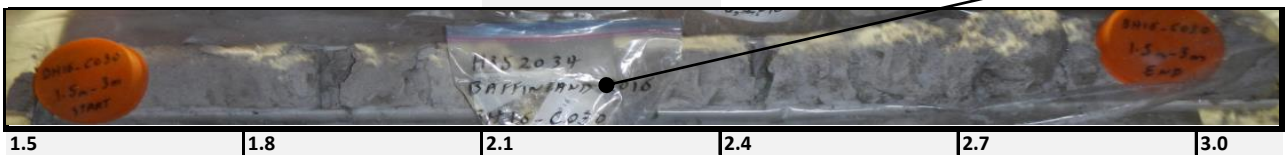
Sample Photographs

Borehole Name:	BH16-C030	Mary River 12 MTPA Mine Expansion
Location:	17 W 555337 7915646	Pre-feasibility Study
Completion Date:	16/11/2016	Baffinland Iron Mines

BH16-C030

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

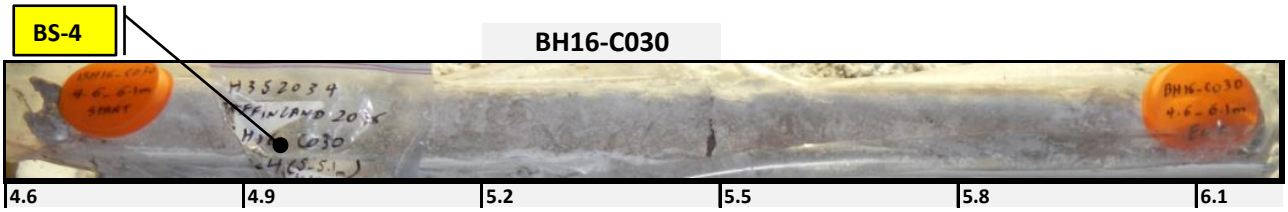
BH16-C030



1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-C030

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6



4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH16-C030

6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

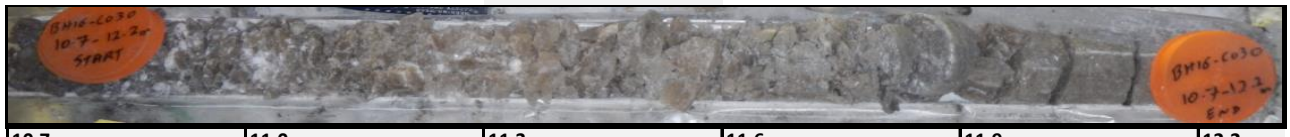
BH16-C030

7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

BH16-C030

9.1	9.4	9.8	10.1	10.4	10.7

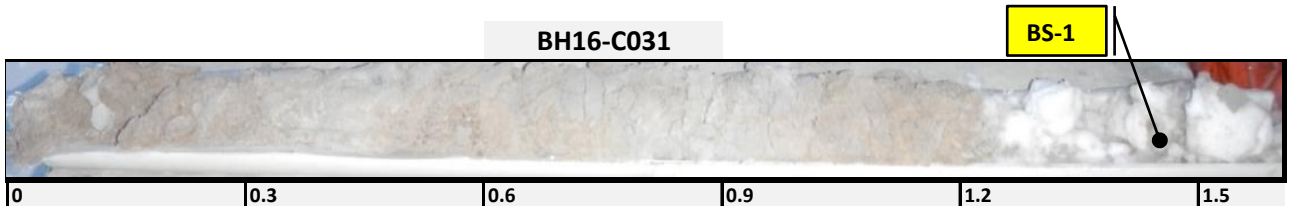
BH16-C030



10.7	11.0	11.3	11.6	11.9	12.2

Sample Photographs

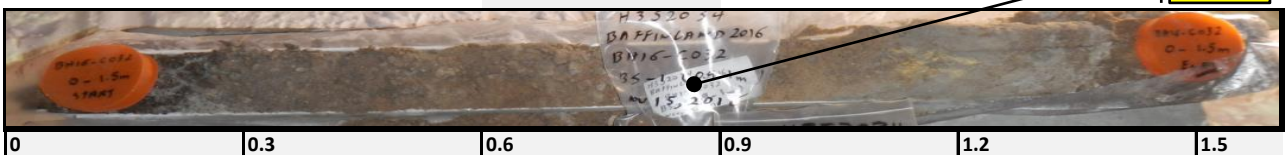
Borehole Name:	BH16-C031	Mary River 12 MTPA Mine Expansion
Location:	17 W 556864 7915216	Pre-feasibility Study
Completion Date:	15/11/2016	Baffinland Iron Mines



Sample Photographs

Borehole Name:	BH16-C032	Mary River 12 MTPA Mine Expansion
Location:	17 W 557282 7915265	Pre-feasibility Study
Completion Date:	15/11/2016	Baffinland Iron Mines

BH16-C032

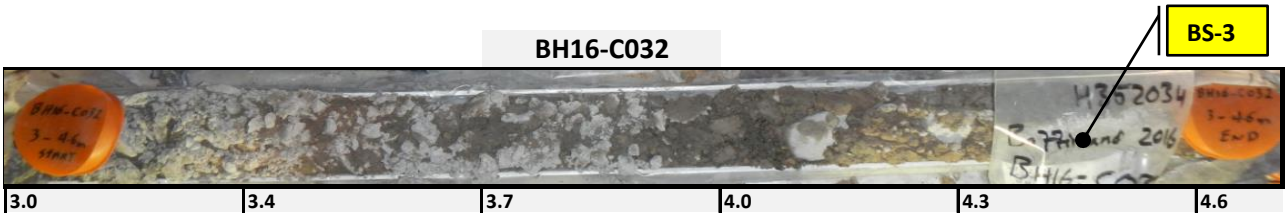


0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-C032

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-C032

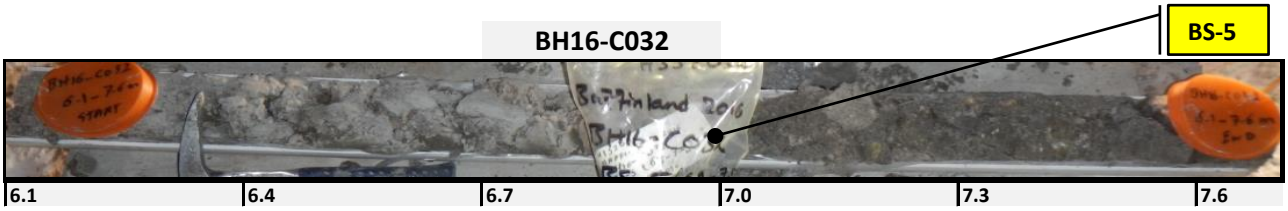


3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH16-C032

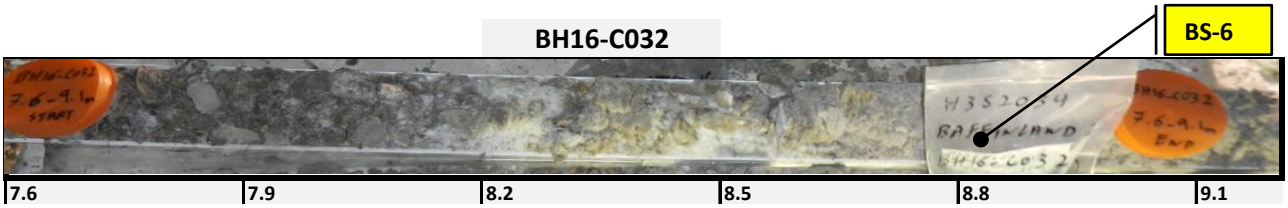
4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH16-C032



6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

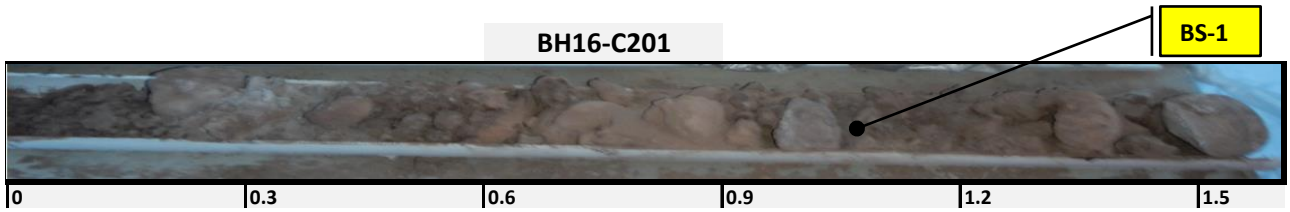
BH16-C032



7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

Sample Photographs

Borehole Name:	BH16-C201	Mary River 12 MTPA Mine Expansion
Location:	17 W 553750 7915276	Pre-feasibility Study
Completion Date:	18/11/2016	Baffinland Iron Mines

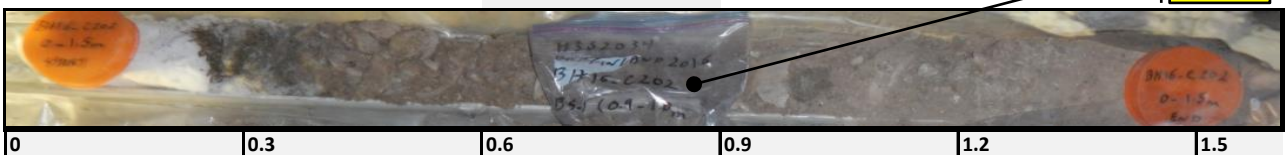


Sample Photographs

Borehole Name:	BH16-C202	Mary River 12 MTPA Mine Expansion
Location:	17 W 554531 7915452	Pre-feasibility Study
Completion Date:	17/11/2016	Baffinland Iron Mines

BH16-C202

BS-1



0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-C202

BS-2

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-C202

BS-3

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BS-4

BH16-C202

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

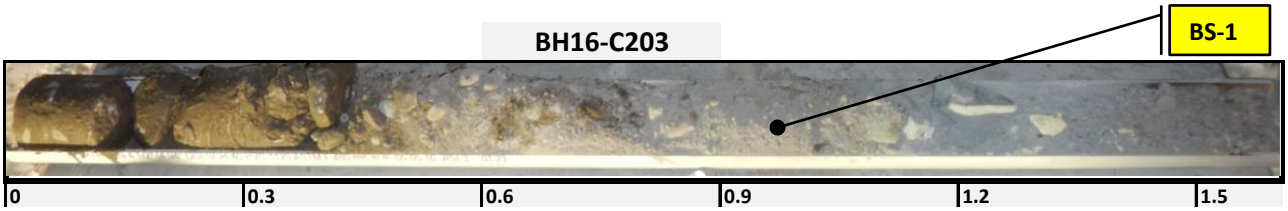
BS-5

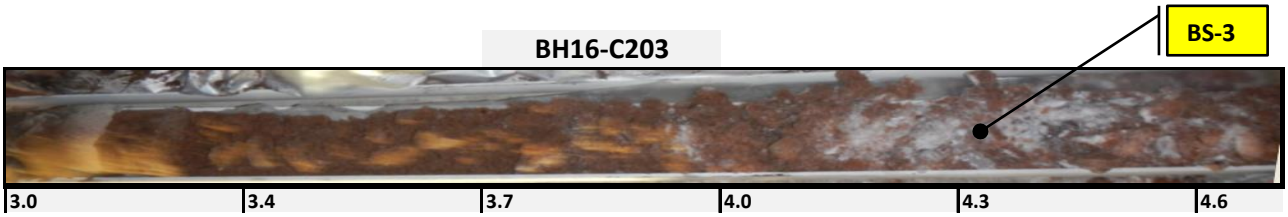
BH16-C202

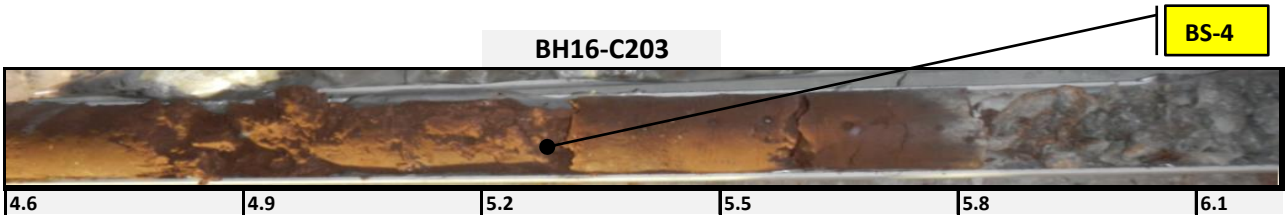
6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

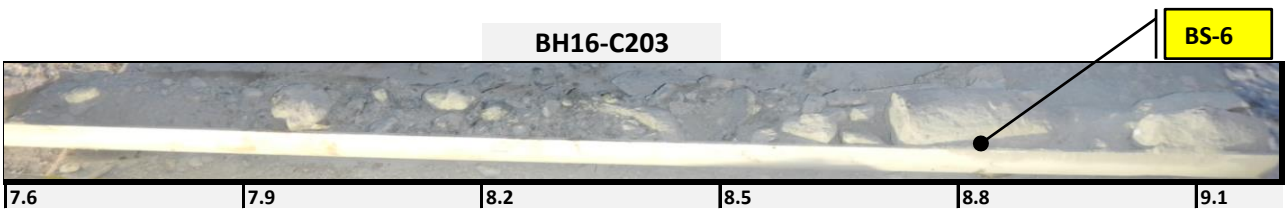
Sample Photographs

Borehole Name:	BH16-C203	Mary River 12 MTPA Mine Expansion
Location:	17 W 555007 7915451	Pre-feasibility Study
Completion Date:	17/11/2016	Baffinland Iron Mines



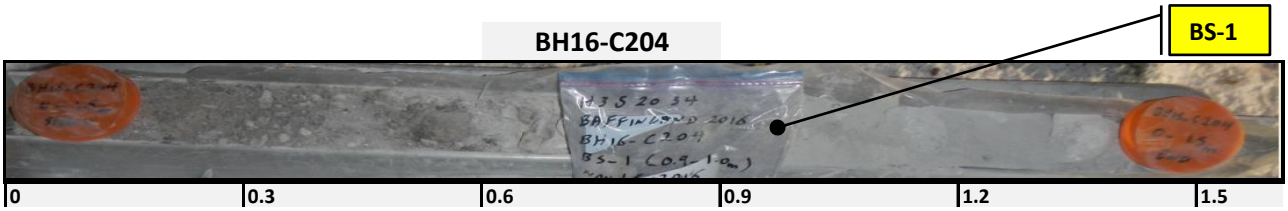


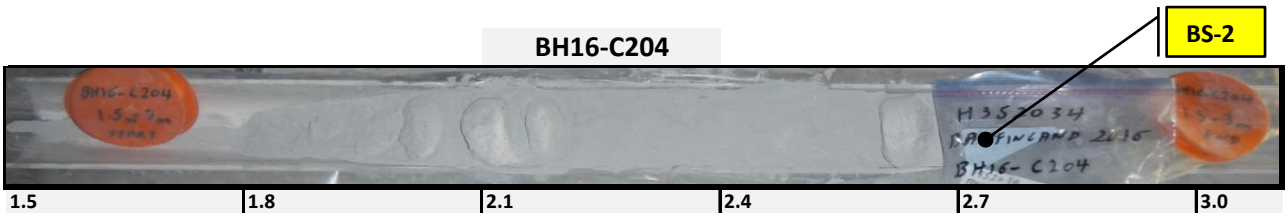




Sample Photographs

Borehole Name:	BH16-C204	Mary River 12 MTPA Mine Expansion
Location:	17 W 555659 7915432	Pre-feasibility Study
Completion Date:	16/11/2016	Baffinland Iron Mines





HATCH

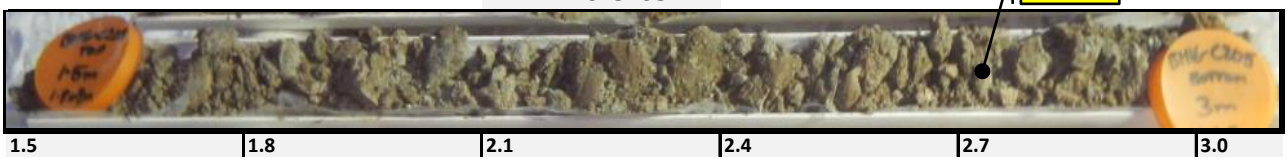
Sample Photographs

Borehole Name:	BH16-C205	Mary River 12 MTPA Mine Expansion
Location:	17 W 555883 7915449	Pre-feasibility Study
Completion Date:	21/11/2016	Baffinland Iron Mines

BH16-C205 BS-1

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-C205 BS-2



1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-C205 BS-3

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH16-C205 BS-4

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH16-C205 BS-5

6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

BH16-C205 BS-6

7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

HATCH

Sample Photographs

Borehole Name:	BH16-C206	Mary River 12 MTPA Mine Expansion
Location:	17 W 556059 7915442	Pre-feasibility Study
Completion Date:	22/11/2016	Baffinland Iron Mines

BH16-C206

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-C206

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

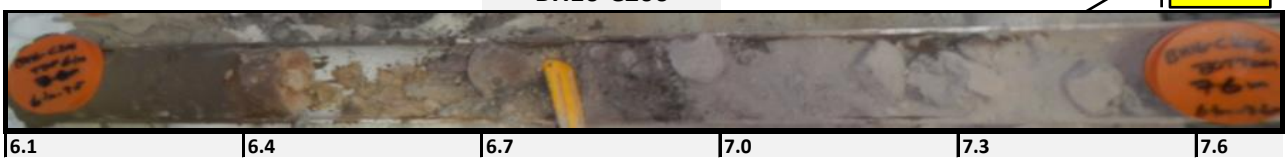
BH16-C206

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH16-C206

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH16-C206



6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

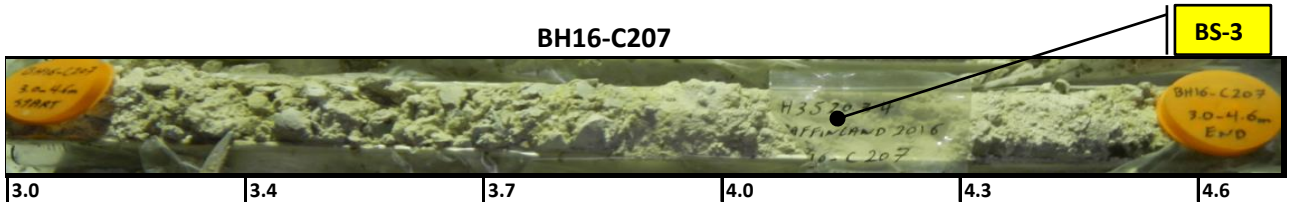
BH16-C206

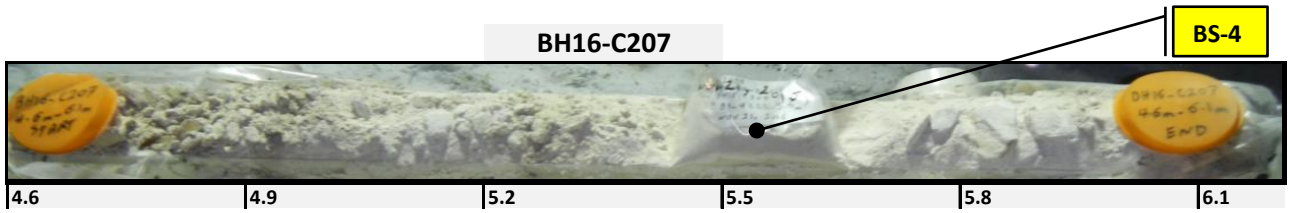
7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

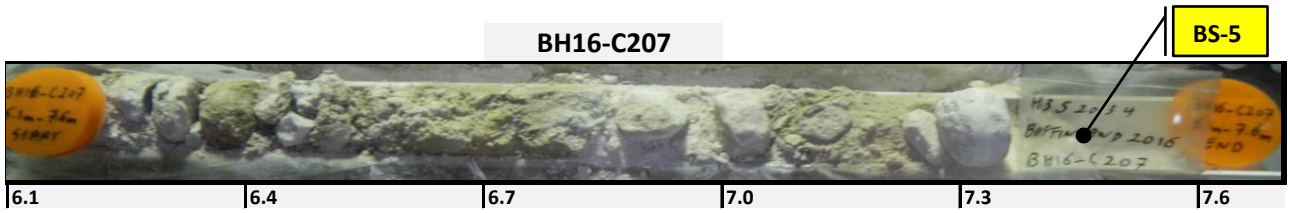
HATCH

Sample Photographs

Borehole Name:	BH16-C207	Mary River 12 MTPA Mine Expansion
Location:	17 W 556679 7915415	Pre-feasibility Study
Completion Date:	22/11/2016	Baffinland Iron Mines







Sample Photographs

Borehole Name:	BH16-Q7002	Mary River 12 MTPA Mine Expansion
Location:	17 W 530561 7928150	Pre-feasibility Study
Completion Date:	28/10/2016	Baffinland Iron Mines

BH16-Q7002

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-Q7002

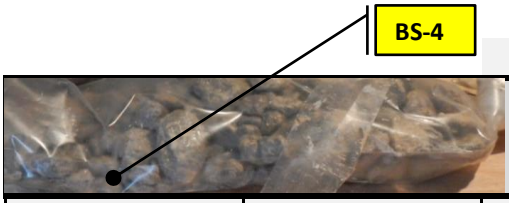
1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-Q7002

Sample photo not taken

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH16-Q7002



4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH16-Q7002

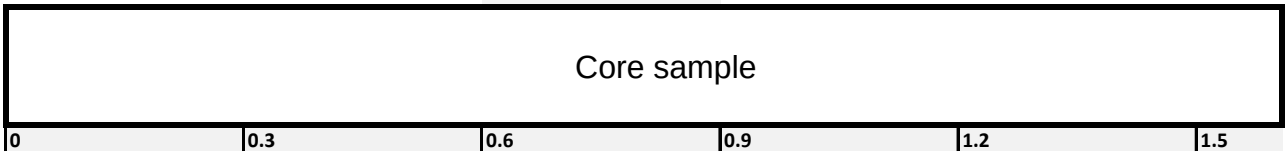
5.2 | 5.5 | 5.8 | 6.1 | 6.4 | 6.7

HATCH

Sample Photographs

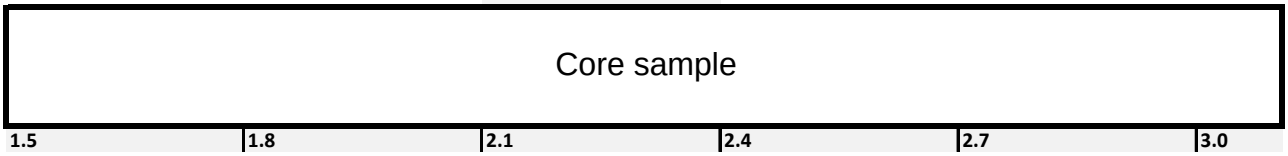
Borehole Name:	BH16-Q7004	Mary River 12 MTPA Mine Expansion
Location:	17 W 529264 7927466	Pre-feasibility Study
Completion Date:	25/10/2016	Baffinland Iron Mines

BH16-Q7004



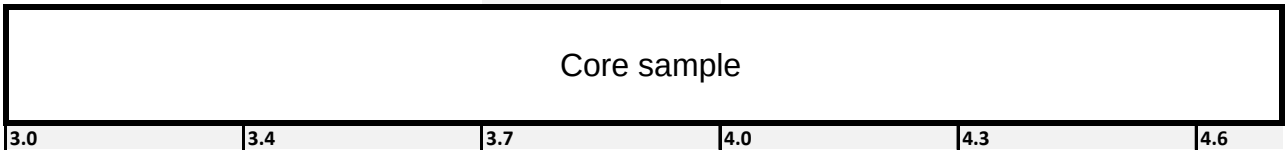
0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-Q7004



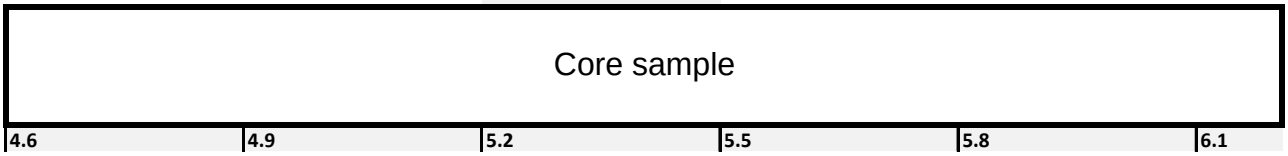
1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-Q7004



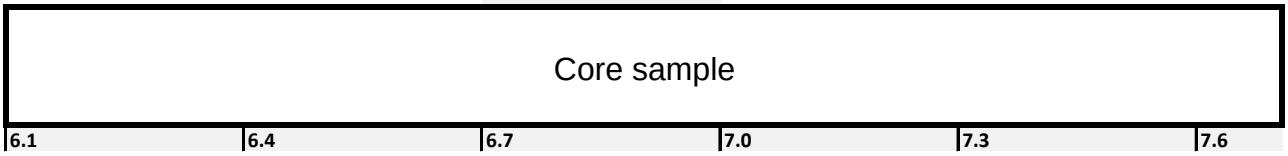
3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH16-Q7004



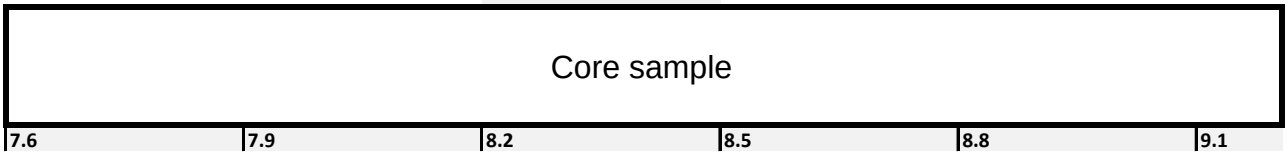
4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH16-Q7004



6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

BH16-Q7004



7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

BH16-Q7004

Core sample

9.1	9.4	9.8	10.1	10.4	10.7

BH16-Q7004

Sample photo not taken

BS-8

10.7	11.0	11.3	11.6	11.9	12.2

BH16-Q7004

Sample photo not taken

BS-9

12.2	12.5	12.8	13.1	13.4	13.7

BH16-Q7004

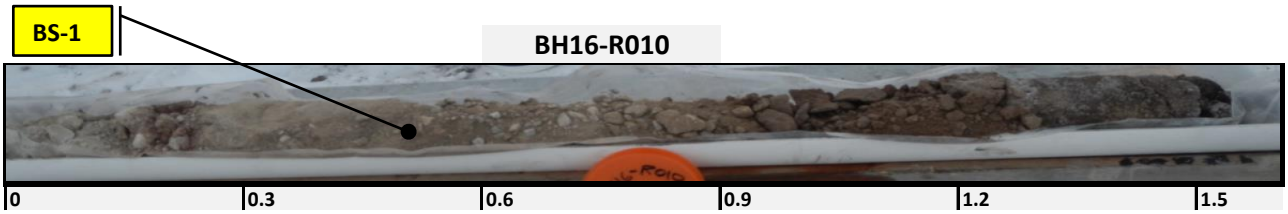
Sample photo not taken

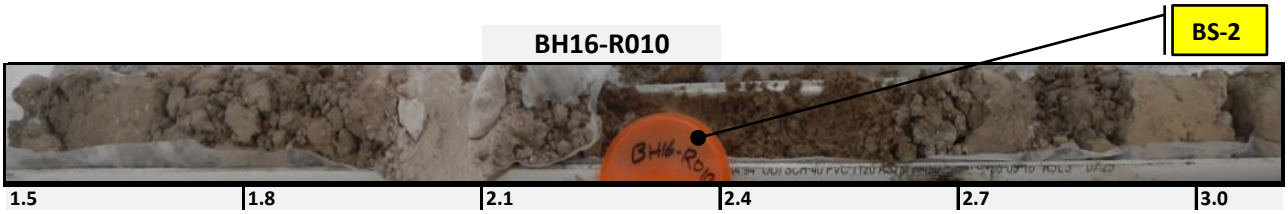
BS-10

13.7	14.0	14.3	14.6	14.9	15.2

Sample Photographs

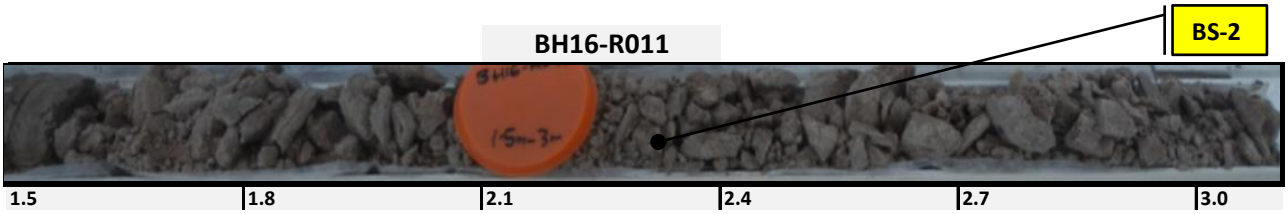
Borehole Name:	BH16-R010	Mary River 12 MTPA Mine Expansion
Location:	17 W 515332 7963810	Pre-feasibility Study
Completion Date:	08/10/2016	Baffinland Iron Mines

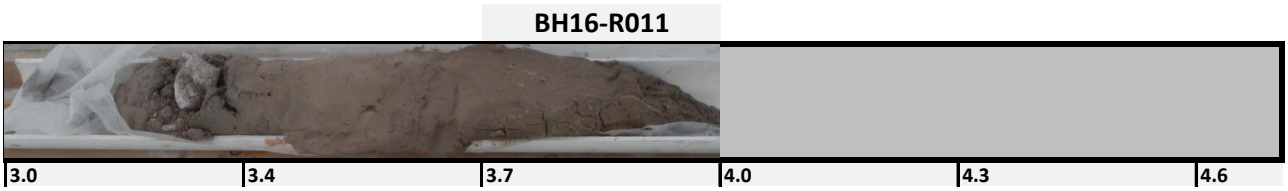




Sample Photographs

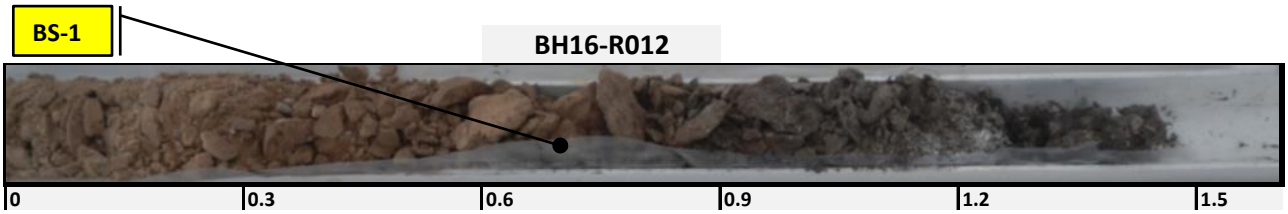
Borehole Name:	BH16-R011	Mary River 12 MTPA Mine Expansion
Location:	17 W 516719 7962461	Pre-feasibility Study
Completion Date:	08/10/2016	Baffinland Iron Mines

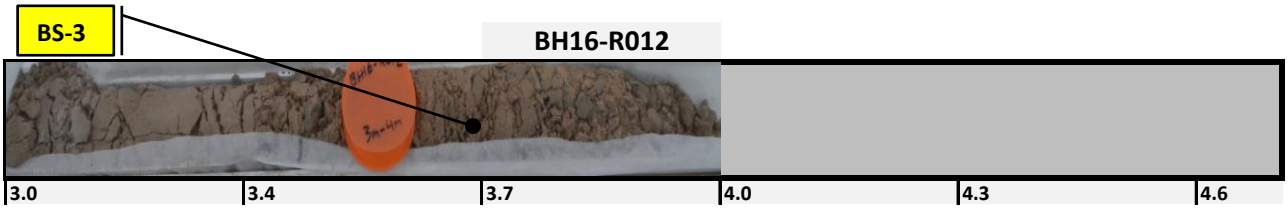




Sample Photographs

Borehole Name:	BH16-R012	Mary River 12 MTPA Mine Expansion
Location:	17 W 516716 7962464	Pre-feasibility Study
Completion Date:	08/10/2016	Baffinland Iron Mines



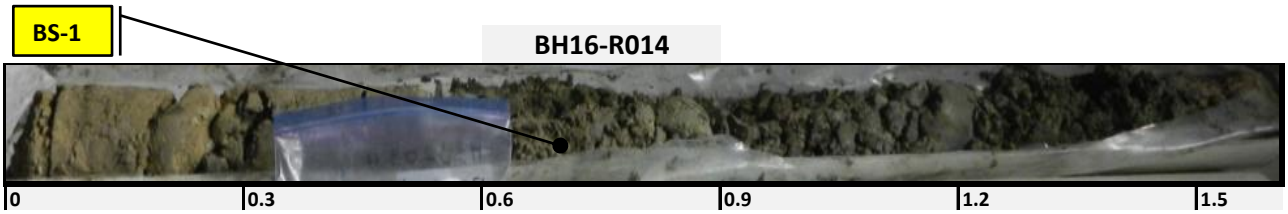


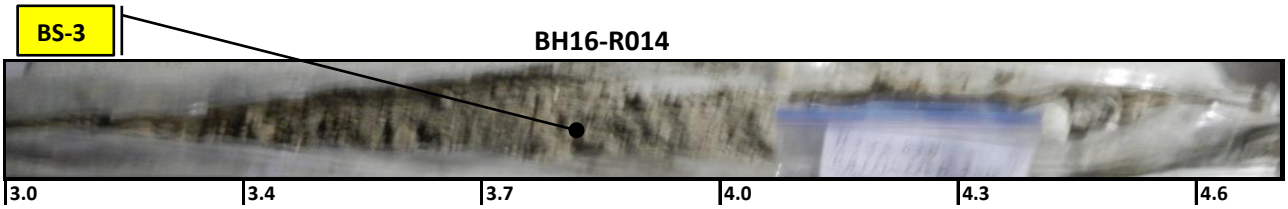
Sample Photographs

Borehole Name:	BH16-R013	Mary River 12 MTPA Mine Expansion
Location:	17 W 518856 7959178	Pre-feasibility Study
Completion Date:	08/10/2016	Baffinland Iron Mines

Sample Photographs

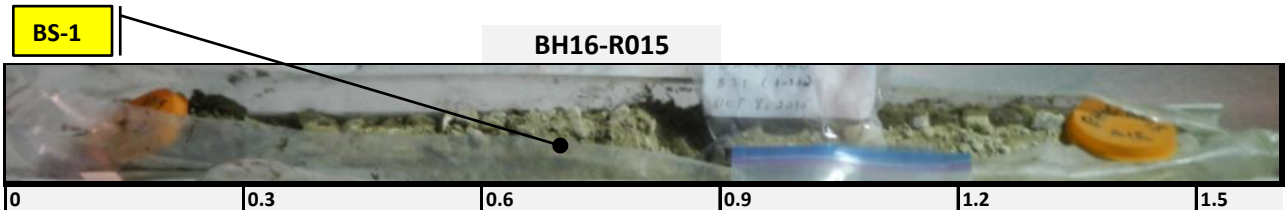
Borehole Name:	BH16-R014	Mary River 12 MTPA Mine Expansion
Location:	17 W 518856 7959178	Pre-feasibility Study
Completion Date:	08/10/2016	Baffinland Iron Mines

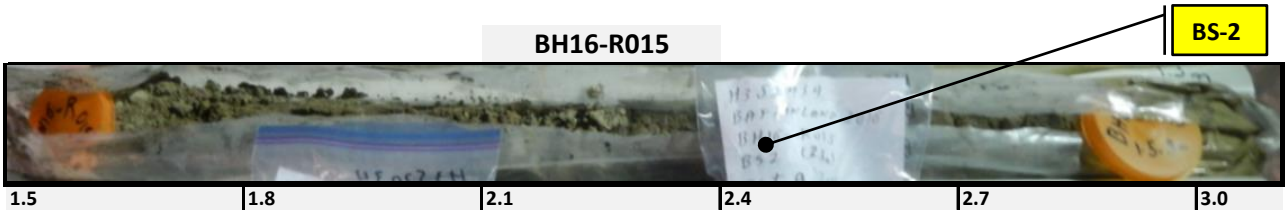


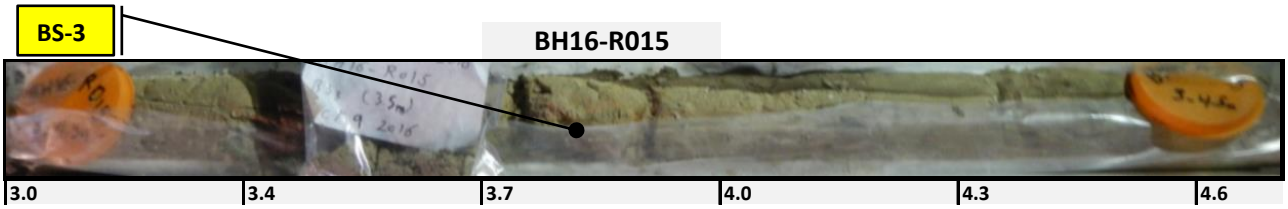


Sample Photographs

Borehole Name:	BH16-R015	Mary River 12 MTPA Mine Expansion
Location:	17 W 520756 7955701	Pre-feasibility Study
Completion Date:	09/10/2016	Baffinland Iron Mines







Sample Photographs

Borehole Name:	BH16-R016	Mary River 12 MTPA Mine Expansion
Location:	17 W 521588 7953865	Pre-feasibility Study
Completion Date:	09/10/2016	Baffinland Iron Mines

BS-1

BH16-R016

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

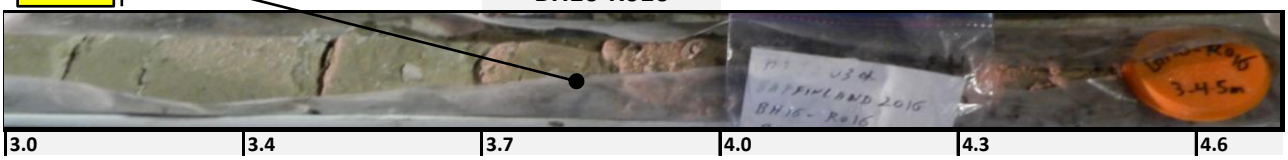
BS-2

BH16-R016

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BS-3

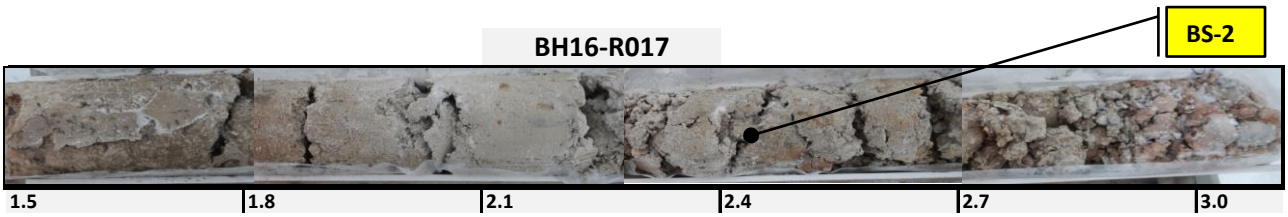
BH16-R016

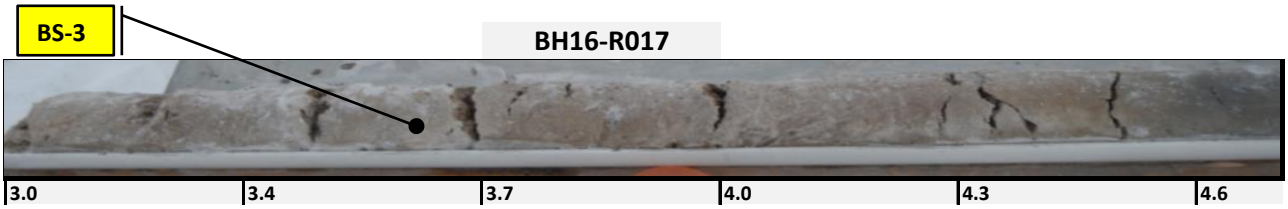


3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

Sample Photographs

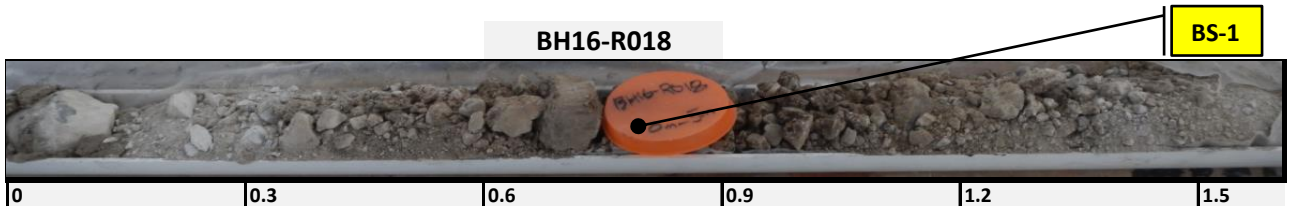
Borehole Name:	BH16-R017	Mary River 12 MTPA Mine Expansion
Location:	17 W 521737 7952929	Pre-feasibility Study
Completion Date:	09/10/2016	Baffinland Iron Mines

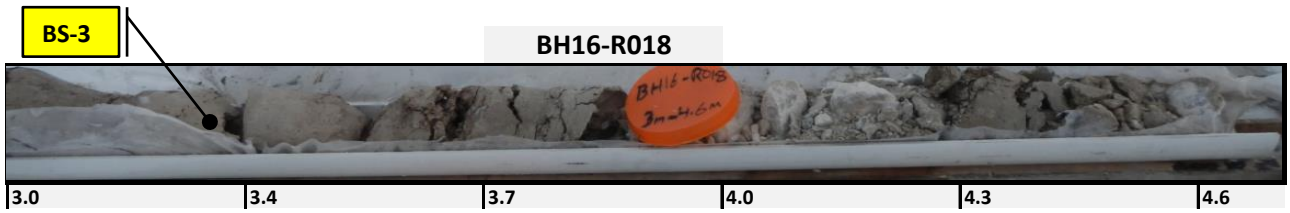




Sample Photographs

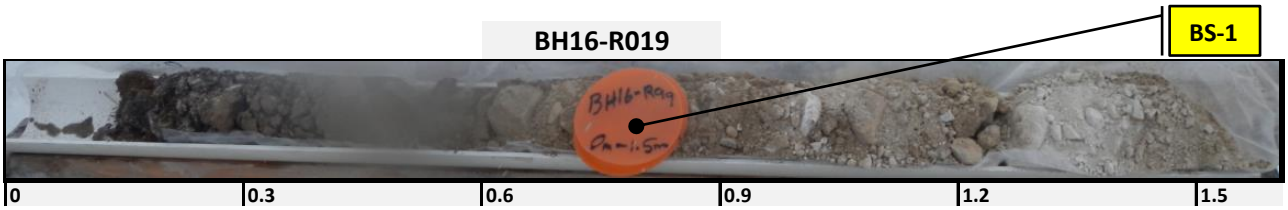
Borehole Name:	BH16-R018	Mary River 12 MTPA Mine Expansion
Location:	17 W 521854 7951940	Pre-feasibility Study
Completion Date:	09/10/2016	Baffinland Iron Mines





Sample Photographs

Borehole Name:	BH16-R019	Mary River 12 MTPA Mine Expansion
Location:	17 W 521994 7950962	Pre-feasibility Study
Completion Date:	09/10/2016	Baffinland Iron Mines



Sample Photographs

Borehole Name:	BH16-R020	Mary River 12 MTPA Mine Expansion
Location:	17 W 521842 7949969	Pre-feasibility Study
Completion Date:	09/10/2016	Baffinland Iron Mines

BH16-R020

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-R020

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BS-3

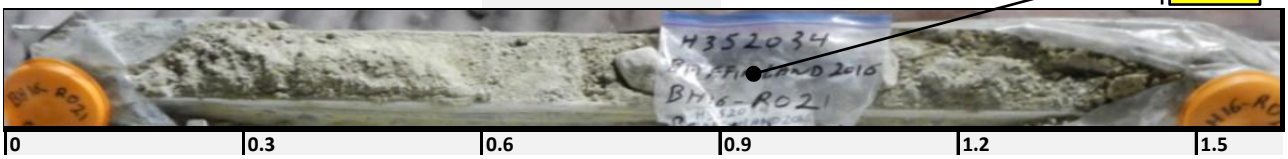
BH16-R020

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

Sample Photographs

Borehole Name:	BH16-R021	Mary River 12 MTPA Mine Expansion
Location:	17 W 522305 7948153	Pre-feasibility Study
Completion Date:	09/10/2016	Baffinland Iron Mines

BH16-R021



0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-R021

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-R021

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

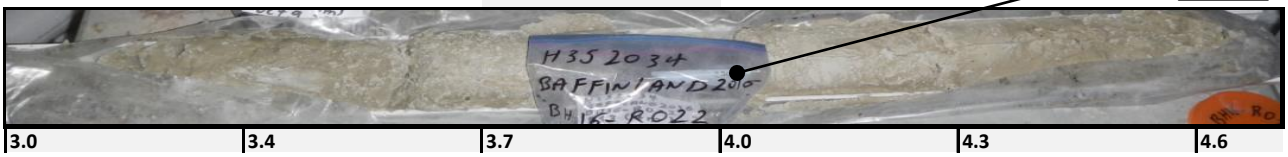
Sample Photographs

Borehole Name:	BH16-R022	Mary River 12 MTPA Mine Expansion
Location:	17 W 522305 7948153	Pre-feasibility Study
Completion Date:	10/10/2016	Baffinland Iron Mines

BH16-R022

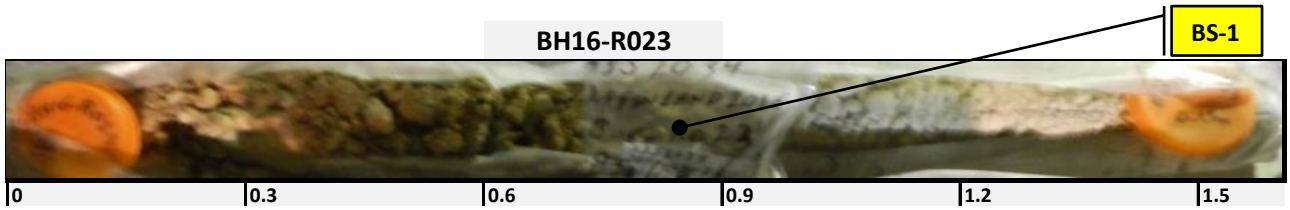
BH16-R022

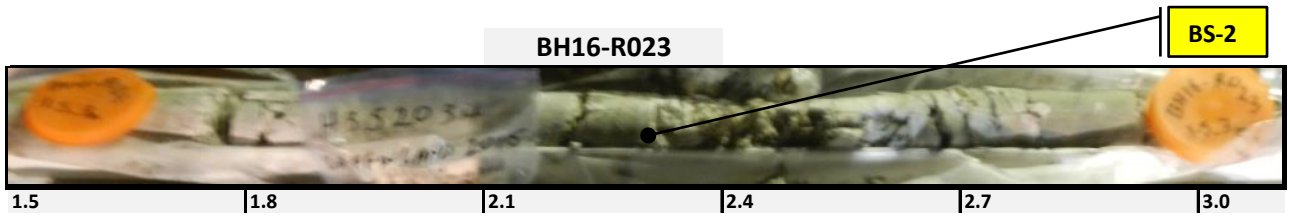
BH16-R022

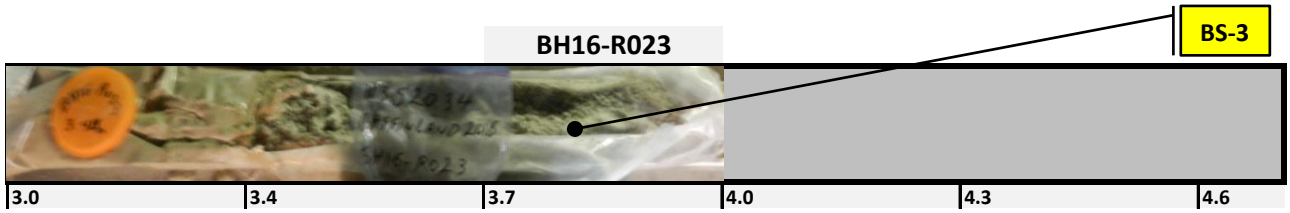


Sample Photographs

Borehole Name:	BH16-R023	Mary River 12 MTPA Mine Expansion
Location:	17 W 522505 7947177	Pre-feasibility Study
Completion Date:	10/10/2016	Baffinland Iron Mines

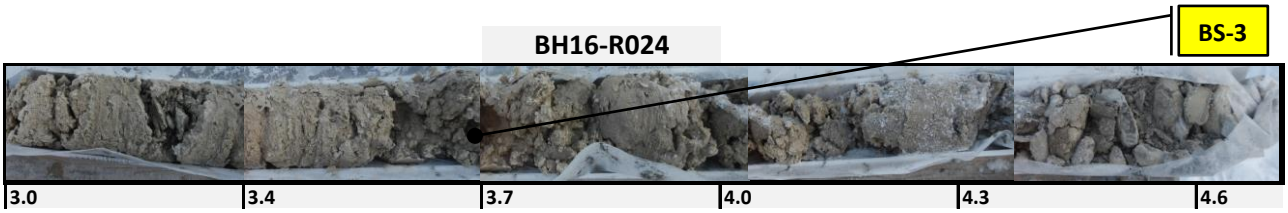






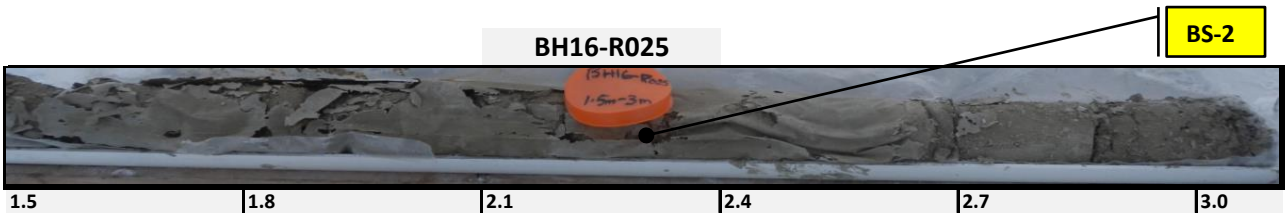
Sample Photographs

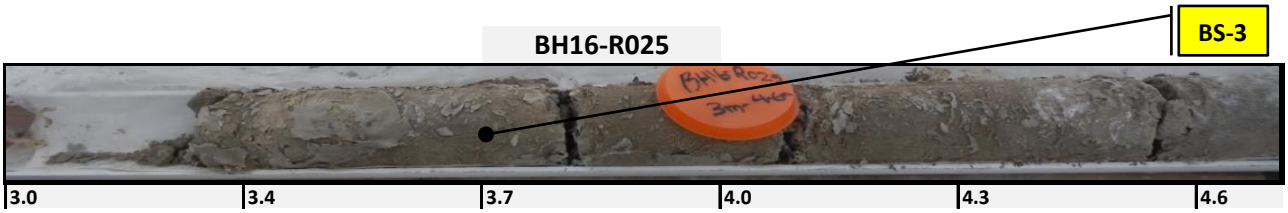
Borehole Name:	BH16-R024	Mary River 12 MTPA Mine Expansion
Location:	17 W 522558 7946129	Pre-feasibility Study
Completion Date:	10/10/2016	Baffinland Iron Mines



Sample Photographs

Borehole Name:	BH16-R025	Mary River 12 MTPA Mine Expansion
Location:	17 W 522989 7945094	Pre-feasibility Study
Completion Date:	10/10/2016	Baffinland Iron Mines

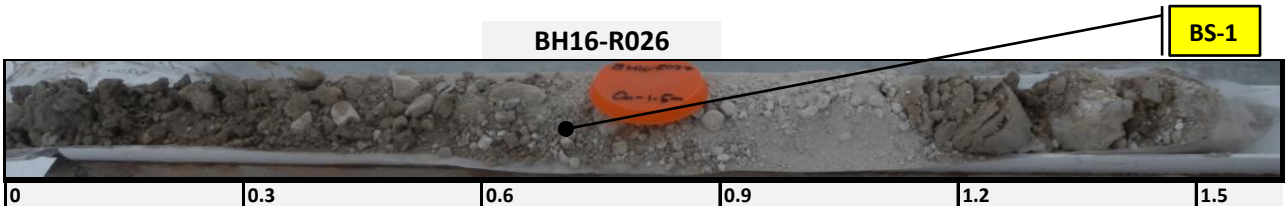


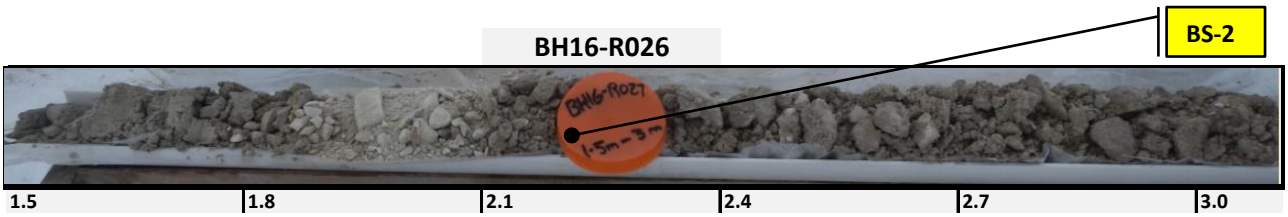


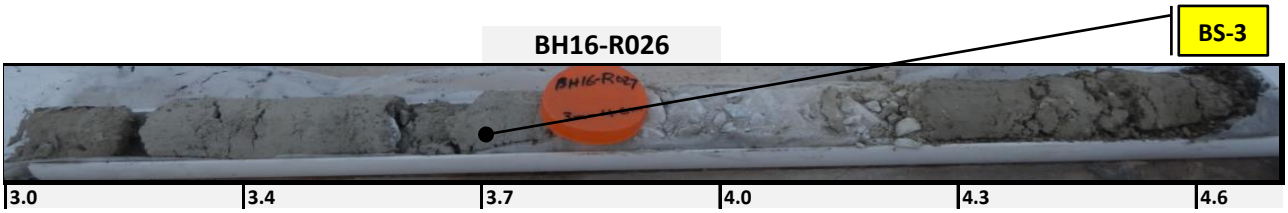
HATCH

Sample Photographs

Borehole Name:	BH16-R026	Mary River 12 MTPA Mine Expansion
Location:	17 W 523165 7944366	Pre-feasibility Study
Completion Date:	10/10/2016	Baffinland Iron Mines

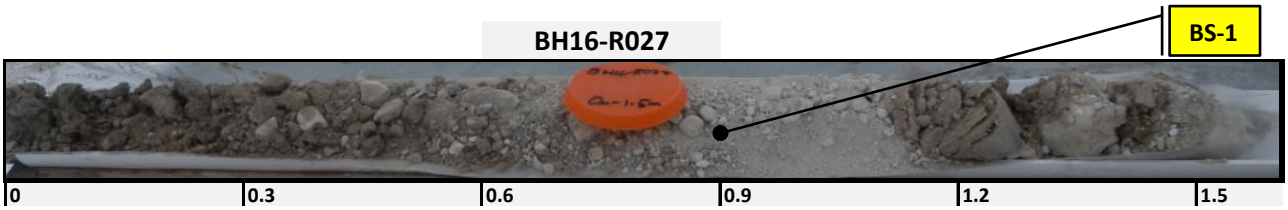


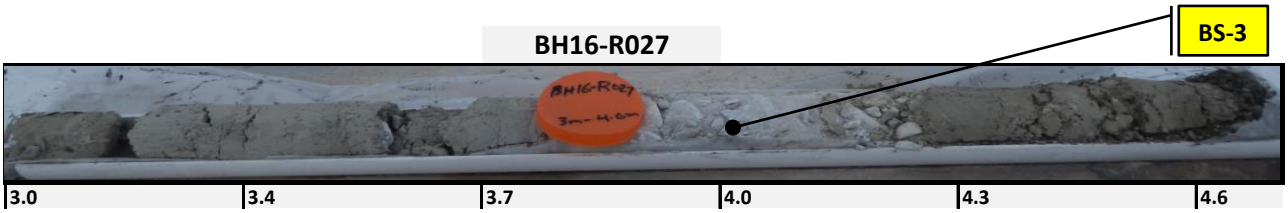




Sample Photographs

Borehole Name:	BH16-R027	Mary River 12 MTPA Mine Expansion
Location:	17 W 523442 7942265	Pre-feasibility Study
Completion Date:	10/10/2016	Baffinland Iron Mines

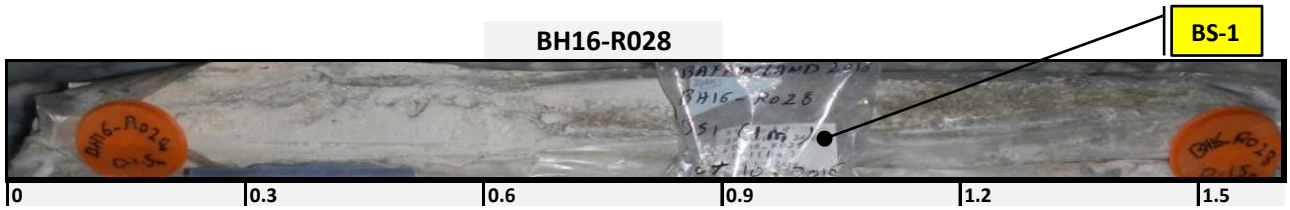


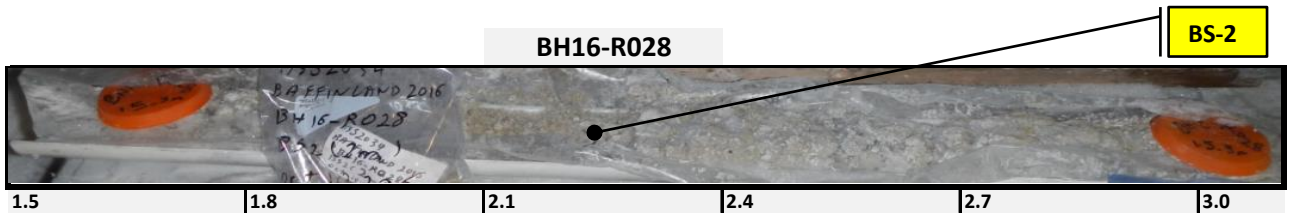


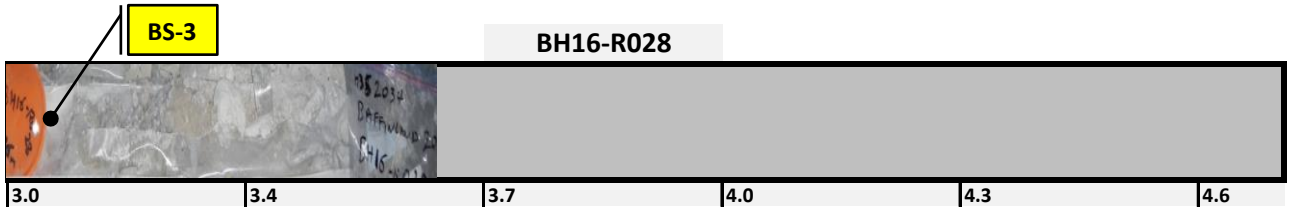
HATCH

Sample Photographs

Borehole Name:	BH16-R028	Mary River 12 MTPA Mine Expansion
Location:	17 W 524061 7940538	Pre-feasibility Study
Completion Date:	10/10/2016	Baffinland Iron Mines





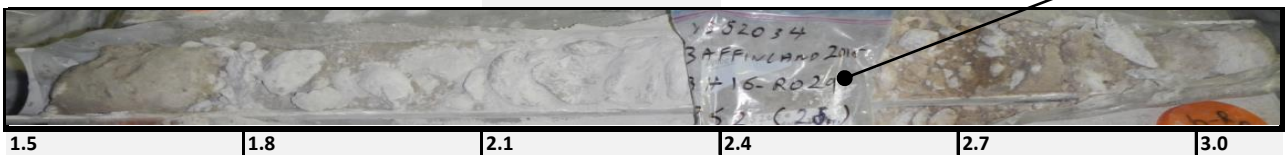


Sample Photographs

Borehole Name:	BH16-R029	Mary River 12 MTPA Mine Expansion
Location:	17 W 525062 7938851	Pre-feasibility Study
Completion Date:	11/10/2016	Baffinland Iron Mines

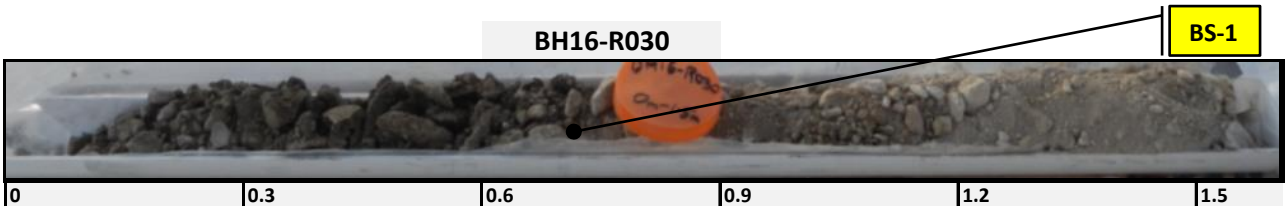
BH16-R029

BH16-R029



Sample Photographs

Borehole Name:	BH16-R030	Mary River 12 MTPA Mine Expansion
Location:	17 W 525291 7937897	Pre-feasibility Study
Completion Date:	11/10/2016	Baffinland Iron Mines

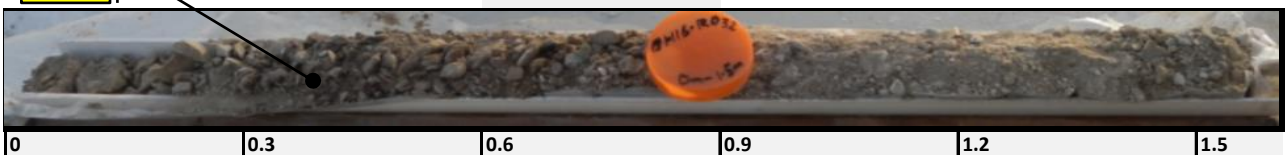


Sample Photographs

Borehole Name:	BH16-R032	Mary River 12 MTPA Mine Expansion
Location:	17 W 525991 7936109	Pre-feasibility Study
Completion Date:	11/10/2016	Baffinland Iron Mines

BS-1

BH16-R032



0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BS-2

BH16-R032

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

Sample Photographs

Borehole Name:	BH16-R033	Mary River 12 MTPA Mine Expansion
Location:	17 W 526653 7935439	Pre-feasibility Study
Completion Date:	11/10/2016	Baffinland Iron Mines

BH16-R033

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-R033

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

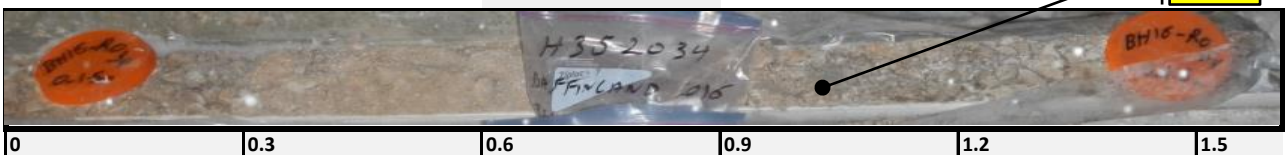
BH16-R033

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

Sample Photographs

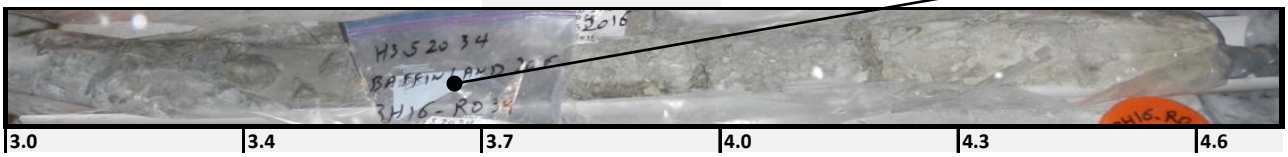
Borehole Name:	BH16-R034	Mary River 12 MTPA Mine Expansion
Location:	17 W 527056 7933500	Pre-feasibility Study
Completion Date:	12/10/2016	Baffinland Iron Mines

BH16-R034



BH16-R034

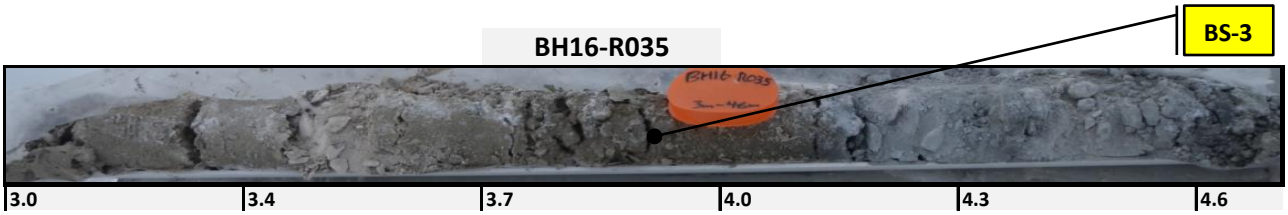
BH16-R034



HATCH

Sample Photographs

Borehole Name:	BH16-R035	Mary River 12 MTPA Mine Expansion
Location:	17 W 527423 7932310	Pre-feasibility Study
Completion Date:	12/10/2016	Baffinland Iron Mines



Sample Photographs

Borehole Name:	BH16-R036	Mary River 12 MTPA Mine Expansion
Location:	17 W 527210 7931660	Pre-feasibility Study
Completion Date:	12/10/2016	Baffinland Iron Mines

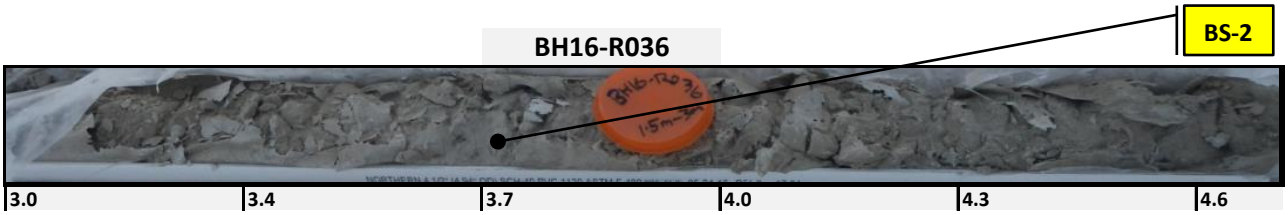
BH16-R036

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-R036

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-R036



3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

HATCH

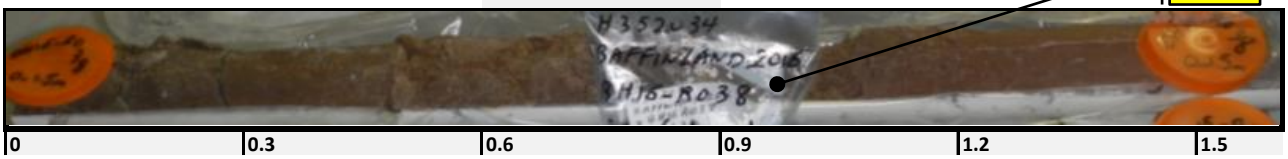
Sample Photographs

Borehole Name:	BH16-R037	Mary River 12 MTPA Mine Expansion
Location:	17 W 527873 7929786	Pre-feasibility Study
Completion Date:	12/10/2016	Baffinland Iron Mines

Sample Photographs

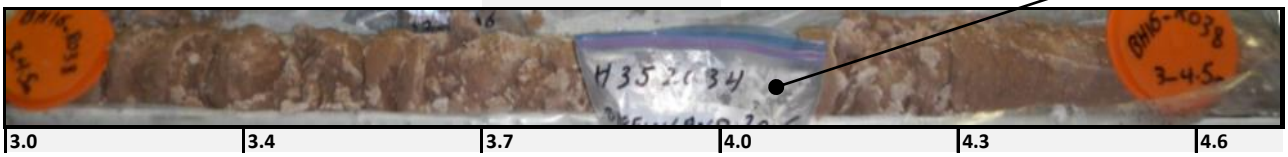
Borehole Name:	BH16-R038	Mary River 12 MTPA Mine Expansion
Location:	17 W 528501 7928421	Pre-feasibility Study
Completion Date:	12/10/2016	Baffinland Iron Mines

BH16-R038



BH16-R038

BH16-R038



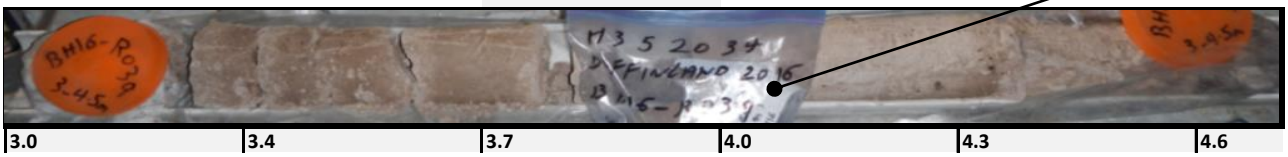
Sample Photographs

Borehole Name:	BH16-R039	Mary River 12 MTPA Mine Expansion
Location:	17 W 528666 7927955	Pre-feasibility Study
Completion Date:	12/10/2016	Baffinland Iron Mines

BH16-R039

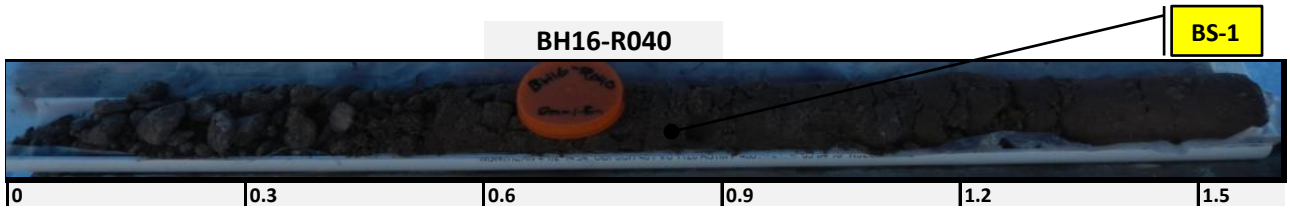
BH16-R039

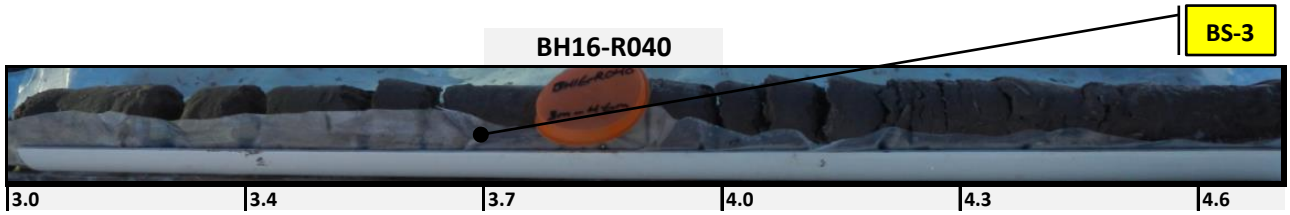
BH16-R039



Sample Photographs

Borehole Name:	BH16-R040	Mary River 12 MTPA Mine Expansion
Location:	17 W 528686 7927755	Pre-feasibility Study
Completion Date:	13/10/2016	Baffinland Iron Mines





Sample Photographs

Borehole Name:	BH16-R041	Mary River 12 MTPA Mine Expansion
Location:	17 W 528605 7927754	Pre-feasibility Study
Completion Date:	14/10/2016	Baffinland Iron Mines

BH16-R041

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

HATCH

Sample Photographs

Borehole Name:	BH16-R042	Mary River 12 MTPA Mine Expansion
Location:	17 W 528517 7927713	Pre-feasibility Study
Completion Date:	14/10/2016	Baffinland Iron Mines

BH16-R042

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-R042

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-R042

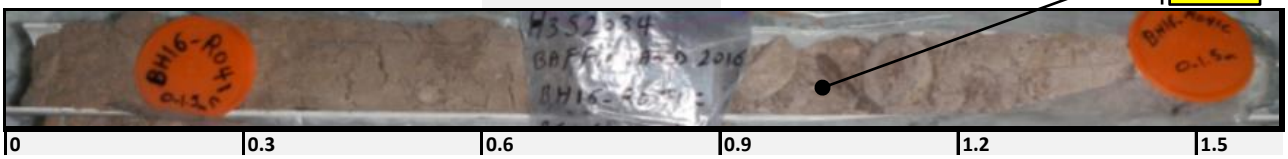
3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

HATCH

Sample Photographs

Borehole Name:	BH16-R043	Mary River 12 MTPA Mine Expansion
Location:	17 W 528428 7927675	Pre-feasibility Study
Completion Date:	13/10/2016	Baffinland Iron Mines

BH16-R043

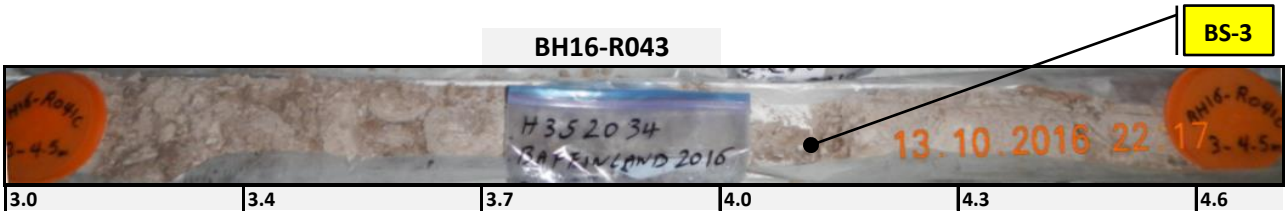


0	0.3	0.6	0.9	1.2	1.5

BH16-R043

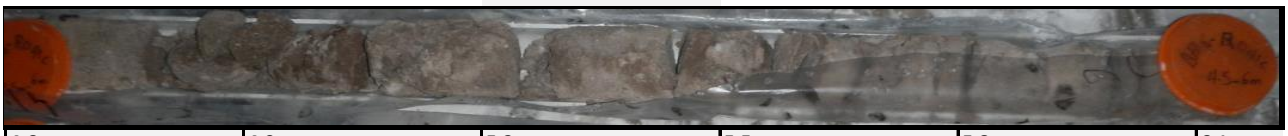
1.5	1.8	2.1	2.4	2.7	3.0

BH16-R043



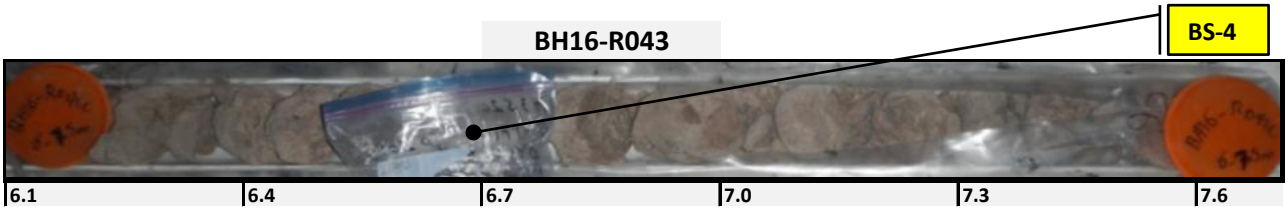
3.0	3.4	3.7	4.0	4.3	4.6

BH16-R043



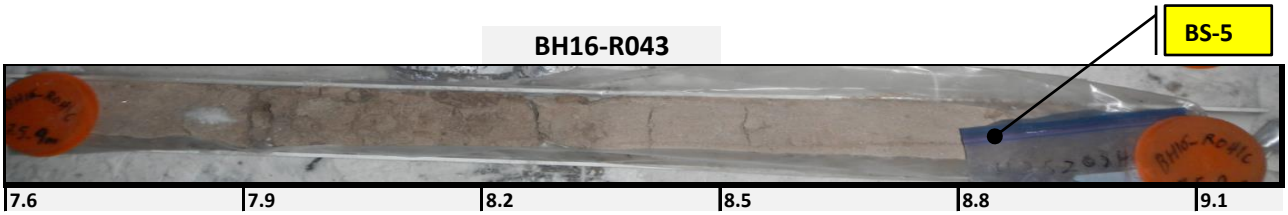
4.6	4.9	5.2	5.5	5.8	6.1

BH16-R043



6.1	6.4	6.7	7.0	7.3	7.6

BH16-R043



7.6	7.9	8.2	8.5	8.8	9.1

Sample Photographs

Borehole Name:	BH16-R044	Mary River 12 MTPA Mine Expansion
Location:	17 W 528736 7926992	Pre-feasibility Study
Completion Date:	28/10/2016	Baffinland Iron Mines

BH16-R044

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-R044

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-R044

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

Sample Photographs

Borehole Name:	BH16-R045	Mary River 12 MTPA Mine Expansion
Location:	17 W 528961 7926756	Pre-feasibility Study
Completion Date:	28/10/2016	Baffinland Iron Mines

BS-1

BH16-R045

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-R045

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-R045

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

Sample Photographs

Borehole Name:	BH16-R053	Mary River 12 MTPA Mine Expansion
Location:	17 W 528238 7928027	Pre-feasibility Study
Completion Date:	28/10/2016	Baffinland Iron Mines

BH16-R053

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

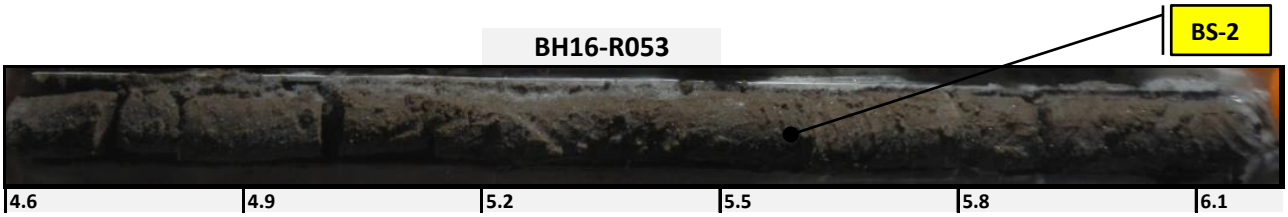
BH16-R053

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-R053

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

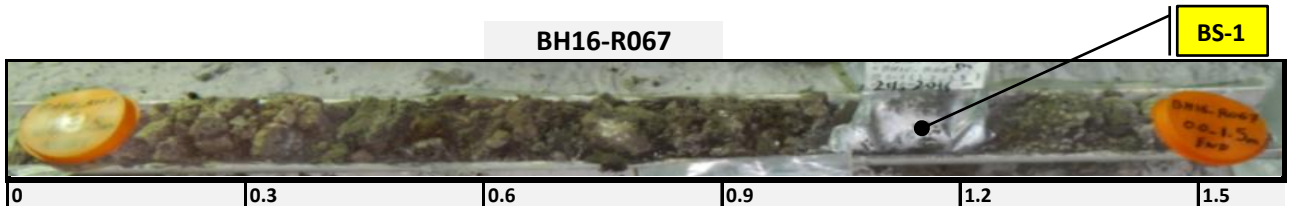
BH16-R053

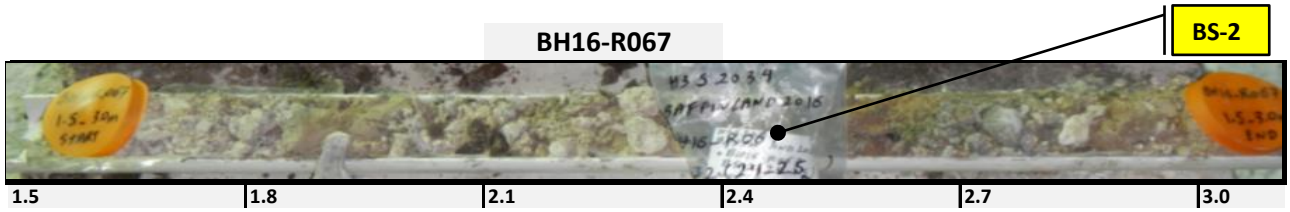


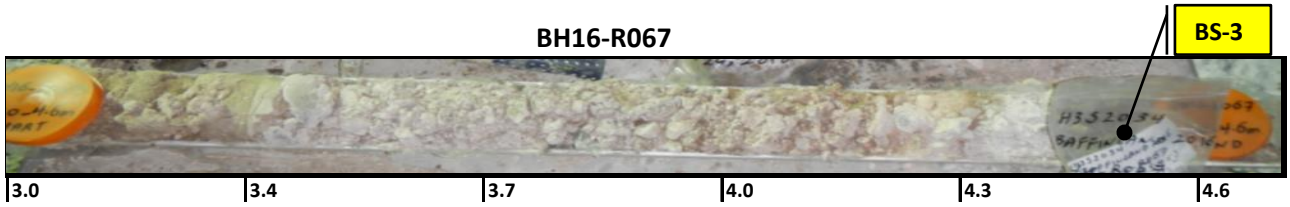
4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

Sample Photographs

Borehole Name:	BH16-R067	Mary River 12 MTPA Mine Expansion
Location:	17 W 535406 7918572	Pre-feasibility Study
Completion Date:	24/11/2016	Baffinland Iron Mines







HATCH

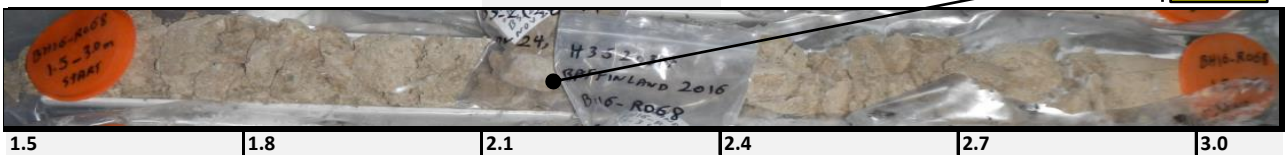
Sample Photographs

Borehole Name:	BH16-R068	Mary River 12 MTPA Mine Expansion
Location:	17 W 537046 7919096	Pre-feasibility Study
Completion Date:	24/11/2016	Baffinland Iron Mines

BH16-R068

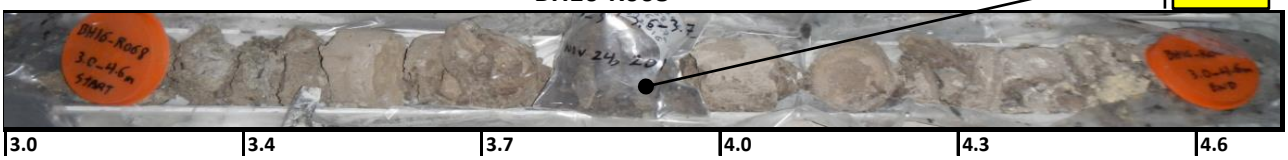
0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-R068



1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-R068

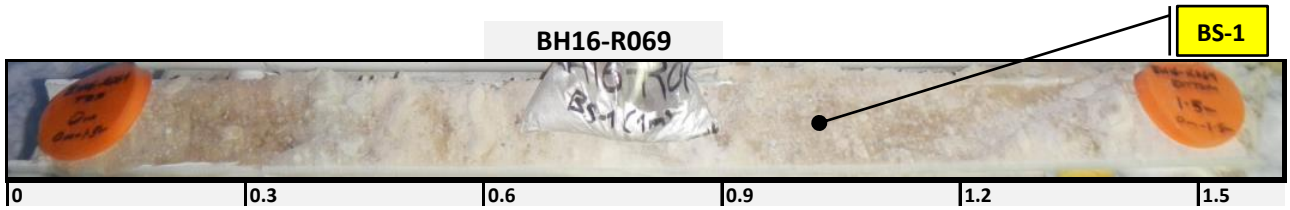


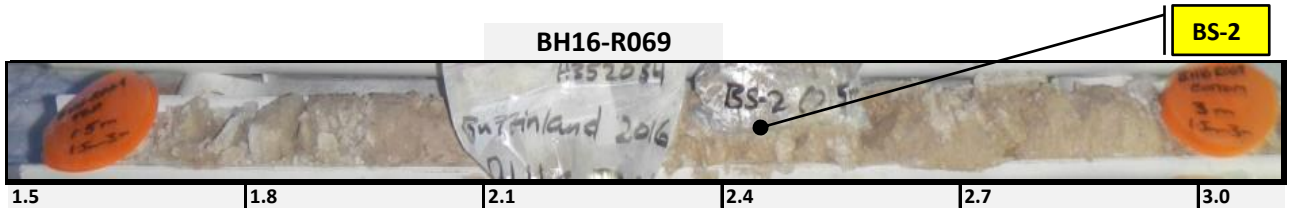
3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

HATCH

Sample Photographs

Borehole Name:	BH16-R069	Mary River 12 MTPA Mine Expansion
Location:	17 W 539489 7920583	Pre-feasibility Study
Completion Date:	23/11/2016	Baffinland Iron Mines





Sample Photographs

Borehole Name:	BH16-R070	Mary River 12 MTPA Mine Expansion
Location:	17 W 540273 7921201	Pre-feasibility Study
Completion Date:	23/11/2016	Baffinland Iron Mines

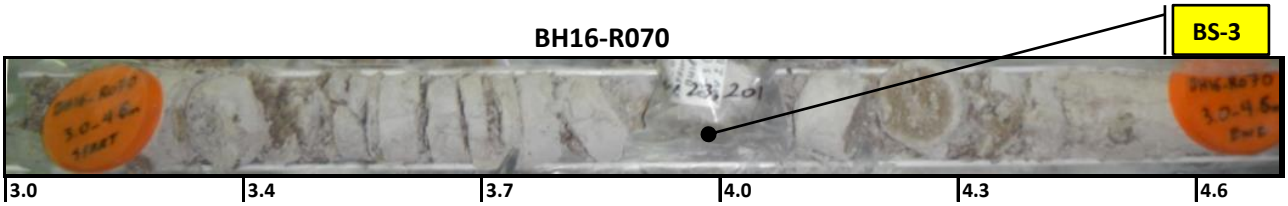
BH16-R070

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH16-R070

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH16-R070



3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

HATCH

Sample Photographs

Borehole Name:	BH17-B001	Mary River Expansion Study Stage 2
Location:	17 W 529031 7916747	2017 Geotechnical Investigation
Completion Date:	April 22, 2017	Baffinland Iron Mines

BH17-B001

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH17-B001

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH17-B001

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH17-B001

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH17-B001

6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

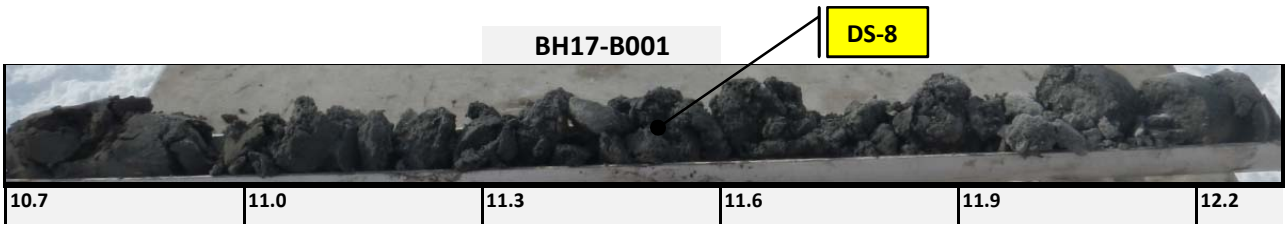
BH17-B001

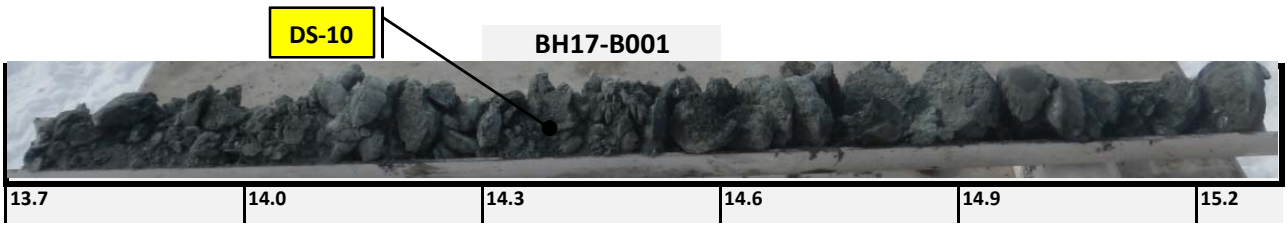
7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

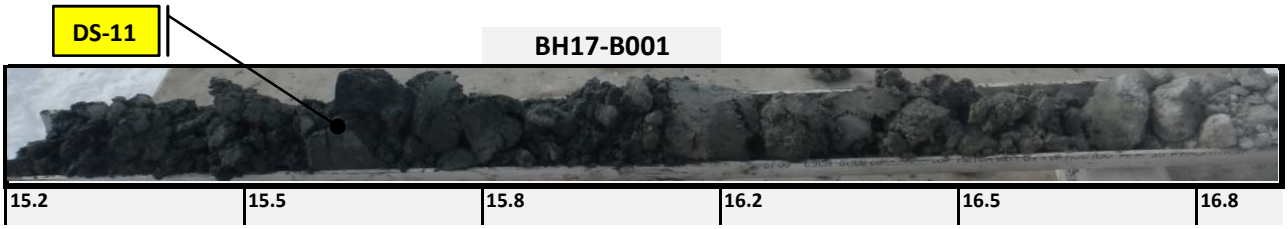
HATCH

Sample Photographs

Borehole Name:	BH17-B001	Mary River Expansion Study Stage 2
Location:	17 W 529031 7916747	
Completion Date:	April 22, 2017	Baffinland Iron Mines







HATCH

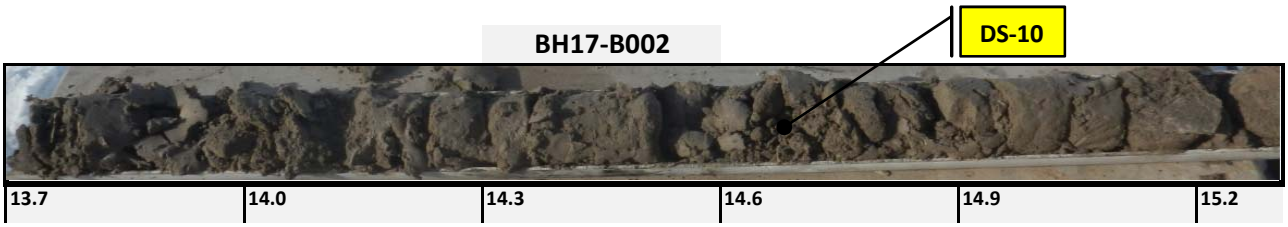
Sample Photographs

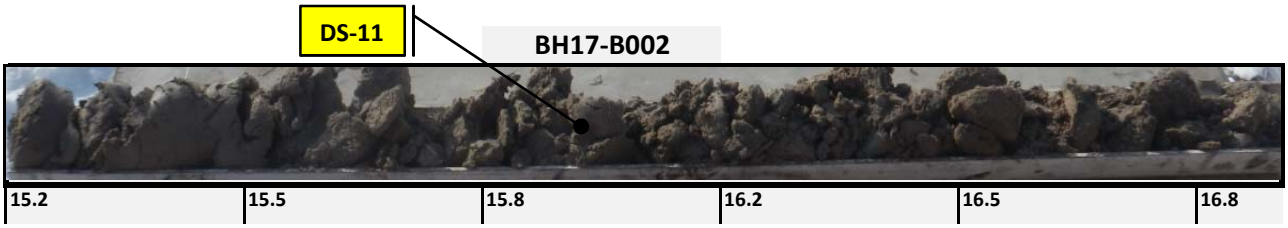
Borehole Name:	BH17-B002	Mary River Expansion Study Stage 2
Location:	17 W 529323 7916577	2017 Geotechnical Investigation
Completion Date:	April 21, 2017	Baffinland Iron Mines

HATCH

Sample Photographs

Borehole Name:	BH17-B002	Mary River Expansion Study Stage 2
Location:	17 W 529323 7916577	
Completion Date:	April 21, 2017	Baffinland Iron Mines

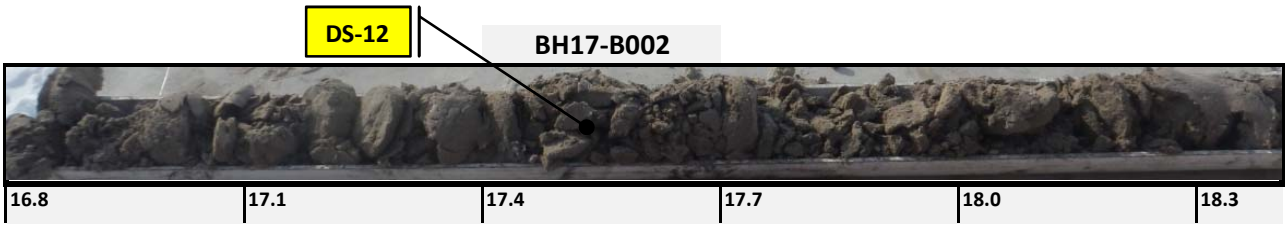




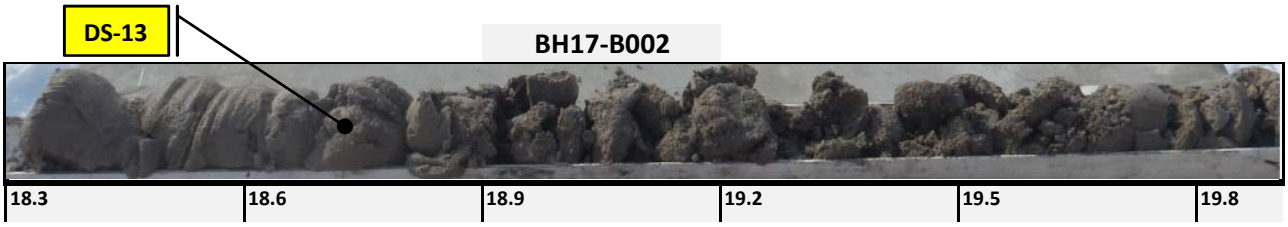
HATCH

Sample Photographs

Borehole Name:	BH17-B002	Mary River Expansion Study Stage 2
Location:	17 W 529323 7916577	
Completion Date:	April 21, 2017	Baffinland Iron Mines



16.8	17.1	17.4	17.7	18.0	18.3



18.3	18.6	18.9	19.2	19.5	19.8

19.8	20.1	20.4	20.7	21.0	21.3

21.3	21.6	21.9	22.3	22.6	22.9

22.9	23.2	23.5	23.8	24.1	24.4

HATCH

Sample Photographs

Borehole Name:	BH17-B002	Mary River Expansion Study Stage 2
Location:	17 W 529323 7916577	
Completion Date:	April 21, 2017	Baffinland Iron Mines

BH17-B002

DRILL BIT LOST; NO SAMPLE COLLECTED. END OF HOLE AT 25.6 M

24.4	**24.7**	**25.0**	**25.3**	**25.6**	**25.9**

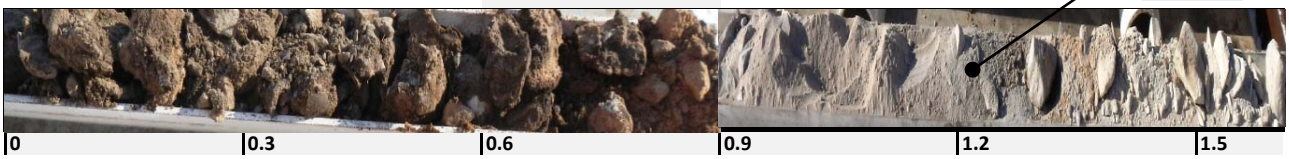
HATCH

Sample Photographs

Borehole Name:	BH17-C001	Mary River Expansion Study Stage 2
Location:	17 W 509861 7967883	2017 Geotechnical Investigation
Completion Date:	April 13, 2017	Baffinland Iron Mines

BH17-C001

DS-1



0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH17-C001

DS-2

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

DS-3

BH17-C001

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

DS-4

BH17-C001

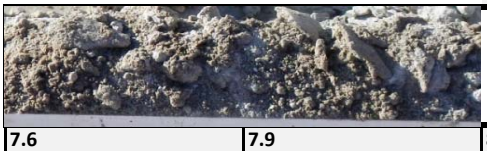
4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH17-C001

DS-5

6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

BH17-C001

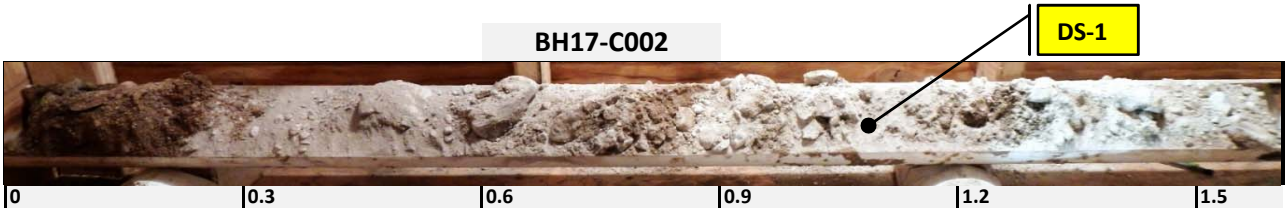


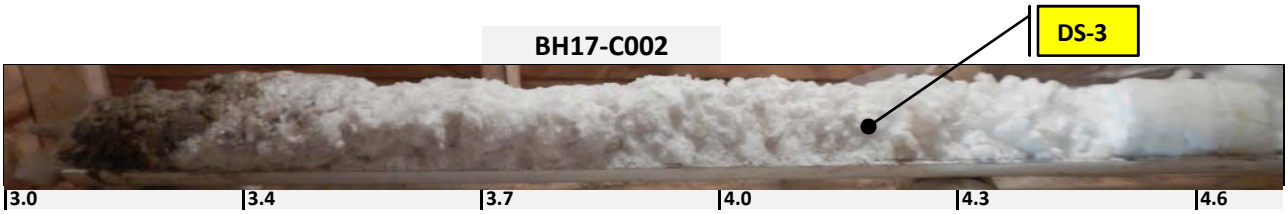
7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

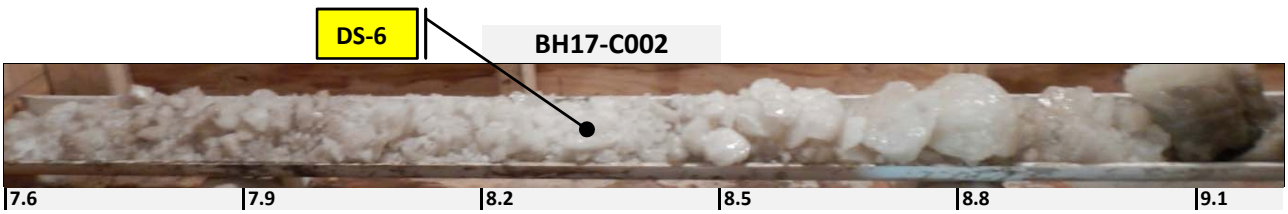
HATCH

Sample Photographs

Borehole Name:	BH17-C002	Mary River Expansion Study Stage 2
Location:	17 W 519513 7957644	2017 Geotechnical Investigation
Completion Date:	April 14, 2017	Baffinland Iron Mines







HATCH

Sample Photographs

Borehole Name:	BH17-C002	Mary River Expansion Study Stage 2
Location:	17 W 519513 7957644	
Completion Date:	April 14, 2017	Baffinland Iron Mines

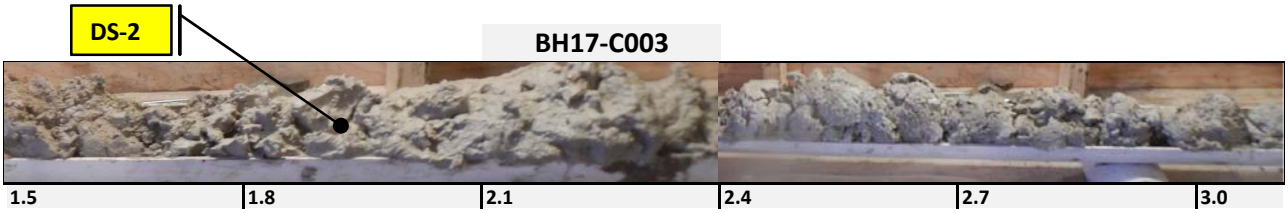
BH17-C002

9.1	9.4	9.8	10.1	10.4	10.7

HATCH

Sample Photographs

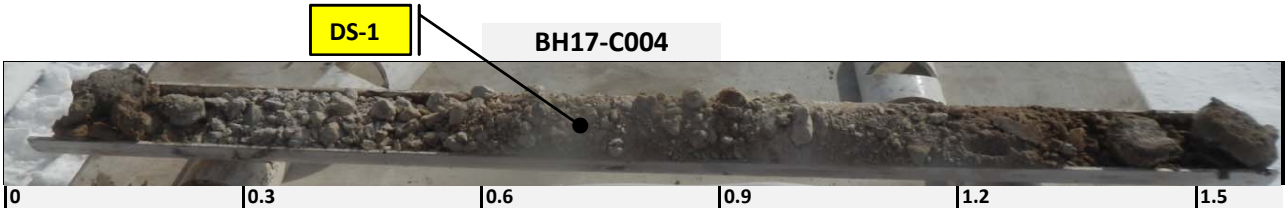
Borehole Name:	BH17-C003	Mary River Expansion Study Stage 2
Location:	17 W 520091 7957302	2017 Geotechnical Investigation
Completion Date:	April 14, 2017	Baffinland Iron Mines



HATCH

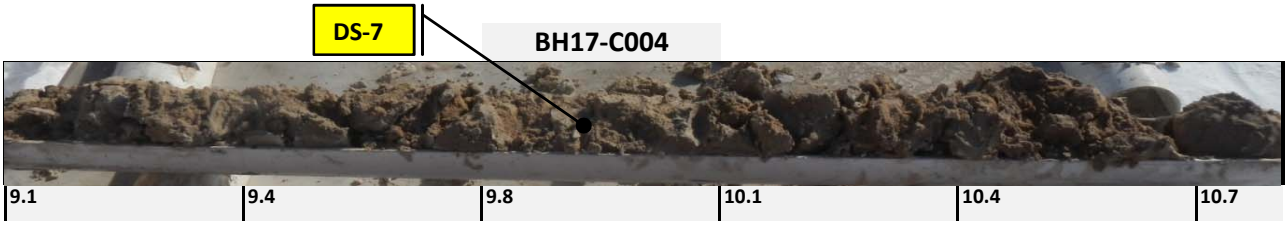
Sample Photographs

Borehole Name:	BH17-C004	Mary River Expansion Study Stage 2
Location:	17 W 520484 7956357	2017 Geotechnical Investigation
Completion Date:	April 14, 2017	Baffinland Iron Mines



Sample Photographs

Borehole Name:	BH17-C004	Mary River Expansion Study Stage 2
Location:	17 W 520484 7956357	
Completion Date:	April 14, 2017	Baffinland Iron Mines



HATCH

Sample Photographs

Borehole Name:	BH17-C005	Mary River Expansion Study Stage 2
Location:	17 W 525227 7938527	2017 Geotechnical Investigation
Completion Date:	April 14, 2017	Baffinland Iron Mines

BH17-C005

DS-1

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH17-C005

DS-2

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH17-C005

DS-3

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH17-C005

DS-4

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH17-C005

DS-5

6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

BH17-C005

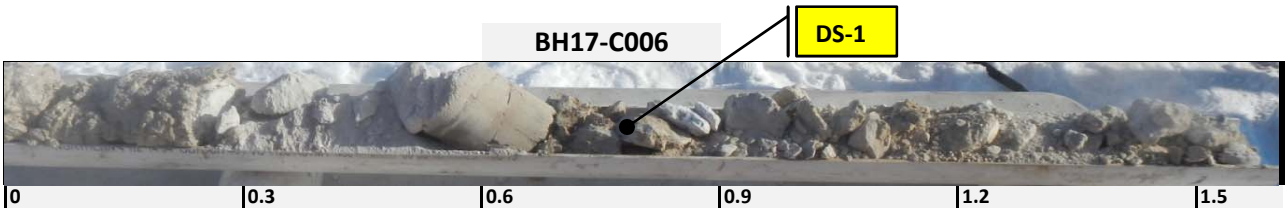
DS-6

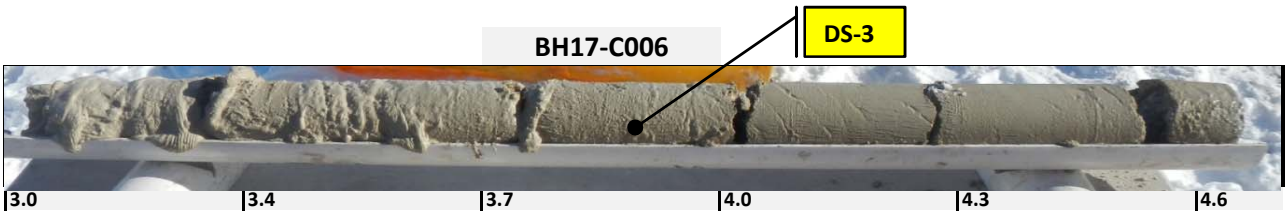
7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

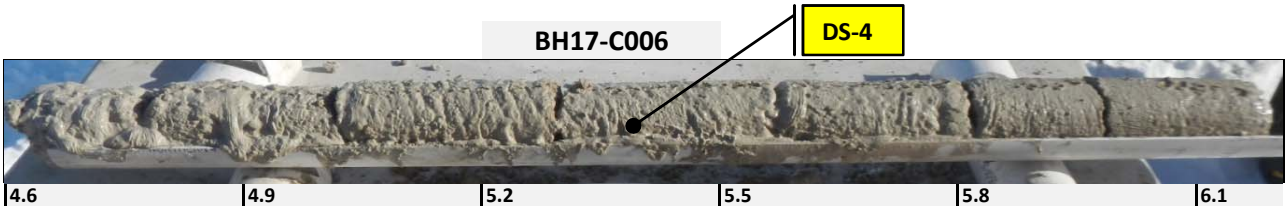
HATCH

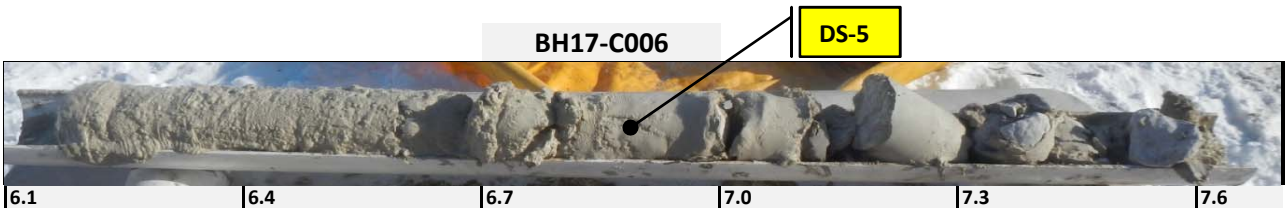
Sample Photographs

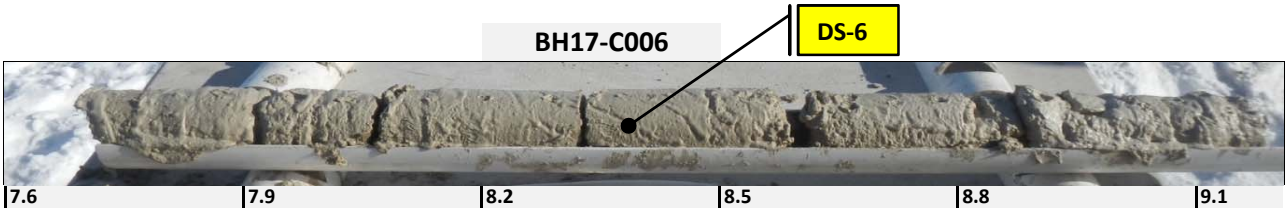
Borehole Name:	BH17-C006	Mary River Expansion Study Stage 2
Location:	17 W 527370 7932609	2017 Geotechnical Investigation
Completion Date:	April 15, 2017	Baffinland Iron Mines











Sample Photographs

Borehole Name:	BH17-C006	Mary River Expansion Study Stage 2
Location:	17 W 527370 7932609	
Completion Date:	April 15, 2017	Baffinland Iron Mines

BH17-C006

9.1	9.4	9.8	10.1	10.4	10.7

HATCH

Sample Photographs

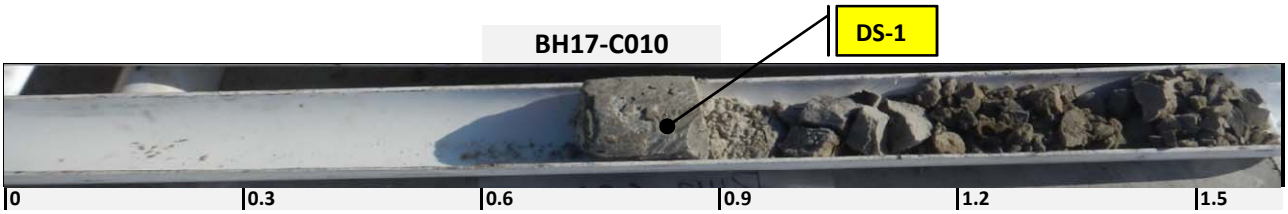
Borehole Name:	BH17-C006B	Mary River Expansion Study Stage 2
Location:	17 W 528253 7929081	2017 Geotechnical Investigation
Completion Date:	April 16, 2017	Baffinland Iron Mines

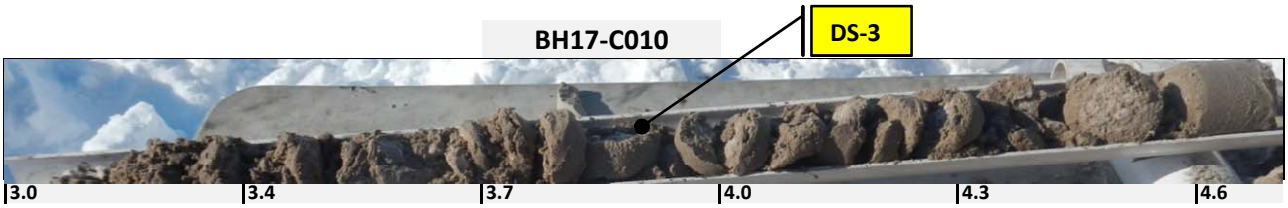
Sample Photographs

Borehole Name:	BH17-C007	Mary River Expansion Study Stage 2
Location:	17 W 528564 7917138	2017 Geotechnical Investigation
Completion Date:	April 22, 2017	Baffinland Iron Mines

Sample Photographs

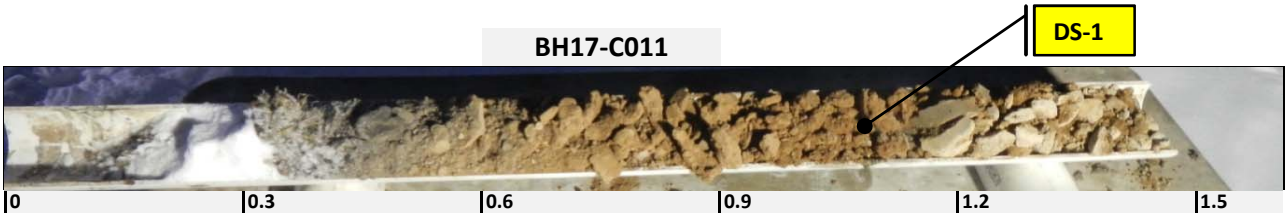
Borehole Name:	BH17-C010	Mary River Expansion Study Stage 2
Location:	17 W 529961 7916702	2017 Geotechnical Investigation
Completion Date:	April 19, 2017	Baffinland Iron Mines

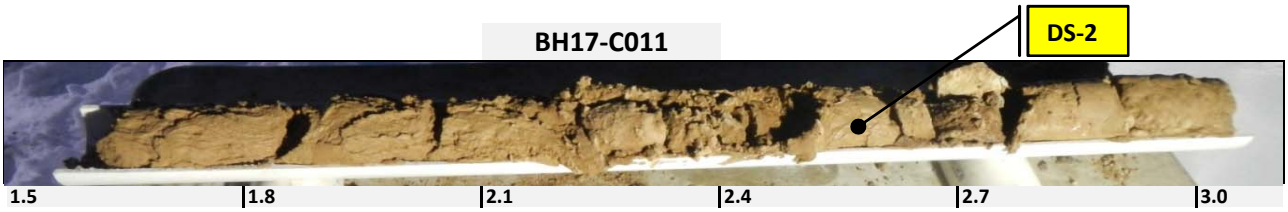




Sample Photographs

Borehole Name:	BH17-C011	Mary River Expansion Study Stage 2
Location:	17 W 532072 7917478	2017 Geotechnical Investigation
Completion Date:	April 19, 2017	Baffinland Iron Mines

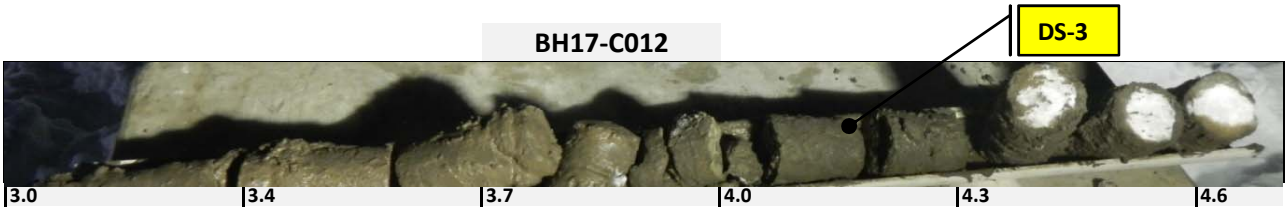




HATCH

Sample Photographs

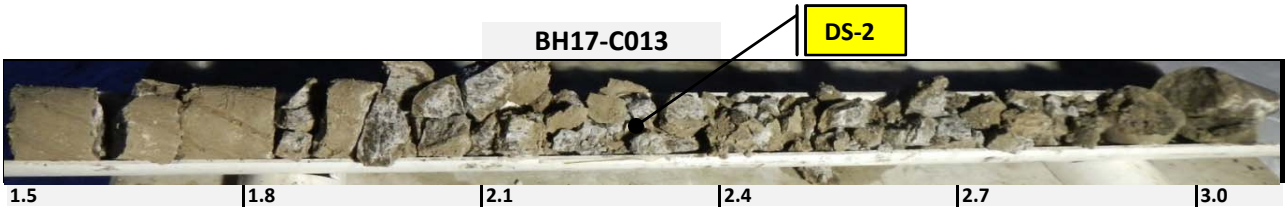
Borehole Name:	BH17-C012	Mary River Expansion Study Stage 2
Location:	17 W 533228 7918553	2017 Geotechnical Investigation
Completion Date:	April 19, 2017	Baffinland Iron Mines

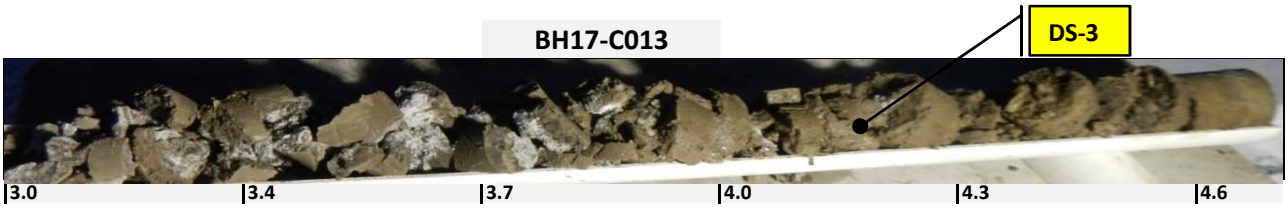


HATCH

Sample Photographs

Borehole Name:	BH17-C013	Mary River Expansion Study Stage 2
Location:	17 W 534196 7918569	2017 Geotechnical Investigation
Completion Date:	April 18, 2017	Baffinland Iron Mines

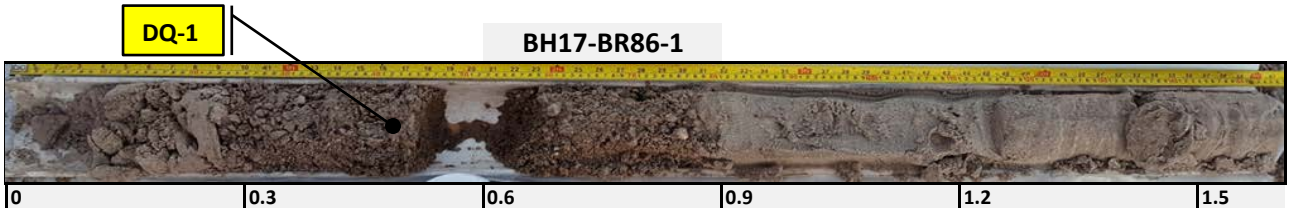




HATCH

Sample Photographs

Borehole Name:	BH17-BR86-1	Mary River Expansion Study Stage 2
Location:	17 W 542257 7922182	2017 Geotechnical Investigation
Completion Date:	October 3, 2017	Baffinland Iron Mines



HATCH

Sample Photographs

Borehole Name:	BH17-BR86-1	Mary River Expansion Study Stage 2
Location:	17 W 542257 7922182	
Completion Date:	October 3, 2017	Baffinland Iron Mines

BH17-BR86-1

9.1 | 9.4 | 9.8 | 10.1 | 10.4 | 10.7

BH17-BR86-1

10.7 | 11.0 | 11.3 | 11.6 | 11.9 | 12.2

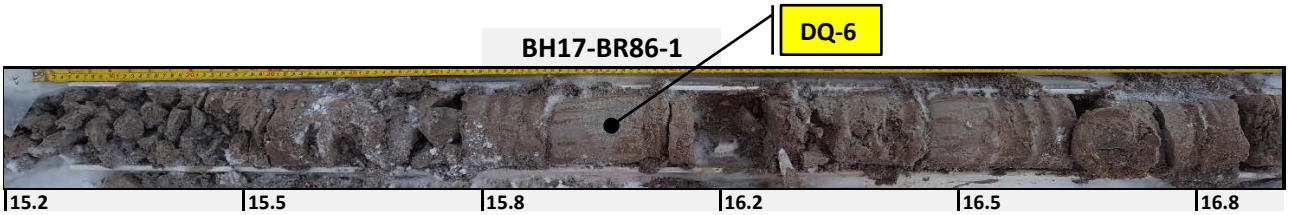
BH17-BR86-1

12.2 | 12.5 | 12.8 | 13.1 | 13.4 | 13.7

BH17-BR86-1

13.7 | 14.0 | 14.3 | 14.6 | 14.9 | 15.2

BH17-BR86-1



15.2 | 15.5 | 15.8 | 16.2 | 16.5 | 16.8

BH17-BR86-1

16.8 | 17.1 | 17.4 | 17.7 | 18.0 | 18.3

HATCH

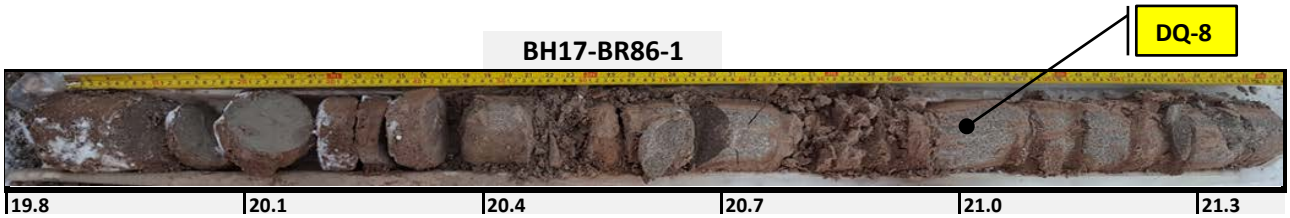
Sample Photographs

Borehole Name:	BH17-BR86-1	Mary River Expansion Study Stage 2
Location:	17 W 542257 7922182	
Completion Date:	October 3, 2017	Baffinland Iron Mines

BH17-BR86-1

18.3 | 18.6 | 18.9 | 19.2 | 19.5 | 19.8

BH17-BR86-1



19.8 | 20.1 | 20.4 | 20.7 | 21.0 | 21.3

BH17-BR86-1

21.3 | 21.6 | 21.9 | 22.3 | 22.6 | 22.9

BH17-BR86-1

22.9 | 23.2 | 23.5 | 23.8 | 24.1 | 24.4

BH17-BR86-1

24.4 | 24.7 | 25.0 | 25.3 | 25.6 | 25.9

BH17-BR86-1

25.9 | 26.2 | 26.5 | 26.8 | 27.1 | 27.4

HATCH

Sample Photographs

Borehole Name:	BH17-BR86-1	Mary River Expansion Study Stage 2
Location:	17 W 542257 7922182	
Completion Date:	October 3, 2017	Baffinland Iron Mines

BH17-BR86-1

DQ-10

BH17-BR86-1

DQ-11

BH17-BR86-1

BH17-BR86-1

BH17-BR86-1

DQ-12

BH17-BR86-1

Sample Photographs

Borehole Name:	BH17-BR86-1	Mary River Expansion Study Stage 2
Location:	17 W 542257 7922182	
Completion Date:	October 3, 2017	Baffinland Iron Mines

BH17-BR86-1

36.6 | 36.9 | 37.2 | 37.5 | 37.8 | 38.1

BH17-BR86-1

38.1 | 38.4 | 38.7 | 39.0 | 39.3 | 39.6

HATCH

Sample Photographs

Borehole Name:	BH17-BR86-2	Mary River Expansion Study Stage 2
Location:	17 W 542269 7922171	2017 Geotechnical Investigation
Completion Date:	October 26, 2017	Baffinland Iron Mines

BH17-BR86-2

DQ-1

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

DQ-2

BH17-BR86-2

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

DQ-3

BH17-BR86-2

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

DQ-4

BH17-BR86-2

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH17-BR86-2

6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

BH17-BR86-2

7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

HATCH

Sample Photographs

Borehole Name:	BH17-BR86-2	Mary River Expansion Study Stage 2
Location:	17 W 542269 7922171	
Completion Date:	October 26, 2017	Baffinland Iron Mines

DQ-5

BH17-BR86-2

9.1 | 9.4 | 9.8 | 10.1 | 10.4 | 10.7

DQ-6

BH17-BR86-2

10.7 | 11.0 | 11.3 | 11.6 | 11.9 | 12.2

BH17-BR86-2

12.2 | 12.5 | 12.8 | 13.1 | 13.4 | 13.7

BH17-BR86-2

13.7 | 14.0 | 14.3 | 14.6 | 14.9 | 15.2

BH17-BR86-2

15.2 | 15.5 | 15.8 | 16.2 | 16.5 | 16.8

BH17-BR86-2

16.8 | 17.1 | 17.4 | 17.7 | 18.0 | 18.3

Sample Photographs

Borehole Name:	BH17-BR86-2	Mary River Expansion Study Stage 2
Location:	17 W 542269 7922171	
Completion Date:	October 26, 2017	Baffinland Iron Mines

BH17-BR86-2

18.3 | 18.6 | 18.9 | 19.2 | 19.5 | 19.8

BH17-BR86-2

19.8 | 20.1 | 20.4 | 20.7 | 21.0 | 21.3

BH17-BR86-2

21.3 | 21.6 | 21.9 | 22.3 | 22.6 | 22.9

BH17-BR86-2

22.9 | 23.2 | 23.5 | 23.8 | 24.1 | 24.4

BH17-BR86-2

24.4 | 24.7 | 25.0 | 25.3 | 25.6 | 25.9

BH17-BR86-2

25.9 | 26.2 | 26.5 | 26.8 | 27.1 | 27.4

Sample Photographs

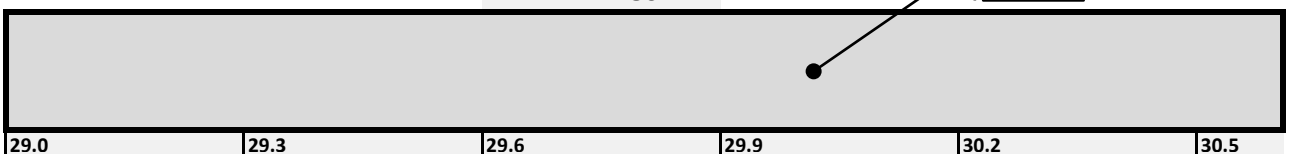
Borehole Name:	BH17-BR86-2	Mary River Expansion Study Stage 2
Location:	17 W 542269 7922171	
Completion Date:	October 26, 2017	Baffinland Iron Mines

BH17-BR86-2

27.4 | 27.7 | 28.0 | 28.3 | 28.7 | 29.0

BH17-BR86-2

DQ-9



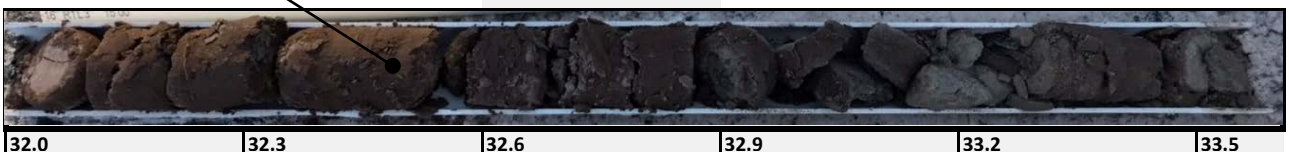
29.0 | 29.3 | 29.6 | 29.9 | 30.2 | 30.5

BH17-BR86-2

30.5 | 30.8 | 31.1 | 31.4 | 31.7 | 32.0

DQ-10

BH17-BR86-2



32.0 | 32.3 | 32.6 | 32.9 | 33.2 | 33.5

BH17-BR86-2

33.5 | 33.8 | 34.1 | 34.4 | 34.7 | 35.1

DQ-11

BH17-BR86-2

35.1 | 35.4 | 35.7 | 36.0 | 36.3 | 36.6

Sample Photographs

Borehole Name:	BH17-BR86-2	Mary River Expansion Study Stage 2
Location:	17 W 542269 7922171	
Completion Date:	October 26, 2017	Baffinland Iron Mines

BH17-BR86-2

36.6 | 36.9 | 37.2 | 37.5 | 37.8 | 38.1

BH17-BR86-2

38.1 | 38.4 | 38.7 | 39.0 | 39.3 | 39.6

Sample Photographs

Borehole Name:	BH17-BR86-3	Mary River Expansion Study Stage 2
Location:	17 W 542305 7922141	2017 Geotechnical Investigation
Completion Date:		Baffinland Iron Mines

Sample Photographs

Borehole Name:	BH17-BR86-3	Mary River Expansion Study Stage 2
Location:	17 W 542305 7922141	
Completion Date:		Baffinland Iron Mines

BH17-BR86-3

9.1 | 9.4 | 9.8 | 10.1 | 10.4 | 10.7

BH17-BR86-3

10.7 | 11.0 | 11.3 | 11.6 | 11.9 | 12.2

BH17-BR86-3

12.2 | 12.5 | 12.8 | 13.1 | 13.4 | 13.7

BH17-BR86-3

13.7 | 14.0 | 14.3 | 14.6 | 14.9 | 15.2

BH17-BR86-3

15.2 | 15.5 | 15.8 | 16.2 | 16.5 | 16.8

BH17-BR86-3

16.8 | 17.1 | 17.4 | 17.7 | 18.0 | 18.3

HATCH

Sample Photographs

Borehole Name:	BH17-BR86-3	Mary River Expansion Study Stage 2
Location:	17 W 542305 7922141	
Completion Date:		Baffinland Iron Mines

BH17-BR86-3

18.3 | 18.6 | 18.9 | 19.2 | 19.5 | 19.8

BH17-BR86-3

19.8 | 20.1 | 20.4 | 20.7 | 21.0 | 21.3

BH17-BR86-3

21.3 | 21.6 | 21.9 | 22.3 | 22.6 | 22.9

BH17-BR86-3

22.9 | 23.2 | 23.5 | 23.8 | 24.1 | 24.4

BH17-BR86-3

24.4 | 24.7 | 25.0 | 25.3 | 25.6 | 25.9

BH17-BR86-3

25.9 | 26.2 | 26.5 | 26.8 | 27.1 | 27.4

HATCH

Sample Photographs

Borehole Name:	BH17-BR86-3	Mary River Expansion Study Stage 2
Location:	17 W 542305 7922141	
Completion Date:		Baffinland Iron Mines

BH17-BR86-3

27.4 | 27.7 | 28.0 | 28.3 | 28.7 | 29.0

BH17-BR86-3

29.0 | 29.3 | 29.6 | 29.9 | 30.2 | 30.5

BH17-BR86-3

30.5 | 30.8 | 31.1 | 31.4 | 31.7 | 32.0

BH17-BR86-3

32.0 | 32.3 | 32.6 | 32.9 | 33.2 | 33.5

BH17-BR86-3

33.5 | 33.8 | 34.1 | 34.4 | 34.7 | 35.1

BH17-BR86-3

35.1 | 35.4 | 35.7 | 36.0 | 36.3 | 36.6

HATCH

Sample Photographs

Borehole Name:	BH17-BR86-3	Mary River Expansion Study Stage 2
Location:	17 W 542305 7922141	
Completion Date:		Baffinland Iron Mines

BH17-BR86-3

36.6 | 36.9 | 37.2 | 37.5 | 37.8 | 38.1

BH17-BR86-3

38.1 | 38.4 | 38.7 | 39.0 | 39.3 | 39.6

HATCH

Sample Photographs

Borehole Name:	BH18-BR15-1	Mary River Expansion Study Stage 2
Location:	17 W 514260 7965610	2018 Geotechnical Investigation
Completion Date:	March 14, 2018	Baffinland Iron Mines

BH18-BR15-1

BH18-BR15-1

BH18-BR15-1

BH18-BR15-1

BH18-BR15-1

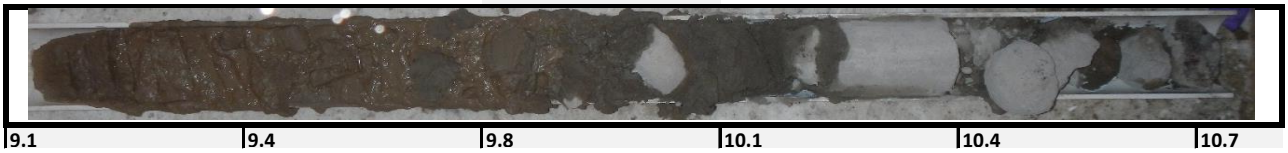
BH18-BR15-1

HATCH

Sample Photographs

Borehole Name:	BH18-BR15-1	Mary River Expansion Study Stage 2
Location:	17 W 514260 7965610	
Completion Date:	March 14, 2018	Baffinland Iron Mines

BH18-BR15-1



9.1	9.4	9.8	10.1	10.4	10.7

BH18-BR15-1

10.7	10.8	10.9	10.9	11.0	11.1

BH18-BR15-1

11.1	11.4	11.7	12.0	12.3	12.6

BH18-BR15-1

12.6	13.0	13.3	13.6	13.9	14.2

BH18-BR15-1

14.2	14.2	14.3			

BH18-BR15-1

14.3	14.6	14.9	15.2	15.5	15.8

HATCH

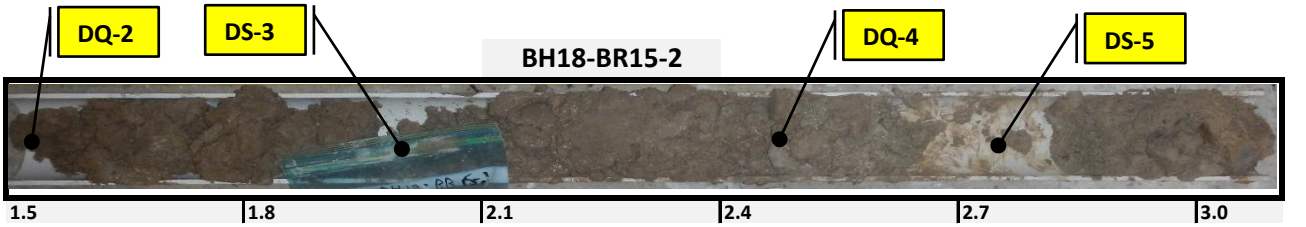
Sample Photographs

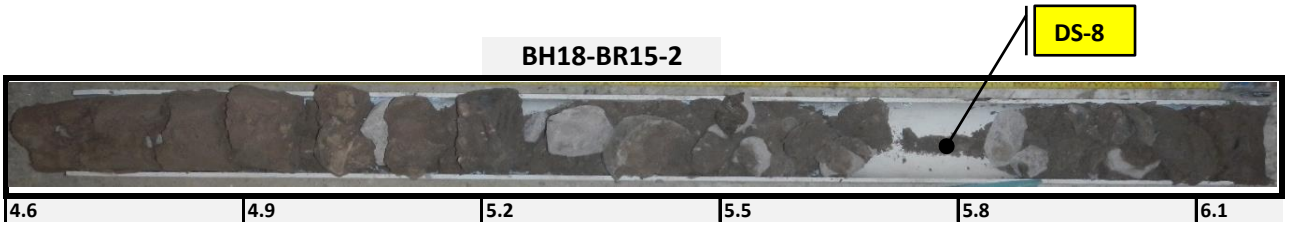
Borehole Name:	BH18-BR15-1	Mary River Expansion Study Stage 2
Location:	17 W 514260 7965610	
Completion Date:	March 14, 2018	Baffinland Iron Mines

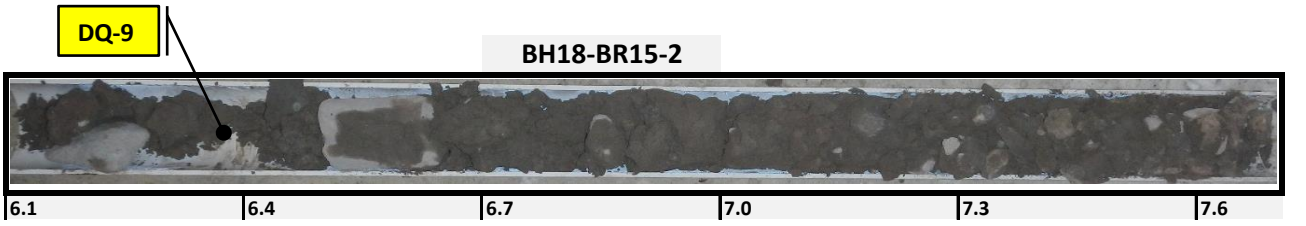
BH18-BR15-1

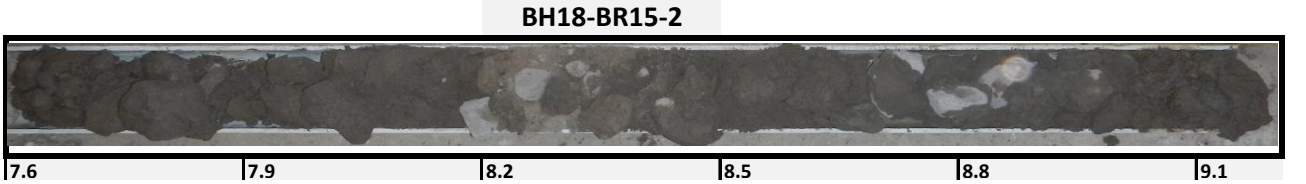
Sample Photographs

Borehole Name:	BH18-BR15-2	Mary River Expansion Study Stage 2
Location:	17 W 514211 7965645	2018 Geotechnical Investigation
Completion Date:	March 12, 2018	Baffinland Iron Mines









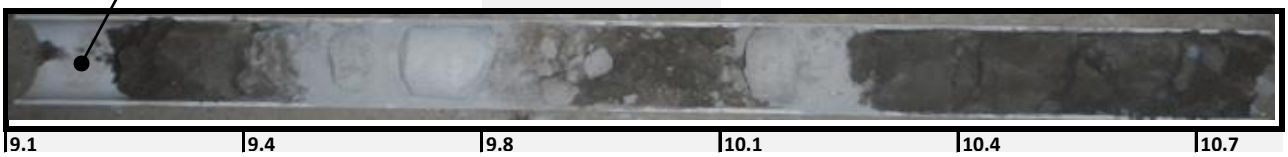
HATCH

Sample Photographs

Borehole Name:	BH18-BR15-2	Mary River Expansion Study Stage 2
Location:	17 W 514211 7965645	
Completion Date:	March 12, 2018	Baffinland Iron Mines

DS-10

BH18-BR15-2



9.1 | 9.4 | 9.8 | 10.1 | 10.4 | 10.7

BH18-BR15-2

10.7 | 11.0 | 11.3 | 11.6 | 11.9 | 12.2

BH18-BR15-2

12.2 | 12.5 | 12.8 | 13.1 | 13.4 | 13.7

BH18-BR15-2

13.7 | 14.0 | 14.3 | 14.6 | 14.9 | 15.2

BH18-BR15-2

15.2 | 15.5 | 15.8 | 16.2 | 16.5 | 16.8

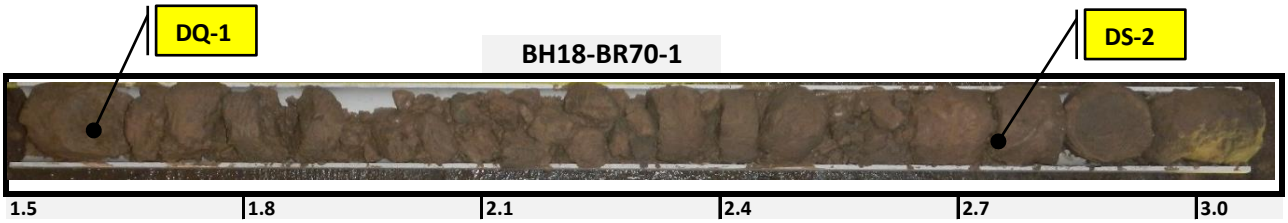
HATCH

Sample Photographs

Borehole Name:	BH18-BR70-1	Mary River Expansion Study Stage 2
Location:	17 W 529138 7916667	2018 Geotechnical Investigation
Completion Date:	April 16, 2018	Baffinland Iron Mines

BH18-BR70-1

BH18-BR70-1

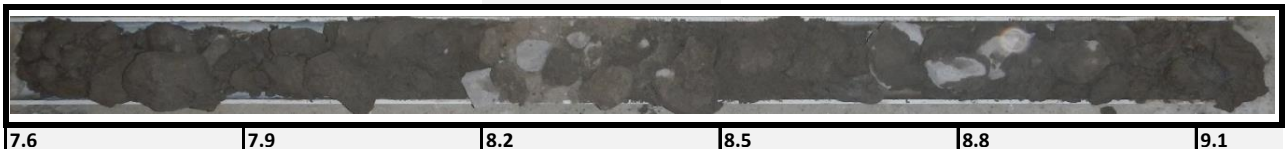


BH18-BR70-1

BH18-BR70-1

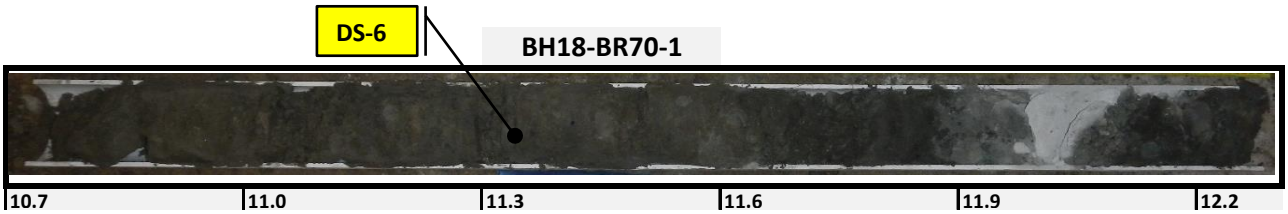
BH18-BR70-1

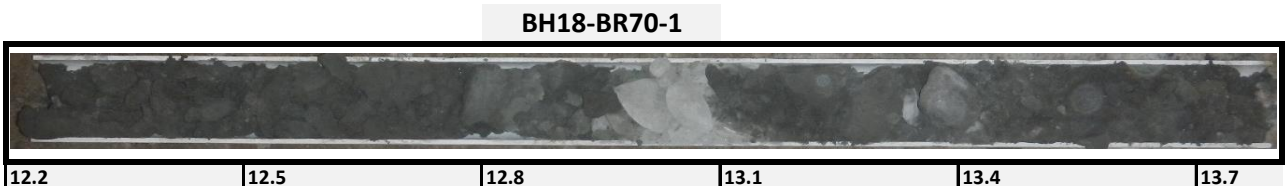
BH18-BR70-1

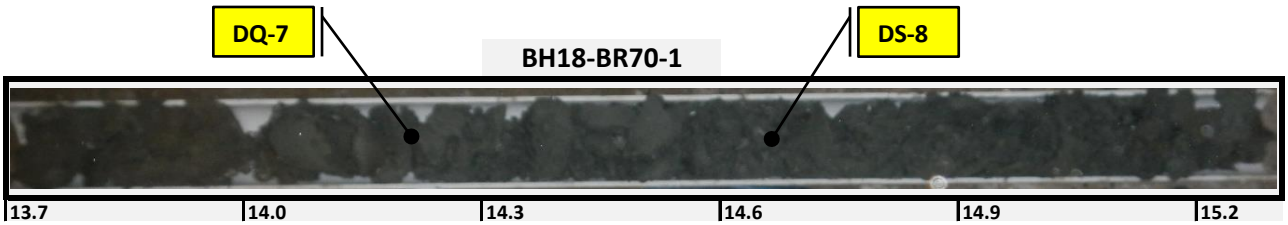


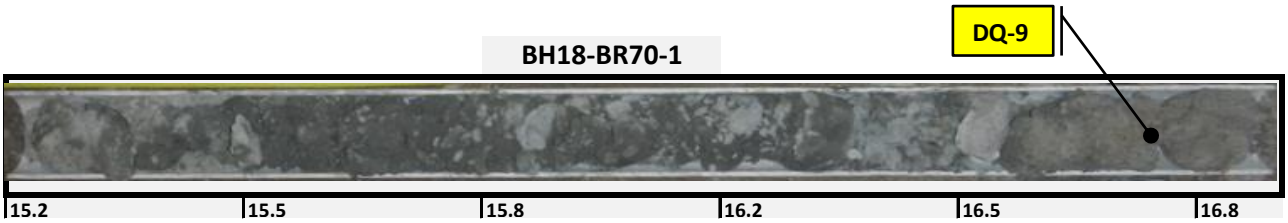
Sample Photographs

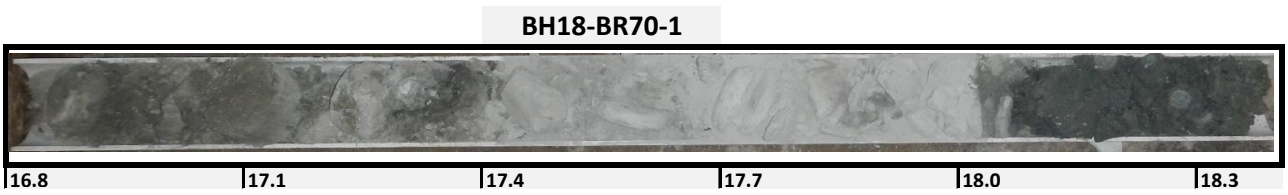
Borehole Name:	BH18-BR70-1	Mary River Expansion Study Stage 2
Location:	17 W 529138 7916667	
Completion Date:	April 16, 2018	Baffinland Iron Mines











HATCH

Sample Photographs

Borehole Name:	BH18-BR70-1	Mary River Expansion Study Stage 2
Location:	17 W 529138 7916667	
Completion Date:	April 16, 2018	Baffinland Iron Mines

BH18-BR70-1

18.3	18.6	18.9	19.2	19.5	19.8

BH18-BR70-1

19.8	20.1	20.4	20.7	21.0	21.3

BH18-BR70-1

21.3	21.6	21.9	22.3	22.6	22.9

BH18-BR70-1

22.9	23.2	23.5	23.8	24.1	24.4

BH18-BR70-1

24.4	24.7	25.0	25.3	25.6	25.9

BH18-BR70-1

25.9	26.2	26.5	26.8	27.1	27.4

HATCH

Sample Photographs

Borehole Name:	BH18-BR70-1	Mary River Expansion Study Stage 2
Location:	17 W 529138 7916667	
Completion Date:	April 16, 2018	Baffinland Iron Mines

BH18-BR70-1

27.4	27.7	27.9	28.1	28.3	28.6

BH18-BR70-1

28.6	28.8	28.9	29.1	29.3	29.5

BH18-BR70-1

29.5	29.8	30.1	30.4	30.7	31.0

BH18-BR70-1

31.0	31.3	31.6	31.9	32.2	32.5

HATCH

Sample Photographs

Borehole Name:	BH18-BR70-2	Mary River Expansion Study Stage 2
Location:	17 W 529107 7916700	2018 Geotechnical Investigation
Completion Date:	April 18, 2018	Baffinland Iron Mines

BH18-BR70-2

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH18-BR70-2

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH18-BR70-2

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH18-BR70-2

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH18-BR70-2

6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

BH18-BR70-2

7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

HATCH

Sample Photographs

Borehole Name:	BH18-BR70-2	Mary River Expansion Study Stage 2
Location:	17 W 529107 7916700	
Completion Date:	April 18, 2018	Baffinland Iron Mines

DQ-3

BH18-BR70-2

9.1 | 9.4 | 9.8 | 10.1 | 10.4 | 10.7

BH18-BR70-2

10.7 | 11.0 | 11.3 | 11.6 | 11.9 | 12.2

BH18-BR70-2

12.2 | 12.5 | 12.8 | 13.1 | 13.4 | 13.7

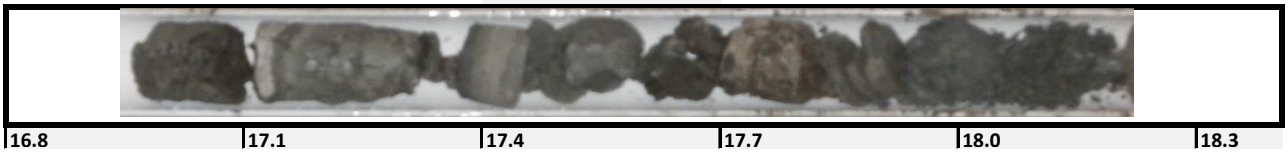
BH18-BR70-2

13.7 | 14.0 | 14.3 | 14.6 | 14.9 | 15.2

BH18-BR70-2

15.2 | 15.5 | 15.8 | 16.2 | 16.5 | 16.8

BH18-BR70-2



16.8 | 17.1 | 17.4 | 17.7 | 18.0 | 18.3

HATCH

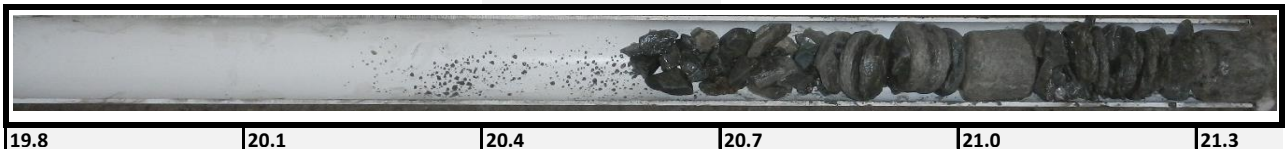
Sample Photographs

Borehole Name:	BH18-BR70-2	Mary River Expansion Study Stage 2
Location:	17 W 529107 7916700	
Completion Date:	April 18, 2018	Baffinland Iron Mines

BH18-BR70-2

18.3	18.6	18.9	19.2	19.5	19.8

BH18-BR70-2



19.8	20.1	20.4	20.7	21.0	21.3

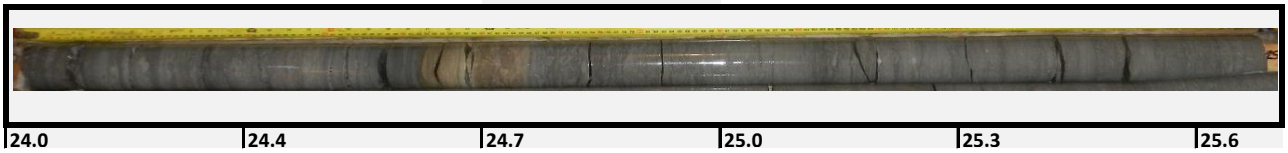
BH18-BR70-2

21.3	21.5	21.6	21.8	21.9	22.1

BH18-BR70-2

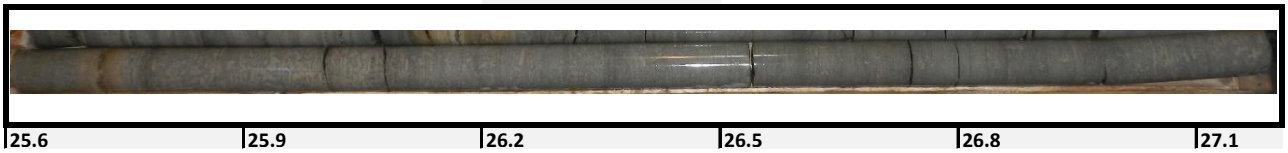
22.1	22.5	22.9	23.3	23.7	24.0

BH18-BR70-2



24.0	24.4	24.7	25.0	25.3	25.6

BH18-BR70-2



25.6	25.9	26.2	26.5	26.8	27.1

Sample Photographs

Borehole Name:	BH18-BR70-2	Mary River Expansion Study Stage 2
Location:	17 W 529107 7916700	
Completion Date:	April 18, 2018	Baffinland Iron Mines

BH18-BR70-2

27.1 | 27.4 | 27.7 | 28.0 | 28.3 | 28.6

Sample Photographs

Borehole Name:	BH18-BR102-1	Mary River Expansion Study Stage 2
Location:	17 W 555763 7915435	2018 Geotechnical Investigation
Completion Date:	April 7, 2018	Baffinland Iron Mines

BH18-BR102-1

0	0.3	0.6	0.9	1.2	1.5

BH18-BR102-1

1.5	1.7	1.8	2.0		

BH18-BR102-1

2.0	2.3	2.6	2.9	3.2	3.5

BH18-BR102-1

3.5	3.8	4.1	4.4	4.7	5.0

BH18-BR102-1

5.0	5.3	5.6	5.9	6.2	6.6

BH18-BR102-1

6.6	6.9	7.2	7.5	7.8	8.1

HATCH

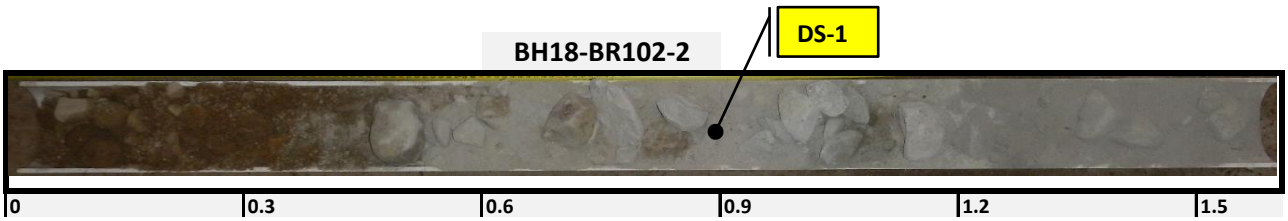
Sample Photographs

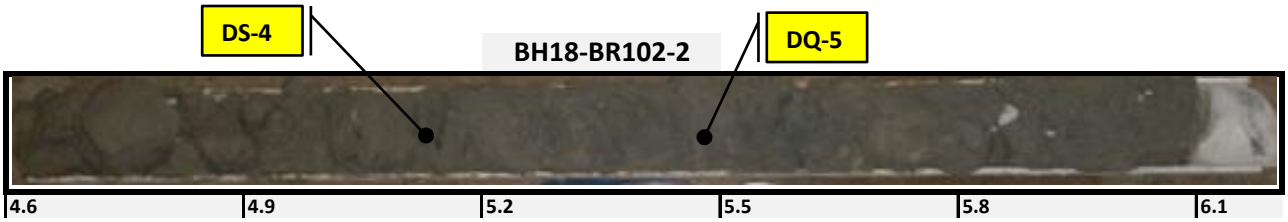
Borehole Name:	BH18-BR102-1	Mary River Expansion Study Stage 2
Location:	17 W 555763 7915435	
Completion Date:	April 7, 2018	Baffinland Iron Mines

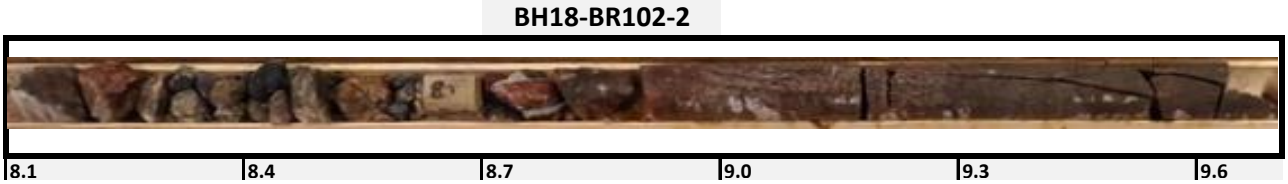
BH18-BR102-1

Sample Photographs

Borehole Name:	BH18-BR102-2	Mary River Expansion Study Stage 2
Location:	17 W 555674 7915443	2018 Geotechnical Investigation
Completion Date:	April 10, 2018	Baffinland Iron Mines







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Sample Photographs

Borehole Name:	BH18-BR102-2	Mary River Expansion Study Stage 2
Location:	17 W 555674 7915443	
Completion Date:	April 10, 2018	Baffinland Iron Mines

BH18-BR102-2

9.6 | 9.9 | 10.2 | 10.5 | 10.8 | 11.1

BH18-BR102-2

11.1 | 11.4 | 11.7 | 12.0 | 12.3 | 12.6

BH18-BR102-2

12.6 | 13.0 | 13.3 | 13.6 | 13.9 | 14.2

BH18-BR102-2

14.2 | 14.5 | 14.8 | 15.1 | 15.4 | 15.7

BH18-BR102-2

15.7 | 16.0 | 16.3 | 16.6 | 16.9 | 17.2

Appendix D
Laboratory Reports

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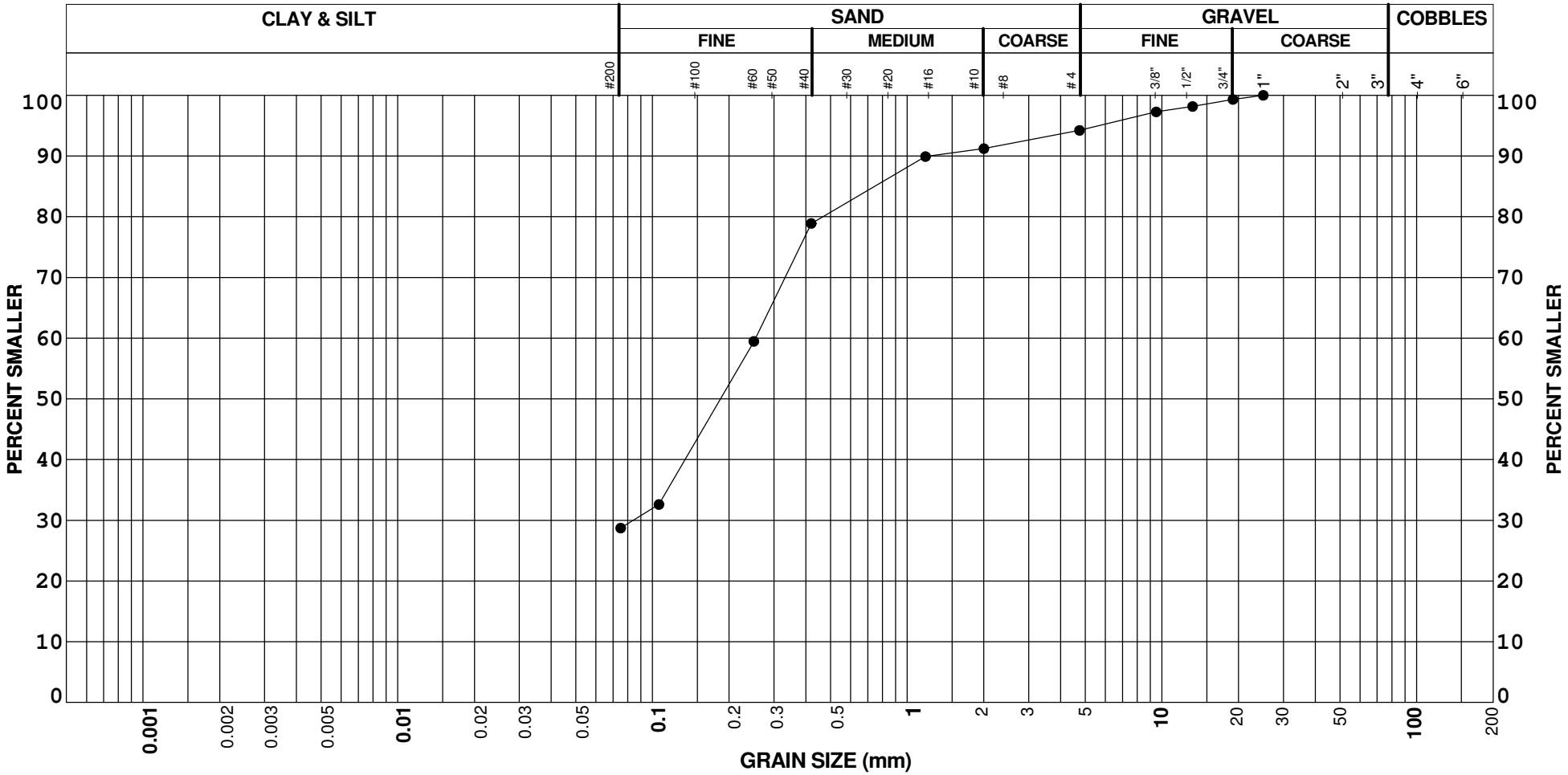
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B001	BS3	3.50	6	66	29		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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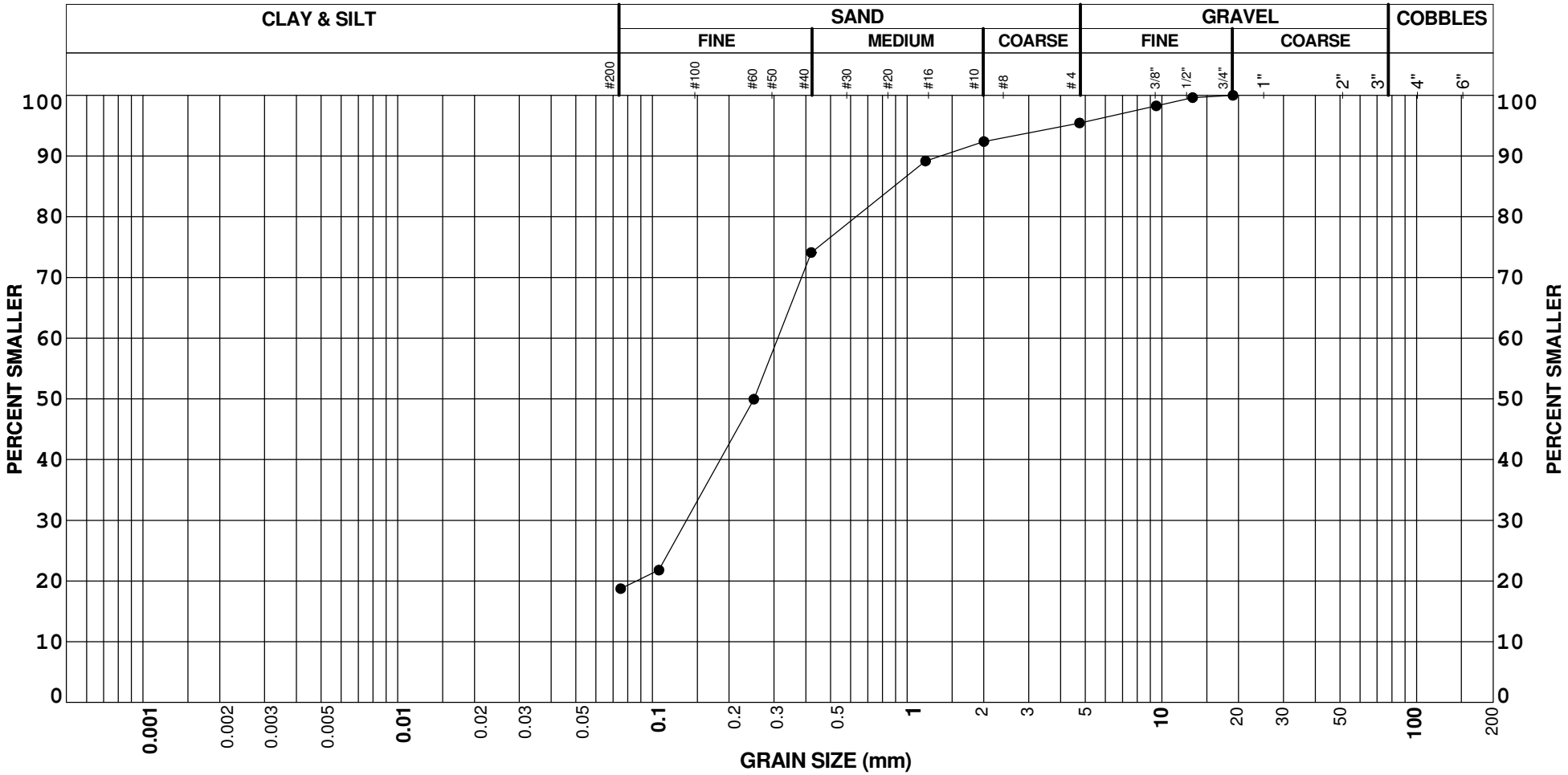
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B002	BS4	5.90	5	77	19		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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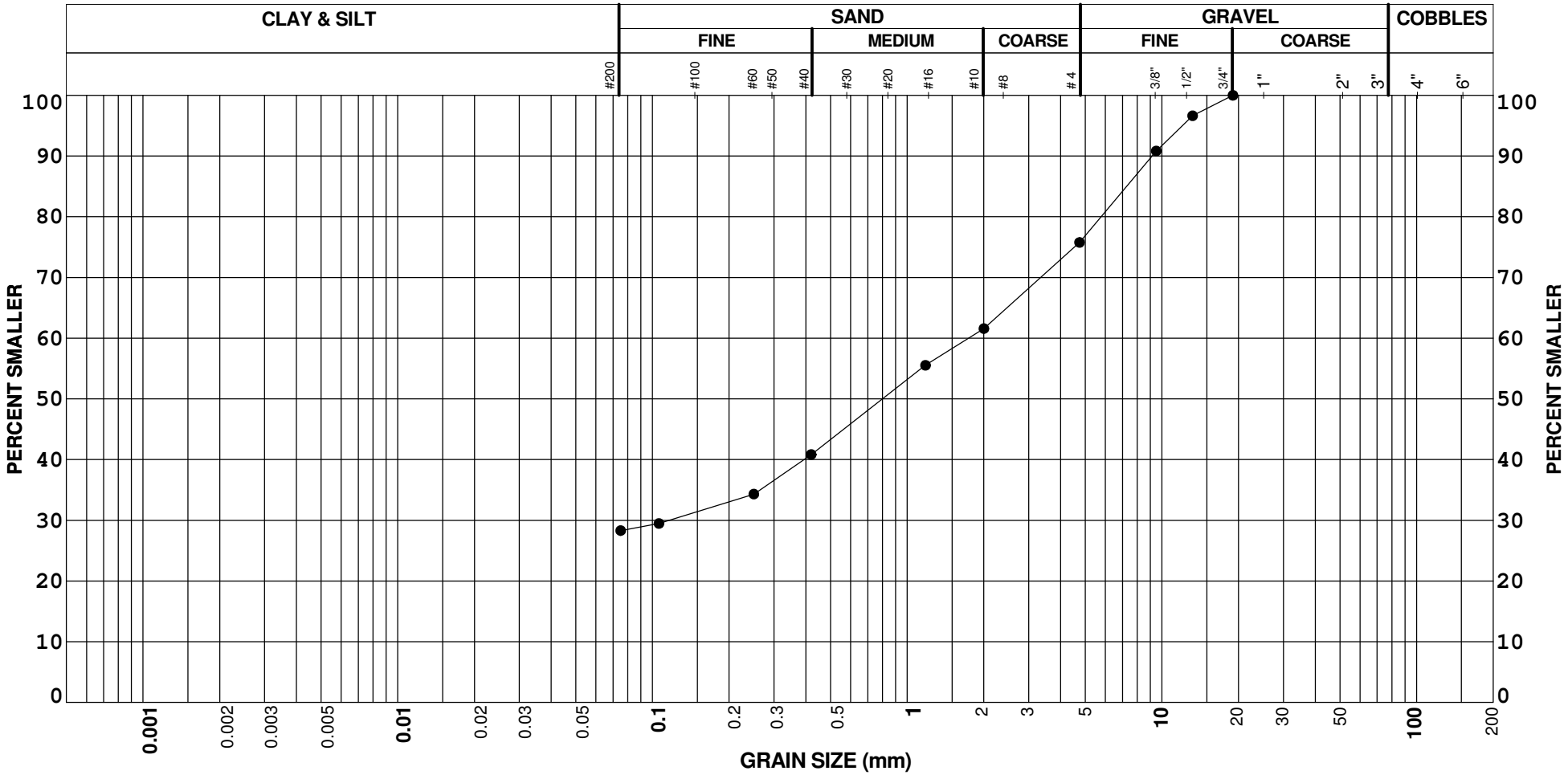
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B003	BS2	1.90	24	47	28		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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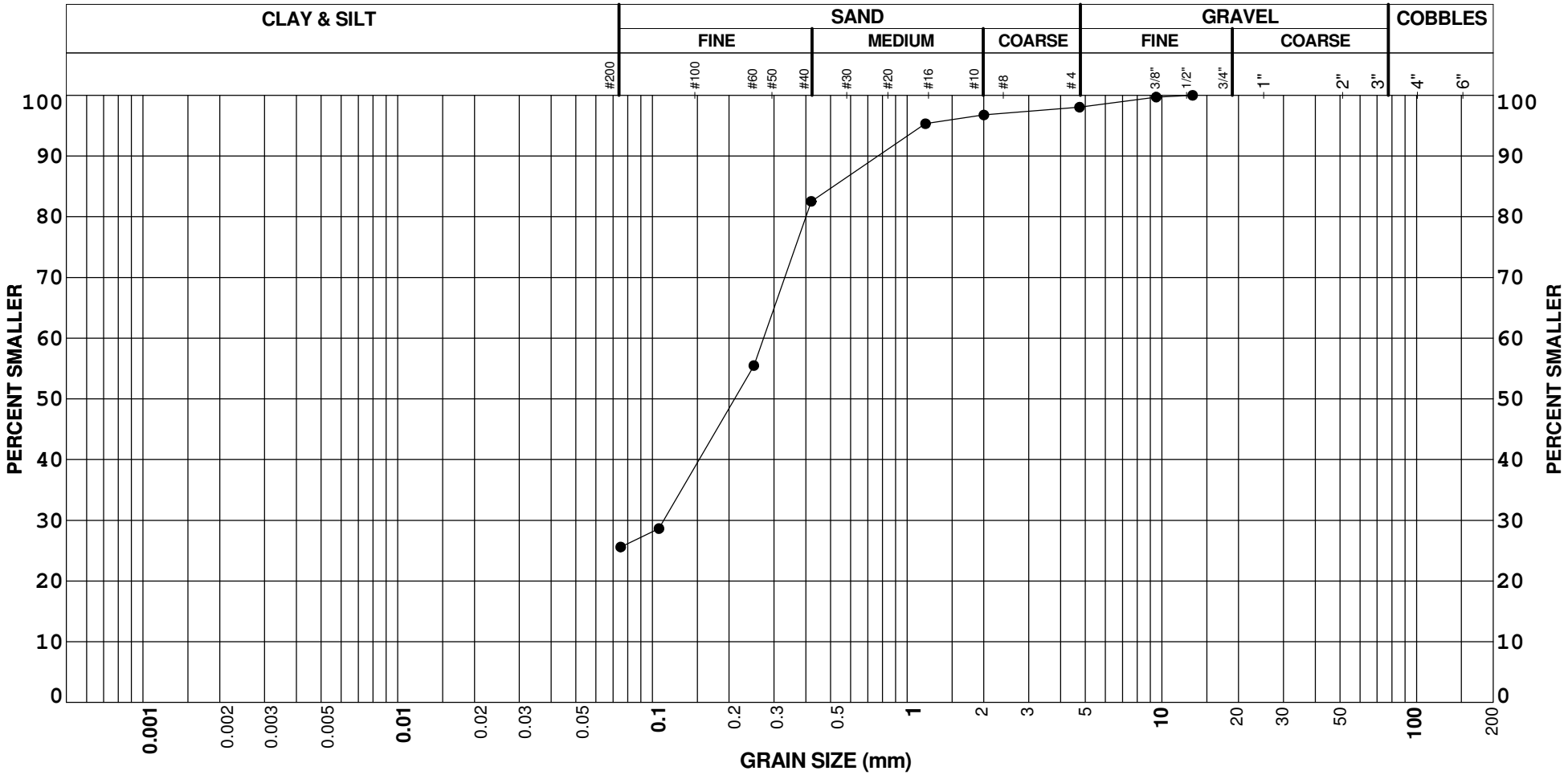
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B003	BS4	5.80	2	72	26		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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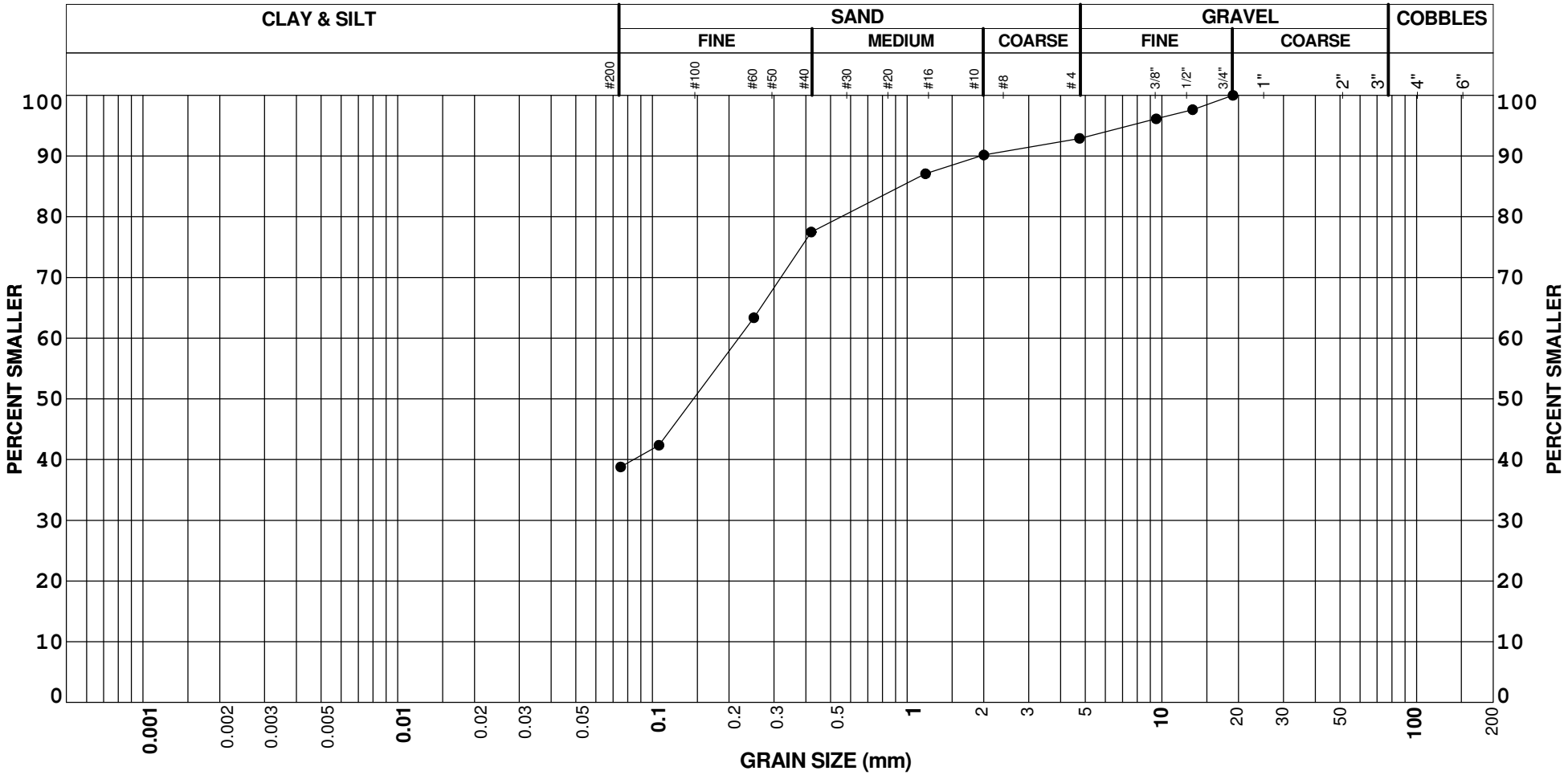
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B004	BS4	5.80	7	54	39		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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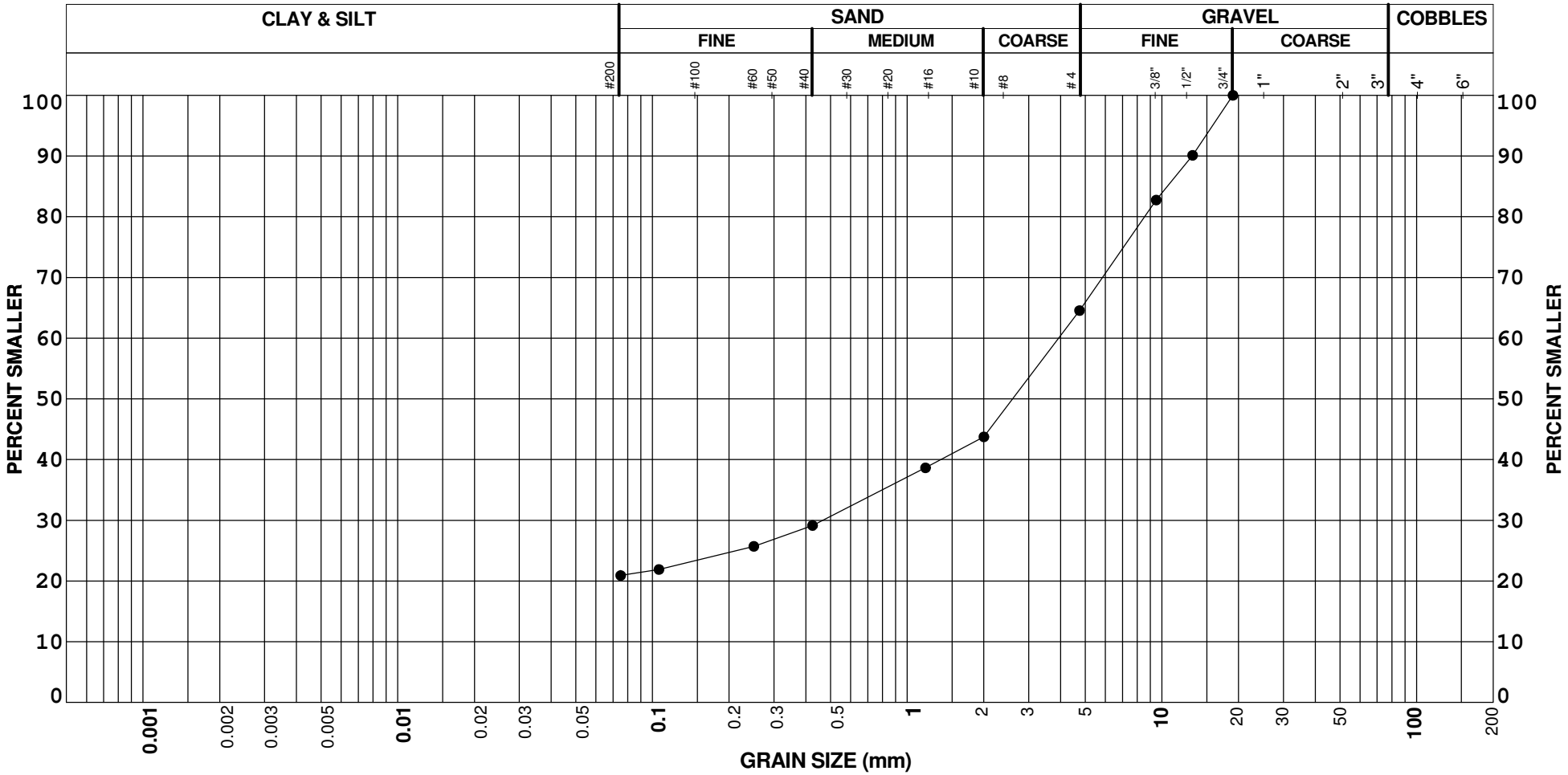
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B004	BS5	7.30	35	44	21		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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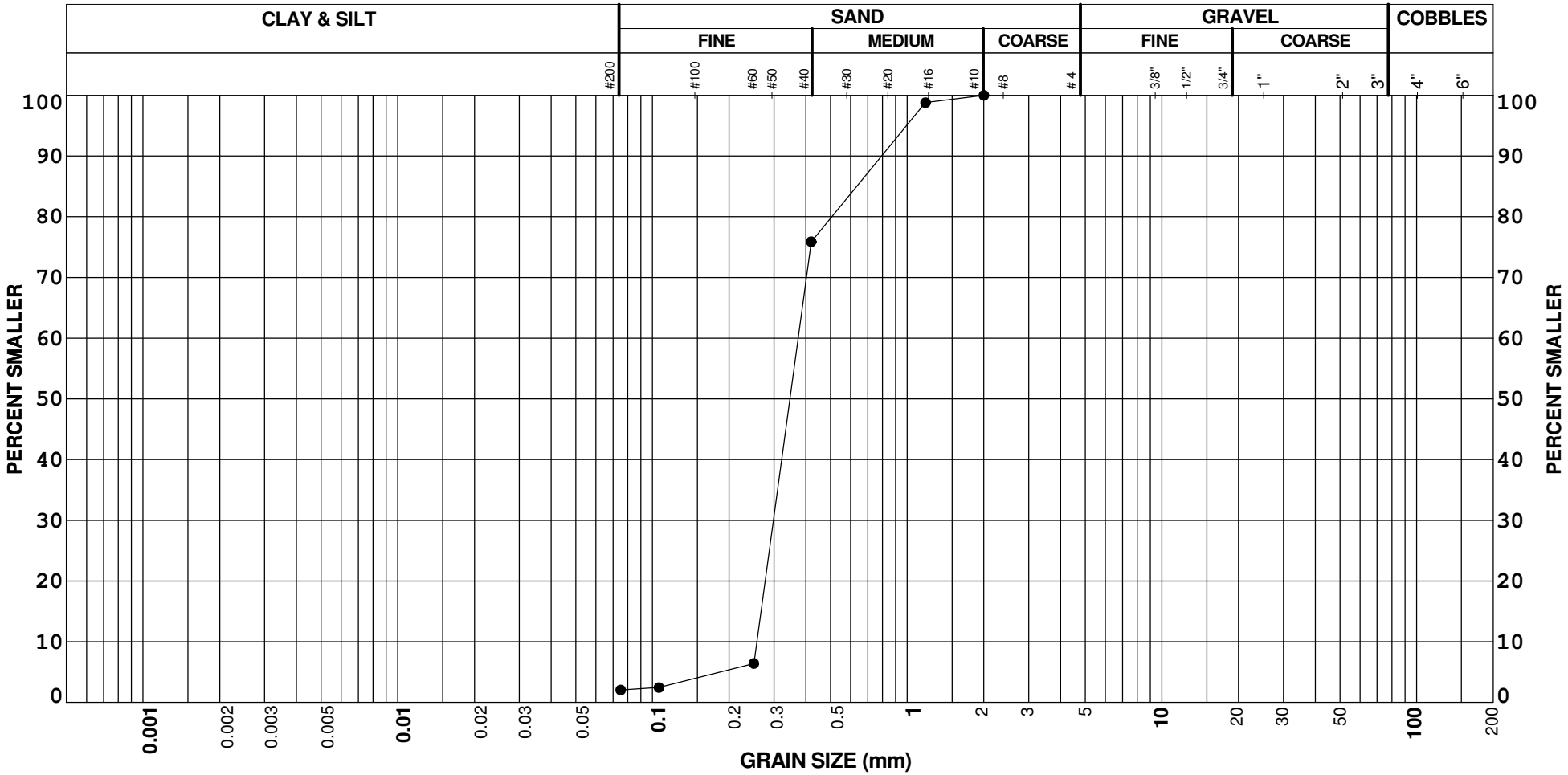
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B009	BS3	9.80	0	98	2		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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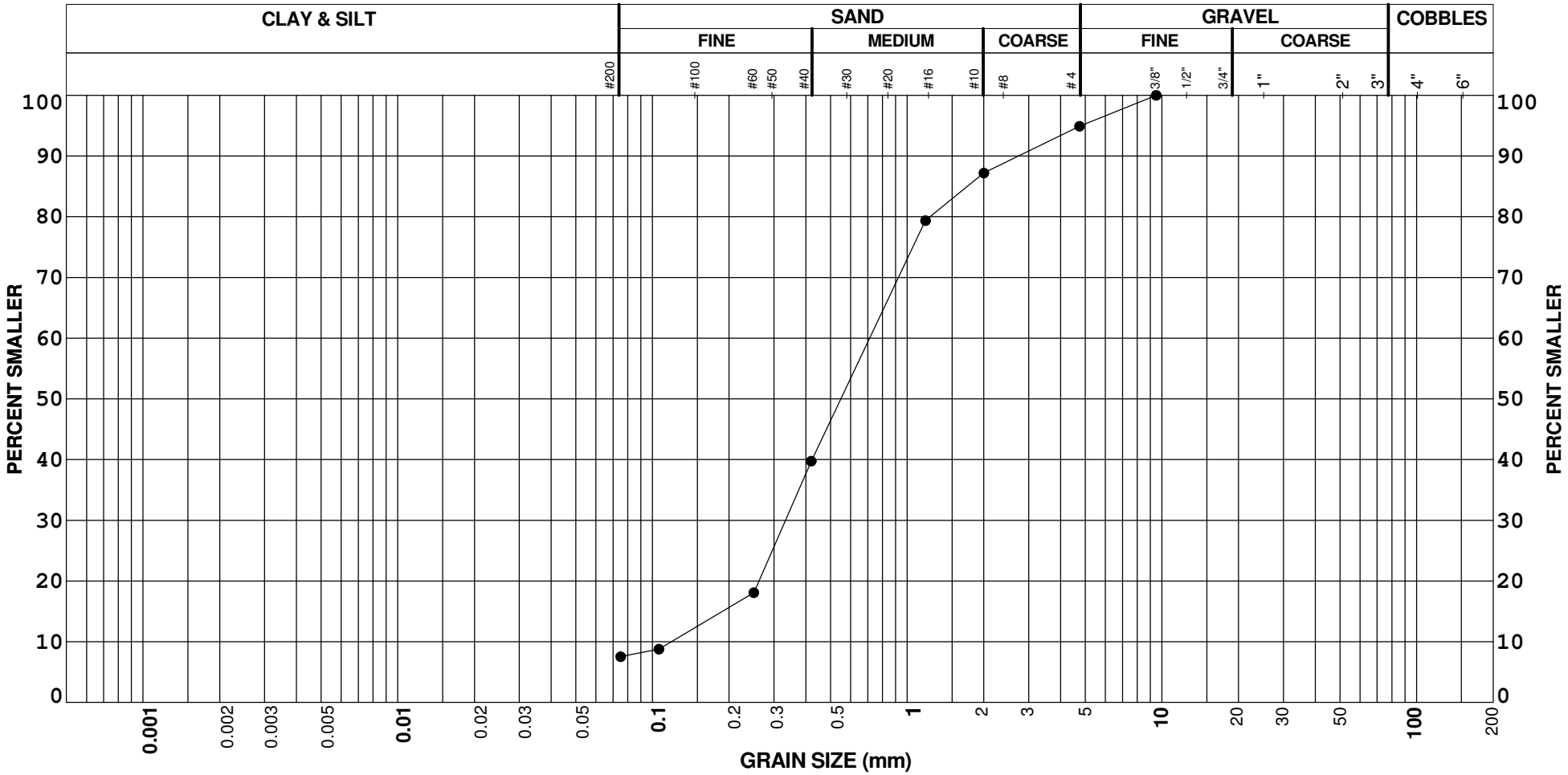
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B010	BS2	2.90	5	87	8		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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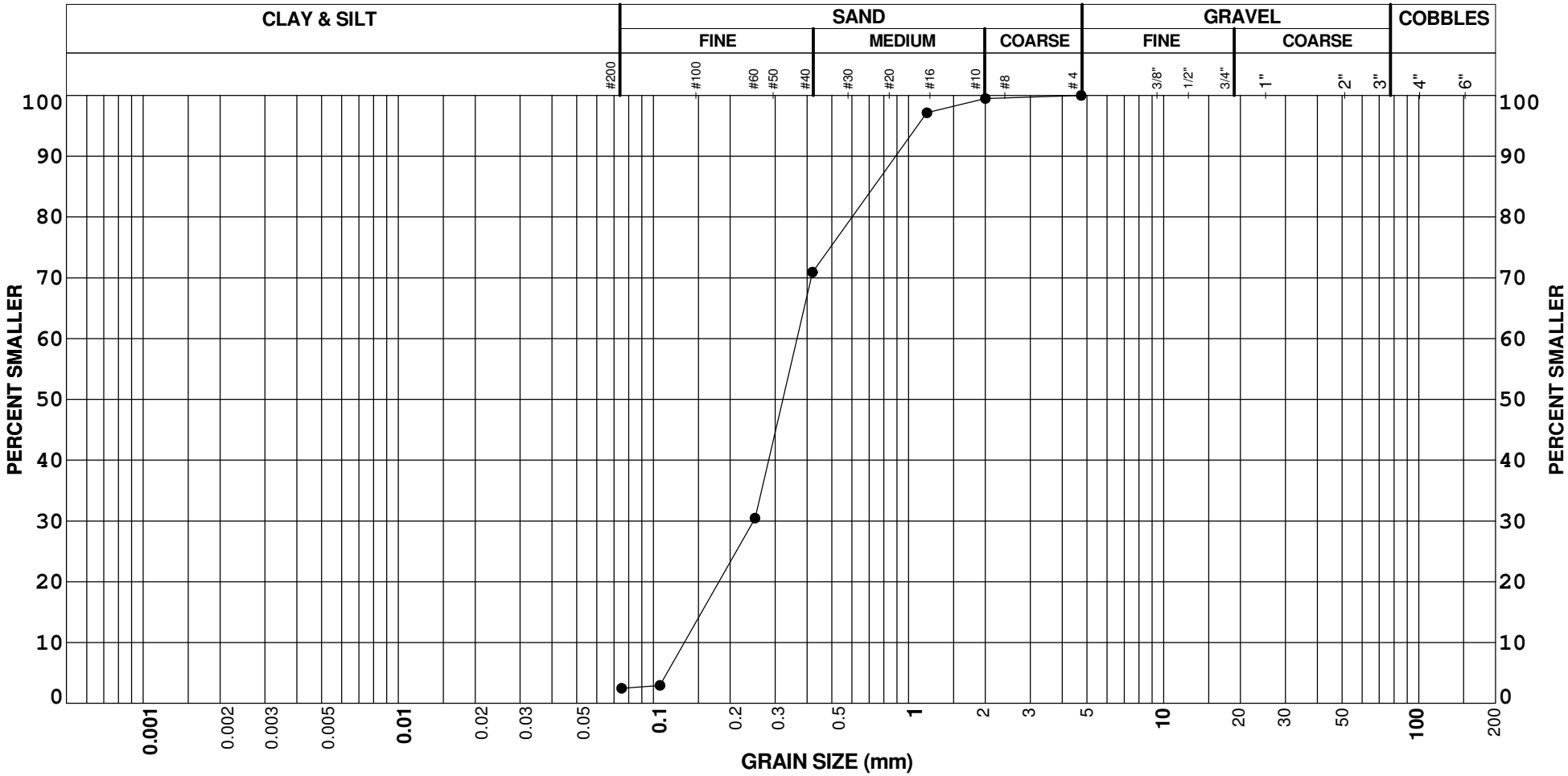
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B010	BS4	5.10	0	98	2		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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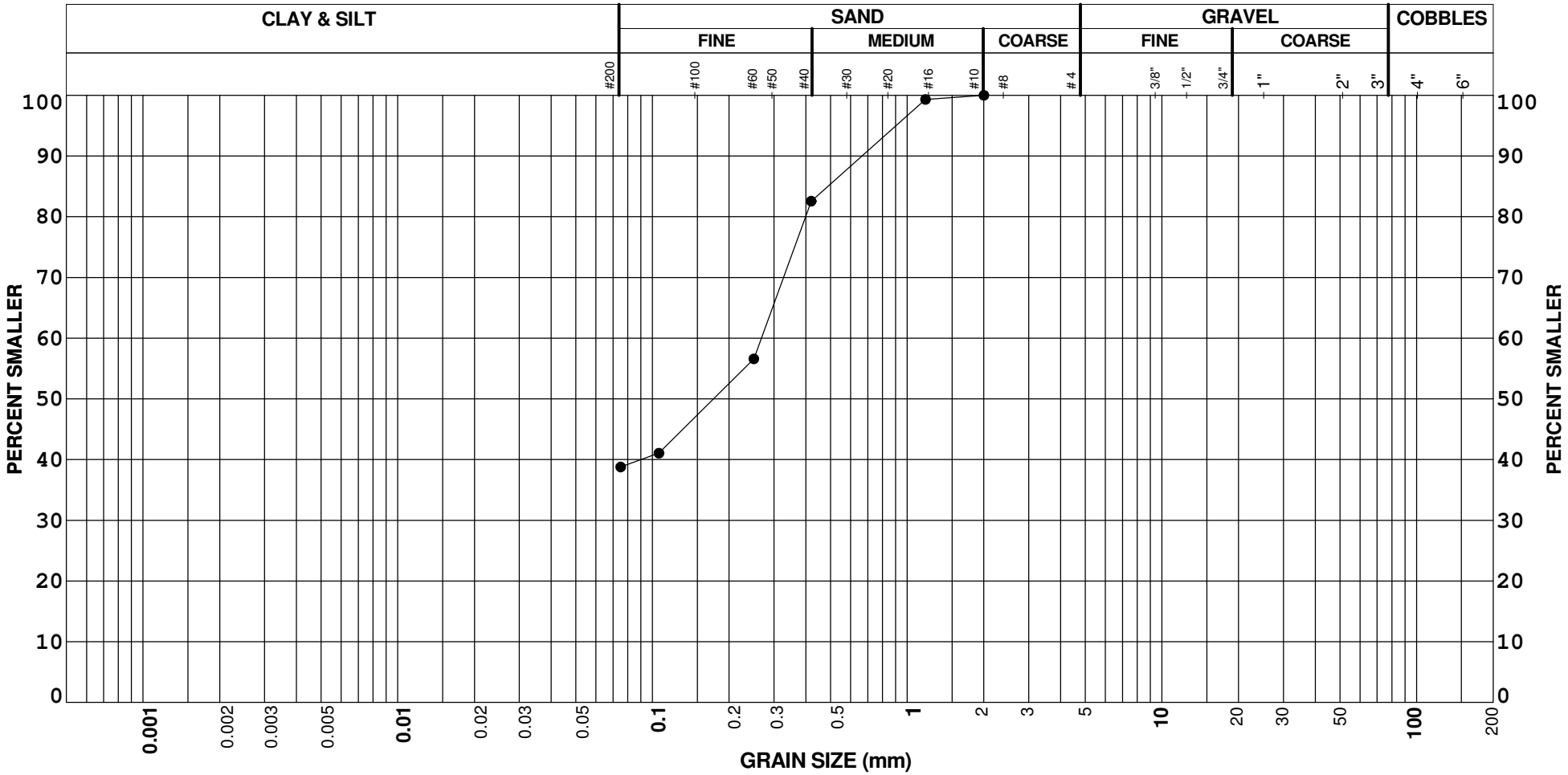
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B010	BS6	9.50	0	61	39		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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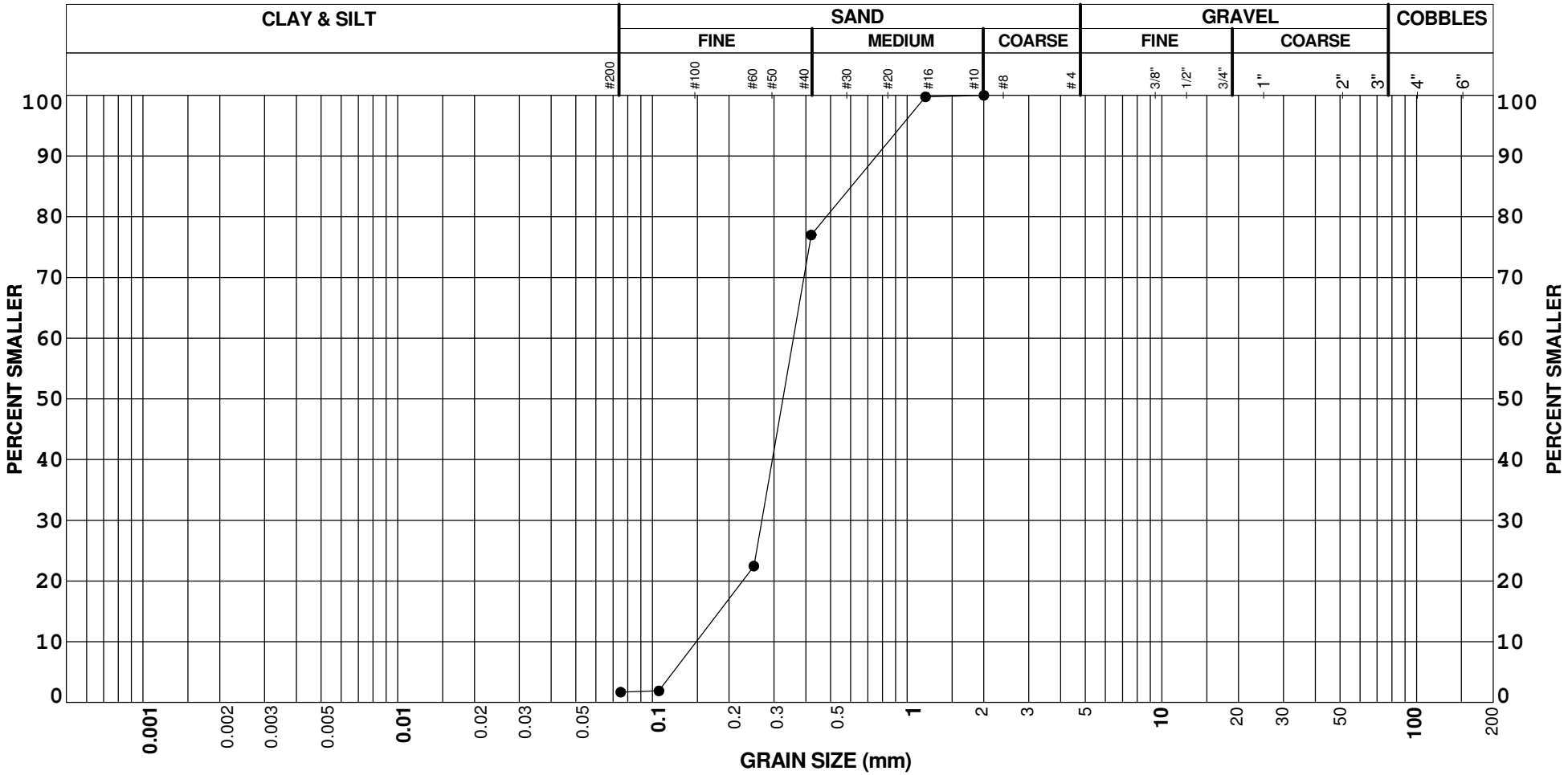
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B011	BS2	9.00	0	98	2		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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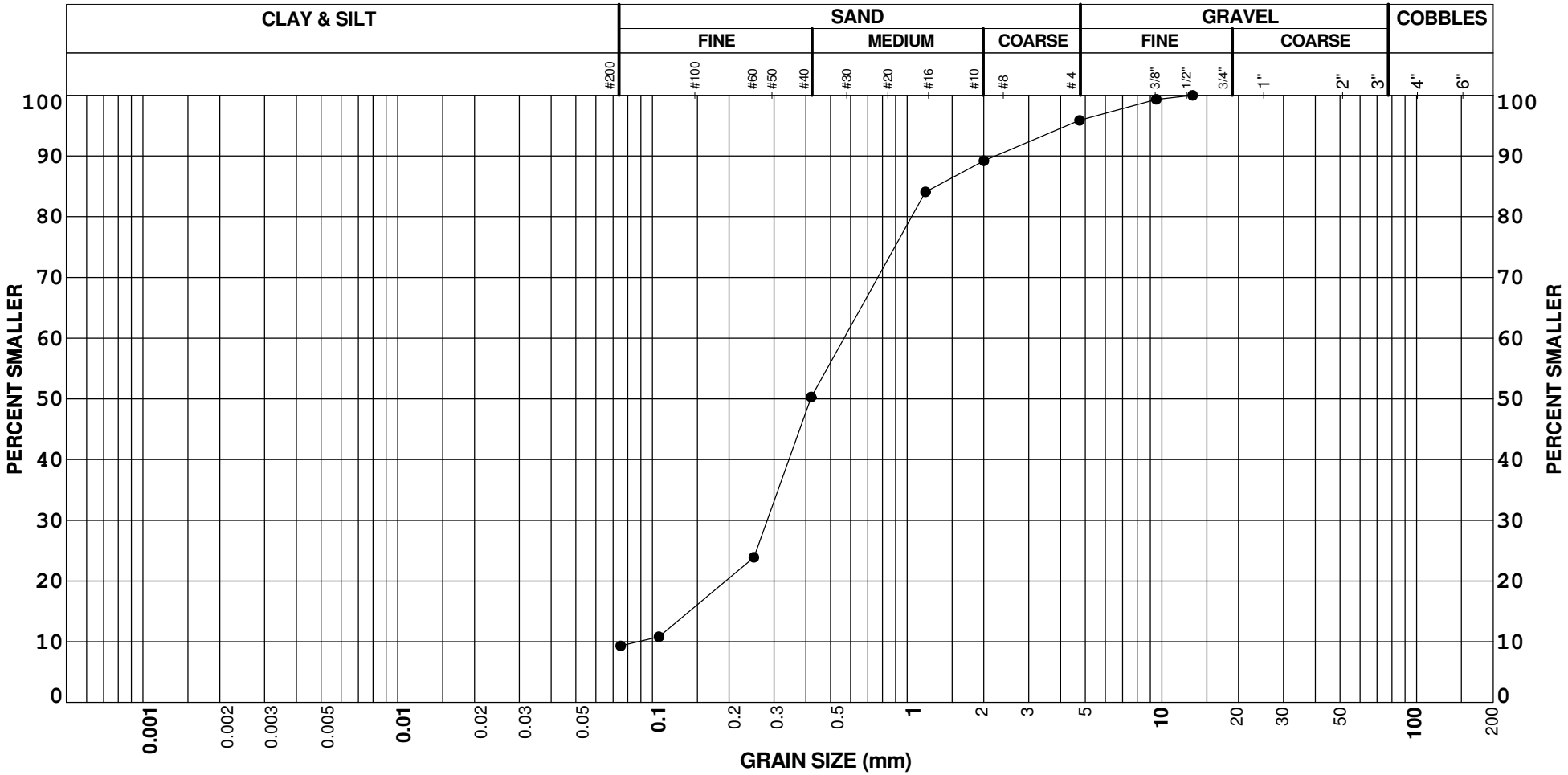
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B012	BS1	3.00	4	87	9		

REMARKS:

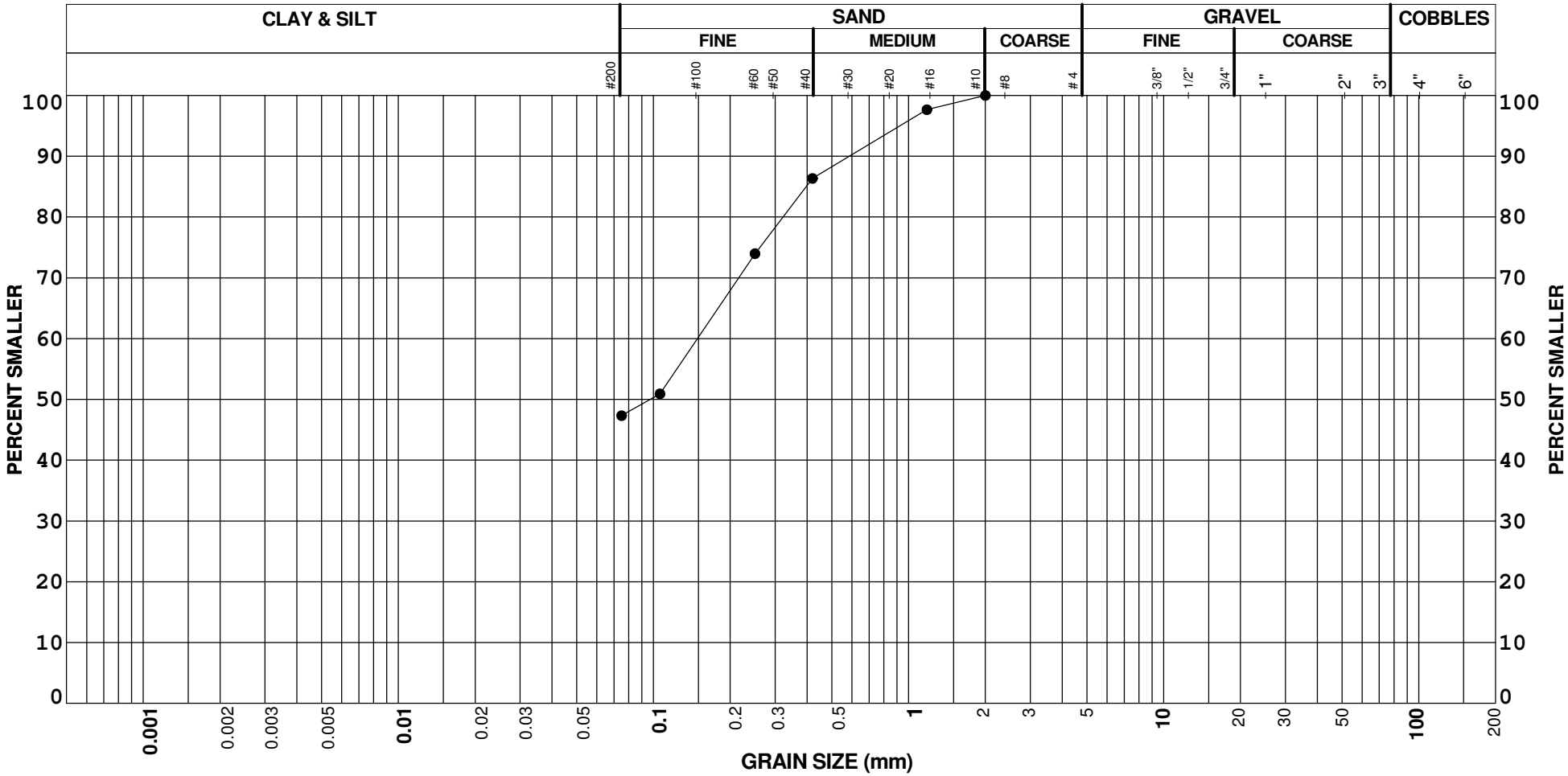
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B013	BS3	4.00	0	53	47		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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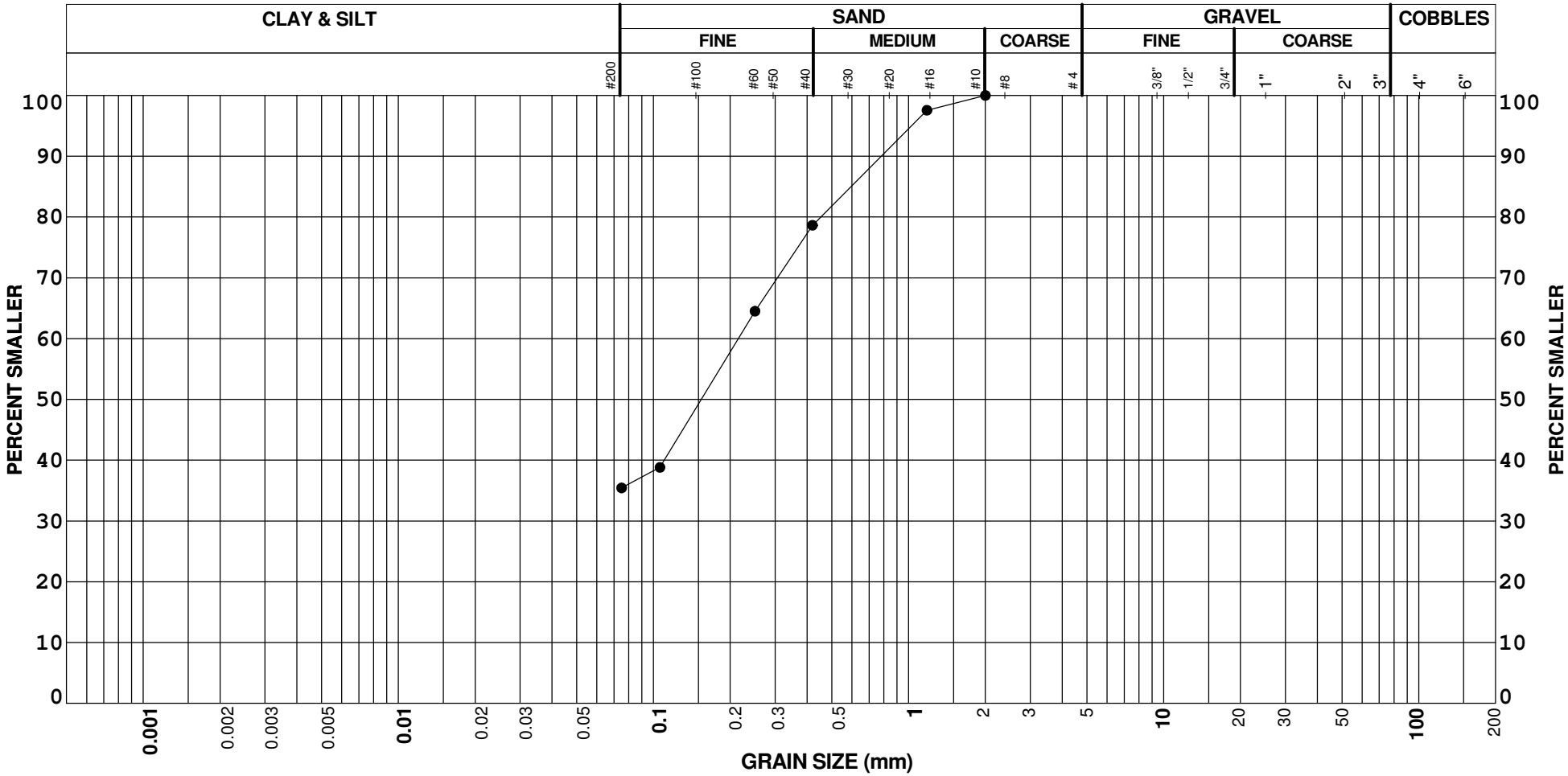
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B014	BS3	3.50	0	65	35		

REMARKS:

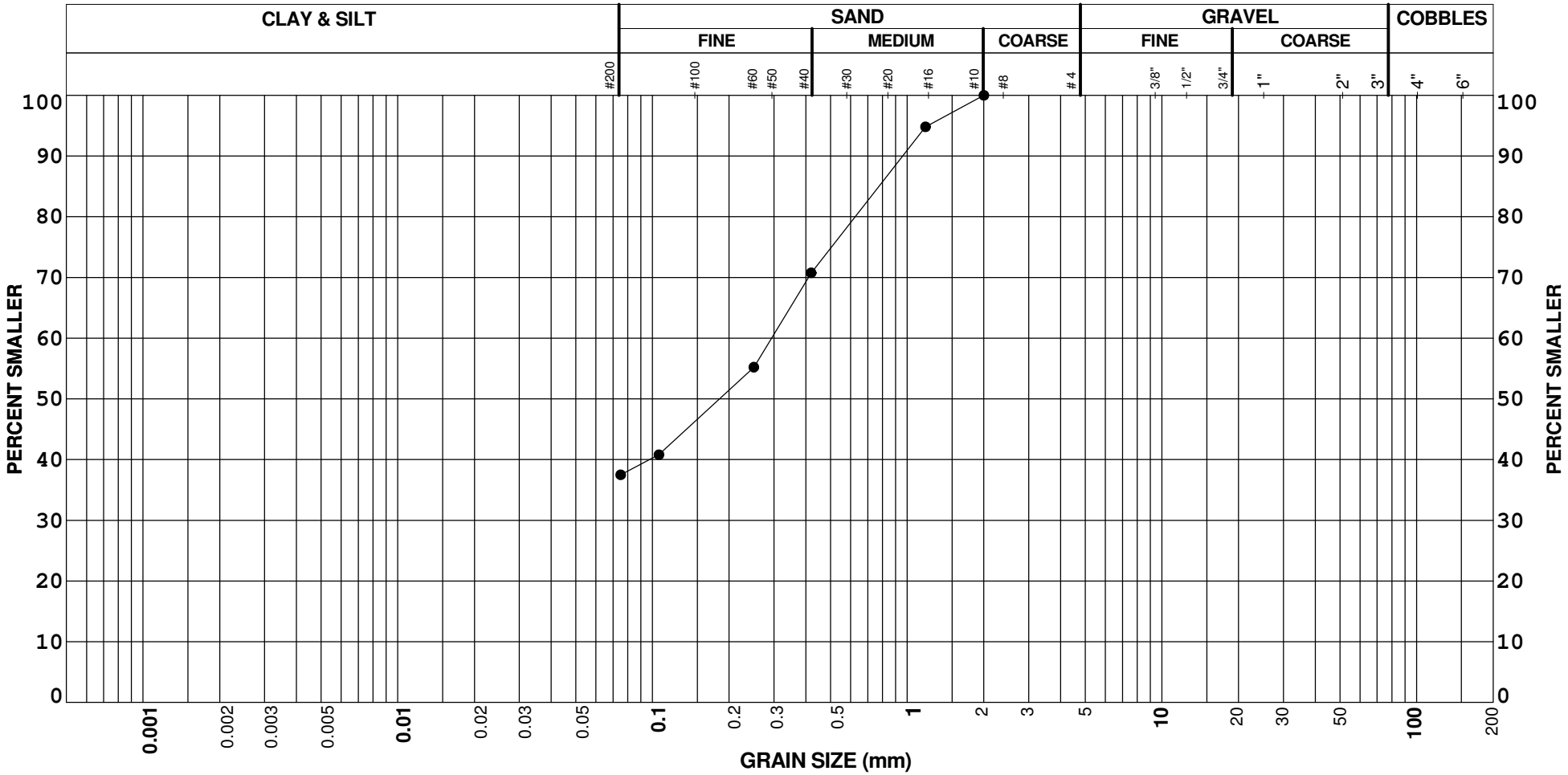
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B014	BS5	7.00	0	63	37		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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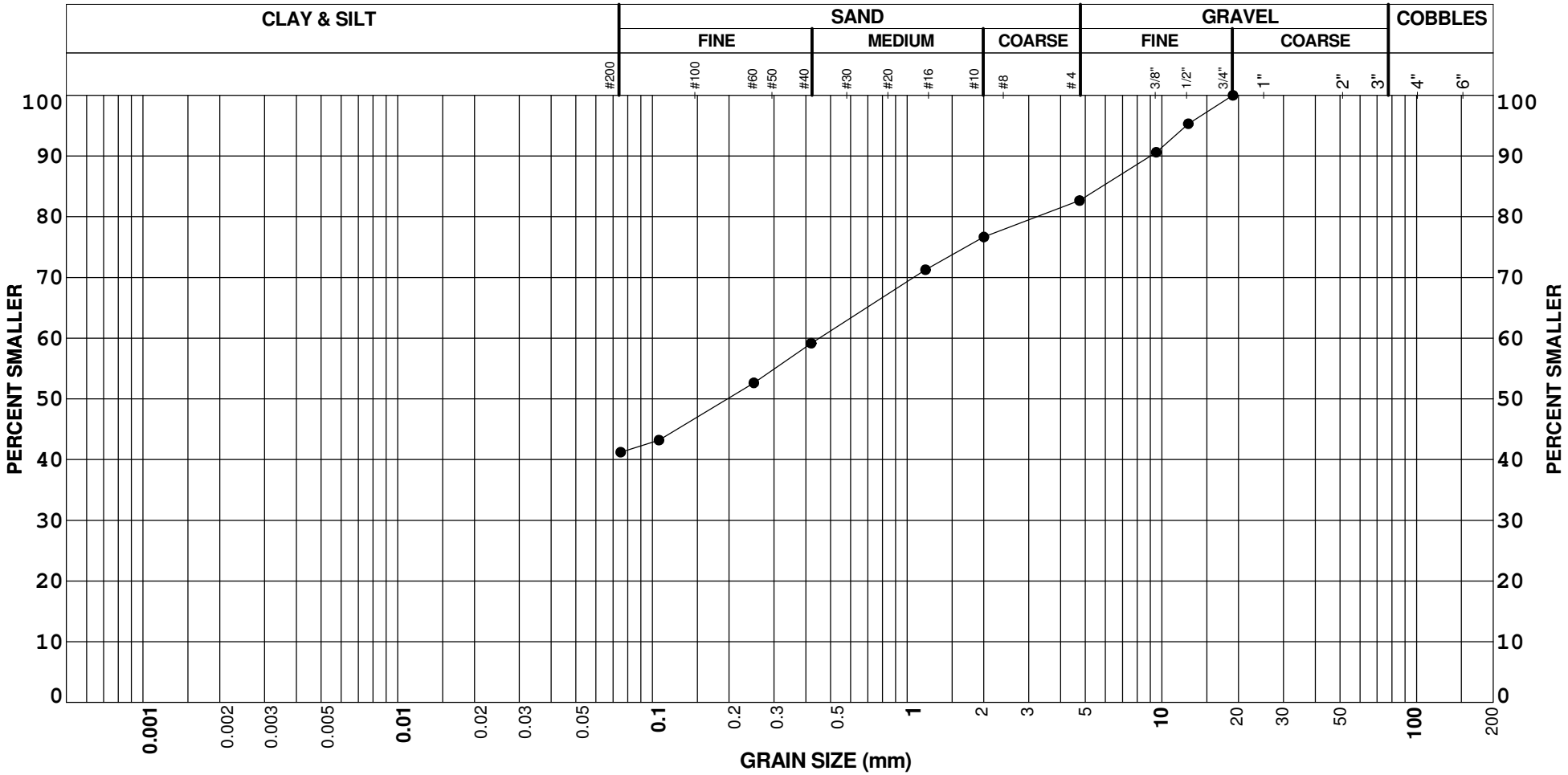
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B015	BS2	2.50	17	41	41		

REMARKS:

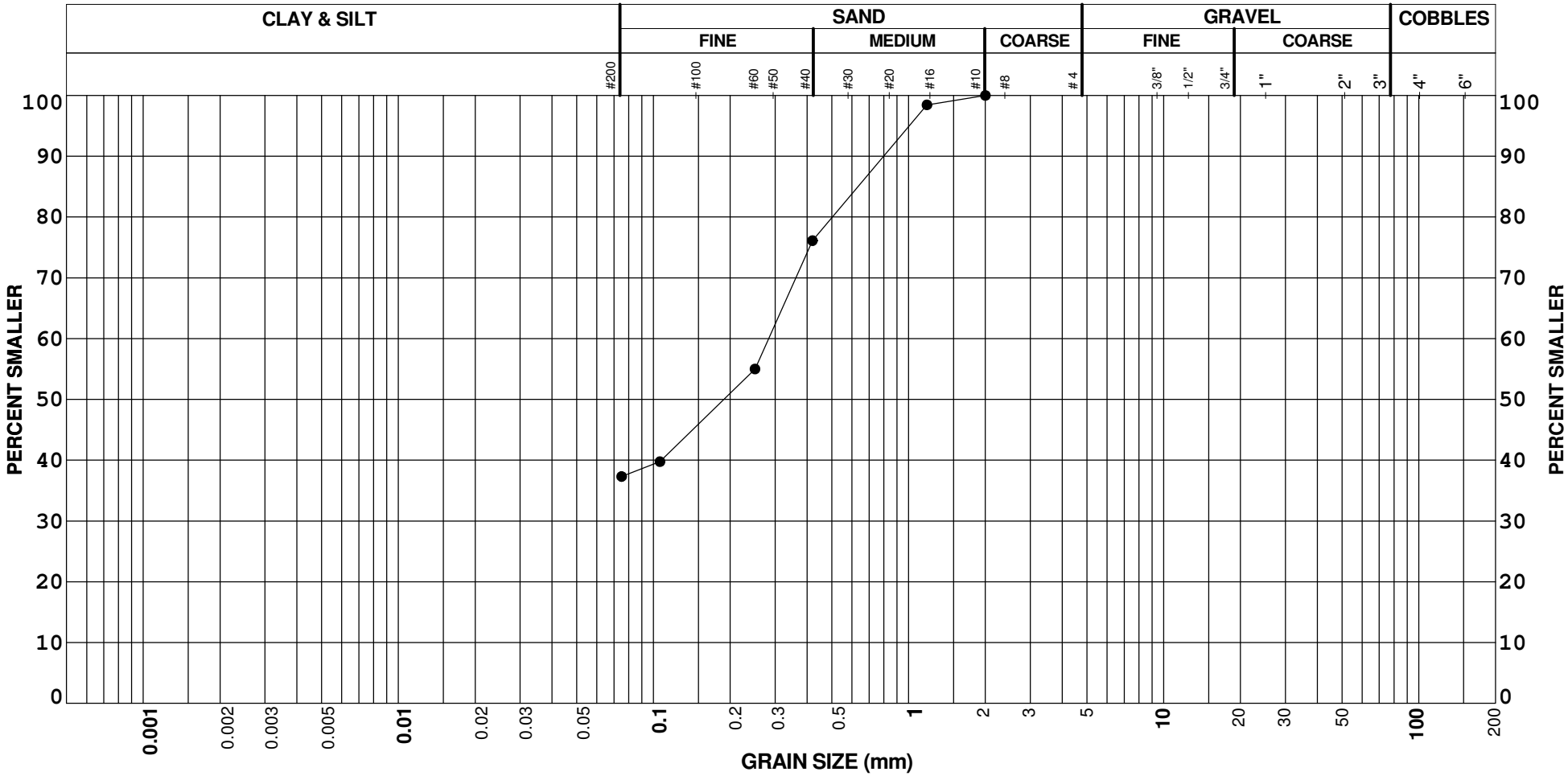
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B015	BS4	5.00	0	63	37		

REMARKS:

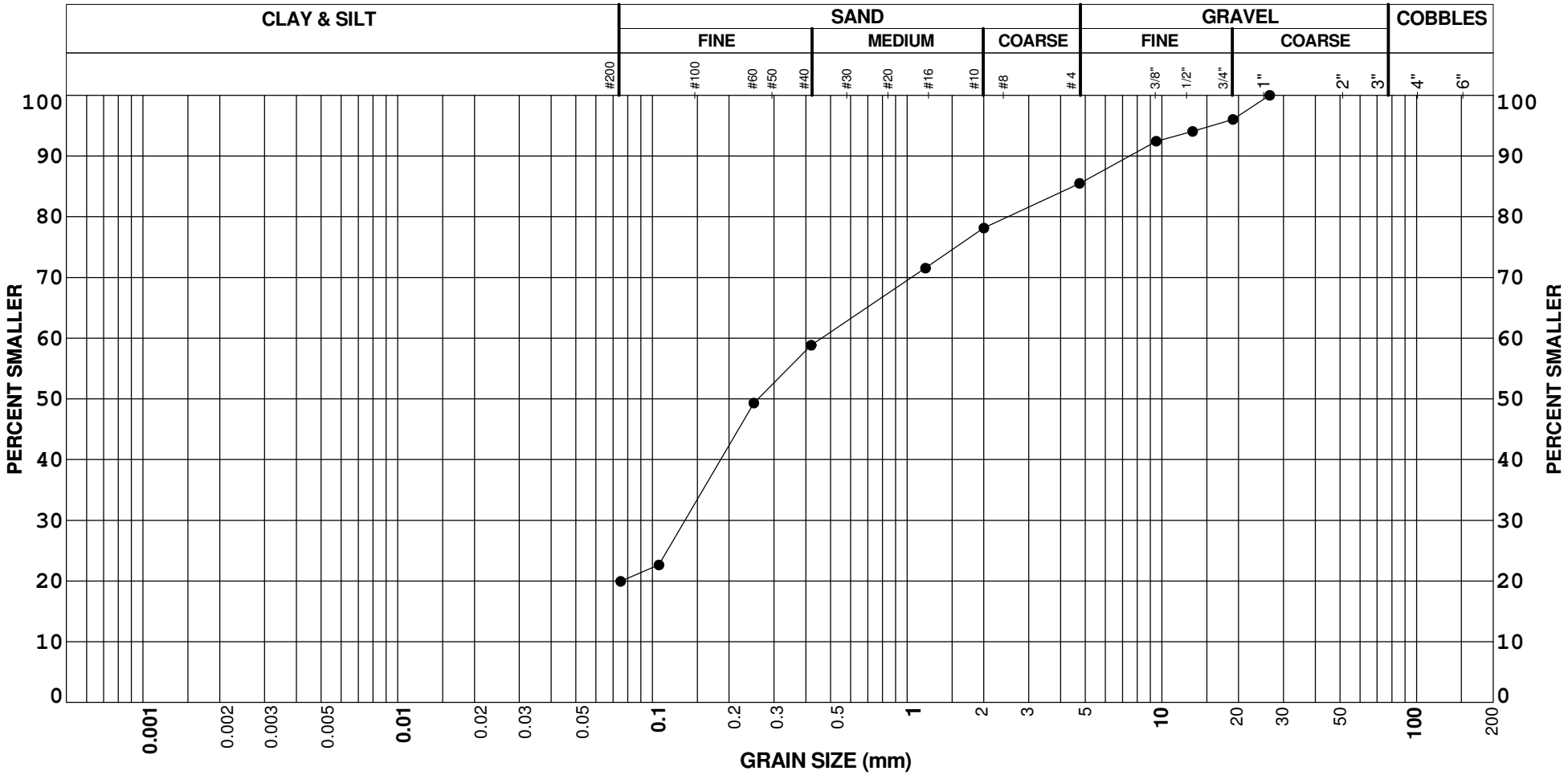
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B015	BS7	10.00	15	66	20		

REMARKS:

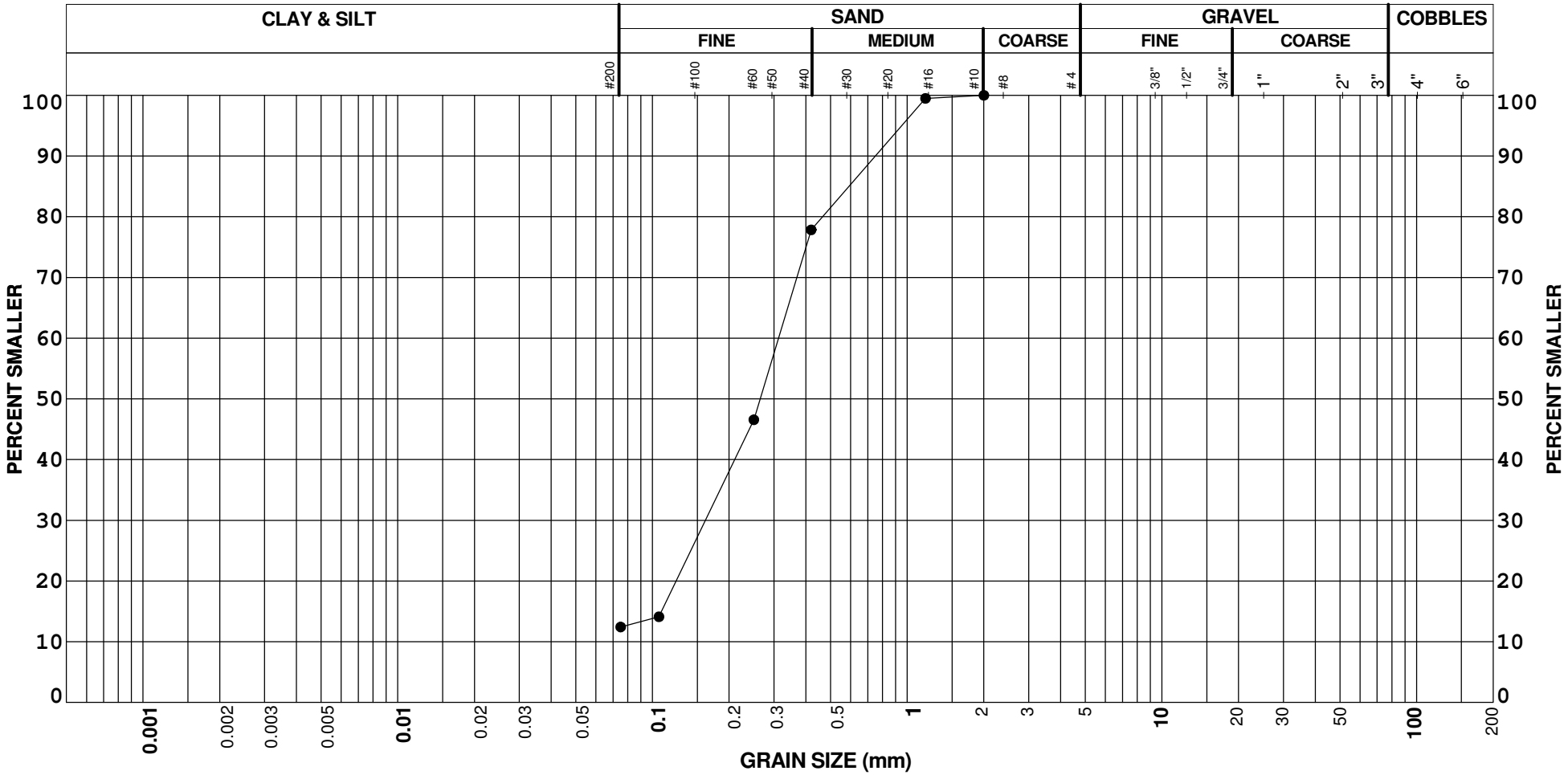
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B016	BS3	3.60	0	88	12		

REMARKS:

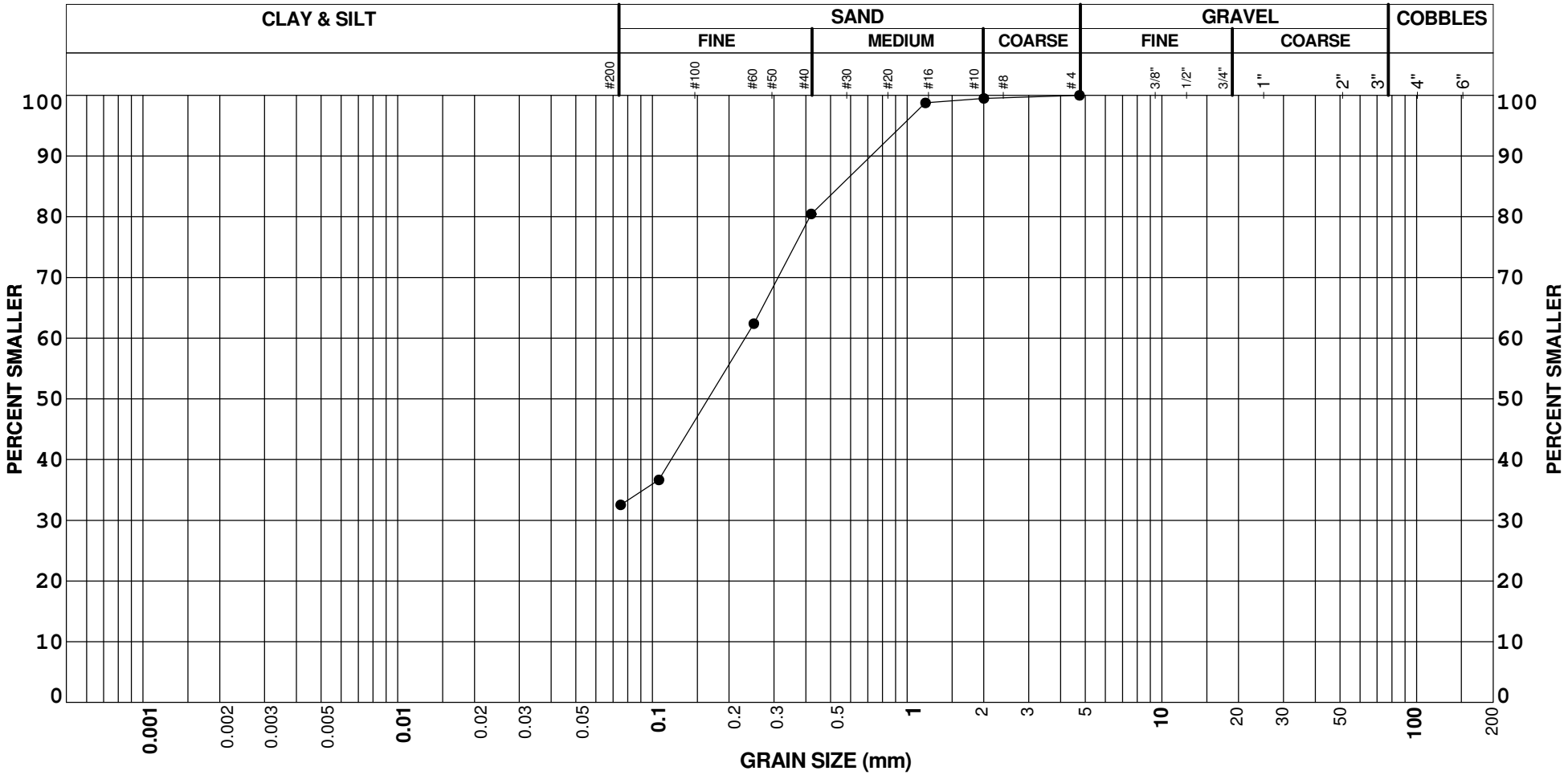
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B016	BS4	5.30	0	67	33		

REMARKS:

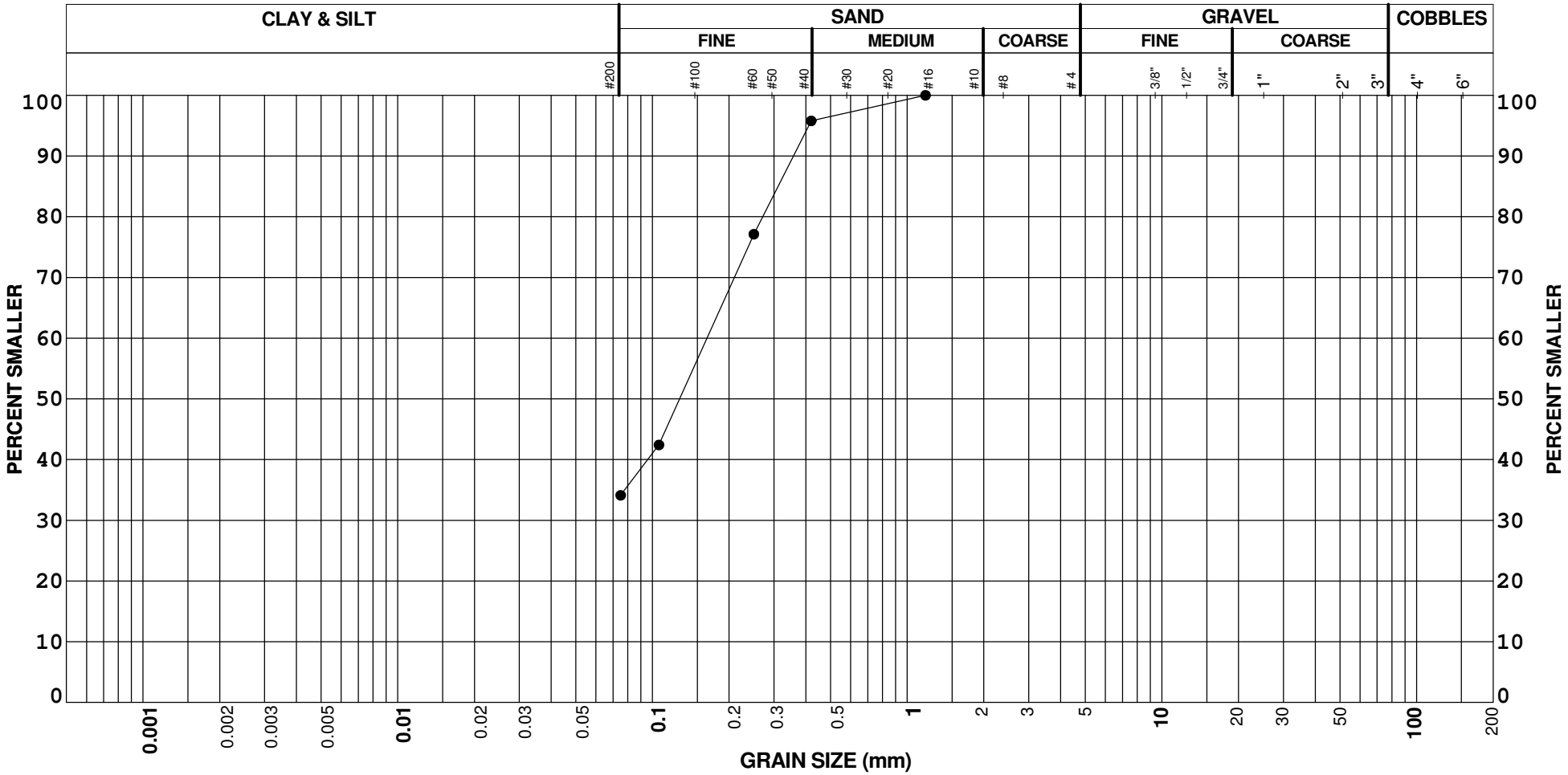
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-B016	BS5	7.20	0	66	34		

REMARKS:

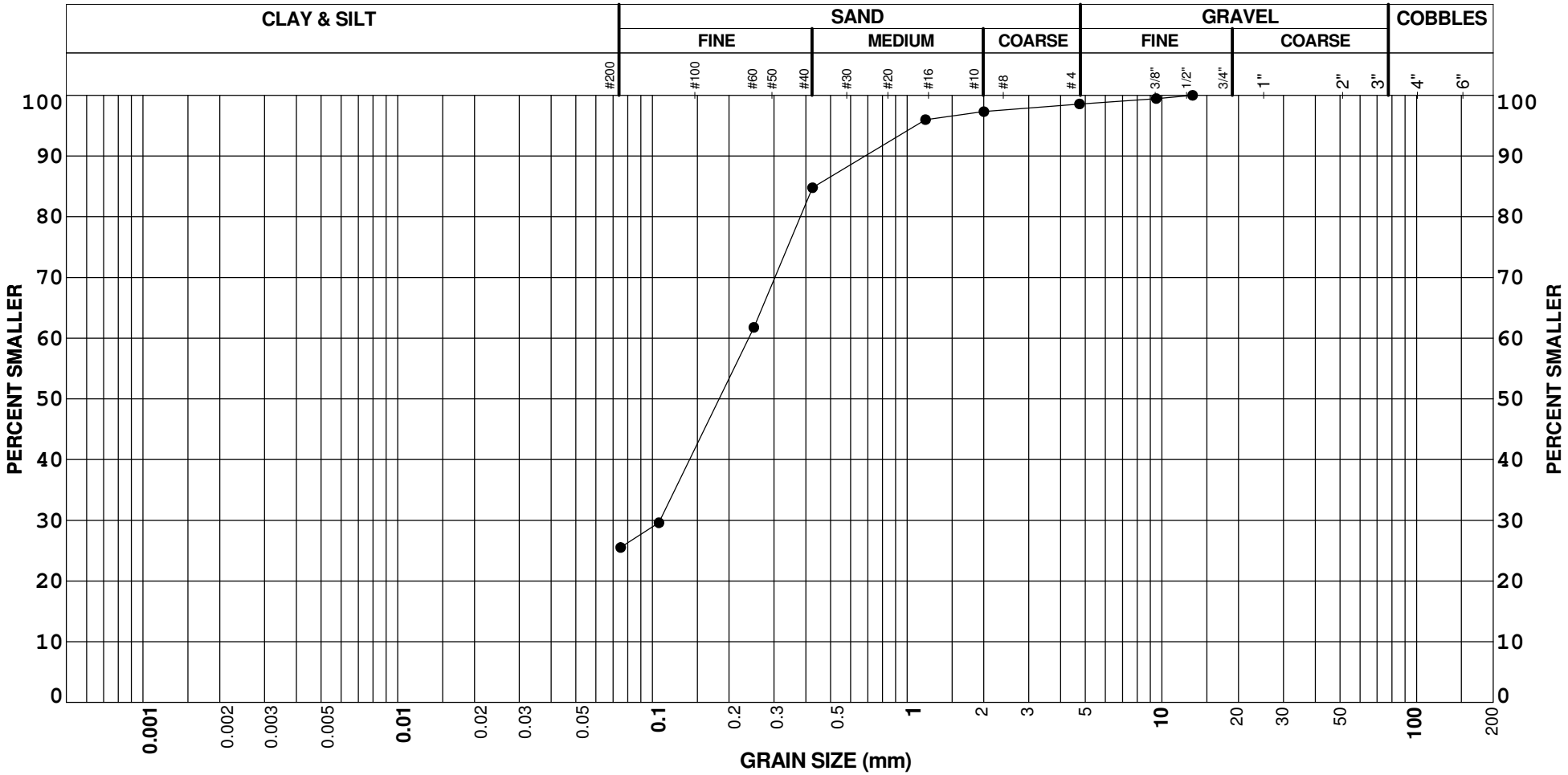
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C007	BS3	3.50	1	73	26		

REMARKS:

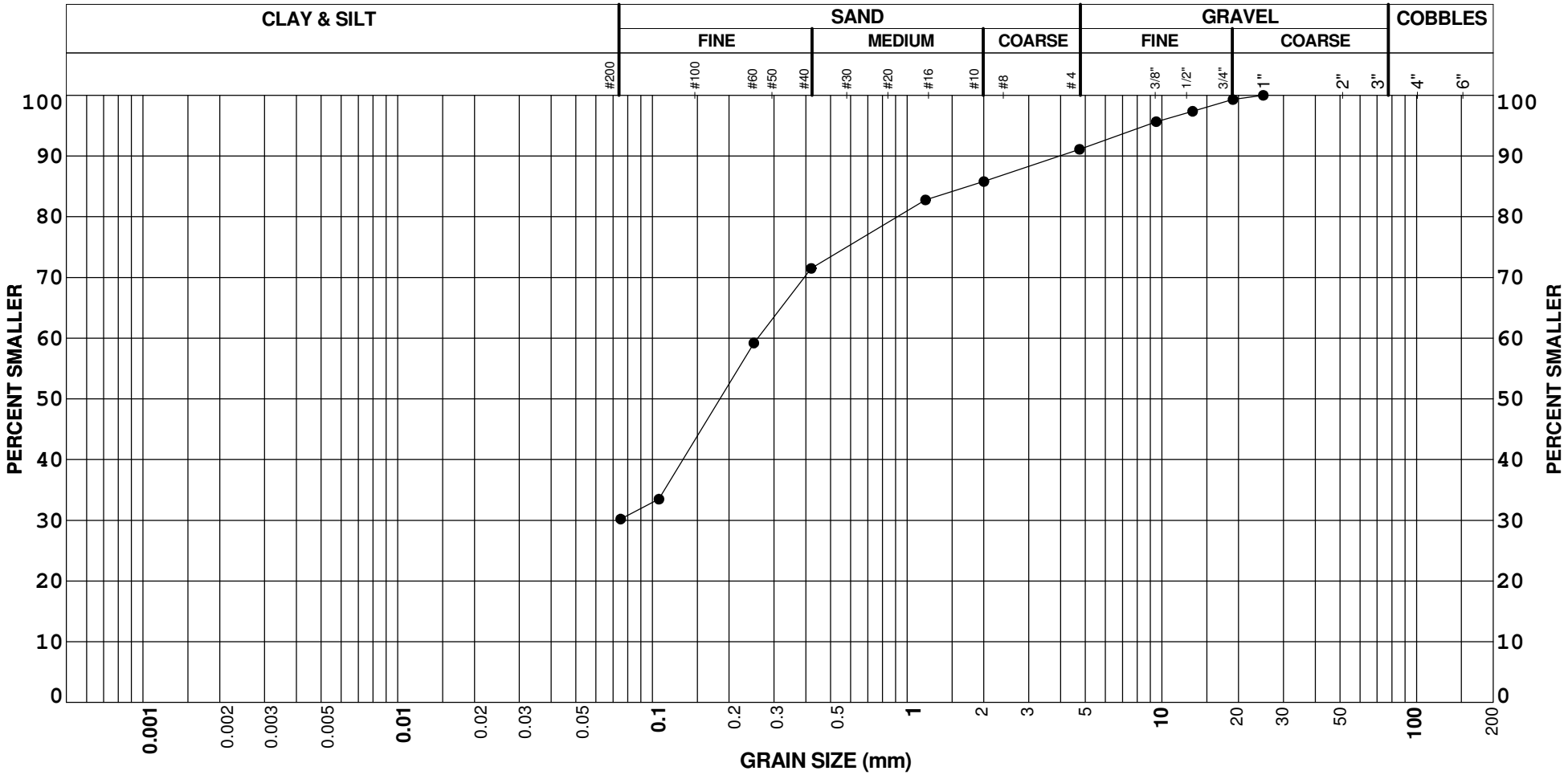
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C009	BS2	2.60	9	61	30		

REMARKS:

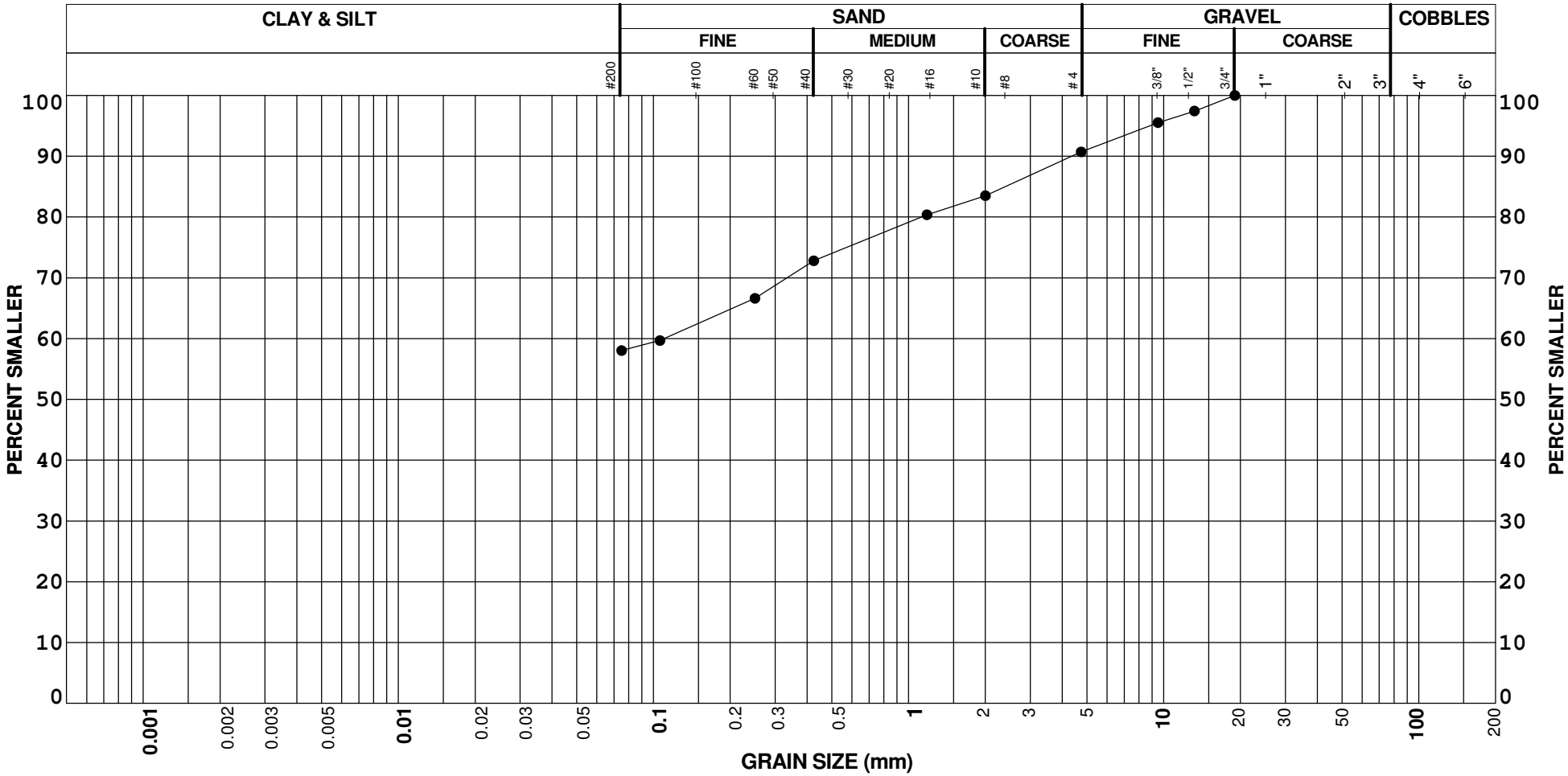
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C010	BS2	2.50	9	33	58		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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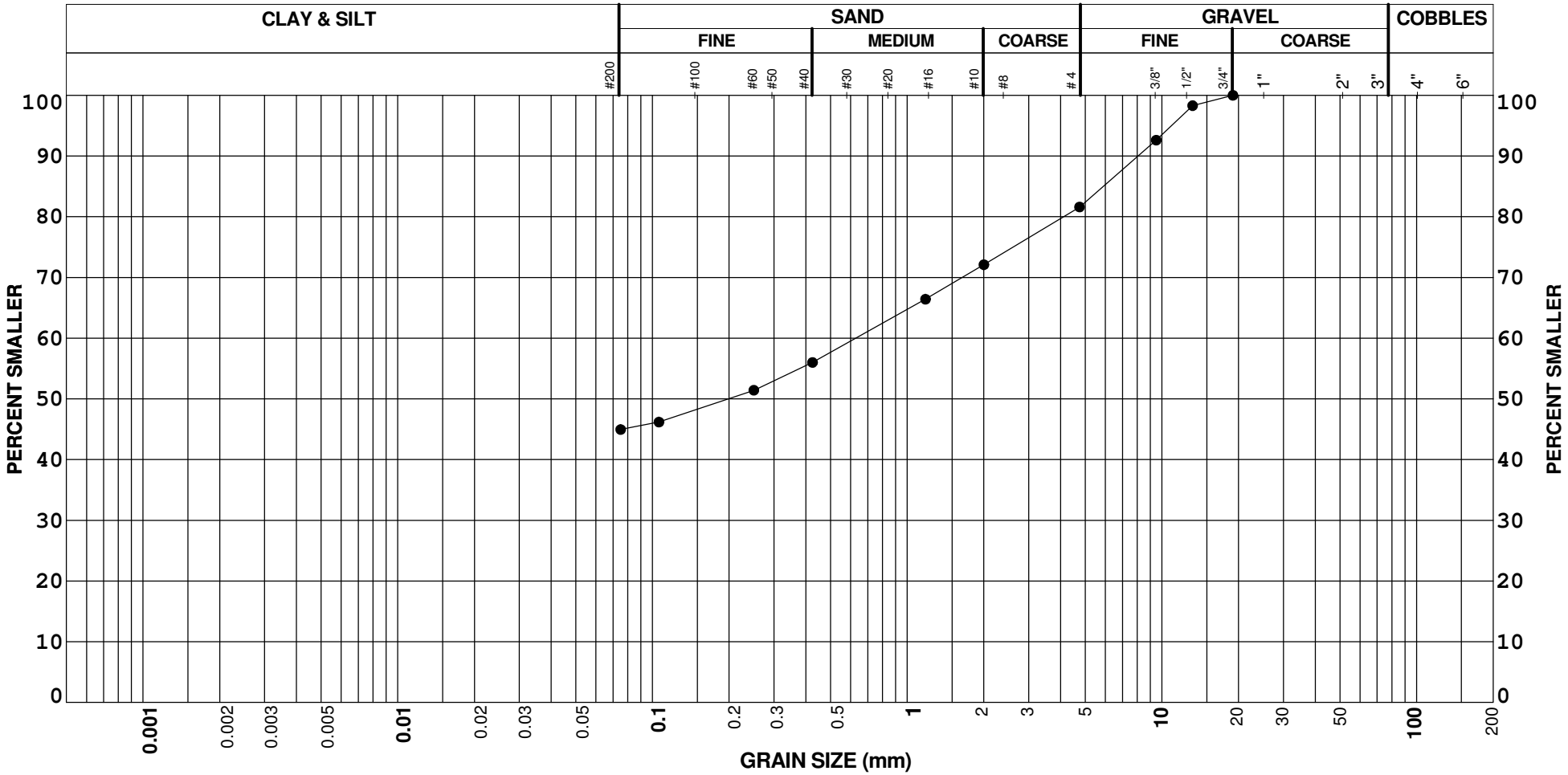
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C012	BS3	4.00	18	37	45		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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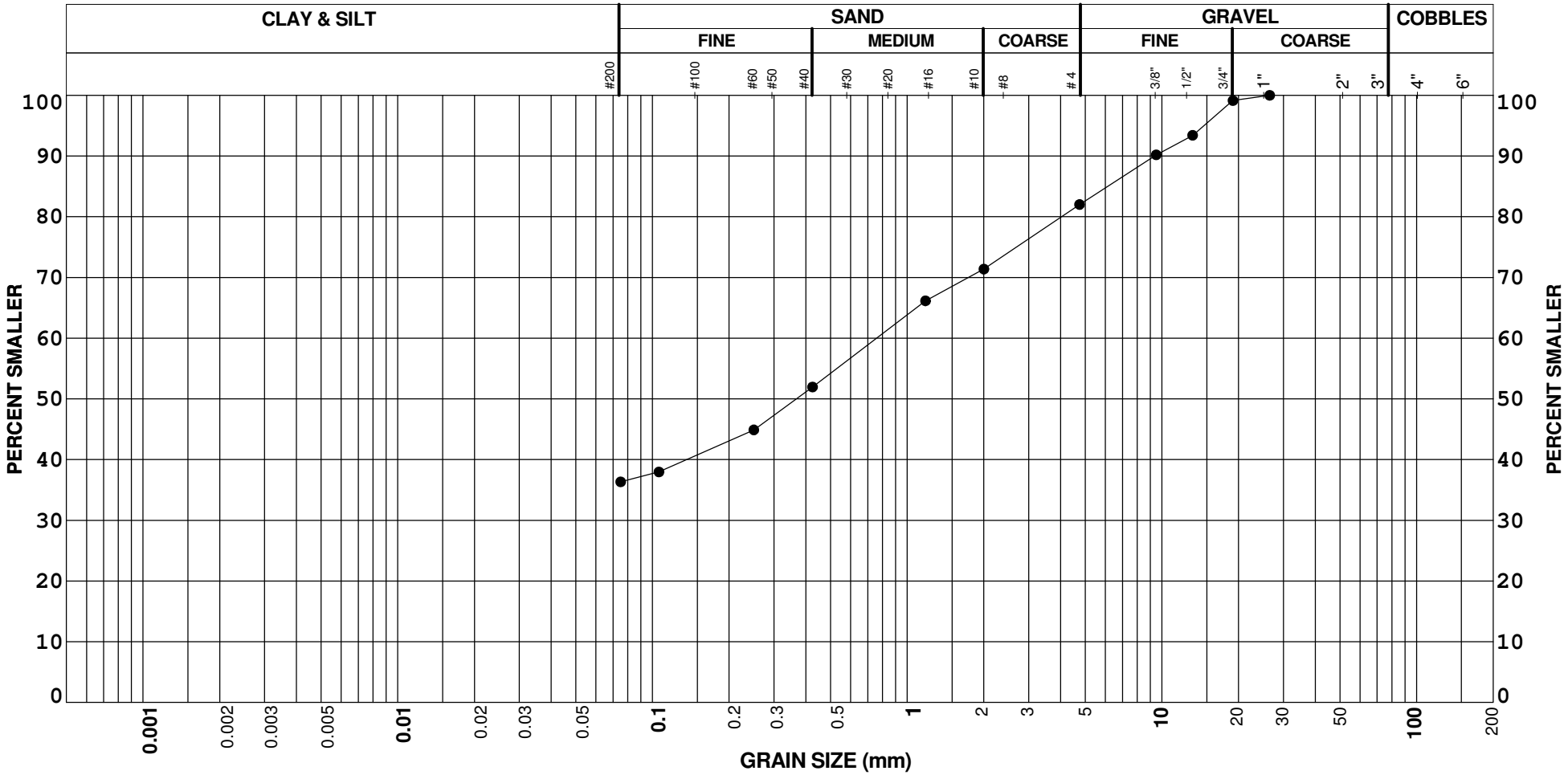
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C015	BS2	2.50	18	46	36		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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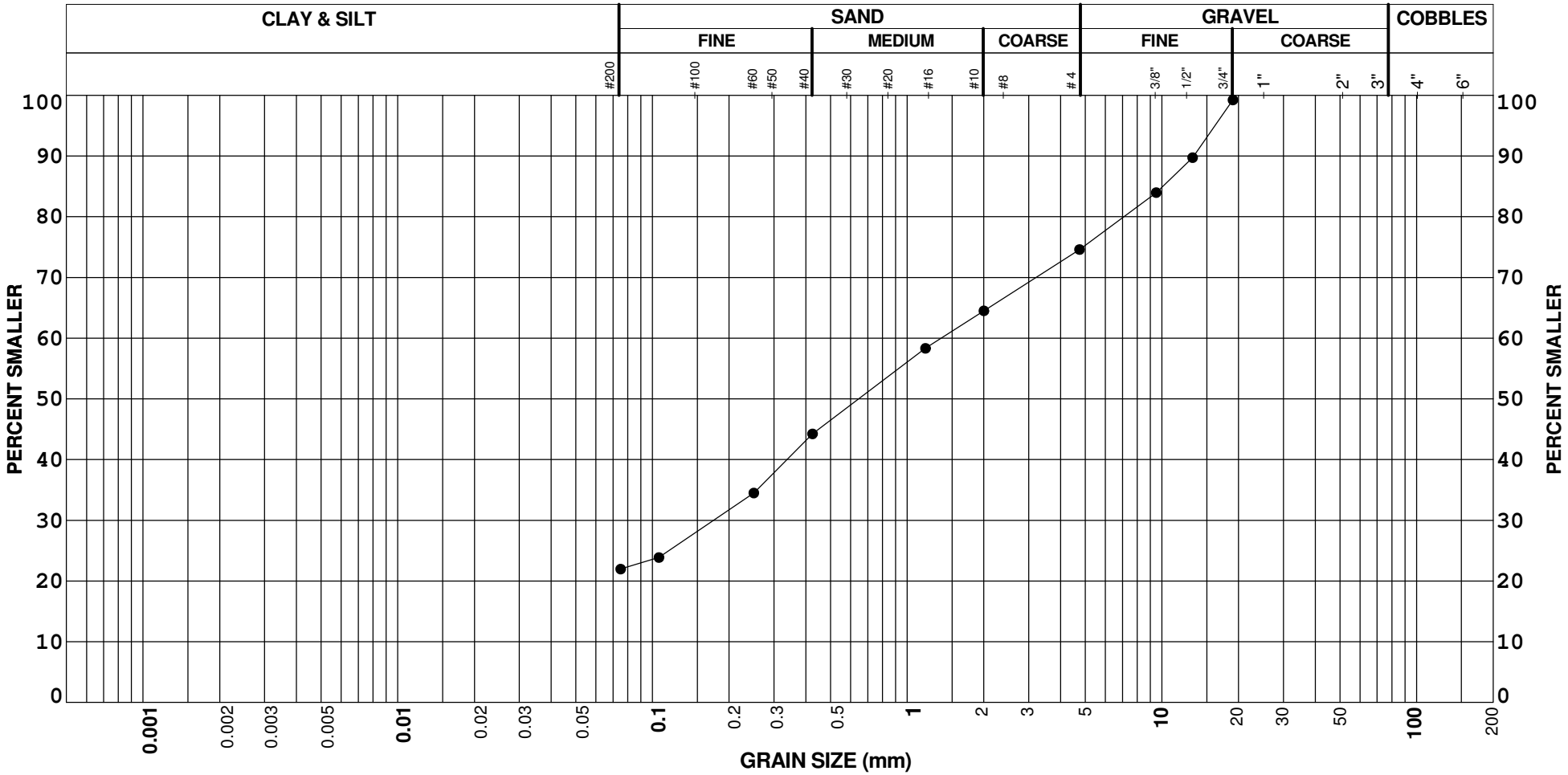
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C016	BS2	2.70	25	53	22		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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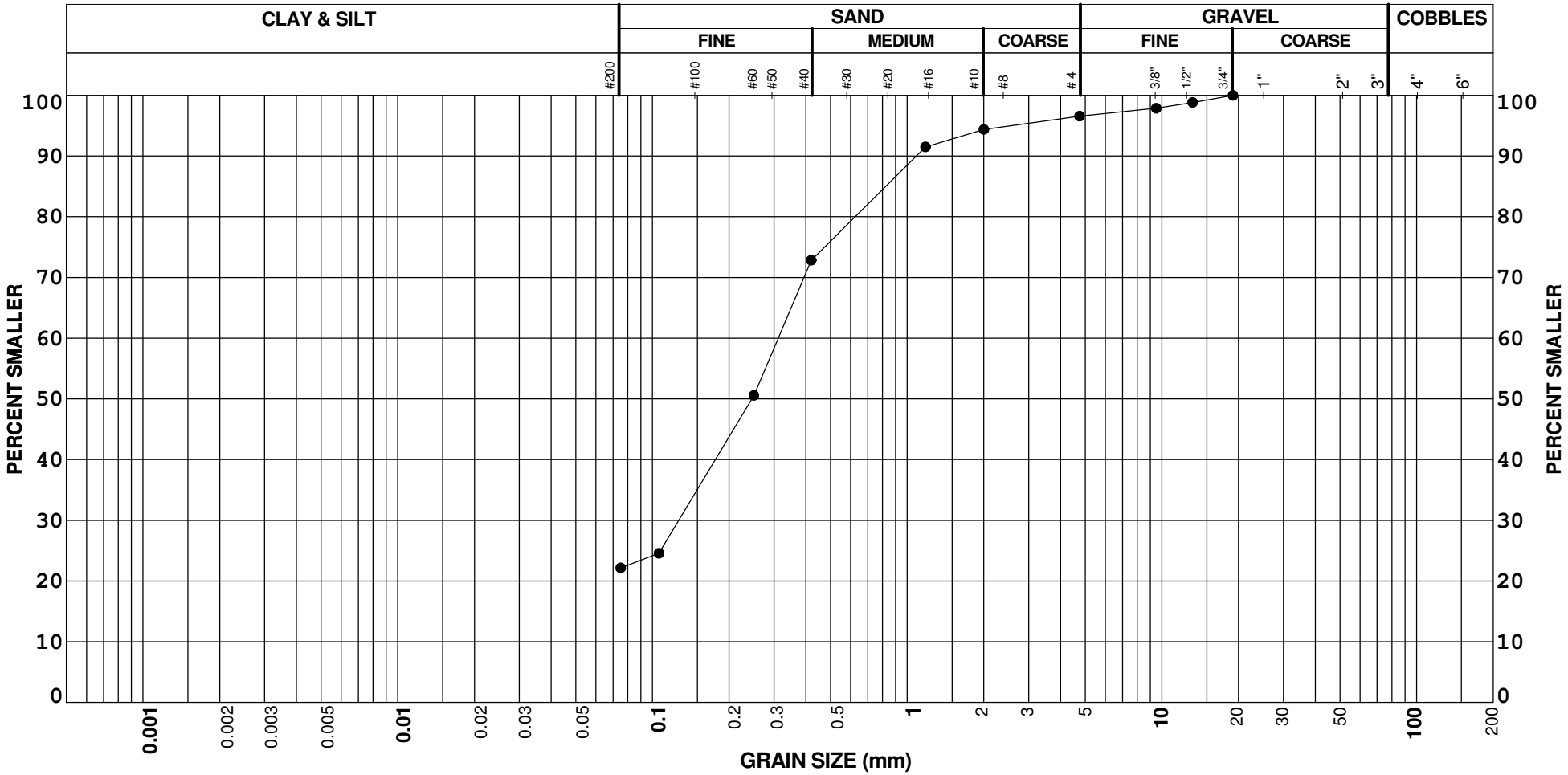
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C017	BS1	0.50	3	74	22		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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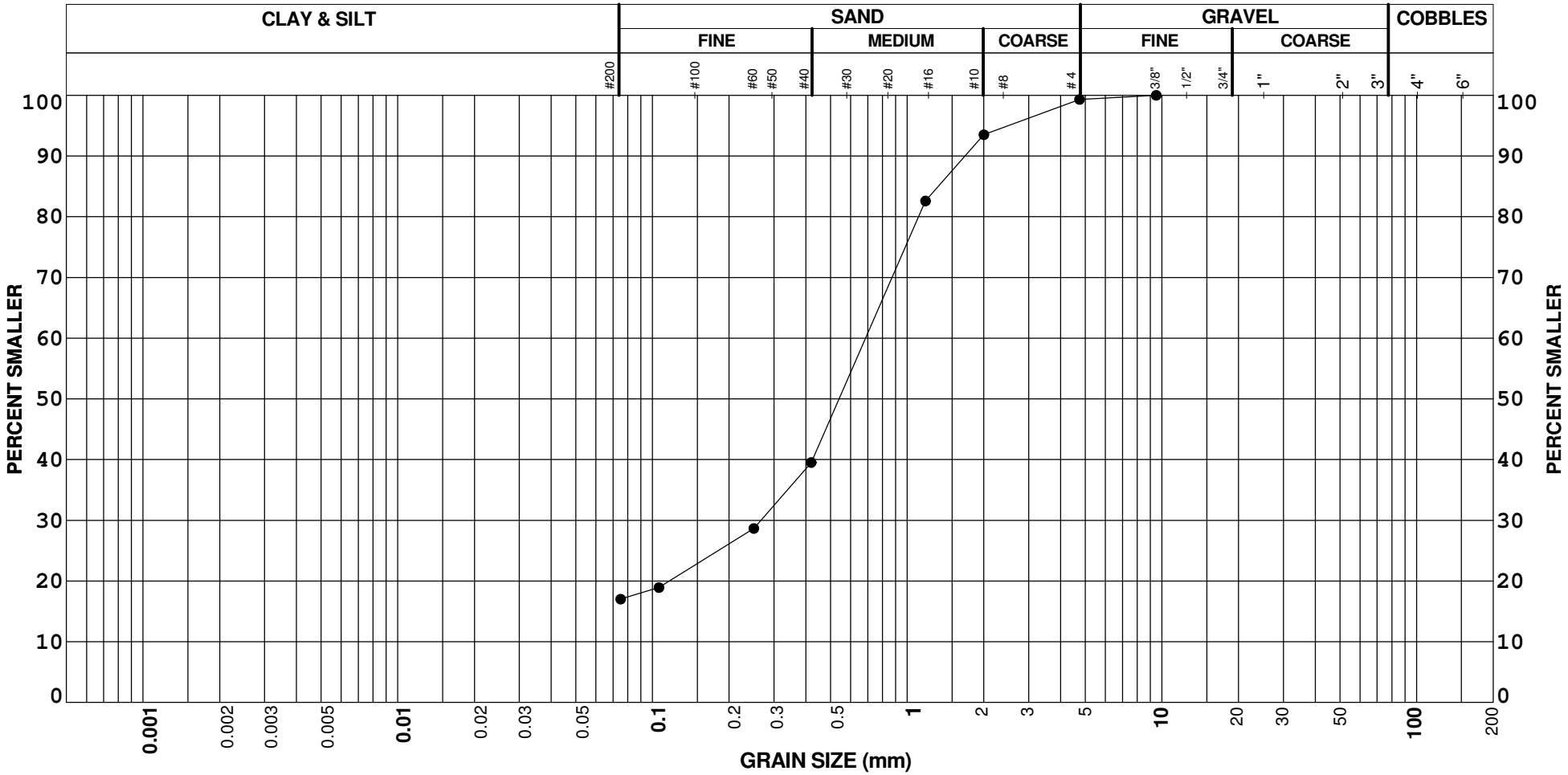
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C018	BS2	2.20	1	82	17		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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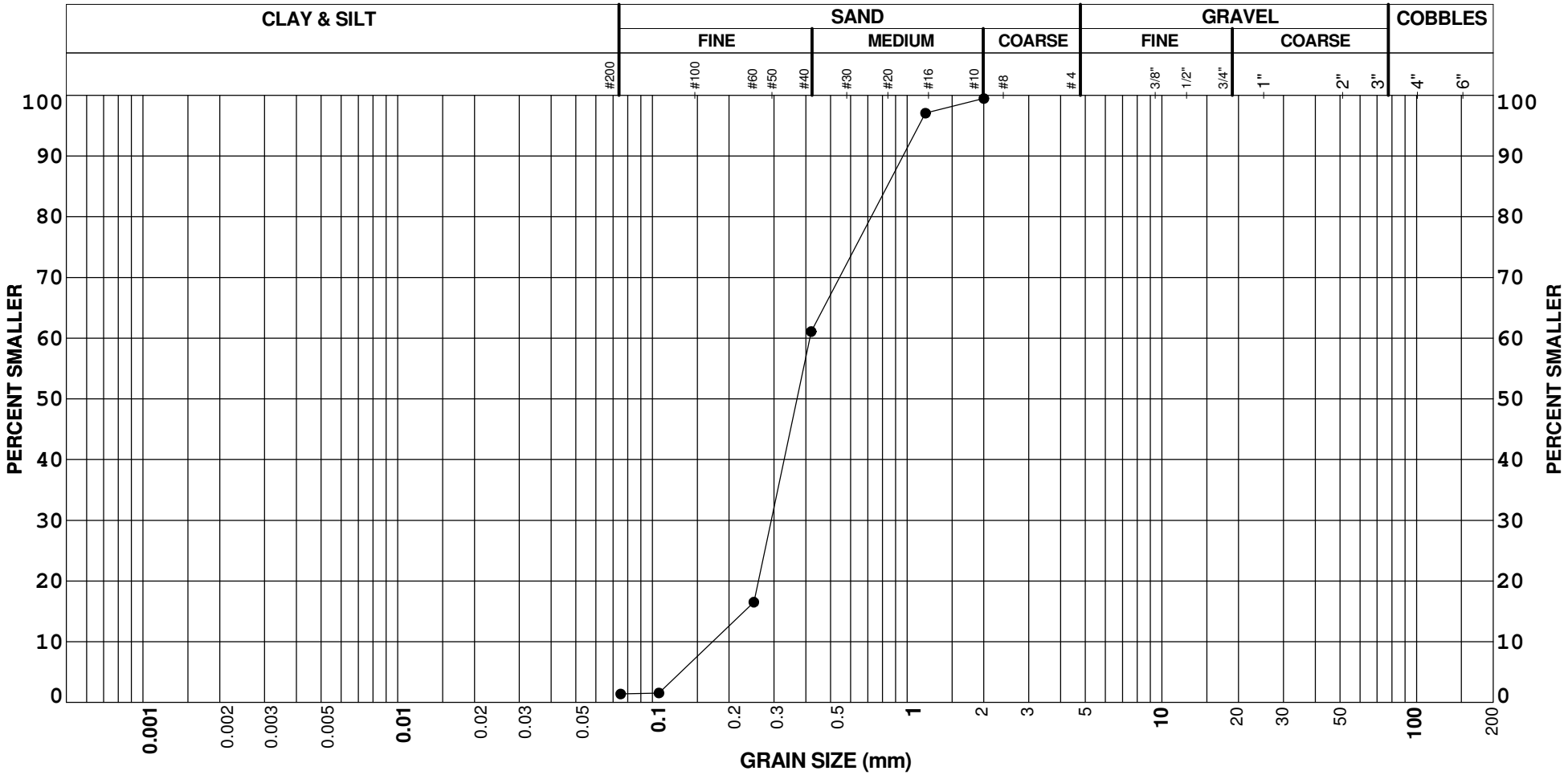
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C019B	BS1	5.80	0	98	1		

REMARKS:

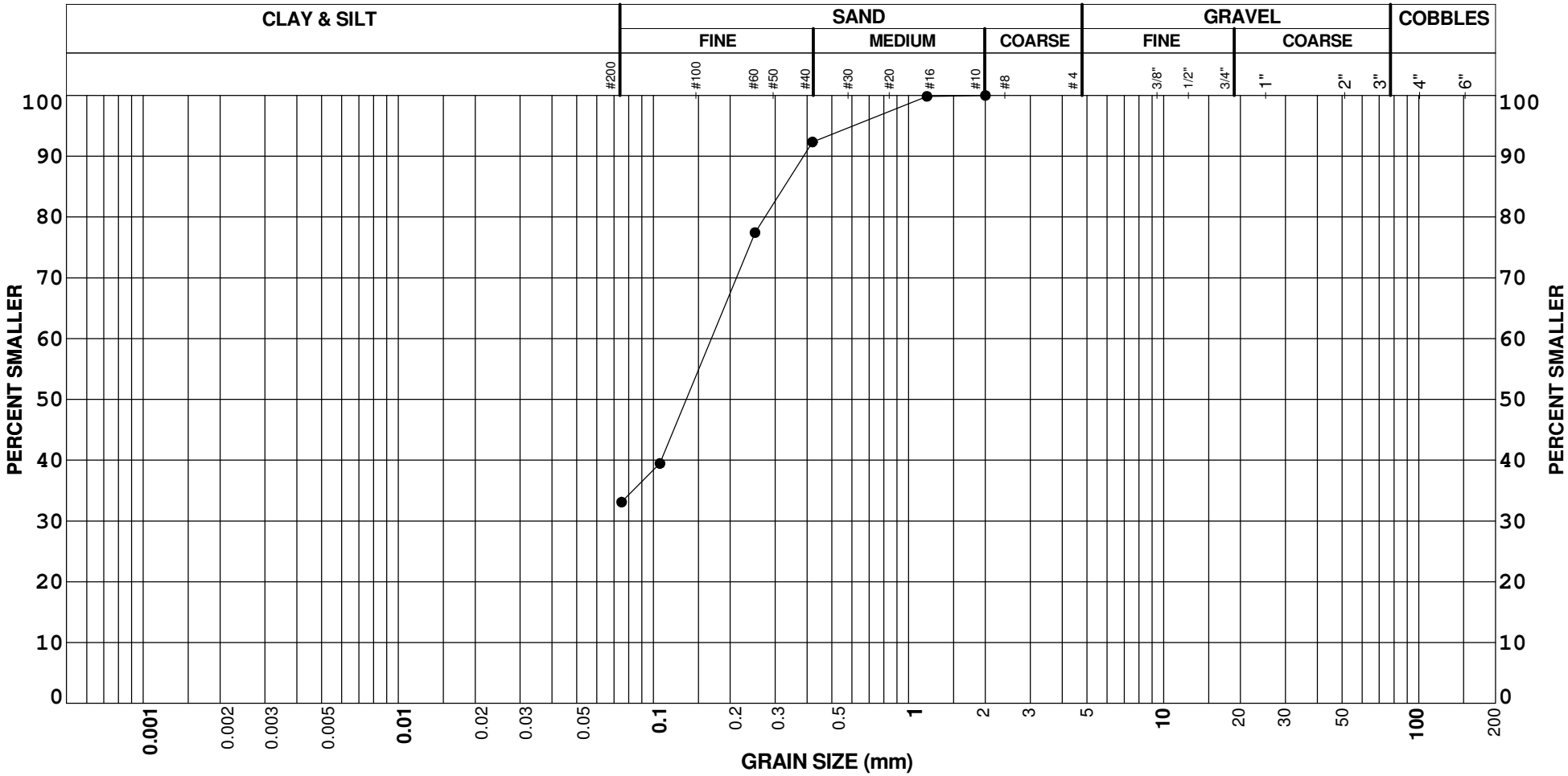
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C021	BS5	8.70	0	67	33		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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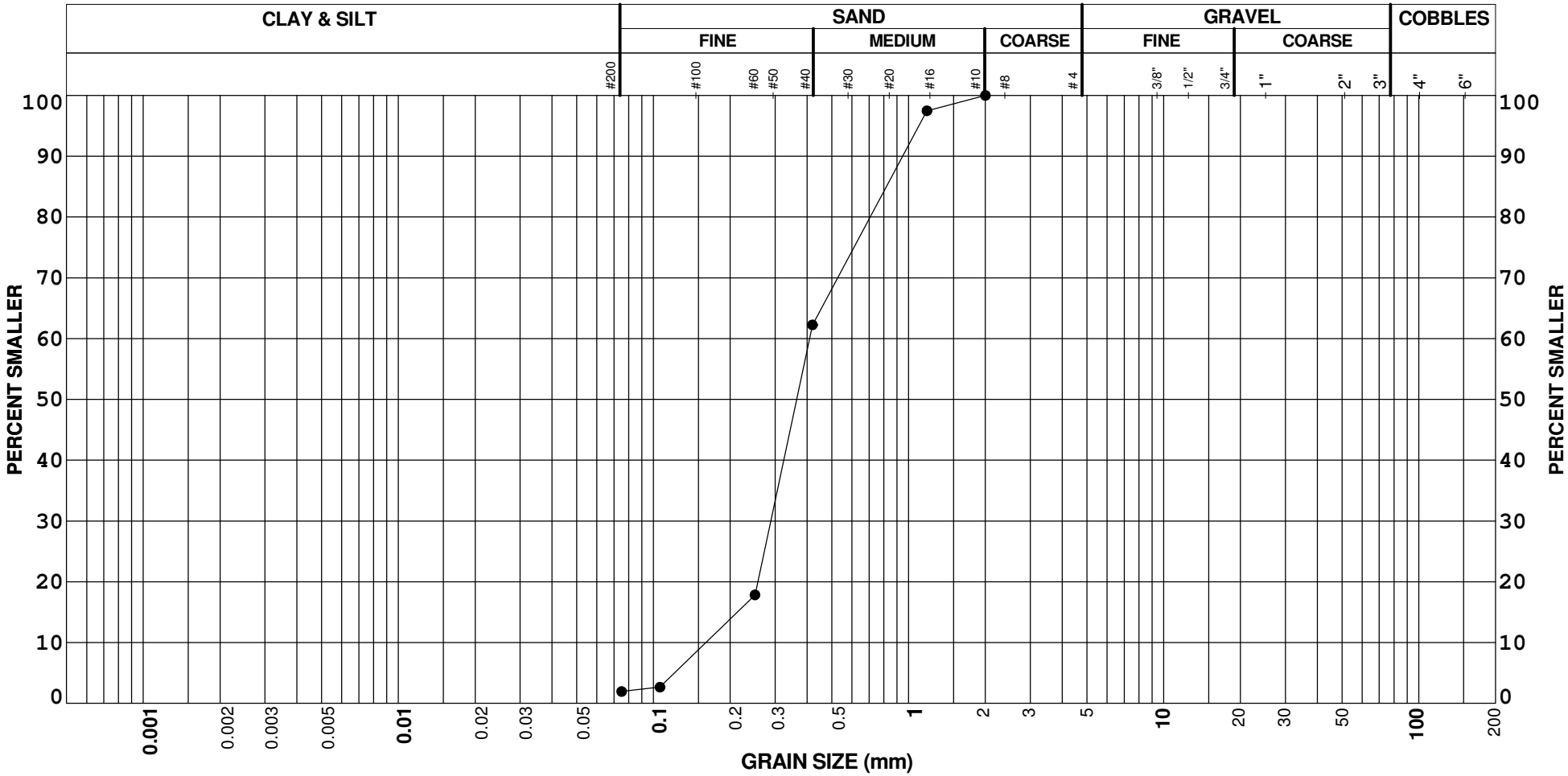
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C022	BS2	4.40	0	98	2		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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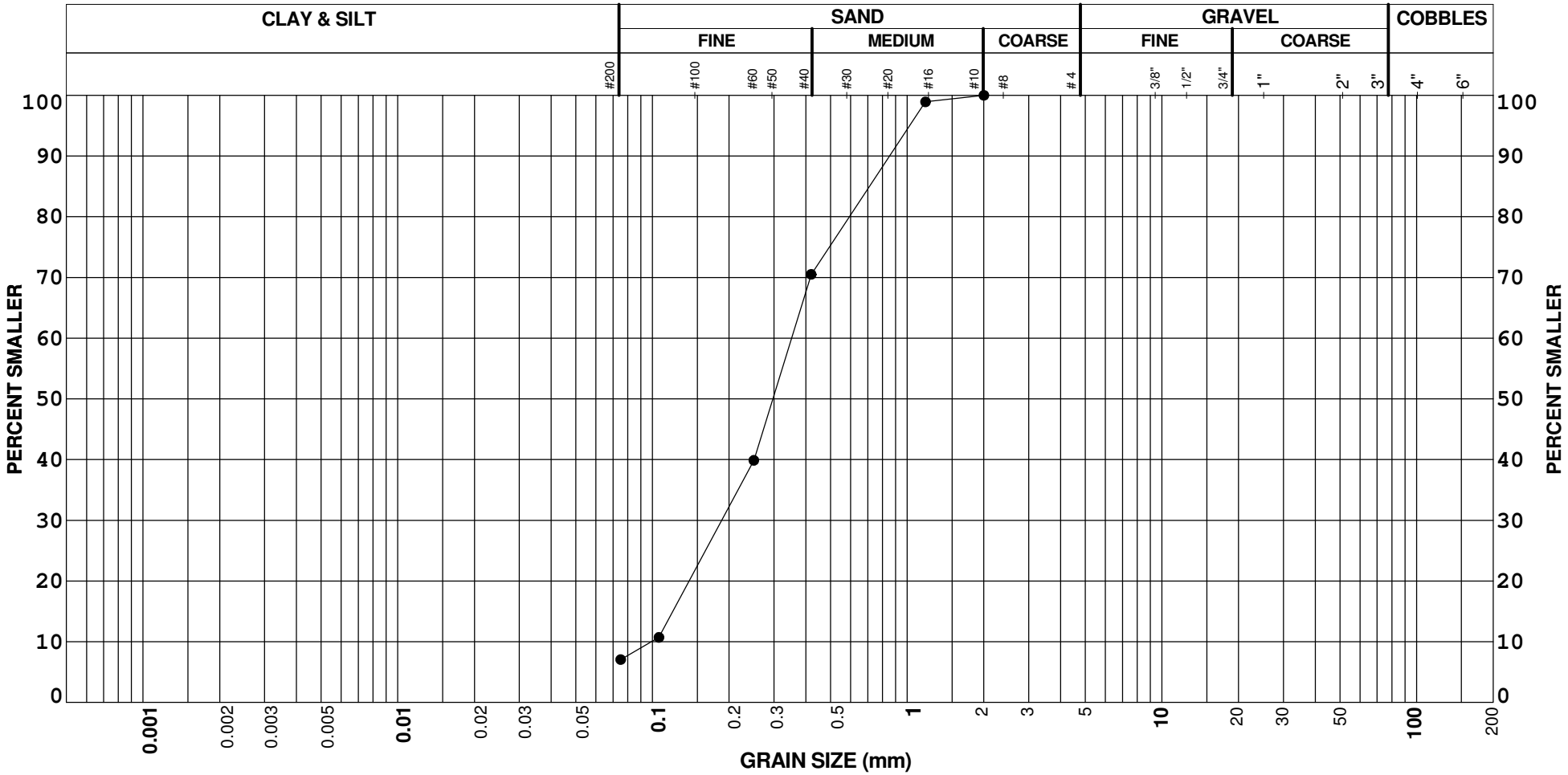
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C023	BS1	3.70	0	93	7		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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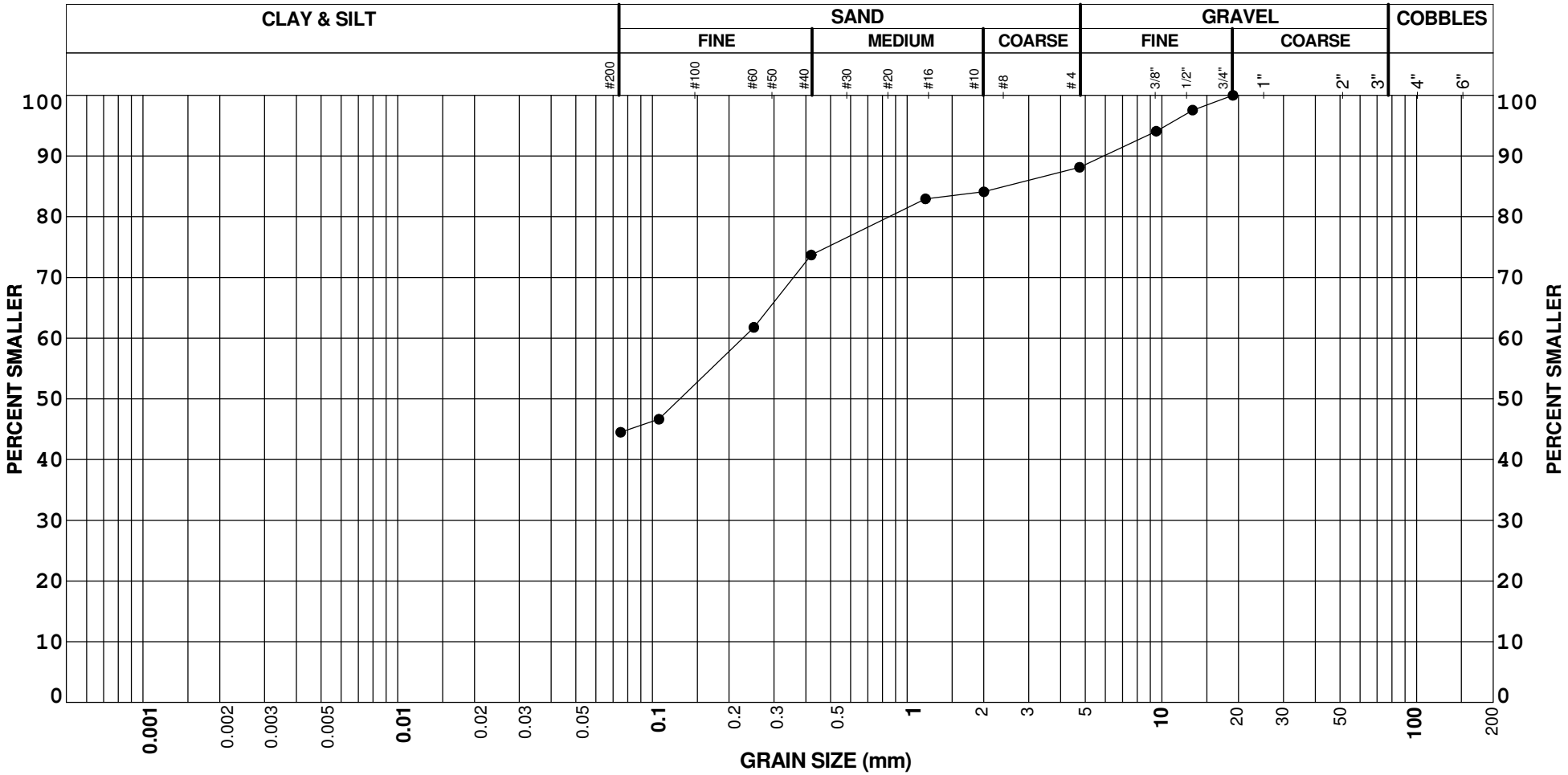
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C023	BS2	5.00	12	44	45		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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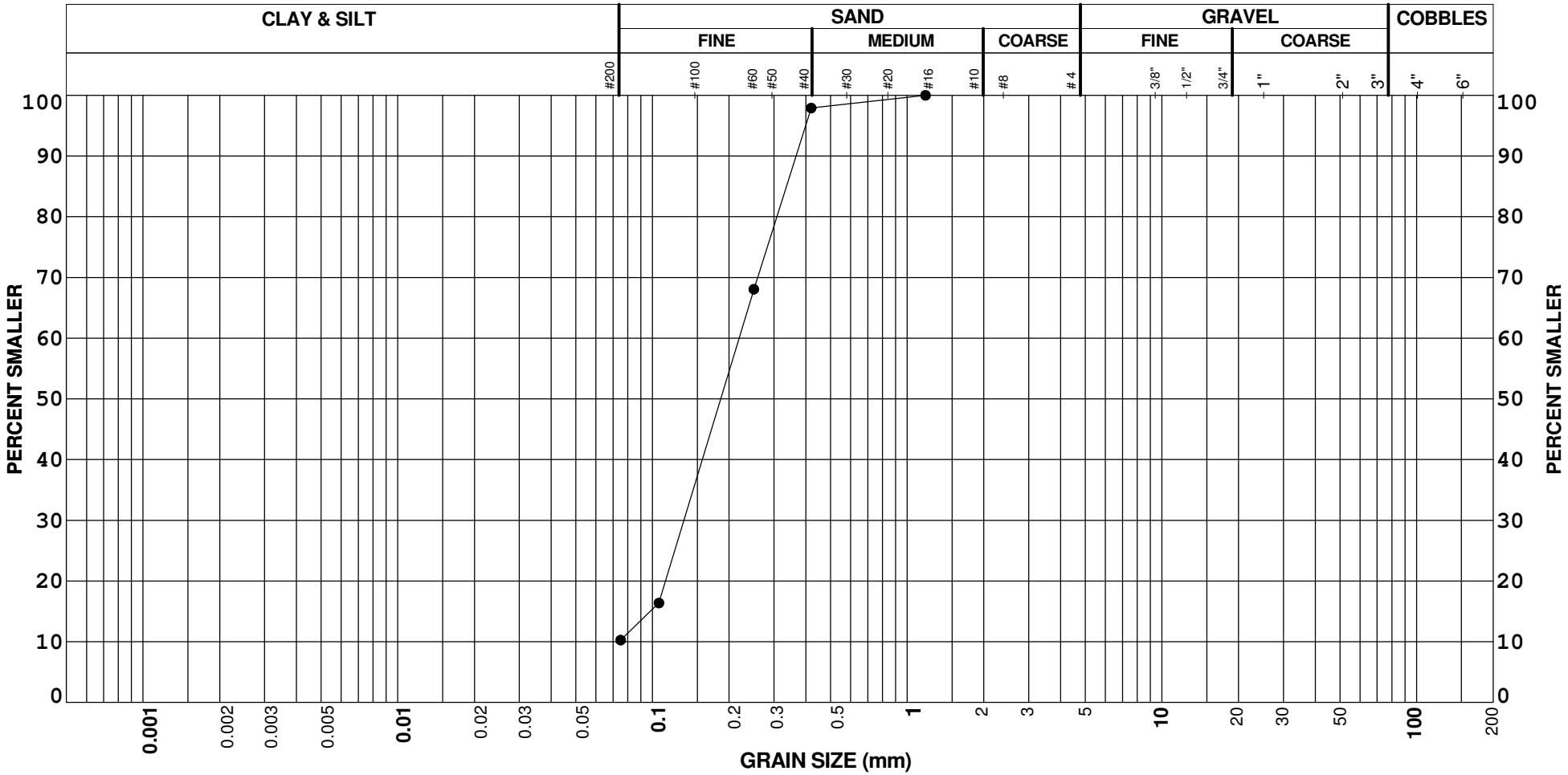
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C024	BS2	5.00	0	90	10		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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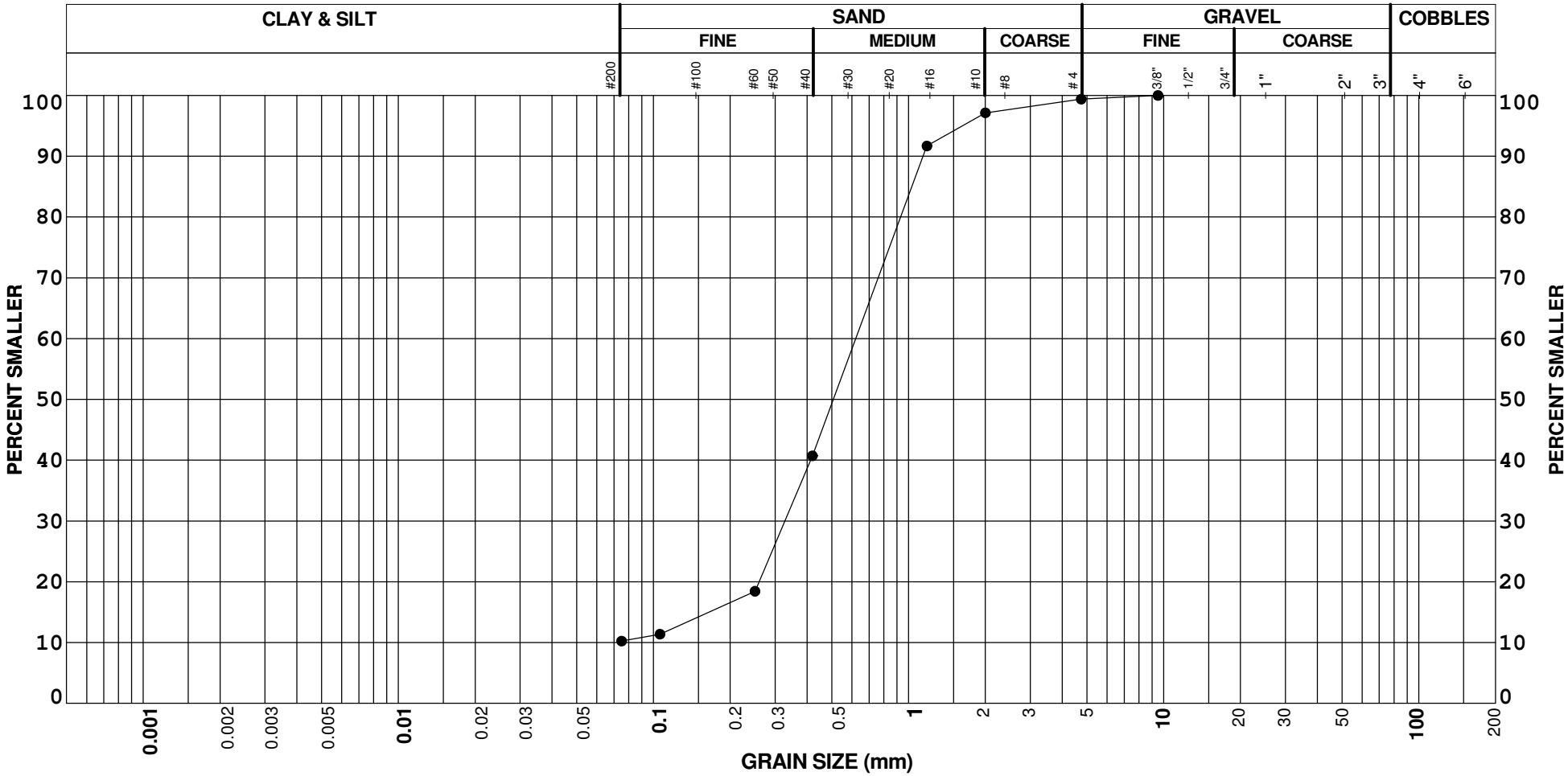
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C025	BS2	4.00	1	89	10		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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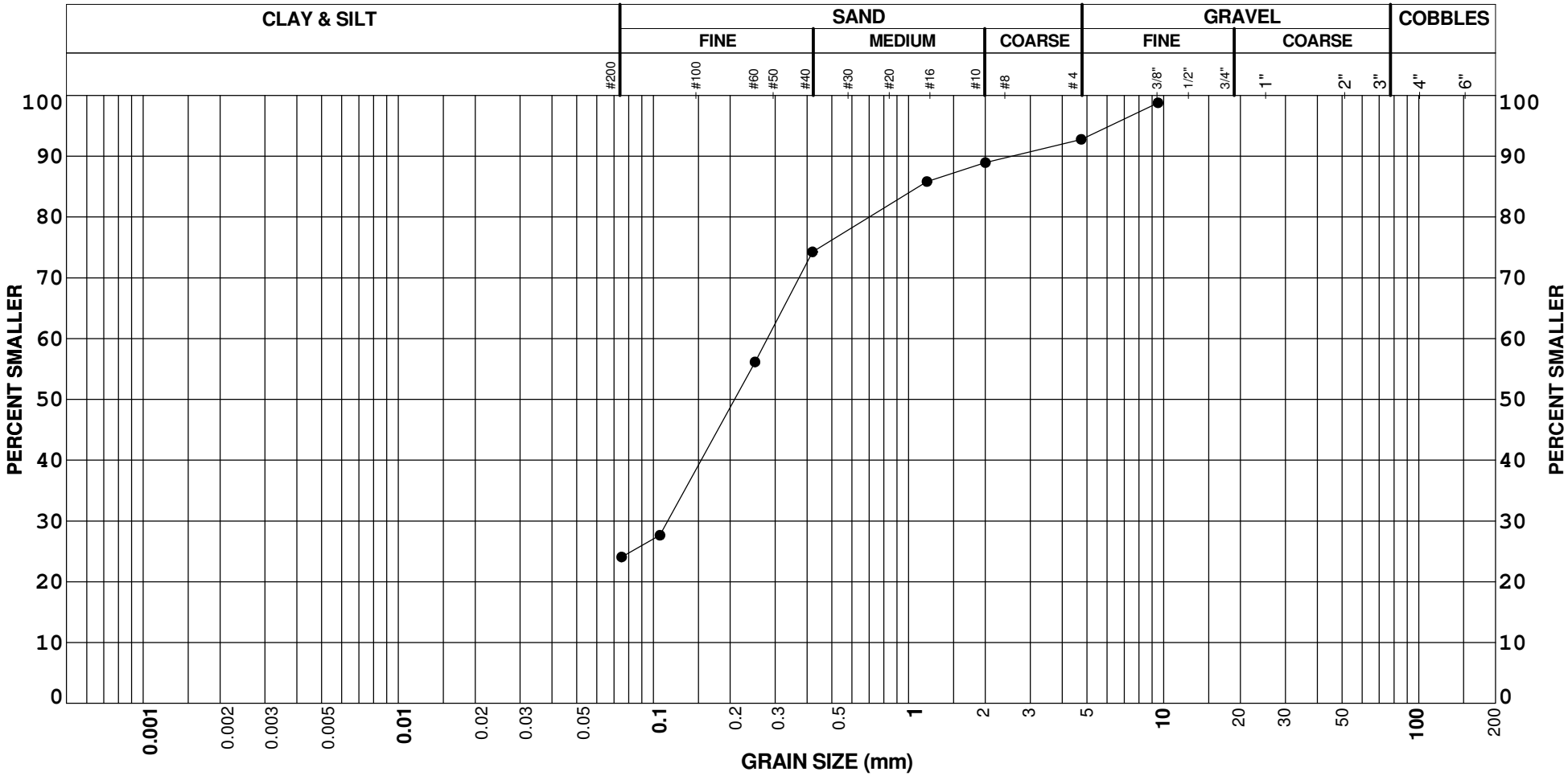
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C026	BS1	2.40	6	69	24		

REMARKS:

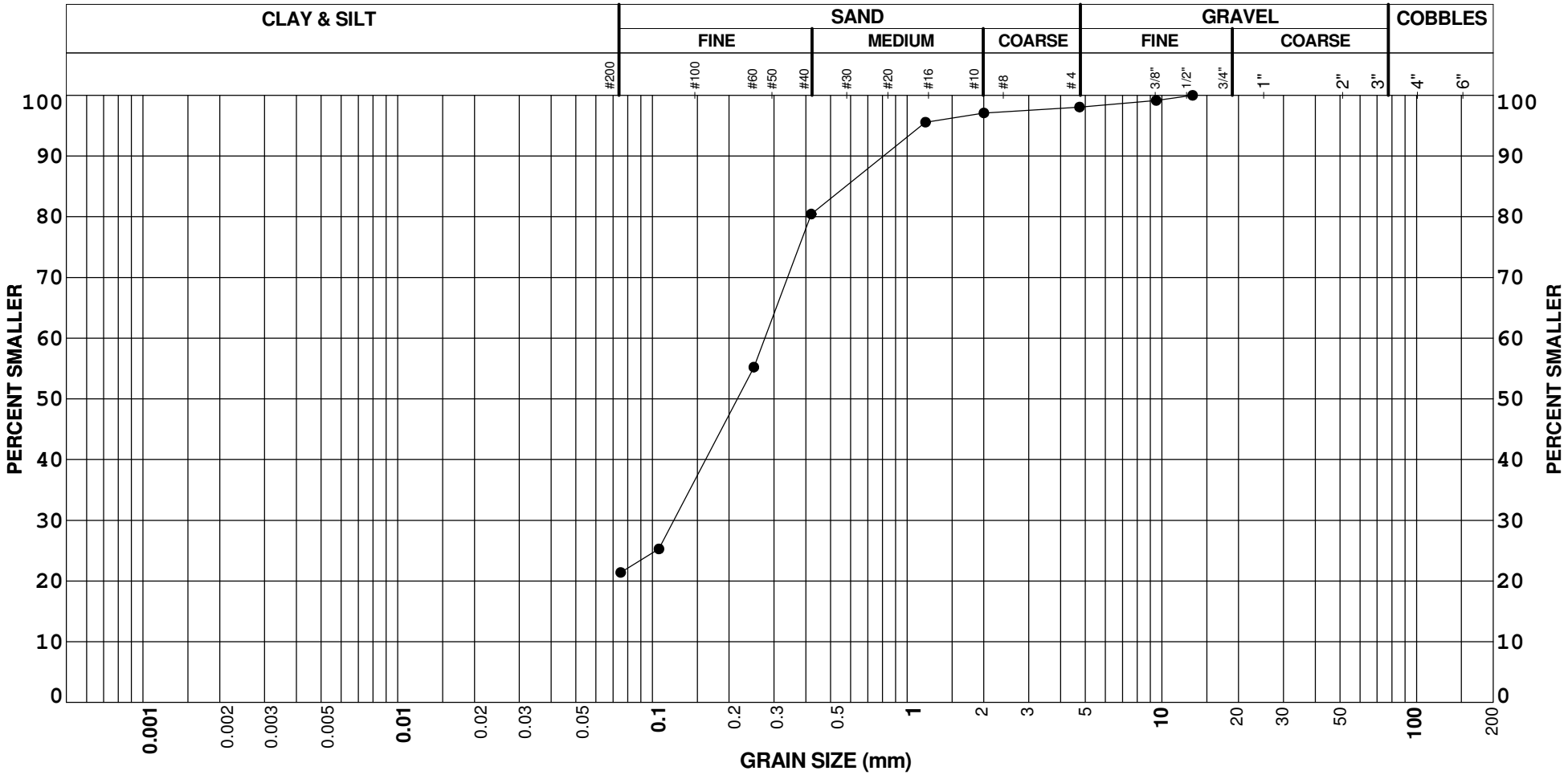
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C026	BS2	4.00	2	77	21		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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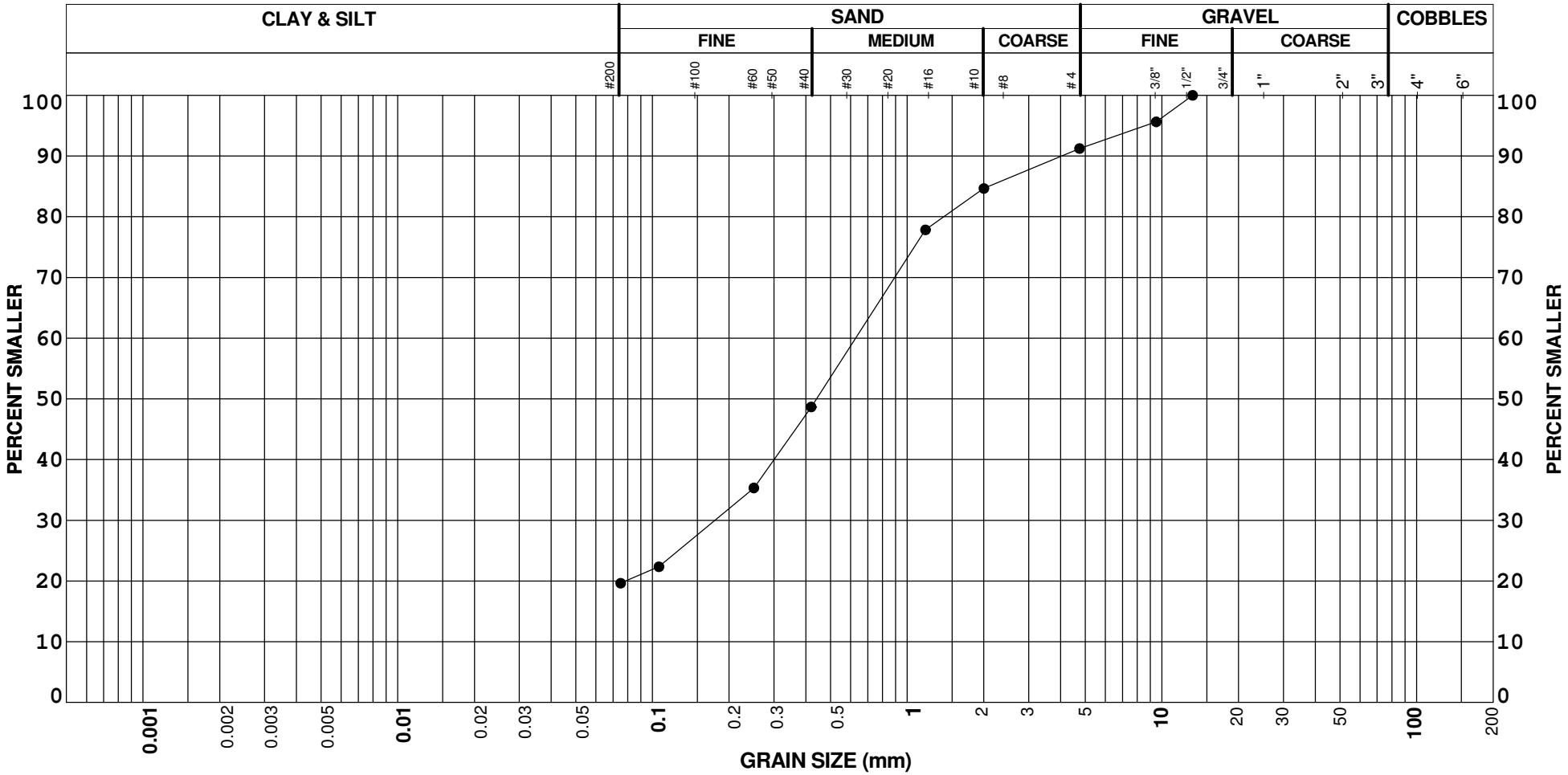
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C027	BS1	4.00	9	72	20		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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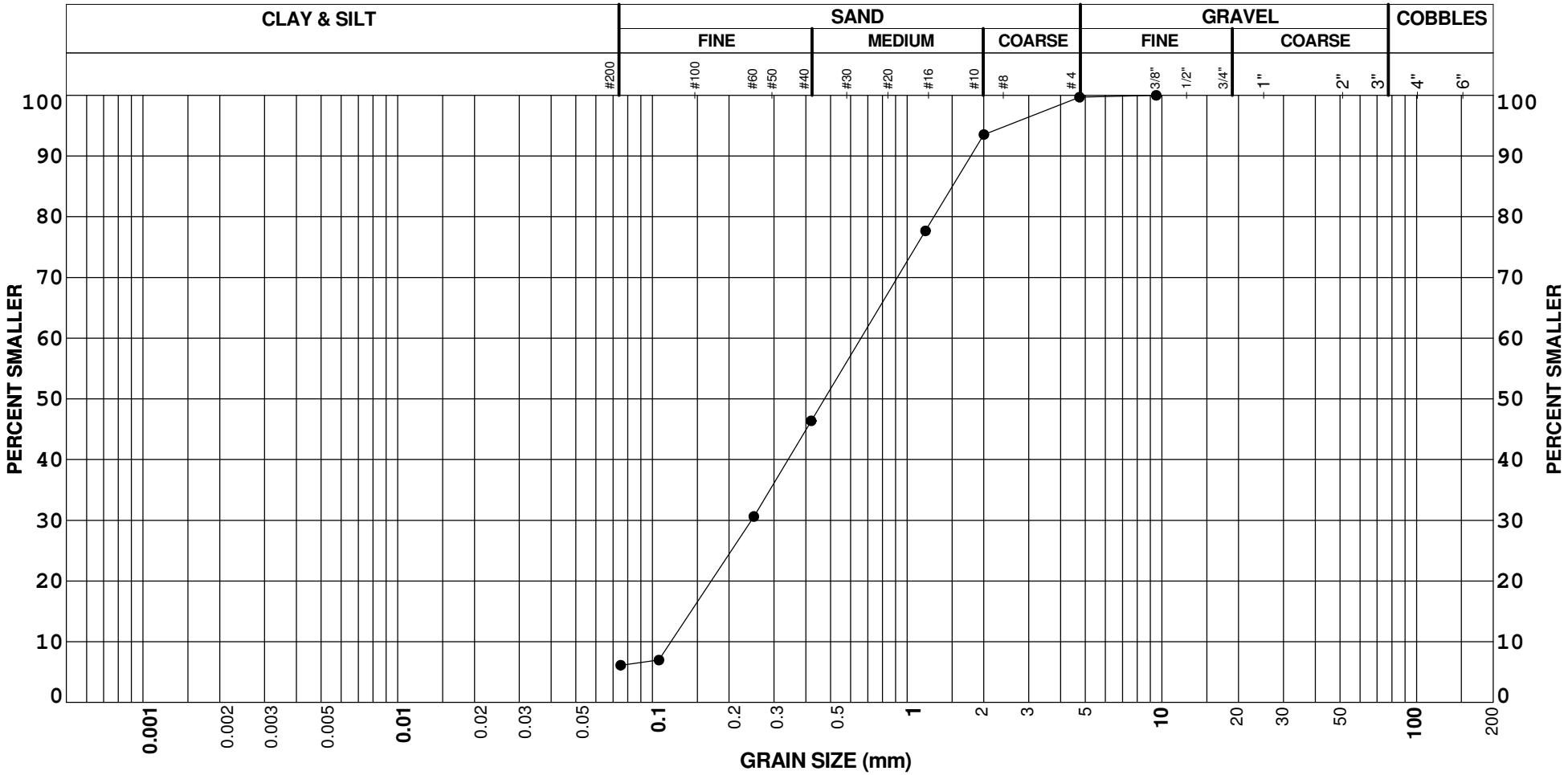
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C028	BS2	8.80	0	94	6		

REMARKS:

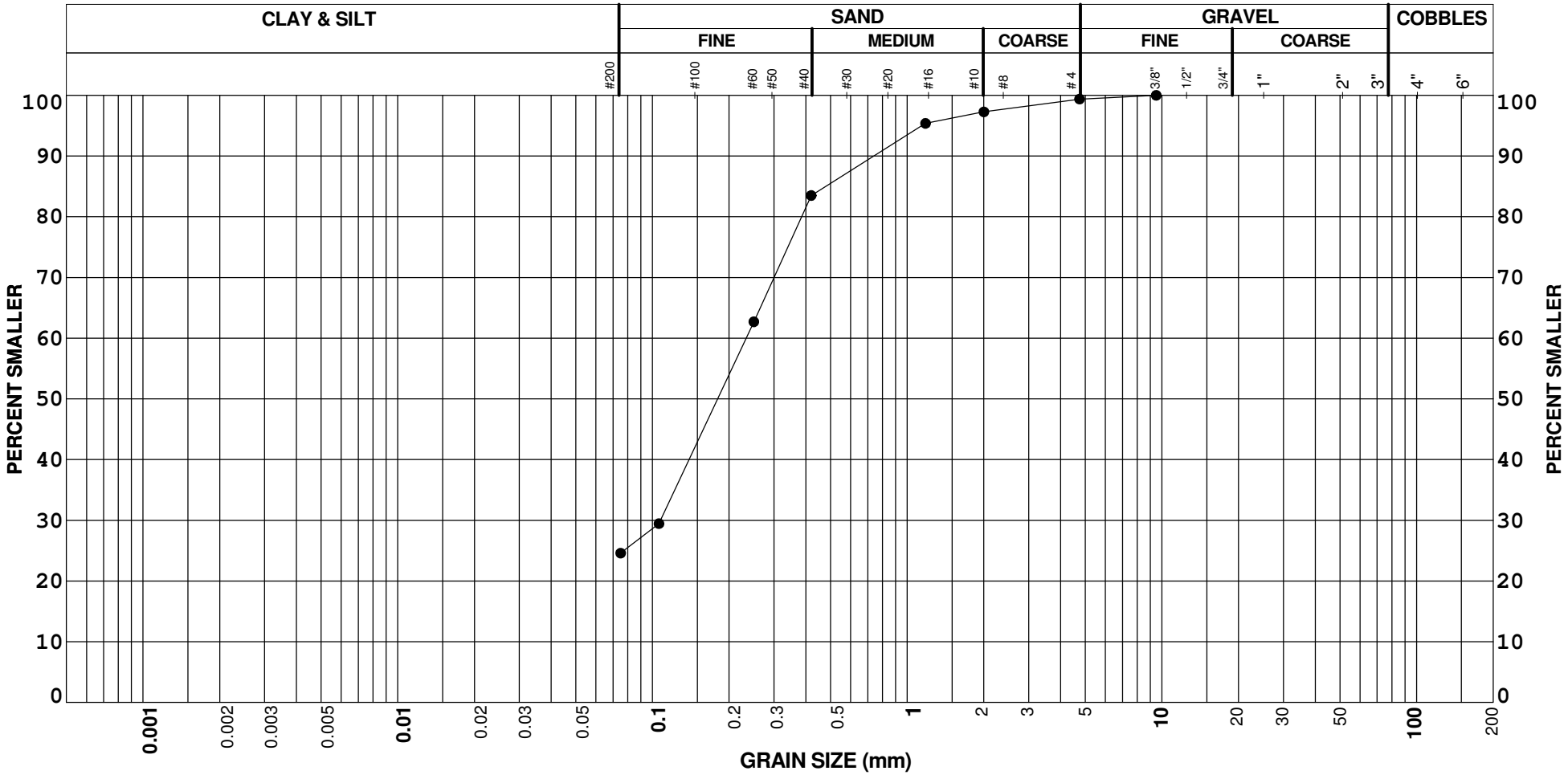
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C029	BS2	2.40	1	75	25		

REMARKS:

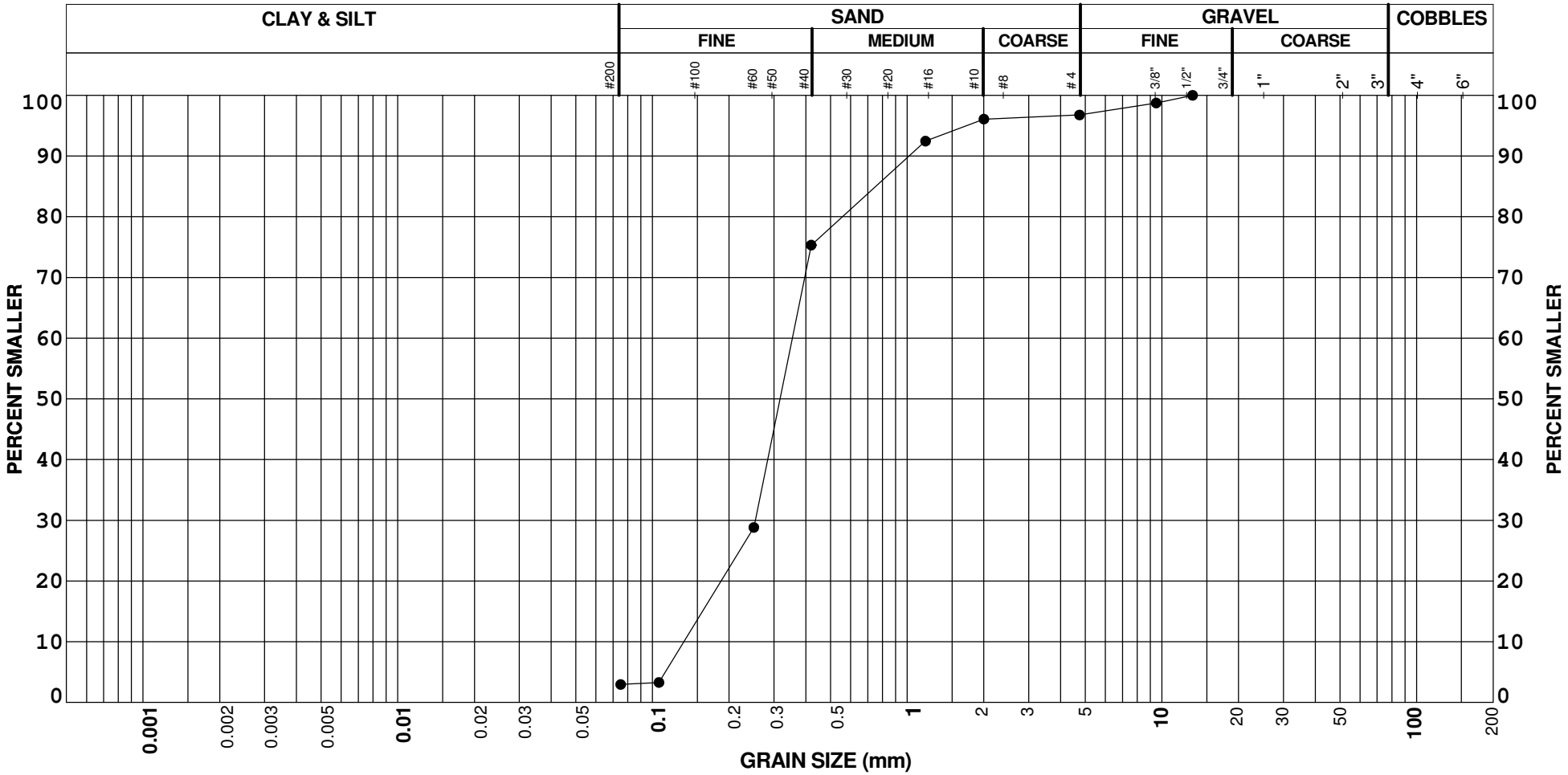
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C030	BS4	5.00	3	94	3		

REMARKS:

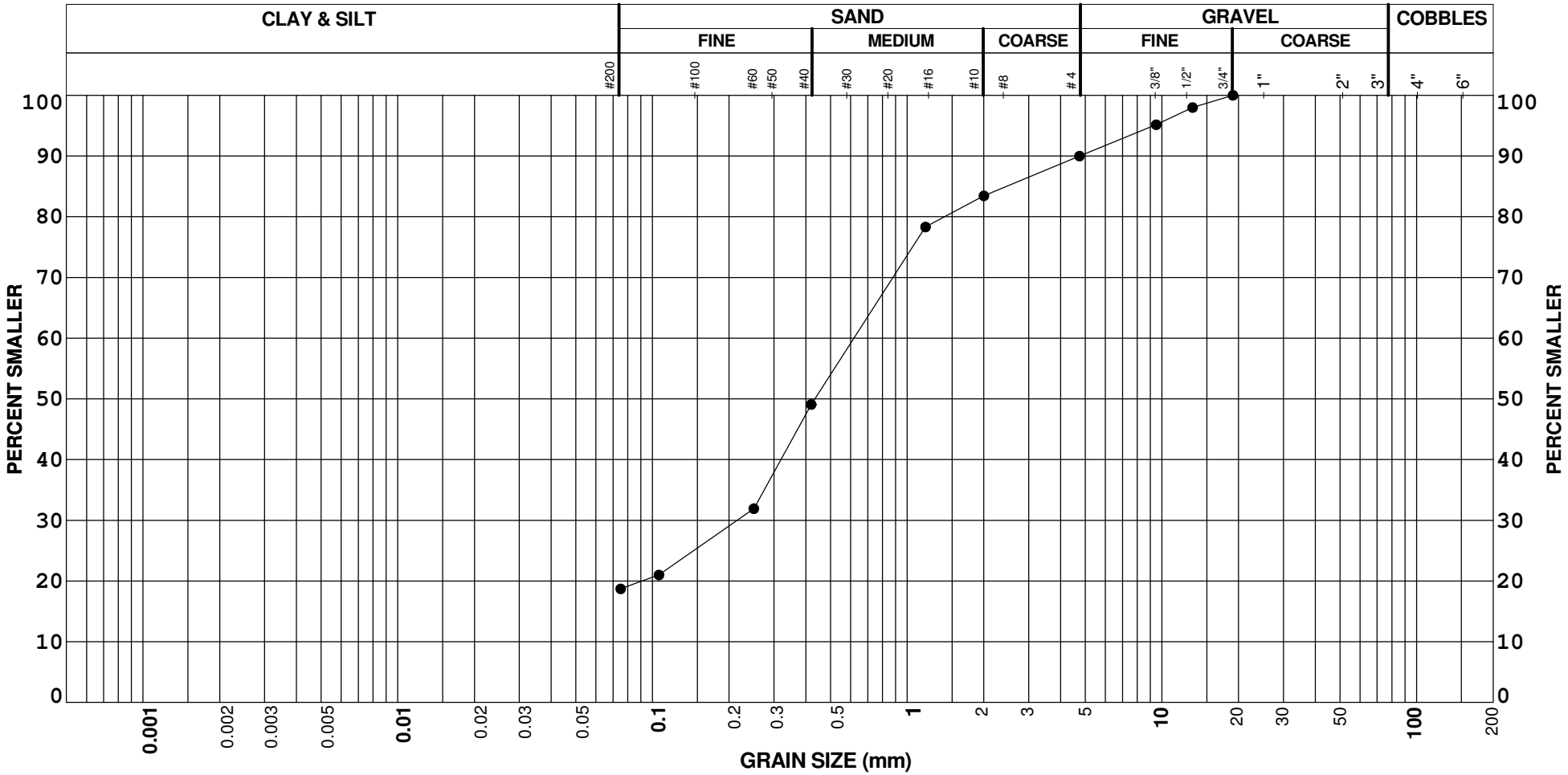
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C032	BS2	2.40	10	71	19		

REMARKS:

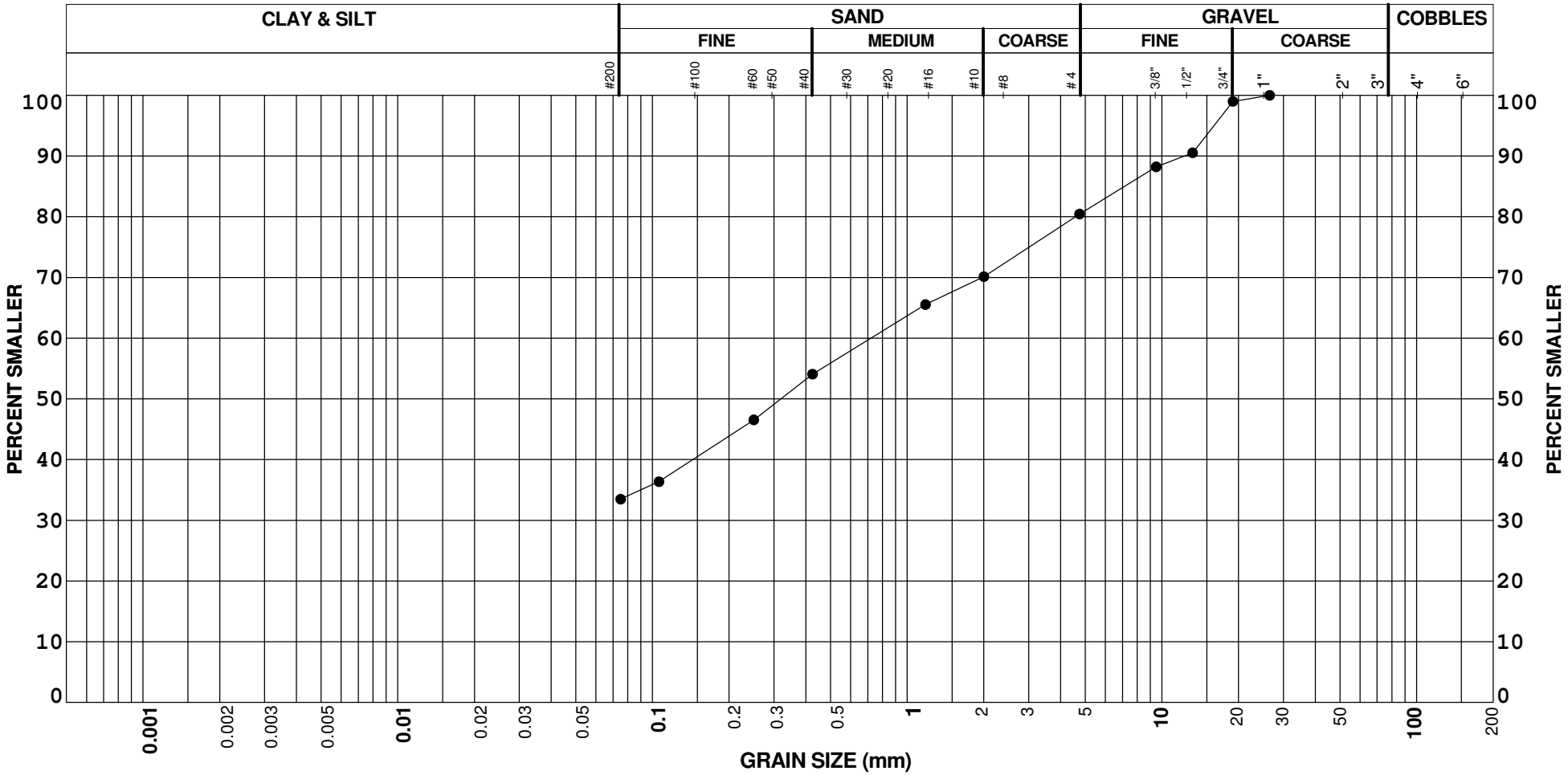
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-C205	BS3	4.00	20	47	33		

REMARKS:

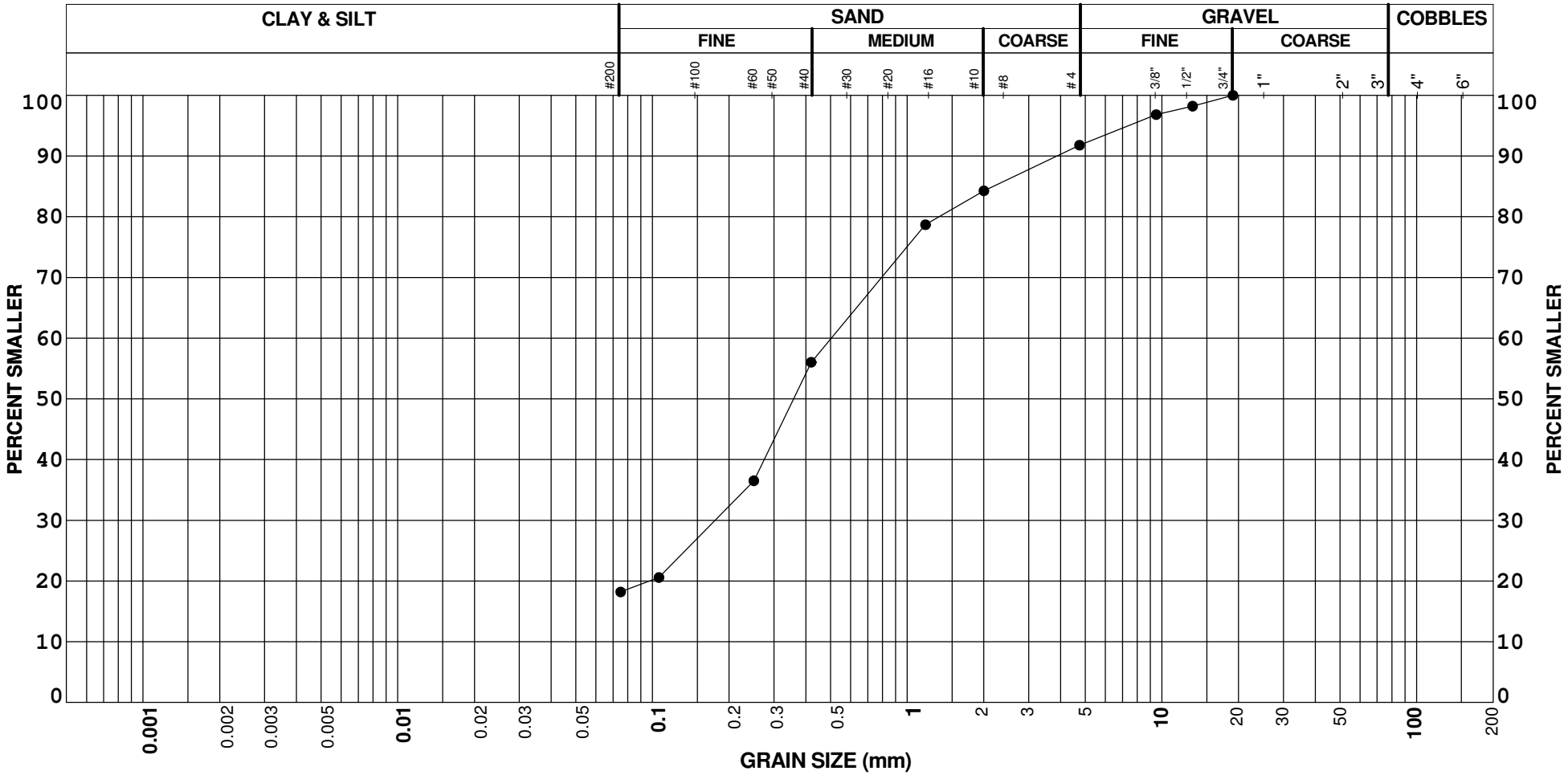
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R004	BS2	2.51	8	74	18		

REMARKS:

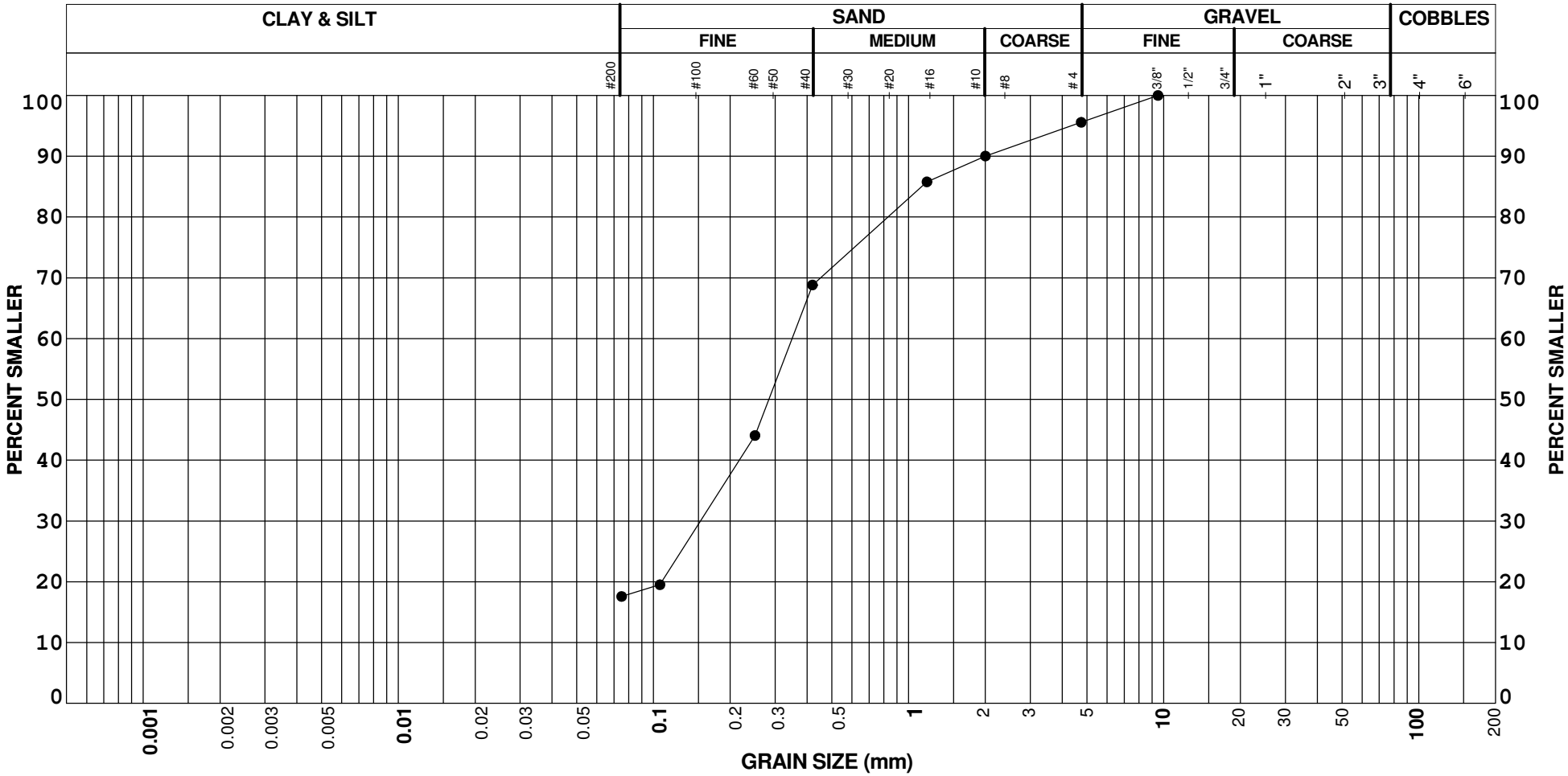
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R005	BS2	2.50	4	78	18		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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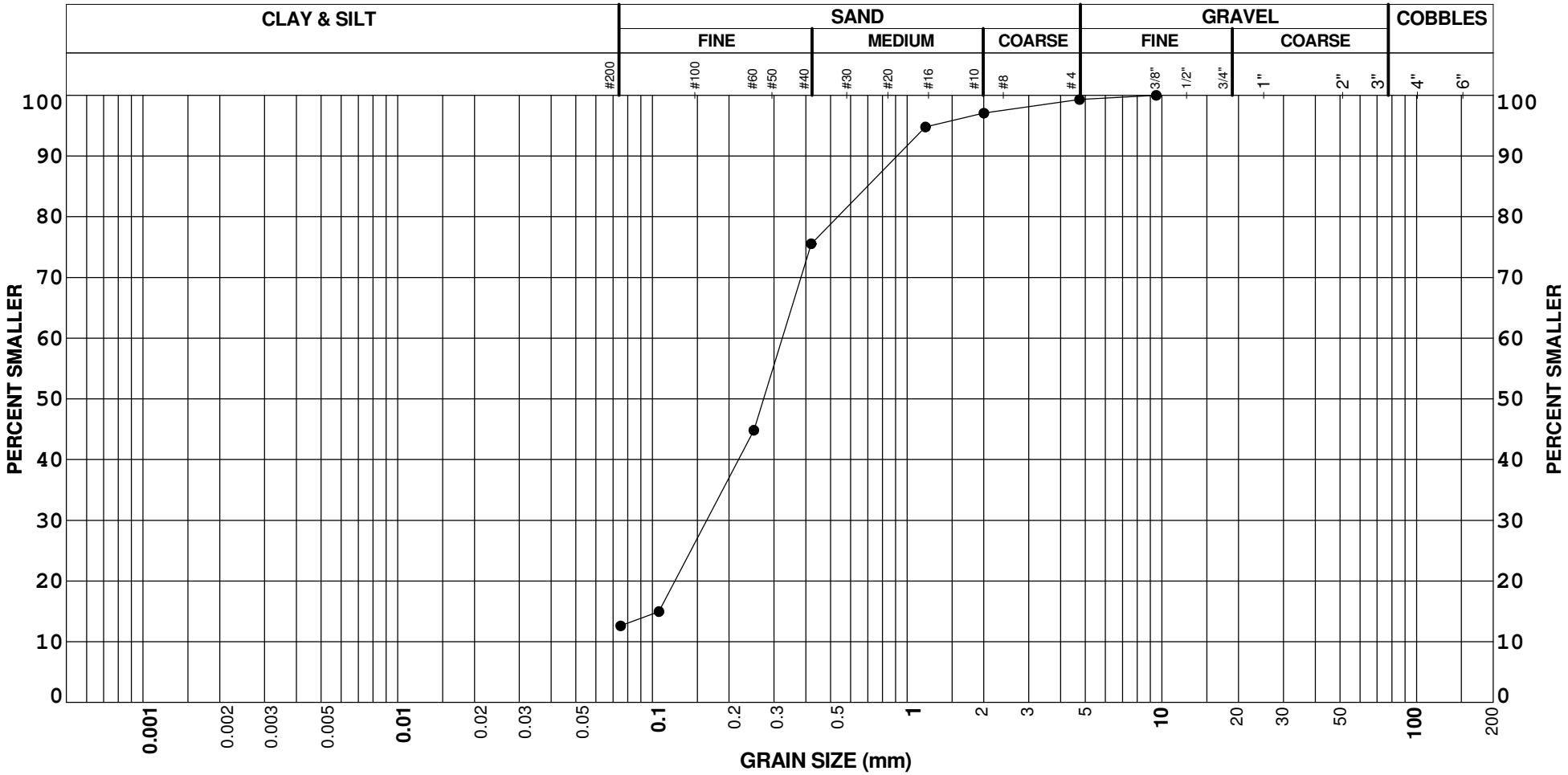
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R007	BS2	2.50	1	87	13		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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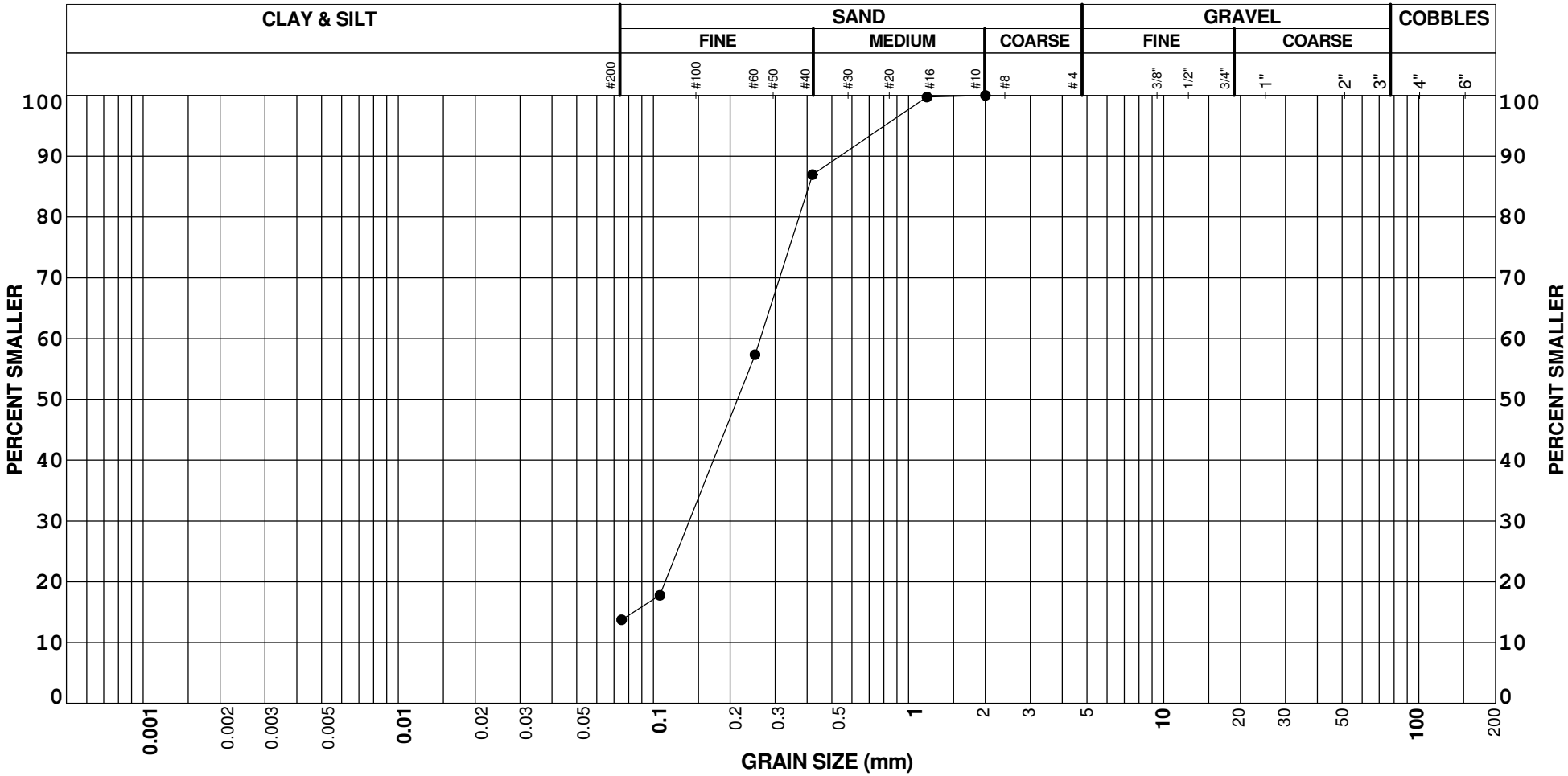
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R011	BS2	2.50	0	86	14		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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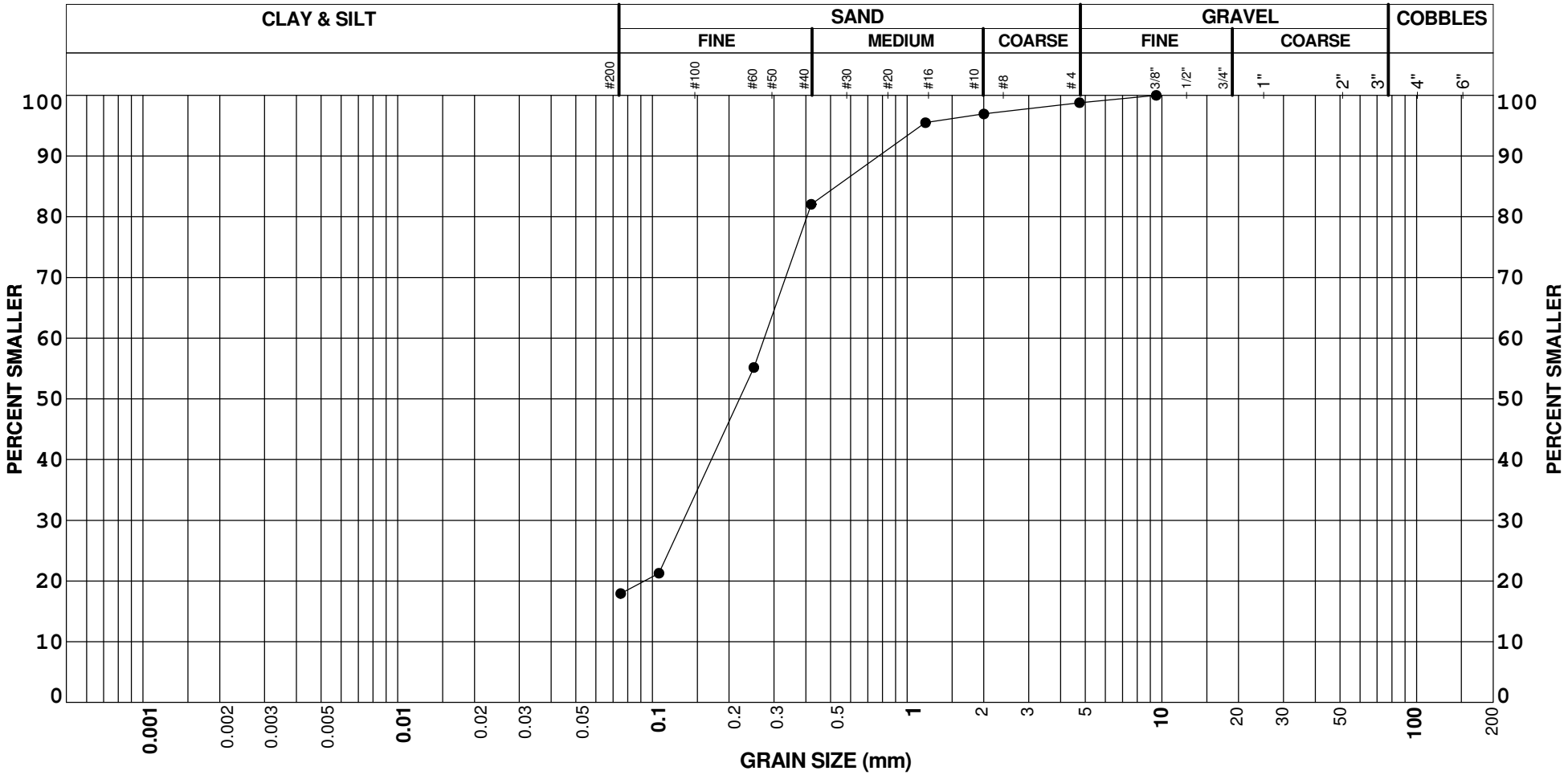
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R012	BS2	2.50	1	81	18		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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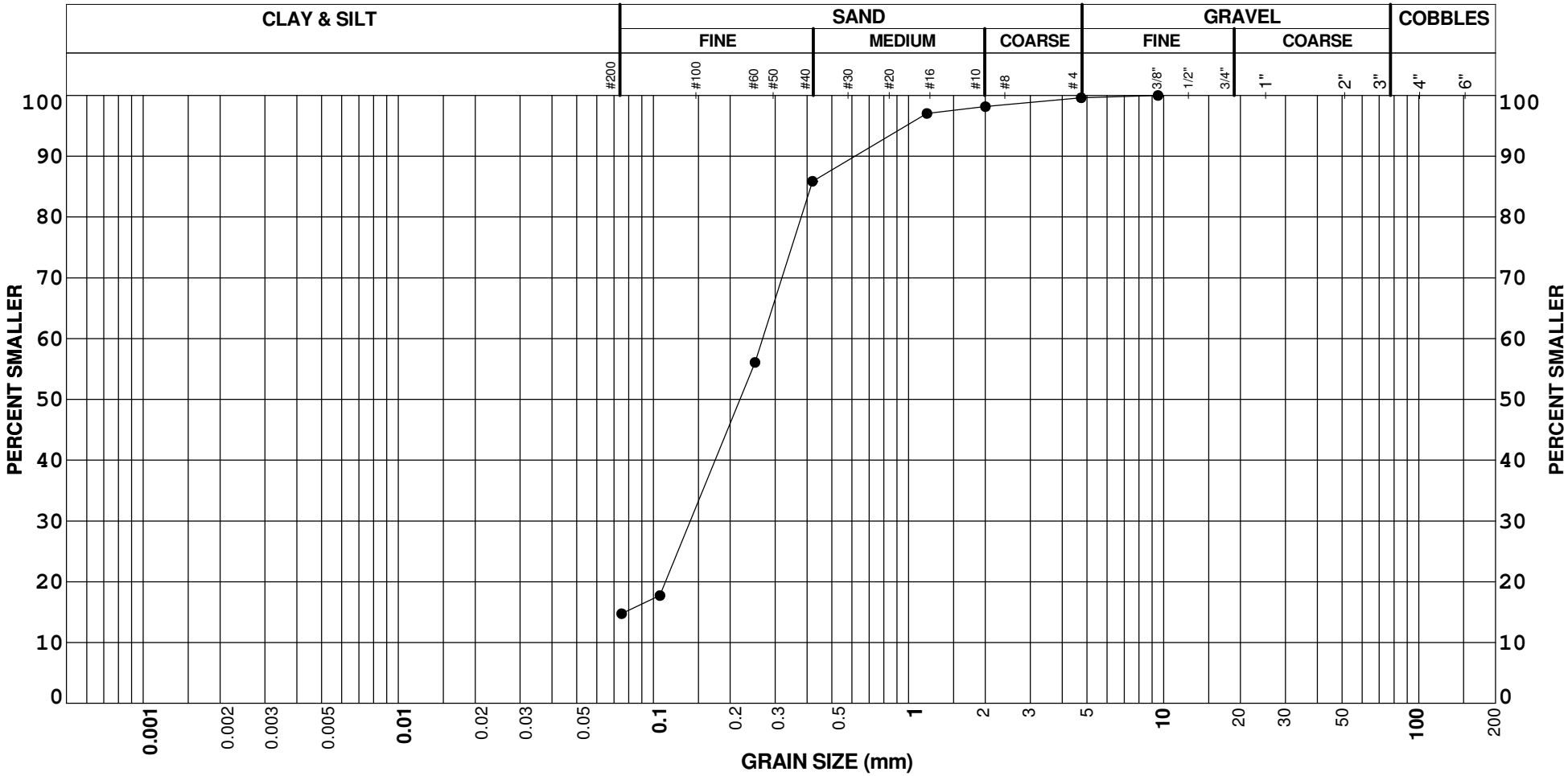
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R013	BS2	2.50	0	85	15		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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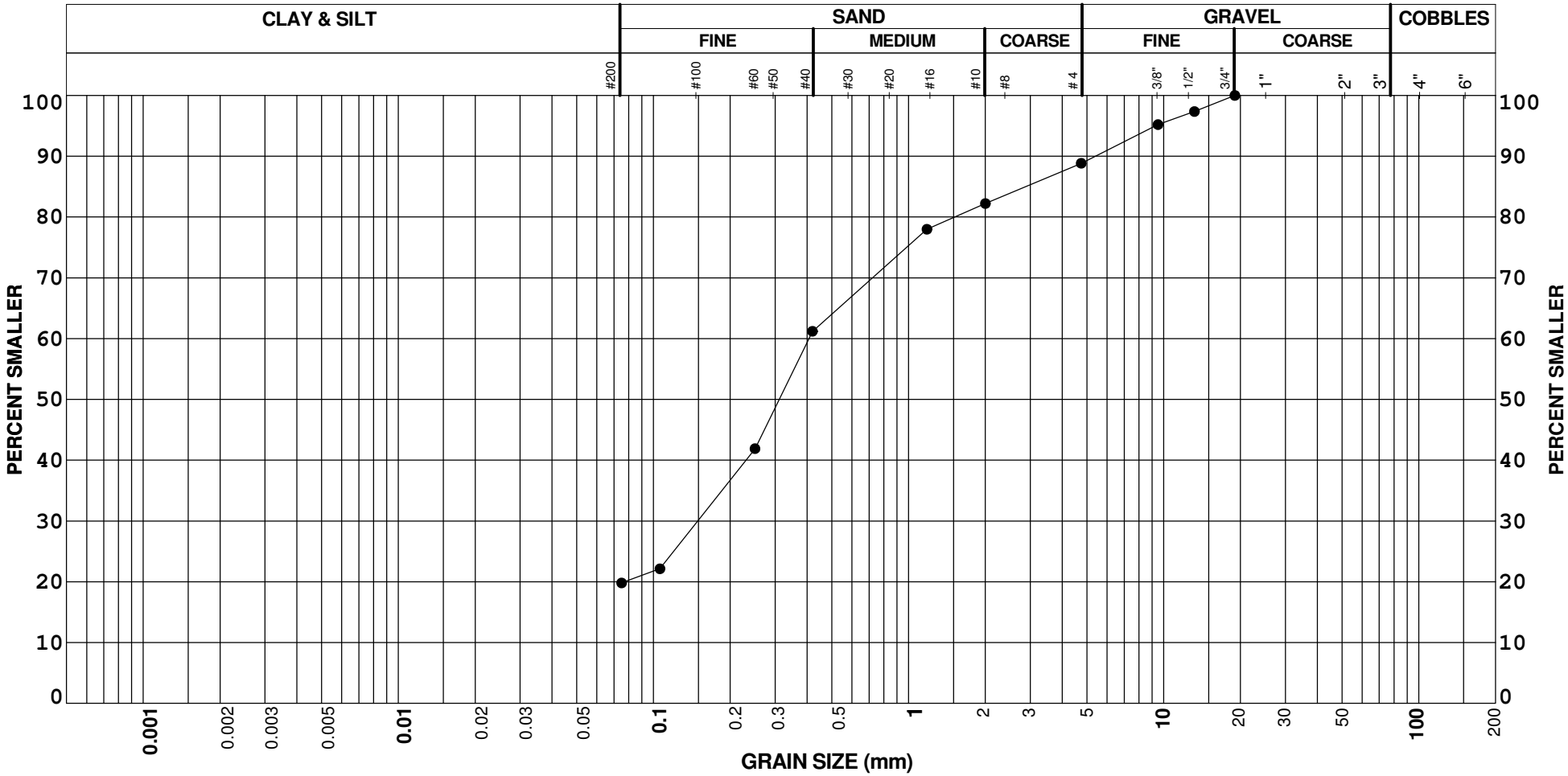
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R014	BS2	2.00	11	69	20		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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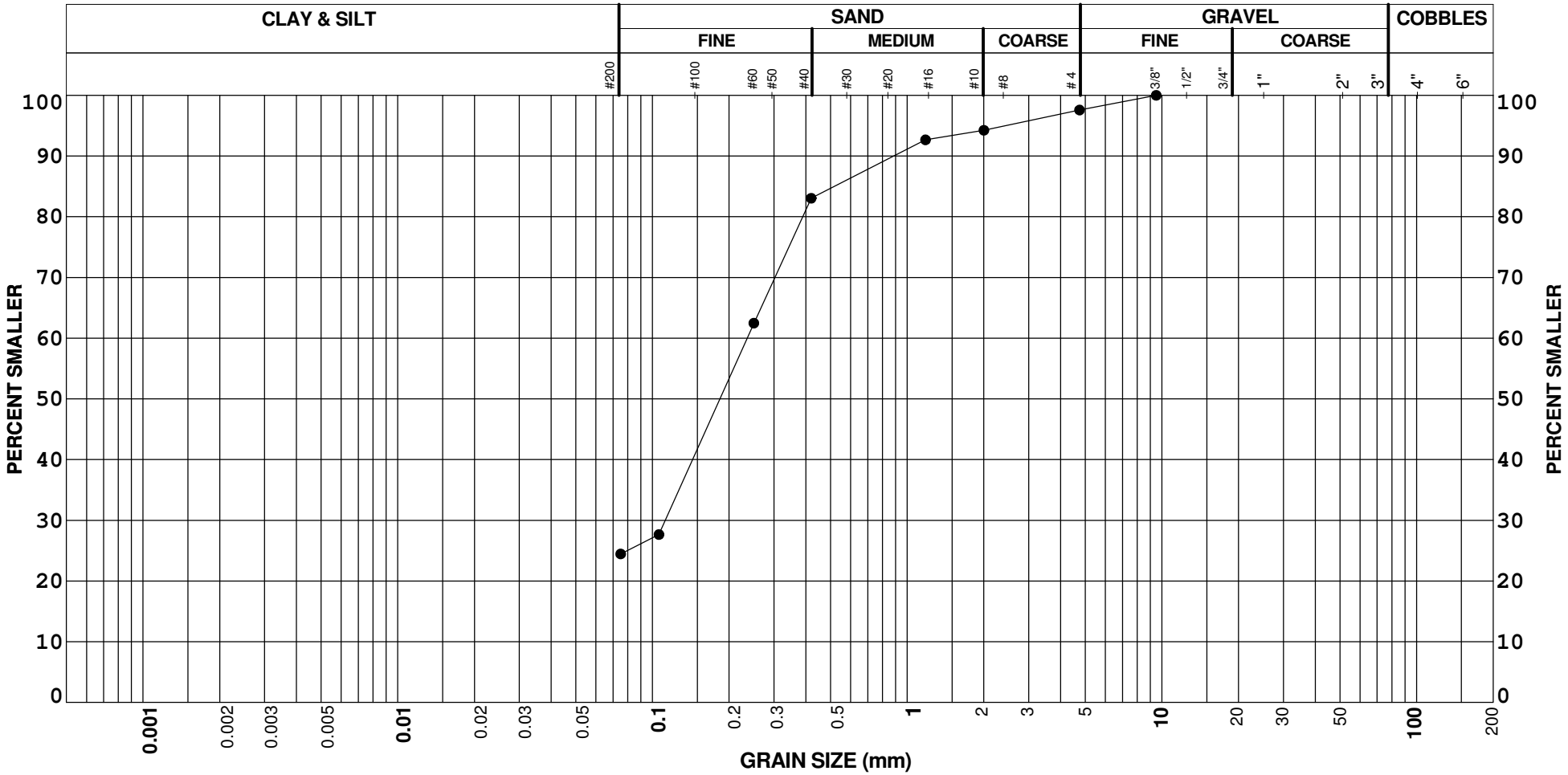
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R015	BS3	4.00	2	73	24		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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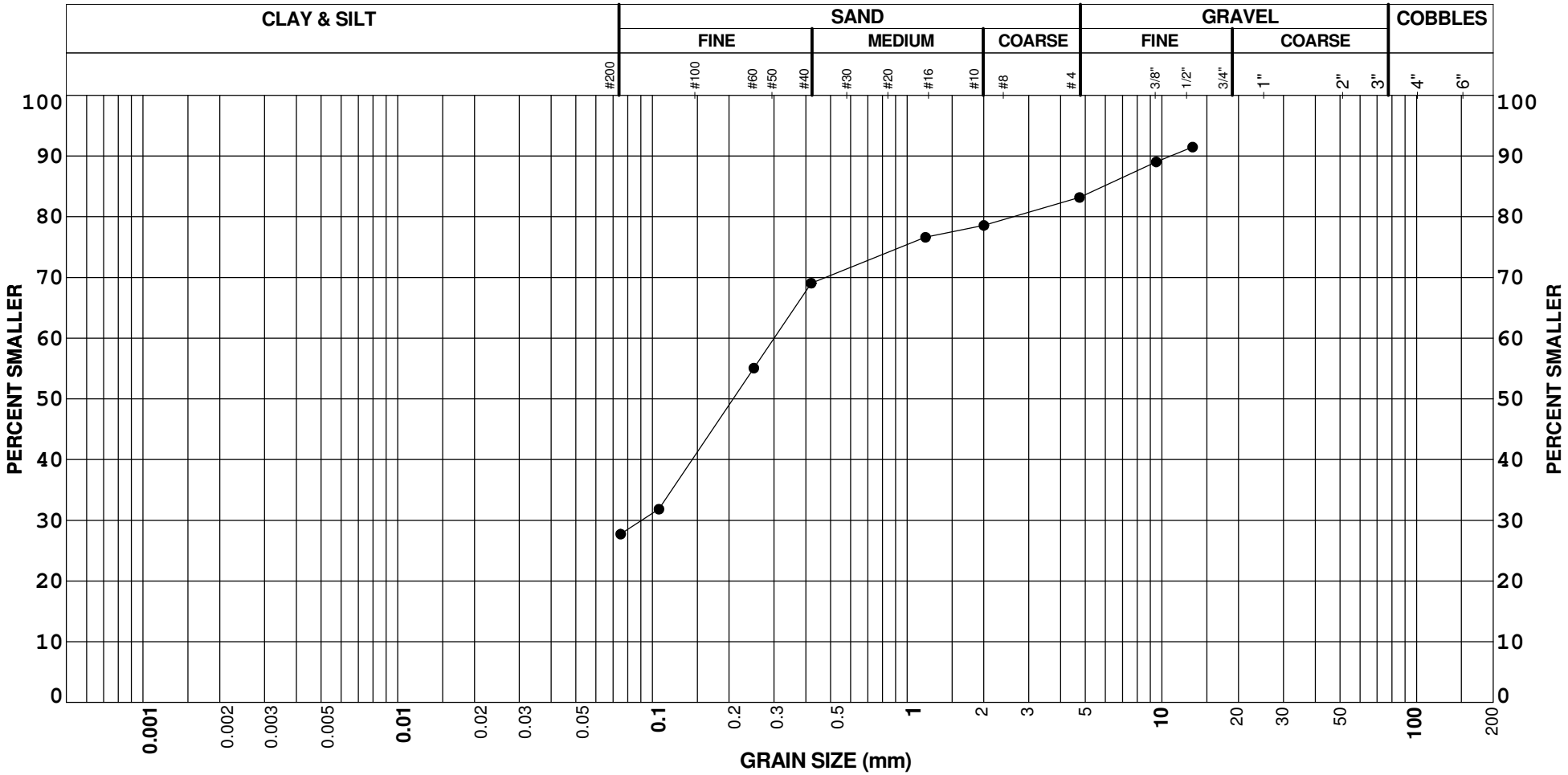
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R016	BS2	2.00	8	55	28		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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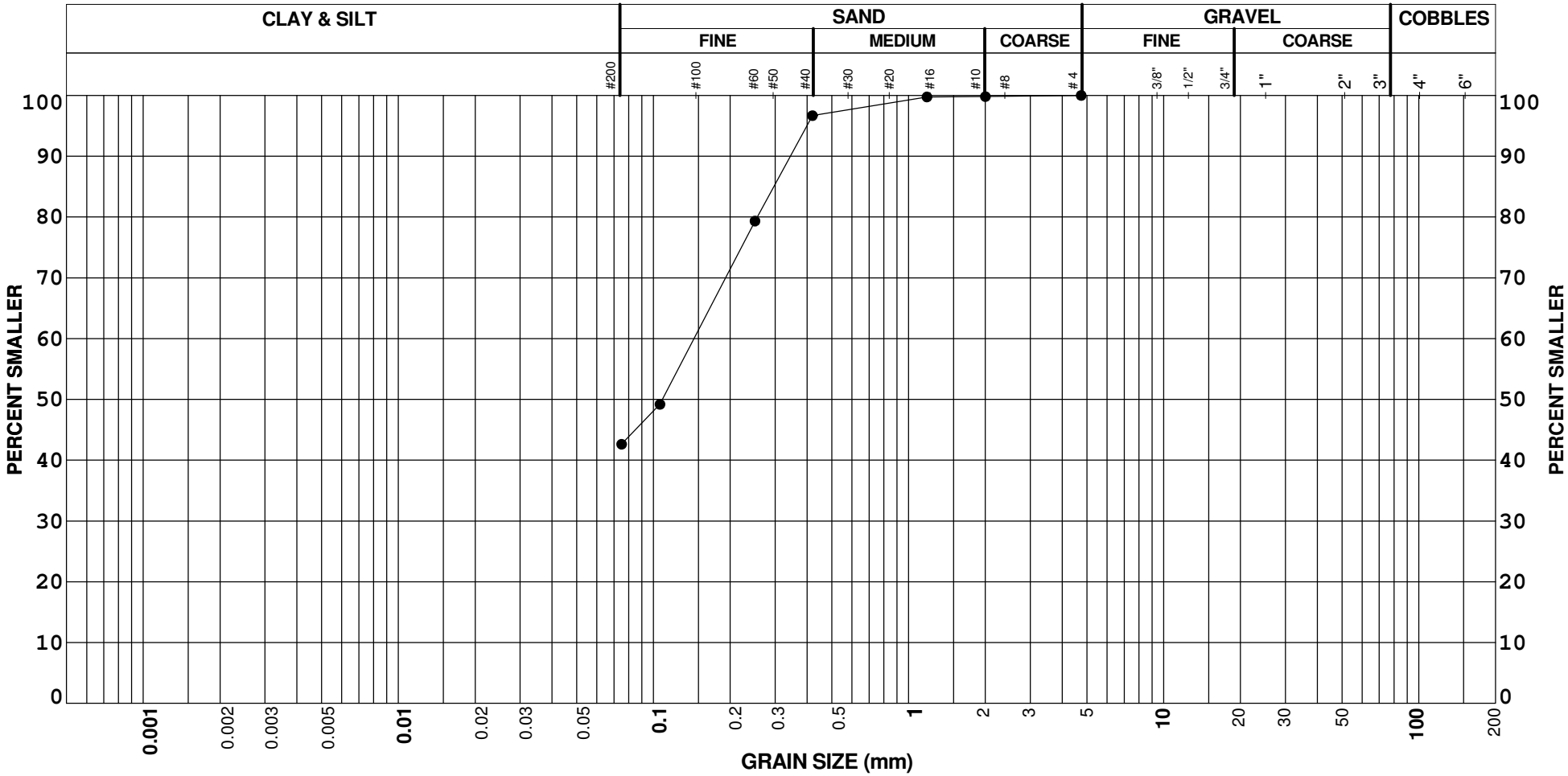
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R020	BS3	4.00	0	57	43		

REMARKS:

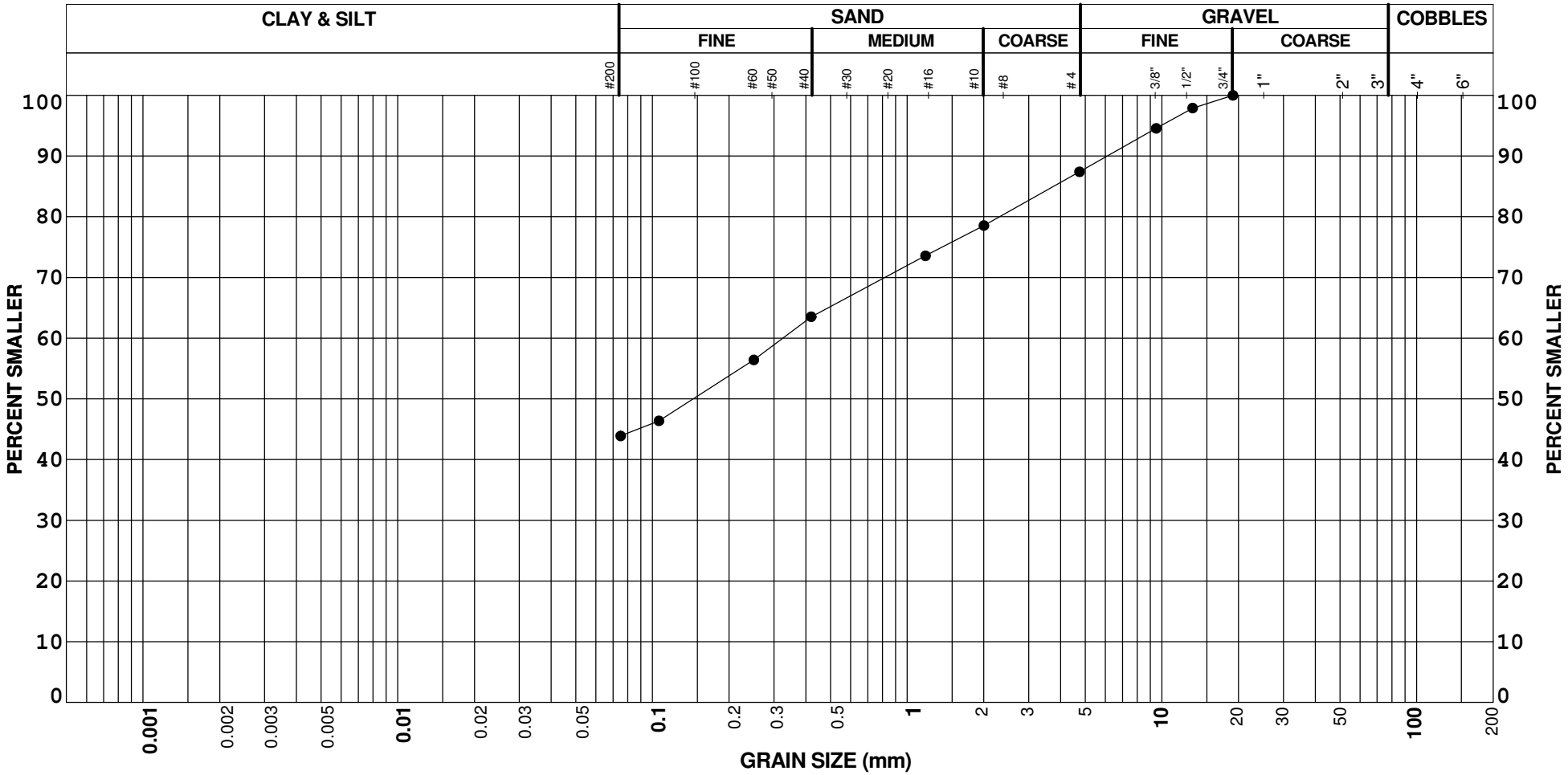
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R022	BS3	4.00	13	44	44		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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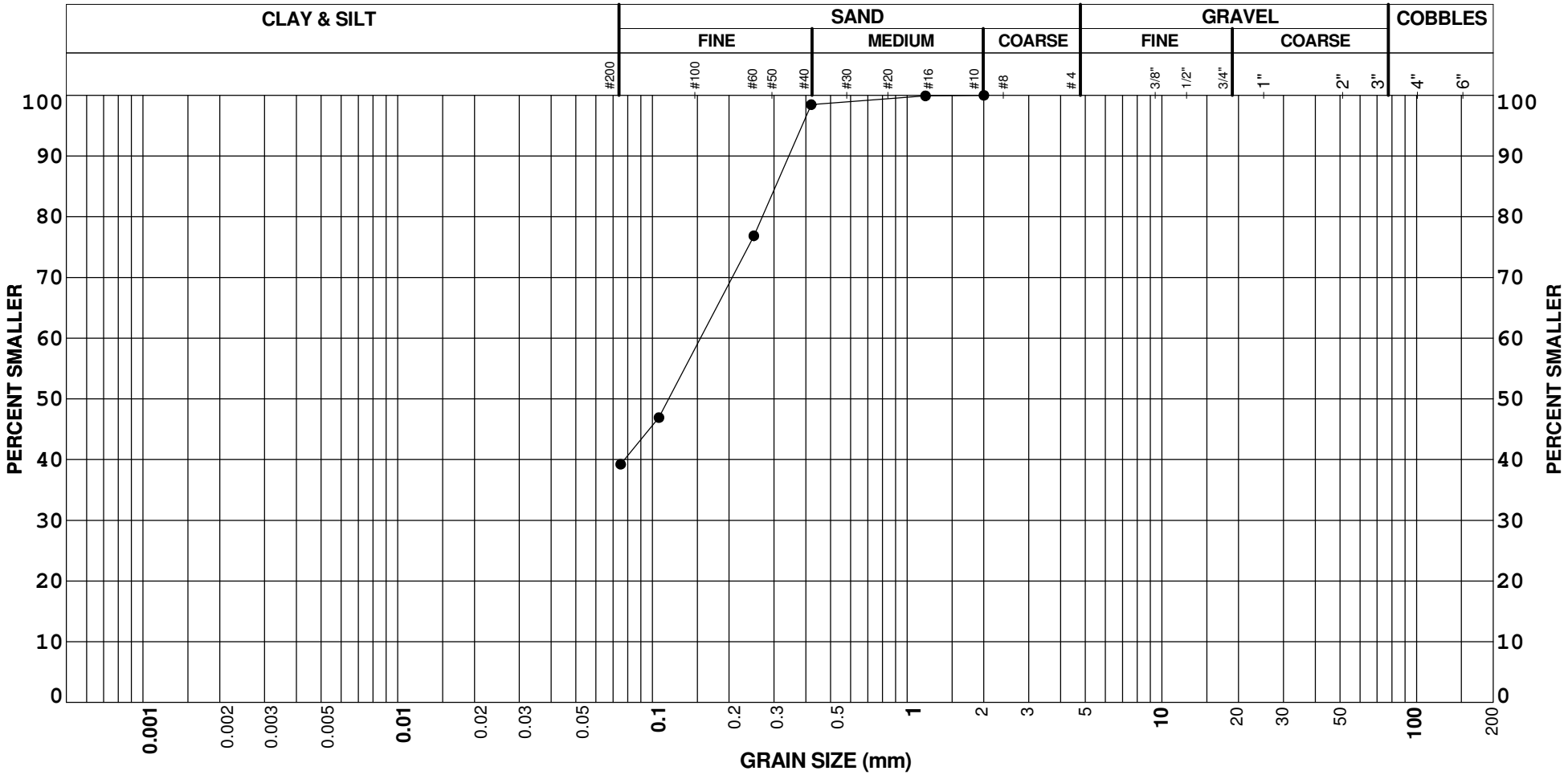
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R023	BS2	2.00	0	61	39		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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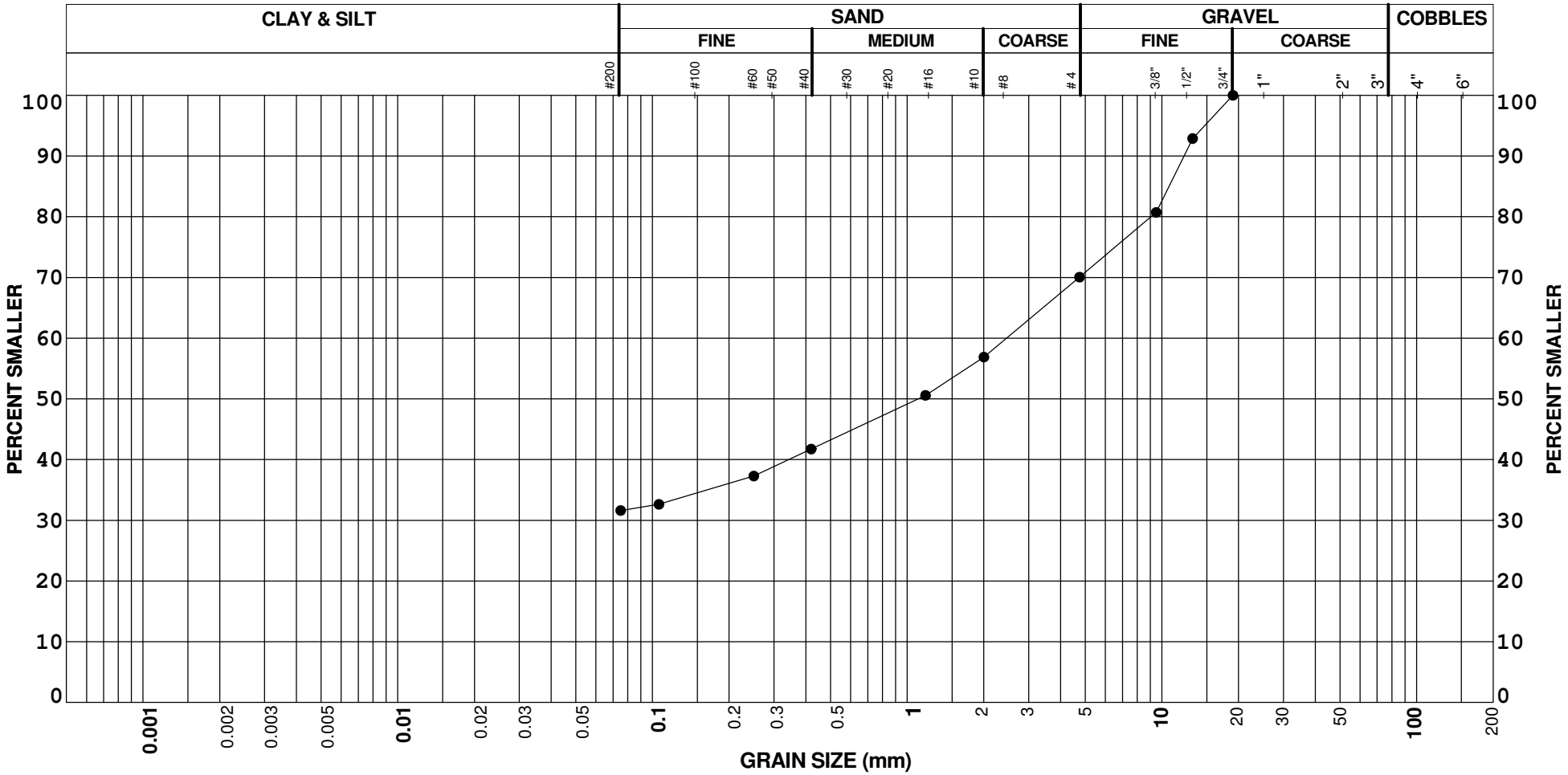
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R024	BS2	1.50	30	38	32		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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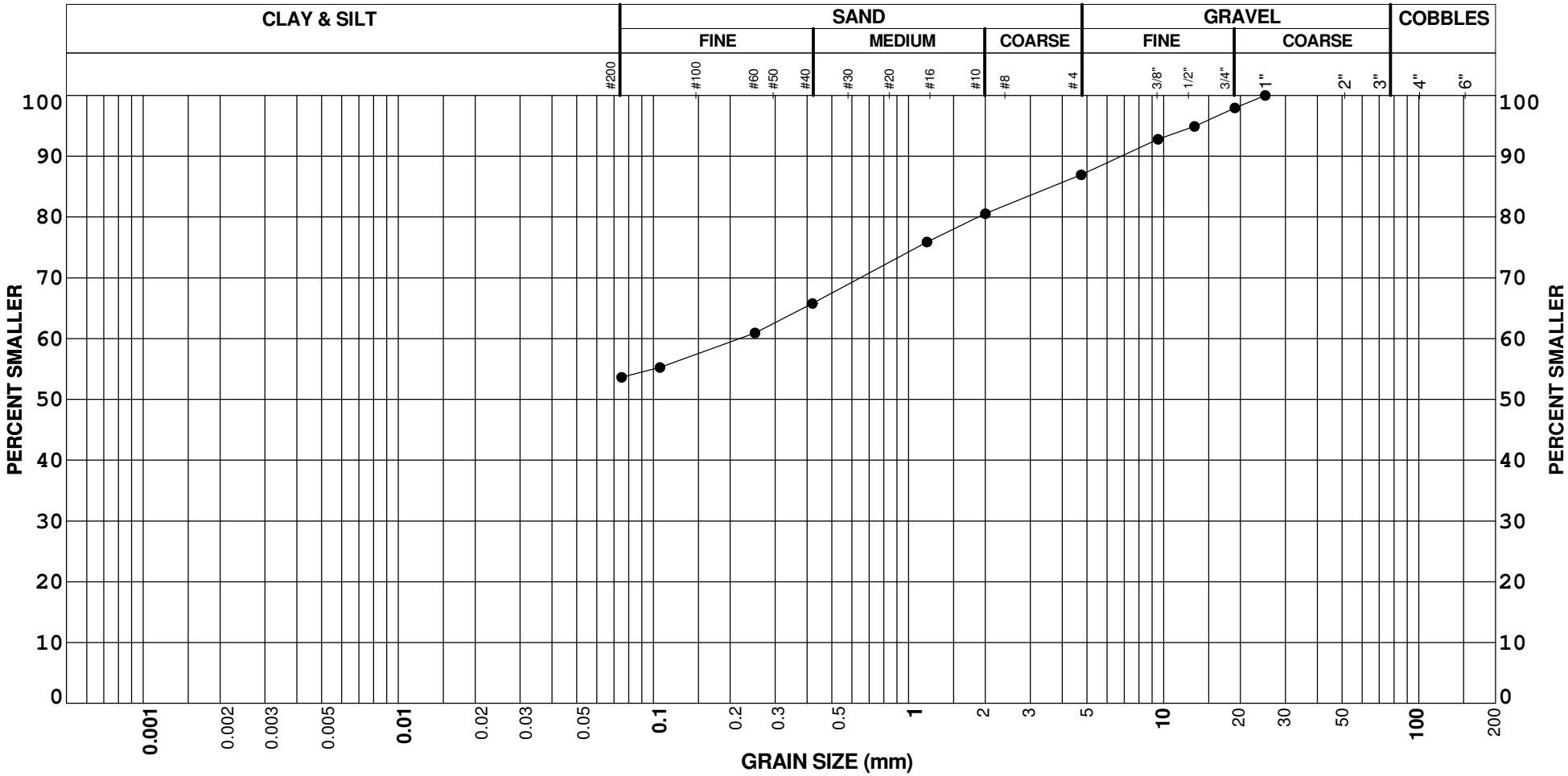
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R025	BS1	1.00	13	33	54		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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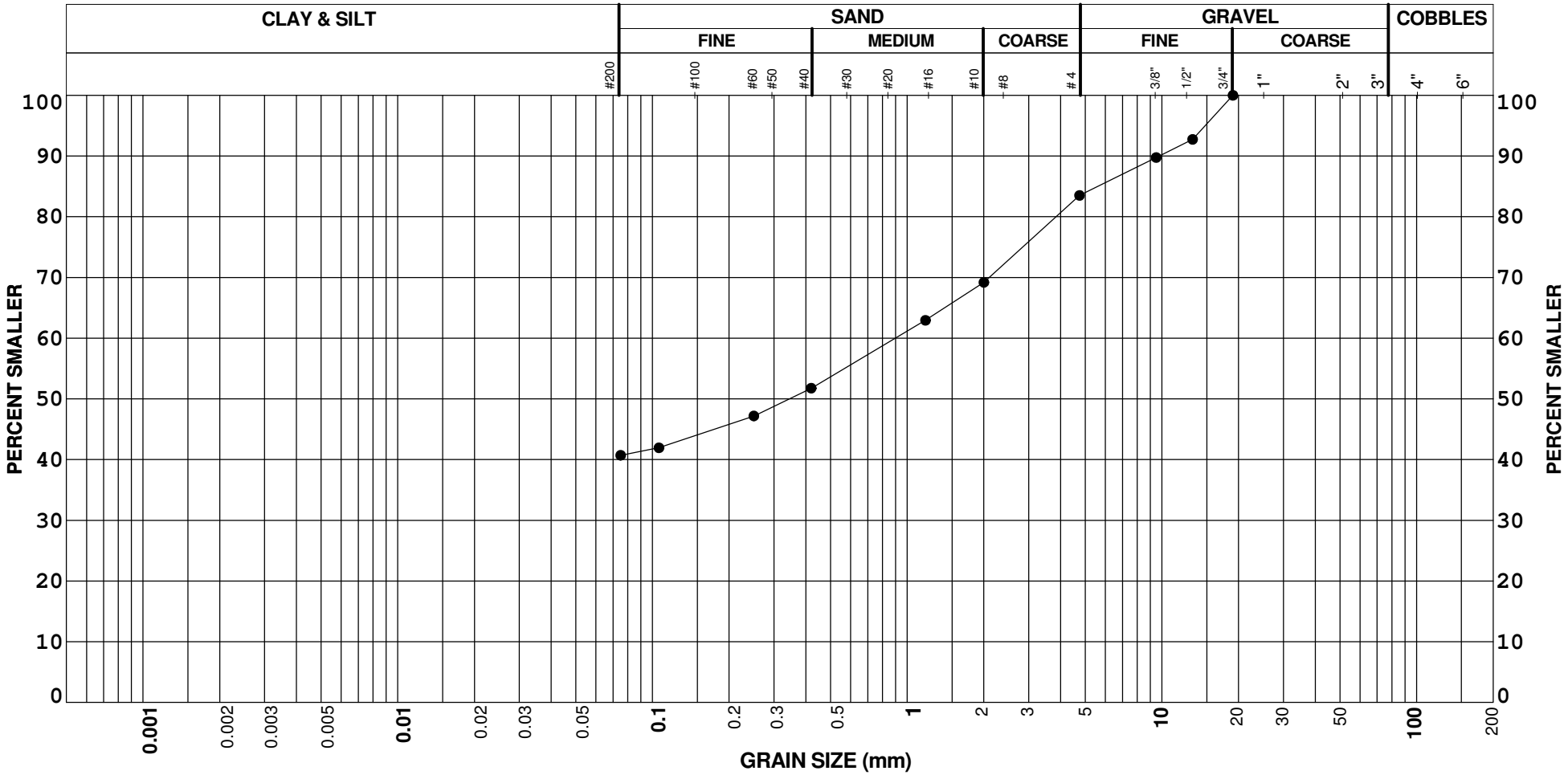
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R025	BS2	2.50	16	43	41		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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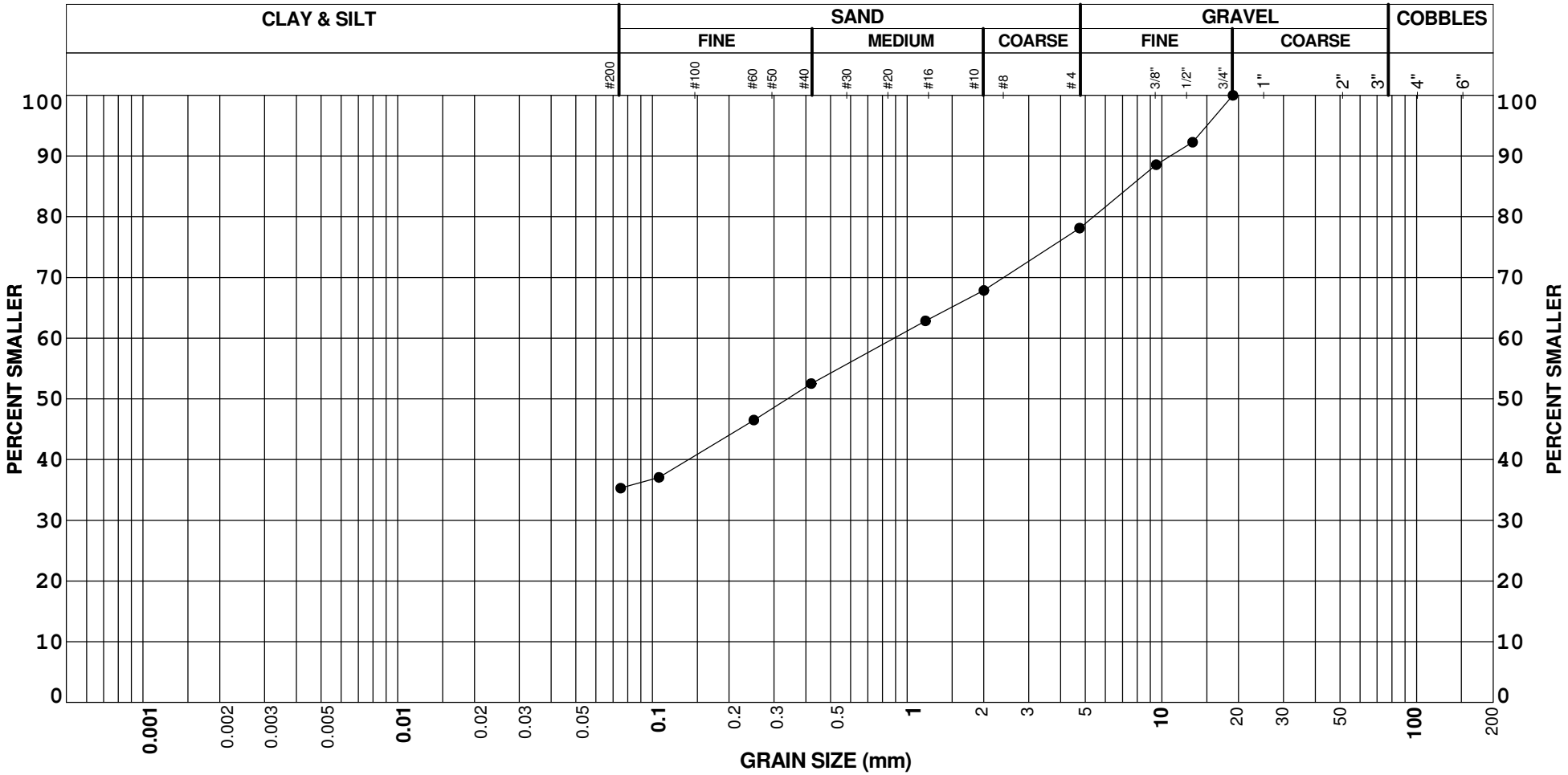
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R027	BS1	1.00	22	43	35		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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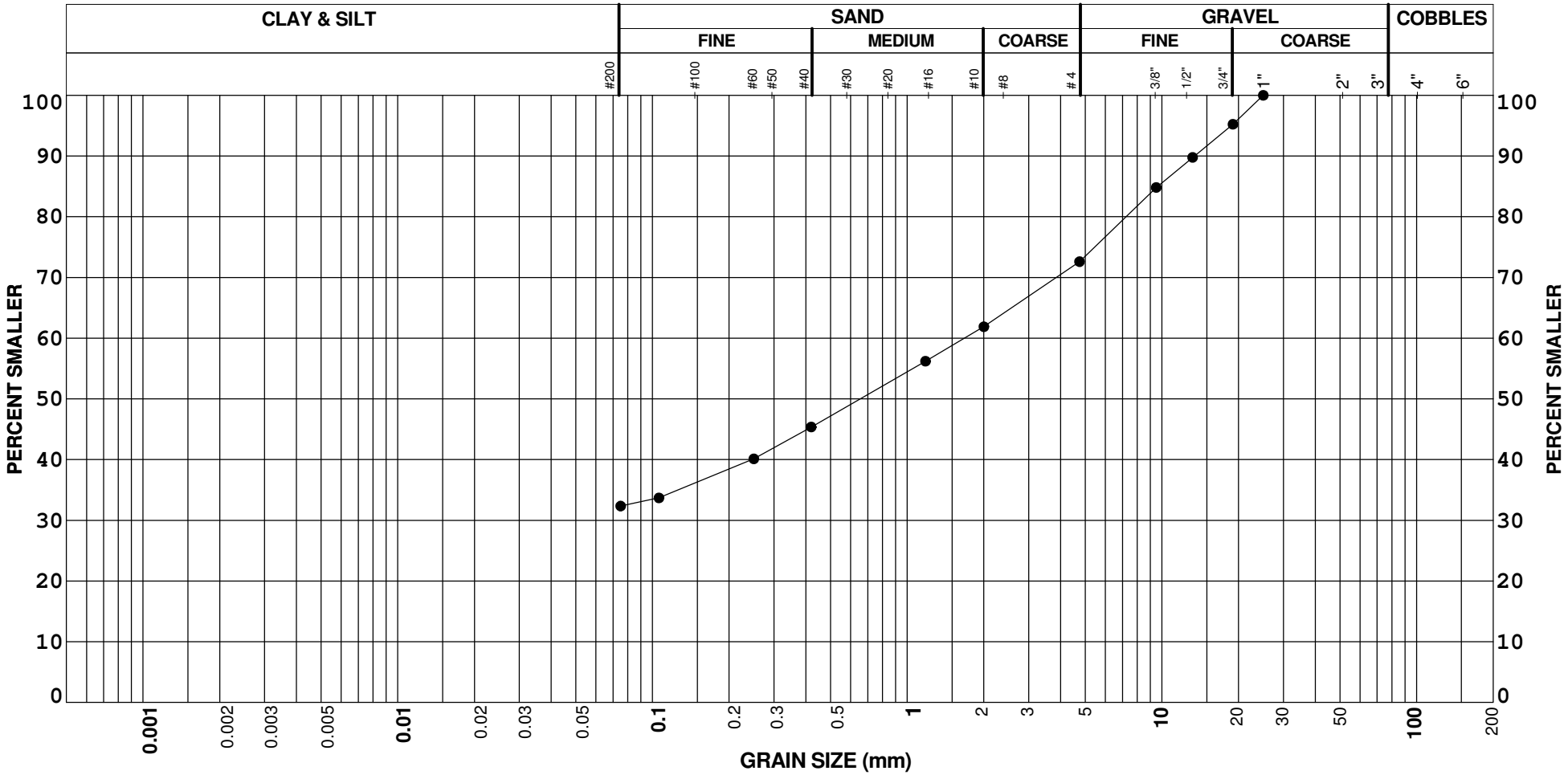
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R034	BS2	2.50	27	40	32		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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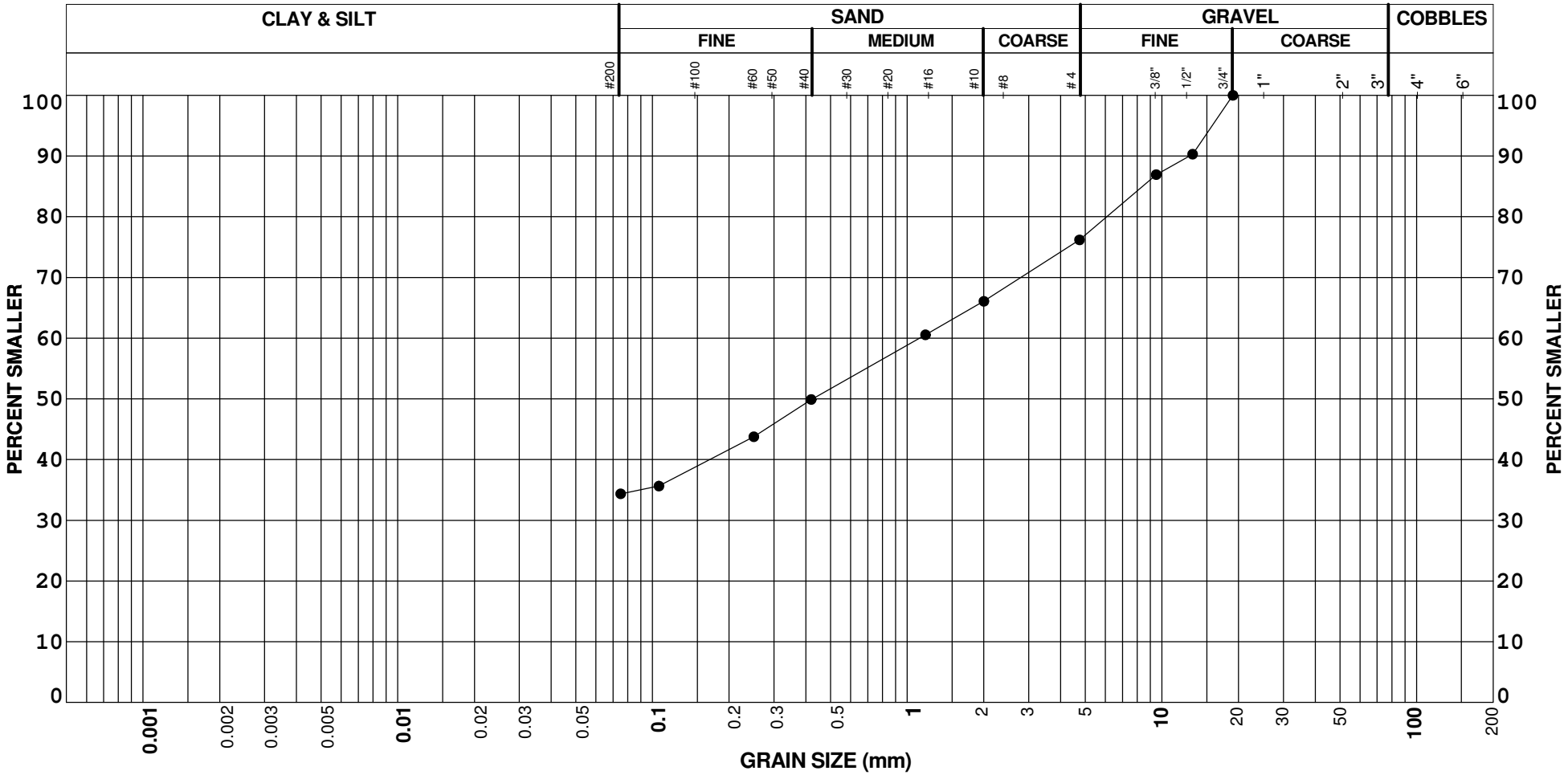
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R035	BS2	2.50	24	42	34		

REMARKS:

GRAIN SIZE DISTRIBUTION

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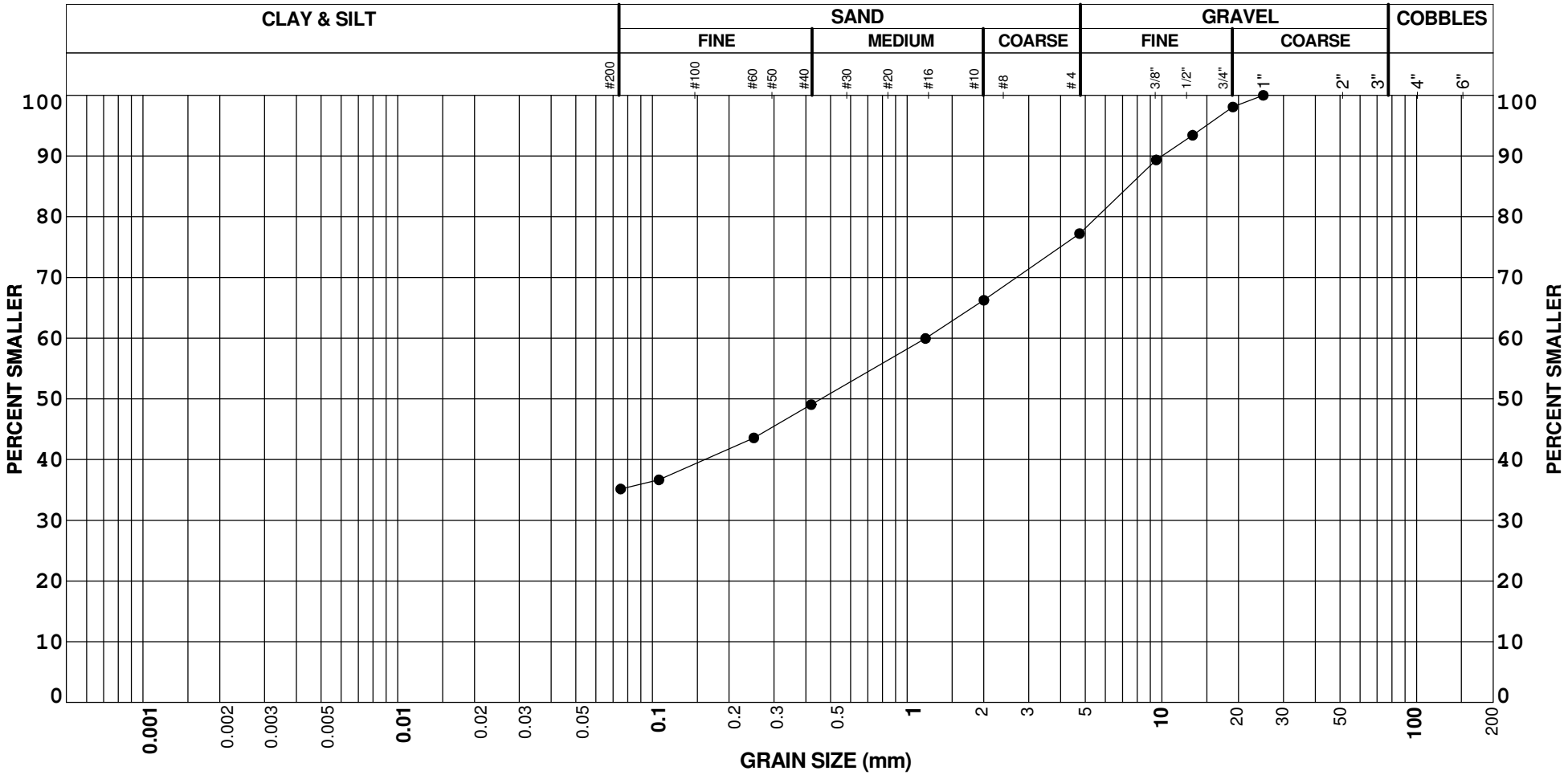

REMARKS:

BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R036	BS2	2.50	23	42	35		

GRAIN SIZE DISTRIBUTION

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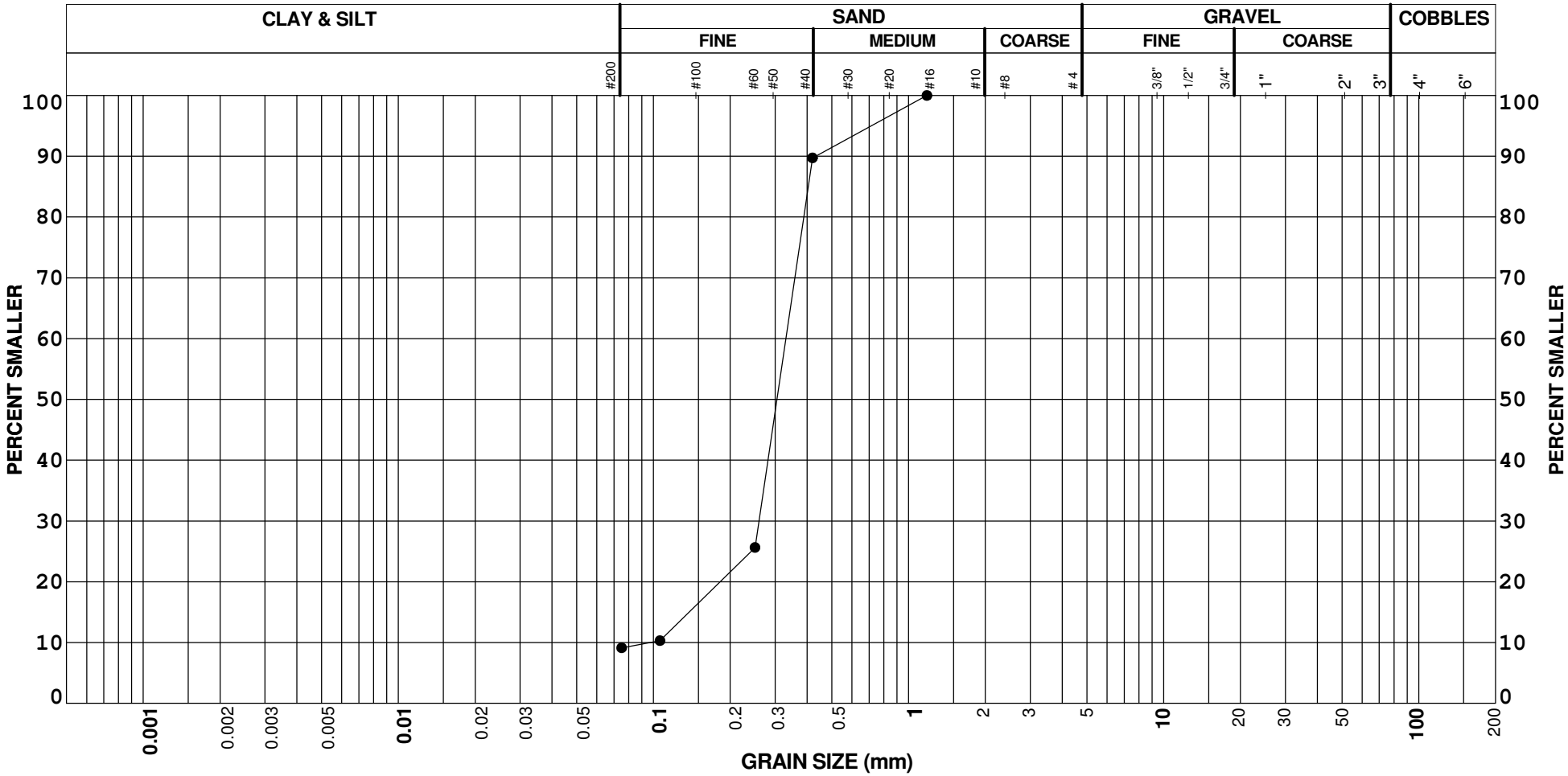

BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R037	BS2	2.50	0	91	9		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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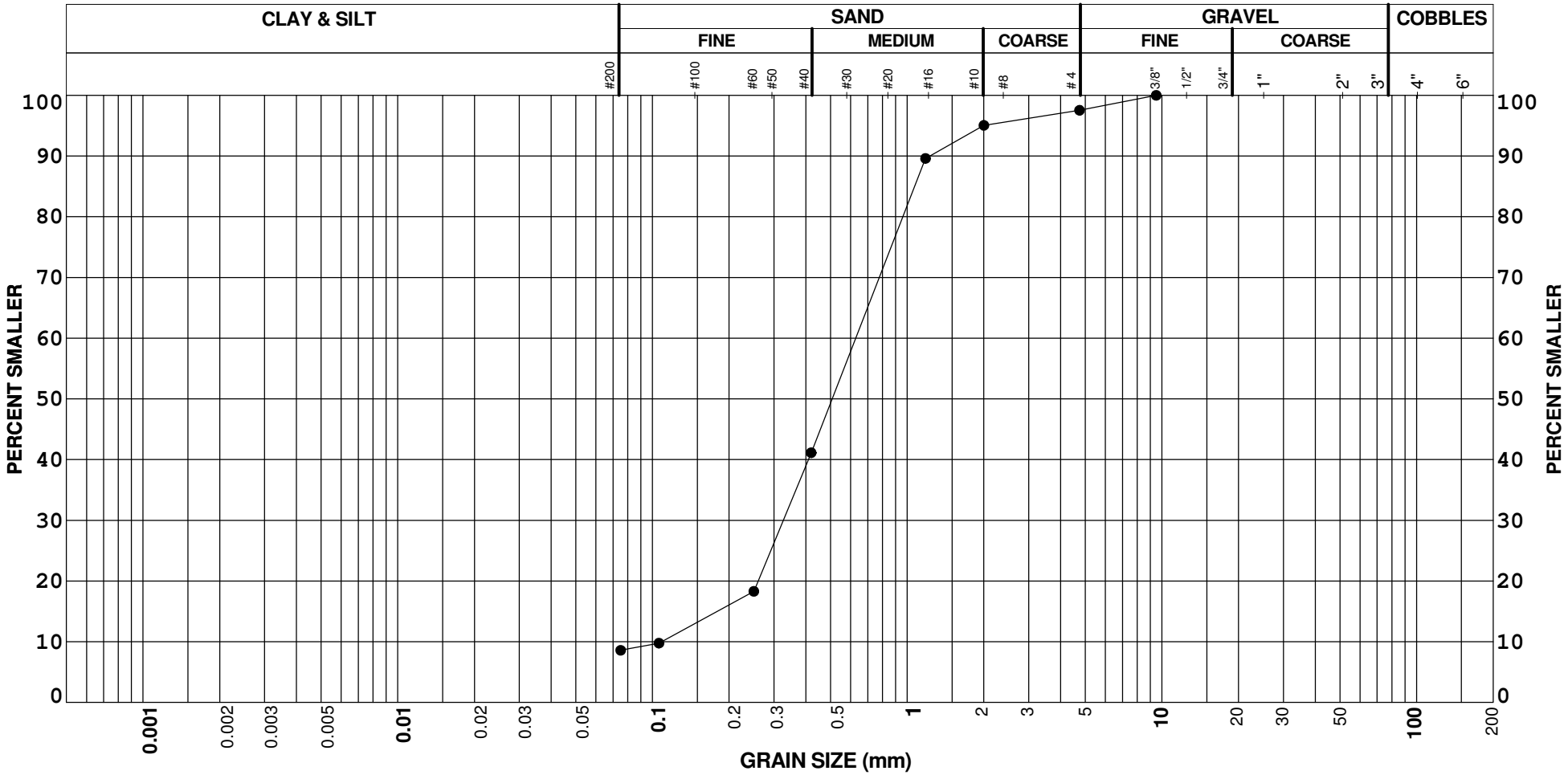
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R038	BS2	2.00	2	89	9		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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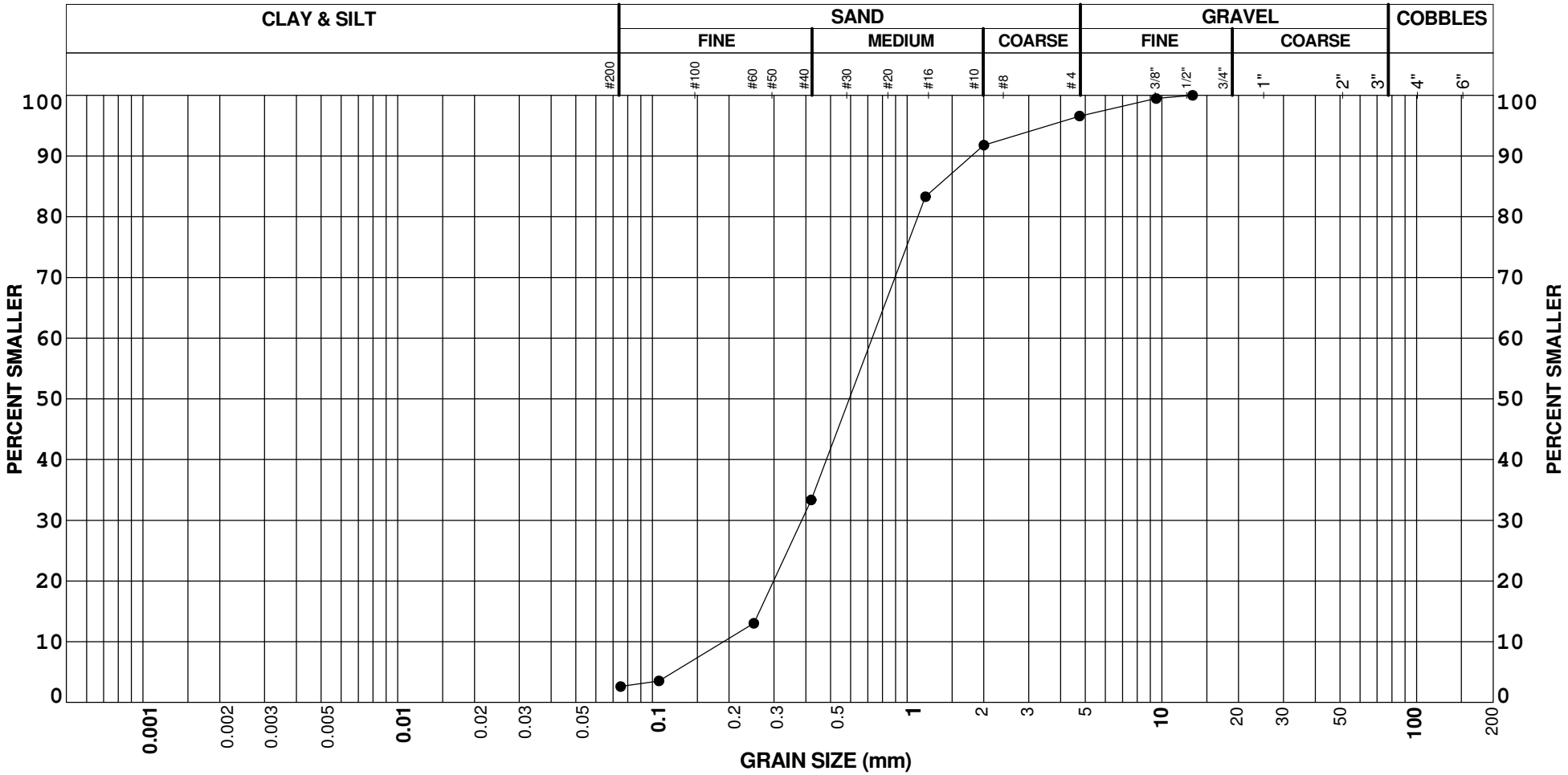
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R039	BS1	1.00	3	94	3		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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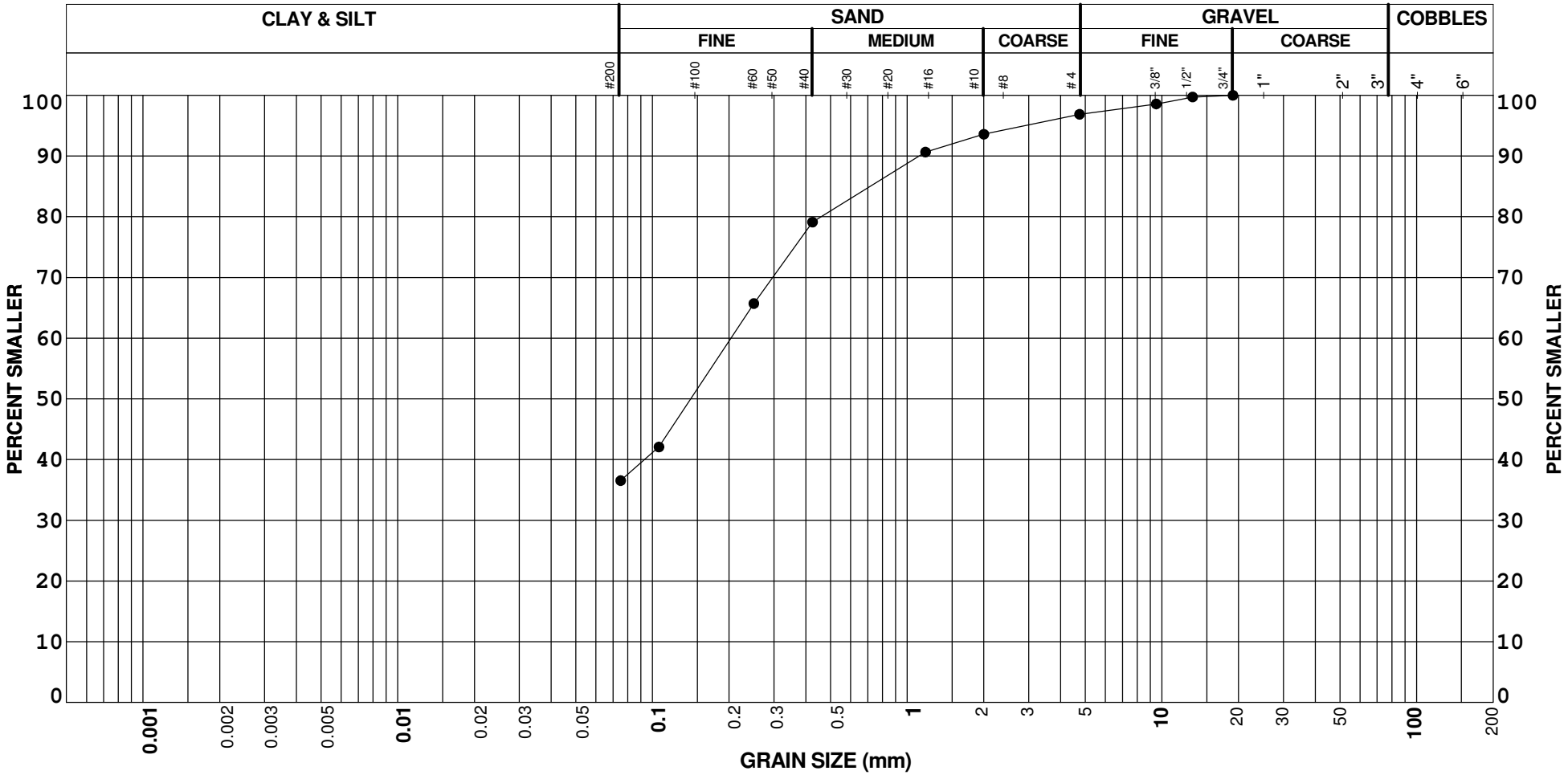
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R067	BS1	1.20	3	60	37		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

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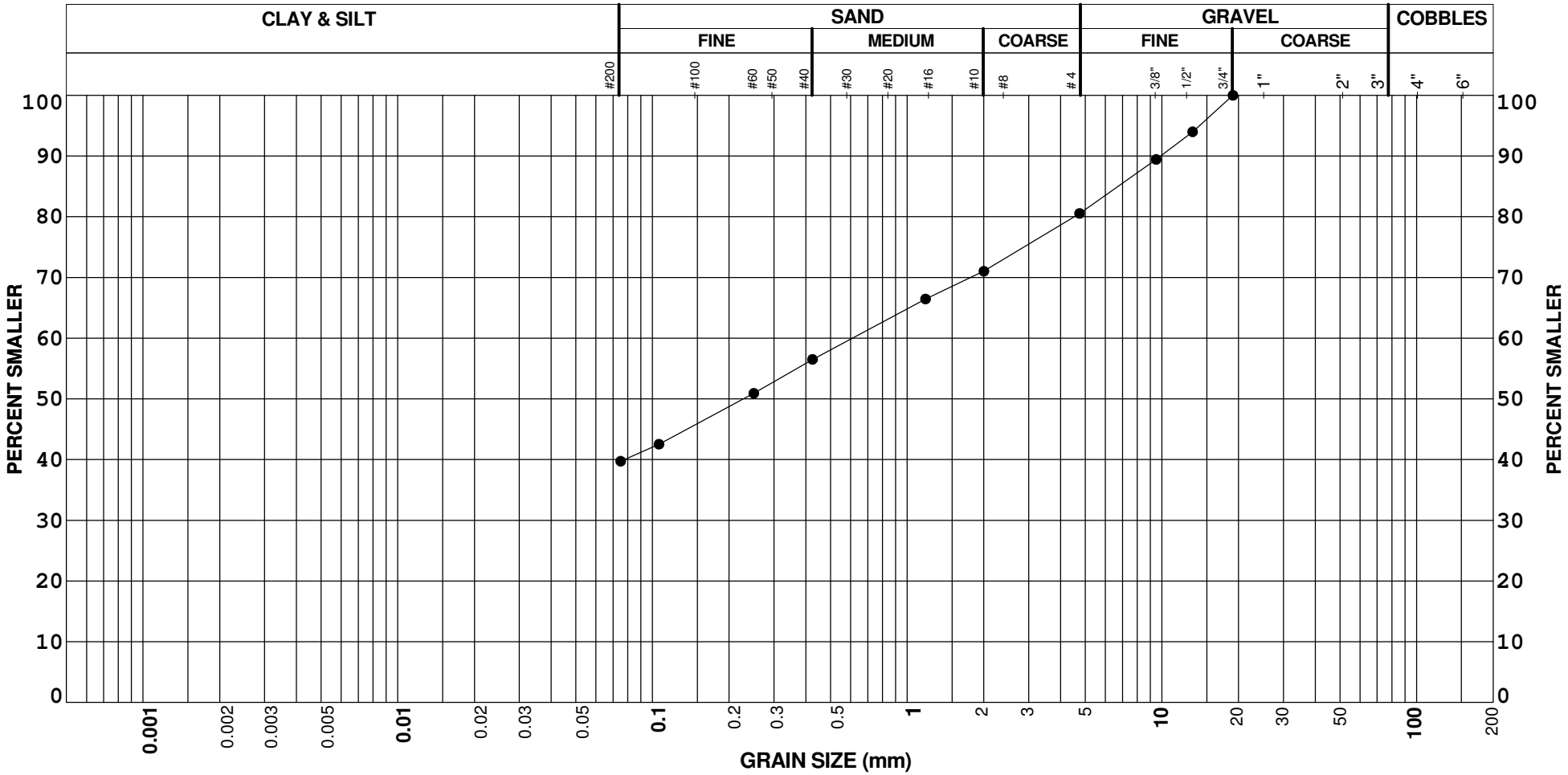
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH16-R069	BS1	1.00	19	41	40		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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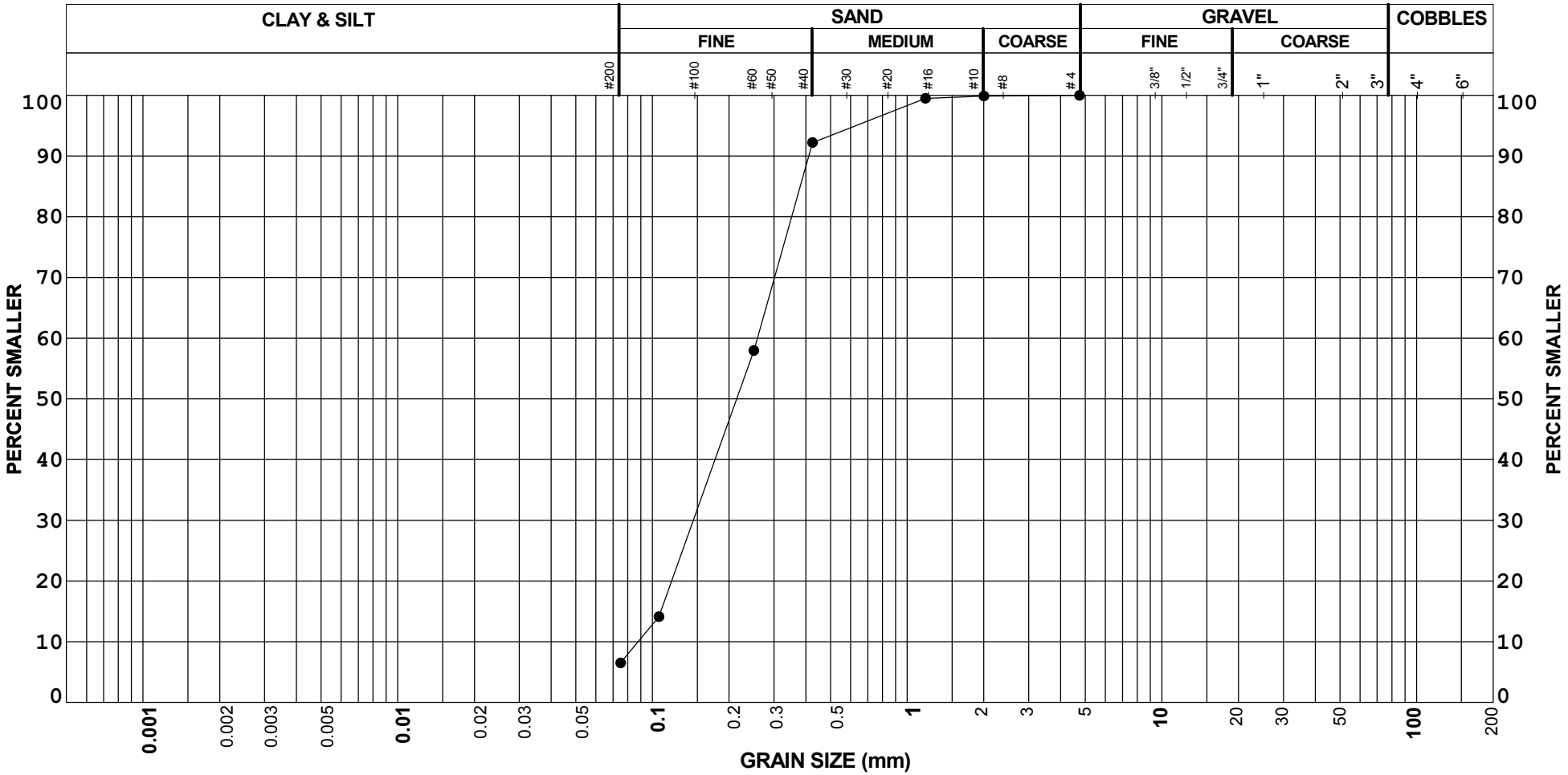
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-B001	DS2	2.40	0	93	7		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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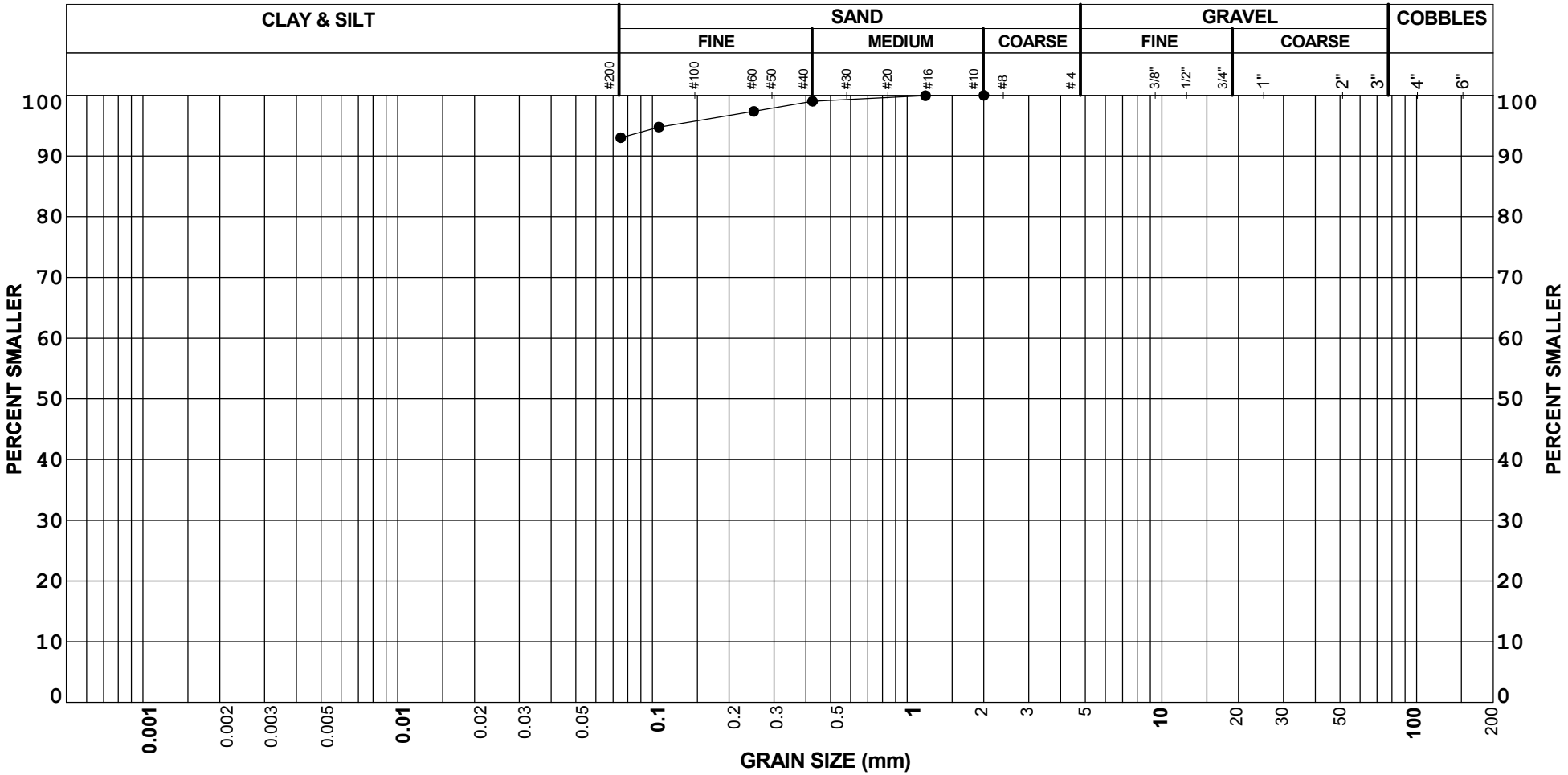
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-B001	DS4	5.50	0	7	93		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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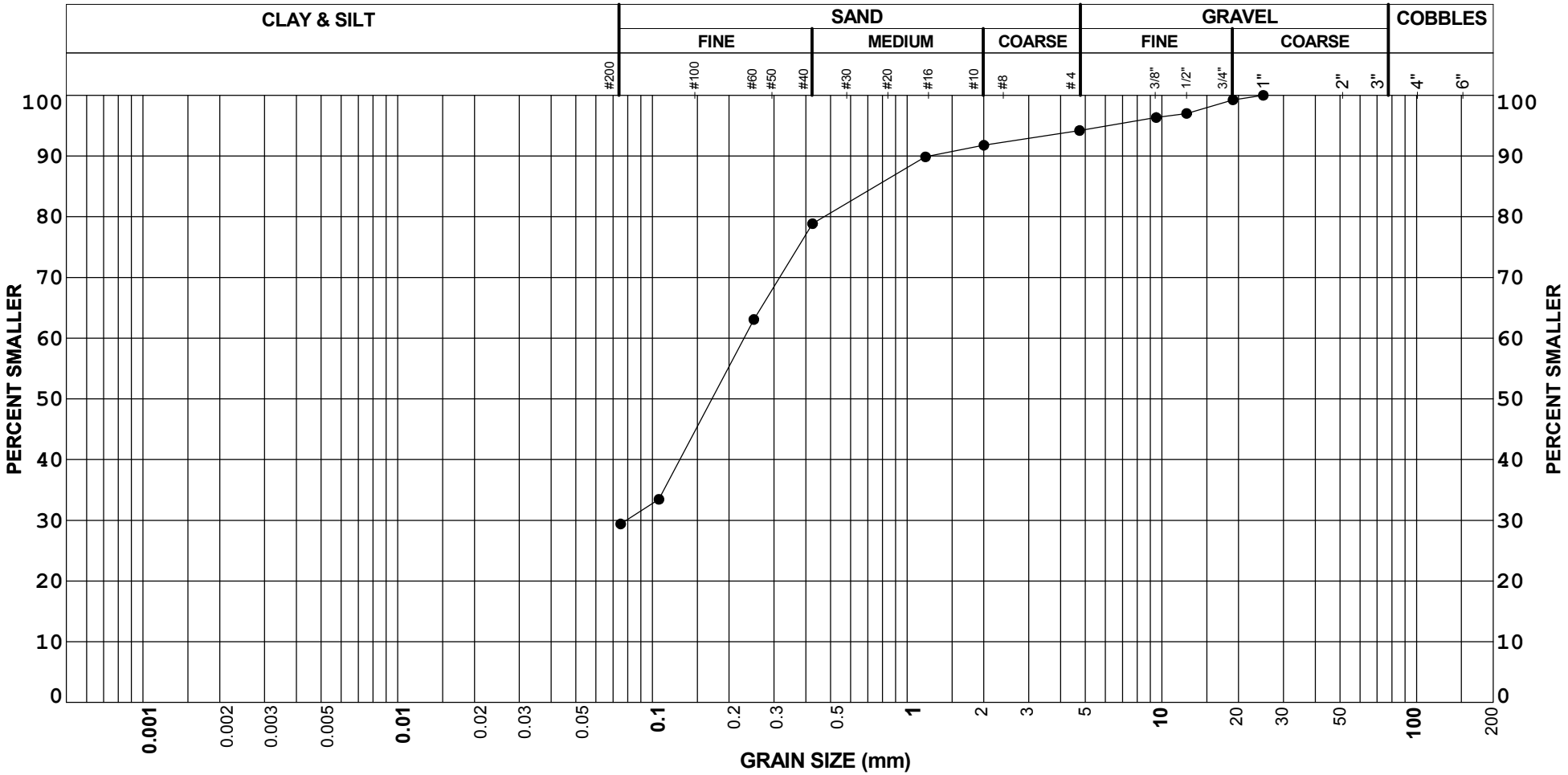
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-B001	DS6	8.50	6	65	29		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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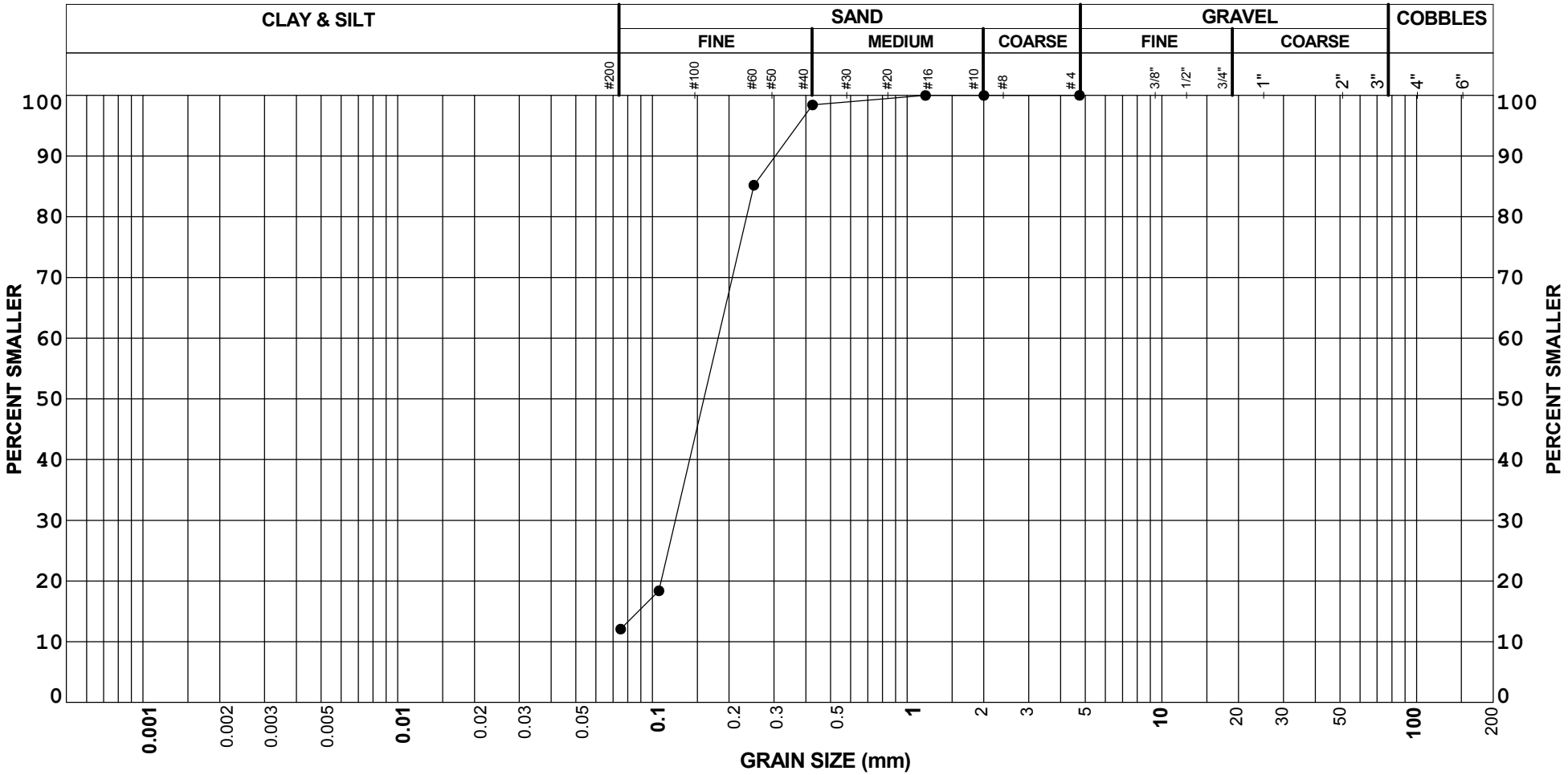
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-B002	DS1	0.50	0	88	12		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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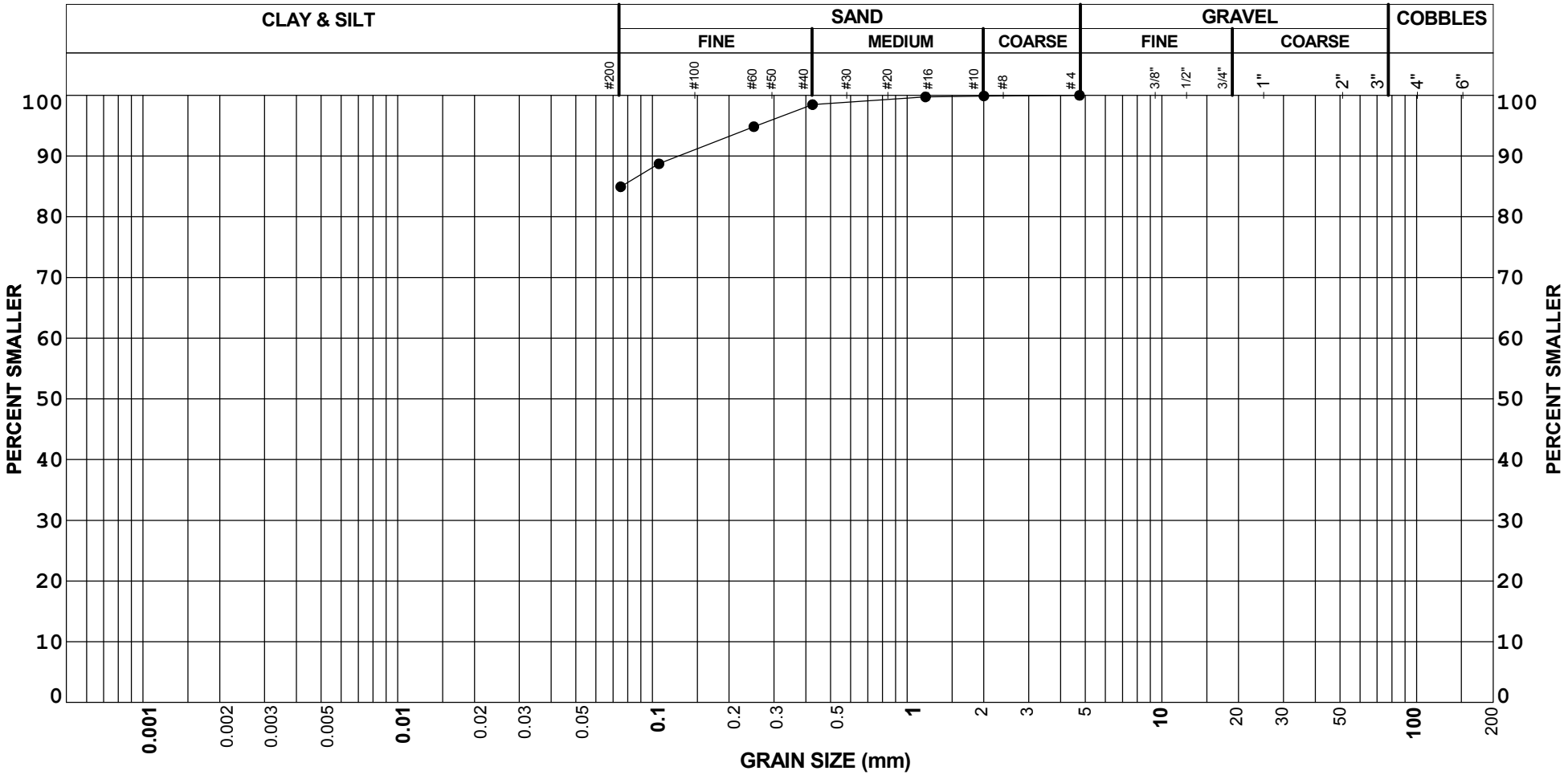
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-B002	DS3	3.70	0	15	85		

REMARKS:

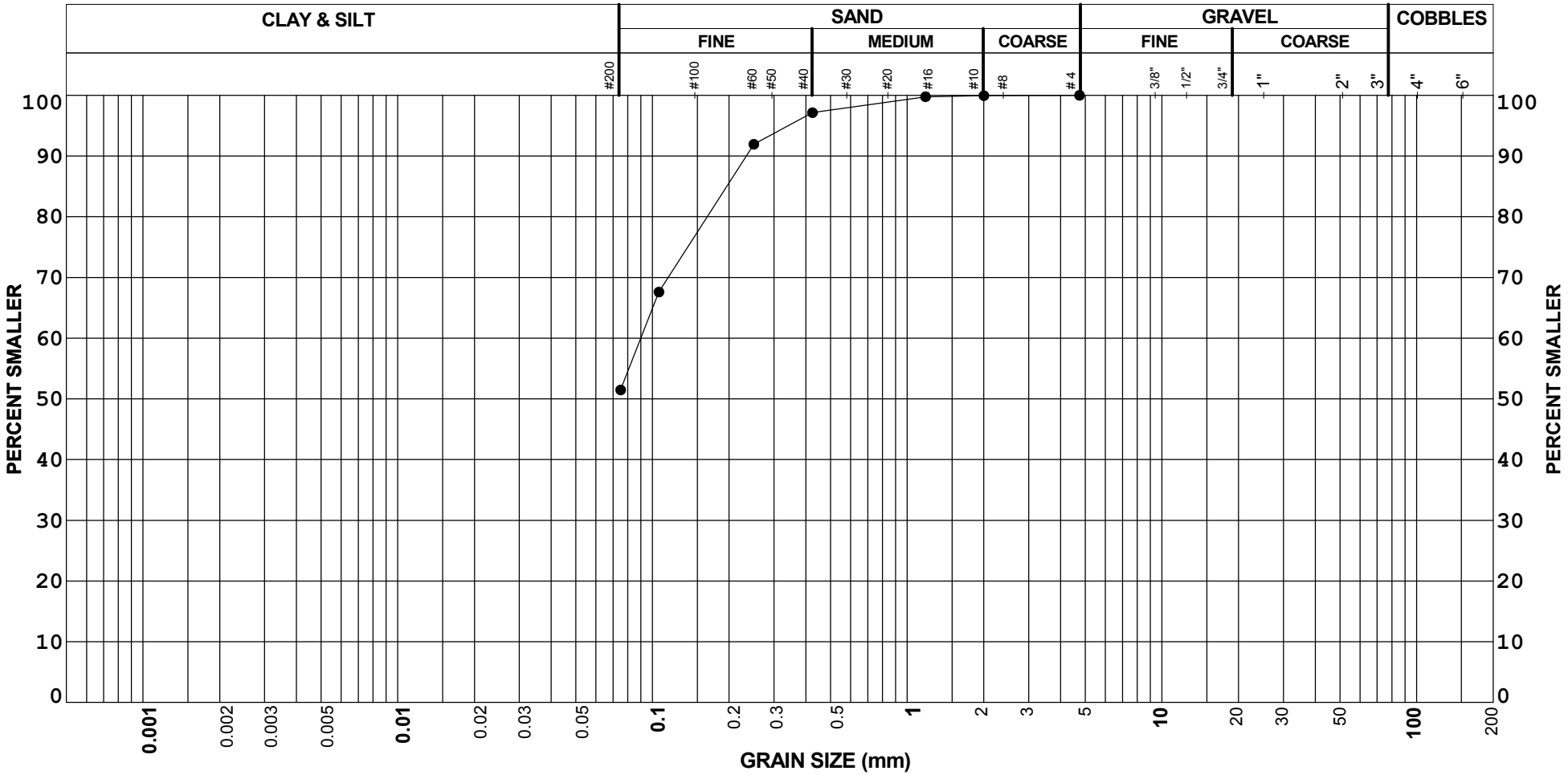
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-B002	DS5	6.70	0	49	51		

REMARKS:

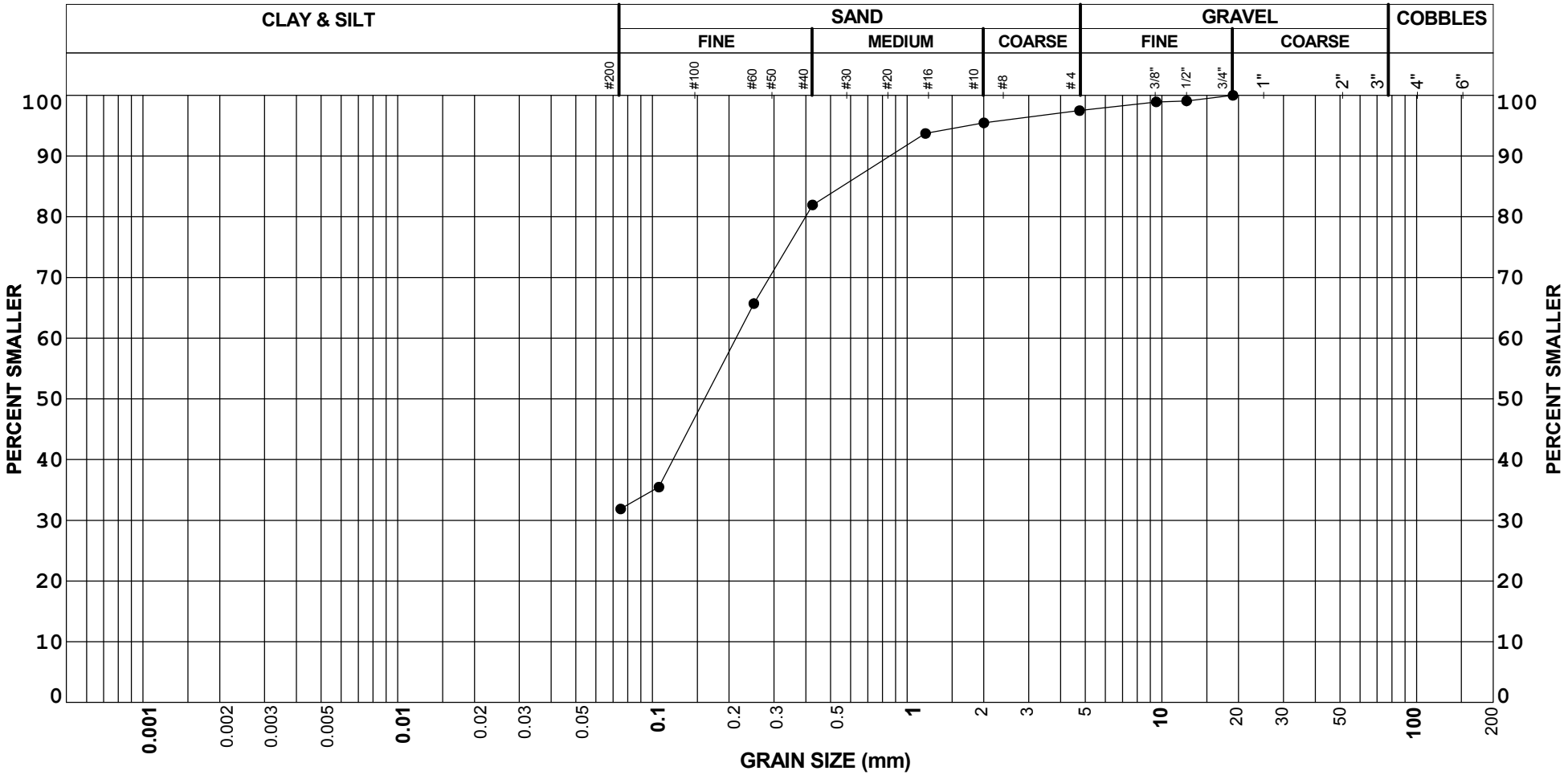
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-B002	DS8	11.50	3	66	32		

REMARKS:

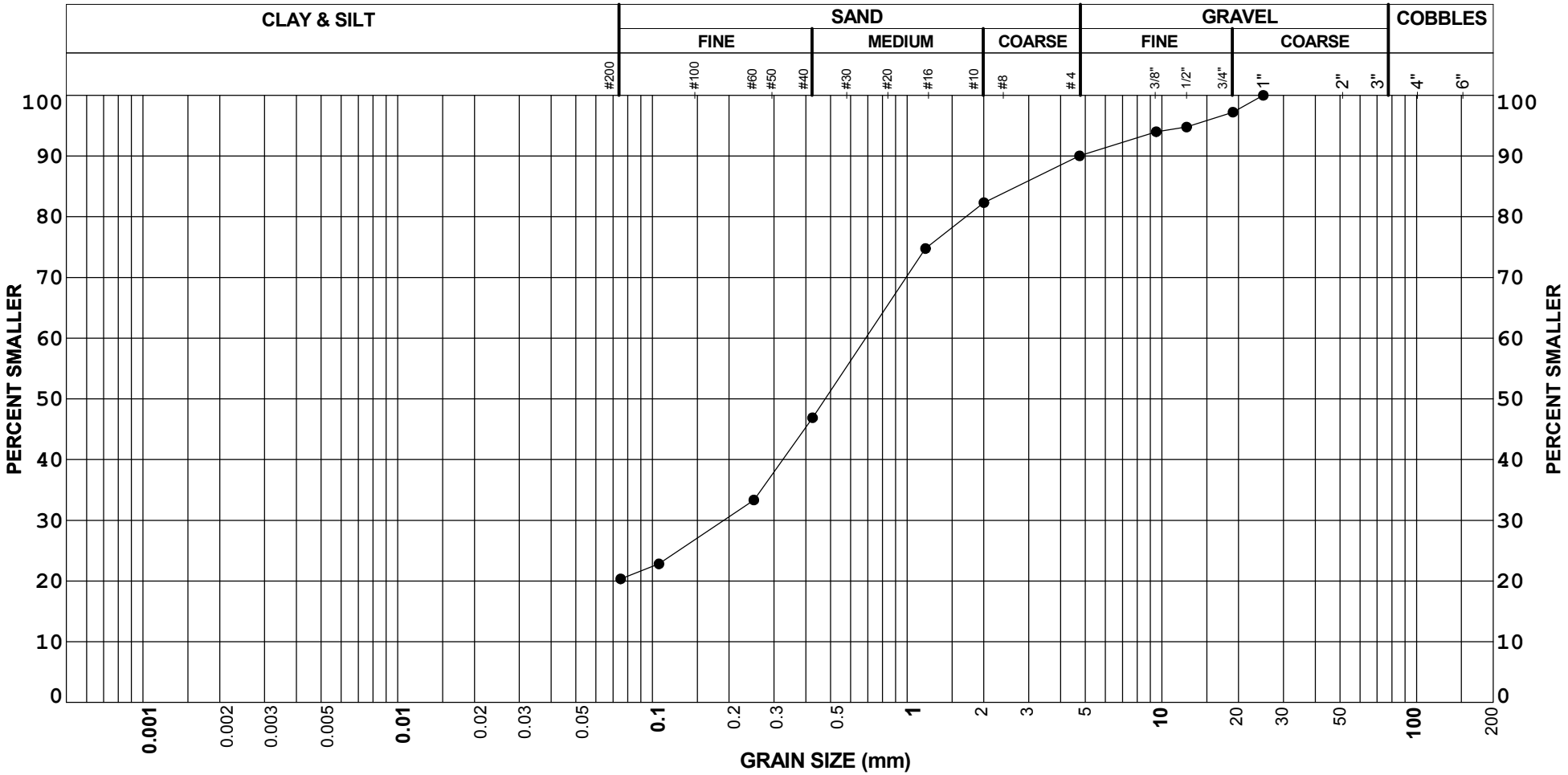
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-B002	DS11	15.80	10	70	20		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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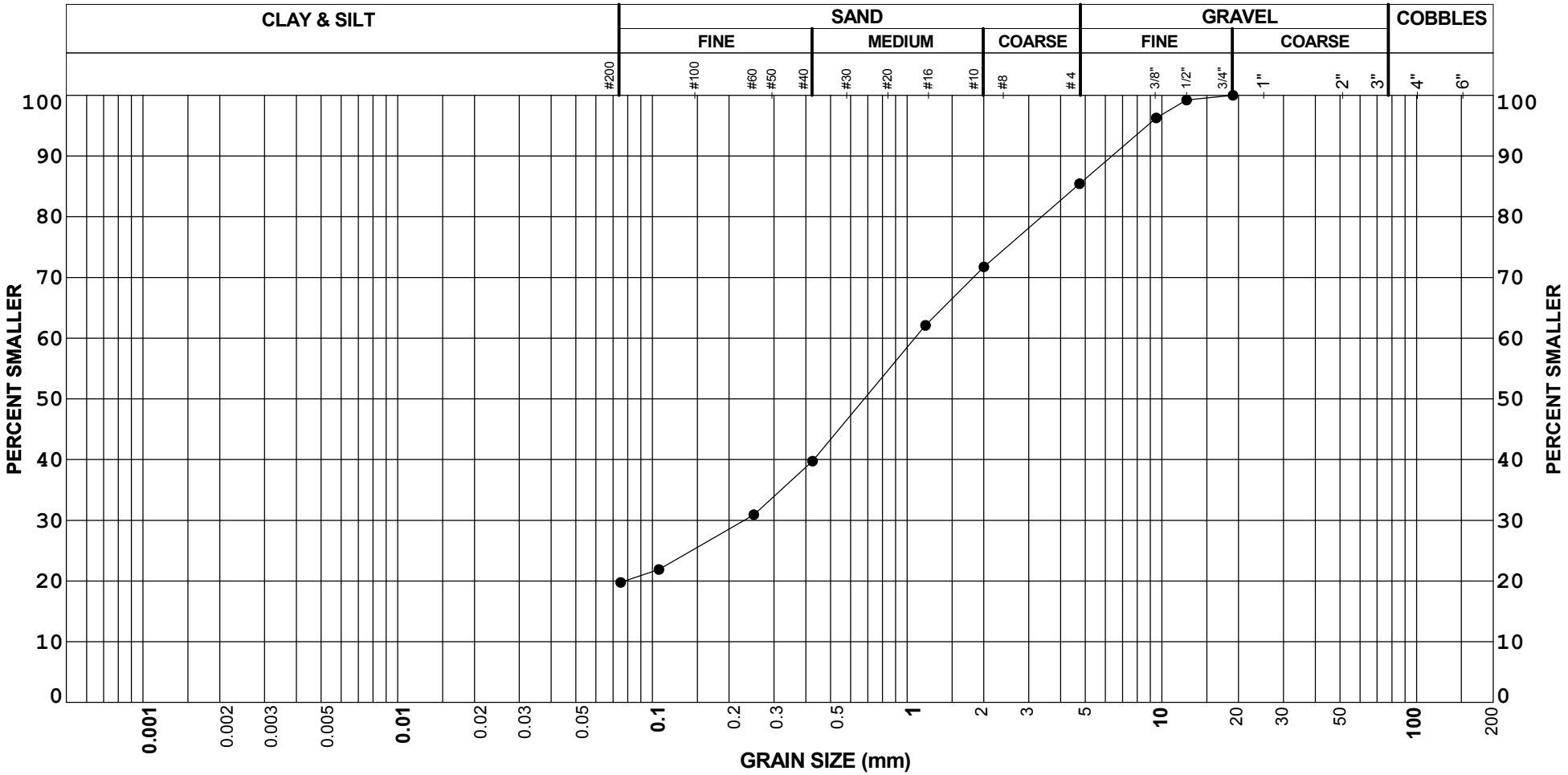
UNIFIED SOIL CLASSIFICATION SYSTEM



REMARKS:

BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-B002	DS13	18.60	15	66	20		

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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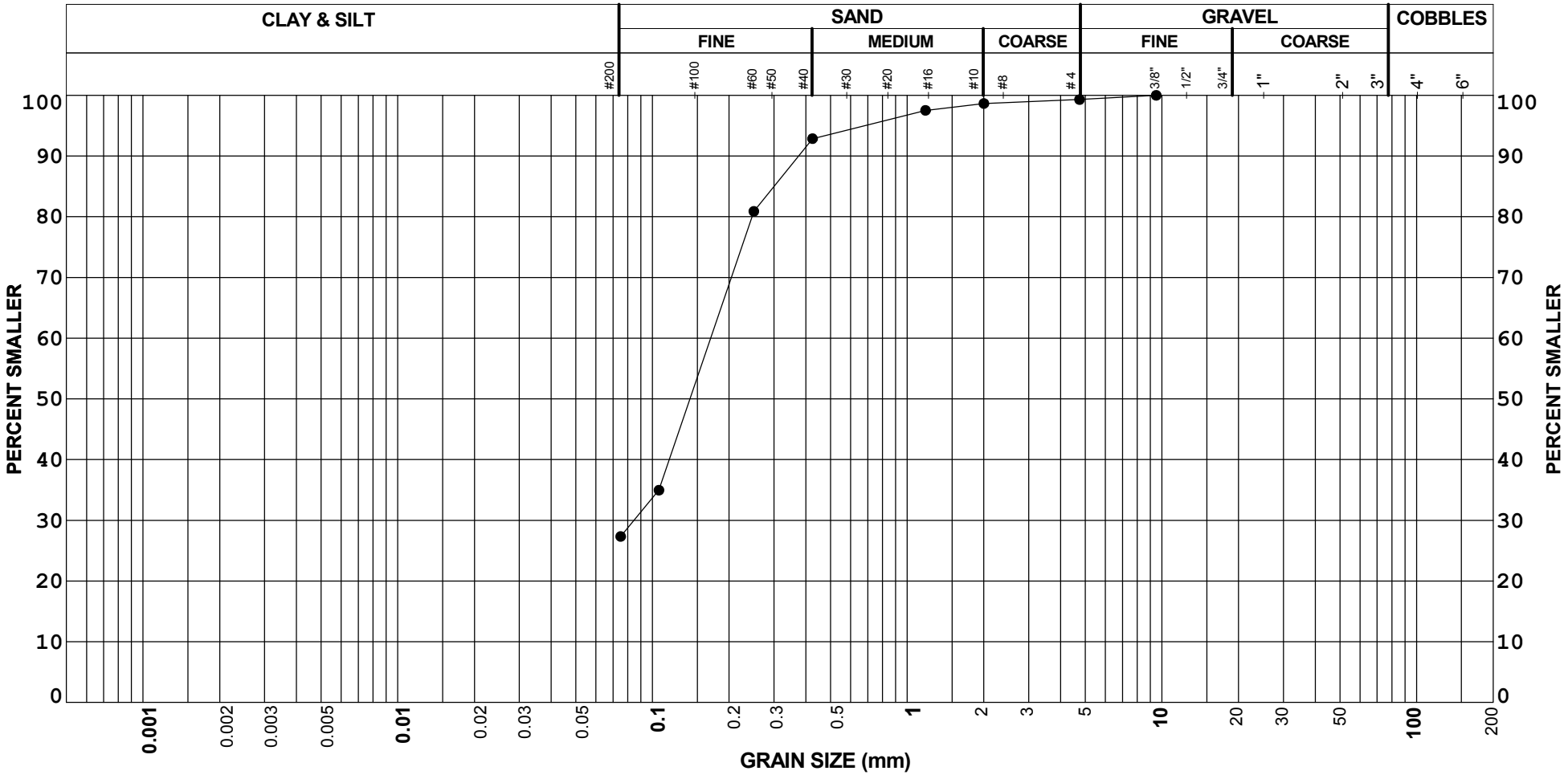
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-B002	DS16	23.50	1	72	27		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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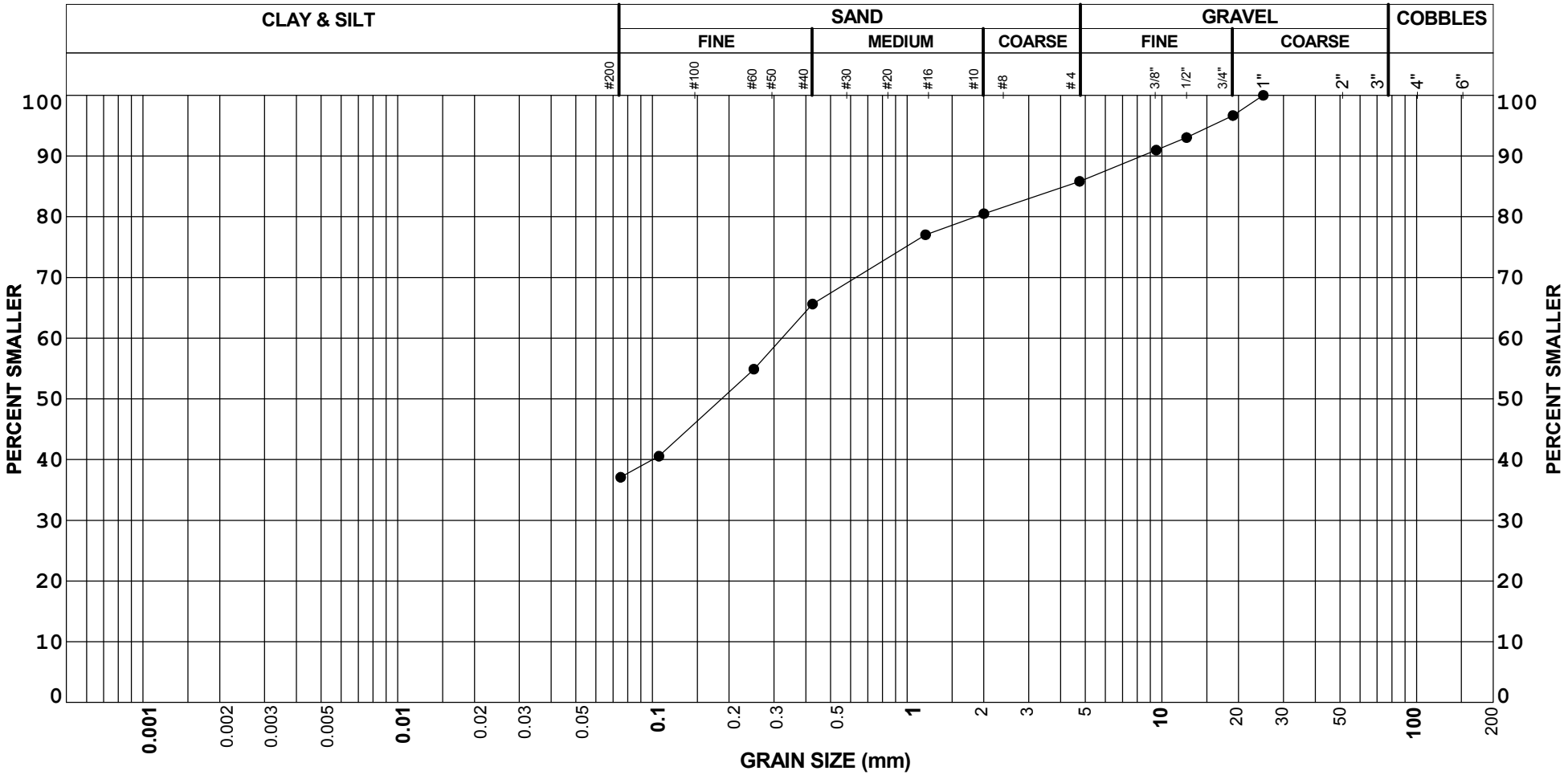
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-C001	DS3	3.10	14	49	37		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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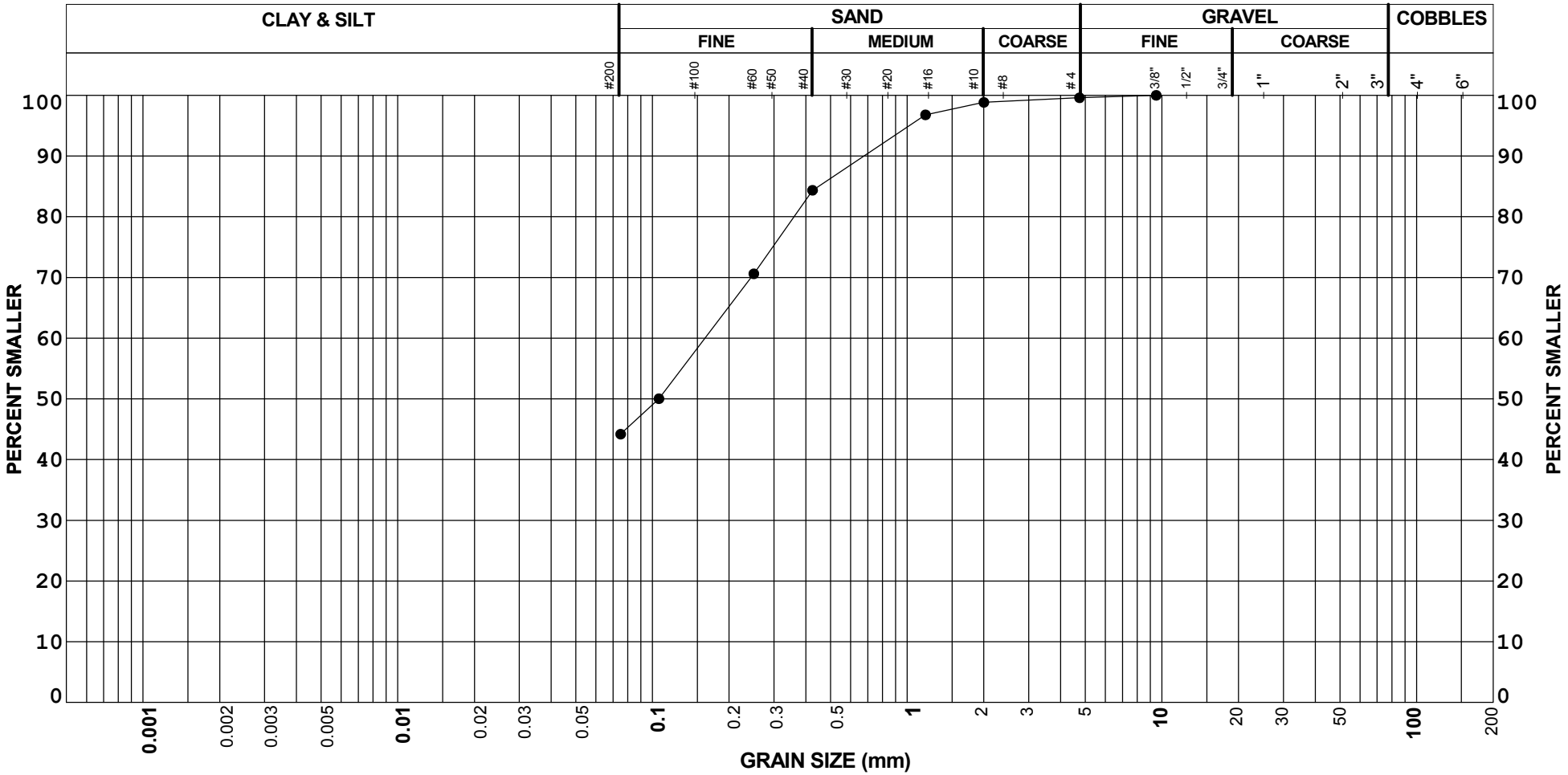
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-C001	DS5	7.00	0	55	44		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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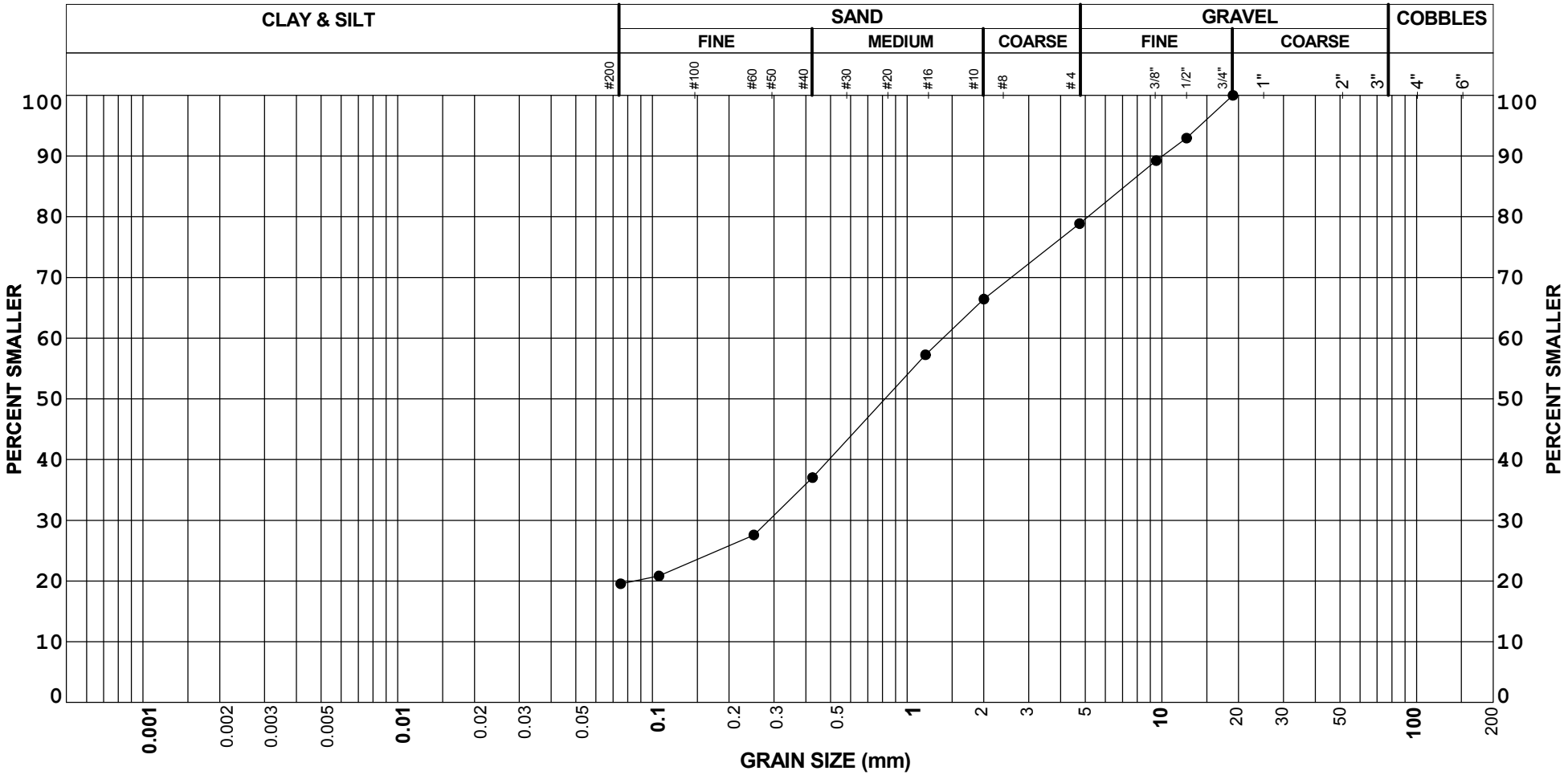
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-C002	DS2	2.40	21	59	20		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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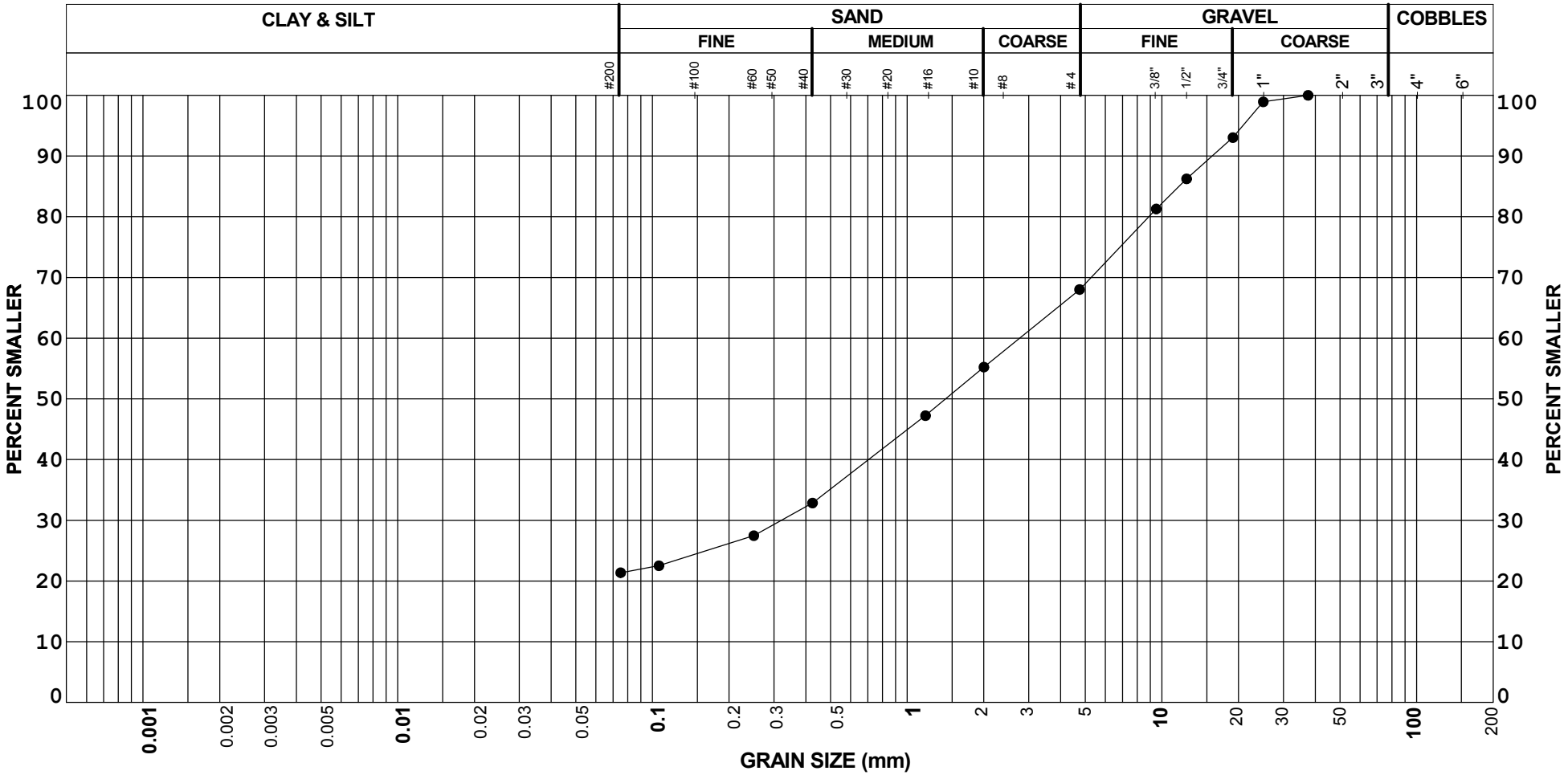
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-C003	DS3	3.40	32	47	21		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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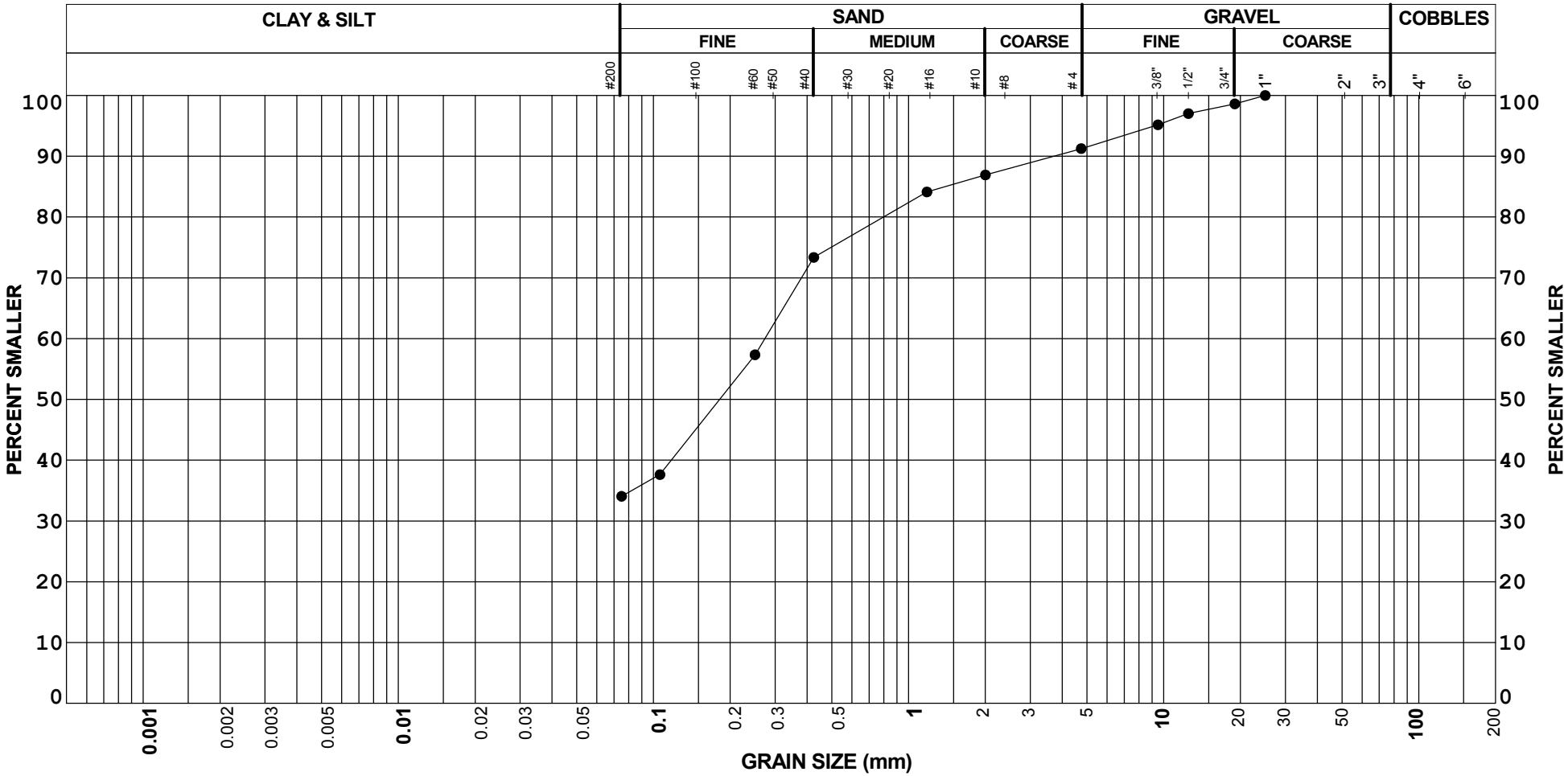
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-C003	DS6	8.80	9	57	34		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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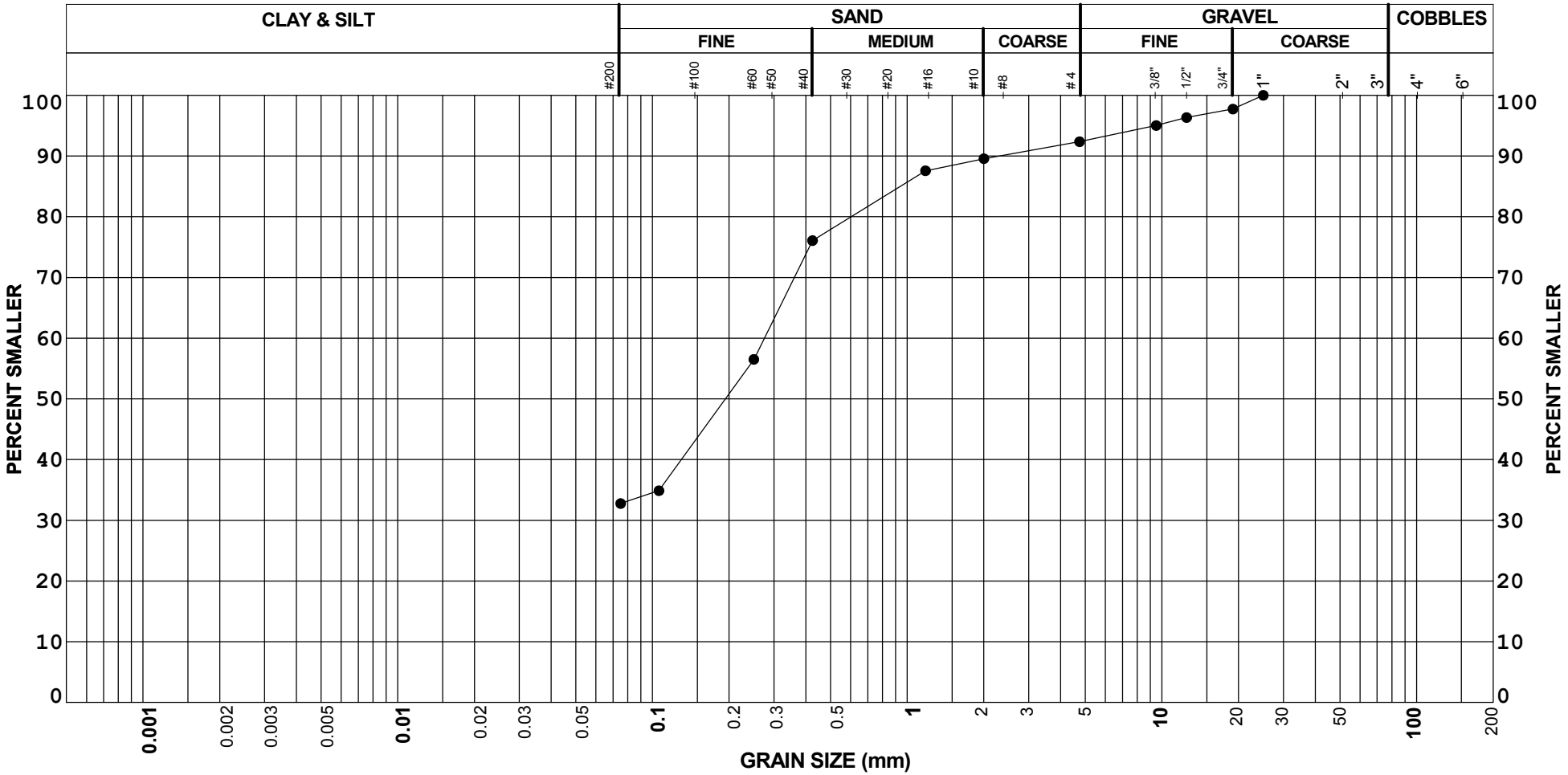
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-C004	DS7	9.80	8	60	33		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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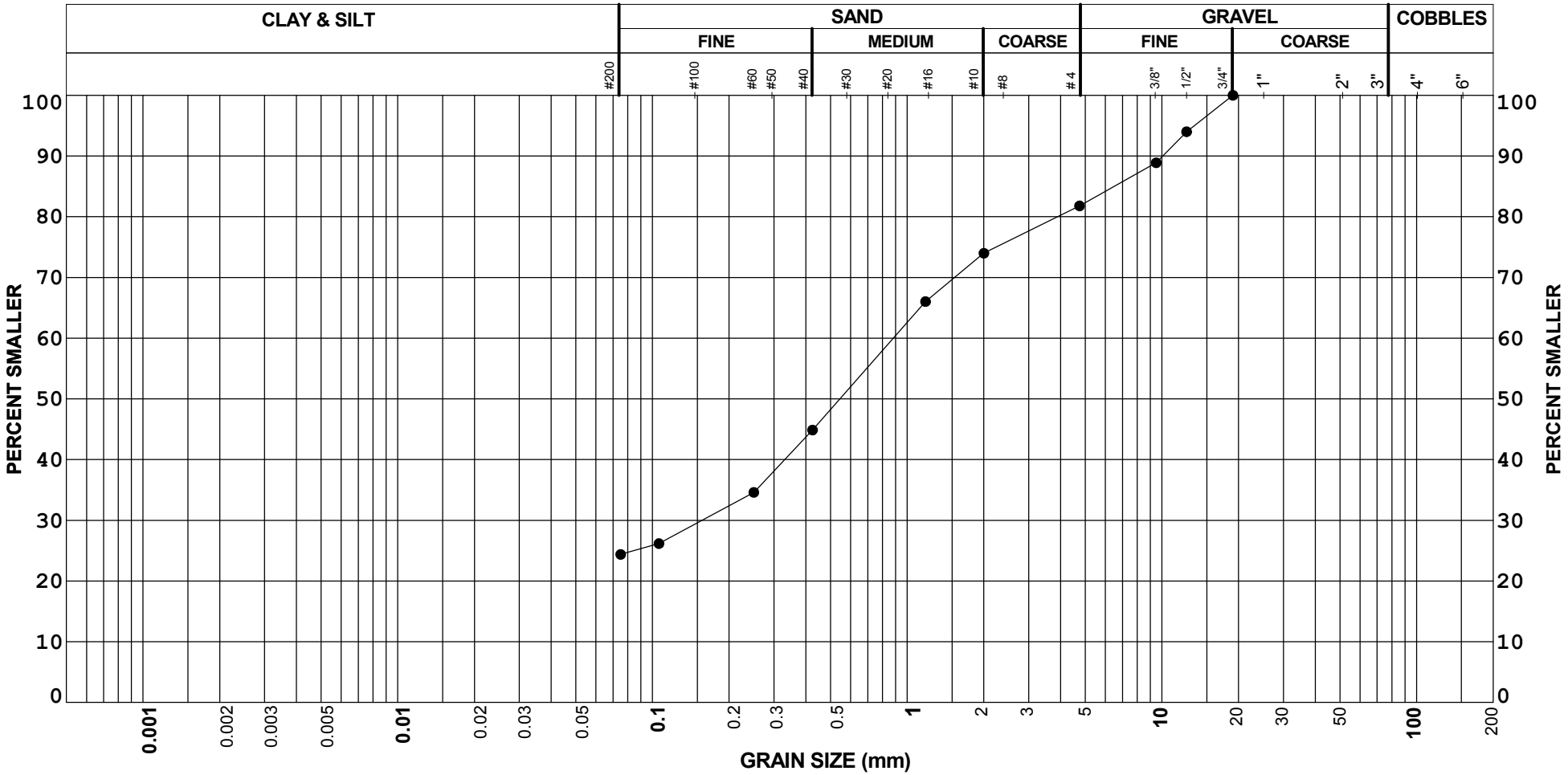
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-C005	DS4	5.50	18	57	24		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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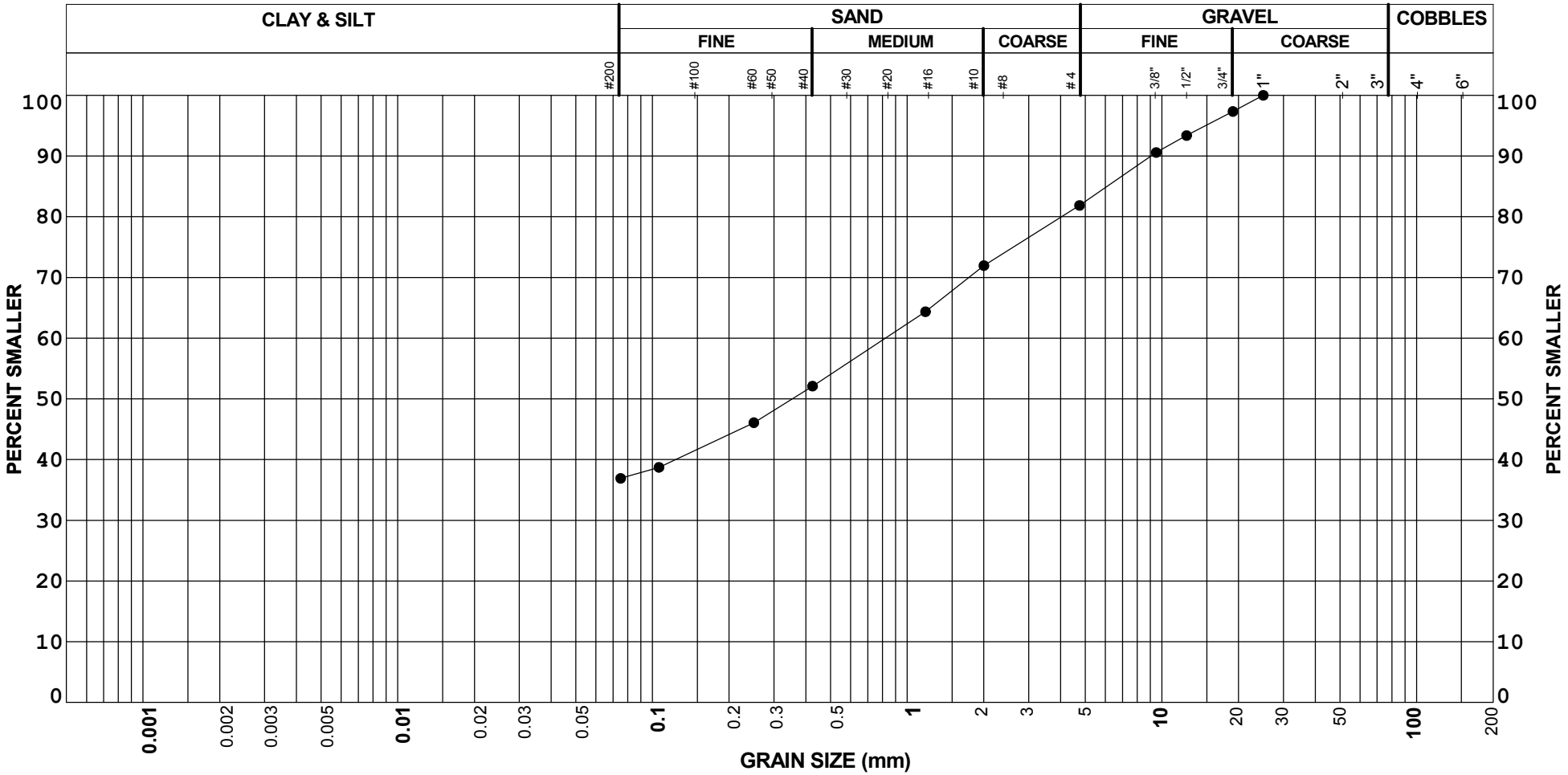
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-C006	DS3	3.70	18	45	37		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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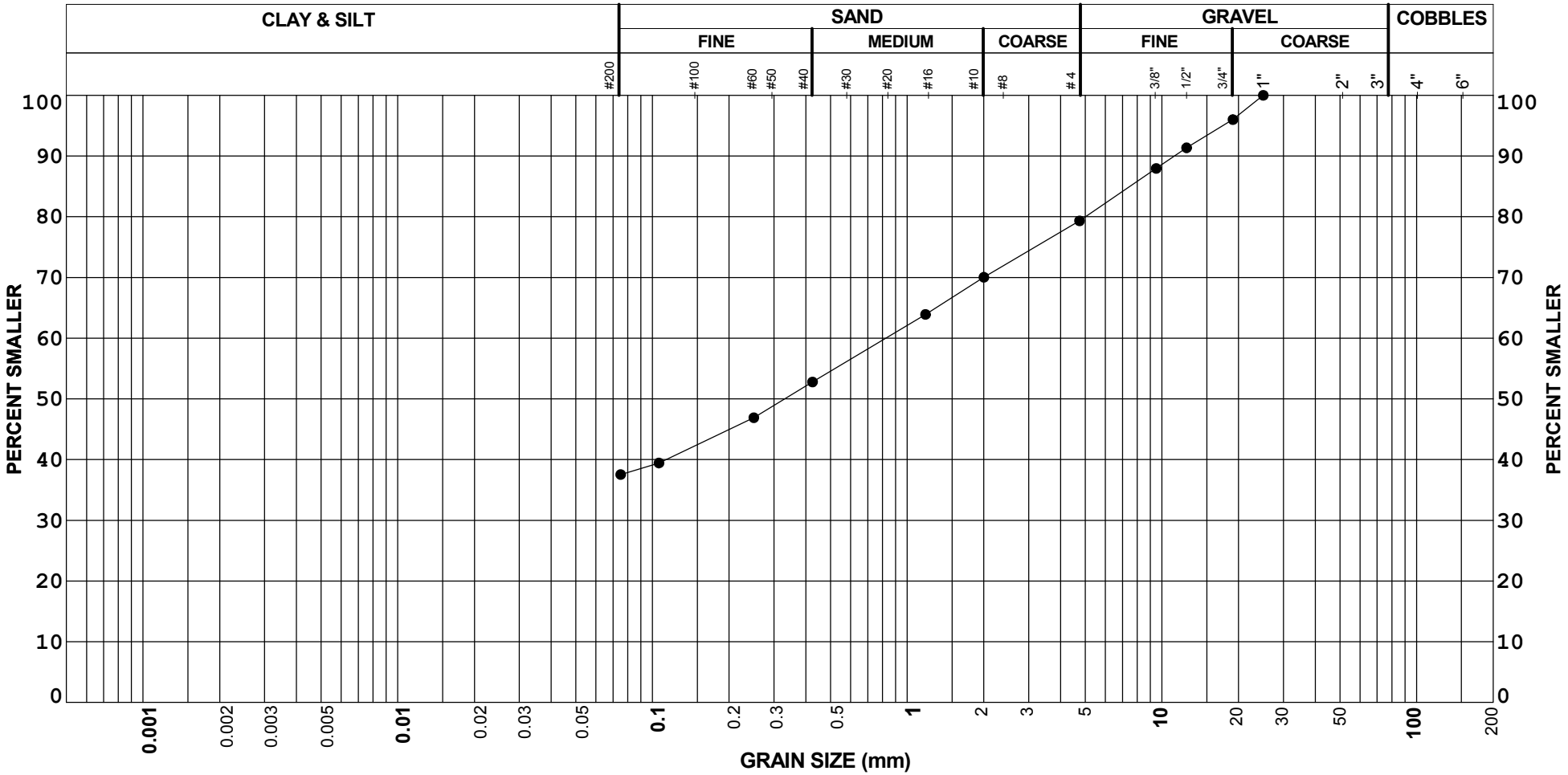
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-C006	DS6	8.20	21	42	38		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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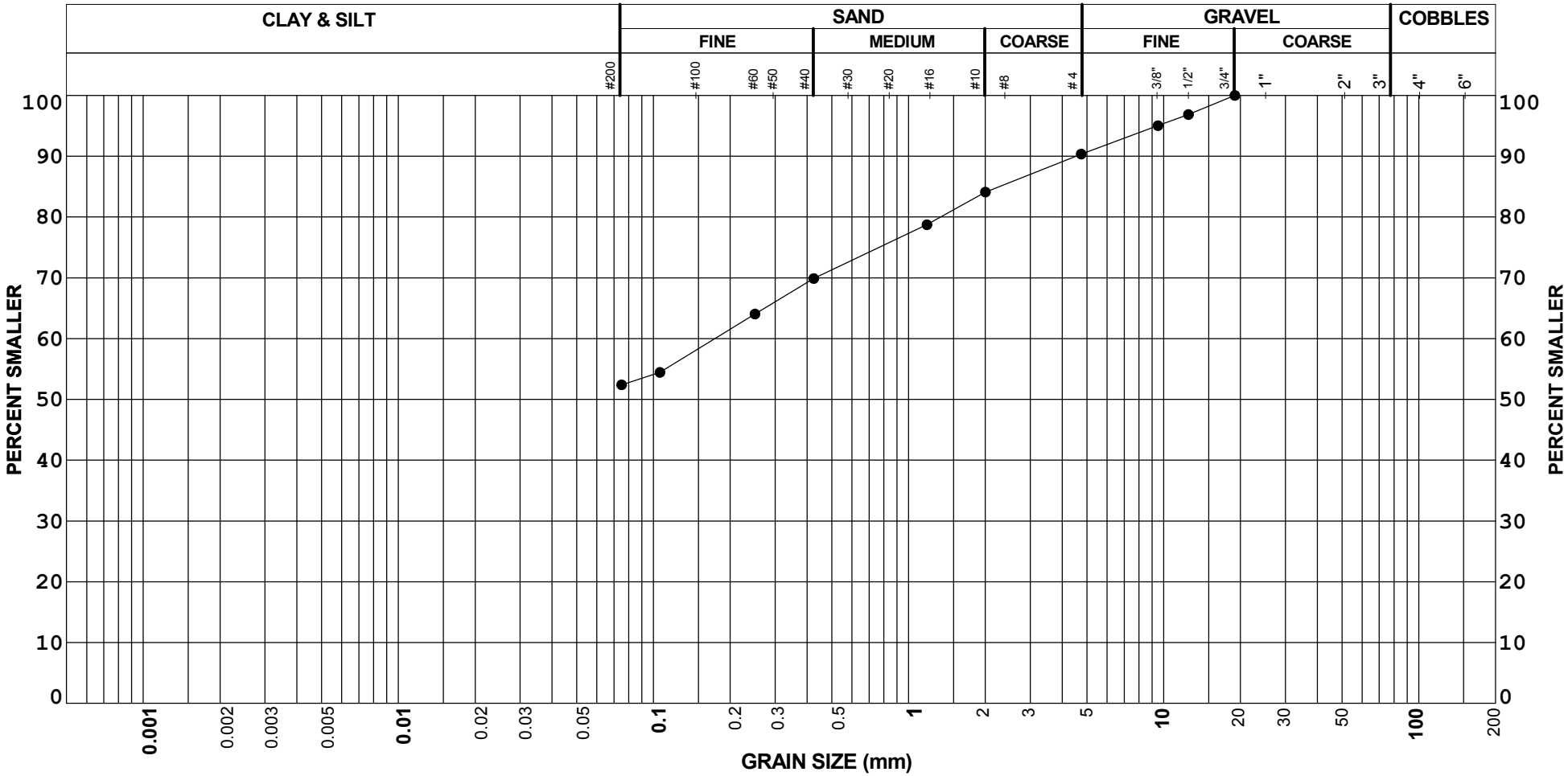
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-C007	DS3	4.00	10	38	52		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

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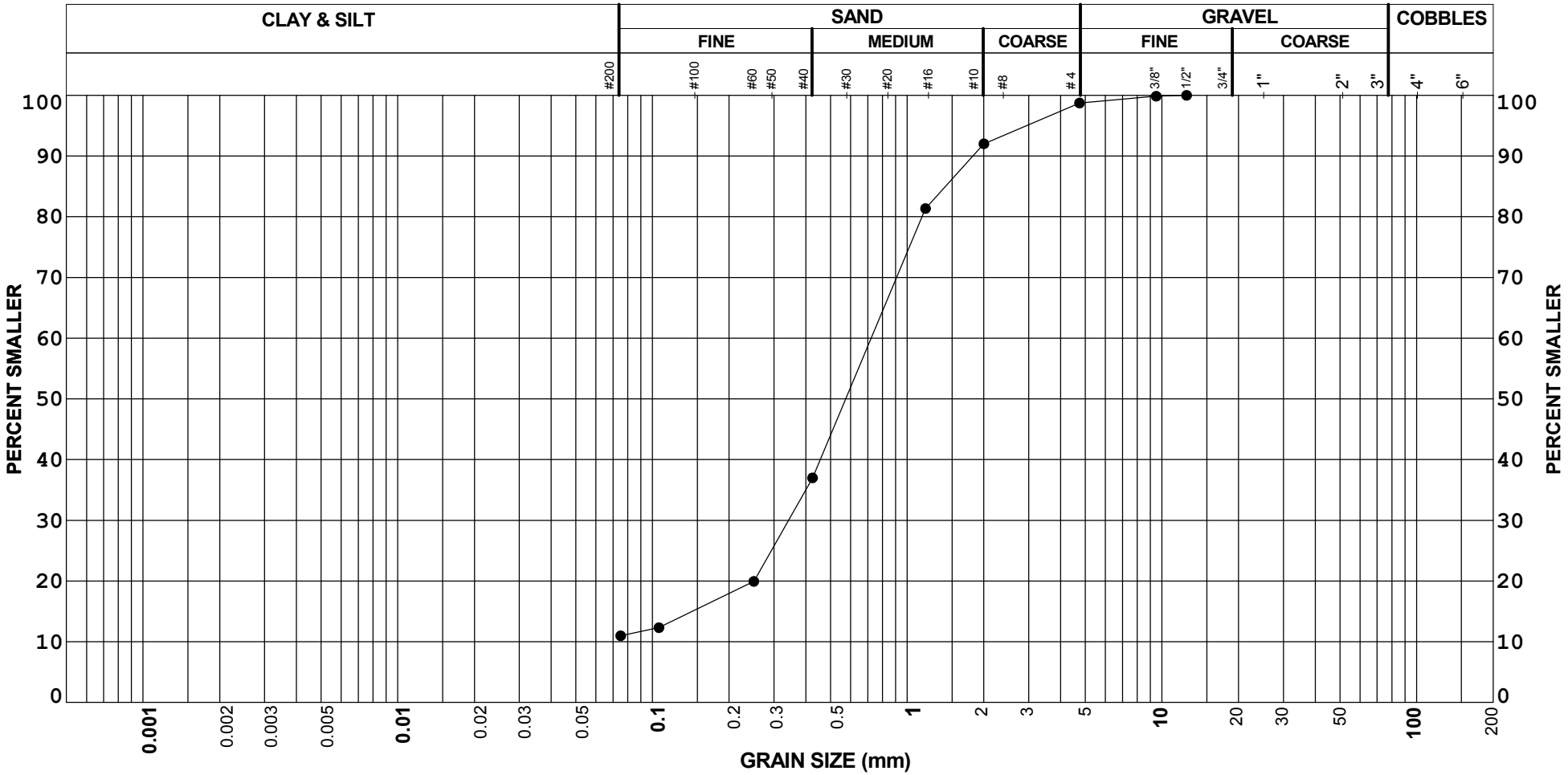
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-C010	DS2	2.40	1	88	11		

REMARKS:

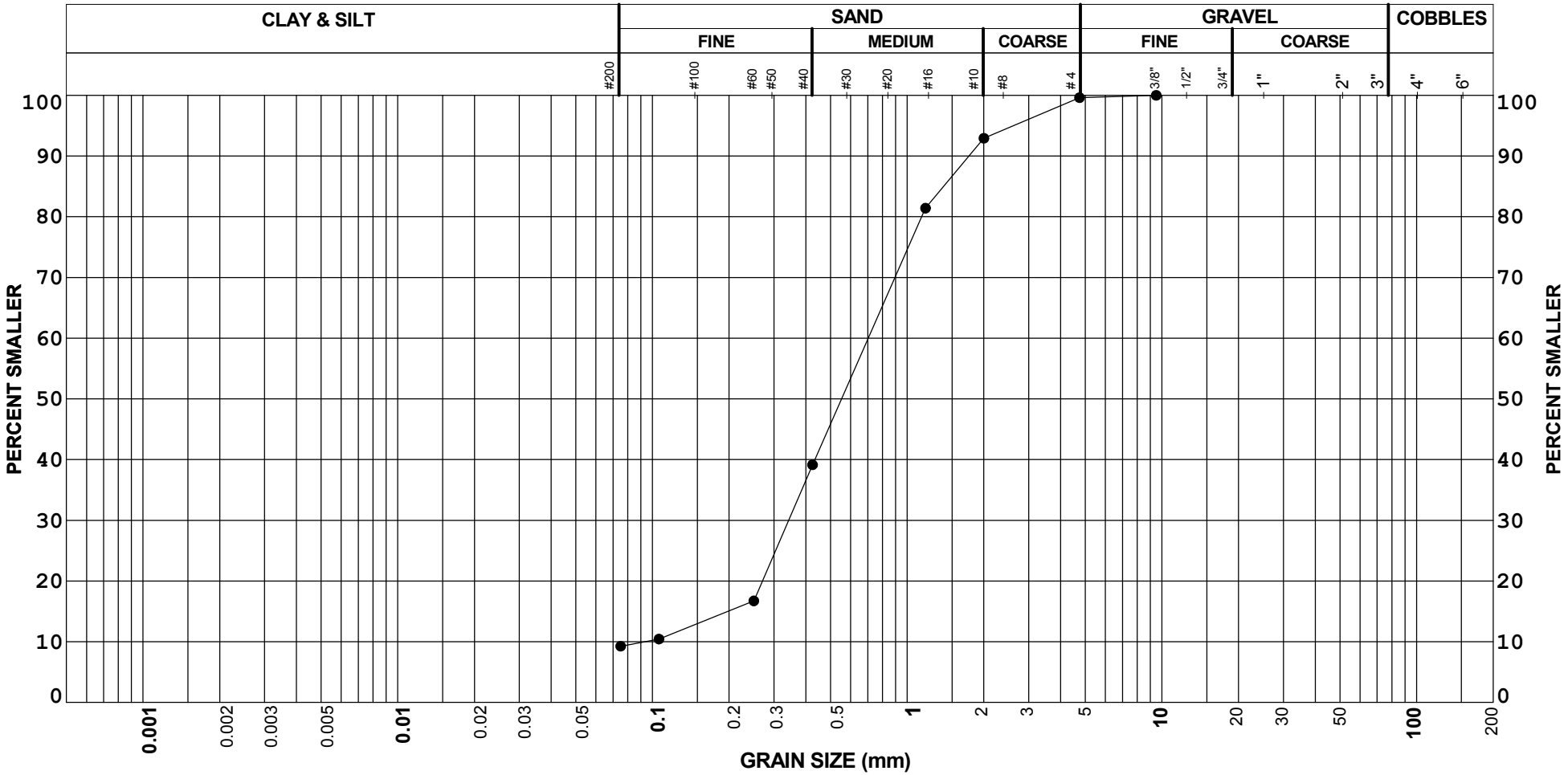
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-C010	DS3	3.70	0	90	9		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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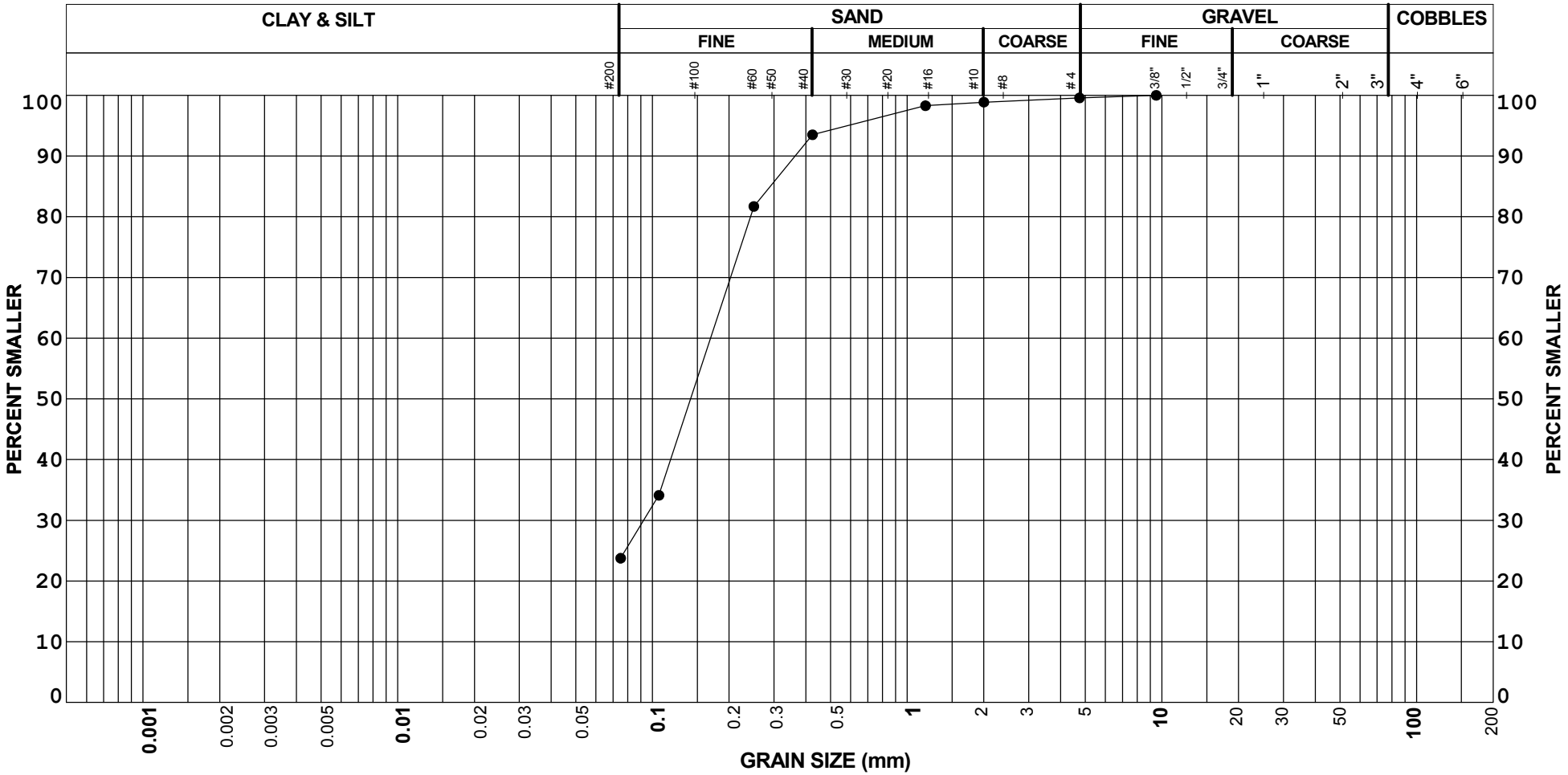
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-C011	DS3	4.00	0	76	24		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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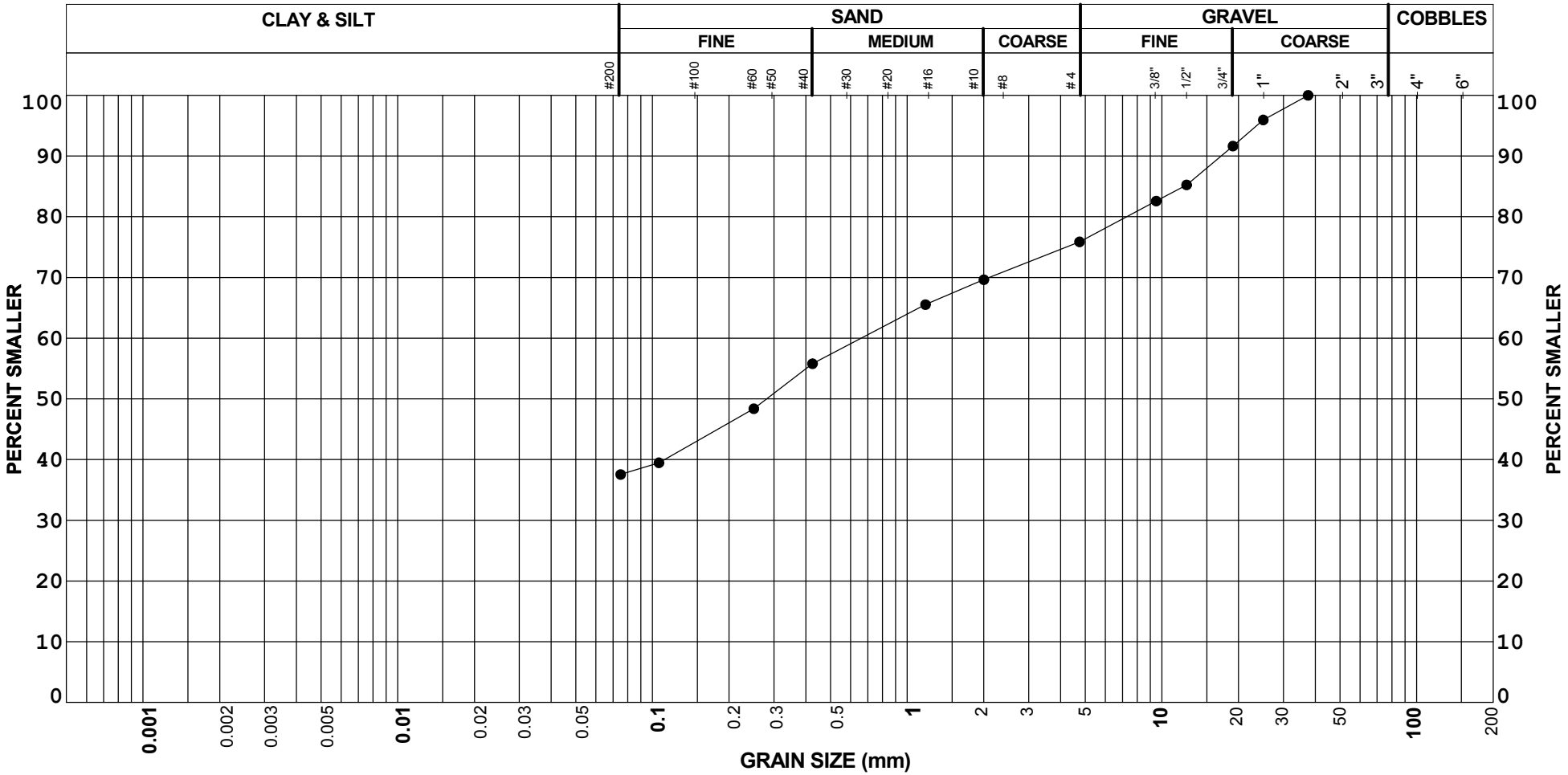
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-C012	DS3	4.00	24	38	38		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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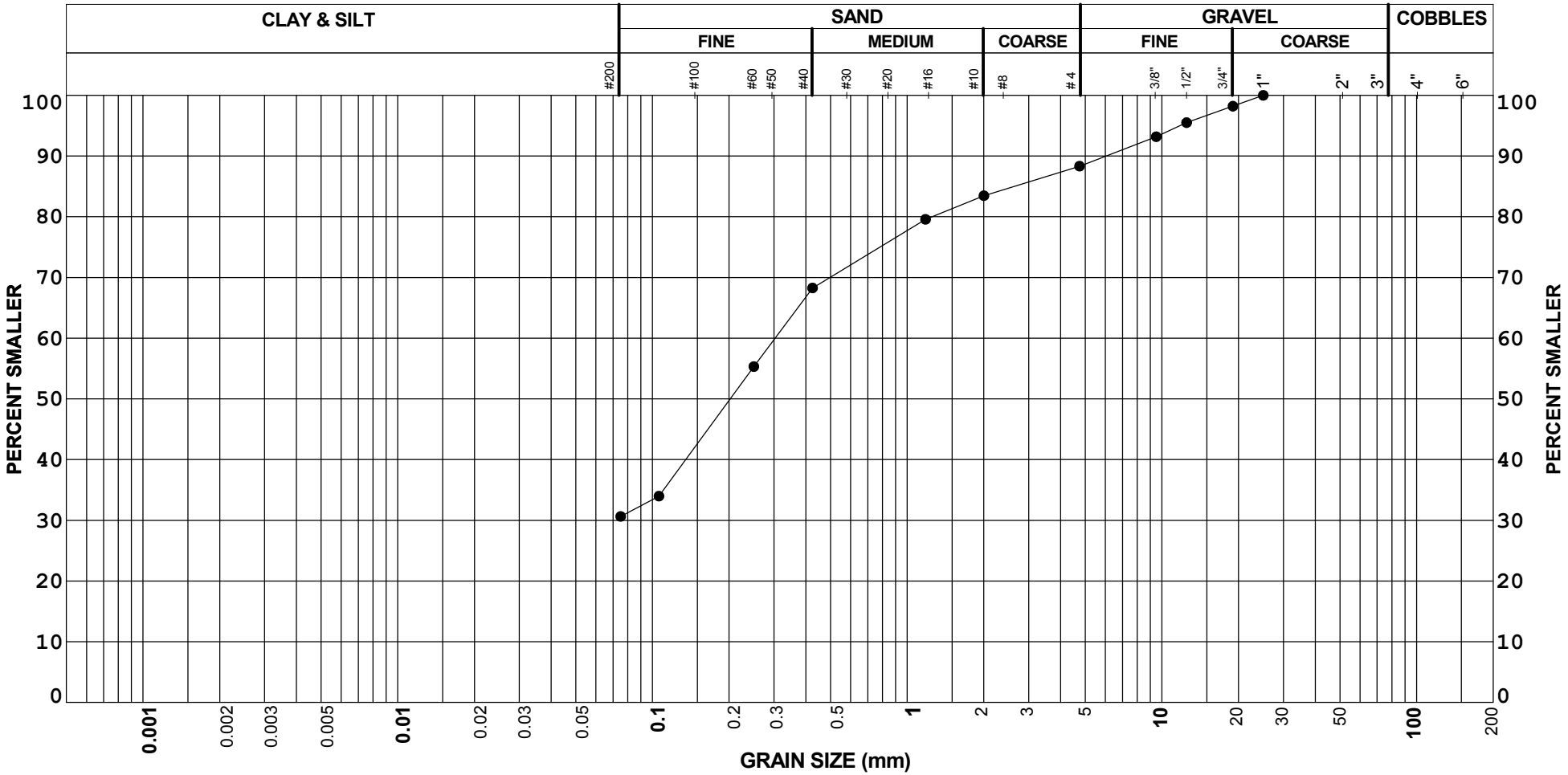
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-C013	DS1	0.90	12	58	31		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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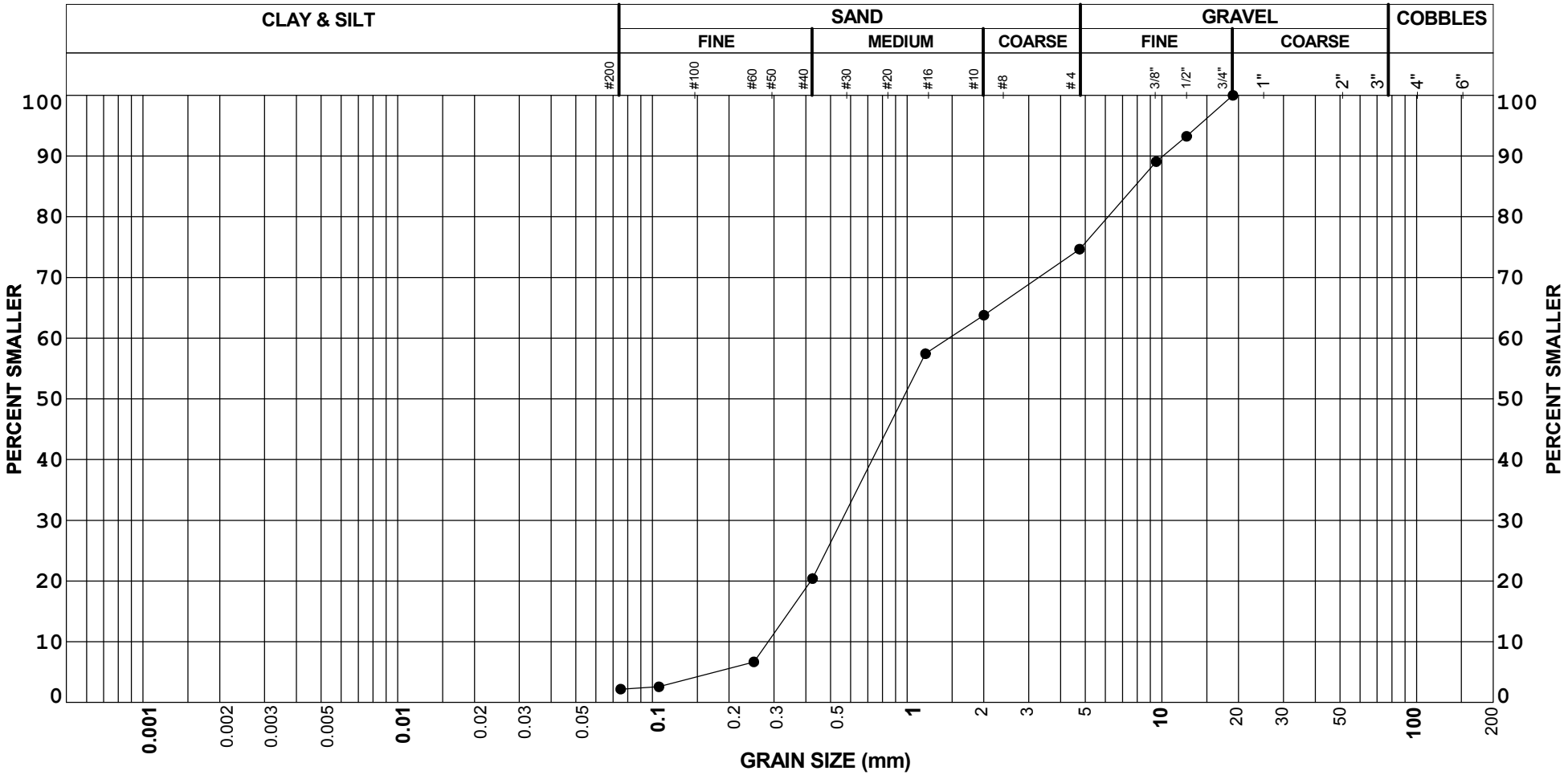
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-BR86-2	DQ1	1.00	25	72	2		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines Corporation

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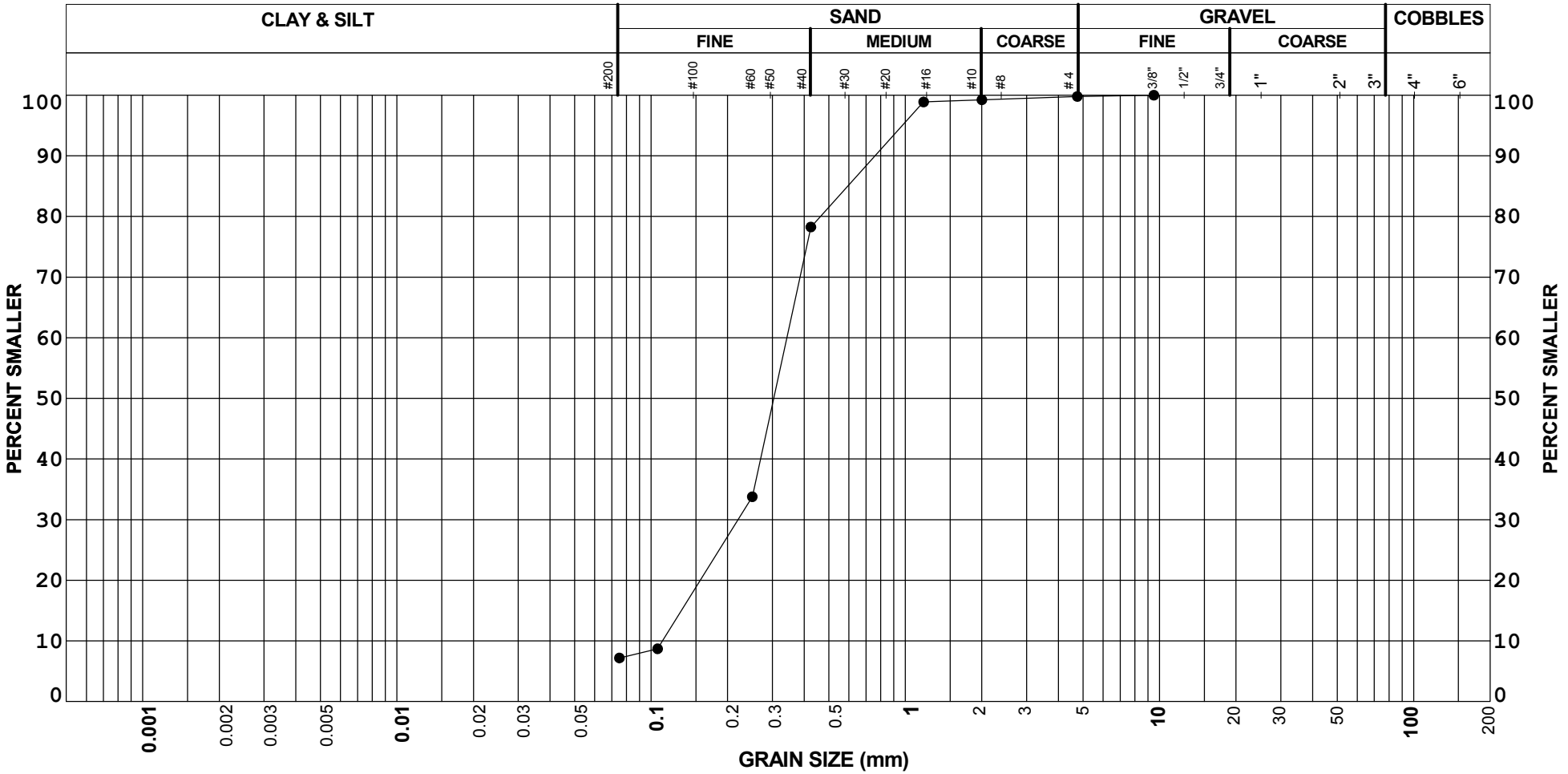
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-BR86-2	DQ2	2.00	0	93	7		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines Corporation

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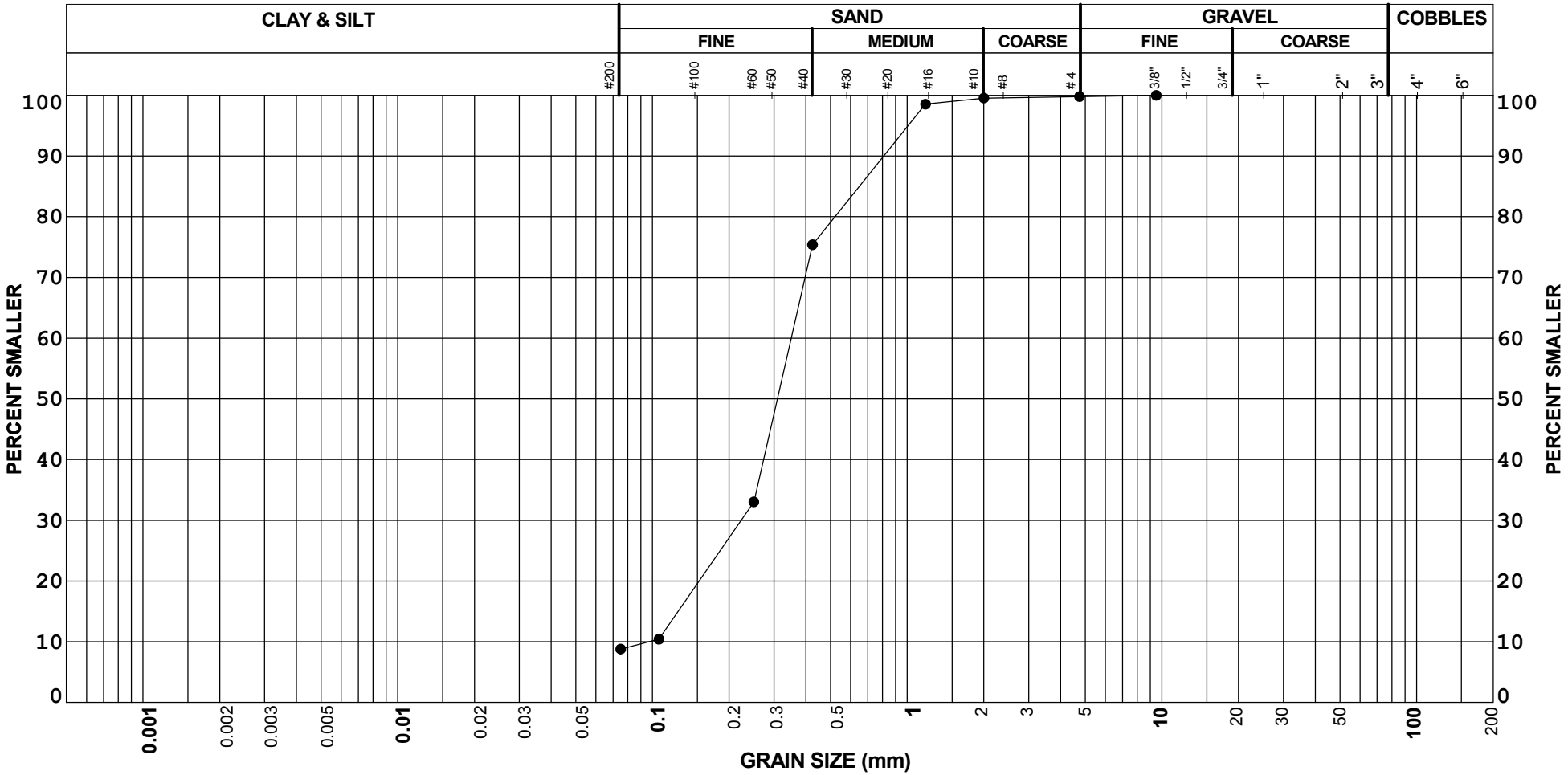
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-BR86-2	DQ3	3.00	0	91	9		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines Corporation

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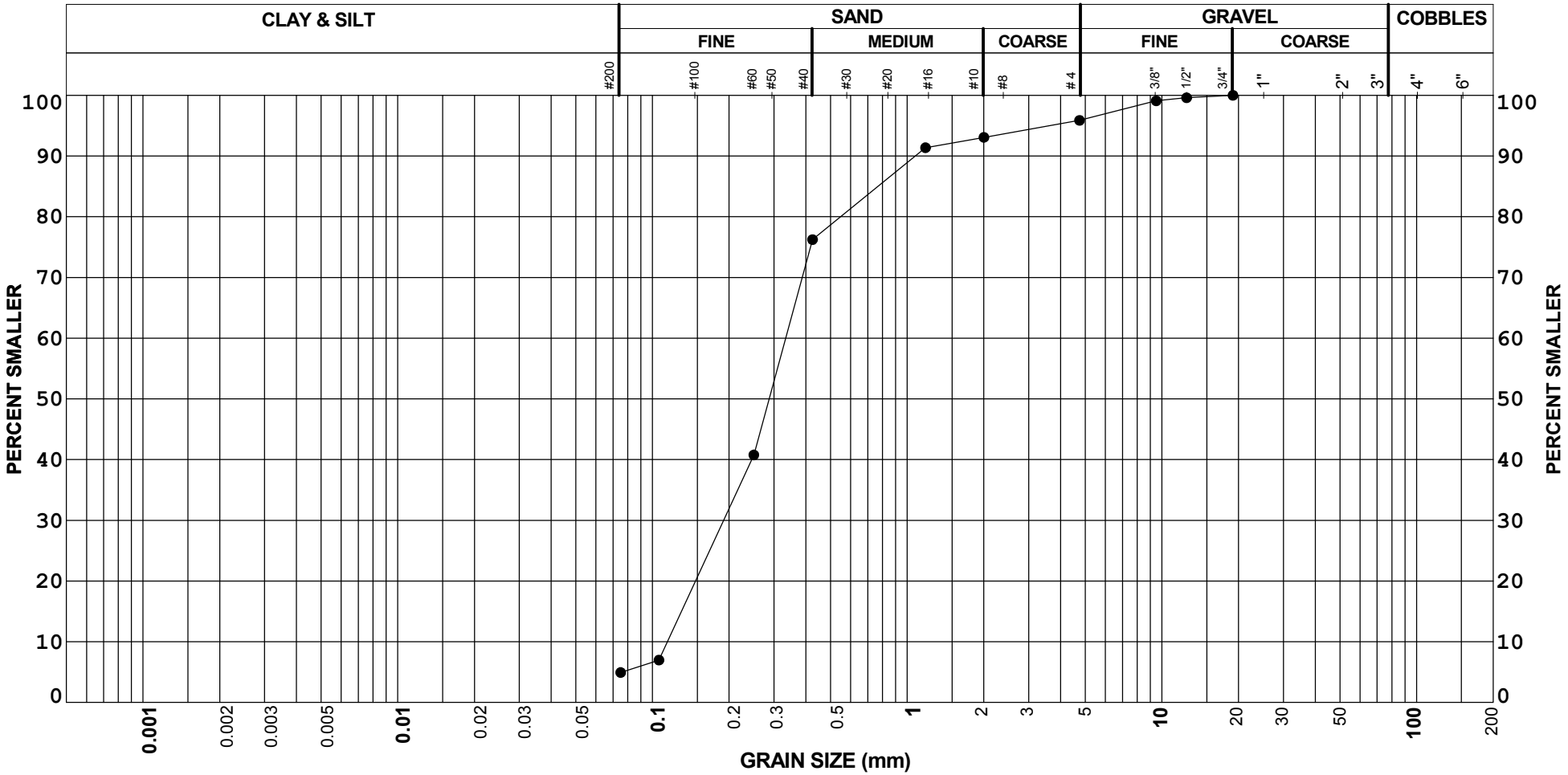
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-BR86-2	DQ4	5.00	4	91	5		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines Corporation

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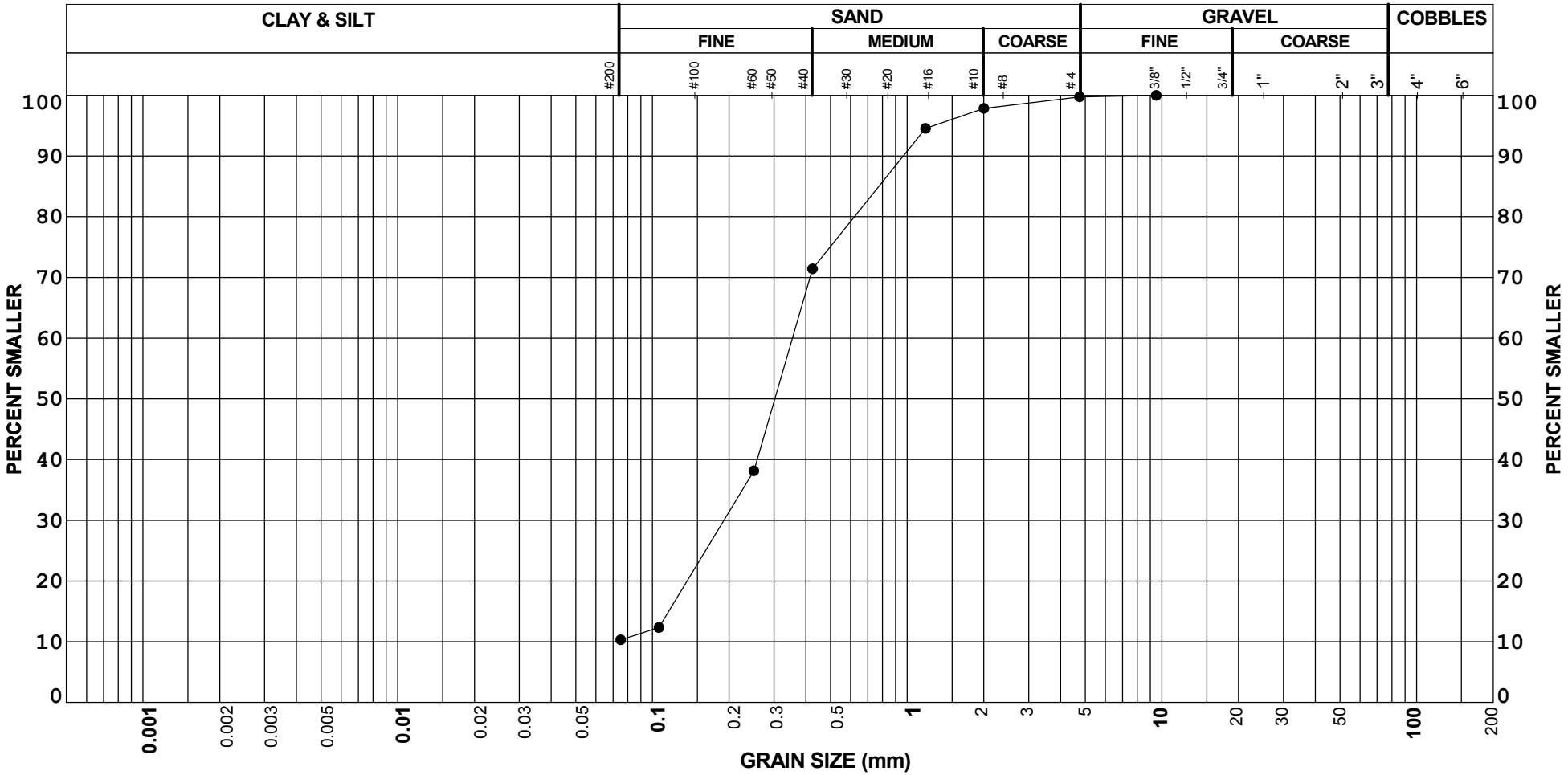
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-BR86-2	DQ5	10.00	0	89	10		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines Corporation

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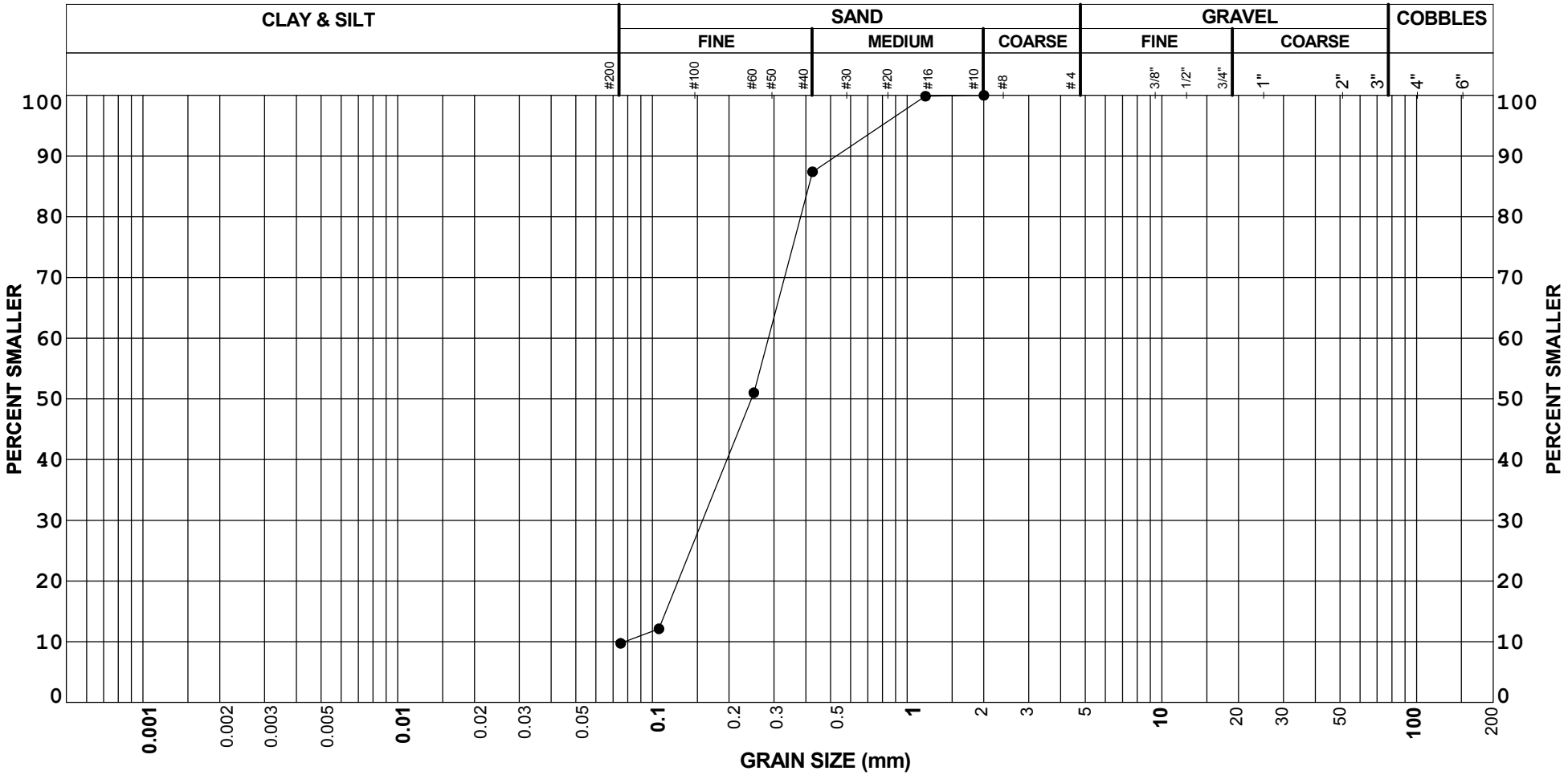
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-BR86-2	DQ7	20.00	0	90	10		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines Corporation

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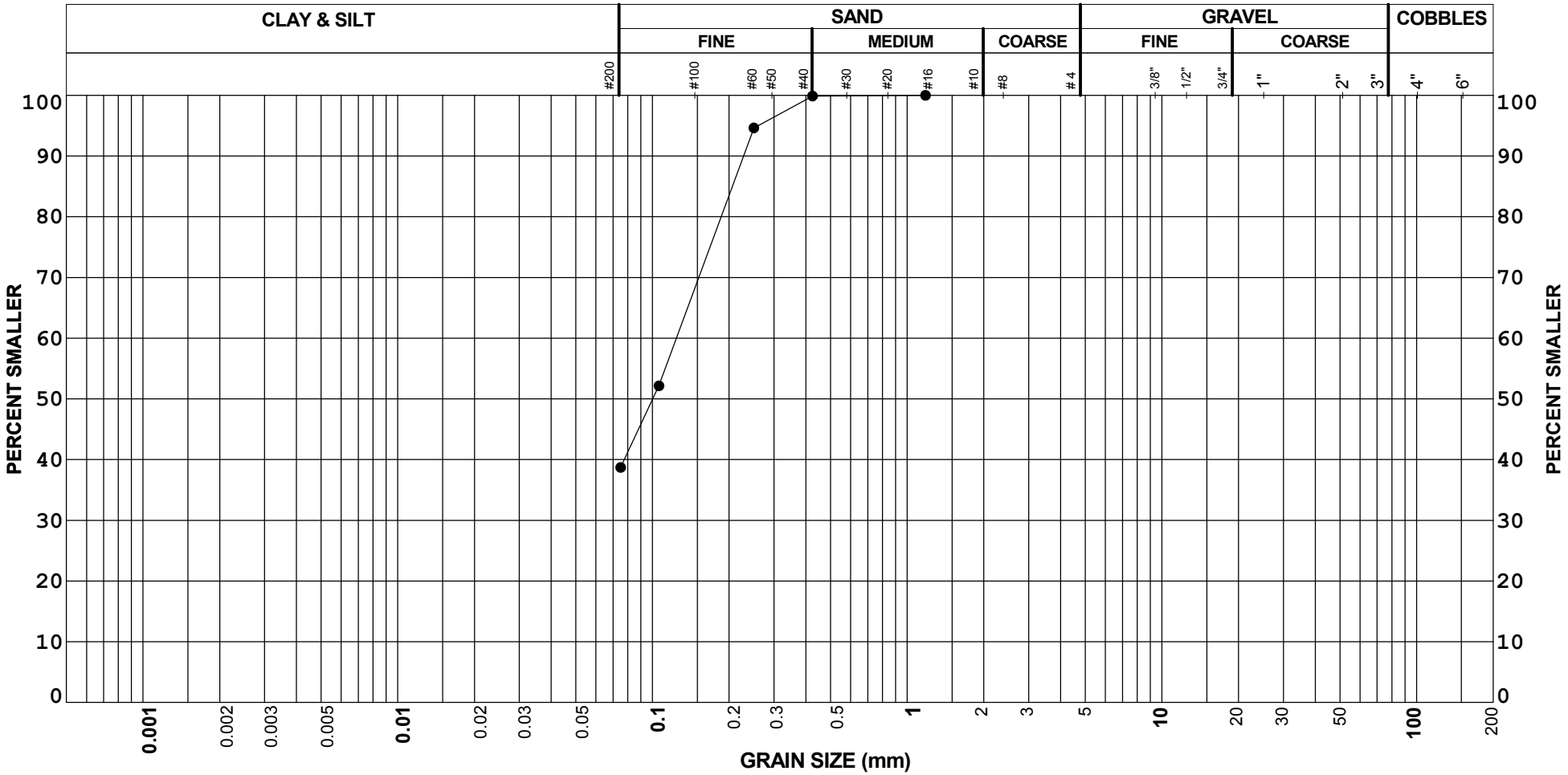
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-BR86-2	DQ13	39.30	0	61	39		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines Corporation

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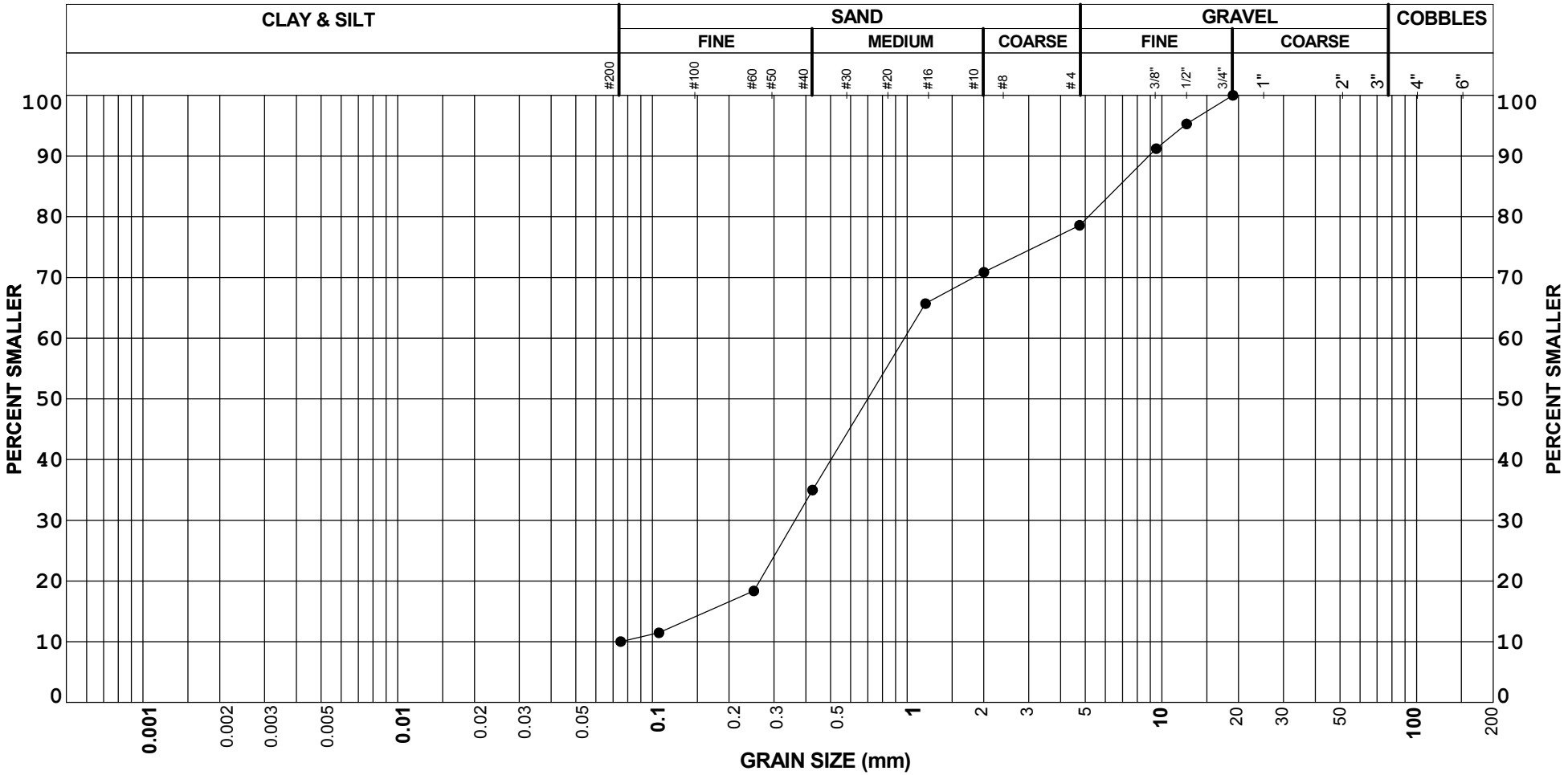
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-BR86-3	DQ1	1.00	21	69	10		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines Corporation

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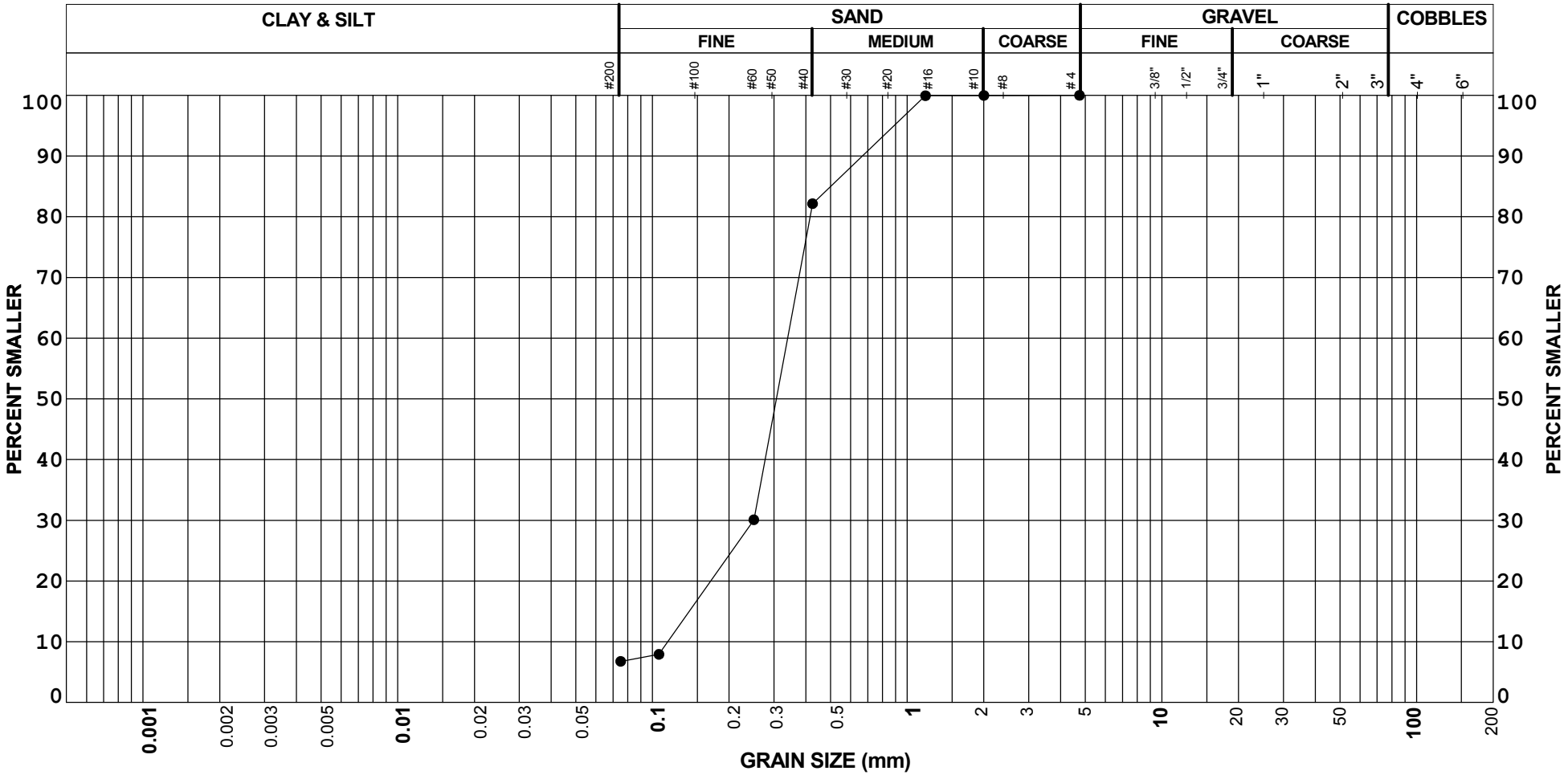
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-BR86-3	DQ2	2.00	0	93	7		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines Corporation

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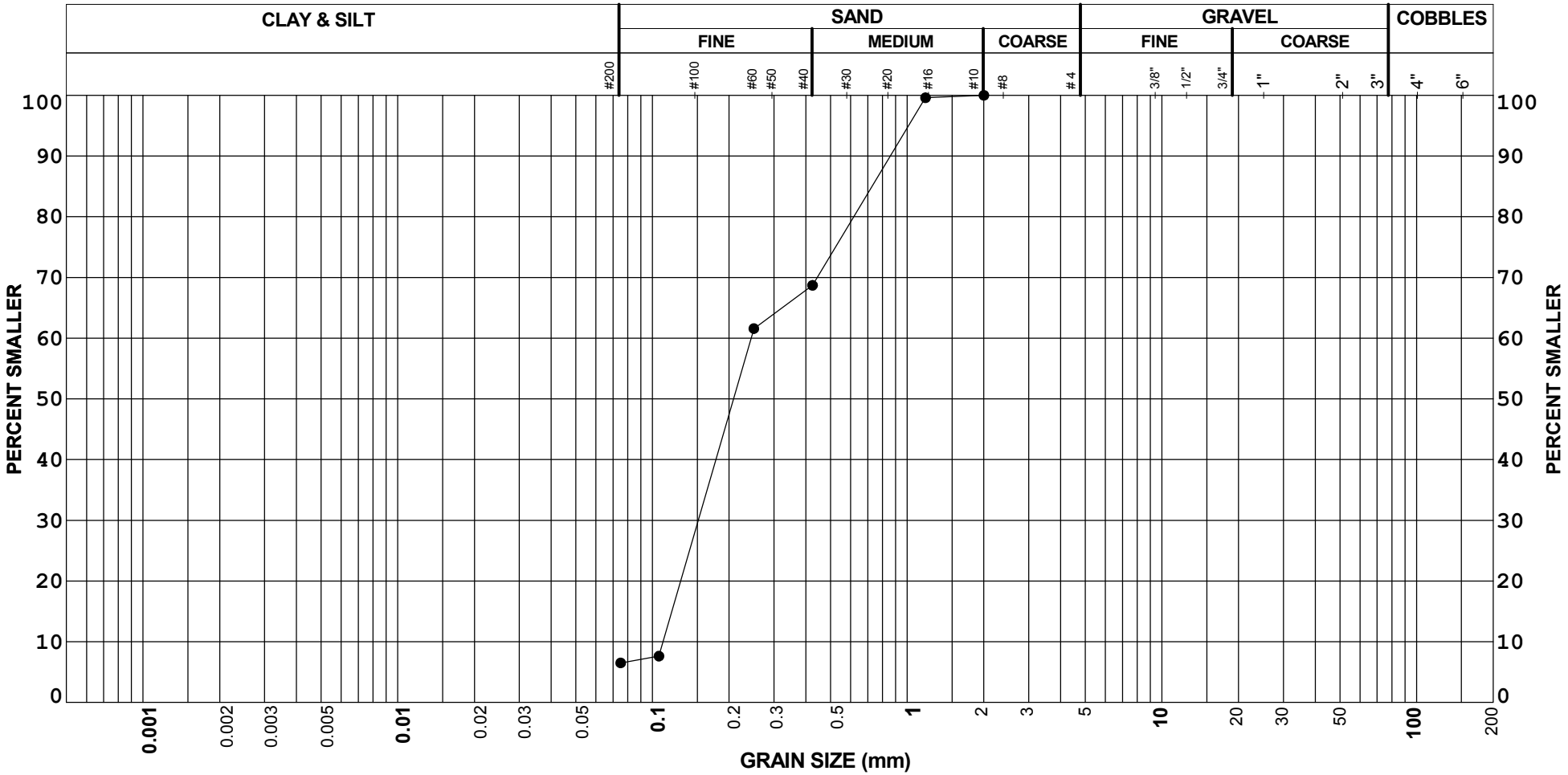
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-BR86-3	DQ3	3.00	0	94	6		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines Corporation

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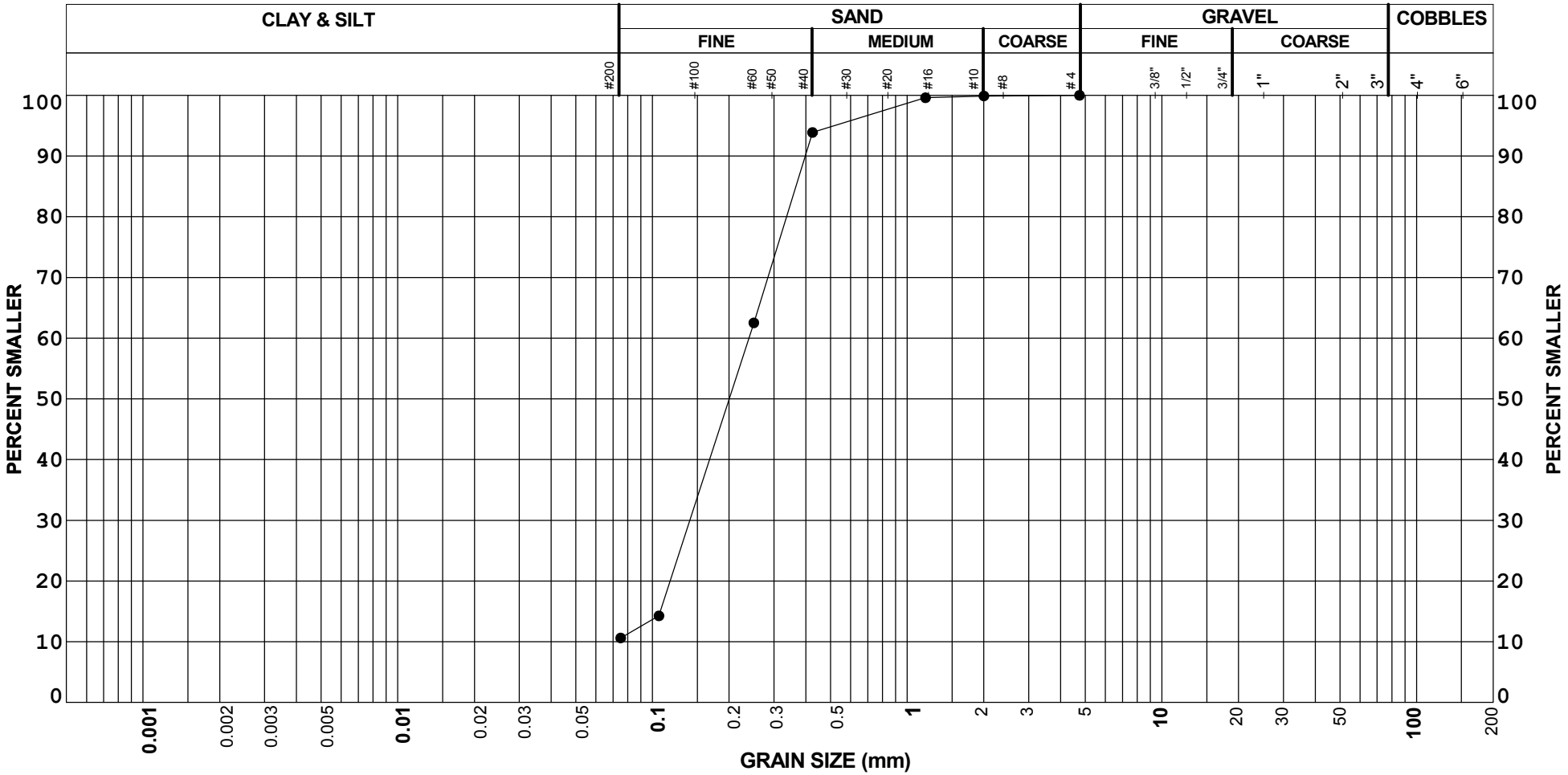
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-BR86-3	DQ4	5.00	0	89	11		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines Corporation

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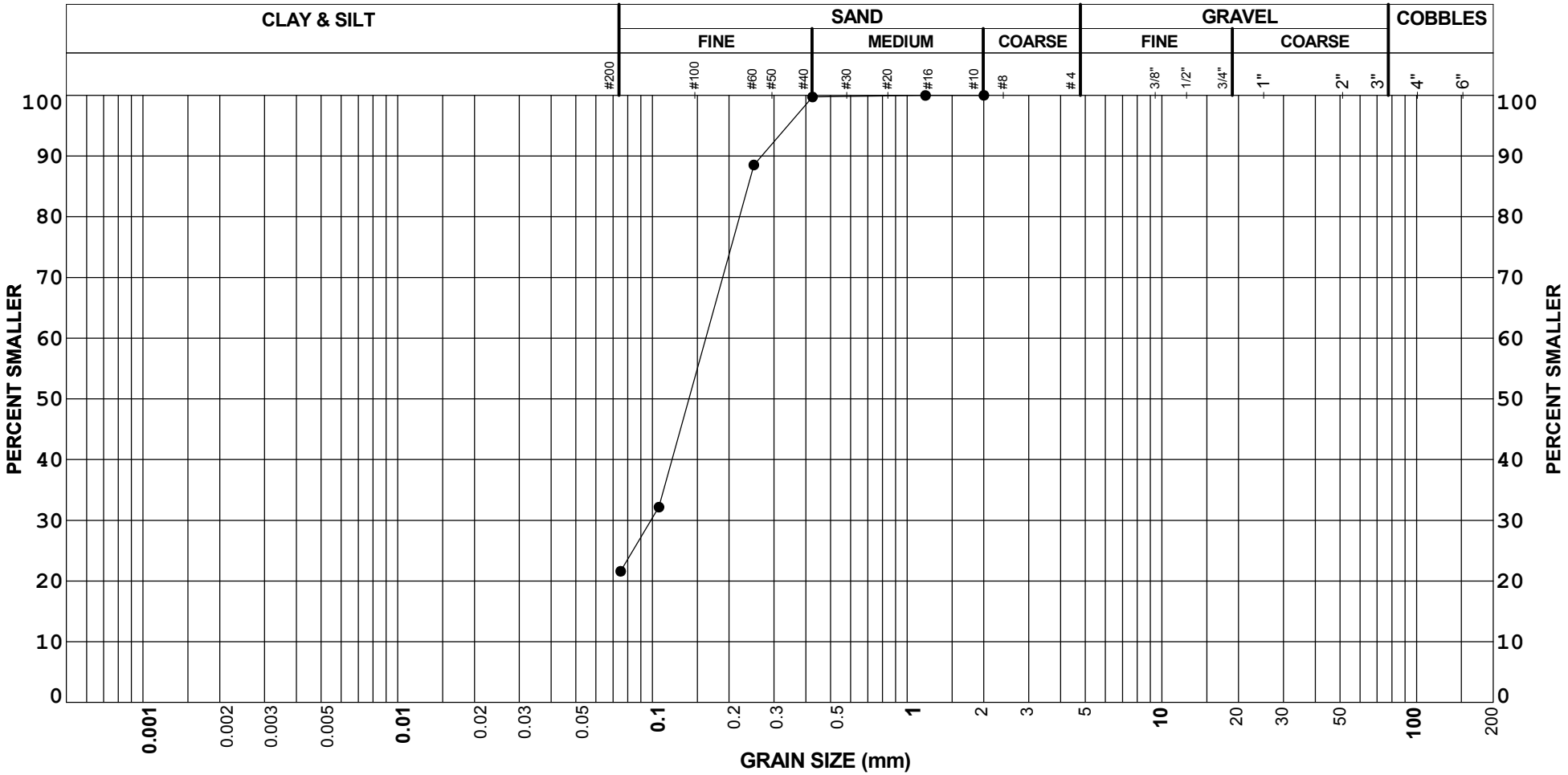
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-BR86-3	DQ5	8.00	0	78	22		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines Corporation

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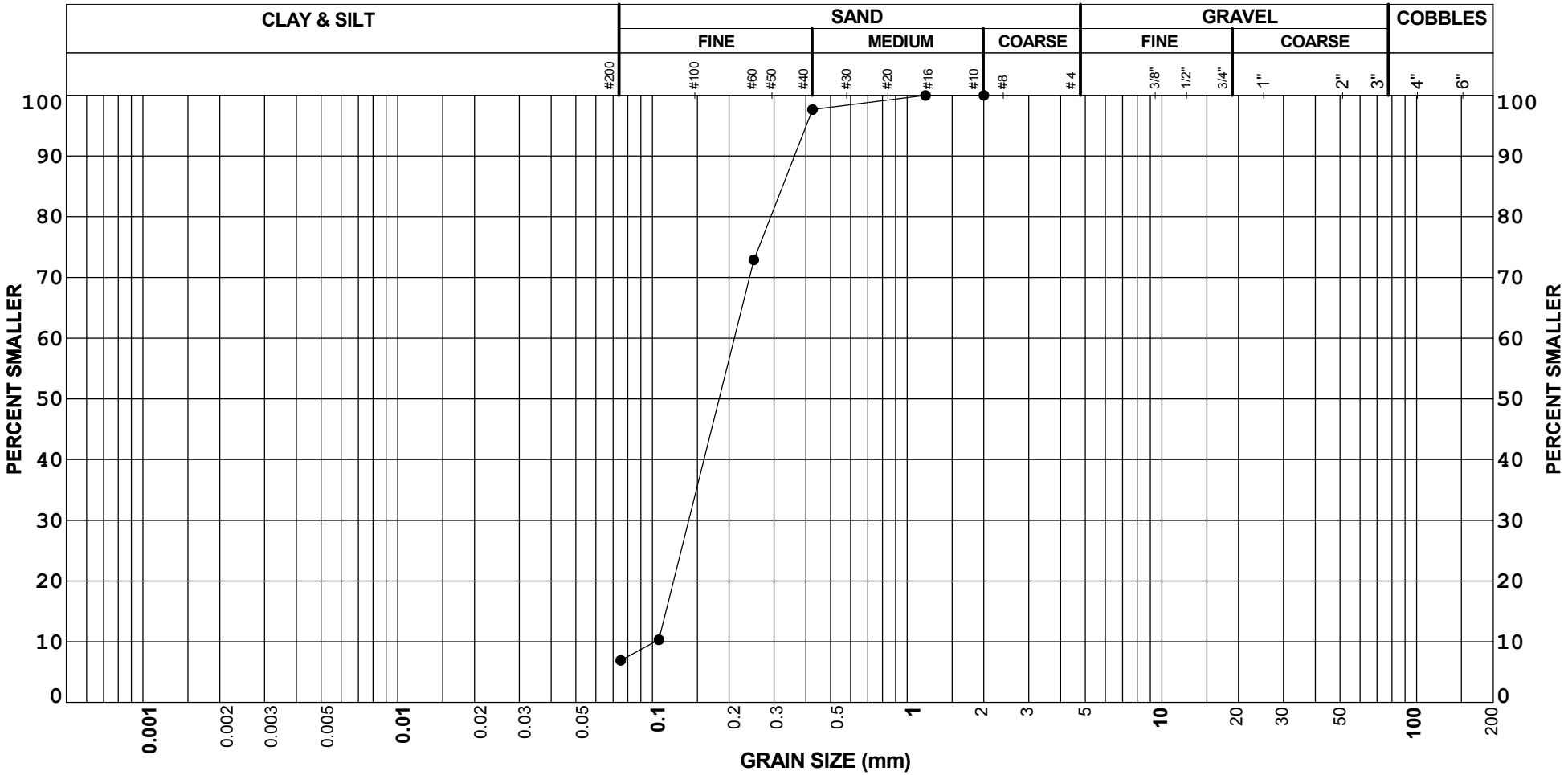
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-BR86-3	DQ6	12.00	0	93	7		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines Corporation

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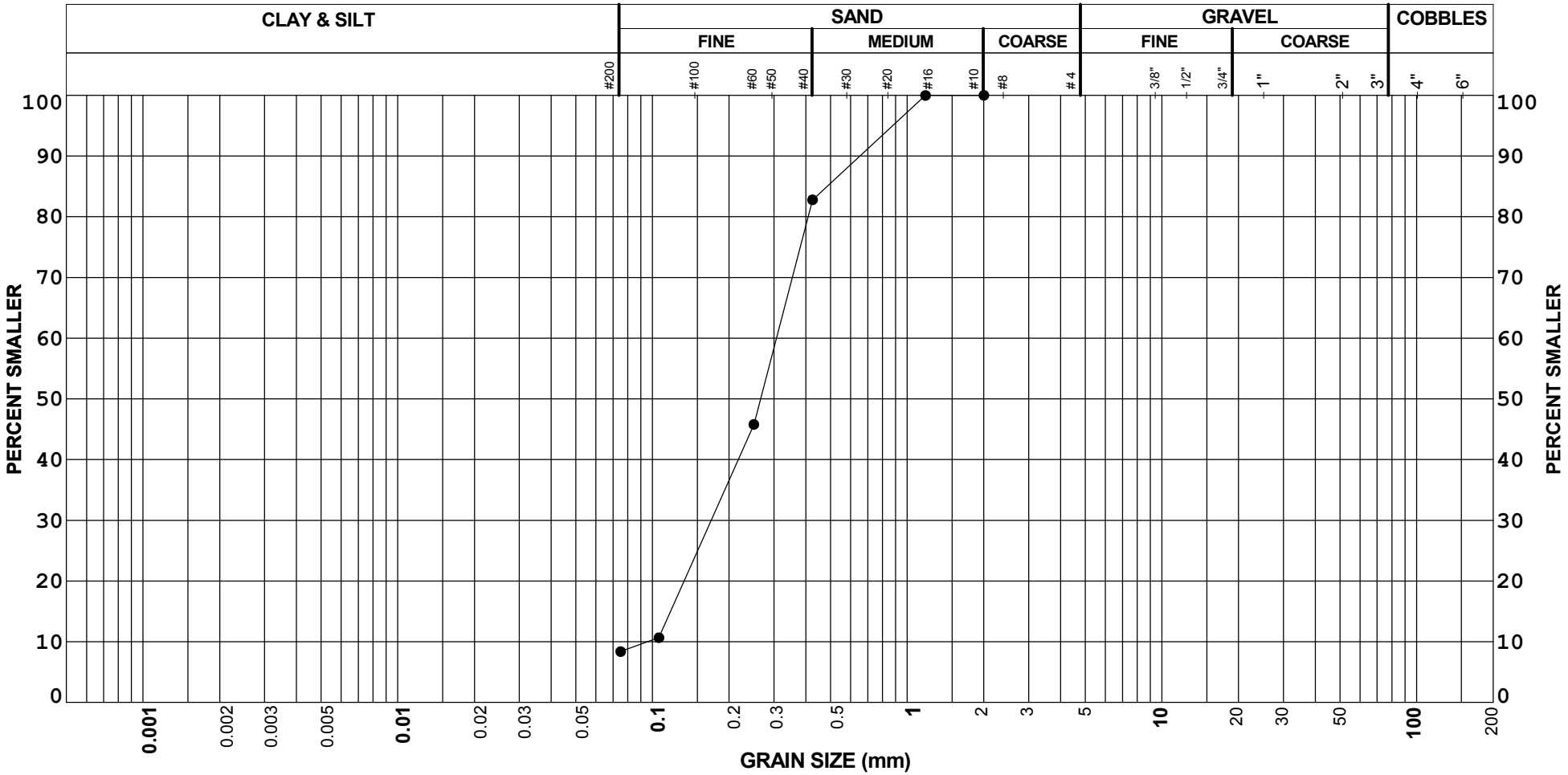
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-BR86-3	DQ8	30.00	0	92	8		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines Corporation

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Project

Pore Water Extraction and Determination of Soluble Salt Content of Soils by Refractometer

ASTM D4542-15

HATCH Geotechnical Laboratory

Date:	December 17, 2017	Baffinland Iron Mines Corporation
Project Number:	H/353004	2275 Upper Middle Rd, Oakville Ontario.
Project:	**Mary River Expansion Project**	**Attention:**

Sample	**As Listed Below**
Source	**BH17-BR86- 2 – Km 86 Rail Bridge N/W Abutment**

Sample I.D	Depth (m)	Salinity Scale (ppt)	Notes
BLANK	NA	0.0	Distilled Water
DQ1	1.00	1.0	
DQ2	2.00	1.0	
DQ4	5.00	1.0	
DQ5	10.00	1.0	
DQ6	11.30	1.0	
BLANK	NA	0.0	Distilled Water
DQ7	20.00	1.0	
DQ8	24.00	1.0	
DQ11	36.40	4.0	
BLANK	NA	0.0	Distilled Water

Comments: Tested with EXTECH Model RF20 Refractometer with automatic temperature compensation.

Reported by: R. Serluca, Lab Tech., Dec. 17, 2017

Name, Title, Date

Reviewed by: W. Hoyle, Feb.16, 2018

Name. Title. Date

Notice: the test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

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Pore Water Extraction and Determination of Soluble Salt Content of Soils by Refractometer

ASTM D4542-15

HATCH Geotechnical Laboratory

Date:	December 17, 2017	Baffinland Iron Mines Corporation
Project Number:	H/353004	2275 Upper Middle Rd, Oakville Ontario.
Project:	**Mary River Expansion Project**	**Attention:**

Sample	**As Listed Below**
Source	**BH17- BR86 - 3 – Km 86 Rail Bridge S/E Abutment**

Sample I.D	Depth (m)	Salinity Scale (ppt)	Notes
BLANK	NA	0.0	Distilled Water
DQ1	1.00	1.0	
DQ2	2.00	1.0	
DQ3	3.00	1.0	
DQ4	5.00	1.0	
BLANK	NA	0.0	Distilled Water
DQ5	8.00	1.0	
DQ6	12.00	1.0	
DQ8	30.00	1.0	
BLANK	NA	0.0	Distilled Water

Comments: Tested with EXTECH Model RF20 Refractometer with automatic temperature compensation.

Reported by: R. Serluca, Lab Tech., Dec. 17, 2017

Name, Title, Date

Reviewed by: W. Hoyle, Feb. 16, 2018

Name, Title, Date

Notice: the test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

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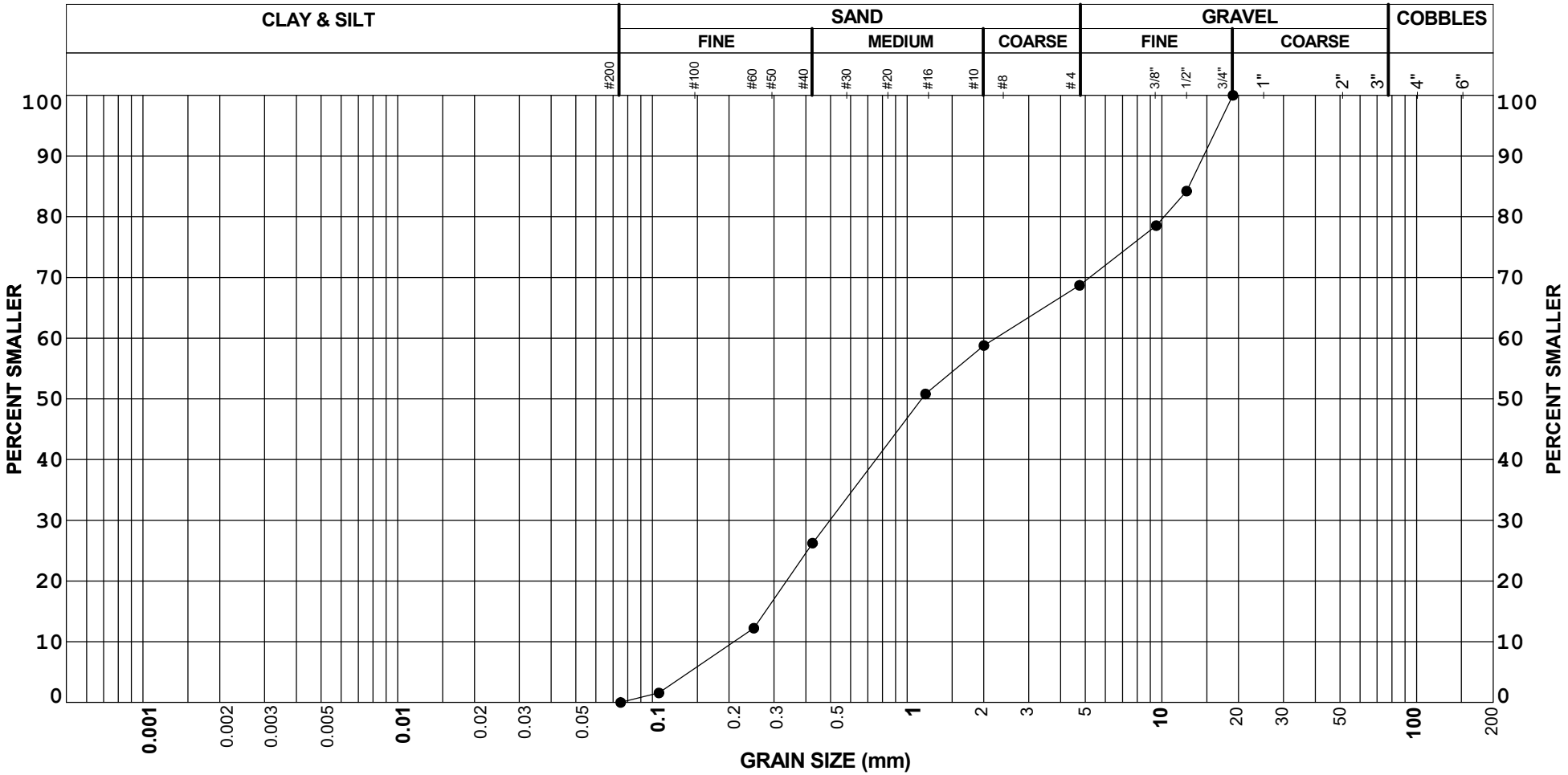
UNIFIED SOIL CLASSIFICATION SYSTEM



REMARKS:

BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-102-2	DQ-3	3.01	31	69	0		

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

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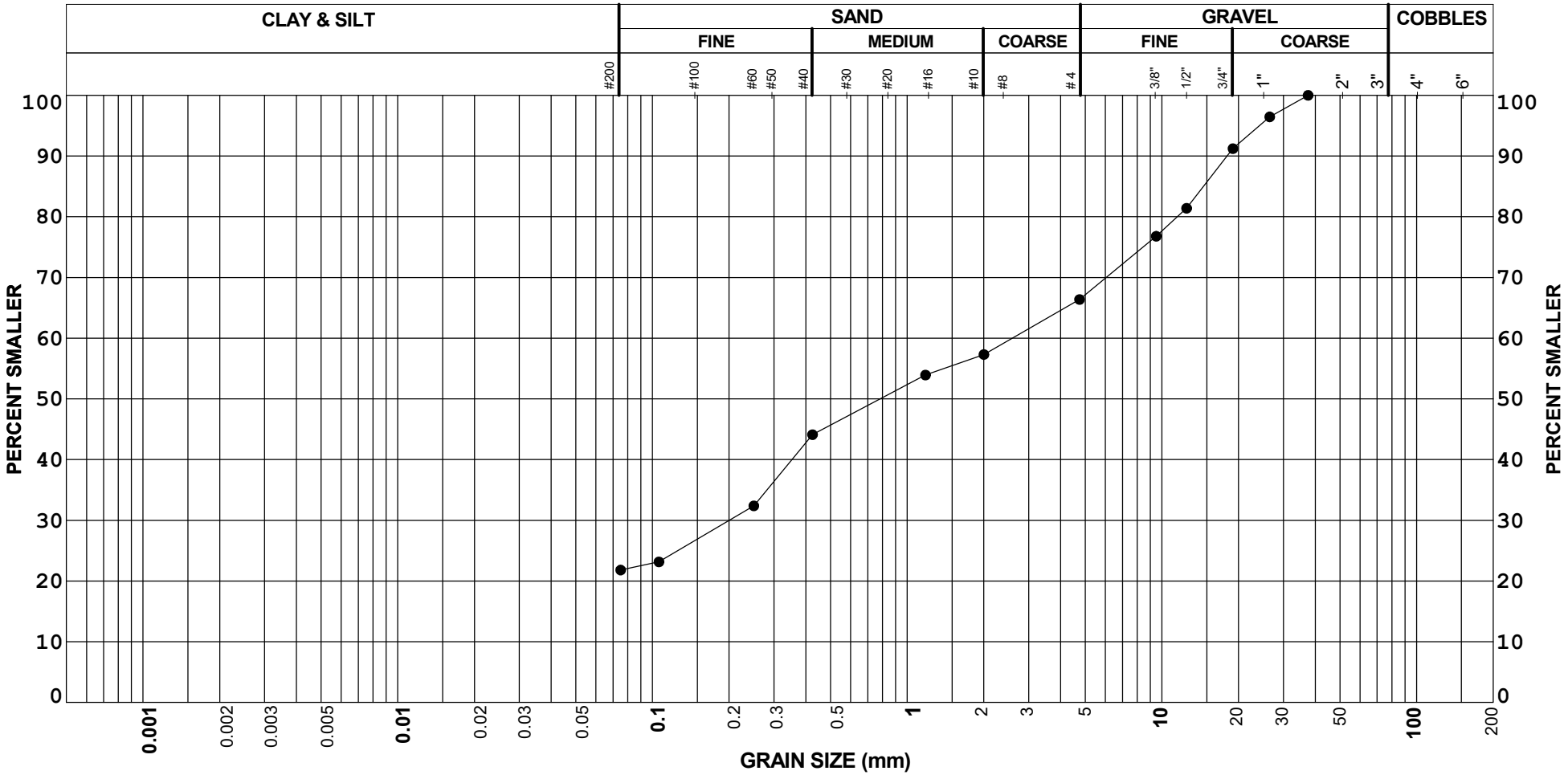
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-BR15-1	DS-2	2.60	34	44	22		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

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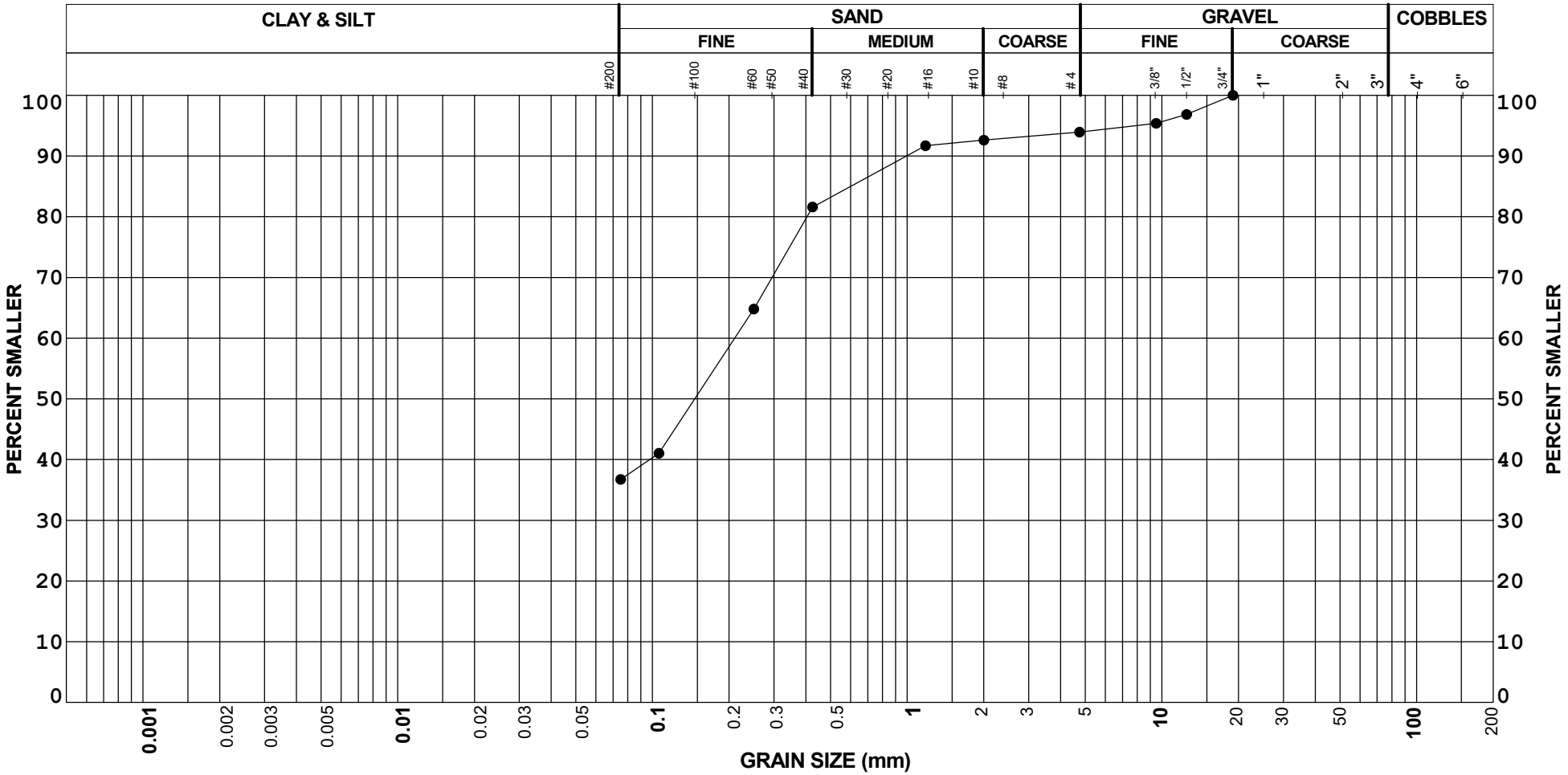
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-BR15-1	DS-3	3.90	6	57	37		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

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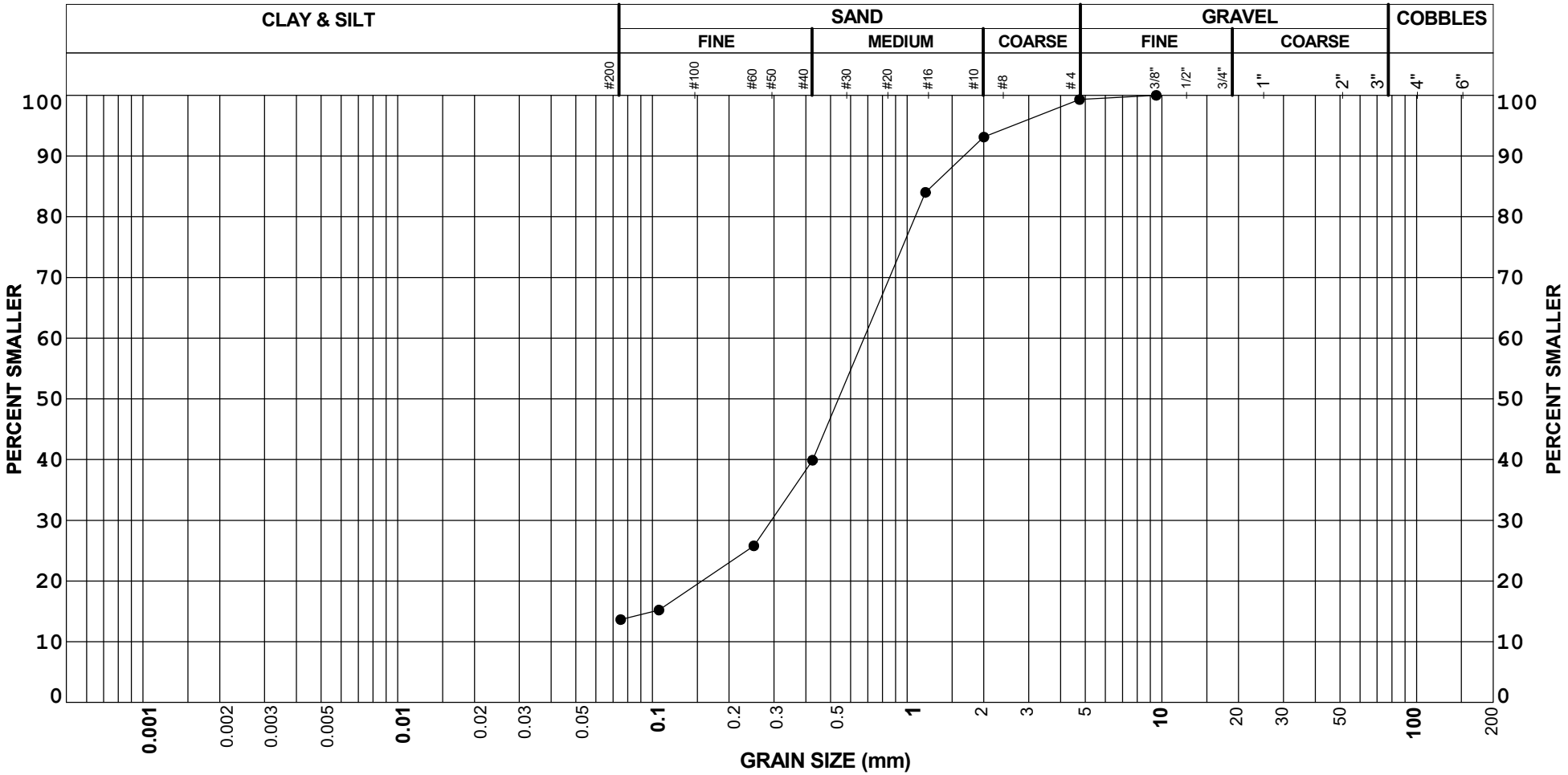
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-BR15-2	DS-1	1.20	1	85	14		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

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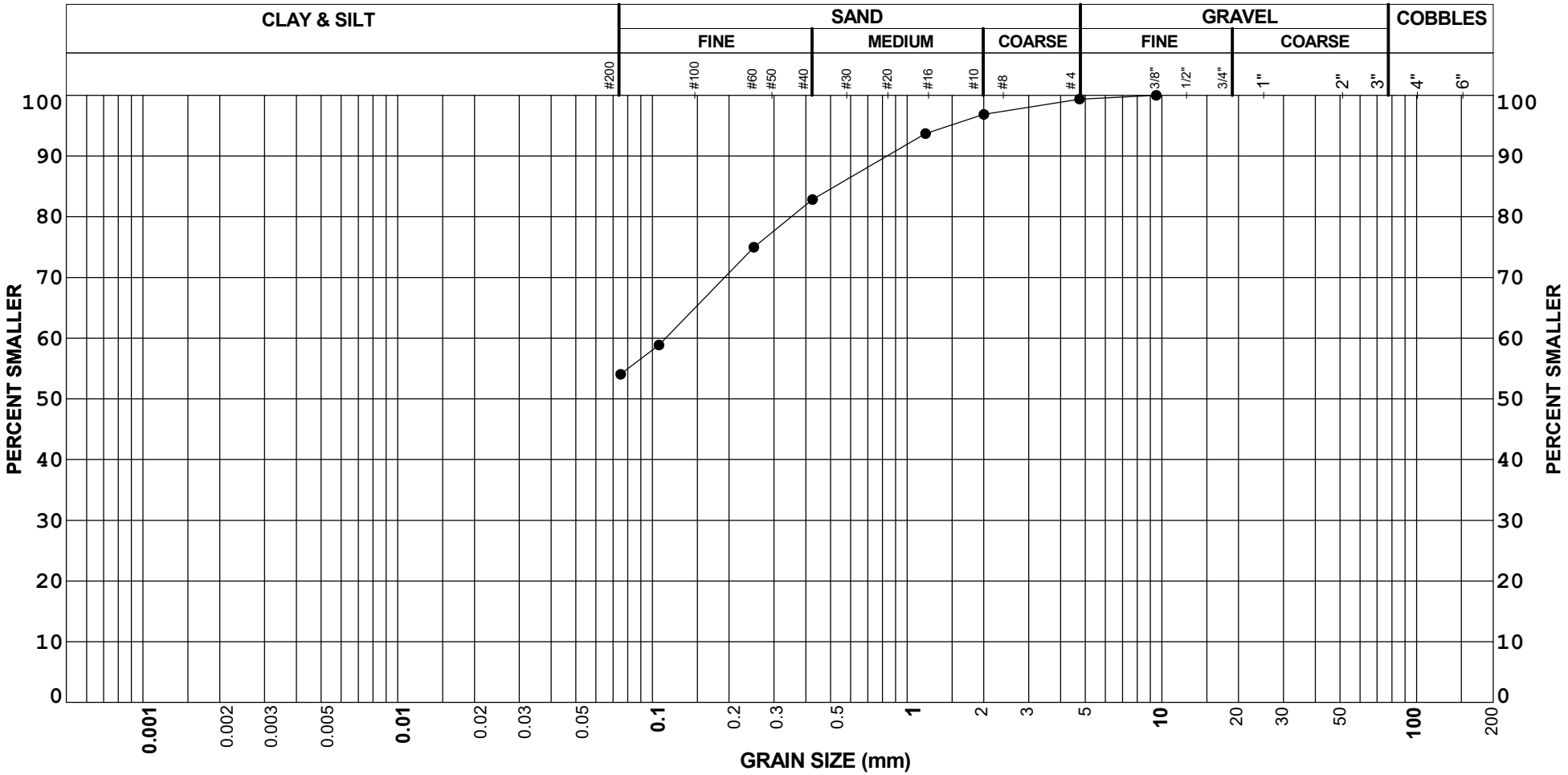
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-BR15-2	DS-3	2.00	1	45	54		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

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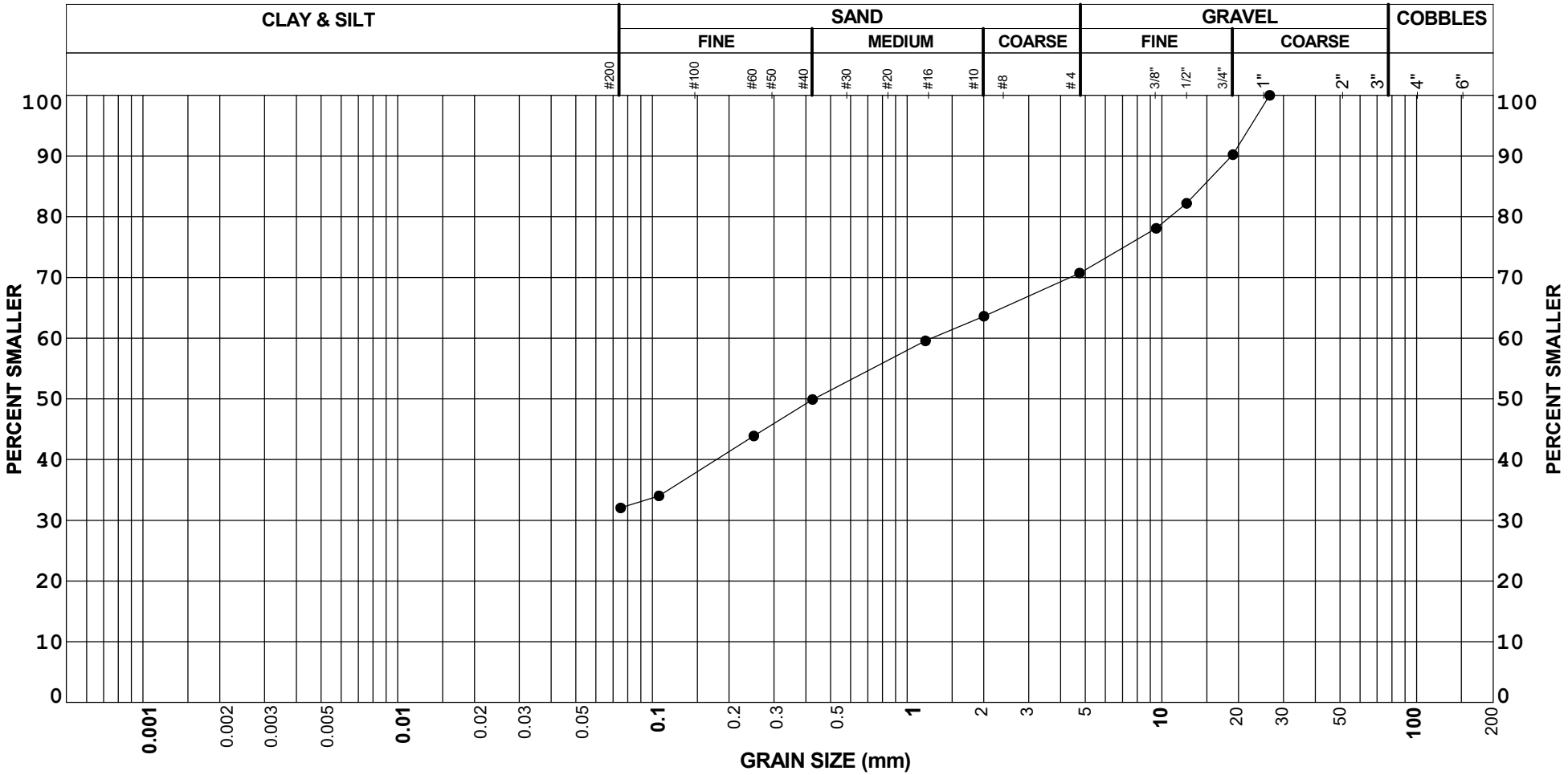
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-BR15-2	DS-5	2.55	29	39	32		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

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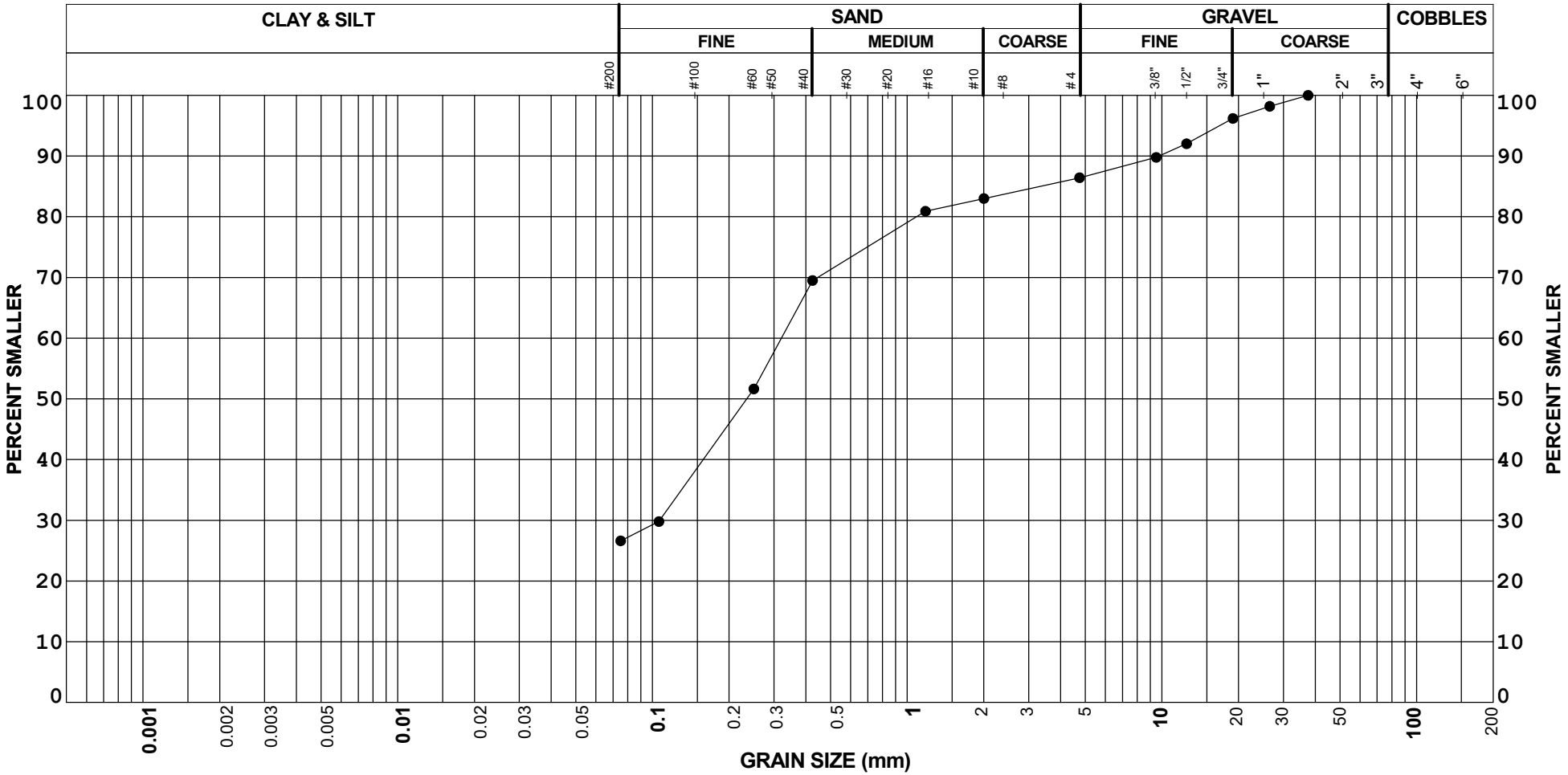
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-BR15-2	DS-7	4.20	14	60	26		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

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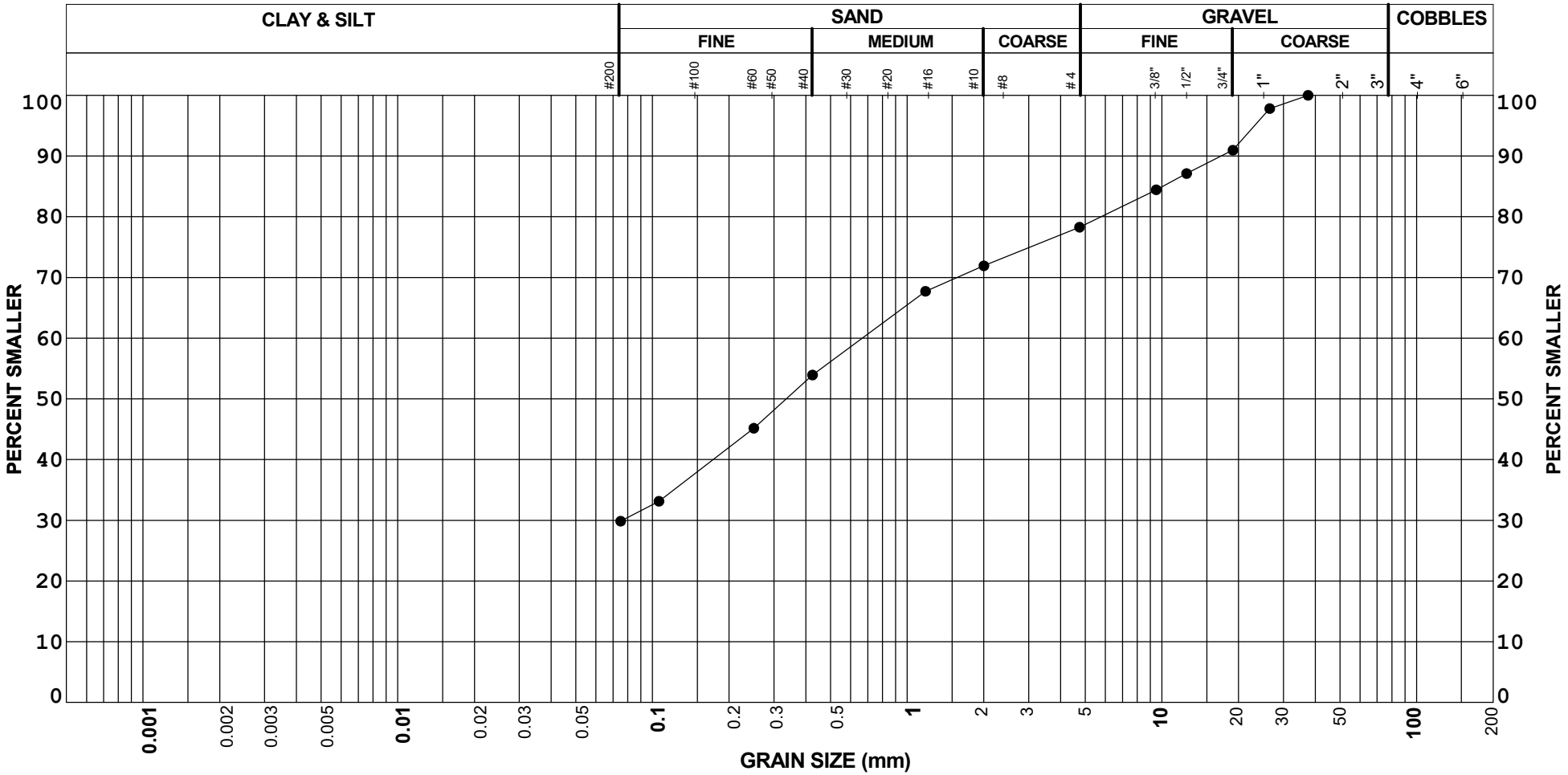
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-BR15-2	DS-8	5.80	22	48	30		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

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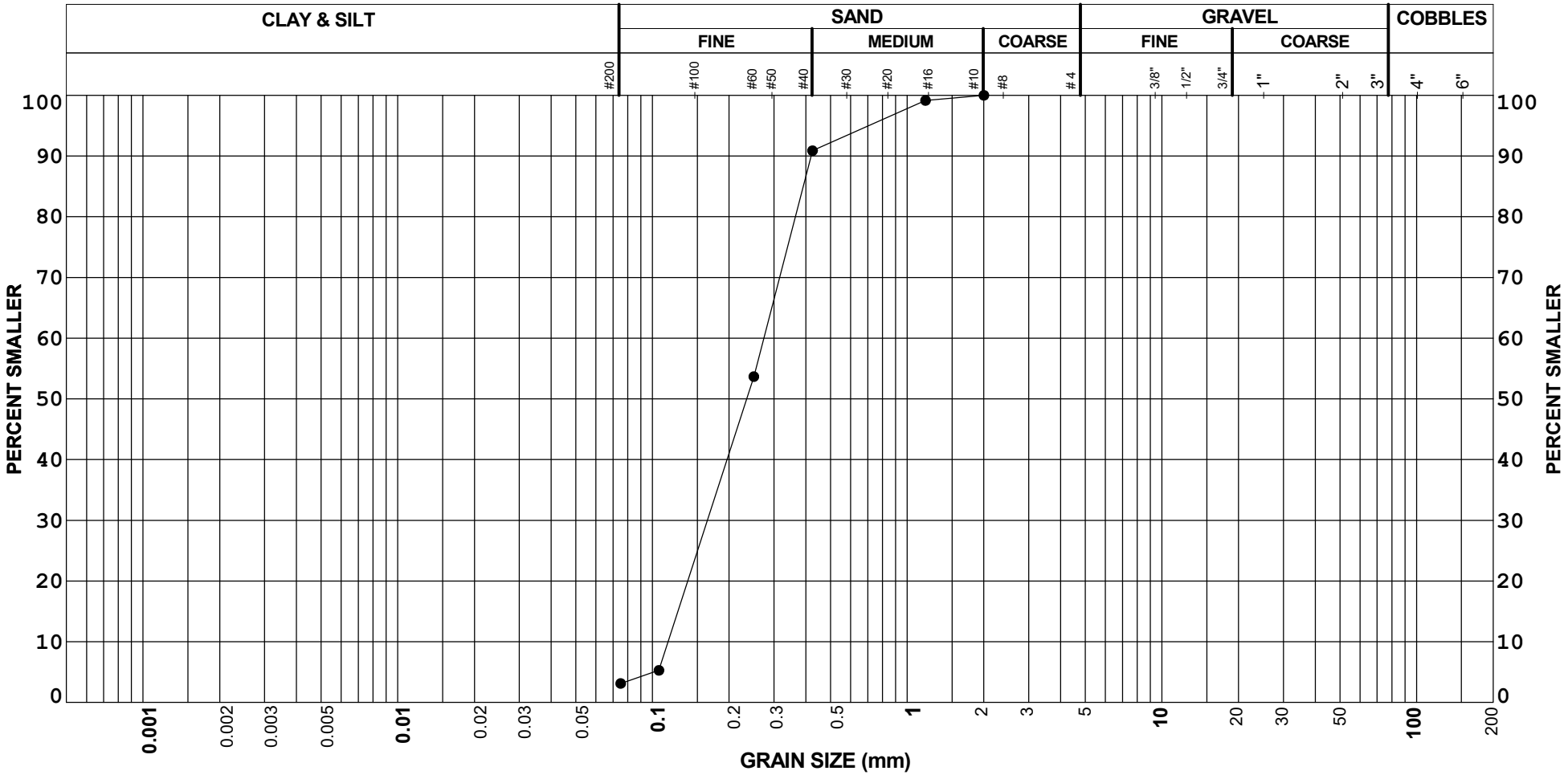
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-BR70-1	DS-2	2.60	0	97	3		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

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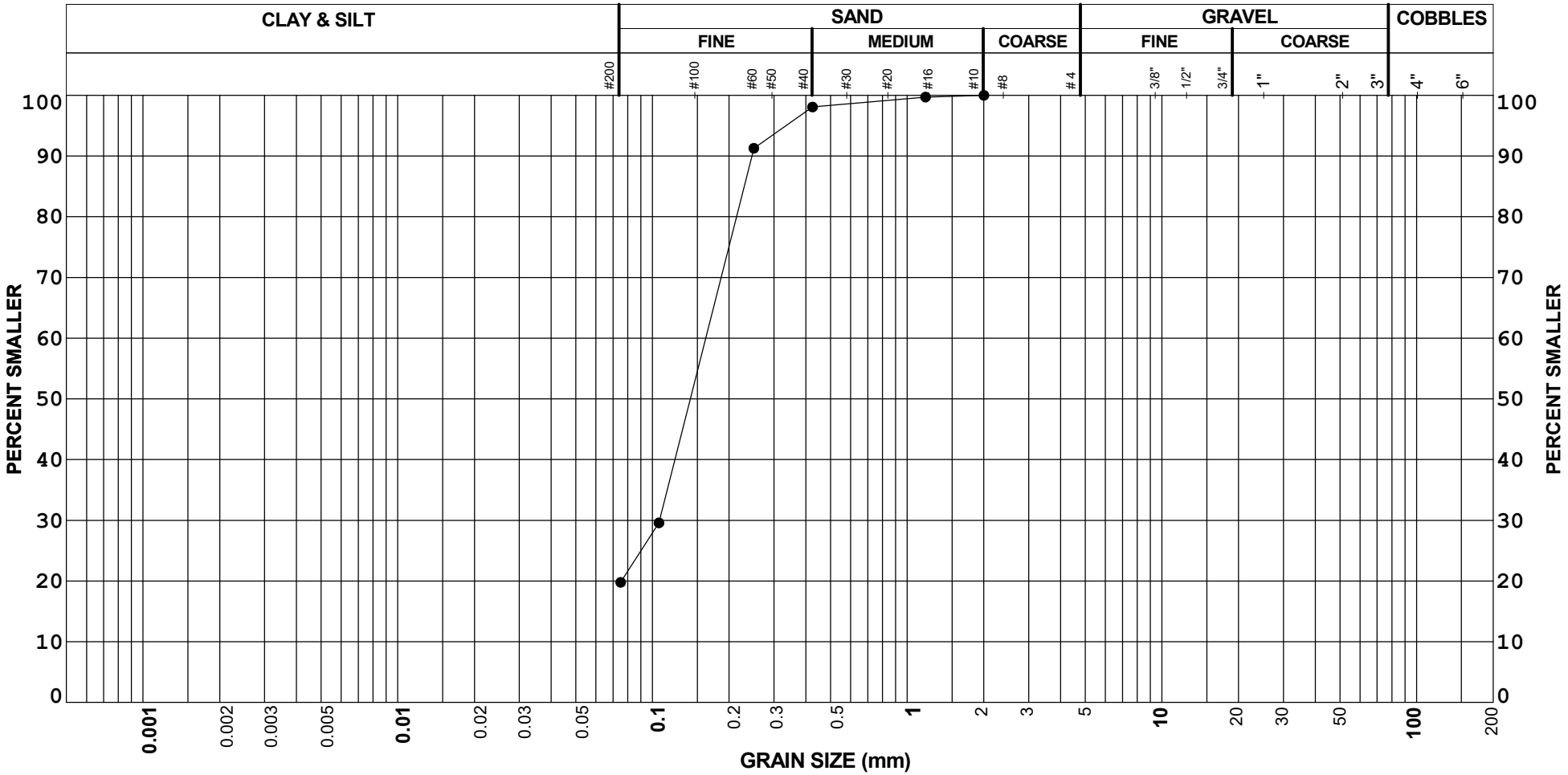
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-BR70-1	DS-4	6.80	0	80	20		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

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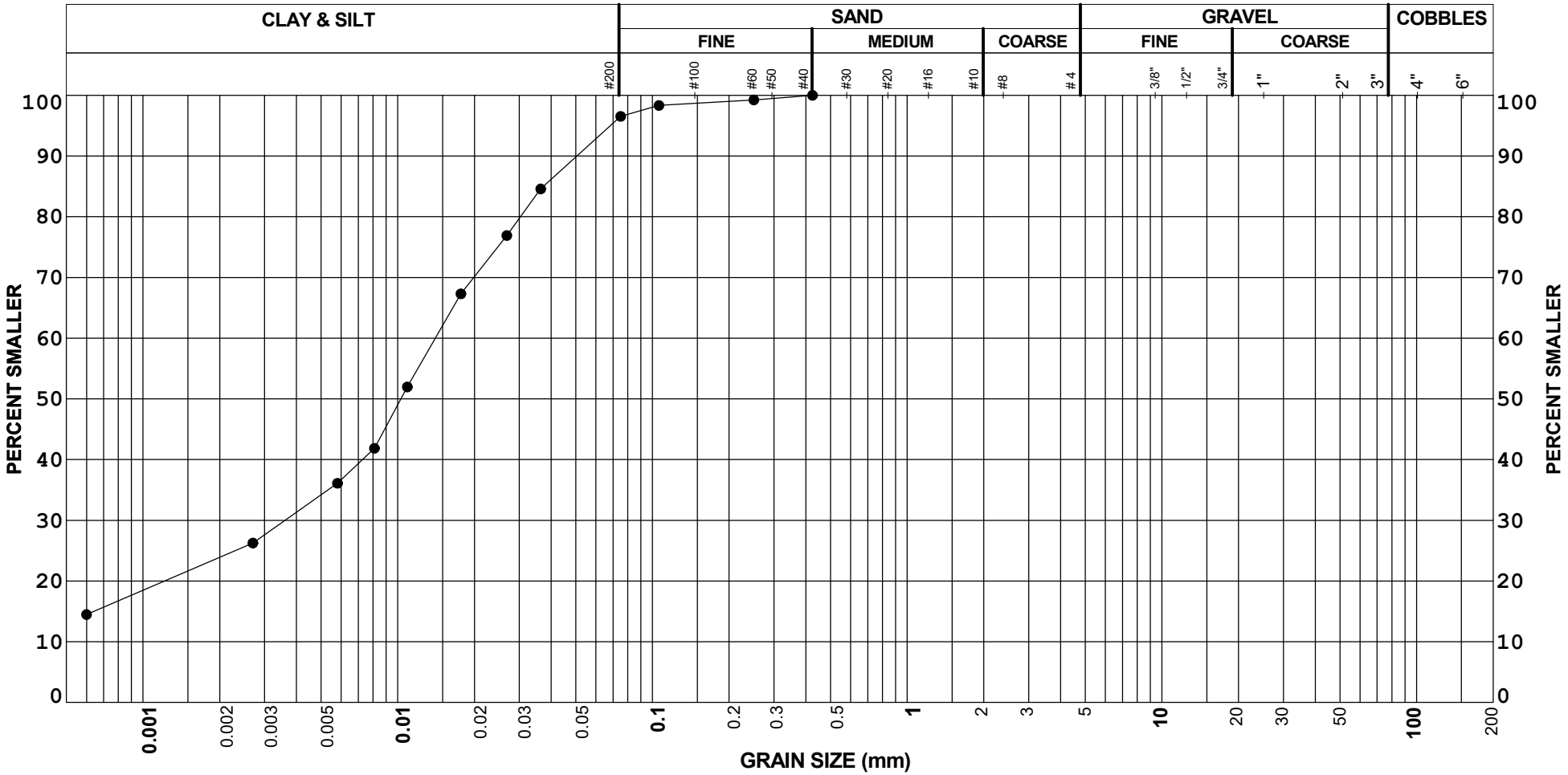
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-BR70-1	DS-5	9.44	0	3	97		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

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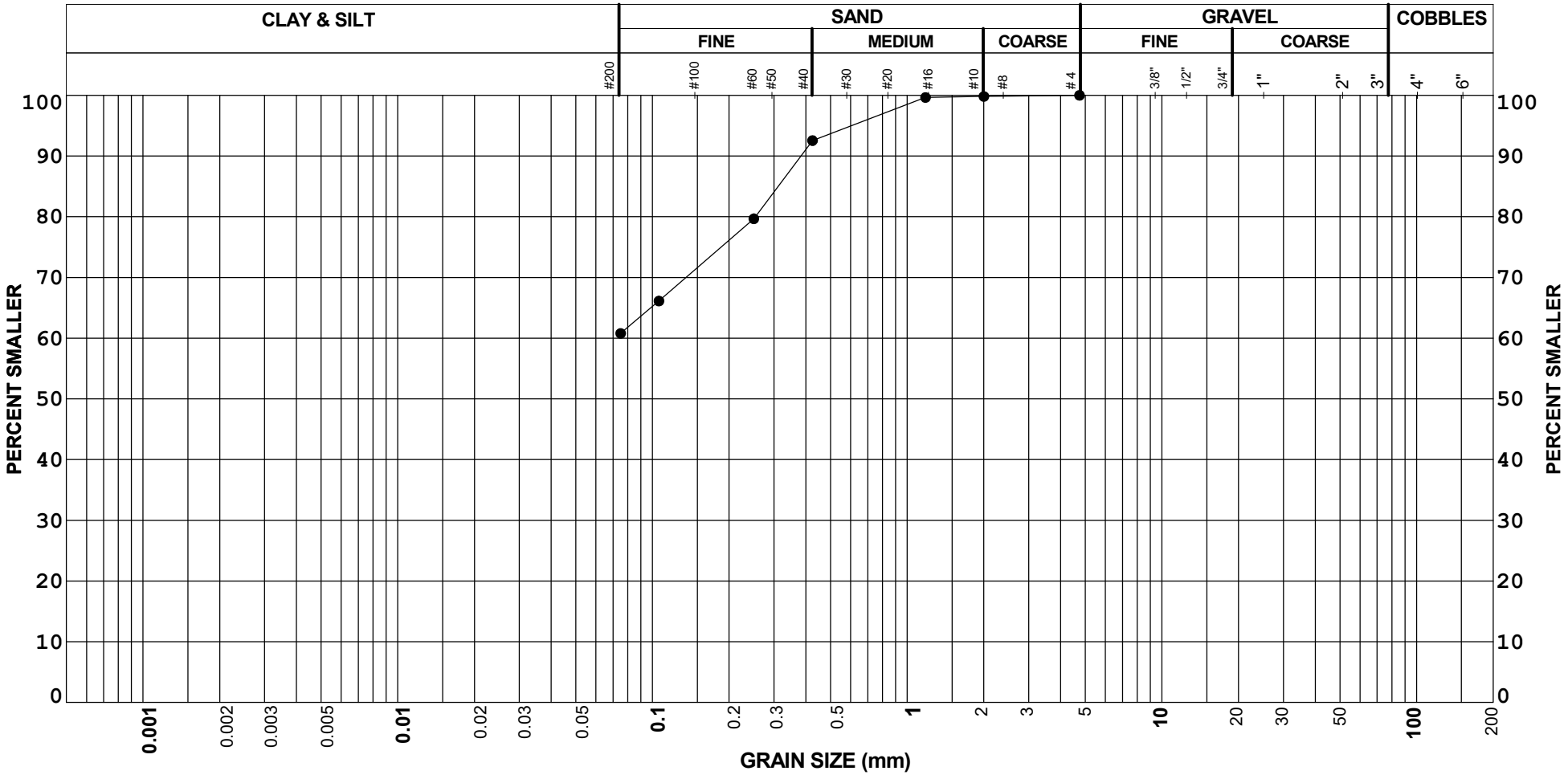
UNIFIED SOIL CLASSIFICATION SYSTEM



REMARKS:

BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-BR70-1	DS-6	11.30	0	39	61		

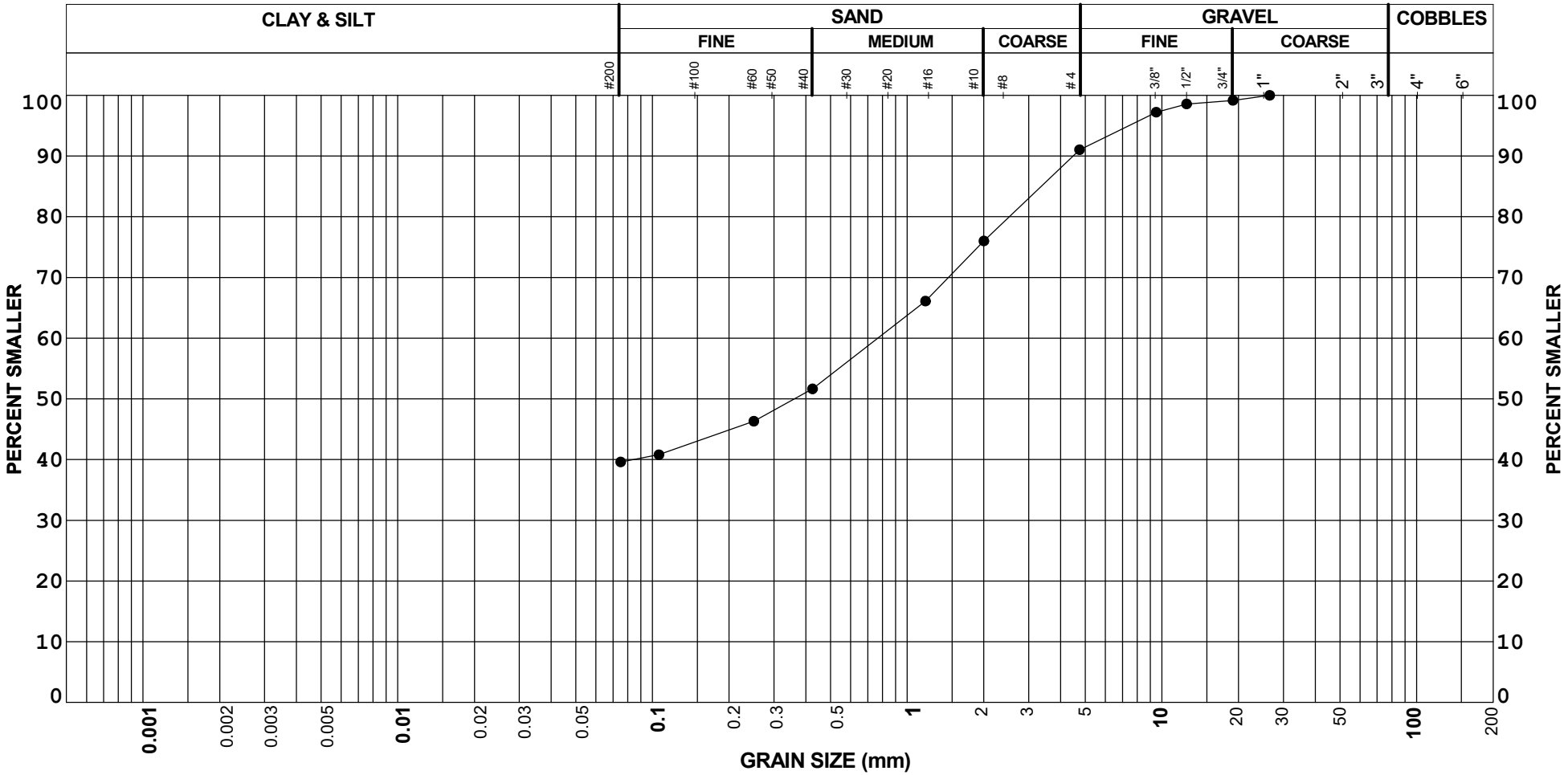
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-BR70-1	DS-8	14.60	9	51	40		

REMARKS:

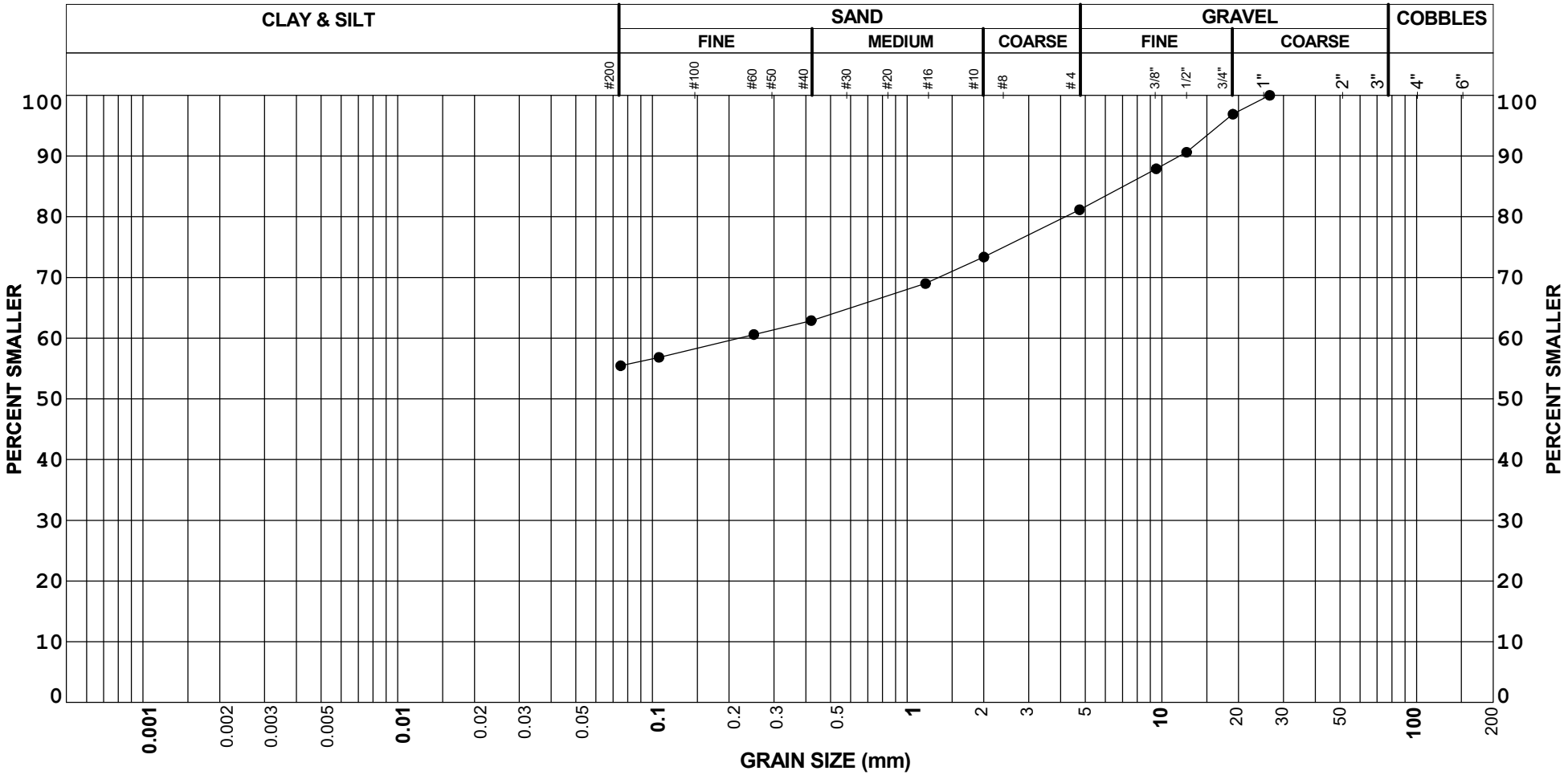
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-BR70-1	DQ-9	16.50	19	26	55		

REMARKS:

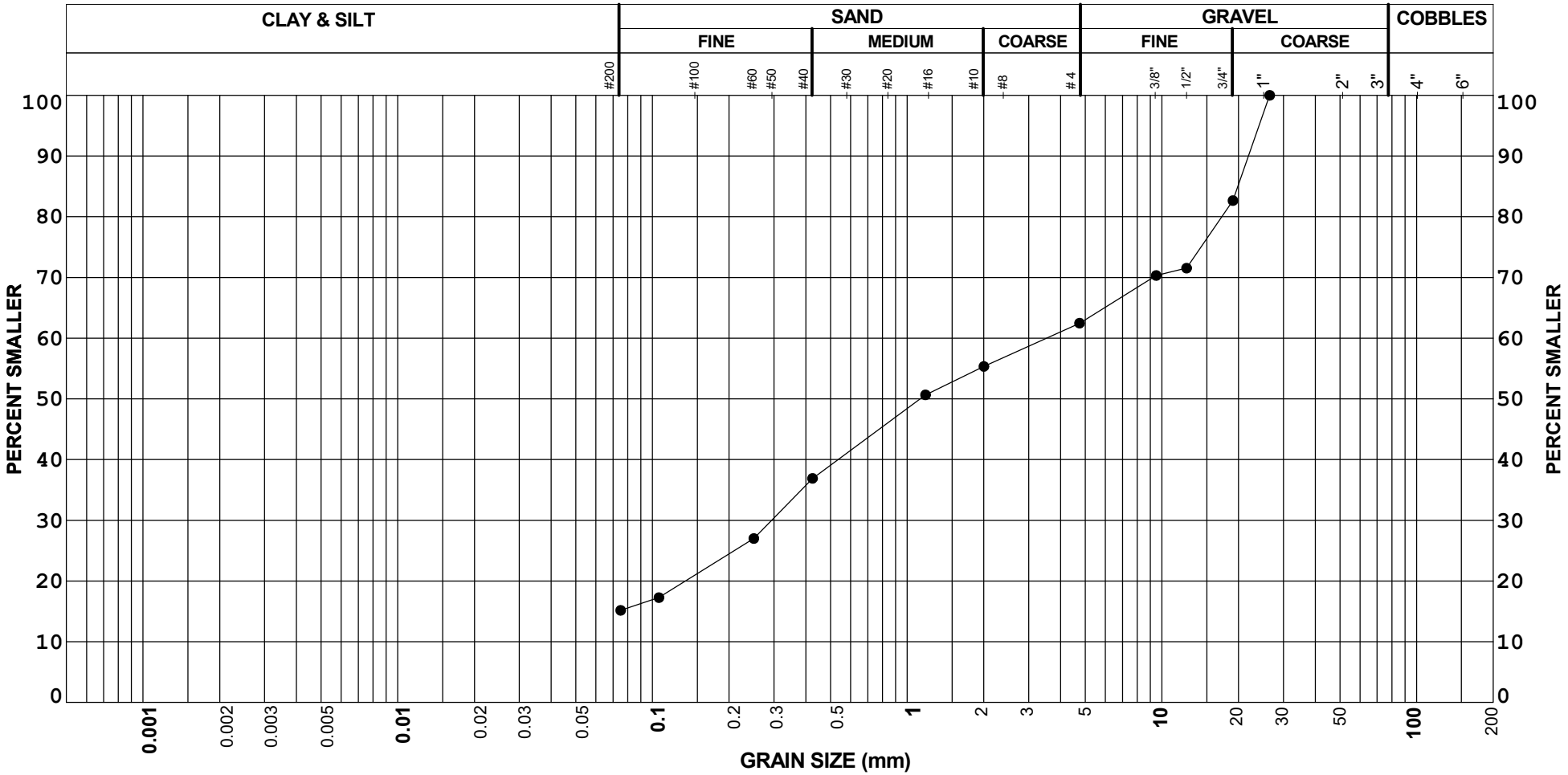
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-BR70-2	DS-1	0.80	38	47	15		

REMARKS:

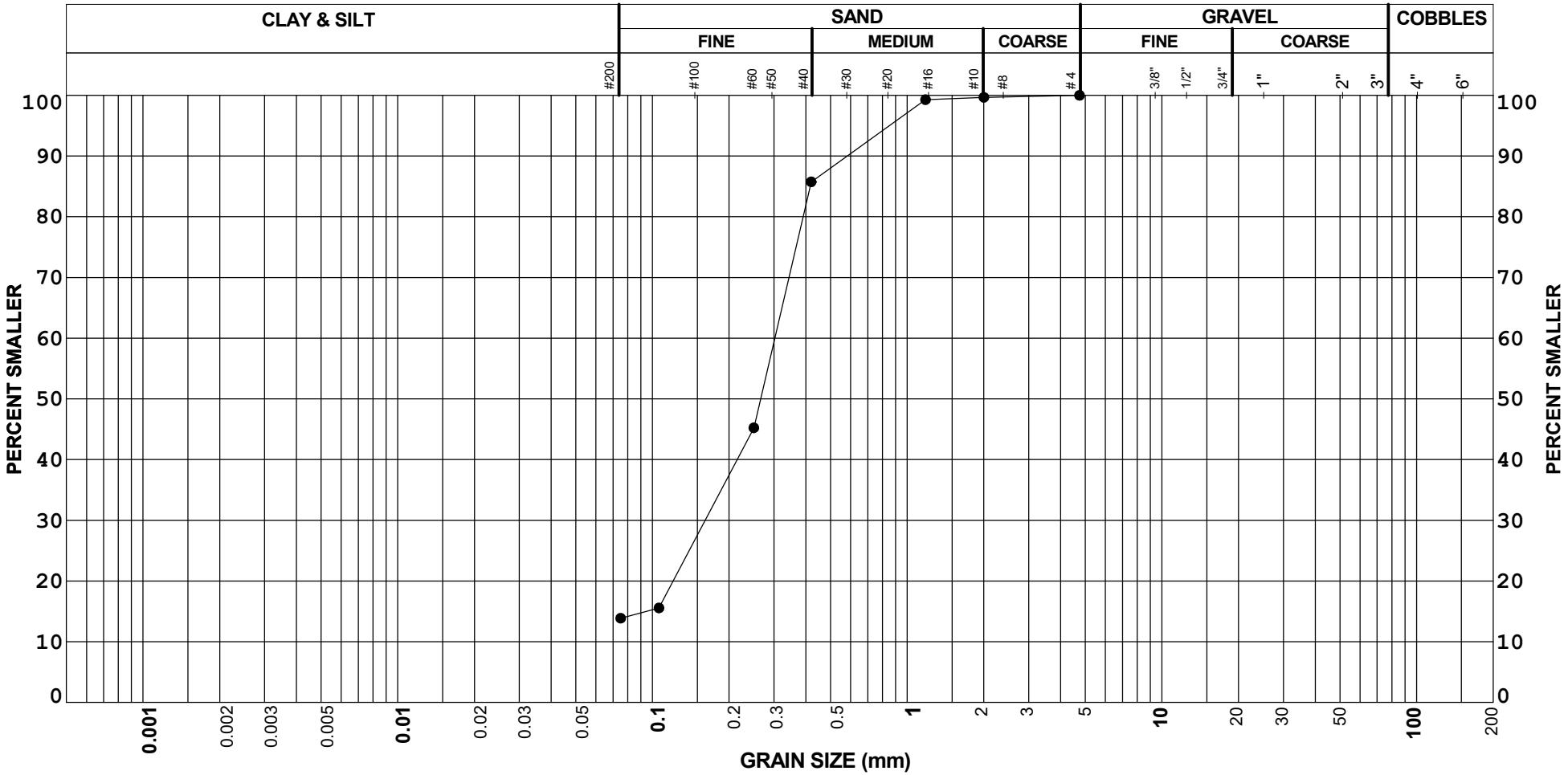
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-BR70-2	DQ-1	1.20	0	86	14		

REMARKS:

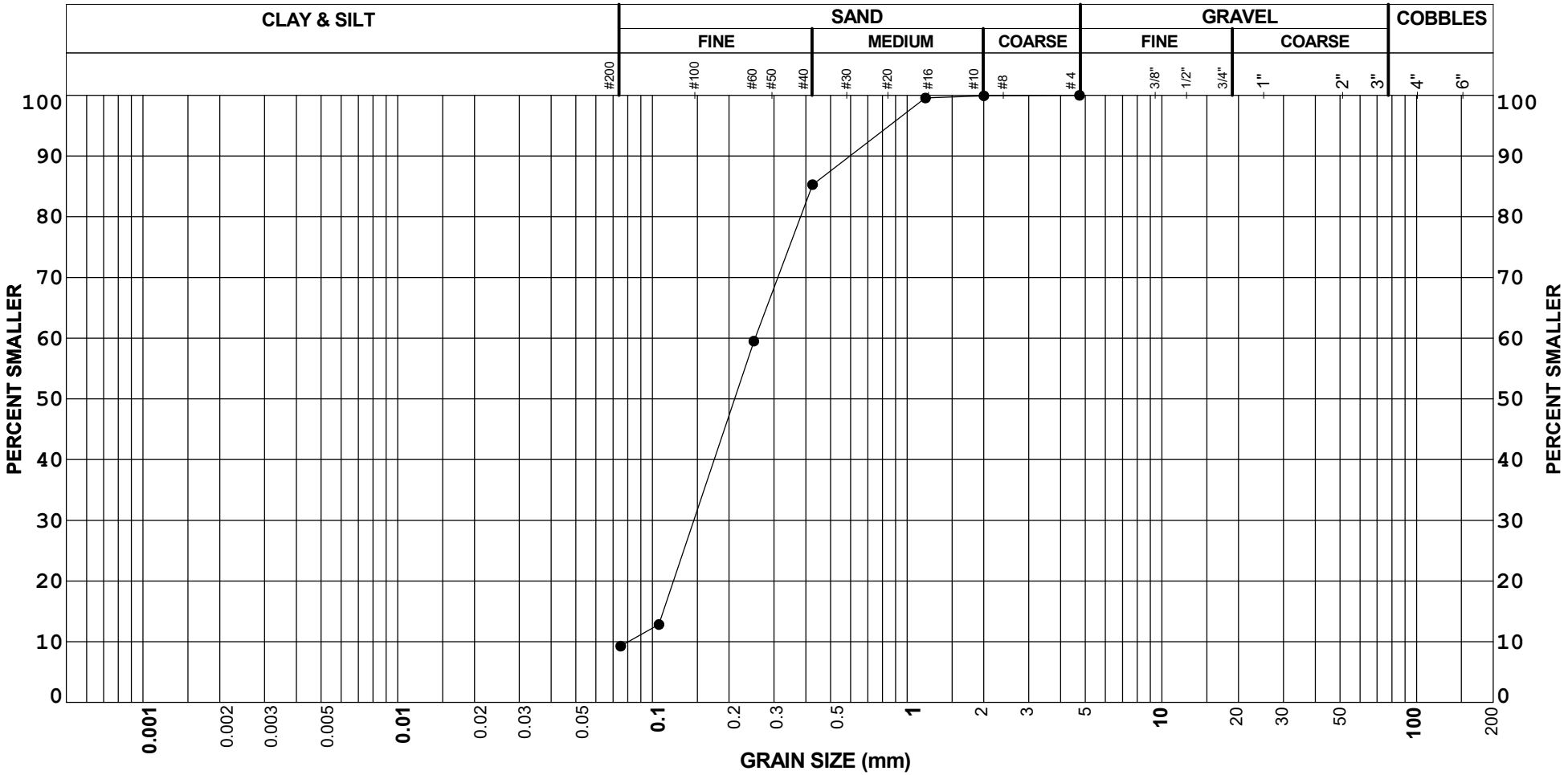
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-BR70-2	DS-2	3.20	0	91	9		

REMARKS:

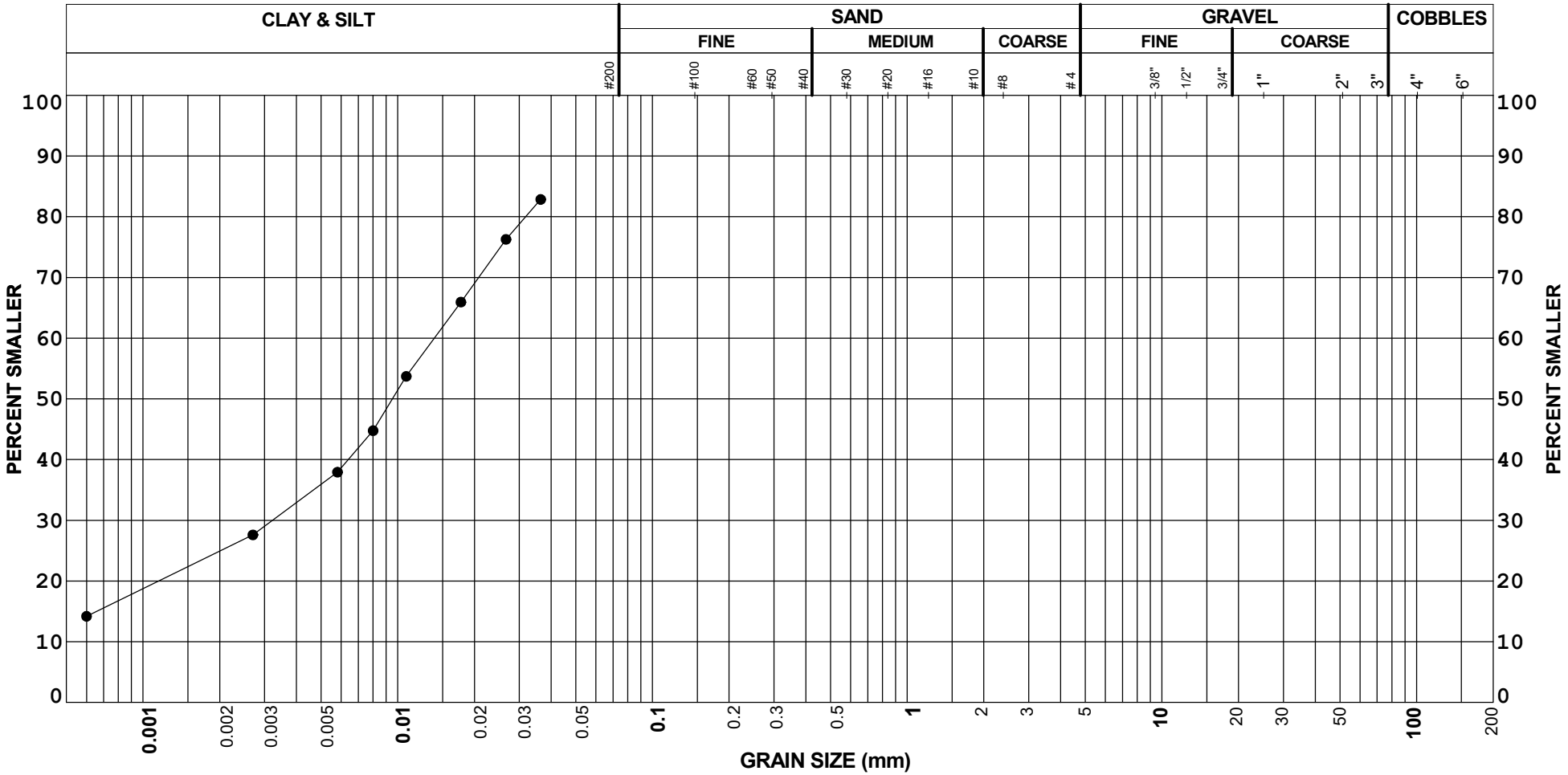
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-BR70-2	DQ-3	9.50					

REMARKS:

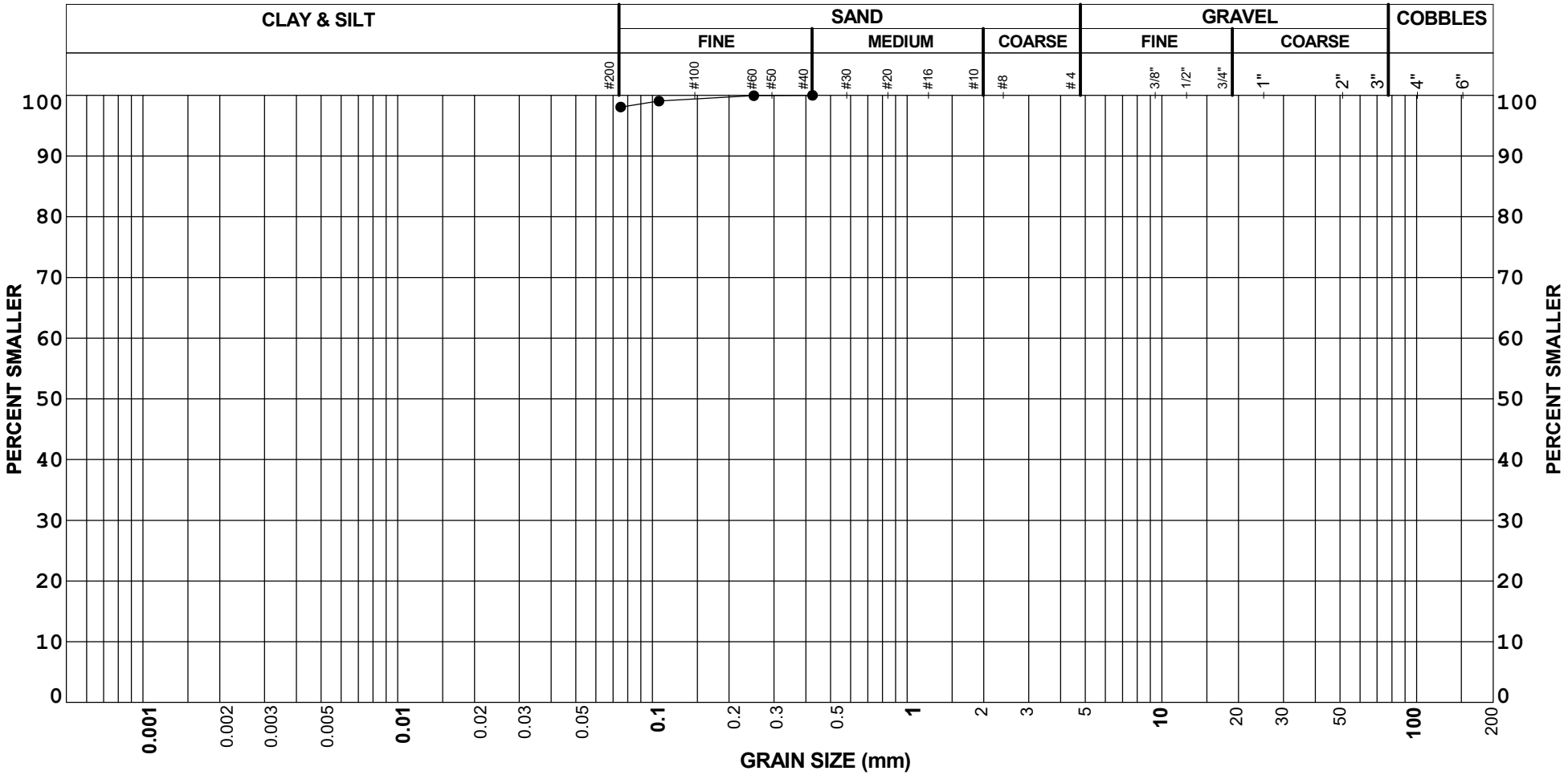
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-BR70-2	DS-5	19.60	0	2	98		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

Appendix E
Fence Diagrams

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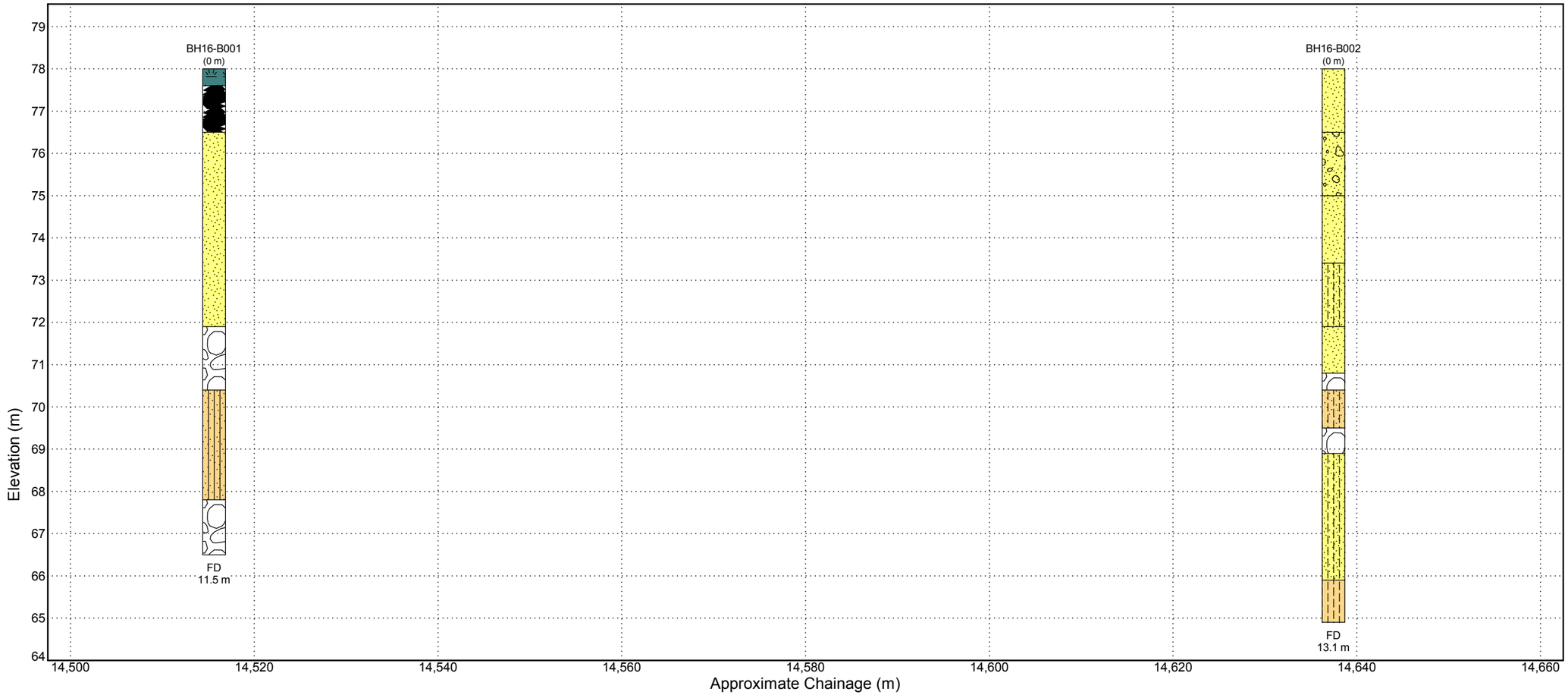
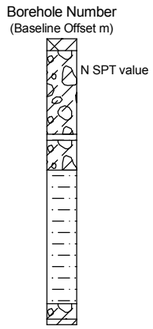


MAP KEY

- BH03 — INVESTIGATION ON SECTION
- TP03 — INVESTIGATION OFF SECTION
- SECTION LINES

POST LEGEND

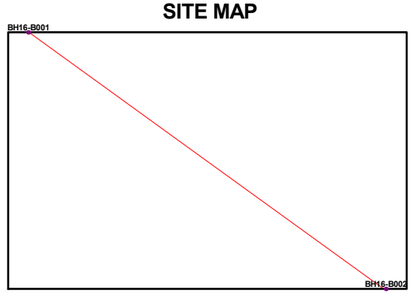


STRATAGRAPHIC BOUNDARIES

MATERIAL GRAPHICS

- PEAT
- Ice
- Poorly-graded SAND
- BOULDERS
- Elastic Sandy SILT
- Poorly-graded Gravelly SAND
- Silty SAND
- Sandy SILT
- SILT

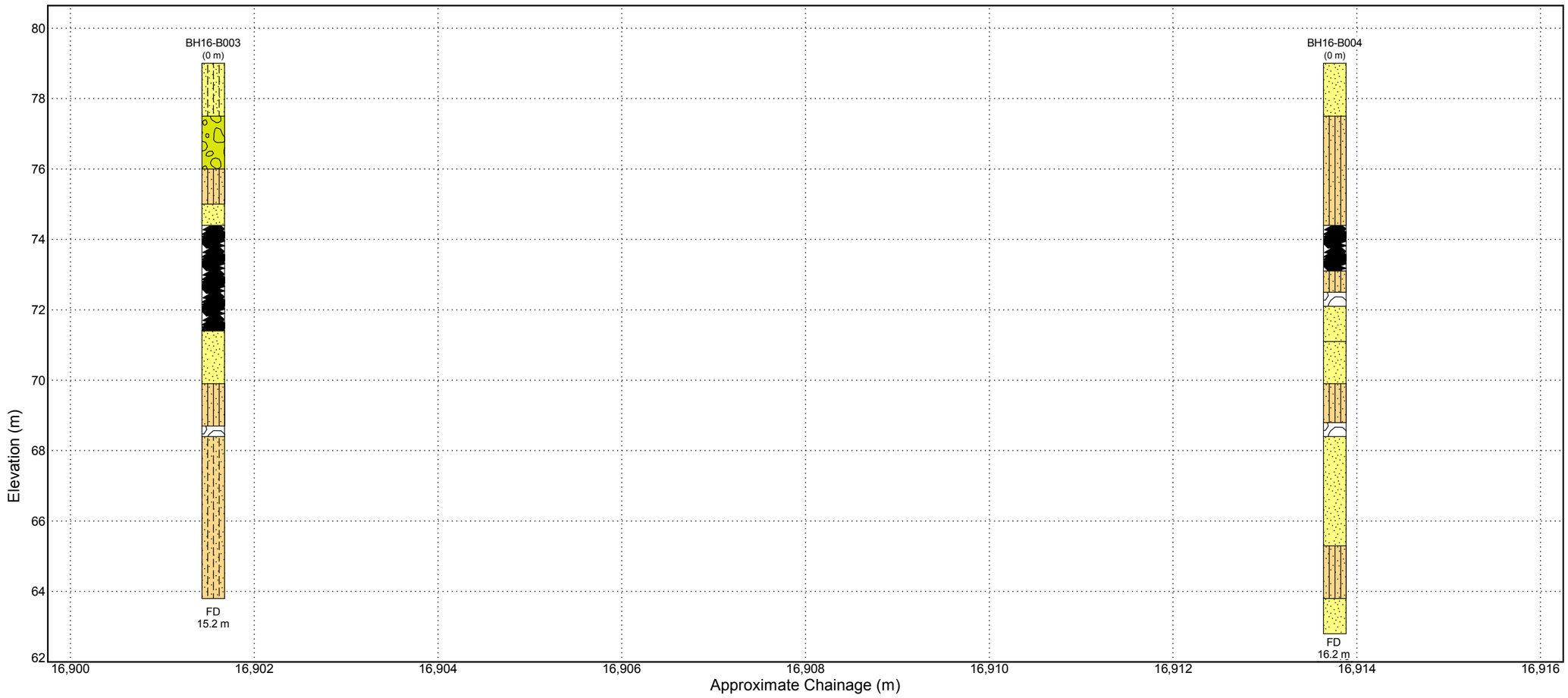
SITE MAP



H 1:492
0 5 10 15 20 25m
V 1:107
0 1 2 3 4 5m
Coord.System: UTM Zone 17 Height Datum: NAD83

HATCH

CLIENT Baffinland Iron Mines		PROJECT Mary River Expansion Study Stage 2	
DRAWN AB/CH	DATE 5/21/2017	TITLE BRIDGE No 1 FENCE DIAGRAM (1 OF 2)	
CHECKED WH	DATE 5/22/2017		
SCALE H 1:492 V 1:107 VE=5X		PROJECT No H352034	FIGURE No E1



MAP KEY

- BH03 — INVESTIGATION ON SECTION
- TP03 — INVESTIGATION OFF SECTION
- SECTION LINES

POST LEGEND

Borehole Number
(Baseline Offset m)

N SPT value

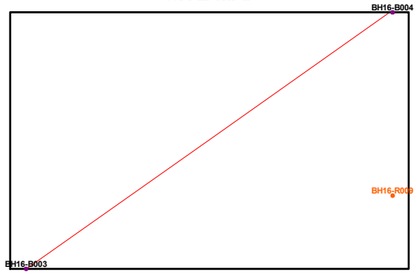
Final Depth m

STRATAGRAPHIC BOUNDARIES

MATERIAL GRAPHICS

- Silty SAND
- Poorly-graded GRAVEL
- Elastic Sandy SILT
- Poorly-graded SAND
- Ice
- BOULDERS
- Sandy SILT

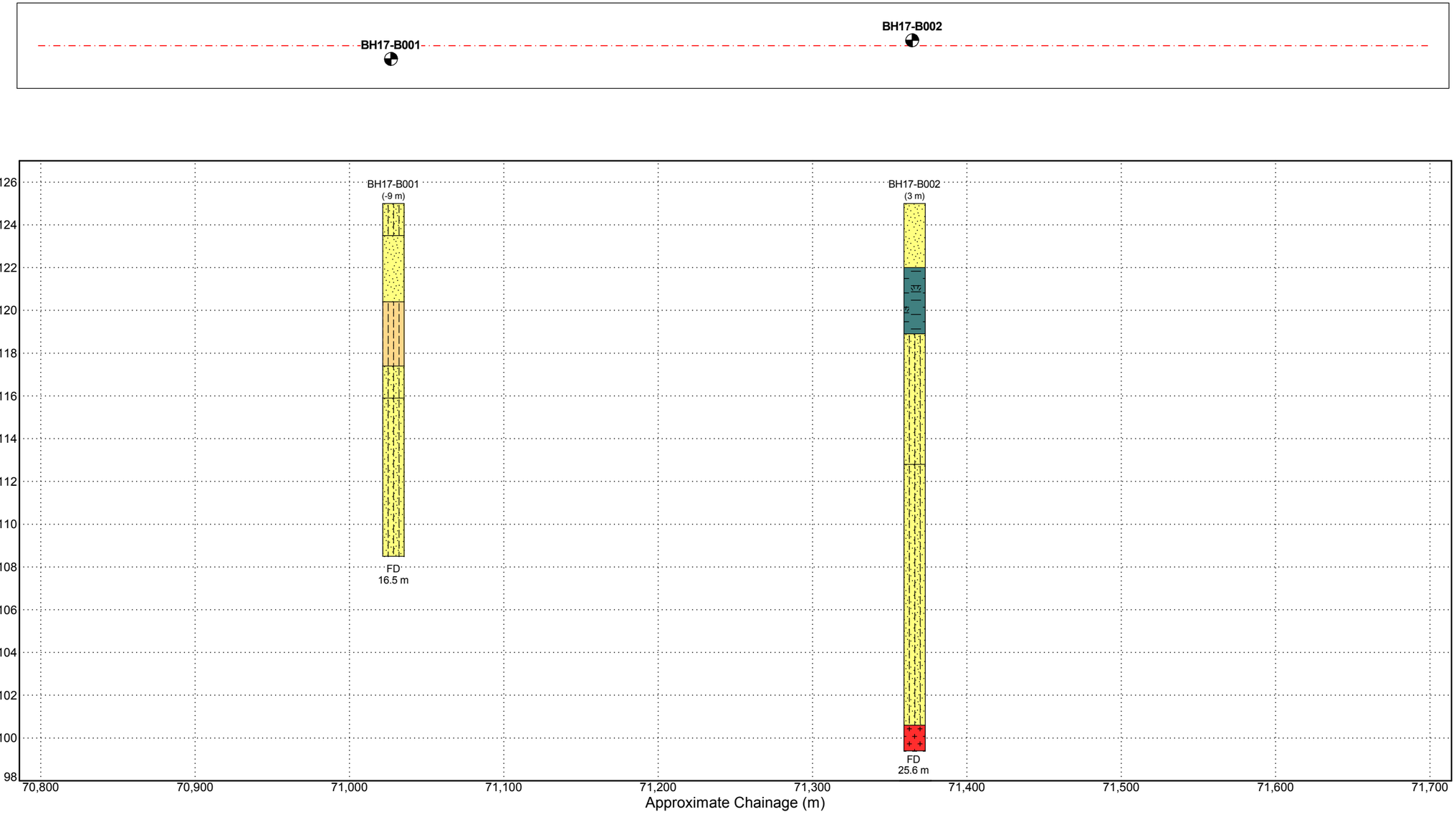
SITE MAP



H 1:49
0 0.5 1 1.5 2 2.5m
V 1:129
0 1 2 3 4 5m
Coord.System: UTM Zone 17 Height Datum: NAD83

HATCH

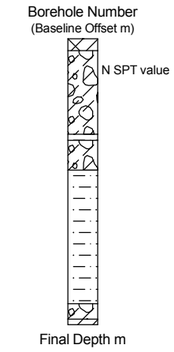
CLIENT Baffinland Iron Mines		PROJECT Mary River Expansion Study Stage 2	
DRAWN AB/CH	DATE 5/21/2017	TITLE BRIDGE No 1 FENCE DIAGRAM (2 OF 2)	
CHECKED WH	DATE 5/22/2017		
SCALE H 1:49 V 1:129 VE=0X		PROJECT No H352034	FIGURE No E2



MAP KEY

- BH03 — INVESTIGATION ON SECTION
- TP03 — INVESTIGATION OFF SECTION
- SECTION LINES

POST LEGEND

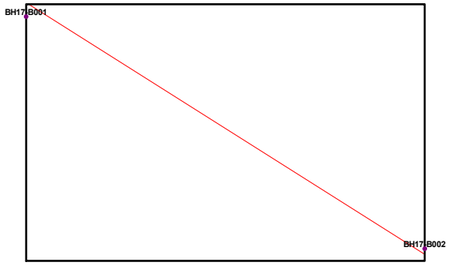


STRATAGRAPHIC BOUNDARIES

MATERIAL GRAPHICS

- Silty SAND
- Poorly-graded SAND
- SILT
- Organic SILT or CLAY
- Inferred Bedrock

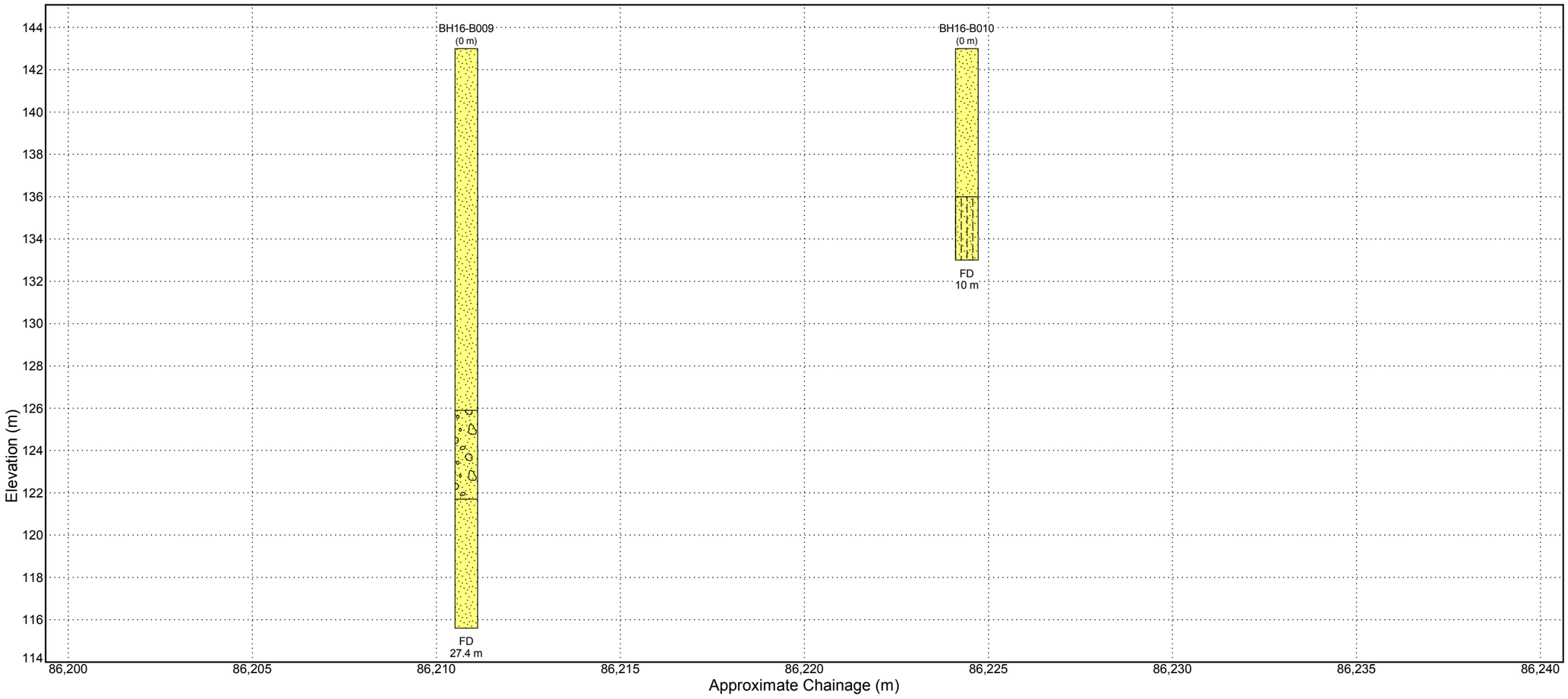
SITE MAP



H 1:2769
0 30 60 90 120 150m
V 1:200
0 2 4 6 8 10m
Coord.System: UTM Zone 17 Height Datum: NAD83

HATCH

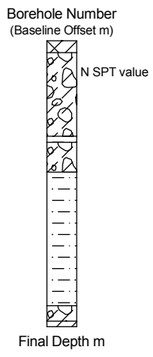
CLIENT: Baffinland Iron Mines		PROJECT: Mary River Expansion Study Stage 2	
DRAWN: AB/CH	DATE: 5/21/2017	TITLE: BRIDGE No 2 FENCE DIAGRAM	
CHECKED: WH	DATE: 5/22/2017		
SCALE: H 1:2769 V 1:200 VE=14X		PROJECT No: H352034	FIGURE No: E3



MAP KEY

- BH03 — INVESTIGATION ON SECTION
- TP03 — INVESTIGATION OFF SECTION
- SECTION LINES

POST LEGEND

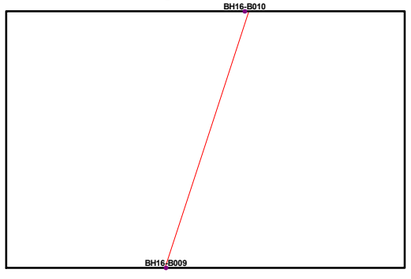


STRATAGRAPHIC BOUNDARIES

MATERIAL GRAPHICS

- Poorly-graded SAND
- Poorly-graded Gravelly SAND
- Silty SAND

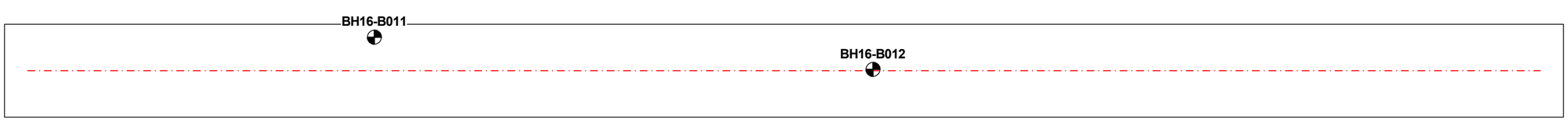
SITE MAP

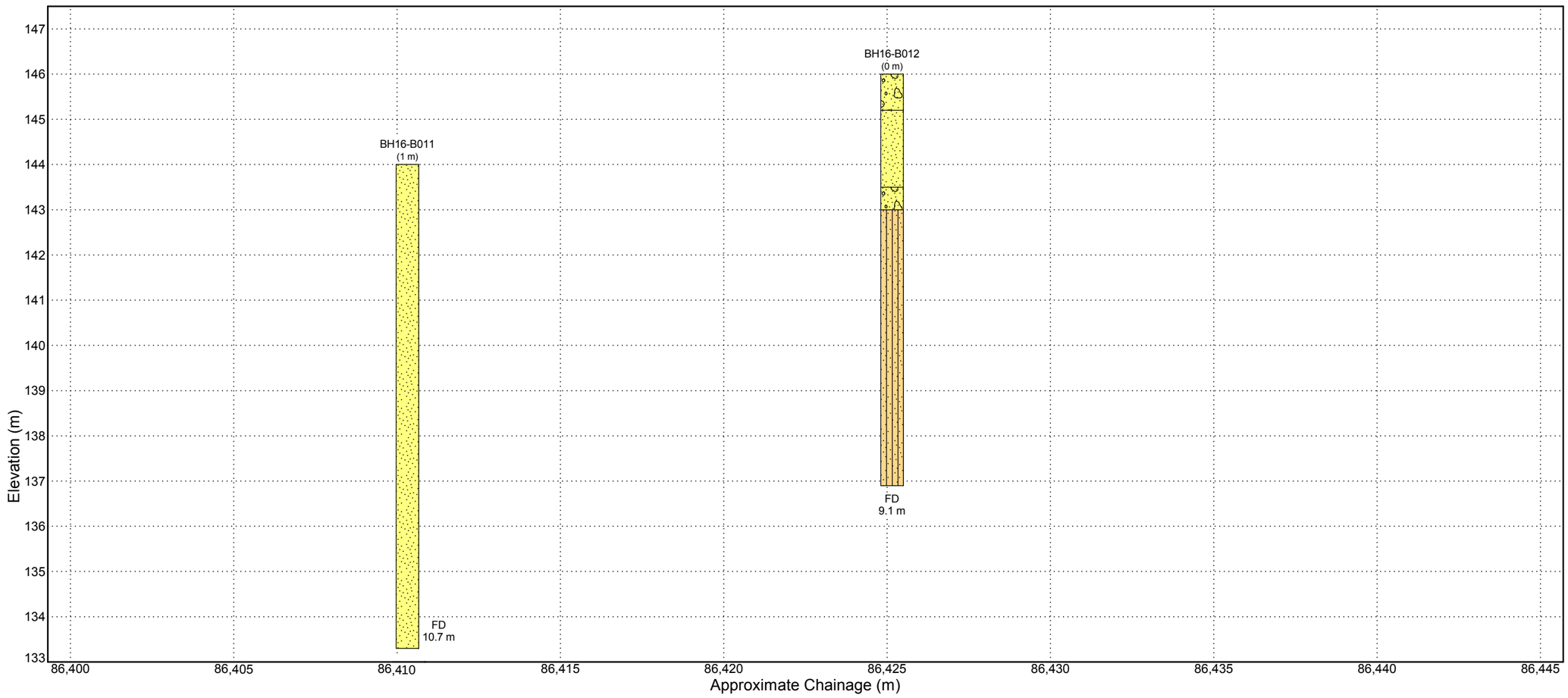


H 1:123
0 1 2 3 4 5m
V 1:214
0 2 4 6 8 10m
Coord.System: UTM Zone 17 Height Datum: NAD83

HATCH

CLIENT Baffinland Iron Mines		PROJECT Mary River Expansion Study Stage 2	
DRAWN AB/CH	DATE 5/23/2017	TITLE BRIDGE No 3 FENCE DIAGRAM (1 OF 2)	
CHECKED WH	DATE 5/23/2017		
SCALE H 1:123 V 1:214 VE=1X		PROJECT No H352034	FIGURE No E4

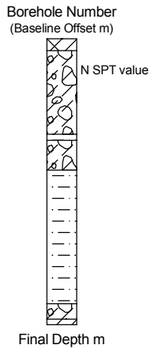




MAP KEY

- BH03 — INVESTIGATION ON SECTION
- TP03 — INVESTIGATION OFF SECTION
- SECTION LINES

POST LEGEND

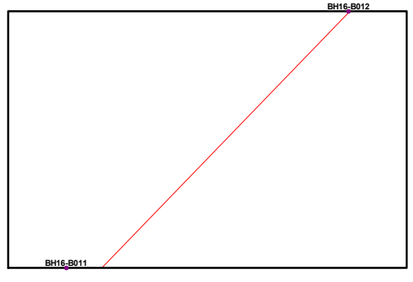


STRATAGRAPHIC BOUNDARIES

MATERIAL GRAPHICS

- Poorly-graded SAND
- Poorly-graded Gravelly SAND
- Elastic Sandy SILT

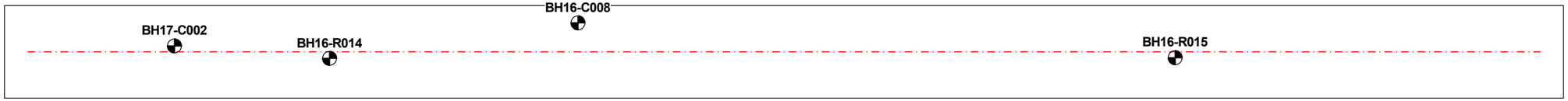
SITE MAP

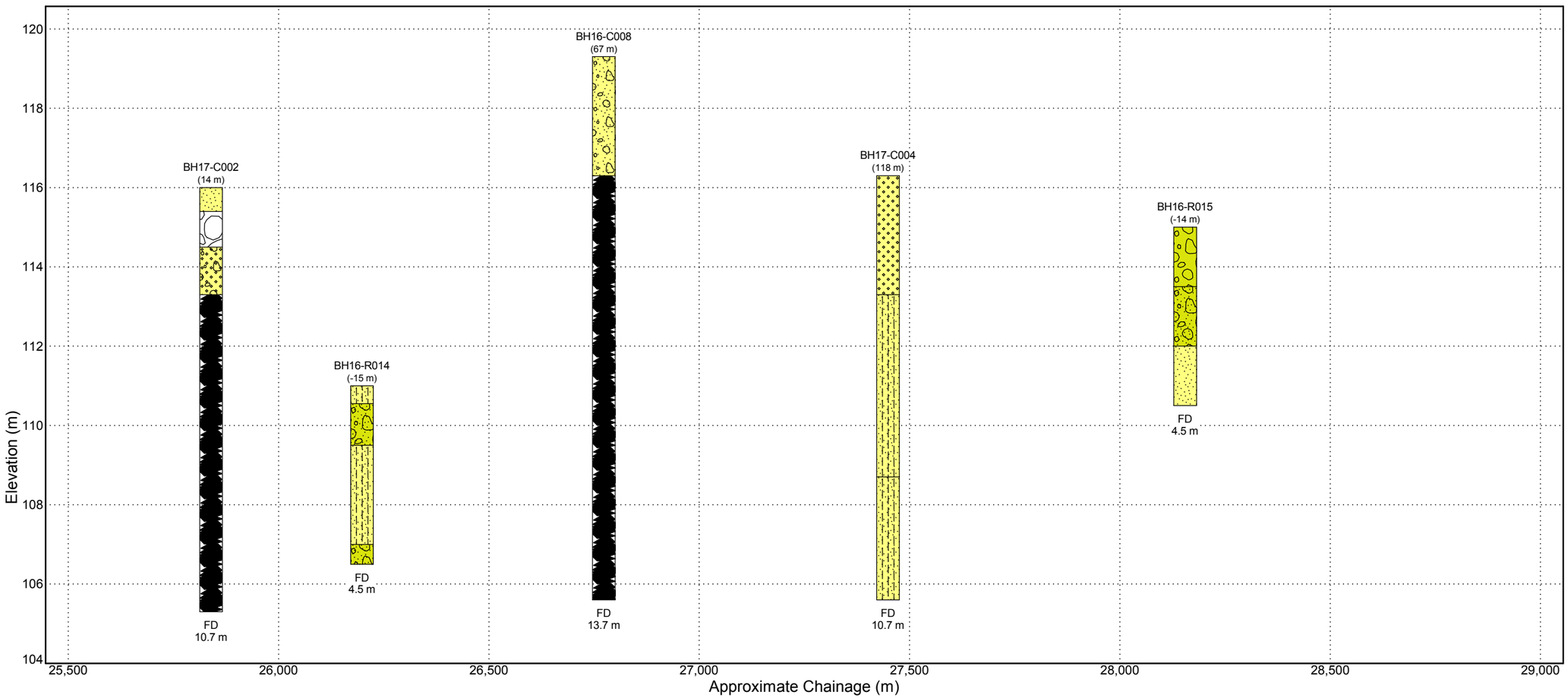


H 1:138
0 1 2 3 4 5m
V 1:100
0 1 2 3 4 5m
Coord.System: UTM Zone 17 Height Datum: NAD83

HATCH

CLIENT Baffinland Iron Mines		PROJECT Mary River Expansion Study Stage 2	
DRAWN AB/CH	DATE 5/23/2017	TITLE BRIDGE No 3 FENCE DIAGRAM (2 OF 2)	
CHECKED WH	DATE 5/23/2017		
SCALE H 1:138 V 1:100 VE=1X		PROJECT No H352034	FIGURE No E5

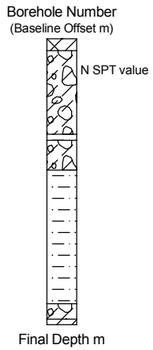




MAP KEY

- BH03 — INVESTIGATION ON SECTION
- TP03 — INVESTIGATION OFF SECTION
- SECTION LINES

POST LEGEND

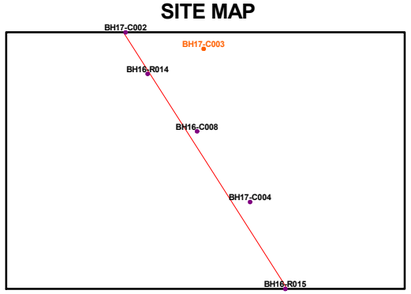


STRATAGRAPHIC BOUNDARIES

MATERIAL GRAPHICS

- Poorly-graded Gravelly SAND
- Poorly-graded SAND
- Ice
- BOULDERS
- Silty SAND
- Well-graded Gravelly SAND
- Poorly-graded Sandy GRAVEL
- Well-graded SAND
- Poorly-graded GRAVEL

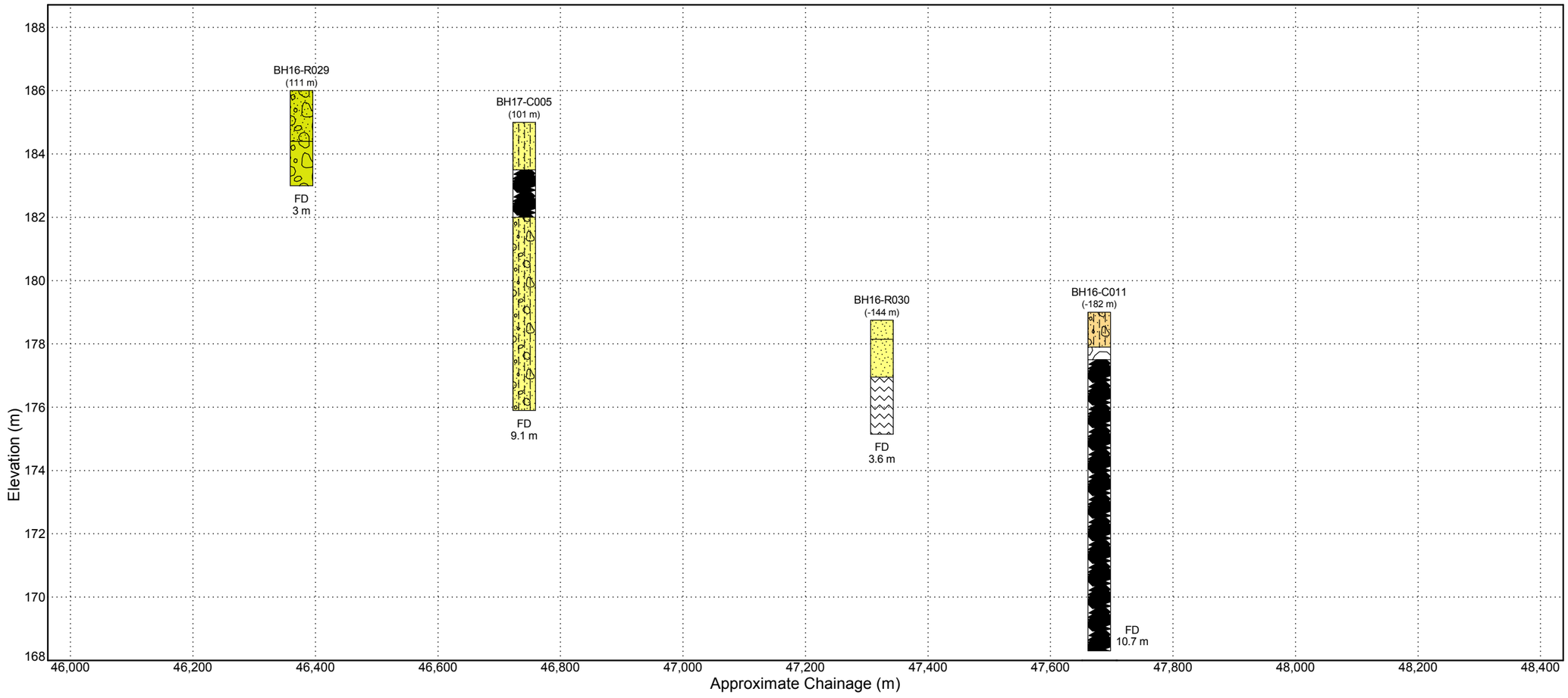
SITE MAP



H 1:10769
0 100 200 300 400 500m
V 1:114
0 1 2 3 4 5m
Coord.System: UTM Zone 17 Height Datum: NAD83

HATCH

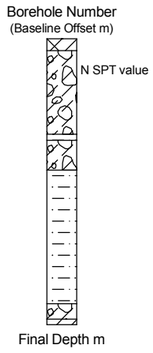
CLIENT Baffinland Iron Mines		PROJECT Mary River Expansion Study Stage 2	
DRAWN AB/CH	DATE 6/21/2017	TITLE ICE RICH AREA 1	
CHECKED WH	DATE 6/21/2017		
SCALE H 1:10769 V 1:114 VE=94X		PROJECT No H352034	FIGURE No E6



MAP KEY

- BH03 — INVESTIGATION ON SECTION
- TP03 — INVESTIGATION OFF SECTION
- SECTION LINES

POST LEGEND

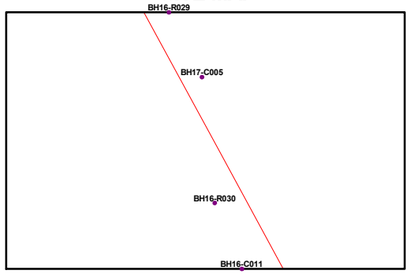


STRATAGRAPHIC BOUNDARIES

MATERIAL GRAPHICS

- Gravelly Sandy SILT
- Poorly-graded SAND
- BOULDERS
- Pulverized Rock
- Ice
- Silty SAND
- Poorly-graded Sandy GRAVEL
- Silty SAND with Gravel
- Poorly-graded GRAVEL

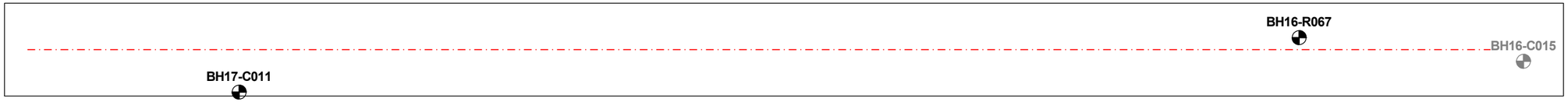
SITE MAP

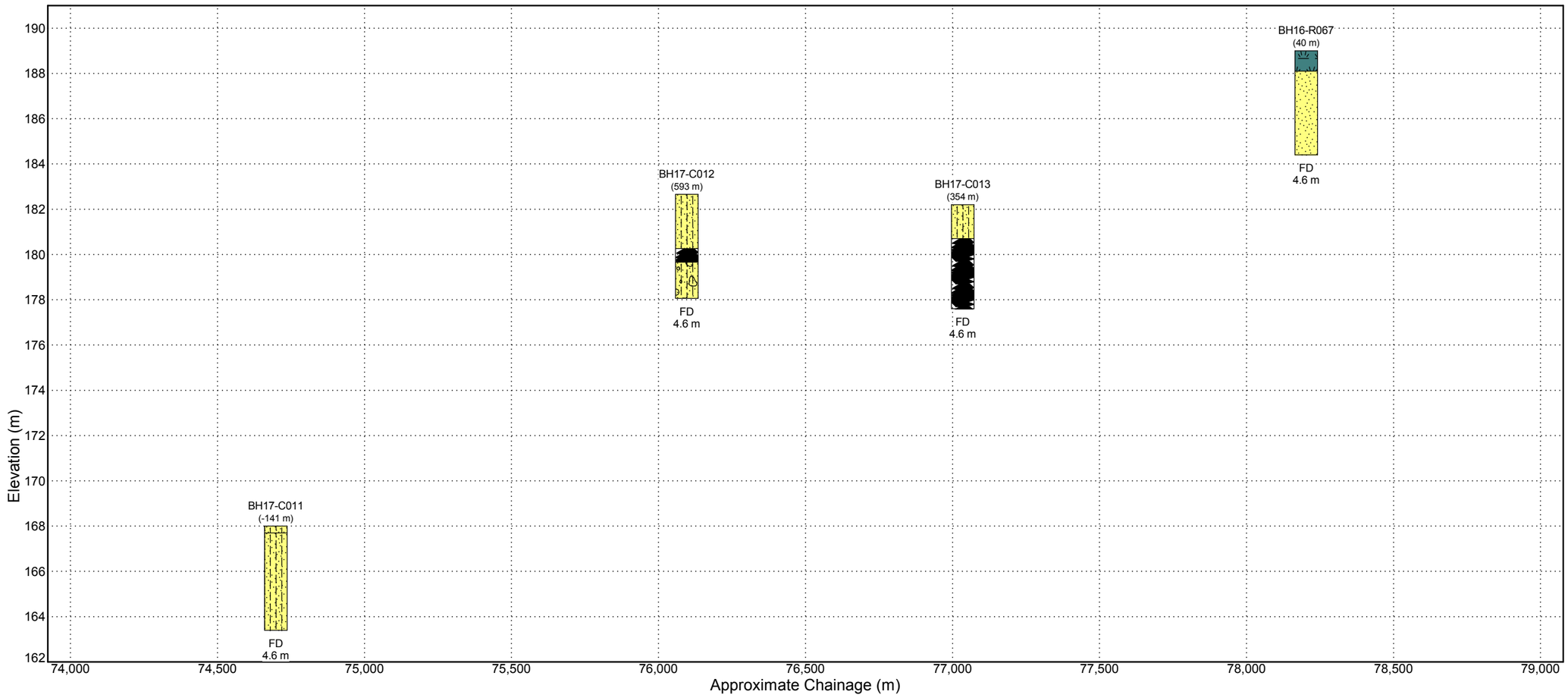


H 1:7385
0 80 160 240 320 400m
V 1:143
0 1 2 3 4 5m
Coord.System: UTM Zone 17 Height Datum: NAD83

HATCH

CLIENT Baffinland Iron Mines		PROJECT Mary River Expansion Study Stage 2	
DRAWN AB/CH	DATE 6/21/2017	TITLE ICE RICH AREA 2	
CHECKED WH	DATE 6/21/2017		
SCALE H 1:7385 V 1:143 VE=52X		PROJECT No H352034	FIGURE No E7





MAP KEY

- BH03 — INVESTIGATION ON SECTION
- TP03 — INVESTIGATION OFF SECTION
- SECTION LINES

POST LEGEND

Borehole Number
(Baseline Offset m)

N SPT value

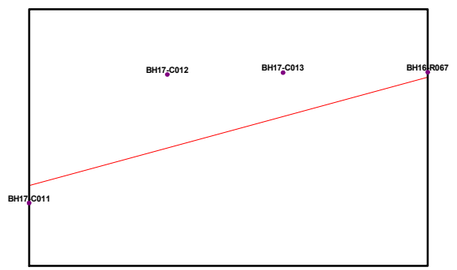
Final Depth m

STRATAGRAPHIC BOUNDARIES

MATERIAL GRAPHICS

- PEAT
- Poorly-graded SAND
- Silty SAND
- Ice
- Silty SAND with Gravel

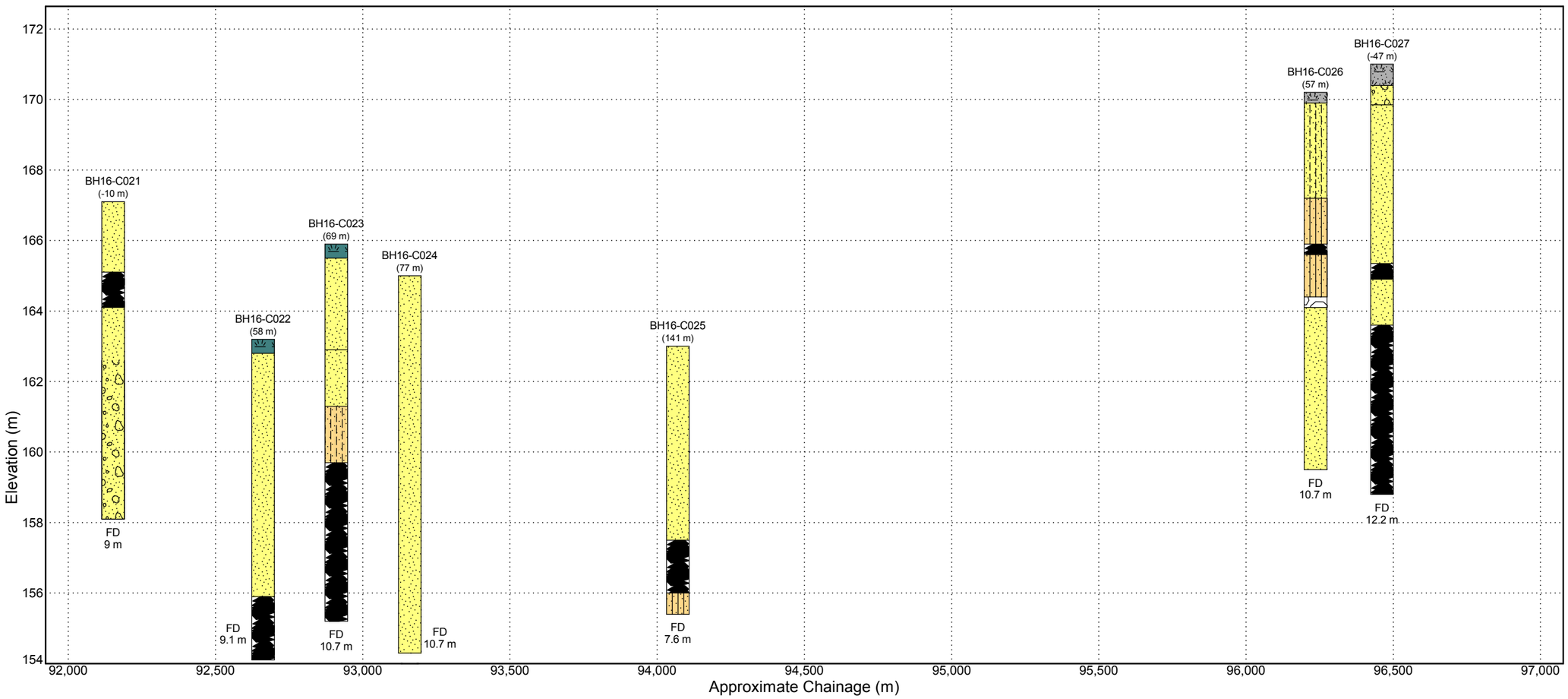
SITE MAP



H 1:15385
0 150 300 450 600 750m
V 1:200
0 2 4 6 8 10m
Coord.System: UTM Zone 17 Height Datum: NAD83

HATCH

CLIENT Baffinland Iron Mines		PROJECT Mary River Expansion Study Stage 2	
DRAWN AB/CH	DATE 6/21/2017	TITLE ICE RICH AREA 3	
CHECKED WH	DATE 6/21/2017		
SCALE H 1:15385 V 1:200 VE=77X		PROJECT No H352034	FIGURE No E8



MAP KEY

- BH03 — INVESTIGATION ON SECTION
- TP03 — INVESTIGATION OFF SECTION
- SECTION LINES

POST LEGEND

Borehole Number
(Baseline Offset m)

N SPT value

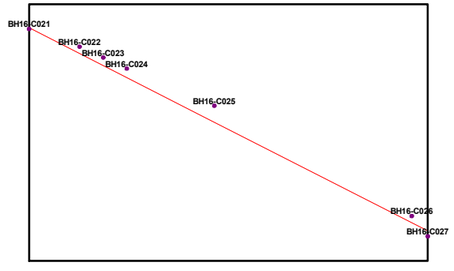
Final Depth m

STRATAGRAPHIC BOUNDARIES

MATERIAL GRAPHICS

- Poorly-graded SAND
- Ice
- Poorly-graded Gravelly SAND
- PEAT
- Sandy SILT
- Elastic Sandy SILT
- Topsoil
- Silty SAND
- BOULDERS

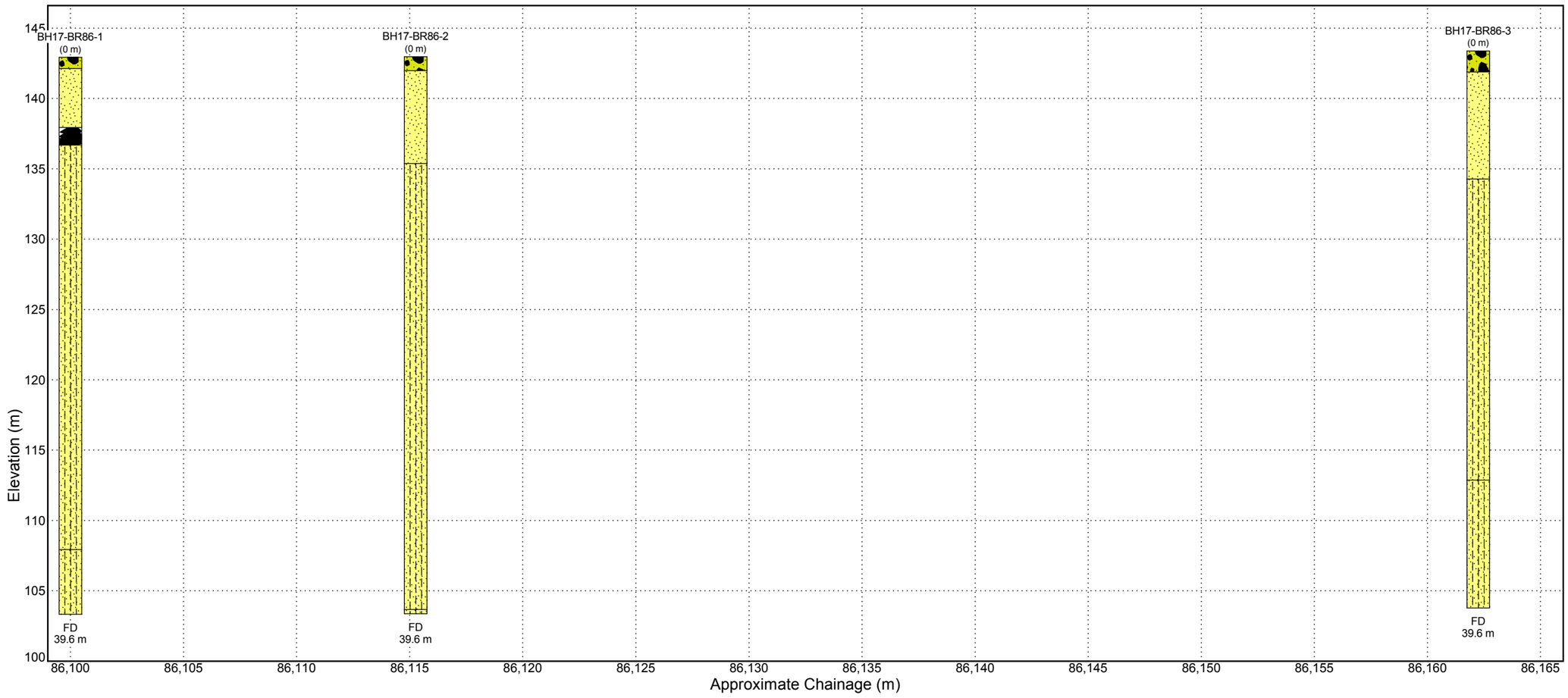
SITE MAP



H 1:15385
0 150 300 450 600 750m
V 1:129
0 1 2 3 4 5m
Coord.System: UTM Zone 17 Height Datum: NAD83

HATCH

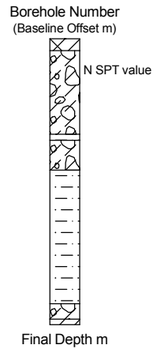
CLIENT Baffinland Iron Mines		PROJECT Mary River Expansion Study Stage 2	
DRAWN AB/CH	DATE 6/21/2017	TITLE ICE RICH AREA 4	
CHECKED WH	DATE 6/21/2017		
SCALE H 1:15385 V 1:129 VE=120X		PROJECT No H352034	FIGURE No E9



MAP KEY

- BH03 — INVESTIGATION ON SECTION
- TP03 — INVESTIGATION OFF SECTION
- SECTION LINES

POST LEGEND

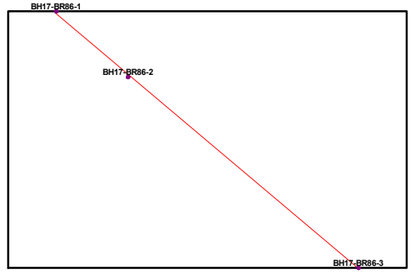


STRATAGRAPHIC BOUNDARIES

MATERIAL GRAPHICS

- Well-graded Sandy GRAVEL
- Poorly-graded SAND
- Ice
- Silty SAND

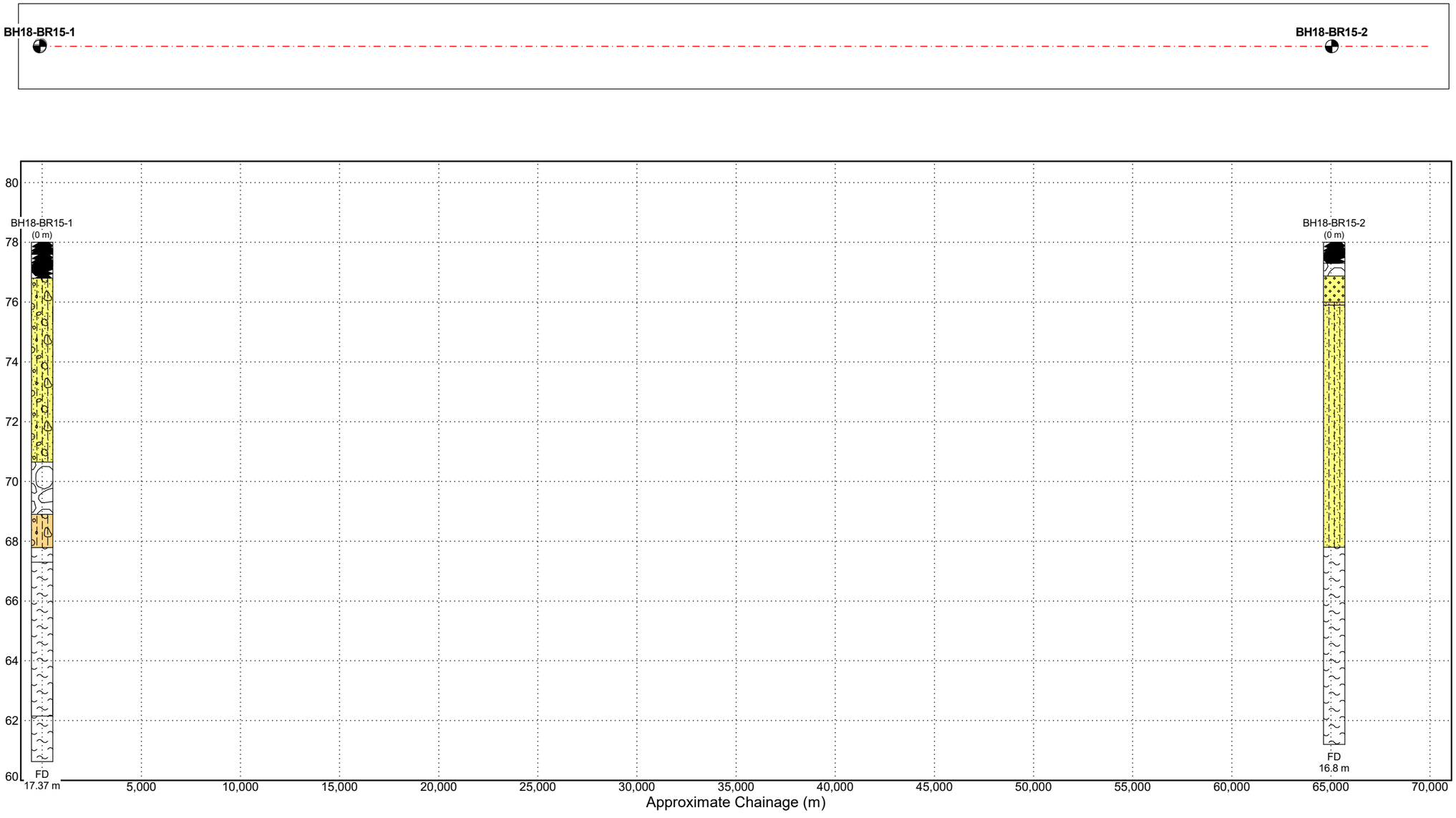
SITE MAP



H 1:200
0 2 4 6 8 10m
V 1:321
0 2 4 6 8 10m
Coord.System: UTM Zone 17 Height Datum: NAD83

HATCH

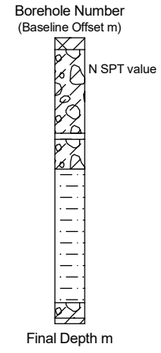
CLIENT Baffinland Iron Mines Corporation		PROJECT Mary River Expansion Project	
DRAWN JH	DATE 4/4/2018	TITLE BRIDGE KM 86	
CHECKED HG	DATE 4/4/2018		
SCALE H 1:200 V 1:321 VE=1X		PROJECT No H353004	FIGURE No E10



MAP KEY

- BH03 — INVESTIGATION ON SECTION
- TP03 — INVESTIGATION OFF SECTION
- SECTION LINES

POST LEGEND

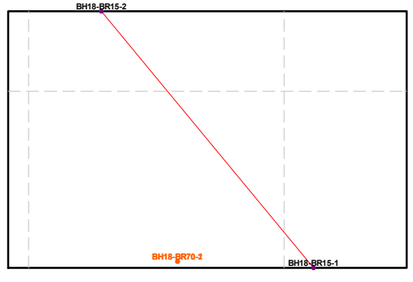


STRATAGRAPHIC BOUNDARIES

MATERIAL GRAPHICS

- Ice
- Well-graded SAND
- Silty SAND with Gravel
- Sandy SILT
- BOULDERS
- Silty SAND
- Gravelly SILT
- GNEISS

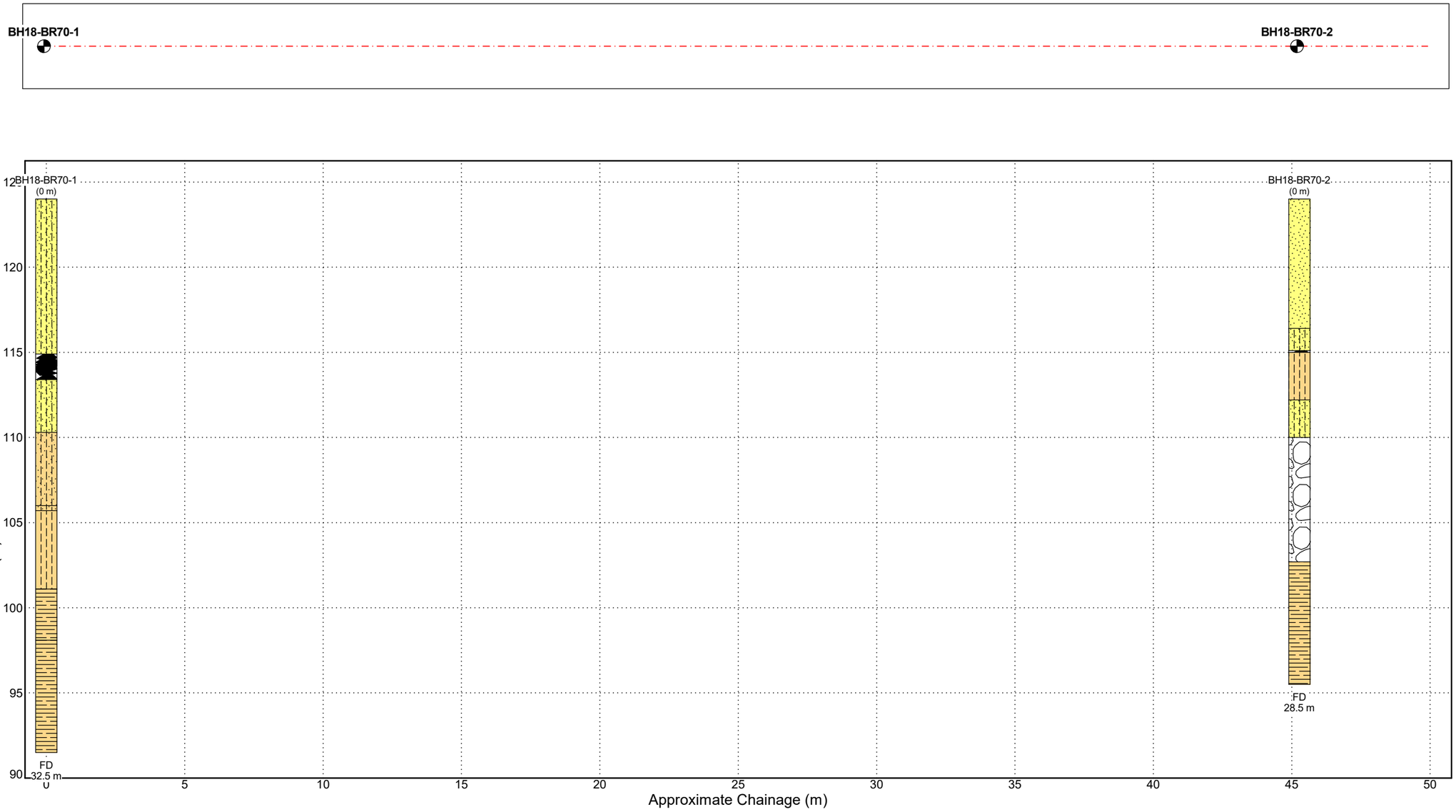
SITE MAP



H 1:215385
0 2000 4000 6000 8000 10000m
V 1:143
0 1 2 3 4 5m
Coord.System: "NAD83" Zone 17 Height Datum: NAD83

HATCH

CLIENT Baffinland Iron Mine		PROJECT Mary River Expansion Study	
DRAWN CL	DATE 8/15/2018	TITLE BRIDGE KM 15	
CHECKED MY	DATE 8/15/2018		
SCALE H 1:215385 V 1:143 VE=1508X		PROJECT No H353004	FIGURE No E11

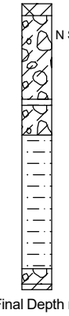


MAP KEY

- BH03 — INVESTIGATION ON SECTION
- TP03 — INVESTIGATION OFF SECTION
- SECTION LINES

POST LEGEND

Borehole Number
(Baseline Offset m)

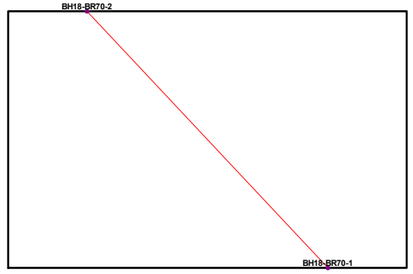


STRATAGRAPHIC BOUNDARIES

MATERIAL GRAPHICS

- Silty SAND
- Poorly-graded SAND
- Ice
- BOUNDERS
- Sandy SILT
- SILT
- SILTSTONE

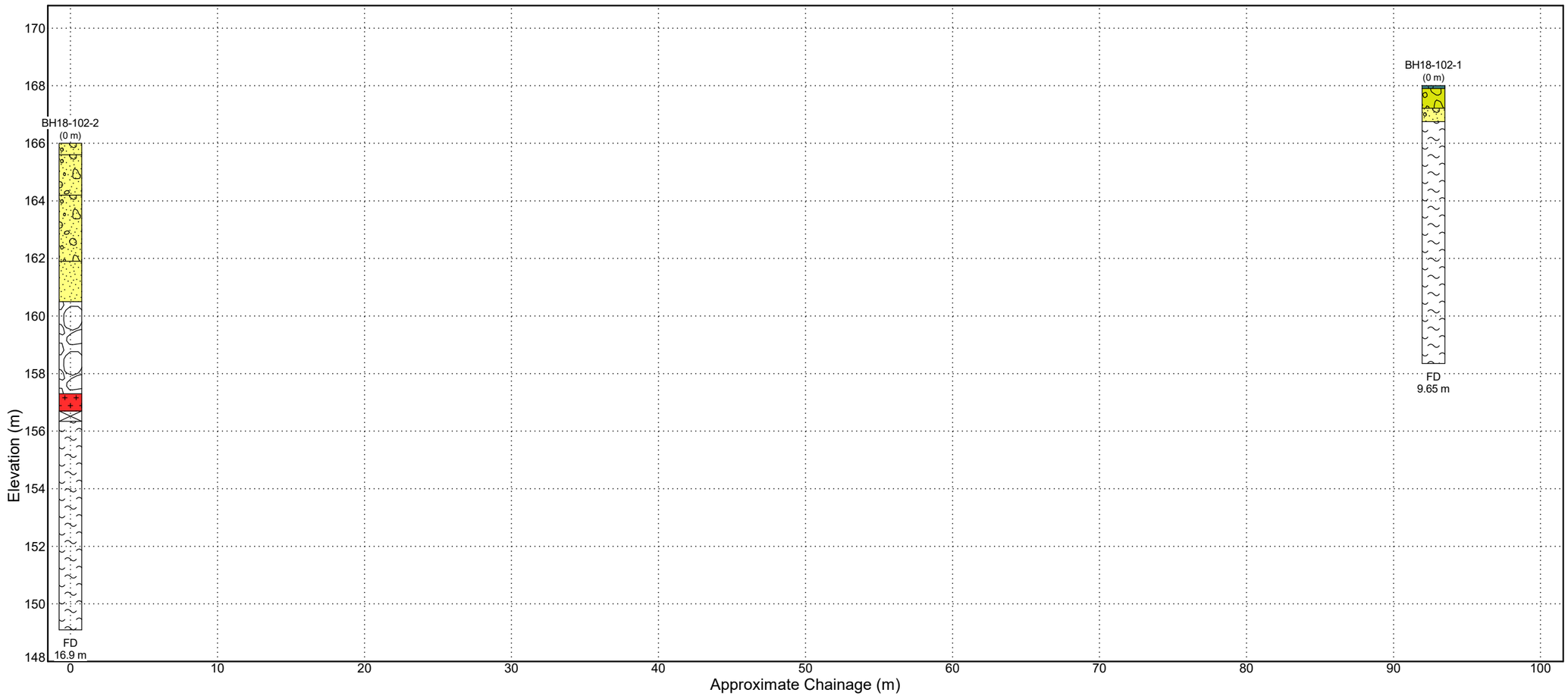
SITE MAP



H 1:154
0 1 2 3 4 5m
V 1:250
0 2 4 6 8 10m
Coord.System: "NAD83" Zone 17 Height Datum: NAD83

HATCH

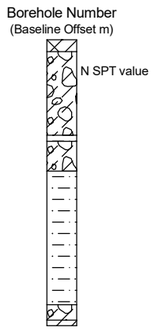
CLIENT Baffinland Iron Mine		PROJECT Mary River Expansion Study	
DRAWN CL	DATE 8/15/2018	TITLE BRIDGE KM 70	
CHECKED MY	DATE 8/15/2018		
SCALE H 1:154 V 1:250 VE=1X		PROJECT No H353004	FIGURE No E12



MAP KEY

- BH03 — INVESTIGATION ON SECTION
- TP03 — INVESTIGATION OFF SECTION
- SECTION LINES

POST LEGEND

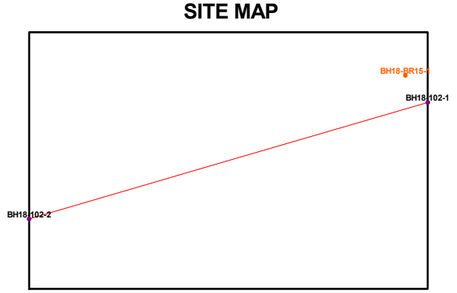


STRATAGRAPHIC BOUNDARIES

MATERIAL GRAPHICS

- PEAT
- Poorly-graded GRAVEL
- Poorly-graded Gravelly SAND
- GNEISS
- Poorly-graded SAND
- BOULDERS
- Granite, Diorite, Gabbro
- Core Loss

SITE MAP



H 1:308
0 2 4 6 8 10m
V 1:157
0 1 2 3 4 5m
Coord.System: "NAD83" Zone 17 Height Datum: NAD83

HATCH

CLIENT Baffinland Iron Mine		PROJECT Mary River Expansion Study	
DRAWN CL	DATE 8/15/2018	TITLE BRIDGE KM 102	
CHECKED MY	DATE 8/15/2018		
SCALE H 1:308 V 1:157 VE=2X		PROJECT No H353004	FIGURE No E13

Appendix F
Summary of Laboratory Results

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Borehole No.	Sample No.	Depth	Moisture Content (%)	Gravel (%)	Sand (%)	Fines (%)
BH16-R003	BS-1	1.0				
	BS-2					
	BS-3					
BH16-R004	BS-1	0.9	30			
	BS-2	2.5	10	8	74	18
	BS-3	4.3				
BH16-R005	BS-1	1.0	11			
	BS-2	2.5		4	78	18
	BS-3	3.6	10			
BH16-R006	BS-1					
	BS-2					
	BS-3					
BH16-R007	BS-1	1.0	13			
	BS-2	2.5	10	1	87	13
	BS-3	4.0				
BH16-R008	BS-1					
	BS-2					
	BS-3					
BH16-R009	BS-1	0.9	23			
	BS-2	2.1				
	BS-3	4.2				
BH16-R010	BS-1	1.0				
	BS-2	3.0				
	BS-3	4.0				
BH16-R011	BS-1	1.0				
	BS-2	2.5	19	0	86	14
	BS-3	4.0	15			
BH16-R012	BS-1	1.0				
	BS-2	2.5	10	1	81	18
	BS-3	3.8				
BH16-R013	BS-1	1.0				
	BS-2	2.5	16	0	85	15
	BS-3	3.5	16			
BH16-R014	BS-1	0.8				
	BS-2	2.0	11	11	69	20
	BS-3	3.8				
BH16-R015	BS-1	1.0				
	BS-2	2.5		2	73	24
	BS-3	4.0	13			
BH16-R016	BS-1	1.0	32			
	BS-2	2.0	15	8	55	28
	BS-3	4.0				
BH16-R017	BS-1	0.0	29			
	BS-2	2.5				
	BS-3	4.0				
BH16-R018	BS-1	1.0				
	BS-2	2.5				
	BS-3	4.0				

Borehole No.	Sample No.	Depth	Moisture Content (%)	Gravel (%)	Sand (%)	Fines (%)
BH16-R019	BS-1	1.0				
	BS-2	2.5				
	BS-3	4.0				
BH16-R020	BS-1	0.5				
	BS-2	2.0				
	BS-3	3.5	20	0	57	43
BH16-R021	BS-1	1.0				
	BS-2	2.5				
	BS-3	3.4				
BH16-R022	BS-1	0.7				
	BS-2	1.9				
	BS-3	4.0	9	13	44	44
BH16-R023	BS-1	0.8				
	BS-2	2.0		0	61	39
	BS-3	3.7				
BH16-R024	BS-1	0.0				
	BS-2	1.5	9	30	38	32
	BS-3	3.0	8			
BH16-R025	BS-1	1.0	18	16	43	41
	BS-2	2.5	15			
	BS-3	4.0	16			
BH16-R026	BS-1	1.0	27			
	BS-2	2.5				
	BS-3	4.0	8			
BH16-R027	BS-1	1.0	8	22	43	35
	BS-2	2.5				
	BS-3	4.0	9			
BH16-R028	BS-1	0.8	3			
	BS-2	2.0				
	BS-3	3.0				
BH16-R029	BS-1	1.0				
	BS-2	2.5				
	BS-3					
BH16-R030	BS-1	1.0				
	BS-3	1.5	10			
	BS-2	2.5				
BH16-R032	BS-1	0.3				
	BS-2	2.5				
	BS-3					
BH16-R033	BS-1	1.0				
	BS-2	2.5	7			
	BS-3	4.0				
BH16-R034	BS-1	1.0				
	BS-2	2.5	8	27	40	32
	BS-3	3.5	9			
BH16-R035	BS-1	1.0				
	BS-2	2.5		24	42	34
	BS-3	4.0				

Borehole No.	Sample No.	Depth	Moisture Content (%)	Gravel (%)	Sand (%)	Fines (%)
BH16-R036	BS-1	1.0				
	BS-2	2.5	10	23	42	35
	BS-3	4.0				
BH16-R037	BS-1	1.0				
	BS-2	2.5	20	0	91	9
	BS-3	4.0	20			
BH16-R038	BS-1	1.0				
	BS-2	2.0	16	2	89	9
	BS-3	4.0	8			
BH16-R039	BS-1	1.0	20	3	94	3
	BS-2	2.5				
	BS-3	4.0				
BH16-R040	BS-1	1.0				
	BS-2	2.5	19			
	BS-3	4.0				
BH16-R041	BS-1					
	BS-2					
	BS-3					
BH16-R042	BS-1	1.0				
	BS-2	2.5				
	BS-3	4.0	15			
BH16-R043	BS-1	1.0				
	BS-2	2.5				
	BS-3	4.0	15			
	BS-4	6.5				
	BS-5	8.8	7			
BH16-R044	BS-1	1.0				
	BS-2	2.0	11			
	BS-3	4.0	16			
BH16-R045	BS-1	1.0	8			
	BS-2					
	BS-3	3.6	21			
BH16-R046	BS-1	0.6				
	BS-2	1.3	6			
	BS-3	2.3	40			
	BS-4	3.9	22			
BH16-R053	BS-1	1.3				
	BS-2	5.5	23			
BH16-R067	BS-1	1.2		3	60	37
	BS-2	2.4				
	BS-3	4.5				
BH16-R068	BS-1	1.0				
	BS-2	2.0				
	BS-3	3.6				
BH16-R069	BS-1	1.0		19	41	40
	BS-2	2.5				
	BS-3	4.0				
BH16-R070	BS-1	1.0		0	84	16
	BS-2	2.4				
	BS-3	3.9				

Borehole No.	Sample No.	Depth	Moisture Content (%)	Gravel (%)	Sand (%)	Fines (%)
BH16-C007	BS-1	1.2	17			
	BS-2	2.5				
	BS-3	3.5		1	73	26
	BS-4	5.0				
	BS-5	7.3	39			
BH16-C008	BS-1	1.0				
	BS-2	2.5				
BH16-C009	BS-1	0.9				
	BS-2	2.6	13	9	61	30
	BS-3	3.5				
	BS-4	5.5				
	BS-5	7.3				
	BS-6	8.8				
BH16-C010	BS-1	1.0				
	BS-2	2.5		9	33	58
	BS-3	4.3				
	BS-4	5.3				
BH16-C011	BS-1	1.0				
	BS-2	2.5	100			
	BS-3	4.0	100			
	BS-4	5.8	100			
	BS-5	7.6	100			
	BS-6	8.8	100			
	BS-7	10.0	100			
BH16-C012	BS-1	1.2				
	BS-2	2.0				
	BS-3	4.0				
BH16-C015	BS-1	1.0				
	BS-2	2.5				
	BS-3	3.4				
	BS-4	5.2				
	BS-5	7.0				
BH16-C016	BS-1	1.0				
	BS-2	2.7		25	53	22
	BS-3	4.0				
	BS-4	5.8				
	BS-5	7.3				
BH16-C017	BS-1	1.0				
	BS-2	2.4		3	74	22
	BS-3	4.0				
	BS-4	5.5				
BH16-C018	BS-1	0.6				
	BS-2	2.2	9	1	82	17
	BS-3	4.0				
	BS-4	5.5				

Borehole No.	Sample No.	Depth	Moisture Content (%)	Gravel (%)	Sand (%)	Fines (%)
BH16-C019	BS-1	1.0				
	BS-2					
	BS-3	4.5	8			
BH16-C019B	BS-1	5.8	0	0	98	1
BH16-C020	BS-1	1.0				
	BS-2	2.5	8			
	BS-3	4.3				
	BS-4	5.5	8			
	BS-5	6.7				
	BS-6	8.5	11			
BH16-C021	BS-1	1.0				
	BS-2	2.5	14			
	BS-3	3.5	12			
	BS-4	7.0				
	BS-5	8.7	5	0	67	33
BH16-C022	BS-1	2.4				
	BS-2	4.4	19	0	98	2
	BS-3	6.3				
	BS-4	7.3	24			
	BS-5	8.2				
BH16-C023	BS-1	3.7	16	0	93	7
	BS-2	5.0	17	12	44	45
	BS-3	6.2	15			
BH16-C024	BS-1	3.4				
	BS-2	5.0	18	0	90	10
	BS-3	7.0	18			
	BS-4	8.5				
	BS-5	10.0	14			
BH16-C025	BS-1	2.7				
	BS-2	4.0	15	1	89	10
	BS-3	5.2				
	BS-4	7.0				
BH16-C026	BS-1	2.4		6	69	24
	BS-2	4.0	14	2	77	21
	BS-3	5.5				
	BS-4	7.0	19			
	BS-5	8.5	13			
	BS-6	10.0				
BH16-C027	BS-1	4.0	10	9	72	20
	BS-2	5.0				
	BS-3	7.0	16			
BH16-C028	BS-1	6.3				
	BS-2	8.8	7	0	94	6
	BS-3	9.6	18			
	BS-4	11.4				

Borehole No.	Sample No.	Depth	Moisture Content (%)	Gravel (%)	Sand (%)	Fines (%)
BH16-C029	BS-1	0.9				
	BS-2	2.4	21	1	75	25
	BS-3	4.0				
	BS-4	7.0				
BH16-C030	BS-1	1.0				
	BS-2	2.0	14			
	BS-3	4.0				
	BS-4	5.0	19	3	94	3
BH16-C031	BS-1	1.4				
BH16-C032	BS-1	0.9				
	BS-2	2.4	11	10	71	19
	BS-3	4.4				
	BS-4	5.5				
	BS-5	6.9				
	BS-6	8.9				
BH16-C201	BS-1	1.4				
	BS-2	2.1				
BH16-C202	BS-1	0.9				
	BS-2	2.5				
	BS-3	4.0				
	BS-4	5.0				
	BS-5	6.1				
BH16-C203	BS-1	0.9				
	BS-2	2.4				
	BS-3	4.3				
	BS-4	5.5				
	BS-5	7.0				
	BS-6	8.8				
BH16-C204	BS-1	0.9				
	BS-2	2.6				
BH16-C205	BS-1	1.1				
	BS-2	2.5				
	BS-3	4.0		20	47	35
	BS-4	5.5				
	BS-5	7.0				
BH16-C206	BS-1	1.2				
	BS-2	2.7	53			
	BS-3	4.0	22			
	BS-4	5.5				
	BS-5	7.3				
BH16-C207	BS-1	0.9				
	BS-2	1.9	12			
	BS-3	4.0				
	BS-4	5.5				
	BS-5	7.4				

BH17-C001	DS1	0.9				
	DS2	2.1				
	DS3	3.1	7	14	49	37
	DS4	4.9				
	DS5	7	3	0	55	44
BH17-C002	DS1	0.9				
	DS2	2.4	10	21	59	20
	DS3	4				
	DS4	5.5				
	DS5	7				
	DS6	8.2				
	DS7	10.1				
BH17-C003	DS1	0.9				
	DS2	1.8				
	DS3	3.4	7	32	47	21
	DS4	5.5	9	4	73	23
	DS5	7				
	DS6	8.8	10	9	57	34
BH17-C004	DS1	0.6				
	DS2	2.4				
	DS3	3.7				
	DS4	5.2				
	DS5	7		9	75	17
	DS6	7.9				
	DS7	9.8		8	60	33
BH17-C005	DS1	0.9				
	DS2	2.4				
	DS3	4				
	DS4	5.5	7	18	57	24
	DS5	7				
	DS6	8.5				
BH17-C006	DS1	0.6				
	DS2	2.4				
	DS3	3.7	14	18	45	37
	DS4	5.2				
	DS5	6.7				
	DS6	8.2	16	21	42	38
BH17-C006B	DS1	0.9				
	DS2	2.4				
	DS3	4				
	DS4	5.5				
BH17-C007	DS1	1				
	DS2	1.9				
	DS3	4	14	10	38	52
BH17-C010	DS1	0.6				
	DS2	2.4	14	1	88	11
	DS3	3.7	15	0	90	9
BH17-C011	DS1	0.9				
	DS2	2.4				
	DS3	4	17	0	76	24

Borehole No.	Sample No.	Depth	Moisture Content (%)	Gravel (%)	Sand (%)	Fines (%)
BH17-C012	DS1	0.9				
	DS2	2.1				
	DS3	4	8	24	38	38
BH17-C013	DS1	0.9	14	12	58	31
	DS2	2.1				
	DS3	4				
BH16-B001	BS-1	0.3				
	BS-2	2.7				
	BS-3	3.5	19	6	66	29
	BS-4	5.5				
	BS-5	6.7				
	BS-6	8.5				
	BS-7	10.3				
BH16-B002	BS-1	1.2				
	BS-2	2.7	11			
	BS-3	4.3				
	BS-4	5.9	14	5	77	19
	BS-5	7.3				
	BS-6	8.4				
	BS-7	8.8				
	BS-8	11.5				
	BS-9	12.8				
BH16-B003	BS-1	1.1				
	BS-2	1.9	9	24	47	28
	BS-3	4.0				
	BS-4	5.8	100	2	72	26
	BS-5	7.3	23			
	BS-6	8.8				
	BS-7	10.3				
	BS-8	11.5				
	BS-9	13.4				
	BS-10	14.6				
BH16-B004	BS-1	1.0				
	BS-2	2.7				
	BS-3	4.3				
	BS-4	5.8	100	7	54	39
	BS-5	7.3	19	35	44	21
	BS-6	8.8				
	BS-7	10.5				
	BS-8	11.8				
	BS-9	13.2				
	BS-10	14.5				
	BS-11	15.5				

BH16-B009	BS-1	0.6				
	BS-2	5.0				
	BS-3	9.8	22	0	98	2
BH16-B010	BS-1	0.9				
	BS-2	2.9	11	5	87	8
	BS-3	4.2				
	BS-4	5.1	21	0	98	2
	BS-5	6.4				
	BS-6	9.5	20	0	61	39
BH16-B011	BS-1	4.2				
	BS-2	9.0	19	0	98	2
BH16-B012	BS-1	3.0	12	4	87	9
	BS-2	8.0				
BH16-B013	BS-1	0.6				
	BS-2	2.7				
	BS-3	4.0				
	BS-4	5.8	12	0	53	47
	BS-5	7.3				
	BS-6	8.5				
	BS-7	10.0				
BH16-B014	BS-1	1.0				
	BS-2	2.5				
	BS-3	3.5	12	0	65	35
	BS-4	5.0				
	BS-5	7.0	1	0	63	37
	BS-6	8.9				
BH16-B015	BS-1	1.0				
	BS-2	2.5	100	17	41	41
	BS-3	4.0				
	BS-4	5.0	11	0	63	37
	BS-5	6.7				
	BS-6	8.0				
	BS-7	10.0	100	15	66	20
	BS-8	11.5				
	BS-9	13.4				
BH16-B016	BS-1	1.0				
	BS-2	2.6				
	BS-3	3.6	15	0	88	12
	BS-4	5.3		0	67	33
	BS-5	7.2	7	0	66	34

Borehole No.	Sample No.	Depth	Moisture Content (%)	Gravel (%)	Sand (%)	Fines (%)
BH17-B001	DS1	0.9				
	DS2	2.4	26	0	93	7
	DS3	4				
	DS4	5.5	37	0	7	93
	DS5	7				
	DS6	8.5	10	6	65	29
	DS7	9.4				
	DS8	11.4		7	30	63
	DS9	13.1	12			
	DS10	14.3				
	DS11	15.5	12			
BH17-B002	DS1	0.5	19	0	88	12
	DS2	2				
	DS3	3.7	37	0	15	85
	DS4	5.1				
	DS5	6.7	24	0	49	51
	DS6	8.2				
	DS7	10.1				
	DS8	11.5	9	3	66	32
	DS9	12.8				
	DS10	14.5				
	DS11	15.8	11	10	70	20
	DS12	17.4				
	DS13	18.6	8	15	66	20
	DS14	20.1				
	DS15	22.3				
	DS16	23.5	15	1	72	27

Borehole No.	Sample No.	Depth	Moisture Content	Gravel (%)	Sand (%)	Fines (%)
BH17-BR86-1	DQ-1	0.5				
	DQ-2	4.4				
	DQ-3	5.6				
	DQ-4	8.9				
	DQ-5	11.9				
	DQ-6	16.0				
	DQ-7	17.0				
	DQ-8	21.0				
	DQ-9	25.5				
	DQ-10	29.5				
	DQ-11	31.9				
	DQ-12	36.0				
	DQ-13	39.0				
BH17-BR86-2	DQ-1	1.0	13.9	25	72	2
	DQ-2	2.0	22.7	0	93	7
	DQ-3	3.0	17.9	0	91	9
	DQ-4	5.0	36.8	4	91	5
	DQ-5	10.0	22.1	0	89	10
	DQ-6	11.3	22.9			
	DQ-7	20.0	21.9	0	90	10
	DQ-8	24.0	24.5			
	DQ-9	30.0	25.9			
	DQ-10	32.5				
	DQ-11	36.4	26.5			
	DQ-12	37.8				
	DQ-13	39.3	25.3	0	61	39
BH17-BR86-3	DQ-1	1.0	13.8	21	69	10
	DQ-2	2.0	22.8	0	93	7
	DQ-3	3.0	24.3	0	94	6
	DQ-4	5.0	25.4	0	89	11
	DQ-5	8.0	26.0	0	78	22
	DQ-6	12.0	26.0	0	93	7
	DQ-7	20.0				
	DQ-8	30.0	24.6	0	92	8

Borehole No.	Sample No.	Depth	Moisture Content	Gravel (%)	Sand (%)	Fines (%)
BH18-BR15-1	DQ-1	1.7				
	DS-2	2.6	6	34	44	22
	DS-3	3.9	11	6	57	37
	DS-4	5.1	7			
	DQ-5	5.8				
BH18-BR15-2	DS-1	1.2	14	1	85	14
	DQ-2	1.5				
	DS-3	2.0	63	1	45	54
	DQ-4	2.5				
	DS-5	2.6	9	29	39	32
	DS-6	3.5				
	DS-7	4.2	11	14	60	26
	DS-8	5.8	5	22	48	30
	DQ-9	6.3				
BH18-BR70-1	DQ-1	1.5				
	DS-2	2.6	22	0	97	3
	DQ-3	6.3				
	DS-4	6.8	28	0	80	20
	DS-5	9.4	36	0	3	97
	DQ-6	9.6				
	DS-6	11.3	19	0	39	61
	DQ-7	14.3				
	DS-8	14.6	15	9	51	40
	DQ-9	16.5	14.0	19	26	55
	DQ-10	18.2				
	DQ-11	20.9				
BH18-BR70-2	DS-1	0.8	1.0	38	47	15
	DQ-1	1.2	20.0	0	86	14
	DS-2	3.2	15.0	0	91	9
	DQ-3	9.5	23.0	0	2	98
	DQ-4	19.5				
	DS-5	19.6		0	2	98
BH18-BR102-2	DS-2	2.1				
	DQ-3	3.0		31	69	0
	DS-4	5.1				
	DQ-5	5.4				

Appendix G
Laboratory Certificate of Conformance

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Canadian Council of Independent Laboratories

CERTIFICATE OF CONFORMANCE

AGGREGATE LABORATORY CERTIFICATION

This is to certify that

Hatch Geotechnical Laboratory

Located at:

Niagara Falls ON

Has met the Standardization and Interlaboratory Testing Requirements of the CCIL/OSSGA AGGREGATE LABORATORY CERTIFICATION PROGRAM and has qualified under the following categories and test methods:

AGGREGATE QUALITY CONTROL LABORATORY (TYPE C)

LS-600/C-702; LS-601/C-117; LS-602/C-136; LS-607; LS-608; LS-621

AGGREGATE PHYSICAL PROPERTY LABORATORY (TYPE D)

LS-706/D698; LS-702/AASHTO T88; LS-703,704/D4318; LS-705/D854; LS-709/D2434

GIB MCINTEE, P. ENG.
CHAIRMAN, CERTIFICATION PROGRAM ADMINISTRATION COMMITTEE

May 1, 2018 - April 30, 2019

Date

GORDON H. LEAMAN, P. ENG.
PRESIDENT

Canadian Council of Independent Laboratories

CERTIFICATE OF CONFORMANCE

AGGREGATE LABORATORY CERTIFICATION

This is to certify that

Hatch

Located at:

Niagara Falls ON

Has met the Standardization and Interlaboratory Testing Requirements of the CCIL/OSSGA AGGREGATE LABORATORY CERTIFICATION PROGRAM and has qualified under the following categories and test methods:

AGGREGATE QUALITY CONTROL LABORATORY (TYPE C)

LS-600/C-702; LS-601/C-117; LS-602/C-136; LS-607; LS-608; LS-621

AGGREGATE PHYSICAL PROPERTY LABORATORY (TYPE D)

LS-706/D698; LS-702/AASHTO T88; LS-703,704/D4318; LS-705/D854; LS-709/D2434

GIB MCINTEE, P. ENG.
CHAIRMAN, CERTIFICATION PROGRAM ADMINISTRATION COMMITTEE

May 1, 2017 - April 30, 2018

Date

GORDON H. LEAMAN, P. ENG.
PRESIDENT

Canadian Council of Independent Laboratories

CERTIFICATE OF CONFORMANCE

AGGREGATE LABORATORY CERTIFICATION

This is to certify that

Amec Foster Wheeler Environment & Infrastructure
A Division of Amec Foster Wheeler Americas Limited

Located at:

Hamilton ON

Has met the Standardization and Interlaboratory Testing Requirements of the CCIL/OSSGA AGGREGATE LABORATORY CERTIFICATION PROGRAM and has qualified under the following categories and test methods:

AGGREGATE QUALITY CONTROL LABORATORY (TYPE C)

LS-600/C-702; LS-601/C-117; LS-602/C-136; LS-607; LS-608; LS-621

AGGREGATE PHYSICAL PROPERTY LABORATORY (TYPE D)

LS-412/CSA A23.2-2C,-4C; LS-603/C131&535; LS-604/C127; LS-605/C128; LS-606/C88; LS-609/C294,5 (Petrographic Analysts : John Balinski, Martin Little, Amy McCulloch & Ivan Severenski); LS-610/C40; LS-613/D3042; LS-614/CSA A23.2-24A; LS-615/CSA A23.2-26A; LS-617; LS-618/D6928; LS-619/D7428; LS-620/CSA A23.2-25A; LS-623/D698; LS-709/D2434

Superpave Aggregate Consensus Properties

AASHTO T176/D2419; LS-629/AASHTO T304; ASTM D4791; ASTM D5821

May 1, 2016 - April 30, 2017

Date

GIB MCINTEE, P. ENG.
CHAIRMAN, CERTIFICATION PROGRAM ADMINISTRATION COMMITTEE

GORDON H. LEAMAN, P. ENG.
PRESIDENT

Appendix H
Coarse Aggregate Physical Testing Reports

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21 July 2017
File: TB152049

Hatch Ltd.
4342 Queen St. Suite 500
Niagara Falls, Ont.
L2E 7J7

Attention: Mr. Ralph Serluca

Dear Sir,

RE: AGGREGATE TESTING – 10" ROCK
GRANITE & DIABASE

We are pleased to present the results of laboratory testing conducted on two samples of 10"rock received in our Amec Foster Wheeler Hamilton laboratory on 27 June 2017. It is understood that a representative of Hatch Ltd. obtained the sample from an unspecified source.

Testing of the 10" rock materials was limited to Mill Abrasion using TMS-004, Track Rock Ballast Specification, rev. 22 Aug. 2013. Oversized samples were crushed to required particle sizes using laboratory Jaw-crusher.

Results of the physical testing can be found in Table 1.

Table 1 – Physical Laboratory Testing Results

Testing Required	NF17-05 (Granitic Gneiss)	NF17-06 (Diabase)
Mill Abrasion	2.7% loss	5.8% loss

If there are any questions concerning this report, please do not hesitate to contact our office.

Yours truly,

Amec Foster Wheeler Environment & Infrastructure
a Division of Amec Foster Wheeler Americas Limited

Reviewed by,

Kristen Hand
Soils & Aggregate Laboratory Supervisor
kh:OL

Ognjenko Lazic
Concrete & Asphalt Laboratory Supervisor

Amec Foster Wheeler Environment and Infrastructure
a Division Amec Foster Wheeler Americas Limited
505 Woodward Avenue, Unit 1
Hamilton, ON L8H 6N6
Canada
Tel (905) 312-0700
Fax (905) 312-0771

15 February 2017
File: TB152049

Hatch Ltd.
4342 Queen St., Suite 500
Niagara Falls, ON
L2E 7J7 Canada

Attention: **Mr. Warren R. Hoyle, P.Geo.**

RE: **PHYSICAL TESTING OF BEDROCK CORE AND ROCK LUMPS**

1.0 INTRODUCTION

We are pleased to present the results of our Amec Foster Wheeler Hamilton laboratory testing conducted on rock lump samples provided by HATCH Limited (HATCH). It is understood the rock lump and bedrock core samples were sampled in January 2017 by a representative of Hatch. These samples were received in our laboratory on 26 January 2017.

2.0 METHODLOGY

A total of four pails of rock grab samples (4-8 inch) and bedrock cores were provided for physical durability testing. The aggregate was crushed using a laboratory crusher at Amec Foster Wheeler Hamilton Laboratory. The material was crushed to produce a 20mm coarse aggregate to be tested.

Testing of the 20mm crushed core samples was limited to:

Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus	(CSA A23.2 - 29A)
Sieve Analysisof Coarse and Fine Aggregate	(CSA A23.2 - 2A)
Relative Density and Absorption of Coarse Aggregate	(CSA A23.2 - 12A)
Resistance of Unconfined Coarse Aggregate to Freezing and Thawing	(CSA A23.2 - 24A)

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Hamilton, Ontario L8H 6N6
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Fax +1 905 312 0771
amecfw.com

The results of testing are summarized in Table 1.

3.0 RESULTS

Table 1. Results of the Physical Testing Crushed Aggregate Sample

Test Required	Test Method	Laboratory Test Results			
		NF17-01	NF17-02	NF17-03	NF17-04
Relative Density (Specific Gravity)	CSA A23.2 - 12A	**2.662**	**2.655**	**2.618**	**2.995**
Absorption (%)	CSA A23.2 - 12A	**0.82**	**0.90**	**0.37**	**0.45**
Micro-Deval Abrasion (% loss)	CSA A23.2 - 29A	**10.5**	**11.0**	**4.5**	**7.9**
Unconfined Freeze-Thaw (% loss)	CSA A23.2 - 24A	**6.7**	**11.1**	**1.6**	**0.8**

Presented in Enclosures 1 through 4 are the gradation results of the coarse portion of each sample.

Please contact us if you have any questions, or if we can be of further service evaluating aggregate sources.

Regards,

Amec Foster Wheeler Environment & Infrastructure
a Division of Amec Foster Wheeler Americas Limited

Reviewed by,

Ognjenko Lazic
Asphalt & Concrete
Laboratory Supervisor

Kristen Hand
Soils & Aggregate
Laboratory Supervisor

LIMITS FOR DELETERIOUS SUBSTANCES AND PHYSICAL PROPERTIES OF AGGREGATE

CSA A23.1 - 14, Table 11 & 12 and A23.2 - 15A & 27A, Rev. August 2014

Clauses 4.2.3.2.2, 4.2.3.4.3, 4.2.3.5.1, 4.2.3.5.3.3, 4.2.3.5.3.4, 4.2.3.7 & 4.2.3.10.1

Job No.:	Client:	Sampled By:	Enclosure:
TB152049	Hatch Ltd.	Client	**2**

Name of Testing Laboratory:	Telephone No.:	Fax No.:
Amec Foster Wheeler Environment & Infrastructure	(905) 312 - 0700	(905) 312 - 0771

Sample Lab No.:	Sample Source:
S018-17	NF17-01

Sample Type:	Date Sampled:	Stockpile Quantity (t)
Crushed Core	January 2017	--

COARSE AGGREGATE

Nominal Max. Size (mm):	Aggregrate Inventory No.:	Gradation Results:	Meets Spec.: (Y/N)
20 mm	n/a	n/a	n/a

Limits for Deleterious Substances and Physical Properties of Aggregates

CSA Laboratory Test and Number	Acceptance Limits		Reference Material Results	Sample Results	Meets Spec.
	Maximum percentage by mass of total sample				
Standard Requirements	**Concrete exposed to freezing & thawing**	**Other exposure conditions**			**Y / N**
Clay lumps - A23.2 - 3A †****	0.3 % maximum	0.5 % maximum	-	-	-
Low - density granular materials - A23.2 - 4A‡****	0.5 % maximum	1 % maximum	-	-	-
Material finer than 80 µm - A23.2 - 5A**	1% maximum[1]	1% maximum[1]	-	-	-
Absorption - A23.2 - 12A	-		0.37%	**0.82%**	-
Flat & elongated particles, Procedure A, 4:1 - A23.2-13A	20.0 % maximum	20.0 % maximum	-	-	-
Micro-Deval test - A23.2 - 29A	17 % maximum	21 % maximum	14.0%	**10.5%**	**Y**
Unconfined freeze-thaw test - A23.2 - 24A‡‡	6 % maximum	10 % maximum	9.5%	**6.7%**	**N/Y**
Abrasion loss - A23.2 - 16A and A23.2 - 17A§§	50 % maximum	50 % maximum	-	-	-
Petrographic examination of aggregate - A23.2 -15A	125 maximum	140 maximum	-	-	-
Alkali-Carbonate reactivity - A23.2 - 26A	chem. comp. must plot in non-exp. field		-	-	-
Accelerated mortar bar - A23.2 - 25A	maximum 0.150% at 14 days		-	-	-
Concrete prism - A23.2 - 14A	maximum 0.040% at one year		-	-	-
Alternative Requirements* **					
$MgSO_4$ soundness loss - A23.2 - 9A	12 % maximum	18 % maximum	-	-	-

Issued By: Kristen Hand (Print Name) — Testing Laboratory Representative Signature — 14 February 2017 (Date)

LIMITS FOR DELETERIOUS SUBSTANCES AND PHYSICAL PROPERTIES OF AGGREGATE

CSA A23.1 - 14, Table 11 & 12 and A23.2-15A & 27A, Rev. August 2014

Clauses 4.2.3.2.2, 4.2.3.4.3, 4.2.3.5.1, 4.2.3.5.3.3, 4.2.3.5.3.4, 4.2.3.7 & 4.2.3.10.1

Enclosure: **2**

*Limits for deleterious substances not listed in this Table, such as coal, ochre (ironstone), shalestone, siltstone, or argillaceous limestone, shall be specified by the owner to encompass deleterious materials known to be present in a particular region. In the absence of such information, aggregate shall be accepted or rejected in accordance with clause 4.2.3.9

†Clay lumps are defined as fine-grained, consolidated, sedimentary materials of a hydrous aluminosilicate nature.

‡A liquid with a relative density of 2.0 is generally used to separate particles classified as coal or lignite. Liquids with relative densities higher or lower than 2.0 might be required to identify other deleterious low-density materials.

The amount of material of clay size shall be determined by performing a hydrometer analysis as per ASTM D 422 on a sample washed through an 80 µm sieve.

**In the case of crushed aggregate, if material finer than the 80 µm sieve consists of the dust of fracture, essentially free from clay or shale, the maximum shall be 2.0%

‡‡CSA A23.2-24A, a test for coarse aggregate, has good precision and shows fair correlation with the MgSO4 soundness test. For further information, see Rogers, Senior, & Boothe (1989)

§§The abrasion loss shall not be greater than 35% when the aggregate is used in concrete paving or for other concrete surfaces subjected to significant wear. This does not refer to air- cooled iron blast-furnace-slag coarse aggregate. The abrasion loss requirements for coarse aggregate shall be waived provided that the material meets the alternative requirements for Micro-deval detailed in this Table.

***The freeze-thaw requirements for coarse aggregate shall be waived provided that the material meets the laternative requirements for $MgSO_4$ soundness loss detailed in this Table.

****If the Coarse Aggregate when tested according to A23.2-15A does not show the presence of either clay lumps or low-density granular materials, the requirements for testing in accordance with 3A and 4A may be waived.

[1]This limit applies to the amount of material finer than 80µm as determined by washing only.

Amec Foster Wheeler Environment & Infrastructure
a Division of Amec Foster Wheeler Americas Limited
505 Woodward Avenue, Unit 1
Hamilton, Ontario
Canada L8H 6N6

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE

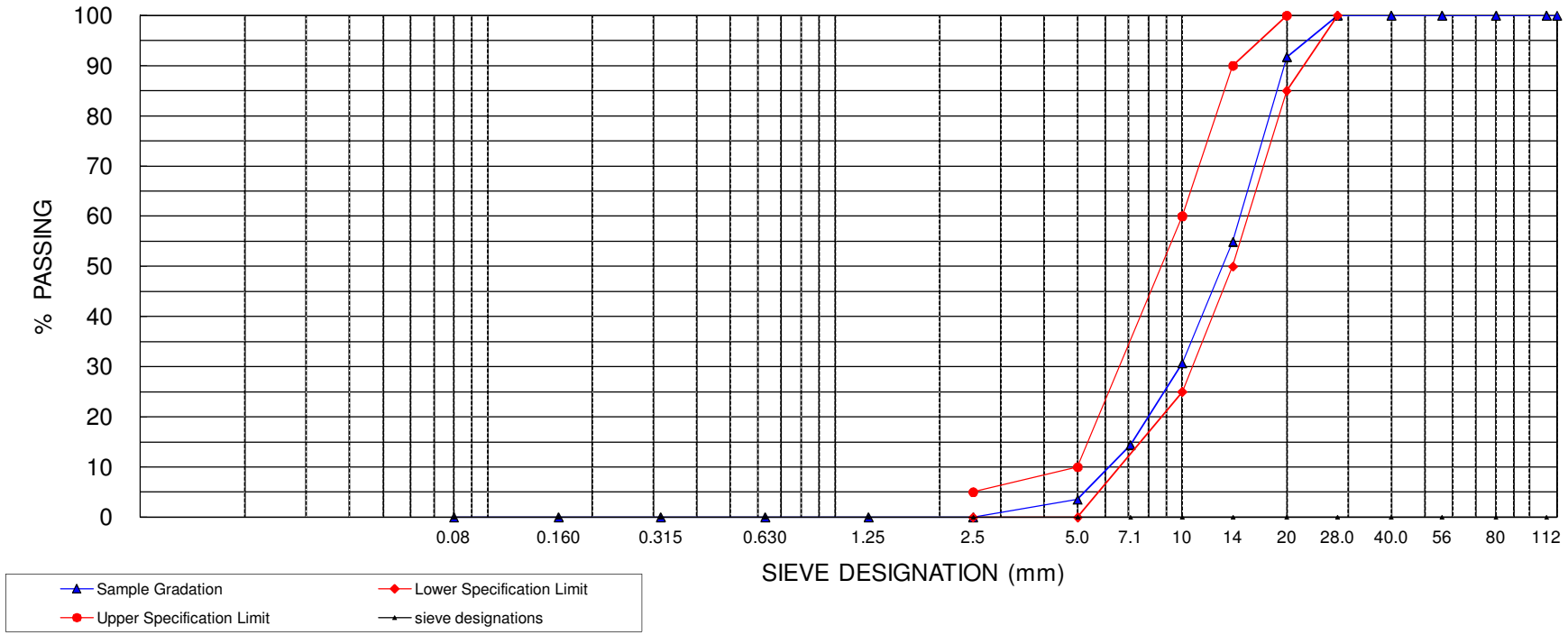
CSA A23.2-2A

Enclosure: 1
Date: 14 February 2017
Project No: TB152049

Client: Hatch
Sample Source: NF17-01
Sampled By: Client
Date Sampled: January 2017
Sample Type: Crushed Core
Specification: CSA A23.1-14, August 2014, Table 11, Group I, 20-5mm Concrete Stone Grading Requirements for Coarse Aggregate

Lab No: S018-17
Date Received: 26 January 2017
Date Tested: 6 February 2017
Lab Technician: KH

SIEVE SIZES (mm)	120	112	80	56	40.0	28.0	20	14	10	7.1	5	2.5	1.25	0.630	0.315	0.160	0.08
SPECIFICATIONS	-	-	-	-	-	100.0	85-100	50-90	25-60	-	0-10	0-5	-	-	-	-	-
% PASSING	100.0	100.0	100.0	100.0	100.0	100.0	91.7	54.9	30.7	14.4	3.5						
% RETAINING	0.0	0.0	0.0	0.0	0.0	0.0	8.3	45.1	69.3	85.6	96.5						



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PH: 905 312 0700
FX: 905 312 0771

LIMITS FOR DELETERIOUS SUBSTANCES AND PHYSICAL PROPERTIES OF AGGREGATE

CSA A23.1 - 14, Table 11 & 12 and A23.2 - 15A & 27A, Rev. August 2014

Clauses 4.2.3.2.2, 4.2.3.4.3, 4.2.3.5.1, 4.2.3.5.3.3, 4.2.3.5.3.4, 4.2.3.7 & 4.2.3.10.1

Job No.:	Client:	Sampled By:	Enclosure:
TB152049	Hatch Ltd	Client	**2**

Name of Testing Laboratory:	Telephone No.:	Fax No.:
Amec Foster Wheeler Environment & Infrastructure	(905) 312 - 0700	(905) 312 - 0771

Sample Lab No.:	Sample Source:
S019-17	NF17-02

Sample Type:	Date Sampled:	Stockpile Quantity (t)
Crushed Core	January 2017	--

COARSE AGGREGATE

Nominal Max. Size (mm):	Aggregrate Inventory No.:	Gradation Results:	Meets Spec.: (Y/N)
20 mm	n/a	n/a	n/a

Limits for Deleterious Substances and Physical Properties of Aggregates

CSA Laboratory Test and Number	Acceptance Limits		Reference Material Results	Sample Results	Meets Spec.
	Maximum percentage by mass of total sample				
Standard Requirements	**Concrete exposed to freezing & thawing**	**Other exposure conditions**			**Y / N**
Clay lumps - A23.2 - 3A †****	0.3 % maximum	0.5 % maximum	-	-	-
Low - density granular materials - A23.2 - 4A‡****	0.5 % maximum	1 % maximum	-	-	-
Material finer than 80 µm - A23.2 - 5A**	1% maximum[1]	1% maximum[1]	-	-	-
Absorption - A23.2 - 12A	-		0.37%	**0.90%**	-
Flat & elongated particles, Procedure A, 4:1 - A23.2-13A	20.0 % maximum	20.0 % maximum	-	-	-
Micro-Deval test - A23.2 - 29A	17 % maximum	21 % maximum	14.0%	**11.0%**	**Y**
Unconfined freeze-thaw test - A23.2 - 24A‡‡	6 % maximum	10 % maximum	9.5%	**11.1%**	**N**
Abrasion loss - A23.2 - 16A and A23.2 - 17A§§	50 % maximum	50 % maximum	-	-	-
Petrographic examination of aggregate - A23.2 -15A	125 maximum	140 maximum	-	-	-
Alkali-Carbonate reactivity - A23.2 - 26A	chem. comp. must plot in non-exp. field		-	-	-
Accelerated mortar bar - A23.2 - 25A	maximum 0.150% at 14 days		-	-	-
Concrete prism - A23.2 - 14A	maximum 0.040% at one year		-	-	-
Alternative Requirements* **					
$MgSO_4$ soundness loss - A23.2 - 9A	12 % maximum	18 % maximum			

Issued By: Kristen Hand (Print Name)

Testing Laboratory Representative Signature

14 February 2017 (Date)

LIMITS FOR DELETERIOUS SUBSTANCES AND PHYSICAL PROPERTIES OF AGGREGATE

CSA A23.1 - 14, Table 11 & 12 and A23.2-15A & 27A, Rev. August 2014

Clauses 4.2.3.2.2, 4.2.3.4.3, 4.2.3.5.1, 4.2.3.5.3.3, 4.2.3.5.3.4, 4.2.3.7 & 4.2.3.10.1

Enclosure: **2**

*Limits for deleterious substances not listed in this Table, such as coal, ochre (ironstone), shalestone, siltstone, or argillaceous limestone, shall be specified by the owner to encompass deleterious materials known to be present in a particular region. In the absence of such information, aggregate shall be accepted or rejected in accordance with clause 4.2.3.9

†Clay lumps are defined as fine-grained, consolidated, sedimentary materials of a hydrous aluminosilicate nature.

‡A liquid with a relative density of 2.0 is generally used to separate particles classified as coal or lignite. Liquids with relative densities higher or lower than 2.0 might be required to identify other deleterious low-density materials.

The amount of material of clay size shall be determined by performing a hydrometer analysis as per ASTM D 422 on a sample washed through an 80 µm sieve.

**In the case of crushed aggregate, if material finer than the 80 µm sieve consists of the dust of fracture, essentially free from clay or shale, the maximum shall be 2.0%

‡‡CSA A23.2-24A, a test for coarse aggregate, has good precision and shows fair correlation with the MgSO4 soundness test. For further information, see Rogers, Senior, & Boothe (1989)

§§The abrasion loss shall not be greater than 35% when the aggregate is used in concrete paving or for other concrete surfaces subjected to significant wear. This does not refer to air- cooled iron blast-furnace-slag coarse aggregate. The abrasion loss requirements for coarse aggregate shall be waived provided that the material meets the alternative requirements for Micro-deval detailed in this Table.

***The freeze-thaw requirements for coarse aggregate shall be waived provided that the material meets the laternative requirements for $MgSO_4$ soundness loss detailed in this Table.

****If the Coarse Aggregate when tested according to A23.2-15A does not show the presence of either clay lumps or low-density granular materials, the requirements for testing in accordance with 3A and 4A may be waived.

[1]This limit applies to the amount of material finer than 80µm as determined by washing only.

Amec Foster Wheeler Environment & Infrastructure
a Division of Amec Foster Wheeler Americas Limited
505 Woodward Avenue, Unit 1
Hamilton, Ontario
Canada L8H 6N6

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE

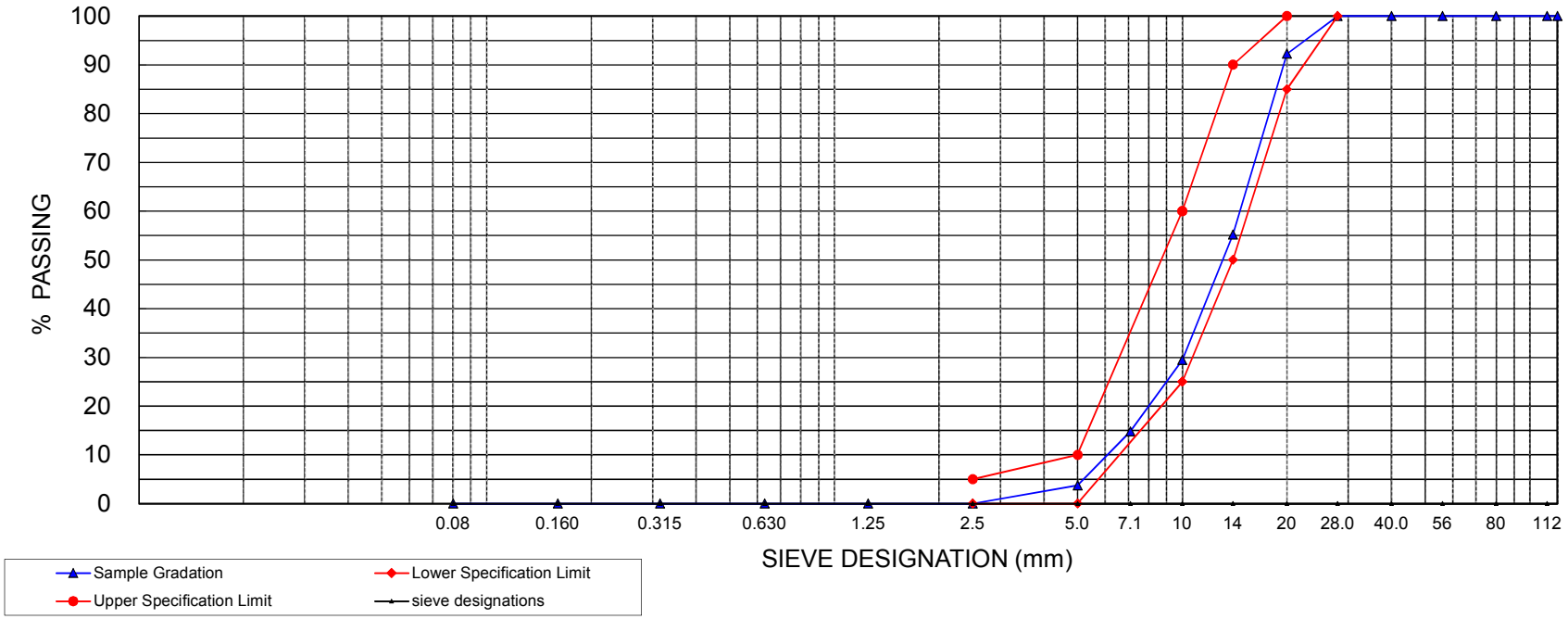
CSA A23.2-2A

Enclosure: 1
Date: 14 February 2017
Project No: TB152049

Client: Hatch Ltd
Sample Source: NF17-02
Sampled By: Client
Date Sampled: January 2017
Sample Type: Crushed Core
Specification: CSA A23.1-14, August 2014, Table 11, Group I, 20-5mm Concrete Stone Grading Requirements for Coarse Aggregate

Lab No: S019-17
Date Received: 26 January 2017
Date Tested: 6 February 2017
Lab Technician: KH

SIEVE SIZES (mm)	120	112	80	56	40.0	28.0	20	14	10	7.1	5	2.5	1.25	0.630	0.315	0.160	0.08
SPECIFICATIONS	-	-	-	-	-	100.0	85-100	50-90	25-60	-	0-10	0-5	-	-	-	-	-
% PASSING	100.0	100.0	100.0	100.0	100.0	100.0	92.3	55.2	29.4	14.8	3.7						
% RETAINING	0.0	0.0	0.0	0.0	0.0	0.0	7.7	44.8	70.6	85.2	96.3						



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LIMITS FOR DELETERIOUS SUBSTANCES AND PHYSICAL PROPERTIES OF AGGREGATE

CSA A23.1 - 14, Table 11 & 12 and A23.2 - 15A & 27A, Rev. August 2014

Clauses 4.2.3.2.2, 4.2.3.4.3, 4.2.3.5.1, 4.2.3.5.3.3, 4.2.3.5.3.4, 4.2.3.7 & 4.2.3.10.1

Job No.:	Client:	Sampled By:	Enclosure:
TB152049	Hatch Ltd.	Client	**2**

Name of Testing Laboratory:	Telephone No.:	Fax No.:
Amec Foster Wheeler Environment & Infrastructure	(905) 312 - 0700	(905) 312 - 0771

Sample Lab No.:	Sample Source:
S020-17	NF17-03

Sample Type:	Date Sampled:	Stockpile Quantity (t)
Crushed Core	Janaury 2017	--

COARSE AGGREGATE

Nominal Max. Size (mm):	Aggregrate Inventory No.:	Gradation Results:	Meets Spec.: (Y/N)
20 mm	n/a	n/a	n/a

Limits for Deleterious Substances and Physical Properties of Aggregates

CSA Laboratory Test and Number	Acceptance Limits		Reference Material Results	Sample Results	Meets Spec.
	Maximum percentage by mass of total sample				
Standard Requirements	**Concrete exposed to freezing & thawing**	**Other exposure conditions**			**Y / N**
Clay lumps - A23.2 - 3A †****	0.3 % maximum	0.5 % maximum	-	-	-
Low - density granular materials - A23.2 - 4A‡****	0.5 % maximum	1 % maximum	-	-	-
Material finer than 80 µm - A23.2 - 5A**	1% maximum[1]	1% maximum[1]	-	-	-
Absorption - A23.2 - 12A	-		0.37%	**0.37%**	-
Flat & elongated particles, Procedure A, 4:1 - A23.2-13A	20.0 % maximum	20.0 % maximum	-	-	-
Micro-Deval test - A23.2 - 29A	17 % maximum	21 % maximum	14.0%	**4.5%**	**Y**
Unconfined freeze-thaw test - A23.2 - 24A‡‡	6 % maximum	10 % maximum	9.5%	**1.6%**	**Y**
Abrasion loss - A23.2 - 16A and A23.2 - 17A§§	50 % maximum	50 % maximum	-	-	-
Petrographic examination of aggregate - A23.2 -15A	125 maximum	140 maximum	-	-	-
Alkali-Carbonate reactivity - A23.2 - 26A	chem. comp. must plot in non-exp. field		-	-	-
Accelerated mortar bar - A23.2 - 25A	maximum 0.150% at 14 days		-	-	-
Concrete prism - A23.2 - 14A	maximum 0.040% at one year		-	-	-
Alternative Requirements* **					
$MgSO_4$ soundness loss - A23.2 - 9A	12 % maximum	18 % maximum			

Issued By: Kristen Hand (Print Name)

Testing Laboratory Representative Signature

14 February 2017 (Date)

LIMITS FOR DELETERIOUS SUBSTANCES AND PHYSICAL PROPERTIES OF AGGREGATE

CSA A23.1 - 14, Table 11 & 12 and A23.2-15A & 27A, Rev. August 2014

Clauses 4.2.3.2.2, 4.2.3.4.3, 4.2.3.5.1, 4.2.3.5.3.3, 4.2.3.5.3.4, 4.2.3.7 & 4.2.3.10.1

Enclosure: **2**

*Limits for deleterious substances not listed in this Table, such as coal, ochre (ironstone), shalestone, siltstone, or argillaceous limestone, shall be specified by the owner to encompass deleterious materials known to be present in a particular region. In the absence of such information, aggregate shall be accepted or rejected in accordance with clause 4.2.3.9

†Clay lumps are defined as fine-grained, consolidated, sedimentary materials of a hydrous aluminosilicate nature.

‡A liquid with a relative density of 2.0 is generally used to separate particles classified as coal or lignite. Liquids with relative densities higher or lower than 2.0 might be required to identify other deleterious low-density materials.

The amount of material of clay size shall be determined by performing a hydrometer analysis as per ASTM D 422 on a sample washed through an 80 µm sieve.

**In the case of crushed aggregate, if material finer than the 80 µm sieve consists of the dust of fracture, essentially free from clay or shale, the maximum shall be 2.0%

‡‡CSA A23.2-24A, a test for coarse aggregate, has good precision and shows fair correlation with the MgSO4 soundness test. For further information, see Rogers, Senior, & Boothe (1989)

§§The abrasion loss shall not be greater than 35% when the aggregate is used in concrete paving or for other concrete surfaces subjected to significant wear. This does not refer to air- cooled iron blast-furnace-slag coarse aggregate. The abrasion loss requirements for coarse aggregate shall be waived provided that the material meets the alternative requirements for Micro-deval detailed in this Table.

***The freeze-thaw requirements for coarse aggregate shall be waived provided that the material meets the laternative requirements for $MgSO_4$ soundness loss detailed in this Table.

****If the Coarse Aggregate when tested according to A23.2-15A does not show the presence of either clay lumps or low-density granular materials, the requirements for testing in accordance with 3A and 4A may be waived.

[1]This limit applies to the amount of material finer than 80µm as determined by washing only.

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SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE

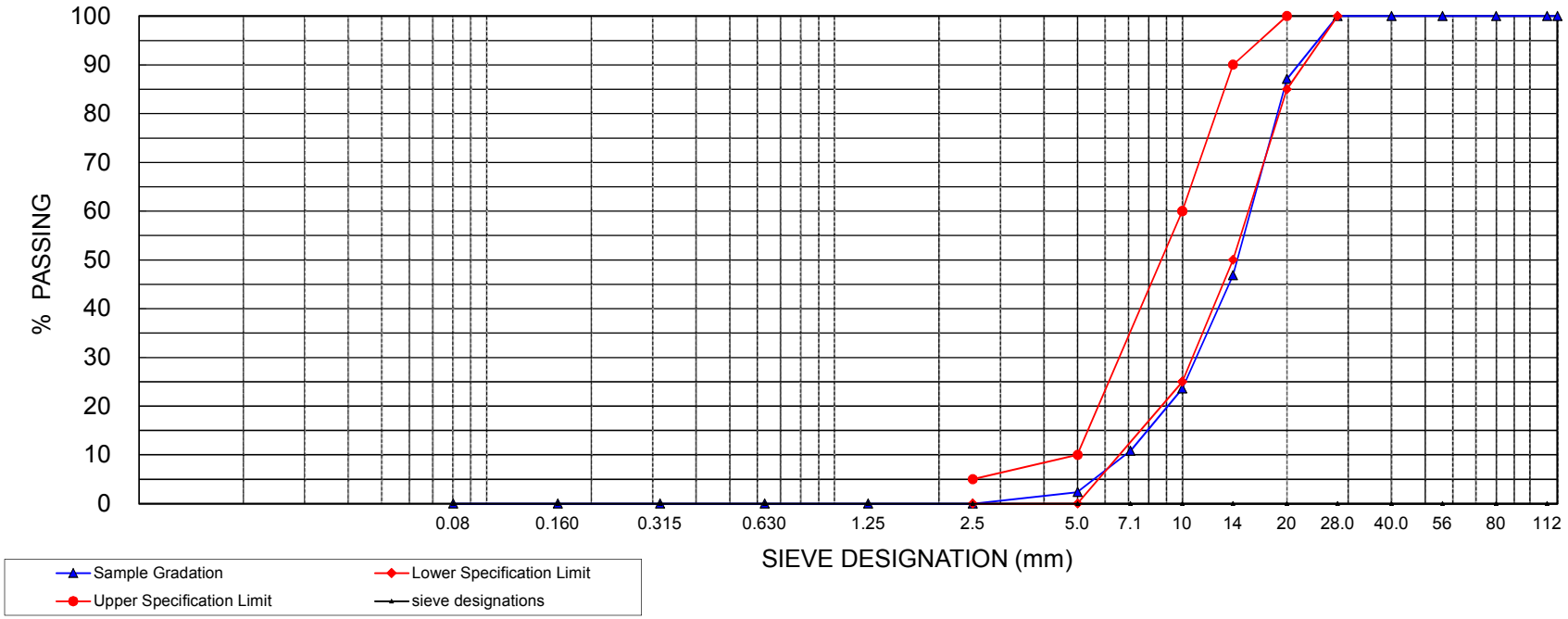
CSA A23.2-2A

Enclosure: 1
Date: 14 February 2017
Project No: TB152049

Client: Hatch Ltd.
Sample Source: NF17-03
Sampled By: Client
Date Sampled: January 2017
Sample Type: Crushed Core
Specification: CSA A23.1-14, August 2014, Table 11, Group I, 20-5mm Concrete Stone Grading Requirements for Coarse Aggregate

Lab No: S020-17
Date Received: 26 January 2017
Date Tested: 6 February 2017
Lab Technician: KH
Fineness Modulus: #DIV/0!

SIEVE SIZES (mm)	120	112	80	56	40.0	28.0	20	14	10	7.1	5	2.5	1.25	0.630	0.315	0.160	0.08
SPECIFICATIONS	-	-	-	-	-	100.0	85-100	50-90	25-60	-	0-10	0-5	-	-	-	-	-
% PASSING	100.0	100.0	100.0	100.0	100.0	100.0	87.1	46.8	23.6	10.8	2.4						
% RETAINING	0.0	0.0	0.0	0.0	0.0	0.0	12.9	53.2	76.4	89.2	97.6						



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LIMITS FOR DELETERIOUS SUBSTANCES AND PHYSICAL PROPERTIES OF AGGREGATE

CSA A23.1 - 14, Table 11 & 12 and A23.2 - 15A & 27A, Rev. August 2014

Clauses 4.2.3.2.2, 4.2.3.4.3, 4.2.3.5.1, 4.2.3.5.3.3, 4.2.3.5.3.4, 4.2.3.7 & 4.2.3.10.1

Job No.:	Client:	Sampled By:	Enclosure:
TB152049	Hatch Ltd.	Client	**2**

Name of Testing Laboratory:	Telephone No.:	Fax No.:
Amec Foster Wheeler Environment & Infrastructure	(905) 312 - 0700	(905) 312 - 0771

Sample Lab No.:	Sample Source:
S021-17	NF17-04

Sample Type:	Date Sampled:	Stockpile Quantity (t)
Crushed Rock	January 2017	--

COARSE AGGREGATE

Nominal Max. Size (mm):	Aggregrate Inventory No.:	Gradation Results:	Meets Spec.: (Y/N)
20 mm	n/a	n/a	n/a

Limits for Deleterious Substances and Physical Properties of Aggregates

CSA Laboratory Test and Number	Acceptance Limits		Reference Material Results	Sample Results	Meets Spec.
	Maximum percentage by mass of total sample				
Standard Requirements	**Concrete exposed to freezing & thawing**	**Other exposure conditions**			**Y / N**
Clay lumps - A23.2 - 3A †****	0.3 % maximum	0.5 % maximum	-	-	-
Low - density granular materials - A23.2 - 4A‡****	0.5 % maximum	1 % maximum	-	-	-
Material finer than 80 µm - A23.2 - 5A**	1% maximum[1]	1% maximum[1]	-	-	-
Absorption - A23.2 - 12A	-		0.37%	**0.45%**	-
Flat & elongated particles, Procedure A, 4:1 - A23.2-13A	20.0 % maximum	20.0 % maximum	-	-	-
Micro-Deval test - A23.2 - 29A	17 % maximum	21 % maximum	14.0%	**7.9%**	**Y**
Unconfined freeze-thaw test - A23.2 - 24A‡‡	6 % maximum	10 % maximum	9.5%	**0.8%**	**Y**
Abrasion loss - A23.2 - 16A and A23.2 - 17A§§	50 % maximum	50 % maximum	-	-	-
Petrographic examination of aggregate - A23.2 -15A	125 maximum	140 maximum	-	-	-
Alkali-Carbonate reactivity - A23.2 - 26A	chem. comp. must plot in non-exp. field		-	-	-
Accelerated mortar bar - A23.2 - 25A	maximum 0.150% at 14 days		-	-	-
Concrete prism - A23.2 - 14A	maximum 0.040% at one year		-	-	-
Alternative Requirements* **					
$MgSO_4$ soundness loss - A23.2 - 9A	12 % maximum	18 % maximum			

Issued By: Kristen Hand (Print Name) _____ (Testing Laboratory Representative Signature) 14 February 2017 (Date)

LIMITS FOR DELETERIOUS SUBSTANCES AND PHYSICAL PROPERTIES OF AGGREGATE

CSA A23.1 - 14, Table 11 & 12 and A23.2-15A & 27A, Rev. August 2014

Clauses 4.2.3.2.2, 4.2.3.4.3, 4.2.3.5.1, 4.2.3.5.3.3, 4.2.3.5.3.4, 4.2.3.7 & 4.2.3.10.1

Enclosure: **2**

*Limits for deleterious substances not listed in this Table, such as coal, ochre (ironstone), shalestone, siltstone, or argillaceous limestone, shall be specified by the owner to encompass deleterious materials known to be present in a particular region. In the absence of such information, aggregate shall be accepted or rejected in accordance with clause 4.2.3.9

†Clay lumps are defined as fine-grained, consolidated, sedimentary materials of a hydrous aluminosilicate nature.

‡A liquid with a relative density of 2.0 is generally used to separate particles classified as coal or lignite. Liquids with relative densities higher or lower than 2.0 might be required to identify other deleterious low-density materials.

The amount of material of clay size shall be determined by performing a hydrometer analysis as per ASTM D 422 on a sample washed through an 80 µm sieve.

**In the case of crushed aggregate, if material finer than the 80 µm sieve consists of the dust of fracture, essentially free from clay or shale, the maximum shall be 2.0%

‡‡CSA A23.2-24A, a test for coarse aggregate, has good precision and shows fair correlation with the MgSO4 soundness test. For further information, see Rogers, Senior, & Boothe (1989)

§§The abrasion loss shall not be greater than 35% when the aggregate is used in concrete paving or for other concrete surfaces subjected to significant wear. This does not refer to air- cooled iron blast-furnace-slag coarse aggregate. The abrasion loss requirements for coarse aggregate shall be waived provided that the material meets the alternative requirements for Micro-deval detailed in this Table.

***The freeze-thaw requirements for coarse aggregate shall be waived provided that the material meets the laternative requirements for $MgSO_4$ soundness loss detailed in this Table.

****If the Coarse Aggregate when tested according to A23.2-15A does not show the presence of either clay lumps or low-density granular materials, the requirements for testing in accordance with 3A and 4A may be waived.

[1]This limit applies to the amount of material finer than 80µm as determined by washing only.

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SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE

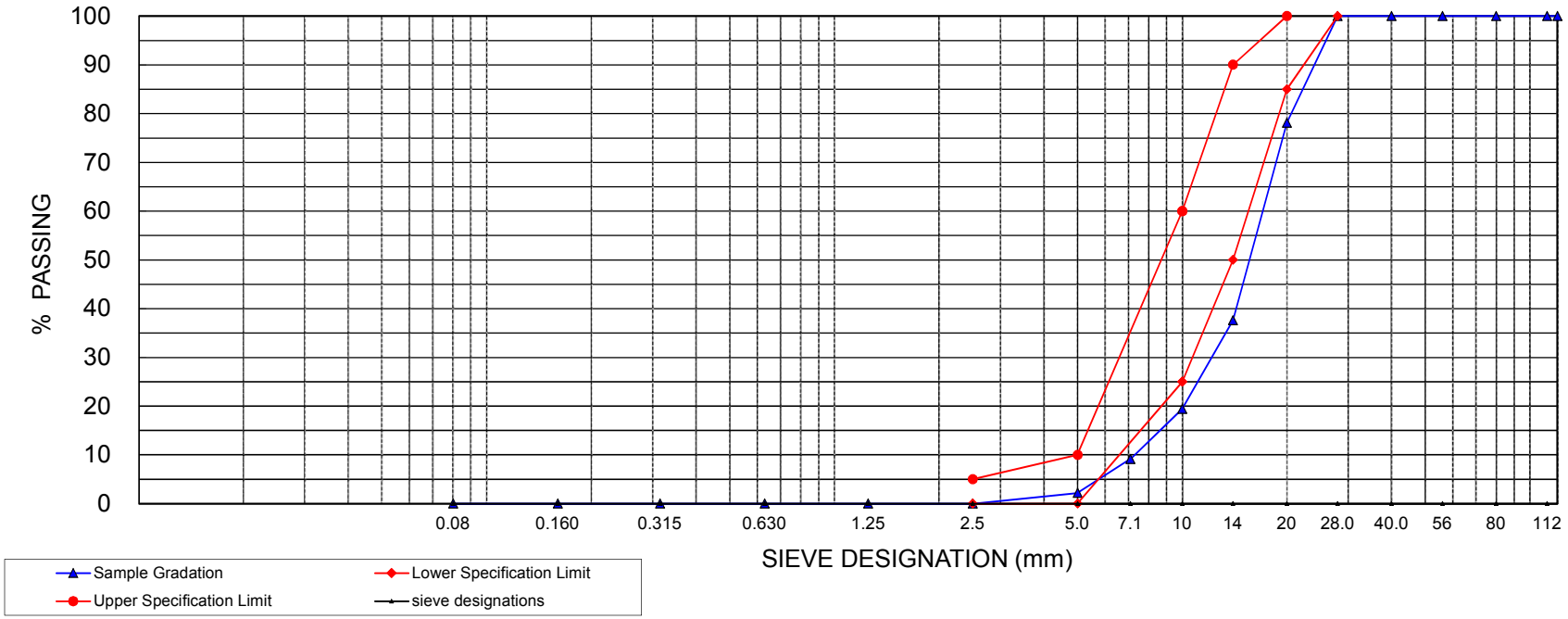
CSA A23.2-2A

Enclosure: 1
Date: 14 February 2017
Project No: TB152049

Client: Hatch Ltd.
Sample Source: NF17-04
Sampled By: Client
Date Sampled: January 2017
Sample Type: Crushed Rock
Specification: CSA A23.1-14, August 2014, Table 11, Group I, 20-5mm Concrete Stone Grading Requirements for Coarse Aggregate

Lab No: S021-17
Date Received: 26 January 2017
Date Tested: 6 February 2017
Lab Technician: KH

SIEVE SIZES (mm)	120	112	80	56	40.0	28.0	20	14	10	7.1	5	2.5	1.25	0.630	0.315	0.160	0.08
SPECIFICATIONS	-	-	-	-	-	100.0	85-100	50-90	25-60	-	0-10	0-5	-	-	-	-	-
% PASSING	100.0	100.0	100.0	100.0	100.0	100.0	78.1	37.6	19.4	9.2	2.2						
% RETAINING	0.0	0.0	0.0	0.0	0.0	0.0	21.9	62.4	80.6	90.8	97.8						



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SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

10-July-2017

Hatch LTD
Attn : Ralph Serluca

4342 Queen St Suite500
Niagara Falls, ON
L2E 6W1,

Phone: 905-374-5200
Fax:905-374-0701

Date Rec. : 27 June 2017
LR Report: **CA13857-JUN17**

Copy: #1

CERTIFICATE OF ANALYSIS

Partial Report

Analysis	5: NF17-07	6: NF17-08	7: NF17-09
Sample Date & Time	Date:N/A	Date:N/A	Date:N/A
Paste pH	9.89	8.89	8.24
Fizz Rate [---]	1	1	3
Sample weight [g]	2.05	1.99	2.00
HCl Added [mL]	20.00	20.00	540.00
HCl [Normality]	0.10	0.10	0.10
NaOH [Normality]	0.10	0.10	0.10
NaOH to [pH=8.3 mL]	17.48	15.50	109
Final pH	1.14	1.73	1.68
NP [t CaCO3/1000 t]	6.1	11	1077
AP [t CaCO3/1000 t]	0.67	0.67	0.67
Net NP [t CaCO3/1000 t]	5.43	10.6	1077
NP/AP [ratio]	9.10	16.9	1608
Sulphur (total) [%]	0.035	0.042	0.029
Acid Leachable SO4-S [%]	0.04	0.04	0.03
Sulphide [%]	< 0.02	< 0.02	< 0.02
Carbon (total) [%]	0.044	0.061	11.1
Carbonate [%]	0.110	< 0.025	54.1

Brian Graham B.Sc.
Project Specialist
Environmental Services, Analytical

OnLine LIMS

0001059049

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SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

LR Report : **CA13857-JUN17**

*NP (Neutralization Potential)

$$= \frac{50 \times (\text{N of HCL} \times \text{Total HCL added} - \text{N NaOH} \times \text{NaOH added})}{\text{Weight of Sample}}$$

*AP (Acid Potential) = % Sulphide Sulphur x 31.25
*Net NP (Net Neutralization Potential) = NP-AP
NP/AP Ratio = NP/AP
*Results expressed as tonnes CaCO3 equivalent/1000 tonnes of material
Samples with a % Sulphide value of <0.02 will be calculated using a 0.02 value.

OnLine LIMS

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Test method information available upon request. “Temperature Upon Receipt” is representative of the whole shipment and may not reflect the temperature of individual samples.

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Appendix I
Geological Investigation Safety Plan

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Safety Management Plan - Geotechnical Drilling Program		Project Number: H352034
Hatch requires a site-specific Occupational Health and Safety Management Plan for all construction projects. Note that backup documentation is required to demonstrate the veracity of any statements made in this plan. If any are is not applicable to your project please provide an explanation as to why.		
1. Project Definition	Project name	12Mtpa 2016 Field Investigation Program
	Project description	Geotechnical drilling investigation for Baffinland Iron Mines (BIM) including (i) along proposed rail alignment from Mary River to Milne Port, (ii) Milne Port Infrastructure area, (iii) Bridge structures, (iv) quarries and (v) offshore (marine area associated with dock location.
	Project location(s) and project work site location(s)	Locations as noted above.
	What are the safety targets for this project? (Consider LTIs, MTIs, audits etc.)	No incidents.
	How will safety statistics be measured and reported?	Will be recorded along with weekly progress meeting/reports.
2. Project Roles and Responsibilities	Who is the Project Manager?	James Cleland.
	Who is the Principal Contractor for the project?	Boart Longyear (BLY).
	Who is the person on the project team responsible for ensuring compliance with the obligations of the Principal Contractor under the applicable legislation?	BIM, with Hatch as site representative.

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Safety Management Plan - Geotechnical Drilling Program			Project Number: H352034	
	Who is responsible for:	**Responsible:**	**Who is responsible for:**	**Responsible:**
	• identifying, controlling (through elimination or mitigation) and documenting the risks during the design phase of the project	Hatch	• managing compliance of all contractors and persons on site with Safe Work Method Statements and the Site Safety Rules.	BLY Lead supported by Hatch Staff
	• reporting safety aspects of the design to the construction team and plant owner	BLY supported by Hatch.	• making sure that all personnel attend the required safety inductions, have been appropriately trained and keeping records of attendance at inductions and other safety training.	BLY Lead supported by Hatch Staff
	• identifying hazards and assessing the risks associated with all other aspects of the work, and determining and documenting the risk control measures necessary	BLY for all equipment operation	• providing contractors and any person involved in the work with the Site-specific Safety Management Plan and any updates.	BLY SMP supported by Hatch
	• regularly reviewing and updating hazard identification, risk assessment and measures to control risks	BLY supported by Hatch	• managing OHS communication and consultation provisions in accordance with the regulatory and other requirements.	BIM – supported by BLY and Hatch
	• managing compliance on the project with OHS, workplace injury management and workers compensation legislation, regulations, standards and codes	BIM – supported by BLY and Hatch	• preparing, maintaining and making available the register of hazardous substances.	BLY – oversight by Hatch
	• assessing and monitoring the safety management capability of contractors and other service providers	BIM	• ensuring first aid is always available and maintaining first aid stocks.	BLY supported by Hatch FA trained individuals

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Safety Management Plan - Geotechnical Drilling Program				Project Number: H352034
	• Any other project safety responsibility issues?	Weekly progress meeting/reports		
3. Risk Assessment and Management	• Has a risk assessment with representatives from the plant, subcontractors and other stakeholders in the project been held? If not, how will project hazards be identified?	BLY has prepared and will be reviewed with all site staff. Individual daily assessments will be conducted and reviewed at the pre-shift meetings.		
	• Where are the results of the risk assessment documented? Is the level of documentation commensurate with the risks involved?	BLY has provided RA and safe work procedure which has been reviewed and accepted by Hatch.		
	• What is the plan for managing and regularly reviewing the risks and documenting any additionally identified risks?	Pre-shift meeting will be used for risk review of the work activities and drilling locations. JHA's will be updated if major changes occur.		
	• Is any other risk assessment required on this project? (e.g. HAZOP, CHAZOP, HAZAN?)	NA		
	• How will changes in the construction process that might affect the health and safety of any person on the construction site be identified and communicated?	Pre-shift meeting will be used for risk review of the work activities and drilling locations. JHA's will be updated if major changes occur.		
	• How will an emergency on site be handled? How will people be trained in these procedures?	Will use the existing BIM emergency procedures. Need to obtain a copy, assess applicability, make any necessary modifications and review with site Team.		

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Safety Management Plan - Geotechnical Drilling Program				Project Number: H352034
	• Any other risk management issues? e.g. do any national or state standards apply to any of the hazards identified?	Travel issues for specific drill locations off of the Tote Road.		
	Consider the other following commonly encountered hazards, indication whether they are an issue on this project and what measures will be taken or put in place to control the hazard:			
	Hazard Will project be exposed to hazard?	**Yes / No**	**Details**	**Control Measure(s) to be implemented**
	Existing services (including electrical, gas or fluid)	No		
	Flammable or toxic gases	Yes	Diesel fuel transport to drills.	Diesel fuel will be transported in closed and safe containers.
	Hazardous materials and dangerous goods (including presence of asbestos)	Yes	BLY	As stated in the BLY RA and procedures.
	Molten metals	No		
	Electrical	Yes	Portable generators.	As stated in the BLY RA and procedures.
	Fire safety	Yes	Portable heating equipment and fuel powered equipment.	As stated in the BLY RA and procedures.
	Internal road safety/ traffic control/ access and egress.	Yes	Tote Road Procedure and BIM Training for individuals driving on the Tote Road.	BIM Procedures and communication requirements, Training by BIM trainer. All other controls to be established in pre-shift meetings and JHA's.

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Safety Management Plan - Geotechnical Drilling Program				Project Number: H352034
	Mobile equipment	Yes	BLY equipment and loaned BIM equipment.	BIM Procedures and communication requirements.
	Rail interactions	No		
	Overhead cranes	No		
	Isolations and stored energy.	Yes	BLY equipment	As stated in the BLY RA and procedures.
	Access to or working around .continuous plant	No		
	Manual handling.	Yes	Drill rods and cores and core boxes, handling tools and equipment.	As stated in the BLY RA and procedures.
	Work at heights.	Yes	Possibly required to access drill mast.	As stated in the BLY RA and procedures.
	Falling in (Excavations etc.) or falling on (overhead work/ loads).	No		
	Management of safety by contractors.	Yes	BLY with Hatch oversight.	
	Other interfaces with operations.	Yes	Tote Road use by Operations and Services.	BIM communication requirements.
	Other conditions on the construction site eg: lighting, security, disposal of waste.	Yes	Procedures to meet BIM requirements as stated by Environment. Weather conditions are evaluated on a shift basis – weather conditions reviewed and responsible Hatch site leads to monitor during the shift.	Hatch site leads responsible to shut down work due to weather conditions.

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Safety Management Plan - Geotechnical Drilling Program			Project Number: H352034
	Commissioning	NA	

Of the hazards identified above and in the project risk studies, the top ten safety-related risks associated with the project are listed as follows. The list includes the control measures and the person responsible for ensuring that the measures are implemented. The list should consider all phases of the project including design, installation, erection and commissioning and handover to the owners of the plant. **(L = likelihood C=Consequence RR=Risk Rating Resp. = Responsible for control of the risk)**

Risk No.	Description	L	C	Raw RR	Controls	Resp.	L	C	Controlled RR
1	Hazardous materials and dangerous goods.	1	2	3	**MSDS and procedures, BLY with Hatch oversight.**	BLY	1	2	3
2	Electrical – portable generators.	2	2	4	**BLY Procedures and Grounding of portable generators.**	BLY	1	2	3
3	Fire Safety – portable heating equipment.	2	2	4	**BLY Procedures and MSDS.**	BLY	1	2	3
4	Internal road safety/ traffic control/ access and egress.	2	2	4	**Tote Road Procedure and Training for individuals driving on the Tote Road. All travel away from the Tote Road will be assessed and appropriate corrective actions applied.**	BLY/Hatch	1	2	3
5	Mobile equipment.	1	2	3	**BLY Procedures. BIM procedures for borrowed mobile equipment.**	BLY	1	2	3
6	Isolations and stored energy.	2	2	4	**BLY Procedures.**	BLY	1	2	3

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Safety Management Plan - Geotechnical Drilling Program						Project Number: H352034			
7	Manual handling	1	2	3	**BLY Procedures.**	**BLY**	1	2	3
8	Work at heights	2	2	4	**BLY Procedures. BLY with Hatch oversight.**	**BLY**	1	2	3
9	Other interfaces with operations.	1	2	3	**BLY Procedures. BLY with Hatch oversight.**	**BLY**	1	2	3
10	Management of safety by contractors.	1	2	3	**BLY Procedures. BLY with Hatch oversight.**	**BLY/Hatch**	1	2	3
11	Other conditions on the construction site e.g.: lighting, security, disposal of waste.	1	2	3	**BLY Procedures. BLY with Hatch oversight.**	**BLY/Hatch**	1	2	3

4. Design	• How will you ensure that the safety hazards and risks (including those associated with the construction phase) will be communicated to the designers and considered through the design process?	**NA**
	• What process will be used to review and verify the design to ensure that the plant/equipment is safe, eliminates, minimizes or controls any OHS risks (including those during construction) and complies with appropriate legislation and standards?	**NA**
	• Does the project include items of plant for which the design or actual item of plant requires registration with government institutions?	**NA**
	• Any other safety related design issues? e.g. process for approving design changes; obtaining appropriate OHS information from suppliers of plant, equipment and materials; designers providing risks identified during design etc.	**Individual drill locations will be assessed for safety accessibility by BLY and supported by Hatch.**

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Safety Management Plan - Geotechnical Drilling Program		Project Number: H352034
5. Occupational Health & Safety Training	• What are the minimum induction requirements for access to project site to ensure that work can be undertaken safely? (Tick box if required)	□ Legislative requirement □ Client Specific □ Dept./Hatch Induction (specify)___BIM Site Orientation_____ □ Project Specific Induction □ Other (specify): _BLY procedures and BIM procedures/training _____
	• How will records of attendance at inductions be kept?	**It will be reported in the weekly meetings/reports**
	• How will records of the type of induction training (including a description of the content of the training) be kept?	**NA**
	• How will you ensure that all personnel have been appropriately inducted before starting work?	**Review with contractor leadership.**
	• How will you ensure that visitors to the site are kept safe and made aware of any safety hazards?	**Visitors will be escorted**
	• How will you ensure that any additional training (required for safe performance of the work) necessitated by a change in the work site is identified and implemented?	**Pre-shift meetings will be used to detail any additional hazards and controls.**
	• Any other training or induction issues?	**NA**
6. Incident Management	• Who will be available to respond to any injury or illness?	**BLY site leadership supported by Hatch. BIM ERT for serious injuries or incidents.**

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Safety Management Plan - Geotechnical Drilling Program		Project Number: H352034
	• What first aid facilities are available for the project site(s)?	**BLY remote FA Kit**
	• How will incidents be reported?	**BLY leadership to BIM safety**
	• Who will be responsible for investigating incidents and ensuring any corrective actions are followed up and completed?	**BLY leadership supported by Hatch**
	• How will any serious incidents be reported to Hatch management (or Legislative instances if required)?	**By Hatch Site staff**
	• How will records of incidents be kept?	**Records will be documented on a daily basis and included in weekly progress reports.**
7. Communication	• Where will the signs, containing the name and contact telephone numbers of the principal contractor, be located?	**NA**
	• Where will this safety management plan be kept to ensure that it is available to all people involved in working on the project (including those working on the work site(s))?	**Onsite with BLY leadership and Hatch.**
	• How will the project safety targets be communicated to all personnel involved with the project?	**Site orientation and reviewed in pre-shift meetings.**
	• How will the project safety rules be communicated so that all personnel involved with the project, including personnel on, and visitors to, the work site are made aware of them?	**Site orientation and reviewed in pre-shift meetings.**

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Safety Management Plan - Geotechnical Drilling Program		Project Number: H352034
	• How will you ensure that sub-contractors or other service providers are provided with the relevant parts of the safety management plan before commencement of work?	**NA – no subcontractors.**
	• How will you ensure that any change to the safety management plan is communicated to project stakeholders including subcontractors and other service providers?	**Pre-shift meetings.**
	• How will you ensure that any changes to the work site likely to affect health and safety are quickly communicated to all affected personnel? (eg. daily pre-start/toolbox meetings)	**Pre-shift meetings.**
	• Other means to communicate safety matters among the project participants? e.g. safety committees, safety meetings, keeping records of all safety communication etc.	**All BIM safety information will be reviewed at Pre-shift meetings.**
8. Access Control and Work Clearance	• How will you restrict access to the work site(s) to people authorized to do so? (including members of the public)	**NA**
	• How will you ensure that other people in the area of the work site (e.g. adjacent operations facilities), or effected by activities on the site, are kept up to date with activities on the site?	**Drilling locations will be communicated in Baffinland daily toolbox memo.**
	• How will interactions with adjacent or effected sites and stakeholders be managed?	**NA**
	• What Personal Protective Equipment will be required to be worn on the work site(s)?	**BLY and Baffinland requirements and weather dependant.**

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Safety Management Plan - Geotechnical Drilling Program		Project Number: H352034
	• Any other access or work clearance issues?	**NA**
9. Audits	• What systems will be used to ensure that project team members, subcontractors, other service providers will comply with this safety management plan and other site safety rules?	**BLY and Hatch site leadership.**
	• What types of audits will be conducted?	**Weekly visible felt leadership inspections.**
	• Who will be involved in audits?	**NA**
	• How often will they be done?	**NA**
	• Any other auditing issues?	**NA**
10. Safe Work Method Statements (for Job Hazard Analysis)	• How will you ensure that subcontractors provide job safety and environmental analysis (JHA), for all work activities assessed as having safety risks, before commencement of work?	**Hatch will oversee work activities based on JHA's.**
	• How will you ensure that the subcontractors comply with the JSEA they have provided?	**NA**
	• What action will be taken if the subcontractor does not comply with the JHA?	**NA**
	• How will you ensure that the JHA is promptly updated to reflect any changes in the way the work is planned to be carried out?	**NA**

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Safety Management Plan - Geotechnical Drilling Program		Project Number: H352034
	• Any other issues regarding JHA?	**NA**
11. Hazardous Materials Register	• How will you keep and maintain a record of the hazardous substances used during the course of the work? This register should include hazardous substances contained in pipes or vessels which are considered a hazard to the project.	**BLY Procedure and requirements.**
	• How will you ensure the register is made accessible to all persons working at the work site?	**NA**
	• Any other hazardous materials issues?	**NA**
12. Review and Update of SMP	How will this plan be monitored, maintained and kept up to date during the course of the project? Who will be responsible for this?	**BLY and Hatch site leadership.**
13. Other Issues	Off road travel, Emergency rescue availability – Stand-down work, Deteriorating weather conditions – decisions/communications, wildlife encounter.	

Safety Management Plan Prepared by:	**Date Prepared:**	**Reviewed by Principal Contractor:** **Date:** Oct 31, 2016
Warren R. Hoyle	**2016-10-12**	**BLY Leadership** Jarrett Campbell
Warren Hoyle		**Principal Contractor Representative: Jarrett Campbell**
		Position: Project Manager **Signature** Jarrett Campbell

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Job Hazard Analysis Form

PROJECT/TASK: ZG003 Geotechnical Marine Drilling Milne Inlet		**Department: Projects Boart Longyear**				**JOB No.:ZG003**			
SUPERVISOR: Emile Beauchamp		**LOCATION: Future Ore Dock Milne Inlet**				**DATE: March 12 ,2017**			
JOB STEP Break the job into steps. Listing work which may be hazardous.	**HAZARDS** List the hazard or type of harm identified with each step.	**Inherent**			**CONTROL MEASURE** List the necessary control measures to be followed to eliminate/reduce the identified hazards.	**Residual**			**ACTION** Person who will ensure this happens
		Consequence	**Likelihood**	**Risk Ranking**		**Consequence**	**Likelihood**	**Risk Ranking**	
1. Pre-job JHA Review.	Missing critical items on the JHA that can lead to an incident	3	2	5	Conduct a pre-job JHA review with Safety and critical team members All workers will have the opportunity to identify changes needed Any changes will be added to this document	1	1	2	Marlon Coakley/Warren Hoyle
2. Workers to complete FLRA card in the field at location prior to starting work.	Additional hazards in the area that may not have been identified on the JHA and daily changes that may pose additional danger to the health and safety of workers, the environment and property	3	3	6	Look at immediate work area for hazards that may exist, not identified on the JHA. Have other workers in the group sign off on the FLHA	1	1	2	All workers
3. Load Weights – The number and types of vehicles and equipment and their maximum gross weights	Not knowing load calculations will run the risk of breaking through the ice.	5	3	8	All equipment and material shall have posted GVW or gross equipment weight or maximum pull back loads available for use with load-ice thickness tables and shall follow the Ice Safety Plan. Refer to Attachment B for minimum ice thickness required for the drilling operations and Attachment C for further guidelines regarding Ice Safety	4	2	6	Warren Hoyle

4. General Site	Ice Conditions – Slip falls Ice Conditions – Adequate load bearing capacity Inadequate lighting Interaction with a Polar Bear Cold Whiteout conditions Emergency Procedures	3	2	5	Construct a working platform for outside of drill shack to store drill steel and allow the use of salt Use of traction aids on work boots will be required for work on ice surfaces. Apply salt to drill shack decks Engineered Assessment of minimum ice thickness as referenced in Attachment B for ice thickness required for the drilling operations and Attachment C for further guidelines regarding Ice Safety Place delineators in the snow marking access from the drilling location to the shoreline Existing Baffinland procedure “Safely Working On Fresh And Salt Water Ice” shall be followed Polar Bear Monitor will be available at all times Employees will have appropriate PPE including clothing available for safely working in -40 C and windy conditions Worksite location is approximately 300 meters from the shoreline. No work will be conducted in whiteout conditions and a safety shelter will be available immediately adjacent to the work area Site emergency procedures will be provided and reviewed at site	2	1	3	All Crew

5. Working around water and sea ice	Water may appear to be completely frozen over, but not enough to support persons Falling in water Equipment breaking through ice Workers unaware of potential dangerous conditions	5 5 4 3	1 1 2 1	6 6 6 4	Ice thickness to be assessed before walking on ice as per BIM Policy. Initial ice profiling will be conducted with an ice auger Floatation suit will be used for the initial ice profiling using an ice auger. Survival Bag (sleeping bag) will be available to reduce the risk of hyperthermia Follow the BIM Working On Ice Procedure (BAF-PH1-320-PRO-005, Rev 0, March 1, 2016) All workers will be required to complete the Alberta Working Safely on Ice Procedure online training	2	1	3	Marlon Coakley/Warren Hoyle
6. Drill testing for ice thickness	Water may appear to be completely frozen over, but not enough to support persons. Large ice cracks or crevices Falling in water Strains/Sprains Slipping on ice Drilling ice with power auger Changes in ice conditions	3	4	7	Traction aids will be used for any ice work Ice thickness to be assessed before walking on ice Floatation suits will be worn by workers while ice auguring, the worker is to be tethered to a primary rescue worker at a distance of 30m Snow must be removed at the hole location so ice can be examined for quality as described in the Ice field guide. Hand shovelling may be necessary If crevices/ cracks greater than 50% of the ice thickness are present, repairs must be made if there is risk of falling through ice into deep water	2	2	4	Warren Hoyle / Marlon Coakley

					Ice thickness for a person to walk on must be a minimum 13 cm. **STOP** all work if this condition is not met and return to shore. Be aware when using power ice auger that auger bit could bind or jam, have secure footing and grip on auger The ice auger hole spacing will be 20 m along the centreline access and the grid established in the designated work area. Secondary test holes will be augured at 10 m spacing within 250 m of the shoreline, if required based on the variable ice thickness Complete daily inspections of ice surfaces and record on ice log inspection sheet				
7. Access from Land to Sea Ice Snow removal equipment, drill rig and access vehicles are to be used for borehole access	Long distances to walk Exposure to cold White Out conditions Risk of falling under sea ice along the shoreline	4	1	5	Proper warm winter wear to be used Sat phones and digital radio use. Rig mats to be used to bridge over the fractured ice transition area if the transition between sea ice and shoreline needs leveling Buddy system is important to verify presence of frost bite or other cold related concerns **Vehicle operators and passengers are not to wear seat belts when working on ice**	1	1	2	All workers

8. Refueling of equipment	Fuel spills Regulatory or social impacts Spills into water bodies	3	2	5	Use of duck ponds with any refueling Have sufficient spill cleanup supplies on hand to respond to potential spills Maximize space between refueling vehicle	3	1	4	All workers
9. Extreme weather exposure when working outdoors or driving to and from the Borehole Location	Stranded work crew in white out conditions Cold emergencies or cold injuries Mechanical equipment failure	4	2	6	BIM has a procedure that is designed for white out conditions – it would be announced on the radio An emergency shelter to be used when in the Marine Drilling areas Emergency Shelter: Heated wooden shack (7' 8" by 7' 8") set on platform with skis Crews to radio from Hatch leads Buddy system to watch out for fellow workers who may not realize they are developing frost bite Workers to dress in arctic gear and layered clothing Proper PPE required Equipment check list Review Tidal charts on a daily basis Workers to take warm up breaks to stay warm and alert At toolbox review weather forecast with crew and prepare accordingly	2	1	3	All workers

10. Chemical handling- No unusual chemicals other than equipment needs are anticipated to be used.	Spills, leaks Chemical splash Chemical exposure	2	2	4	All products to be stored in secondary containment MSDS to supplied to BIM for review MSDS books to be accessible at the work front MSDS training and WHMIS training completed before arriving to site PPE will be followed as per MSDS recommendations as will first aid and environmental responses Spills response training and supplies to be kept with the equipment	1	1	2	Boart Longyear
11. Waste management and Wildlife Encounters	Risk of wildlife encounters due to improper waste controls Regulatory non compliance	3	2	5	Crews will collect waste daily and transport it back to camp Crews will follow BIM waste management guidelines No placing or storing of food in the back of pickup trucks Secure all small tools and PPE as foxes may carry away small articles from the site	2	2	4	All workers
12. Ecological and Cultural sensitive areas	Risk of causing damage to archeological areas Destroying vegetation Sensitive wildlife and marine life areas Regulatory and reputation damage	3	3	6	Crews have been instructed that there will be **NO** entry to the area east of the sealift ramp Crews are not to build or alter any inukshuk's or other rock formations on the tundra Permits will be required for the work	2	2	4	All personnel

13. Assemble Drill on skid platform skid and construct four walls and roofs	General hazards associated with drill assembly Inadequate communication between Boart Longyear and Site Services / mobile equipment operators	2	2	4	FLRA to be complete by Boart Longyear supervisor prior to executing work Boart Longyear Drilling operations SOPs to be followed including Boart Longyear Procedure 4001	1	1	2	Warren Hoyle / Marlon Coakley
14. Auguring holes in ice for sonic drilling and CPT work	Large ice cracks or crevices Falling in water Strains/Sprains Slipping on ice Drilling ice with power auger Changes in ice conditions	3	3	6	Wear traction aids for any ice work PFDs to be worn by workers while ice auguring during the sonic drilling and CPT operations Snow must be removed at the hole location so ice can be examined for quality. Hand shovelling may be necessary Be aware when using power ice auger that auger bit could bind or jam, have secure footing and grip on auger Complete daily inspections of ice surfaces and record on ice log inspection sheet All holes must be marked using an orange spray paint Any hole in ice over 30 cm in diameter must have a physical barrier around the hole	3	2	5	
15. Working around rotating equipment	Entanglement injuries	3	2	5	All equipment guards to be in place and in good working condition No loose clothing or drawstrings that can get pulled into rotating equipment Long hair must be contained to prevent entanglement into rotating equipment	2	1	3	All workers

					If any maintenance is required then energy isolation procedures to be followed				
16. Isolation of energy sources	Potential energy release that causes injury	3	2	5	All crews will follow the BIM Zero Energy State (ZES) procedure Crews to be given the BIM ZES training on site and fully understand the BIM requirements	1	1	2	Boart Longyear Crews BIM H&S
17. Working on equipment	Slip and trip hazards around railings, stairs and uneven ground.	2	2	4	Rails are installed around deck and to be properly maintained in good condition Stairs to be used on equipment A head cage will be used to reduce chance of contact with the rotating head Estops to be in good working order and easily accessible FLRA to be completed daily to review hazards All crews will follow the BIM Zero Energy State (ZES) procedure	1	1	2	Boart Longyear crew
18. Ice monitoring during drilling activities	Excessive deflection in ice	4	3	7	Hatch geotechs crew will monitor ice conditions during drilling including cracks around the work area, monitor freeboard in drilled holes for signs of ice deflection	2	2	4	All crew

19. Spotter activities	Equipment could come in contact with Spotter	4	2	6	Spotter to maintain eye contact with driver Spotter to review FLRA Agreed hand signals to be used with drivers in conjunction with BIM spotter procedure Agreed hand signals will be documented on the FLRA Drivers to immediately stop if the Spotter is out of eye contact	1	1	2	Boart Longyear crew
20. Manual lifting	Pinch point, back injuries, muscle and joint sprains and strains	2	3	5	Work in pairs, FLRA reviews Work with a buddy on heavy or awkward lifts Use proper lifting techniques 100 pound pipes to be handled by two workers	1	1	2	All crew
21. Working with pressure systems	Pressurized water and hydraulic fluids are used on drill and support equipment	3	2	5	Pre operational inspection Follow all safe work procedures. ZES when maintenance is required.	1	1	2	Boart Longyear crew
22. Falling objects	Potential exists for falling of drill rod and casing falling from overhead	3	2	5	Rigging and slinging training required when working with suspended loads and overhead hazards Perform FLRA	1	1	2	Boart Longyear Hatch Geotec EHS techs
23. High noise and vibration areas on the rigs	Hearing damage	2	2	4	Hearing protection is required by use of ear plugs or muffs.	2	1	3	Boart Longyear Hatch Geotec EHS techs

24. Housekeeping	Potential exists for poor housekeeping causing slip/trips and other hazards	3	2	5	Daily site assessments and toolbox meetings by drillers and site supervisors BIM EHS techs to perform daily inspections	2	2	4	All Crew
25. Fatigue	Potential exists for crew fatigue	2	2	4	Fit for duty confirmation required for all employees, daily FLRA reviews Micro breaks to stretch Proper rest during off shift period	1	1	2	All Crew
26. Working at night or 24 hour darkness	Higher risk of injury due to poor visibility	3	3	6	Hi-vis work gear to be used Use of flashlight and headlamp Workers to stay within 10 meters (30 feet) of the worksites at any time Use of wobble lights and light tower Emergency shelter	1	1	2	All Crew
27. Hot work - welding	Fire risk Burn injuries Welders Flash	2	2	4	Hot work training Use of hot work permits and JHA for any Hot Work Fire Watch required Proper PPE Welding training required	1	1	2	Boart Longyear crew

28. Rescue Plan	Rough terrain Further injuries to casualty during transit. Snow storm, white out conditions. Darkness	3	3	6	The track unit will be used to pull the survival shack (survival shack is 7' 8" x 7' 8" square) on platform with skis. When an incident has occurred, the Geotechnical Engineer must call a Code 1. Provide first aid treatment to the injured person until MRT arrives on site MRT will be dispatched to the location. MRT will transport the casualty. Visibility (whiteout conditions) will hinder rescue time, rescuers will have to wait out the storm, or until the whiteout conditions have subsided.	2	2	4	Marlon Coakley/ Warren Hoyle
29. Cleanup and Demob	Unfrozen open holes Complacency	3	3	6	All drill holes must be filled in with water and snow upon completion of drilling operations A Hatch site representative will confirm safe conditions upon demob All debris must be removed from ice surface and disposed off site per waste management plan BIM safety and environment representatives to attend a post project closeout inspection to document the completion of the clean-up	2	2	4	Boart Longyear

Comments:

Score	CONSEQUENCE		
	People	Plant	Environment
5 – Very High/ Catastrophic	Multiple Fatalities.	Greater than $10 Million Loss	Catastrophe, destruction of sensitive environment, worldwide attention. Likely EPA prosecution. More than 30 days delay.
4 – High/ Major	Fatality or Permanent Disabilities.	$1 Million to $10 Million Loss	Disaster, high levels of media attention, high cost of clean-up. Offsite environmental harm; more than 10 days delay.
3 – Moderate	Major Injuries – Incapacitations or requiring time of work.	$100 Thousand to $1 Million Loss	Major spills, onsite release, substantial environmental nuisance, more than 1day delay. (Leads to additional resources call out i.e. SES).
2 – Low/ Minor	Significant Injuries – Medical Treatments, non-permanent injury.	$10 Thousand to $100 Thousand Loss	Significant spills. (Leads to a call out of Site Emergency Response Group).
1 – Very Low/ Insignificant	Minor Injuries – First Aid Treatments (cuts/bruises).	Less than $10 Thousand Loss	Low environmental impact. Minor Spills less than 80 Litres.

Score	LIKELIHOOD
5 – Almost Certain	The event is expected to occur in most circumstances. Likely to occur frequently - More than 1 per year.
4 – Likely/ Probable	The event will probably occur in most circumstances. Likely to occur several times – 1 per year.
3 – Moderate/ Occasional	The event should occur at some time. Likely to occur at some time – 1 per 5 years.
2 – Remote/ Unlikely	The event could occur at some time. Unlikely but possible. 1 per 10 years.
1 – Rare/ Very Unlikely	The event may occur only in exceptional circumstances. Assumed it may not be experienced. 1 per 100 years.

Job Hazard Analysis Attendees: Darryl Finlay, Marlon Coakley, Warren Hoyle, Usman Khan, Alex Boissonneault

	Name	Signature	Date
Written by:	Marlon Coakley	Marlon Coakley	Mar 20/2017
Reviewed by:	Warren Hoyle (Hatch)	Warren Hoyle	March 20, 2017
	Darryl Finlay (BIM Safety Coordinator)		March 20, 2017

Risk Rating = Consequence + Likelihood

Consequence	Risk Rating				
5	6	7	8	9	10
4	5	6	7	8	9
3	4	5	6	7	8
2	3	4	5	6	7

Risk Rating - Definitions

Risk Rating	Definitions	*Action Required*
8 - 10	Intolerable	Task not to start till the risk is eliminated or reduced. Bring to the immediate attention of management. Formal assessment required. MUST reduce the risk as a matter of priority.
7	High	Bring to the immediate attention of management. Task not to start till the risk is eliminated or reduced. Further Assessment required. MUST reduce the risk as a matter of priority.
6	Significant Risk	Bring to the attention of supervision. Review risks and ensure that they are reduced to as low as reasonably practicable. To be dealt with as soon as possible, preferably before the task commences. Introduce some form of hardware to control risk.
5	Moderate Risk	Needs to be controlled but not necessarily immediately, an action plan to control the risk should be drawn up. Review effectiveness of controls. Ensure responsibilities for

1	2	3	4	5	6
	1	2	3	4	5
	Likelihood				

		control are specified.
2-4	Low Risk	If practical reduce the risk. Ensure personnel are competent to do the task. Manage by routing procedure. Monitor for change

A JHA considers a variety of activities/tasks involved in a job scope and analyses the key hazards (sources of harm) and their consequences (types of harm) eg. Sources of harm – lifting a heavy pipe - manual handling. Types of harm – Back strain.

Main Points – On how to write a JHA.

1. Define the task – what is to be done.
2. Review previous JHA if any – have we done it before?
3. Identify the steps – what is to be done.
4. Identify the hazards of each step.
5. Identify who or what could be harmed.
6. Give the task a risk rating – Consequence + Frequency
7. Develop solutions to eliminate or control hazards in each step.
8. Review the risk rating after the control system has been implemented.
9. If risk rating unacceptable review the solutions till risk rating acceptable.
10. Agree who will implement the control system.
11. Document the JHA and discuss with the relevant personnel.

Hierarchy of Hazard Management – Control Measures

These steps outline what should be planned for when deciding what control measures are to be put in place. Whenever possible the highest step should be used first and then progress down the list.

1. Eliminate the hazard.
2. Substitution.
3. Reducing the frequency of a hazardous task.
4. Enclosing the hazard.
5. Additional procedures.
6. Additional supervision.
7. Additional training.
8. Instructions / information.
9. Some personal protective equipment.

Worker / Visitor review	Signature
Warren Hoyle	March 19/2017
Marlon Coakley	March 19/2017
Usman Khan	
Alex Boissonneault	March 19, 2017
Emile Beauchamp	March 19/2017
Samuel Flynn	March 19/2017
Ruben Gross	March 19/2017
Justin Gross	March 19/2017
Chris Entz	March 19/2017
Doug Roach	
Robbie Jordan	

Enclosed:

Attachment A – BIM Working on Ice Procedure
Attachment B – On Ice Platform for Geotechnical Drilling
Attachment C – Best Practice for Building and Working Safely on Ice Covers in Alberta
Attachment D – Ice Thickness Assessment
Attachment E – Ice Assessment Drawing

Appendix J
Geophysics Assessment

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GEOPHYSICS GPR
INTERNATIONAL INC.

GEOPHYSICAL INVESTIGATION FOR BAFFINLAND RAILWAY, MARY RIVER PROJECT, NUNAVUT

Prepared for:
Baffinland Iron Mines Corporation

Presented to:
HATCH

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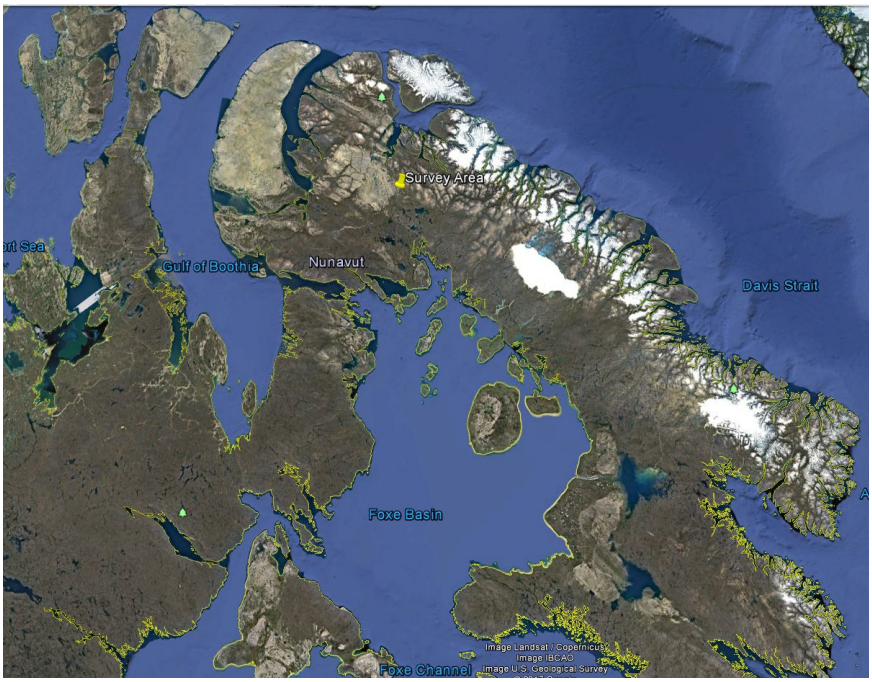

Project T17001-Revision#006 **April 2018**

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June 2017 **T-17001**

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1 INTRODUCTION

Geophysics GPR International Inc. was requested by Hatch Ltd. to carry out a geophysical survey to aid in projection and planning of a proposed railway for the Mary River Project, Baffin Island, Nunavut.

The purpose of this investigation was to determine the depth to bedrock and to measure the thickness and extent of subsurface ice.

The seismic refraction and the ground penetrating radar (georadar) methods were applied to measure the depth to bedrock and the georadar method was applied to ice thickness measurements.

Data were collected from April 21st to May 2nd, 2017.

The investigation included the following:

1) Georadar mapping of subsurface ice at three sites approximately at Km 26, Km 47, and Km 76 along the proposed rail alignment.

2) Depth to bedrock measurements using the seismic refraction and georadar methods at seven sites in the limited access area ("Deviation area") of the proposed rail alignment (approximately from Km 63 to Km 68).

3) Depth to bedrock measurements using the seismic refraction method at the rail unloading area site at Milne Port.

4) Depth to bedrock measurements using the seismic refraction and georadar methods at the proposed rail alignment Km 4.5 site.

Figure 1 presents an overview map of the investigation area with the locations of the respective sites.

The following report describes the various aspects of the survey including field techniques, survey design, interpretation techniques, and finally an interpretation in the form of bedrock profiles and ice thickness maps.

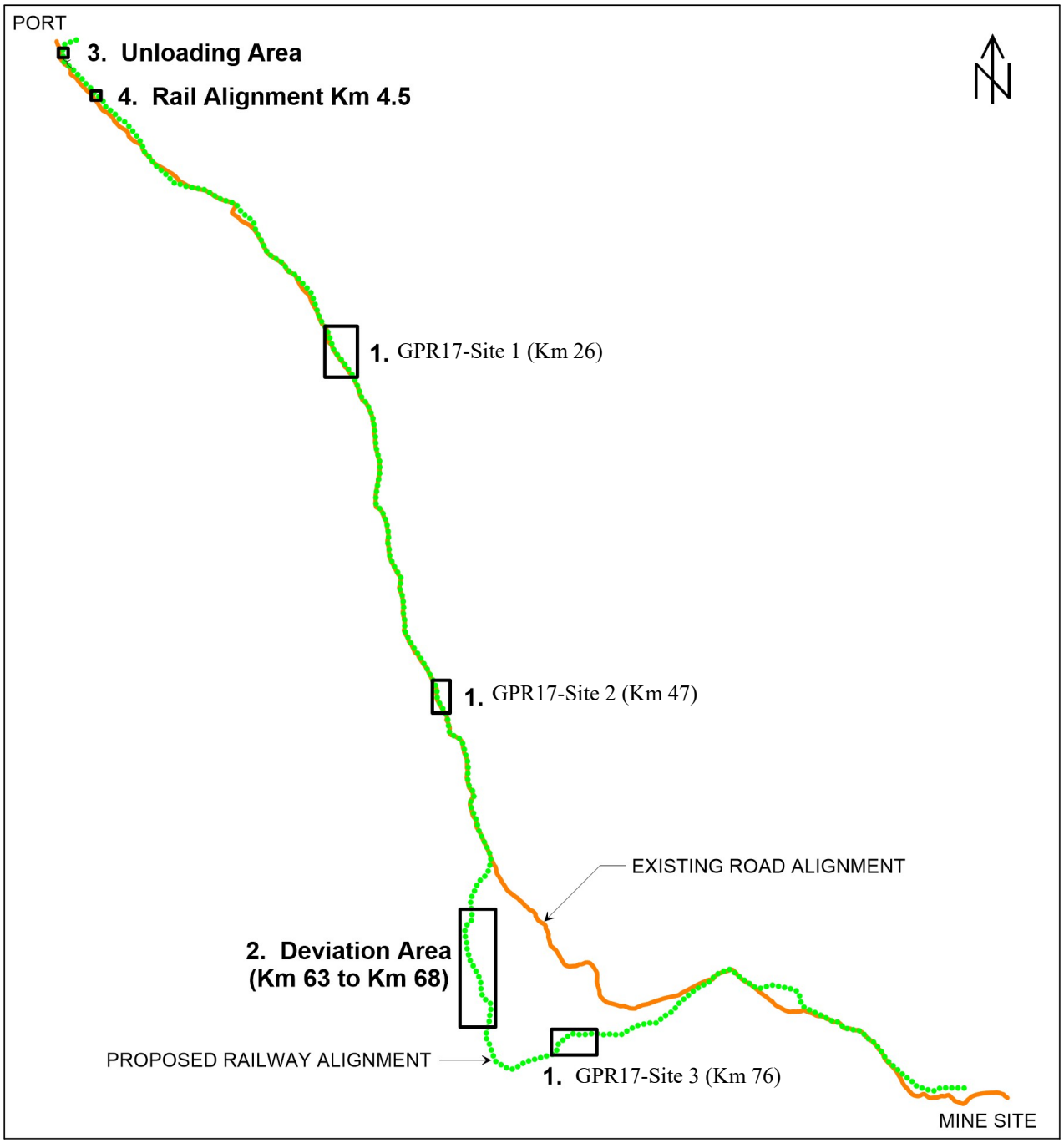


Figure 1: Overview map of the investigation area

2 METHODOLOGY

The Seismic Refraction and Georadar techniques were used for mapping the depth to bedrock. The Georadar method was used to determine ice thicknesses.

2.1 Positioning, Topography and Units of Measurement

The emplacement of the survey areas was determined by the client.
The locations of the georadar survey lines for the purpose of subsurface ice mapping were oriented to align with the design of the proposed railway. Length and number of the lines were chosen based on in-field interpretation of georadar data. Positioning was controlled by the GPS device integrated into the georadar antenna. The UTM coordinates should be accurate to within +/- 2.0 m.

Seismic data were collected along ten (10) profiles. Ground penetrating radar data for the purpose of bedrock mapping were collected along the seismic lines. Positioning was controlled by the georadar antenna built-in GPS and by a handheld GPS device. The beginning and end coordinates of the seismic lines are provided in Table 1.

Table 1: UTM coordinates of seismic lines

Area	Seismic Line	Start (0+00)		End (0+69)		Methodologies
		Easting	Northing	Easting	Northing	
Deviation Area	SL17-D1	527599.0	7919317.4	527599.9	7919386.2	Seismic, Radar
	SL17-D2	527857.7	7920710.1	527895.1	7920768.4	Seismic, Radar
	SL17-D3	527564.2	7922077.5	527527.9	7922137.9	Seismic, Radar
	SL17-D4	526825.1	7924354.0	526889.1	7924325.9	Seismic, Radar
	SL17-D5	526909.9	7924618.2	526929.1	7924684.4	Seismic, Radar
	SL17-D6	527259.7	7925605.9	527242.9	7925673.0	Seismic
	SL17-D7	527184.7	7925311.0	527207.9	7925376.7	Seismic, Radar
Unloading Area	SL17-M1	503783.5	7974922.0	503792.6	7974990.0	Seismic
	SL17-M2	503804.0	7974917.0	503816.1	7974985.0	Seismic
Km 4.5	SL17-R1	505743.6	7972485.5	505690.4	7972529.4	Seismic

The provided coordinates are NAD83/WGS84, UTM zone 17N.

The topography for the Unloading Area site has been estimated using field observations and borehole elevation data.

The depth measurements are noted as depth from surface.

All geophysical measurements were collected in SI units.

2.2 Ground Penetrating Radar (Georadar)

Basic Theory

Georadar utilises radar technology to obtain a near-continuous profile of the subsurface. The basic principle is to emit an electromagnetic impulse into the ground at a predetermined frequency rate (typically 10 to 80 scans/second). This pulse will travel through the sub-surface and reflect off boundaries of differing dielectric constants (contrasts of EM impedances). The reflected pulse returns to the surface and is recorded by a receiver and displayed in real-time as a cross-sectional image. Only by moving the antennas along a profile directly over the targets can the locations and depths be determined. Examples of radar reflecting boundaries include air/water (water table); water/earth (bathymetry); earth/metal, PVC, or concrete (pipe locating); and differing earth materials (stratigraphic profiles, including bedrock profiles).

The depth of investigation is controlled by the frequency and power of the antenna limited by attenuation and diffraction of the radar signal. Lower frequency antennas provide greater depth penetration at the expense of resolution. The radar signal is attenuated by conductive ground materials (e.g. clays, dissolved salts etc.). The radar signal is diffracted by irregular shaped material (e.g. boulders, debris etc.) that prevents the clear return of the reflected pulse.

More information on the georadar operating principle can be found in Appendix B.

Survey Design

The georadar data were collected with a MALA Ground Explorer system and 160 MHz antenna. This antennas is usually the most appropriate for resolution of stratigraphic layers at greater depths.

Positioning for the georadar survey was controlled by built-in GPS receiver.

For the bedrock mapping survey radar lines were collected along seismic profiles. Prior to data collection, test profiles were collected to determine the optimal time window and gain settings for the given subsurface conditions.

Interpretation Method

Processing of the radar images involved basic horizontal normalization, elevation corrections and gain adjustments.

The vertical scale on all radar images is a two-way time scale representing the time taken for a radar pulse to transmit to a reflector and back to the receiver. In order to convert the time scale to a depth scale a signal velocity must be applied. The velocity with which the pulse travels through the given material is determined by the dielectric constant. This dielectric will vary with the type of material.

Calculating a velocity can be done in many ways but the most reliable method is with a test pit or borehole where the real rock contact can be exposed. Based on in-situ measurements or borehole data, the dielectric value can be approximated depending on the expect material type. An underestimate of the dielectric will result in an over estimate of the signal velocity and in

turn an over estimate of the depths. For this site a dielectric of 4 (velocity of 15 cm/ns) was assumed based on the expected soil type and tables of relative dielectric values for commonly encountered materials. In this case the materials were mostly frozen granular/boulders with high ice content. This velocity model showed good agreement with the borehole data and the estimated time-to-depth conversion error should not exceed 15% for this particular site.

Interpretation of the data is based primarily on the qualitative analysis of three characteristics of radar reflections: continuity, amplitude and shape. The interpreter then identifies reflectors and textures within the radar records that represent subsurface contacts, objects or zones. The true nature of the interpreted features can only be assumed without corroborating evidence.

Ice bodies have a distinctive appearance on radar images. Granular host material appears as "noise" on the images, whereas uniform ice layer looks transparent with clearly defined top and bottom contacts and can be confidently identified. An example of a uniform ice lens is presented in Figure 3.

Non-uniform ice bodies (stratified or containing layers of soil) are more challenging for interpretation since structure irregularities create multiple reflections within the ice body. Often a borehole is needed to confirm the presence of ice. Other features such as increasing depth of investigation in the presence of thick ice layer may corroborate the interpretation. Example of interpreted radar image illustrating the pattern created by non-uniform ice body is presented in Figure 4.

In summary, ability of georadar is limited by the structure of the ice layer being surveyed and its composition. The identification of an ice layer may be impacted by irregularities inside the ice body, such as layering, fractures and soil inclusions. However, it is possible to create two categories of ice lenses, the obvious and less obvious that may need some ground truthing.

2.3 Seismic Refraction

Basic Theory

The seismic refraction method relies on measuring the transit time of the wave that takes the shortest time to travel from the shot-point to each geophone. The fastest seismic waves are the compressional (P) or acoustic waves, where displaced particles oscillate in the direction of wave propagation. The energy that follows this first arrival (including reflected waves, transverse (S) waves and resonance) is not considered under routine seismic refraction interpretation. Figure 2 illustrates the basic operating principle for refraction surveys.

Survey Design

The seismic spread consisted of 24 vibration-monitoring devices (geophones) connected in line (spread) to a seismograph (ABEM Terraloc Mark 6). Spacing between geophones was 3 m for a total length of 69 m per spread. Seismic pulses (shots) were then generated at various locations with respect to the spread. Typically, six shots were executed per seismic spread: two shots on either side of the spread and two shots at a 'far' distance off either side of the spread (typically 45 m and 90 m). A sledgehammer was used as the primary energy source.

Interpretation Method and Accuracy of Results

Interpretation of the seismic data was primarily done using the Hawkins' method. The Hawkins' method allows the computation of the rock depth to every geophone. This method provides information on the thickness of the various overburden layers, depth to bedrock and rock quality. It is based on the closure times of the inner shots. It can calculate the true velocities of the rock using the apparent velocities, measured with information provided by the outer shots. A full description of the strengths and limitations of the refraction seismic method is presented in Appendix A. A basic description of the Hawkins' method can also be found in the article Seismic Refraction Surveys for Civil Engineering by L. Hawkins (1961).

The seismic refraction method typically allows the determination of the bedrock profile with a precision of 10% or better for depths greater than 10 m and a precision of 1 m for depths less than 10 m. The precision in the determination of rock velocities is plus or minus 3%. The vertical contacts (lateral velocity change), usually associated with faults and deep valleys, are generally accurate to within 5 m in width; although, this is somewhat site specific.

The two most significant problem areas for refraction mapping are the "hidden" layer and effect of velocity inversions. A "hidden" layer or "blind zone" is a stratigraphic layer that is not possible to discern from the arrival time data due to insufficient velocity variation or thickness. The unknown presence of a hidden layer has the effect of making the interpreted bedrock depth too shallow. The presence of a "hidden" layer is typically revealed through borehole or test-pit data and calculations can be made to compensate for the presence of such a layer. Without borehole or secondary bedrock depth information, it is not possible to predict the presence of a hidden layer.

Velocity inversions occur when the velocity does not increase with depth. The velocity inversion can result from the presence of a low or high velocity layer. Refractions from low-velocity layers cannot be determined from the arrival time data. The unknown presence of a low velocity layer has the effect of making the interpreted depths deeper than actual depths.

There is always the potential for "hidden" layers, although the likelihood is decreased for shallow sites. For this particular site the only possibility of velocity inversion is caused an unfrozen layer below permafrost, as the permafrost more easily transmits waves (~3000m/s) while the unfrozen layer transmits waves slower (1500-2000m/s). This results in a lower velocity after a higher velocity, resulting in the inversion.

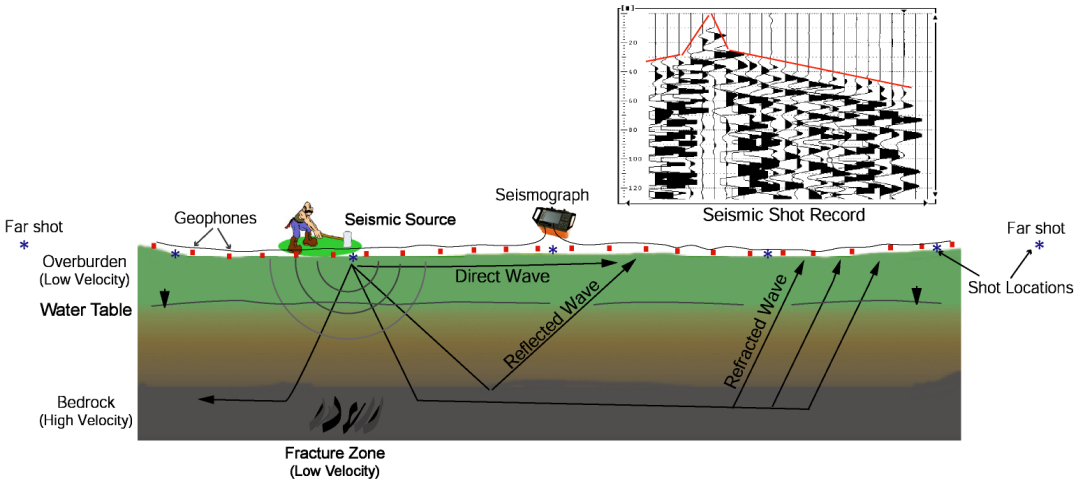


Figure 2: Seismic refraction operating principle

3 RESULTS

3.1 Subsurface Ice Mapping

Georadar data were collected at three sites approximately at Km 26, Km 47, and Km 76 along the proposed rail alignment.

Locations of the survey lines and results of the georadar survey are presented in drawings T17001-A2-1, T17001-A2-2, and T17001-A2-3.

GPR17-Site 1 (Km 26)

A long line 3300 m in length was collected from borehole BH16-R013 to borehole BH17-C004 to delineate potential ice bodies along the proposed rail alignment. The length of the line was chosen based on the borehole information. Eleven cut lines from 130 m to 410 m long were then collected to map ice extents east of the proposed railway. Scanning involved on-site data interpretation and length of the cut lines was controlled by the operator. Locations of the survey lines and results of the survey are presented in Drawing T17001-A2-1.

Distinct subsurface ice bodies were easy interpretable from the georadar images. Uniform ice was identified as a lens-shaped body with little to no signal return (reflection) from within its boundaries. Five separate ice formations were interpreted from the georadar data collected at GPR17-Site 1. Example georadar image showing a typical ice body is presented in Figure 3. The presented line is crossing interpreted ice lens #1 in NW–SE direction.

Drawing T17001-A2-1 provides ice thickness maps for each interpreted ice formation. Top of the ice layers was interpreted to be at a depth range of 1.5 m to 4 m. Ice extends to a maximum depth of 19.5 m below grade.

GPR17-Site 2 (Km 47)

The design of the survey was in general the same as at GPR17-Site 1. First a 1950 m long line was collected along the rail alignment passing the boreholes locations where the ground ice was encountered. Then eight cut lines from 80 m to 420 m long were collected to map ice extents east of the proposed railway. Locations of the survey lines and results of the survey are presented in Drawing T17001-A2-2.

Two ice formations were identified within the georadar data collected at GPR17-Site 2. The ice bodies on the georadar images were less well defined comparing to the data set at GPR17-Site 1. The interpretation was complicated by layered (stratified) ice structure that creates multiple reflections within the ice body. An example georadar image showing a fragment of ice body #2 is presented in Figure 4. The line crosses interpreted ice lens #2 in NW–SE direction. Borehole BH16-C011 is located at chainage 155 m of the presented line.

Drawing T17001-A2-2 provides ice thickness maps for each interpreted ice formation. Top of the ice layers was interpreted to be at a depth range of 1.1 m to 9.4 m. Ice extends to a maximum depth of 20.1 m below grade.

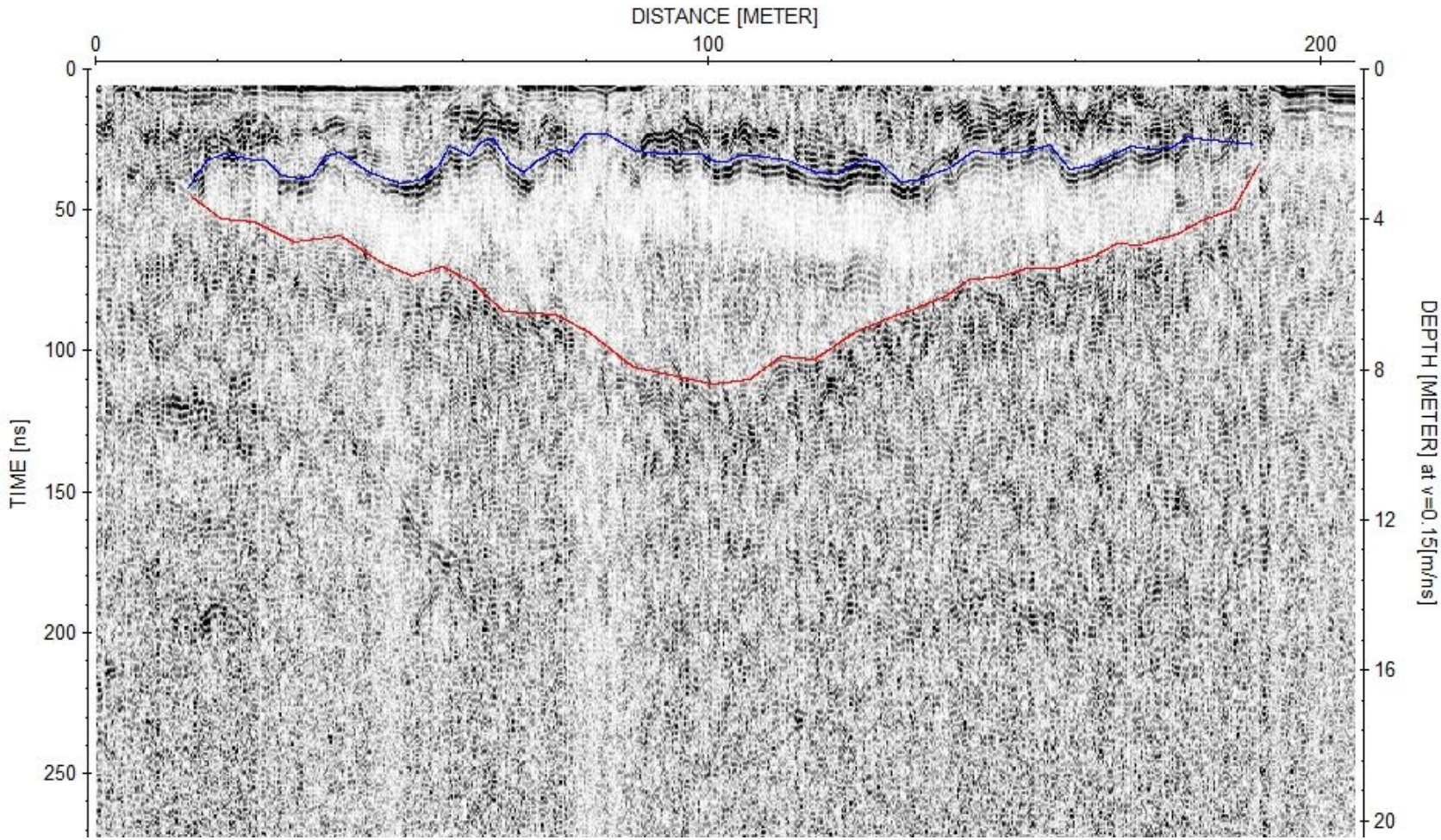


Figure 3: Interpreted georadar image showing a typical ice body at GPR17-Site 1

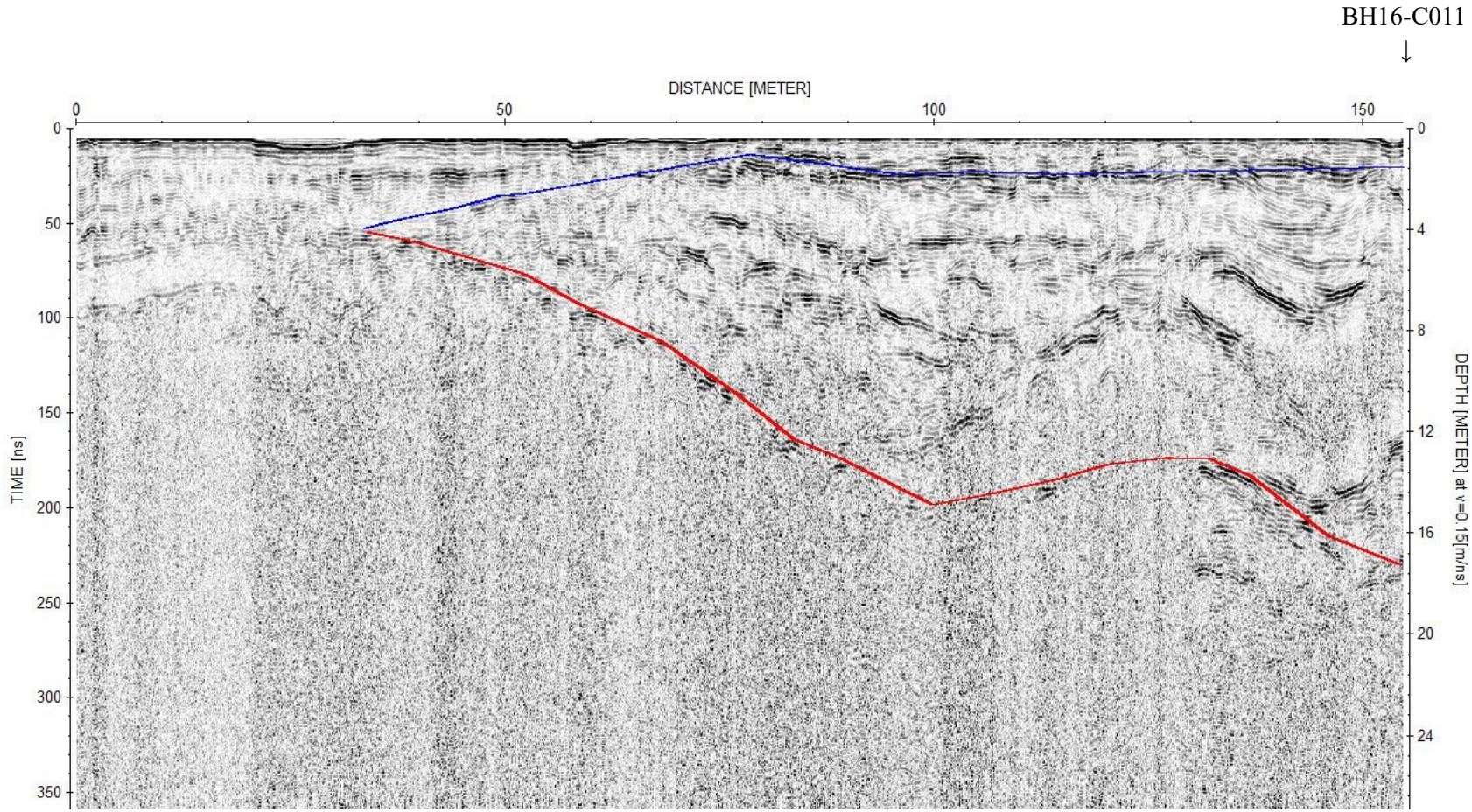


Figure 4: Interpreted georadar image showing a fragment of ice body # 2 at GPR17-Site 2.

GPR17-Site 3 (Km 76)

No large ice bodies were found within the geotechnical boreholes at this site, however, some ground ice and individual ice inclusions were encountered. A 3150 m long line was collected along the rail alignment from borehole BH17-C011 to borehole BH17-C013. Two ice lenses were identified within the data collected between boreholes BH17-C011 and BH17-C012. Two cut lines 460 m and 500 m long were then collected to map ice extents east and west of the proposed railway.

Locations of the survey lines and results of the survey including ice thickness maps for each interpreted ice formation are presented in Drawing T17001-A2-3. Of the two lenses interpreted from the georadar images at GPR17-Site 3 lens #1 was clearly identified as an ice body, whereas lens #2 was interpreted with a lesser level of confidence. The pattern on the radar images of the supposed ice lens #2 was similar to that observed at GPR17-Site 2, however, there is no borehole data to confirm that this formation contains ice.

Top of the ice layers was interpreted to be at a depth range of 1.2 m to 4.9 m. Ice extends to a maximum depth of 9.4 m below grade.

3.2 Deviation Area Bedrock Depth Mapping

A total of 7 sites were investigated at the Deviation Area of the proposed rail alignment. Initially it was presumed that the depth to bedrock should not exceed 10 meters and the survey methodology was chosen to ensure the depth of investigation approximately 20 meters below grade. The interpretation of the data proved that at 4 sites top of bedrock was deeper than the maximum investigation depth of the applied refraction technique.

Analysis of the complete data set collected for this project showed that the general compressional (P) wave velocity model consists of three layers.

The upper layer, with a velocity range of 1200 m/s to 3000 m/s, is interpreted as frozen active layer of overburden (layer with lower ice content). This layer extends from surface to a maximum depth of approximately 3.5 m below grade.

The second layer, with a velocity range of 3700 m/s to 5000 m/s, is interpreted as permafrost overburden. Higher velocity values for this layer imply higher boulder content.

The third layer, with a velocity range of 4700 m/s to 5900 m/s, is interpreted as bedrock. According to geotechnical investigation report provided by the client, from Km 0 approximately to Km 40 of the proposed railway the bedrock is granitic gneiss and from Km 40 to Km 90 the bedrock is limestone. Average measured P-wave velocities were approximately the same for both types of bedrock, with slightly lower values for limestone bedrock.

As it might be seen, there is an overlap in observed velocity ranges for permafrost overburden and bedrock complicating the interpretation of the refraction data and providing additional source of error. To help the interpretation two refraction lines at two different test sites with known bedrock depth were acquired. Test #1 was done above bedrock outcrop with less than 1 m to 1.5 m of overburden and test #2 was done at a borehole location with bedrock 5 to 7 m deep. The second test showed velocity range from 3500 m/s to 4000 m/s for permafrost overburden and both test showed velocity of 5700 m/s for limestone bedrock.

Interpretation of the Deviation area data set was done following these general considerations:

- The three-layer model described above. According to borehole data, the permafrost extends to a considerable depth and probability of a velocity inversion is low.
- The overburden permafrost velocities should not be at a higher end of the observed velocity range (4500 to 5000 m/s) as these values were only observed at sites close to the Milne Port with visibly higher large-size gneiss boulder content on the surface. The average permafrost overburden velocity measured at Deviation area sites was 3900 m/s.
- Velocities higher than 5000 m/s are expected for limestone bedrock.

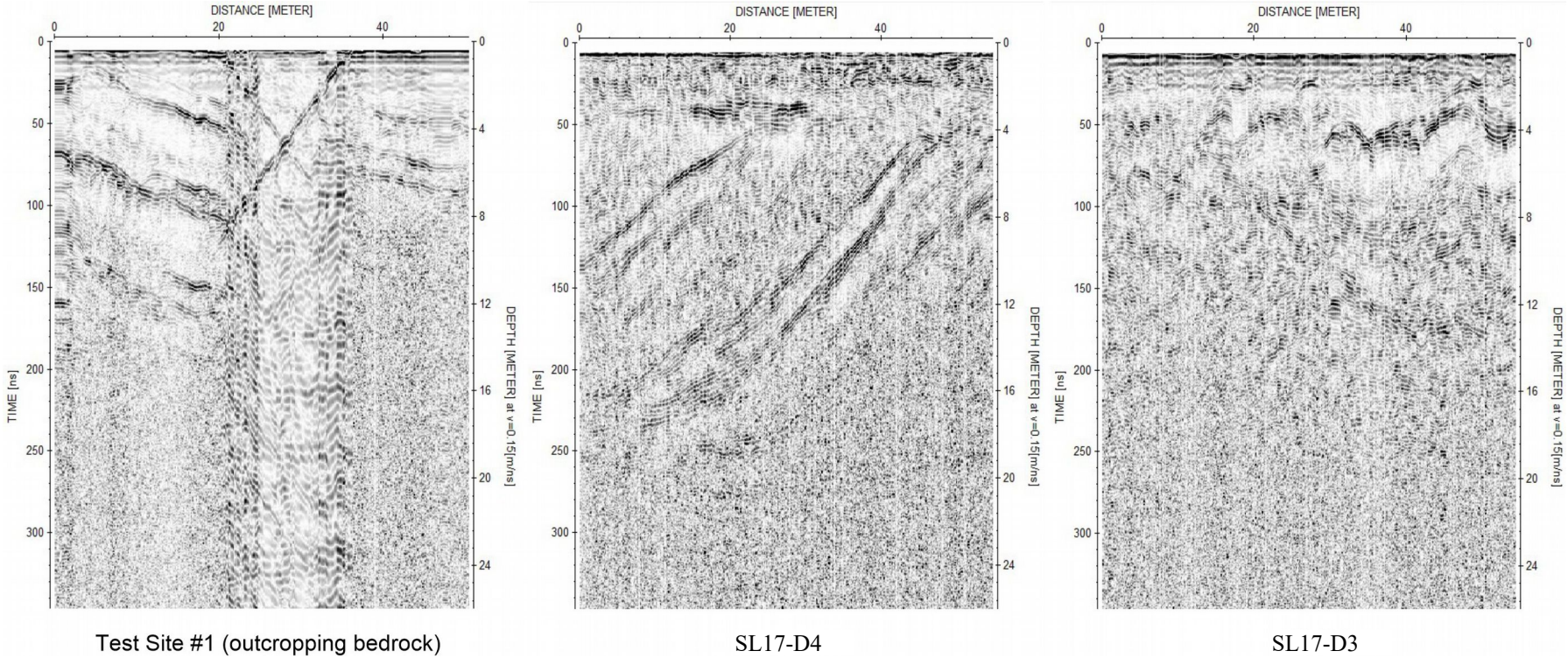
The radar data was also used in the refraction data interpretation. Analysis of the radar data collected at the Deviation area sites as well as at Km 47 showed that the limestone bedrock have a distinct pattern on the georadar images. It could be described as “parallel layering” appearing at the images as a series of parallel reflections. Figure 5 provides examples of georadar images showing limestone bedrock.

Locations of the survey lines and results of the survey are presented in Drawing T17001-A2-4. The drawing presents P-wave velocity models based on refraction data.

Bedrock was identified at 3 sites. At sites 1 and 6 bedrock depth ranged from 21 m to 26 m. At Site 6 (SL17-D6) depth to bedrock was calculated approximately as the interface was too deep to perform full reciprocal time analysis.

At Site 4 (SL17-D4) a shallow interface was interpreted with the layer velocity of 4700 m/s, which is borderline between permafrost overburden and bedrock. This interface was interpreted as bedrock contact as the georadar image taken at line SL17-D4 was the only one of the seven lines in the Deviation area which had the clear “parallel layering” pattern characteristic to limestone (Figure 5).

At sites 2, 3, 5, and 7 there was no indication of bedrock refraction on seismic records. Some calculations using the above described velocity model show that the bedrock at these locations should be more than 20 m deep.



Test Site #1 (outcropping bedrock) SL17-D4 SL17-D3

Figure 5: Example georadar images at Test Site #1 and SL17-D4 showing "parallel layering" pattern typical for limestone bedrock. Image SL17-D3 is typical for sites with deep bedrock contact.

3.3 Rail Unloading Area Bedrock Depth Mapping

Two seismic refraction lines were performed at the Rail Unloading Area to determine depth to bedrock. The seismic spreads were oriented perpendicular to the actual line of interest (which was the line from borehole BH16-M008 to borehole BH16-M007) due to a busy road crossing the line. Thus, depth to bedrock was determined at two points along the line of interest.

Position of the seismic lines and results of the survey in the form of bedrock profiles are presented in Drawing T17001-A3-1.

Three-layer velocity model described above was used for the interpretation. The upper layer, with a velocity range of 1800 m/s to 3000 m/s, extends from surface to a maximum depth of approximately 2.4 m below grade. The second layer interpreted as permafrost overburden has a velocity of 4300 m/s.

True bedrock P-wave velocities ranged from 5800 to 5900 m/s. Based on the refraction interpretation, the bedrock depth ranged approximately from 12 m to 19 m below grade for line SL17-M1, and approximately from 10.5 m to 12 m below grade for line SL17-M2.

The calculated depth to bedrock at intersections of the seismic profiles with the line of interest is 12.0 m for SL17-M1 and 10.9 m for SL17-M2. It should be noted that these values are not vertical distances from points on surface to bedrock interface, but rather shortest distances which will be different from vertical distances in case of dipping bedrock interface.

3.4 Bedrock Depth Mapping at Proposed Rail Alignment Km 4.5

One seismic refraction line and seven georadar lines were performed at the Proposed Rail Alignment Km 4.5 site for the purpose of bedrock depth mapping.

Position of the survey lines and results of the survey in the form of seismic velocity model and bedrock depth map are presented in Drawing T17001-A3-2.

Seismic refraction interpretation utilized the three-layer velocity model described above. The calculated bedrock depth ranged from 5.0 m to 6.5 m below grade.

Seven georadar lines from 50 m to 85 m long were collected with distance between lines ranging from 20 m to 40 m. Although bedrock contact was not always clearly apparent on the georadar images, corroboration of the georadar data by seismic refraction results allowed to identify bedrock reflection with higher level of confidence. Interpreted example georadar image taken at RL-4 can be seen in Drawing T17001-A3-2.

The interpreted bedrock depth from combined seismic and georadar data sets ranged from 3.0 m to 7.5 m below grade.

4 CONCLUSIONS

A geophysical investigation involving seismic and georadar methodologies was carried out at the Mary River Project, Baffin Island, Nunavut.

The seismic refraction and georadar methods were applied to measure the depth to bedrock and the georadar method was applied to ice thickness measurements.

Subsurface ice mapping was carried out at three sites along the proposed rail alignment. Results of the survey are presented in Drawings T17001-A2-1, T17001-A2-2, and T17001-A2-3 as ice layer extent and thickness maps. Overall georadar data quality was excellent. The subsurface ice was easily identifiable on most of the lines. Total of 9 lens-shaped ice bodies have been delineated. It is possible that these bodies have a high ice percentage. If there are formations with lower ice content and the ice presence is masked by the sand and gravel content it is not certain they can be delineated. However, with some ground truthing through boreholes it may be possible to create a second catagory of ice lense.

Bedrock depth mapping at the Deviation area of the rail alignment using seismic refraction and georadar methods proved the bedrock contact to be deeper than 20 m at all of the investigated sites with the exception of Site 4 (SL17-D4). The bedrock depths at Site 4 ranged from 2.5 m to 3.5 m below grade. Results of the survey are presented in Drawing T17001-A2-4 in form of P-wave velocity models.

Two seismic refraction lines were performed at the Rail Unloading Area to determine depth to bedrock between boreholes BH16-M008 and BH16-M007. Results of the survey in the form of bedrock profiles are presented in Drawing T17001-A3-1.

One seismic refraction line and series of parallel georadar lines were performed at the Proposed Rail Alignment Km 4.5 site to map bedrock depth. Results of the survey in the form of seismic velocity model and bedrock depth map are presented in Drawing T17001-A3-2. The interpreted bedrock depth from combined seismic and georadar data sets ranged from 3.0 m to 7.5 m below grade.

Interpretation of the geophysical data has been performed by Ilia Gusakov, GIT. This report has been written by Milan Situm, P.Geo.

Milan Situm, P.Geo.

Manager

APPENDIX A

Seismic Equipment and Methodology Fact Sheets

TERRALOC MK6 FEATURES

Great features in a small seismograph

The Terraloc mark 6 is a high resolution multi-channel seismograph with an 18-bit A/D converter and 3-bit instantaneous floating point (IFP) amplifier. Overall resolution is thus 21 bits. Its dynamic range, 126 dB, eliminates all gain setting hassles and satisfies the most stringent shallow reflection requirements.

7,8" full colour daylight-visible backlit display with VGA resolution
Armoured glass LCD protection
Sealed, Rugged aluminium case protects against weather and rough handling
sealed 1.44 MB 3.5" floppy drive
Numeric keyboard
Command keyboard

Added Terraloc advantages:

Great for tomography thanks to high sampling rates starting at 25 µs.

Usable with various energy sources (even mini-vabrators) thanks to long record lenghts, auxiliary source signature channel input and built-in correlation software.

provides sophisticated automation. Aversatile digital (TTL) interface (trigger IN/OUT,arming IN/OUT signals) makes it easy to connect several Terralocs and supports handshaking with vibrators and marine seismic energy sources.

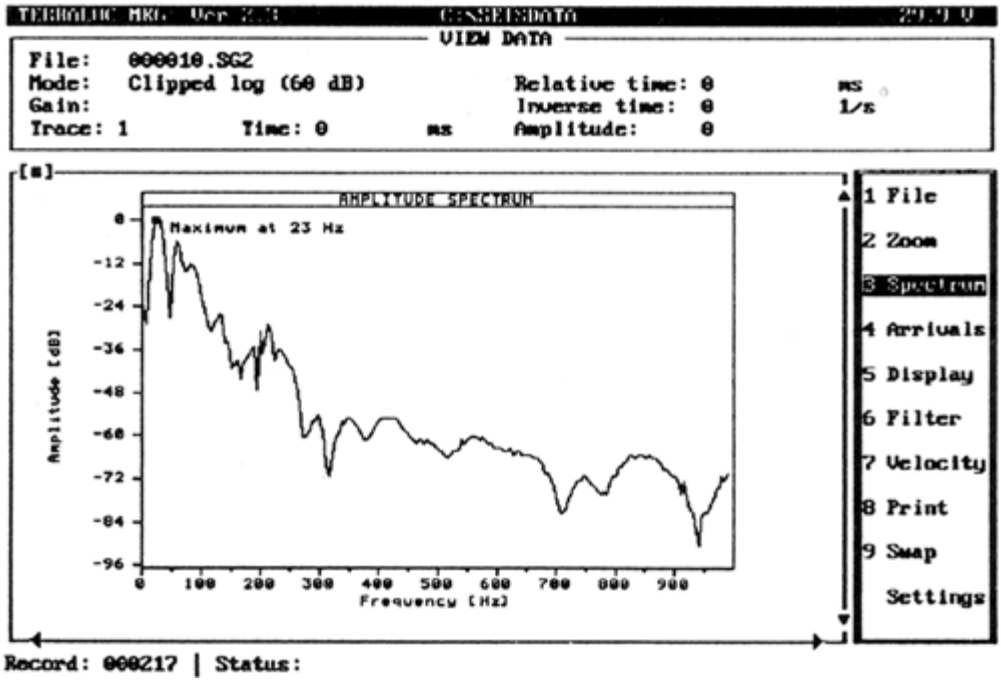
Ideal for refraction as well as shallow reflection seismics thanks to built-in roll-along function and a broad spectrum of analog and digital filters

In-field quality control. On-site geophone testing, cable testing and noise monitoring. Wide choice of multi- or single-trace view modes and frequency spectrum analysis (FFT)

Powerful computer

Fully compatible with your office computer thanks to MS-DOS 6.0 or higher, an internal hard disk, a built-in 1.44mb floppy disk, and compliance with the international SEG-2 format for storing of seismic traces and header information.

Interpretation software can be installed and run right in your Terraloc field unit.



Spectrum analysis helps you select the right filter, and it can also reveal soil properties

Lightweight and easy to use

The compact, lightweight Terraloc mark6 weighs only 16kg (24-channel version) and is less than half the size of its predecessor the popular Terraloc mark 3.

Carefully prepared, logically arranged documentation includes a copies of the operators manual (one for the field, and one to keep in the office), a user's manual for the computer , a complete description of the SEG-2 format and a service manual loaded with detailed technical information and schematics. Also included are a DOS manual and practice records to get you started.

Broad range of viewing provisions.

Scroll through records
Change display settings as desired
Select different time-scales
Select display mode
Select trace mode
Select AGC window length and set time and amplitude scale factors
Analyse single-trace frequency content (FFT)
Calculate refractor velocities
Analyse ground noise
Re-Scale traces individually
Create a geophone test report
Enlarge traces individually (Zoom)

Broad Printer support

The terraloc mark 6 supports a wide range of printers through dynamic link libraries (DLLs) via either the parallel or serial port and new printers can be added easily if required in the future.

Roll-along optimum offset

You can type in numerical values for roll-along start-trace, end-trace and step, you can roll along part of your receiver spread a step at a time . This feature is used in reflection surveys that include CDP stacking.

Expand your system

Two or more Mark 6's can easily be linked together to form a larger system. The print-out below is from a 96channel survey in which four 24-channel Terraloc's were connected

Technical Specifications for the Terraloc

- Number of channels (smaller unit)..... 4-24 in steps of 4
- Number of channels (larger unit)..... 4-48 in steps of 4
- Additional channels..... Easily obtained by linking two or more units together
- Up-hole channel..... Yes
- Sampling rate (selectable)..... 25, 50, 100, 200, 500,1000 & 2000 µs
- Record length (selectable)..... 128, 256, 512, 1024, 2048,4096, 8192 or 16384 samples per trace equivalent to: 3.2 ms - 32.7 s
- Pre-trig record (selectable)..... 0-100 % of record length
- Pre stack correlation..... Yes, cross correlation with reference or any other channel
- Delay time ..... Related to sampling rate May be set (for example) from: 0-0.8 s at 25 ps ,sampling rate 0-131 s at 2 ms sampling rate
- Stacking..... 32 bits, up to 999 impacts
- Unstack..... Remove last shot from stack
- First-arrivals picking..... Automatic or manual. Times can be saved with record
- Trigger inputs..... Trigger coil, make/brake, geophone, TTL
- A/D converter resolution..... 21 bits (18 bits plus 3-bit IFP)
- Dynamic range (theoretical/measured)..... 126 / 114 dB
- Max input signal..... 500 mV p-p
- Frequency range..... 1 - 4000 Hz (at 25 ps sampling rate)
- Total harmonic distortion..... - 80 dB
- Crosstalk..... - 86 dB
- Input impedance..... 3 k
- Noise monitor..... Amplitude or full waveform display available on-line

Analog filters

- Low cut (selectable)..... 12 or 24 dB/octave 16 steps from 12 to 240 Hz
- Notch..... 50 or 60 Hz specify when ordering
- Anti-aliasing..... set automatically based on sampling rate

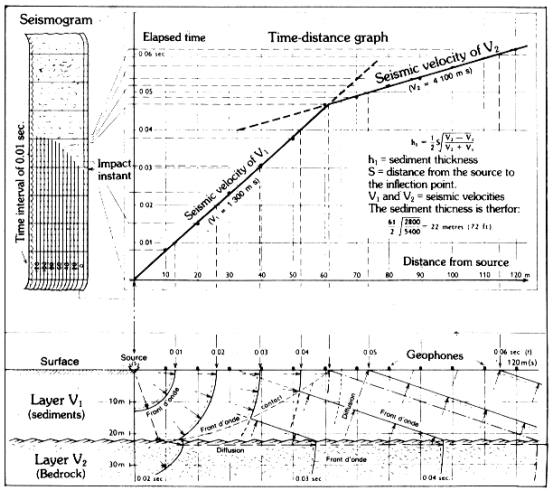
Digital filters

- Bandpass, low-cut, high-cut, bandreject, alpha-beta and remove DC offset Spectrum analysis..... Any single trace

SEISMIC REFRACTION

Seismic refraction consists of recording the length of time taken for an artificially provoked surface vibration to propagate through the earth. By processing the data, the seismic velocities and depths of the underlying rock layers can be determined. These velocities are characteristic of the nature and quality of the bedrock; a fissured, fractured or sheared rock will be characterized by reduced seismic velocities.

The method is generally used to obtain a better geological analysis of the sub-surface and to determine the following characteristics: the quality, profile and depth of bedrock, its nature, degree of alteration and any other physical contrasts. Seismic refraction ensures that maximum information may be gained from geological field work, and that direct investment costs (drilling, excavation), will be reduced.



PRINCIPLE OF SEISMIC REFRACTION

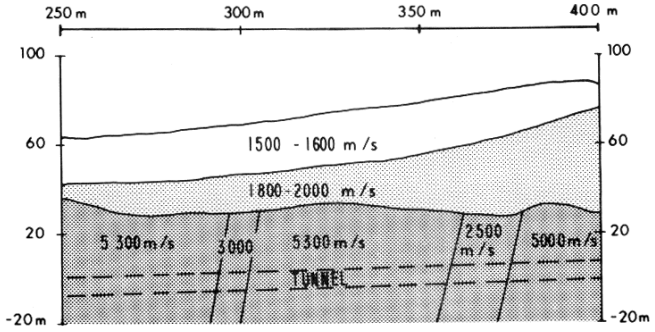
FEATURES

- Precise determination of soil thickness .
- Precise determination of the seismic velocities (rock type and quality).
- Localization and identification of geological units.
- Detailed analysis of soil.
- Year-round use.
- Sea and land surveys (above and below ground).
- Great accessibility possible to rough terrain and remote regions.

AREAS OF APPLICATION

Civil Engineering/Mining Exploration - Exploitation/Petroleum and Gas Sectors/ Geotechnology/Geology/ Hydrology.

- Identification of faults, fractures, shear zones.
- Detection of rock differences (veins, dykes, cavities, etc.).
- Determination of rock topography.
- Evaluation of volume of soil present or to be excavated.
- Excellent complement to geological mapping.
- Recognition of geophysical anomalies such as VLF, gravimetry, etc.
- Drill site selection, better target identification.
- Evaluation of the size, thickness and condition of surface shafts (mining exploitation).
- Mass Rock Quality Determination (MRQD).
- Detection of rock irregularities and breaks.
- Hydrogeology (detection of water tables, veins, reservoirs).
- Excellent complement to any geological analysis.



Interpretation results of a seismic profile

ADDITIONAL REMARKS

Geophysics GPR International Inc. has been recognized for the past fifteen years as a leader in both the application and the development of seismic methods. Seismic refraction is currently used in both civil and mining engineering; the use of lighter high-performance equipment and better tomographical interpretation of the results have contributed to its growing popularity.

GEOPHYSICS G P R INTERNATIONAL INC.

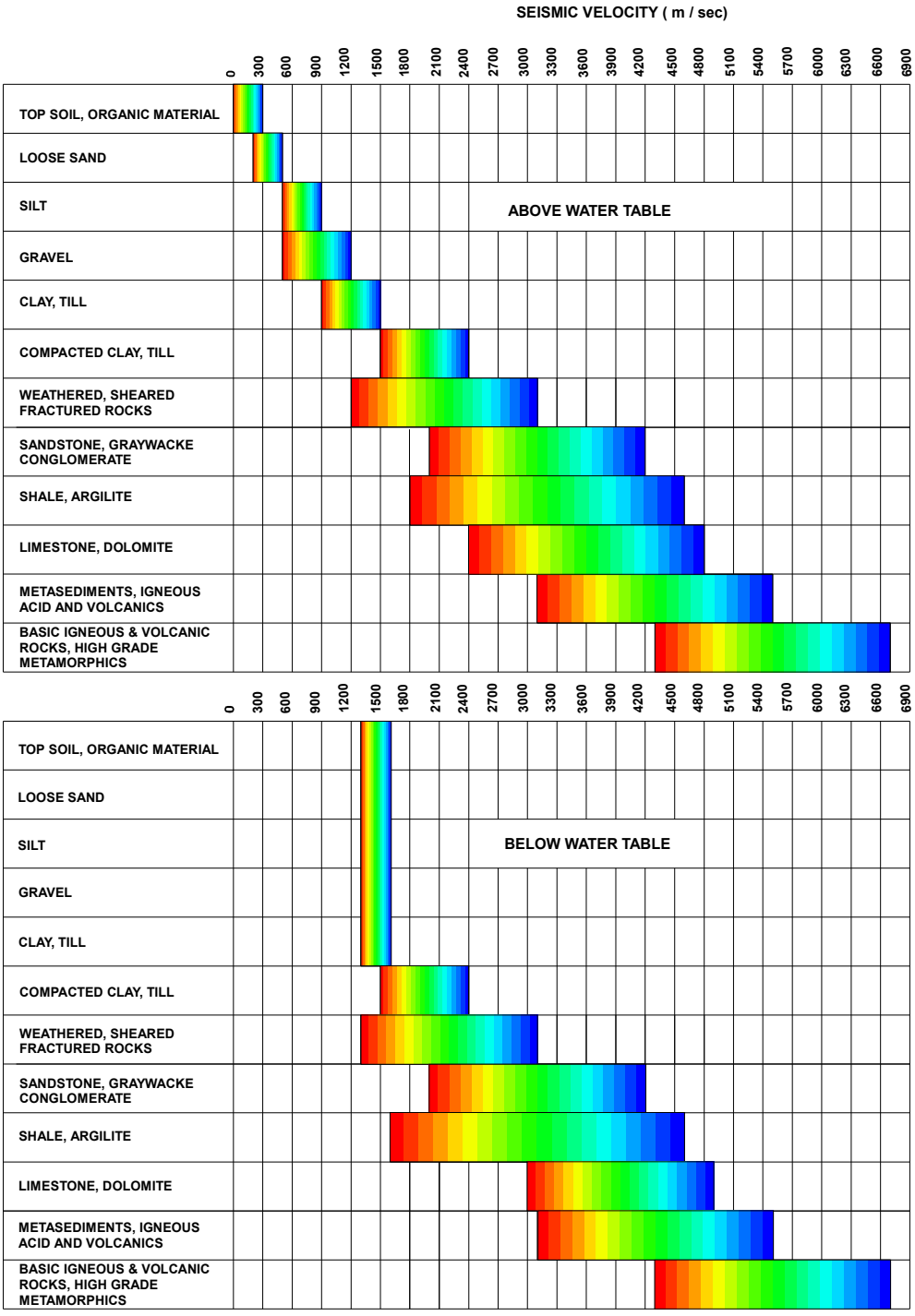
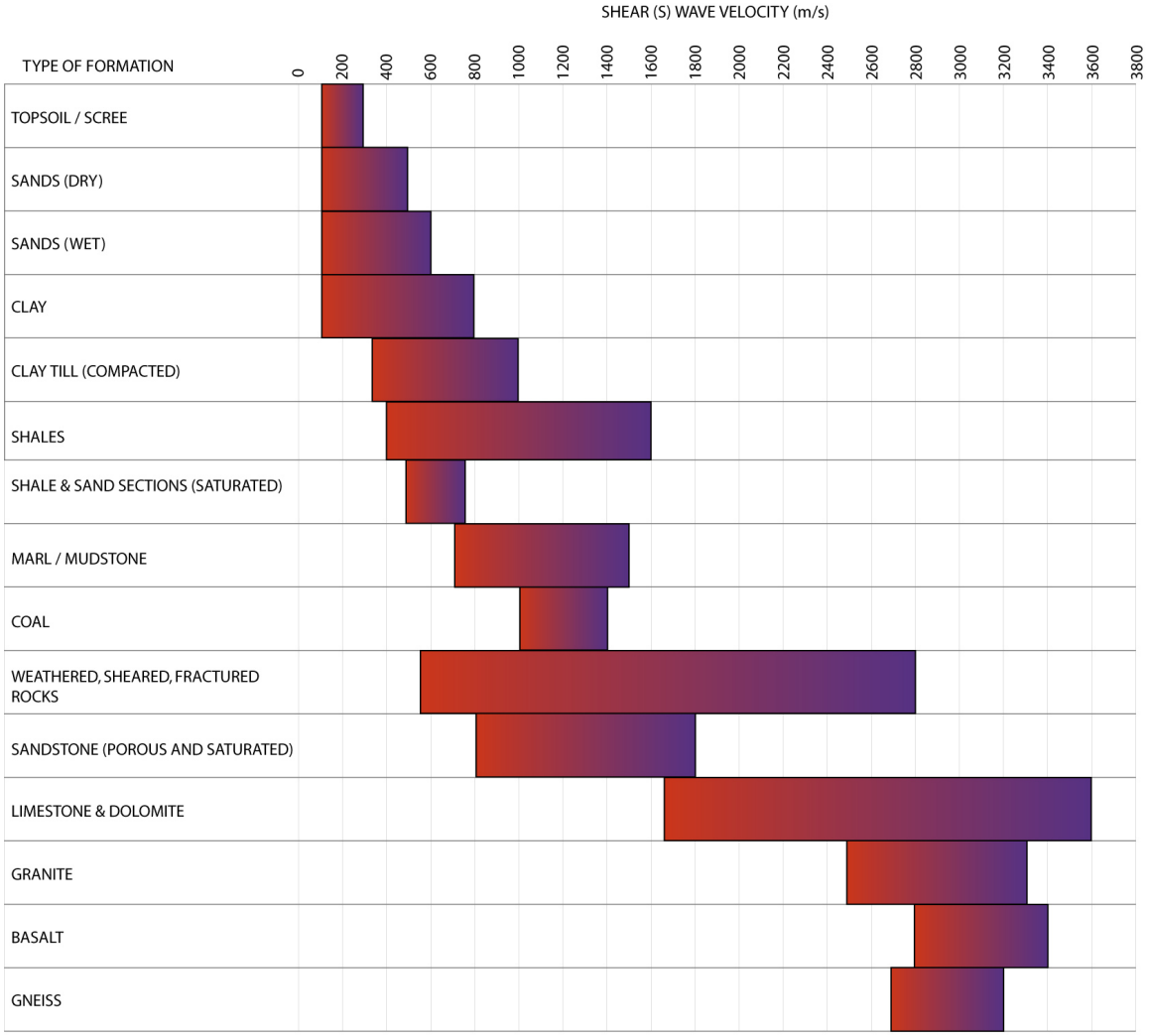


Figure 6: Classification of Geological Materials by Seismic Velocities

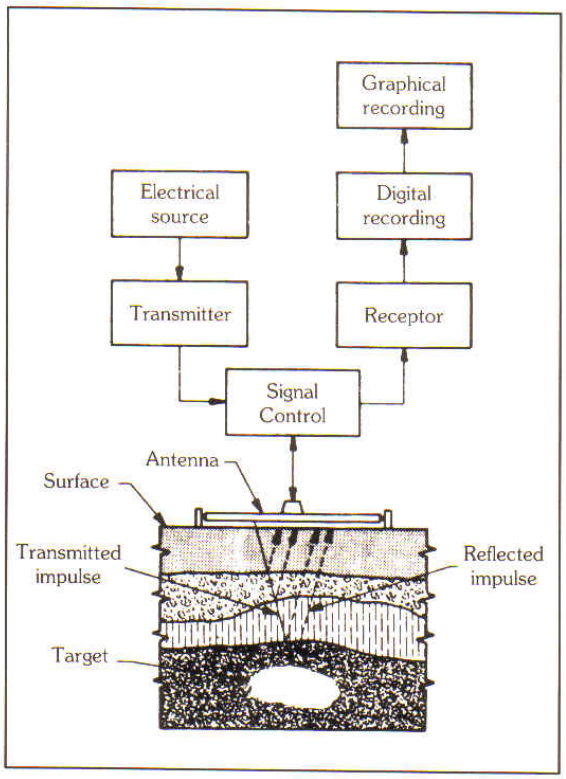


Typical rock velocities, Based on Bourbie, Coussy and Zinszner, Acoustics of Porous Media, 1987
with modifications by Geophysics GPR. Rev A.1 July 2011

Figure 7: S-wave velocities for given materials

GEORADAR

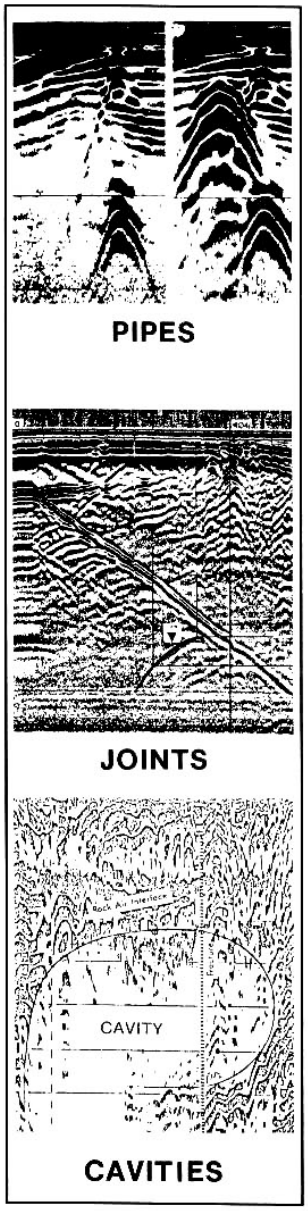
As indicated by its name, georadar combines high resolution radar with geology. The underlying principle is based on the propagation of electromagnetic wave impulses (VHF) that are reflected by anomalies in the terrain (joints, irregularities, interfaces, etc.) at different depths, and then captured by the antenna. The georadar records the time taken by each transmitted signal to complete the cycle in order to calculate the depth of the anomaly. The result is similar to a seismic reflection profile where all the reflections are displayed graphically. This technique is used to solve problems for which there had previously been no practical solution.



PRINCIPLES OF GEORADAR

FEATURES

- Penetration of more than 20 metres in certain materials (penetration being inversely proportional to conductivity).
- Surveying in continuous mode.
- Identification of objects measuring only a few centimeters.
- Light and manoeuvrable equipment.
- Detection of conductivity, open spaces and/or holes (cavities).
- Detection of breaks: faults, fractures, joints, cavities.
- Results similar to seismic reflection: continuous underground profile.
- Results available immediately.
- Can be used in land, sea or airborne surveys.



FIELDS OF APPLICATION

Civil Engineering / Mining Exploration-Exploitation / Research / Archaeology / Environment

- Geotechnology: investigation of soils and surface deposits.
- Optimal selection of anchor bolts in mines and quarries.
- Detection of buried pipes before beginning excavation.
- Detection of liquid or gas leakage in soils.
- Detection of cracks in concrete structures.
- Checking material homogeneity.
- Detection of cavities beneath road pavement.
- Determination of water saturation level.
- Detection of girders in reinforced concrete.
- Detection of pollutant leakage in water bodies.
- Inspection of buried disposal sites and or dangerous deposits.
- Continuous measurement of ice thickness.
- Archaeological research: ancient foundations, artifacts.
- Non-destructive method for measuring road pavement thickness.
- Localization and measurement of soil's thickness (swamps, peat bogs).
- Determination of rock beddings (location and thickness).
- Bathymetric studies (depth sounding).
- Calculation of the thickness of permafrost and ice.
- Geotechnical studies for the installation of aqueducts.

SPECIAL FEATURES

The equipment is practical, easy to manoeuvre, and multi-faceted. The field of application of georadar continues to expand in various sectors, particularly in geotechnology (aqueducts), civil engineering (excavation, structures) and mining (structures).

GEOPHYSICS G P R INTERNATIONAL INC.

SIR-3000 System by GSSI

Rugged, high-performance GPR data acquisition system

Benefits

- Rugged, lightweight, hand-held and portable
- User-friendly
- High-resolution screen—easy to read in daylight
- Large data storage capacity
- Compatible with all GSSI ground-coupled antennas
- Built with pride in the U.S.A.

Applications

Concrete Inspection
Utility Mapping
Bridge Deck Inspection
Geological Investigation
Archaeology
Forensics/Law Enforcement
Snow/Ice Thickness Measurement
Research

GSSI

The World Leader in Subsurface Imaging™

Geophysical Survey Systems, Inc.
www.geophysical.com

APPENDIX B

Georadar Fact Sheet and Equipment

SIR-3000 System Specifications

System

Antennas:
Compatible with all GSSI ground-coupled antennas

Number of Channels: 1 (one)

Data Storage:
Internal memory: 1 GB Flash memory card

Compact Flash port: Accepts industry standard CF memory up to 2 GB (user provided)

Processor: 32-bit Intel StrongArm™ RISC processor @ 206 MHz

Display: Enhanced 8.4" TFT, 800 x 600 resolution, 64K colors

Display Modes: Linescan, O-scope, 3D

Data Acquisition

Data Format: RADAN (dzt)

Scan Rate Examples:
220 scans/sec at 256 samples/scan, 16 bit
120 scans/sec at 512 samples/scan, 16 bit

Sample size: 8-bit or 16-bit, user-selectable

Scan Interval: User-selectable

Number of samples per scan:
256, 512, 1024, 2048, 4096, 8192

Operating Modes:
Free run, survey wheel, point mode

Time Range:
0-8,000 nanoseconds full scale, user-selectable

Gain: Manual or automatic, 1-5 gain points (-20 to +80 dB)

Filters:
Vertical: Low-Pass and High-Pass IIR and FIR
Horizontal: Stacking, Background Removal

Operating

Operating Temperature:
-10°C to 40°C ambient

Charging Power Requirements:
15 V DC, 4 amps

Battery: 10.8 V DC, internal

Transmit Rate: Up to 100 KHz

Input/Output

Available Ports:
Antenna input
DC power input
Serial RS232 (GPS port)
Compact Flash memory
USB master and slave

Mechanical

Dimensions:
31.5 (L) x 22 (W) x 10.5 (H) cm
12.4" x 8.7" x 4.1"

Weight: 4.1 kg, (9 lbs) including battery

Environmental: Water resistant

System Includes:

SIR-3000 data acquisition system
Transit case
2 batteries
Battery charger
AC adapter (also works as charger)
User manual
Sunshade
Carrying harness (optional)

Antennas and antenna control cables sold separately

FCC Compliant

13 Klein Drive, PO Box 97
North Salem, NH 03073-0097
Tel: (603) 893-1109 Fax: (603) 889-3984
Sales@Geophysical.com

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Geophysical Survey Systems, Inc.
www.geophysical.com

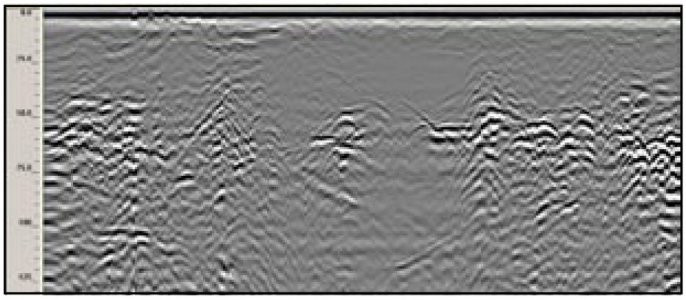
Antennas

Model 5104 - 270MHz

Utility Detection and Mapping
Engineering/Environmental
Geotechnical

The Model 5104 is suited for deeper utility, engineering and geotechnical applications.

Center Frequency:	270 MHz
Depth Range:	0- 6 m (0 - 18 ft)
Dimensions:	45 x 45 x 17 cm (18 x 18 x 6.5 in)
Weight:	8.6 kg (18.5 lbs)



GPR profile showing bedrock interface.

Model 3207 - 100MHz

Bistatic and Monostatic Operation

Geotechnical/Environmental
Mining

Center Frequency:	100 MHz
Depth Range:	2 - 15 m (5 - 50 ft) monostatic 0 - 30 m (0-100 ft) bistatic
Dimensions:	25 x 96 x 56 cm (10 x 38 x 22 in.) monostatic 25 x 96 x 200 cm (10 x 38 x 79 in.) bistatic
Weight:	13 kg (28 lbs) monostatic 28 kg (61 lbs) bistatic

The Model 3207 antenna is used for deep subsurface applications. The 3207AP (monostatic, left) combines the transmit and receive electronics in a single antenna housing. The 3207P (bistatic, right) is a versatile antenna pair that can operate in three different configurations to optimize performance.

Note: This antenna is currently for use outside the U.S.

Geophysical Survey Systems, Inc.
12 Industrial Way, Salem, NH 03079-4843 USA
Tel: 603-893-1109 / Fax: 603-889-3984
www.geophysical.com / sales@geophysical.com

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March, 2006

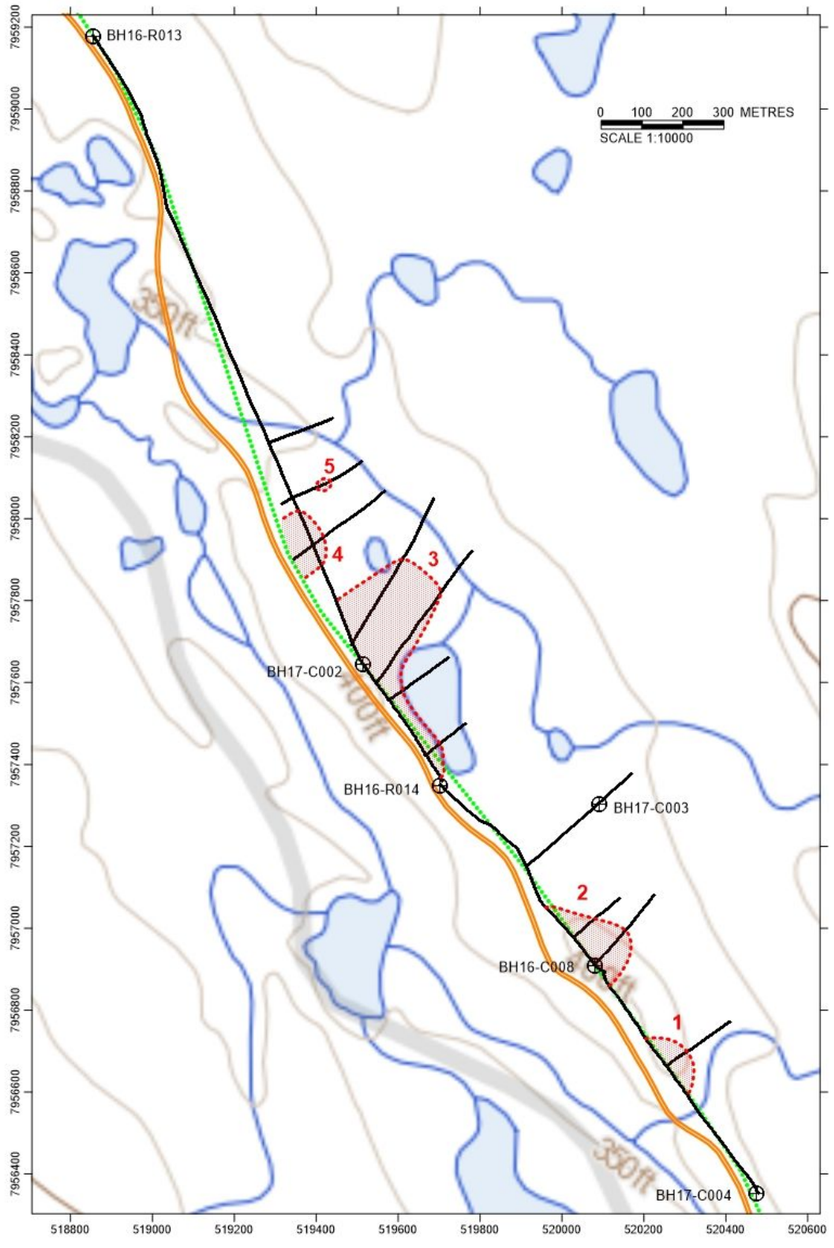
APPENDIX C

Drawings T17001-A2-1, T17001-A2-2,

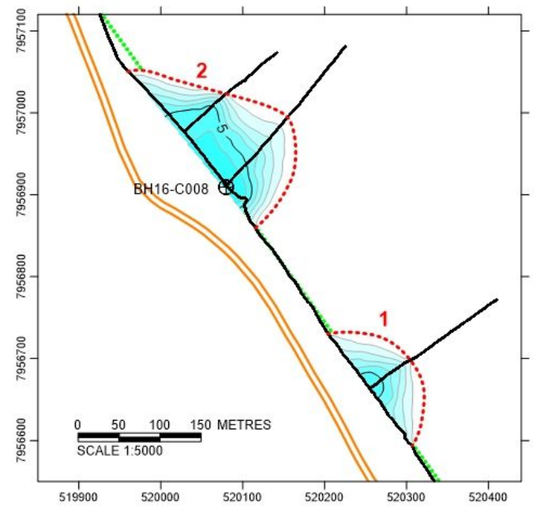
T17001-A2-3, T17001-A2-4, T17001-A3-1,

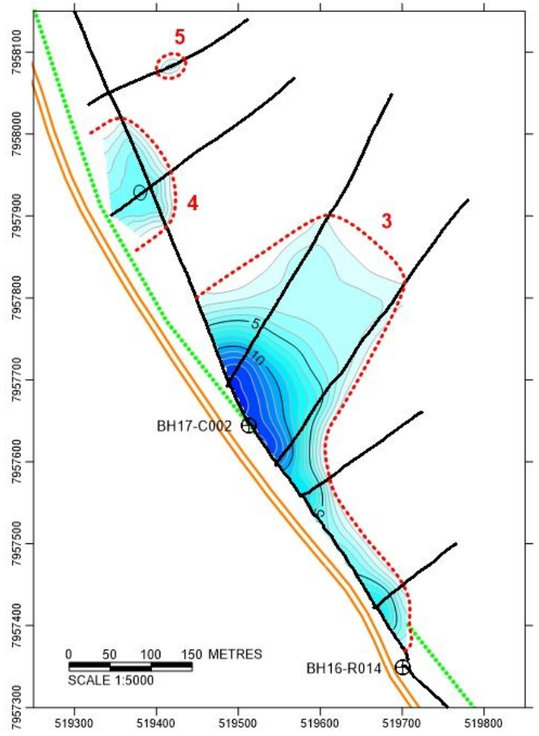
T17001-A3-2

GPR17-**SITE 1**

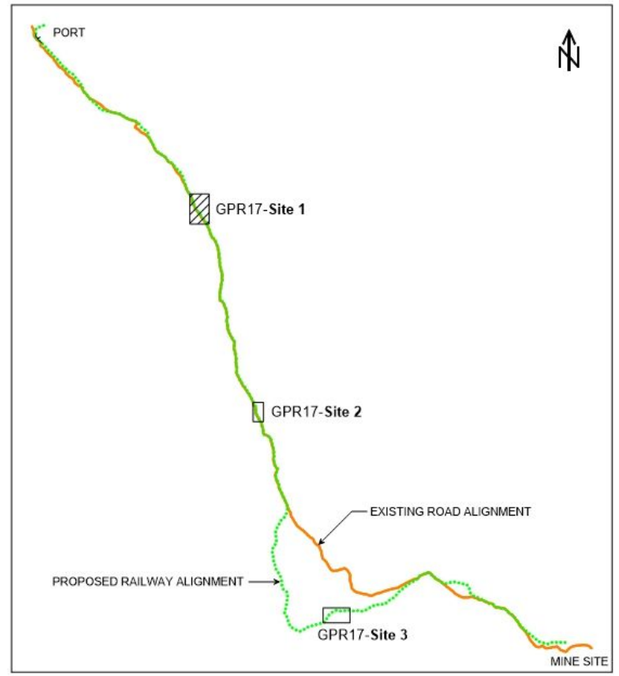


ICE THICKNESS MAP





OVERVIEW MAP



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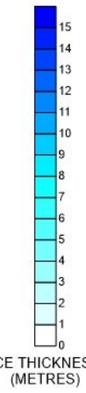


- EXISTING ROAD ALIGNMENT
- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 — GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE
- 1 — INTERPRETED ICE LAYER EXTENT

No	NOTES
1	THE RADAR SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. APRIL 2017
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W
3	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS
4	BOREHOLE DATA PROVIDED BY THE CLIENT FOR REFERENCE PURPOSES
5	
6	

No	DATE	MODIFICATIONS	GPR	APP

SCEAU PROFESSIONNEL / PROFESSIONAL SEAL

GEOPHYSICS GPR INTERNATIONAL INC.

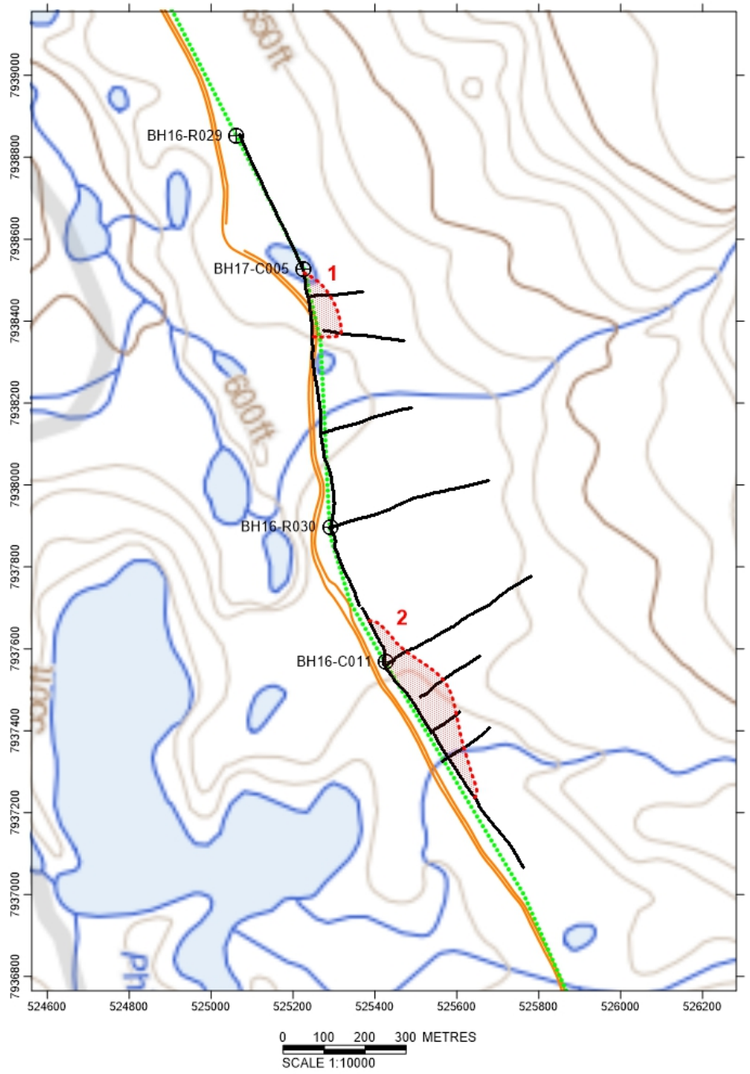
DESSINÉ PAR / DRAWN BY	I.Gusakov, GIT
VERIFIÉ PAR / CHECKED BY	
APPROUVÉ PAR / APPROVED BY	M.Situm, P. Geo
# CONTRAT / CONTRACT #	T17001
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17001-A2-1

CLIENT: HATCH

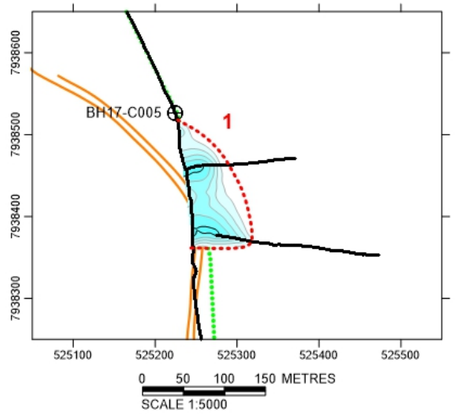
PROJET / PROJECT: BAFFINLAND EXPANSION

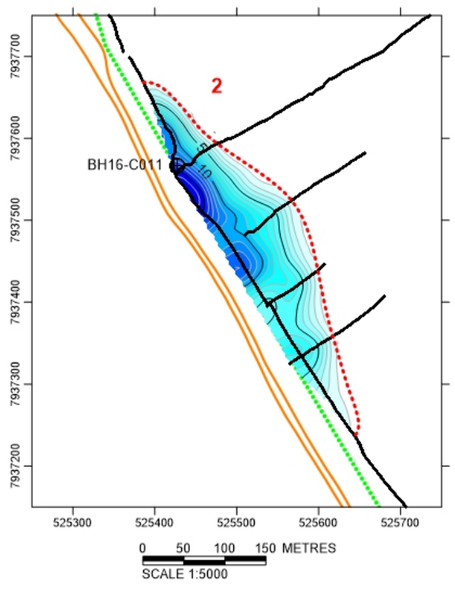
TITRE / TITLE: GROUND RADAR SURVEY
GPR17-SITE 1

GPR17-**SITE 2**

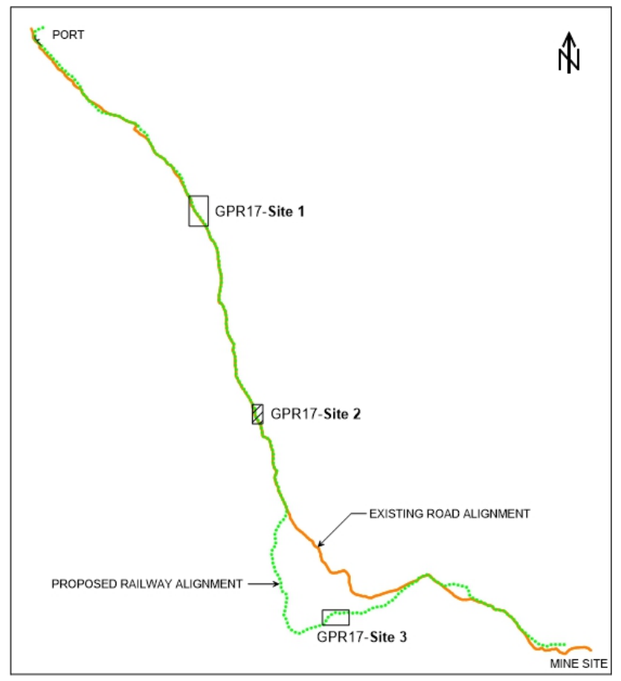


ICE THICKNESS MAP





OVERVIEW MAP



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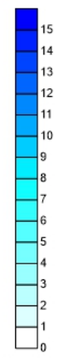

EXISTING ROAD ALIGNMENT

PROPOSED RAILWAY ALIGNMENT

BH17-C002 GEOTECHNICAL BOREHOLE

GROUND RADAR SURVEY LINE

1 INTERPRETED ICE LAYER EXTENT

1	THE RADAR SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. APRIL 2017				
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W				
3	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS				
4	BOREHOLE DATA PROVIDED BY THE CLIENT FOR REFERENCE PURPOSES				
5					
6					
No	NOTES	No	DATE	MODIFICATIONS	GPR APP.

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PROFESSIONAL SEAL

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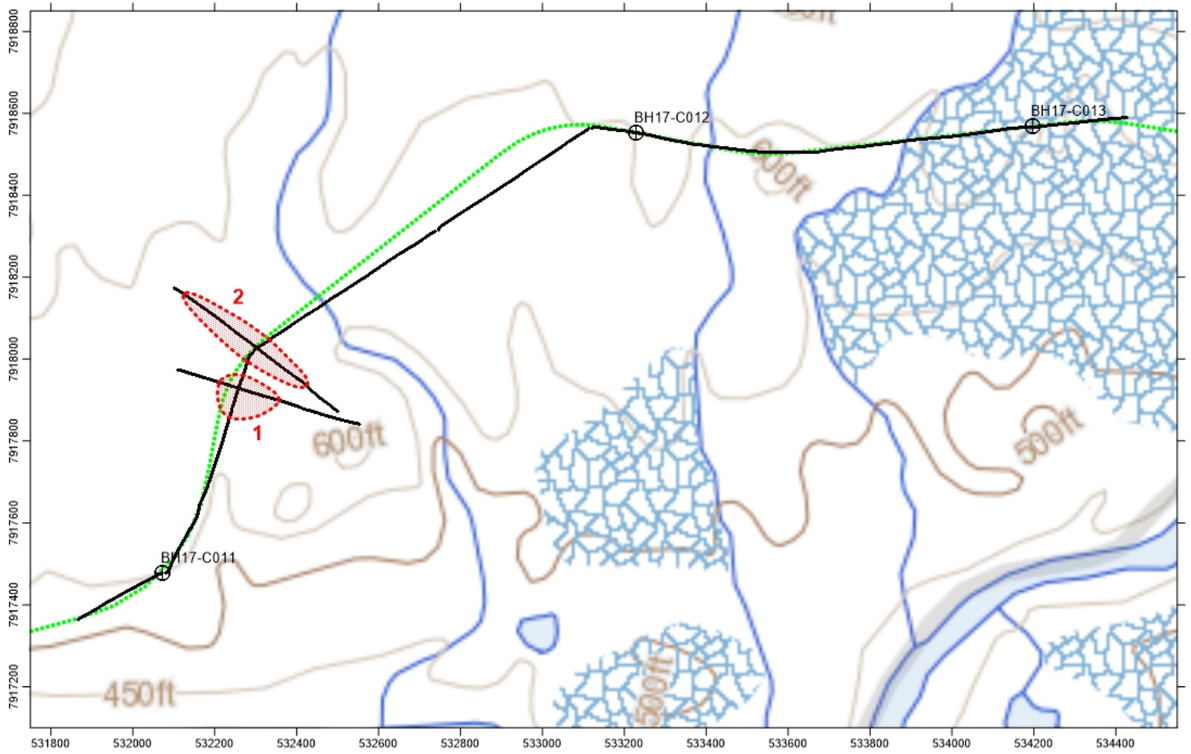
VERIFIÉ PAR / CHECKED BY			
APPROUVÉ PAR / APPROVED BY	M.Situm, P. Geo		
# CONTRAT / CONTRACT #	T17001		
ECHELLE / SCALE	AS SHOWN	# DESSIN / DRAWING #	T17001-A2-2

CLIENT: HATCH

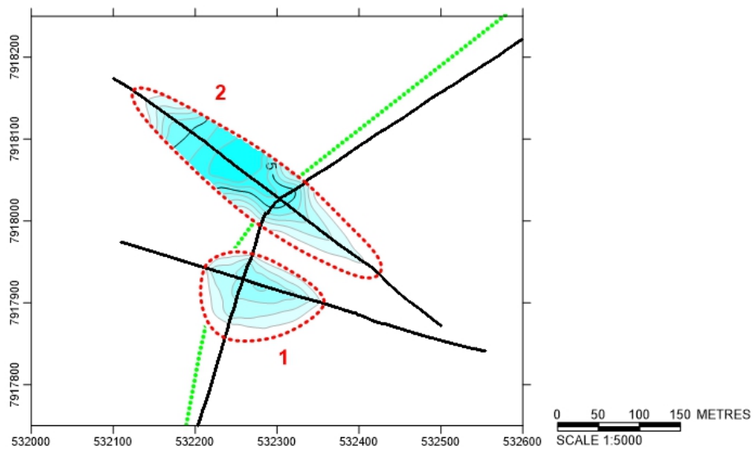
PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY
GPR17-SITE 2

GPR17-**SITE 3**



ICE THICKNESS MAP



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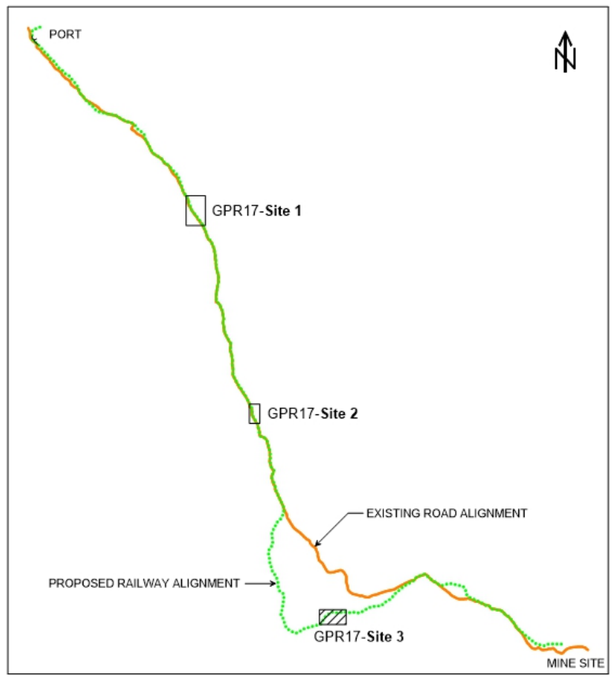

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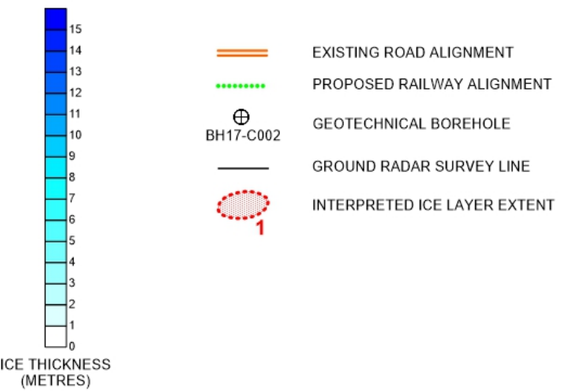

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No	NOTES	No	DATE	MODIFICATIONS	GPR APP

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PROFESSIONAL SEAL

GEOPHYSICS GPR INTERNATIONAL INC.

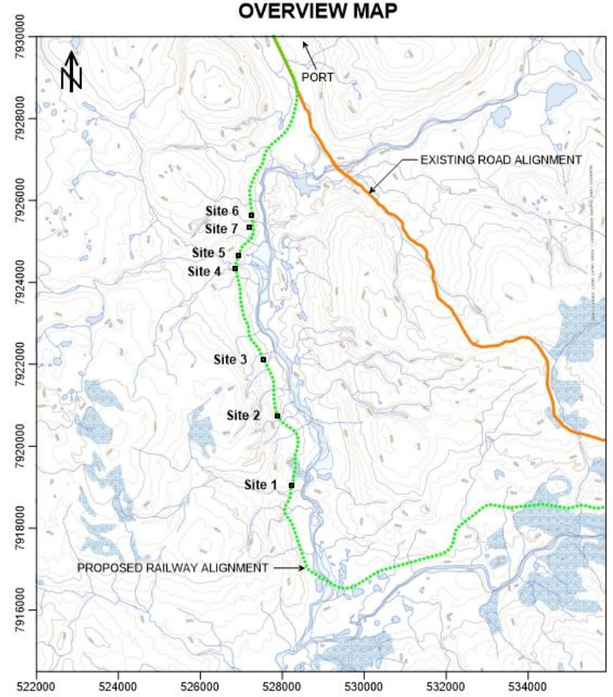
DESSINÉ PAR DRAWN BY	I.Gusakov, GIT		
VERIFIÉ PAR CHECKED BY			
APPROUVÉ PAR APPROVED BY	M.Situm, P. Geo		
# CONTRAT CONTRACT #	T17001		
ECHELLE SCALE	AS SHOWN	# DESSIN DRAWING #	T17001-A2-3

CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY GPR17-SITE 3

OVERVIEW MAP



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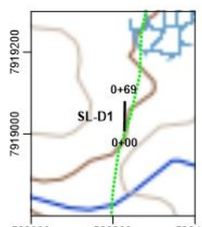

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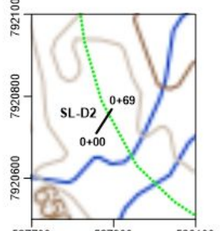

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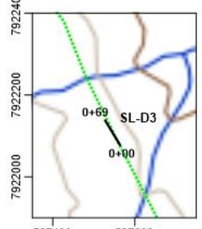

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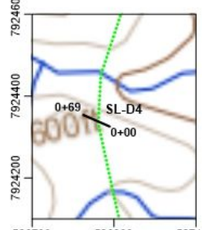

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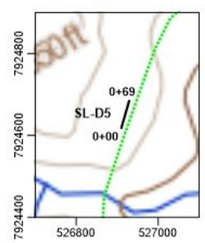

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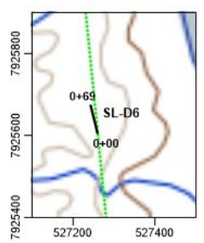

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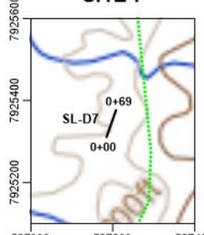

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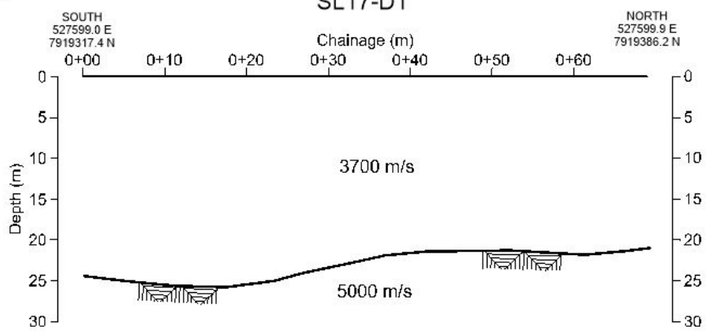
SL17-D1



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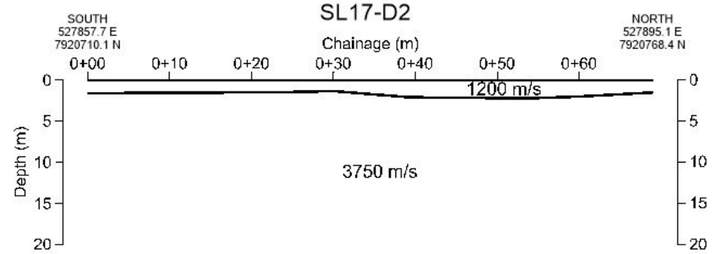

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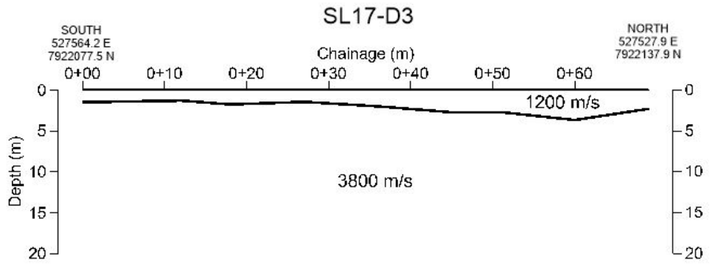

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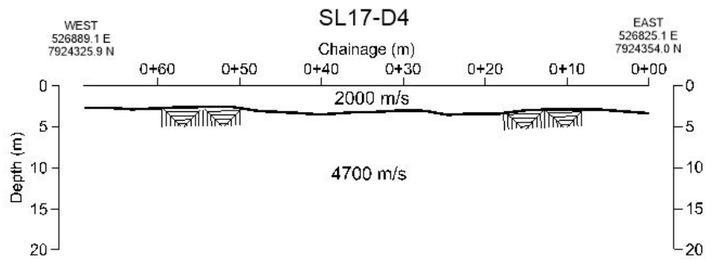

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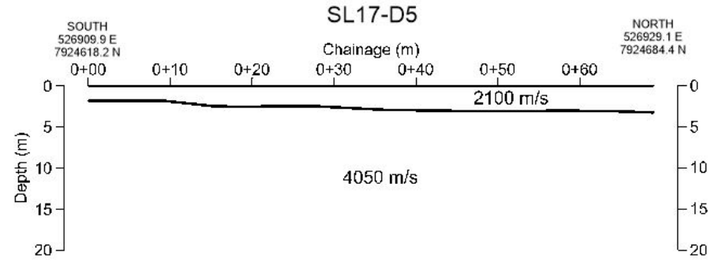

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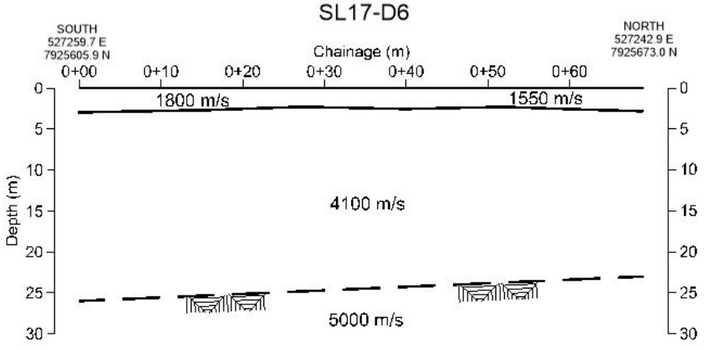

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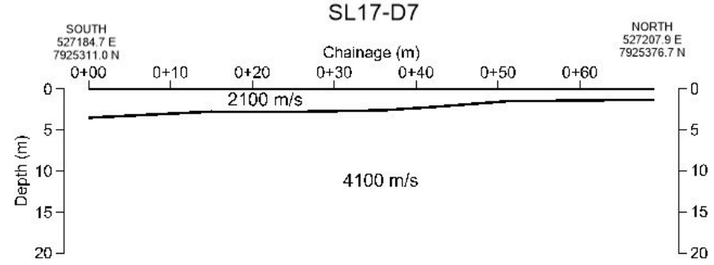


LEGEND

0+00 SL-D1 0+69	SEISMIC REFRACTION SURVEY LINE
	BEDROCK PROFILE
	APPROXIMATE BEDROCK PROFILE
3700 m/s	P-WAVE VELOCITY

No	NOTES
1	THE SEISMIC SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. APRIL 2017
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W
3	DEPTHS ARE RELATIVE TO GROUND SURFACE
4	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS
5	
6	

No	DATE	MODIFICATIONS	GPR APP.

SCEAU PROFESSIONNEL

PROFESSIONAL SEAL

GEOPHYSICS GPR INTERNATIONAL INC.

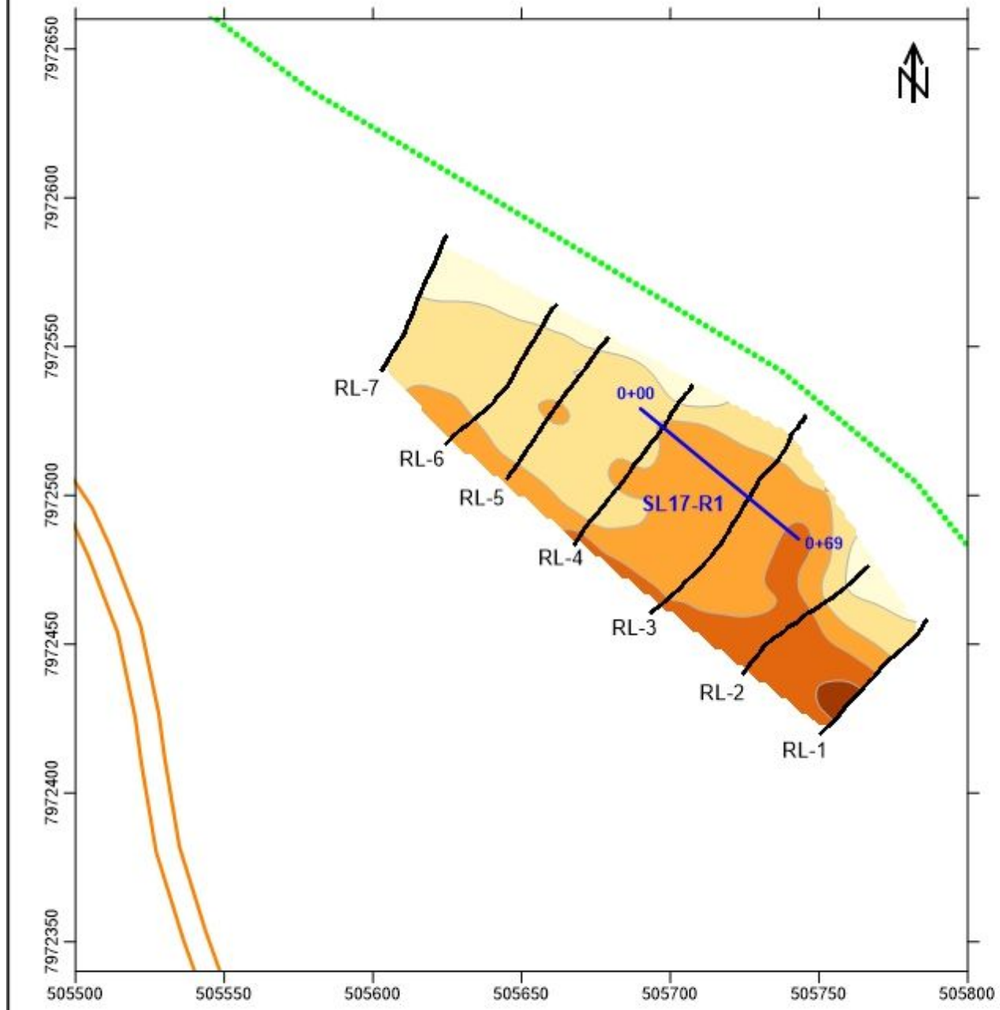
DESSINÉ PAR / DRAWN BY	I.Gusakov, GIT
VÉRIFIÉ PAR / CHECKED BY	
APPROUVÉ PAR / APPROVED BY	M.Situm, P. Geo
# CONTRAT / CONTRACT #	T17001
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17001-A2-4

CLIENT: HATCH

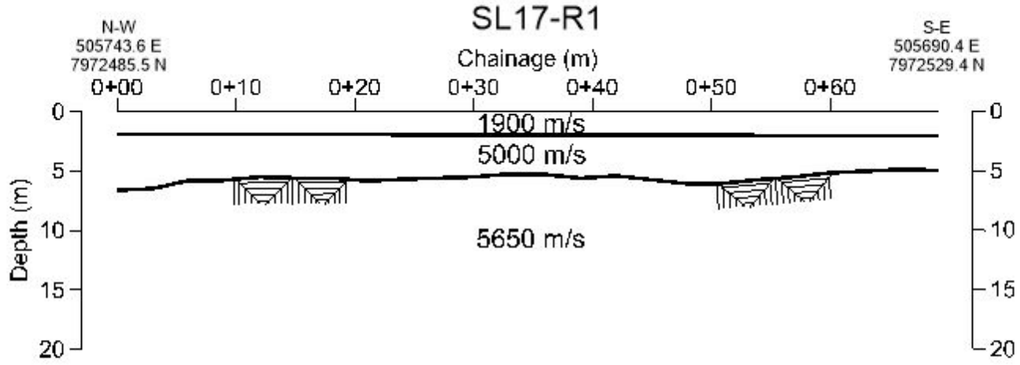
PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: SEISMIC REFRACTION SURVEY DEVIATION AREA

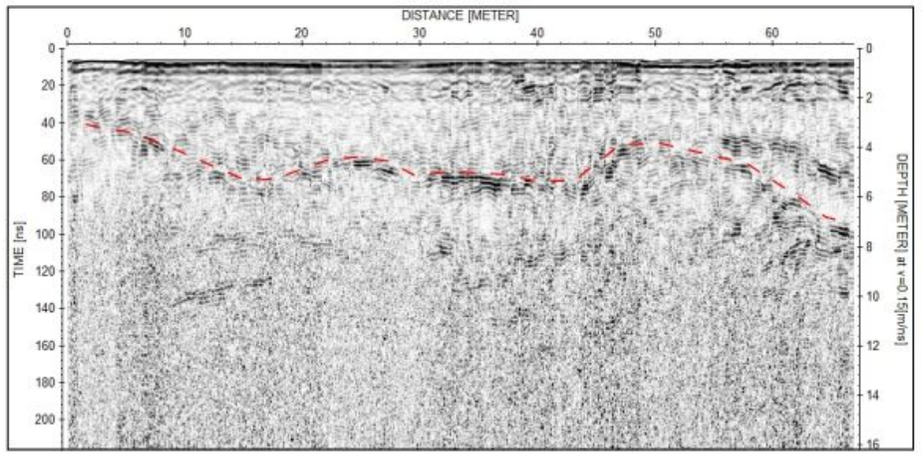
BEDROCK DEPTH MAP



SL17-R1



EXAMPLE RADAR IMAGE (RL-4)



LEGEND

EXISTING ROAD ALIGNMENT	BEDROCK PROFILE
PROPOSED RAILWAY ALIGNMENT	5650 m/s — P-WAVE VELOCITY
SL17-R1 — SEISMIC REFRACTION SURVEY LINE	
RL-1 — GROUND RADAR SURVEY LINE	

NOT VALID FOR CONSTRUCTION

No	NOTES
1	THE SEISMIC SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. APRIL 2017
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W. POSITIONING ACCURACY +/- 2 METRES
3	ELEVATION DATA PROVIDED BY THE CLIENT. DEPTHS ARE RELATIVE TO GROUND SURFACE
4	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS
5	BOREHOLE DATA PROVIDED BY THE CLIENT FOR REFERENCE PURPOSES
6	

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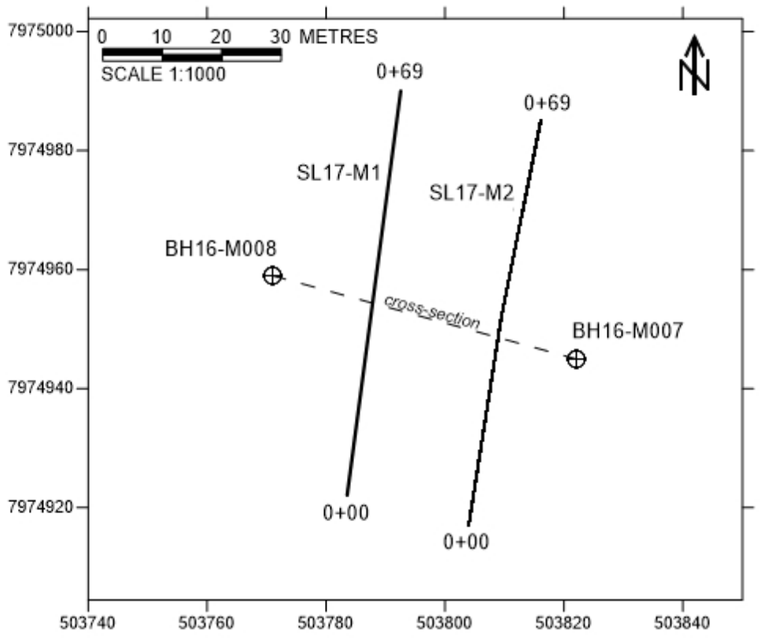
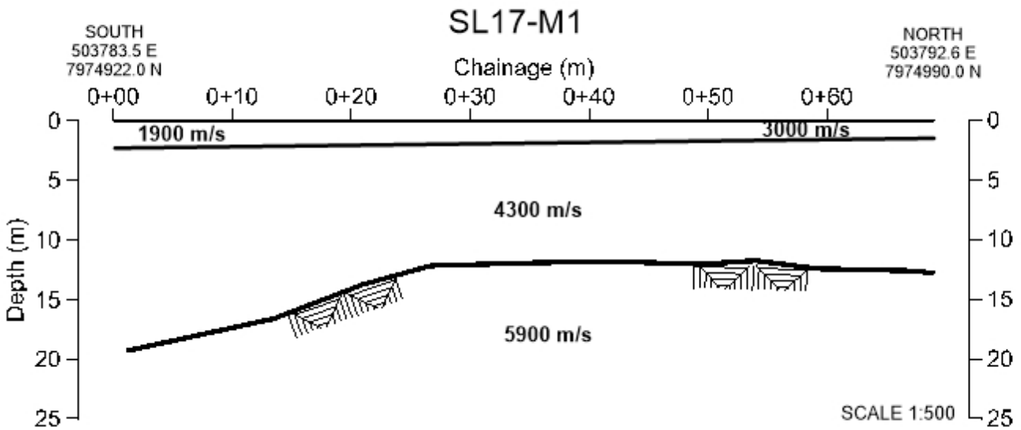
APPROUVÉ PAR / APPROVED BY	M.Situm, P. Geo		
# CONTRAT / CONTRACT #	T17001		
ÉCHELLE / SCALE	AS SHOWN	# DESSIN / DRAWING #	T17001-A3-2

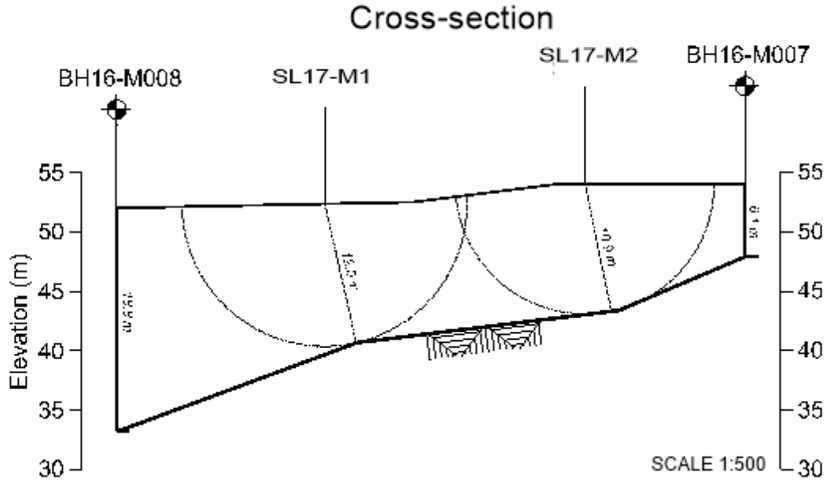
CLIENT / CLIENT: HATCH

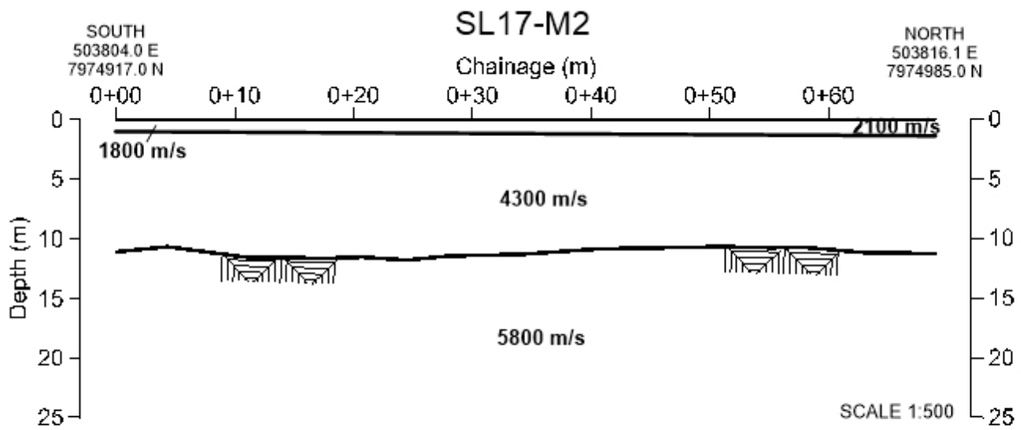
PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: SEISMIC AND GEORADAR SURVEY
PROPOSED RAIL ALIGNMENT KM 4.5









1	THE SEISMIC SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. APRIL 2017	SCEAU PROFESSIONNEL	GEOPHYSICS GPR INTERNATIONAL INC.	CLIENT	CLIENT
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W. POSITIONING ACCURACY +/- 2 METRES			HATCH	
3	ELEVATION DATA PROVIDED BY THE CLIENT. DEPTHS ARE RELATIVE TO GROUND SURFACE		DESSINÉ PAR / DRAWN BY: I.Gusakov, GIT	PROJET	PROJECT
4	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS		VERIFIÉ PAR / CHECKED BY:	BAFFINLAND EXPANSION	
5	BOREHOLE DATA PROVIDED BY THE CLIENT FOR REFERENCE PURPOSES		APPROUVÉ PAR / APPROVED BY: M.Situm, P. Geo	TITRE	TITLE
6			# CONTRAT / CONTRACT #: T17001	SEISMIC SURVEY RAILWAY UNLOADING AREA	
No	NOTES	PROFESSIONAL SEAL	ÉCHELLE / SCALE: AS SHOWN; # DESSIN / DRAWING #: T17001-A3-1		

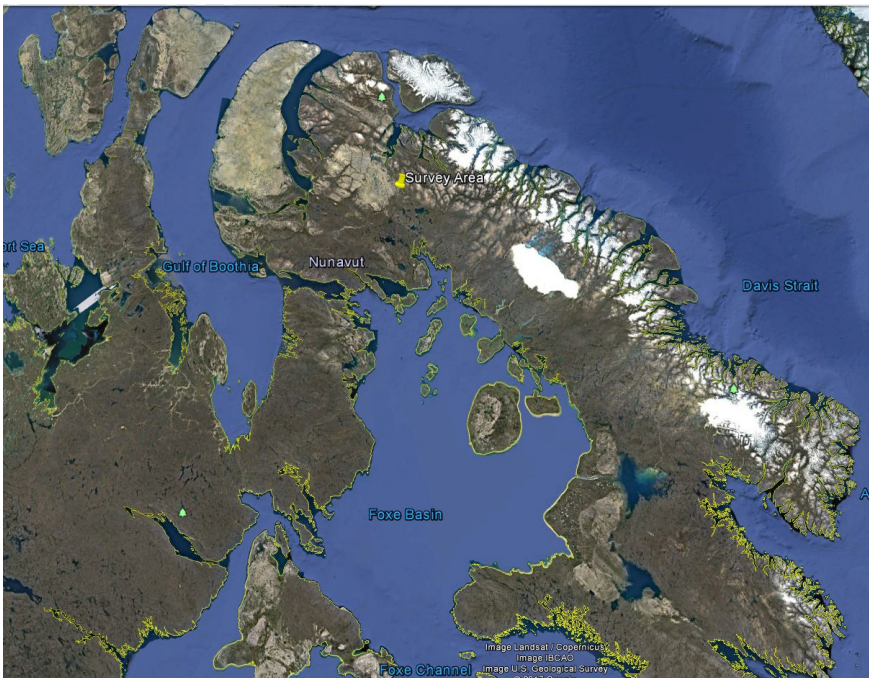
GEOPHYSICS GPR
INTERNATIONAL INC.

GEOPHYSICAL INVESTIGATION FOR BAFFINLAND RAILWAY, MARY RIVER PROJECT, NUNAVUT

PREPARED FOR:
Baffinland Iron Mines Corporation

Presented to:

4342 Queen Street, Suite 500
Niagara Falls, Ontario
L2E 7J7



Project T17001B-Revision#004 **April 2018**

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January 2018 T-17001B

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APPENDIX B – Georadar Fact Sheet

1 INTRODUCTION

Geophysics GPR International Inc. was requested by Hatch Ltd. to carry out a geophysical survey to aid in projection and planning of a proposed railway for the Mary River Project, Baffin Island, Nunavut.

The purpose of this investigation was to determine the extent of, as well as the thickness of subsurface ice.

The ground penetrating radar (georadar) method was applied to determine the presence of ice and calculate its thickness.

Data was collected from November 3rd to November 15, 2017.

The investigation included the following:

1) Georadar mapping of subsurface ice at nine sites approximately at Km 0, 19.4, 20.5, 39.5, 49.3, 82.2, 97.0, 100.1 and 109 along the proposed rail alignment. Further exploration with gridded georadar lines was conducted in regions both with and without the presence of ice.

Figure 1 presents an overview map of the investigation area with the locations of the respective sites.

The following report describes the various aspects of the survey including field techniques, survey design, interpretation techniques, and finally an interpretation in the form ice thickness maps.

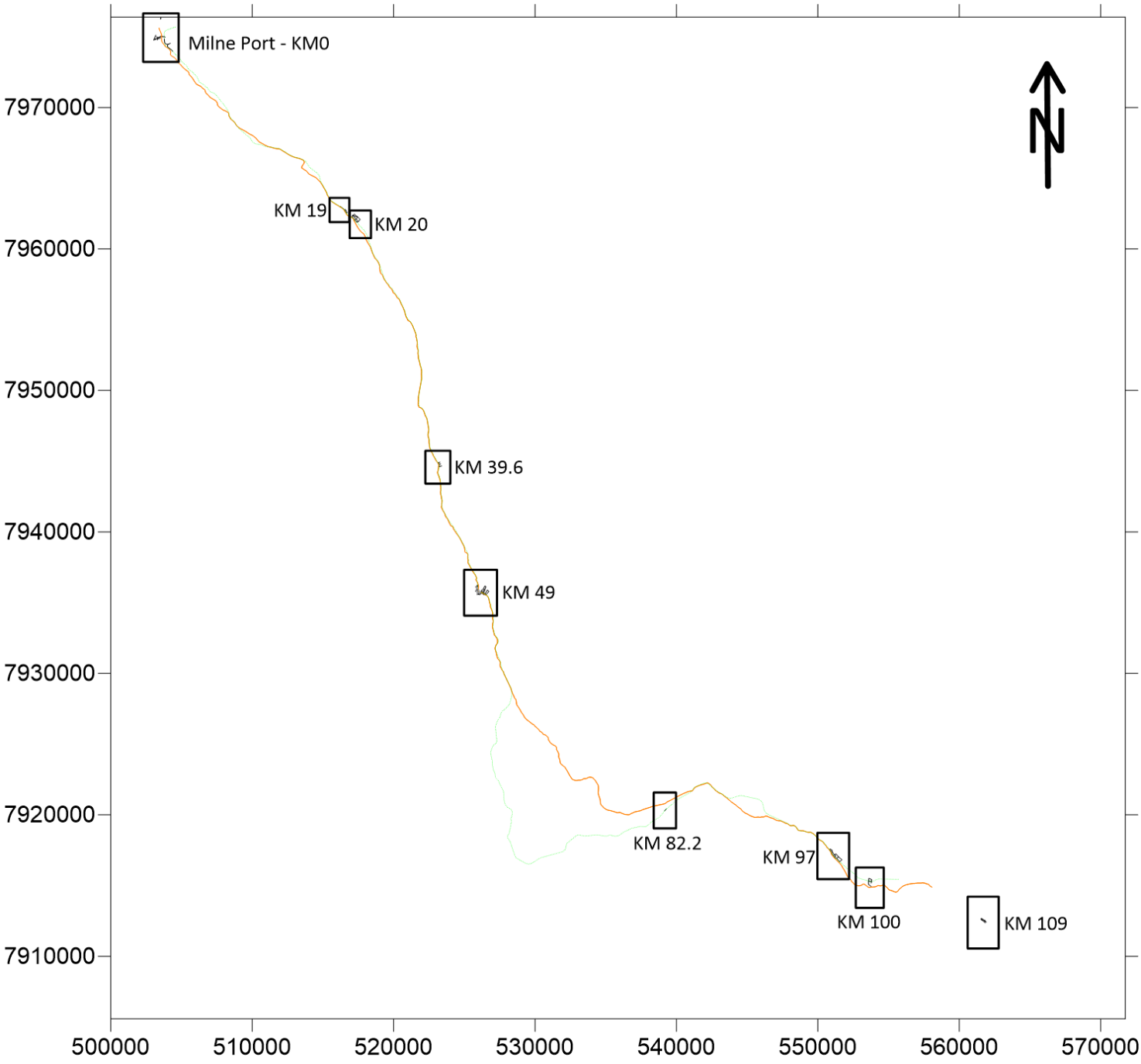


Figure 1: Overview map of the investigation area

2 METHODOLOGY

Georadar was used to determine the presence and thickness of ice.

2.1 Positioning, Topography and Units of Measurement

The emplacement of the survey areas was determined by the client.

The locations of the georadar survey lines for the purpose of subsurface ice mapping were oriented to align with the design of the proposed railway. Length and number of the lines were chosen based on in-field interpretation of georadar data. Positioning was controlled by the GPS device integrated into the georadar antenna. The UTM coordinates should be accurate to within +/- 2.0 m.

Table 1: UTM coordinates of GPR survey lines

Line No.	Start (0+00)		End (0+69)		Chainage (km)		Notes
	Easting	Northing	Easting	Northing	Start	End	
Line 0	502871.8	7976754.0	504000.0	7974502.0	0	2	Milne Port Area
Line 19.4	516252.0	7962974.0	516644.0	7962535.0	19.25	19.85	
Line 20.5	517047.0	7962251.0	517390.0	7961888.0	20.46	20.9	
Line 39.6	523146.0	7944888.0	523216.0	7944604.0	39.6	39.9	
Line 49.3	525992.0	7935880.0	526497.0	7935589.0	49.5	49.9	Rough Terrain
Line 82.2	539154.0	7920274.0	539291.0	7920419.0	82.2	82.4	
Line 97.0	551121.0	7917097.0	551250.0	7916944.0	97.0	97.6	Rough Terrain
Line 100.1	553584.0	7915318.0	553779.0	7915281.0	100.1	100.3	
Line 109.0	561530.0	7912604.0	561844.0	7912356.0	109.0	109.4	

The provided coordinates are NAD83/WGS84, UTM zone 17N.

The depth measurements are noted as depth from surface.

All geophysical measurements were collected in SI units.

In addition to Table 1, further georadar survey lines were created to further explore the given areas. These additional survey lines were generated in a grid-like fashion with the topography dictating the spacing of the lines.

2.2 Ground Penetrating Radar (Georadar)

Basic Theory

Georadar utilises radar technology to obtain a near-continuous profile of the subsurface. The basic principle is to emit an electromagnetic impulse into the ground at a predetermined frequency rate (typically 10 to 80 scans/second). This pulse will travel through the sub-surface and reflect off boundaries of differing dielectric constants (contrasts of EM impedances). The reflected pulse returns to the surface and is recorded by a receiver and displayed in real-time as a cross-sectional image. Only by moving the antennas along a profile directly over the targets can the locations and depths be determined. Examples of radar reflecting boundaries include air/water (water table); water/earth (bathymetry); earth/metal, PVC, or concrete (pipe locating); and differing earth materials (stratigraphic profiles, including bedrock profiles).

The depth of investigation is controlled by the frequency and power of the antenna limited by attenuation and diffraction of the radar signal. Lower frequency antennas provide greater depth penetration at the expense of resolution. The radar signal is attenuated by conductive ground materials (e.g. clays, dissolved salts etc.). The radar signal is diffracted by irregular shaped material (e.g. boulders, debris etc.) that prevents the clear return of the reflected pulse.

More information on the georadar operating principle can be found in Appendix B.

Survey Design

The georadar data were collected with a MALA Ground Explorer system and 160 MHz antenna. This antenna provides a favourable trade off between depth and resolution for ice detection. As well, this antenna has sufficient durability for the terrain and weather conditions for Baffin Island.

Positioning for the georadar survey was controlled by built-in GPS receiver.

Interpretation Method

Processing of the radar images involved basic horizontal normalization, elevation corrections and gain adjustments.

The vertical scale on all radar images is a two-way time scale representing the time taken for a radar pulse to transmit to a reflector and back to the receiver. In order to convert the time scale to a depth scale a signal velocity must be applied. The velocity with which the pulse travels through the given material is determined by the dielectric constant. This dielectric will vary with the type of material.

Calculating a velocity can be done in many ways but the most reliable method is with a test pit or borehole where the real rock contact can be exposed. Based on in-situ measurements or borehole data, the dielectric value can be approximated depending on the expect material type. An underestimate of the dielectric will result in an over estimate of the signal velocity and in turn an over estimate of the depths. For this site a dielectric of 4 (velocity of 15 cm/ns) was assumed based on the expected soil type and tables of relative dielectric values for commonly encountered materials. In this case the materials were mostly frozen granular/boulders with high ice content.

Interpretation of the data is based primarily on the qualitative analysis of three characteristics of radar reflections: continuity, amplitude and shape. The interpreter then identifies reflectors and textures within the radar records that represent subsurface contacts, objects or zones. The true nature of the interpreted features can only be assumed without corroborating evidence.

Ice bodies have a distinctive appearance on radar images. Granular host material appears as "noise" on the images, whereas uniform ice layer looks transparent with clearly defined top and bottom contacts and can be confidently identified. An example of a uniform ice lens is presented in Figure 2.

Non-uniform ice bodies (stratified or containing layers of soil) are more challenging for interpretation since structure irregularities create multiple reflections within the ice body. Often a borehole is needed to confirm the presence of ice. Other features such as increasing depth of investigation in the presence of thick ice layer may corroborate the interpretation.

In summary, ability of georadar is limited by the structure of the ice layer being surveyed and its composition. The identification of an ice layer may be impacted by irregularities inside the ice body, such as layering, fractures and soil inclusions. However, it is possible to create two categories of ice lenses, the obvious and less obvious that may need some ground truthing.

3 RESULTS

3.1 Subsurface Ice Mapping

Georadar data was collected at nine sites approximately at Km 0, 19.4, 20.5, 39.5, 49.3, 82.2, 97.0, 100.1 and 109 along the proposed rail alignment.

Locations of the survey lines and results of the georadar survey are presented in drawings GPR17 – MILNE INLET, GPR17 –KM19, GPR17 –KM20, GPR17 –KM39.6, GPR17 –KM49, GPR17 –KM82.2, GPR17 –KM97, GPR17 –KM100.1, GPR17 –KM109.

KM 0 - GPR17 – MILNE INLET

Multitude of survey lines conducted in the Milne Port area with no evidence of the presence of ice. Georadar penetration of the surface appeared shallow with poor signal attenuation, possibly due to material used for subsurface in port area. Total distance of 1.2km covered.

KM 19 - GPR17 –KM19

Two main survey lines conducted. No apparent ice presence in area. Area was not explored further due to time constraints. Total distance of 1.0km covered.

KM 20 - GPR17 –KM20

No apparent ice presence in area. Grid-like survey conducted to further explore region for ice; two further longitudinal lines, with three additional perpendicular cuts. Total distance of 2.9km covered.

KM 39.6 - GPR17 –KM39.6

No apparent ice presence in area. Latitudinal cuts conducted to further explore region for ice. No longitudinal lines due to topographic obstacle in area. Total distance of 1.5km covered.

KM 49 - GPR17 –KM49

Ice found in region, explored with additional lines where possible. Survey lines constrained due to topography and water in area. Total distance of 4.5km

KM 82.2 - GPR17 –KM82.2

No apparent ice presence in area. Due to distance from tote-road and time constraints no additional surveying was conducted in this area. Total distance of 200m covered.

KM 97 - GPR17 –KM97

No apparent ice presence in area. Area heavily constrained by topographic change. Additional survey lines done around topography to ensure safety maintained. Total distance of 2.2 km covered.

KM 100.1 - GPR17 –KM100.1

No apparent ice presence in area. Area constrained by water. Additional survey lines conducted in area. Total distance of 1.2km covered.

KM 109 - GPR17 –KM109

No apparent ice presence in area. Area constrained by topographic change. Additional survey lines conducted in area. Total distance of 1.2km covered.

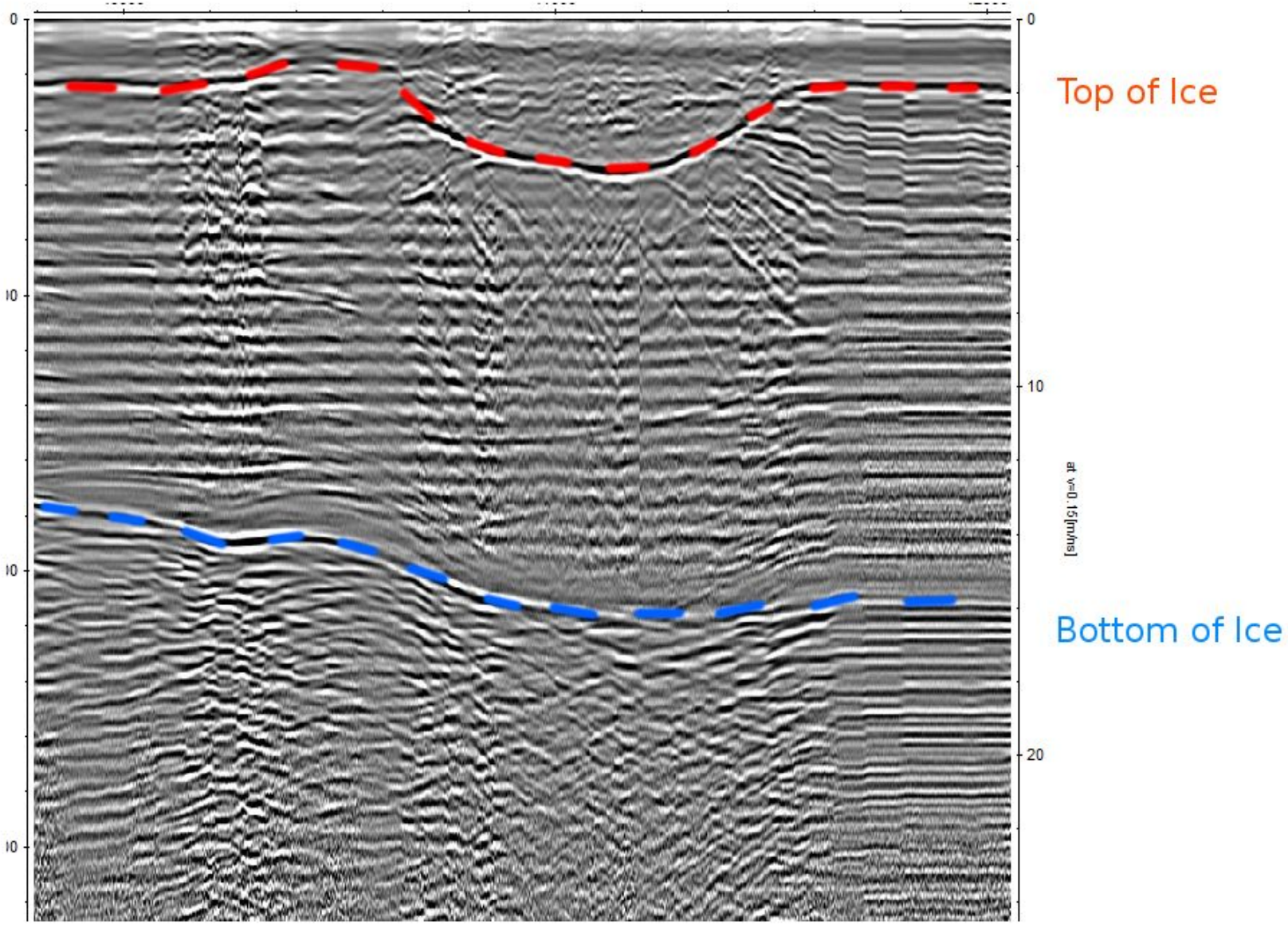


Figure 2: Interpreted georadar image showing a typical ice body

4 CONCLUSIONS

A geophysical investigation involving Georadar was carried out at the Mary River Project, Baffin Island, Nunavut.

Subsurface ice mapping was carried out at nine sites along the proposed rail alignment. Results of the survey are presented in Drawings GPR17 – MILNE INLET, GPR17 –KM19, GPR17 –KM20, GPR17 –KM39.6, GPR17 – KM49, GPR17 –KM82.2, GPR17 –KM97, GPR17 –KM100.1, GPR17 –KM109. Ice was only found in Km 49, seen in drawing GPR17-KM49.

Interpretation of the geophysical data has been performed by Mauritz van Zyl. This report has been written by Milan Situm, P.Geo.

_____
Milan Situm, P.Geo.
Manager

APPENDIX A

Drawings GPR17 – MILNE INLET,

GPR17 –KM19,

GPR17 –KM20,

GPR17 –KM39.6,

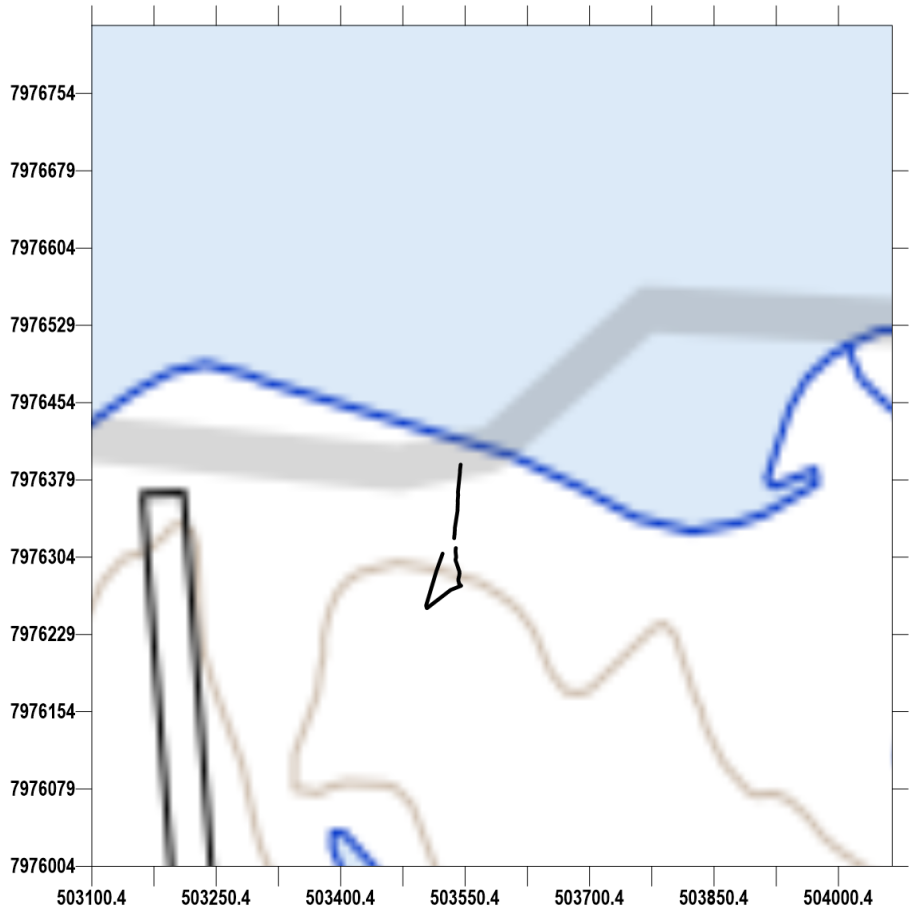
GPR17 –KM49, Ice was only found in Km 49, seen in drawing GPR17-KM49.

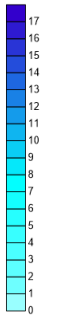
GPR17 –KM82.2,

GPR17 –KM97,

GPR17 –KM100.1,

GPR17 –KM109.





ICE THICKNESS (m)

LEGEND

- EXISTING ROAD ALIGNMENT
- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE

No	NOTES
1	THE RADAR SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. NOVEMBER 2017
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W
3	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS
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5	
6	

No	DATE	MODIFICATIONS	GPR APP.

SCEAU PROFESSIONNEL

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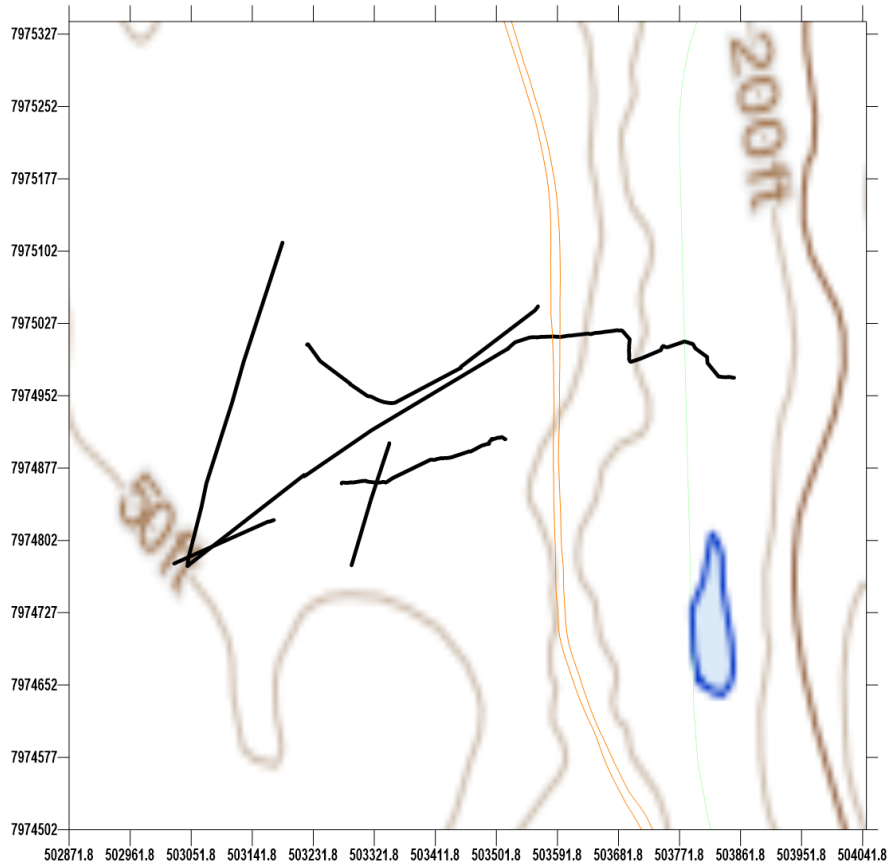
GEOPHYSICS GPR INTERNATIONAL INC.

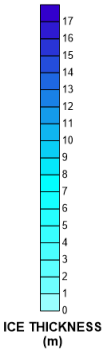
DESSINÉ PAR / DRAWN BY	M. Van Zyl
VERIFIÉ PAR / CHECKED BY	
APPROUVÉ PAR / APPROVED BY	M.Situm, P. Geo
# CONTRAT / CONTRACT #	T17001b
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17001b-A2

CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY GPR17-MILNE INLET





LEGEND

- EXISTING ROAD ALIGNMENT
- PROPOSED RAILWAY ALIGNMENT
- ⊕ BH17-C002 — GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE

No	NOTES
1	THE RADAR SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. NOVEMBER 2017
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W
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5	
6	

No	DATE	MODIFICATIONS	GPR	APP

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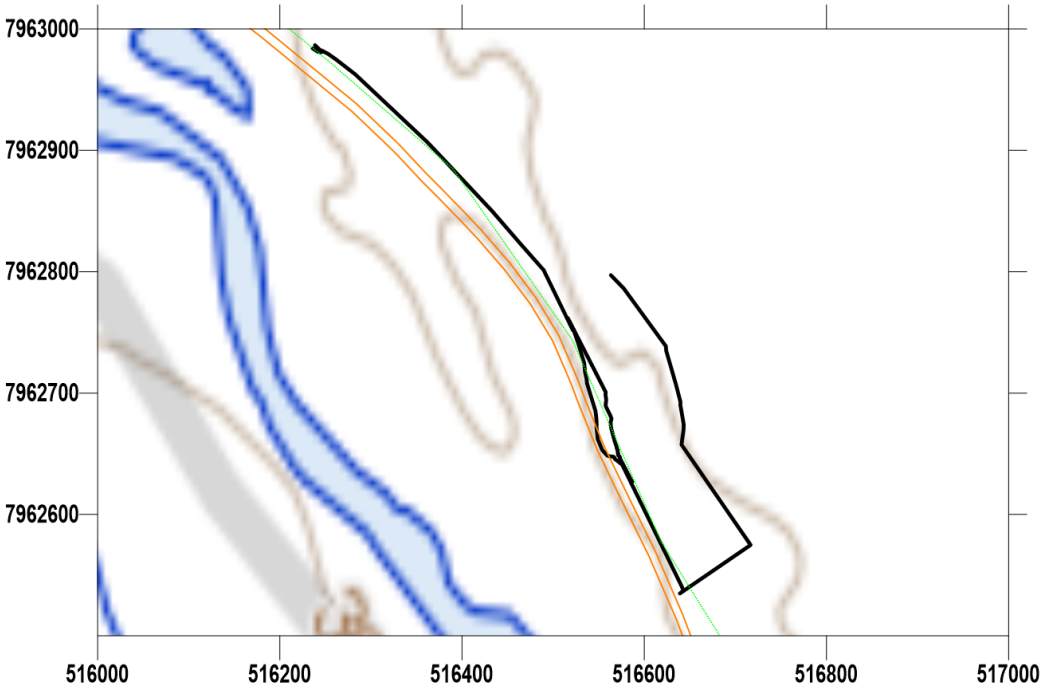
GEOPHYSICS GPR INTERNATIONAL INC.

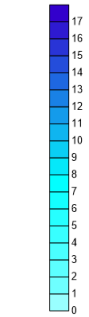
DESSINÉ PAR / DRAWN BY	M. Van Zyl
VÉRIFIÉ PAR / CHECKED BY	
APPROUVÉ PAR / APPROVED BY	M.Situm, P. Geo
# CONTRAT / CONTRACT #	T17001b
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17001b-A2

CLIENT / CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY
GPR17-MILNE INLET





ICE THICKNESS
(m)

LEGEND

- EXISTING ROAD ALIGNMENT
- PROPOSED RAILWAY ALIGNMENT
- ⊕ BH17-C002 — GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE

No	NOTES
1	THE RADAR SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. NOVEMBER 2017
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W
3	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS
4	BOREHOLE DATA PROVIDED BY THE CLIENT FOR REFERENCE PURPOSES
5	
6	

No	DATE	MODIFICATIONS	GPR	APP

SCEAU PROFESSIONNEL
PROFESSIONAL SEAL

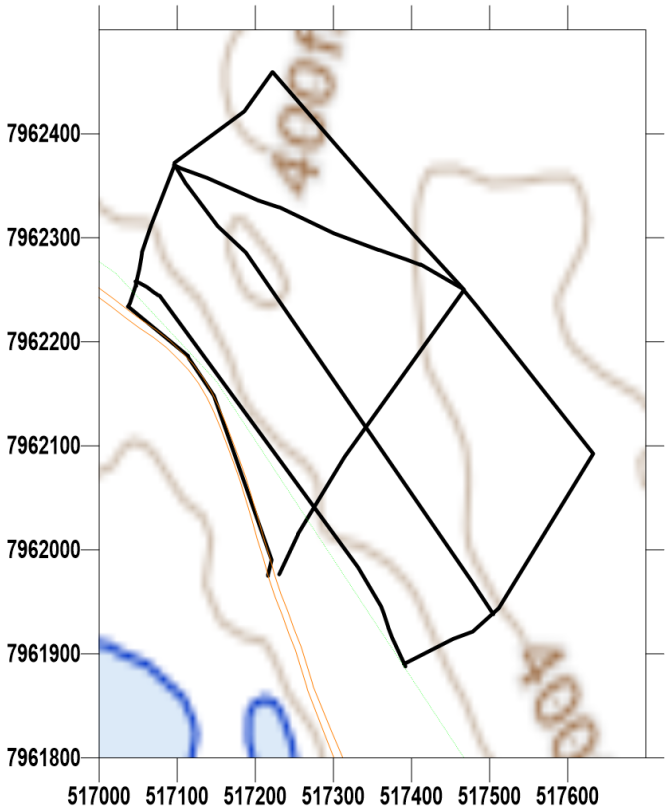
GEOPHYSICS GPR INTERNATIONAL INC.

DESSINÉ PAR / DRAWN BY	M. Van Zyl
VERIFIÉ PAR / CHECKED BY	
APPROUVÉ PAR / APPROVED BY	M.Situm, P. Geo
# CONTRAT / CONTRACT #	T17001b
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17001b-A2

CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY
GPR17-KM19



ICE THICKNESS
(m)

LEGEND

- EXISTING ROAD ALIGNMENT
- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 — GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE

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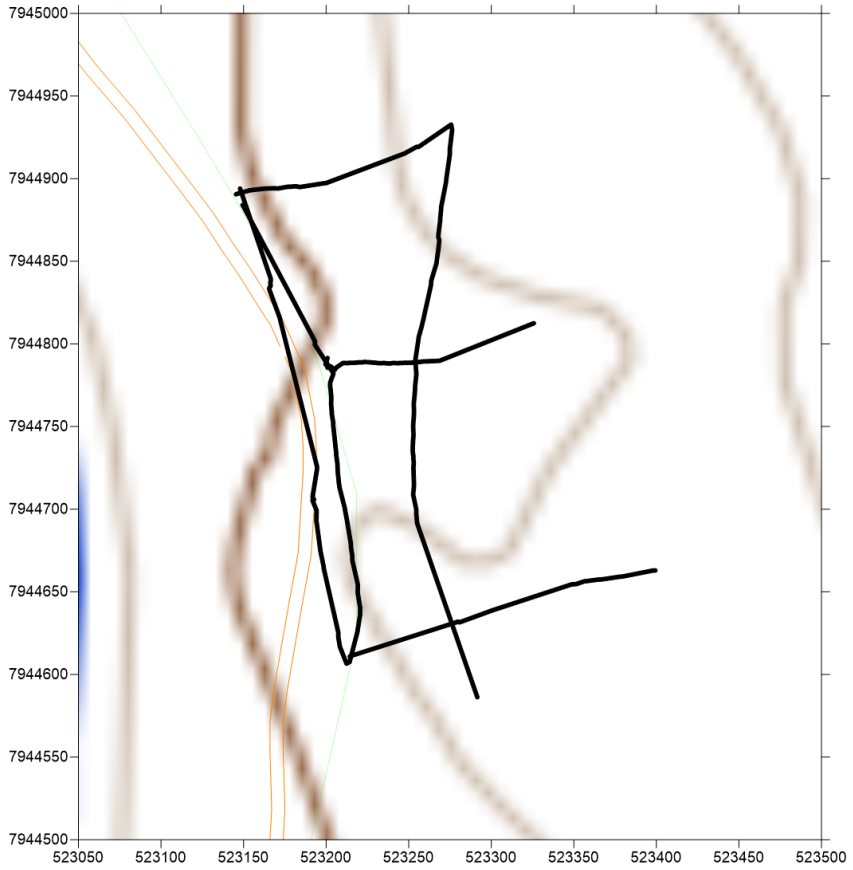
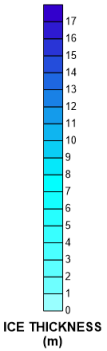
CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY
GPR17-KM20





LEGEND

- EXISTING ROAD ALIGNMENT
- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 — GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE

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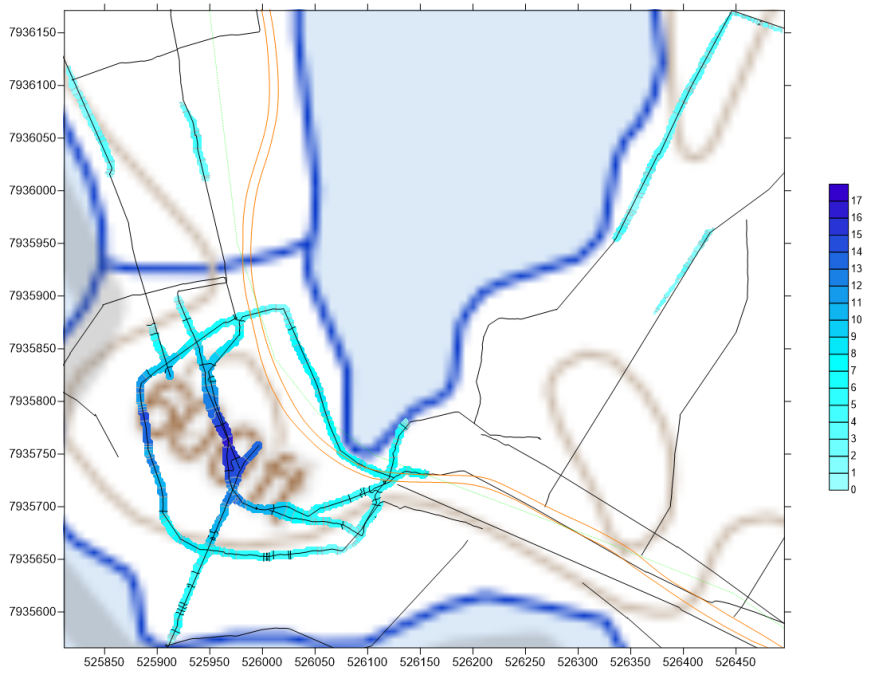
CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY
GPR17-KM39.6

Ice Thickness
KM49



PRELIMINARY

LEGEND

- EXISTING ROAD ALIGNMENT
- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 — GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE
- 1 — INTERPRETED ICE LAYER EXTENT

No	NOTES
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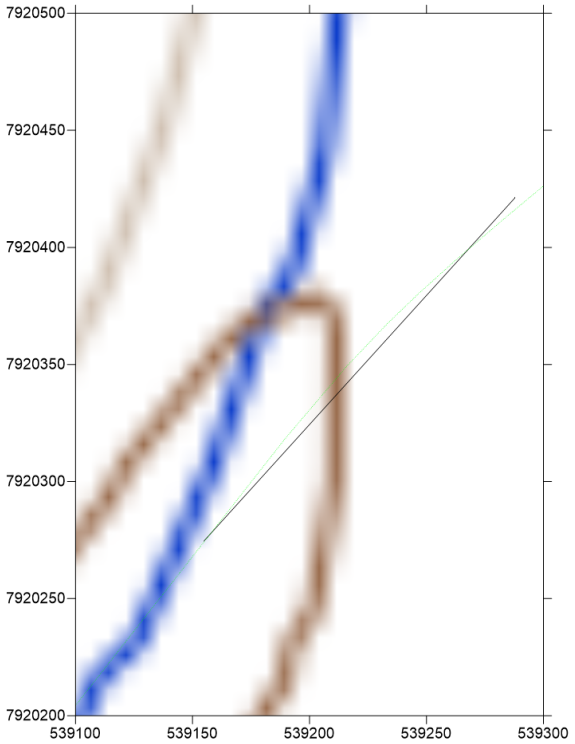
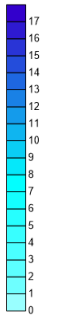
# DESSIN / DRAWING #	T17001b-A1-1

CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY
GPR17-SITE 1





ICE THICKNESS
(m)

LEGEND

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- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 — GEOTECHNICAL BOREHOLE
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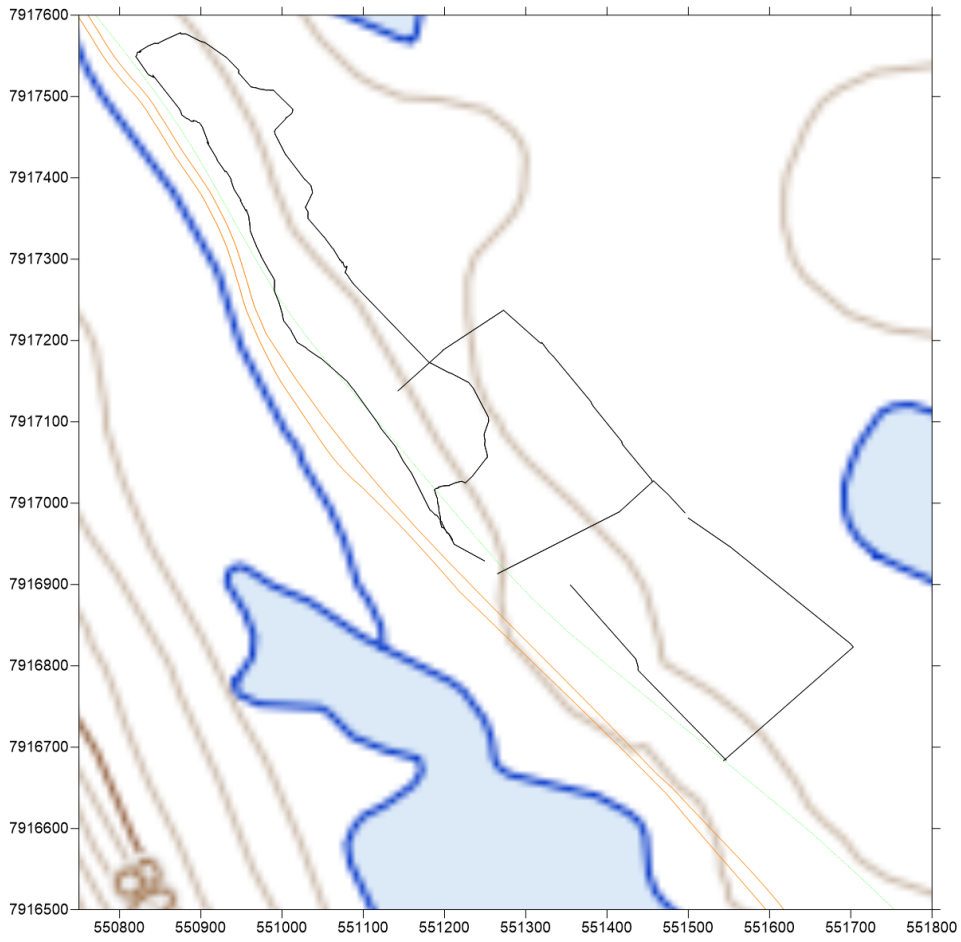
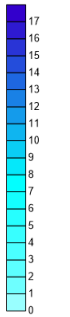
# DESSIN / DRAWING #	T17001b-A2

CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY
GPR17-KM82.2





ICE THICKNESS
(m)

LEGEND

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- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE

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GEOPHYSICS GPR INTERNATIONAL INC.

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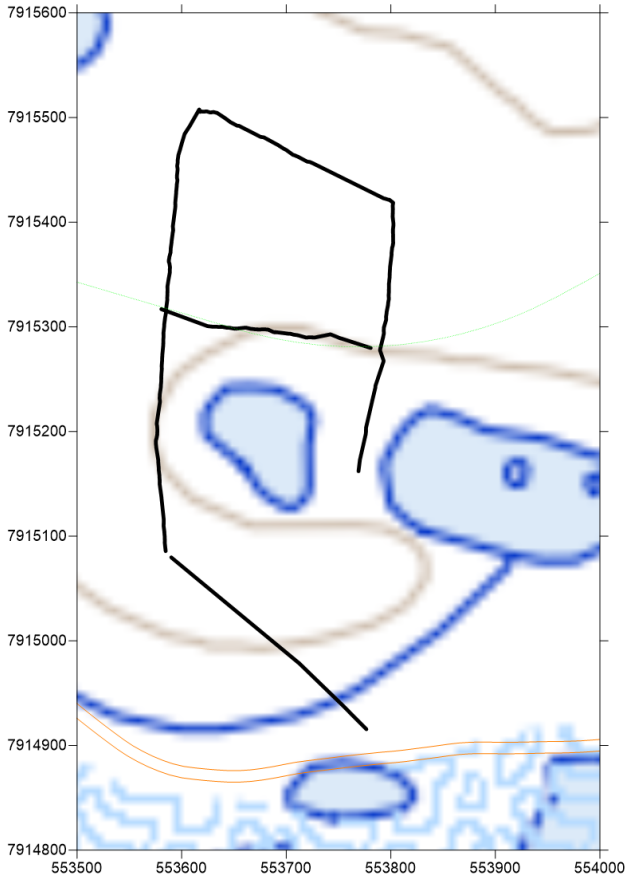
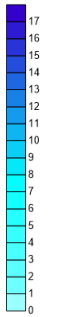
CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY
GPR17-KM97





ICE THICKNESS
(m)

LEGEND

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- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 — GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE

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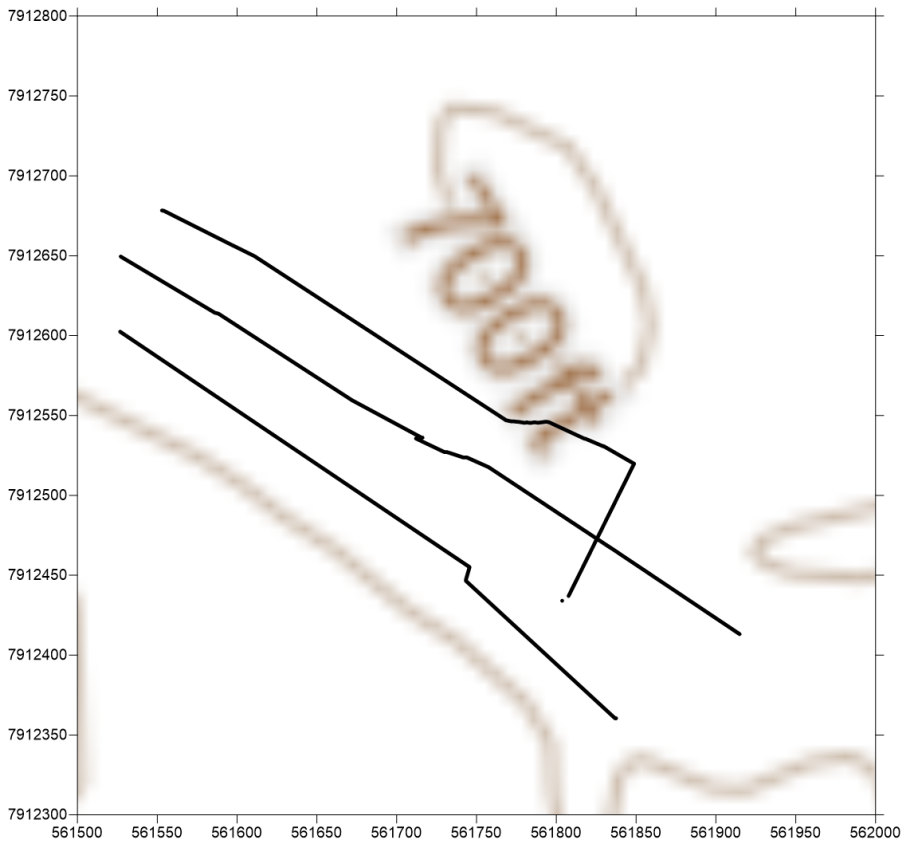
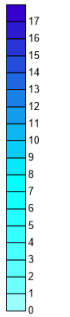
CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY
GPR17-KM100.1





ICE THICKNESS
(m)

LEGEND

- EXISTING ROAD ALIGNMENT
- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 — GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE

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ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17001b-A2

CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY
GPR17-KM109

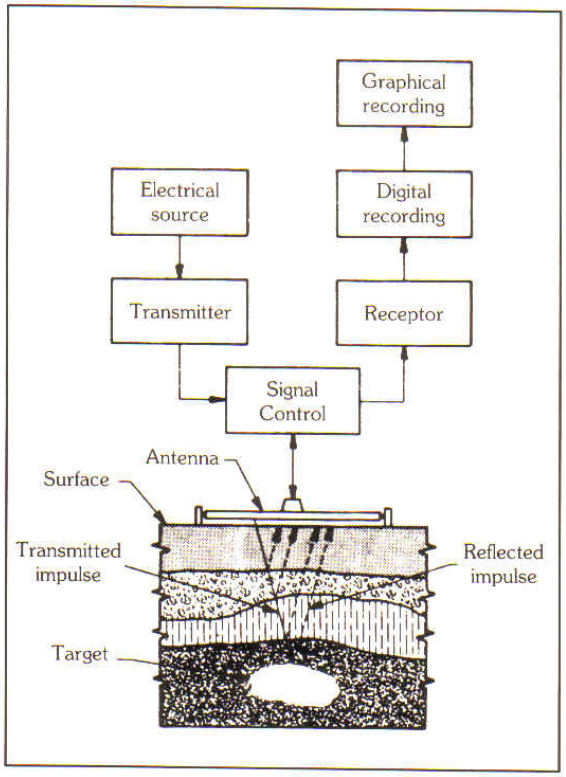
APPENDIX B

Additional Georadar information

GEOPHYSICS G P R INTERNATIONAL INC.

GEORADAR

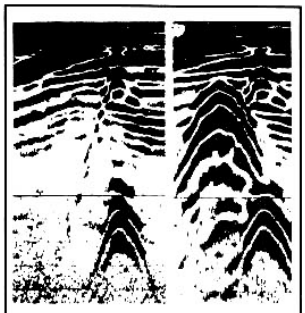
As indicated by its name, georadar combines high resolution radar with geology. The underlying principle is based on the propagation of electromagnetic wave impulses (VHF) that are reflected by anomalies in the terrain (joints, irregularities, interfaces, etc.) at different depths, and then captured by the antenna. The georadar records the time taken by each transmitted signal to complete the cycle in order to calculate the depth of the anomaly. The result is similar to a seismic reflection profile where all the reflections are displayed graphically. This technique is used to solve problems for which there had previously been no practical solution.



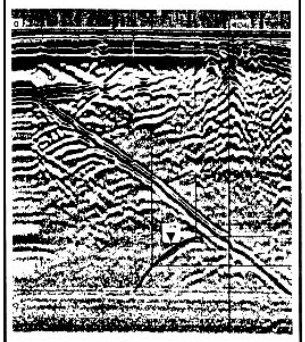
PRINCIPLES OF GEORADAR

FEATURES

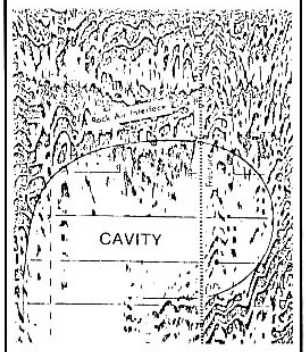
- Penetration of more than 20 metres in certain materials (penetration being inversely proportional to conductivity).
- Surveying in continuous mode.
- Identification of objects measuring only a few centimeters.
- Light and manoeuvrable equipment.
- Detection of conductivity, open spaces and/or holes (cavities).
- Detection of breaks: faults, fractures, joints, cavities.
- Results similar to seismic reflection: continuous underground profile.
- Results available immediately.
- Can be used in land, sea or airborne surveys.



PIPES



JOINTS



CAVITIES

FIELDS OF APPLICATION

Civil Engineering / Mining Exploration-Exploitation / Research / Archaeology / Environment

- Geotechnology: investigation of soils and surface deposits.
- Optimal selection of anchor bolts in mines and quarries.
- Detection of buried pipes before beginning excavation.
- Detection of liquid or gas leakage in soils.
- Detection of cracks in concrete structures.
- Checking material homogeneity.
- Detection of cavities beneath road pavement.
- Determination of water saturation level.
- Detection of girders in reinforced concrete.
- Detection of pollutant leakage in water bodies.
- Inspection of buried disposal sites and or dangerous deposits.
- Continuous measurement of ice thickness.
- Archaeological research: ancient foundations, artifacts.
- Non-destructive method for measuring road pavement thickness.
- Localization and measurement of soil's thickness (swamps, peat bogs).
- Determination of rock beddings (location and thickness).
- Bathymetric studies (depth sounding).
- Calculation of the thickness of permafrost and ice.
- Geotechnical studies for the installation of aqueducts.

SPECIAL FEATURES

The equipment is practical, easy to manoeuvre, and multi-faceted. The field of application of georadar continues to expand in various sectors, particularly in geotechnology (aqueducts), civil engineering (excavation, structures) and mining (structures).

GUIDELINEGEO

MALÅ GroundExplorer

GROUND PENETRATING RADAR

GPR with exceptional range and resolution

MALÅ GroundExplorer (GX) is an integrated GPR solution with four MALÅ GX antenna options: GX80, GX160, GX450 and GX750. Through unique hyperstacking HDR technology, MALÅ GX offers significantly faster data acquisition rates, with outstanding signal-to-noise ratio and depth penetration. An easy-to-use GPR solution on a rugged platform, with excellent detection capabilities for a wide range of applications.

MALÅ GX CONTROLLER

Processor	1.6 GHz Intel Atom
Display	1024 x 768 mm
OS	Linux
Memory	8 GB compact Flash memory
Data output resolution	32 bit
Comms	Ethernet, WiFi (optional), USB 3.0, RS232 (serial)
GPS	Integrated support for built-in GPS, or external GPS via USB/serial port (NMEA 0183 protocol)
Power supply	Internal 12V/20.8 Ah Li-Ion battery, or any external 10-15 V DC source
Charger	Internal. Unit can also be charged from any external 12 - 15 V DC source
Power consumption	1.3 – 2.0 A
Operating time	8 – 10 h
Dimensions	326 x 216 x 92 mm including handles 326 x 216 x 52 mm excluding handles
Weight	3.2 kg
Operating temp	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

GX WIFI OPTION

Wireless standard:	IEEE802.11 g
Power consumption:	0,3 A

MALÅ

MALÅ GX ANTENNAS

MALÅ GX750 HDR

Technology	MALÅ Semi-Real- Time pat pending
Antenna center freq.	750 MHz
SNR	97 dB
No. of bits	16 bit
Scans/second	> 1290, time window 75 ns
Survey speed	460 [km/h] point distance 10 cm
Bandwidth	120%, fractional, -10 dB
Time window	75 ns
Positioning	Built-in DGPS, external GPS (NMEA 0183 protocol), wheel encoder
Operating time	5 h
Power supply	Interchangeable 12 V Li-Ion batt. or ext. 12 V DC source
Power consumption	1.3 A
Acq. mode	Wheel, time or manual
Dimensions	375 x 235 x 170 mm
Weight	3.6 kg
Operating temp.	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

MALÅ GX450 HDR

Technology	MALÅ Semi-Real-Time pat pending
Antenna center freq.	450 MHz
SNR	101 dB
No. of bits	> 16 bit
Scans/second	> 770, time window 300 ns
Survey speed	275 [km/h] point distance 10 cm
Bandwidth	>120%, fractional, -10 dB
Time window	300 ns
Positioning	Inbuilt DGPS, external GPS (NMEA 0183 protocol), wheel encoder
Operating time	5 h
Power supply	Interchangeable 12 V Li-Ion batt. or ext. 12 V DC source
Power consumption	1.3 A
Acq. mode	Wheel, time or manual
Dimensions	430 x 360 x 180 mm
Weight	5.5 kg
Operating temp.	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

MALÅ GX160 HDR

Technology	MALÅ Semi-Real-Time pat pending
Antenna center freq.	160 MHz
SNR	> 107 dB
No. of bits	> 17 bit
Scans/second	> 880, time window 625 ns
Survey speed	320 [km/h] point distance 10 cm
Bandwidth	>120 %, fractional, -10 dB
Time window	625 ns
Positioning	Inbuilt DGPS, external GPS (NMEA 0183 protocol), wheel encoder
Operating time	5 h
Power supply	Interchangeable 12 V Li-Ion batt. or ext. 12 V DC source
Power consumption	1.3 A
Acq. mode	Wheel, time or manual
Dimensions	720 x 480 x 190 mm
Weight	10.7 kg
Operating temp.	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

MALÅ GX80 HDR

Technology	MALÅ Semi-Real-Time pat pending
Antenna center freq.	80 MHz
SNR	> 114.4 dB
No. of bits	> 19 bit
Scans/second	> 1200, time window 812 ns
Survey speed	430 [km/h] point distance 10 cm
Bandwidth	>120 %, fractional, -10 dB
Time window	812 ns
Positioning	Built-in DGPS, external GPS (NMEA 0183 protocol), wheel encoder
Operating time	5 h
Power supply	Interchangeable 12 V Li-Ion batt. or ext. 12 V DC source
Power consumption	1.3 A
Acq. mode	Wheel, time or manual
Dimensions	1010 x 780 x 220 mm
Weight	24,6 kg
Operating temp.	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

ABEM | MALÅ

Guideline Geo is a world-leader in geophysics and geo-technology offering sensors, software, services and support necessary to map and visualize the subsurface. Guideline Geo operates in four international market areas: Infrastructure – examination at start-up and maintenance of infrastructure, Environment – survey of environmental risks and geological hazards, Water – mapping and survey of water supplies and Minerals – efficient exploration. Our offices and regional partners serve clients in 121 countries. The Guideline Geo AB share (GGEO) is listed on NGM Equity.

GUIDELINEGEO

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sales@guidelinegeo.com
www.guidelinegeo.com

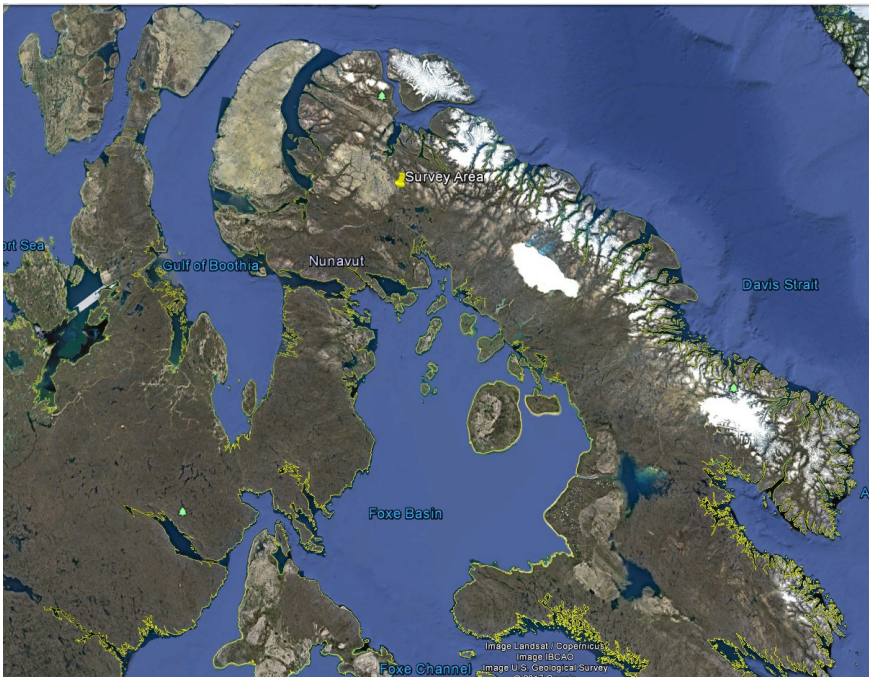
GEOPHYSICS GPR
INTERNATIONAL INC.

GEOPHYSICAL INVESTIGATION FOR BAFFINLAND RAILWAY, MARY RIVER PROJECT, NUNAVUT

PREPARED FOR:
Baffinland Iron Mines Corporation

Presented to:

4342 Queen Street, Suite 500
Niagara Falls, Ontario
L2E 7J7



May 2018

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info@geophysicsgpr.com
May 2018 **T-18552**

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APPENDIX B – Georadar Fact Sheet

1 INTRODUCTION

Geophysics GPR International Inc. was requested by Hatch Ltd. to carry out a geophysical survey to aid in projection and planning of a proposed railway for the Mary River Project, Baffin Island, Nunavut.

The purpose of this investigation was to determine the extent of, as well as the thickness of subsurface ice.

The ground penetrating radar (georadar) method was applied to determine the presence of ice and calculate its thickness.

Data was collected from April 16 to May 2, 2018.

The investigation included the following:

1. Georadar mapping of subsurface ice at seven sites across the 'deviation' of the proposed rail alignment.
2. Further exploration with gridded georadar lines were conducted in regions of ice to delineate the extent.

Figure 1 presents an overview map of the investigation area with the locations of the respective sites.

The following report describes the various aspects of the survey including field techniques, survey design, interpretation techniques, and finally an interpretation in the form of ice thickness maps.

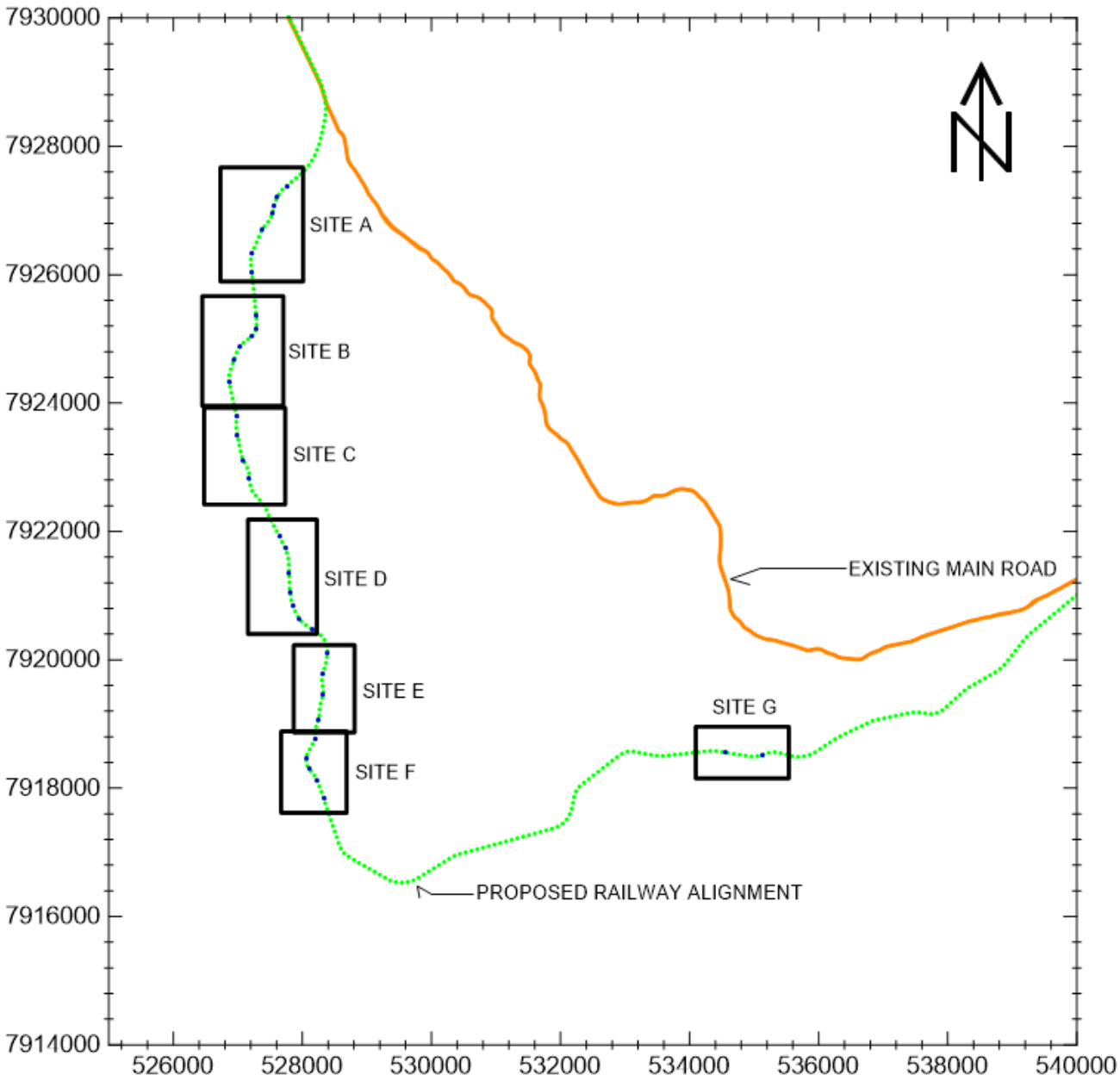


Figure 1: Overview map of the investigation area

2 METHODOLOGY

2.1 Positioning, Topography and Units of Measurement

The emplacement of the survey areas was determined by the client.

The locations of the georadar survey lines for the purpose of subsurface ice mapping were oriented to align with the design of the proposed railway. Length and number of the lines were chosen based on in-field interpretation of georadar data. Positioning was controlled by the GPS device integrated into the georadar antenna. The UTM coordinates should be accurate to within +/- 2.0 m.

Table 1: UTM coordinates of GPR survey lines

Point	Chainage	Northing	Easting
Site A			
a	58.9	7927382.002	527756.0006
b	59.1	7927213.037	527611.0001
c	59.2	7927079.046	527557
d	59.3	7926949.981	527539.0009
e	59.7	7926703.946	527376.0013
f	60.1	7926329.02	527225.0004
Site B			
a	60.4	7926033.002	527218.0006
b	61	7925358.001	527285.0006
c	61.2	7925154.024	527288.0003
d	61.4	7925033.038	527212.0001
e	61.6	7924885.943	527029.0013
f	61.9	7924671.045	526944
g	62.2	7924334.034	526861.0002
h	62.7	7923796.949	526977.0012
i	63	7923502.003	526993.0006
j	63.5	7923106.979	527087.0009

k	63.8	7922823.019	527178.0004
Site C			
a	64.7	7921919.978	527644.0009
b	64.9	7921741.995	527734.0007
Site D			
a	65.3	7921350.032	527795.0002
b	65.6	7921050.977	527812.0009
Site E			
A	65.8	7920854.939	527851.0014
B	66	7920630.979	527956.0009
c	66.3	7920475.027	528152.0003
Site F			
a	66.9	7920106.987	528386.0008
b	67.2	7919773.977	528306.0009
c	67.5	7919452.95	528323.0013
d	68	7919071.027	528247.0003
e	68.3	7918765.022	528193.0003
f	68.6	7918471.991	528056.0007
g	68.7	7918297.02	528103.0002
h	69	7918131.944	528231.0014
i	69.3	7917838.974	528329.001
Site G			
a	77.4	7918561.942	534544.0017
b	78	7918521.023	535132.0004

The provided coordinates are NAD83/WGS84, UTM zone 17N.

The depth measurements are noted as depth from surface.

All geophysical measurements were collected in SI units.

In addition to Table 1, further georadar survey lines were created to further explore the given areas. These additional survey lines were generated in a grid-like fashion with the topography dictating the spacing of the lines.

2.2 Ground Penetrating Radar (Georadar)

Basic Theory

Georadar utilises radar technology to obtain a near-continuous profile of the subsurface. The basic principle is to emit an electromagnetic impulse into the ground at a predetermined frequency rate (typically 10 to 80 scans/second). This pulse will travel through the sub-surface and reflect off boundaries of differing dielectric constants (contrasts of EM impedances). The reflected pulse returns to the surface and is recorded by a receiver and displayed in real-time as a cross-sectional image. Only by moving the antennas along a profile directly over the targets can the locations and depths be determined. Examples of radar reflecting boundaries include air/water (water table); water/earth (bathymetry); earth/metal, PVC, or concrete (pipe locating); and differing earth materials (stratigraphic profiles, including bedrock profiles).

The depth of investigation is controlled by the frequency and power of the antenna limited by attenuation and diffraction of the radar signal. Lower frequency antennas provide greater depth penetration at the expense of resolution. The radar signal is attenuated by conductive ground materials (e.g. clays, dissolved salts etc.). The radar signal is diffracted by irregular shaped material (e.g. boulders, debris etc.) that prevents the clear return of the reflected pulse.

More information on the georadar operating principle can be found in Appendix B.

Survey Design

The georadar data were collected with a MALA Ground Explorer system and 160 MHz antenna. This antenna provides a favourable trade off between depth and resolution for ice detection. As well, this antenna has sufficient durability for the terrain and weather conditions for Baffin Island.

Positioning for the georadar survey was controlled by built-in GPS receiver.

Interpretation Method

Processing of the radar images involved basic horizontal normalization, elevation corrections and gain adjustments.

The vertical scale on all radar images is a two-way time scale representing the time taken for a radar pulse to transmit to a reflector and back to the receiver. In order to convert the time scale to a depth scale a signal velocity must be applied. The velocity with which the pulse travels through the given material is determined by the dielectric constant. This dielectric will vary with the type of material.

Calculating a velocity can be done in many ways but the most reliable method is with a test pit or borehole where the real rock contact can be exposed. Based on in-situ measurements or borehole data, the dielectric value can be approximated depending on the expect material type.

An underestimate of the dielectric will result in an over estimate of the signal velocity and in turn an over estimate of the depths. For this site a dielectric of 4 (velocity of 15 cm/ns) was assumed based on the expected soil type and tables of relative dielectric values for commonly encountered materials. In this case the materials were mostly frozen granular/boulders with high ice content.

Interpretation of the data is based primarily on the qualitative analysis of three characteristics of radar reflections: continuity, amplitude and shape. The interpreter then identifies reflectors and textures within the radar records that represent subsurface contacts, objects or zones. The true nature of the interpreted features can only be assumed without corroborating evidence.

Ice bodies have a distinctive appearance on radar images. Granular host material appears as "noise" on the images, whereas uniform ice layer looks transparent with clearly defined top and bottom contacts and can be confidently identified. An example of a uniform ice lens is presented in Figure 2.

Non-uniform ice bodies (stratified or containing layers of soil) are more challenging for interpretation since structure irregularities create multiple reflections within the ice body. Often a borehole is needed to confirm the presence of ice. Other features such as increasing depth of investigation in the presence of thick ice layer may corroborate the interpretation.

In summary, ability of georadar is limited by the structure of the ice layer being surveyed and its composition. The identification of an ice layer may be impacted by irregularities inside the ice body, such as layering, fractures and soil inclusions. However, it is possible to create two categories of ice lenses, the obvious and less obvious that may need some ground truthing.

3 RESULTS

3.1 Subsurface Ice Mapping

Georadar data was collected at seven sites along the proposed railway deviation. Most sites collected were in the Western region (Sites A – F).

Locations of the survey lines and results of the georadar survey are presented in drawings GPR18_SITE_A, GPR18_SITE_B, GPR18_SITE_C, GPR18_SITE_D, GPR18_SITE_E, and GPR18_SITE_F.

GPR18_SITE_A

Thin ice lenses were possibly detected – neither the shape nor reflection of georadar data appeared well. This could possibly indicate an ice lens with poor homogeneity or structural breakages. Area was explored with subsequent radar profiles; data continued to be generally poor in this area. Estimation of ice depth from surface; 5-8m.

GPR18_SITE_B

The data indicates a considerable amount of ice in this area with varying thickness. The thickest region appeared to have a 12m thick chunk. Estimation of ice depth from surface; 4 to 9m. Topography constrained ability to delineate further.

GPR18_SITE_C

Region appears rich in ice – delineation was able to encapsulate lenses. Estimation of ice depth from surface; 7 to 9m.

GPR18_SITE_D

Region appears to have shallow and small ice lenses. Estimation of ice depth from surface; 4 to 5m.

GPR18_SITE_E

Single possible ice lens found and delineated. Topography limited the amount of delineation possible. Estimation of ice depth from surface; 4 to 5m.

GPR18_SITE_F

Possible ice lenses found in area – region had poor signal attenuation. Topography also limited the amount of delineation possible. Estimation of ice depth from surface; 6m.

No ice found in Eastern end of delineation, chainage 77.4 to 78km.

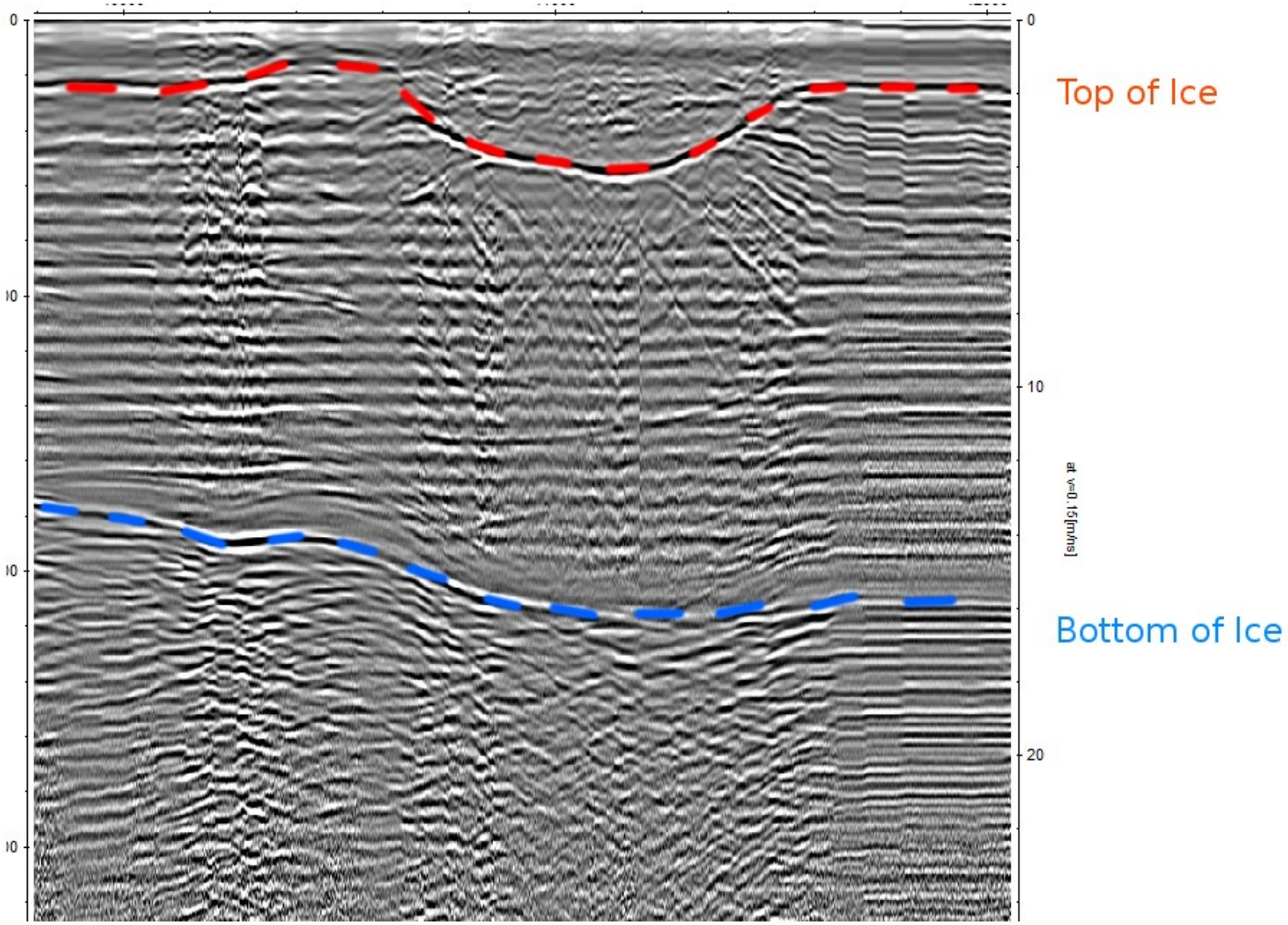


Figure 2: *Interpreted georadar image showing a typical ice body*

4 CONCLUSIONS

A geophysical investigation involving Georadar was carried out at the Mary River Project, Baffin Island, Nunavut.

Subsurface ice mapping was carried out at nine sites along the proposed rail alignment. Results of the survey are presented in Drawings GPR18_SITE_A, GPR18_SITE_B, GPR18_SITE_C, GPR18_SITE_D_GPR18_SITE_E, and GPR18_SITE_F.

Interpretation of the geophysical data has been performed by Mauritz van Zyl. This report has been written by Milan Situm, P.Geo.

_____
Milan Situm, P.Geo.
Manager

APPENDIX A

DRAWINGS

GPR18_SITE_A

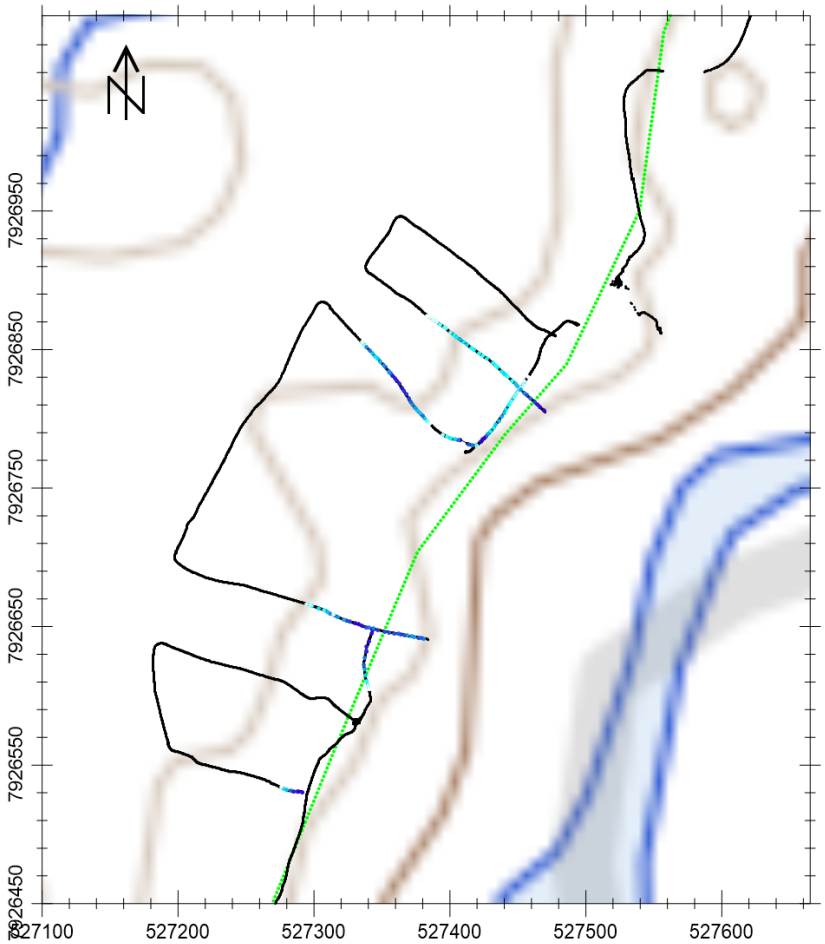
GPR18_SITE_B

GPR18_SITE_C

GPR18_SITE_D

GPR18_SITE_E

GPR18_SITE_F



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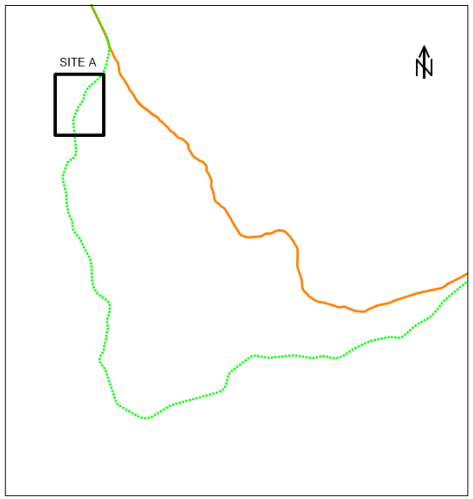
OVERVIEW MAP



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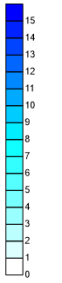


ICE THICKNESS (METRES)

EXISTING ROAD ALIGNMENT

PROPOSED RAILWAY ALIGNMENT

BH17-C002 GEOTECHNICAL BOREHOLE

GROUND RADAR SURVEY LINE

No	NOTES
1	THE RADAR SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. APRIL 2018
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W
3	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS
4	BOREHOLE DATA PROVIDED BY THE CLIENT FOR REFERENCE PURPOSES
5	
6	

No	DATE	MODIFICATIONS	GPR APP.

SCEAU PROFESSIONNEL
PROFESSIONAL SEAL

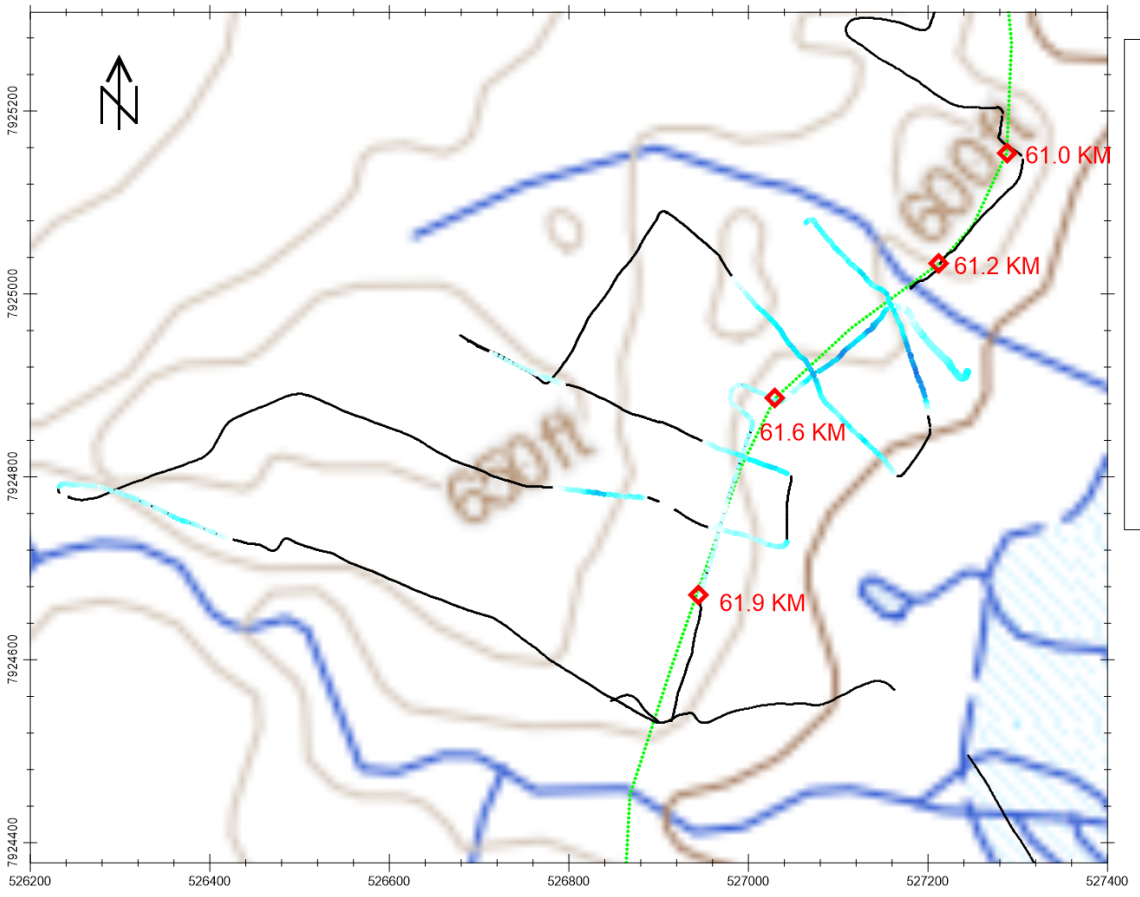
GEOPHYSICS GPR INTERNATIONAL INC.

DESSINÉ PAR / DRAWN BY	M. van Zyl
VERIFIÉ PAR / CHECKED BY	
APPROUVÉ PAR / APPROVED BY	M.Situm, P. Geo
# CONTRAT / CONTRACT #	T17001
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17001-A2-3

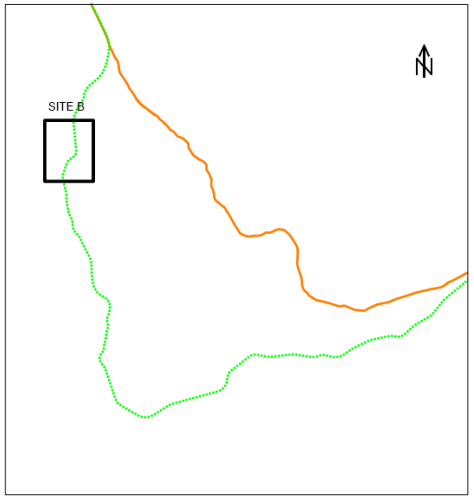
CLIENT / CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY
GPR18 - SITE A



OVERVIEW MAP



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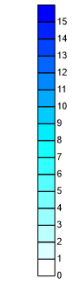
- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 — GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE



ICE THICKNESS (METRES)

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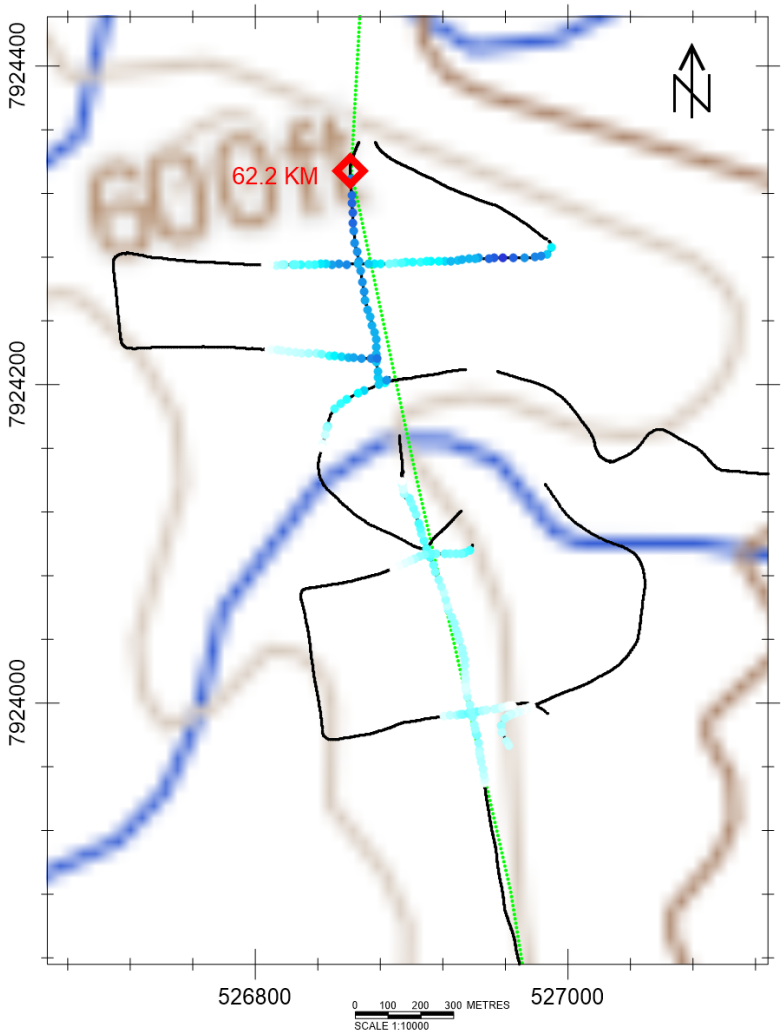
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17001-A2-3

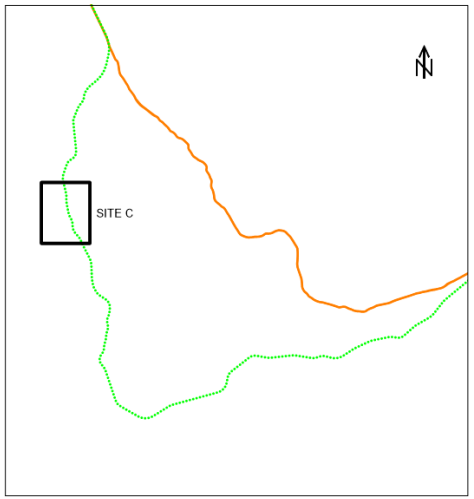
CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY
GPR18 - SITE B



OVERVIEW MAP



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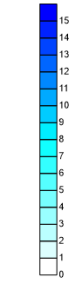

ICE THICKNESS (METRES)

EXISTING ROAD ALIGNMENT

PROPOSED RAILWAY ALIGNMENT

BH17-C002 GEOTECHNICAL BOREHOLE

GROUND RADAR SURVEY LINE

No	NOTES
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2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W
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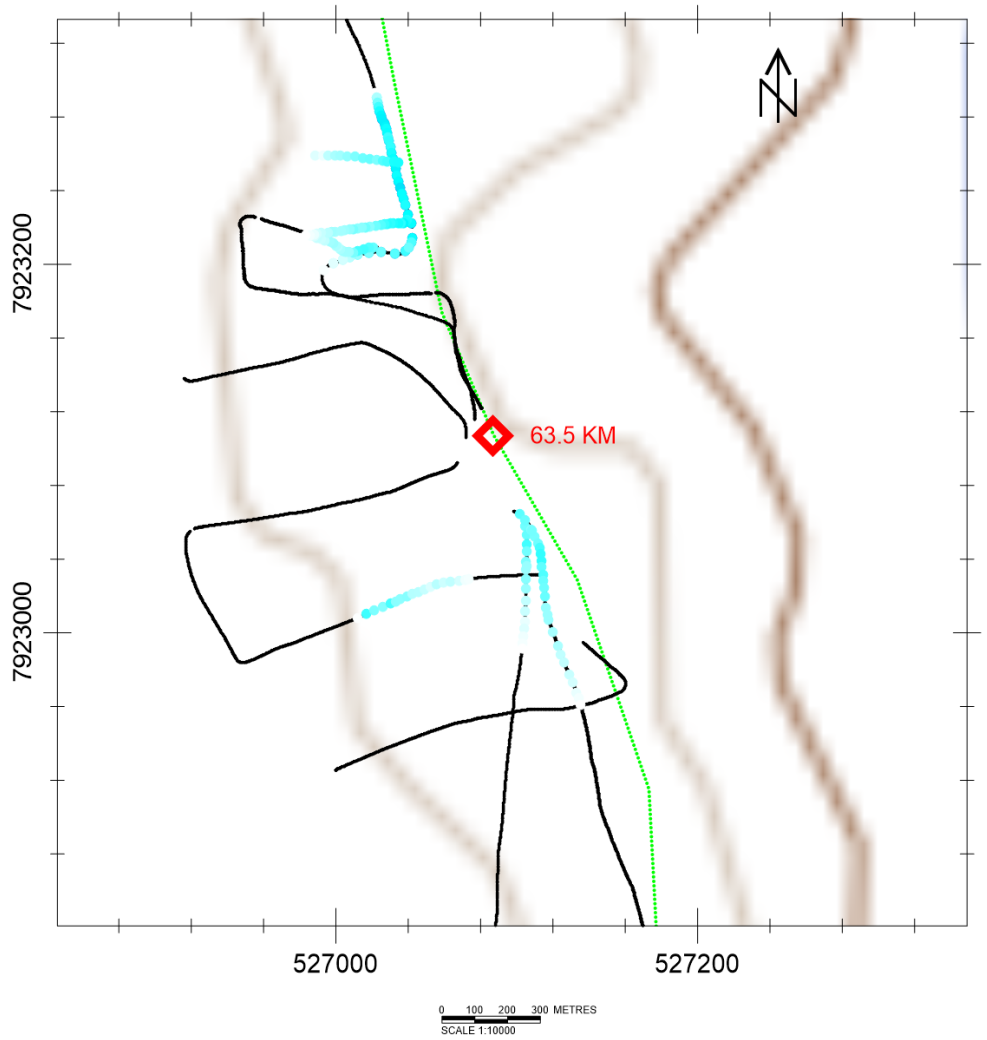
PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY
GPR18 - SITE C



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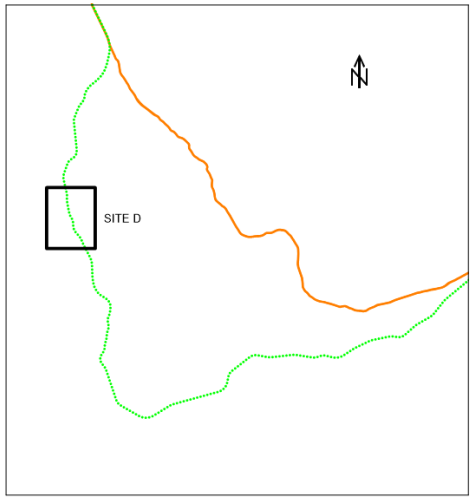

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ICE THICKNESS (METRES)

- EXISTING ROAD ALIGNMENT
- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE

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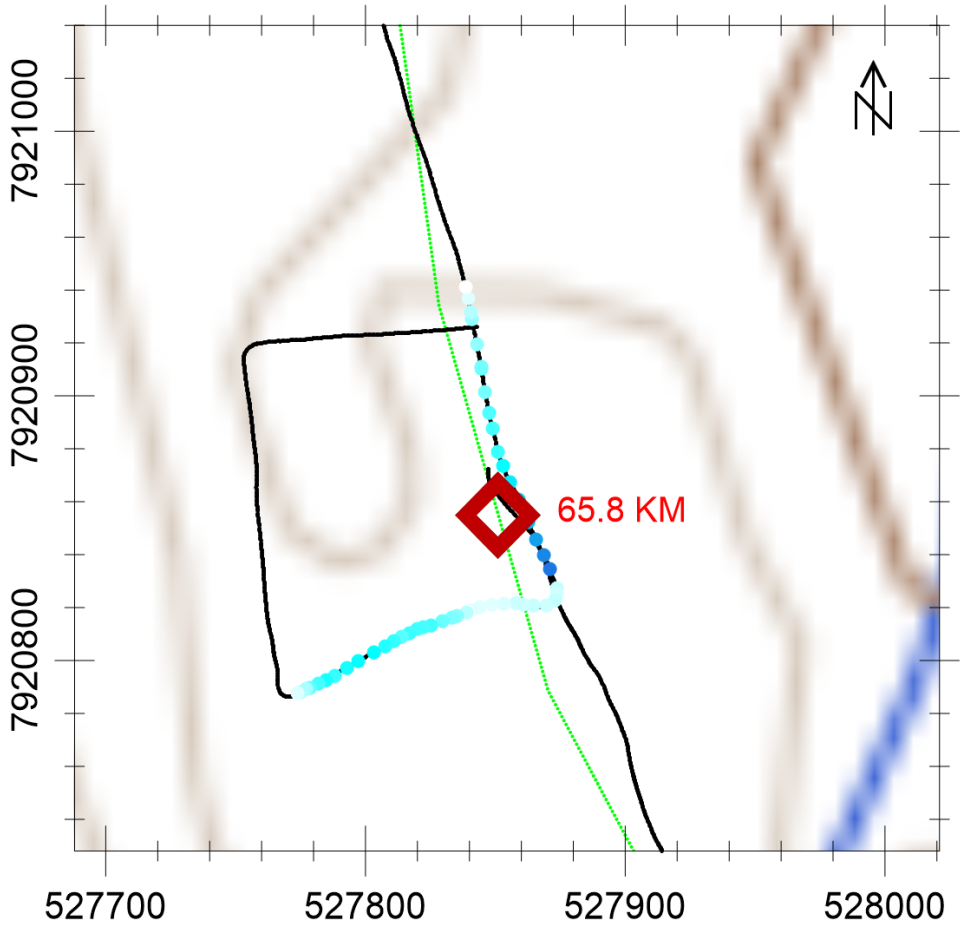
ÉCHELLE / SCALE: AS SHOWN
DESSIN / DRAWING: 17001-A2-3

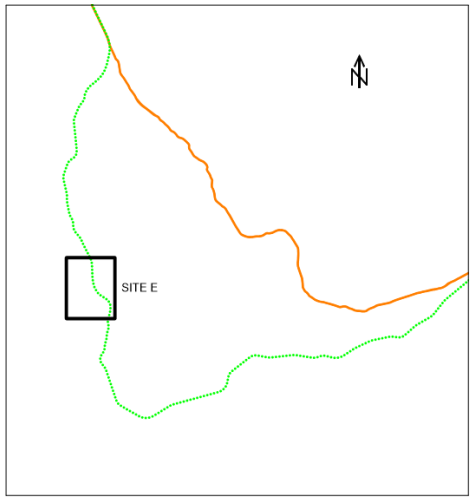
CLIENT / CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY
GPR18 - SITE D



OVERVIEW MAP



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ICE THICKNESS (METRES)

- EXISTING ROAD ALIGNMENT
- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 — GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE

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No	DATE	MODIFICATIONS	APP.

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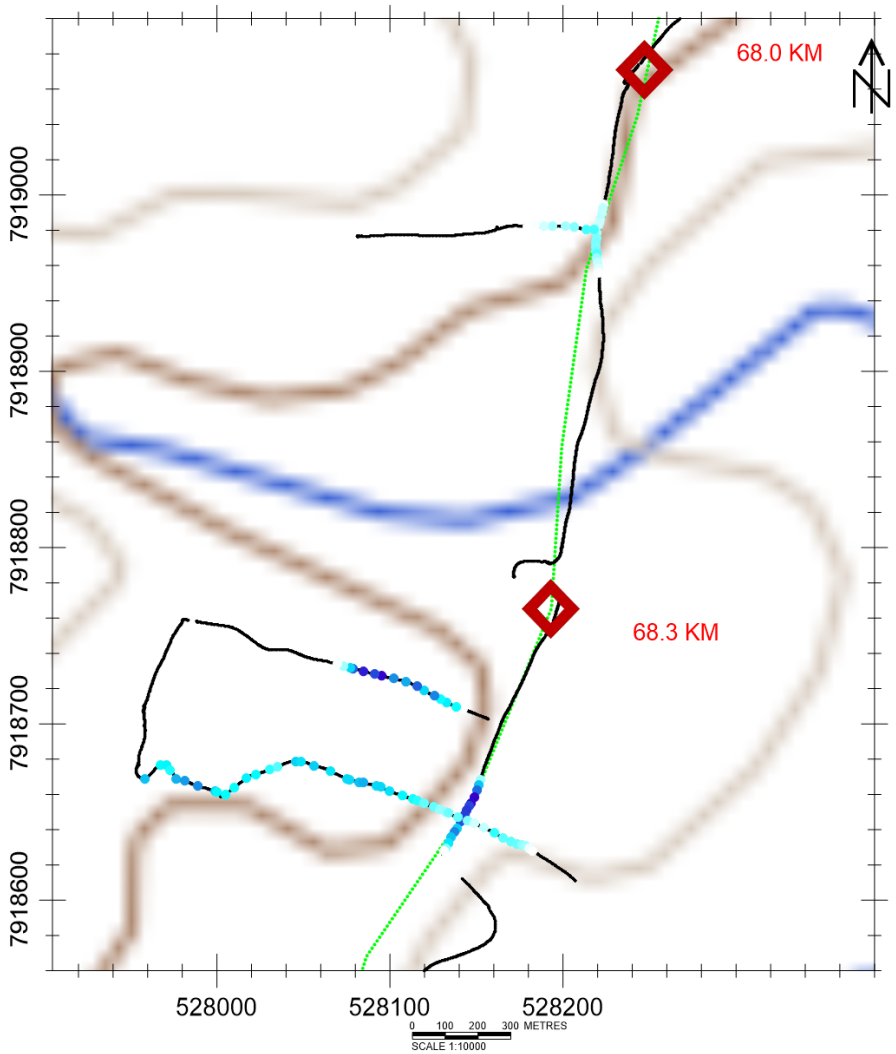
CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY
GPR18 - SITE E



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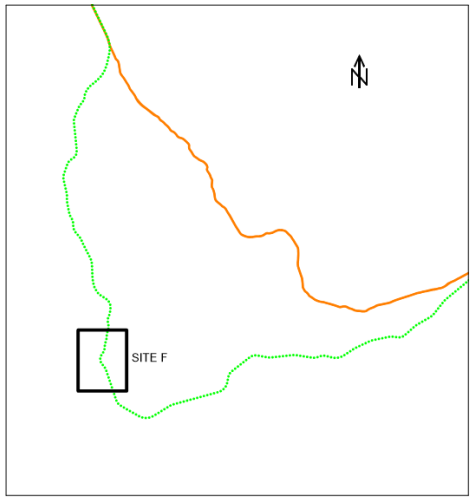

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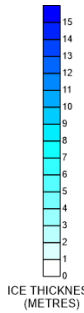

ICE THICKNESS (METRES)

EXISTING ROAD ALIGNMENT

PROPOSED RAILWAY ALIGNMENT

BH17-C002 GEOTECHNICAL BOREHOLE

GROUND RADAR SURVEY LINE

1	THE RADAR SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. APRIL 2018				
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W				
3	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS				
4	BOREHOLE DATA PROVIDED BY THE CLIENT FOR REFERENCE PURPOSES				
5					
6					
No	NOTES	No	DATE	MODIFICATIONS	GPR APP

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VERIFIÉ PAR / CHECKED BY:

APPROUVÉ PAR / APPROVED BY: S. Situm, P. Geo

CONTRAT / CONTRACT #: T17001

ÉCHELLE / SCALE: AS SHOWN

DESSIN / DRAWING #: [illegible]001-A2-3

CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY
GPR18 - SITE F

APPENDIX B

Additional Georadar information

GUIDELINEGEO

MALÅ GroundExplorer

GROUND PENETRATING RADAR

GPR with exceptional range and resolution

MALÅ GroundExplorer (GX) is an integrated GPR solution with four MALÅ GX antenna options: GX80, GX160, GX450 and GX750. Through unique hyperstacking HDR technology, MALÅ GX offers significantly faster data acquisition rates, with outstanding signal-to-noise ratio and depth penetration. An easy-to-use GPR solution on a rugged platform, with excellent detection capabilities for a wide range of applications.

MALÅ GX CONTROLLER

Processor	1.6 GHz Intel Atom
Display	1024 x 768 mm
OS	Linux
Memory	8 GB compact Flash memory
Data output resolution	32 bit
Comms	Ethernet, WiFi (optional), USB 3.0, RS232 (serial)
GPS	Integrated support for built-in GPS, or external GPS via USB/serial port (NMEA 0183 protocol)
Power supply	Internal 12V/20.8 Ah Li-Ion battery, or any external 10-15 V DC source
Charger	Internal. Unit can also be charged from any external 12 - 15 V DC source
Power consumption	1.3 – 2.0 A
Operating time	8 – 10 h
Dimensions	326 x 216 x 92 mm including handles 326 x 216 x 52 mm excluding handles
Weight	3.2 kg
Operating temp	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

GX WIFI OPTION

Wireless standard:	IEEE802.11 g
Power consumption:	0,3 A

MALÅ

MALÅ GX ANTENNAS

MALÅ GX750 HDR

Technology	MALÅ Semi-Real- Time pat pending
Antenna center freq.	750 MHz
SNR	97 dB
No. of bits	16 bit
Scans/second	> 1290, time window 75 ns
Survey speed	460 [km/h] point distance 10 cm
Bandwidth	120%, fractional, -10 dB
Time window	75 ns
Positioning	Built-in DGPS, external GPS (NMEA 0183 protocol), wheel encoder
Operating time	5 h
Power supply	Interchangeable 12 V Li-Ion batt. or ext. 12 V DC source
Power consumption	1.3 A
Acq. mode	Wheel, time or manual
Dimensions	375 x 235 x 170 mm
Weight	3.6 kg
Operating temp.	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

MALÅ GX450 HDR

Technology	MALÅ Semi-Real-Time pat pending
Antenna center freq.	450 MHz
SNR	101 dB
No. of bits	> 16 bit
Scans/second	> 770, time window 300 ns
Survey speed	275 [km/h] point distance 10 cm
Bandwidth	>120%, fractional, -10 dB
Time window	300 ns
Positioning	Inbuilt DGPS, external GPS (NMEA 0183 protocol), wheel encoder
Operating time	5 h
Power supply	Interchangeable 12 V Li-Ion batt. or ext. 12 V DC source
Power consumption	1.3 A
Acq. mode	Wheel, time or manual
Dimensions	430 x 360 x 180 mm
Weight	5.5 kg
Operating temp.	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

MALÅ GX160 HDR

Technology	MALÅ Semi-Real-Time pat pending
Antenna center freq.	160 MHz
SNR	> 107 dB
No. of bits	> 17 bit
Scans/second	> 880, time window 625 ns
Survey speed	320 [km/h] point distance 10 cm
Bandwidth	>120 %, fractional, -10 dB
Time window	625 ns
Positioning	Inbuilt DGPS, external GPS (NMEA 0183 protocol), wheel encoder
Operating time	5 h
Power supply	Interchangeable 12 V Li-Ion batt. or ext. 12 V DC source
Power consumption	1.3 A
Acq. mode	Wheel, time or manual
Dimensions	720 x 480 x 190 mm
Weight	10.7 kg
Operating temp.	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

MALÅ GX80 HDR

Technology	MALÅ Semi-Real-Time pat pending
Antenna center freq.	80 MHz
SNR	> 114.4 dB
No. of bits	> 19 bit
Scans/second	> 1200, time window 812 ns
Survey speed	430 [km/h] point distance 10 cm
Bandwidth	>120 %, fractional, -10 dB
Time window	812 ns
Positioning	Built-in DGPS, external GPS (NMEA 0183 protocol), wheel encoder
Operating time	5 h
Power supply	Interchangeable 12 V Li-Ion batt. or ext. 12 V DC source
Power consumption	1.3 A
Acq. mode	Wheel, time or manual
Dimensions	1010 x 780 x 220 mm
Weight	24,6 kg
Operating temp.	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

ABEM | MALÅ

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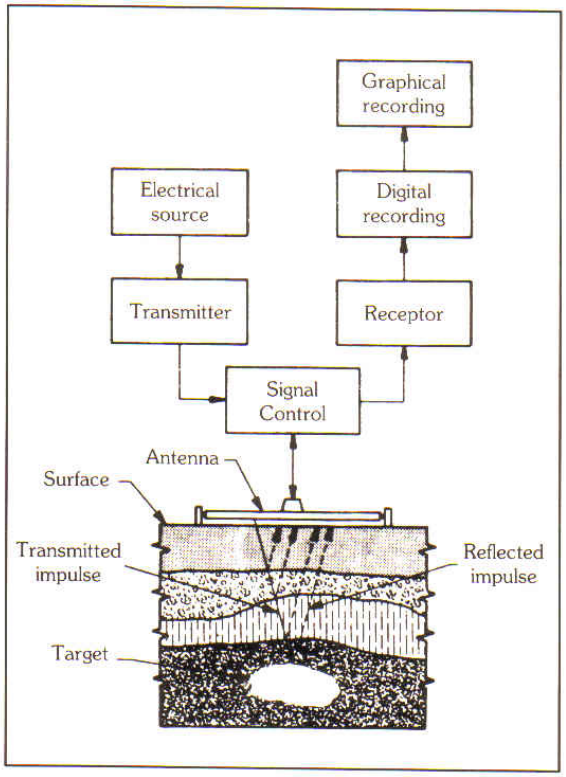
GEOPHYSICS G P R INTERNATIONAL INC.

GEORADAR

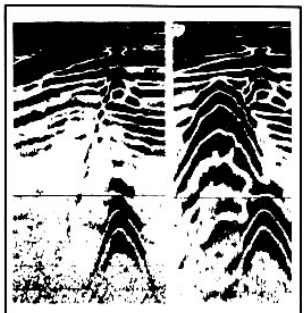
As indicated by its name, georadar combines high resolution radar with geology. The underlying principle is based on the propagation of electromagnetic wave impulses (VHF) that are reflected by anomalies in the terrain (joints, irregularities, interfaces, etc.) at different depths, and then captured by the antenna. The georadar records the time taken by each transmitted signal to complete the cycle in order to calculate the depth of the anomaly. The result is similar to a seismic reflection profile where all the reflections are displayed graphically. This technique is used to solve problems for which there had previously been no practical solution.



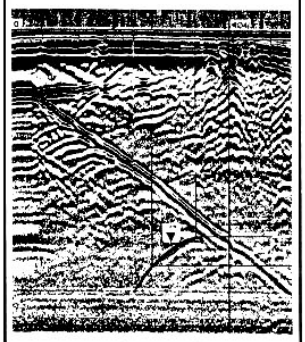
PRINCIPLES OF GEORADAR

FEATURES

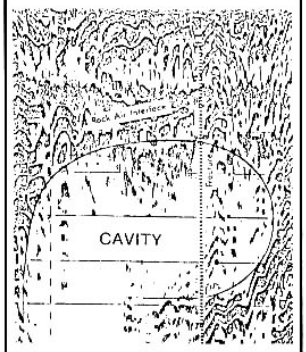
- Penetration of more than 20 metres in certain materials (penetration being inversely proportional to conductivity).
- Surveying in continuous mode.
- Identification of objects measuring only a few centimeters.
- Light and manoeuvrable equipment.
- Detection of conductivity, open spaces and/or holes (cavities).
- Detection of breaks: faults, fractures, joints, cavities.
- Results similar to seismic reflection: continuous underground profile.
- Results available immediately.
- Can be used in land, sea or airborne surveys.



PIPES



JOINTS



CAVITIES

FIELDS OF APPLICATION

Civil Engineering / Mining Exploration-Exploitation / Research / Archaeology / Environment

- Geotechnology: investigation of soils and surface deposits.
- Optimal selection of anchor bolts in mines and quarries.
- Detection of buried pipes before beginning excavation.
- Detection of liquid or gas leakage in soils.
- Detection of cracks in concrete structures.
- Checking material homogeneity.
- Detection of cavities beneath road pavement.
- Determination of water saturation level.
- Detection of girders in reinforced concrete.
- Detection of pollutant leakage in water bodies.
- Inspection of buried disposal sites and or dangerous deposits.
- Continuous measurement of ice thickness.
- Archaeological research: ancient foundations, artifacts.
- Non-destructive method for measuring road pavement thickness.
- Localization and measurement of soil's thickness (swamps, peat bogs).
- Determination of rock beddings (location and thickness).
- Bathymetric studies (depth sounding).
- Calculation of the thickness of permafrost and ice.
- Geotechnical studies for the installation of aqueducts.

SPECIAL FEATURES

The equipment is practical, easy to manoeuvre, and multi-faceted. The field of application of georadar continues to expand in various sectors, particularly in geotechnology (aqueducts), civil engineering (excavation, structures) and mining (structures).

ATTACHMENT 6.3

NORTH RAILWAY GEOTECHNICAL EMBANKMENT REPORT

Baffinland Iron Mines Corporation
Mary River Expansion Study - Stage II

Preliminary Geotechnical Recommendation for Railway Embankment (Between Milne Inlet and Mine Site)

△2

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Date	**Rev.**	**Status**	**Prepared By**	**Checked By**	**Approved By**	**Approved By**
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Appendix

Appendix A

2016 Site Investigation Plan Photos

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1. Introduction

Baffinland Iron Mines (BIM) currently operates the Mary River iron ore mine in Nunavut, Canada. BIM plans to increase the production rate of the mine from currently 4.2 million tonnes per annum (Mtpa) to 12Mtpa, shipping the output through Milne Port. This will be achieved by upgrading the mine fleet, constructing a 105 km long rail line from the mine site to the port, building a new crushing and screening facility at the port, construction of larger ore stockpiles and building a second ore dock and ship loader.

This report summarizes preliminary geotechnical recommendations for railway embankment design based on site reconnaissance and the existing geotechnical investigation data, as part of the Pre Feasibility Study of the Baffinland Expansion 12Mtpa Mine Option Project. The purpose is to support the estimation of earthworks quantities. The embankment structures developed in this report are preliminary based on experience.

It should be noted that thermal analysis and stability analysis will be required to optimize the preliminary design and to confirm their performance. Detailed geotechnical recommendations and construction considerations are not discussed in this report.

2. Scope of Work

The geotechnical work summarized in this report was developed to support the pre feasibility study for the railway embankment between Milne Inlet and the Mine Site. The total length is about 105 km. Appendix A contains drawings showing the proposed rail alignment and the anticipated terrain and soil conditions (surficial geology), compiled using the geologic maps listed in Section 3 of this report.

Figure 2-1 shows the approximate Chainage (Cha) along the Tote Road. In general, the proposed railway alignment follows the existing Tote road except for the main deviation between Cha 60+000 and 82+000 (see Figure 2-1). At the time this report was prepared, the alignment was being optimized and changes. Consequently, the Tote Road chainages are used herein for discussion purposes.

The alignment with chainage will be updated and finalized during the feasibility stage based on site specific geotechnical investigation data and additional design. .

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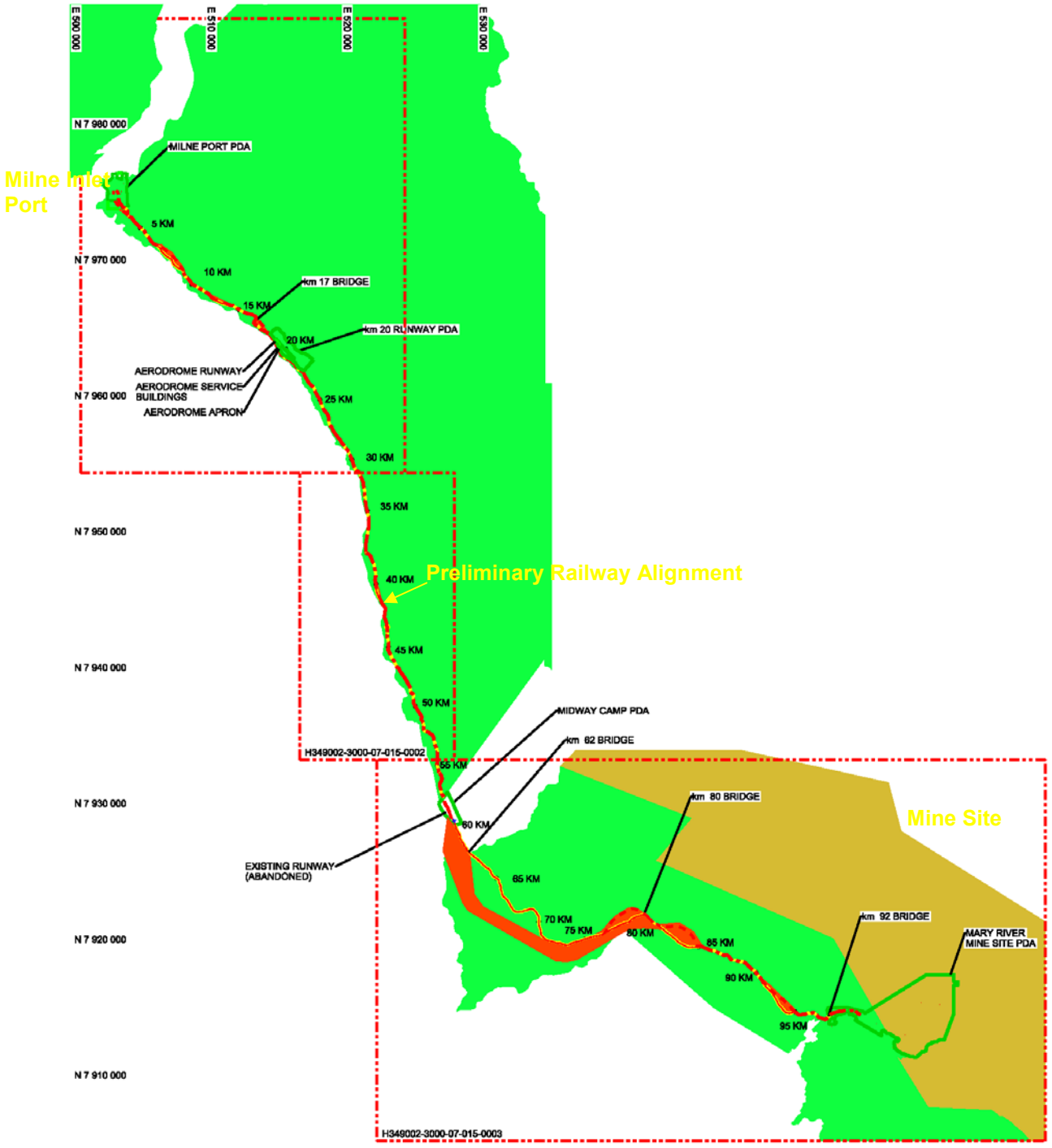

Figure 2-1: Chainage along Tote Road Alignment (Used for reference of the proposed rail line, the sketch was developed based on Hatch Drawing H349002-3000-07-015-0001)

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3. Reference Document

A site specific geological investigation has not been undertaken at this time for the proposed rail line between Milne Inlet and Mine site. The preliminary geotechnical recommendation for the railway embankment provided in this report are based on the following information and investigations:

- AMEC Earth & Environmental, 2010. Geotechnical, Geochemical and Quarry Sourcing Investigation (Draft). Project No. TC101510. Dec. 2010.
- Knight Piesold Consulting Ltd. (KP) report “Mine Site Infrastructure, Pit Overburden and Waste Dumps – 2006 Site Investigation Summary Report”, (Ref. No. NB102-00181/3-2), February 28, 2007.
- Knight Piesold Consulting Ltd. (KP) report “Mine Site Infrastructure, Pit Overburden and Waste Dumps – 2007 Site Investigations and Foundations Recommendations Summary Report”, (Ref. No. NB102-00181/8-2), December 14, 2007.
- Knight Piesold Consulting Ltd. (KP) boreholes (PMT-001, PMBC-002, PMPL-002, PMTF-001, PMSD-001 and BS-001) advanced at Milne Inlet in May 2007.
- EBA Engineering Consultants Ltd. (EBA) memo “Foundation Recommendations, Mary River Mine Site Infrastructure”, (File: E14101009.003), September 9, 2010.
- Hatch Ltd. H337697-0000-15-124-0004.Geotechnical Data Report –Infrastructure. April 5, 2012.
- Hatch Ltd. H349000-1000-15-122-0001. Geotechnical Design Criteria. Aug 08, 2013.
- Little, E.C., Holme, P.J., and Kerr, D.E., 2013. Surficial Geology Icebound Lakes (Southwest) Baffin Island, Nunavut, Geological Survey of Canada Map 74 (preliminary), scale 1:100,000.
- Dyke, A.S. 2000, Surficial Geology Phillips Creek, Baffin Island, Nunavut, Geological Survey of Canada, Map 1961A, scale 1:250,000.
- Jackson, G.D., Morgan, W.C. and Davidson, A., 1975. Geology Icebound Lake District of Franklin, Geological Survey of Canada Map 1451A, scale 1:250,000
- Blackadar, R.G. and Davison, W.L., 1968, Geology Phillips Creek District of Franklin, Baffin Island, Geological Survey of Canada Map 1239A, scale 1:253,440.

4. Regional Geology

The proposed railway alignment in preliminary design stage generally follows the existing Tote road. Regional geologic mapping is available for the entire route of Tote Road (i.e. Scott and de Kemp, 1998), which can be used for railway preliminary design. Summarizing:

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- The first 10± km of the Tote Road from Milne Inlet passes through either Precambrian terrain or glacial fluvial sand and gravel terraces. The Precambrian terrain is situated between 100 to 500 m west of the road (approximate), which mainly traverses the sand and gravel terraces.
- The middle 73 km of the road travels across relatively flat lying Paleozoic rocks (Limestone and Dolomitic Limestone Units). The Limestone and Dolostone units have been eroded by glaciations forming Mesa landforms, which locally rise 50 to 100m above the Tote Road level. The Limestone units are locally exposed at the Mesa ridges and elsewhere are typically overlain by glacial till or moraine. The till is generally fine grained comprising predominantly silt and sand whereas the moraine is sandy with embedded relic glacial ice; The thickness varies from a few meters to over 10 m.
- The final 14 km of the road to the Mary River mine site traverses a series of glacial lacustrine (sand and silty sand) and glacial fluvial plains, terraces and eskers, which are situated along the boundary between the Precambrian terrain to the north and Limestone units to the south.

The detailed regional geology was described in AMEC 2010 geotechnical Investigation Report (AMEC TC101510, 2010).

5. Site Geotechnical Summary

Based on the existing geotechnical investigation data along the Tote Road, alternating deposits of cohesionless soils consisting of sand, sand and gravel, gravel, cobbles and boulders were generally encountered. Bedrock was encountered at three of the bridge locations at depths varying between about 6 m and 14 m below existing ground surface. Typically gneiss bedrock was encountered near Milne Inlet and gneiss, schist and carbonate bedrock were encountered near Mary River Site.

Layers of cobbles and boulders were encountered at Milne Inlet and along the Tote Road. Based on the limited geotechnical investigations, cobbles and boulders were noted to be present within the majority of the cohesionless deposits at various depths with variable thickness.

The entire Tote Road site is underlain by permafrost and the estimated annual depth of thaw ranges from 2 m to 5 m and varies significantly.

6. Railway Embankment Recommendation

6.1 Ground Ice Definition

Ground ice refers to all kinds of ice formed in permafrost. The Unified Soil Classification System designates the ground frozen soil as “ice”, where the ground ice thickness is greater than 25 mm (1 inch).

“Massive ground ice”, however, is a comprehensive term, which refers to large masses of ground ice, including ice wedges, buried ice, and predominantly horizontal beds of segregated ice (Glossary of permafrost 1988). In the literature (Roujanski et. al. 2010), ice beds with a thickness

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in excess of 0.3 m are referred to as “massive ice” or “ground ice”. Whereas, layers of ice less than 0.3 m in thickness are termed “ice lenses”.

It should be noted that comments cannot be made regarding the presence of ground ice for areas where boreholes do not exist along the Tote road or the proposed railway. Generally, however, the following assumptions have been made to support the development of a pre-feasibility level rail route and preliminary embankment designs.

- All embankments should be constructed using compacted rock fill overlain by crusher run granular sub-ballast and ballast layers
- Based on the performance of the Tote Road, it has been decided that embankments will not be designed to maintain the ground in a frozen state. Thaw-freeze ground movements, if any, will be accommodated by maintenance and re-ballasting.
- To the extent possible, the rail alignment should avoid cuts in soil permafrost. However, if such cuts are required, then the subgrade should be insulated to avoid extending the thaw depth significantly below the historic maximum thaw depth (i.e. do not thaw previously unthawed permafrost). The insulation requirements for this purpose have been estimated for the current study phase.
- Based on site reconnaissance, there are numerous bedrock outcrops in the Precambrian terrain. Although frozen, the Precambrian rock is not expected to be susceptible to large thaw-induced settlement. As such, cuts are permissible in Precambrian terrain in order to produce rock fill for construction and to found the embankments on bedrock.
- In the Paleozoic terrain (i.e. Cha 10+000 to 83+000), there are several limestone beds, which are either exposed or covered by a thin veneer of till. Thick massive limestone beds are visible as large mesa structures; whereas, the thinner beds are present as more subtle ridges or ledges in the terrain (i.e. where the nose of these beds are exposed or within a meter of the ground surface). Because the limestone beds are relatively flat (i.e. sub-horizontal), there is an opportunity to route the railway along the smaller mesa structures or ledges to de-risk the railway. Where this can be done, it is considered feasible to make cuts into the ledges to found the embankments on limestone bedrock and produce rock fill for embankment construction.

6.2 Thaw Period

The thaw period corresponds to the period in which the foundation is not frozen. In this design, it is assumed that the railway foundation (generally along tote road) is frozen for eight months of the year. Therefore, the thaw period is assumed to be four months during each year.

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Table 6–1: Preliminary Railway Embankment Recommendation

Embankment Section	Ground Frost/Thaw Susceptibility	Ground Ice Content	Classification	Thaw Settlement Estimate (mm)	Typical Section
Section I	Granitic Rock; Non Susceptible	None expected	Bedrock	Insignificant	Figure 6-1
Section II	Limestone Rock; Non Susceptible	None expected	Bedrock	Insignificant	Figure 6-2
Section III (700 mm)	Non Susceptible	Non to low	Segregated ice is not visible by eye[1]	<20	Figure 6-3
	Potentially Susceptible	Low to Mediate	Segregated ice is visible by eye, less than 25mm (1") in thickness[1]	20-100	
	Moderately Susceptible	Mediate to High	Ice greater than 25mm (1") thickness[1]	100-300	
Section III (1500 mm)	Highly Susceptible	Very High	Ice greater than 0.3m [2]	>300	Figure 6-3

Notes:[1]- Classification is based on Unified Soil Classification System of Frozen Soils; [2]- Based on Roujanski et. al. (2010).

6.3 Typical Railway Embankment Section

The geometry and configuration of the preliminary railway embankment depends on the condition of the foundation soil or rock considering ground frost and thaw susceptibility along the railway routine. The recommended types of embankment sections are summarized in Table 6–1 and discussed below.

6.3.1 Railway Embankment-Section I – Cuts in Precambrian Rock

Figure 6-1 shows the typical Cross Section I of the railway embankment. Embankment Section I can be utilized where the railway is re-routed through the Precambrian terrain in order to found the embankments on rock. This is expected to be feasible between approximately Cha 0+000 and 10+000, 82+000 and 85+000 and 95+000 and 105+000. Section I consists of:

- A layer of sub-ballast material (i.e. crusher run granular material) to level the blasted bedrock. The thickness is expected to vary because the blasting is expected to produce an irregular surface. The minimum leveling layer thickness is 150mm.
- A ballast layer (Type 25) placed on top of the Type 26 leveling material. The detail design of ballast and sub-ballast layer should follow the standard railway drawing.
- The bedrock is expected to be massive; and as, such slopes of 8V:1H should be feasible with benches at 5m vertical intervals.
- There should be a 2000 mm off-set between the edge of the railway embankment and the toe of the rock slope to collect debris. Ideally, this zone should be sloped toward culverts to allow cross-drainage.

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- Embankment Section 1 is recommended for the railway on bedrock in the Precambrian terrains.

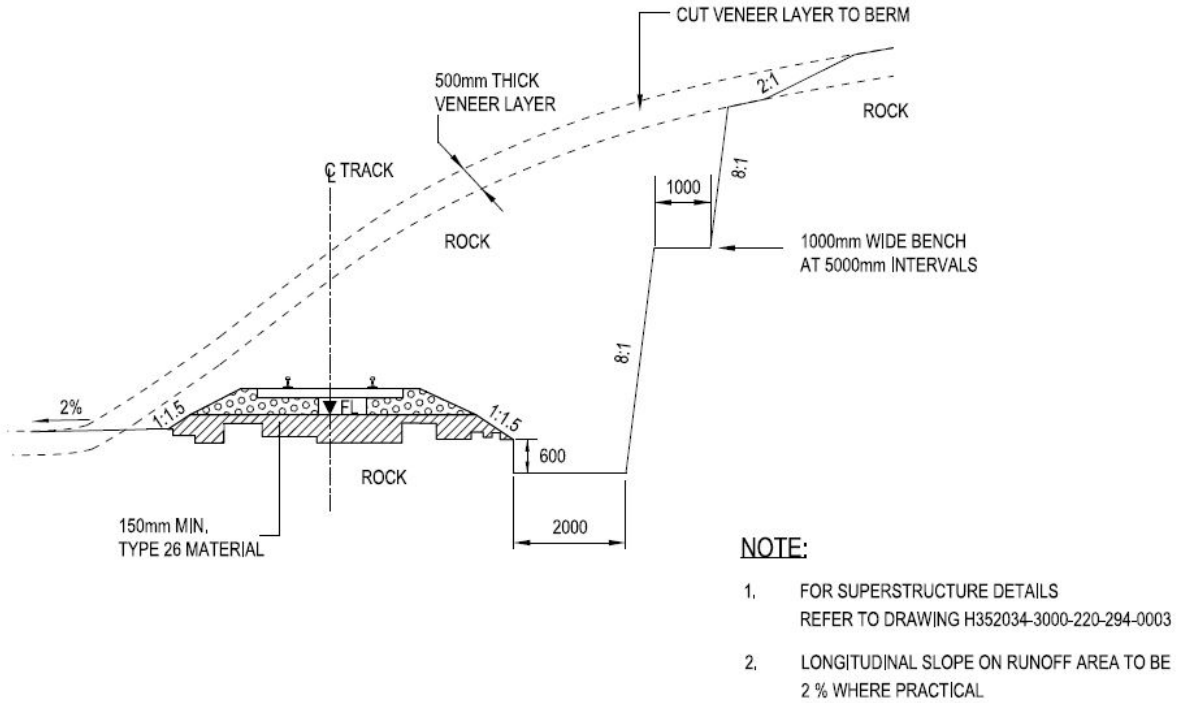

Figure 6-1: Typical Cross Section of Railway Embankment – Section I

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6.3.2 *Railway Embankment-Section II – Cuts in Limestone*

Section II is proposed for the railway deviation between Cha 60+000 and 75+000 where the alignment can be situated to follow shallow or outcropping limestone beds, which show as small mesas or ledges in the terrain.

As shown in Figure 6-2, this type of embankment section consists of:

- A layer of sub-ballast material (i.e. crusher run granular material) to level the blasted bedrock. The thickness is expected to vary because blasting is expected to produce an irregular surface. The minimum leveling layer thickness is 150mm.
- Ballast material (Type 25) placed on top of the Type 26 leveling material. The detail design of ballast and sub-ballast layer should follow the standard railway drawing.
- The bedrock is expected to be bedded and the depth of cut should be predominantly less than 5m. In most areas, the rock should remain stable if cut at 8H:1V.
- There should be a 2000 mm off-set between the edge of the railway embankment and the toe of the rock slope to collect debris. Ideally, this zone should be sloped toward culverts to allow cross-drainage.
- The soil veneer is expected to be less than a meter thick; but locally it could be thicker. The soil will need to be stripped and stored in quarries or used to construct diversion berms to route run-off toward creek and stream beds.

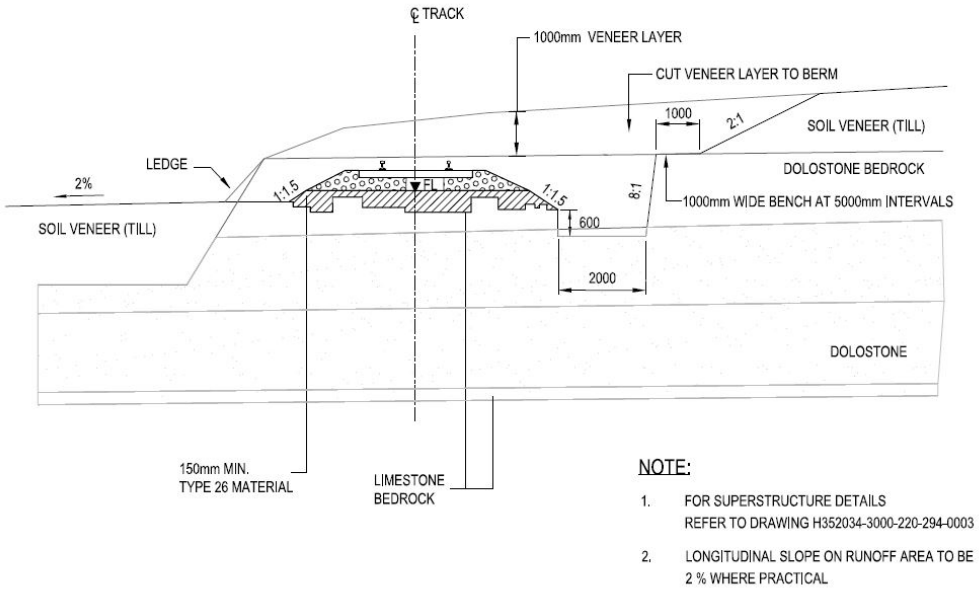

Figure 6-2: Typical Cross Section of Railway Embankment – Section II

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6.3.3 *Railway Embankment Section III – Embankments on Permafrost Soil*

Section III is proposed for the railway on undisturbed (uncut) permafrost soil. As shown in Figure 6-3, this type of embankment consists of:

- A layer of compacted run-of-quarry rockfill (Type 12) founded directly on the undisturbed permafrost. A non-woven geotextile should be placed over the permafrost soil where the railway traverses ice-rich and fine-grained soils.
- A minimum 150mm thick sub-ballast layer (Type 26) on the Type 12 fill. The Type 26 material should be used to choke the rock fill embankment prior to placing the sub-ballast layer. Choking refers to using bulldozers, tired trucks and vibratory rollers to force the finer Type 26 material into the open pore space of the Type 12 rock fill until a stable base is achieved.
- The combined minimum thickness of the Type 12 and Type 26 materials should be 700mm for embankments on non-, potentially- and moderately - thaw susceptible permafrost. It should be increased to 1500mm on ice-rich soils or highly thaw-susceptible soils. Due to the sloping and undulating terrain, it is expected that the minimum thickness will occur only rarely at high-points in the sub-grade along the rail alignment. These high points should be assessed during detailed design.
- A ballast layer (Type 25) placed on top of the Type 26 leveling material. The detail design of ballast should follow the standard railway drawing.
- Type 12 fill is expected to comprise either run-of-quarry granitic blast rock or limestone blast rock. A side slope gradient of 1.5H:1V is considered suitable for estimating the fill quantities.
- The Type 25 and Type 26 materials should be placed with a 2H:1V side-slope gradient.
- A ditch or diversion berm can be used to manage run-off. The attached figure shows a ditch.

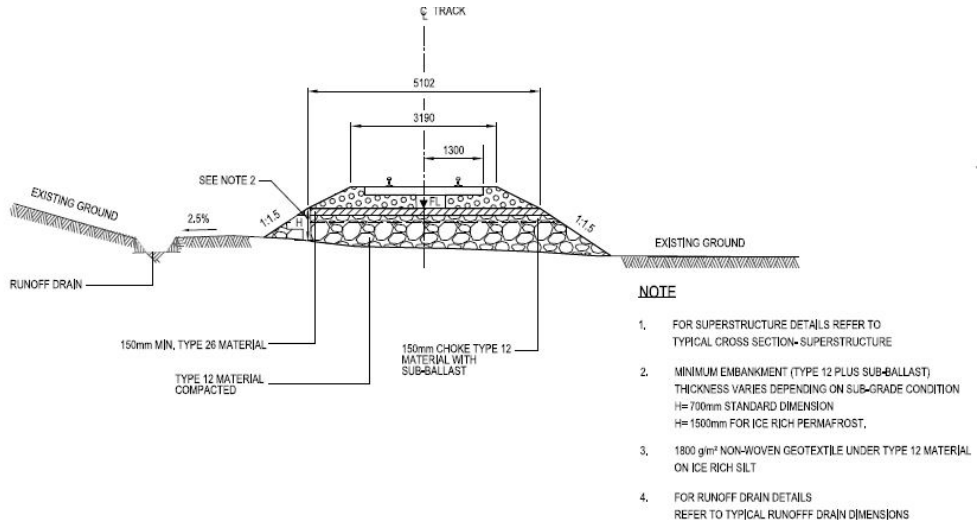

Figure 6-3: Typical Cross Section Railway Embankment on Soil – Section III

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6.3.4 *Embankment Section IV – Cuts in Permafrost Soil*

Lastly, Section IV is proposed for cuts in permafrost soil. Such cuts should be avoided to the extent possible; However, based on the behaviour of cuts made for the Tote Road, occasional cuts in permafrost soil can be managed using the cross-section illustrated in Figure 6-4. Boreholes should be advanced at cut locations to determine if ground ice is present and thermal modelling should be used for design and to assess the risk.

This type of embankment consists of:

- A 1500mm layer of compacted run-of-quarry rock fill (Type 12) underlain by a zone of insulation materials. For estimating quantities, the insulation can be assumed to comprise either an additional 1500mm thick layer of Type 12 fill underlain by non-geotextile (1000 g/m^2) or 100mm thick rigid expanded polystyrene insulation board covered by non-woven geotextile (1000 g/m^2).
- A minimum 150mm thick sub-ballast layer (Type 26) on the Type 12 fill. The Type 26 material should be used to choke the rock fill embankment prior to placing the sub-ballast layer. Choking refers to using bulldozers, tired trucks and vibratory rollers to force the finer Type 26 material into the open pore space of the Type 12 rock fill until a stable base is achieved.
- A ballast layer (Type 25) placed on top of the Type 26 leveling material. The detail design of ballast should follow the standard railway drawing.
- Type 12 fill is expected to comprise either run-of-quarry granitic blast rock or limestone blast rock. A side slope gradient of 1.5H:1V is considered suitable for estimating the fill quantities.
- The Type 25 and Type 26 materials should be placed with a 2H:1V side-slope gradient.
- The cut side-slopes should be covered with a 500mm thick layer of Type 12 material to retain the soil as it thaws.

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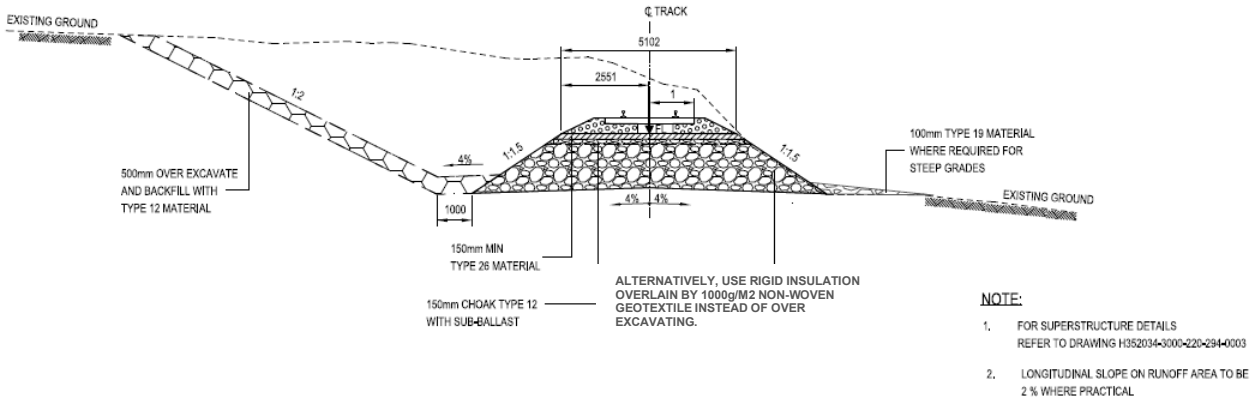

Figure 6-4: Typical Cross Section Railway Embankment in Soil Cut – Section IV

6.3.5 Use of Insulation Block

The thickness of railway embankment can be reduced with the installation of rigid type high strength polystyrene blocks or panels. The insulation would be most effective if placed as close to the surface of the embankment (i.e. under the sub-ballast) as possible, but the depth of cover above the insulation has to be thick enough to prevent crushing of the insulation. Thermal analysis has to be carried out to determine the optimum location and layout of the insulation within the embankment and the thickness of insulation to be adopted. Stability analysis will then be performed to ensure that the stability of the embankment will not be affected by the installation of insulation. If insulation is designed and installed at the right place, the thickness as well as thaw settlement of the embankment could be reduced.

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7. Embankment Design along Railway Alignment

7.1 Subgrade Properties

As part of the Tote Road upgrade project in 2007/2008, Knight Piesold identified four categories of thaw susceptibility to delineate the subgrade conditions along the Tote Road. It is assumed that the subgrade conditions for the proposed railway will be similar to that of the Tote Road, except where the alignment is moved away from the Tote road to situate the railway on rock or meet railway grade requirements. The subgrade properties along the railway should be updated based on the site specific geotechnical investigation program.

The following foundation categories were described by Knight Piesold (ref. Road Upgrade Design Summary NB-102-0018/10-1) and are used herein:

7.1.1 Type 1 - Non Susceptible

This foundation condition is expected to require minimal road or rail embankment. Approximately 27.5 km of the road alignment was identified with this foundation condition.

7.1.2 Type 2 - Potentially Susceptible

Based on the existing geotechnical data, approximately 37.5 km of the road alignment was identified with this foundation condition.

7.1.3 Type 3 - Moderately Susceptible

Based on the existing geotechnical data, approximately 12.5 km of the road alignment was identified with this foundation condition.

7.1.4 Type 4: Highly Susceptible

Based on the existing geotechnical data, approximately 27.5 km of the road alignment was identified with this foundation condition.

For design purposes, Embankment Section III (700 mm) can be used on the Type 1, 2 and 3 subgrades. It is assumed that thaw-induced settlements will be small and can managed by re-ballasting the rail to accommodate the settlement.

Embankment Section III (1500 mm) can be used on Type 4 soils. The objective is to provide sufficient fill thickness to insulate the ground and avoid thawing to depths greater than that historically experienced by the soil.

7.2 Recommendations

Table 7–1 summarizes the recommended embankment types to be applied along the railway alignment during the pre-feasibility study. As noted above the Tote Road chainage has been used for reference purposes The recommended embankments are listed in the right-hand side column of Table 7–1. This column also includes recommendations to re-align the railway in order to found the embankments on bedrock.

The following summarizes the likely length of each embankment type if the railway were to follow the Tote road alignment:

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- 75± km of railway will be constructed on non thaw-susceptible and potentially and moderately thaw-susceptible ground; Embankment Section III can be used. The minimum thickness of the combined Zone 12 and 26 materials should be 700 mm.
- 30± km railway will be founded on highly thaw-susceptible ground. Embankment Section III can be used; The minimum combined thickness of the Zone 12 and 26 materials should be increased to 1500mm.

Taking into account the deviation between Ch 60+000 and 82+000 and the re-alignments recommended in Table 7–1, the following approximate embankment types are expected:

- 20± km of Embankment Section I between Ch 0+000 and Ch 8+000, Ch 83+00 and Ch 85+000 and Ch 95+000 to Ch 105+000.
- 8± km of rail Embankment Section II between Ch66+000 and Ch74+000.
- 52± km of Embankment Section III (700 mm) – various locations.
- 25± km of Embankment Section III (1500 mm) – various locations.

It should be noted that the preceding quantities are approximate. The quantities should be re-estimated after re-aligning the railway and after each time the alignment is revised or optimized based on site specific geotechnical data using the CAD model.

Table 7–1: Summary of Type Railway Embankment along the Alignment

Starting Cha (km)	End Cha (km)	Frost/Thaw Susceptibility (km)[1]	Distance (km)	Recommended Embankment Section
0.0	10.0	Non Susceptible	10	Apply Section III (700mm) on soil; or apply Section I on Precambrian terrain
10.0	12.5	Potentially Susceptible	2.5	Apply Section III (700mm)
12.5	15.0	Highly Susceptible	2.5	Apply Section III (1500mm)
15.0	17.5	Potentially Susceptible	2.5	Apply Section III (700mm)
17.5	22.5	Non Susceptible	5	Apply Section III (700mm)
22.5	30.0	Potentially Susceptible	7.5	Apply Section III (700mm)
30.0	42.5	Highly Susceptible	12.5	Apply Section III (1500mm)
42.5	52.5	Potentially Susceptible	10	Apply Section III (700mm)
52.5	55.0	Moderately Susceptible	2.5	Apply Section III (700mm)
55.0	57.5	Highly Susceptible	2.5	Apply Section III (1500mm)
57.5	60.0	Moderately Susceptible	2.5	Apply Section III (700mm)
62.5	72.5	Highly Susceptible	10.0	Apply Section III (1500mm); Or realign onto Limestone Ledges and Apply Section II
72.5	80.00	Moderately Susceptible	7.5	Apply Section III (700mm)
80.0	95.0	Potentially Susceptible	15	Apply Section III (700mm); or Re-align onto Precambrian Terrain and apply Section I
95.0	105.0	Non Susceptible	10	Apply Section III (700mm); or

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Starting Cha (km)	End Cha (km)	Frost/Thaw Susceptibility (km)[1]	Distance (km)	Recommended Embankment Section
				Re-align onto Precambrian Terrain and apply Section I

Note: [1-] The road foundation classifications are approximate. Foundations Classifications were based on report by Knight Piesold.

7.3 Properties of Embankment Fill Materials

The following Expansion Study – Stage II material gradations are recommended for the railway embankment fill. △2

Table 7–2: Type 12 Fill - Run of Quarry

Nominal Sieve Size (mm)	Percentage Finer Than (By Weight)
1000	100
600	95 - 100
300	50 - 100
150	0 - 80
19	0 - 30
4.75	0 - 10

Table 7–3: Type 25 Fill – Ballast

Nominal Sieve Size (mm)	Percentage Finer Than (By Weight)
37.5	100
25.4	70 – 100
19	50 – 80
12.7	10 - 40
9.5	0 – 15
4.75	<1

Table 7–4: Type 26 Fill – Sub-ballast

Nominal Sieve Size (mm)	Percentage Finer Than (By Weight)
50	100
13.2	60 – 80
4.75	20 – 45
1.18	0 – 15
0.075	0– 5

7.4 Drainage Consideration

Proper drainage design should be addressed in civil design along the railway alignment to prevent blocking of run-off resulting in ponding adjacent to the embankment fill.

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8. References

1) Corps of Engineers, U.S. Army. Description and Classification of Frozen Soils. August 1966.

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3) Natural Resources Canada, 1995, Quantity-Distance Principles, first printing.

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7) Canadian Geotechnical Society, 2006, “Canadian Foundation Engineering Manual”, Forth Edition.

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9) Roujanski V.E., Jones K.W., Haley J., Hawton K., Fitzpatrick C., 2010, “Some Permafrost-Related Terrain Features and Associated Design Considerations along the Proposed Southern Rail Alignment, Mary River Project, Baffin Island, Nunavut”.

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Appendix A

2016 Site Investigation Plan Photos

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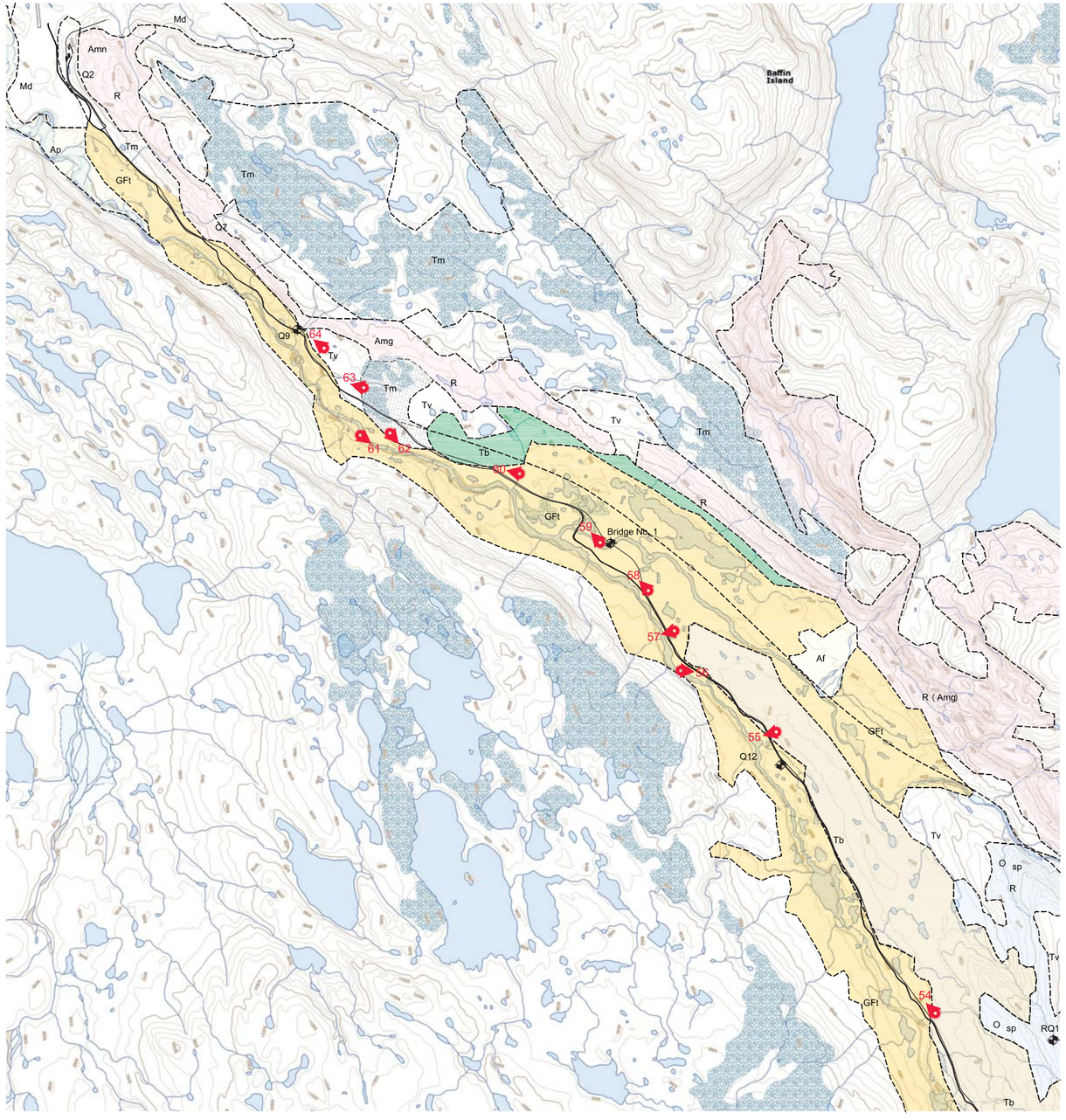

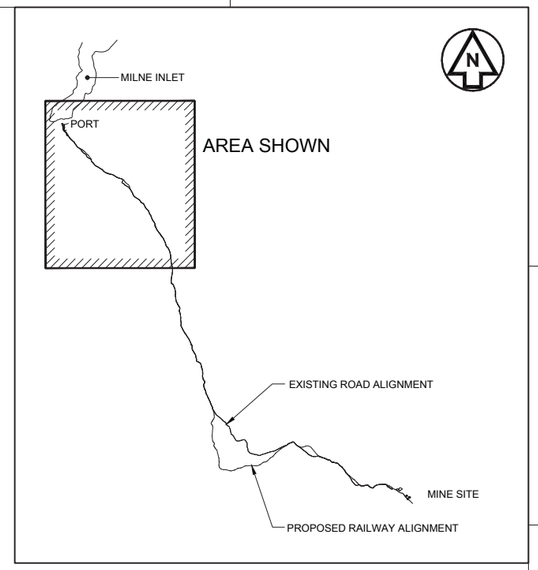

KEY PLAN

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LEGEND

55 PHOTOGRAPH LOCATION AND DIRECTION

UNIT	DESCRIPTION
R (Amg)	UNDIFFERENTIATED GNEISS AND GRANITIC ROCKS
R (Oba)	BAILLARGE FORMATION: DOLOMITIC LIMESTONE, IN PART SHALY; MINOR DOLOMITE
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Co	COLLUVIUM
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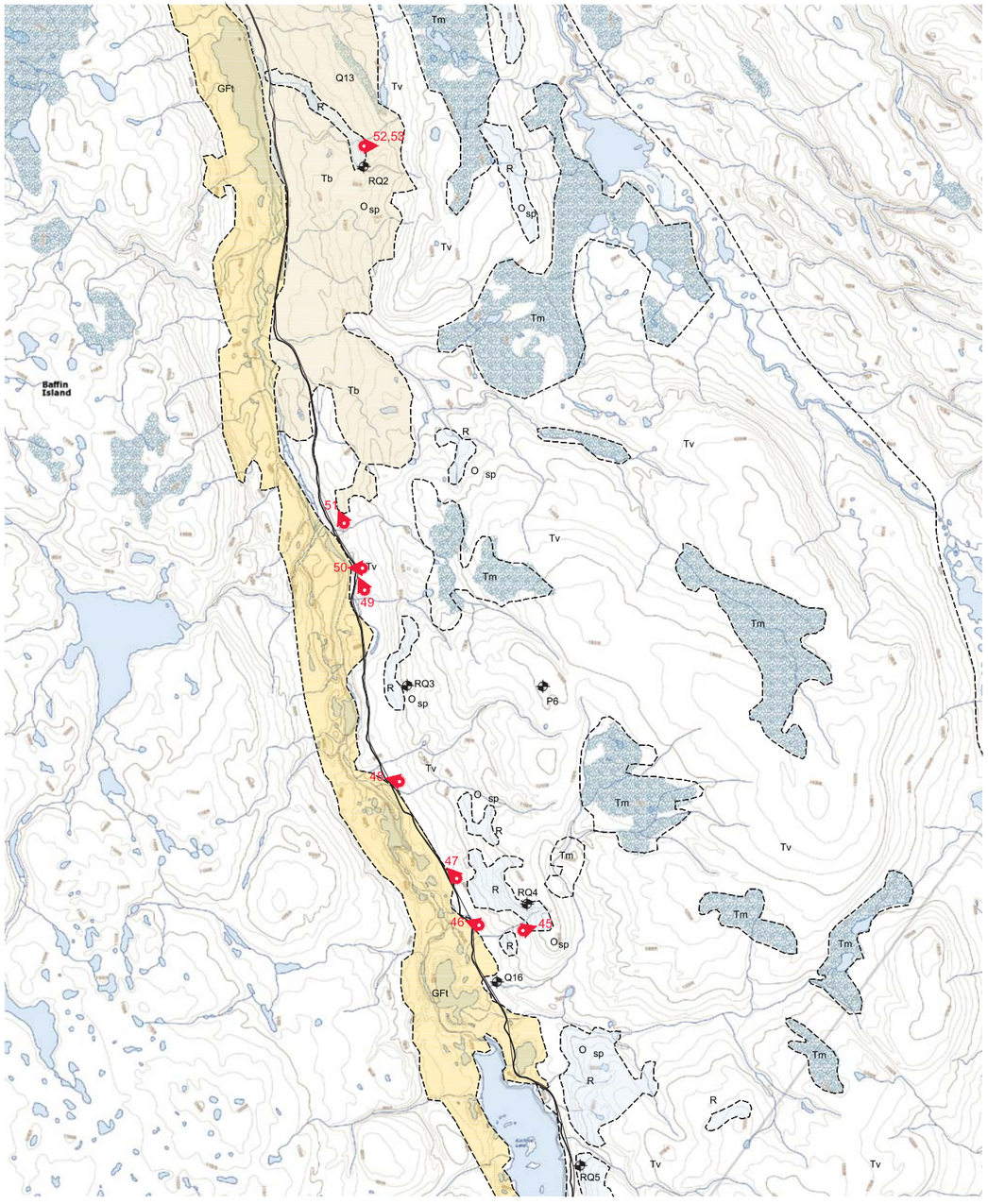

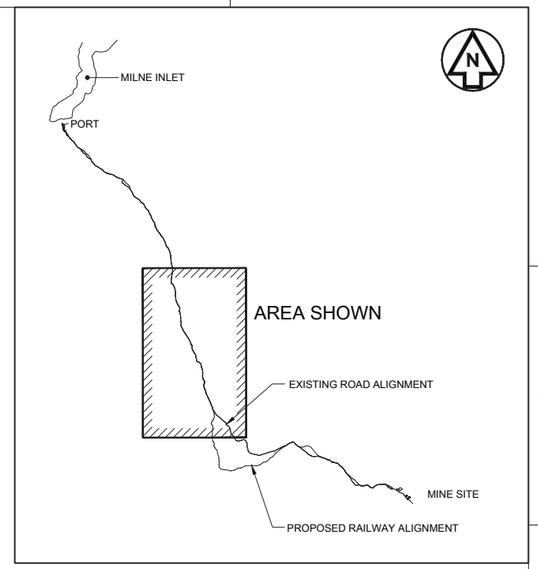

KEY PLAN

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SCALE 1:500 000

LEGEND

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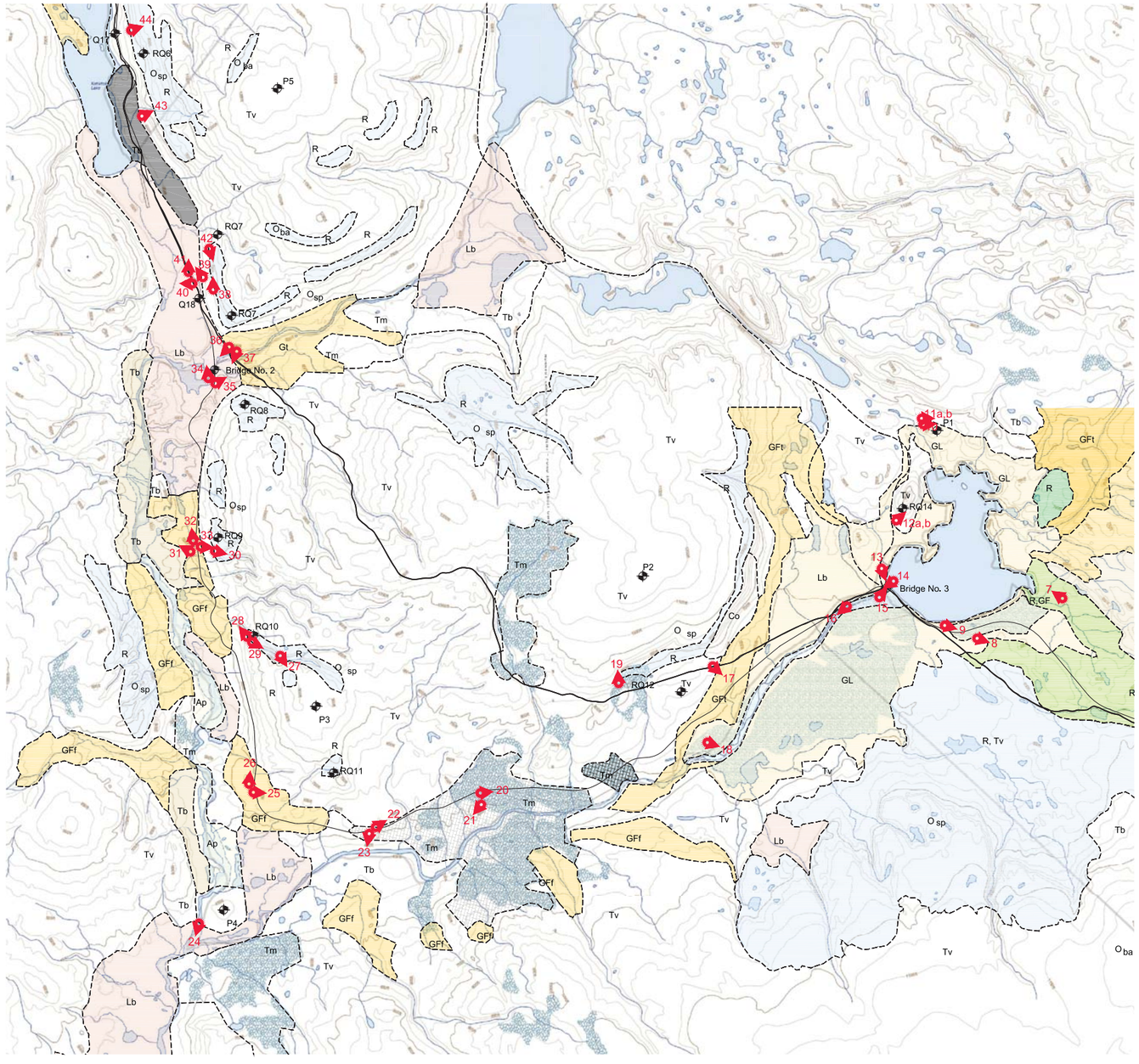

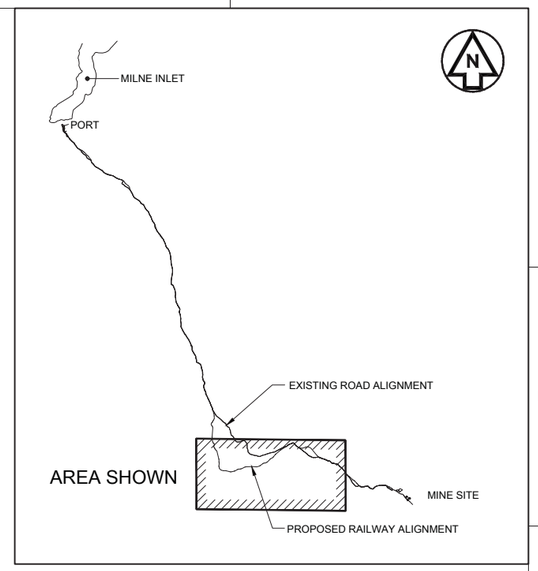

KEY PLAN

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SCALE 1:500 000

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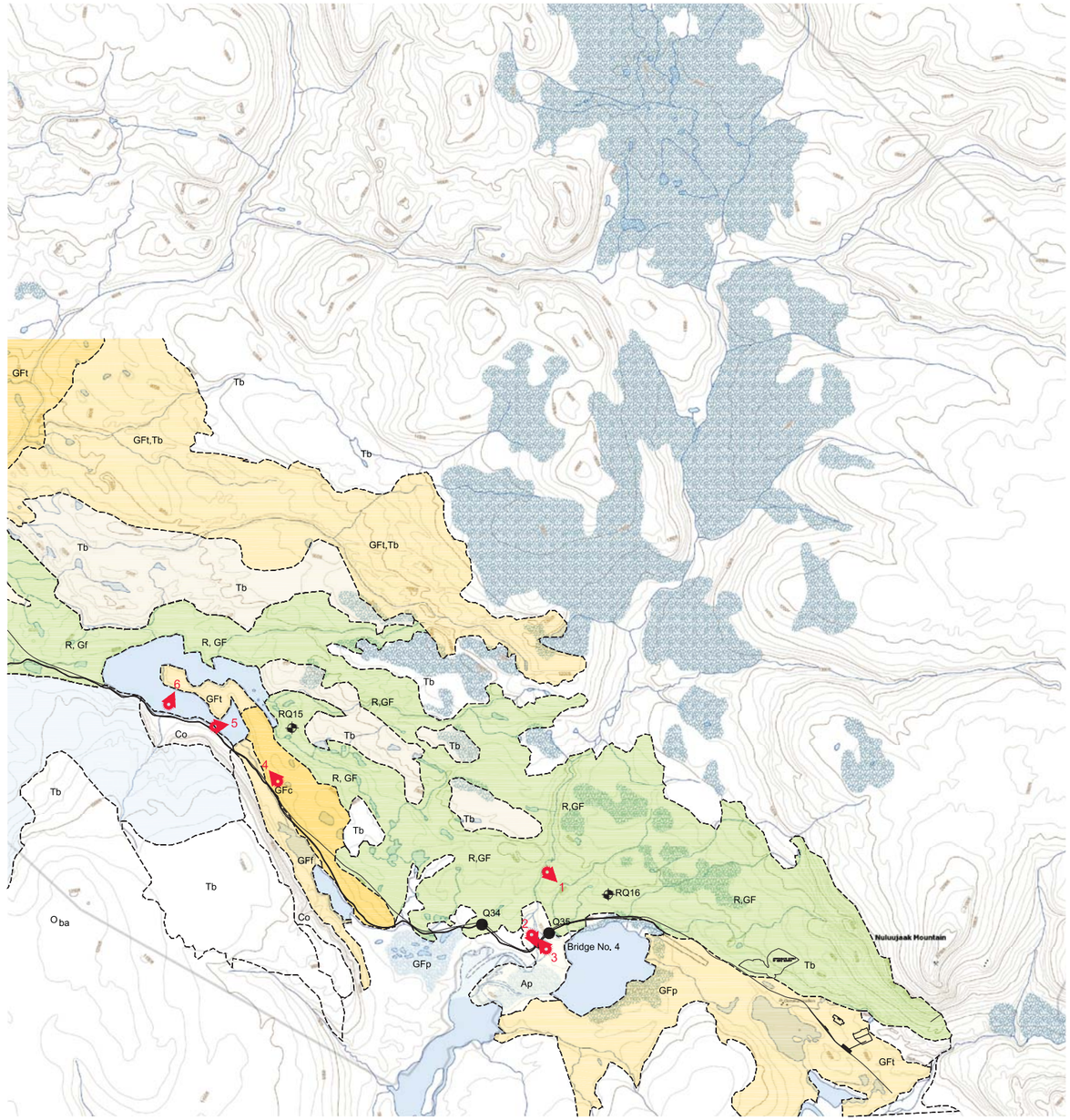

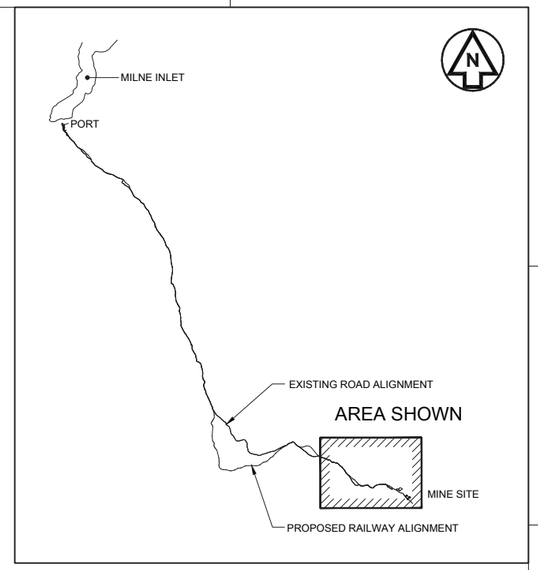

KEY PLAN

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SCALE 1:500 000

LEGEND

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DESIGN COORD.			
RESP. ENG.			
LEAD DISC. ENG.			
ENG. MANAGER			
PROJ. MANAGER			

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Baffinland

BAFFINLAND EXPANSION 12 MTPA MINE OPTION
PRE FEASIBILITY STUDY

2016 SITE INVESTIGATION PLAN
4 OF 4

SCALE AS SHOWN OR AS NOTED

DWG. No. Geotech Photo Locations

REV A

SHEET SIZE: D

Sep 27, 2016 - 7:57pm Login name: pork110733 LayoutL: 0004
Drawing Name: C:\Work\352034_Mary River Bin\Photo Locations\H352034-Geotech Photo Locations.dwg

ATTACHMENT 6.4

QUARRY GEOCHEMICAL EVALUATION

Knight Piésold CONSULTING

DRAFT

APPENDIX G

GEOTECHNICAL INVESTIGATIONS - ACID ROCK DRAINAGE ASSESSMENT
(H353004-00000-229-030-0002, REV. 2)

(Pages G-1 to G-7)

Project Memo

H353004

September 11, 2017

To: M Weaver

From: W Hoyle

cc:

BIM
T Atiba
F Pittman
R Stefan

Hatch
A Aquil
S Heiner
S Hinchberger
J Howes
N Mills
N Mason
F van Biljon

Baffinland Iron Ore Mines LP
Mary River Project

Geotechnical Investigations - Acid Rock Drainage Assessment

1. Introduction

Hatch Ltd. (Hatch) was retained by Baffinland Iron Mines (BIM) to complete an assessment of bedrock materials that will potentially be used as construction materials associated with the proposed railway from Mary River to Milne Port on Baffin Island, Nunavut. Testing was carried out on three rock samples, representative of the likely materials available during the construction of the railway. Hatch's objective was to assess the suitability of rock materials for use as construction materials.

Acid Rock Drainage (ARD) occurs when minerals containing sulphide and elemental sulphur are exposed to the weathering effects of oxygen and water. Acidity is generated from the oxidation of sulphur and precipitation of ferric iron. ARD occurs when the resulting acidity is entrained by water. High metal solubility and sulphide weathering occur under acidic conditions. Metal Leaching (ML) is typically associated with acid rock drainage. Although a neutral pH does not necessarily prevent metal leaching, in many environments, metal leaching will only be significant if the drainage pH is less than 5.5 or 6 (Price and Errigton 1998).

The Fizz Rating test is another aspect of the acid-base accounting testing program. This test is carried out by adding 1 to 2 drops of 25 % HCL to a prepared sample. The 'fizz' is rated on a scale for 0 to 3, with 0 for no reaction, 1 for a slight reaction, 2 for a moderate reaction and 3 for a strong reaction. There should be a correlation between NP and Fizz Rating. As an example, for a Fizz Rating of 3, there would likely be a highly positive NP and for a Fizz Rating of 0, a likely very low positive or negative NP.

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An assessment of the potential of acid generating potential of excavated bedrock is typically required as part of the regulatory permitting and approvals process for facilities where imported natural materials will be potentially exposed to weathering.

During the geotechnical investigation program, a number of bedrock samples were collected, including samples of granitic gneiss, limestone and diabase that are located along the alignment of the proposed railway.

2. Testing Methodology

The rock samples were considered to be representative of the bedrock encountered along the railway. The samples were shipped to SGS Lakefield Research Limited for static laboratory analysis. The analysis procedure utilized was the acid-base accounting which included measurement of sulphur species, total carbon and carbonate, Neutralization Potential (NP), pH, acid potential (AP), and the NP/AP ratio. Testing was carried out as per Government of British Columbia Technical Circular T-04/13.

3. Results

The bedrock samples included:

- granitic gneiss sampled at approximately Km 3; medium to coarse, fresh, comprised mostly of plagioclase, quartz and mafic minerals
- diabase sampled at approximately Km 95; fine to medium, fresh, blackish green comprised of mostly mafic minerals, some quartz
- limestone sampled at approximately Km 62; fine to medium, fresh, light yellowish grey.

The results of the ABA testing are summarized in Table 1 and the laboratory test reports are attached. The ABA test includes several components that provide an indicator of the acid—generating potential of the materials sampled, including paste pH, the sulphide sulphur component (%), neutralization potential (NP): acid potential (AP) ratio and net neutralization potential (NP-AP) (tonnes $CaCO_3$/1000 tonnes). The AP is calculated based on the sulphide sulphur concentration, and the NP is measurement of the amount of neutralizing base minerals, including carbonate in the samples. The net NP is the difference between the NP and the AP and the NP/AP ratio is the NP divided by the AP.

Table 1: Results of ABA Testing

Laboratory Sample Number	Description	Paste pH	NP/AP Ratio	Net NP (tonnes $CaCO_3$/ 1000 tonnes)	Total Sulphur (%)	Sulphide Sulphur (%)	Fizz Rate	Carbonate (%)
NF17-07	Granitic Gneiss	9.89	9.10	5.43	0.035	<0.02	1	0.110
NF17-08	Diabase	8.89	16.9	10.6	0.042	<0.02	1	<0.025
NF17-09	Limestone	8.24	1608	1077	0.029	<0.02	3	54.1

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While there is a very low concentration of total sulphur in the samples, the majority of the sulphur in the sample is likely sulphide sulphur. The samples had a paste pH near or over 9, which indicates that neutralization potential will be available immediately under leaching conditions. Based on results from ARD studies in the Appalachian coal mines (Brady et al. 1994), a net NP value that exceeds 15 tonnes $CaCO_3$/tonne was considered to be non-acid generating, a net NP value less than or equal to 0 tonnes $CaCO_3$/tonne was considered to be acid generating, and a net NP value between 0 and 15 tonnes $CaCO_3$/tonne represented a grey zone that was potentially acid generating, but for which prediction was difficult.

Based on this classification system, the limestone sample (NF17-09) with a net NP value at 1077 is classified as non-acid generating and the diabase (NF17-08) at a net NP value of 10.6 is likely non-acid generating. The granitic gneiss (NF17-07) with a net NP value of 5.4 falls in the zone that is difficult to predict, however likely closer to the non-acid generating classification as there is a very low percentage of sulphides (sulphur) present. The ABA screening criteria developed by the BC Ministry of Energy and Mines, (Price 1997) (Table 6.4), are described in Table 2.

Table 2: **Acid-Base Accounting Screening Criteria (Price 1997)**

Potential for ARD	Initial Screening Criteria	Comments
Likely	NPR < 1	Likely ARD-generating unless sulphide minerals are non-reactive.
Possible	1 < NPR < 2	Possibly ARD-generating if NP is insufficiently reactive or is depleted at a faster rate than sulphides.
Low	2 < NPR < 4	Not potentially ARD-generating unless there is significant preferential exposure of sulphides along fracture planes or extremely reactive sulphides in combination with an insufficiently reactive NP.
None	NPR > 4	

The results of the ABA testing indicated that for the tested rock samples from the BIM site, the Net NP was more than or slightly less than 15 tonnes $CaCO_3$ and the NP/AP ratio was greater than 4. Therefore the rock is unlikely to be acid-generating. Given the high paste pH for the sample, metal leaching is unlikely to be an issue since most metals are not soluble under alkaline conditions.

4. Recommendations

△2

Based on the results, no further testing is recommended if rock material is consistent with the samples of rock that were collected during the geotechnical investigation program. Since the excavated bedrock is unlikely to be acid-generating, there is very little concern, with respect to ARD, with its use as a source of construction material.

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5. References

Brady, K.B., Perry, E.F., Beam, R.L., Bisko, D.C., Gardner, M.D. and Tarantino, J.M. (1994). Evaluation of Acid-Base Accounting to Predict the Quality of Drainage at Surface Coal Mines in Pennsylvania, USA, Proc. International Land Reclamation and Mine Drainage Conference and 3rd International Conference on the Abatement of Acidic Drainage, Pittsburgh, PA; USBM SP 06A-94, v1, p138-146.

Government of British Columbia (2013). Technical Circular T-04/13, Evaluating The Potential For Acid Rock Drainage and Metal Leaching at Quarries, Rock Cut Sites and From Stockpiles Rock or Talus Materials Used by MOTI, September 15, 2013.

Price, W.A. 1997. Draft Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Mine sites in British Columbia. British Columbia Ministry of Employment and Investment.

Price, W.A. and Errington, J.C. (1998): Guidelines for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia.

W Hoyle

WH:kf

Attachments:
Attachment A: C of C CA13857-JUN17
Attachment B: Report CA13857-JUN17

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Jun 13857
06/27/17 JB

HATCH

GEOTECHNICAL LABORATORY

P.O Box 1001, 4342 Queen St. Niagara Falls, Ontario. L2E 7J7

PH. 905-374-0701 ext e-mail ralph.serluca@hatch.com

GEOTECHNICAL LABORATORY SAMPLE - CHAIN OF CUSTODY

SAMPLE I.D	QUANTITY	TESTS REQUIRED	
NF17-07	1 Bag 350 g	Test for Acid Rock Drainage Potential / ABA	(Granitic Gneiss)
NF17-08	1 Bag 350 g	Test for Acid Rock Drainage Potential / ABA	(Diabase)
NF17-09	1 Bag 350 g	Test for Acid Rock Drainage Potential / ABA	(Limestone)

Samples Relinquished By:	R Serluca	Samples Recieved By:	Jeanette Barker
Date:	June 26th 2017	Date:	Jun 27/17
Time:	3:00 PM	Time:	15:00
Signature:		Signature:	Jeanette Barker
Reciving Labs Address:	185 Concession St. P.O Box 4300		
	Lakefield Ontario, K0L 2H0		
	1-705-652-2000 Attention Mr. Chris Sullivan		

FedEx

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

10-July-2017

Hatch LTD
Attn : Ralph Serluca

4342 Queen St Suite500
Niagara Falls, ON
L2E 6W1,

Phone: 905-374-5200
Fax:905-374-0701

Date Rec. : 27 June 2017
LR Report: **CA13857-JUN17**

Copy: #1

CERTIFICATE OF ANALYSIS

Partial Report

Analysis	5: NF17-07	6: NF17-08	7: NF17-09
Sample Date & Time	Date:N/A	Date:N/A	Date:N/A
Paste pH	9.89	8.89	8.24
Fizz Rate [---]	1	1	3
Sample weight [g]	2.05	1.99	2.00
HCl Added [mL]	20.00	20.00	540.00
HCl [Normality]	0.10	0.10	0.10
NaOH [Normality]	0.10	0.10	0.10
NaOH to [pH=8.3 mL]	17.48	15.50	109
Final pH	1.14	1.73	1.68
NP [t CaCO3/1000 t]	6.1	11	1077
AP [t CaCO3/1000 t]	0.67	0.67	0.67
Net NP [t CaCO3/1000 t]	5.43	10.6	1077
NP/AP [ratio]	9.10	16.9	1608
Sulphur (total) [%]	0.035	0.042	0.029
Acid Leachable SO4-S [%]	0.04	0.04	0.03
Sulphide [%]	< 0.02	< 0.02	< 0.02
Carbon (total) [%]	0.044	0.061	11.1
Carbonate [%]	0.110	< 0.025	54.1

Brian Graham B.Sc.
Project Specialist
Environmental Services, Analytical

OnLine LIMS

0001059049

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Test method information available upon request. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

LR Report : **CA13857-JUN17**

*NP (Neutralization Potential)

$$= \frac{50 \times (\text{N of HCL} \times \text{Total HCL added} - \text{N NaOH} \times \text{NaOH added})}{\text{Weight of Sample}}$$

*AP (Acid Potential) = % Sulphide Sulphur x 31.25
*Net NP (Net Neutralization Potential) = NP-AP
NP/AP Ratio = NP/AP
*Results expressed as tonnes CaCO3 equivalent/1000 tonnes of material
Samples with a % Sulphide value of <0.02 will be calculated using a 0.02 value.

OnLine LIMS

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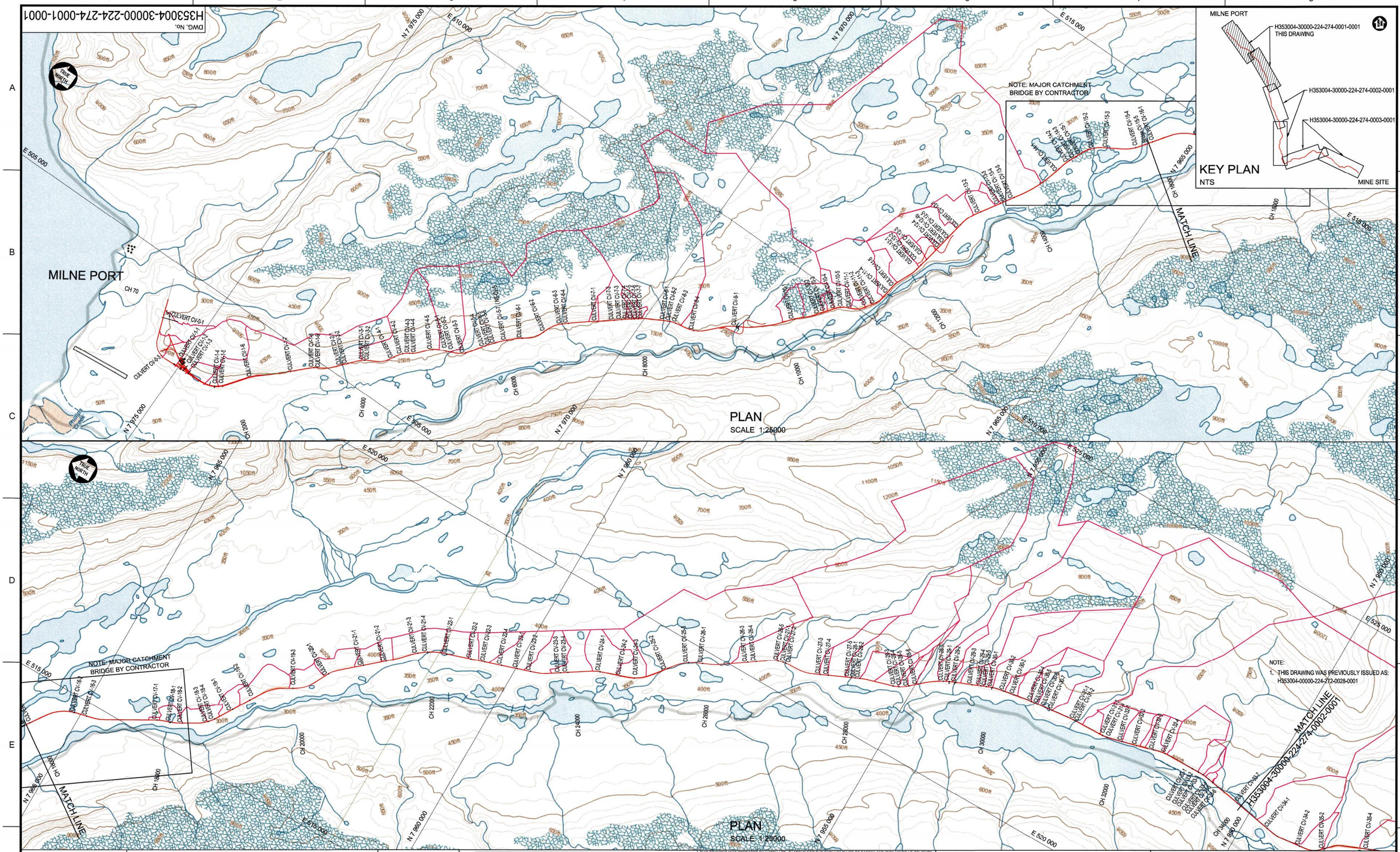
Test method information available upon request. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

0001059049

ATTACHMENT 6.5

NORTH RAILWAY CATCHMENT DRAWINGS

DWG. No. H353004-30000-224-274-0001-0001



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HATCH

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

RAIL SITE
DRAINAGE CATCHMENTS
SHEET 1 OF 3

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	M HERBST	NR	2017/02/09
DESIGNER	M HERBST	NR	2017/02/09
CHECKER	A AQUIL		2018/04/23
DESIGN COORD.	A AQUIL		2018/04/23
RESP. ENG.	F VAN BILJON		2018/04/25
LEAD DISC. ENG.	F VAN BILJON		2018/04/25
AREA LEAD	F VAN BILJON		2018/04/25
ENG. MANAGER	D STANGER		2018/4/26
AREA MANAGER	P. PITTMAN		2018/4/25

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REFERENCE DRAWINGS

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H353004-30000-224-274-0002-0001	DRAINAGE CATCHMENTS SHEET 2 of 3

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SCALE	DWG. No.	REV
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SHEET SIZE: A1

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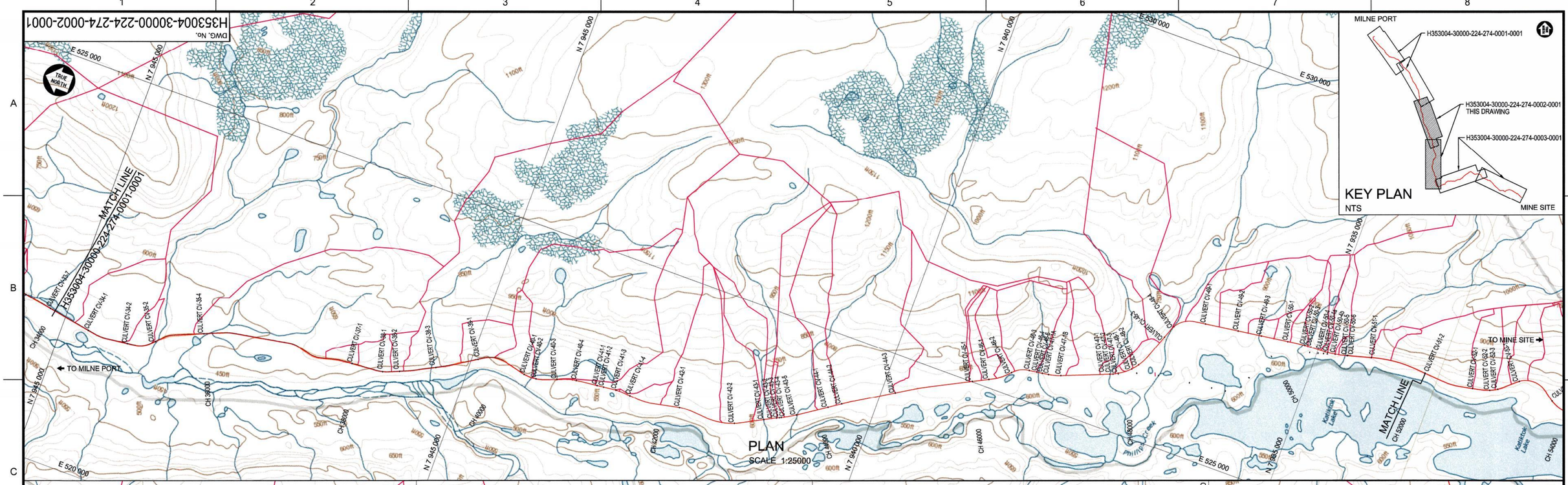

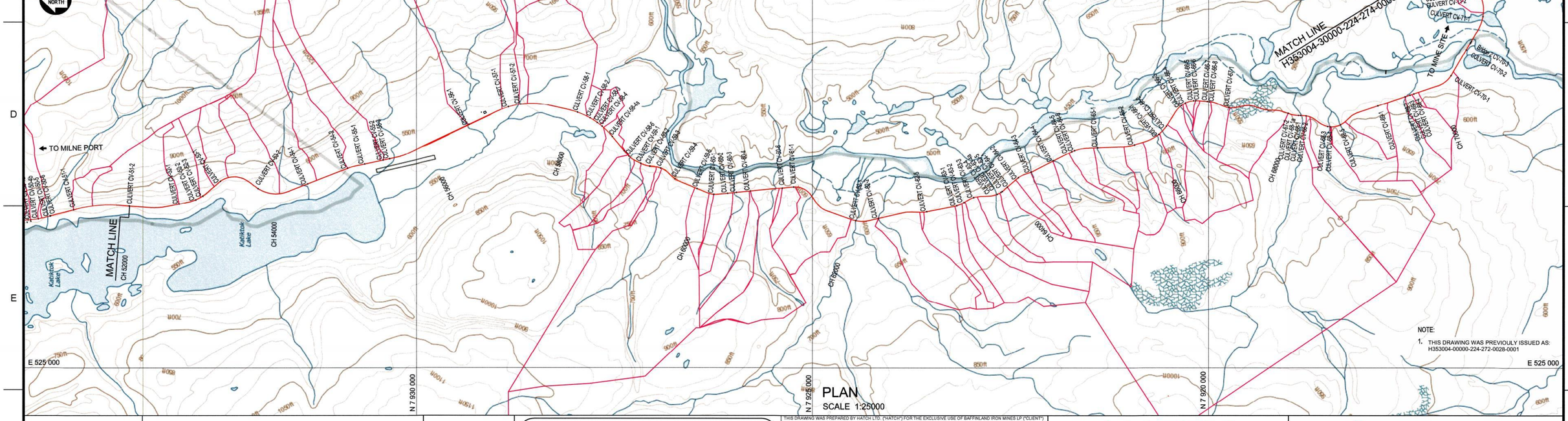

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DRAFTSPERSON	M HERBST	NR	2017/02/09	
DESIGNER	M HERBST	NR	2017/02/09	
CHECKER	A AQUIL		2018/04/23	
DESIGN COORD.	A AQUIL		2018/04/23	
RESP. ENG.	F VAN BILJON		2018/04/23	
LEAD DISC. ENG.	F VAN BILJON		2018/04/23	
AREA LEAD	F VAN BILJON		2018/04/23	
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CLIENT	F PITTMAN		2018/4/25	
ROLE	NAME	SIGNATURE	DATE	

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H353004-30000-224-274-0001-0001	DRAINAGE CATCHMENTS SHEET 1 of 3

REFERENCE DRAWINGS

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

RAIL SITE
DRAINAGE CATCHMENTS
SHEET 2 OF 3

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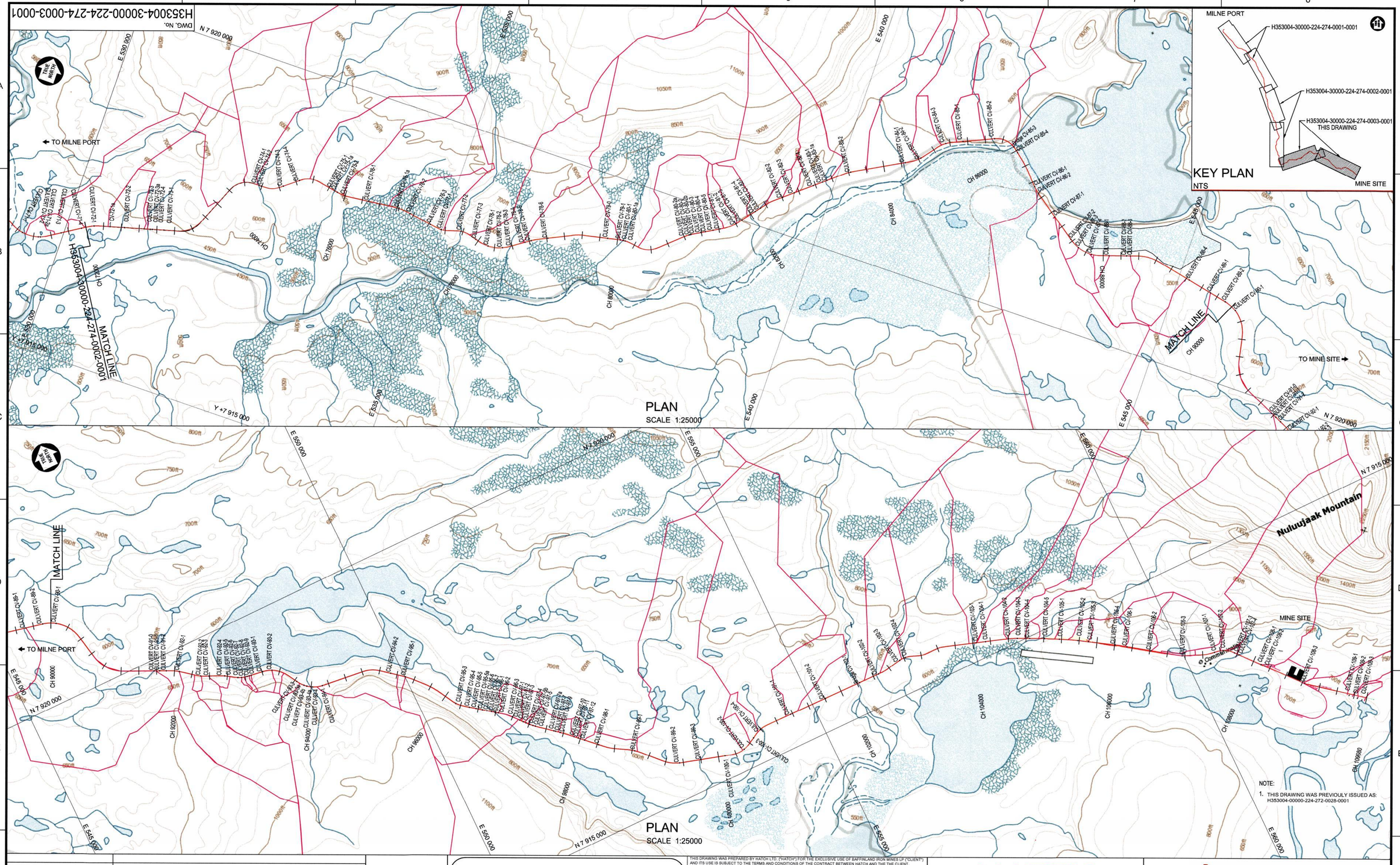

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DRAWING No.	DRAWING TITLE
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H353004-30000-224-274-0001-0001	DRAINAGE CATCHMENTS SHEET 1 of 3

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No.	DESCRIPTION	BY	CHK'D	DATE
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CHECKER	A AQUIL		2018/04/23
DESIGN COORD.	A AQUIL		2018/04/23
RESP. ENG.	F VAN BILJON		2018/04/24
LEAD DISC. ENG.	F VAN BILJON		2018/04/24
AREA LEAD	F VAN BILJON		2018/04/24
ENG. MANAGER	D STANGER		2018/4/24
CLIENT	F PITTMAN		2018/4/25

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BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

RAIL SITE
DRAINAGE CATCHMENTS
SHEET 3 OF 3

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ATTACHMENT 6.6

DIAGRAMMATIC CONCEPTUAL LAYOUT

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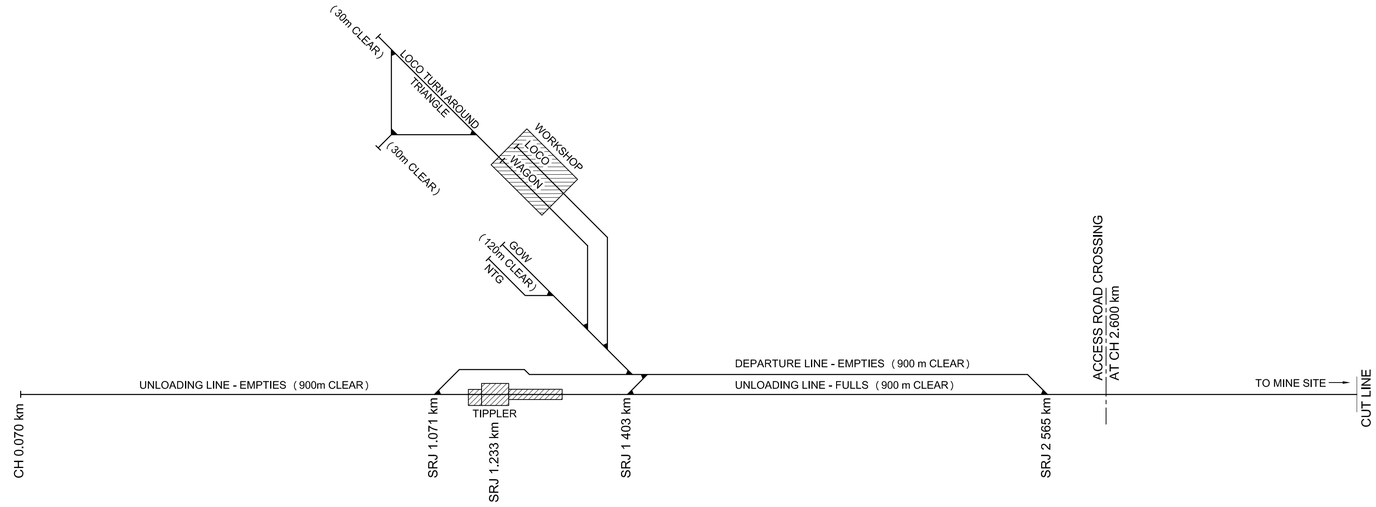
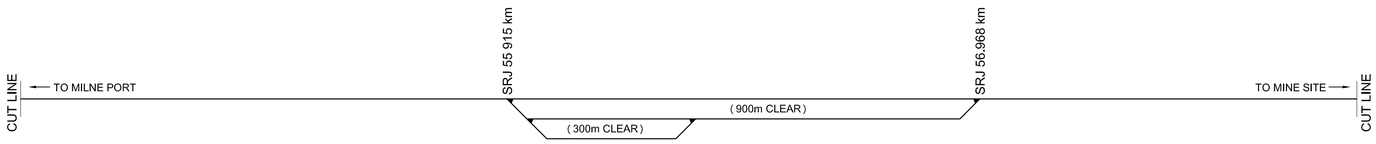
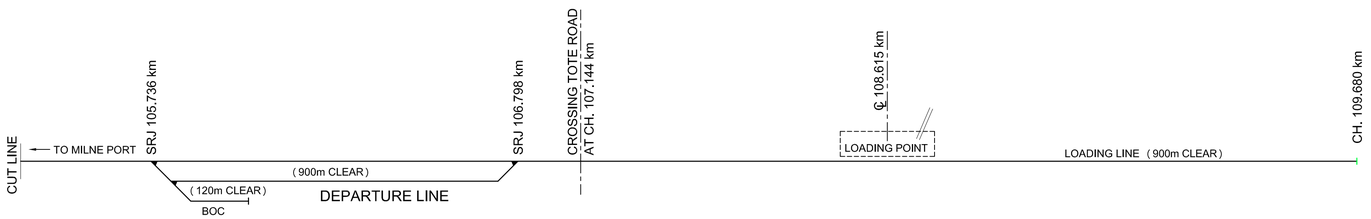


MILNE PORT FACILITIES



PASSING LOOP



MINE SIDE FACILITIES

DIAGRAMMATIC LAYOUT
NTS

HATCH PARALLEL REVIEW – Internal and Client

HATCH	Signature	Date
Port Area Lead		
Rail Area Lead		
PEng Reviewer (NAPEG)		
Construction		
Other		
Other		

BIM	Signature	Date
Port Area Manager		
Mine / Rail Area Manager		
Environmental		
Permitting		
Operations		
Other		
Other		

Review Grade *(check applicable box below)*

C1	C2	C3
Proceed to next submission & status	*Proceed with exceptions as noted to next submission & status*	*Do not proceed. Revise as noted & resubmit*
Client Rep.		*Date:*

NOTA:

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REFERENCE DRAWINGS	
DRAWING No.	DRAWING TITLE
H353004-33000-224-272-0003	LINE PLAN AND LONGGITUDINAL SECTION CH. 74.250km TO 109.680km
H353004-30000-224-272-0002	LINE PLAN AND LONGGITUDINAL SECTION CH. 37.250km TO 74km
H353004-30000-224-272-0001	LINE PLAN AND LONGGITUDINAL SECTION CH. 0.070km TO 37km

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NAME
SIGNATURE
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REVISION DATE
ORIGINAL DATE

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No.	DESCRIPTION	BY	CHK'D	DATE
0A	DIAGAMMATIC LAYOUT: INTERNAL / CLIENT REVIEW	AJVN	AA	2016/12/13

DRAWING APPROVAL STATUS: INTERNAL / CLIENT REVIEW			
ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	A VAN NIEKERK	NR	2016/12/07
DESIGNER	A VAN NIEKERK	NR	
CHECKER	A AQUIL		03/21/2018
DESIGN COORD.	A AQUIL		
RESP. ENG.	F VAN BILJON		
LEAD DISC. ENG.	F VAN BILJON		03/21/2018
ENG. MANAGER	F VAN BILJON		
PROJ. MANAGER			

HATCH

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

SITE PLAN
DIAGRAMMATIC LAYOUT
MILNE PORT TO MINE SITE

SCALE	DWG. No.	REV
NTS OR AS NOTED	H353004-30000-224-262-0001-0001	0A

SHEET SIZE: A1

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$DATES
$FILES
$TIMES

ATTACHMENT 6.7

NORTH RAILWAY PLAN & PROFILE DRAWINGS

DWG. No. H353004-00000-224-272-0001-0001

DEVIATION 1
CH 0m TO CH 315m
DISTANCE: 315m
MAX. DISTANCE FROM PERMITTING BOUNDARY: 339m

DEVIATION 2
CH 6 250m TO CH 7 932m
DISTANCE: 1 682m
MAX. DISTANCE FROM BOUNDARY: 229m

DEVIATION 3
CH 10 080m TO CH 11 912m
DISTANCE: 1 832m
MAX. DISTANCE FROM BOUNDARY: 254m

DEVIATION 4
CH 15 238m TO CH 16 943m
DISTANCE: 1 705m
MAX. DISTANCE FROM BOUNDARY: 359m

DEVIATION 5
CH 20 940m TO CH 22 760m
DISTANCE: 1 820m
MAX. DISTANCE FROM BOUNDARY: 128m

DEVIATION 6
CH 24 828m TO CH 27 266m
DISTANCE: 2 438m
MAX. DISTANCE FROM BOUNDARY: 275m

LEGEND
- EXISTING TOTE ROAD
- PROPOSED RAILWAY LINE
- EXISTING PDA
- PROPOSED PDA EXPANSION
- IMPACT AREA
- STREAM
- WATER BODY
- ICE RICH PERMAFROST

MILNE PORT
EXIST. PDA
PROPOSED PDA EXPANSION
EXIST. QUARRY RADIO TOWER KM00 (TO BE DEMOLISHED AND REMOVED)
NEW RADIO TOWER KM00
NEW RADIO TOWER KM03
NEW RADIO TOWER KM07
NEW RADIO TOWER KM26
RERPLACE RADIO TOWER KM40
COMMUNICATION TOWER # 3
IMPACT AREA
LEVEL CROSSING AT CH 12 450m
BRIDGE No.1 AT CH 15 950
LAYDOWN No.1
LAYDOWN No.2
LAYDOWN No.3
LAYDOWN No.4
LAYDOWN No.5
QUARRY PQ1 A
QUARRY PQ1 B
QUARRY PQ1 C
QUARRY PQ1 D
QUARRY Q12
QUARRY PQ2 A
TIPPLER CH: 1+235.220 Y = 7 979 966.417 Z = 58.581 (FL)
ERA PORT YARD CH: 2+385.000
MATCH LINE FOR CONTINUATION SEE H353004-0000-224-272-0002
TO MINE SITE

PLAN
SCALE 1:50000

KEY PLAN
NTS
MILNE PORT
THIS DRAWING
H353004-0000-224-272-0001 CH. 0.220 TO 37.000km
H353004-0000-224-272-0002 CH. 37.250 TO 74.000km
H353004-0000-224-272-0003 CH. 74.250 TO 109.611km
MINE SITE

NOTE:
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FORMATION LEVEL
NGL-CENTRELINE

SCALES:
HOR. 1:50000
VERT. 1:5000

FILL HEIGHT:	
CUT DEPTH:	
FORMATION:	
NGL:	
CHAINAGE:	
HORIZONTAL:	

LONGITUDINAL SECTION

						DRAFTSPERSON	A VAN NIEKERK	NR	2016/12/06
		NAME				DESIGNER		NR	
		SIGNATURE				CHECKER			
						DESIGN COORD.			
		ENG REG NUMBER				RESP. ENG.			
		REVISION DATE				LEAD DISC. ENG.			
						ENG. MANAGER			
H353004-0000-224-272-0003	LINE PLAN AND LONGGITUDINAL SECTION CH. 74km TO 109.611km		2	APPROVED FOR CONSTRUCTION				PROJ. MANAGER	
H353004-0000-224-272-0001	LINE PLAN AND LONGGITUDINAL SECTION CH. 37.250km TO 74km		1	APPROVED FOR BID	AJVN	GM	2017/02/10		
DRAWING No.	DRAWING TITLE	ORIGINAL DATE	0	APPROVED FOR BID	AJVN	GM	2016/12/13	DRAWING APPROVAL STATUS:	Approved for Construction
REFERENCE DRAWINGS		REG. PROFESSIONAL	No.	DESCRIPTION	BY	CHK'D	DATE	ROLE	NAME

Reserved space for Issue Reason stamp applied by Document Control

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HATCH

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

SITE PLAN
PLAN AND LONGITUDINAL SECTION
CH. 070km TO CH. 37.000km

SCALE	DWG. No.	REV
1:50,000 OR AS NOTED	H353004-00000-224-272-0001-0001	2

SHEET SIZE: A1

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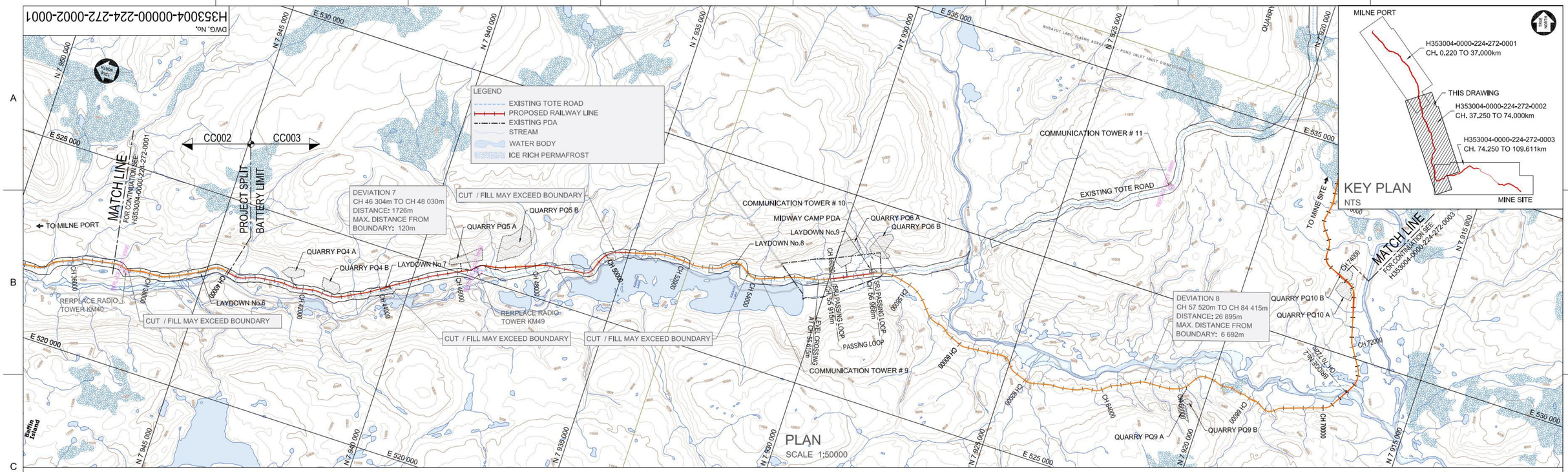
$STIMES
$SCALES
$FILES



NOTE:
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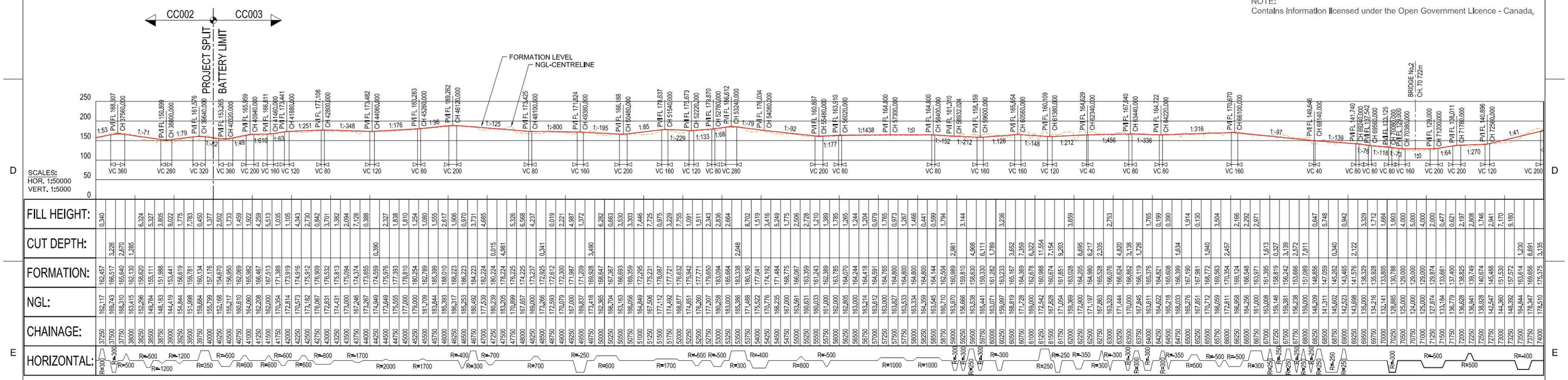

LONGITUDINAL SECTION

DRAWING No.	DRAWING TITLE
H353004-0000-224-272-0003	LINE PLAN AND LONGGITUDINAL SECTION CH. 74.250km TO 109.611km
H353004-0000-224-272-0001	LINE PLAN AND LONGGITUDINAL SECTION CH. 0.220km TO 37km

REFERENCE DRAWINGS

NAME
SIGNATURE
ENG REG NUMBER
REVISION DATE
ORIGINAL DATE
REG. PROFESSIONAL

Reserved space for Issue Reason stamp applied by Document Control

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No.	DESCRIPTION	BY	CHK'D	DATE
2	APPROVED FOR CONSTRUCTION			
1	APPROVED FOR BID	AJVN	GM	2017/02/10
0	APPROVED FOR BID	AJVN	GM	2016/12/13

REVISIONS

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	A VAN NIEKERK	NR	2016/12/06
DESIGNER		NR	
CHECKER			
DESIGN COORD.			
RESP. ENG.			
LEAD DISC. ENG.			
ENG. MANAGER			
PROJ. MANAGER			

DRAWING APPROVAL STATUS: Approved for Construction

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

SITE PLAN
PLAN AND LONGITUDINAL SECTION
CH. 37.250km TO CH. 74km

SCALE 1:50,000 OR AS NOTED
DWG. No. H353004-00000-224-272-0002-0001
REV 2
SHEET SIZE: A1

SUSERNAMES STIMES
SDATES
SFILES

PLAN
SCALE 1:50000

NOTE:
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SCALES:
HOR. 1:50000
VERT. 1:5000

CHAINAGE:	NGL:	FORMATION:	CUT DEPTH:	FILL HEIGHT:
74250	178.000	177.103	0.897	
74500	180.970	178.105	2.865	
74750	177.463	179.107		1.644
75000	175.617	180.109		4.492
75250	178.707	181.111		2.404
75500	182.223	182.113	0.110	
75750	183.992	183.115	0.877	
76000	179.626	184.117		4.491
76250	180.000	184.791		4.791
76500	184.000	184.884		0.884
76750	179.710	184.977		5.267
77000	183.764	185.069		1.305
77250	178.696	185.162		6.466
77500	183.558	185.255		1.697
77750	180.210	185.347		5.137
78000	189.000	185.440	3.560	
78250	185.085	185.906		0.821
78500	178.976	188.721		9.745
78750	189.120	191.573		2.453
79000	189.629	191.552		1.923
79250	187.121	188.459		1.338
79500	182.682	185.348		2.666
79750	182.612	182.238	0.374	
80000	174.575	179.127		4.552
80250	174.810	176.059		1.249
80500	172.132	173.305		1.173
80750	168.192	170.551		2.359
81000	166.956	167.748		0.792
81250	161.216	163.813		2.597
81500	158.871	159.830		0.959
81750	153.520	155.846		2.326
82000	155.013	154.337	0.676	
82250	154.688	154.220	0.468	
82500	153.491	154.103		0.612
82750	153.000	152.021	0.979	
83000	145.000	148.630		3.630
83250	145.990	146.935		0.945
83500	144.831	146.806		1.975
83750	146.335	146.676		0.341
84000	145.468	146.546		1.078
84250	144.928	146.434		1.506
84500	145.000	146.747		1.747
84750	146.000	147.060		1.060
85000	145.383	147.373		1.990
85250	146.000	147.686		1.686
85500	147.283	147.999		0.716
85750	147.000	148.024		1.024
86000	143.621	148.024		4.403
86250	146.000	148.024		2.024
86500	147.000	148.024		1.024
86750	144.904	148.409		3.505
87000	148.000	149.150		1.150
87250	148.819	149.890		1.071
87500	148.342	150.631		2.289
87750	150.251	151.371		1.120
88000	150.829	151.572		0.743
88250	149.823	151.349		1.526
88500	151.387	151.125	0.262	
88750	150.000	151.167		1.167
89000	151.713	151.546	0.167	
89250	151.944	151.925	0.019	
89500	151.000	152.304		1.304
89750	150.476	152.853		2.377
90000	152.939	155.227		2.288
90250	155.949	157.689		1.740
90500	162.299	160.150	2.149	
90750	169.105	162.500	6.605	
91000	161.000	161.925		0.925
91250	165.378	160.809	4.569	
91500	164.968	159.693	5.275	
91750	160.135	160.249		0.114
92000	163.454	165.243		1.789
92250	169.503	169.045	0.458	
92500	169.179	169.316		0.137
92750	168.082	169.478		1.396
93000	169.322	169.640		0.318
93250	167.599	169.802		2.203
93500	169.096	169.965		0.869
93750	166.837	170.602		3.765
94000	163.808	173.807		9.999
94250	173.664	177.110		3.446
94500	177.950	180.414		2.464
94750	182.264	183.472		1.208
95000	180.971	183.906		2.935
95250	182.531	184.215		1.684
95500	178.286	184.135		5.849
95750	179.275	180.950		1.675
96000	170.803	177.377		6.574
96250	169.563	173.804		4.241
96500	166.792	170.231		3.439
96750	160.000	169.277		9.277
97000	167.137	173.781		6.644
97250	178.965	179.121		0.156
97500	188.855	184.461	4.394	
97750	188.361	189.013		0.652
98000	185.941	188.874		2.933
98250	180.756	187.686		6.930
98500	181.984	186.498		4.514
98750	185.000	185.310		0.310
99000	184.183	184.051	0.132	
99250	178.326	179.944		1.618
99500	174.790	175.196		0.406
99750	167.000	171.482		4.482
100000	173.000	171.872	1.128	
100250	177.153	172.635	4.518	
100500	173.615	173.397	0.218	
100750	172.000	174.160		2.160
101000	173.795	174.906		1.111
101250	173.781	174.192		0.411
101500	175.733	173.333	2.400	
101750	171.105	172.473		1.368
102000	176.000	171.613	4.387	
102250	168.184	171.062		2.878
102500	172.514	171.050	1.464	
102750	169.727	171.020		1.293
103000	169.974	171.135		1.161
103250	175.173	171.556	3.617	
103500	170.932	171.978		1.046
103750	173.702	172.399	1.303	
104000	164.543	172.820		8.277
104250	171.645	173.159		1.514
104500	168.000	173.349		5.349
104750	172.298	173.540		1.242
105000	168.000	173.731		5.731
105250	173.000	173.921		0.921
105500	173.000	174.562		1.562
105750	174.000	176.160		2.160
106000	174.000	176.980		2.980
106250	175.000	177.605		2.605
106500	176.000	178.230		2.230
106750	176.689	178.855		2.166
107000	177.703	179.480		1.777
107250	179.000	181.371		2.371
107500	178.898	184.106		5.208
107750	179.350	185.744		6.394
108000	182.000	186.369		4.369
108250	183.340	186.994		3.654
108500	185.243	187.619		2.376
108750	188.000	188.244		0.244
109000	189.000	188.869	0.131	
109250	192.000	189.466	2.534	
109500	187.347	188.931		1.584
109680	191.134			

HORIZONTAL: R=300, R=-300, R=300, R=-500, R=500, R=-300, R=300, R=-500, R=800, R=500, R=500, R=-300, R=500, R=-500, R=500, R=500, R=500, R=-400, R=400, R=300, R=1000, R=-1000, R=-500, R=600, R=500, R=-500, R=500, R=-400, R=-400, R=500, R=400, R=-400, R=400, R=1000, R=1000, R=-400, R=500, R=-1000, R=1500, R=-600, R=600, R=-500, R=-400, R=400, R=-500, R=-300, R=-300, R=-300, R=1000, R=1700, R=1700, R=1700, R=-500, R=-500, R=300, R=-300

LONGITUDINAL SECTION

DRAWING No.	DRAWING TITLE
H353004-0000-224-272-0002	LINE PLAN AND LONGGITUDINAL SECTION CH. 37.250km TO 74km
H353004-0000-224-272-0001	LINE PLAN AND LONGGITUDINAL SECTION CH. 0.220km TO 37km

REFERENCE DRAWINGS

NAME
SIGNATURE
ENG REG NUMBER
REVISION DATE
ORIGINAL DATE
REG. PROFESSIONAL

Reserved space for Issue Reason stamp applied by Document Control

THIS DRAWING WAS PREPARED BY HATCH LTD. ("HATCH") FOR THE EXCLUSIVE USE OF BAFFINLAND IRON MINES LP ("CLIENT") AND ITS USE IS SUBJECT TO THE TERMS AND CONDITIONS OF THE CONTRACT BETWEEN HATCH AND THE CLIENT, INCLUDING ANY LIMITATIONS ON LIABILITY CONTAINED THEREIN. THIS DRAWING AND ITS CONTENTS REMAIN THE INTELLECTUAL PROPERTY OF HATCH SUBJECT TO CLIENT'S ROYALTY-FREE, IRREVOCABLE, PERPETUAL AND NON-EXCLUSIVE LICENSE TO USE AND REPRODUCE THE DRAWING FOR PURPOSES CONNECTED WITH THE PROJECT, INCLUDING THE CONSTRUCTION, COMPLETION, MAINTENANCE, EXTENSION, REINSTATEMENT AND REPAIR OF THE PROJECT. THIS DRAWING, AND THE INFORMATION CONTAINED HEREIN, SHALL BE TREATED AS CONFIDENTIAL FOR ALL OTHER PURPOSES AND SHALL NOT BE MODIFIED WITHOUT THE WRITTEN CONSENT OF HATCH.

No.	DESCRIPTION	BY	CHK'D	DATE
2	APPROVED FOR CONSTRUCTION			
1	APPROVED FOR BID	AJVN	GM	2017/02/10
0	APPROVED FOR BID	AJVN	GM	2016/12/13

REVISIONS

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	A VAN NIEKERK	NR	2016/12/07
DESIGNER		NR	
CHECKER			
DESIGN COORD.			
RESP. ENG.			
LEAD DISC. ENG.			
ENG. MANAGER			
PROJ. MANAGER			

DRAWING APPROVAL STATUS: Approved for Construction

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

SITE PLAN
PLAN AND LONGITUDINAL SECTION
CH. 74.250km TO CH. 109.680km

SCALE 1:50,000 OR AS NOTED

DWG. No. H353004-00000-224-272-0003-0001

REV 2

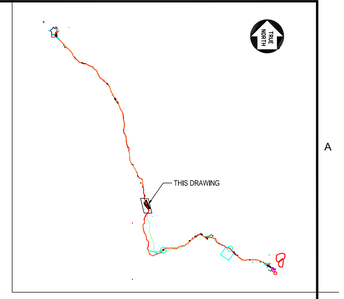
SHEET SIZE: A1

$USERNAME$ $DATE$ $FILE$ $TIME$

ATTACHMENT 6.8

KM57 TEMPORARY ORE TRANSFER AREA DRAWINGS

DWG. No. H353004-30000-224-271-0029-0001



KEY PLAN
N.T.S.

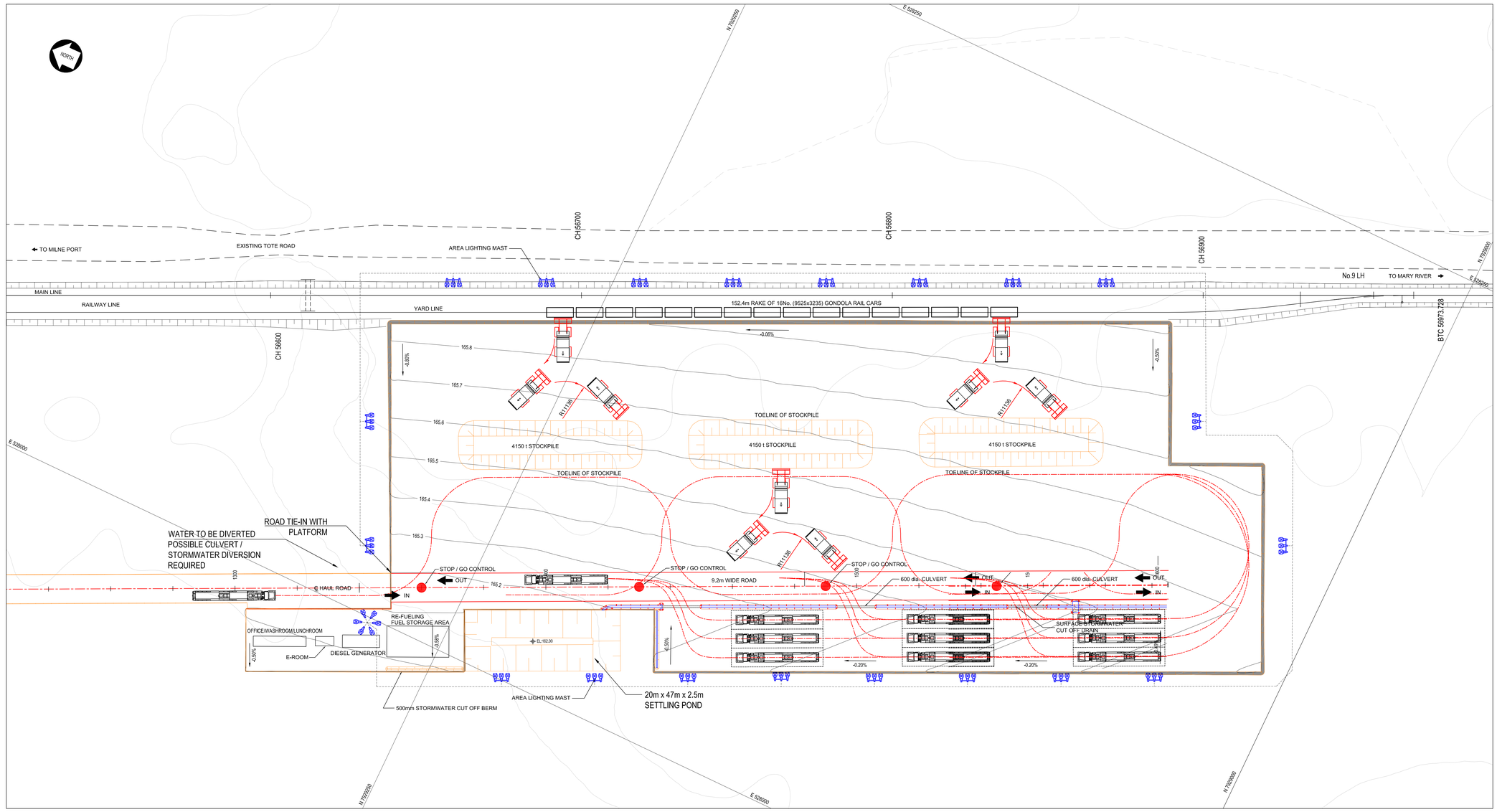
NOTES:

1. LIDAR SURVEY PROVIDED BY PHOTSAT (2016)
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METERS.
3. CONTOURS ARE IN METERS. CONTOUR INTERVAL IS 0.5m.
4. ALL DIMENSIONS SHOWN ARE IN METERS, UNLESS OTHERWISE SPECIFIED.

LEGEND:

198 — CONTOUR

NEW TREATED EFFLUENT



LOADING PLATFORM LAYOUT
SCALE 1:500

DRAWING No.	DRAWING TITLE
H353004-30000-224-273-0032-0001	TEMPORARY LOADOUT CROSS SECTION
H353004-30000-224-271-0029-0003	HAUL ROAD LAYOUT AND PROFILE 800m to 1600m
H353004-30000-224-271-0029-0002	HAUL ROAD LAYOUT AND PROFILE 0.0m to 800m

REFERENCE DRAWINGS

NAME
SIGNATURE
ENG REG NUMBER
REVISION DATE
ORIGINAL DATE
REG. PROFESSIONAL

INTERNAL/CLIENT REVIEW

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No.	DESCRIPTION	BY	CHK'D	DATE
A	INTERNAL / CLIENT REVIEW	WR	FVB	2017/02/03

REVISIONS

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	S VAN DER WALT	NR	2018/03/21
DESIGNER	S VAN DER WALT	NR	2018/03/21
CHECKER	A AQUIL		.
DESIGN COORD.	A AQUIL		.
RESP. ENG.	F VAN BILJON		.
LEAD DISC. ENG.	F VAN BILJON		.
AREA LEAD	F VAN BILJON		.
ENG. MANAGER			.
AREA MANAGER			.

DRAWING APPROVAL STATUS: INTERNAL / CLIENT REVIEW

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

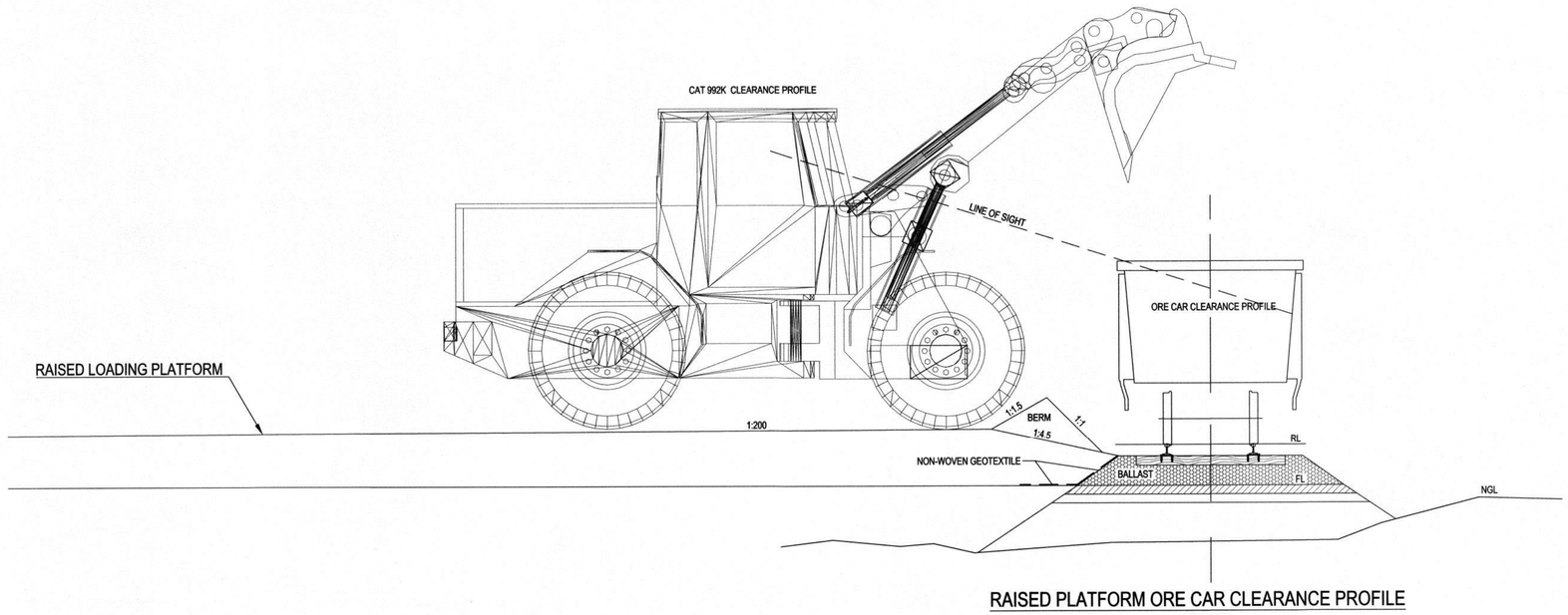
RAIL SITE (56km)
RAIL TEMPORARY LOADING FACILITY

SCALE 1:2000 OR AS NOTED | DWG. No. H353004-30000-224-271-0029-0001 | REV A

SHEET SIZE: A0

$USERNAME$
$TIMES$
$DATE$

DWG. No. H353004-30000-224-273-0032-0001



RAISED PLATFORM ORE CAR CLEARANCE PROFILE

SCALE 1:50

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NOT FOR CONSTRUCTION

HATCH

Baffinland

DRAWING No.	DRAWING TITLE
H353004-30000-224-271-0029-0001	RAIL TEMPORARY LOADING FACILITY

REFERENCE DRAWINGS

REG. PROFESSIONAL

No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR USE	WR	FVB	2017/02/03

REVISIONS

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	S VAN DER WALT	NR	2018/04/06
DESIGNER	S VAN DER WALT	NR	2018/04/06
CHECKER	A Aquil		2018/05/04
DESIGN COORD.	A Aquil		2018/05/04
RESP. ENG.	F VAN BILJON		2018/05/08
LEAD DISC. ENG.	F VAN BILJON		2018/05/08
AREA LEAD	F VAN BILJON		2018/05/08
ENG. MANAGER	D STANGER		2018/05/09
CLIENT	F PITTMAN		2018/05/08

DRAWING APPROVAL STATUS: APPROVED FOR USE

BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

RAIL SITE (56 km)
RAIL TEMPORARY LOADOUT
CROSS SECTION

SCALE 1:50 OR AS NOTED

DWG. No. H353004-30000-224-273-0032-0001

REV 0

SHEET SIZE: A1

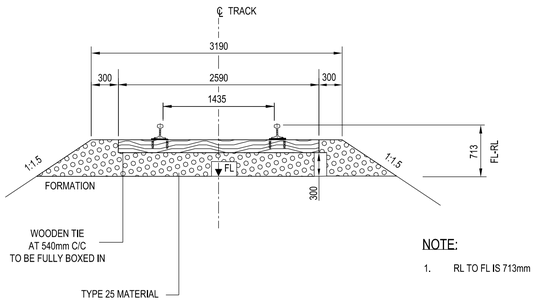
$USERNAME$
$DATE$
$FILE$

$TIME$

ATTACHMENT 6.9

RAIL EMBANKMENT DRAWINGS

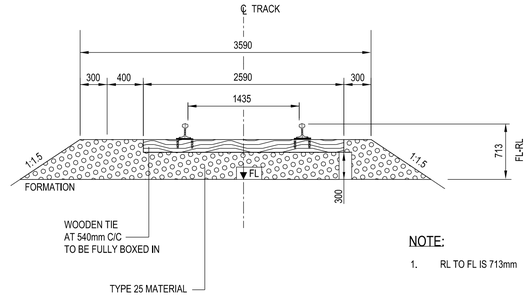
DWG. No. H353004-30000-224-294-0003-0001



NOTE:

1. RL TO FL IS 713mm

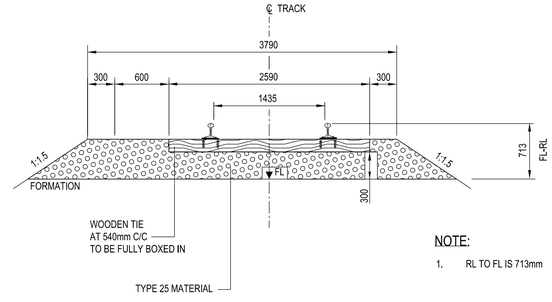
TYPICAL CROSS SECTION- SUPERSTRUCTURE
HARDWOOD TIES
R > 800m AND TANGENT TRACK
NTS



NOTE:

1. RL TO FL IS 713mm

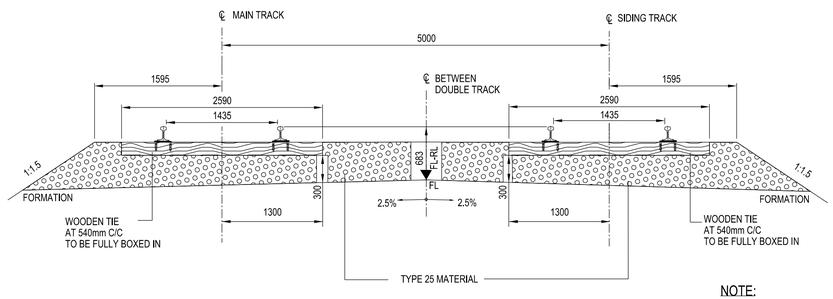
TYPICAL CROSS SECTION- SUPERSTRUCTURE
HARDWOOD TIES
400m < R ≤800m
NTS



NOTE:

1. RL TO FL IS 713mm

TYPICAL CROSS SECTION- SUPERSTRUCTURE
HARDWOOD TIES
R ≤ 400m
NTS

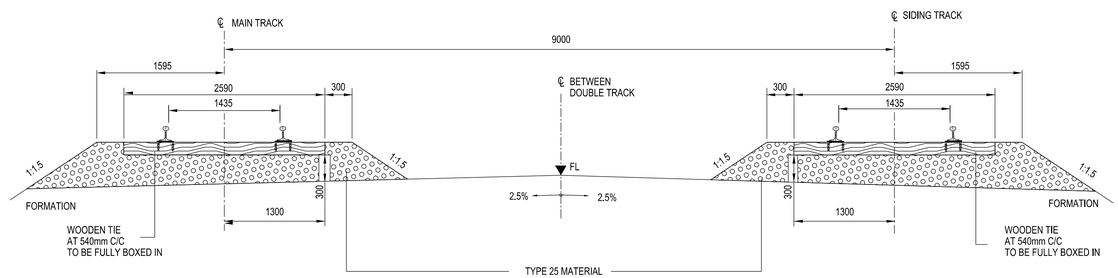


NOTE:

1. RL TO FL IS 683mm

TYPICAL CROSS SECTION AT PASSING LOOP LOCATION-SUPERSTRUCTURE
HARDWOOD TIES

NTS



TYPICAL CROSS SECTION AT PASSING LOOP LOCATION- SUPERSTRUCTURE
IN YARD
HARDWOOD TIES
NTS

NOTE:

1. THIS DRAWING WAS PREVIOUSLY ISSUED AS H353004-00000-220-294-0003-0001.

DRAWING No.	DRAWING TITLE
H353004-30000-224-294-0006-0001	TYPICAL CROSS SECTION- SHEET 4 OF 4
H353004-30000-224-294-0005-0001	TYPICAL CROSS SECTION- SHEET 3 OF 4
H353004-30000-224-294-0004-0001	TYPICAL CROSS SECTION- SHEET 2 OF 4

REFERENCE DRAWINGS

NAME
SIGNATURE
ENG REG NUMBER
REVISION DATE
ORIGINAL DATE
REG. PROFESSIONAL

NOT FOR CONSTRUCTION

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No.	DESCRIPTION	BY	CHK'D	DATE
A	INTERNAL/CLIENT REVIEW	SP-A	AA	2018/03/19

REVISIONS

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	S PINKNEY-ATKINSON	NR	2016/12/07
DESIGNER	S PINKNEY-ATKINSON	NR	
CHECKER	ALI AQUIL		2016/12/13
DESIGN COORD.	ALI AQUIL		
RESP. ENG.	FANUS VAN BILJON		2016/12/13
LEAD DISC. ENG.	FANUS VAN BILJON		2016/12/13
AREA MANAGER	FANUS VAN BILJON		03/26/2018
PROJ. MANAGER			2016/12/13
CLIENT			

DRAWING APPROVAL STATUS: INTERNAL/CLIENT REVIEW

HATCH

Baffinland

MARY RIVER EXPANSION STAGE 3
BAFFINLAND IRON ORE MINES

RAIL SITE
STANDARD DRAWING
TYPICAL CROSS SECTION- SHEET 1 OF 4

SCALE NTS OR AS NOTED

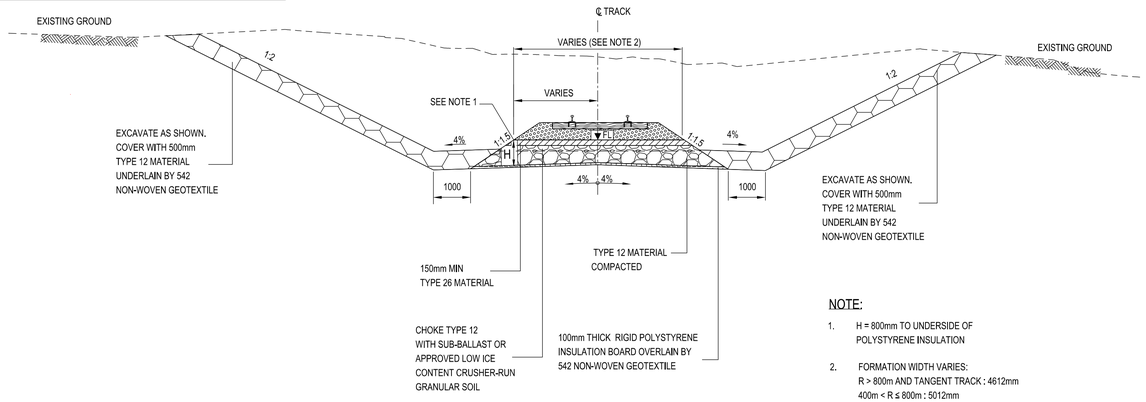
DWG. No. H353004-30000-224-294-0003-0001

REV A

SHEET SIZE: D

$USERNAMES $DATES $FILES $TIMES

DWG. No. H353004-30000-224-294-0004-0001

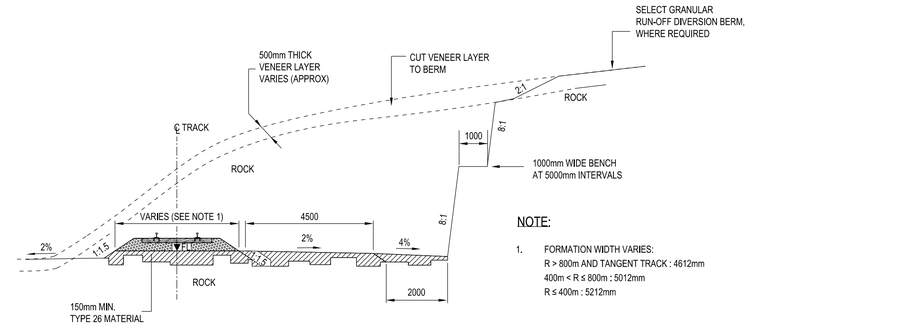


NOTE:

1. H = 800mm TO UNDERSIDE OF POLYSTYRENE INSULATION
2. FORMATION WIDTH VARIES:
   R > 800m AND TANGENT TRACK : 4612mm
   400m < R ≤ 800m : 5012mm
   R ≤ 400m : 5212mm

TYPICAL CROSS SECTION (CUT IN PERMAFROST)

NTS

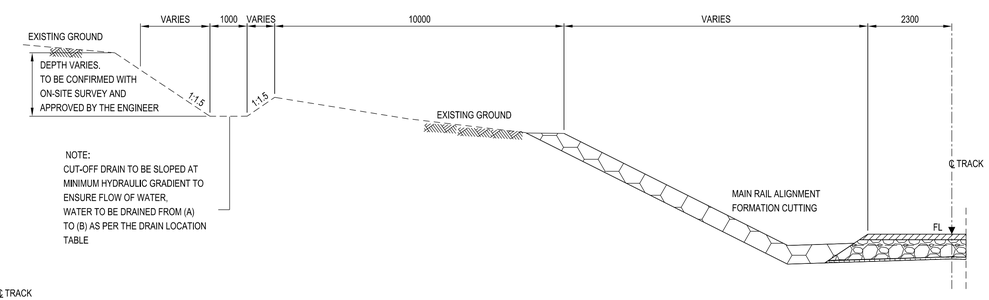


NOTE:

1. FORMATION WIDTH VARIES:
   R > 800m AND TANGENT TRACK : 4612mm
   400m < R ≤ 800m : 5012mm
   R ≤ 400m : 5212mm

TYPICAL CROSS SECTION (CUT IN GRANITIC ROCK) WITH SERVICE ROAD

NTS

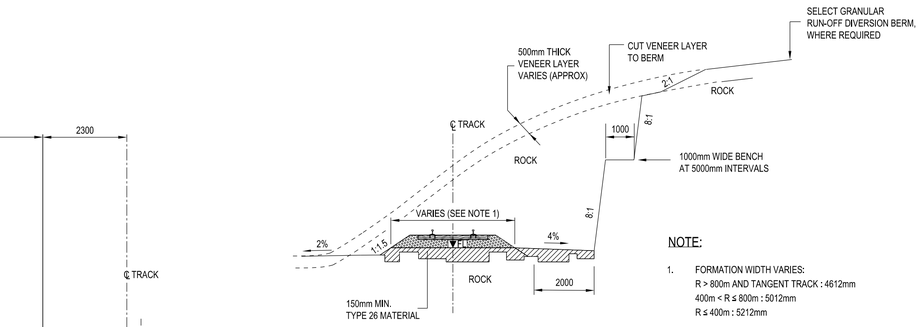


TYPICAL CROSS SECTION (CUT-OFF DRAIN)

NTS

NOTE:

1. MATERIAL TYPE DEFINITION:
   TYPE 12: RUN OF QUARRY/ ROCK FILL LAYER
   TYPE 19: RIP RAP LAYER
   TYPE 26: SUB-BALLAST LAYER
   VENEER LAYER: INSITU SAND AND GRAVEL LAYER
2. PROPOSED EMBANKMENT DOES NOT HAVE SUB-BALLAST SHOULDERS. EMPLOYER SHALL DEVELOP SAFE OPERATING PROCEDURES FOR ACCESS TO INSPECT AND REPAIR TRAIN EQUIPMENT IN THE CASE OF A BREAKDOWN ON A HIGH EMBANKMENT.
3. FOR SUPERSTRUCTURE DETAILS REFER TO DRAWING H353004-30000-224-294-0003-0001.
4. LONGITUDINAL SLOPE ON RUNOFF AREA TO BE 2 % WHERE PRACTICAL.
5. THIS DRAWING WAS PREVIOULSY ISSUED AS H353004-00000-220-294-0004-0001.

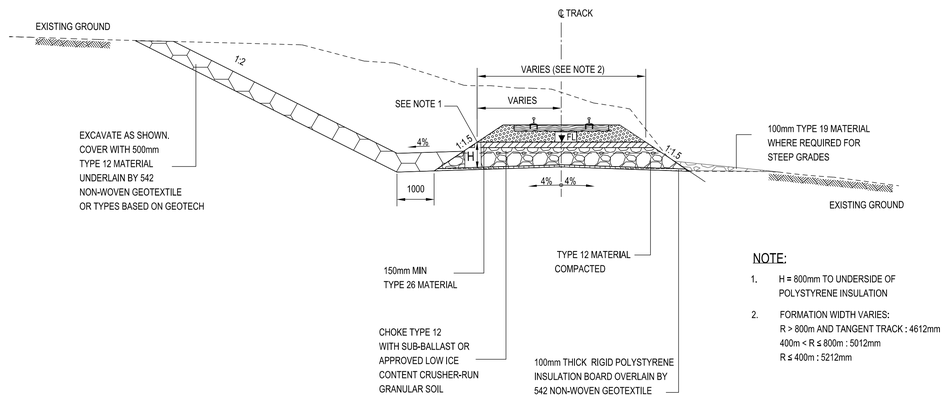


NOTE:

1. FORMATION WIDTH VARIES:
   R > 800m AND TANGENT TRACK : 4612mm
   400m < R ≤ 800m : 5012mm
   R ≤ 400m : 5212mm

TYPICAL CROSS SECTION (CUT IN GRANITIC ROCK)

NTS

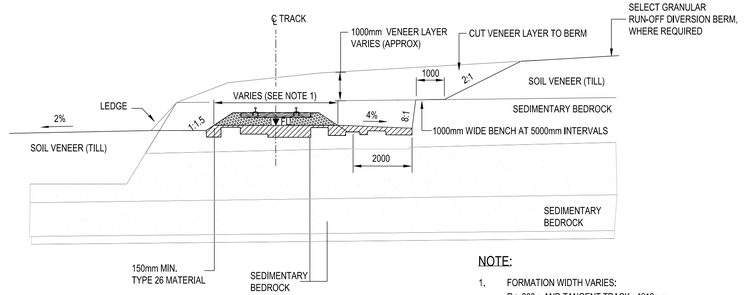


NOTE:

1. H = 800mm TO UNDERSIDE OF POLYSTYRENE INSULATION
2. FORMATION WIDTH VARIES:
   R > 800m AND TANGENT TRACK : 4612mm
   400m < R ≤ 800m : 5012mm
   R ≤ 400m : 5212mm

TYPICAL CROSS SECTION (CUT IN PERMAFROST WITH DAYLIGHTING)

NTS



NOTE:

1. FORMATION WIDTH VARIES:
   R > 800m AND TANGENT TRACK : 4612mm
   400m < R ≤ 800m : 5012mm
   R ≤ 400m : 5212mm

TYPICAL CROSS SECTION (CUT IN SEDIMENTARY BEDROCK LEDGES)

NTS

		NAME	NOT FOR CONSTRUCTION					DRAFTSPERSON	SAMANTHA P-ATKINSON	NR	2016/12/07
		SIGNATURE						DESIGNER	SAMANTHA P-ATKINSON	NR	
		ENG REG NUMBER						CHECKER	ALI AQUIL		03/21/2018
		REVISION DATE						DESIGN COORD.	ALI AQUIL		
								RESP. ENG.	FANUS VAN BILJON		
								LEAD DISC. ENG.	FANUS BAN BILJON		03/21/2018
								AREA MANAGER	FANUS VAN BILJON		
								PROJ. MANAGER			
H353004-30000-224-294-0003-0001	TYPICAL CROSS SECTION: SHEET 1 OF 4	ORIGINAL DATE	A	INTERNAL/CLIENT REVIEW		SP-A	AA	2018/03/19	CLIENT		
DRAWING No.	DRAWING TITLE		No.	DESCRIPTION		BY	CHK'D	DATE	ROLE	NAME	SIGNATURE	DATE
REFERENCE DRAWINGS		REG. PROFESSIONAL	REVISIONS						DRAWING APPROVAL STATUS: INTERNAL/ CLIENT REVIEW			

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HATCH

Baffinland

BAFFINLAND IRON ORE MINES LP
MARY RIVER EXPANSION PROJECT

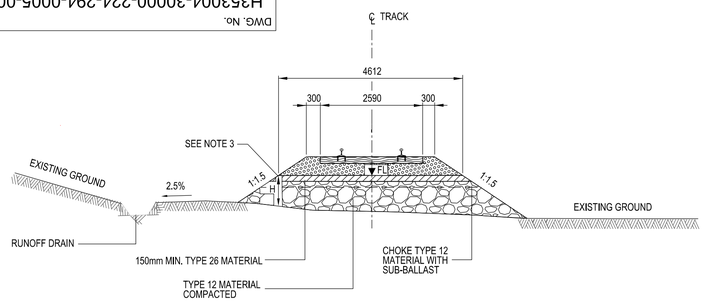
RAIL SITE
STANDARD DRAWING
TYPICAL CROSS SECTION- SHEET 2 OF 4

SCALE	DWG. No.	REV
NTS OR AS NOTED	H353004-30000-224-294-0004-0001	A

SHEET SIZE: D

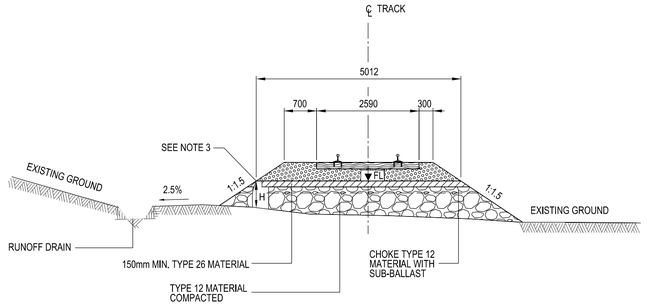
$USERNAME$
$DATE$
$TIME$
$FILE$

DWG. No. H353004-30000-224-294-0005-0001



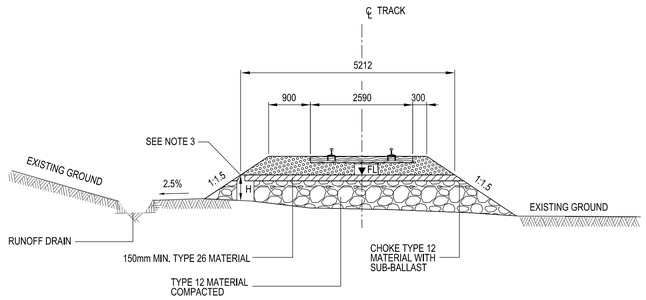
TYPICAL CROSS SECTION (FILL)
R > 800m AND TANGENT TRACK

NTS



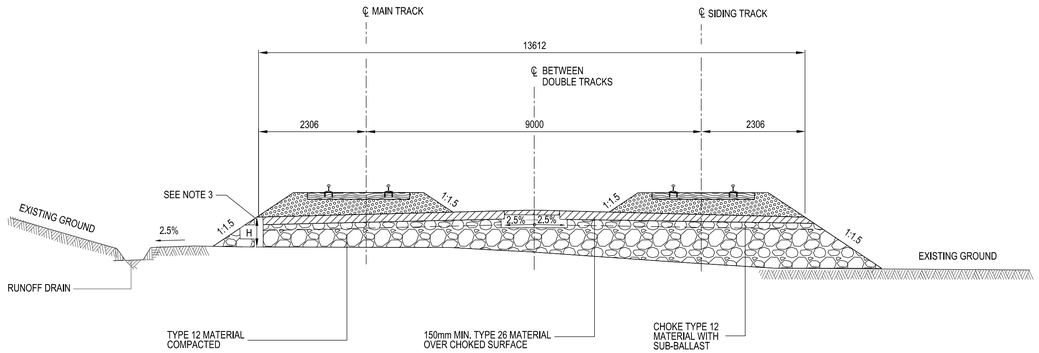
TYPICAL CROSS SECTION (FILL)
400m < R ≤ 800m

NTS



TYPICAL CROSS SECTION (FILL)
R ≤ 400m

NTS



TYPICAL CROSS SECTION AT PASSING LOOP LOCATION (FILL)
IN YARD

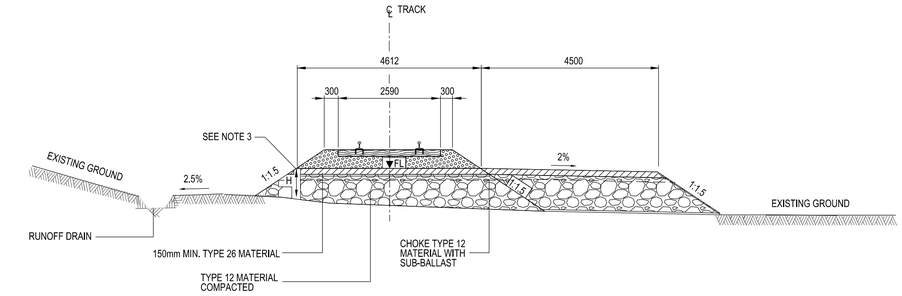
NTS

NOTE

1. RUNOFF DRAINS WILL BE SLOPED AT 2% LONGITUDINAL WHERE PRACTICAL

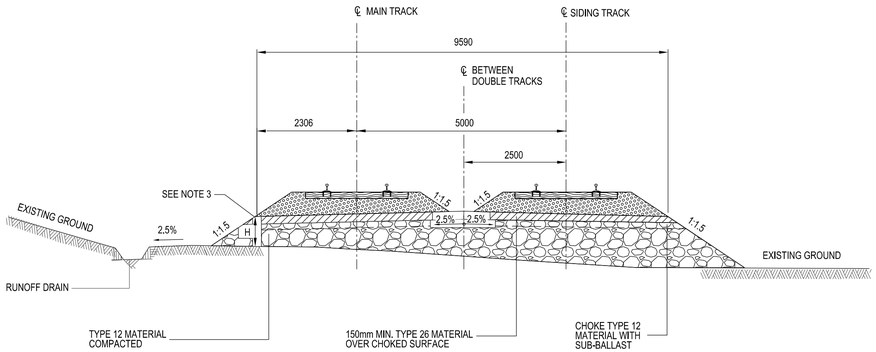
TYPICAL RUNOFF DRAIN DIMENSIONS

NTS



TYPICAL CROSS SECTION (FILL)
WITH SERVICE ROAD

NTS



TYPICAL CROSS SECTION AT PASSING LOOP LOCATION (FILL)

NTS

NOTE:

1. MATERIAL TYPE DEFINITION:
   TYPE 12: RUN OF QUARRY/ROCK FILL LAYER
   TYPE 25: BALLAST LAYER
   TYPE 26: SUB-BALLAST LAYER
2. PROPOSED EMBANKMENT DOES NOT HAVE SUB-BALLAST SHOULDERS. EMPLOYER SHALL DEVELOP SAFE OPERATING PROCEDURES FOR ACCESS TO INSPECT AND REPAIR TRAIN EQUIPMENT IN THE CASE OF A BREAKDOWN ON A HIGH EMBANKMENT.
3. MINIMUM EMBANKMENT (TYPE 12 PLUS SUB-BALLAST) THICKNESS VARIES DEPENDING ON SUB-GRADE CONDITION
   H= 700mm STANDARD DIMENSION
   H= 1500mm FOR ICE RICH PERMAFROST.
4. 542 NON-WOVEN GEOTEXTILE UNDER TYPE 12 MATERIAL ON ICE RICH SILT.
5. FOR RUNOFF DRAIN DETAILS REFER TO TYPICAL RUNOFFF DRAIN DIMENSIONS.
6. FOR SUPERSTRUCTURE DETAILS REFER TO DRAWING H353004-30000-224-294-0003-0001.
7. THIS DRAWING WAS PREVIOUSLY ISSUED AS H353004-00000-220-294-0005-0001.

NOT FOR CONSTRUCTION

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DRAFTSPERSON	S ATKINSON	NR	2016/12/09			
DESIGNER	S ATKINSON	NR				
CHECKER			03/26/2018			
DESIGN COORD.						
RESP. ENG.						
LEAD DISC. ENG.						
AREA MANAGER			03/26/2018			
PROJ. MANAGER						
CLIENT						

HATCH

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

RAIL SITE
STANDARD DRAWING
TYPICAL CROSS SECTION- SHEET 3 OF 4

No.	DESCRIPTION	BY	CHK'D	DATE
A	INTERNAL/CLIENT REVIEW	SP-A	AA	2018/03/19

ROLE	NAME	SIGNATURE	DATE

DRAWING APPROVAL STATUS: INTERNAL/CLIENT REVIEW

DRAWING No.	DRAWING TITLE
H353004-30000-224-294-0003-0001	TYPICAL CROSS SECTION- SHEET 1 OF 4

REFERENCE DRAWINGS

NAME
SIGNATURE
ENG REG NUMBER
REVISION DATE
ORIGINAL DATE
REG. PROFESSIONAL

SCALE NTS OR AS NOTED

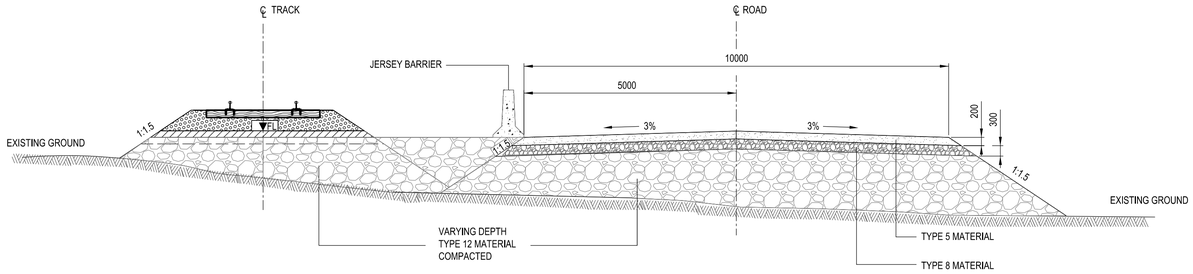
DWG. No. H353004-30000-224-294-0005-0001

REV A

SHEET SIZE: D

$USERNAMES $DATES $FILES $TIMES

DWG. No. H353004-30000-224-294-0006-0001

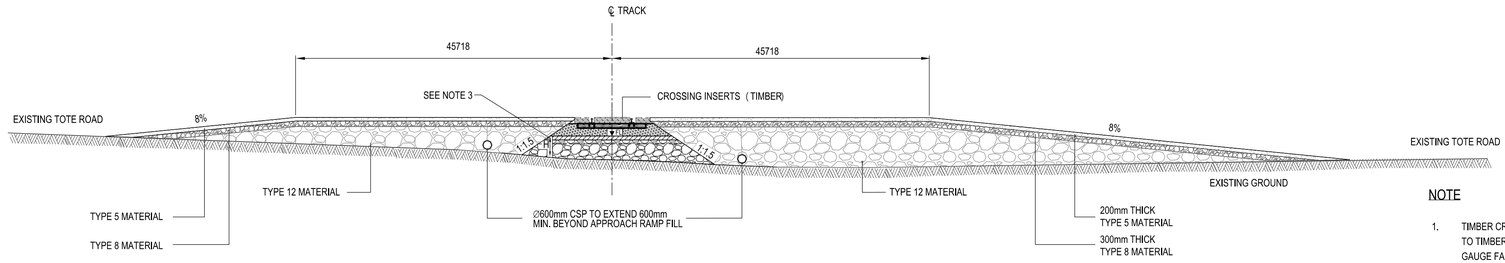


TYPICAL CROSS SECTION FOR TOTE ROAD AND RAIL INTERFACE

NTS

NOTE

1. WHERE REQUIRED, JERSEY BARRIER LOCATED ON RAIL SIDE.

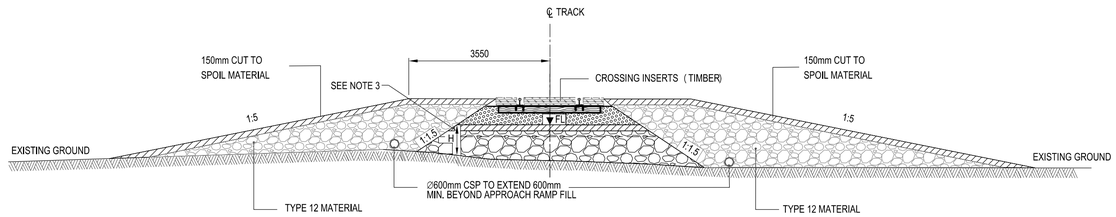


TYPICAL CROSS SECTION FOR LEVEL CROSSING

NTS

NOTE

1. TIMBER CROSSING INSERTS SHALL BE 178mm HIGH AND 229mm WIDE INSERTS TO BE FASTENED TO TIMBER TIES USING 305mm LAG SCREWS. MINIMUM OF 76mm SHALL BE MAINTAINED BETWEEN GAUGE FACE OF THE RAIL AND NEAREST CROSSING INSERT.



TYPICAL CROSS SECTION FOR CARIBOU CROSSING

NTS

NOTE:

1. MATERIAL TYPE DEFINITION:
   - TYPE 5: 32mm MINUS
   - TYPE 8: 150mm MINUS
   - TYPE 12: RUN OF QUARRY/ROCK FILL LAYER
   - TYPE 25: BALLAST LAYER
   - TYPE 26: SUB-BALLAST LAYER
2. PROPOSED EMBANKMENT DOES NOT HAVE SUB-BALLAST SHOULDERS. EMPLOYER SHALL DEVELOP SAFE OPERATING PROCEDURES FOR ACCESS TO INSPECT AND REPAIR TRAIN EQUIPMENT IN THE CASE OF A BREAKDOWN ON A HIGH EMBANKMENT.
3. MINIMUM EMBANKMENT (TYPE 12 PLUS SUB-BALLAST) THICKNESS VARIES DEPENDING ON SUB-GRADE CONDITION
   H= 700mm STANDARD DIMENSION
   H= 1500mm FOR ICE RICH PERMAFROST.
4. 542 NON-WOVEN GEOTEXTILE UNDER TYPE 12 MATERIAL ON ICE RICH SILT.
5. FOR JERSEY BARRIER DETAILS REFER TO TYPICAL JERSEY BARRIER DIMENSIONS.
6. FOR SUPERSTRUCTURE DETAILS REFER TO DRAWING H353004-30000-224-294-0003-0001.
7. THIS DRAWING WAS PREVIOUSLY ISSUED AS H353004-00000-220-294-0006-0001.

NOT FOR CONSTRUCTION

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No.	DESCRIPTION	BY	CHK'D	DATE
A	INTERNAL/CLIENT REVIEW	SPA	AA	2018/03/19

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	S ATKINSON	NR	2016-12-12
DESIGNER		NR	
CHECKER			03/26/2018
DESIGN COORD.			
RESP. ENG.			
LEAD DISC. ENG.			
AREA MANAGER			03/26/2018
PROJ. MANAGER			
CLIENT			

DRAWING APPROVAL STATUS: INTERNAL/CLIENT REVIEW

HATCH

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

RAIL SITE
STANDARD DRAWING
TYPICAL CROSS SECTION- SHEET 4 OF 4

DRAWING No.	DRAWING TITLE
H353004-30000-224-294-0003-0001	TYPICAL CROSS SECTION- SHEET 1 OF 4

REFERENCE DRAWINGS

NAME
SIGNATURE
ENG REG NUMBER
REVISION DATE
ORIGINAL DATE
REG. PROFESSIONAL

SCALE NTS OR AS NOTED

DWG. No. H353004-30000-224-294-0006-0001

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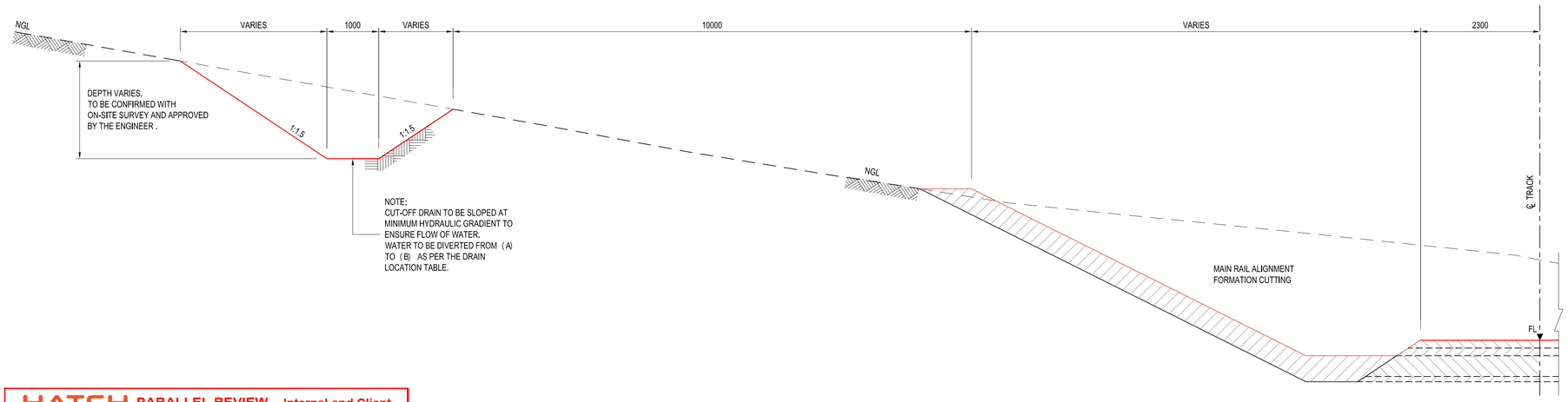
$FILE$
$TIME$

DWG. No. H353004-30000-224-294-0008-0001



CUT-OFF DRAIN
TYPICAL CROSS SECTION
SCALE 1::50

DIRECTION OF FLOW OF STREAM DIVERSION		
CHAINAGE FROM (km)	CHAINAGE TO (km)	LENGTH (m)
12661	12760	99
20818	20498	320
46454	46473	19
47552	47602	50
49799	49980	181
58940	59060	120
58940	59060	120
59442	59552	110
59706	59552	154
60623	60950	327
61580	61340	240
62550	62920	370
63110	62930	180
63090	62930	160
63724	63555	169
64827	64950	123
66164	66228	64
82266	82094	172
90726	90910	184
89200	90500	1300
91216	90910	306
97286	97194	92

NOTE:

1. THIS DRAWING WAS PREVIOUSLY ISSUED:
   H353004-00000-224-272-0032-0001

HATCH PARALLEL REVIEW – Internal and Client

HATCH	Signature	Date
Port Area Lead		
Rail Area Lead		
PEng Reviewer (NAPEG)		
Construction		
Other		
Other		

BIM	Signature	Date
Port Area Manager		
Mine / Rail Area Manager		
Environmental		
Permitting		
Operations		
Other		
Other		

Review Grade *(check applicable box below)*

C1	C2	C3
Proceed to next submission & status	Proceed with exceptions as noted to next submission & status	Do not proceed. Revise as noted & resubmit
Client Rep.		Date:

NOT FOR CONSTRUCTION

THIS DRAWING WAS PREPARED BY HATCH LTD. ("HATCH") FOR THE EXCLUSIVE USE OF BAFFINLAND IRON MINES LP ("CLIENT") AND ITS USE IS SUBJECT TO THE TERMS AND CONDITIONS OF THE CONTRACT BETWEEN HATCH AND THE THE CLIENT, INCLUDING ANY LIMITATIONS ON LIABILITY CONTAINED THEREIN. THIS DRAWING AND ITS CONTENTS REMAIN THE INTELLECTUAL PROPERTY OF HATCH SUBJECT TO CLIENT'S ROYALTY-FREE, IRREVOCABLE, PERPETUAL AND NON-EXCLUSIVE LICENSE TO USE AND REPRODUCE THE DRAWING FOR PURPOSES CONNECTED WITH THE PROJECT, INCLUDING THE CONSTRUCTION, COMPLETION, MAINTENANCE, EXTENSION, REINSTATEMENT AND REPAIR OF THE PROJECT. THIS DRAWING, AND THE INFORMATION CONTAINED HEREIN, SHALL BE TREATED AS CONFIDENTIAL FOR ALL OTHER PURPOSES AND SHALL NOT BE MODIFIED WITHOUT THE WRITTEN CONSENT OF HATCH.

No.	DESCRIPTION	BY	CHK'D	DATE
.	.	.	.	
0A	INTERNAL / CLIENT REVIEW	.	AA	03/21/2018

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	A VAN NIEKERK	NR	22/11/17
DESIGNER	A VAN NIEKERK	NR	22/11/17
CHECKER	A AQUIL		03/21/2018
DESIGN COORD.	A AQUIL		
RESP. ENG.	F VAN BILJON		
LEAD DISC. ENG.	F VAN BILJON		03/21/2018
AREA LEAD	F VAN BILJON		
ENG. MANAGER			
AREA MANAGER			

DRAWING APPROVAL STATUS: INTERNAL / CLIENT REVIEW

HATCH

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

RAIL SITE
STANDARD DRAWING
TYPICAL CUT-OFF DRAIN DETAIL

DRAWING No.	DRAWING TITLE
.	.

REFERENCE DRAWINGS

REG. PROFESSIONAL

REVISIONS

SCALE 1:100 OR AS NOTED

DWG. No. H353004-30000-224-294-0008-0001

REV 0A

SHEET SIZE: D

$USERNAME$
$DATE$
$FILE$
$TIME$

ATTACHMENT 7

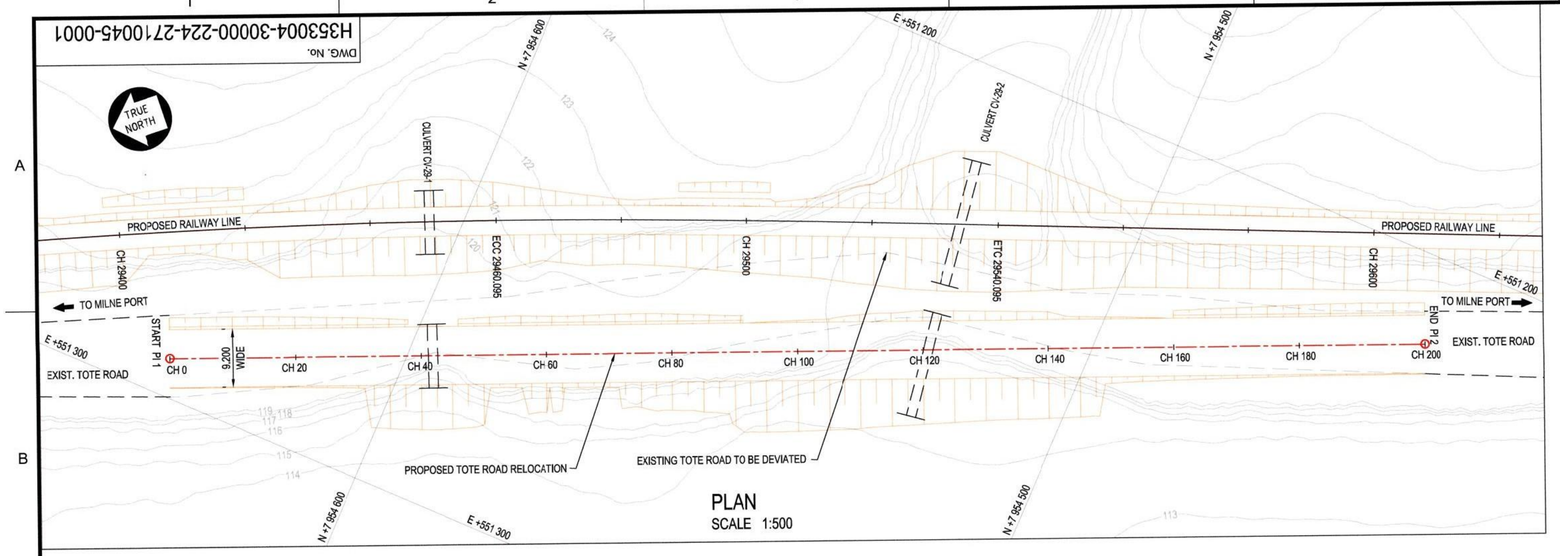
TOTE ROAD REALIGNMENT DRAWINGS

7.1 Tote Road Relocation Drawings
7.2 Tote Road Rail Crossing Drawings
7.3 Tote Road Typical Drawings

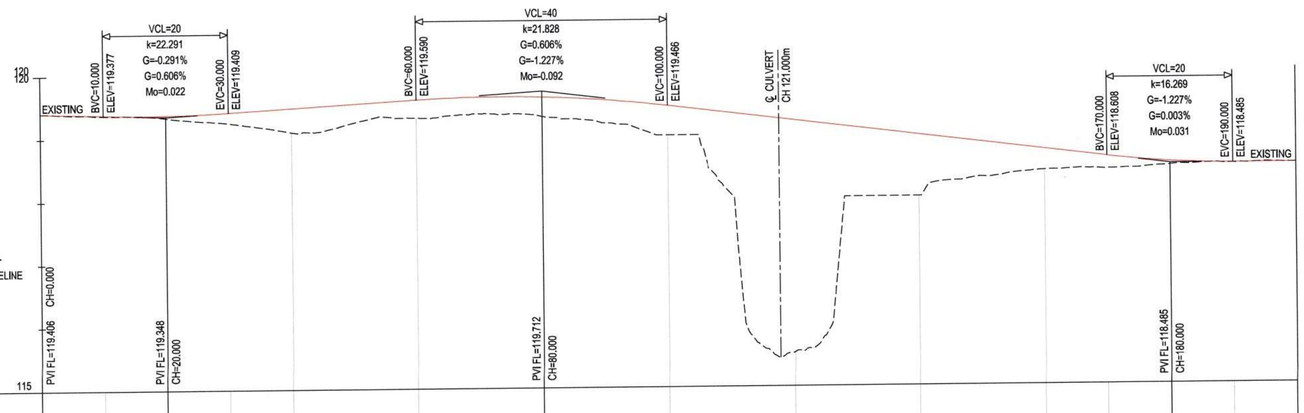
ATTACHMENT 7.1

TOTE ROAD RELOCATION DRAWINGS

DWG. No. H353004-30000-224-2710045-0001



PLAN
SCALE 1:500



SCALE:
HOR 1:500
VERT 1:50
DATUM 115

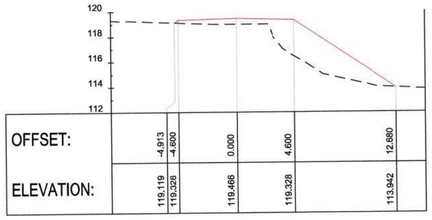
CUT DEPTH: 0.001																				0.002
FILL HEIGHT:		0.007	0.041	0.168	0.382	0.287	0.308	0.466	3.687	0.976	0.333	0.201	0.054	0.004						
ROAD LEVEL: 119.406	PVI FL=119.406	119.377	119.370	119.409	119.469	119.590	119.620	119.466	119.221	118.976	118.730	118.608	118.516	118.485	PVI FL=118.485					118.485
NGL: 119.407		119.370	119.329	119.241	119.087	119.303	119.312	119.000	115.334	118.000	118.397	118.407	118.462	118.481						118.487
CHAINAGE: 0.000	CH=0.000	10.000	20.000	30.000	40.000	60.000	80.000	100.000	120.000	140.000	160.000	170.000	180.000	190.000	CH=180.000					200.000
HORIZONTAL:										L=200.000										
VERTICAL:		L=10.00 G=1:-343.14	VC=20.00	L=30.00 G=1:165.07				VC=40.00		L=70.00 G=1:-81.52				VC=20.00		L=10.00 G=1:3770.60				

PVI FL=119.348, CH=20.000; PVI FL=119.712, CH=80.000

LONGITUDINAL SECTION

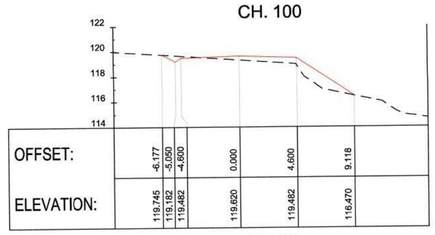
CO-ORDINATE LIST UTM (NAD83) ZONE 17		
	E	N
PI 1 START	521305.852	7954634.540
PI 2 END	521386.398	7954451.477

CROSS SECTIONS
SCALE 1:200



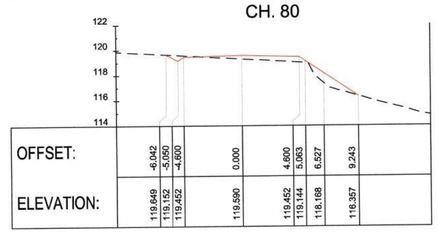
OFFSET:	-4.913	-4.600	0.000	4.600	12.680
ELEVATION:	119.119	119.328	119.466	119.328	113.942

CH. 100



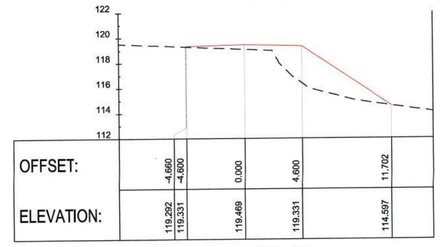
OFFSET:	-6.177	-5.050	-4.600	0.000	4.600	9.118
ELEVATION:	119.745	119.167	119.482	119.620	119.482	116.470

CH. 80



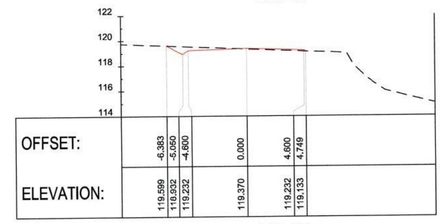
OFFSET:	-6.042	-5.050	-4.600	0.000	4.600	5.063	6.527	9.243
ELEVATION:	119.649	119.152	119.452	119.590	119.452	119.144	119.188	116.357

CH. 60



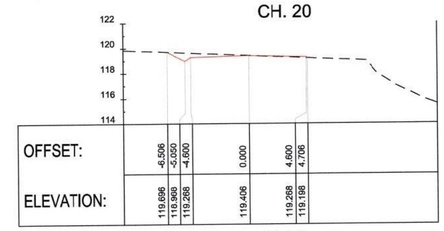
OFFSET:	-6.660	-4.600	0.000	4.600	11.702
ELEVATION:	119.292	119.331	119.469	119.331	114.597

CH. 40



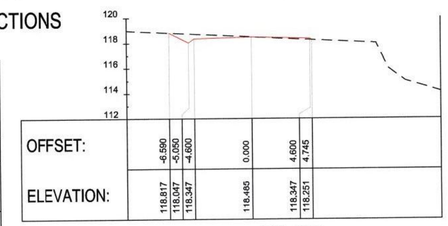
OFFSET:	-6.383	-5.050	-4.600	0.000	4.600	4.749
ELEVATION:	119.599	119.932	119.232	119.370	119.232	119.133

CH. 20



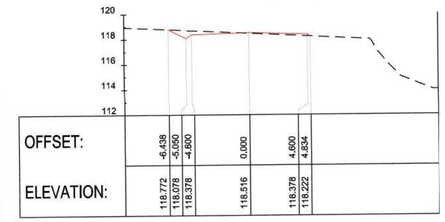
OFFSET:	-6.506	-5.050	-4.600	0.000	4.600	4.706
ELEVATION:	119.696	119.969	119.268	119.406	119.268	119.198

CH. 0



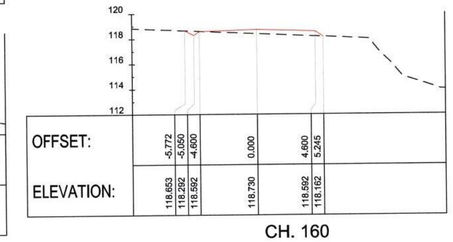
OFFSET:	-6.590	-5.050	-4.600	0.000	4.600	4.745
ELEVATION:	118.817	118.047	118.347	118.465	118.347	118.251

CH. 200



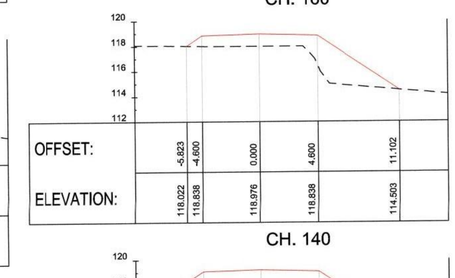
OFFSET:	-6.438	-5.050	-4.600	0.000	4.600	4.834
ELEVATION:	118.772	118.078	118.378	118.516	118.378	118.222

CH. 180



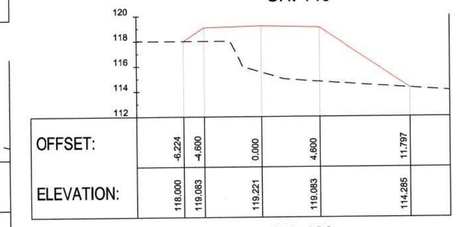
OFFSET:	-5.772	-5.050	-4.600	0.000	4.600	5.245
ELEVATION:	118.653	118.292	118.592	118.730	118.592	118.162

CH. 160



OFFSET:	-5.823	-4.600	0.000	4.600	11.102
ELEVATION:	118.022	118.838	118.976	118.838	114.503

CH. 140



OFFSET:	-6.224	-4.600	0.000	4.600	11.797
ELEVATION:	118.000	119.083	119.221	119.083	114.285

CH. 120

GENERAL NOTES:

1. LIDAR SURVEY PROVIDED BY PHOTSAT (2018)
2. CO-ORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METERS.
3. CONTOURS ARE IN METERS. CONTOUR INTERVAL IS 1m.
4. ALL DIMENSIONS SHOWN ARE IN MILLIMETERS, UNLESS OTHERWISE SPECIFIED.
5. FOR TYPICAL ROAD CROSS SECTION SEE DRG. NO.: H353004-30000-224-294-0010-0001
6. ALL CHAINAGES INDICATED FOR THE ROAD ARE LOCAL CHAINAGES.

LEGEND :
FORMATION
NGL

PERMIT TO PRACTICE
HATCH LTD.
Signature
Date 2019-4-24
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

REGISTERED PROFESSIONAL ENGINEER D. STANGER LICENSEE NT/NU

APPROVED FOR CONSTRUCTION

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No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR CONSTRUCTION	AJVN	AA	2018/04/06

DRAWING No.	DRAWING TITLE
H353004-30000-224-294-0010-0001	TYPICAL HAUL ROAD CROSS SECTION

REFERENCE DRAWINGS

REG. PROFESSIONAL

REVISIONS

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	A VAN NIEKERK	NR	22/03/18
DESIGNER	A VAN NIEKERK	NR	22/03/18
CHECKER	A AQUIL		2018/04/23
DESIGN COORD.	A AQUIL		2018/04/23
RESP. ENG.	D STANGER		2018/04/23
LEAD DISC. ENG.	F VAN BILJON		2018/04/23
AREA LEAD	F VAN BILJON		2018/04/23
ENG. MANAGER	D STANGER		2018/04/23
AREA MANAGER	F. PITTMAN		2018/4/25

DRAWING APPROVAL STATUS: APPROVED FOR CONSTRUCTION

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

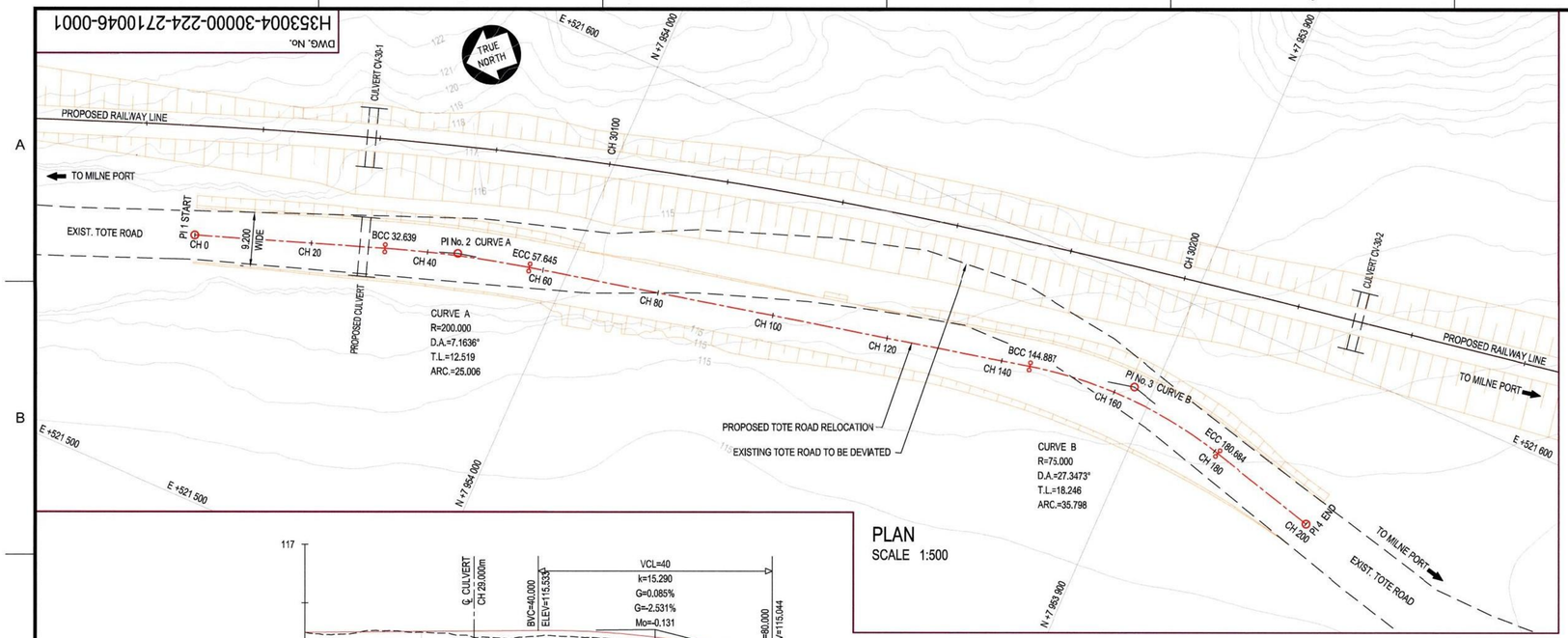
TOTE ROAD
ROAD RELOCATION AT CH. 29+500
LAYOUT, LONGITUDINAL AND CROSS SECTIONS

SCALE	DWG. No.	REV
AS NOTED OR AS NOTED	H353004-30000-224-2710045-0001	0

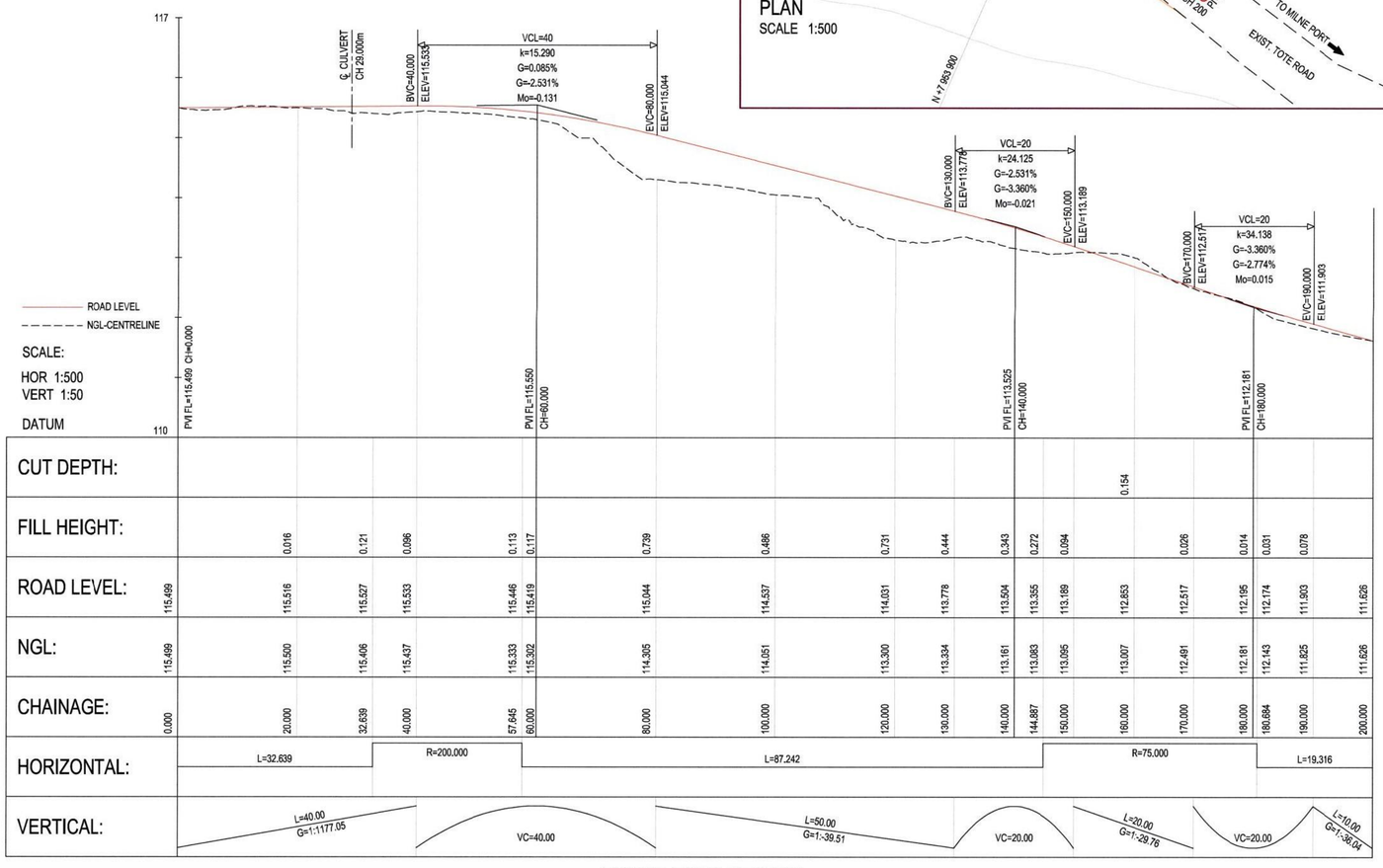
SHEET SIZE: A1

$USERNAMES
$DATES
$FILES
$TIMES

DWG. No. H353004-30000-224-2710046-0001

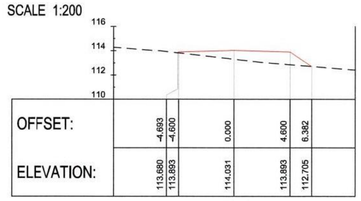


PLAN
SCALE 1:500

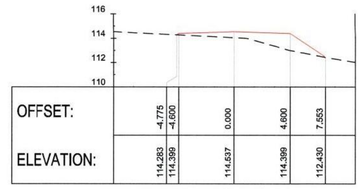


LONGITUDINAL SECTION

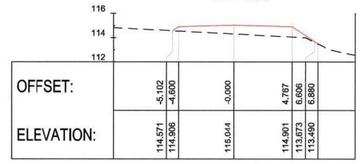
CROSS SECTIONS
SCALE 1:200



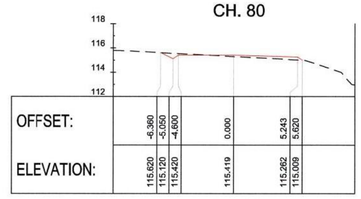
CH. 120



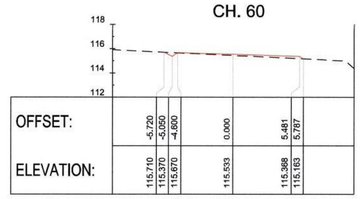
CH. 100



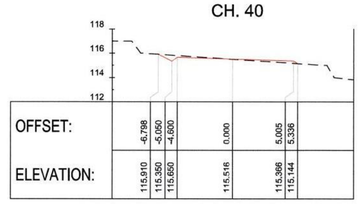
CH. 80



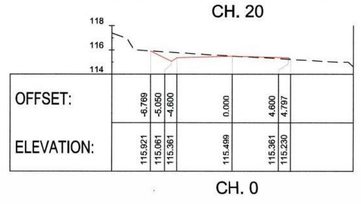
CH. 60



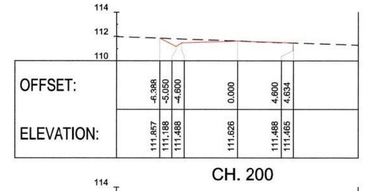
CH. 40



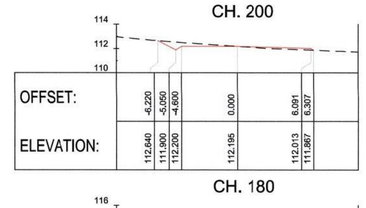
CH. 20



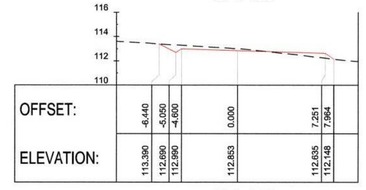
CH. 0



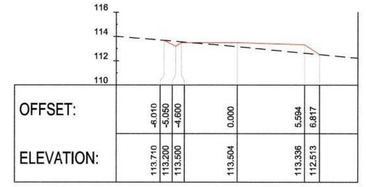
CH. 200



CH. 180



CH. 160



CH. 140

GENERAL NOTES:
1. LIDAR SURVEY PROVIDED BY PHOTSAT (2016)
2. CO-ORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METERS.
3. CONTOURS ARE IN METERS. CONTOUR INTERVAL IS 1m.
4. ALL DIMENSIONS SHOWN ARE IN MILLIMETERS, UNLESS OTHERWISE SPECIFIED.
5. FOR TYPICAL ROAD CROSS SECTION SEE DRG. NO.: H353004-30000-224-294-0010-0001
6. ALL CHAINAGES INDICATED FOR THE ROAD ARE LOCAL CHAINAGES.

CO-ORDINATE LIST UTM (NAD83) ZONE 17		
	E	N
PI 1 START	521541.910	7954060.966
BCC CURVE A	521552.951	7954030.251
PI 2 CURVE A	521557.186	7954018.470
ECC CURVE A	521559.919	7954006.252
BCC CURVE B	521578.961	7953921.114
PI 3 CURVE B	521582.944	7953903.307
ECC CURVE B	521578.301	7953885.661
PI 4 END	521573.387	7953866.981

LEGEND :
FORMATION
NGL

PERMIT TO PRACTICE
HATCH LTD.
Signature
Date 2018-4-24
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

APPROVED FOR CONSTRUCTION

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REGISTERED PROFESSIONAL ENGINEER D. STANGER LICENSEE NT/NU

No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR CONSTRUCTION	AJVN	AA	06/04/2018

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	A VAN NIEKERK	NR	22/03/18
DESIGNER	A VAN NIEKERK	NR	22/03/18
CHECKER	A AQUIL		2018/04/23
DESIGN COORD.	A AQUIL		2018/04/23
RESP. ENG.	D STANGER		2018/04/23
LEAD DISC. ENG.	F VAN BILJON		2018/04/23
AREA LEAD	F VAN BILJON		2018/04/23
ENG. MANAGER	D STANGER		2018/04/23
AREA MANAGER	F. PITTMAN		2018/4/25

DRAWING APPROVAL STATUS: APPROVED FOR CONSTRUCTION

HATCH

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

TOTE ROAD
ROAD RELOCATION AT CH. 31+200
LAYOUT, LONGITUDINAL AND CROSS SECTIONS

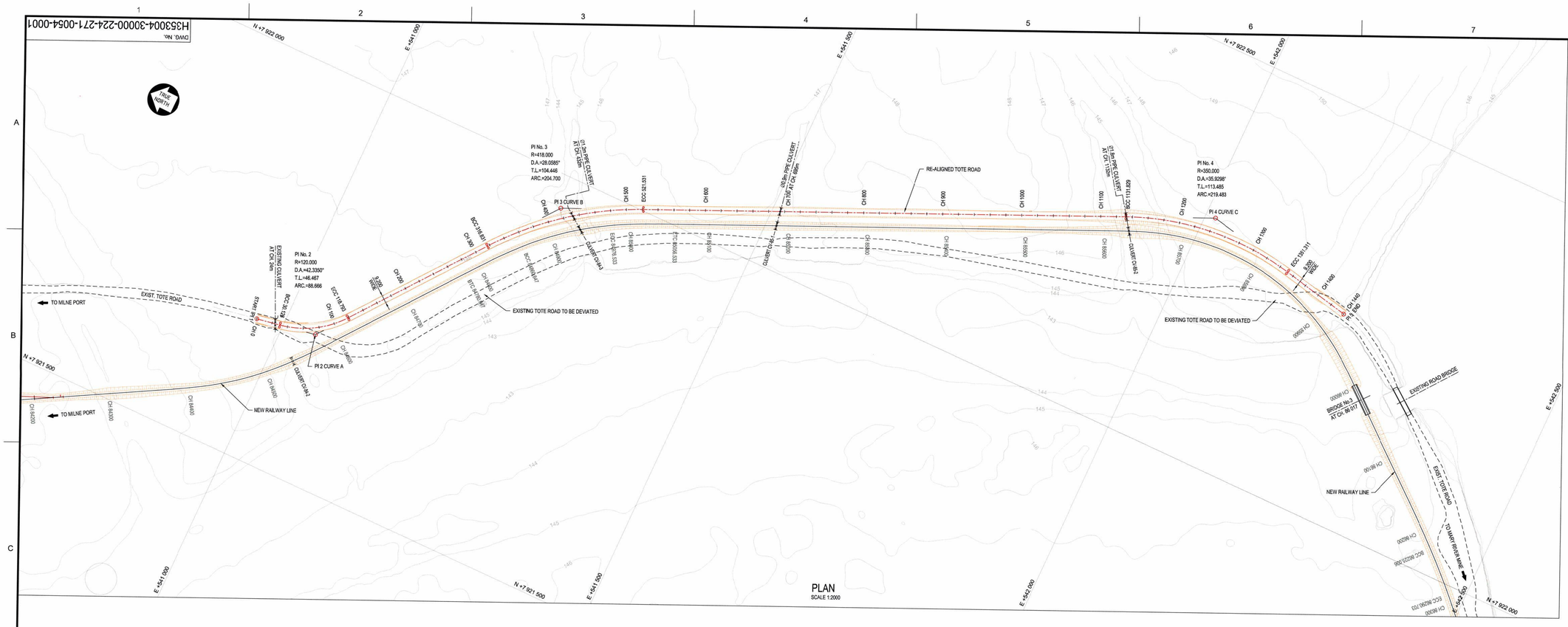
REFERENCE DRAWINGS		REG. PROFESSIONAL
DRAWING No.	DRAWING TITLE	
H353004-30000-224-294-0010-0001	TYPICAL HAUL ROAD CROSS SECTION	

SCALE: AS NOTED OR AS NOTED
D/WG. No.: H353004-30000-224-2710046-0001
REV: 0
SHEET SIZE: A1

$USERNAMES $DATES $TIMES $FILES

DWG. No. H353004-30000-224-271-0054-0001

TRUE NORTH

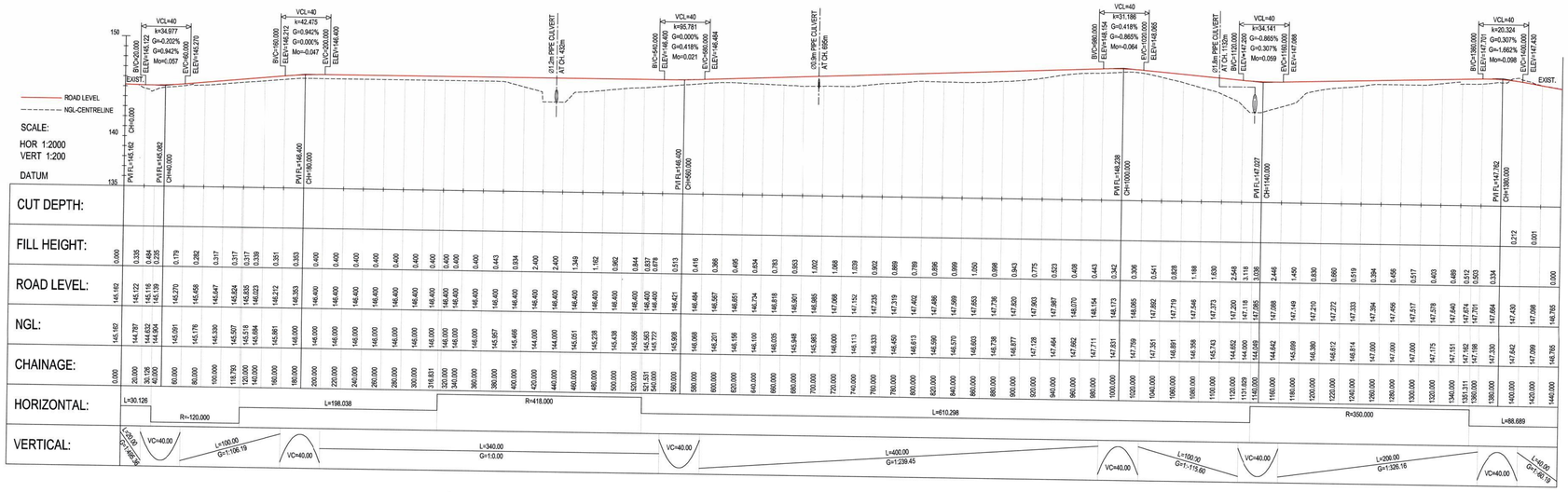


PLAN
SCALE 1:2000

GENERAL NOTES:

1. LIDAR SURVEY PROVIDED BY PHOTSAT (2016)
2. CO-ORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METERS.
3. CONTOURS ARE IN METERS. CONTOUR INTERVAL IS 1m.
4. ALL DIMENSIONS SHOWN ARE IN MILLIMETERS, UNLESS OTHERWISE SPECIFIED.
5. FOR TYPICAL ROAD CROSS SECTION SEE DRG. NO.: H353004-30000-224-294-0010-0001
6. ALL CHAINAGES INDICATED FOR THE ROAD ARE LOCAL CHAINAGES.

CO-ORDINATE LIST UTM (NAD83) ZONE 17		
	E	N
PI 1 START	540966.499	7921671.108
BCC CURVE A	540996.191	7921676.208
PI 2 CURVE A	541041.987	7921684.075
ECC CURVE A	541070.542	7921720.733
BCC CURVE B	541192.241	7921876.964
PI 3 CURVE B	541256.426	7921959.361
CULVERT AT CH.432m	541274.451	7921956.905
ECC CURVE B	541351.825	7922001.882
CULVERT AT CH.699m	541509.910	7922072.346
BCC CURVE C	541909.256	7922250.345
CULVERT AT CH.1132m	541909.712	7922250.548
PI 4 CURVE C	542012.910	7922296.547
ECC CURVE C	542123.954	7922273.135
PI 5 END	542210.735	7922254.838



LONGITUDINAL SECTION

H353004-30000-224-294-0010	TYPICAL HAUL ROAD CROSS SECTION
H353004-30000-224-273-0031	CROSS SECTIONS CH. 0.000m TO CH. 1440.000m
DRAWING No.	DRAWING TITLE

REFERENCE DRAWINGS

APPROVED FOR CONSTRUCTION

THIS DRAWING WAS PREPARED BY HATCH LTD. ("HATCH") FOR THE EXCLUSIVE USE OF BAFFINLAND IRON MINES LP ("CLIENT") AND ITS USE IS SUBJECT TO THE TERMS AND CONDITIONS OF THE CONTRACT BETWEEN HATCH AND THE THE CLIENT. ANY USE OF THIS DRAWING BY ANY THIRD PARTY IS AT THAT PARTY'S SOLE RISK. THE INTELLECTUAL PROPERTY OF HATCH CONTAINED IN OR CONTAINED THEREIN. THIS DRAWING AND ITS CONTENTS REMAIN THE NON-EXCLUSIVE LICENSE TO USE AND REPRODUCE THE CLIENT'S ROYALTY-FREE, IRREVOCABLE, PERPETUAL AND WORLDWIDE LICENSE TO USE AND REPRODUCE THE DRAWING FOR ANY PURPOSE RELATED TO THE PROJECT, INCLUDING THE CONSTRUCTION, COMPLETION, MAINTENANCE, EXTENSION, REINSTATEMENT AND REPAIR OF THE PROJECT. THIS DRAWING, AND THE INFORMATION CONTAINED HEREIN, SHALL BE TREATED AS CONFIDENTIAL FOR ALL OTHER PURPOSES AND SHALL NOT BE MODIFIED WITHOUT THE WRITTEN CONSENT OF HATCH.

No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR CONSTRUCTION	AJVN	TDL	2018/04/06

REVISIONS

REG. PROFESSIONAL ENGINEER D. STANGER LICENSEE NTNU

HATCH

DRAFTSPERSON	A VAN NIEKERK	NR	2018/03/27
DESIGNER	A VAN NIEKERK	NR	2018/03/27
CHECKER	A AQUIL		2018/04/23
DESIGN COORD.	A AQUIL		2018/04/23
RESP. ENG.	D STANGER		2018/04/23
LEAD DISC. ENG.	F VAN BILJON		2018/04/23
AREA LEAD	F VAN BILJON		2018/04/23
ENG. MANAGER	D STANGER		2018/04/23
AREA MANAGER	F.PITTMAN		2018/04/25
ROLE	NAME	SIGNATURE	DATE

DRAWING APPROVAL STATUS: APPROVED FOR CONSTRUCTION

PERMIT TO PRACTICE
HATCH LTD.
Signature
Date 2018-04-24
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

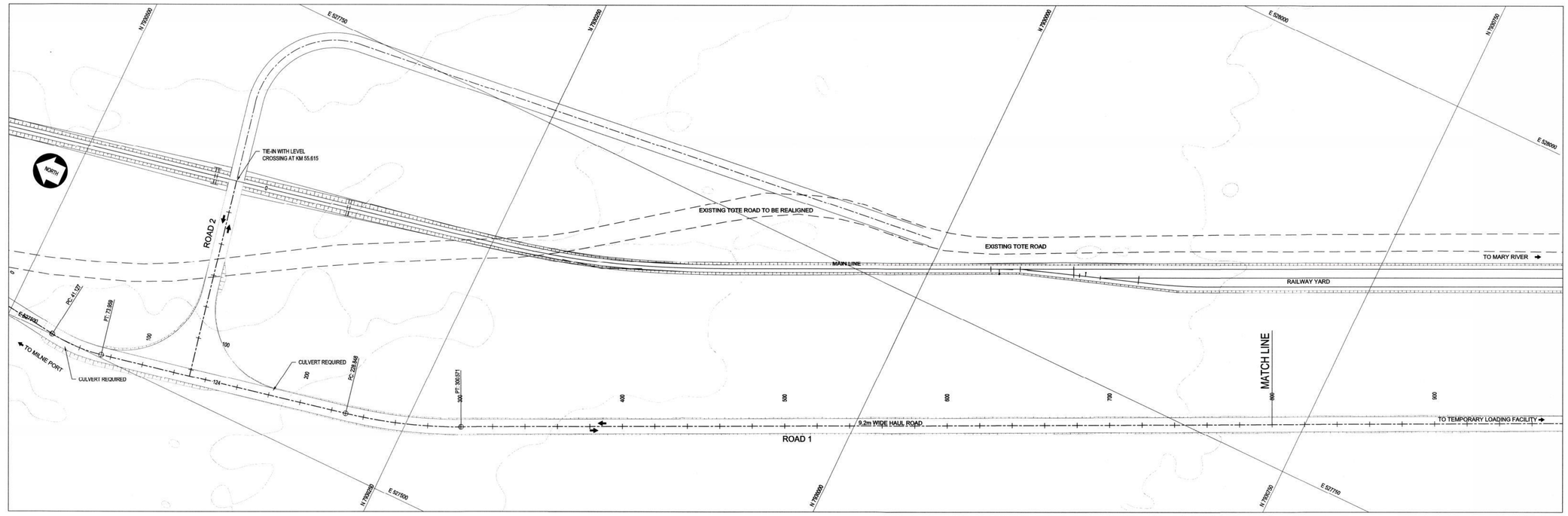
TOTE ROAD
ROAD RELOCATION RAIL CH. 84+500 - 85+900
LAYOUT AND LONGITUDINAL SECTION

SCALE	DWG. No.	REV
1:2000 OR AS NOTED	H353004-30000-224-271-0054-0001	0

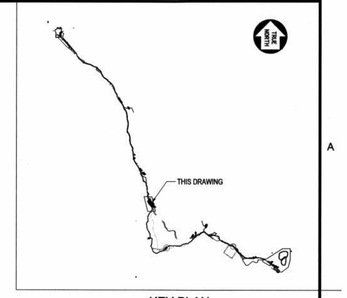
SHEET SIZE: A0

USERNAMES
$TIMES
SCXTB
SPALES

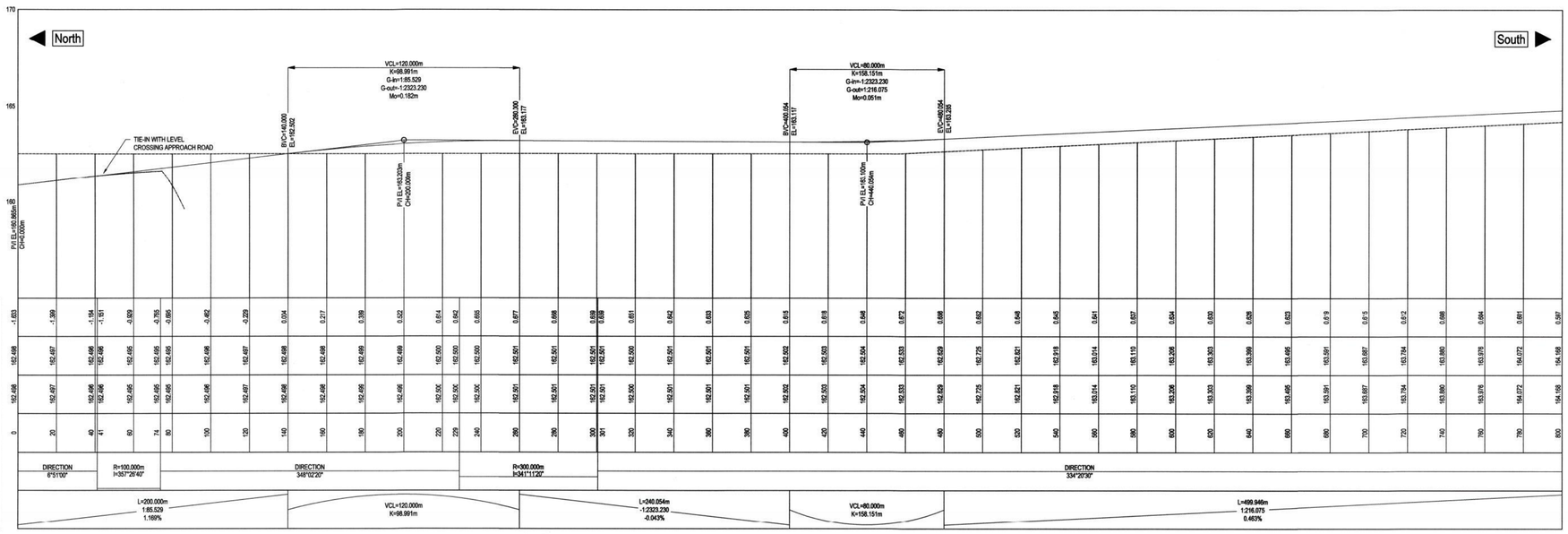
DWG. No. H353004-30000-224-271-0029-0002



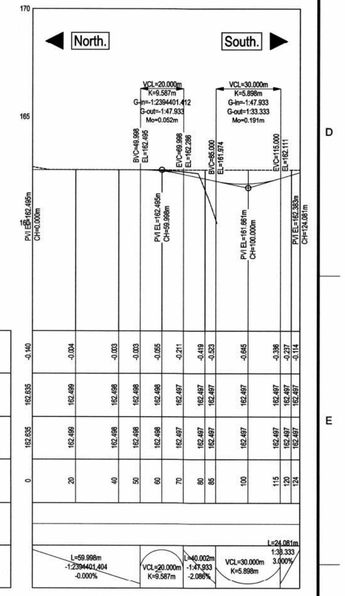
HAUL ROAD LAYOUT
SCALE 1:1000



KEY PLAN
N.T.S.



LONGSECTION PLATFORM ROAD 1
FROM 0.000 TO 800.000



LONGSECTION PLATFORM ROAD 2
FROM 0.000 TO 124.081

H353004-30000-224-273-0032-0001	TEMPORARY LOADOUT CROSS SECTION
H353004-30000-224-271-0029-0003	HAUL ROAD LAYOUT AND PROFILE 800m to 1600m
H353004-30000-224-271-0029-0001	RAIL TEMPORARY LOADING FACILITY
DRAWING No.	DRAWING TITLE

REFERENCE DRAWINGS

NAME
SIGNATURE
ENG REG NUMBER
REVISION DATE
ORIGINAL DATE
REG. PROFESSIONAL

NOT FOR CONSTRUCTION

THIS DRAWING WAS PREPARED BY HATCH LTD. (HATCH) FOR THE EXCLUSIVE USE OF BAFFINLAND IRON MINES LP (CLIENT) AND ITS USE IS SUBJECT TO THE TERMS AND CONDITIONS OF THE CONTRACT BETWEEN HATCH AND THE THE CLIENT. ANY REUSE OF THIS DRAWING BY THE CLIENT OR ANY THIRD PARTY IS AT THE SOLE RISK OF THE USER. HATCH RETAINS THE INTELLECTUAL PROPERTY OF HATCH SUBJECT TO CLIENT'S ROYALTY FREE, IRREVOCABLE, PERPETUAL AND NON-EXCLUSIVE LICENSE TO USE AND REPRODUCE THE DRAWING FOR PURPOSES CONNECTED WITH THE PROJECT, INCLUDING THE CONSTRUCTION, COMPLETION, MAINTENANCE, EXTENSION, REINSTATEMENT AND REPAIR OF THE PROJECT. THIS DRAWING, AND THE INFORMATION CONTAINED HEREIN, SHALL BE TREATED AS CONFIDENTIAL FOR ALL OTHER PURPOSES AND SHALL NOT BE MODIFIED WITHOUT THE WRITTEN CONSENT OF HATCH.

No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR USE	WR	FVB	2017/02/03

REVISIONS

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	S VAN DER WALT	NR	2018/03/21
DESIGNER	S VAN DER WALT	NR	2018/03/21
CHECKER	A AQUIL		2018/05/08
DESIGN COORD.	A AQUIL		2018/05/04
RESP. ENG.	F VAN BILJON		2018/05/08
LEAD DISC. ENG.	F VAN BILJON		2018/05/07
AREA LEAD	F VAN BILJON		2018/05/08
ENG. MANAGER	D STANGER		2018/05/08
CLIENT	F PITTMAN		2018/05/08

DRAWING APPROVAL STATUS: APPROVED FOR USE

Baffinland

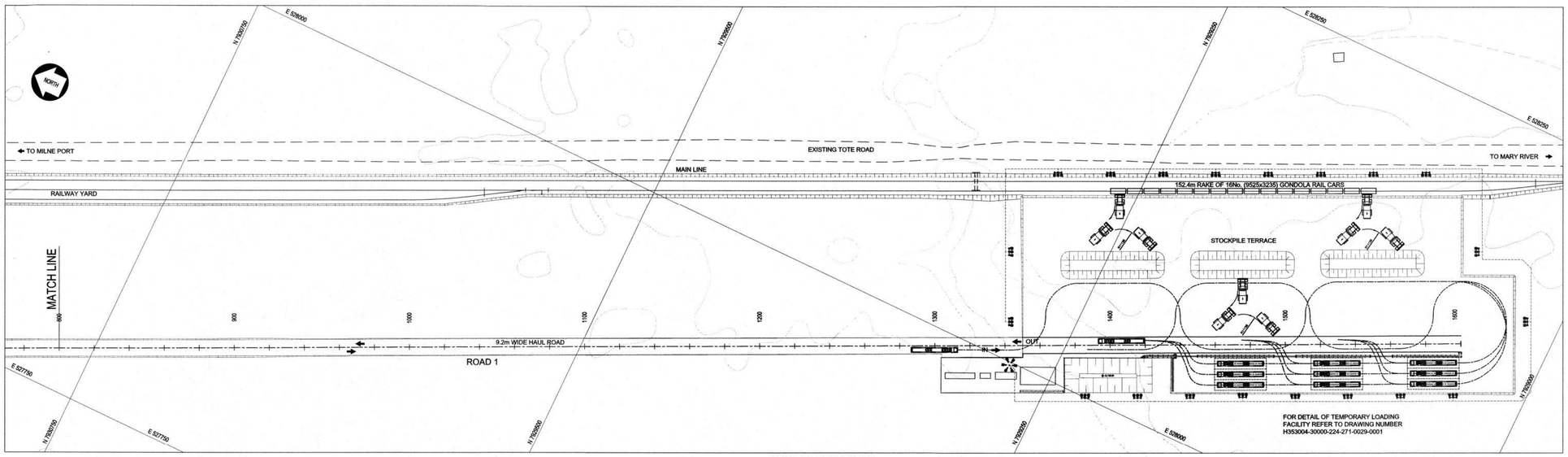
BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

RAIL SITE (56km)
HAUL ROAD LAYOUT AND PROFILE
0.000 KM TO 0.800 KM

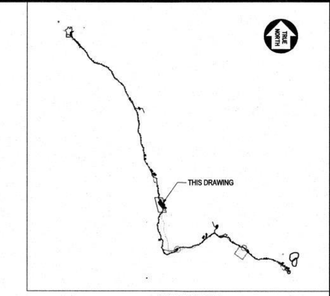
SCALE 1:2000 OR AS NOTED
DWG. No. H353004-30000-224-271-0029-0002
REV 0
SHEET SIZE: A0

$USERNAME
$DATE
$TIME

DWG. No. H353004-30000-224-271-002B-0003



HAUL ROAD LAYOUT
SCALE 1:1000



KEY PLAN
N.T.S.

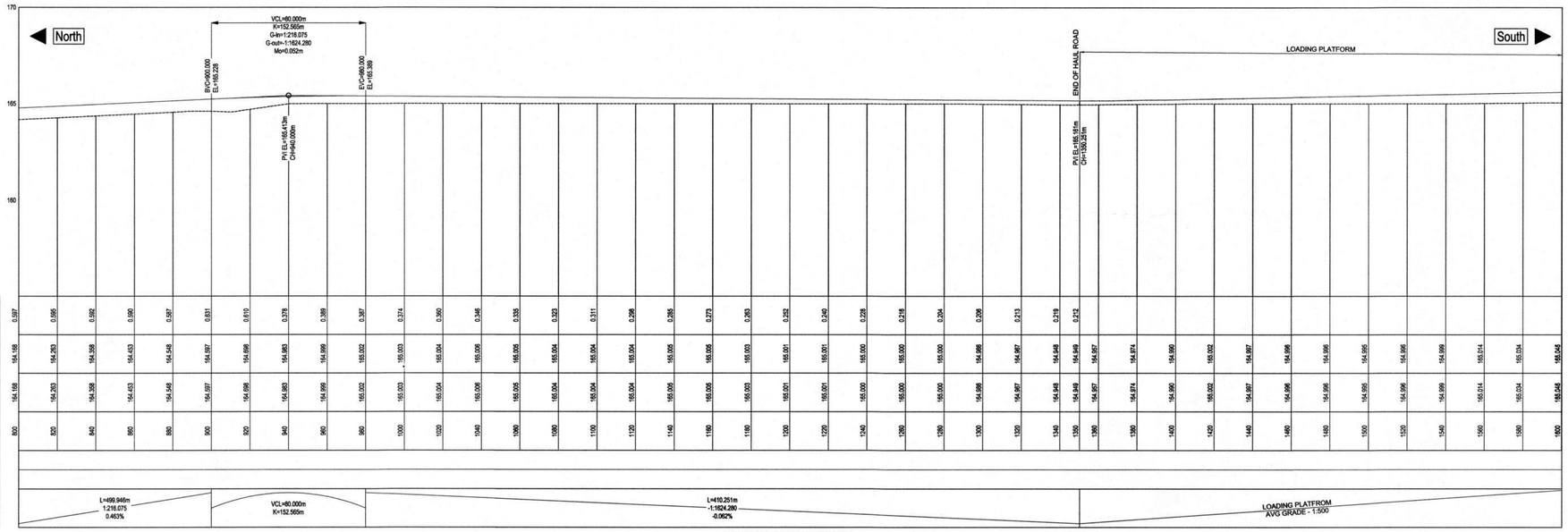
NOTES:

1. LIDAR SURVEY PROVIDED BY PHOTSAT (2016)
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METERS.
3. CONTOURS ARE IN METERS. CONTOUR INTERVAL IS 0.5m.
4. ALL DIMENSIONS SHOWN ARE IN METERS, UNLESS OTHERWISE SPECIFIED.

LEGEND:

198 — CONTOUR

NEW TREATED EFFLUENT



LONGSECTION PLATFORM ROAD 1
FROM 800.000 TO 1350.250

DRAWING No.	DRAWING TITLE
H353004-30000-224-273-0032-0001	TEMPORARY LOADOUT CROSS SECTION
H353004-30000-224-271-0029-0002	HAUL ROAD LAYOUT AND PROFILE 0.0m to 800m
H353004-30000-224-271-0029-0001	RAIL TEMPORARY LOADING FACILITY

REFERENCE DRAWINGS

NAME
SIGNATURE
ENG REG NUMBER
REVISION DATE
ORIGINAL DATE
REG. PROFESSIONAL

NOT FOR CONSTRUCTION

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No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR USE	WR	FVB	2017/02/03

REVISIONS

HATCH

DRAFTSPERSON	S VAN DER WALT	NR	2018/03/21
DESIGNER	S VAN DER WALT	NR	2018/03/21
CHECKER	A AQUIL		2018/05/04
DESIGN COORD.	A AQUIL		2018/05/04
RESP. ENG.	F VAN BILJON		2018/05/04
LEAD DISC. ENG.	F VAN BILJON		2017/07/28
AREA LEAD	F VAN BILJON		2017/07/28
ENG. MANAGER	D STANGER		2017/07/28
CLIENT	F PITTMAN		2018/05/08

ROLE	NAME	SIGNATURE	DATE

DRAWING APPROVAL STATUS: APPROVED FOR USE

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

RAIL SITE (56km)
HAUL ROAD LAYOUT AND PROFILE
0.800 KM TO 1.350 KM

SCALE	DWG. No.	REV
1:1000 OR AS NOTED	H353004-30000-224-271-0029-0003	0

SHEET SIZE: A0

$USERNAME
$DATE
$TIME

DWG. No. H353004-10000-223-271-0001-0001

KEY PLAN
NOT TO SCALE

LEGEND:

- 175 — CONTOUR
- EXISTING POWER LINE
- EXISTING RAW WATER PIPELINE

SETTING OUT DATA - TOTE ROAD1				
NAME	CHAINAGE	E	N	DETAILS
START	0.000	559 915.860	7 913 842.912	L = 175.853m
BCC1 PI1 ECC1	175.853 289.877	560 050.515 560 114.788 560 145.066	7 913 729.808 7 913 675.822 7 913 754.109	R = 60.000m DA = 108°53'00" TL = 83.938m AL = 114.023m
BCC2 PI2 ECC2	307.990 401.478	560 151.600 560 172.970 560 228.492	7 913 771.003 7 913 826.259 7 913 805.590	R = 60.000m DA = 89°16'30" TL = 59.244m AL = 93.487m
BCC3 PI3 ECC3	680.370 933.554	560 489.862 560 611.102 560 695.239	7 913 708.293 7 913 663.161 7 913 564.890	R = 500.000m DA = 29°00'50" TL = 129.368m AL = 253.184m
BCC4 PI4 ECC4	1036.850 1099.000	560 762.419 560 783.306 560 814.492	7 913 486.424 7 913 462.029 7 913 454.356	R = 100.000m DA = 35°36'30" TL = 32.116m AL = 62.151m
END	1100.000	560 815.463	7 913 454.117	L = 1.000m

SCALES:
Horizontal 1:1000
Vertical 1:200

DATUM 175.000

STAKE VALUE (SV)	0	20	40	60	70	80	90	100	120	140	145	160	175	180	200	220	240
GROUND LEVELS ON CL	177.791	177.686	177.613	177.344	177.012	176.972	177.032	177.056	177.203	177.982	178.172	178.638	178.803	178.812	178.756	178.647	178.241
FINAL DESIGN ROAD LEVELS – LEFT EDGE (HL)	177.670	177.598	177.525	177.452	177.416	177.436	177.568	177.755	178.130	178.505	178.599	178.876	179.082	179.102	179.381	179.691	180.002
FINAL DESIGN ROAD LEVELS – CENTRE LINE (CL)	177.790	177.690	177.591	177.492	177.442	177.455	177.593	177.794	178.196	178.598	178.698	178.983	179.233	179.310	179.621	179.931	180.242
FINAL DESIGN ROAD LEVELS – RIGHT EDGE (HR)	177.670	177.598	177.525	177.453	177.416	177.436	177.568	177.755	178.130	178.505	178.599	178.976	179.384	179.519	179.861	180.171	180.482

STAKE VALUE (SV)	255	260	265	275	280	300	315	320	330	340	345	360	380	400	420	440	460	480	500	520	540	550
GROUND LEVELS ON CL	178.097	178.203	178.413	178.911	179.006	180.126	178.900	178.885	178.902	178.931	178.944	179.032	179.180	179.083	179.138	179.025	178.936	178.741	178.779	178.492	178.348	178.415
FINAL DESIGN ROAD LEVELS – LEFT EDGE (HL)	180.235	180.303	180.371	180.480	180.510	180.630	180.720	180.739	180.715	180.605	180.489	180.111	179.756	179.572	179.372	179.334	179.365	179.396	179.427	179.457	179.437	179.399
FINAL DESIGN ROAD LEVELS – CENTRE LINE (CL)	180.475	180.543	180.591	180.630	180.630	180.630	180.630	180.628	180.611	180.578	180.555	180.479	180.379	180.278	180.178	180.077	179.977	179.876	179.776	179.675	179.598	179.576
FINAL DESIGN ROAD LEVELS – RIGHT EDGE (HR)	180.715	180.783	180.791	180.780	180.750	180.630	180.540	180.499	180.355	180.125	180.009	179.631	179.276	179.216	179.302	179.334	179.365	179.396	179.427	179.457	179.437	179.399

VERTICAL PROFILE GRADES
BVC 70.000 VCL=20.000m K=8 EVC 90.000; BVC 145.000 VCL=30.000m K=66 EVC 175.000; BVC 255.000 VCL=20.000m K=13 EVC 275.000; BVC 315.000 VCL=30.000m K=60 EVC 345.000; BVC 520.000 VCL=40.000m K=87 EVC 560.00
-0.498% | 80.000 177.392 | 2.010% | 160.000 179.000 | 1.552% | 265.000 180.630 | 0.000% | 330.000 180.630 | -0.502% | 540.000 179.575

SUPERELEVATION (LEFT ········ RIGHT – – –)
-2.0% / -2.0% | 4.0% / -4.0% | 4.0% / -4.0% | 4.0% / -4.0% | 4.0% / -4.0% | -2.0% / -2.0%

HORIZONTAL ALIGNMENT
DIRECTION 310° 01' 40" | BCC 0.175853 | R=60.000m I=255° 35' 10" | ECC 0.289877 | DIRECTION 201° 08' 40" | BCC 0.307990 | R=60.000m I=245° 46' 50" | ECC 0.401478 | DIRECTION 290° 25' 10"

NOTES:

1. LIDAR SURVEY PROVIDED BY PHOTSAT (2016)
2. CO-ORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METERS.
3. CONTOURS ARE IN METERS. CONTOUR INTERVAL IS 0.5m.
4. ALL DIMENSIONS SHOWN ARE IN METERS, UNLESS OTHERWISE SPECIFIED.
5. REFER TO THE "PRIMARY ROAD - TYPICAL CROSS SECTION" ON DRAWING No. H353004-10000-221-0002-0001 FOR CROSS SECTIONAL DETAILS.

ROAD DATA LEGEND:

BVC	BEGINNING VERTICAL CURVE
EVC	END VERTICAL CURVE
BCC	BEGINNING CIRCULAR CURVE
ECC	END CIRCULAR CURVE
R	RADIUS (CURVE)
DA	DEFLECTION ANGLE (CURVE)
TL	TANGENT LENGTH (CURVE)
AL	ARC LENGTH (CURVE)

PERMIT TO PRACTICE
HATCH LTD.
Signature [signature]
Date 2017-12-05
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

REFERENCE DRAWINGS

DRAWING No.	DRAWING TITLE
H353004-00000-221-294-0001-0001	STANDARD DRAWING - TYPICAL CULVERT DETAILS
H353004-00000-224-272-0027-0001	RAILWAY PLAN AND LONGITUDINAL SECTION CH106,900km TO CH109,611km
H353004-10000-221-273-0002-0001	HAUL, PRIMARY AND SECONDARY ROADS - TYPICAL CROSS SECTIONS
H353004-10000-223-272-0009-0001	TOTE ROAD & RAILROAD LEVEL CROSSING - LAYOUT PLAN AND DETAILS
H353004-10000-223-271-0002-0001	TOTE ROAD RE-ALIGNMENT SHEET 2 OF 2- PLAN AND PROFILE

REG. PROFESSIONAL: REGISTERED PROFESSIONAL ENGINEER R. A. HALIM L1247 LICENSEE 2017-12-05 NWT/NU

FOR CONSTRUCTION

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REVISIONS

No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR CONSTRUCTION	IHB	EB	28/11/2017

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	I BARNARD	NR	
DESIGNER	S HALL	NR	
CHECKER	E BALEGAMIRE	[signature]	2017-12-05
DESIGN COORD.	R GOOSEN	[signature]	2017-12-05
RESP. ENG.	R HALIM	[signature]	2017-12-05
LEAD DISC. ENG.	A GROBBELAAR	[signature]	2017-12-05
AREA MANAGER	V LAVRIC	[signature]	2017-12-08
PROJ. MANAGER	S HEINER	[signature]	2017-12-08
CLIENT	F PITTMAN	[signature]	2017-12-18

DRAWING APPROVAL STATUS: Approved for Construction

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

MINE SITE
TOTE ROAD RE-ALIGNMENT SHEET 1 OF 2
PLAN AND PROFILE

SCALE 1:1000 OR AS NOTED | DWG. No. H353004-10000-223-271-0001-0001 | REV 0

SHEET SIZE: D

$USERNAMES $DATES $FILES $TIMES

H353004-10000-223-271-0002-0001
DWG. No.

CULVERT SCHEDULE

CULVERT ID	FISH BEARING	NUMBER OF PIPES	D (mm)	LENGTH (m)	E (mm)	W (mm)	TYPE	UPSTREAM CULVERT CENTRE NORTHING	UPSTREAM CULVERT CENTRE EASTING	U/S INV. ELEV (m)	RIP RAP REQ'D	DOWNSTREAM CULVERT CENTRE NORTHING	DOWNSTREAM CULVERT CENTRE EASTING	D/S INV. ELEV (m)	RIP RAP REQ'D	C (mm)	L (m)	S (%)	SKEW (DEGREE)
M-CULV-4	YES	2	1500	31.330	150	3500	CSP	7913499.8	560764.4	179.139	YES	7913501.4	560734.3	178.678	YES	500	6.08	1.81	46
M-CULV-5	NO	1	600	16.601	0	600	CSP	7913751.1	560351.4	178.35	NO	7913766.6	560357.5	178.215	NO	300	2.4	0.82	90
M-CULV-15	NO	1	600	22.646	0	600	CSP	7913712.0	560118.9	178.23	NO	7913726.9	560102.0	178.115	NO	300	2.4	0.49	61.7
M-CULV-16	NO	1	600	16.925	0	600	CSP	7913706.6	560516.9	178.39	NO	7913691.0	560510.2	178.390	NO	300	2.4	0.00	90

CULVERT SCHEDULE LEGEND:

D	CULVERT DIAMETER
E	EMBEDMENT DEPTH
C	CULVERT SPACING AND BEDDING CLEARANCE C = 500 WHILE D > 900mm C = 300 WHILE D < = 900mm
W	CULVERT BACKFILL TOP WIDTH W = (n*D) + (n-1)*C
TYPE	CULVERT MATERIAL
U/S INV.	CULVERT UPSTREAM INVERT ELEVATION
D/S INV.	CULVERT DOWNSTREAM INVERT ELEVATION
L	RIPRAP APRON LENGTH L = 4xD (APPROX)
S	CULVERT SLOPE
LENGTH	CULVERT LENGTH
CSP	CORRUGATED STEEL PIPE

KEY PLAN
NOT TO SCALE

LEGEND:

180 — CONTOUR

SETTING OUT DATA - TOTE ROAD1

NAME	CHAINAGE	E	N	DETAILS
START	0.000	559 915.860	7 913 842.912	L = 175.853m
BCC1 PI1 ECC1	175.853 289.877	560 050.515 560 114.788 560 145.066	7 913 729.808 7 913 675.822 7 913 754.109	R = 60.000m DA = 108°53'00" TL = 83.938m AL = 114.023m
BCC2 PI2 ECC2	307.990 401.478	560 151.600 560 172.970 560 228.492	7 913 771.003 7 913 826.259 7 913 805.590	R = 60.000m DA = 89°16'30" TL = 59.244m AL = 93.487m
BCC3 PI3 ECC3	680.370 933.554	560 489.862 560 611.102 560 695.239	7 913 708.293 7 913 663.161 7 913 564.890	R = 500.000m DA = 29°00'50" TL = 129.368m AL = 253.184m
BCC4 PI4 ECC4	1036.850 1099.000	560 762.419 560 783.306 560 814.492	7 913 486.424 7 913 462.029 7 913 454.356	R = 100.000m DA = 35°36'30" TL = 32.116m AL = 62.151m
END	1100.000	560 815.463	7 913 454.117	L = 1.000m

SCALES:
Horizontal 1:1000
Vertical 1:200

DATUM 175.000

STAKE VALUE (SV)	GROUND LEVELS ON CL	FINAL DESIGN ROAD LEVELS: LEFT EDGE (HL)	FINAL DESIGN ROAD LEVELS: CENTRE LINE (CL)	FINAL DESIGN ROAD LEVELS: RIGHT EDGE (HR)
550	178.415	179.399	179.576	179.399
560	178.488	179.345	179.566	179.345
580	178.553	179.230	179.557	179.230
600	178.646	179.116	179.548	179.116
620	178.573	179.001	179.539	179.001
640	178.414	178.887	179.530	178.887
660	178.390	178.772	179.521	178.772
665	178.390	178.743	179.519	178.743
680	178.390	178.719	179.547	178.719
690	178.390	178.773	179.604	178.773
700	178.390	178.883	179.691	178.883
715	178.441	179.152	179.881	179.152
720	178.475	179.263	179.955	179.263
740	178.433	179.705	180.254	179.705
760	178.679	180.146	180.553	180.146
775	178.846	180.478	180.777	180.478
780	179.368	180.588	180.849	180.588
800	180.772	180.984	181.093	180.984
820	180.828	181.148	181.264	181.148
825	180.866	181.178	181.296	181.178
840	180.778	181.266	181.383	181.266
860	181.129	181.384	181.500	181.384
880	181.202	181.502	181.616	181.502
900	180.333	181.620	181.733	181.620
910	179.960	181.679	181.791	181.679
920	180.039	181.738	181.836	181.738
930	180.193	181.779	181.853	181.779
940	180.334	181.734	181.844	181.734
950	180.261	181.688	181.808	181.688
960	180.063	181.642	181.758	181.642
980	179.648	181.551	181.658	181.551
1000	179.428	181.459	181.558	181.459
1020	178.969	181.367	181.458	181.443
1040	180.137	181.275	181.358	181.515
1060	180.692	181.184	181.258	181.424
1080	180.987	181.092	181.158	181.212
1100	181.120	181.000	181.058	181.000

VERTICAL PROFILE GRADES
BVC 520.000 — VCL=40.000m K=87 — EVC 560.000; 540.000 179.575; -0.045%
BVC 665.000 — VCL=50.000m K=33 — EVC 715.000; 690.000 179.507; 1.493%
BVC 775.000 — VCL=50.000m K=55 — EVC 825.000; 800.000 181.150; 0.583%
BVC 910.000 — VCL=40.000m K=37 — EVC 950.000; 930.000 181.908; -0.500%

SUPERELEVATION LEFT ·········· RIGHT – – – –
-2.0% -2.0% | 2.0% -2.0% | 2.0% -2.0% | -2.0% -2.0%

HORIZONTAL ALIGNMENT
DIRECTION 290° 25' 10" | BCC 0.680370 | R=500.000m I=304° 55' 30" | ECC 0.933554 | DIRECTION 319° 25' 50" | BCC 1.036850 | R=100.000m I=301° 37' 30" | ECC 1.099000

NOTES:

1. LIDAR SURVEY PROVIDED BY PHOTSAT (2016)
2. CO-ORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METERS.
3. CONTOURS ARE IN METERS. CONTOUR INTERVAL IS 0.5m.
4. ALL DIMENSIONS SHOWN ARE IN METERS, UNLESS OTHERWISE SPECIFIED.
5. REFER TO THE "PRIMARY ROAD - TYPICAL CROSS SECTION" ON DRAWING No. H353004-10000-221-0002-0001 FOR CROSS SECTIONAL DETAILS.

ROAD DATA LEGEND:

BVC	BEGINNING VERTICAL CURVE
EVC	END VERTICAL CURVE
BCC	BEGINNING CIRCULAR CURVE
ECC	END CIRCULAR CURVE
R	RADIUS (CURVE)
DA	DEFLECTION ANGLE (CURVE)
TL	TANGENT LENGTH (CURVE)
AL	ARC LENGTH (CURVE)

PERMIT TO PRACTICE
HATCH LTD.
Signature [signature]
Date 2017-12-05
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

DRAWING No.	DRAWING TITLE
H353004-00000-221-294-0001-0001	STANDARD DRAWING - TYPICAL CULVERT DETAILS
H353004-00000-224-272-0027-0001	RAILWAY PLAN AND LONGITUDINAL SECTION CH106,900km TO CH109,611km
H353004-10000-221-273-0002-0001	HAUL, PRIMARY AND SECONDARY ROADS - TYPICAL CROSS SECTIONS
H353004-10000-223-272-0009-0001	TOTE ROAD AND RAILROAD LEVEL CROSSING - LAYOUT PLAN AND DETAILS
H353004-10000-223-271-0001-0001	TOTE ROAD RE-ALIGNMENT SHEET 1 OF 2 - PLAN AND PROFILE

REFERENCE DRAWINGS

REGISTERED PROFESSIONAL ENGINEER L1247 R. A. HALIM LICENSEE 2017-12-05 NWT/NU

REG. PROFESSIONAL

FOR CONSTRUCTION

THIS DRAWING WAS PREPARED BY HATCH LTD. ("HATCH") FOR THE EXCLUSIVE USE OF BAFFINLAND IRON MINES LP ("CLIENT") AND ITS USE IS SUBJECT TO THE TERMS AND CONDITIONS OF THE CONTRACT BETWEEN HATCH AND THE THE CLIENT, INCLUDING ANY LIMITATIONS ON LIABILITY CONTAINED THEREIN. THIS DRAWING AND ITS CONTENTS REMAIN THE INTELLECTUAL PROPERTY OF HATCH SUBJECT TO CLIENT'S ROYALTY-FREE, IRREVOCABLE, PERPETUAL AND NON-EXCLUSIVE LICENSE TO USE AND REPRODUCE THE DRAWING FOR PURPOSES CONNECTED WITH THE PROJECT, INCLUDING THE CONSTRUCTION, COMPLETION, MAINTENANCE, EXTENSION, REINSTATEMENT AND REPAIR OF THE PROJECT. THIS DRAWING, AND THE INFORMATION CONTAINED HEREIN, SHALL BE TREATED AS CONFIDENTIAL FOR ALL OTHER PURPOSES AND SHALL NOT BE MODIFIED WITHOUT THE WRITTEN CONSENT OF HATCH.

No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR CONSTRUCTION	IHB	EB	28/11/2017

REVISIONS

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	I BARNARD	NR	06/10/2017
DESIGNER	S HALL	NR	06/10/2017
CHECKER	E BALEGAMIRE	[signature]	2017-12-05
DESIGN COORD.	R GOOSEN	[signature]	2017-12-05
RESP. ENG.	R HALIM	[signature]	2017-12-05
LEAD DISC. ENG.	A GROBBELAAR	[signature]	2017-12-05
AREA MANAGER	V LAVRIC	[signature]	2017-12-08
PROJ. MANAGER	S HEINER	[signature]	2017-12-08
CLIENT	F PITTMAN	[signature]	2017-12-18

DRAWING APPROVAL STATUS: Approved for Construction

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

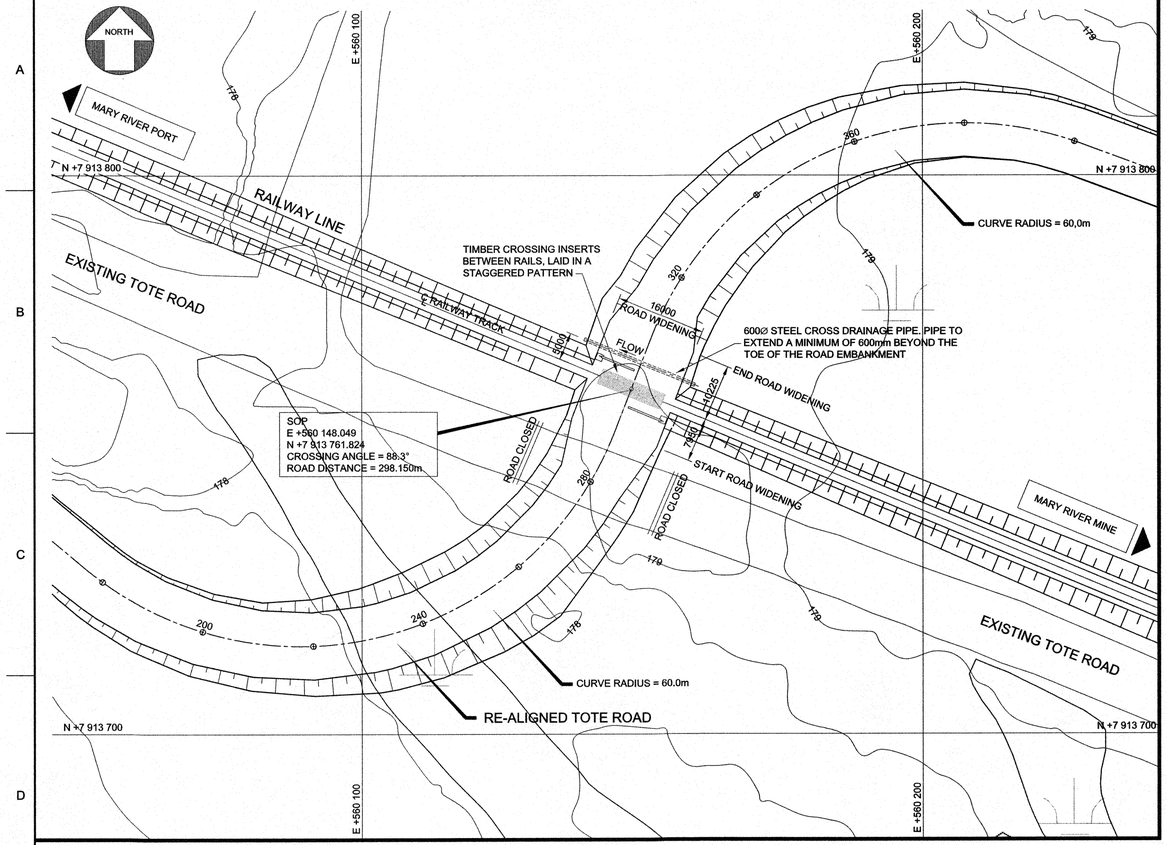
MINE SITE
TOTE ROAD RE-ALIGNMENT SHEET 2 OF 2
PLAN AND PROFILE

SCALE 1:1,000 OR AS NOTED | DWG. No. H353004-10000-223-271-0002-0001 | REV 0

SHEET SIZE: D

$USERNAME$ $DATE$ $FILE$ $TIME$

DWG. No. H353004-10000-223-272-0009-0001

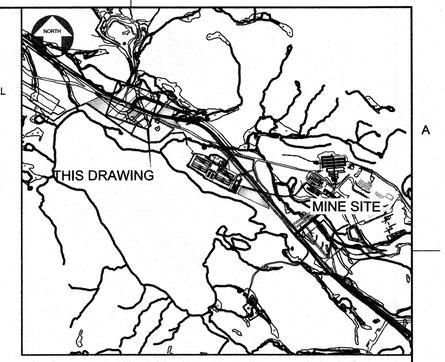


PLAN ON RAILWAY LEVEL CROSSING

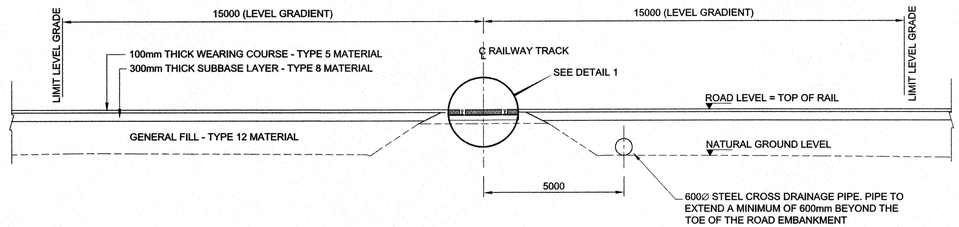
SCALE 1:500

NOTES:

1. LIDAR SURVEY PROVIDED BY PHOTSAT (2016)
2. CO-ORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METERS.
3. CONTOURS ARE IN METERS. CONTOUR INTERVAL IS 0.5m.
4. ALL DIMENSIONS SHOWN ARE IN MILLIMETERS, UNLESS OTHERWISE SPECIFIED.



KEY PLAN



CROSS SECTION THROUGH RAILWAY LEVEL CROSSING

SCALE 1:100

DETAIL 1

SCALE 1:25

NOTE:

1. TIMBER CROSSING INSERTS SHALL BE 178mm HIGH AND 229mm WIDE. INSERTS ARE TO BE FASTENED TO TIMBER TIES USING 305mm LONG LAG SCREWS. A MINIMUM DISTANCE OF 76mm SHALL BE MAINTAINED ON EITHER SIDE THE RAIL HEAD AND THE NEAREST CROSSING INSERT.
2. GRADE CROSSING TO BE SUPPLIED WITH FLASHING LIGHTS AND IS TO HAVE GATED PROTECTION. THE DESIGN AND CONSTRUCTION OF THIS WORK SHALL FORM PART OF THE RAIL SYSTEM CONTRACTORS' SCOPE OF WORK.

PERMIT TO PRACTICE
HATCH LTD.
Signature
Date 2018-01-23
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

H353004-00000-220-294-0006-0001	STANDARD DRAWING - TYPICAL CROSS SECTIONS SHEET 4 OF 4
H353004-00000-224-272-0027-0001	RAILWAY PLAN AND LONGITUDINAL SECTION CH106.900km TO CH109.611km
H353004-10000-223-271-0001-0001	TOTE ROAD RE-ALIGNMENT - PLAN AND LONGITUDINAL SECTION SHEET 1
DRAWING No.	DRAWING TITLE
REFERENCE DRAWINGS	

REGISTERED PROFESSIONAL ENGINEER — R. A. HALIM — L1247 — LICENSEE — 2018-01-23 — NWT/NU

REG. PROFESSIONAL

FOR CONSTRUCTION

THIS DRAWING WAS PREPARED BY HATCH LTD. ("HATCH") FOR THE EXCLUSIVE USE OF BAFFINLAND IRON MINES LP ("CLIENT") AND ITS USE IS SUBJECT TO THE TERMS AND CONDITIONS OF THE CONTRACT BETWEEN HATCH AND THE THE CLIENT. INCLUDING ANY LIMITATIONS ON LIABILITY CONTAINED THEREIN. THIS DRAWING AND ITS CONTENTS REMAIN THE INTELLECTUAL PROPERTY OF HATCH SUBJECT TO CLIENT'S ROYALTY-FREE, IRREVOCABLE, PERPETUAL AND NON-EXCLUSIVE LICENSE TO USE AND REPRODUCE THE DRAWING FOR PURPOSES CONNECTED WITH THE PROJECT, INCLUDING THE CONSTRUCTION, COMPLETION, MAINTENANCE, EXTENSION, REINSTATEMENT AND REPAIR OF THE PROJECT. THIS DRAWING, AND THE INFORMATION CONTAINED HEREIN, SHALL BE TREATED AS CONFIDENTIAL FOR ALL OTHER PURPOSES AND SHALL NOT BE MODIFIED WITHOUT THE WRITTEN CONSENT OF HATCH.

No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR CONSTRUCTION	IHB	FH	23/01/2017

REVISIONS

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	I BARNARD	NR	
DESIGNER	S HALL	NR	
CHECKER	F HUGO		2018-01-23
DESIGN COORD.	R GOOSEN		2018-01-23
RESP. ENG.	R HALIM		2018-01-23
LEAD DISC. ENG.	A GROBBELAAR		2018-01-23
AREA MANAGER	V LAVRIC		
ENG. MANAGER	D STANGER		2018-1-23
CLIENT	F PITTMAN		2018-01-26

DRAWING APPROVAL STATUS: Approved for Construction

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

MINE SITE
TOTE ROAD & RAILROAD CROSSING
LAYOUT PLAN AND DETAILS

SCALE 1:500 OR AS NOTED

DWG. No. H353004-10000-223-272-0009-0001

REV 0

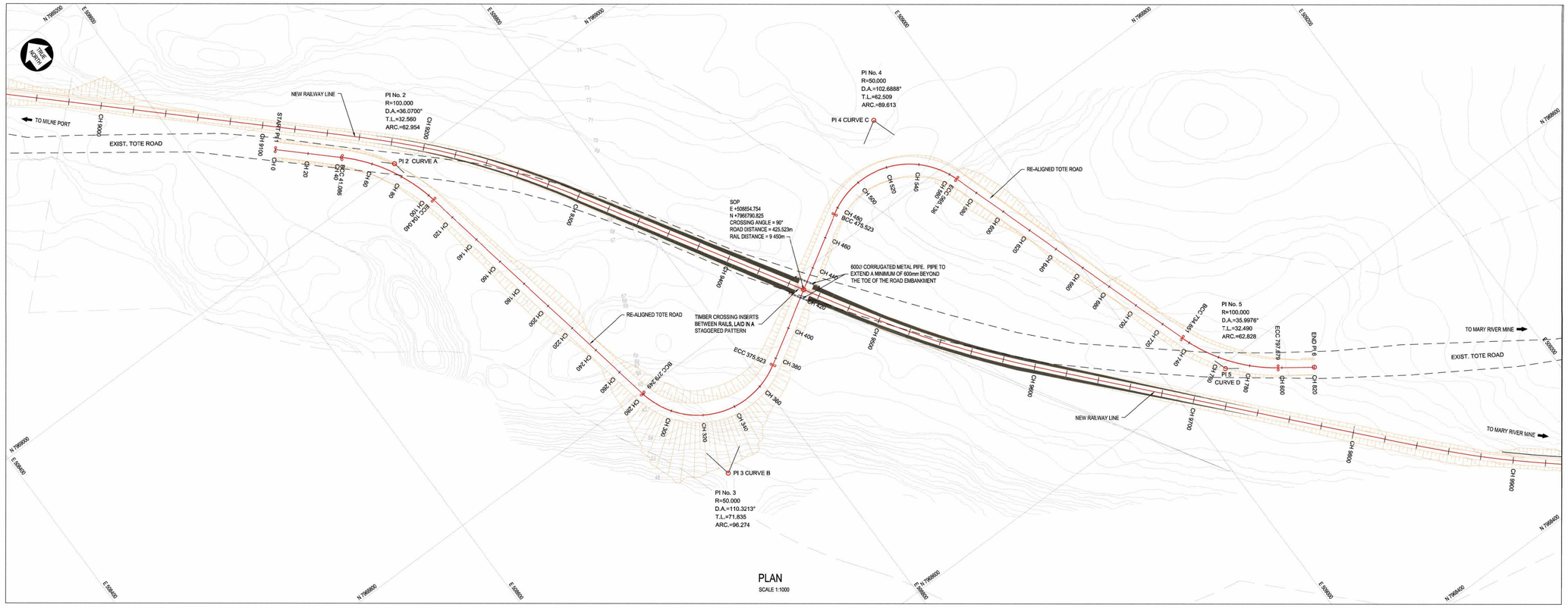
SHEET SIZE: D

dtc 25-JAN-2018 11:44
J:\DCP\PDF03\PDFtemp\\418861115048_306\H353004-10000-223-272-0009-0001.dwg

ATTACHMENT 7.2

TOTE ROAD RAIL CROSSING DRAWINGS

DWG. No. H353004-30000-224-271-0033-0001

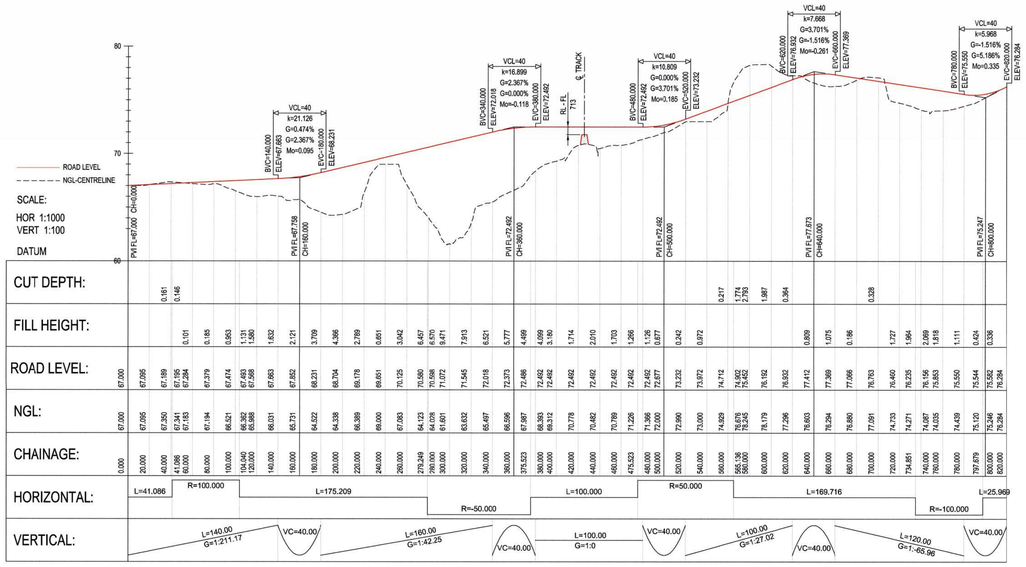


PLAN
SCALE 1:1000

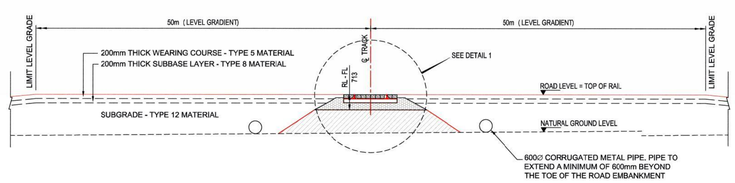
GENERAL NOTES:

1. LIDAR SURVEY PROVIDED BY PHOTSAT (2016)
2. CO-ORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METERS.
3. CONTOURS ARE IN METERS. CONTOUR INTERVAL IS 1m.
4. ALL DIMENSIONS SHOWN ARE IN MILLIMETERS, UNLESS OTHERWISE SPECIFIED.
5. TIMBER CROSSING INSERTS SHALL BE 178mm HIGH AND 229mm WIDE. INSERTS ARE TO BE FASTENED TO TIMBER TIES USING 305mm LONG LAG SCREWS. A MINIMUM DISTANCE OF 76mm SHALL BE MAINTAINED ON GAUGE SIDE THE RAIL HEAD AND THE NEAREST CROSSING INSERT.
6. THIS DRAWING WAS PREVIOUSLY ISSUED AS : H353004-00000-224-272-0037-0001
7. ALL CHAINAGES INDICATED FOR TOTE ROAD ARE LOCAL CHAINAGES.

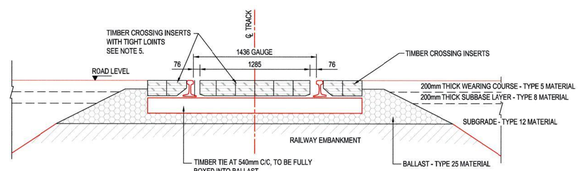
CO-ORDINATE LIST UTM (NAD83) ZONE 17		
	E	N
PI 1 START	508645.316	7969053.655
BCC CURVE A	508675.193	7969025.451
PI 2 CURVE A	508698.870	7969003.101
ECC CURVE A	508704.849	7968997.095
BCC CURVE B	508737.023	7968798.866
PI 3 CURVE B	508750.215	7968728.252
ECC CURVE B	508811.852	7968765.146
LEVEL CROSSING	508854.754	7968790.825
BCC CURVE C	508897.656	7968816.504
PI 4 CURVE C	508901.292	7968848.607
ECC CURVE C	508970.830	7968788.230
BCC CURVE D	509023.877	7969828.018
PI 5 CURVE D	509034.033	7968597.158
ECC CURVE D	509060.388	7968578.156
PI 6 END	509078.494	7968565.103



LONGITUDINAL SECTION



CROSS SECTION THROUGH RAILWAY LEVEL CROSSING
SCALE 1:100



DETAIL 1
SCALE 1:25

PERMIT TO PRACTICE
HATCH LTD.
Signature
Date
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

H353004-30000-224-294-0007	ROAD SIGNAGE DETAIL
H353004-30000-224-294-0010	TYPICAL HAUL ROAD CROSS SECTION
H353004-30000-224-294-0009	TYPICAL LEVEL CROSSING LAYOUT
H353004-30000-224-273-0021	CROSS SECTIONS CH. 0.000m TO CH. 820.000m
DRAWING No.	DRAWING TITLE

REFERENCE DRAWINGS

REG. PROFESSIONAL

APPROVED FOR CONSTRUCTION

THIS DRAWING WAS PREPARED BY HATCH LTD. (HATCH) FOR THE EXCLUSIVE USE OF BAFFINLAND IRON MINES LP ("CLIENT") AND IT'S USE IS SUBJECT TO THE TERMS AND CONDITIONS OF THE CONTRACT BETWEEN HATCH AND THE CLIENT, INCLUDING ANY LIMITATIONS ON LIABILITY CONTAINED THEREIN. THE DRAWING AND ITS CONTENTS REMAIN THE INTELLECTUAL PROPERTY OF HATCH SUBJECT TO CLIENT'S ROYALTY-FREE, IRREVOCABLE, PERPETUAL AND NON-EXCLUSIVE LICENSE TO USE AND REPRODUCE THE DRAWING FOR PURPOSES CONNECTED WITH THE PROJECT, INCLUDING THE CONSTRUCTION, COMPLETION, MAINTENANCE, EXTENSION, ADVERTISEMENT AND REPAIR OF THE PROJECT. THE DRAWING IS TO BE TREATED AS CONFIDENTIAL AND IS ONLY TO BE USED FOR PURPOSES CONFIDENTIAL FOR ALL OTHER PURPOSES AND SHALL NOT BE MODIFIED WITHOUT THE WRITTEN CONSENT OF HATCH.

No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR CONSTRUCTION	AJVN	QQ	2018/04/06

REVISIONS

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	A VAN NIEKERK	NR	2018/02/17
DESIGNER	A VAN NIEKERK	NR	2018/02/17
CHECKER	A AQUIL		2018/04/20
DESIGN COORD.	A AQUIL		2018/04/23
RESP. ENG.	D STANGER		2018/04/23
LEAD DISC. ENG.	F VAN BILJON		2018/4/27
AREA LEAD	F VAN BILJON		2018/4/23
ENG. MANAGER	D STANGER		2018/04/23
AREA MANAGER	J. PITTMAN		2018/4/25

DRAWING APPROVAL STATUS: APPROVED FOR CONSTRUCTION

HATCH

Baffinland

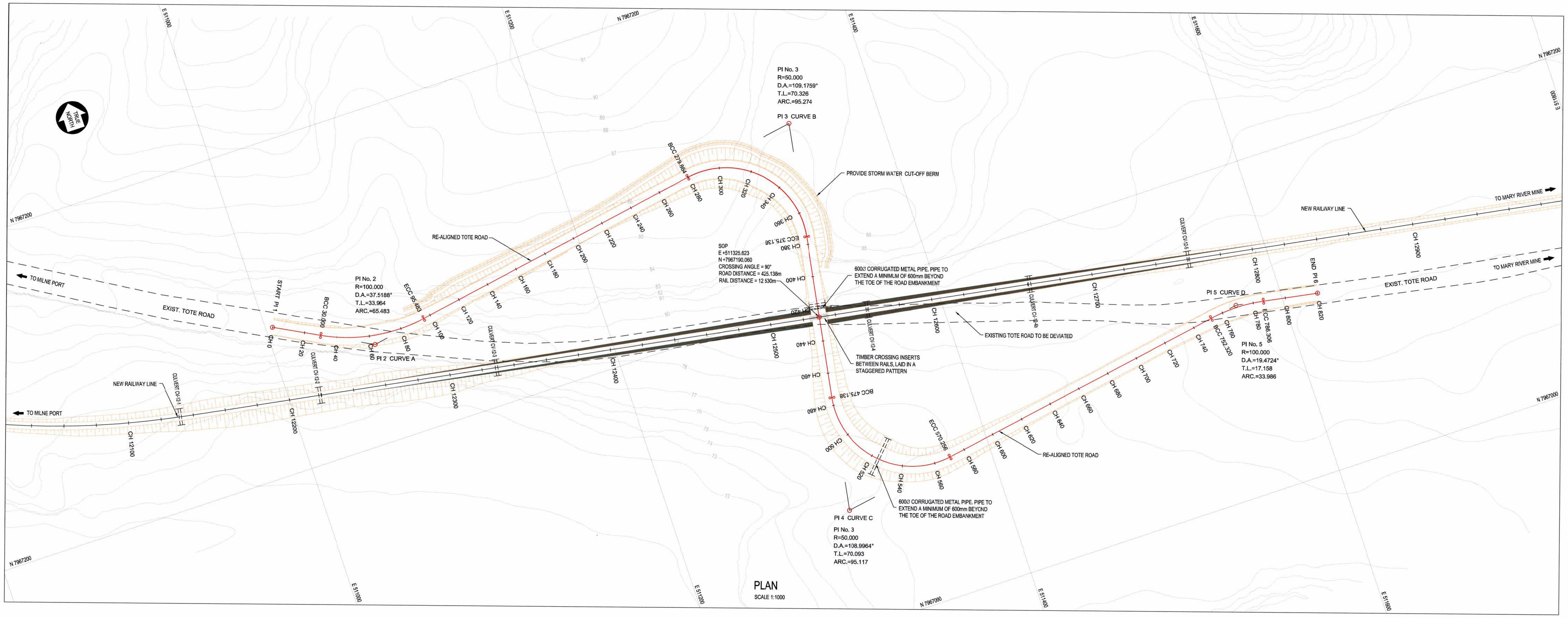
BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

TOTE ROAD
LAYOUT AND LONGITUDINAL SECTION
GRADE CROSSING AT CH. 9+450

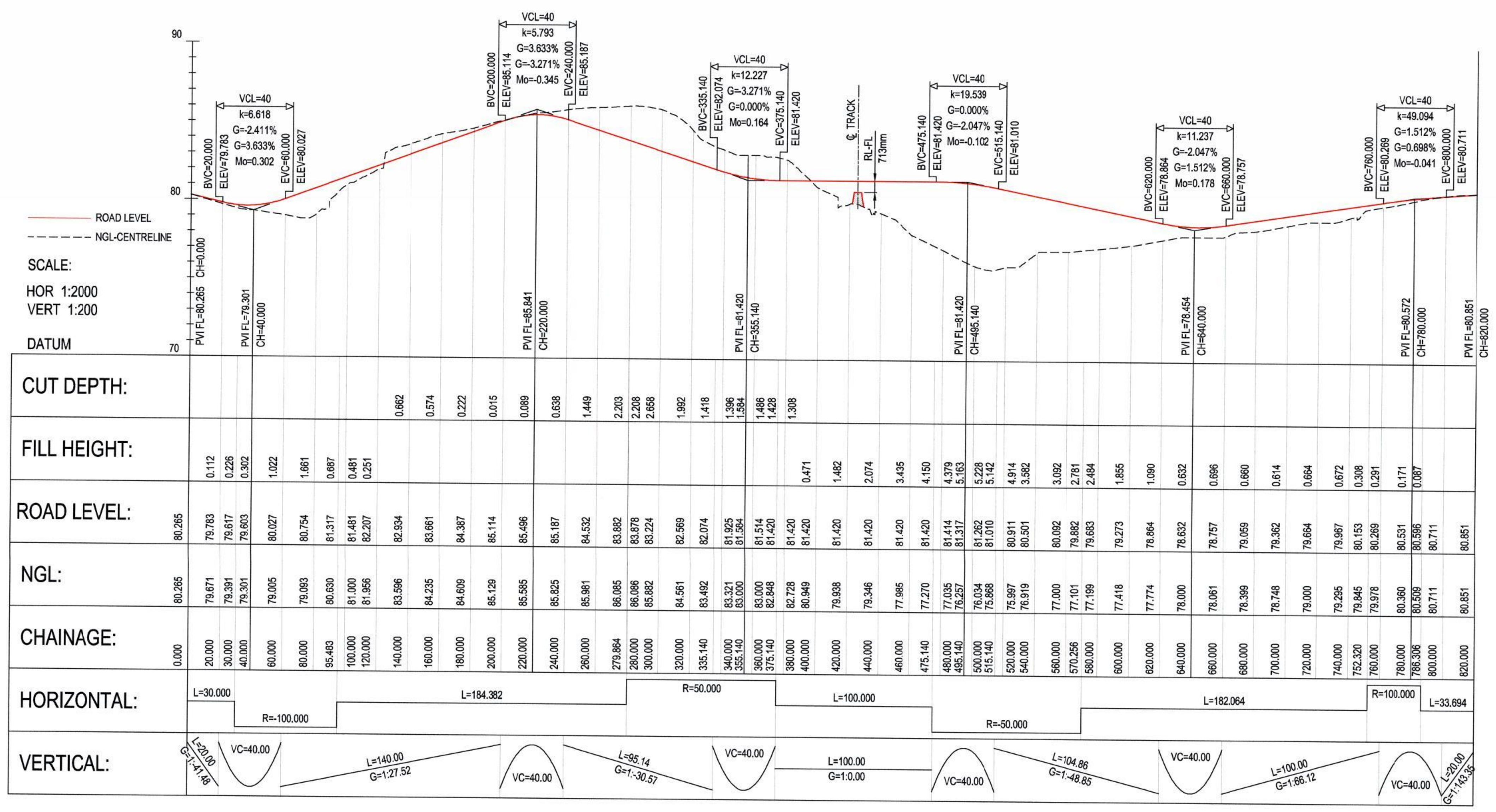
SCALE 1:1,000 OR AS NOTED
DWG. No. H353004-30000-224-271-0033-0001
REV 0
SHEET SIZE: A0

$USERNAME $TIMES $DATE $FILES

H353004-30000-224-271-0034-0001
DWG. No.



PLAN
SCALE 1:1000

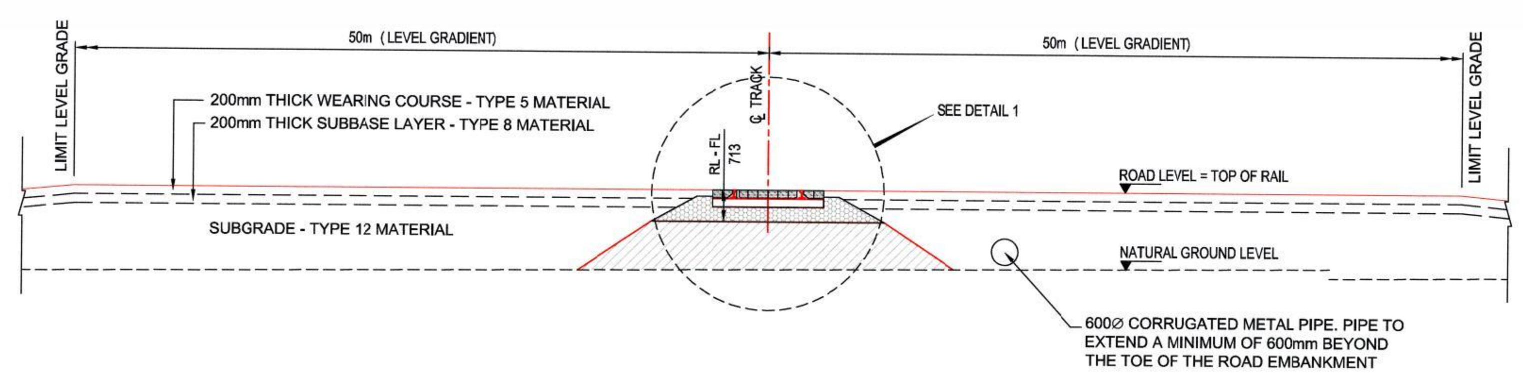


LONGITUDINAL SECTION

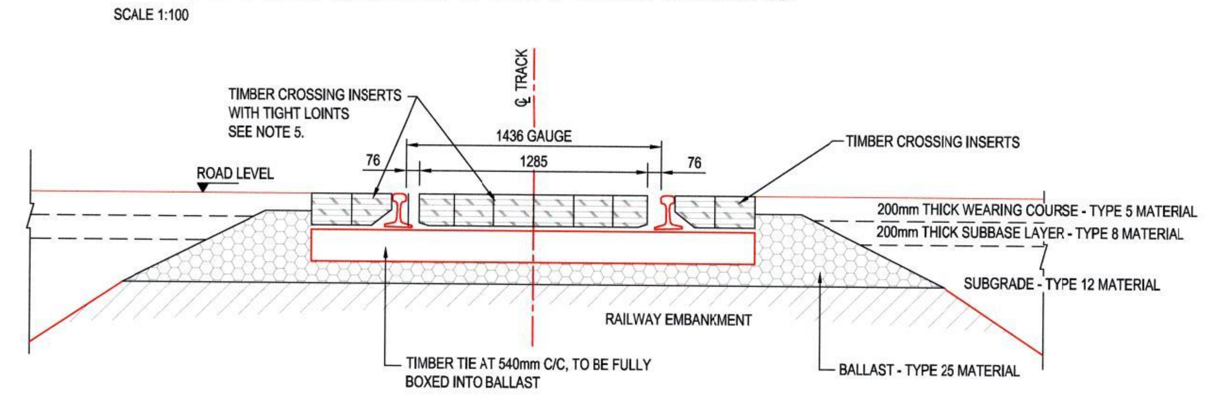
GENERAL NOTES:

1. LIDAR SURVEY PROVIDED BY PHOTSAT (2016)
2. CO-ORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METERS.
3. CONTOURS ARE IN METERS. CONTOUR INTERVAL IS 1m.
4. ALL DIMENSIONS SHOWN ARE IN MILLIMETERS, UNLESS OTHERWISE SPECIFIED.
5. TIMBER CROSSING INSERTS SHALL BE 178mm HIGH AND 229mm WIDE. INSERTS ARE TO BE FASTENED TO TIMBER TIES USING 305mm LONG LAG SCREWS. A MINIMUM DISTANCE OF 76mm SHALL BE MAINTAINED ON GAUGE SIDE THE RAIL HEAD AND THE NEAREST CROSSING INSERT.
6. THIS DRAWING WAS PREVIOUSLY ISSUED AS : H353004-00000-224-272-0038-0001
7. ALL CHAINAGES INDICATED FOR TOTE ROAD ARE LOCAL CHAINAGES.

CO-ORDINATE LIST UTM (NAD83) ZONE 17		
	E	N
PI 1 START	511004.291	7967289.875
BCC CURVE A	511030.828	7967275.881
PI 2 CURVE A	511060.870	7967260.038
ECC CURVE A	511094.347	7967265.769
BCC CURVE B	511276.085	7967296.878
PI 3 CURVE B	511345.402	7967308.743
ECC CURVE B	511333.841	7967239.375
LEVEL CROSSING	511325.621	7967190.056
BCC CURVE C	511317.401	7967140.735
PI 4 CURVE C	511305.877	7967071.596
ECC CURVE C	511375.002	7967083.206
BCC CURVE D	511554.552	7967113.362
PI 5 CURVE D	511571.473	7967116.204
ECC CURVE D	511588.374	7967113.242
PI 6 CURVE D	511621.562	7967107.427



CROSS SECTION THROUGH RAILWAY LEVEL CROSSING
SCALE 1:100



DETAIL 1
SCALE 1:25

PERMIT TO PRACTICE
HATCH LTD.
Signature
Date 2018-4-24
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

DRAWING No.	DRAWING TITLE
H353004-30000-224-294-0007	ROAD SIGNAGE DETAIL
H353004-30000-224-294-0010	TYPICAL HAUL ROAD CROSS SECTION
H353004-30000-224-294-0009	TYPICAL LEVEL CROSSING LAYOUT
H353004-30000-224-273-0022	CROSS SECTIONS CH. 0.000m TO CH. 820.000m

REFERENCE DRAWINGS

PROFESSIONAL ENGINEER D. STANGER LICENSEE NT/NU
REG. PROFESSIONAL

APPROVED FOR CONSTRUCTION

THIS DRAWING WAS PREPARED BY HATCH LTD. ("HATCH") FOR THE EXCLUSIVE USE OF BAFFINLAND IRON MINES LP ("CLIENT") AND ITS USE IS SUBJECT TO THE TERMS AND CONDITIONS OF THE CONTRACT BETWEEN HATCH AND THE THE CLIENT, INCLUDING ANY LIMITATIONS ON LIABILITY CONTAINED THEREIN. THIS DRAWING AND ITS CONTENTS REMAIN THE INTELLECTUAL PROPERTY OF HATCH SUBJECT TO CLIENT'S ROYALTY-FREE, IRREVOCABLE, PERPETUAL AND NON-EXCLUSIVE LICENSE TO USE AND REPRODUCE THE DRAWING FOR PURPOSES CONNECTED WITH THE PROJECT, INCLUDING THE CONSTRUCTION, COMPLETION, MAINTENANCE, EXTENSION, REINSTATEMENT AND REPAIR OF THE PROJECT. THIS DRAWING, AND THE INFORMATION CONTAINED HEREIN, SHALL BE TREATED AS CONFIDENTIAL FOR ALL OTHER PURPOSES AND SHALL NOT BE MODIFIED WITHOUT THE WRITTEN CONSENT OF HATCH.

No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR CONSTRUCTION	AJVN	AA	2018/04/06

REVISIONS

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	A VAN NIEKERK	NR	2018/02/19
DESIGNER	A VAN NIEKERK	NR	2018/02/19
CHECKER	A AQUIL	[signature]	2018/04/28
DESIGN COORD.	A AQUIL	[signature]	2018/04/28
RESP. ENG.	D STANGER	[signature]	2018/04/28
LEAD DISC. ENG.	F VAN BILJON	[signature]	2018/04/28
AREA LEAD	F VAN BILJON	[signature]	2018/04/28
ENG. MANAGER	D STANGER	[signature]	2018/04/28
AREA MANAGER	F. PITTMAN	[signature]	2018/4/25

DRAWING APPROVAL STATUS: APPROVED FOR CONSTRUCTION

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

TOTE ROAD
LAYOUT AND LONGITUDINAL SECTION
GRADE CROSSING AT CH. 12+530

SCALE 1:1,000 OR AS NOTED

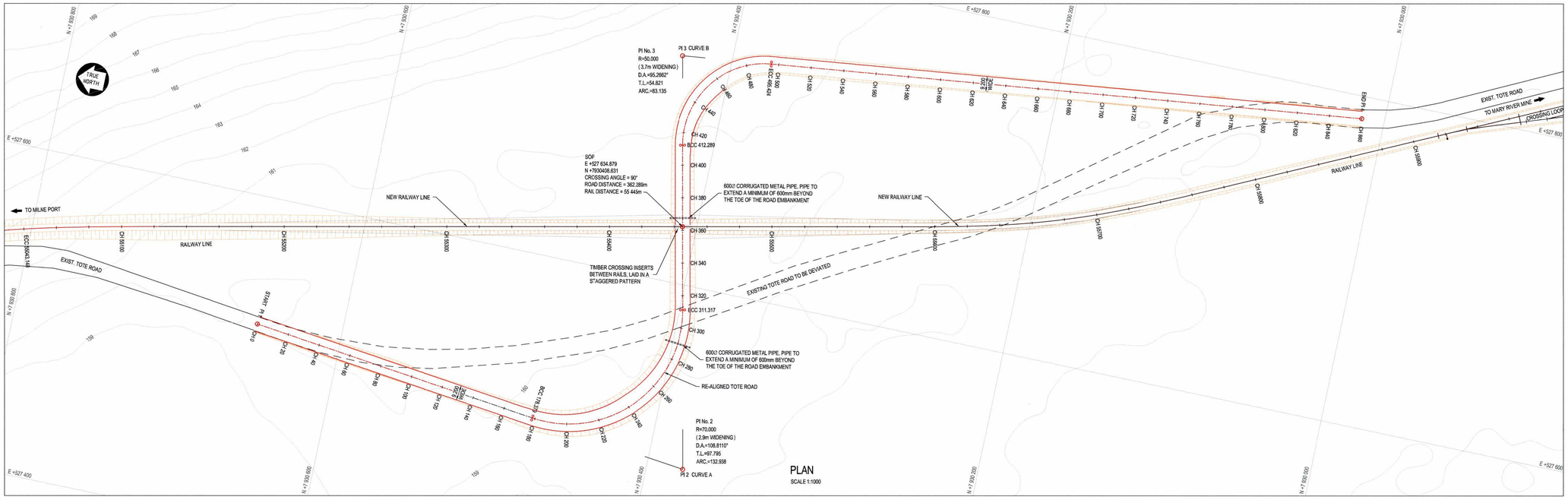
DWG. No. H353004-30000-224-271-0034-0001

REV 0

SHEET SIZE: A0

$USERNAME$ $DATE$ $FILE$ $TIME$

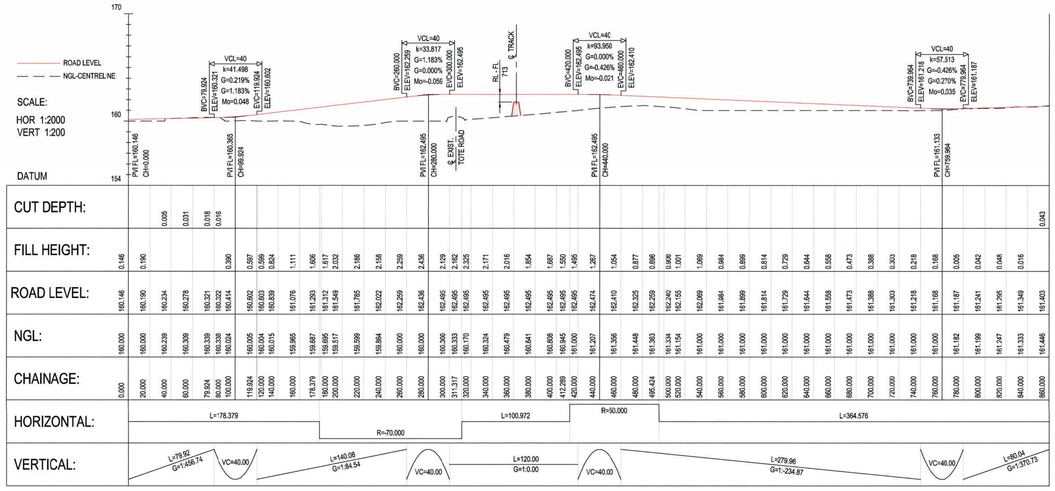
DWG. No. H353004-30000-224-271-0035-0001



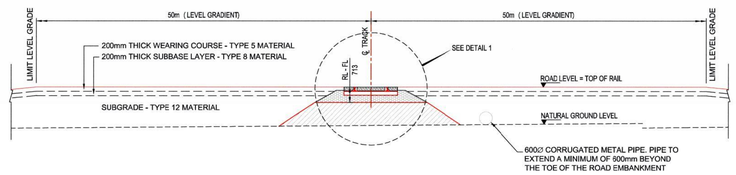
GENERAL NOTES:

1. LIDAR SURVEY PROVIDED BY PHOTSAT (2016)
2. CO-ORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METERS.
3. CONTOURS ARE IN METERS. CONTOUR INTERVAL IS 1m.
4. ALL DIMENSIONS SHOWN ARE IN MILLIMETERS, UNLESS OTHERWISE SPECIFIED.
5. TIMBER CROSSING INSERTS SHALL BE 178mm HIGH AND 229mm WIDE. INSERTS ARE TO BE FASTENED TO TIMBER TIES USING 305mm LONG LAG SCREWS. A MINIMUM DISTANCE OF 76mm SHALL BE MAINTAINED ON GAUGE SIDE THE RAIL HEAD AND THE NEAREST CROSSING INSERT.
6. THIS DRAWING WAS PREVIOUSLY ISSUED AS : H353004-00000-224-272-0035-0001
7. ALL CHAINAGES INDICATED FOR TOTE ROAD ARE LOCAL CHAINAGES.

CO-ORDINATE LIST UTM (NAD83) ZONE 17		
	E	N
PI 1 START	527522.280	7930652.001
BCC CURVE A	527501.007	7930474.895
PI CURVE A	527489.343	7930377.798
ECC CURVE A	527585.015	7930398.067
LEVEL CROSSING	527634.879	7930408.631
BCC CURVE B	527683.794	7930418.993
PI CURVE 3	527737.424	7930430.355
ECC CURVE B	527743.816	7930375.908
PI 4 END	527786.321	7930913.819

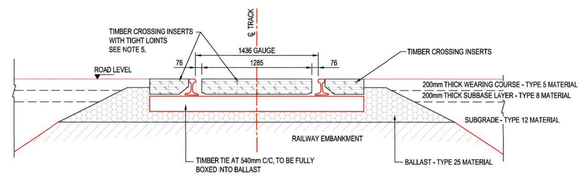


LONGITUDINAL SECTION



CROSS SECTION THROUGH RAILWAY LEVEL CROSSING

SCALE 1:100



DETAIL 1

SCALE 1:25

PERMIT TO PRACTICE
HATCH LTD.
Signature
Date 2018-04-24
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

H353004-30000-224-294-0007	ROAD SIGNAGE DETAIL
H353004-30000-224-294-0010	TYPICAL HAUL ROAD CROSS SECTION
H353004-30000-224-294-0009	TYPICAL LEVEL CROSSING LAYOUT
H353004-30000-224-273-0023	CROSS SECTIONS CH. 0.000m TO CH. 860.000m
DRAWING No.	DRAWING TITLE
REFERENCE DRAWINGS	

REGISTERED PROFESSIONAL ENGINEER D. STANGER LICENSEE NT/NU

REG. PROFESSIONAL

APPROVED FOR CONSTRUCTION

THE DRAWING AND PRINTED MATERIAL CONTAINED IN THIS DRAWING (EXCEPTING ANY PART THEREOF OF CLIENT) AND ITS USE IS SUBJECT TO THE TERMS AND CONDITIONS OF THE CONTRACT BETWEEN HATCH AND THE CLIENT, INCLUDING ANY LIMITATIONS ON LIABILITY CONTAINED THEREIN. THIS DRAWING AND ITS CONTENTS REMAIN THE INTELLECTUAL PROPERTY OF HATCH SUBJECT TO CLIENT'S ROYALTY-FREE, IRREVOCABLE, PERPETUAL AND NON-EXCLUSIVE LICENSE TO USE AND REPRODUCE THE DRAWING FOR PURPOSES CONNECTED WITH THE PROJECT, INCLUDING THE CONSTRUCTION, COMPLETION, MAINTENANCE, EXTENSION, REINSTATEMENT AND REPAIR OF THE PROJECT. THE DRAWING IS PROVIDED IN CONFIDENCE AND IS NOT TO BE DISCLOSED AS CONFIDENTIAL FOR ALL OTHER PURPOSES AND SHALL NOT BE MODIFIED WITHOUT THE WRITTEN CONSENT OF HATCH.

No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR CONSTRUCTION	AJVN	AA	2018/04/06

REVISIONS

HATCH

DRAFTSPERSON	A VAN NIEKERK	NR	09/02/18
DESIGNER	A VAN NIEKERK	NR	09/02/18
CHECKER	A AQUIL		2018/04/25
DESIGN COORD.	A AQUIL		2018/04/25
RESP. ENG.	D STANGER		2018/04/25
LEAD DISC. ENG.	F VAN BILJON		2018/04/11
AREA LEAD	F VAN BILJON		2018/04/11
ENG. MANAGER	D STANGER		2018/04/25
AREA MANAGER	F PITTMAN		2018/4/25
ROLE	NAME	SIGNATURE	DATE

DRAWING APPROVAL STATUS: APPROVED FOR CONSTRUCTION

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

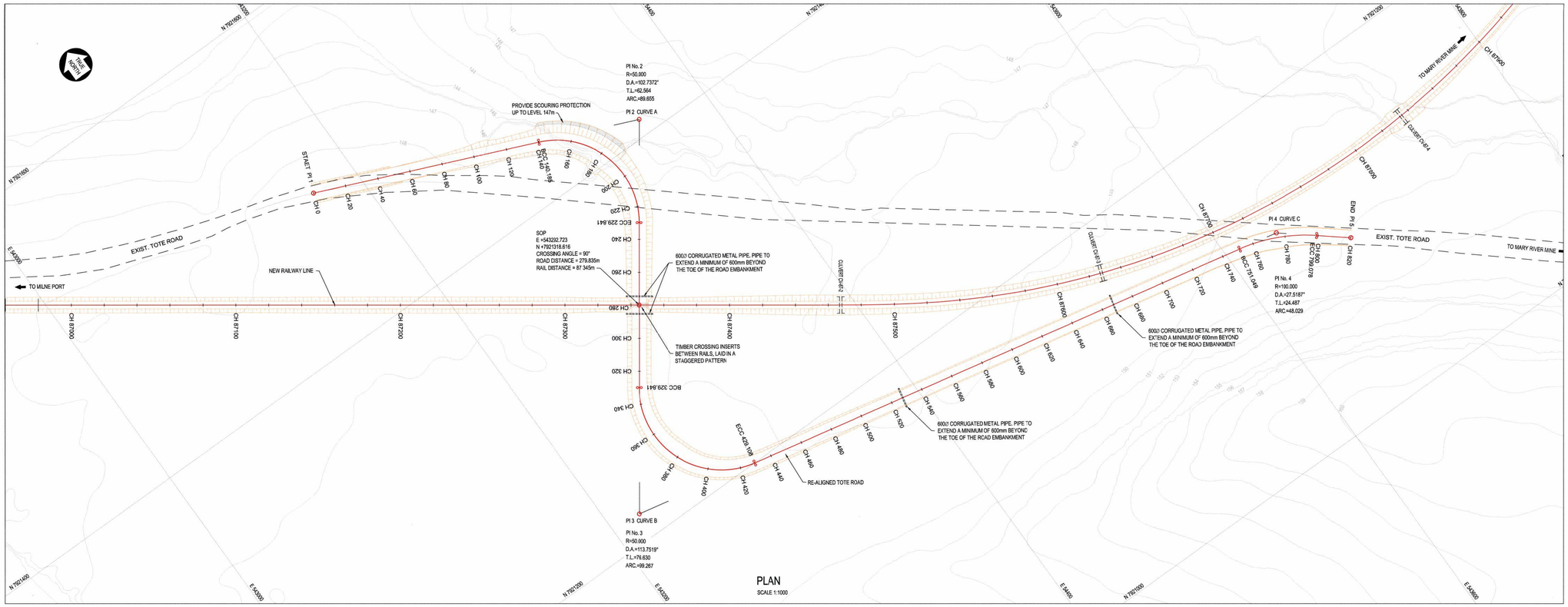
TOTE ROAD
LAYOUT AND LONGITUDINAL SECTION
GRADE CROSSING AT CH. 55+445

SCALE	DWG. No.	REV
1:1000 OR AS NOTED	H353004-30000-224-271-0035-0001	0

SHEET SIZE: A0

$USERNAME$
$DATE$
$TIME$

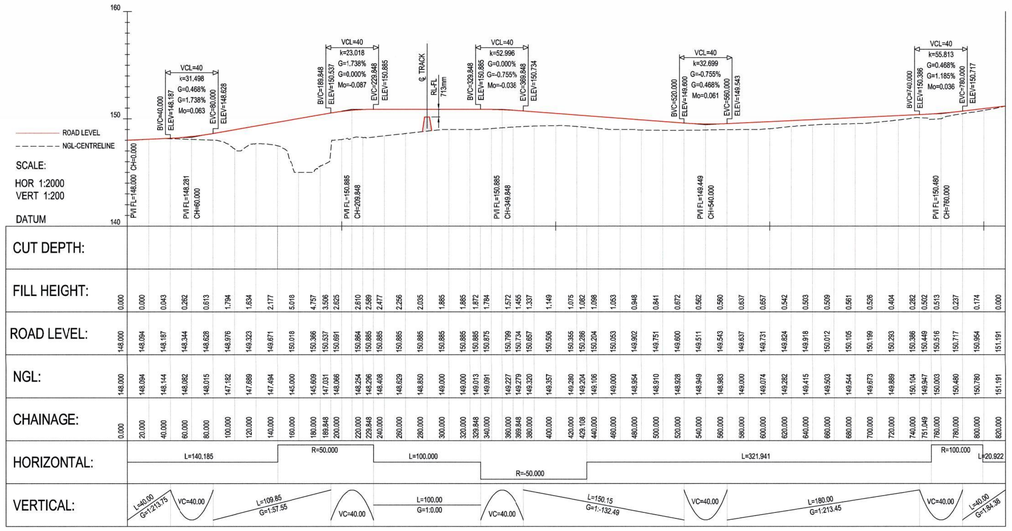
DWG. No. H353004-30000-224-271-0036-0001



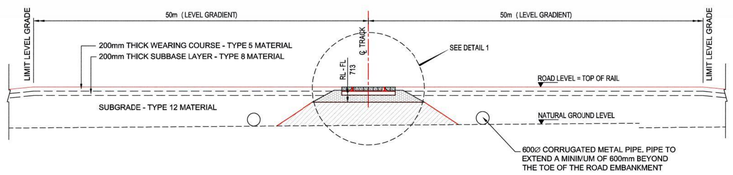
GENERAL NOTES:

1. LIDAR SURVEY PROVIDED BY PHOTSAT (2016)
2. CO-ORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METERS.
3. CONTOURS ARE IN METERS. CONTOUR INTERVAL IS 1m.
4. ALL DIMENSIONS SHOWN ARE IN MILLIMETERS, UNLESS OTHERWISE SPECIFIED.
5. TIMBER CROSSING INSERTS SHALL BE 178mm HIGH AND 229mm WIDE. INSERTS ARE TO BE FASTENED TO TIMBER TIES USING 305mm LONG LAG SCREWS. A MINIMUM DISTANCE OF 76mm SHALL BE MAINTAINED ON GAUGE SIDE THE RAIL HEAD AND THE NEAREST CROSSING INSERT.
6. THIS DRAWING WAS PREVIOUSLY ISSUED AS : H353004-00000-224-272-0039-0001
7. ALL CHAINAGES INDICATED FOR TOTE ROAD ARE LOCAL CHAINAGES.

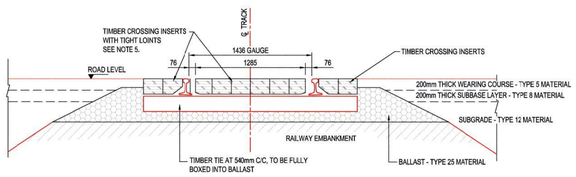
CO-ORDINATE LIST UTM (NAD83) ZONE 17		
	E	N
PI 1 START	543171.741	7921489.136
BCC CURVE A	543300.812	7921434.430
PI CURVE A	543358.415	7921410.016
ECC CURVE A	543321.901	7921359.213
LEVEL CROSSING	543292.719	7921318.612
BCC CURVE B	543263.537	7921278.011
PI CURVE B	543218.813	7921215.787
ECC CURVE B	543293.781	7921199.914
BBC C	543608.740	7921133.228
PI 4 CURVE C	543632.696	7921128.156
ECC CURVE C	543651.598	7921112.589
PI 5 END	543667.748	7921099.288



LONGITUDINAL SECTION



CROSS SECTION THROUGH RAILWAY LEVEL CROSSING
SCALE 1:100



DETAIL 1
SCALE 1:25

PERMIT TO PRACTICE
HATCH LTD.
Signature
Date 2018-04-24
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

REFERENCE DRAWINGS	
DRAWING No.	DRAWING TITLE
H353004-30000-224-294-0007	ROAD SIGNAGE DETAIL
H353004-30000-224-294-0010	TYPICAL HAUL ROAD CROSS SECTION
H353004-30000-224-294-0007	TYPICAL LEVEL CROSSING LAYOUT
H353004-30000-224-273-0024	CROSS SECTIONS CH. 0.000m TO CH. 820.000m

REGISTERED PROFESSIONAL ENGINEER D. STANGER LICENSEE NT/NU
REG. PROFESSIONAL

APPROVED FOR CONSTRUCTION

THIS DRAWING WAS PREPARED BY HATCH LTD. (HATCH) FOR THE EXCLUSIVE USE OF BAFFINLAND IRON MINES LP (CLIENT) AND ITS USE IS SUBJECT TO THE TERMS AND CONDITIONS OF THE CONTRACT BETWEEN HATCH AND THE CLIENT, INCLUDING ANY LIMITATIONS ON LIABILITY CONTAINED THEREIN. THIS DRAWING AND ITS CONTENTS REMAIN THE INTELLECTUAL PROPERTY OF HATCH SUBJECT TO CLIENT'S ROYALTY-FREE, IRREVOCABLE, PERPETUAL AND NON-EXCLUSIVE LICENCE TO USE THE DRAWING FOR THE PURPOSES OF CONSTRUCTING THE PROJECT, INCLUDING THE CONSTRUCTION, COMPLETION, MAINTENANCE, EXTENSION, REINSTATEMENT AND REPAIR OF THE PROJECT. THIS DRAWING, AND THE INFORMATION CONTAINED HEREIN, SHALL BE TREATED AS CONFIDENTIAL FOR ALL OTHER PURPOSES AND SHALL NOT BE MODIFIED WITHOUT THE WRITTEN CONSENT OF HATCH.

No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR CONSTRUCTION	AJVN	QQ	2018/04/06

REVISIONS

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	A VAN NIEKERK	NR	2018/02/22
DESIGNER	A VAN NIEKERK	NR	2018/02/22
CHECKER	A AQUIL		2018/04/23
DESIGN COORD.	A AQUIL		2018/04/23
RESP. ENG.	D STANGER		2018/04/23
LEAD DISC. ENG.	F VAN BILJON		2018/04/23
AREA LEAD	F VAN BILJON		2018/04/23
ENG. MANAGER	D STANGER		2018/04/23
AREA MANAGER	F. PITTMAN		2018/04/25

DRAWING APPROVAL STATUS: APPROVED FOR CONSTRUCTION

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

TOTE ROAD
LAYOUT AND LONGITUDINAL SECTION
GRADE CROSSING AT CH. 87+345

SCALE	DWG. No.	REV
1:1,000 OR AS NOTED	H353004-30000-224-271-0036-0001	0

SHEET SIZE: A0

$USERNAME$
$DATE$
$TIME$

DWG. No. H353004-30000-224-271-0037-0001

PLAN
SCALE 1:1000

GENERAL NOTES:

1. LIDAR SURVEY PROVIDED BY PHOTSAT (2016)
2. CO-ORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METERS.
3. CONTOURS ARE IN METERS. CONTOUR INTERVAL IS 1m.
4. ALL DIMENSIONS SHOWN ARE IN MILLIMETERS, UNLESS OTHERWISE SPECIFIED.
5. TIMBER CROSSING INSERTS SHALL BE 178mm HIGH AND 229mm WIDE. INSERTS ARE TO BE FASTENED TO TIMBER TIES USING 305mm LONG LAG SCREWS. A MINIMUM DISTANCE OF 76mm SHALL BE MAINTAINED ON GAUGE SIDE THE RAIL HEAD AND THE NEAREST CROSSING INSERT.
6. THIS DRAWING WAS PREVIOUSLY ISSUED AS : H353004-00000-224-272-0040-0001
7. ALL CHAINAGES INDICATED FOR TOTE ROAD ARE LOCAL CHAINAGES.

CO-ORDINATE LIST UTM (NAD83) ZONE 17	E	N
PI 1 START	546764.587	7919767.972
BCC CURVE A	546815.348	7919761.528
PI 2 CURVE A	546851.465	7919756.943
ECC CURVE A	546866.918	7919789.907
LEVEL CROSSING	546889.576	7919838.241
BCC CURVE B	546910.799	7919883.513
PI 3 CURVE B	546938.316	7919942.213
ECC CURVE B	546988.099	7919900.685
BCC CURVE C	547371.175	7919581.130
PI 4 CURVE C	547381.578	7919572.452
ECC CURVE C	547393.916	7919566.854
PI 5 END	547407.885	7919560.517

SCALE:
HOR 1:2000
VERT 1:200
DATUM 150

CHAINAGE:	CUT DEPTH:	FILL HEIGHT:	ROAD LEVEL:	NGL:
0.000		0.047	160.584	160.537
20.000	0.132		160.868	161.000
40.000	0.540		160.962	161.502
51.168	0.758		160.962	161.720
60.000	0.910		160.962	161.872
80.000	0.771		160.962	161.733
100.000	0.518		160.962	161.480
114.104	0.324		160.962	161.286
120.000	0.240		160.962	161.202
140.000		0.083	160.962	160.879
160.000		0.583	160.962	160.379
180.000		1.962	160.962	159.000
200.000		0.297	160.962	160.665
217.485	1.481		160.962	162.443
220.000	1.654		160.962	162.616
240.000	2.708		161.030	163.738
260.000	3.119		161.235	164.354
280.000	2.219		161.507	163.726
300.000	1.367		161.780	163.147
308.868	1.006		161.901	162.907
320.000	0.671		162.052	162.723
340.000	0.214		162.325	162.539
360.000		0.243	162.597	162.354
380.000		0.619	162.870	162.251
400.000		1.239	163.142	161.903
420.000		1.923	163.415	161.492
440.000		1.790	163.687	161.897
460.000		1.960	163.960	162.000
480.000		2.102	164.232	162.130
500.000		1.983	164.505	162.522
520.000		2.013	164.777	162.764
540.000		2.050	165.050	163.000
560.000		2.083	165.322	163.239
580.000		2.071	165.595	163.524
600.000		2.159	165.867	163.708
620.000		2.165	166.140	163.975
640.000		1.976	166.412	164.436
660.000		1.621	166.685	165.064
680.000		1.590	166.957	165.367
700.000		1.543	167.230	165.687
720.000		1.542	167.502	165.960
740.000		1.239	167.775	166.536
760.000		0.724	168.047	167.323
780.000		0.183	168.320	168.137
800.000	0.033		168.482	168.515
807.729	0.043		168.486	168.529
820.000		0.018	168.424	168.406
834.661		0.008	168.301	168.293
840.000		0.002	168.256	168.254
850.000		0.008	168.172	168.172

HORIZONTAL: L=51.168 | R=-50.000 | L=103.381 | R=50.000 | L=498.861 | R=-100.000 | L=15.339

VERTICAL: VC=40.00 | L=180.00 G=1:0.00 | VC=40.00 | L=520.00 G=1:73.39 | VC=40.00 | L=30.00 G=1:-118.96

LONGITUDINAL SECTION

CROSS SECTION THROUGH RAILWAY LEVEL CROSSING
SCALE 1:100

DETAIL 1
SCALE 1:25

PERMIT TO PRACTICE
HATCH LTD.
Signature
Date 2018-4-24
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

DRAWING No.	DRAWING TITLE
H353004-30000-224-294-0007	ROAD SIGNAGE DETAIL
H353004-30000-224-294-0010	TYPICAL HAUL ROAD CROSS SECTION
H353004-30000-224-294-0009	TYPICAL LEVEL CROSSING LAYOUT
H353004-30000-224-273-0025	CROSS SECTIONS CH. 0.000m TO CH. 850.000m

REFERENCE DRAWINGS

REGISTERED PROFESSIONAL ENGINEER D. STANGER LICENSEE NT/NU
REG. PROFESSIONAL

APPROVED FOR CONSTRUCTION

THIS DRAWING WAS PREPARED BY HATCH LTD. ("HATCH") FOR THE EXCLUSIVE USE OF BAFFINLAND IRON MINES LP ("CLIENT") AND ITS USE IS SUBJECT TO THE TERMS AND CONDITIONS OF THE CONTRACT BETWEEN HATCH AND THE THE CLIENT, INCLUDING ANY LIMITATIONS ON LIABILITY CONTAINED THEREIN. THIS DRAWING AND ITS CONTENTS REMAIN THE INTELLECTUAL PROPERTY OF HATCH SUBJECT TO CLIENT'S ROYALTY-FREE, IRREVOCABLE, PERPETUAL AND NON-EXCLUSIVE LICENSE TO USE AND REPRODUCE THE DRAWING FOR PURPOSES CONNECTED WITH THE PROJECT, INCLUDING THE CONSTRUCTION, COMPLETION, MAINTENANCE, EXTENSION, REINSTATEMENT AND REPAIR OF THE PROJECT. THIS DRAWING, AND THE INFORMATION CONTAINED HEREIN, SHALL BE TREATED AS CONFIDENTIAL FOR ALL OTHER PURPOSES AND SHALL NOT BE MODIFIED WITHOUT THE WRITTEN CONSENT OF HATCH.

No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR CONSTRUCTION	AJVN	AQ	2018/04/06

REVISIONS

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	A VAN NIEKERK	NR	2018/02/27
DESIGNER	A VAN NIEKERK	NR	2018/02/27
CHECKER	A AQUIL		2018/04/23
DESIGN COORD.	A AQUIL		2018/04/23
RESP. ENG.	D STANGER		2018/04/23
LEAD DISC. ENG.	F VAN BILJON		2018/04/23
AREA LEAD	F VAN BILJON		2018/04/23
ENG. MANAGER	D. STANGER		2018/04/23
AREA MANAGER	F. PITTMAN		2018/4/25

DRAWING APPROVAL STATUS: APPROVED FOR CONSTRUCTION

Baffinland

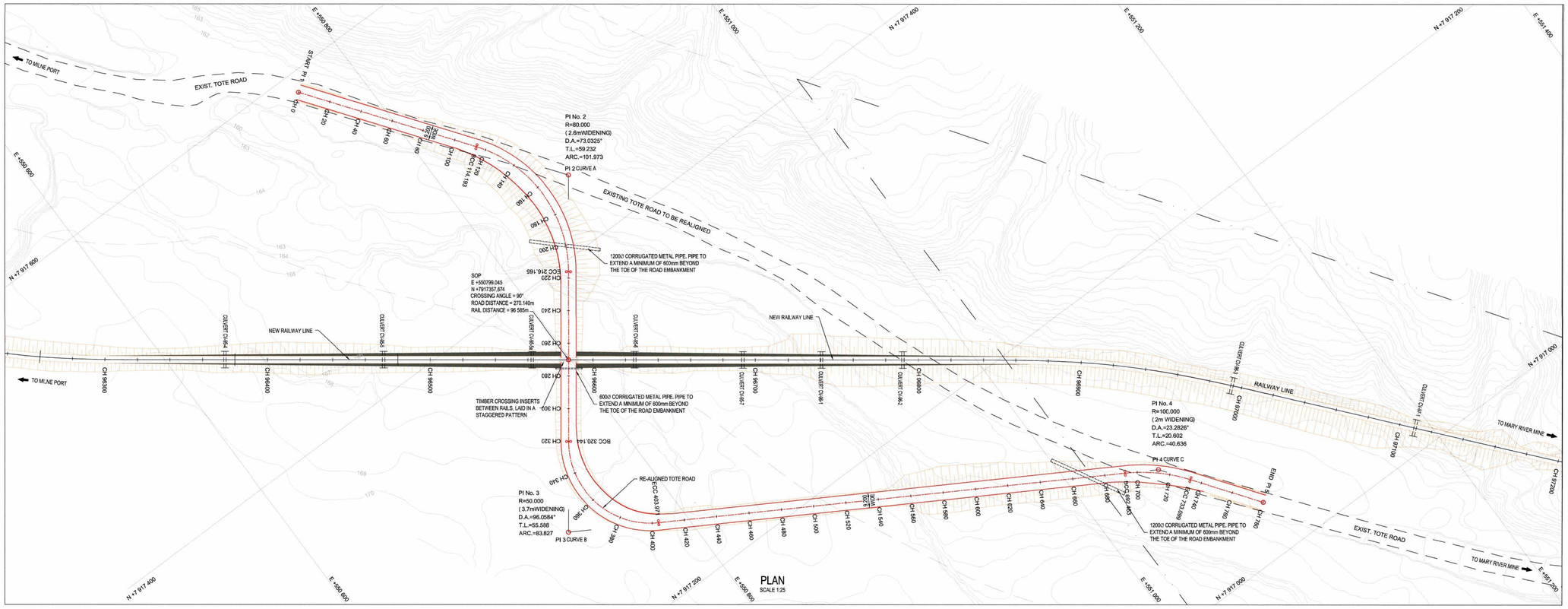
BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

TOTE ROAD
LAYOUT AND LONGITUDINAL SECTION
GRADE CROSSING AT CH. 91+750

SCALE 1:1,000 OR AS NOTED
DWG. No. H353004-30000-224-271-0037-0001
REV 0
SHEET SIZE: A0

$USERNAME$ $DATE$ $FILE$ $TIME$

DWG. No. H353004-30000-224-271-0038-0001

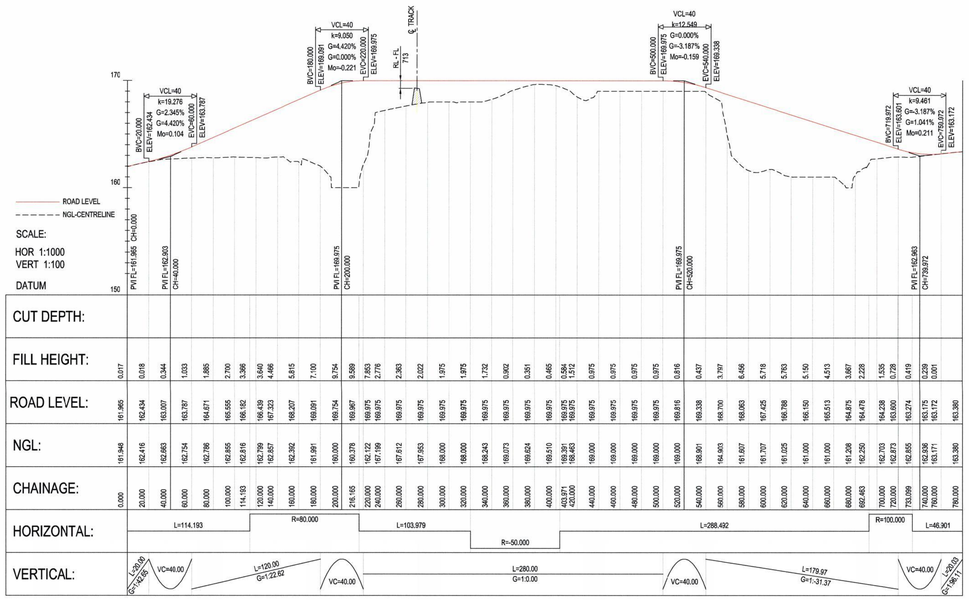


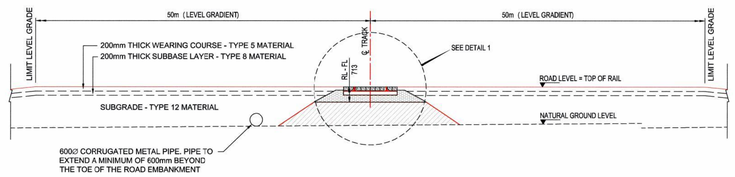
GENERAL NOTES:

1. LIDAR SURVEY PROVIDED BY PHOTSAT (2016)
2. CO-ORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METERS.
3. CONTOURS ARE IN METERS. CONTOUR INTERVAL IS 1m.
4. ALL DIMENSIONS SHOWN ARE IN MILLIMETERS, UNLESS OTHERWISE SPECIFIED.
5. TIMBER CROSSING INSERTS SHALL BE 178mm HIGH AND 229mm WIDE. INSERTS ARE TO BE FASTENED TO TIMBER TIES USING 305mm LONG LAG SCREWS. A MINIMUM DISTANCE OF 76mm SHALL BE MAINTAINED ON GAUGE SIDE THE RAIL HEAD AND THE NEAREST CROSSING INSERT.
6. THIS DRAWING WAS PREVIOUSLY ISSUED AS : H353004-00000-224-272-0036-0001
7. ALL CHAINAGES INDICATED FOR TOTE ROAD ARE LOCAL CHAINAGES.

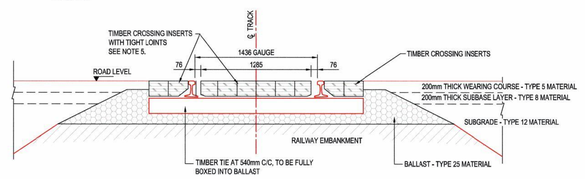
CO-ORDINATE LIST UTM (NAD83) ZONE 17

	E	N
PI 1 START	550763.942	7917588.155
BCC CURVE A	550831.601	7917466.164
PI 2 CURVE A	550866.695	7917448.449
ECC CURVE A	550831.299	7917400.957
LEVEL CROSSING	550799.040	7917357.873
BCC CURVE B	550769.161	7917317.587
PI 3 CURVE B	550735.942	7917273.016
ECC CURVE B	550783.770	7917244.687
BCC CURVE C	551031.986	7917067.662
PI CURVE C	551049.712	7917067.162
ECC CURVE C	551061.844	7917070.511
PI 5 END	551089.464	7917022.605





CROSS SECTION THROUGH RAILWAY LEVEL CROSSING
SCALE 1:100



DETAIL 1
SCALE 1:25

PERMIT TO PRACTICE
HATCH LTD.
Signature
Date 2013-4-24
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

H353004-30000-224-294-0007	ROAD SIGNAGE DETAIL
H353004-30000-224-294-0010	TYPICAL HAUL ROAD CROSS SECTION
H353004-30000-224-294-0009	TYPICAL LEVEL CROSSING LAYOUT
H353004-30000-224-273-0026	CROSS SECTIONS CH. 0.000m TO CH. 780.000m
DRAWING No.	DRAWING TITLE

REFERENCE DRAWINGS

REGISTERED PROFESSIONAL ENGINEER D. STANGER LICENSEE NT/NU

REG. PROFESSIONAL

APPROVED FOR CONSTRUCTION

THIS DRAWING WAS PREPARED BY HATCH LTD. (HATCH) FOR THE EXCLUSIVE USE OF BAFFINLAND IRON MINES LP ("CLIENT") AND ITS USE IS SUBJECT TO THE TERMS AND CONDITIONS OF THE CONTRACT BETWEEN HATCH AND THE THE CLIENT, INCLUDING ANY LIMITATIONS ON LIABILITY CONTAINED THEREIN. THIS DRAWING AND ITS CONTENTS REMAIN THE PROPERTY OF HATCH AND SHALL NOT BE USED BY THE CLIENT OR ANY THIRD PARTY EXCEPT THAT THE CLIENT HAS A NON-EXCLUSIVE LICENSE TO USE AND REPRODUCE THE DRAWING FOR PURPOSES CONNECTED WITH THE PROJECT, INCLUDING THE CONSTRUCTION, COMPLETION, MAINTENANCE, EXTENSION, REINSTATEMENT AND REPAIR OF THE PROJECT. THIS DRAWING AND THE INFORMATION CONTAINED HEREIN, SHALL BE TREATED AS CONFIDENTIAL FOR ALL OTHER PURPOSES AND SHALL NOT BE MODIFIED WITHOUT THE WRITTEN CONSENT OF HATCH.

No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR CONSTRUCTION	AJVN		2018/04/06

REVISIONS

DRAFTSPERSON	A VAN NIEKERK	N'R	2018/02/13
DESIGNER	A VAN NIEKERK	N'R	2018/02/13
CHECKER	A AQUIL		2018/04/23
DESIGN COORD.	A AQUIL		2018/04/23
RESP. ENG.	D STANGER		2018/04/23
LEAD DISC. ENG.	F VAN BILJON		2018/04/23
AREA LEAD	F VAN BILJON		2018/04/23
ENG. MANAGER	D STANGER		2018/04/23
AREA MANAGER	F. PITTMAN		2018/04/25
ROLE	NAME	SIGNATURE	DATE

DRAWING APPROVAL STATUS: APPROVED FOR CONSTRUCTION

HATCH

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

TOTE ROAD
LAYOUT AND LONGITUDINAL SECTION
GRADE CROSSING AT CH. 96+585

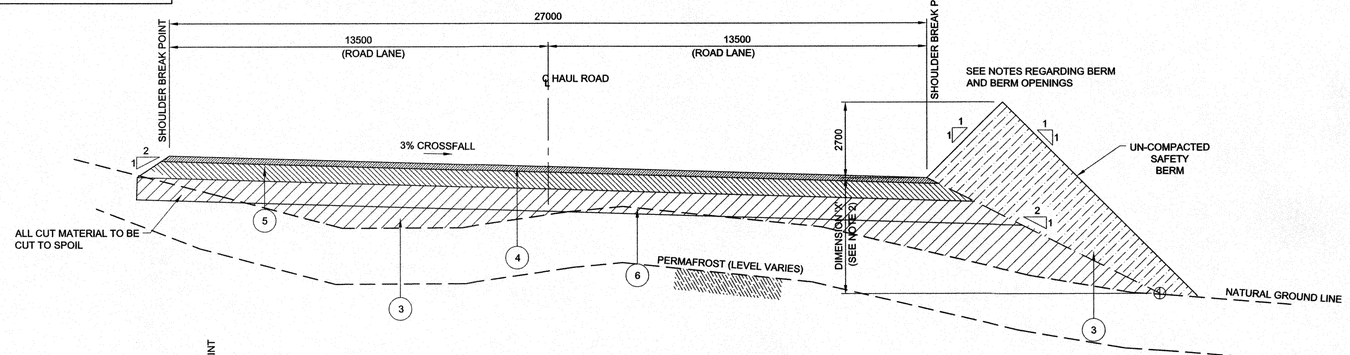
SCALE 1:1,000 OR AS NOTED
DWG. No. H353004-30000-224-271-0038-0001
REV 0
SHEET SIZE: A0

$USERNAMES
$DATES
$PLOTS
$TIMES

ATTACHMENT 7.3

TOTE ROAD TYPICAL DRAWINGS

DWG. No. H353004-10000-221-273-0002-0001



HAUL ROAD - TYPICAL CROSS SECTION

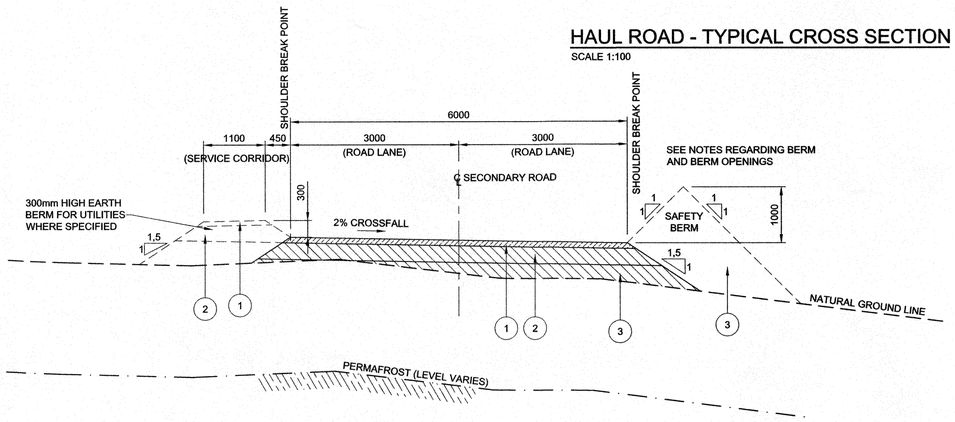
SCALE 1:100

ROAD MATERIAL IDENTIFICATION: (SEE NOTE 4)

1. 100mm WEARING COURSE / BASE LAYER, TYPE 5 (-32mm) MATERIAL
2. 300mm ROCK SUBBASE LAYER, TYPE 8 (-150mm) MATERIAL WHERE FILL IS LESS THAN 600mm THICK,
   OR,
   TYPE 12 (-600mm) MATERIAL WHERE FILL IS GREATER THAN 600mm
3. GENERAL FILL, TYPE 8 (-150mm) MATERIAL WHERE FILL IS LESS THAN 600mm THICK,
   OR,
   TYPE 12 (-600mm) MATERIAL WHERE FILL IS GREATER THAN 600mm
4. 200mm WEARING COARSE / BASE LAYER, TYPE 5 (-32mm) MATERIAL
5. 600mm ROCK SUBBASE LAYER, TYPE 8 (-150mm) MATERIAL
6. 800mm ROCK SUBGRADE LAYER, TYPE 12 (-600mm) MATERIAL

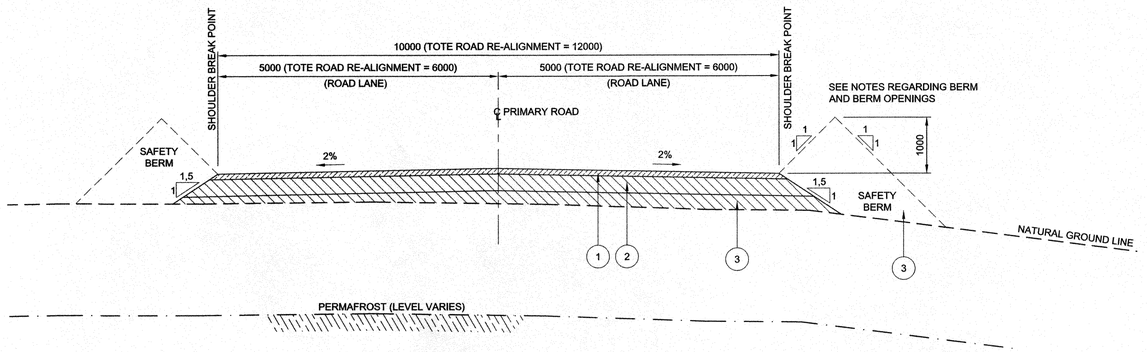
GENERAL NOTES:

1. SAFETY BERMS FOR ALL ROADS SHALL BE PROVIDED BASED ON THE NUNAVUT MINE HEALTH AND SAFETY ACT.
2. THIS BARRIER SHALL BE PROVIDED WHERE THE ELEVATION DIFFERENCE IS GREATER THAN 3.0m (DIMENSION 'X'), MEASURED AT THE ROAD SHOULDER BREAK POINT, SEE TYPICAL SECTIONS FOR LOCATION. BERMS TO BE CONSTRUCTED AS PRESCRIBED BY THE ENGINEER ON SITE.
3. 1.0m WIDE OPENINGS ARE TO BE PROVIDED IN THE BERMS AT 25.0m C/C FOR WATER RUN OFF AND SNOW CLEARANCE DURING MAINTENANCE.
4. THICKNESS FOR ROAD FILL MATERIALS ARE MINIMUM, AND TO BE ADJUSTED IN THE FIELD DEPENDING ON SITE AND LOCAL CONDITIONS



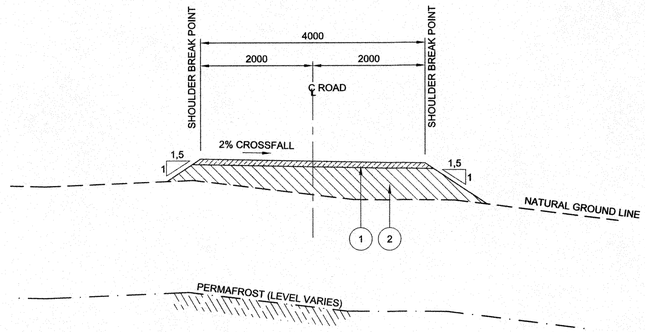
SECONDARY ROAD - TYPICAL CROSS SECTION

SCALE 1:50



PRIMARY ROAD - TYPICAL CROSS SECTION

SCALE 1:50



TERTIARY AND TEMPORARY ROAD - TYPICAL CROSS SECTION

SCALE 1:50

PERMIT TO PRACTICE
HATCH LTD.
Signature
Date 2018-01-23
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

REGISTERED PROFESSIONAL ENGINEER R.A. HALIM LICENSEE 2018-01-23 NWT/NU

FOR CONSTRUCTION

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No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR CONSTRUCTION	IHB	FH	23/01/2018

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	I BARNARD	NR	
DESIGNER	I BARNARD	NR	
CHECKER	F HUGO		2018-01-23
DESIGN COORD.	R GOOSEN		2018-01-23
RESP. ENG.	R HALIM		2018-01-23
LEAD DISC. ENG.	A GROBBELAAR		2018-01-23
AREA MANAGER	V LAVRIC	N/A	
ENG. MANAGER	D STANGER		2018-1-23
CLIENT	F PITTMAN		2018-01-26

DRAWING APPROVAL STATUS: Approved for Construction

HATCH

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

MINE SITE
HAUL, PRIMARY AND SECONDARY ROADS
TYPICAL CROSS SECTIONS

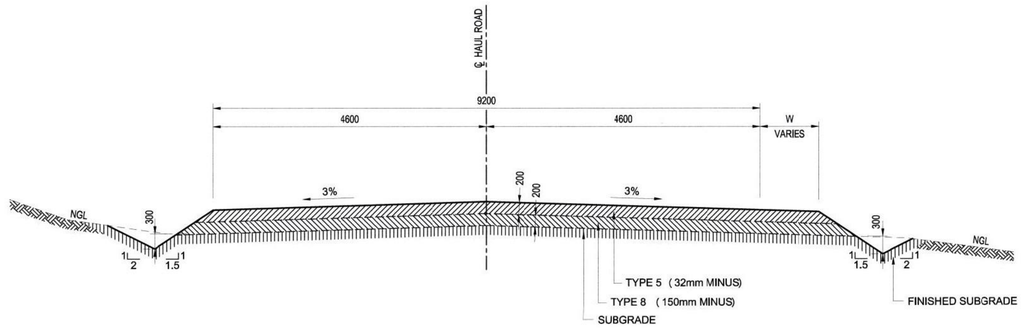
SCALE 1:50 OR AS NOTED | DWG. No. H353004-10000-221-273-0002-0001 | REV 0

SHEET SIZE: D

DRAWING No.	DRAWING TITLE
REFERENCE DRAWINGS	REG. PROFESSIONAL

jdc_pwservice 11:41 23-JAN-2018 \\DCPWPDFP03\PDFtemp\4188\5115048_300\H353004-10000-221-273-0002-0001.dwg

DWG. No. H353004-30000-224-294-0010-0001



TYPICAL HAUL ROAD CROSS SECTION

SCALE 1::50

ROAD PAVEMENT STRUCTURE BY SOIL TYPE		
SOIL TYPE BY FROST SUSCEPTIBILITY	TYPE 8 DEPTH (mm)	TYPE 5 DEPTH (mm)
HIGHLY SUSCEPTIBLE (HS)	150	150
MODERATELY SUSCEPTIBLE (MS)	150	150
POTENTIALLY SUSCEPTIBLE (PS)	-	150
NON SUSCEPTIBLE	-	150

WIDENING TABLE					
DESIGN SPEED: 65 km/h		DESIGN SPEED: 65 km/h		DESIGN SPEED: 65 km/h	
RADIUS	WIDENING	RADIUS	WIDENING	RADIUS	WIDENING
10000	0	475	0.3	190	1
5000	0	390	0.4	180	1.1
3000	0	380	0.5	170	1.2
2000	0	370	0.5	160	1.3
1500	0	360	0.5	150	1.4
1200	0	350	0.5	140	1.5
1000	0	340	0.5	130	1.6
950	0	330	0.5	120	1.7
900	0	320	0.6	110	1.9
850	0.1	310	0.6	100	2
800	0.1	300	0.6	90	2.3
750	0.1	290	0.6	80	2.6
700	0.1	280	0.7	70	2.9
650	0.2	270	0.7	60	3.3
600	0.2	260	0.7	55	3.5
575	0.2	250	0.8	50	3.7
550	0.2	240	0.8		
525	0.2	200	1		

NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE INDICATED.
2. 'W' - REFER TO WIDENING TABLE FOR WIDTH OF WIDENING.
3. THIS DRAWING WAS PREVIOUSLY ISSUED: H353004-00000-224-272-0034-0001

PERMIT TO PRACTICE
HATCH LTD.
Signature
Date 2018-4-24
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

REGISTERED PROFESSIONAL ENGINEER D. STANGER LICENSEE NT/NU

APPROVED FOR CONSTRUCTION

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No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR CONSTRUCTION	AVN	AA	2018/04/20

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	A VAN NIEKERK	NR	22/11/17
DESIGNER	A VAN NIEKERK	NR	22/11/17
CHECKER	A AQUIL		2018/04/23
DESIGN COORD.	A AQUIL		2018/04/23
RESP. ENG.	D STANGER		2018/04/23
LEAD DISC. ENG.	F VAN BILJON		2018/04/23
AREA LEAD	F VAN BILJON		2018/04/23
ENG. MANAGER	D STANGER		2018/04/23
AREA MANAGER	F. PITTMAN		2018/4/25

DRAWING APPROVAL STATUS: APPROVED FOR CONSTRUCTION

HATCH

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

TOTE ROAD
STANDARD DRAWING
TYPICAL HAUL ROAD CROSS SECTION

DRAWING No.	DRAWING TITLE

REFERENCE DRAWINGS

REG. PROFESSIONAL

REVISIONS

SCALE 1:100 OR AS NOTED

DWG. No. H353004-30000-224-294-0010-0001

REV 0

SHEET SIZE: D

ATTACHMENT 8

WATERCOURSE CROSSINGS LIST AND ENGINEERING DRAWINGS

8.1 North Railway Crossing List
8.2 Tote Road Crossing List
8.3 North Railway Bridge Drawings

ATTACHMENT 8.1

NORTH RAILWAY CROSSING LIST

Table 8.1 North Railway Culvert Crossings, Bridges, Cuts, Diversions, and Encroachments on Waterbodies and Fish Habitat

Site ID	Description	Waterbody Type[1]	Diversion to	Receives Diversion From	Rail Chainage (m)	UTM Coordinates[2]		Arctic Char		Ninespine Stickleback		Habitat Quality	No. Barrels	Culvert Length (m)	Culvert Diameter (mm)	Stream Order		Culvert Footprint in Arctic Char Habitat			Catchment Areas	Mean Annual Flow		Ranges of results			
						Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty					Stream Order at Crossing	Ave. Bank-full Habitat Width (est.)[7]	Area Without Apron (m^2)	Apron Area (m^2)	Total Area (m^2)	(m^2)	Low Flow Scenario (L/s)	High Flow Scenario (L/s)	Min velocity (m/s)	Max Velocity (m/s)	Min Depth (m)	Max Depth (m)
CV-0-1	Culvert	S		CV-0-2	275	504289	7975593	No	N/A	No	N/A	None	1	6.0	900	n/a	n/a				11703	0.1	0.1	0.00	0.00	0.00	0.00
CV-0-2	Cut	S	CV-0-1		328	504234	7975572	No	N/A	No	N/A	None	NA	NA	NA	n/a	n/a				143614	1.0	1.6	0.00	0.00	0.00	0.00
CV-0-3	Culvert	S			888	503796	7975281	No	N/A	No	N/A	None	TBD	TBD	TBD	n/a	n/a										
CV-1-1	Culvert	S			1122	503802	7975052	No	N/A	No	N/A	None	TBD	TBD	TBD	n/a	n/a										
CV-1-2	Culvert	S			1266	503830	7974912	No	N/A	No	N/A	None	TBD	TBD	TBD	n/a	n/a										
CV-1-3	Culvert	S/P			1350	503820	7974824	No	N/A	No	N/A	None	TBD	TBD	TBD	n/a	n/a										
CV-1-4	Culvert	LP			1780	503877	7974421	No	N/A	No	N/A	None	TBD	TBD	TBD	n/a	n/a										
CV-1-5	Culvert	LP			1896	503938	7974333	No	N/A	No	N/A	None	TBD	TBD	TBD	n/a	n/a										
CV-1-6	Culvert	S			2345	504292	7974064	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				60907	0.4	0.7	0.00	0.00	0.00	0.00
CV-1-7	Culvert	S			2895	504662	7973667	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				24266	0.2	0.3	0.00	0.00	0.00	0.00
CV-1-8	Culvert	S			3225	504895	7973426	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				54475	0.4	0.6	0.00	0.00	0.00	0.00
CV-1-9	Culvert	S			3283	504924	7973381	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				38355	0.3	0.4	0.00	0.00	0.00	0.00
CV-2-1	Culvert	S			3625	505154	7973121	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				328690	2.4	3.6	0.00	0.00	0.00	0.00
CV-2-2	Culvert	S			3720	505217	7973067	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				11440	0.1	0.1	0.00	0.00	0.00	0.00
CV-3-1	Culvert	S			3940	505388	7972906	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-3-2	Culvert	S			3955	505396	7972893	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				17518	0.1	0.2	0.00	0.00	0.00	0.00
CV-4-1	Culvert	S			4395	505666	7972585	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				38452	0.3	0.4	0.00	0.00	0.00	0.00
CV-4-2	Culvert	S			4520	505774	7972512	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				8996	0.1	0.1	0.00	0.00	0.00	0.00
CV-4-3	Culvert	S			4620	505836	7972435	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				12408	0.1	0.1	0.00	0.00	0.00	0.00
CV-4-4	Culvert	S			4665	505862	7972397	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				10441	0.1	0.1	0.00	0.00	0.00	0.00
CV-4-5	Culvert	S			4950	506070	7972201	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				53676	0.4	0.6	0.00	0.00	0.00	0.00
CV-5-1	Culvert	S			5130	506158	7972031	No	N/A	No	N/A	None	1	10.0	900	n/a	n/a				454159	3.3	5.0	0.00	0.00	0.00	0.00
CV-5-2	Culvert	S			5165	506172	7971999	No	N/A	No	N/A	None	1	10.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-5-3	Culvert	S			5421	506297	7971792	No	N/A	No	N/A	None	1	10.0	900	n/a	n/a				1086870	7.9	12.0	0.00	0.00	0.00	0.00
CV-5-4	Culvert	S			5700	506540	7971622	No	N/A	No	N/A	None	1	10.0	900	n/a	n/a				3288	0.0	0.0	0.00	0.00	0.00	0.00
CV-5-5	Culvert	S			5838	506643	7971540	No	N/A	No	N/A	None	1	10.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-5-6	Culvert	S			5861	506661	7971526	No	N/A	No	N/A	None	1	10.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-5-7	Culvert	S			6030	506781	7971420	No	N/A	No	N/A	None	1	10.0	900	n/a	n/a				71246	0.5	0.8	0.00	0.00	0.00	0.00
CV-6-1	Culvert	S			6240	506927	7971257	No	N/A	No	N/A	None	2	24.0	1200	n/a	n/a				32214	0.2	0.4	0.00	0.00	0.00	0.00
CV-6-2	Culvert	S			6557	507170	7971061	No	N/A	No	N/A	None	1	10.0	900	n/a	n/a				206389	1.5	2.3	0.00	0.00	0.00	0.00
CV-6-3	Culvert	S			6852	507417	7970910	No	N/A	No	N/A	None	1	10.0	900	n/a	n/a				656037	4.8	7.2	0.00	0.00	0.00	0.00
CV-6-4	Culvert	S			6945	507476	7970841	No	N/A	No	N/A	None	1	10.0	900	n/a	n/a				506312	3.7	5.6	0.00	0.00	0.00	0.00
CV-7-1	Culvert	LP			7350	507732	7970526	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-7-2	Culvert	LP			7593	507884	7970336	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-7-3	Culvert	LP			7700	507953	7970255	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-7-4	Culvert	LP			7838	508038	7970146	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-7-5	Culvert	LP			7875	508060	7970116	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-7-6	Culvert	LP			7930	508094	7970073	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-7-7	Culvert	LP			7935	508097	7970069	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-8-0	Cut	S	CV-8-1 and CV-8-2		8305	508293	7969747	No	N/A	No	N/A	None	0	NA	NA	n/a	n/a				1211530	8.8	13.3	0.00	0.00	0.00	0.00
CV-8-1	Culvert	S		CV-8-0	8352	508311	7969712	No	N/A	No	N/A	None	1	12.0	1200	n/a	n/a				1211530	8.8	13.3	0.00	0.00	0.00	0.00
CV-8-2	Culvert	S		CV-8-0	8384	508325	7969683	No	N/A	No	N/A	None	1	18.0	1200	n/a	n/a				1211530	8.8	13.3	0.00	0.00	0.00	0.00
CV-8-3	Culvert	S			8470	508351	7969601	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				601962	4.4	6.6	0.00	0.00	0.00	0.00
CV-8-4	Culvert	S			8740	508412	7969338	No	N/A	No	N/A	None	1	12.0	1200	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-9-1	Culvert	S			9360	508805	7968873	No	N/A	No	N/A	None	6	12.0	900	n/a	n/a				1127610	8.2	12.4	0.00	0.00	0.00	0.00
CV-10-1	Culvert	LP			10188	509365	7968264	No	N/A	No	N/A	None	1	6.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-10-2	Culvert	LP			10560	509637	7968011	No	N/A	No	N/A	None	1	6.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-10-3	Culvert	LP			10580	509653	7967999	No	N/A	No	N/A	None	1	6.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-10-4	Culvert	LP			10800	509829	7967867	No	N/A	No	N/A	None	1	6.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-10-5	Culvert	S			10861	509872	7967824	No	Low	No	Low	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-11-1	Culvert	S			11040	509931	7967723	Potential	High	Potential	High	Marginal	1	6.0	900	1	2.8	17	20	37	88631	0.6	1.0	0.21	0.38	0.01	0.02
CV-11-2	Culvert	LP			11219	510076	7967537	No	N/A	No	N/A	None	1	12.0	1200	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-11-3	Culvert	S			11380	510214	7967455	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				230752	1.7	2.5	0.00	0.00	0.00	0.00
CV-11-4	Culvert	LP			11645	510472	7967402	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				117068	0.9	1.3	0.00	0.00	0.00	0.00
CV-11-5	Culvert	LP			11764	510589	7967385	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-12-1	Culvert	S			12132	510933	7967256	Unlikely	Moderate	Unlikely	Moderate	None-Marginal	1	18.0	900	1	2.8	50	20	71	348946	2.5	3.8	0.32	0.59	0.02	0.04
CV-12-2	Culvert	S			12219	511019	7967241	Unlikely	Moderate	Unlikely	Moderate	None-Marginal	1	18.0	900	1	2.8	50	20	71	91287	0.7	1.0	0.21	0.39	0.01	0.02
CV-12-3	Culvert	LP			12329	511127	7967223	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-12-4	Culvert	LP			12560	511355	7967185	No	N/A	No	N/A	None	1	6.0	900	n/a	n/a				51395	0.4	0.6	0.00	0.00	0.00	0.00
CV-12-4b	Cut	LP	CV-12-5 and CV-13-1		12505	511455	7967168	No	N/A	No	N/A	None	0	NA	NA	n/a	n/a				467079	3.4	5.1	0.00	0.00	0.00	0.00
CV-12-5	Culvert	S		CV-12-4b	12760	511552	7967152	No	N/A	No	N/A	None	1	10.0	900	n/a	n/a				58945	0.4	0.6	0.00	0.00	0.00	0.00
CV-13-1	Culvert	LP		CV-12-4b	13009	511798	7967111	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-13-2	Culvert	LP			13360	512120	7966981	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				78503	0.6	0.9	0.00	0.00	0.00	0.00
CV-13-3	Culvert	S			13660	512375	7966823	No	N/A	No	N/A	None	1	7.5	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-13-4	Culvert	S			13707	512415	7966799	Yes	N/A	Yes	N/A	Important	2	18.0	1400	3	16.3	293	183	476	10849900	79.2	119.3	0.69	1.27	0.08	0.14
CV-13-5	Culvert	S			13880	512556	7966712	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				127304	0.9	1.4	0.00	0.00	0.00	0.00
CV-14-1	Culvert	S			14629	513252	7966428	No	N/A	No	N/A	None	1	12.5	1200	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00

Table 8.1 North Railway Culvert Crossings, Bridges, Cuts, Diversions, and Encroachments on Waterbodies and Fish Habitat

Site ID	Description	Waterbody Type[1]	Diversion to	Receives Diversion From	Rail Chainage (m)	UTM Coordinates[2]		Arctic Char		Ninespine Stickleback		Habitat Quality	No. Barrels	Culvert Length (m)	Culvert Diameter (mm)	Stream Order		Culvert Footprint in Arctic Char Habitat			Catchment Areas	Mean Annual Flow		Ranges of results			
						Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty					Stream Order at Crossing	Ave. Bank-full Habitat Width (est.)[7]	Area Without Apron (m^2)	Apron Area (m^2)	Total Area (m^2)	(m^2)	Low Flow Scenario (L/s)	High Flow Scenario (L/s)	Min velocity (m/s)	Max Velocity (m/s)	Min Depth (m)	Max Depth (m)
CV-14-2	Culvert	P			14821	513436	7966375	No	N/A	No	N/A	None	1	12.0	1200	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-14-3	Culvert	P			14926	513532	7966333	No	N/A	No	N/A	None	1	12.0	1200	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-15-1	Culvert	LP			15026	513624	7966294	No	N/A	No	N/A	None	1	12.0	1200	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-15-2	Culvert/ encroachment	S/P			15216	513781	7966188	Yes	N/A	Yes	N/A	Marginal(ARCH) Important (NNST)	1	24.0	1400	3	36				1038020	7.6	11.4	0.42	0.76	0.04	0.06
CV-15-3	Culvert/ encroachment	S/P			15407	513892	7966034	Yes	N/A	Yes	N/A	Marginal - Important	2	17.5	900	2	27.3				331285	2.4	3.6	0.25	0.47	0.02	0.03
CV-15-4	Culvert	P			15806	514123	7965711	No	Low	No	Low	None	1	15.0	1200	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-15-5	Bridge	S			15950	514239	7965626	Yes	N/A	Yes	N/A	Important	N/A	N/A	N/A	3+	Bridge				538280000	3929.4	5921.1	0.00	0.00	0.00	0.00
CV-16-1	Culvert	LP			16055	514325	7965565	No	N/A	No	N/A	None	4	15.0	1200	n/a	n/a				538280000	3929.4	5921.1	0.00	0.00	0.00	0.00
CV-16-2	Culvert/ encroachment	S/P			16722	514768	7965089	No	N/A	No	N/A	None	4	12.5	1200	n/a	n/a				117686	0.9	1.3	0.14	0.26	0.01	0.01
CV-16-3	Culvert	S			16961	514811	7964916	No	Low	Potential	High	Marginal	1	12.0	900	n/a	n/a				117686	0.9	1.3	0.23	0.42	0.02	0.03
CV-17-1	Culvert	P			17903	515261	7964025	No	N/A	No	Low	None	1	17.5	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-18-1	Encroachment	P			18095	515331	7963846	No	N/A	Unlikely	Moderate	None - Marginal	1	30.0	900	1	2.8				1094950	8.0	12.0	0.45	0.83	0.04	0.07
CV-18-2	Culvert	S			18266	515405	7963693	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				42825	0.3	0.5	0.00	0.00	0.00	0.00
CV-18-3	Culvert	S			18633	515607	7963389	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-18-4	Culvert	S			18729	515682	7963328	No	N/A	No	N/A	None	1	15.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-19-1	Culvert	S			19018	515927	7963175	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				56868	0.4	0.6	0.00	0.00	0.00	0.00
CV-19-2	Culvert	P			19293	516161	7963031	No	N/A	No	Low	None	1	30.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-19-3	Culvert	S			19940	516613	7962587	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				44195	0.3	0.5	0.00	0.00	0.00	0.00
CV-20-1	Culvert	LP		CV-20-2	20498	517040	7962255	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				29676	0.2	0.3	0.00	0.00	0.00	0.00
CV-20-2	Cut	S	CV-20-1		20818	517267	7962029	No	N/A	No	N/A	None	0	NA	NA	n/a	n/a				28804	0.2	0.3	0.00	0.00	0.00	0.00
CV-21-1	Culvert	LP			21008	517391	7961887	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-21-2	Culvert	LP			21336	517607	7961640	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-21-3	Culvert	LP			21798	517928	7961308	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-21-4	Culvert	LP			21955	518010	7961196	No	N/A	No	N/A	None	0	18.0	0	n/a	n/a				254847	1.9	2.8	0.00	0.00	0.00	0.00
CV-22-1	Pond Infilling	P			22209	518123	7960950	No	N/A	Unlikely	Moderate	None - Marginal	1	12.0	900	n/a (LE)	n/a				-	-	-	0.03	0.04	0.00	0.00
CV-22-2	Encroachment	P			22680	518232	7960617	No	N/A	Unlikely	Moderate	None - Marginal	1	12.0	900	n/a (LE)	n/a				-	-	-	0.03	0.04	0.00	0.00
CV-22-3	Culvert	LP			22759	518295	7960427	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-22-4	Encroachment	P			23000	518370	7960198	No	N/A	Unlikely	Moderate	None - Marginal	does not require modeling			n/a (LE)	n/a				Encroachment						
CV-23-1	Culvert	S			23200	518441	7959981	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				198672	1.5	2.2	0.00	0.00	0.00	0.00
CV-23-2	Culvert	S			23421	518501	7959798	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				105039	0.8	1.2	0.00	0.00	0.00	0.00
CV-23-3	Culvert	LP			23844	518695	7959425	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-23-4	Culvert	S			23952	518754	7959335	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				59007	0.4	0.6	0.00	0.00	0.00	0.00
CV-24-1	Culvert	S			24407	518988	7958946	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				177168	1.3	1.9	0.00	0.00	0.00	0.00
CV-24-2	Culvert	S			24689	519081	7958667	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				3029	0.0	0.0	0.00	0.00	0.00	0.00
CV-24-3	Culvert	S			24863	519153	7958481	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				1240640	9.1	13.6	0.00	0.00	0.00	0.00
CV-25-1	Culvert	S			25162	519225	7958229	No	N/A	No	N/A	None	2	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-25-2	Culvert	S			25250	519507	7958144	Probable	Moderate	Probable	Moderate	Marginal - Important	1	13.6	900	1	2.8	38	20	58							
CV-25-3	Culvert	S			25690	519661	7958016	Potential	High	Potential	High	Marginal	2	20.6	1200	3	16.3	336	156	492							
CV-26-1	Culvert/Infill	S/P			26159	519989	7957450	Potential	High	Potential	High	Marginal				3	16.3										
CV-26-3	Culvert	LP			26502	520156	7957209	No	N/A	No	N/A	None	TBD	TBD	TBD	n/a	n/a										
CV-26-4	Culvert	LP			26847	520224	7957110	No	N/A	No	N/A	None	TBD	TBD	TBD	n/a	n/a										
CV-26-5	Culvert	S				520386	7956847	No	N/A	No	N/A	None	TBD	TBD	TBD												
CV-27-1	Culvert	S			27177	520406	7956775	Potential	High	Potential	High	Marginal	1	13.6	900	1	2.8	3	0	3							
CV-27-2	Culvert	S			27237	520412	7956735	Potential	High	Potential	High	Marginal	1	13.6	900	3	16.3	222	117	339							
CV-27-3	Culvert	LP			27555	520516	7956235	No	N/A	No	N/A	None	1	12.5	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-27-4	Culvert	LP			27670	520564	7956131	No	N/A	No	N/A	None	1	12.5	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-27-5	Culvert	S			27997	520699	7955833	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				487112	3.6	5.4	0.00	0.00	0.00	0.00
CV-28-1	Culvert	LP			28051	520722	7955784	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-28-2	Culvert	S			28090	520749	7955722	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				694568	5.1	7.6	0.00	0.00	0.00	0.00
CV-28-3	Culvert	LP			28601	520891	7955261	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-28-4	Culvert	LP			28687	520924	7955182	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-28-5	Culvert/encroachment	P			28828	521005	7955067	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-28-6	Culvert	S			28959	521092	7954969	Yes	Low	Yes	Low	Important	1	17.5	1400	3	16.3	285	183	468	2677000	19.5	29.4	0.56	1.02	0.06	0.10
CV-28-7	Culvert	S			29319	521305	7954680	No	N/A	No	N/A	None	1	15.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-29-1	Culvert	S			29400	521341	7954608	No	N/A	No	N/A	None	1	17.5	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-29-2	Culvert	S			29499	521379	7954516	Yes	N/A	Yes	N/A	Important	1	25.0	1400	3	16.3	408	183	590	2696280	19.7	29.7	0.56	1.02	0.06	0.10
CV-29-3	Culvert	S			29726	521464	7954306	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-29-4	Culvert	S			29854	521512	7954187	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-29-5	Culvert	S			29932	521541	7954115	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				415593	3.0	4.6	0.00	0.00	0.00	0.00
CV-30-1	Culvert	S			30012	521569	7954040	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-30-2	Culvert	LP			30184	521609	7953873	No	N/A	No	N/A	None	1	18.0	1200	n/a	n/a				430250	3.1	4.7	0.00	0.00	0.00	0.00
CV-30-3	Culvert	S/LP			30339	521635	7953720	No	N/A	No	N/A	None	1	24.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-30-4	Culvert	S			30601	521676	7953461	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				125312	0.9	1.4	0.00	0.00	0.00	0.00
CV-30-5	Culvert	S			30660	521687	7953363	Yes	Low	Yes	Low	Important	1	7.5	900	2	6.8	51	49	100	976854	7.1	10.7	0.44	0.80	0.04	0.07
CV-30-6	Culvert	S			30814	521700	7953250	No	N/A	Unlikely	Moderate	None - Marginal	1	12.0	900	1	2.8				78862	0.6	0.9	0.20	0.37	0.01	0.02

Table 8.1 North Railway Culvert Crossings, Bridges, Cuts, Diversions, and Encroachments on Waterbodies and Fish Habitat

Site ID	Description	Waterbody Type[1]	Diversion to	Receives Diversion From	Rail Chainage (m)	UTM Coordinates[2]		Arctic Char		Ninespine Stickleback		Habitat Quality	No. Barrels	Culvert Length (m)	Culvert Diameter (mm)	Stream Order		Culvert Footprint in Arctic Char Habitat			Catchment Areas	Mean Annual Flow		Ranges of results			
						Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty					Stream Order at Crossing	Ave. Bank-full Habitat Width (est.)[7]	Area Without Apron (m^2)	Apron Area (m^2)	Total Area (m^2)	(m^2)	Low Flow Scenario (L/s)	High Flow Scenario (L/s)	Min velocity (m/s)	Max Velocity (m/s)	Min Depth (m)	Max Depth (m)
CV-30-7	Pond Infilling	S/P			30921	521712	7953143	No	N/A	Unlikely	Moderate	None - Marginal	1	12.5	900	n/a (LE)	n/a				-	-	-	0.03	0.04	0.00	0.00
CV-31-1	Culvert	S			31278	521748	7952788	Yes	N/A	Yes	N/A	Important	1	20.0	1200	3	16.3	326	156	482	4378030	32.0	48.2	0.66	1.21	0.08	0.13
CV-31-2	Culvert	S			31290	521749	7952776	Yes	N/A	Yes	N/A	Important	1	20.0	1200	3	16.3	326	156	482	4378030	32.0	48.2	0.66	1.21	0.08	0.13
CV-31-3	Culvert	LP			31720	521763	7952346	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				362829	2.6	4.0	0.00	0.00	0.00	0.00
CV-31-4	Culvert	LP			31789	521772	7952278	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				362829	2.6	4.0	0.00	0.00	0.00	0.00
CV-32-1	Culvert	LP			32008	521827	7952066	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				362829	2.6	4.0	0.00	0.00	0.00	0.00
CV-32-2	Culvert	LP			32220	521882	7951861	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				362829	2.6	4.0	0.00	0.00	0.00	0.00
CV-32-3	Culvert	LP			32470	521946	7951620	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				362829	2.6	4.0	0.00	0.00	0.00	0.00
CV-32-4	Culvert	S			32580	521983	7951453	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				336611	2.5	3.7	0.00	0.00	0.00	0.00
CV-33-1	Culvert	LP			33083	521990	7951011	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				163261	1.2	1.8	0.00	0.00	0.00	0.00
CV-33-2	Culvert	LP			33183	521991	7950911	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-33-3	Culvert	LP			33255	521990	7950839	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-33-4	Culvert	S			33362	521976	7950733	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-33-5	Culvert	S			33434	521964	7950662	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				2059530	15.0	22.7	0.00	0.00	0.00	0.00
CV-33-6	Culvert	S			33530	521947	7950568	Yes	N/A	Yes	N/A	Important	4	18.0	1200	3	16.3	293	156	450	1772810	12.9	19.5	0.33	0.60	0.03	0.04
CV-33-7	Culvert	P			33888	521885	7950215	No	N/A	No	N/A	None	1	10.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-34-1	Culvert	S			34439	521789	7949673	No	N/A	No	N/A	None	1	24.0	1200	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-34-2	Culvert	S			34963	521801	7949153	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-35-2	Culvert	S			35331	521947	7948828	Yes	N/A	Yes	N/A	Important	5	22.5	1400	3+	14.1	317	158	475	34732700	253.5	382.1	0.74	1.36	0.09	0.15
CV-35-4	Culvert	S		CV-35-5	35959	522249	7948287	No	N/A	No	N/A	None	4	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-35-5	Cut	LP	CV-35-4		36070	522298	7948170	No	N/A	No	N/A	None	0	NA	NA	n/a	n/a				2757860	20.1	30.3	0.00	0.00	0.00	0.00
CV-37-1	Culvert	LP			37897	522533	7946398	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-38-1	Culvert	S			38297	522570	7946000	No	N/A	No	N/A	None	1	30.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-38-2	Culvert	S			38509	522646	7945802	No	N/A	No	N/A	None	1	36.0	900	n/a	n/a				180963	1.3	2.0	0.00	0.00	0.00	0.00
CV-38-3	Culvert	S			38970	522846	7945387	No	N/A	No	N/A	None	3	30.0	1400	n/a	n/a				6203670	45.3	68.2	0.00	0.00	0.00	0.00
CV-39-1	Culvert	S			39513	523125	7944922	No	N/A	No	N/A	None	1	36.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-40-1	Culvert	LP			40160	523148	7944309	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-40-2	Culvert	S			40320	523147	7944150	No	N/A	No	N/A	None	2	18.0	1200	n/a	n/a				3211670	23.4	35.3	0.00	0.00	0.00	0.00
CV-40-3	Culvert	LP			40586	523231	7943898	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-40-4	Culvert	LP			40830	523301	7943665	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-41-1	Culvert	S			41100	523332	7943397	No	N/A	No	N/A	None	1	12.5	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-41-2	Culvert	S			41186	523342	7943311	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-41-3	Culvert	LP			41346	523359	7943152	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-41-4	Culvert	LP			41536	523351	7942963	No	N/A	No	N/A	None	1	24.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-42-1	Culvert	S			42225	523423	7942323	No	N/A	No	N/A	None	1	24.0	1200	n/a	n/a				1453950	10.6	16.0	0.00	0.00	0.00	0.00
CV-42-2	Culvert	S			42954	523475	7941603	No	N/A	No	N/A	None	1	22.5	900	n/a	n/a				321511	2.3	3.5	0.00	0.00	0.00	0.00
CV-43-1	Culvert	S			43331	523647	7941268	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				3951760	28.8	43.5	0.00	0.00	0.00	0.00
CV-43-2	Culvert	LP			43448	523721	7941127	No	N/A	No	N/A	None	2	12.0	1200	n/a	n/a				3951760	28.8	43.5	0.00	0.00	0.00	0.00
CV-43-3	Culvert	S			43526	523738	7941095	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				3951760	28.8	43.5	0.00	0.00	0.00	0.00
CV-43-4	Culvert	S			43549	523749	7941075	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				3951760	28.8	43.5	0.00	0.00	0.00	0.00
CV-43-5	Culvert	S			43746	523846	7940904	No	Low	No	Low	None	1	30.0	900	n/a	n/a				1116680	8.2	12.3	0.00	0.00	0.00	0.00
CV-44-1	Culvert	S			44156	524074	7940563	No	N/A	No	N/A	None	2	12.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-44-2	Culvert	S			44335	524174	7940415	No	N/A	No	N/A	None	2	18.0	1200	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-44-3	Culvert	S			44983	524536	7939827	No	N/A	No	N/A	None	2	12.0	1200	n/a	n/a				1634200	11.9	18.0	0.00	0.00	0.00	0.00
CV-45-1	Culvert	LP			45965	525004	7938965	No	N/A	No	N/A	None	1	12.0	900	n/a	n/a				1634200	11.9	18.0	0.00	0.00	0.00	0.00
CV-46-1	Culvert	LP			46214	525118	7938743	No	N/A	No	N/A	None	1	18.0	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-46-1a	Cut	P	CV-46-3		46454	525226	7938529	No	Low	No	Low	None	NA	NA	NA	n/a	n/a				-			0.00	0.00	0.00	0.00
CV-46-2	Culvert	S			46473	525278	7938537	No	Low	No	Low	None	TBD	TBD	TBD	n/a	69.9										
CV-46-3	Culvert	S		CV-46-1a	46776	525380	7938336	No	N/A	No	N/A	None	TBD	TBD	TBD	n/a	n/a										
CV-46-4	Culvert	S			46870	525394	7938239	No	N/A	No	N/A	None	TBD	TBD	TBD	n/a	n/a										
CV-46-6	Culvert	S			46920	525404	7938168	No	N/A	No	N/A	None	TBD	TBD	TBD												
CV-47-1A	Culvert	S			47000	525415	7938089	No	N/A	No	N/A	None	TBD	TBD	TBD												
CV-47-1B	Culvert	S			47155	525454	7937939	No	N/A	No	N/A	None	TBD	TBD	TBD												
CV-47-1	Culvert	S			47602	525683	7937366	Yes	N/A	No	Low	Important	1	13.6	900	3	16.3	222	117	339							
CV-47-2	Culvert	S			47773	525698	7937327	Yes	N/A	Yes	N/A	Important	4	15.0	1400	3	16.3	245	183	427	7445800	54.4	81.9	0.50	0.91	0.05	0.08
CV-47-3	Culvert	S			47817	525729	7937268	Yes	N/A	Yes	N/A	Important	2	17.5	1400	3	16.3	285	183	468	7445800	54.4	81.9	0.62	1.13	0.07	0.11
CV-48-1	Culvert	S/LP			48025	525839	7937127	No	High	No	High	None	TBD	TBD	TBD	1	2.8										
CV-48-2	Culvert	S/LP			48346	525916	7937063	No	High	No	High	None	TBD	TBD	TBD	1	2.8										
CV-48-3	Culvert	S/LP			48382	526356	7936875	No	High	No	High	None	TBD	TBD	TBD	3	16.3										
CV-48-4	Culvert	S			48402	526523	7936808	Yes	N/A	Yes	N/A	Important	2	27.5	1200	3	16.3	448	156	605	-	-	-	0.02	0.04	0.00	0.00
CV-49-1	Culvert	S			49089	526690	7936443	No	Low	No	Low	None	TBD	TBD	TBD	n/a	n/a										
CV-49-2	Culvert	S			49267	526737	7936101	Potential	High	Potential	High	Marginal	1	16.1	900	2	6.8	109	49	158							
CV-49-3	Culvert	S/LP			49476	526788	7935730	No	Low	No	Low	None	TBD	TBD	TBD	n/a (LE)	n/a										
CV-50-1	Culvert	S			50473	526835	7935393	No	N/A	No	N/A	None	TBD	TBD	TBD	n/a	n/a										
CV-50-2	Culvert	S			50578	526863	7935175	No	N/A	No	N/A	None	TBD	TBD	TBD	n/a	n/a										
CV-50-3	Culvert	S			50647	526868	7935095	No	N/A	No	N/A	None	TBD	TBD	TBD	n/a	n/a										
CV-50-4	Culvert	LP			50695	526874	7934905	No	N/A	No	N/A	None	TBD	TBD	TBD	n/a	n/a										

Table 8.1 North Railway Culvert Crossings, Bridges, Cuts, Diversions, and Encroachments on Waterbodies and Fish Habitat

Site ID	Description	Waterbody Type[1]	Diversion to	Receives Diversion From	Rail Chainage (m)	UTM Coordinates[2]		Arctic Char		Ninespine Stickleback		Habitat Quality	No. Barrels	Culvert Length (m)	Culvert Diameter (mm)	Stream Order		Culvert Footprint in Arctic Char Habitat			Catchment Areas	Mean Annual Flow		Ranges of results			
						Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty					Stream Order at Crossing	Ave. Bank-full Habitat Width (est.)[7]	Area Without Apron (m^2)	Apron Area (m^2)	Total Area (m^2)	(m^2)	Low Flow Scenario (L/s)	High Flow Scenario (L/s)	Min velocity (m/s)	Max Velocity (m/s)	Min Depth (m)	Max Depth (m)
CV-50-4a	Culvert	LP			50820	526876	7934875	No	N/A	No	N/A	None	TBD	TBD	TBD						-	-	-	0.00	0.00	0.00	0.00
CV-50-4b	Culvert	LP			50920	526888	7934776	No	N/A	No	N/A	None	TBD	TBD	TBD						-	-	-	0.00	0.00	0.00	0.00
CV-50-5	Culvert	S			50945	526924	7934630	Yes	Low	Yes	Low	Marginal	2	30	1200	3	16.3	489	156	645	7949400	58.0	87.4	0.64	1.18	0.07	0.12
CV-50-6	Culvert	S			50955	526926	7934620	Yes	N/A	Yes	N/A	Important	2	30	1200	3	16.3	489	156	645	7949400	58.0	87.4	0.64	1.18	0.07	0.12
CV-51-1	Culvert	LP			51255	527006	7934331	No	N/A	No	N/A	None	1	24	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-51-2	Culvert	LP			51964	527054	7933628	No	N/A	No	N/A	None	1	30	1200	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-52-1	Culvert	S			52599	527080	7932998	No	N/A	No	N/A	None	1	12	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-52-2	Culvert	S			52817	527132	7932787	No	N/A	No	N/A	None	1	18	900	n/a	n/a				541062	3.9	6.0	0.00	0.00	0.00	0.00
CV-52-3	Culvert	LP			52918	527180	7932698	No	N/A	No	N/A	None	1	12	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-53-1	Culvert	LP			53208	527366	7932476	No	N/A	No	N/A	None	1	12	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-53-2	Culvert	P			53737	527274	7932000	No	N/A	No	Low	None	1	36	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-54-1	Culvert	S			54398	527333	7931375	No	N/A	No	N/A	None	1	24	1200	n/a	n/a				1597470	11.7	17.6	0.00	0.00	0.00	0.00
CV-54-2	Culvert	S			54940	527529	7930869	No	N/A	No	N/A	None	2	12.5	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-55-1	Culvert	LP			55163	527583	7930653	No	N/A	No	Low	None	1	18	1200	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-55-2	Culvert	LP			55400	527632	7930421	No	N/A	No	Low	None	1	12	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-55-3	Culvert	S			55484	527650	7930339	Yes	N/A	Yes	N/A	Important	5	12.5	900	3	16.3	204	117	321	2783990	20.3	30.6	0.37	0.68	0.03	0.05
CV-56-1	Culvert	S			56580	528085	7929337	Yes	N/A	Yes	N/A	Marginal	2	12.2	1200	3	16.3	199	156	355	2731000	19.9	30.0	0.46	0.85	0.04	0.07
CV-57-1	Culvert	S			57125	528309	7928841	Yes	N/A	Yes	N/A	Marginal	1	12.2	900	2	6.8	83	49	132	1613800	11.8	17.8	0.51	0.93	0.05	0.09
CV-57-2	Culvert	S			57287	528345	7928683	Yes	N/A	Yes	N/A	Marginal	1	12.2	900	2	6.8	83	49	132	886436	6.5	9.8	0.42	0.78	0.04	0.06
CV-58-1	Culvert	S			58017	528241	7927966	Probable	Moderate	Probable	Moderate	Marginal	2	9.76	900	1	2.8	27	20	47	94000	0.7	1.0	0.17	0.32	0.01	0.02
CV-58-2	Culvert	S			58192	528168	7927807	Yes	Low	Yes	Low	Marginal - Important	1	9.76	900	1	2.8	27	20	47	115501	0.8	1.3	0.23	0.42	0.01	0.02
CV-58-3	Culvert	S			58301	528109	7927716	Potential	High	Potential	High	Marginal	1	9.76	900	1	2.8	27	20	47	7281	0.1	0.1	0.10	0.18	0.00	0.01
CV-58-4	Culvert	S			58377	528062	7927656	Yes	Low	Yes	Low	Marginal - Important	1	12.2	900	2	6.8	83	49	132	192771	1.4	2.1	0.27	0.49	0.02	0.03
CV-58-4a	Culvert	S			58540	527931	7927527	Yes	Low	Yes	Low	Marginal - Important	1	12.2	900	1	2.8	34	20	54	64172	0.5	0.7	0.19	0.35	0.01	0.02
CV-58-5	Culvert	S			58795	527751	7927378	Probable	Moderate	Probable	Moderate	Marginal - Important	1	12.2	900	2	6.8	83	49	132	18710	0.1	0.2	0.13	0.24	0.01	0.01
CV-58-6	Culvert	S			58887	527681	7927318	Probable	Moderate	Probable	Moderate	Marginal - Important	1	12.2	900	1	2.8	34	20	54	417954	3.1	4.6	0.34	0.62	0.03	0.05
CV-58-7	Cut	S	CV-59-1		58940	527650	7927282	Unlikely	Moderate	Unlikely	Moderate	None - Marginal	NA	NA	NA	1	2.8				417954	3.1	4.6	0.00	0.00	0.00	0.00
CV-58-8	Cut	S	CV-59-1		58960	527613	7927217	Potential	High	Potential	High	None - Marginal	NA	NA	NA	1	2.8				304042	2.2	3.3	0.00	0.00	0.00	0.00
CV-59-1	Culvert	S		CV-58-7 and CV-58-6	59062	527590	7927169	Probable	Moderate	Probable	Moderate	Marginal - Important	1	9.76	900	2	6.8	66	49	115	93947	0.7	1.0	0.21	0.39	0.01	0.02
CV-59-2	Culvert	S			59186	527553	7927052	Potential	High	Potential	High	Marginal	1	14.64	900	1	2.8	41	20	61	49972	0.4	0.5	0.18	0.32	0.01	0.02
CV-59-3	Culvert	S			59323	527529	7926917	Potential	High	Potential	High	None - Marginal	1	9.76	900	1	2.8	27	20	47	38859	0.3	0.4	0.16	0.30	0.01	0.02
CV-59-4b	Cut	LP	CV-59-4		59442	527467	7926817	No	N/A	No	N/A	None	0		0	n/a	n/a				4768110	34.8	52.4	0.00	0.00	0.00	0.00
CV-59-4	Culvert	S		CV-59-4a & b	59552	527395	7926734	Yes	Low	Yes	Low	Important	3	21.96	1200	2	6.8	149	65	215	4768110	34.8	52.4	0.49	0.89	0.05	0.08
CV-59-4a	Cut	S	CV-59-4		59706	527329	7926595	No	Low	No	Low	None	0	NA	NA	n/a	n/a				4768110	34.8	52.4	0.00	0.00	0.00	0.00
CV-59-5	Culvert	S			59855	527272	7926457	No	Low	No	Low	None	1	12.2	900	n/a	n/a				435215	3.2	4.8	0.00	0.00	0.00	0.00
CV-60-1	Culvert	S			60079	527202	7926246	No	Low	No	Low	None	1	9.76	900	n/a	n/a				280444	2.0	3.1	0.00	0.00	0.00	0.00
CV-60-2	Culvert/ encroachment	S/P			60255	527214	7926070	No	Low	No	Low	None	1	17.08	900	n/a	n/a				295078	2.2	3.2	0.00	0.00	0.00	0.00
CV-60-3	Culvert	S			60365	527225	7925961	Probable	Moderate	Probable	Moderate	Marginal - Important	1	24.4	900	2	6.8	166	49	215	278620	2.0	3.1	0.30	0.55	0.02	0.04
CV-60-4	Culvert	S		CV-60-4a	60545	527243	7925782	Unlikely	Low	Unlikely	Low	None - Marginal	1	9.76	900	2	6.8	66	49	115	247545	1.8	2.7	0.29	0.53	0.02	0.04
CV-60-4a	Cut	S	CV-60-5		60623	527252	7925685	No	Low	No	Low	None	0	NA	NA	n/a	n/a				31987	0.2	0.4	0.00	0.00	0.00	0.00
CV-60-5	Culvert	S			60848	527273	7925480	Potential	High	Potential	High	Marginal - Important	1	26.84	1200	2	6.8	183	65	248	601714	4.4	6.6	0.36	0.66	0.03	0.05
CV-60-6	Culvert	S			60948	527283	7925381	Unlikely	Low	Unlikely	Low	None - Marginal	1	26.84	900	1	2.8	75	20	95	16958	0.1	0.2	0.13	0.23	0.01	0.01
CV-61-1	Culvert	S			61092	527296	7925237	Probable	Moderate	Probable	Moderate	Marginal - Important	1	31.72	900	1	2.8	89	20	109	488972	3.6	5.4	0.35	0.65	0.03	0.05
CV-61-2	Culvert	S		CV-61-3	61360	527181	7925009	Probable	Moderate	Probable	Moderate	Marginal - Important	1	9.76	900	1	2.8	27	20	47	135669	1.0	1.5	0.24	0.44	0.02	0.03
CV-61-3	Cut	S	CV-61-2		61580	527023	7924876	Potential	High	Potential	High	Marginal - Important	NA	NA	NA	1	2.8				135669	1.0	1.5	0.00	0.00	0.00	0.00
CV-62-1	Culvert	S			62020	526868	7924453	Yes	Low	Yes	Low	Important	7	51.24	1800	3+	16.3	835	235	1070	117005000	854.1	1287.1	0.94	1.72	0.13	0.22
CV-62-2	Culvert	S			62310	526897	7924167	Probable	Moderate	Probable	Moderate	Marginal - Important	1	12.2	900	2	6.8	83	49	132	375979	2.7	4.1	0.33	0.60	0.03	0.04
CV-62-3	Cut	S	CV-62-4		62560	526951	7923938	Unlikely	Low	Unlikely	Low	None - Marginal	NA	NA	NA	1	2.8				375979	2.7	4.1	0.00	0.00	0.00	0.00
CV-62-4	Culvert	S		CV-62-3	62865	526975	7923621	No	Low	No	Low	None	1	9.76	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-62-5	Culvert	LP		CV-62-6 and CV-62-6b	62930	526982	7923557	No	Low	No	Low	None	1	12.2	900	n/a	n/a				462093	3.4	5.1	0.00	0.00	0.00	0.00
CV-62-6	Cut	S	CV-62-5		63110	527016	7923383	Unlikely	Low	Unlikely	Low	None - Marginal	NA	NA	NA	1	2.8				462093	3.4	5.1	0.00	0.00	0.00	0.00
CV-62-6b	Cut	S	CV-62-5		63090	527011	7923411	Unlikely	Low	Unlikely	Low	None - Marginal	NA	NA	NA	1	2.8				462093	3.4	5.1	0.00	0.00	0.00	0.00
CV-63-1	Culvert	S			63317	527058	7923177	Potential	High	Potential	High	None - Marginal	1	14.64	900	1	2.8	41	20	61	111322	0.8	1.2	0.22	0.41	0.01	0.02
CV-63-2	Culvert	S			63418	527100	7923086	Potential	High	Potential	High	None - Marginal	1	12.2	900	2	6.8	83	49	132	304270	2.2	3.3	0.31	0.56	0.02	0.04
CV-63-3	Culvert	S		CV-63-3a	63555	527162	7922964	Potential	High	Potential	High	Marginal - Important	1	14.64	900	1	2.8	41	20	61	74396	0.5	0.8	0.20	0.36	0.01	0.02
CV-63-3a	Cut	LP	CV-63-3		63724	527179	7922796	No	Low	No	Low	None	0	NA	NA	n/a	n/a				74396	0.5	0.8	0.00	0.00	0.00	0.00
CV-63-4	Culvert	S			63856	527204	7922667	Probable	Moderate	Probable	High	Marginal - Important	1	12.2	900	2	6.8	83	49	132	1164850	8.5	12.8	0.46	0.85	0.04	0.07
CV-63-4a	Culvert	S			63900	527229	7922619	Potential	High	Potential	High	Marginal	1	12.2	900	1	2.8	34	20	54	23078	0.2	0.3	0.14	0.25	0.01	0.01
CV-63-5	Culvert	S			63931	527241	7922603	Potential	High	Potential	Low	Marginal	1	12.2	900	1	2.8	34	20	54	-	-	-	0.03	0.04	0.00	0.00
CV-64-1	Culvert	S			64015	527295	7922538	Unlikely	Low	Unlikely	Low	None - Marginal	1	9.76	900	1	2.8	27	20	47	82363	0.6	0.9	0.21	0.38	0.01	0.02
CV-64-2	Culvert	S			64198	527414	7922399	Unlikely	Low	Unlikely	Low	None - Marginal	1	12.2	900	1	2.8	34	20	54	13643	0.1	0.2	0.12	0.22	0.01	0.01
CV-64-3	Culvert	S			64373	527482	7922239	No	Low	No	Low	None	1	12.2	900	n/a	n/a				491726	3.6	5.4	0.00	0.00	0.00	0.00
CV-64-4	Culvert	S			64690	527625	7921956	Yes	Low	Yes	Low	Marginal - Important	1	19.52	900	1	2.8	55	20	75	313201	2.3	3.4	0.31	0.57	0.02	0.04
CV-64-5a	Cut	LP	CV-64-5		64827	527688	7921835	No	Low	No	Low	None	0	NA	NA	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-64-5	Culvert	S		CV-64-5a	64949	527743	7921726	No	Low	No	Low	None	1	12.2	900	n/a	n/a				140599	1.0	1.5	0.00	0.00	0.00	0.00

Table 8.1 North Railway Culvert Crossings, Bridges, Cuts, Diversions, and Encroachments on Waterbodies and Fish Habitat

Site ID	Description	Waterbody Type[1]	Diversion to	Receives Diversion From	Rail Chainage (m)	UTM Coordinates[2]		Arctic Char		Ninespine Stickleback		Habitat Quality	No. Barrels	Culvert Length (m)	Culvert Diameter (mm)	Stream Order		Culvert Footprint in Arctic Char Habitat			Catchment Areas	Mean Annual Flow		Ranges of results			
						Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty					Stream Order at Crossing	Ave. Bank-full Habitat Width (est.)[7]	Area Without Apron (m^2)	Apron Area (m^2)	Total Area (m^2)	(m^2)	Low Flow Scenario (L/s)	High Flow Scenario (L/s)	Min velocity (m/s)	Max Velocity (m/s)	Min Depth (m)	Max Depth (m)
CV-64-6	Culvert	S			65000	527757	7921691	No	Low	No	Moderate	None	1	12.2	900	n/a	n/a				140599	1.0	1.5	0.00	0.00	0.00	0.00
CV-65-1	Culvert	S			65285	527793	7921396	Probable	Moderate	Probable	High	Marginal - Important	1	17.08	900	3	16.3	278	117	396	612555	4.5	6.7	0.38	0.70	0.03	0.05
CV-65-2a	Cut	LP	CV-65-2		65541	527803	7921140	Unlikely	Low	No	Low	None - Marginal	0	NA	NA	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-65-2	Pond Infilling/Culvert	P		CV-65-2a	65750	527828	7920934	Potential	High	Potential	Low	None - Important	1	21.96	900	1	25				129361	0.9	1.4	0.24	0.43	0.02	0.03
CV-66-1	Culvert	S			66086	527959	7920627	Unlikely	Low	Unlikely	Low	None - Marginal	1	12.2	900	2	6.8	83	49	132	329312	2.4	3.6	0.31	0.58	0.02	0.04
CV-66-2a	Cut	LP	CV-66-2		66164	528013	7920571	No	Low	No	Low	None	0	NA	NA	n/a	n/a				-			0.00	0.00	0.00	0.00
CV-66-2	Culvert	S		CV-66-2a	66228	528063	7920532	No	Low	No	Moderate	None	1	14.64	900	n/a	n/a				602401	4.4	6.6	0.00	0.00	0.00	0.00
CV-66-3	Culvert	S			66555	528328	7920342	Probable	Moderate	Probable	Low	Marginal - Important	1	19.52	900	1	2.8	55	20	75	182193	1.3	2.0	0.26	0.48	0.02	0.03
CV-66-4	Culvert	S			66615	528359	7920292	No	Low	No	Low	None	1	12.2	900	n/a	n/a				182193	1.3	2.0	0.00	0.00	0.00	0.00
CV-66-5	Culvert	S			66724	528389	7920187	No	Low	No	Low	None	1	14.64	900	n/a	n/a				84029	0.6	0.9	0.00	0.00	0.00	0.00
CV-66-6	Culvert	S			66750	528390	7920161	No	Low	No	Low	None	1	9.76	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-66-7	Culvert	S			66898	528378	7920014	No	Low	No	Moderate	None	1	9.76	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-66-8	Culvert	S			66925	528376	7919987	Probable	Moderate	Probable	Moderate	Marginal - Important	1	9.76	900	1	2.8	27	20	47	36437	0.3	0.4	0.16	0.29	0.01	0.01
CV-67-1	Culvert	S			67182	528299	7919743	Probable	Moderate	Probable	Low	Marginal - Important	1	14.64	900	1	2.8	41	20	61	331786	2.4	3.6	0.31	0.58	0.02	0.04
CV-67-2	Culvert	S			68020	528226	7918995	No	Low	No	Low	None	1	9.76	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-68-1a	Culvert	S			68080	528200	7918864	Yes	Low	Yes	Low	Marginal - Important	1	33	900	2	6.8	224	49	273	3551025	25.9	39.1	0.65	1.18	0.07	0.13
CV-68-1	Culvert	S			68107	528199	7918838	Yes	Low	Yes	Low	Important	3	31.72	1400	2	6.8	216	76	292	3551025	25.9	39.1	0.43	0.80	0.04	0.07
CV-68-2	Culvert	S			68177	528194	7918768	No	Low	No	Moderate	None	1	21.96	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-68-3	Culvert	S			68484	528059	7918496	Probable	Moderate	Probable	Low	Marginal - Important	1	21.96	1200	2	6.8	149	65	215	1076140	7.9	11.8	0.43	0.79	0.04	0.07
CV-68-4	Culvert	S			68519	528055	7918461	No	Low	No	High	None	1	12.2	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-68-5	Culvert	S			68650	528081	7918334	Potential	High	Potential	Low	Marginal - Important	1	26.84	900	2	6.8	183	49	231	587722	4.3	6.5	0.37	0.69	0.03	0.05
CV-69-1	Culvert	S			69190	528322	7917862	No	Low	No	Low	None	1	12.2	900	n/a	n/a				214538	1.6	2.4	0.00	0.00	0.00	0.00
CV-69-2	Culvert	S			69552	528438	7917517	Yes	Low	Yes	Low	Marginal - Important	1	14.64	900	2	6.8	100	49	149	469963	3.4	5.2	0.35	0.64	0.03	0.05
CV-69-3	Culvert	S			69616	528458	7917456	Yes	Low	Yes	High	Marginal - Important	1	14.64	900	1	2.8	41	20	61	83120	0.6	0.9	0.21	0.38	0.01	0.02
CV-69-4	Culvert	S			69668	528474	7917407	Potential	High	Potential	Moderate	Marginal - Important	1	12.2	900	1	2.8	34	20	54	-	-	-	0.03	0.04	0.00	0.00
CV-70-1	Encroachment	P			70201	528704	7916939	No	N/A	Unlikely	Moderate	None - Marginal	1	12.2	900	n/a (LE)					-	-	-	0.03	0.04	0.00	0.00
CV-70-2	Culvert	S			70580	529030	7916745	Yes	N/A	Yes	N/A	Important	1	17.08	900	2	6.8	116	49	165	-	-	-	0.03	0.04	0.00	0.00
CV-70-3	Bridge	S			70684	529120	7916693	Yes	N/A	Yes	Low	Important	0	NA	NA	3+	Bridge				-	-	-	0.00	0.00	0.00	0.00
CV-71-1	Pond Infilling	S/P			71053	529451	7916535	Yes	Low	Yes	Low	Important	4	17.08	1800	3	74.9				2962380	21.6	32.6	0.36	0.66	0.03	0.05
CV-71-2a	Encroachment	S/P			71315	529708	7916558	Probable	Moderate	Probable	Moderate	Marginal	NA	NA	NA	1	8.7				Encroachment						
CV-71-3	Culvert	S			71860	529965	7916706	No	Low	Unlikely	Moderate	None - Marginal	1	12.2	900	1	2.8				-	-	-	0.03	0.04	0.00	0.00
CV-71-4	Culvert	S			71905	530214	7916862	No	Low	Unlikely	Moderate	None - Marginal	1	9.76	900	1	2.8				11370	0.1	0.1	0.11	0.21	0.01	0.01
CV-72-1	Culvert	S			72085	530370	7916951	No	Low	Unlikely	Moderate	None - Marginal	1	17.08	1200	3	16.3				332965	2.4	3.7	0.30	0.55	0.02	0.04
CV-72-1a	Culvert	S			72320	530587	7917015	No	Low	Unlikely	Moderate	None - Marginal	1	12.2	1200	1	2.8				128088	0.9	1.4	0.22	0.41	0.01	0.02
CV-72-2	Culvert	S			72515	530784	7917069	No	Low	Unlikely	High	None - Marginal	1	12.2	900	1	2.8				189785	1.4	2.1	0.26	0.49	0.02	0.03
CV-72-3	Culvert	S			72789	531048	7917142	Potential	High	Potential	High	None - Marginal	1	12.2	900	1	2.8	34	20	54	9437	0.1	0.1	0.11	0.19	0.00	0.01
CV-72-3a	Culvert	S			72890	531130	7917165	Potential	High	Potential	High	None - Marginal	1	12.2	900	1	2.8	34	20	54	68079	0.5	0.7	0.19	0.35	0.01	0.02
CV-72-4	Culvert	S			72905	531160	7917173	Potential	High	Potential	Moderate	None - Marginal	2	9.76	900	2	6.8	66	49	115	416570	3.0	4.6	0.27	0.50	0.02	0.03
CV-73-1	Culvert	S			73585	531794.997	7917555	Unlikely	Moderate	Unlikely	Moderate	None - Marginal	1	9.76	900	1	2.8	27	20	47	-	-	-	0.03	0.04	0.00	0.00
CV-73-2	Culvert	S				532007	7918051	Potential	High	Potential	High	None - Marginal	1	16.1	900	2	6.8	109	49	158							
CV-73-3	Culvert	S				532156	7918212	Potential	High	Potential	High	None - Marginal	1	16.1	900	2	6.8	109	49	158							
CV-73-4	Culvert	S				532303	7918244	Potential	High	Potential	High	None - Marginal	1	13.6	900	1	2.8	38	20	58							
CV-74-1	Culvert	S			74247	532376	7918246	Probable	Moderate	Probable	Low	Marginal - Important	2	20.6	1200	3	16.3	336	156	492							
CV-74-2	Culvert	S			74534	532406	7918246	Yes	Low	Yes	Low	Marginal - Important	2	20.6	1200	3	16.3	336	156	492							
CV-74-3	Culvert	S			74676	532735	7918374	Potential	High	Potential	High	Marginal	1	14.64	1800	1	2.8	41	40	81	73490	0.5	0.8	0.18	0.33	0.01	0.02
CV-74-4	Culvert	S			75035	532888	7918494	Potential	High	Potential	High	Marginal	1	14.64	1800	1	2.8	41	40	81	69500	0.5	0.8	0.18	0.32	0.01	0.02
CV-74-6	Culvert	S		CV-74-7	75350	532988	7918553	Potential	High	Potential	High	Marginal - Important	1	9.76	900	1	2.8	27	20	47	207620	1.5	2.3	0.27	0.50	0.02	0.03
CV-74-7	Cut	S	CV-74-6		75640	533258	7918549	Potential	High	Potential	High	Marginal - Important	NA	NA	NA	1	2.8				-	-	-	0.00	0.00	0.00	0.00
CV-75-1	Culvert	S			75765	533398	7918521	Potential	High	Potential	High	Marginal	1	12.2	1200	1	2.8	34	27	61	11949	0.1	0.1	0.11	0.20	0.00	0.01
CV-75-1a	Culvert	S			75810	533444	7918512	Potential	High	Potential	High	Marginal	1	12.2	1200	3	16.3	199	156	355	1402300	10.2	15.4	0.47	0.86	0.04	0.07
CV-75-2	Culvert	S			75927	533559	7918501	Potential	High	Potential	Moderate	Marginal	1	17.08	900	1	2.8	48	20	68	1402300	10.2	15.4	0.49	0.89	0.05	0.08
CV-76-1	Culvert	S			76270	533900	7918535	Probable	Moderate	Probable	High	Marginal	1	19.52	1200	2	6.8	133	65	198	1164060	8.5	12.8	0.44	0.81	0.04	0.07
CV-76-1a	Culvert	S			76710	534333	7918581	Potential	High	Potential	Low	None - Marginal	1	19.52	1200	1	2.8	55	27	82	237009	1.7	2.6	0.27	0.50	0.02	0.03
CV-76-2	Culvert	LP			76880	534506	7918563	No	Low	No	High	None	1	9.76	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-76-3	Culvert	S			77200	534825	7918511	Potential	High	Potential	High	None - Marginal	1	19.52	900	1	2.8	55	20	75	260046	1.9	2.9	0.29	0.53	0.02	0.04
CV-77-1	Culvert	S			77372	534992	7918491	Potential	High	Potential	Low	Marginal	1	19.52	900	1	2.8	55	20	75	57775	0.4	0.6	0.18	0.34	0.01	0.02
CV-77-2	Culvert	S			77656	535267	7918560	Yes	Low	Yes	Moderate	Marginal - Important	3	39.04	1400	3	16.3	636	183	819	11197600	81.7	123.2	0.62	1.13	0.07	0.11
CV-77-3	Culvert	S			77891	535497	7918521	Probable	Moderate	Probable	Low	Marginal	1	9.76	900	2	6.8	66	49	115	122463	0.9	1.3	0.23	0.42	0.02	0.03
CV-78-1	Culvert	LP			78089	535691	7918488	No	Low	No	Moderate	None	1	14.64	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-78-2	Culvert	S			78294	535890	7918531	Unlikely	Moderate	Unlikely	Low	None - Marginal	1	14.64	900	1	2.8	41	20	61	36136	0.3	0.4	0.16	0.29	0.01	0.01
CV-78-3	Culvert	S			78429	536006	7918599	Yes	Low	Yes	Low	Marginal - Important	1	29.28	900	3	16.3	477	117	595	1212000	8.8	13.3	0.47	0.86	0.04	0.07
CV-78-4	Culvert	LP			78619	536163	7918706	No	Low	No	Moderate	None	1	9.76	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-78-5	Culvert	S			78729	536237	7918756	Unlikely	Moderate	Unlikely	Moderate	None - Marginal	1	9.76	900	1	2.8	27	20	47	-	-	-	0.03	0.04	0.00	0.00
CV-78-6	Culvert	S			78947	536450	7918866	Probable	Moderate	Probable	Moderate	Marginal - Important	1	10	900	1	2.8	28	20	48	70000	0.5	0.8	0.20	0.36	0.01	0.02
CV-79-0	Culvert	S			79792	537243	7919138	Probable	Moderate	Probable	Moderate	Marginal - Important	1	10	900	2	6.8	68	49	117	775494	5.7	8.5	0.41	0.75	0.04	0.06
CV-79-1	Culvert	S			79971	537418	7919175	Unlikely	Moderate	Unlikely	Low	None - Marginal	1	17.08	900	1	2.8	48	20	68	-	-	-	0.03	0.04	0.00	0.00
CV-80-1	Culvert	S			80014	537461	7919180	Yes	Low	Yes	Moderate	Marginal - Important	2	24.4	1200	3	16.3	398	156	554	3261440	23.8	35.9	0.49	0.90	0.05	0.08

Table 8.1 North Railway Culvert Crossings, Bridges, Cuts, Diversions, and Encroachments on Waterbodies and Fish Habitat

Site ID	Description	Waterbody Type[1]	Diversion to	Receives Diversion From	Rail Chainage (m)	UTM Coordinates[2]		Arctic Char		Ninespine Stickleback		Habitat Quality	No. Barrels	Culvert Length (m)	Culvert Diameter (mm)	Stream Order		Culvert Footprint in Arctic Char Habitat			Catchment Areas	Mean Annual Flow		Ranges of results			
						Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty					Stream Order at Crossing	Ave. Bank-full Habitat Width (est.)[7]	Area Without Apron (m^2)	Apron Area (m^2)	Total Area (m^2)	(m^2)	Low Flow Scenario (L/s)	High Flow Scenario (L/s)	Min velocity (m/s)	Max Velocity (m/s)	Min Depth (m)	Max Depth (m)
CV-80-1a	Culvert	S			80039	537487	7919182	Unlikely	Moderate	Unlikely	Moderate	None - Marginal	1	**12.2**	1200	1	2.8	34	27	61	94000	0.7	1.0	0.20	0.37	0.01	0.02
CV-80-2	Culvert	S			81003	538320	7919565	Unlikely	Moderate	Unlikely	Moderate	None - Marginal	1	10	900	1	2.8	28	20	48	2415	0.0	0.0	0.07	0.13	0.00	0.00
CV-80-2a	Culvert	S			81019	538307	7919556	Unlikely	Moderate	Unlikely	Moderate	None - Marginal	1	10	900	1	2.8	28	20	48	26262	0.2	0.3	0.14	0.26	0.01	0.01
CV-80-2b	Culvert	S			81034	538334	7919573	Unlikely	Moderate	Unlikely	Moderate	None - Marginal	1	10	900	2	6.8	68	49	117	161892	1.2	1.8	0.25	0.46	0.02	0.03
CV-80-3	Culvert	S			81171	538453	7919642	Unlikely	Moderate	Unlikely	Moderate	None - Marginal	1	10	900	1	2.8	28	20	48	74433	0.5	0.8	0.20	0.36	0.01	0.02
CV-80-4	Culvert	S			81236	538510	7919675	Unlikely	Moderate	Unlikely	Moderate	None - Marginal	1	10	900	1	2.8	28	20	48	47083	0.3	0.5	0.17	0.32	0.01	0.02
CV-80-5	Culvert	S			81347	538604	7919729	Unlikely	Moderate	Unlikely	Low	None - Marginal	1	10	900	2	6.8	68	49	117	38715	0.3	0.4	0.16	0.30	0.01	0.01
CV-81-1	Culvert	S			81447	538691	7919779	No	Low	No	Moderate	None	2	9.76	900	n/a	n/a				31756	0.2	0.3	0.00	0.00	0.00	0.00
CV-81-2	Culvert	S			81687	538879	7919924	Probable	Moderate	Probable	Moderate	Marginal - Important	1	12.2	900	1	2.8	34	20	54	145625	1.1	1.6	0.24	0.45	0.02	0.03
CV-81-3	Culvert	S			81788	538942	7920004	Probable	Moderate	Probable	Moderate	Marginal - Important	1	12.2	900	2	6.8	83	49	132	263562	1.9	2.9	0.29	0.54	0.02	0.04
CV-81-4	Culvert	S			82000	539077	7920175	Unlikely	Moderate	Unlikely	Moderate	None - Marginal	1	12.2	900	1	2.8	34	20	54	149049	1.1	1.6	0.25	0.45	0.02	0.03
CV-82-1	Culvert	S		CV-82-1a	82060	539131	7920244	Unlikely	Moderate	Unlikely	Moderate	None - Marginal	2	12.2	900	2	6.8	83	49	132	2043550	14.9	22.5	0.44	0.81	0.04	0.07
CV-82-1a	Cut	LP	CV-82-1		82266	539242	7920376	No	Low	No	Low	None	0	NA	NA	n/a (cut)					-	-	-	0.00	0.00	0.00	0.00
CV-82-2	Culvert	S			82442	539376	7920489	Unlikely	Moderate	Unlikely	Moderate	None - Marginal	1	9.76	900	1	2.8	27	20	47	-	-	-	0.03	0.04	0.00	0.00
CV-82-3	Culvert	S			82614	539508	7920599	Unlikely	Moderate	Unlikely	Moderate	None - Marginal	1	12.2	900	1	2.8	34	20	54	110862	0.8	1.2	0.22	0.41	0.01	0.02
CV-82-4	Culvert	S			82901	539729	7920783	Probable	Moderate	Probable	Moderate	Marginal - Important	1	13.2	1200	1	2.8	37	27	64	69358	0.5	0.8	0.19	0.34	0.01	0.02
CV-83-1	Culvert	S			83039	539835	7920871	Probable	Moderate	Probable	High	Marginal - Important	1	12.2	1200	2	6.8	83	65	148	1235590	9.0	13.6	0.45	0.83	0.04	0.07
CV-83-1a	Culvert	S			83105	539887	7920915	Potential	High	Potential	N/A	Marginal - Important	1	12.2	1200	1	2.8	34	27	61	92203	0.7	1.0	TBD	TBD	TBD	TBD
CV-83-2	Culvert	S			83459	540162	7921134	Yes	N/A	Yes	N/A	Marginal	4	12.2	1800	3	16.3	199	235	434	3235620	23.6	35.6	0.37	0.68	0.03	0.05
CV-84-1	Culvert	S			84236	540842	7921510	Yes	N/A	Yes	Moderate	Important	1	17.08	1200	3+	5.6	96	54	149	11469400	83.7	126.2	0.88	1.62	0.12	0.20
CV-84-2	Culvert	S			84467	541030	7921642	Unlikely	Moderate	Unlikely	N/A	None - Marginal	1	12.2	900	2	6.8	83	49	132	473522	3.5	5.2	0.35	0.64	0.03	0.05
CV-84-3	Culvert	S			84873	541294	7921948	No	N/A	No	N/A	None	1	14.64	1200	n/a	n/a				536112	3.9	5.9	0.00	0.00	0.00	0.00
CV-85-1	Culvert	S			85117	541514	7922054	No	N/A	No	N/A	None	1	12.2	900	n/a	n/a				75263	0.5	0.8	0.00	0.00	0.00	0.00
CV-85-2	Culvert	S			85563	541921	7922236	No	N/A	No	N/A	None	2	17.08	1800	n/a	n/a				762696	5.6	8.4	0.00	0.00	0.00	0.00
CV-85-3	Bridge	S			85868	542213	7922215	Yes	N/A	Yes	N/A	Important		NA	NA	3+	Bridge				-	-	-	0.00	0.00	0.00	0.00
CV-85-4	Culvert	S			85964	542288	7922156	Yes	N/A	Yes	High	Important	1	17.08	1800	3+	25	427	360	787	-	-	-	0.02	0.03	0.00	0.00
CV-86-1	Encroachment	P			86502	542671	7921780	No	N/A	Potential	High	None - Marginal	6	9.76	900	n/a (LE)					-	-	-	0.03	0.04	0.00	0.00
CV-86-2	Culvert	S			86611	542753	7921708	Yes	N/A	Yes	Low	Marginal	2	19.52	1800	3	60	1171	864	2035	24812000	181.1	272.9	0.86	1.57	0.11	0.19
CV-87-1	Culvert	LP			87012	543078	7921473	No	Low	No	Low	None	1	9.76	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-87-2	Culvert	LP			87399	543392	7921247	No	Low	No	Low	None	1	12.2	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-87-3	Culvert	LP			87559	543532	7921170	No	Low	No	N/A	None	1	9.76	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-87-4	Culvert	S			87735	543736	7921141	Yes	N/A	Yes	Low	Marginal	1	9.76	900	2	6.8	66	49	115	481790	3.5	5.3	0.35	0.65	0.03	0.05
CV-88-1	Culvert	LP			88015	543976	7921204	No	Low	No	Low	None	1	9.76	900	n/a	n/a				193563	1.4	2.1	0.00	0.00	0.00	0.00
CV-88-2	Culvert	S			88261	544209	7921282	Yes	Low	Yes	Low	Marginal	1	14.64	900	2	6.8	100	49	149	154608	1.1	1.7	0.25	0.46	0.02	0.03
CV-88-3	Culvert	S			88314	544259	7921299	Yes	Low	Yes	Low	Marginal	1	12.2	900	2	6.8	83	49	132	162324	1.2	1.8	0.25	0.46	0.02	0.03
CV-88-4	Culvert	LP			89225	545151	7921245	No	Low	No	Low	None	1	15	900	n/a	n/a				278410	2.0	3.1	0.00	0.00	0.00	0.00
CV-89-1	Culvert	S			89574	545492	7921173	Yes	Low	Yes	Moderate	Important	1	24.4	900	3	16.3	398	117	515	3859280	28.2	42.5	0.66	1.22	0.08	0.13
CV-89-2	Pond Infilling	P			89817	545729	7921121	No	Low	Unlikely	Moderate	None - Marginal	1	12.2	1400	n/a (LE)					26727	0.2	0.3	0.14	0.25	0.01	0.01
CV-90-1	Culvert	LP			90006	545902	7921048	No	N/A	No	Moderate	None	1	12.2	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-90-2	Cut	S	CV-90-3		90726	546181	7920409	No	Low	Unlikely	Low	None - Marginal	NA	NA	NA	1	2.8				29653	0.2	0.3	0.00	0.00	0.00	0.00
CV-90-3	Culvert	S		CV-90-2 and CV-90-4	90910	546240	7920244	No	Low	No	Low	None	0	12.2	0	n/a	n/a				52465	0.4	0.6	0.00	0.00	0.00	0.00
CV-90-4	Cut	S	CV-90-3		91216	546459	7920041	No	Low	No	Low	None	0	NA	NA	n/a	n/a				60080	0.4	0.7	0.00	0.00	0.00	0.00
CV-91-0	Culvert	S			91660	546858	7919853	No	Low	No	Low	None	1	12.2	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-91-1	Culvert	S			91720	546928	7919820	No	Low	No	Low	None	1	12.2	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-91-2	Culvert	S			91817	547012	7919781	No	Low	No	Moderate	None	1	9.76	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-92-1b	Cut	S	CV-92-1		91960	547125	7919725	No	N/A	No	N/A	None	0	NA	NA	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-92-1	Culvert/ encroachment	S/P		CV-92-1b	92000	547173	7919694	No	Low	Unlikely	Moderate	None - Marginal	1	9.76	1200	n/a (LE)					-	-	-	0.02	0.04	0.00	0.00
CV-92-2	Culvert	LP			92307	547416	7919506	No	N/A	No	N/A	None	1	9.76	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-92-3	Culvert	S			92424	547521	7919456	No	N/A	No	N/A	None	1	9.76	900	n/a	n/a				242485	1.8	2.7	0.00	0.00	0.00	0.00
CV-92-4	Culvert	S			92644	547721	7919363	No	N/A	No	Low	None	1	12.2	900	n/a	n/a				119106	0.9	1.3	0.00	0.00	0.00	0.00
CV-92-5	Culvert	S			92807	547879	7919262	Yes	Low	Yes	N/A	Marginal	1	14.64	900	2	6.8	100	49	149	647107	4.7	7.1	0.39	0.71	0.03	0.06
CV-92-6	Culvert	S			92884	547927	7919241	No	N/A	No	N/A	None	1	9.76	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-92-7	Culvert	S			92961	548001	7919220	No	N/A	No	N/A	None	1	14.64	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-92-8	Culvert	LP			92994	548033	7919215	No	N/A	No	N/A	None	1	12.2	900	n/a	n/a				28186	0.2	0.3	0.00	0.00	0.00	0.00
CV-92-9	Culvert	S			93022	548062	7919211	No	N/A	No	N/A	None	1	12.2	900	n/a	n/a				45827	0.3	0.5	0.00	0.00	0.00	0.00
CV-93-1	Culvert	LP			93191	548228	7919188	No	N/A	No	N/A	None	1	14.64	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-93-2	Culvert	LP			93324	548355	7919148	No	N/A	No	N/A	None	1	17.08	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-93-3	Culvert	LP			93712	548601	7918857	No	N/A	No	N/A	None	1	12.2	900	n/a	n/a				14694	0.1	0.2	0.00	0.00	0.00	0.00
CV-93-3a	Culvert	S			93840	548670	7918765	No	N/A	No	Moderate	None	1	24.4	1200	n/a	n/a				45827	0.3	0.5	0.00	0.00	0.00	0.00
CV-93-4a	Culvert	S			93930	548749	7918703	Probable	Moderate	Probable	Moderate	Marginal	1	12.2	900	1	2.8	34	20	54	21011	0.2	0.2	0.14	0.25	0.01	0.01
CV-93-4b	Culvert	S			93880	548701	7918736	Probable	Moderate	Probable	N/A	Marginal	1	24.2	1200	1	2.8	68	27	95	450089	3.3	5.0	0.33	0.61	0.03	0.04
CV-93-4	Culvert	S			93953	548770	7918691	Yes	N/A	Yes	N/A	Important	3	24.4	1400	3	16.3	398	183	580	5385000	39.3	59.2	0.49	0.90	0.05	0.08
CV-94-1	Culvert	LP			94089	548899	7918649	No	N/A	No	N/A	None	1	12.2	900	n/a	n/a				5384660	39.3	59.2	0.00	0.00	0.00	0.00
CV-94-2	Culvert	S		CV-95-1	95100	549840	7918391	No	N/A	No	N/A	None	1	12	900	n/a	n/a				176180	1.3	1.9	0.00	0.00	0.00	0.00
CV-95-1	Cut	LP	CV-94-2		95303	550005	7918257	No	N/A	No	N/A	None		NA	NA	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-95-2	Culvert	S			95500	550144	7918111	No	N/A	No	Moderate	None	1	9.76	900	n/a	n/a				376911	2.8	4.1	0.00	0.00	0.00	0.00

Table 8.1 North Railway Culvert Crossings, Bridges, Cuts, Diversions, and Encroachments on Waterbodies and Fish Habitat

Site ID	Description	Waterbody Type[1]	Diversion to	Receives Diversion From	Rail Chainage (m)	UTM Coordinates[2]		Arctic Char		Ninespine Stickleback		Habitat Quality	No. Barrels	Culvert Length (m)	Culvert Diameter (mm)	Stream Order		Culvert Footprint in Arctic Char Habitat			Catchment Areas	Mean Annual Flow		Ranges of results			
						Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty					Stream Order at Crossing	Ave. Bank-full Habitat Width (est.)[7]	Area Without Apron (m^2)	Apron Area (m^2)	Total Area (m^2)	(m^2)	Low Flow Scenario (L/s)	High Flow Scenario (L/s)	Min velocity (m/s)	Max Velocity (m/s)	Min Depth (m)	Max Depth (m)
CV-95-3	Culvert	S			96108	550483	7917613	Probable	Moderate	Probable	Moderate	Marginal - Important	1	12.2	900	1	2.8	34	20	54	49194	0.4	0.5	0.18	0.32	0.01	0.02
CV-95-4	Culvert	S			96307	550630	7917484	Probable	Moderate	Probable	Low	Marginal	1	12.2	900	1	2.8	34	20	54	30074	0.2	0.3	0.15	0.28	0.01	0.01
CV-95-5	Culvert	S			96403	550708	7917426	No	Low	No	Low	None	1	12.2	900	n/a	n/a				726430	5.3	8.0	0.00	0.00	0.00	0.00
CV-95-5a	Culvert	S			96500	550781	7917371	No	N/A	No	N/A	None	1	12.2	900	n/a	n/a				9173	0.1	0.1	0.00	0.00	0.00	0.00
CV-95-6	Culvert	S			96556	550832	7917333	No	Low	No	Low	None	1	12.2	900	n/a	n/a				30505	0.2	0.3	0.00	0.00	0.00	0.00
CV-95-7	Culvert	S			95620	550885	7917294	No	Low	No	N/A	None	1	12.2	900	n/a	n/a				7970	0.1	0.1	0.00	0.00	0.00	0.00
CV-96-1	Culvert	S			96672	550924	7917265	Yes	N/A	Yes	N/A	Important	1	26.84	900	3	5.3	142	38	180	16427000	119.9	180.7	1.02	1.87	0.15	0.27
CV-96-2	Culvert	S			96722	550964	7917235	No	N/A	No	N/A	None	1	26.84	900	n/a	n/a				114204	0.8	1.3	0.00	0.00	0.00	0.00
CV-96-3	Culvert	LP			96940	551117	7917101	No	N/A	No	N/A	None	1	26.84	900	n/a	n/a				33258	0.2	0.4	0.00	0.00	0.00	0.00
CV-97-1	Culvert	LP			97041	551191	7917013	No	N/A	No	N/A	None	1	12.2	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-97-2	Culvert	S			97095	551226	7916972	No	N/A	No	N/A	None	1	21.96	900	n/a	n/a				105572	0.8	1.2	0.00	0.00	0.00	0.00
CV-97-3	Culvert	S			97137	551254	7916940	No	N/A	No	N/A	None	1	9.76	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-97-4	Culvert	S			97194	551292	7916898	No	N/A	No	N/A	None	1	19.52	900	n/a	n/a				102526	0.7	1.1	0.00	0.00	0.00	0.00
CV-97-5	Culvert	S		CV-97-6	97286	551351	7916843	No	N/A	No	N/A	None	1	12.2	900	n/a	n/a				102526	0.7	1.1	0.00	0.00	0.00	0.00
CV-97-5b	Culvert	S			97241	551326	7916865	No	N/A	No	N/A	None	1	12.2	900	n/a	n/a				102526	0.7	1.1	0.00	0.00	0.00	0.00
CV-97-6	Cut	LP	CV-97-5		97425	551457	7916754	No	N/A	No	N/A	None		NA	NA	n/a	n/a				22328	0.2	0.2	0.00	0.00	0.00	0.00
CV-97-7	Culvert	S			97562	551576	7916658	No	N/A	No	N/A	None	1	12	900	n/a	n/a				61508	0.4	0.7	0.00	0.00	0.00	0.00
CV-97-7a	Culvert	S			97550	551560	7916671	No	N/A	No	N/A	None	1	12.2	900	n/a	n/a				61508	0.4	0.7	0.00	0.00	0.00	0.00
CV-97-9	Culvert	S			97635	551629	7916614	No	N/A	No	N/A	None	1	19.52	900	n/a	n/a				61508	0.4	0.7	0.00	0.00	0.00	0.00
CV-97-10	Culvert	S			97841	551781	7916475	No	N/A	No	N/A	None	1	19.52	900	n/a	n/a				30153	0.2	0.3	0.00	0.00	0.00	0.00
CV-97-11	Culvert	LP			97900	551823	7916434	No	N/A	No	N/A	None	1	12.2	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-97-12	Culvert	LP			97993	551891	7916370	No	N/A	No	N/A	None	1	14.64	900	n/a	n/a				20951	0.2	0.2	0.00	0.00	0.00	0.00
CV-98-0	Culvert	LP			98130	552001	7916266	No	N/A	No	N/A	None	1	19.52	900	n/a	n/a				24482	0.2	0.3	0.00	0.00	0.00	0.00
CV-98-1	Culvert	LP			98203	552043	7916226	No	N/A	No	High	None	1	19.52	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-99-1	Culvert/ encroachment	S/P			98720	552464	7915930	No	N/A	Potential	High	None - Marginal	1	12.2	900	1	2.8				20380	0.1	0.2	0.13	0.25	0.01	0.01
CV-99-2	Culvert	S			99370	552958	7915502	No	N/A	Potential	Low	None - Marginal	5	12.2	900	1	2.8				-	-	-	0.03	0.04	0.00	0.00
CV-99-3	Culvert	S			99687	553253	7915414	Yes	Low	Yes	N/A	Marginal - Important	5	12.2	900	3	16.3	199	117	316	6936290	50.6	76.3	0.49	0.89	0.05	0.08
CV-100-1	Culvert	LP			100026	553579	7915319	No	N/A	No	N/A	None	5	7.32	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-100-2	Culvert	LP			100315	553862	7915292	No	N/A	No	High	None	1	9.76	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-100-3	Culvert	LP			100523	554050	7915379	No	N/A	No	N/A	None	1	9.76	900	1	2.8				783746	-	-	0.03	0.04	0.00	0.00
CV-100-4	Culvert	S			100673	554185	7915443	Probable	Moderate	Probable	Moderate	Marginal	2	12.2	1200	3	16.3	199	156	355	783746	5.7	8.6	0.32	0.58	0.02	0.04
CV-101-1	Culvert	S		CV-101-1a and CV-101-1b	101153	554664	7915456	Probable	Moderate	Probable	Moderate	Marginal	1	9.76	900	3	16.3	159	117	276	783746	5.7	8.6	0.41	0.75	0.04	0.06
CV-101-1a	Cut	S	CV-101-1		101280	554772	7915455	No	N/A	No	N/A	None		NA	NA	2	6.8				783746	5.7	8.6	0.00	0.00	0.00	0.00
CV-101-1b	Cut	S	CV-101-1		101380	554885	7915454	No	N/A	No	N/A	None		NA	NA	2	6.8				783746	5.7	8.6	0.00	0.00	0.00	0.00
CV-101-2	Culvert	S			101690	555200	7915449	No	N/A	Unlikely	N/A	None - Marginal	5	9.76	1400	1	2.8				123606	0.9	1.4	0.13	0.24	0.01	0.01
CV-102-1	Bridge	S			102218	555728	7915442	Yes	N/A	Yes	N/A	Important	0	NA	NA	3+	Bridge				-	-	-	0.00	0.00	0.00	0.00
CV-102-1a	Cut	S	CV-102-2		12380	555891	7915441	No	N/A	No	N/A	None	0	NA	NA	n/a	n/a				251176000	1833.6	2762.9	0.00	0.00	0.00	0.00
CV-102-2	Culvert	S		CV-102-1a	102509	556019	7915438	Yes	N/A	Yes	Moderate	Important	1	21.96	1200	3	16.3	358	156	514	1674540	12.2	18.4	0.49	0.91	0.05	0.08
CV-102-3	Culvert	S			102867	556373	7915485	Probable	Moderate	Probable	Low	Marginal - Important	1	14.64	900	1	2.8	41	20	61	78218	0.6	0.9	0.20	0.37	0.01	0.02
CV-102-4	Culvert	S			102955	556461	7915488	Yes	Low	Yes	High	Marginal - Important	3	9.76	900	1	2.8	27	20	47	307965	2.2	3.4	0.22	0.40	0.01	0.02
CV-102-5	Cut	S	CV-103-1		103640	557111	7915356	No	N/A	No	N/A	None	NA	NA	NA	1	2.8				8505630	62.1	93.6	0.00	0.00	0.00	0.00
CV-103-1	Culvert	S		CV-102-5	103979	557447	7915244	Yes	N/A	Yes	Moderate	Important	1	41.48	1800	3	8.9	369	128	497	8505630	62.1	93.6	0.76	1.40	0.09	0.16
CV-104-1	Culvert	S			104113	557574	7915202	Probable	Moderate	Probable	Low	Marginal	1	17.08	900	1	2.8	48	20	68	117626	0.9	1.3	0.23	0.42	0.02	0.03
CV-104-2	Culvert	S			104438	557882	7915099	Yes	Low	Yes	N/A	Marginal - Important	1	21.96	1200	2	6.8	149	65	215	355737	2.6	3.9	0.31	0.56	0.02	0.04
CV-104-3	Culvert	S			104561	557996	7915052	Yes	N/A	Yes	N/A	Important	3	26.84	1400	1	2.8	75	31	107	196000	1.4	2.2	0.18	0.33	0.01	0.02
CV-104-4	Culvert	LP			104736	558154	7914976	No	N/A	No	N/A	None	1	12.2	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-104-5	Culvert	S			104944	558340	7914885	Yes	N/A	Yes	Moderate	Important	1	21.96	1800	3	5.6	123	81	204	8097550	59.1	89.1	0.75	1.38	0.09	0.15
CV-105-1	Culvert	S			105150	558521	7914785	Probable	Moderate	Probable	N/A	Marginal	1	9.76	900	1	2.8	27	20	47	-	-	-	0.03	0.04	0.00	0.00
CV-105-2	Culvert	S			105413	558750	7914656	Yes	N/A	Yes	Low	Marginal	1	9.76	900	3	16.3	159	117	276	2357990	17.2	25.9	0.57	1.05	0.06	0.10
CV-105-3	Pond Infilling	P			105560	558875	7914578	Yes	N/A	Yes	N/A	Marginal - Important	1	9.76	900	n/a (LE)	n/a				-	-	-	0.03	0.04	0.00	0.00
CV-105-4	Culvert	S			105950	559196	7914375	Yes	N/A	Yes	N/A	Marginal	1	14.64	900	3	16.3	239	117	356	2357990	17.2	25.9	0.57	1.05	0.06	0.10
CV-106-1	Pond Infilling	P			106107	559334	7914281	Yes	N/A	Yes	N/A	Marginal - Important	1	12.2	900	n/a (LE)	n/a				-	-	-	0.03	0.04	0.00	0.00
CV-106-2	Pond Infilling	P			106450	559615	7914085	Yes	N/A	Yes	Low	Marginal - Important	1	12.2	900	n/a (LE)	n/a				-	-	-	0.03	0.04	0.00	0.00
CV-106-3	Encroachment	P			106893	559980	7913834	Yes	N/A	Yes	Moderate	Marginal - Important	1	14.64	900	n/a (LE)	n/a				-	-	-	0.03	0.04	0.00	0.00
CV-107-1	Encroachment	P			107350	560409	7913682	Probable	Moderate	Probable	High	Marginal - Important	1	19.52	900	n/a (LE)	n/a				-	-	-	0.03	0.04	0.00	0.00
CV-107-2	Encroachment	P			107473	560529	7913655	Potential	High	Potential	Low	None - Marginal	1	19.52	900	n/a (LE)	n/a				-	-	-	0.03	0.04	0.00	0.00
CV-107-3	Encroachment	P			107640	560660	7913555	No	Low	No	N/A	None	1	24.4	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-107-4	Culvert	S			107710	560706	7913502	Yes	N/A	Yes	N/A	Important	1	26.84	1400	3	16.3	437	183	620	1879500	13.7	20.7	0.50	0.92	0.05	0.08
CV-108-1	Culvert	S			108047	560926	7913247	No	N/A	No	N/A	None	1	17.08	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-108-2	Culvert	S			108104	560963	7913204	No	N/A	No	N/A	None	1	17.08	900	n/a	n/a				-	-	-	0.00	0.00	0.00	0.00
CV-108-3	Culvert	S			108718	561364	7912739	No	N/A	No	High	None	1	9.76	900	n/a	n/a				150290	1.1	1.7	0.00	0.00	0.00	0.00
CV-109-1	Cut	S	CV-109-2		109364	561856	7912346	Unlikely	High	Unlikely	High	None - Marginal	NA	NA	NA	1	2.8				8459	0.1	0.1	0.10	0.19	0.00	0.01
CV-109-2	Culvert	S		CV-109-1	109484	561973	7912254	No	Low	No	N/A	None	TBD	TBD	TBD	n/a	n/a										
CV-109-3	Culvert	LP			109553	562024	7912215	No	N/A	No	N/A	None	TBD	TBD	TBD	n/a	n/a										
CV-110-1	Culvert	S			MS Rail Loop	561084	7912910	No	N/A	No	N/A	None	TBD	TBD	TBD												

Table 8.1 North Railway Culvert Crossings, Bridges, Cuts, Diversions, and Encroachments on Waterbodies and Fish Habitat

Site ID	Description	Waterbody Type[1]	Diversion to	Receives Diversion From	Rail Chainage (m)	UTM Coordinates[2]		Arctic Char		Ninespine Stickleback		Habitat Quality	No. Barrels	Culvert Length (m)	Culvert Diameter (mm)	Stream Order		Culvert Footprint in Arctic Char Habitat			Catchment Areas	Mean Annual Flow		Ranges of results			
						Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty					Stream Order at Crossing	Ave. Bank-full Habitat Width (est.)[7]	Area Without Apron (m^2)	Apron Area (m^2)	Total Area (m^2)	(m^2)	Low Flow Scenario (L/s)	High Flow Scenario (L/s)	Min velocity (m/s)	Max Velocity (m/s)	Min Depth (m)	Max Depth (m)
CV-110-2	Culvert/ encroachment	P			MS Rail Loop	561266	7912241	No	N/A	No	N/A	None	TBD	TBD	TBD												
CV-110-3	Pond Infilling	P			MS Rail Loop	561445	7912240	No	N/A	No	N/A	None	TBD	TBD	TBD												
CV-110-4	Culvert	S			MS Rail Loop	561546	7912425	No	N/A	No	N/A	None	TBD	TBD	TBD												
																		20,316.8	10,304.5	30,621.4							

NOTES:

1. Waterbody Types: S = stream; P = pond; LP = Low point; L = Lake

2. UTM Coordinates in NAD83, Zone 17

ATTACHMENT 8.2

TOTE ROAD CROSSING LIST

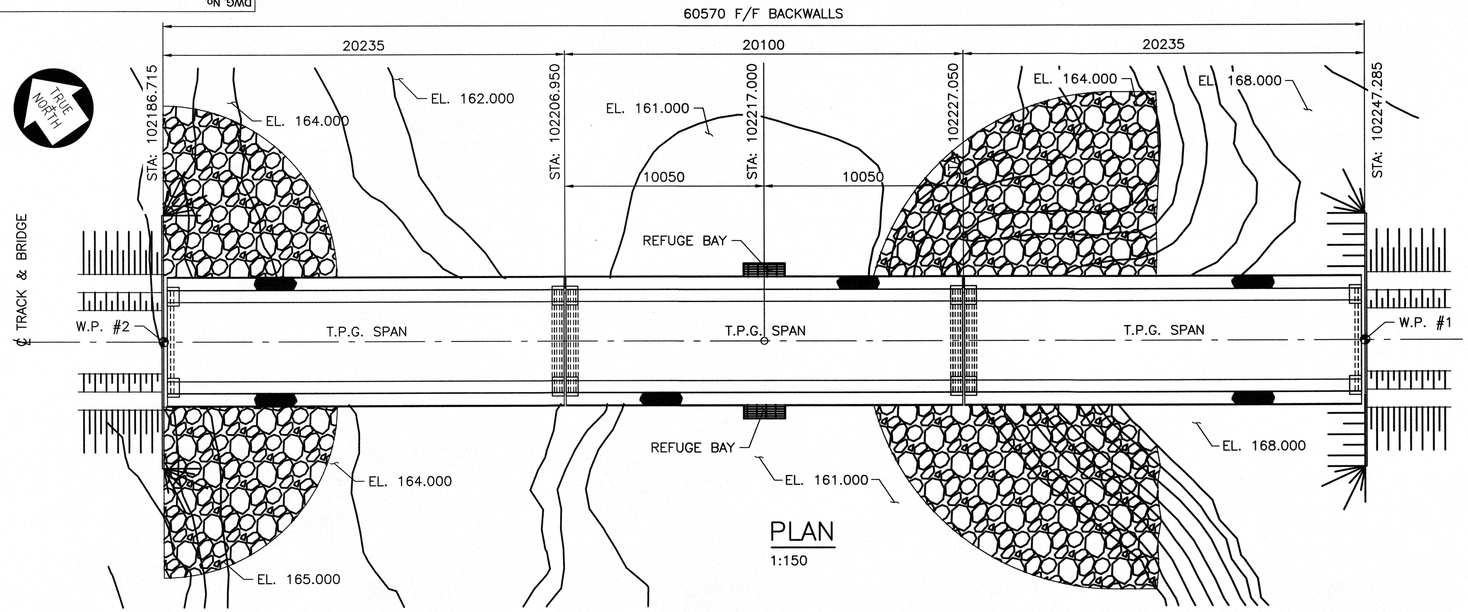
Table 8.2 Tote Road Crossing List

Road Section	Culvert Name		Feature	Road Chainage Reference	UTM Coordinates		Fish Bearing
				(m)	Easting	Northing	
Temporary Haul Road	CV-059-1	New	New Culvert	60500	528033	7929251	Potential
Temporary Haul Road	CV-060-1	New	New Culvert	55445	527517	7930366	Fish Bearing
Tote Road Realignment 12-530	CV-131-1	New	New Culvert	12530	511333	7967096	No
Tote Road Realignment 55-445	CV-060-2	New	New Culvert	55445	527756	7930278	Fish Bearing
Tote Road Realignment 84-500	CV-214-1	Relocate	Relocation of existing tote road culvert CV-214	84500	541273	7921956	No
Tote Road Realignment 84-500	CV-214-2	New	New culvert; no recorded culvert along existing road in the same drainage). Near rail culvert CV-85-1	84500	541507	7922071	No
Tote Road Realignment 84-500	CV-215-1		Relocation of existing tote road culvert CV-215	84500	541909	7922250	Potential
Tote Road Realignment 87+345	CV-216-1	New	New culvert; no recorded culvert along existing road in the same drainage). Near rail culvert CV-87-2	87345	543381	7921181	No
Tote Road Realignment 87+345	CV-216-2	New	New culvert; no recorded culvert along existing road in the same drainage). Near rail culvert CV-87-3	87345	543524	7921151	No
Tote Road Realignment 91-750	CV-020-1	New	New culvert in stream that runs parallel to road and eventually drains into nearby pond at existing tote road culvert CV-021. Near rail culvert CV 91-2.	91750	547094	7919813	No
Tote Road Realignment 91-750	CV-020-2	New	Same as CV020-1 above. Near rail culvert CV-91-0 and CV-91-0.	91750	546893	7919846	No
Tote Road Realignment 9-450	CV-146-1	Relocate	Relocation of existing tote road culvert CV-146	9450	508928	7968816	No
Tote Road Realignment 9-450	CV-146-2	Relocate	Relocation of existing tote road culvert CV-146	9450	508728	7968856	
Tote Road Realignment 9-450	CV-146-3	Relocate	Relocation of existing tote road culvert CV-146	9450	508720	7968885	
Tote Road Realignment 96-585	BG-13-1	New	New culvert near existing CV-007 but in a different watercourse that runs parallel to the existing road.	96585	551001	7917116	No
Tote Road Realignment 96-585	BG-14-1	New	New culvert near existing BG-14 but in a different watercourse that runs parallel to the existing road.	96585	550839	7917414	No
Laydown LD-4 off Tote Road 5-500	CV-169-1	New	New Culvert	5500	505149	7972688	Potential

ATTACHMENT 8.3

NORTH RAILWAY BRIDGE DRAWINGS

DWG. No. H353004-35000-224-270-0004-0001



PLAN
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WORKING POINT COORDINATES		
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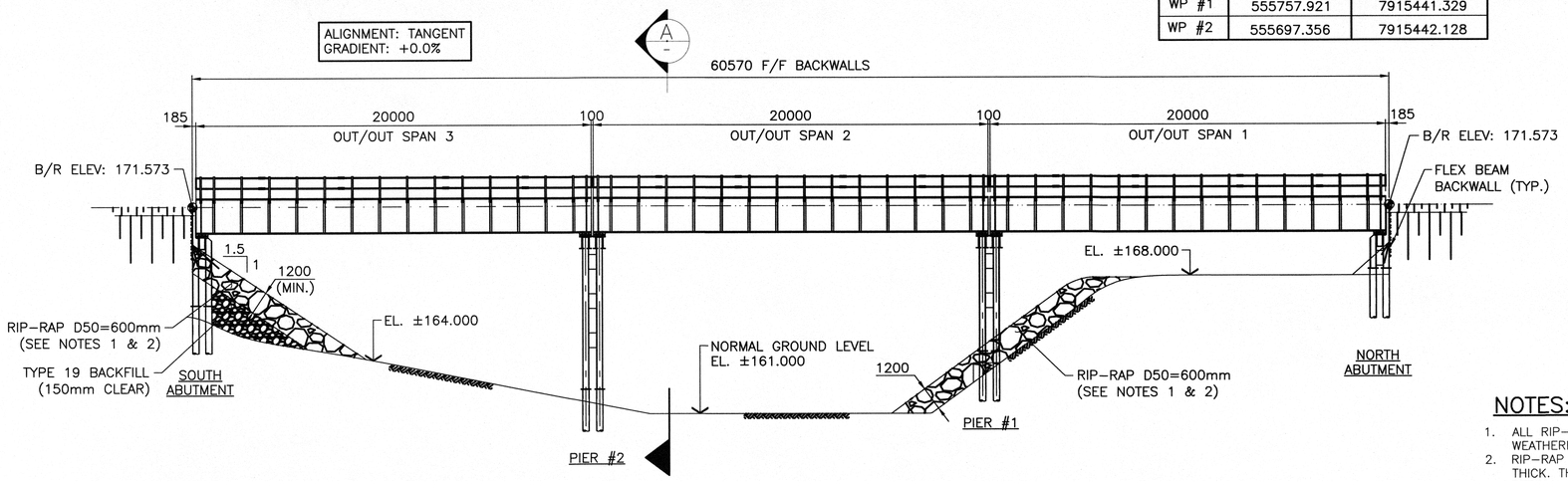
WP #2	555697.356	7915442.128

ALIGNMENT: TANGENT
GRADIENT: +0.0%



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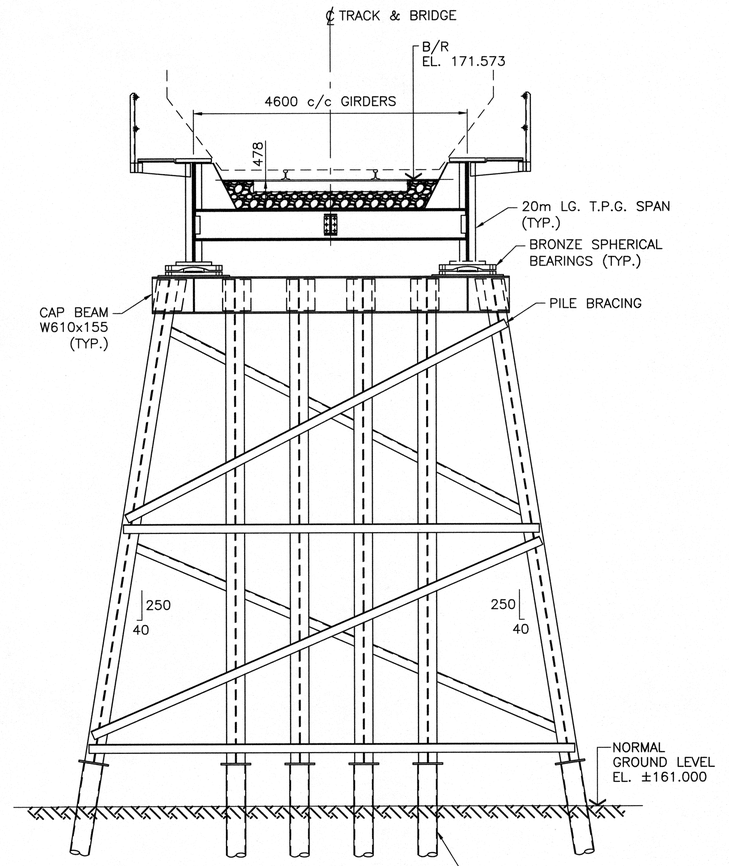


SECTION A-A
1:50

NOTES:

1. ALL RIP-RAP MATERIAL SHALL BE RESISTANT TO WEATHERING AND WATER ACTION.
2. RIP-RAP PROTECTION IS TO BE MINIMUM 1.2m THICK. THE GRADATION SHALL BE SUCH THAT 50 PERCENT OF THE RIP RAP CONSISTS OF MATERIAL HAVING A MINIMUM DIMENSION OF 600mm (D50).
3. THIS DRAWING WAS PREVIOUSLY ISSUED AS: H353004-35000-224-270-0004-0001
4. ALL DIMENSIONS IN mm UNLESS INDICATED OTHERWISE.

ESTIMATED QUANTITIES:

DESCRIPTION	QUANTITIES
HP310x101 PILES (QTY-48)	234 l.m.
610mm dia.x19mm thk. STEEL PIPE PILES (QTY-48)	LENGTHS T.B.D.
W610x155 CAP BEAMS (QTY-12)	72 l.m.
FLEXBEAM BACKWALL (QTY-2)	78 m²
BRONZE BEARINGS (QTY-12)	8,790 Kg
20m T.P.G. SPANS (QTY-3)	156,000 Kg
WALKWAY HANDRAIL	121 l.m. (1,015 Kg)
WALKWAY GRATING	74 m²
WALKWAY BRACKETS/POSTS (QTY-96)	3,840 Kg
TYPE 19 BACKFILL (150mm CLEAR)	180 m³
RIP-RAP D50 (600mm)	570 m³

NOT FOR CONSTRUCTION

THIS DRAWING WAS PREPARED BY HATCH LTD. ("HATCH") FOR THE EXCLUSIVE USE OF BAFFINLAND IRON MINES LP ("CLIENT") AND ITS USE IS SUBJECT TO THE TERMS AND CONDITIONS OF THE CONTRACT BETWEEN HATCH AND THE THE CLIENT, INCLUDING ANY LIMITATIONS ON LIABILITY CONTAINED THEREIN. THIS DRAWING AND ITS CONTENTS REMAIN THE INTELLECTUAL PROPERTY OF HATCH SUBJECT TO CLIENT'S ROYALTY-FREE, IRREVOCABLE, PERPETUAL AND NON-EXCLUSIVE LICENSE TO USE AND REPRODUCE THE DRAWING FOR PURPOSES CONNECTED WITH THE PROJECT, INCLUDING THE CONSTRUCTION, COMPLETION, MAINTENANCE, EXTENSION, REINSTATEMENT AND REPAIR OF THE PROJECT. THIS DRAWING, AND THE INFORMATION CONTAINED HEREIN, SHALL BE TREATED AS CONFIDENTIAL FOR ALL OTHER PURPOSES AND SHALL NOT BE MODIFIED WITHOUT THE WRITTEN CONSENT OF HATCH.

No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR USE	AJVN	AM	2018/04/09

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	J ESTRADE	NR	2016/09/06
DESIGNER	J ESTRADE	NR	
CHECKER	A MIDDLETON	andrew.middleton@hatch.ca	2018/04/23
DESIGN COORD.	A AQUIL		2018/04/23
RESP. ENG.	A MIDDLETON	andrew.middleton@hatch.ca	2018/04/23
LEAD DISC. ENG.	F VAN BILJON		2018/04/23
AREA LEAD	F VAN BILJON		2018/04/23
ENG. MANAGER	D STANGER		2018/04/24
CLIENT	F PITTMAN		2018/04/25

DRAWING APPROVAL STATUS: APPROVED FOR USE

HATCH

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

RAIL SITE
BRIDGE GENERAL LAYOUT
BR-102-1

DRAWING No.	DRAWING TITLE
H353004-30000-224-271-0025	LAYOUT AND LONGITUDINAL SECTION CH. 97+620 TO CH. 102+240

REFERENCE DRAWINGS

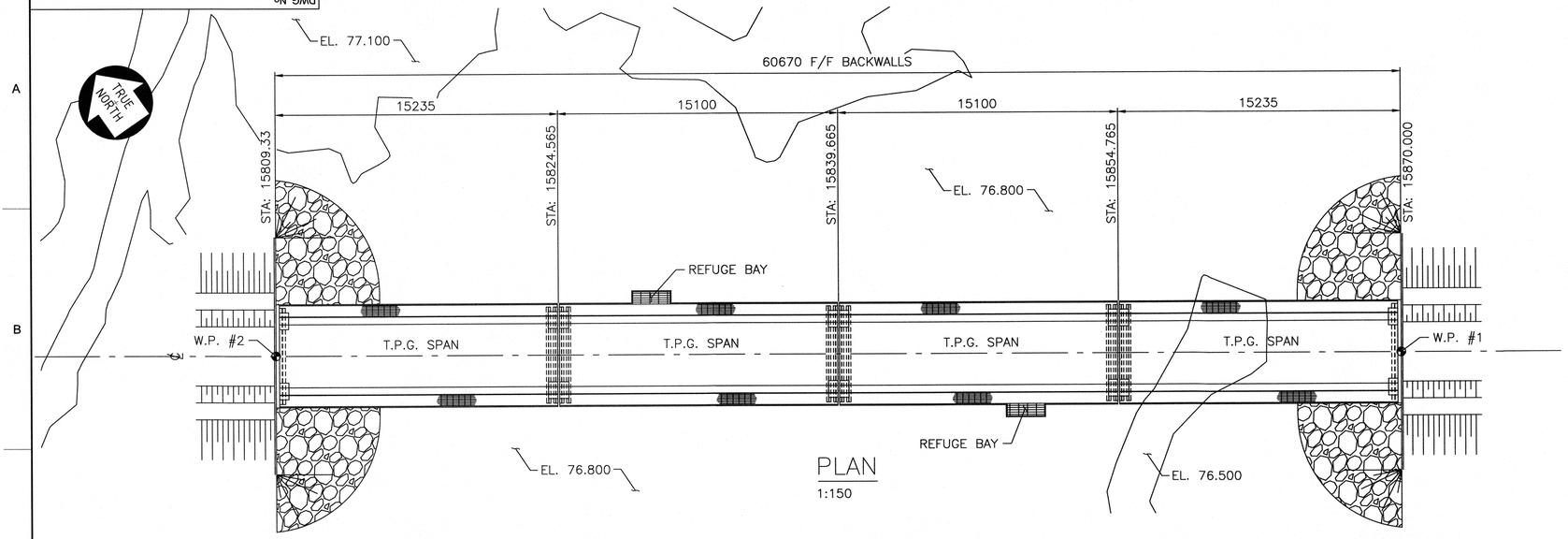
REG. PROFESSIONAL

SCALE	DWG. No.	REV
OR AS NOTED	H353004-35000-224-270-0004-0001	0

SHEET SIZE: D

$TIME$
$USERNAME$
$DATE$

DWG. No. H353004-35000-224-270-0001-0001



PLAN
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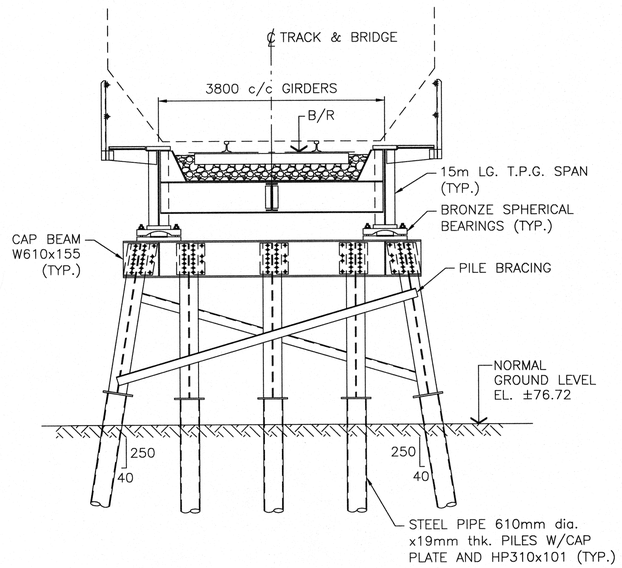
WP #2	514210.6739	7965645.3887

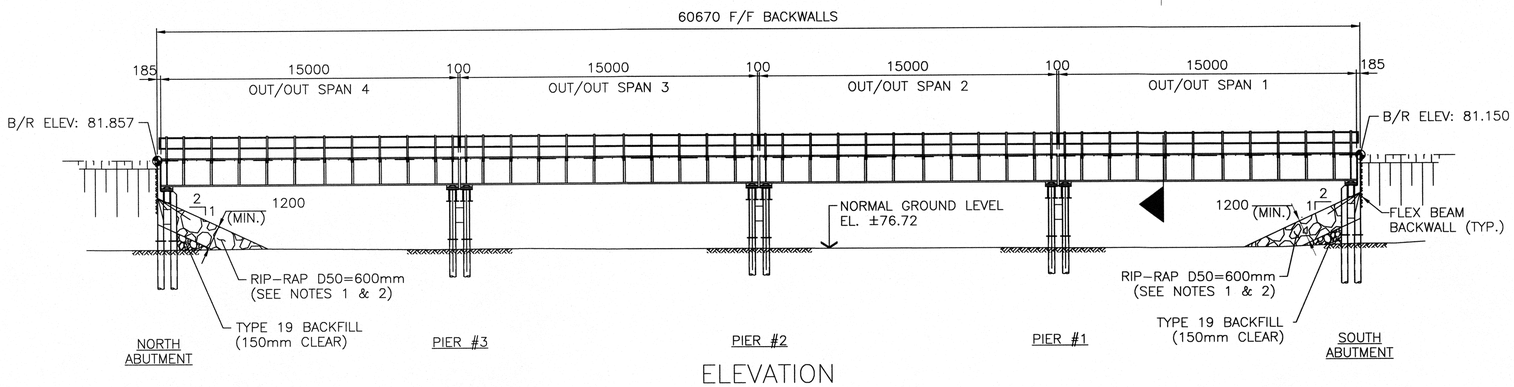


SECTION A
1:50

NOTES:

1. ALL RIP–RAP MATERIAL SHALL BE RESISTANT TO WEATHERING AND WATER ACTION.
2. RIP–RAP PROTECTION IS TO BE MINIMUM 1.2m THICK. THE GRADATION SHALL BE SUCH THAT 50 PERCENT OF THE RIP RAP CONSISTS OF MATERIAL HAVING A MINIMUM DIMENSION OF 600mm (D50).
3. PRE–FABRICATED BRIDGE SPANS TO BE USED FOR THIS PROJECT.
4. THIS DRAWING WAS PREVIOUSLY ISSUED AS: H353004–3330–230–270–0001–0001
5. ALL DIMENSIONS IN mm UNLESS INDICATED OTHERWISE.

ALIGNMENT: TANGENT
GRADIENT: –0.32%



ELEVATION
1:150

ESTIMATED QUANTITIES:	
DESCRIPTION	QUANTITIES
HP310x101 PILES (QTY–50)	145 l.m.
ø610mm x19mm thk. STEEL PIPE PILES (QTY–50)	LENGTHS T.B.D.
W610x155 CAP BEAMS (QTY–16)	80 l.m.
FLEXBEAM BACKWALL (QTY–2)	78 m²
BRONZE BEARINGS (QTY–16)	10,675 Kg
15m T.P.G. SPANS (QTY–4)	148,320 Kg
WALKWAY HANDRAIL	121 l.m. (1,015 Kg)
WALKWAY GRATING	74 m²
WALKWAY BRACKETS/POSTS (QTY–96)	3,840 Kg
TYPE 19 BACKFILL (150mm CLEAR)	55 m³
RIP–RAP D50 (600mm)	180 m³

NOT FOR CONSTRUCTION

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No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR USE	JE	AM	2018/04/09

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	J ESTRADE	NR	2016/09/06
DESIGNER	J ESTRADE	NR	
CHECKER	A MIDDLETON	andrew.middleton@hatch.com	
DESIGN COORD.	A AQUIL		2018/04/23
RESP. ENG.	A MIDDLETON	andrew.middleton@hatch.com	
LEAD DISC. ENG.	F VAN BILJON		2018/04/27
AREA LEAD	F VAN BILJON		2018/04/27
ENG. MANAGER	D STANGER		2018/4/24
CLIENT	F PITTMAN		2018/4/24

DRAWING APPROVAL STATUS: APPROVED FOR USE

HATCH

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

RAIL SITE
BRIDGE GENERAL LAYOUT
BR-15-1

SCALE	DWG. No.	REV
OR AS NOTED	H353004-35000-224-270-0001-0001	0

SHEET SIZE: D

DRAWING No.	DRAWING TITLE
H353004-30000-224-271-0007	LAYOUT AND LONGITUDINAL SECTION CH. 14+100 TO CH. 18+720

REFERENCE DRAWINGS

REG. PROFESSIONAL

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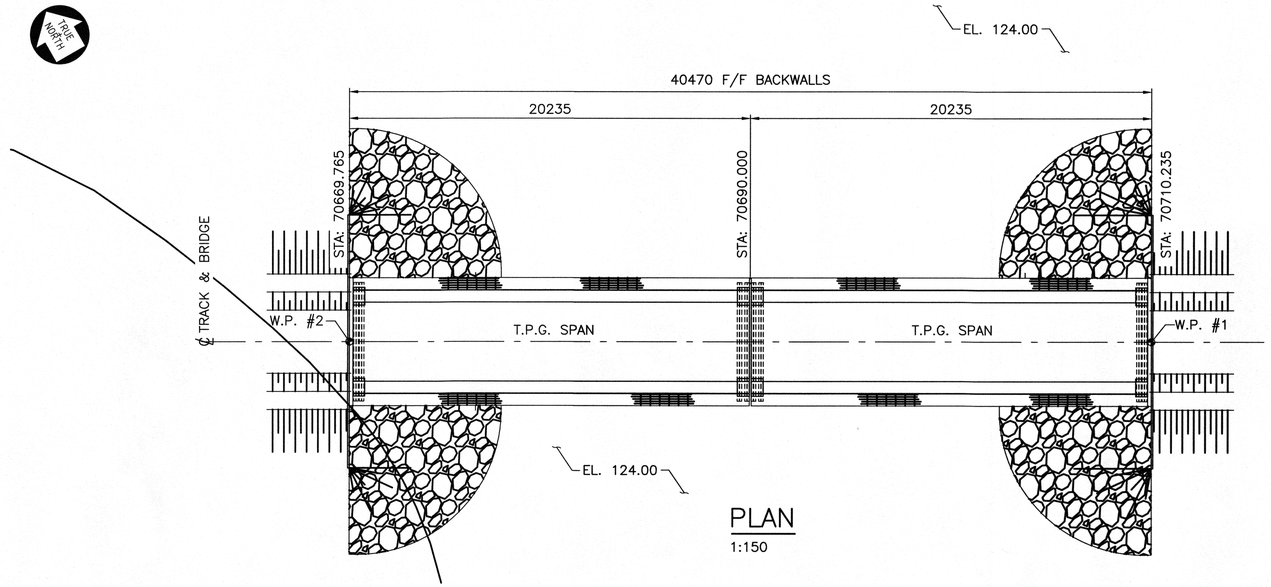
$TIME$

DWG. No. H353004-35000-224-270-0002-0001



PLAN
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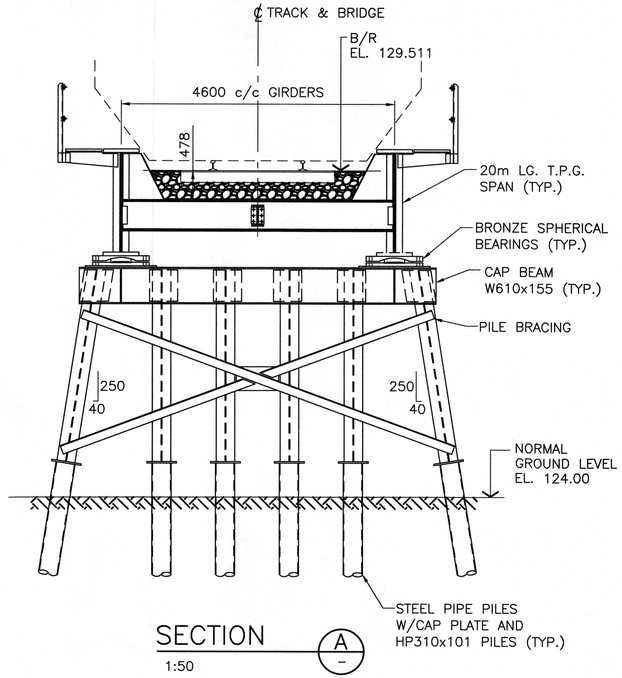

SECTION A
1:50

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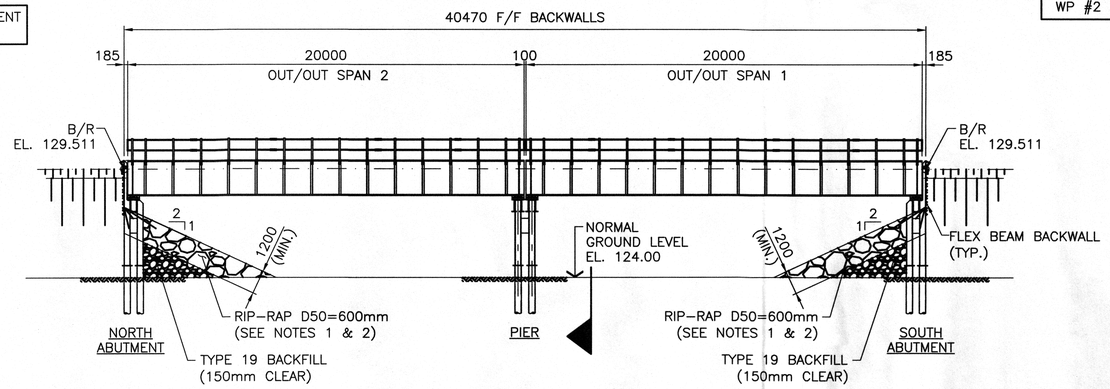
GRADIENT: +0.0%



ELEVATION

WORKING POINT COORDINATES		
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WP #2	529,107.458	7,916,699.747

NOTES:

1. ALL RIP-RAP MATERIAL SHALL BE RESISTANT TO WEATHERING AND WATER ACTION.
2. RIP-RAP PROTECTION IS TO BE MINIMUM 1.2m THICK. THE GRADATION SHALL BE SUCH THAT 50 PERCENT OF THE RIP RAP CONSISTS OF MATERIAL HAVING A MINIMUM DIMENSION OF 600mm (D50).
3. THIS DRAWING WAS PREVIOUSLY ISSUED AS: H353004-3330-230-270-0002-0001
4. ALL DIMENSIONS IN mm UNLESS INDICATED OTHERWISE.

ESTIMATED QUANTITIES:

DESCRIPTION	QUANTITIES
HP310x101 PILES (QTY-36)	143 l.m.
610mm dia.x19mm thk. STEEL PIPE PILES (QTY-36)	LENGTHS T.B.D.
W610x155 CAP BEAMS (QTY-8)	48 l.m.
FLEXBEAM BACKWALL (QTY-2)	78 m^2
BRONZE BEARINGS (QTY-8)	5,860 Kg
20m T.P.G. SPANS (QTY-2)	104,000 Kg
WALKWAY HANDRAIL	80 l.m. (680 Kg)
WALKWAY GRATING	49 m^2
WALKWAY BRACKETS/POSTS (QTY-64)	2,495 Kg
TYPE 19 BACKFILL (150mm CLEAR)	310 m^3
RIP-RAP D50 (600mm)	340 m^3

THIS DRAWING WAS PREPARED BY HATCH LTD. ("HATCH") FOR THE EXCLUSIVE USE OF BAFFINLAND IRON MINES LP ("CLIENT") AND ITS USE IS SUBJECT TO THE TERMS AND CONDITIONS OF THE CONTRACT BETWEEN HATCH AND THE THE CLIENT, INCLUDING ANY LIMITATIONS ON LIABILITY CONTAINED THEREIN. THIS DRAWING AND ITS CONTENTS REMAIN THE INTELLECTUAL PROPERTY OF HATCH SUBJECT TO CLIENT'S ROYALTY-FREE, IRREVOCABLE, PERPETUAL AND NON-EXCLUSIVE LICENSE TO USE AND REPRODUCE THE DRAWING FOR PURPOSES CONNECTED WITH THE PROJECT, INCLUDING THE CONSTRUCTION, COMPLETION, MAINTENANCE, EXTENSION, REINSTATEMENT AND REPAIR OF THE PROJECT. THIS DRAWING, AND THE INFORMATION CONTAINED HEREIN, SHALL BE TREATED AS CONFIDENTIAL FOR ALL OTHER PURPOSES AND SHALL NOT BE MODIFIED WITHOUT THE WRITTEN CONSENT OF HATCH.

NOT FOR CONSTRUCTION

HATCH

No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR USE	AJVN	AM	2018/04/09

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	S HANDY	NR	2016/09/06
DESIGNER	S HANDY	NR	
CHECKER	A MIDDLETON	andrew.middleton@hatch.com	2018/04/23
DESIGN COORD.	A AQUIL		2018/04/23
RESP. ENG.	A MIDDLETON	andrew.middleton@hatch.com	2018/04/23
LEAD DISC. ENG.	F VAN BILJON		2018/04/23
AREA LEAD	F VAN BILJON		2018/04/23
ENG. MANAGER	D STANGER		2018/04/24
CLIENT	F PITTMAN		2018/04/25

DRAWING APPROVAL STATUS: APPROVED FOR USE

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

RAIL SITE
BRIDGE GENERAL LAYOUT
BR-70-1

DRAWING No.	DRAWING TITLE
H353004-30000-224-271-0019	LAYOUT AND LONGITUDINAL SECTION CH. 69+780 TO CH. 74+400

REFERENCE DRAWINGS

REG. PROFESSIONAL

REVISIONS

SCALE: OR AS NOTED

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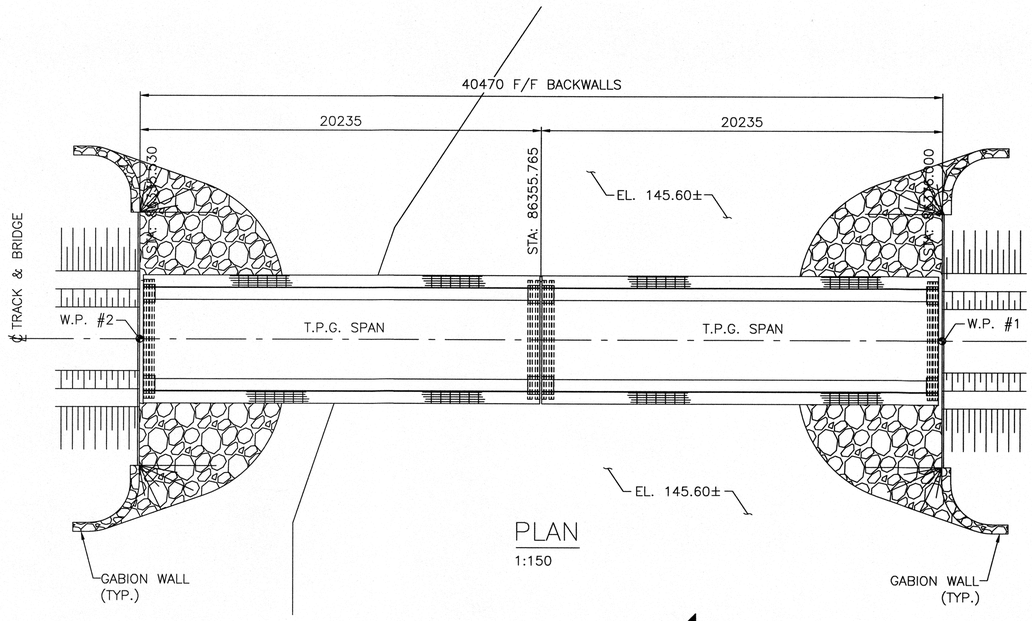

PLAN
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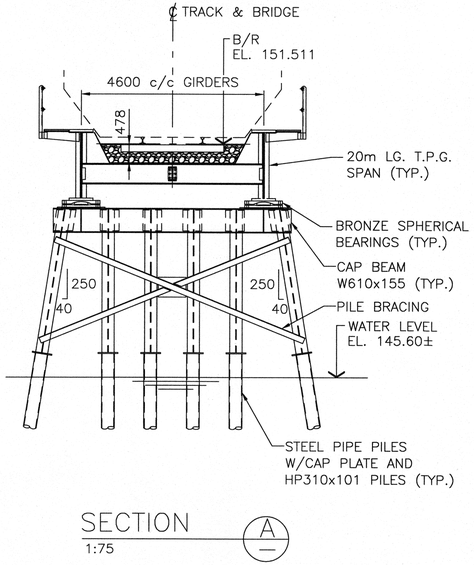

SECTION A
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WORKING POINT COORDINATES		
	E	N
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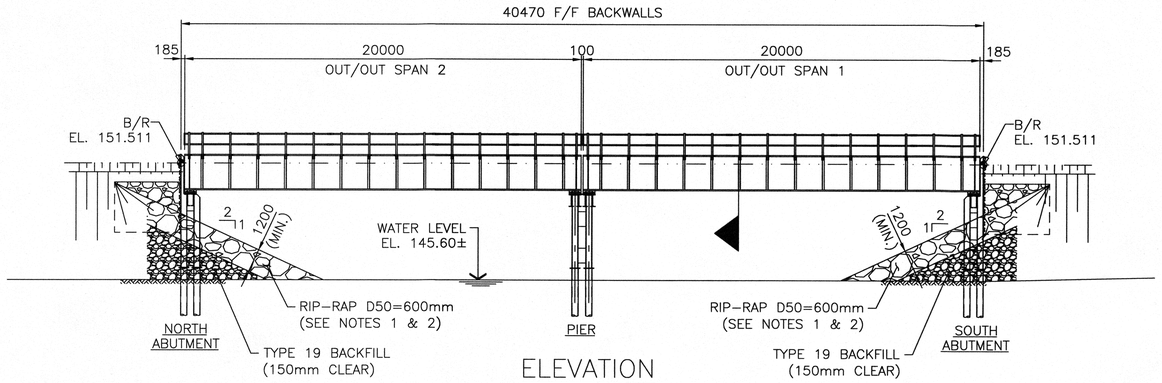
WP #2	542,257.182	7,922,181.626

ALIGNMENT: TANGENT
GRADIENT: +0.0%



ELEVATION
1:150

NOTES:

1. ALL RIP-RAP MATERIAL SHALL BE RESISTANT TO WEATHERING AND WATER ACTION.
2. RIP-RAP PROTECTION IS TO BE MINIMUM 1.2m THICK. THE GRADATION SHALL BE SUCH THAT 50 PERCENT OF THE RIP RAP CONSISTS OF MATERIAL HAVING A MINIMUM DIMENSION OF 600mm (D50).
3. PRE-FABRICATED BRIDGE SPANS TO BE USED FOR THIS PROJECT.
4. THIS DRAWING WAS PREVIOUSLY ISSUED AS: H353004-3330-230-270-0003-0001
5. ALL DIMENSIONS IN mm UNLESS INDICATED OTHERWISE.

ESTIMATED QUANTITIES:

DESCRIPTION	QUANTITIES
HP310x101 PILES (QTY-36)	160 l.m.
610mm dia.x19mm thk. STEEL PIPE PILES (QTY-36)	LENGTHS T.B.D.
W610x155 CAP BEAMS (QTY-8)	48 l.m.
FLEXBEAM BACKWALL (QTY-2)	104 m^2
BRONZE BEARINGS (QTY-8)	5,860 Kg
20m T.P.G. SPANS (QTY-2)	104,000 Kg
WALKWAY HANDRAIL	80 l.m. (670 Kg)
WALKWAY GRATING	49 m^2
WALKWAY BRACKETS/POSTS (QTY-64)	2,497 Kg
GABION WALL (QTY-4)	60 m^2
TYPE 19 BACKFILL (150mm CLEAR)	300 m^3
RIP-RAP D50 (600mm)	260 m^3

NOT FOR CONSTRUCTION

THIS DRAWING WAS PREPARED BY HATCH LTD. ("HATCH") FOR THE EXCLUSIVE USE OF BAFFINLAND IRON MINES LP ("CLIENT") AND ITS USE IS SUBJECT TO THE TERMS AND CONDITIONS OF THE CONTRACT BETWEEN HATCH AND THE THE CLIENT, INCLUDING ANY LIMITATIONS ON LIABILITY CONTAINED THEREIN. THIS DRAWING AND ITS CONTENTS REMAIN THE INTELLECTUAL PROPERTY OF HATCH SUBJECT TO CLIENT'S ROYALTY-FREE, IRREVOCABLE, PERPETUAL AND NON-EXCLUSIVE LICENSE TO USE AND REPRODUCE THE DRAWING FOR PURPOSES CONNECTED WITH THE PROJECT, INCLUDING THE CONSTRUCTION, COMPLETION, MAINTENANCE, EXTENSION, REINSTATEMENT AND REPAIR OF THE PROJECT. THIS DRAWING, AND THE INFORMATION CONTAINED HEREIN, SHALL BE TREATED AS CONFIDENTIAL FOR ALL OTHER PURPOSES AND SHALL NOT BE MODIFIED WITHOUT THE WRITTEN CONSENT OF HATCH.

HATCH

No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR USE	SH	AM	2018/04/09

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	S HANDY	NR	2016/09/06
DESIGNER	S HANDY	NR	
CHECKER	A MIDDLETON	andrew.middleton@hatch.com	
DESIGN COORD.	A AQUIL		2018/04/23
RESP. ENG.	A MIDDLETON	andrew.middleton@hatch.com	
LEAD DISC. ENG.	F VAN BILJON		2018/04/23
AREA LEAD	F VAN BILJON		2018/04/23
ENG. MANAGER	D STANGER		2018/04/24
CLIENT	F PITTMAN		2018/04/25

DRAWING APPROVAL STATUS: Approved for Use

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

RAIL SITE
BRIDGE GENERAL LAYOUT
BR-86-1

DRAWING No.	DRAWING TITLE
H353004-30000-224-271-0022	LAYOUT AND LONGITUDINAL SECTION CH. 83+700 TO CH. 88+320

REFERENCE DRAWINGS

REG. PROFESSIONAL

SCALE OR AS NOTED

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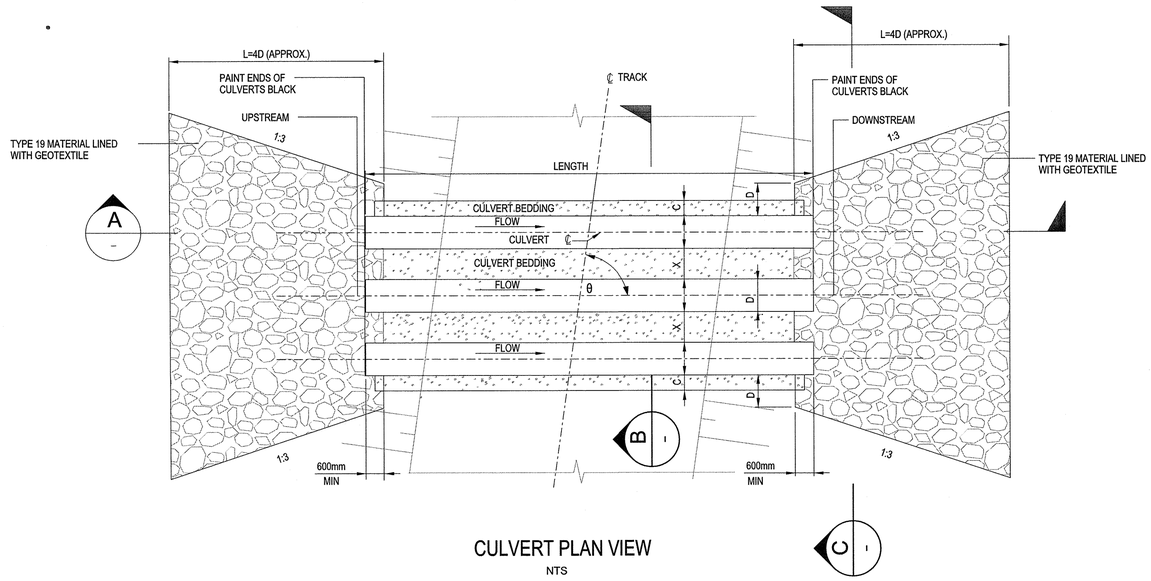
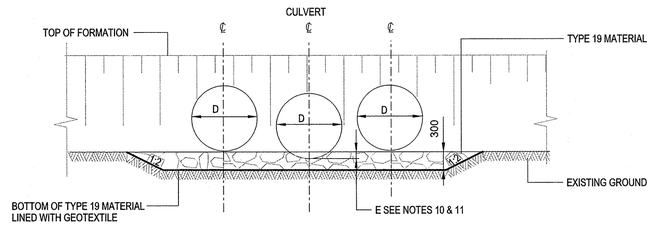
DWG. No. H353004-00000-220-294-0001-0001



CULVERT PLAN VIEW

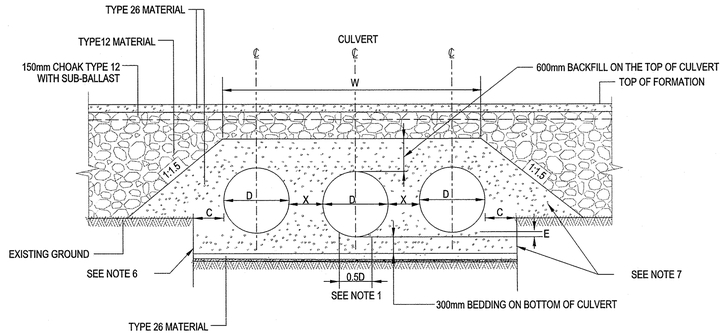
NTS



MULTIPLE PIPE SECTION

NTS

C1



MULTIPLE PIPE SECTION

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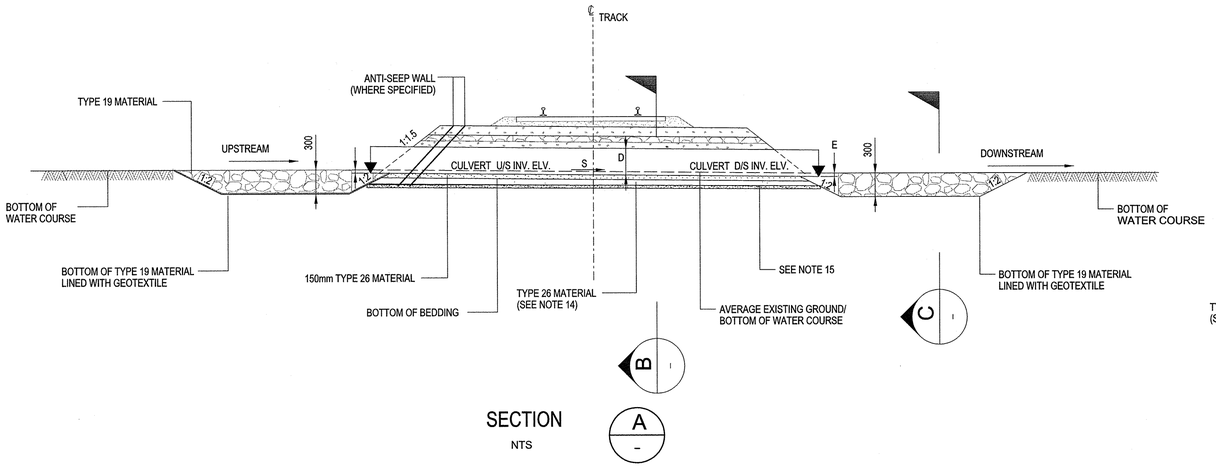

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NTS

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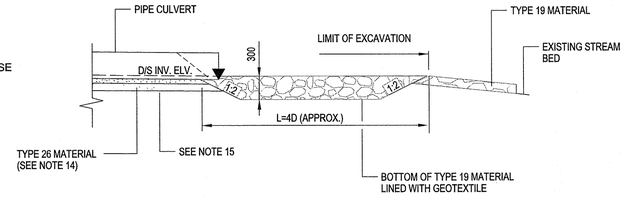

RIP RAP APRON TREATMENT ON STEEP STREAM

NTS

NOT FOR CONSTRUCTION

LEGEND

D	CULVERT DIAMETER
E	EMBEDMENT DEPTH
C	CULVERT SPACING AND BEDDING CLEARANCE C=500 WHILE D>900mm C=300 WHILE D<=900mm
W	CULVERT BACKFILL TOP WIDTH W=n*D+(n-1)*C
U/S INV. ELV.	CULVERT UPSTREAM INVERT ELEVATION
D/S INV. ELV.	CULVERT DOWNSTREAM INVERT ELEVATION
L	RIPRAP APRON LENGTH L=4*D (APPROX.)
S	CULVERT SLOPE
LENGTH	CULVERT LENGTH
INV	INVERT
θ	ANGLE OF SKEW
X	DISTANCE BETWEEN CULVERTS

NOTES:

1. THE PIPE BED SHALL BE SHAPED TO RECEIVE THE BOTTOM OF THE PIPE.
2. GRANULAR MATERIAL PLACED UNDER THE HAUNCH MUST BE COMPACTED.
3. BEDDING AND BACKFILL MATERIAL SHALL BE HOMOGENEOUS GRANULAR MATERIAL, AND SHALL BE PLACED AND COMPACTED UNIFORMLY AROUND THE PIPE.
4. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS NOTED OTHERWISE
5. ALL ELEVATIONS ARE IN METERS UNLESS NOTED OTHERWISE.
6. WHERE VERTICAL EXCAVATION IS NOT POSSIBLE, MODIFY EXCAVATION SLOPE TO MIN. 1V:1.5H
7. PROVIDE 300mm TYPE 8 (150mm MINUS) AROUND BEDDING AND BACK FILL MATERIAL ONLY WHEN ROCKFILL IS PRESENT.
8. ADJUST CULVERT START AND END COORDINATES AND INVERT ELEVATIONS IN THE FIELD AS APPROVED BY COMPANY'S REPRESENTATIVE.
9. PROVIDE AVERAGE STREAM SLOPE ALONG THE CULVERT AS CULVERT SLOPE BASED ON ACTUAL FIELD CONDITION.
10. FOR FISH BEARING CULVERT, E=0.1D-0.25D
    FOR NON-FISH BEARING CULVERT, E=0
11. FOR FISH BEARING CULVERT WITH MULTIPLE PIPES, ONLY ONE PIPE SHALL BE EMBEDDED BY "E" (APPROXIMATELY 0.1D-0.25D) ALL OTHER PIPES SHALL BE PLACED ON GROUND/BOTTOM OF WATER COURSE.
12. COMPACTED ROCK-FILL (TYPE 8) MATERIAL TO BE PLACED ON THE NATURAL GROUND OR RAISED GRADE. DEPTH OF ROCK-FILL VARIES BETWEEN 1m AND 1.5m.
13. ADDITIONAL FILL OF RUN OF QUARRY (TYPE 12) OR ROCK-FILL (TYPE 8) MAY BE REQUIRED TO RAISE GRADE OF EMBANKMENT TO MATCH VERTICAL PROFILE OF RAILROAD OR WHERE A WEAK FOUNDATION SOIL IS PRESENT.
14. THE DEPTH OF THE EXCAVATION UNDER THE CULVERT AND THE REQUIREMENT OF THE INSULATION LAYER IS TO BE DEFINED BY CULVERT LOCATION.
15. 100mm OF DRY SAND, TYPE 9 FILL-CRUSHER FINES/LINER BEDDING OR A FILTER CLOTH PLACED ABOVE AND BELOW INSULATION LAYER FOR PROTECTION.
16. PREFABRICATED CONCRETE WINGWALLS WILL BE ALLOWED FOR. FLAG WILL BE PLANTED TO INDICATE BEGINNING/END OF PIPE.
17. DESIGN FOR 1:100 RETURN PERIOD.
18. MATERIAL TYPE DEFINITION:
    TYPE 12: RUN OF QUARRY/ROCK FILL LAYER
    TYPE 19: RIP RAP LAYER
    TYPE 25: BALLAST LAYER
    TYPE 26: SUB-BALLAST LAYER

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Reserved space for Issue Reason stamp applied by Document Control

No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR BID	SPA		2016/12/07

REVISIONS

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	S ATKINSON		2016/12/07
DESIGNER		NB	
CHECKER	R MEISERS		2016/12/15
DESIGN COORD.			
RESP. ENG.	E VAN WYK		2016/12/13
LEAD DISC. ENG.	E VAN WYK		2016/12/13
ENG. MANAGER	J Cameron		2016/12/13
PROJ. MANAGER			
	M WEEVER	MW	12/14/16

DRAWING APPROVAL STATUS:

NAME
SIGNATURE
ENG REG NUMBER
REVISION DATE
ORIGINAL DATE

DRAWING No. | DRAWING TITLE

REFERENCE DRAWINGS

REG. PROFESSIONAL

HATCH

Baffinland

MARY RIVER EXPANSION STAGE 3
BAFFINLAND IRON ORE MINES

RAIL SITE
STANDARD DRAWING

TYPICAL CROSS SECTION- MULTIPLE BARREL PIPE CULVERT

SCALE: NTS OR AS NOTED

DWG. No. H353004-00000-220-294-0001-0001

REV 0

SHEET SIZE: A1

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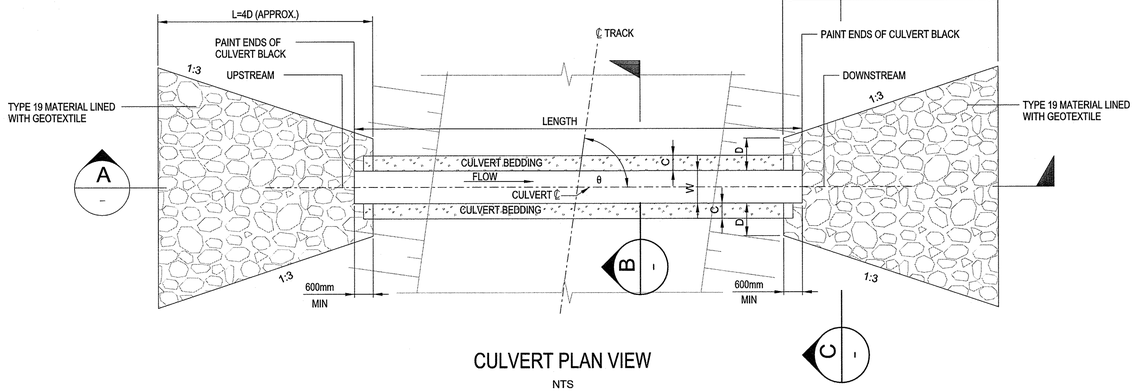
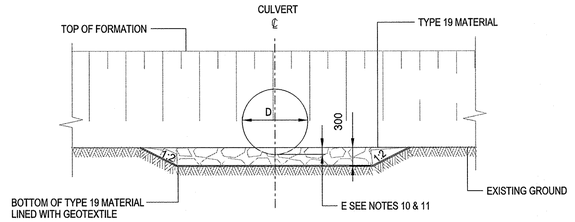


CULVERT PLAN VIEW

NTS



SINGLE PIPE SECTION

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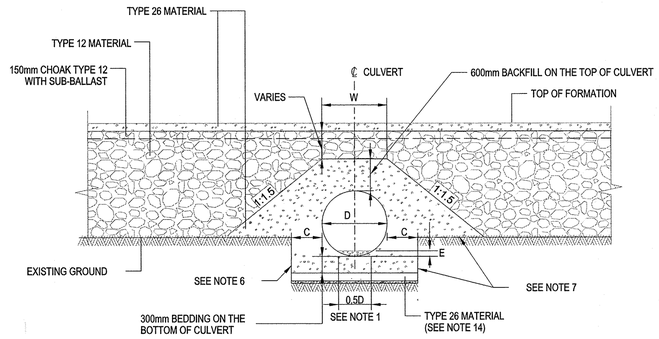

SINGLE PIPE SECTION

NTS

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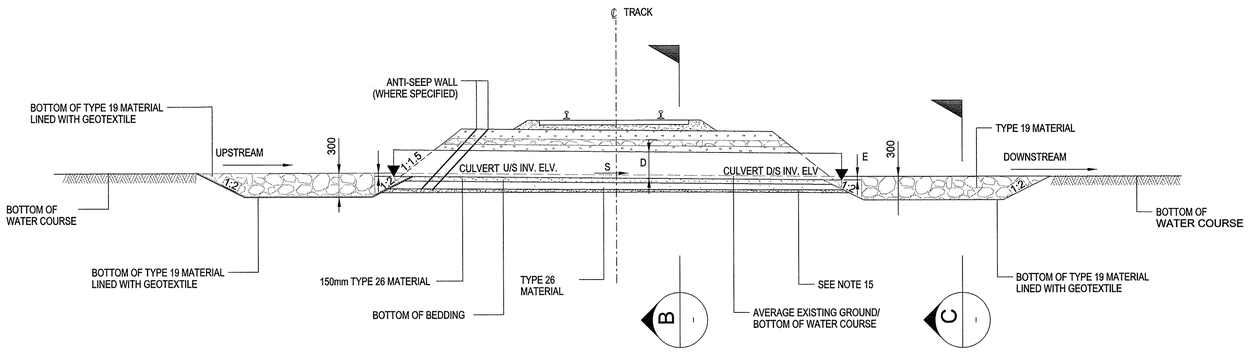

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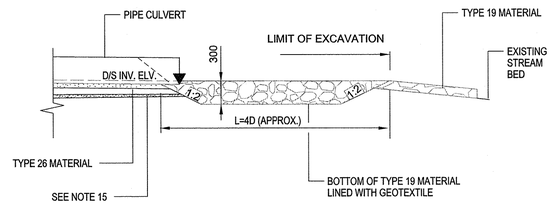

RIP RAP APRON TREATMENT ON STEEP STREAM

NTS

LEGEND

D	CULVERT DIAMETER
E	EMBEDMENT DEPTH
C	CULVERT SPACING AND BEDDING CLEARANCE C=500 WHILE D>900mm C=300 WHILE D<=900mm
W	CULVERT BACKFILL TOP WIDTH W=n*D+(n-1)*C
U/S INV. ELV.	CULVERT UPSTREAM INVERT ELEVATION
D/S INV. ELV.	CULVERT DOWNSTREAM INVERT ELEVATION
L	RIPRAP APRON LENGTH L=4*D (APPROX.)
S	CULVERT SLOPE
LENGTH	CULVERT LENGTH
INV	INVERT
θ	ANGLE OF SKEW

NOTES:

1. THE PIPE BED SHALL BE SHAPED TO RECEIVE THE BOTTOM OF THE PIPE.
2. GRANULAR MATERIAL PLACED UNDER THE HAUNCH MUST BE COMPACTED.
3. BEDDING AND BACKFILL MATERIAL SHALL BE HOMOGENEOUS GRANULAR MATERIAL, AND SHALL BE PLACED AND COMPACTED UNIFORMLY AROUND THE PIPE.
4. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS NOTED OTHERWISE
5. ALL ELEVATIONS ARE IN METERS UNLESS NOTED OTHERWISE.
6. WHERE VERTICAL EXCAVATION IS NOT POSSIBLE, MODIFY EXCAVATION SLOPE TO MIN. 1.5H: 1V.
7. PROVIDE 300mm TYPE 8 (150mm MINUS) AROUND BEDDING AND BACK FILL MATERIAL ONLY WHEN ROCKFILL IS PRESENT.
8. ADJUST CULVERT START AND END COORDINATES AND INVERT ELEVATIONS IN THE FIELD AS APPROVED BY COMPANY'S REPRESENTATIVE.
9. FLOW DIRECTION MUST BE FROM UPSTREAM TO DOWNSTREAM. PROVIDE AVERAGE STREAM SLOPE ALONG THE CULVERT AS CULVERT SLOPE BASED ON ACTUAL FIELD CONDITION.
10. FOR FISH BEARING CULVERT, E=0.1D-0.25D
    FOR NON-FISH BEARING CULVERT, E=0
11. FOR FISH BEARING CULVERT WITH MULTIPLE PIPES, ONLY ONE PIPE SHALL BE EMBEDDED BY "E" (APPROXIMATELY 0.1D-0.25D) ALL OTHER PIPES SHALL BE PLACED ON GROUND/BOTTOM OF WATER COURSE.
12. COMPACTED ROCK-FILL (TYPE 8) MATERIAL TO BE PLACED ON THE NATURAL GROUND OR RAISED GRADE. DEPTH OF ROCK-FILL VARIES BETWEEN 1m AND 1.5m
13. ADDITIONAL FILL OF RUN OF QUARRY (TYPE 12) OR ROCK-FILL (TYPE 8) MAY BE REQUIRED TO RAISE GRADE OF EMBANKMENT TO MATCH VERTICAL PROFILE OF RAILROAD OR WHERE A WEAK FOUNDATION SOIL IS PRESENT.
14. THE DEPTH OF THE EXCAVATION UNDER THE CULVERT AND THE REQUIREMENT OF THE INSULATION LAYER IS TO BE DEFINED BY CULVERT LOCATION.
15. 100mm OF DRY SAND, TYPE 9 FILL-CRUSHER FINES/ LINER BEDDING OR A FILTER CLOTH PLACED ABOVE AND BELOW INSULATION LAYER FOR PROTECTION.
16. PREFABRICATED CONCRETE WINGWALLS WILL BE ALLOWED FOR. FLAG WILL BE PLANTED TO INDICATE BEGINNING/END OF PIPE.
17. DESIGN FOR 1:100 RETURN PERIOD.
18. MATERIAL TYPE DEFINITION:
    TYPE 12: RUN OF QUARRY/ ROCK FILL LAYER
    TYPE 19: RIP RAP LAYER
    TYPE 25: BALLAST LAYER
    TYPE 26: SUB-BALLAST LAYER

NOT FOR CONSTRUCTION

0	APPROVED FOR BID	SPA			2016/12/13	
No.	DESCRIPTION	BY	CHK'D		DATE	

REVISIONS

Reserved space for Issue Reason stamp applied by Document Control

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HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	S ATKINSON	NR	2016/12/09
DESIGNER		NR	
CHECKER	P MEISERS		2016/12/13
DESIGN COORD.			
RESP. ENG.			2016/12/13
LEAD DISC. ENG.			2016/12/13
ENG. MANAGER	J Cleland		2016/12/14
PROJ. MANAGER			
	M Weaver	MW	12/16/16

DRAWING APPROVAL STATUS: Approved for Bid

Baffinland

MARY RIVER EXPANSION STAGE 3
BAFFINLAND IRON ORE MINES

STANDARD DRAWING

TYPICAL CROSS SECTION- SINGLE BARREL PIPE CULVERT

SCALE	DWG. No.	REV
NTS OR AS NOTED	H353004-00000-220-294-0002-0001	0

SHEET SIZE: A1

$TIMES
$USERNAMES
$DATES
$FILES

DRAWING No.	DRAWING TITLE
REFERENCE DRAWINGS	

NAME
SIGNATURE
ENG REG NUMBER
REVISION DATE
ORIGINAL DATE
REG. PROFESSIONAL

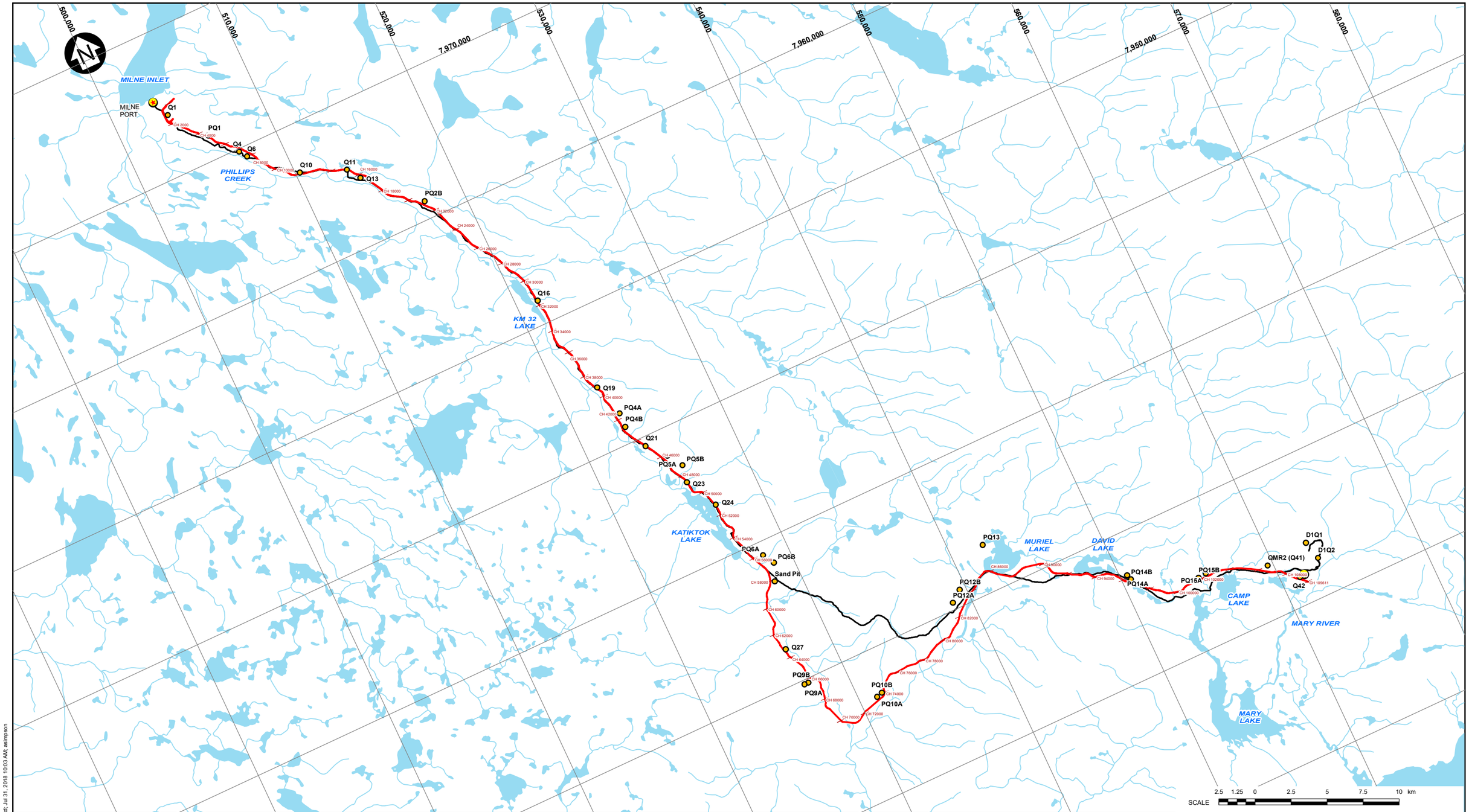
ATTACHMENT 9

QUARRY AND LAYDOWN LOCATION FIGURES

9.1 Proposed Quarry Locations
9.2 Proposed Laydown Area Locations

ATTACHMENT 9.1

PROPOSED QUARRY LOCATIONS



LEGEND

- PROJECT FACILITY LOCATION
- NORTH RAILWAY
- MILNE INLET TOTE ROAD
- QUARRY LOCATIONS
- NORTH RAILWAY CHAINAGE (m)
- WATER

NOTES:

1. COORDINATE GRID IS IN KILOMETRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP/IMAGERY: © ESRI AND DATA (ONLINE) SERVICE LAYERS (2017). REDLANDS, CA: ENVIRONMENTAL SYSTEM RESEARCH INSTITUTE. ALL RIGHTS RESERVED.
3. FIGURE CREATED BY KPL.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	31JUL'18	ISSUED WITH REPORT	AMH	AS	RAC

SAVED: I:\1\02\001181\45\A\GIS\Figs\B07_f0.mxd, Jul 31, 2018 10:03 AM, asimpson

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

PROPOSED QUARRY LOCATIONS

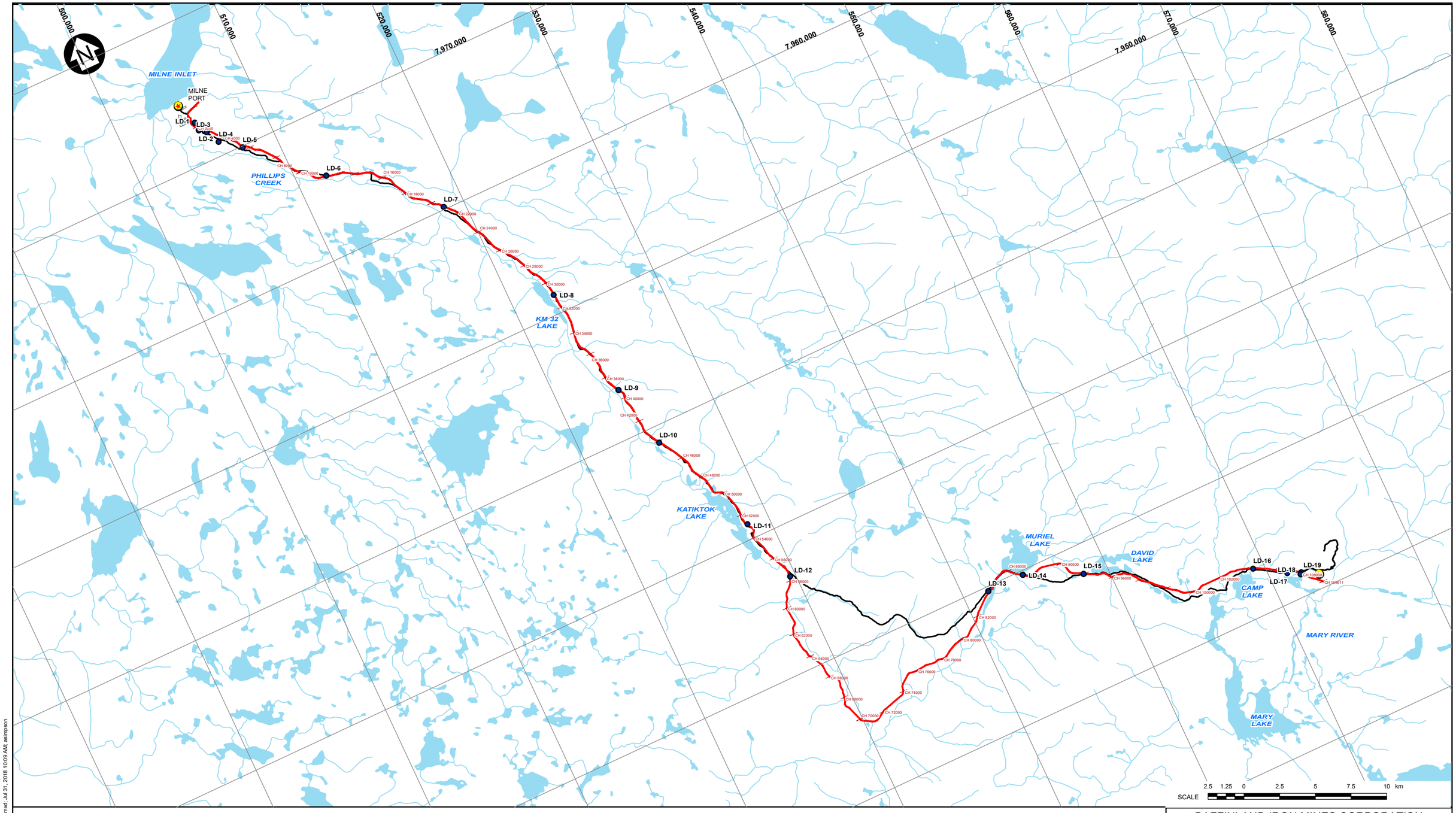
Baffinland

P/A NO.	REF NO.
NB102-181/45	2

FIGURE 9.1 REV A

ATTACHMENT 9.2

PROPOSED LAYDOWN AREA LOCATIONS



LEGEND

- PROJECT FACILITY LOCATION
- NORTH RAILWAY
- MILNE INLET TOTE ROAD
- LAYDOWN AREA
- NORTH RAILWAY CHAINAGE (m)
- WATER

NOTES:

1. COORDINATE GRID IS IN KILOMETRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP/IMAGERY: © ESRI AND DATA (ONLINE) SERVICE LAYERS (2017). REDLANDS, CA: ENVIRONMENTAL SYSTEM RESEARCH INSTITUTE. ALL RIGHTS RESERVED.
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BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

PROPOSED LAYDOWN AREA LOCATIONS

Baffinland

P/A NO.	REF NO.
NB102-181/45	2

FIGURE 9.2 REV 0

ATTACHMENT 10

WATER MANAGEMENT PLANS

10.1 Mine Site Water Management Plan
10.2 Milne Port Water Management Plan
10.3 Mine Site Crusher Pad Drawings

ATTACHMENT 10.1

MINE SITE WATER MANAGEMENT PLAN

Mine Surface Water Management Plan

					Stanger, Daniel	
11-09-2018	0	Issued for Use	F Hugo	A Grobbelaar	D Stanger	T Atiba
Date	Rev.	Status	Prepared By	Checked By	Approved By	Approved By
			HATCH			Client

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Appendix B Drawing H353004-10000-220-272-0008-0001 – Surface Water Management Plan – Mine Site

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1. Introduction

This document describes the various earthworks and infrastructure features that are planned to be constructed as part of the Expansion Project and how storm water is managed as a result of the new features. This document covers the design of all surface water infrastructure required to satisfy the approved Civil Design Philosophy for the Mary River Mine Site.

Storm water management and drainage systems were applied in various locations across the site to ensure that surface water runoff will have limited interference with infrastructure at the mine infrastructure site.

Care was taken to ensure that where possible, the existing watersheds and streams remained in their original state. This was done through the use of berms, ditches, swales and culverts.

For more detail refer to the Issued for Construction (IFC) drawings for the relevant areas. For a list of the related IFC drawings see Appendix A.

The overall layout for the Mine Site Storm Water Drainage Plan can be seen in Appendix B.

2. References

2.1 General

2.1.1 All applicable federal, territorial (Nunavut) and local laws and regulations apply, in particular the following apply:

- OHSA Occupational Health and Safety Act
- CSA Canadian Standards Association
- MHSA Mine Health and Safety Act (Nunavut – S.N.W.T. 1994)
- OHSR Occupational Health and Safety Regulations
- NBCC National Building Code of Canada (2010)
- ASTM American Society for Testing and Materials
- ASCE American Society of Civil Engineers
- NFPA National Fire Protection Association
- NRC Natural Resources Canada – Explosives Safety and Security Branch

2.2 Reference Documents

Reference is made to the contents of the following documents, articulated during the previous phases of the project and the current phase:

- H353004-00000-200-210-0001: Civil Design Philosophy
- H337697-0000-10-122-0001: Storm Water Management and Drainage System Design

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- H337697-6170-10-122-0001: Milne Port Drainage System and Storm Water Management Ponds
- H337697-6170-10-122-0002: Mine Site Drainage System, Storm Water and Sediment Management
- Standard Specification H353004-00000-260-200-0001: Quarried Fill Materials
- Standard Specification H353004-00000-200-078-0008: Site Conditions
- NB 102-181/30-7: Baseline Hydrology Report, Knight Piésold, Jan 04, 2012
- Updated Design Peak Flow Assessment. Knight Piésold, 2016
- Final Environmental Impact Statement (FEIS), Mary River Project, February 2012
- H353004-00000-228-066-0001: Mary River – Snowmelt and Rainfall Frequency Analysis.
- H353004-40000-200-210-0001: 2018 Water Management Report.

3. Overview

This document is divided into different areas of interest. The areas are grouped as follows:

- 800 Person Camp – Storm water management in and around the new 800-person camp
- Haul Road & Stormwater Diversion Berms 1 and 2 – These diversion berms divert water away from the crusher pad and haul road
- Mine Crusher Pad – Runoff from the crusher pad into swales and culverts draining towards the new Mine settling pond
- Mine Settling Pond – A new settling pond designed for runoff from the new crusher pad
- New Mine workshop pad and access road – Storm water management for the workshop pad and access road to the pad
- New Mine Fuel Tank Farm – Storm water management in and around the new fuel tank terrace and berms created for containment of spillage
- Mine Culvert 3A, 3B and 4 – These culverts are designed to manage storm water runoff from an existing stream underneath the new Tote Road diversion and proposed rail alignment and associated service road
- Kohler Gen Sets – Storm water management at the pad where new generator sets will be located
- Tote Road Diversion – Storm water management along the Tote Road Diversion and new airport access required as a result of the rail construction
- Rail Service & Access road – Stormwater management for the service road along the rail line providing access to the 800 person camp and the treated effluent discharge point

The layout of the various drainage areas described above is depicted in Figure 3-1 below.

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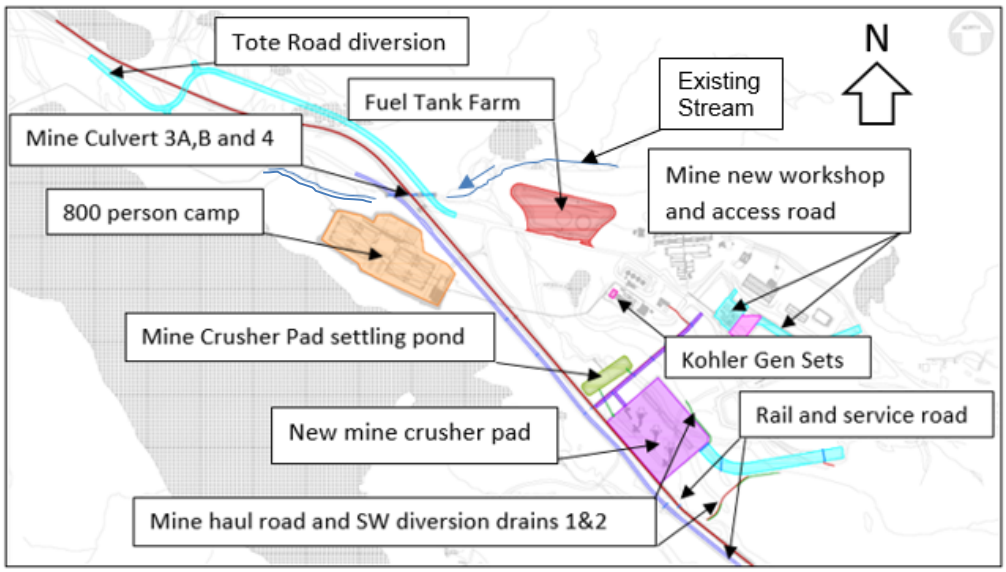

Figure 3-1: Mine Site Drainage Areas

4. 800-Person Camp Area Drainage

This section describes the drainage for the terrace created for the new 800 person camp.

The 800-person camp is constructed on top of a purpose-built pad. This camp pad includes a parking area for vehicles & personnel transport as well as a raised platform for delivery of food and other consumables to the kitchen area.

The camp pad is designed with a gradient to direct storm water from the perimeter areas of the pad to the sides of the pad. On top of the camp pad, additional level pads were constructed for the accommodation, kitchen and other facilities (wastewater treatment plant, waste disposal and electrical plant, etc.).

Storm water runoff from the level pads underlying these units (8 accommodation wings and common core with kitchen/dining area) is nominal and any run off is managed through troughs on the pad. Note that The accommodation wings are raised above the pad level and no water can enter the buildings.

Storm water runoff from the larger underlying camp pad is through overland sheet flow off the pad. No storm water is concentrated through swales, culverts or canals.

Figure 4-1 shows the 800-person camp site drainage.

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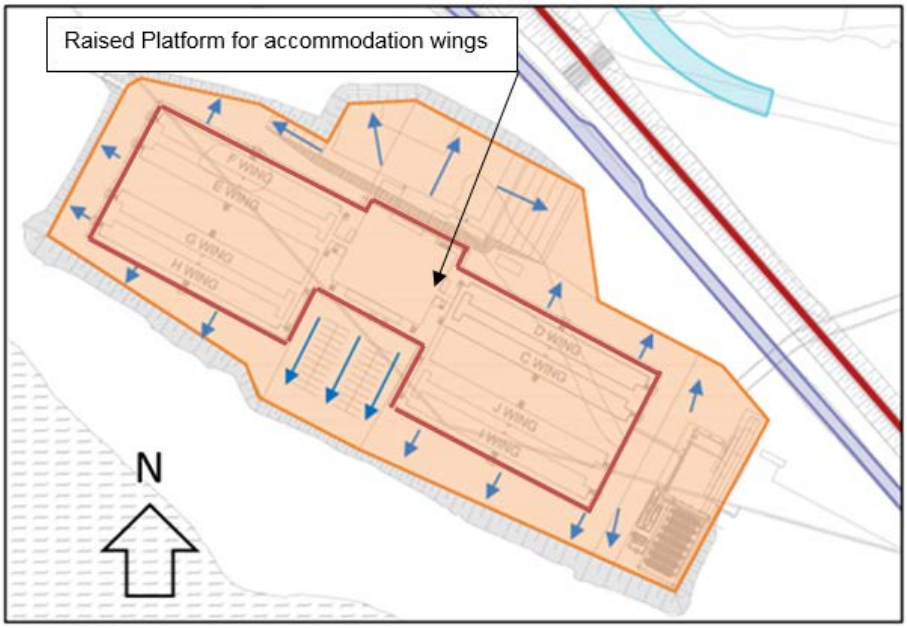

Figure 4-1: 800 Person Camp Site Drainage

5. Haul Road and Storm Water Diversion Berms 1 and 2

A new haul road is to be constructed to access the new crusher pad and on-loading platform for the rail wagons.

The haul road and storm water diversion berms 1 & 2 are indicated on Figure 5-1.

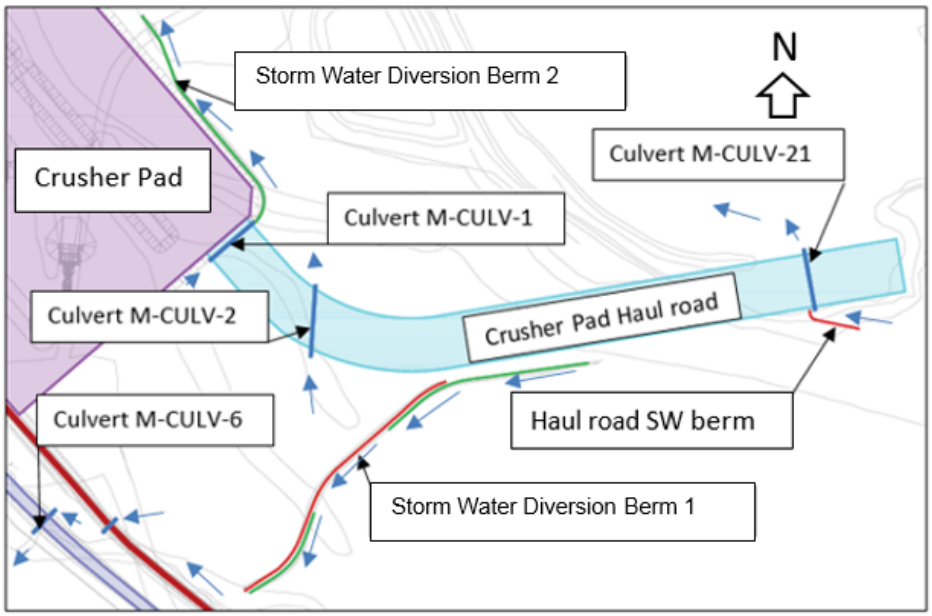

Figure 5-1: Mine Crusher Pad Haul Road And Diversion Berms 1 & 2

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The haul road is graded in one direction ensuring sheet flow runoff from the road towards the downstream slope of the surrounding ground level. Openings in the safety berms adjacent to the road allows water to escape to the natural environment.

Two storm water diversions (SWD 1 & 2) and a haul road storm water berm are designed to divert storm water away from the crusher and on loading platform and direct it to natural drainage ditches / culverts in the vicinity (M-CULV-1, 2 and 21).

Storm Water Diversion 1 (SWD-1) – The diversion is located to the south of the haul road. Storm water accumulates against the toe of the haul road fill and runs towards the crusher pad. At a point close to the pad, a diversion ditch is created, directing the flow to the south to a low point where it joins a natural stream. This stream eventually crosses the rail and adjacent service road through a 1 200 mm diameter CSP culvert (M-CULV-6) where it subsequently drains into the surrounding environment. This SWD-1 diversion has the following dimensions:

- Minimum vertical depth of 800mm
- Side slopes at 1V:2H
- Bottom Width - 0.5m
- Flow (1:100) - 1.52 m^3/s
- Velocity - 1.35 m/s

Rip rap will be provided for the first section of the diversion since the hydraulic analysis showed that the velocity will be greater than 1.5 m/s when no rip rap is present.

Storm Water Diversion 2 (SWD-2) – This diversion caters for storm water accumulating at the low point where the haul roads enters the crusher pad. The accumulated water from a small catchment to the south of the haul road is conveyed underneath the haul road through a 600mm diameter CSP culvert (M-CULV-1). From the exit of the culvert the storm water is conveyed in a ditch and directed to an existing stream adjacent to the crusher pad.

The diversion has the following dimensions and detail:

- Side slopes at 1V:2H
- Bottom Width - 0.5m
- Flow (1:100) - 0.67 m^3/s
- Velocity - 1.08 m/s
- No rip rap will be required for this diversion.

6. Mine Crusher Pad Drainage

The crusher pad drainage area is depicted is Figure 6-1 below.

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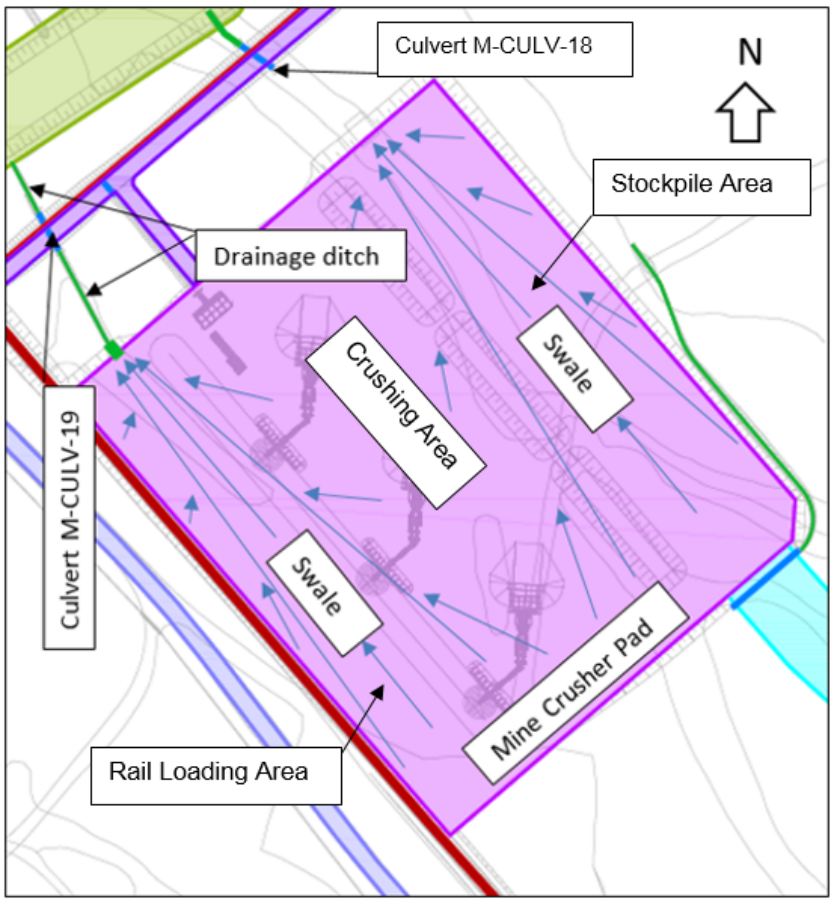

Figure 6-1: Mine Crusher Pad Drainage Area

The crusher pad consist of three distinct areas:

- Stockpiling area
- Crushing area
- Rail wagon on-loading area.

The crusher pad is elevated from the surrounding natural ground to prevent any storm water discharging onto the pad, either through sheet flow or concentrated flow. The runoff from the pad may be impacted by high levels of total suspended solids and therefore needs to be contained and tested before release.

Storm water runoff is directed towards a settling pond (See section 7) in two separate swales on top of the pad. The pad is graded to form the swales.

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The swale on the north side of the pad discharges to the natural environment and ends up at a low point where it continues flowing to the settling pond via a culvert (M-CULV-18) and eventually into the setting pond via a channel (Eastern). At the discharge point from the pad, erosion protection is provided on the pad embankment in the form of rip-rap. The drainage channel (Eastern) has the following properties:

- Bottom Width - 0.1m
- Side Slopes - 1V:1.5H
- Flow - 0.10 m^3/s
- Velocity - 0.78 m/s

The pad swale to the south discharges in a similar manner as the one to the north except that it continues flow in a drainage ditch and then passes underneath the utility berm and road through a 600mm diameter CSP culvert (M-CULV- 19) before finally discharging into the settling pond. The drainage channel (Western) was designed with the following properties:

- Bottom Width - 0.1m
- Side Slopes - 1V:1.5H
- Flow - 0.10 m^3/s
- Velocity - 0.57 m/s

7. Mine Crusher Pad Settling Pond

An overall layout of the settling pond area can be seen in Figure 7-1 below.

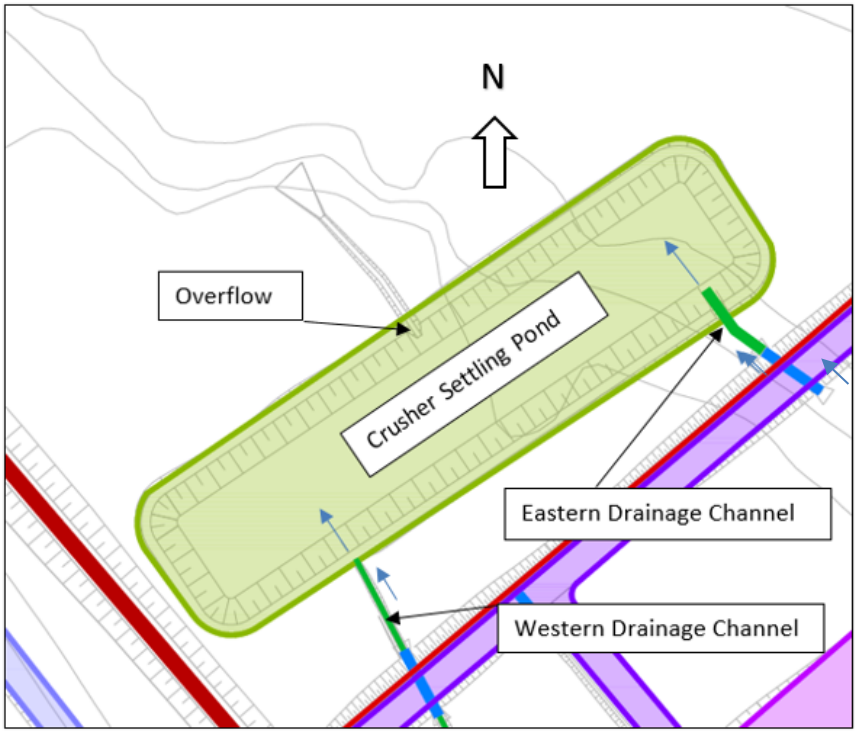

Figure 7-1: Crusher Pad Settling Pond

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The inflow to the pond is from the Mine Crusher Pad Eastern and Western drainage channels which capture the runoff from the pad. The pond has an emergency overflow that flows into the natural environment and is designed in accordance with the Civil Design Philosophy. At the bottom of the overflow, rip rap is provided to dissipate the energy and prevent erosion.

The following values were applied in sizing the pond:

- Catchment area - 47 435 m2
- Runoff Coefficient - 0.9
- Rainfall (1:10 year 24 hour) - 40.8 mm

Based on these parameters it was determined that the required pond capacity is 1 742 m^3.

The overflow is designed to safely discharge the 1:200 year return period rainfall event. The result of the design and analysis are as follows:

- Bottom Width - 0.5 m
- Depth - 0.3 m
- Flow - 0.20 m3/s

8. New Mine Workshop Pad and Access Road

8.1 Truck Workshop Terrace

The truck workshop terrace layout is indicated below in Figure 8-1.

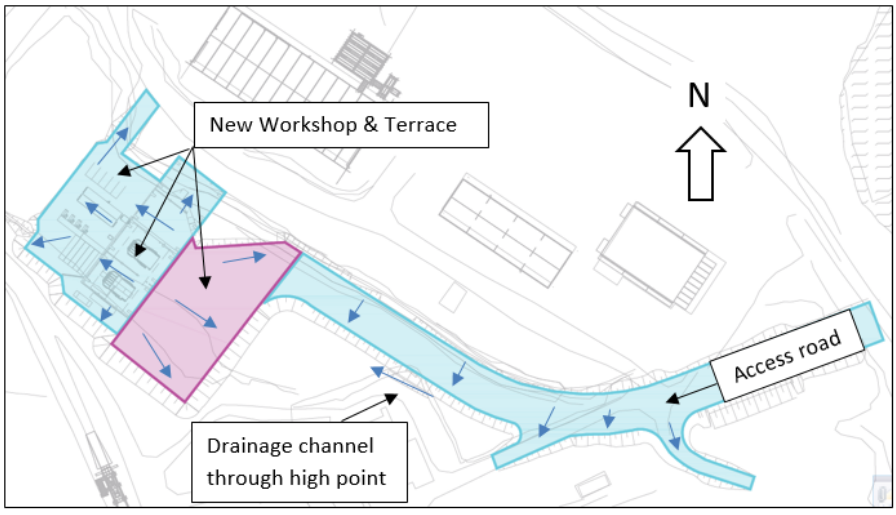

Figure 8-1: Mine New Workshop and Access Road Drainage

The new workshop terrace is graded to slope towards the outside of the terrace away from the footprint of the workshop building. The workshop footprint area is level to accommodate the floor and general structure. The parking area to the northwest is also

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graded from the centre of the terrace toward the outside to accommodate overland flow. Once storm water flows off the terrace, it follows the natural drainage path.

8.2 Workshop Access Road Drainage

The access road to the new workshops is singularly graded to one side to allow natural drainage off the road surface. Safety berms on the access road have openings every 25m to allow for storm water to exit the access road surface.

A high point at the toe end of the fill to the access road has been cut to allow flow to continue past this high point. This side drain has a bottom width of 0.6m and side slopes of 1V:2H.

9. Mine New Fuel Tank Farm

Figure 9-1 indicates the Mine new fuel tank farm drainage.

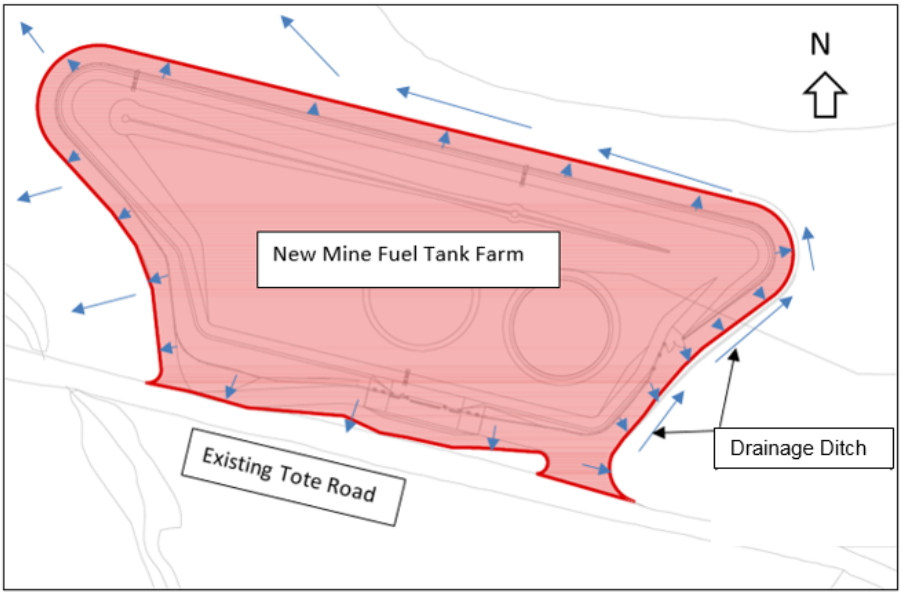

Figure 9-1: New Fuel Tank Farm Drainage

The tank farm consists of perimeter dykes and berms to ensure containment of any possible spillage. The containment dyke creates capacity for fuel spill storage of the largest tank volume plus 10% of the remaining tank/s volume. The design is in accordance with all relevant legislation and regulations governing the tank farm construction and design.

All precipitation collected inside the fuel tank farm is contained and tested before being discharged. If required, the water is treated to remove contaminants and then discharged. The road around the perimeter of the tank farm provides access for maintenance and emergency vehicles. Storm water drains to the outside of the road, off the terrace and into the natural environment.

On the south eastern side, a localised ditch is created to divert local rainfall towards the north (falling onto the access & service roads). This ditch is graded to convey the water to the north and into the existing natural drainage ditch.

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10. Mine Culvert 3A, 3B and 4

The culvert M-CULV3-A, 3-B and 4 is to be constructed in phases. Culverts 3-A and -4 are to be constructed first as part of the Tote Road diversion (M-CULV-4) and the new airport access road and 800 personnel camp (M-CULV3-A). Culvert 3B will be constructed later, during construction of the rail embankment.

The culvert layout is depicted in Figure 10-1.

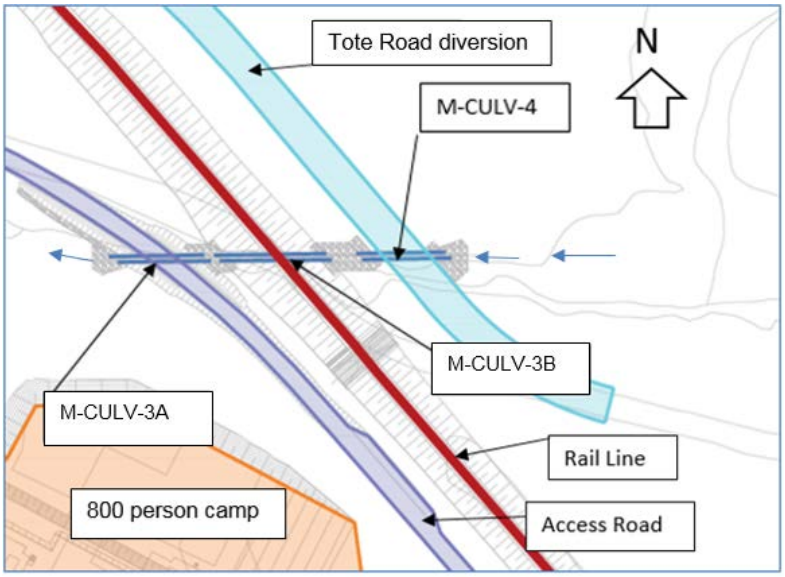

Figure 10-1: Mine Culvert 3A, 3B and 4

Each culvert has an inlet and outlet with rip rap to protect the embankment and its surrounds against scouring.

The culverts consists of 2 x 1.5 m diameter CSP barrels. Details of these culverts are shown on drawing No. H353004-10000-228-272-0004-0001.

The hydraulic calculations indicated the following:

- The upstream catchment area of the culvert is 3.7 ha
- Based on the 1:100 year return period flood, the computed headwater elevation at the culvert inlet is 180.139 m. This elevation is lower than the top of the tote road and the rail line, with an allowance of 300 mm freeboard.
- Calculated maximum velocity is equal to 1.83 m/s and as a result, rip rap will be placed at the inlet and outlet of the culverts to protect against erosion.

11. Kohler Gen Sets

Additional electrical generation sets are required for the mine expansion program. These Gen Sets are located on a existing terrace that will be expanded. The terrace is graded to allow sheet flow off the terrace where it then flows into the natural environment, , as shown on Figure 11-1.

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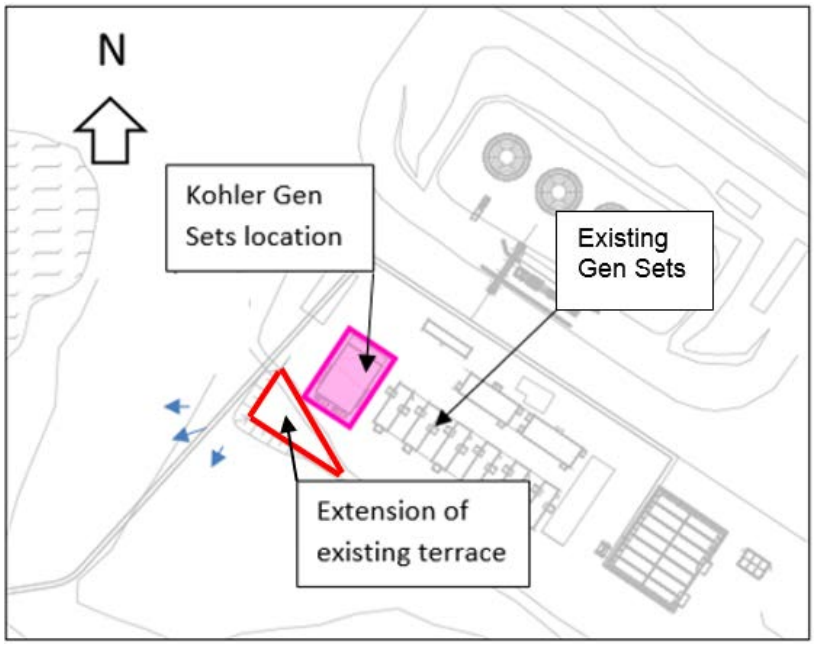

Figure 11-1: Kohler Gen Set Drainage

12. Tote Road Diversion

Drainage of the Tote Road diversion is based on surface runoff from the graded road. The drainage is from either side of the centre line to the sides of the road, and then onto the natural environment.

See Figure 12-1 below for the layout of the Tote Road diversion.

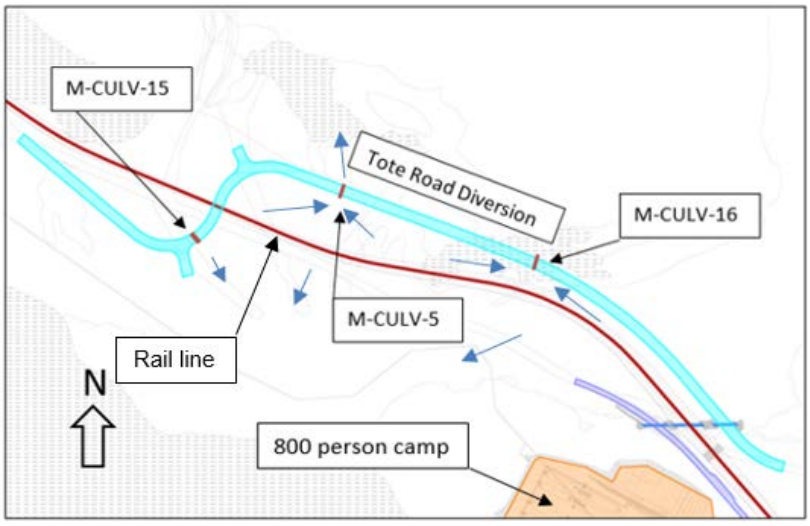

Figure 12-1: Tote Road Diversion Drainage

Apart from culverts M-CULV-3A, 3B & 4 described in Section 10, three additional culverts provide drainage at low points along the Tote Road diversion. These culverts are:

- M-CULV-5 - 1 x 600mm diameter CSP barrel

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- M-CULV-15 - 1 x 600mm diameter CSP barrel
- M-CULV-16 - 1 x 600mm diameter CSP barrel.

None of the flow velocities through these culverts exceeds 1.5m/s and thus no erosion protection is required.

13. Rail Service and Access Road

The rail service and access road to the 800 personnel camp also serves as access to the treated effluent discharge point. The discharge point is located at the southern terminus of the road. This road follows the alignment of the rail embankment in a southeasterly direction. Storm water runoff from the catchment area between the rail line and the access road is directed to culverts at low points along the road. The location of these culverts are shown on Figure 13-1 and Figure 13-2.The design details for these culverts are:

- M-CULV-7 - 1 x 600mm diameter CSP barrel - no erosion protection required
- M-CULV-8 - 1 x 600mm diameter CSP barrel - no erosion protection required
- M-CULV-10 - 1 x 600mm diameter CSP barrel- no erosion protection required
- M-CULV-11 - 1 x 600mm diameter CSP barrel- no erosion protection required
- M-CULV-12 - 1 x 600mm diameter CSP barrel- requires erosion protection
- M-CULV-13 - 1 x 600mm diameter CSP barrel- requires erosion protection.

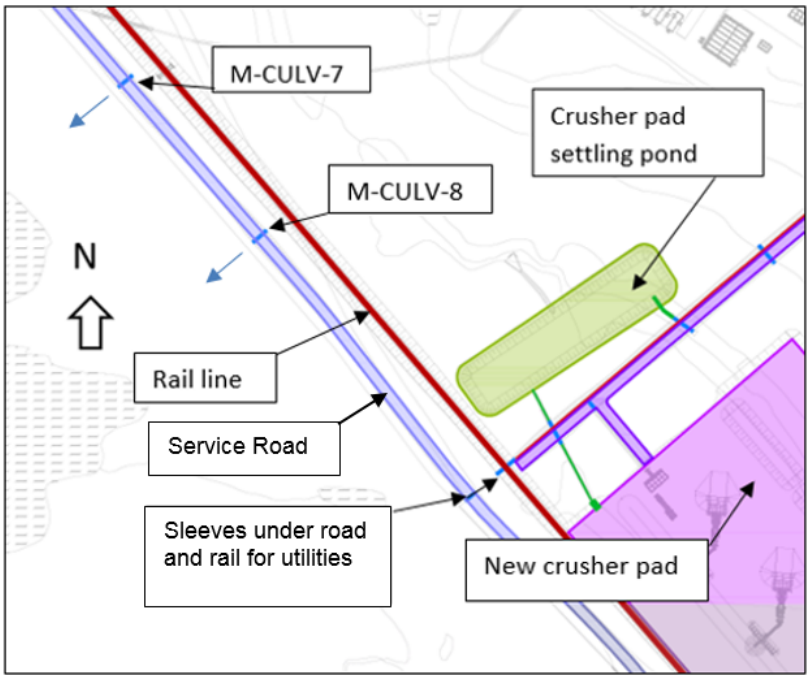

Figure 13-1: Rail Service & Access Road - Cross Drainage Culverts

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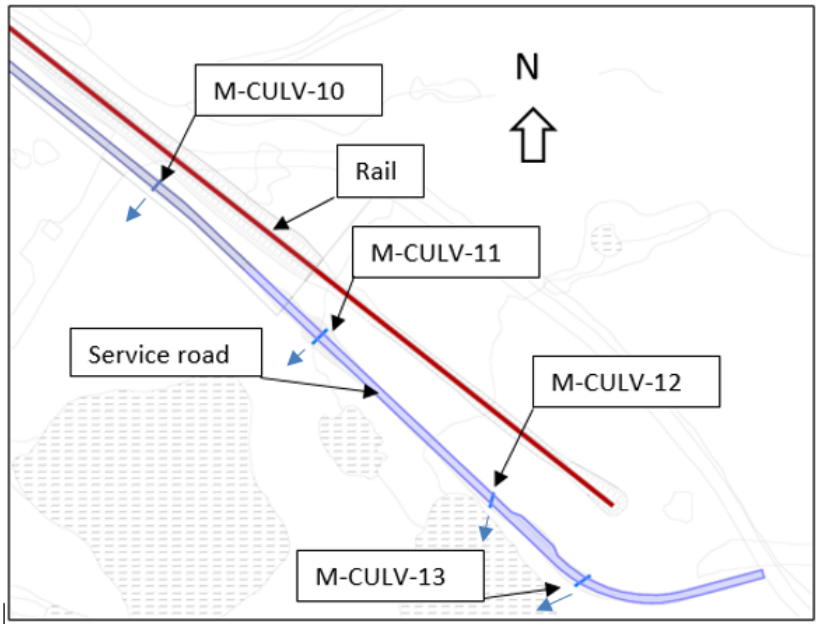

Figure 13-2: Rail Service & Access Road – Cross Drainage Culverts

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Appendix A
IFC Drainage Drawing List

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Drainage Drawings	
H353004-10000-228-272-0001-0001	Mine Site - 800 Person Camp Pad - Drainage Plan
H353004-10000-228-272-0005-0001	Mary River Expansion Project - Mine Site - Crusher Pad - Drainage Plan
H353004-10000-228-273-0001-0001	Mary River Expansion Project - Mine Site - Rail Loadout Terrace- Polluted Water Dam - Cross Section & Details
H353004-10000-228-272-0006-0001	Mary River Expansion Project - Mine Site - Rail Loadout Terrace- Polluted Water Dam - Layout Drawing
H353004-10000-228-272-0004-0001	Mine Site - Service Road Culvert Detail
H353004-10000-221-273-0001-0001	Mine Site – Mine Truck Workshop pad – Earthworks cross sections
H353004-10000-221-271-0009-0001	Mine Site – Mine Truck Workshop pad – Access Road plan & profile

Other	
H353004-00000-200-210-0001	Civil Design Philosophy
H353004-10000-220-272-0008-0001	Mary River Project - Mine Site - 2018 Surface Water - Management Plan

Typical	
H353004-00000-221-294-0001-0001	Site Wide - Standard Drawing - Typical Culvert Details
H353004-00000-221-294-0002-0001	Site Wide - Standard Drawing - Earthworks & Drainage Details
H353004-00000-221-294-0003-0001	Site Wide - Standard Drawing - Earthworks & Drainage Details
H353004-00000-221-294-0004-0001	Site Wide - Standard Drawing - Earthworks & Drainage Details
H353004-00000-221-294-0005-0001	Site Wide - Standard Drawing - Earthworks & Drainage Details
H353004-00000-221-294-0006-0001	Site Wide - Standard Drawing - Earthworks & Drainage Details
H353004-00000-221-294-0007-0001	Site Wide - Standard Drawing - Road Signage Placement Details
H353004-00000-221-294-0008-0001	Site Wide - Standard Drawing - Typical Pad, Ditch & Berm Sections
H353004-00000-221-294-0009-0001	Site Wide - Standard Drawing - Typical Internal Road Sections
H353004-00000-221-294-0010-0001	Site Wide - Standard Drawing - Typical Internal Road Sections

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Appendix B
Drawing H353004-10000-220-272-0008-0001 – Surface Water Management Plan – Mine Site

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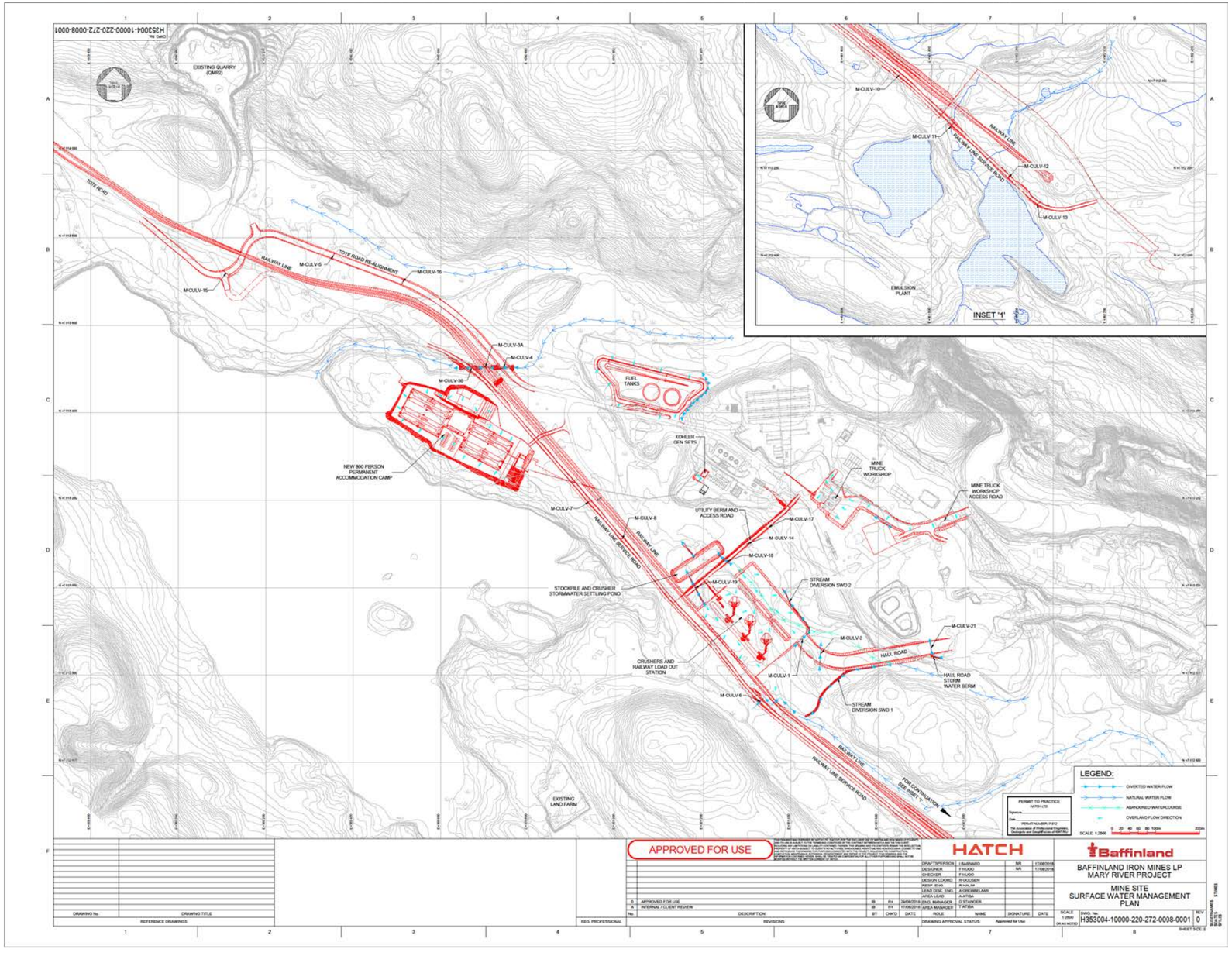

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ATTACHMENT 10.2

MILNE PORT WATER MANAGEMENT PLAN

Mary River Expansion Project

Port Surface Water Management Plan

			p.p.		Stanger, Daniel Digitally signed by Stanger, Daniel DN: cn=Stanger, Daniel Date: 2018.09.17 15:03:01 -04'00'	
2018-09-13	0	Approved for Use	A Grobbelaar	R Goosen	D Stanger	T Atiba
Date	**Rev.**		**Prepared By**	**Checked By**	**Approved By**	**Approved By Client**

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1. Introduction

This document describes the various earthworks and infrastructure features that are planned to be constructed as part of the Expansion Project and how storm water is managed as a result of the new features. This document covers the design of all surface water infrastructure required to satisfy the approved Civil Design Philosophy for the Milne Port.

Storm water management and drainage systems were applied in various locations across the site to ensure that surface water runoff will have limited interference with infrastructure at the port.

Care was taken to ensure that where possible, the existing watersheds and streams remained in their original state. This was done through the use of berms, ditches, swales and culverts.

For more detail refer to the Issued for Construction (IFC) drawings for the relevant areas. For a list of the related IFC drawings see Appendix A.

The overall layout for the Port storm water Drainage Plan can be seen in Appendix B.

2. References

2.1 General

2.1.1 All applicable federal, territorial (Nunavut) and local laws and regulations apply, in particular, the following are applicable:

- OHSA Occupational Health and Safety Act
- CSA Canadian Standards Association
- MHSA Mine Health and Safety Act (Nunavut – S.N.W.T. 1994)
- OHSR Occupational Health and Safety Regulations
- NBCC National Building Code of Canada (2010)
- ASTM American Society for Testing and Materials
- ASCE American Society of Civil Engineers
- NFPA National Fire Protection Association
- NRC Natural Resources Canada – Explosives Safety and Security Branch

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2.2 Reference Documents

Reference is made to the contents of the following documents, articulated during the previous phases of the project and the current phase:

- H353004-00000-200-210-0001: Civil Design Philosophy
- H337697-0000-10-122-0001: Storm Water Management and Drainage System Design
- H337697-6170-10-122-0001: Milne Port Drainage System and Storm Water Management Ponds
- H337697-6170-10-122-0002: Mine Site Drainage System, Storm Water and Sediment Management
- Standard Specification H353004-00000-260-200-0001: Quarried Fill Materials
- Standard Specification H353004-00000-200-078-0008: Site Conditions
- NB 102-181/30-7: Baseline Hydrology Report, Knight Piesold, Jan 04, 2012
- Updated Design Peak Flow Assessment. Knight Piesold, 2016
- Final Environmental Impact Statement (FEIS), Mary River Project, February 2012
- H353004-00000-228-066-0001: Mary River – Snowmelt and Rainfall Frequency Analysis.
- H353004-40000-200-210-0001: 2018 Water Management Report.

3. Overview

This document is divided into different areas of interest. The areas are grouped as follows:

- Rail Dumper drainage area that consists of the rail yard, dumper and storm water diversions berms / canals / ditches in the area.
- Ore Processing drainage area which will include the feed stockpile pad as well as the crushing and screening pad. This area will also include for laydowns that are constructed next to the areas and storm water diversions required as a result.
- Stockpile No.1 drainage area that will include the extension of the existing Stockpile and the upgrade/modifications to the existing settling pond No.1 as well as No.2 and associated storm water infrastructure.
- Stockpile No.2 drainage area that will include the stockpiles, stacker reclaimer berm, maintenance area, eastern berm and the western berm.
- Roads drainage areas will be grouped together. These include various access roads, existing road modifications and larger bypasses.

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- Balance of Work drainage areas. All other areas not covered in the above mentioned shall be referred to as the balance of work and will include a number of laydown areas, accommodation camp pad and some storm water diversions.

The layout of the various drainage areas above is depicted in Figure 3-1 below.

General principles applied to the drainage management plan are as follows:

- All hydraulics designs where done using software from Bentley “Flow Master” or “HEC-Ras” by the USA Army Engineering Core.
- Where velocities in channels or ditches are above 1.5m/s, erosion protection is provided through placement of rip rap (Stone pitching).
- Erosion protection is provided at all concentrated discharge points i.e., culvert / channel / ditches exits into the environment. The protection is in the form of rip rap.
- Culverts are Corrugated Steel Pipes (CSP) unless otherwise stated.

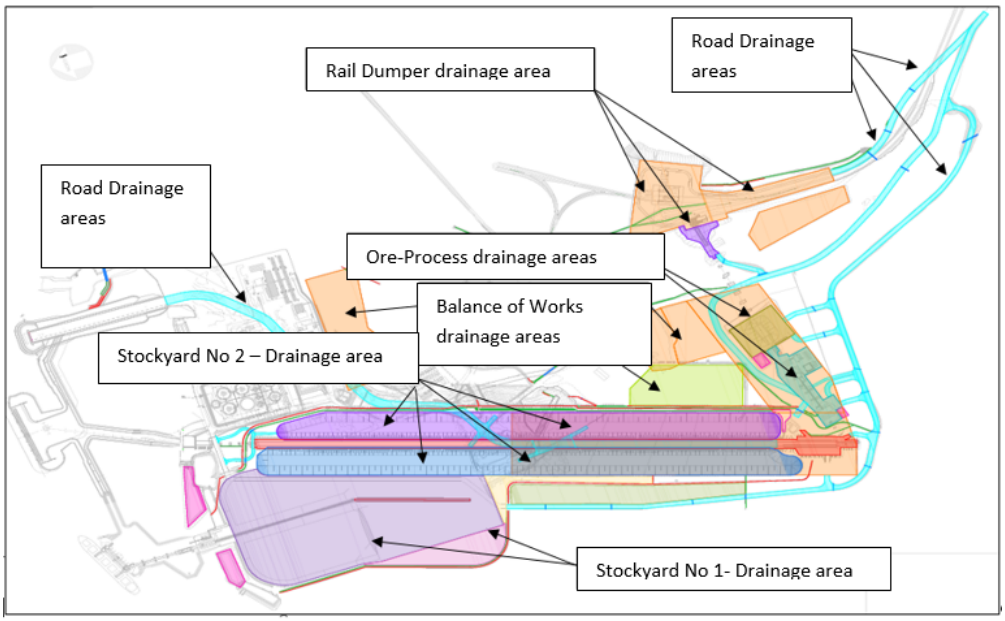

Figure 3-1: Port Drainage Areas

4. Rail Dumper Area Drainage

This section describes the drainage for the Rail Yard, Dumper and cut-off drains P-SWD-5 and P-SWD-6.

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4.1 Rail Yard

The rail yard is to be constructed close to where the existing quarry (Q1) is located. Due to the grading requirements for the railway, the majority of the rail yard terrace is flat. Where possible, the terrace is graded away from the facilities to facilitate natural overland drainage. It is then collected in a cut-off ditch and diverted towards storm water diversion P-SWD-5.

Figure 4-1 shows the rail yard drainage.

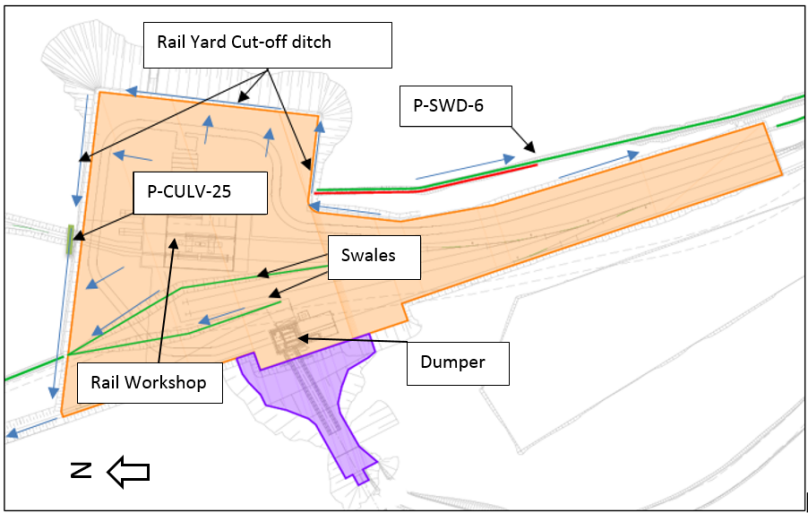

Figure 4-1: Rail Yard Drainage Plan

The rail yard terrace cut-off ditch was designed and analysed with the following results:

- Bottom Width - 1m
- Side Slopes - 1V:1.5H
- Flow - 1.621 m^3/s
- Velocity - 1.43 m/s (no rip rap required).

The rail yard cut-off ditch crosses the future railway formation with a 1200mm diameter culvert (see P-CULV-25 in Figure 4.1) with widenings and rip rap upstream and downstream. This will be constructed when the railway line is constructed.

As shown in Figure 4-1, the rail yard has two swales in between the rails to facilitate drainage in the area. The swales discharge towards the north and into P-SWD-5.

Where storm water flow velocities are modelled above 1.5m/s, adequate rip rap protection against erosion is provided as per drawing titled “Site Wide – Standard Drawing – Earthworks & Drainage Details” No. H353004-00000-221-294-0006-0001.

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Two nominal 600mm diameter culverts are designed beneath the southern end of the rail yard to drain water that accumulates between the rail terrace and P-SWD-6.

4.2 Rail Car Dumper

The drainage for the rail car dumper is shown by the flow direction arrows in Figure 4-2.

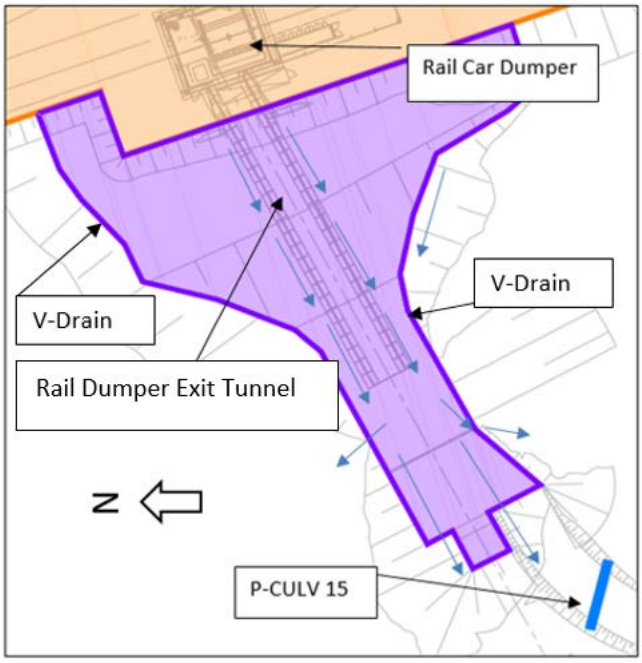

Figure 4-2: Rail Car Dumper Drainage Plan

The design ensures that water drains away from the dumper and the dumper exit tunnel. General drainage is based on overland flow with the various dumper areas graded to facilitate this. Vee-Drains are provided at the interface between the excavation/backfill slope interface.

Due to the steep slopes of the backfill, there are high flow velocities expected and rip rap is placed where water concentrates. This is to protect against scouring.

The results of the analysis are as follows:

- V-Drain with side slopes of 1V:3.52H and 1V:3.13H for the left and right sides of the dumper tunnel backfill.
- Flow - 0.008 m^3/s
- Velocity - 1.05 m/s

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4.3 P-SWD-6

Storm water diversion No.6 will initially extend inside the rail yard area. When the rail yard is constructed the portion of the diversion overlapping the rail yard will be demolished. The diversion collects runoff from the rail yard but will primarily serve as a cut-off for water flowing from the catchment area to the east and diverting it towards the south. Figure 4-3 shows the diversion.

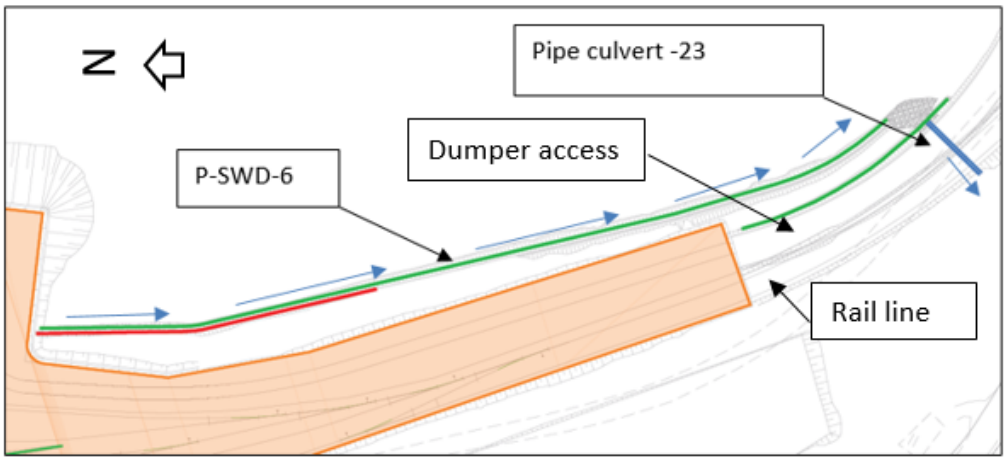

Figure 4-3: P-SWD-6

The ditch will daylight at the downstream end where it passes through P-CULV-23, underneath the Rail Yard Access Road. This road and its drainage is described in Section 8.1.

The diversion was modelled and analysed as a combination of berm and channel taking into account the surrounding existing ground. The results were as follows:

- Berm Height Required = 1 m
- Channel bottom width = 0.5 m
- Maximum Velocity = 1.28 m/s

Based on the results rip rap will only be provided at the discharge point.

4.4 P-SWD-5

Storm water diversion No.5 is planned for construction in 2018 and will extend inside the Rail Yard area. When the rail yard is constructed the portion of the diversion overlapping the rail yard will be demolished. The diversion will collect runoff from the rail yard but will primarily serve as a cut-off for water flowing from the catchment area to the east and diverting it towards the north. Figure 4-4 shows the diversion.

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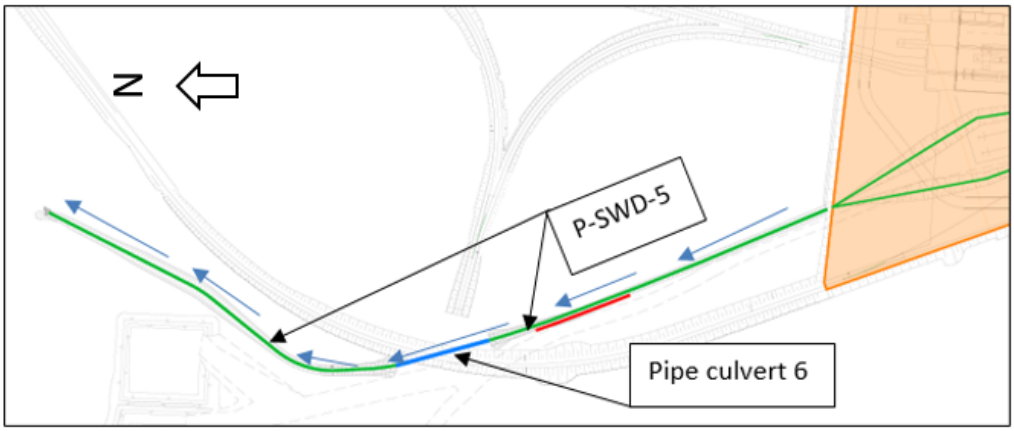

Figure 4-4: P-SWD-5

When the railway line is constructed it will require construction of a new culvert (P-CULV-6) to allow water to pass underneath the railway formation. The culvert is designed as a 1200mm diameter CSP with rip rap placed on the upstream and downstream side. The channel will also be widened at the culvert to allow space for the placing of pipes.

The diversion was modelled and analysed as a combination of berm and channel taking into account the surrounding existing ground. The results are as follows:

- Berm Height Required = 1 m
- Channel bottom width = 0.5 m
- Maximum Velocity = 1.40 m/s

Based on the results no rip rap, will be required in the channel except at the culvert as mentioned above and at the discharge point.

5. Ore Processing Area Drainage

5.1 Crushing Feed Stockpile

The crushing feed stockpile will be used to store ore before it is crushed and screened. In accordance with the civil design philosophy, runoff from this area needs to be contained in a settling pond and discharged once the water quality criteria has been met. The pad and pond is indicated in Figure 5-1.

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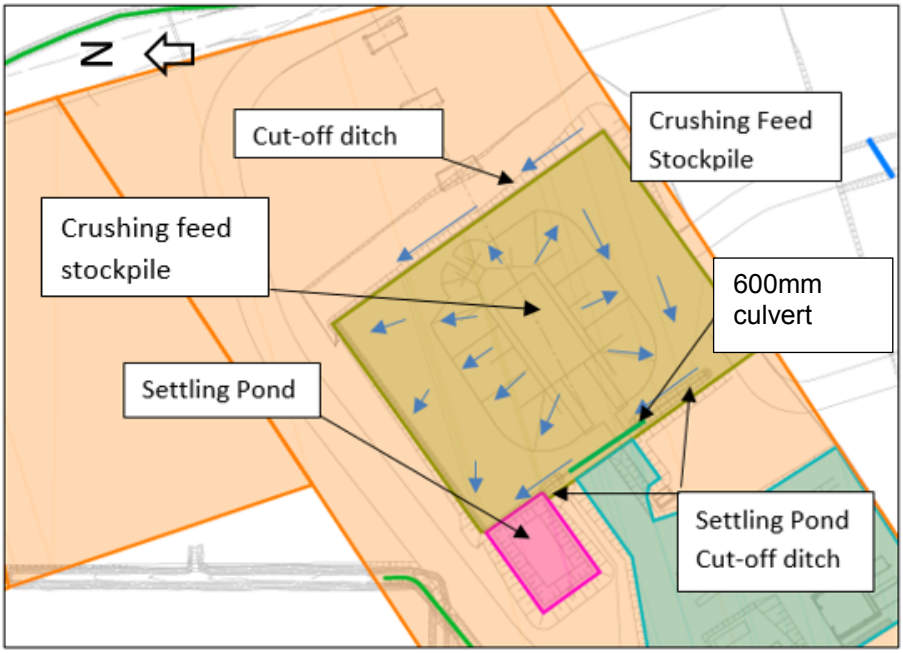

Figure 5-1: Crushing Feed Stockpile Pad Drainage Plan

5.1.1 Crushing Feed Stockpile Pad

The pad mainly drains through overland sheet flow and into a ditch on the western side and down a berm on the northern side. The ditch has one culvert crossing to allow access to the pad from the crushing and screening pad. The details of the ditch are as follows:

- Bottom Width - 0.5m
- Side Slopes - 1V:1.5H
- Flow (1:200) - 0.064 m^3/s
- Velocity - 0.95 m/s

The culvert is constructed as a 600mm diameter CSP.

On the eastern side of the pad a cut-off ditch is constructed to separate clean water from potential sediment impacted runoff on the pad. The ditch will flow in 2 directions (to the north and to the west) around the pad and daylight onto laydown LP5 and LP6 respectively. The channel was designed and analysed with the following results:

- Bottom Width - 0.5m
- Side Slopes - 1V:1.5H
- Flow - 0.035 m^3/s
- Velocity - 0.52 m/s

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5.1.2 Crushing Feed Stockpile Settling Pond

The main inflow to the pond is from the settling pond drainage ditch. The pond has an emergency overflow that flows onto laydown LP5 and is designed in accordance with the Civil design philosophy.

The following values were applied in sizing the pond:

- Catchment area - 14 389 m²
- Runoff Coefficient - 0.9
- Rainfall (1:10 year 24 hour) - 40.8mm

With the above it was determined that the required pond capacity is 528 m^3.

The spillway is designed to safely discharge the 1:200 year return period rainfall event. The result of the design and analysis are as follows:

- Bottom Width - 0.5m
- Depth - 0.15m
- Flow - 0.064 m^3/s

5.2 Crushing and Screening Pad

Storm water runoff as a result of precipitation on the crushing and screening pad is dealt with as sheet flow. This flow is depicted in Figure 5-2.

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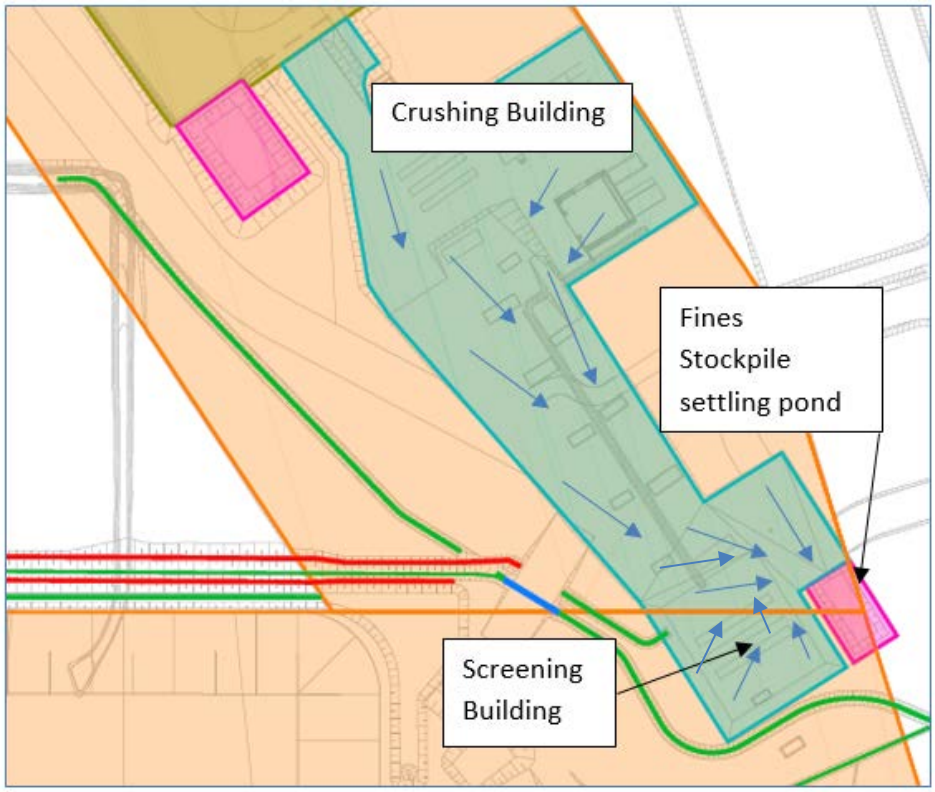

Figure 5-2: Crushing and Screening Pad Drainage Plan

Where utility berms are constructed, nominal 600mm diameter culverts are installed to ensure no ponding of water and promote free flow through the area.

The fines stockpile is situated next to the screening building. Runoff from the fines stockpile must be captured in a settling pond. The pond calculation results are as follows:

- Catchment area - 1 577 m^2
- Runoff Coefficient - 0.9
- Rainfall (1:10 year 24 hour) - 40.8mm

With the above it is determined that the required pond capacity must be 58 m^3.

The spillway is designed to safely discharge the 1:200 year return period rainfall. The result of the design and analysis are as follows:

- Bottom Width - 0.5m
- Depth - 0.15m
- Flow - 0.007 m^3/s

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6. Stockpile No.1 Drainage

Stockpile No.1 is to be extended to allow for fines product stockpiling. (Stockpile No.2 will occupy a portion of the footprint area of the existing Stockpile No.1). Due to the need to maintain the area for the stockpile No.1 while Stockpile No.2 is developed, the Stockpile No.1 extension area is required.

The drainage of the new Stockpile No.1 extension area (Measuring 26 300m^2) is linked to the existing Stockpile No.1 drainage area, conveying storm water to settlement pond No.1/1A. The stockpile area is graded through nominal fill and cut to facilitate this drainage. The overland flow is then intercepted by storm water drain P-SWD-4 (berm) which, at the downstream end, links up with the existing drainage system. Figure 6-1 shows the layout.

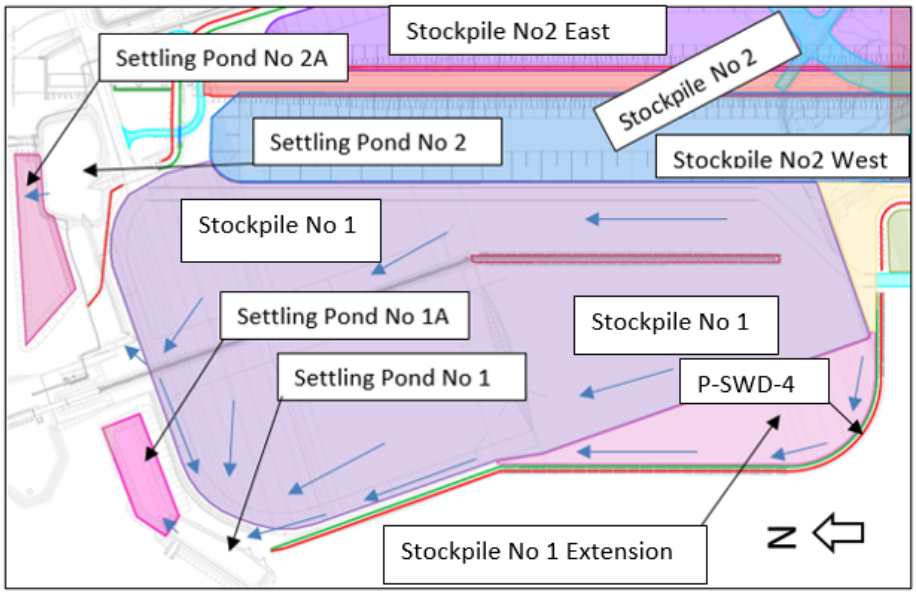

Figure 6-1: Stockpile No.1 Extension with Settling Pond No.1 and No.1A

The catchment area for Settling Pond No.1 will increase due to the following reasons:

- Stockpile No.1 extension (see Section 6) increases the catchment area
- South Western part of Stockpile No.2 drains towards this pond.

Due to the increase in catchment area, the existing pond is calculated to be under capacity for the new development. A second compartment is designed to linked with Settling Pond No.1 which will be referred to as Settling Pond No.1A.

This ensures that there is enough storage capacity as per the requirement specified in the civil design philosophy.

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The two compartments are interlinked with a spillway. The existing emergency spillway of Pond No.1 is retained. The existing spillway is adequate in terms of the design philosophy requirements.

Figure 6-2 shows both the existing Pond No.1 and the additional 1A compartment.

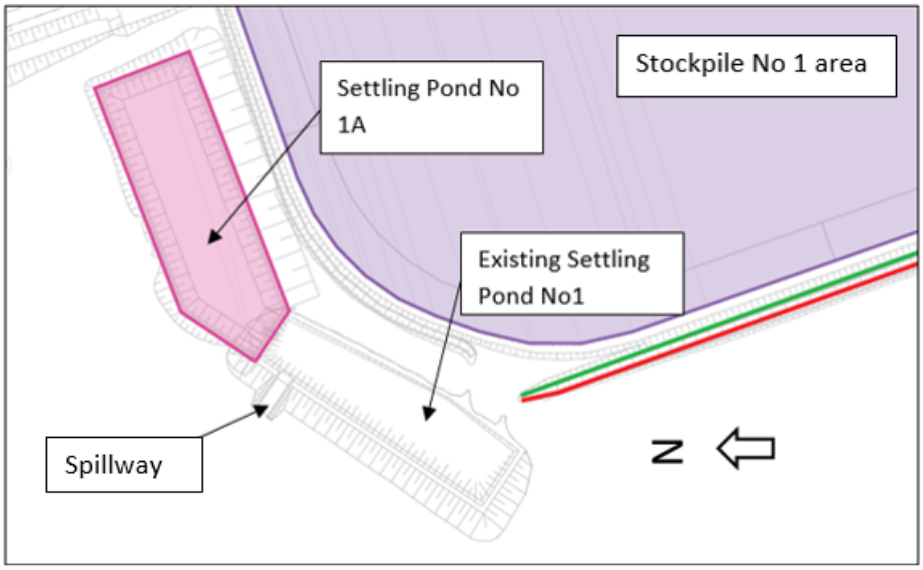

Figure 6-2: Settling Pond 1 and 1A

The pond extension calculation results can be seen below:

- Catchment area - 183 441 m^2
- Runoff Coefficient - 0.9
- Rainfall (1:10 year 24 hour) - 40.8mm

Using the calculations above the total required pond capacity required is 6,750 m^3. From as-built information it was determined that the available storage in the existing pond is 2,600 m^3. Settling pond No.1A is therefore to be constructed to provide additional storage capacity of 4,150 m^3.

6.1 Settling Pond No.2 and No.2A

The catchment area for Settling Pond No.2 will increase due to the construction of the new Stockpile No.2. A portion of the Stockpile No.2 will drain to the existing Pond No.2. Due to the increase in the catchment area for Pond No.2, the settling pond will not have sufficient capacity to contain the run-off.

A new compartment will be constructed to provide sufficient storage capacity. The existing pond crest and spillway need to be lifted to increase storage capacity.

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The emergency spillway is re-designed at a higher elevation with the same cross-sectional profile which then provides sufficient capacity to discharge the 1:200 year return period flow. Figure 6-3 shows the proposed modifications.

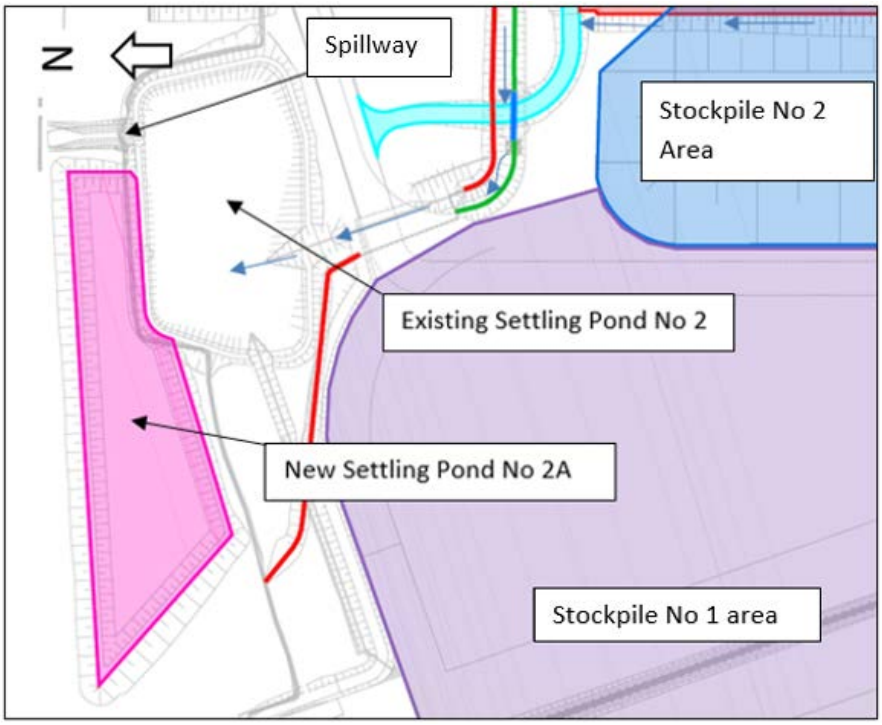

Figure 6-3: Settling Pond 2 and 2A

The results of the calculations associated with the pond extension can be seen below:

- Catchment area - 147 759 m^2
- Runoff Coefficient - 0.9
- Rainfall (1:10 year 24 hour) - 40.8mm

Using the calculations above the total required pond capacity must be 5,430 m^3. The combination of Settling Pond No.2 and No.2A will be constructed to ensure that this volume is achieved.

6.2 Northern Utility Berm

Due to the construction of Settling Pond No.2A, Ship Loader No.1 power cables will have to be relocated. A utility berm will be constructed between the existing road and Settling Pond 2. The berm crosses an existing drainage ditch that discharge water into Settling Pond 2.
A culvert (P-CULV-28) will be constructed as a 600mm CSP. No rip rap is required since the velocity is calculated below 1.5m/s for the design return period of 1:25 years. See Figure 6-4 for the utility berm and culvert.

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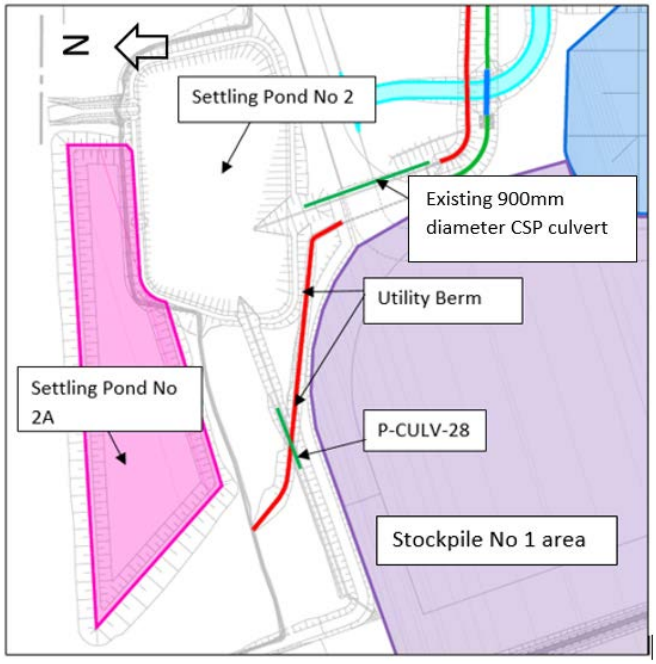

Figure 6-4: Northern Utility Berm Drainage

7. Stockpile No. 2 Drainage Area

Stockpile No.2 area consists of the following:

- Stockpile No.2 East
- Stockpile No.2 West
- Stacker reclaimer Berm
  - Northern Section
    - Access Roads
  - Middle Section
  - Southern Section
    - Maintenance Area / Storm Lock Position
    - Storm Lock Cradle
    - Berm Surroundings

The above will be discussed in the following sections. An overall layout of the area can be seen in Figure 7-1.

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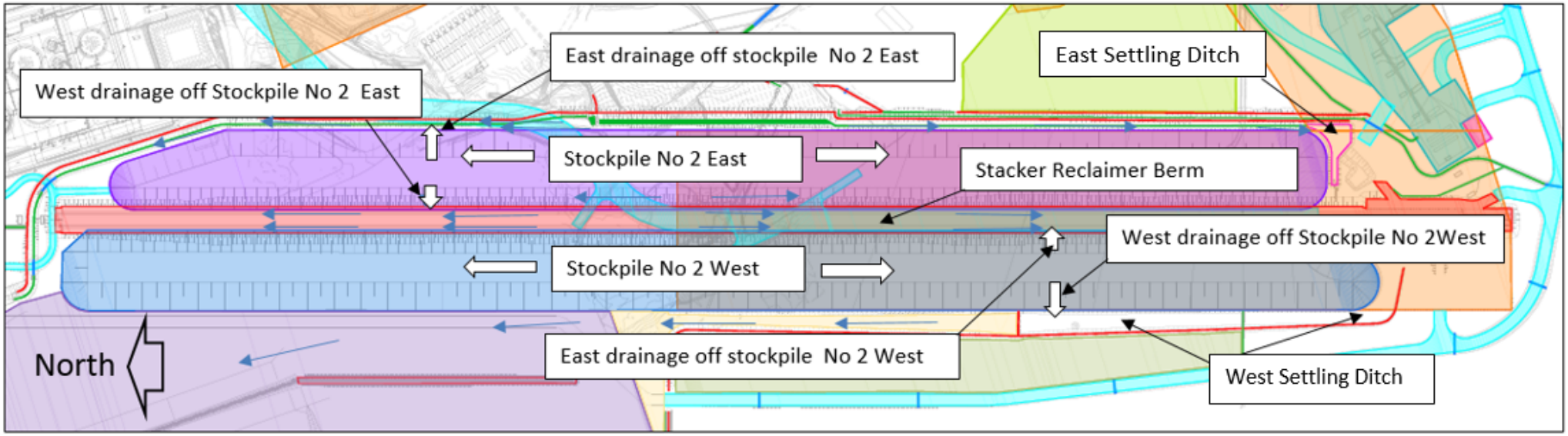

Figure 7-1: Stockpile No.2 Drainage Plan

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7.1 Stockpile No.2 East

Runoff from the stockpile draining towards the outside of the stockpile is collected in the Eastern Berm. (The eastern berm drainage is discussed in more detail in Section 7.4.)

Stockpile runoff draining inwards to the stacker reclaimer berm is collected in a precast 900mm x 900mm concrete drain on top of the berm. The drain will be constructed with no gradient due to limitations of the stacker reclaimer rail. The accumulated run-off flows in both north and south directions through hydraulic head build up inside the 900mm x 900mm drain. At the end points it discharges off the berm where the following occurs:

- In the south direction, water is conveyed in a swale towards a settling ditch along the Eastern Berm where it is retained (Similar to the settling ponds described previously).
- In the north direction, discharge is onto the stockpile area itself which is graded to drain into Settling Pond No.2.

7.2 Stockpile No.2 West

Runoff from the stockpile draining to the outside of the stockpile will be contained by the Western Berm. Due to limitations on natural ground gradient there are 2 ways in which the runoff will be managed:

- On the southern end water will be contained inside the western berm enclosed area which forms a containment / settling pond (see Section 7.5.1)
- On the northern end, water is conveyed towards the north and eventually ends up in Settling Pond No.1 /1A or No.2/2A - pending gradients. (see Section 7.5.2).

Runoff draining inside the stockpile to the stacker reclaimer berm is managed similar to Section 7.1 in the 900mm x 900mm drainage channel. Storm water finding its way to the southern end will be retained through surrounding berms (forming the West Settling Ditch – See Figure 7-1) until after suspended solids testing. Channel flow to the north will drain to the settling ponds to the north and is facilitated through construction of berms and specific located culverts draining into the Settling Ponds No.1/1A and No.2/2A.

7.3 Stacker Reclaimer Berm Southern Section

The southern end of the stacker reclaimer berm will include a maintenance area (incorporating the storm lockdown position). Figure 7-2 shows the southern section in more detail.

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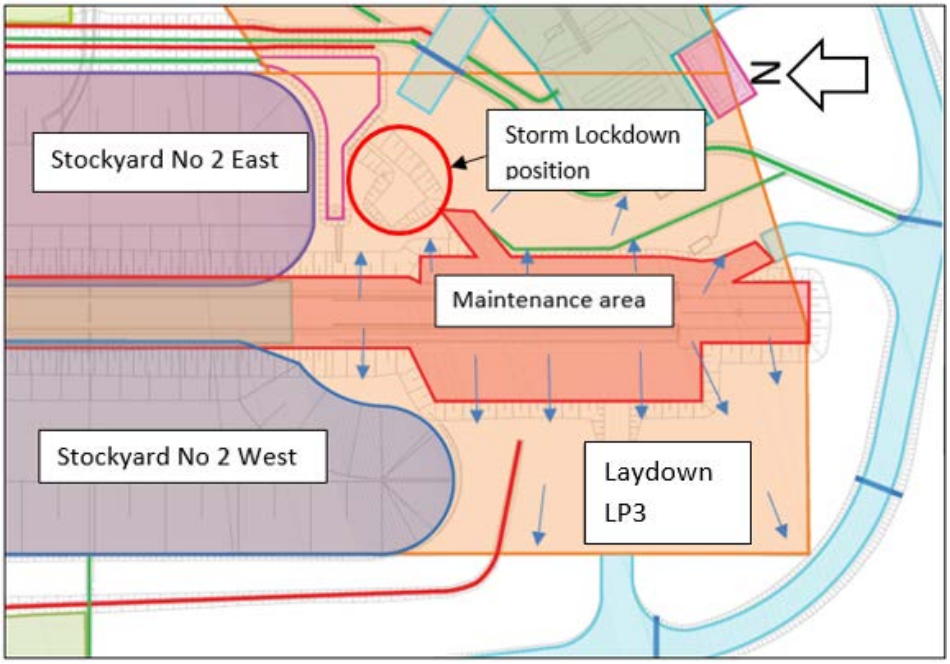

Figure 7-2: Stacker Reclaimer Berm Southern Section Drainage Plan

Storm water runoff from this area will be facilitated through natural run-off from the maintenance area onto the surrounding LP3 lower level ground. From here it is either directed to a swale or culvert and onto the natural environment.

The surrounding area will flow on Laydown LP3 as described in the 2018 Water Management Plan, H353004-40000-200-210-0001, and be diverted through the use of swales and ditches.

7.4 Stockpile No.2 Eastern Berm

The eastern berm has multiple functions as summarized below:

- Due to the natural low point along the eastern section of stockpile No 2, clean water runoff will have accumulated against the eastern berm. The berm serves to prevent clean water from entering the stockpile area by ponding against the berm
- Allow for overflow of the clean water towards the south when accumulating in access of the berm height during extreme events.
- Prevent potential sediment impacted runoff from Stockpile No.2 from enter the natural surroundings
- Settling out suspended solids from runoff generated inside the stockpile area
- Conveying water north toward the existing Settling Pond No.2
- Used for utilities such as electricity and fibre optic cable routing.

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7.4.1 *Eastern Clear Water Pond*

The clear water pond will be used to temporarily store runoff which will be pumped out or discharged into the overflow channel. The berm will be lined with a geomembrane to prevent water from the clear water pond entering the stockpile area. Figure 7-3 shows the extents of the pond.

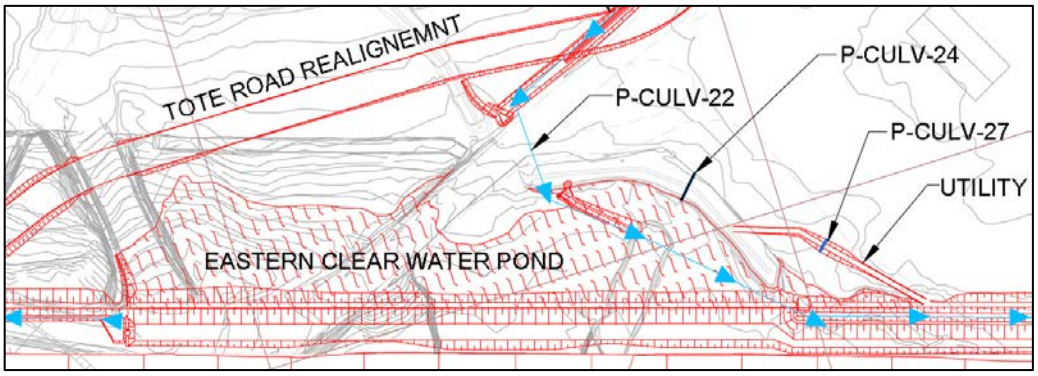

Figure 7-3: Eastern Clear Water Pond

The extent of the pond is dictated by the overflow level of the pond and care was taken to ensure that no infrastructure such as road or cables will be inundated.

7.4.2 *Eastern Berm – Clear Water Overflow Channel*

Although the Eastern Clear Water pond must be operated as empty during the rainy season by means of pumping, it may not always be empty when a large storm event occurs. It is therefore necessary to have an emergency overflow. This overflow channel can be seen in Figure 7-4.

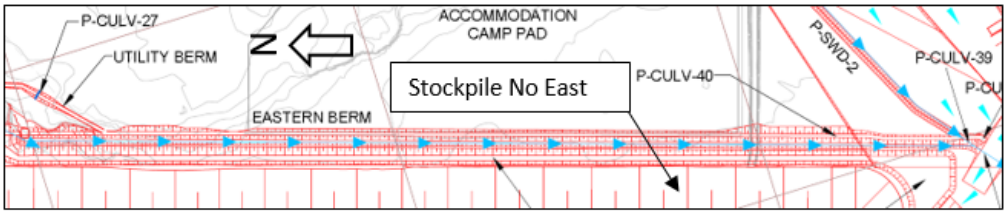

Figure 7-4: Eastern Berm – Clear Water Overflow Channel

The overflow channel has been designed as a trapezoidal channel to convey the 1:100 year flood event and is built on top of the eastern berm. The water will flow south and connect with P-SWD-2 (see Section 9.7). South of the Accommodation Camp Pad a 600mm diameter culvert (P-CULV-40) will be installed through the berm to allow water to enter the channel. The area will also be locally shaped to ensure that there is no ponding of water against this portion of the berm/channel. The calculation results for the overflow channel are as follows:

- Bottom Width - 0.5m
- Side Slopes - 1V:1.5H

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- Flow - 1.144 m^3/s
- Normal Flow Depth - 0.727m
- Velocity - 0.99 m/s

7.4.3 *Eastern Berm – Settling Ditch*

As part of the containment of runoff from the stockpile area, a settling pond in the form of an elongated ditch is designed and is constructed on the south eastern end of the stockpile area as can be seen in Figure 7-5.

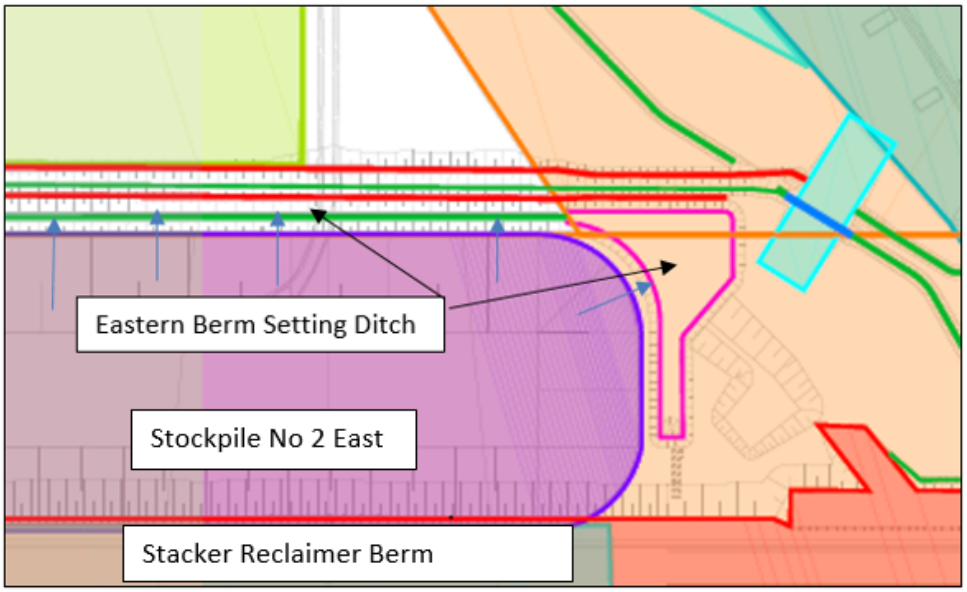

Figure 7-5: Eastern Berm – Settling Ditch

The settling ditch must be able to contain the runoff volume from the 1:10 year 24-hour storm event. The ditch will have a sump at the southern end that will be used to empty the ditch by means of pumping as soon as the necessary criteria is achieved for discharge as per the Environmental Design Criteria. An emergency overflow is designed to the north that will discharge into the northern section in an extreme event. This overflow was designed for the 1:200 peak flood. The calculations are as follows:

- Catchment area - 83 766 m^2
- Runoff Coefficient - 0.9
- Rainfall (1:10 year 24 hour) - 40.8mm

With the above it was determined that the required pond capacity is 3 075 m^3.

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The spillway is designed for the 1:200 year return period. The spillway design result is as follows:

- Bottom Width - 1.5m
- Depth - 0.2m
- Flow - 0.346 m^3/s

7.4.4 Eastern Berm – Northern Section

The northern section of the eastern berm is a combination of ditch and berm conveying water towards the existing Settling Pond 2. Figure 7-6 shows this section.

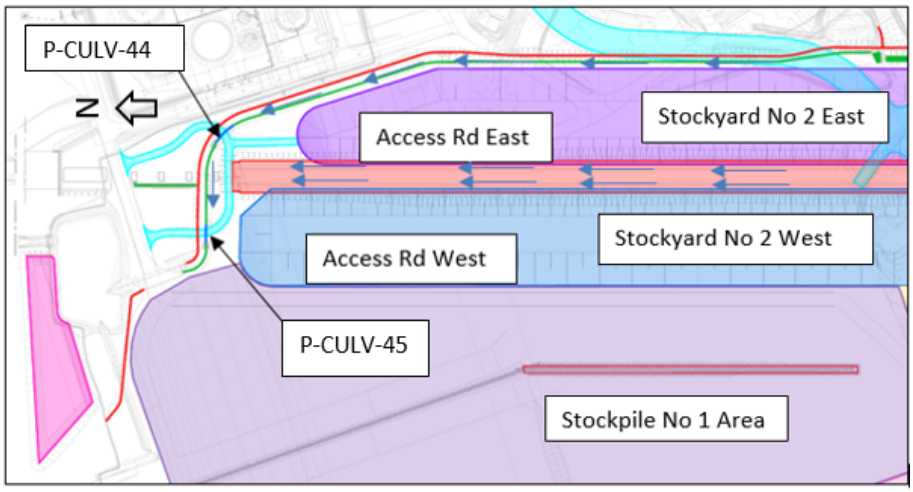

Figure 7-6: Eastern Berm – Northern Section

The ditch will cross two access roads where culverts will be used to allow for safe passage of the flow. The culverts and the ditch were designed to cope with the 1:100 year flood. The ditch will link up with the existing drainage system, from where it will pass underneath an existing culvert and into settling pond 2 (see Section 6.1).

The results from the design and analysis of the ditch is reflected below:

- Bottom Width - 1m
- Side Slopes - 1V:2H
- Flow - 0.772 m^3/s
- Max Normal Flow Depth (0.2% fall) - 0.486m
- Max Velocity (1.6% fall) - 1.22 m/s

Based on the above there is no need for rip rap except for the culverts (see Section 8.5).

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7.5 Western Berm

The western berm will be constructed to perform the following functions:

- Prevent runoff from Stockpile No 2 from entering the natural surroundings
- Settling out suspended solids from runoff generated inside the Stockpile No.2 West area for the southern section of the berm
- Convey runoff towards Stockpile No.1 west for the northern section of the berm.

Figure 7-7 shows the overall layout of the Western Berm.

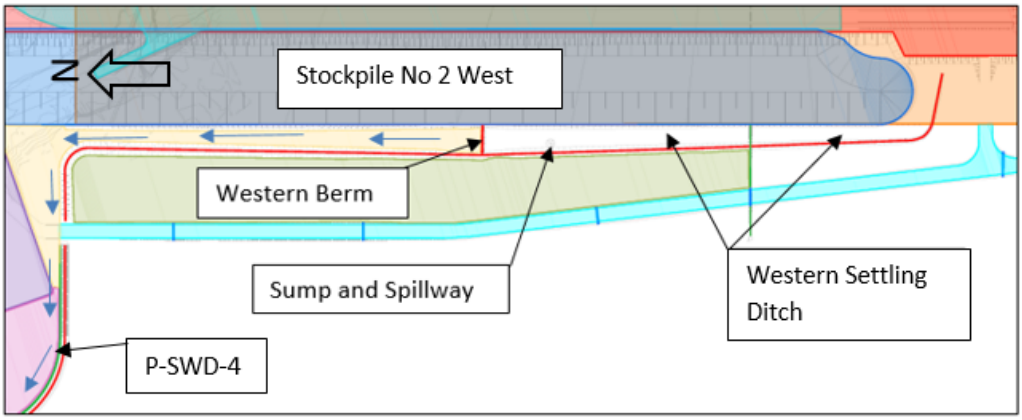

Figure 7-7: Western Berm Drainage Plan

7.5.1 Western Berm Settling Ditch

As part of the environmental requirement to contain runoff from the stockpile area and due to a lack of gradient to drain storm water naturally, a settling pond in the form of an elongated ditch is designed and will be constructed on the south western end of the stockpile.

The settling ditch is designed to contain the runoff volume from the 1:10 year 24-hour storm event. The ditch has a sump that is centrally placed and will be used to empty the ditch as soon as the necessary Environmental criteria for discharge has been achieved. An emergency overflow channel will be constructed in the same location as the sump that allows spillway water into the natural environment. This overflow is designed for the 1:200 peak flood. Calculation results are reflected below:

- Catchment area - 47 435 m^2
- Runoff Coefficient - 0.9
- Rainfall (1:10 year 24 hour) - 40.8mm

With the above calculations the required pond capacity is 1 742 m^3.

The spillway is designed to safely discharge the 1:200 year return period. The result of the spillway design indicates the following geometry:

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- Bottom Width - 0.5m
- Depth - 0.3m
- Flow - 0.196 m^3/s

7.5.2 Western Berm – Northern Section

The northern section of the western berm conveys water towards Stockpile No.1. The drainage system of Stockpile No.1 is discussed in Section 6.

7.6 Drive Station

The yard conveyor drive station is situated at the northern end of Stockpile No 2. This area is designed to allow for sheet flow runoff to drain off the pad and into the ocean. A 20m wide road connects the existing area with the proposed ship loader causeway. This road does not require any drainage culverts as there are no stream / drainage crossings. Figure 7-8 shows the area.

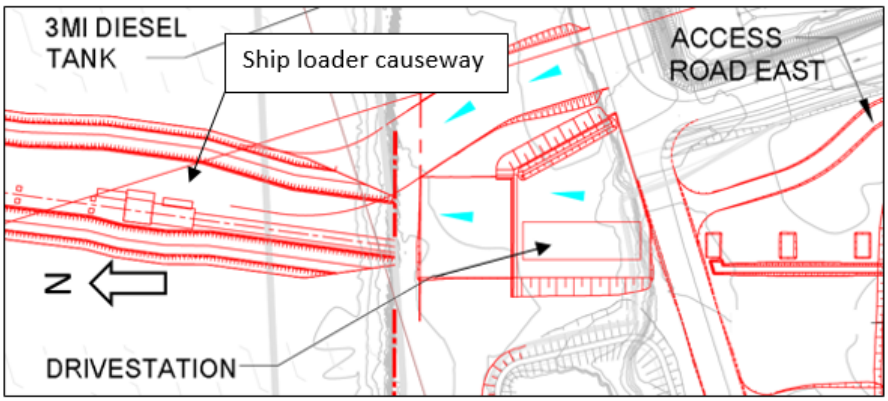

Figure 7-8: Drive Station

8. Road Drainage Areas

8.1 Rail Yard Access Road

The rail yard access road will be constructed to facilitate the delivery of the dumper module and will be utilised for future access to the rail yard. The road is designed with 3 drainage culverts:

- P-CULV-23 – 2 x 900mm Diameter CSP
  - This culvert crosses both the rail yard access road as well as the future rail formation. The culvert will initially be constructed underneath the road and will be extended when the railway is constructed.
- P-CULV-48 - 600mm Diameter CSP
- P-CULV-47 - 600mm Diameter CSP

The Rail Yard Access Road is shown in Figure 8-1.

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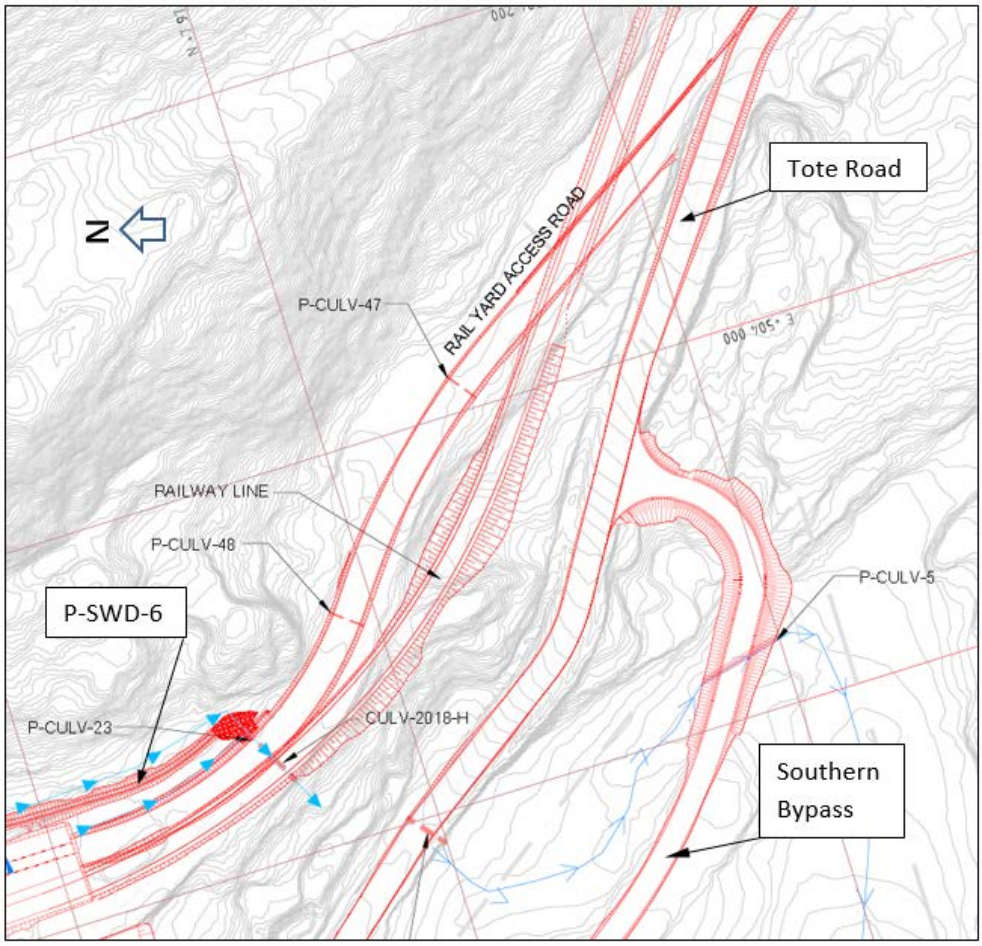

Figure 8-1: Rail Yard Access Road Drainage

8.2 Tote Road Drainage

This section discusses the drainage of the Tote Road and is covered in 3 Sections.

8.2.1 Tote Road Upgrade

At the southern end of the port the Tote Road requires upgrading to allow for the transportation of the dumper module and indexer building module. Figure 8-2 shows the area of consideration.

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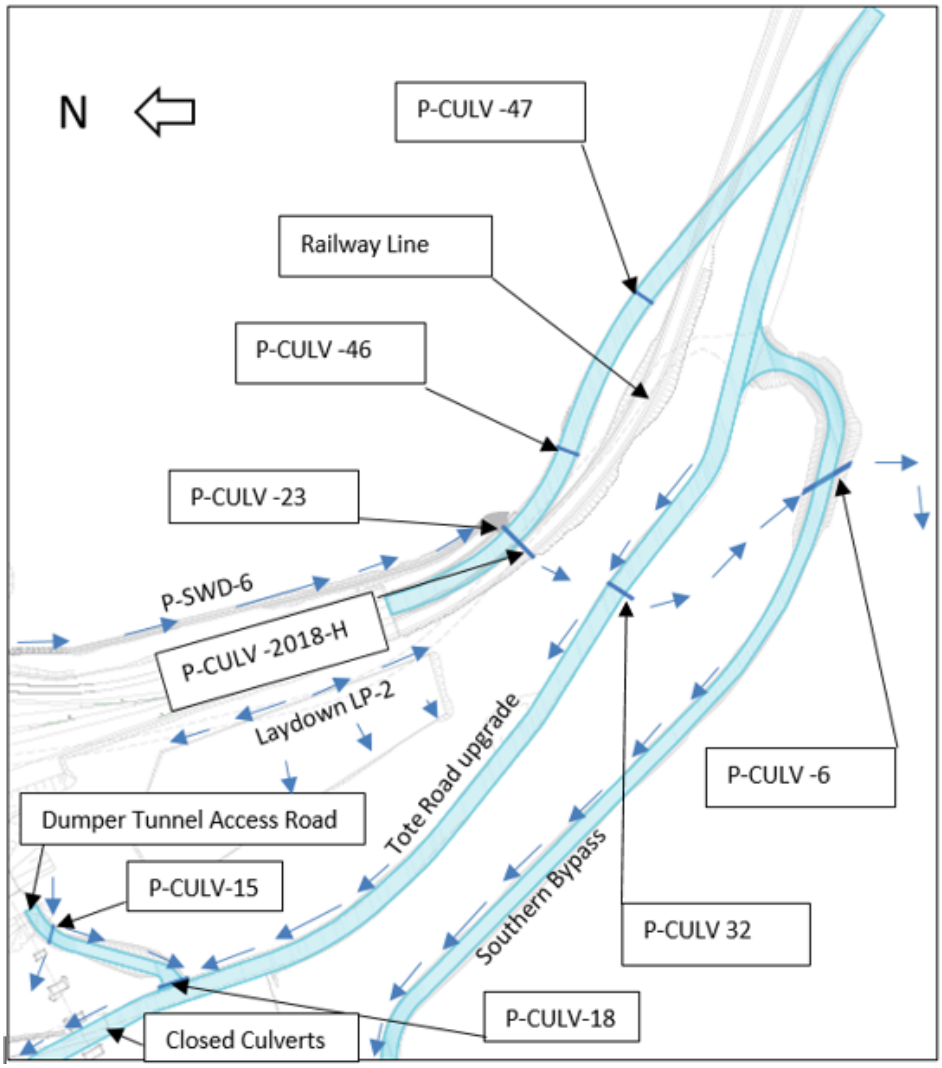

Figure 8-2: Tote Road Upgrade Drainage Plan

For this section, two existing culverts indicated in Figure 8-2 will be closed off to direct runoff away from construction activities. Water must flow to the north where it is collected in the Tote Road ditch.

This drainage section requires an additional culvert. Culvert P-CULV-32 allows safe passage of surface runoff water that primarily comes from P-SWD-6. Flow is discharged through this culvert. The culvert will be constructed out of 2x900mm diameter CSP with rip rap on both ends.

8.2.2 Tote Road Drainage Ditch

The existing Tote Road has a drainage ditch on the eastern side of the road. This ditch directs water to the north. The drainage ditch requires upgrading due to the additional catchment area enforced by the culvert closures. Figure 8-3 shows the ditch location and culverts.

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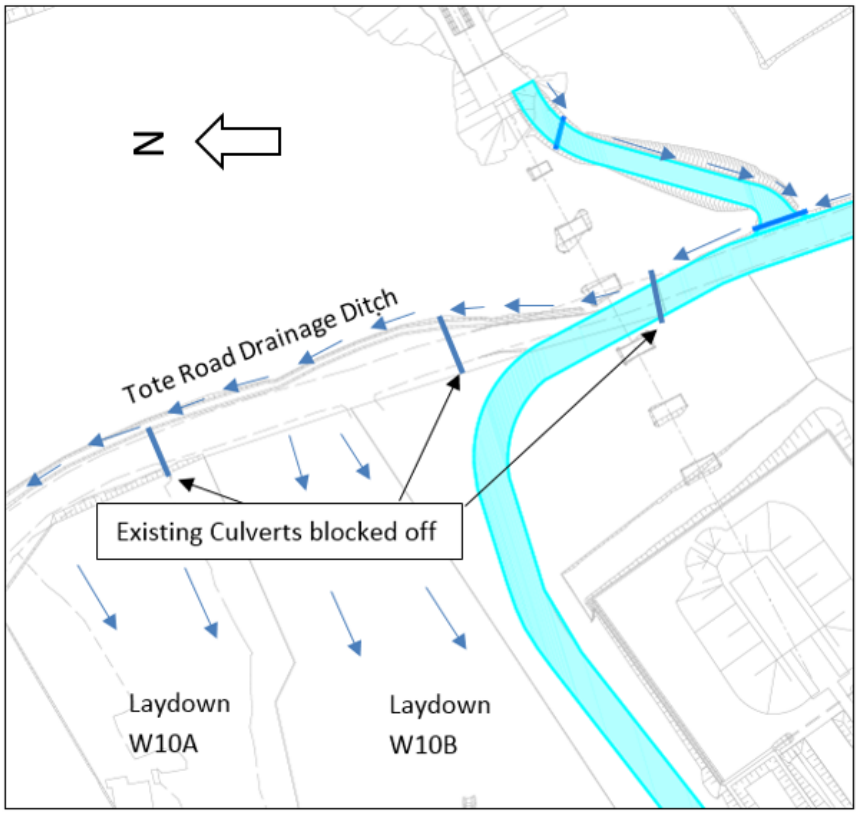

Figure 8-3: Tote Road Drainage Ditch

The ditch was sized and analysed. The results from the analyses are reflected below:

- Bottom Width = 2 m
- Side Slopes = 1V:2H
- Discharge (1:100) = 0.87 m^3/s
- Velocity = 1.82 m/s

Rip rap is provided to protect against erosion since the velocity exceeds 1.5 m/s.

In the first construction phase planned for 2018, the water is unobstructed up to the point where it needs to cross the Tote Road to the west at Culvert P-CULV-22. This culvert is designed to allow water to pass underneath the existing Tote Road into a ditch that will link up with an existing drainage ditch. The culvert will be constructed as 2x600mm diameter CSP pipes. 4 shows more detail for this area.

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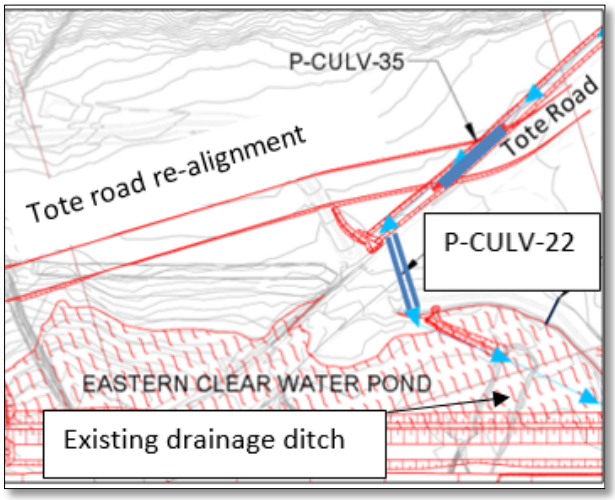

Figure 8-4: P-CUVL-22

In future, a Tote Road realignment is required which requires a crossing of the Tote Road drainage ditch – this is further discussed in Section 8.2.3 below.

8.2.3 Tote Road Realignment

The Tote Road realignment will be constructed to allow vehicles to travel around the proposed Stockpile No.2. The drainage of this road requires two culverts:

- P-CULV-35 - 2x600mm diameter CSP
  - Culvert to be placed inside the Tote Road drainage ditch (see section 8.2.2)
- P-CULV-9 - 600mm diameter CSP

Figure 8-5 shows this section.

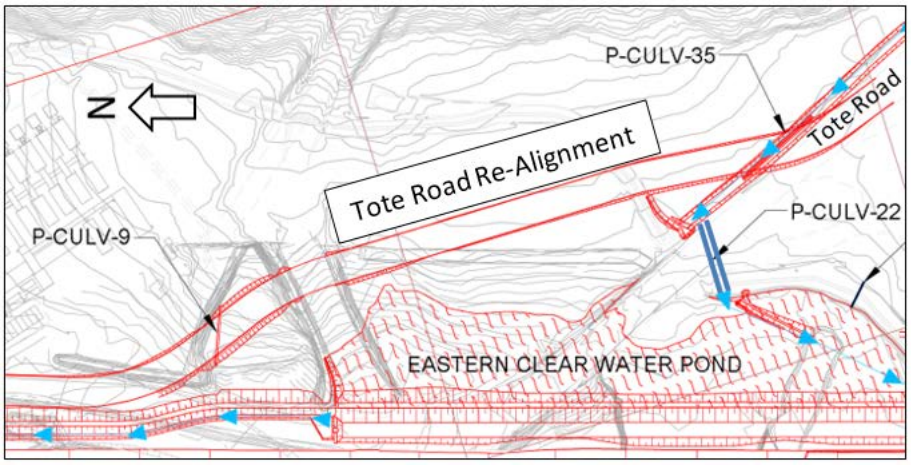

Figure 8-5: Tote Road Realignment Drainage Plan

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8.3 Dumper Tunnel Access Road

This road connects the Tote Road to the dumper exit tunnel. Figure 8-6 shows the road.

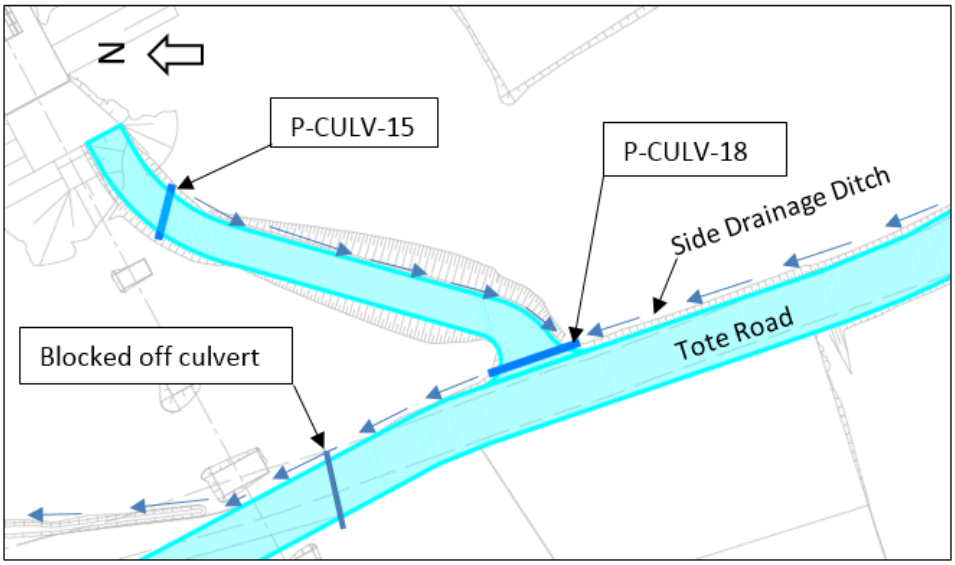

Figure 8-6: Dumper Tunnel Access Road Drainage Plan

The road will be constructed with the following storm water infrastructure:

- Side ditch to prevent water flowing over the road from the upstream catchment. The results from the design and analyses for this ditch are as follows:
  - Bottom Width - 0.5m
  - Side Slopes - 1V:1.5H
  - Depth - 0.4m
  - Flow - 0.05 m^3/s
  - Velocity - 1.45 m/s
- P-CULV-18 - 600mm diameter CSP
  - Culvert that will be constructed to allow flow from the Tote Road side ditch to drain underneath the dumper tunnel access road
- P-CULV-15 - 600mm diameter CSP
  - Culvert at low point to allow water to pass underneath the road.

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8.4 Western Bypass Road

The Western Bypass will allow for vehicle access around the western and the northern side of Stockpile No.2.

Figure 8-7 shows the Western Bypass Road.

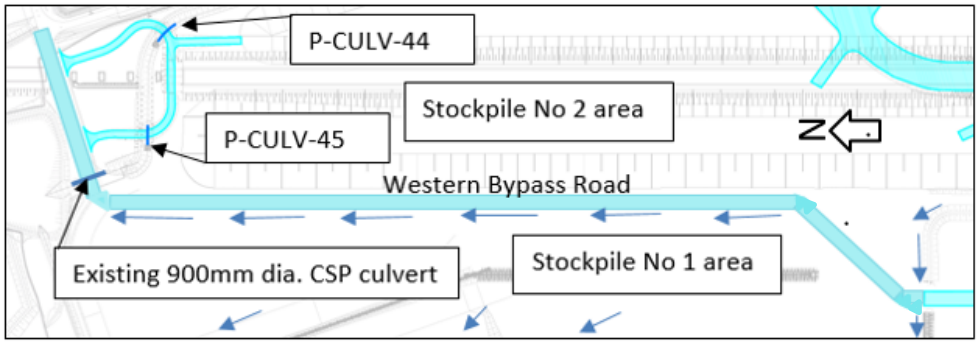

Figure 8-7: Western Bypass Drainage Plan

The road will only be demarcated route where it is routed through the existing stockpile area as no road layerworks required on the stockpile area. Drainage will be as per the stockpile drainage plan.

In the north, the road will be lowered to allow vehicles to pass underneath the stockpile conveyor gantry. The road section is sloped in one direction to allow water run off when it exits a cut.

The demarcated road area on top of the Stockpile No.1 terrace also crosses an existing culvert that discharges into the existing Settling Pond No.2. From survey information it was determined that the culvert is a 950mm diameter CSP. The survey information was used to confirm that there is sufficient capacity in this culvert.

Two access roads are connected to the Western Bypass road that will allow vehicle access to the stacker reclaimer berm from the north.

The drainage for these roads will be discussed in Section 8.5.

8.5 Northern Access Roads

Two roads, access road east & access road west, will be constructed to allow for vehicle access to the northern section of the stacker reclaimer berm. These roads can be seen in in Figure 8-8.

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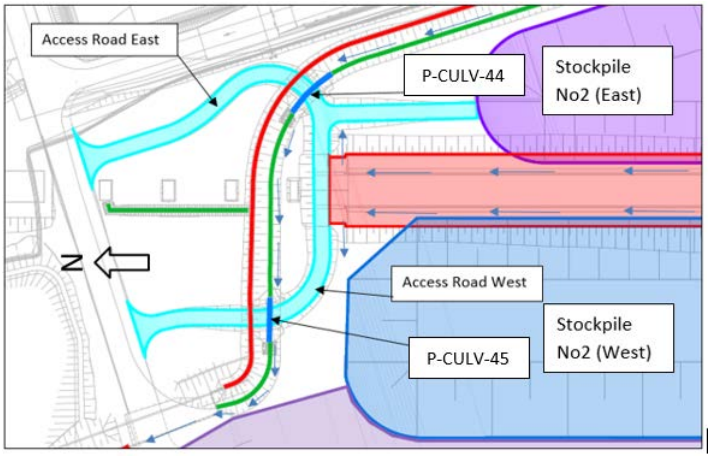

Figure 8-8: Northern Access Roads

The roads will be constructed across the Eastern berm as described in section 7.4.4.

The culvert details are as follows:

- P-CULV-44 - 900mm diameter CSP
- P-CULV-45 - 900mm diameter CSP

8.6 Southern Bypass Road

The main function of the Southern Bypass is to connect the Tote Road with Stockpile No.1. The road will also have roads branching off to provide access to the following areas:

- Stockpile No.2
  - Access Rd - 6
  - Access Rd - 7
- Fines Stockpile at the fines crusher
  - Access Rd - 1
  - Access Rd - 2
- Crushing and screening pad
  - Access Rd - 3
- Crushing Feed Stockpile
  - Access Rd - 4
  - Access Rd - 5

The road can be seen in Figure 8-9.

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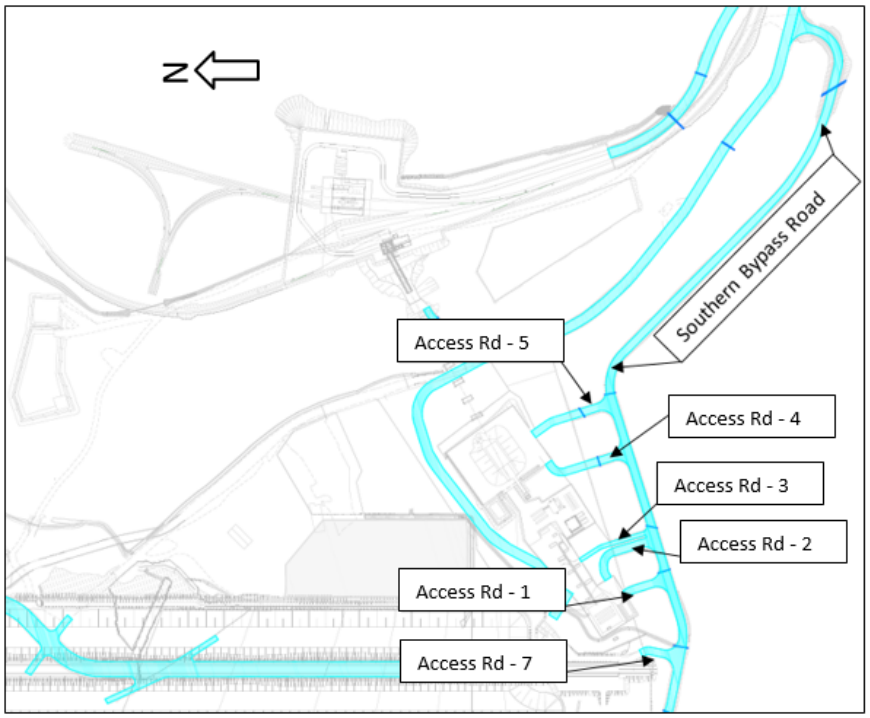

Figure 8-9: Southern Bypass Drainage Plan (i)

The following drainage culverts will be constructed at locations indicated in Figure 8-10, Figure 8-11 and Figure 8-12.

- P-CULV-34 - 600mm Diameter CSP
- P-CULV-1 - 600mm Diameter CSP
- P-CULV-2 - 600mm Diameter CSP
- P-CULV-43 - 600mm Diameter CSP
  - Culvert will be constructed inside Laydown LP3 daylight ditch as per the 2018 Surface Water Management Plan
- P-CULV-19 - 600mm Diameter CSP
- P-CULV-3 - 600mm Diameter CSP

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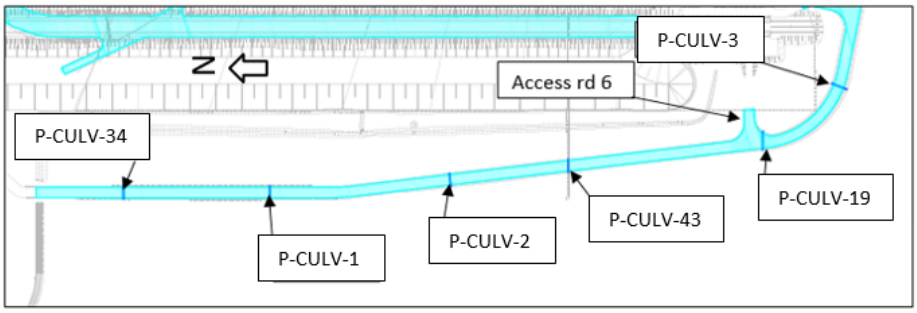

Figure 8-10: Southern Bypass Drainage Plan (ii)

- P-CULV-38 - 1200mm Diameter CSP
  - Culvert will discharge flow from P-SWD-2 (See Section 9.7)
- P-CULV-21 - 600mm Diameter CSP
- P-CULV-20 - 900mm Diameter CSP
- P-CULV-7 - 900mm Diameter CSP
- P-CULV-33 - 900mm Diameter CSP
- P-CULV-4 - 600mm Diameter CSP

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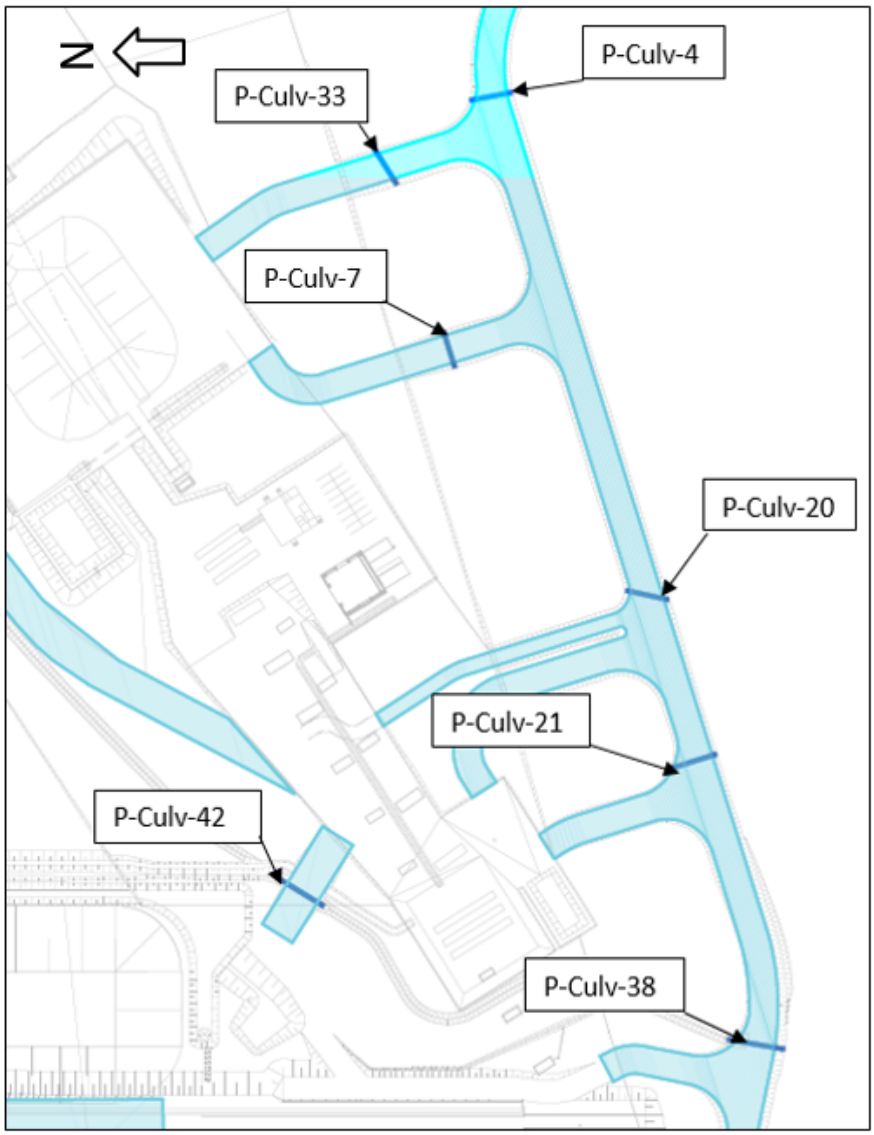

Figure 8-11: Southern Bypass Drainage Plan (iii)

- P-CULV-5 - 2 x 1200mm Diameter
  - Culvert will discharge flow from the east that was diverted through P-SWD-6 and underneath the Tote Road through P-CULV-32.

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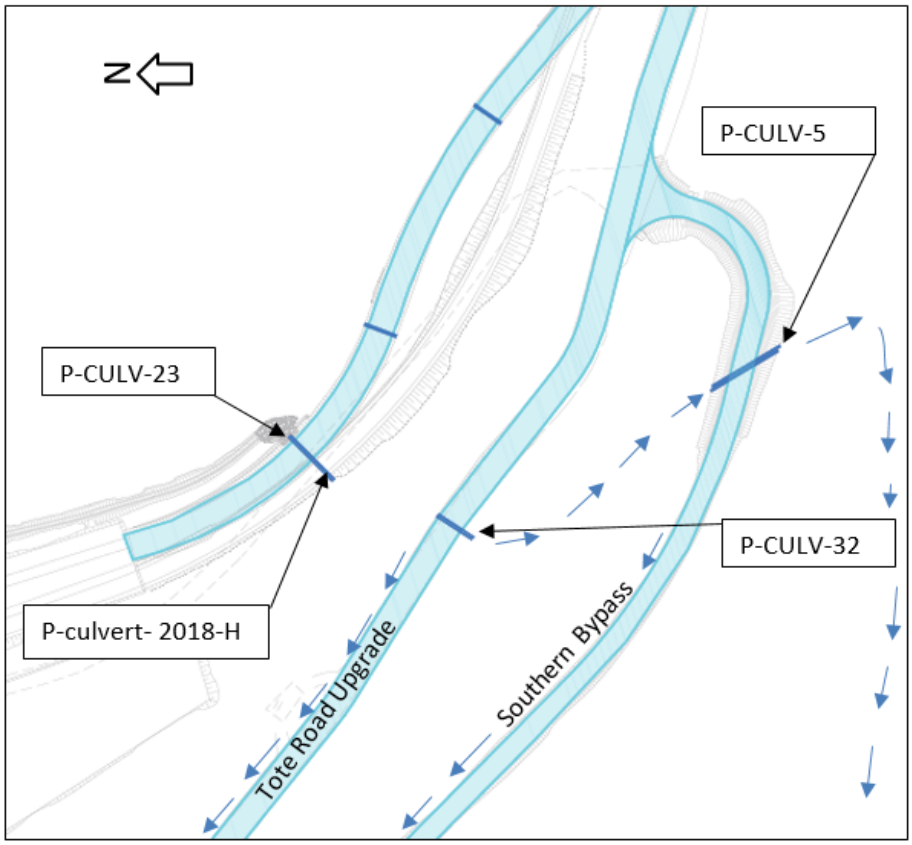

Figure 8-12: Southern Bypass Drainage Plan (iv)

For more detail on the culverts refer to the relevant road Issued for Construction (IFC) drawings.

The Southern Bypass also has one roadside ditch to allow drainage of a low-lying area from east to west toward P-CULV-38. The ditch can be seen in Figure 8-13.

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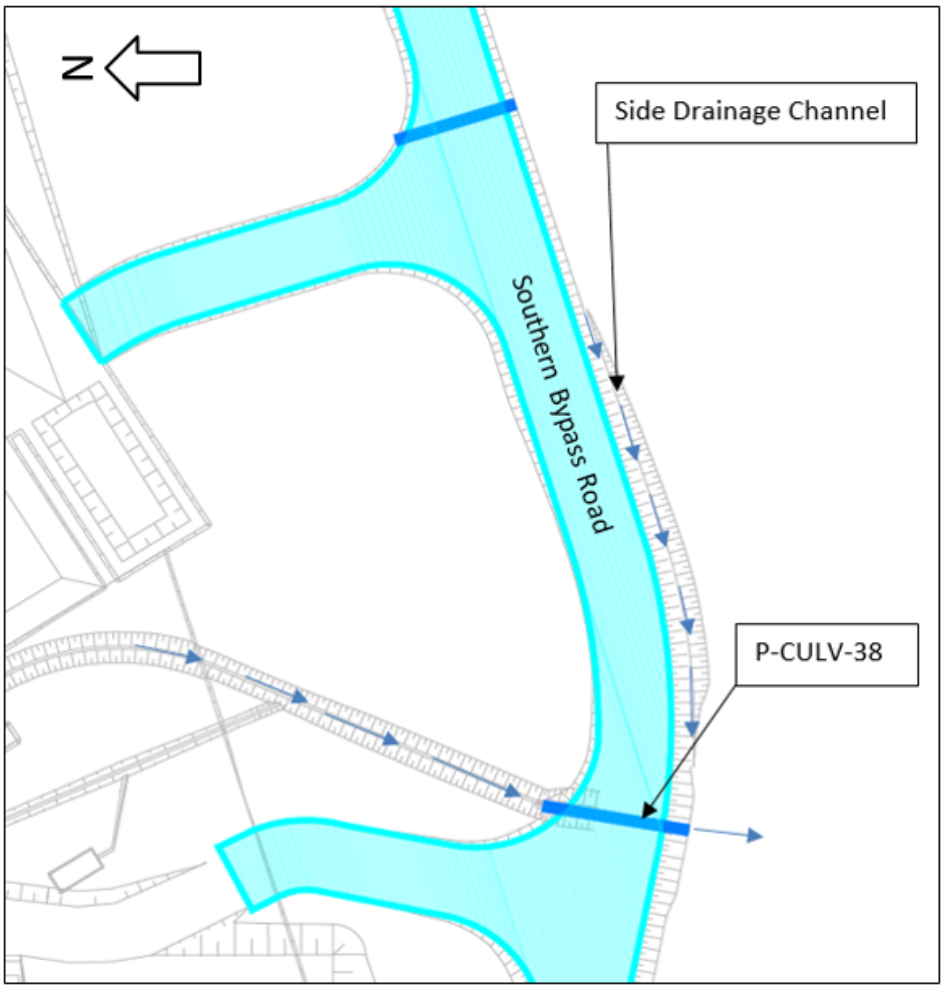

Figure 8-13: Southern Bypass Road Side Drainage Channel

9. Balance of Work Drainage

9.1 Storm Water Diversion - P-SWD-3

Storm water diversion number 3 will be constructed to divert water away from Laydown LP2 situated to the south of the existing Port Site Camp. Both the diversion and the laydown area are planned to be constructed in 2018. Figure 9-1 indicates the diversion.

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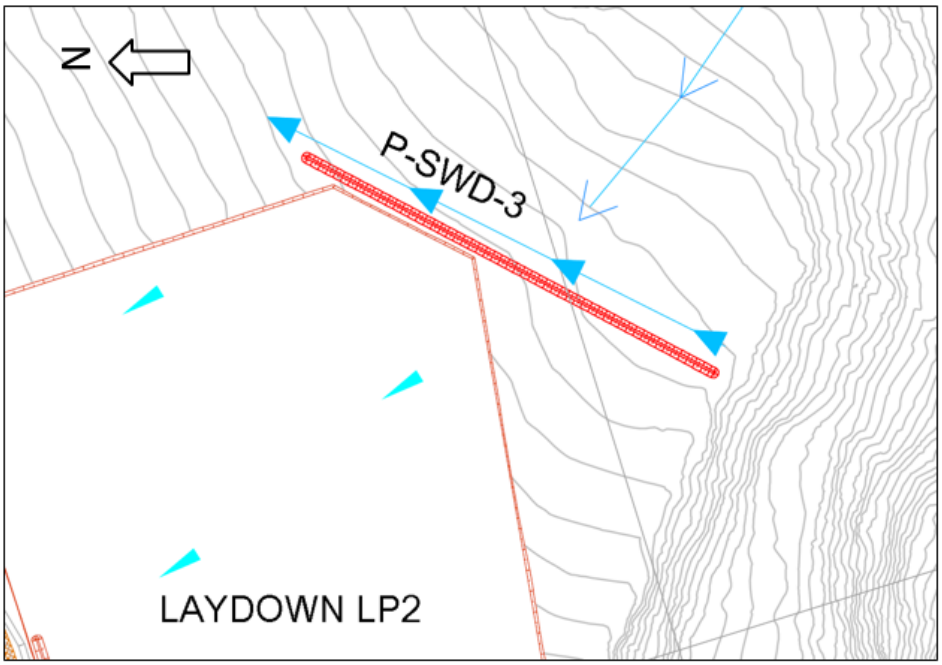

Figure 9-1: P-SWD-3

The diversion will be constructed as a berm collecting water from the catchment area to the south and primarily from P-SWD-5. When exiting the berm, the water will flow naturally towards the north joining the natural stream east of the Port Site Camp (PSC).

The diversion was modelled and analysed as a berm taking into account the surrounding natural ground. The results were as follows:

- Berm Height Required = 0.6 m
- Maximum Velocity = 1.49 m/s

9.2 Laydown LP2 Drainage

Laydown LP2 will be constructed south of the existing Port Site Camp. This area will be used for laydown of equipment and construction plant as well as to serve as the location of relocated buildings as indicated in Figure 9-2.

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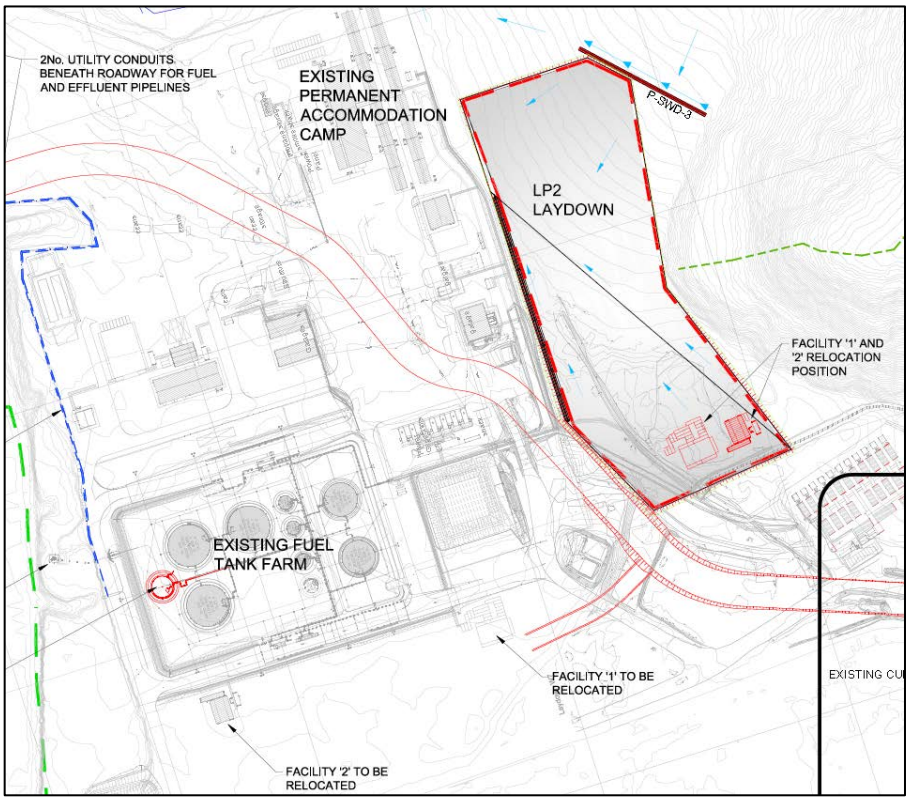

Figure 9-2: Laydown LP2 Location

Figure 9-3 shows the proposed LP2 laydown area in more detail.

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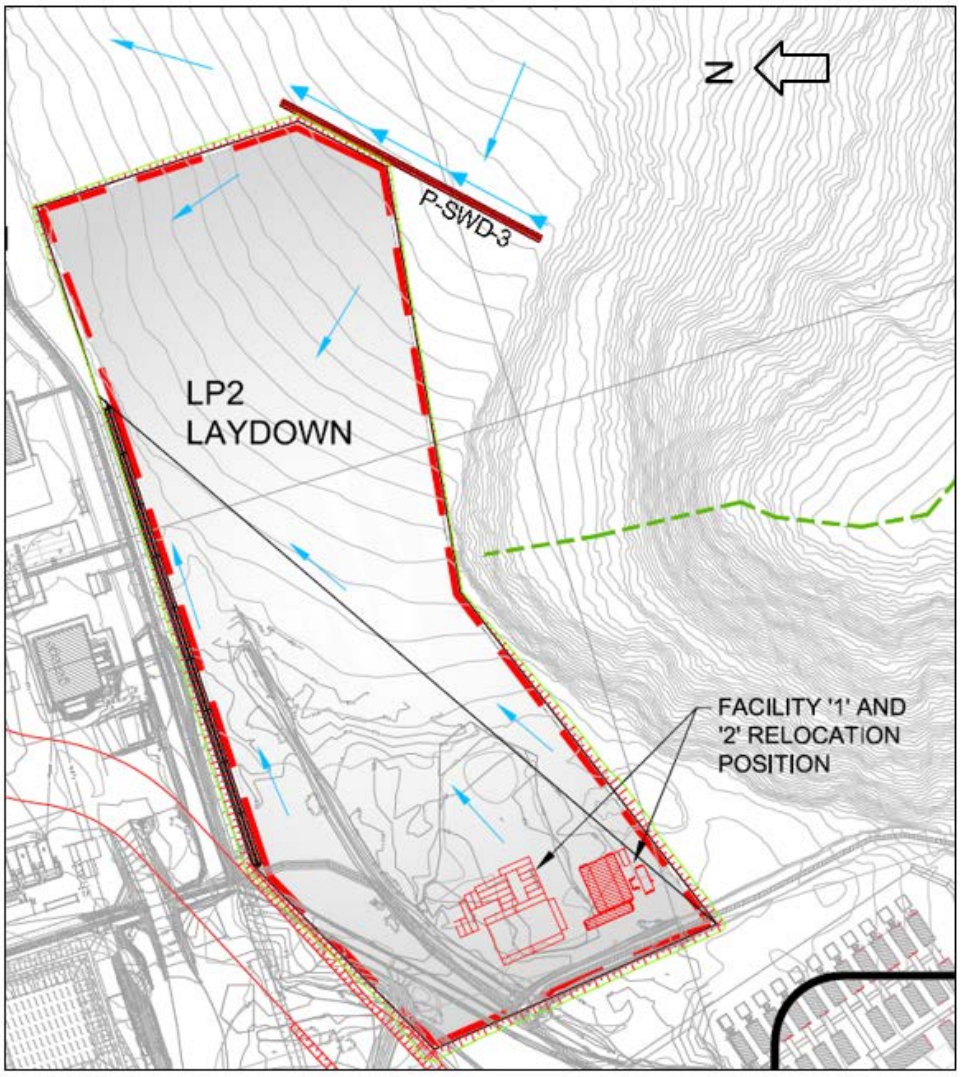

Figure 9-3: Laydown LP2 Drainage

The laydown area will be constructed with a swale sloping towards the northeast where it will discharge any storm water runoff into the existing drainage ditch. The discharge location was determined as the highest point in the existing drainage ditch to ensure water discharges to the east. A berm will be constructed on top of the laydown area to direct runoff to this point. This ditch discharges to the natural drainage path that will convey the water to the north.

9.3 Drainage in the Barge Offloading Dock Area - P-SWD-7

At the existing barge offloading dock, there is an existing culvert (referred to as Culv-Exg-B) that conveys runoff from the south and discharges it to the west. The storm water is directed towards the sea via a berm (P-SWD-7) after exiting the culvert. Refer to Figure 9-4.

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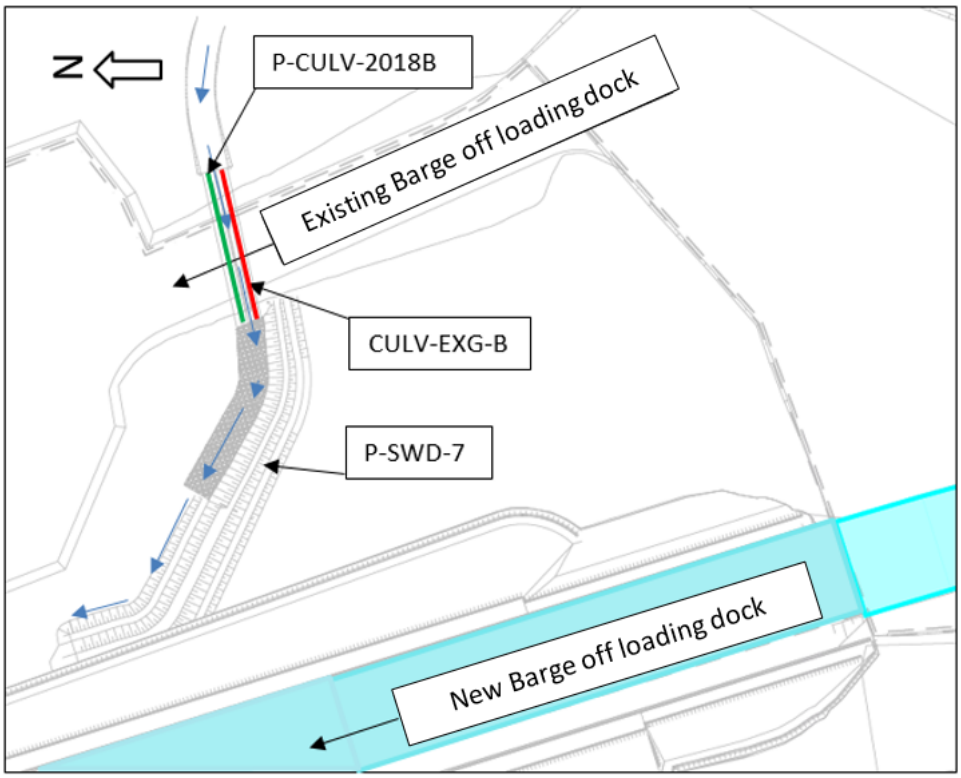

Figure 9-4: P-SWD-7

The existing culvert must be modified to ensure that no water for the 1:100 year flood event (See Civil Design Philosophy) will discharge towards the north which is not the natural discharge location for this stream. The berm P-SWD-7 is designed so that runoff will not interfere with the construction of the new barge offloading dock.

The existing culvert has two barrels of 1200mm diameter each. These are to be modified by lowering the inlet invert elevations and adding two additional 1200mm diameter barrels to the culvert at the same elevation.

- Based on the 1:100 year return period flood, the computed headwater elevation at the culvert's inlet is equal to 3.23 m. This is less than the maximum allowable elevation of 3.24m before a spill will occur to the north and into the sea.
- The calculated maximum velocity is equal to 1.83 m/s and as a result, rip rap will be placed at the inlet and outlet of the culverts to protect against erosion.

The diversion berm (P-SWD-7) is modelled and analysed taking into account the surrounding existing ground. The results are as follows:

- Berm Height Required = 1.2 m
- Maximum Velocity = 1.53 m/s

Based on the results, adequate rip rap shall be placed to protect against erosion.

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9.4 Laydown W10A and W10B

Storm water runoff from laydown W10A and W10B will be directed to the west by constructing laydown levels that ensures adequate slope and flow. No swales will be constructed for the laydown area and all runoff will be considered as sheet flow. W10A and W10B are indicated on Figure 9-5.

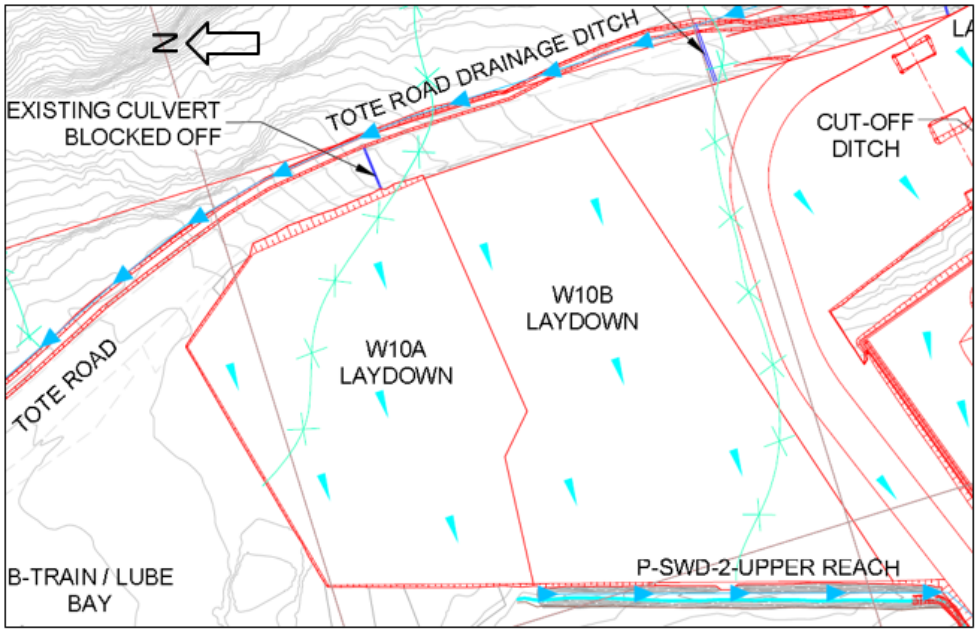

Figure 9-5: Laydown W10A and W10B Drainage Plan

Runoff from W10A will continue as sheet flow across the Accommodation Camp pad and runoff from W10B will flow into P-SWD-2-Upper Reach.

9.5 Laydown LP5

Laydown LP5 will drain towards the southwest through a combination of swales and sheet flow as per Figure 9-6.

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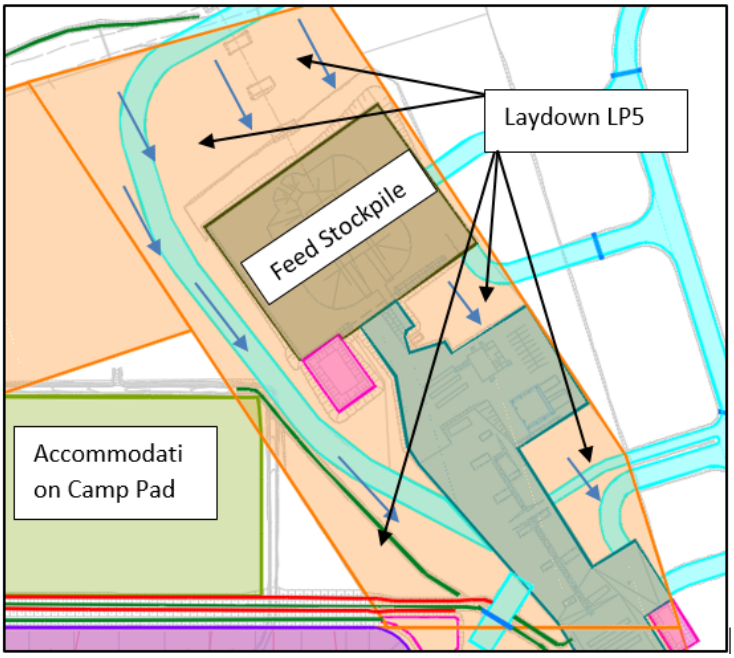

Figure 9-6: Laydown LP5 Drainage

9.6 Laydown LP6

This laydown area will drain towards the west as sheet flow. This is achieved through grading the laydown to ensure adequate slope. The LP6 laydown area will discharge into the natural environment as shown on Figure 9-7.

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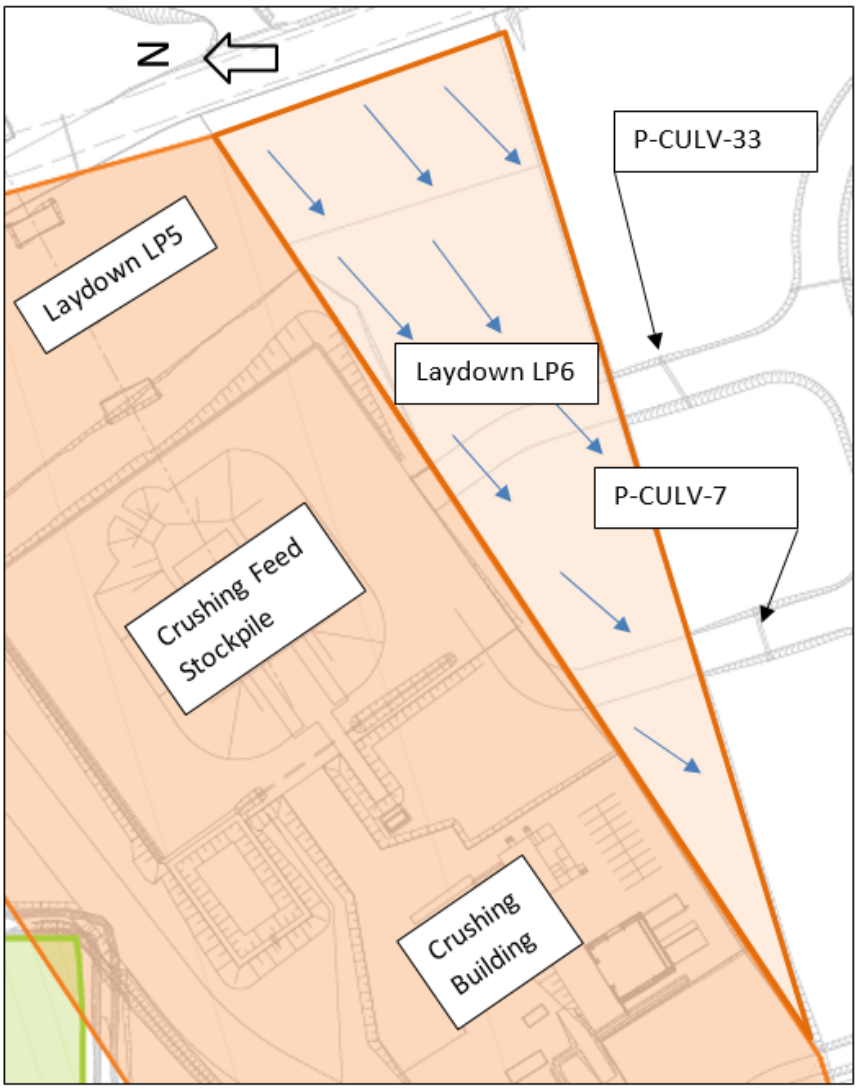

Figure 9-7: Laydown LP6 Drainage Plan

9.7 P-SWD-2

Storm water diversion No.2 consists of two sections:

- Upper Reach that was previously designed and constructed to facilitate drainage around the Accommodation Camp Pad.
- Lower reach that was designed to convey water to the south where it will discharge into the natural environment.

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9.7.1 *P-SWD-2 – Upper Reach*

This section of the diversion was designed and constructed to convey flow from a large catchment area upstream of the existing Tote Road and discharge it on the western side of the construction accommodation camp pad. For the future phase, this section will link up with P-SWD-2 – Lower Reach which is described in Section 9.7.2.

9.7.2 *P-SWD-2 - Lower Reach*

This reach will be constructed to convey water from the P-SWD-2 – Upper Reach, upstream catchment area and the Eastern Berm – Clear Water Overflow Channel around the crushing and screening pad. The ditch will have several culvert crossings as follows:

- P-CULV-39 - 1200mm Diameter CSP
  - Crossing to allow for utilities crossing over the ditch, on top of a berm
- P-CULV-37 - 1200mm Diameter CSP
  - Crossing to allow access into the stockpile area for front end loader and maintenance vehicles
- P-CULV-38 - 1200mm Diameter CSP
  - Crossing at the Southern Bypass

Figure 9-8 shows the diversion.

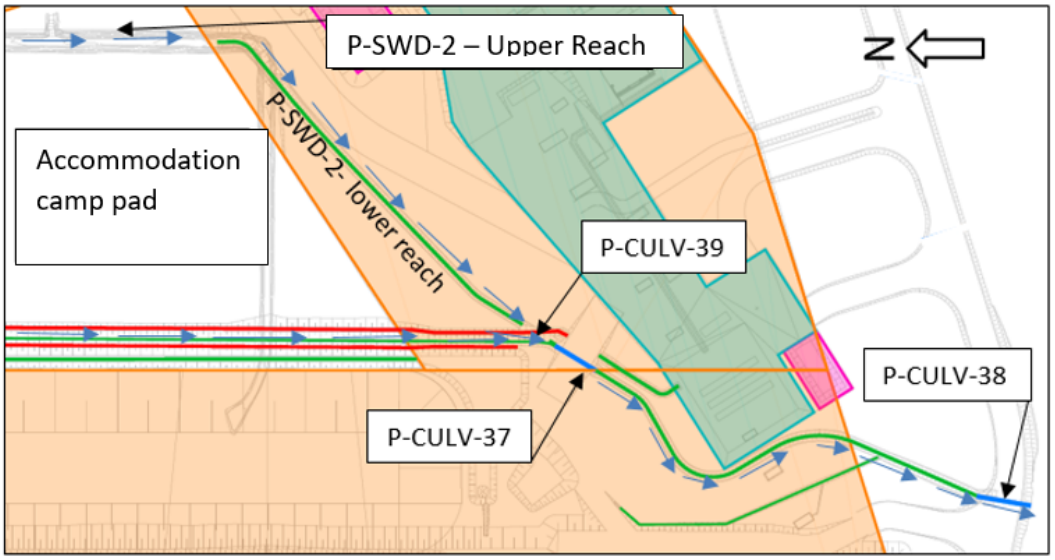

Figure 9-8: P-SWD-2

As part of the stacker reclaimer berm, a small trapezoidal ditch is designed to connect to this diversion.

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The results of the design calculations for P-SWD-2 are as follows:

- Bottom Width - 0.5m
- Side Slopes - 1V:1.5H
- Flow - 2.348 m^3/s
- Max Normal Flow Depth - 0.995m
- Max Velocity - 1.18 m/s

Since this ditch drains a number of drainage areas; the above results are for the total drainage area when the highest flow is expected.

9.8 Laydown LP7

Figure 9-9 indicates the location of laydown LP7.

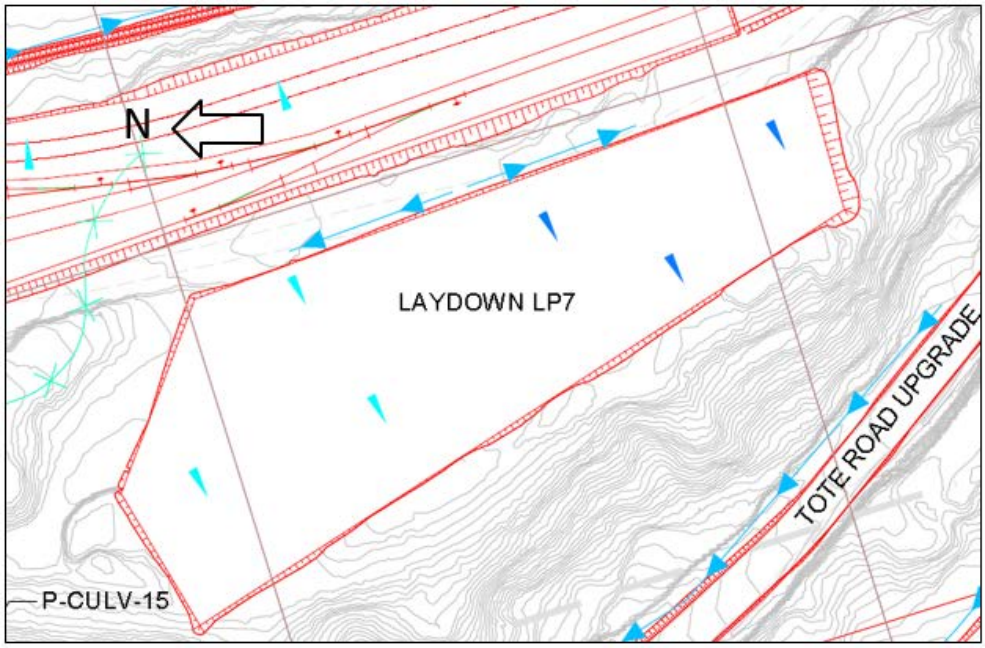

Figure 9-9: Laydown LP7 Drainage Plan

This laydown area will be drained as sheet flow to the west where it joins the Tote Road drainage and then diverts to the north.

9.9 Utility Berm – From Generation Station to South

Two drainage culverts will be provided beneath a utility berm. The details for the culverts are as follows:

- P-CULV-24 - 600mm Diameter
  - This culvert will be constructed beneath the existing utility berm located to the east of the eastern berm. No rip rap will be required.

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- P-CULV-27 - 600mm Diameter
  - This culvert will be constructed beneath the new section of the utility berm. No rip rap will be required.

The area can be seen in Figure 9-10.

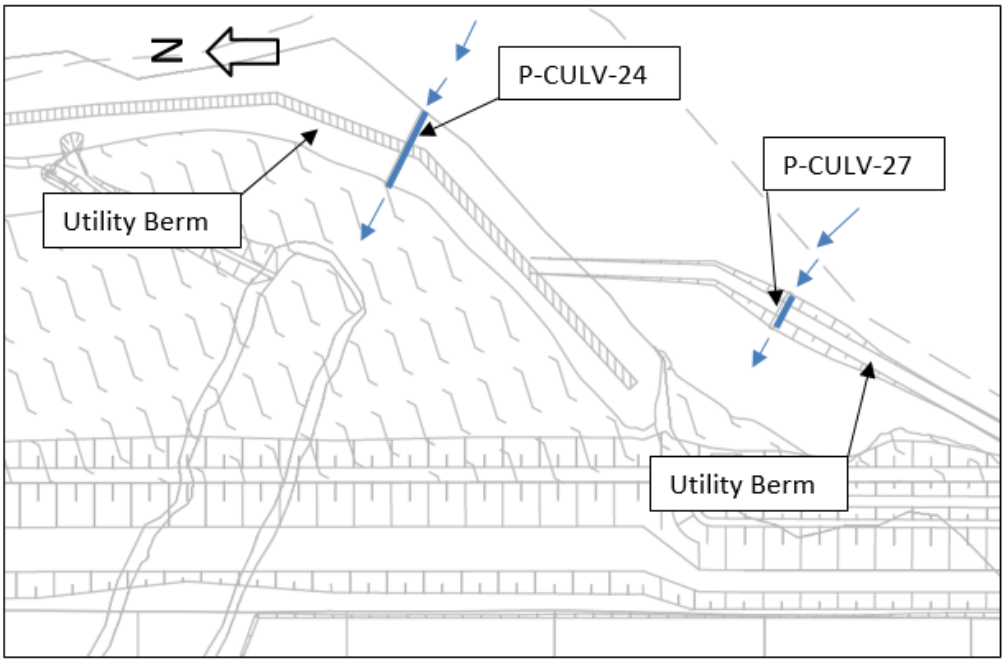

Figure 9-10: Utility Berm

9.10 Conveyor Bent Pads

Pads will be constructed along the conveyor alignment to support the conveyor bents located as per Figure 9-11. These platforms are in fill with a 1:200 fall across to facilitate drainage. Where they are in cut, daylight ditches will be constructed at 1:200 fall to ensure adequate drainage is achieved.

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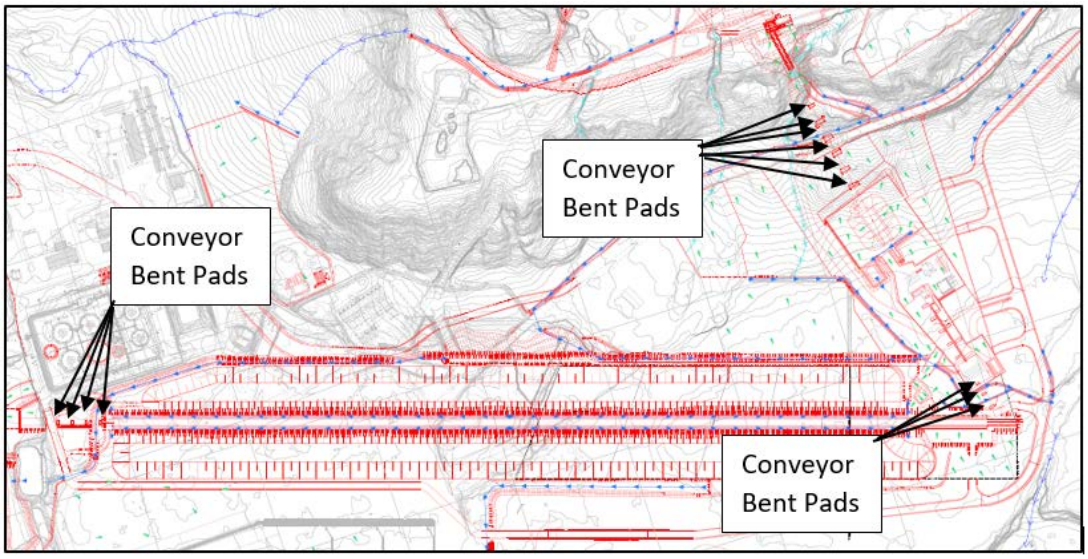

Figure 9-11: Conveyor Bent Pads

9.11 Accommodation Camp Pad

The Accommodation Camp Pad has been designed to allow for sheet flow across the pad. The catchment area only includes storm water runoff from the pad and flow from Laydown W10A. The pad drains toward the eastern berm and enters the clear water channel through P-CULV-40 as described in Section 7. Figure 9-12 shows the pad.

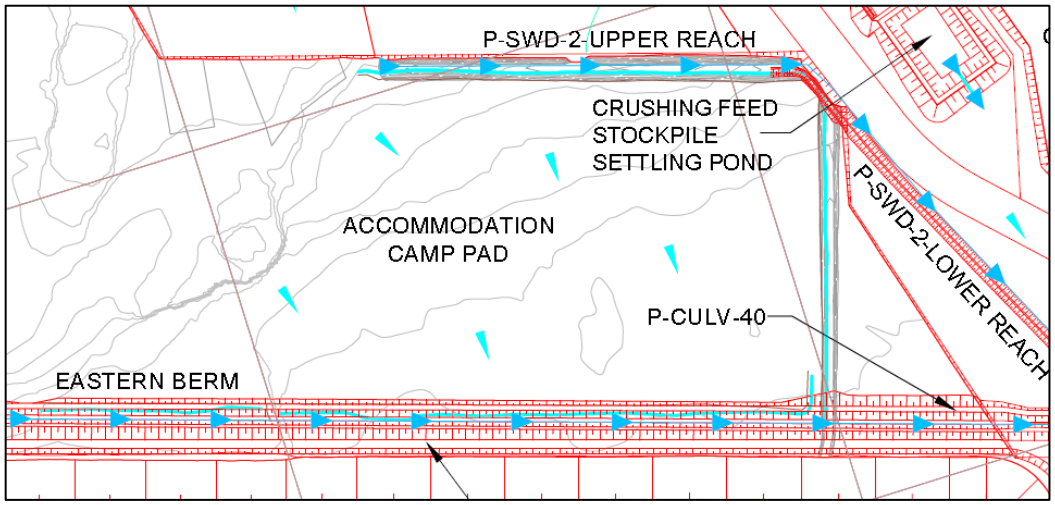

Figure 9-12: Accommodation Camp Pad Drainage

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Appendix A
IFC Drainage Drawings List

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Doc Number	Rev.	Doc Title	Status	Doc Type Code
H353004-00000-221-294-0002-0001	0	Site Wide - Standard Drawing - Earthworks & Drainage Details	Approved for Construction	294 - Standard Drawing
H353004-00000-221-294-0003-0001	0	Site Wide - Standard Drawing - Earthworks & Drainage Details	Approved for Construction	294 - Standard Drawing
H353004-00000-221-294-0004-0001	0	Site Wide - Standard Drawing - Earthworks & Drainage Details	Approved for Construction	294 - Standard Drawing
H353004-00000-221-294-0005-0001	0	Site Wide - Standard Drawing - Earthworks & Drainage Details	Approved for Construction	294 - Standard Drawing
H353004-00000-221-294-0006-0001	0	Site Wide - Standard Drawing - Earthworks & Drainage Details	Approved for Construction	294 - Standard Drawing
H353004-10000-221-272-0009-0001	0	MINE SITE - 2018 GENERATOR PAD EXPANSION - LAYOUT AND DRAINAGE DRAWING	Approved for Construction	272 - Layout Drawing
H353004-40000-221-272-0010-0001	0	PORT SITE - RAIL CAR DUMPER - DRAINAGE PLAN	Approved for Construction	272 - Layout Drawing
H353004-40000-223-271-0009-0001	0	PORT SITE - TOTE ROAD DRAINAGE UPGRADE - PLAN AND PROFILE SHEET 1 OF 3	Approved for Construction	271 - Plan / Profile
H353004-40000-228-271-0005-0001	0	PORT SITE - CONSTRUCTION PHASE - ACCESS ROADS DRAINAGE DETAILS	Approved for Construction	271 - Plan / Profile
H353004-40000-228-271-0007-0001	1	PORT SITE - STOCKYARD NO 1 - BERM (P-SWD-4) - DRAINAGE PLAN	Approved for Construction	271 - Plan / Profile
H353004-40000-228-272-0005-0001	0	PORT SITE - CRUSHING FEED STOCKPILE PAD - DRAINAGE PLAN	Approved for Construction	272 - Layout Drawing
H353004-40000-228-272-0006-0001	0	PORT SITE - CRUSHING AND SCREENING PAD - DRAINAGE PLAN	Approved for Construction	272 - Layout Drawing
H353004-40000-228-272-0009-0001	0	PORT SITE - LOCOMOTIVE WORKSHOP PAD - DRAINAGE PLAN	Approved for Construction	272 - Layout Drawing

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Doc Number	Rev.	Doc Title	Status	Doc Type Code
H353004-40000-228-272-0011-0001	0	PORT SITE - LAYDOWN AREA LP2 - DRAINAGE PLAN	Approved for Construction	272 - Layout Drawing
H353004-40000-228-272-0012-0001	0	PORT SITE - LAYDOWN AREA LP3 - DRAINAGE PLAN	Approved for Construction	272 - Layout Drawing
H353004-40000-228-272-0013-0001	0	PORT SITE - LAYDOWN AREA LP7 - DRAINAGE PLAN	Approved for Construction	272 - Layout Drawing
H353004-40000-228-272-0014-0001	0	PORT SITE - LAYDOWN AREA W10A - DRAINAGE PLAN	Approved for Construction	272 - Layout Drawing
H353004-40000-228-272-0015-0001	0	PORT SITE - LAYDOWN AREA W10B - DRAINAGE PLAN	Approved for Construction	272 - Layout Drawing
H353004-40000-228-272-0016-0001	0	PORT SITE - LAYDOWN AREA LP6 - DRAINAGE PLAN	Approved for Construction	272 - Layout Drawing
H353004-40000-228-272-0017-0001	0	PORT SITE - LAYDOWN AREA LP5 - DRAINAGE PLAN	Approved for Construction	272 - Layout Drawing

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Appendix B
Drawing H353004-40000-220-272-0008-0001 - Surface Water Management Plan - Milne Port

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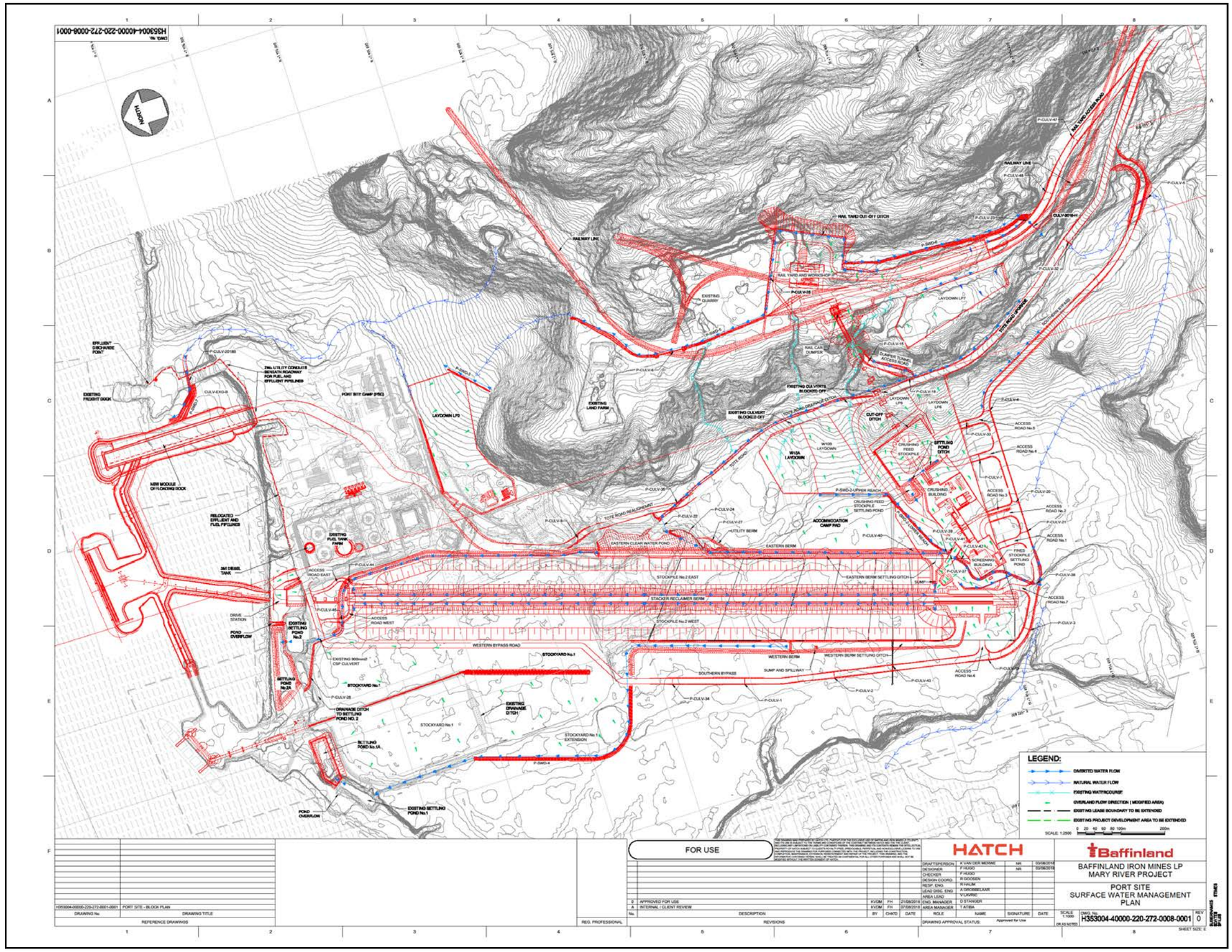

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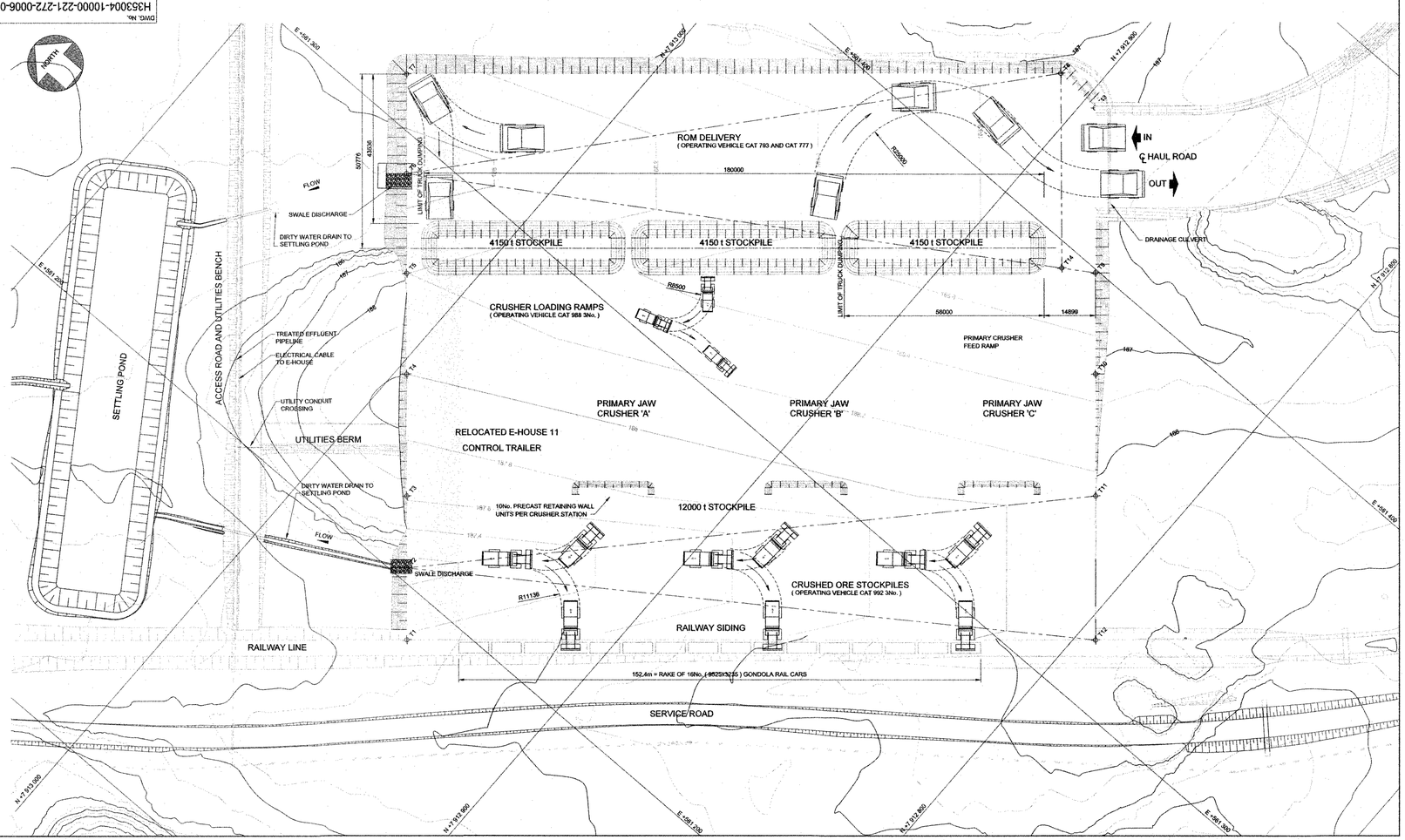
ATTACHMENT 10.3

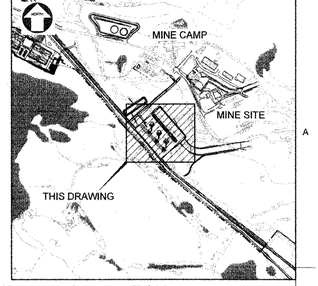
MINE SITE CRUSHER PAD DRAWINGS

DWG. No. H353004-10000-221-272-0006-0001



PLAN ON CRUSHER LOADING PAD

SCALE 1:500



KEY PLAN

NOTES:

1. LIDAR SURVEY PROVIDED BY PHOTSAT (2016)
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METERS.
3. CONTOURS ARE IN METERS. CONTOUR INTERVAL IS 0.5m.
4. ALL DIMENSIONS SHOWN ARE IN METERS, UNLESS OTHERWISE SPECIFIED.

LEGEND:

- 198 — CONTOUR
- EXISTING TREATED EFFLUENT
- NEW TREATED EFFLUENT
- ELECTRICAL CABLE

CRUSHER PAD SETTING OUT CO-ORDINATES

POINT	E	N	LEVEL
T1	561 187.603	7 912 946.397	187.630
T2	561 203.499	7 912 960.095	187.430
T3	561 219.407	7 912 973.804	187.630
T4	561 246.259	7 912 996.979	188.000
T5	561 268.645	7 913 016.237	187.630
T6	561 290.613	7 913 035.168	187.630
T7	561 312.582	7 913 054.100	187.630
T8	561 436.553	7 912 910.245	188.130
T9	561 399.145	7 912 864.606	188.130
T10	561 376.815	7 912 845.528	188.480
T11	561 349.940	7 912 822.334	188.130
T12	561 318.095	7 912 794.951	188.130
T13	561 435.506	7 912 896.141	188.130
T14	561 393.858	7 912 873.106	188.700

DRAWING No.	DRAWING TITLE
H353004-00000-221-294-0009-0001	STANDARD DRAWINGS - TYPICAL PAD, DITCH AND BERM SECTIONS
H353004-00000-221-294-0006-0001	STANDARD DRAWINGS - EARTHWORKS AND DRAINAGE DETAILS
H353004-10000-228-272-0005-0001	CRUSHER PAD - DRAINAGE PLAN
H353004-10000-221-273-0003-0001	CRUSHER PAD - PAD CROSS SECTIONS
H353004-10000-221-272-0007-0001	CRUSHER PAD - CRUSHER BARRIER SETTING OUT PLAN
H353004-00000-224-272-0027-0001	RAILWAY PLAN AND LONGITUDINAL SECTION CH106.900km TO CH109.610KM
H353004-41000-231-260-0002-0001	PRIMARY CRUSHER FEED RAMP - CONCRETE ARRANGEMENT AND DETAILS
H353004-19000-231-260-0001-0003	PRIMARY CRUSHER AREA - RETAINING WALL DETAILS
H353004-19000-231-260-0001-0001	PRIMARY JAW CRUSHER FOUNDATIONS - ARRANGEMENT AND DETAILS

REFERENCE DRAWINGS

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LEAD DISC. ENG.	A GROBBELAAR		2018-09-03
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ENG. MANAGER	D STANIER		
AREA MANAGER	T ATIBA		2018-08-03
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Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

MINE SITE
CRUSHER PAD
LAYOUT PLAN

SCALE	DWG. No.	REV
1:500 OR AS NOTED	H353004-10000-221-272-0006-0001	1

SHEET SIZE: E

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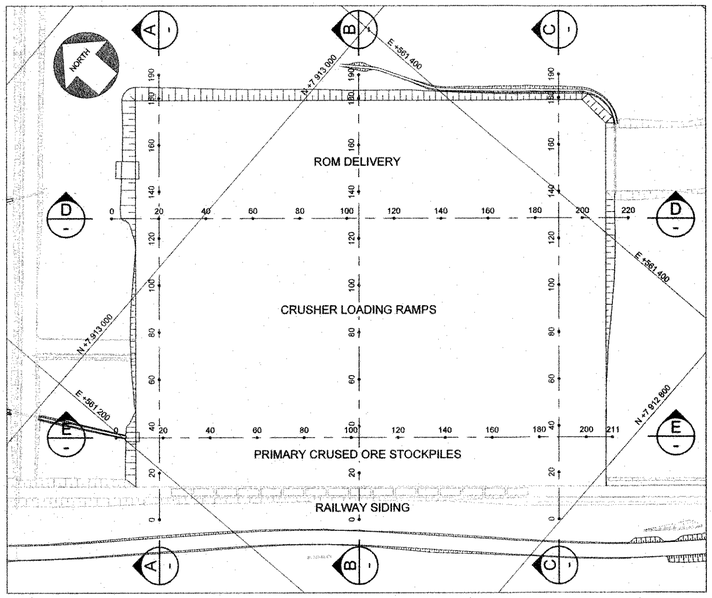
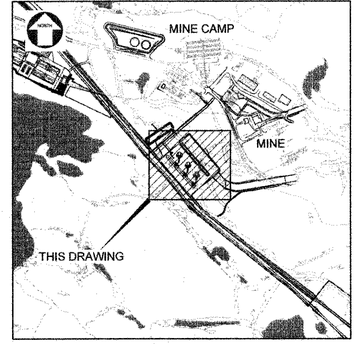
$TIMES
$FILES

DWG. No. H353004-10000-221-273-0003-0001



PLAN ON CRUSHER PAD
SCALE 1:1000



KEY PLAN

NOTES:

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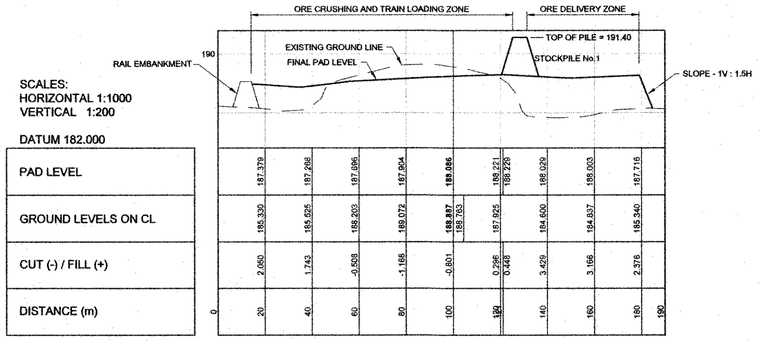
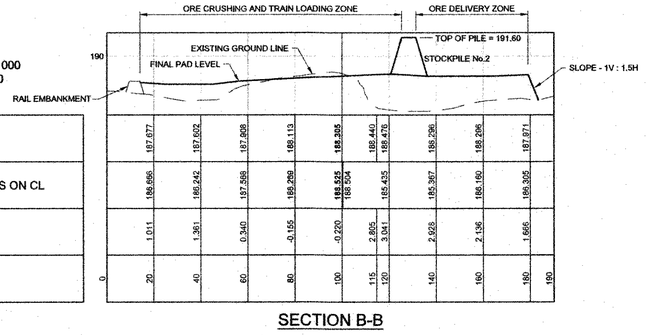


SCALES:
HORIZONTAL 1:1000
VERTICAL 1:200

DATUM 182.000

PAD LEVEL	187.379	187.268	187.096	187.804	188.086	189.221	189.229	188.029	188.003	187.718	
GROUND LEVELS ON CL	185.330	185.526	188.203	188.072	188.887	188.763	187.926	184.600	184.837	185.340	
CUT (-) / FILL (+)	2.050	1.743	-0.938	-1.168	-0.801	0.296	0.448	3.429	3.166	2.378	
DISTANCE (m)	0	20	40	60	80	100	104	120	140	160	180	190

SECTION A-A

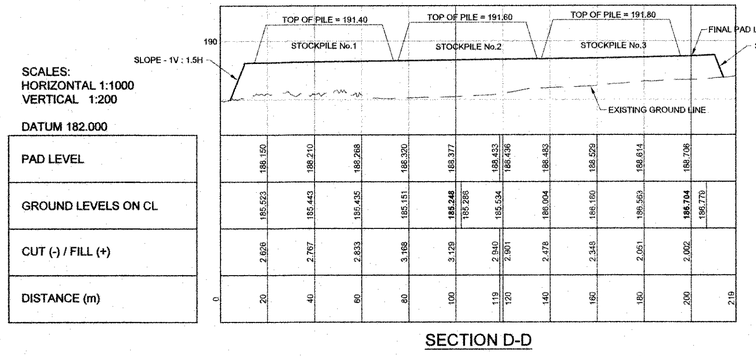


SCALES:
HORIZONTAL 1:1000
VERTICAL 1:200

DATUM 185.000

PAD LEVEL	187.677	187.602	187.268	188.113	188.385	188.440	188.476	188.286	188.286	187.971	
GROUND LEVELS ON CL	186.666	186.242	187.588	188.269	188.525	188.504	189.435	185.367	186.160	186.305	
CUT (-) / FILL (+)	1.011	1.361	0.340	-0.155	-0.220	2.805	3.041	2.928	2.136	1.666	
DISTANCE (m)	0	20	40	60	80	100	115	120	140	160	180	190

SECTION B-B

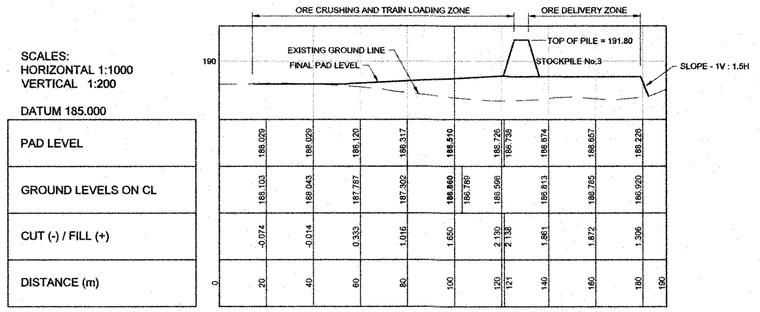


SCALES:
HORIZONTAL 1:1000
VERTICAL 1:200

DATUM 182.000

PAD LEVEL	188.150	188.210	188.268	188.320	188.377	188.433	188.436	188.483	188.559	188.614	188.706	
GROUND LEVELS ON CL	185.523	185.443	185.435	185.151	185.248	185.286	185.534	186.004	186.160	186.553	186.704	186.779
CUT (-) / FILL (+)	2.626	2.767	2.833	3.168	3.129	2.940	2.901	2.478	2.348	2.061	2.002	
DISTANCE (m)	0	20	40	60	80	100	119	120	140	160	180	200	219

SECTION D-D

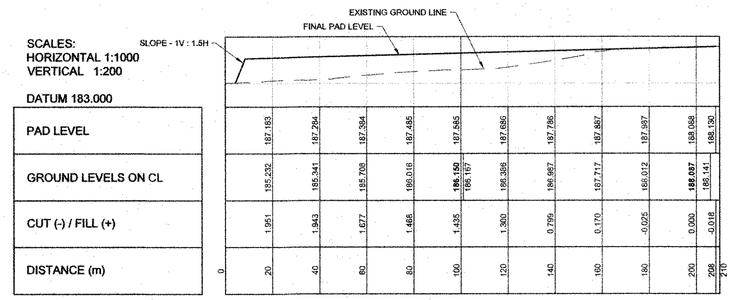


SCALES:
HORIZONTAL 1:1000
VERTICAL 1:200

DATUM 185.000

PAD LEVEL	188.029	188.029	188.120	188.317	188.510	188.726	188.738	188.674	188.657	188.229	
GROUND LEVELS ON CL	188.103	188.043	187.787	187.302	186.860	186.769	186.596	186.813	186.785	186.920	
CUT (-) / FILL (+)	-0.074	-0.014	0.333	1.016	1.650	2.130	2.138	1.861	1.872	1.306	
DISTANCE (m)	0	20	40	60	80	100	120	121	140	160	180	190

SECTION C-C



SCALES:
HORIZONTAL 1:1000
VERTICAL 1:200

DATUM 183.000

PAD LEVEL	187.183	187.294	187.384	187.485	187.585	187.686	187.786	187.887	187.987	188.068	188.130	
GROUND LEVELS ON CL	185.232	185.341	185.708	186.016	186.159	186.167	186.386	186.967	187.717	188.012	188.037	188.141
CUT (-) / FILL (+)	1.951	1.943	1.677	1.468	1.425	1.300	0.799	0.170	-0.025	0.000	-0.018	
DISTANCE (m)	0	20	40	60	80	100	120	140	160	180	200	208	210

SECTION E-E

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DRAWING No.	DRAWING TITLE
H353004-00000-221-294-0008-0001	STANDARD DRAWINGS - TYPICAL PAD, DITCH AND BERM SECTIONS
H353004-10000-221-272-0006-0001	CRUSHER PAD - LAYOUT PLAN
H353004-10000-231-260-0003-0001	PRIMARY CRUSHER STOCKPILE - RETAINING WALL DETAILS
H353004-10000-231-280-0002-0001	PRIMARY CRUSHER FFED RAMP - CONCRETE ARRANGEMENT AND DETAILS
H353004-10000-231-260-0001-0001	PRIMARY JAW CRUSHER - ARRANGEMENT AND DETAILS

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1	EDC NOTE REMOVED	JM	FH	02/08/2018
0	APPROVED FOR CONSTRUCTION	IHB	FH	13/04/2018

REVISIONS

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	I BARNARD	NR	01/08/2018
DESIGNER	I BARNARD	NR	01/08/2018
CHECKER	F HUGO		2018-08-02
DESIGN COORD.	R GOOSEN		2018-08-03
RESP. ENG.	R HALIM		2018-08-03
LEAD DISC. ENG.	A GROBBELAAR		2018-08-03
AREA LEAD	T ATIBA		2018-08-03
ENG. MANAGER	D STANGER		
AREA MANAGER	T ATIBA		2018-08-03

DRAWING APPROVAL STATUS: Approved for Construction

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

MINE SITE
CRUSHER PAD
PAD CROSS SECTIONS

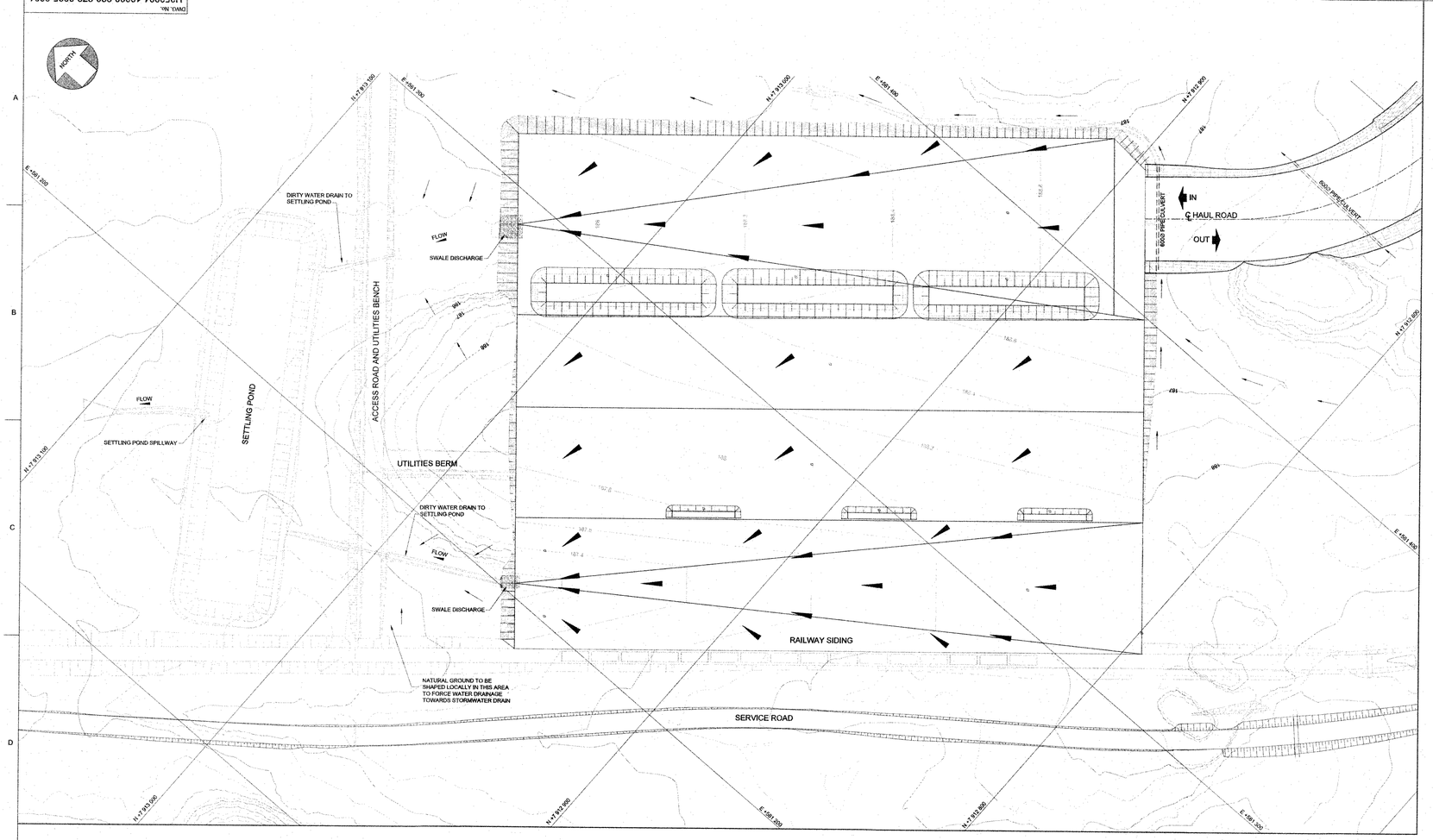
SCALE 1:1000 OR AS NOTED

DWG. No. H353004-10000-221-273-0003-0001

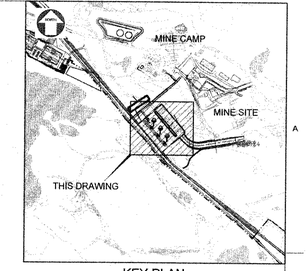
REV 1

SHEET SIZE: E

USERNAMES
STIMES
SDATES



PLAN ON CRUSHER PAD
SCALE 1:500



KEY PLAN

NOTES:

1. LIDAR SURVEY PROVIDED BY PHOTSAT (2016).
2. CO-ORDINATE GRID IS SHOWN IN UTM (NAD83), ZONE 17 AND IS IN METERS.
3. CONTOURS ARE IN METERS. THE CONTOUR INTERVAL IS 0.5m.
4. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE NOTED.
5. THE POND IS DESIGNED TO BE OPERATED EMPTY.
6. IT IS ASSUMED THAT ALL RUN OFF COLLECTED BY THE SETTLING POND IS NON-ACID GENERATING AND CAN BE DISCHARGED TO THE ENVIRONMENT ONCE THE REQUIREMENTS OF BIM ENVIRONMENTAL DESIGN CRITERIA HAS BEEN ACHIEVED. WATER TO BE DISCHARGED TO AN APPROVED POINT, IN ACCORDANCE WITH THE CLIENT'S (BIM) ENVIRONMENTAL REQUIREMENTS.
7. THE INSTALLATION OF THE GEOMEMBRANE (ENVIRO LINER 6050HD) IS TO BE IN STRICT ACCORDANCE WITH THE SPECIALIST PROVIDERS SPECIFICATIONS.

LEGEND:

- OFF PAD FLOW DIRECTION
- ON PAD FLOW DIRECTION

PERMIT TO PRACTICE
HATCH LTD.
Signature _____
Date _____
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

H353004-10000-228-272-0006-0001	CRUSHER PAD SETTLING POND - DETAILS
H353004-10000-228-272-0005-0001	CRUSHER PAD SETTLING POND - PLAN AND PROFILES
H353004-10000-221-273-0003-0001	CRUSHER PAD - PAD CROSS SECTIONS
H353004-10000-221-272-0006-0001	CRUSHER PAD - LAYOUT PLAN
DRAWING No.	DRAWING TITLE

REFERENCE DRAWINGS

REG. PROFESSIONAL

FOR CONSTRUCTION

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No.	DESCRIPTION	BY	CHKD	DATE
1	EDC NOTE REMOVED	JM	FH	01/08/2018
0	APPROVED FOR CONSTRUCTION	IHB	FH	16/04/2018

REVISIONS

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	I BARNARD	NR	01/08/2018
DESIGNER	S HALL	NR	01/08/2018
CHECKER	F HUGO		2018-08-03
DESIGN COORD.	R GOOSEN		2018-08-03
RESP. ENG.	R HAUM		2018-08-03
LEAD DISC. ENG.	A GROBBELAAR		2018-08-03
AREA LEAD	T ATTIBA		2018-08-03
ENG. MANAGER	D STANGER		2018-08-03
AREA MANAGER	T ATTIBA		2018-08-03

DRAWING APPROVAL STATUS: Approved for Construction

Baffinland

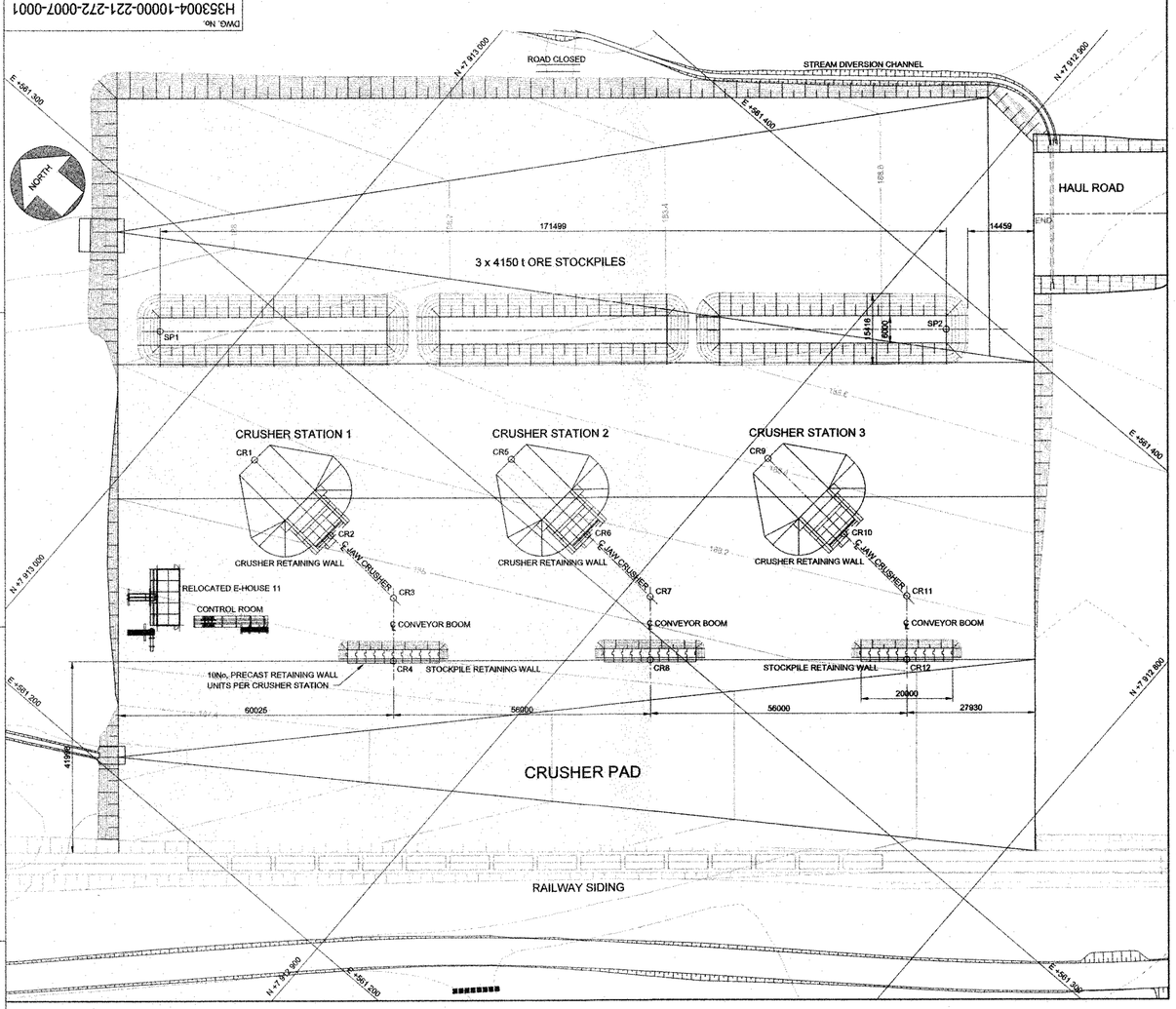
BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

MINE SITE
CRUSHER PAD
DRAINAGE PLAN

SCALE 1:500 OR AS NOTED
DWG. No. H353004-10000-228-272-0005-0001
REV 1
SHEET SIZE: E

STAGES
SCREENNAMES
STYLES
SHEETS

DWG. No. H353004-10000-221-272-0007-0001



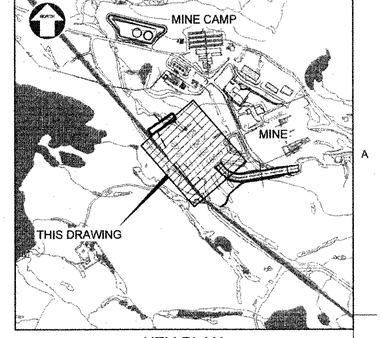
PLAN ON CRUSHER LOADING PAD

SCALE 1:500

SETTING OUT CO-ORDINATES		
POINT	E	N
ORE STOCKPILES		
SP1	561 280.150	7 913 013.946
SP2	561 392.157	7 912 884.075
CRUSHER STATIONS		
CR1	561 272.137	7 912 979.908
CR2	561 270.406	7 912 956.622
CR3	561 268.974	7 912 937.297
CR4	561 256.561	7 912 928.370
CR5	561 308.711	7 912 937.501
CR6	561 306.982	7 912 914.215
CR7	561 305.549	7 912 894.912
CR8	561 295.155	7 912 885.939
CR9	561 345.285	7 912 895.094
CR10	561 343.556	7 912 871.808
CR11	561 342.123	7 912 852.505
CR12	561 331.728	7 912 843.532

LEGEND:

195	CONTOUR
— — — —	TREATED EFFLUENT PIPELINE
TOC	TOP OF CONCRETE
FPL	FINAL PAD LEVEL



KEY PLAN

NOTES:

1. LIDAR SURVEY PROVIDED BY PHOTSAT (2016)
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METERS.
3. CONTOURS ARE IN METERS. CONTOUR INTERVAL IS 0.5m.
4. ALL DIMENSIONS SHOWN ARE IN METERS, UNLESS OTHERWISE SPECIFIED.

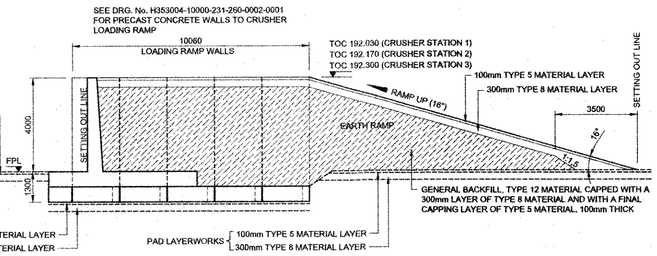
MATERIAL AND COMPACTION SPECIFICATION:

SUBGRADE PREPARATION:
THE SUBGRADE SHOULD SHOULD BE PROOF-ROLLED AND INSPECTED PRIOR TO PLACING FILL MATERIALS. THE IDENTIFIED SOFT AREAS SHALL BE FURTHER COMPACTED, OR IF NECESSARY, BE MITIGATED USING GRANULAR OR ROCK FILL. A QUALIFIED GEOTECHNICAL ENGINEER SHALL INSPECT AND APPROVE THE SUBGRADE.
THE ROCKFILL SHALL NOT BE PLACED IN WATER OR ON ICE. DEWATERING IS REQUIRED WHERE PONDING WATER IS ENCOUNTERED, OVER-EXCAVATION IS REQUIRED FOR GROUND ICE, IF ENCOUNTERED.
THE SUBGRADE ON THE GROUND SHALL BE LEFT AS IT IS NATURALLY BEFORE CONSTRUCTION AS MUCH AS POSSIBLE. THE OVER-EXCAVATION SHOULD BE MINIMIZED TO AVOID DISTURBANCE OF THE EXISTING PERMAFROST.

TYPE 5 (CRUSHER RUN 32mm MINUS MATERIAL) OR TYPE 3 (CRUSHER RUN 50mm MINUS):
THE MATERIAL MUST BE PLACED IN LIFTS NOT EXCEEDING 200mm AND SHALL BE COMPACTED BY MINIMUM 5 PASSES OF A MINIMUM 15 TON VIBRATORY ROLLER WITH VIBRATIONS IN THE RANGE OF 1200 TO 1500 vpm AND THE ROLLER SPEED OF ABOUT 2mph (3.2km/h). ALTERNATIVELY, THE COMPACTION SHOULD ACHIEVE A MINIMUM OF 100 PERCENT OF MAXIMUM DRY DENSITY AS DETERMINED BY TEST METHOD ASTM D698.

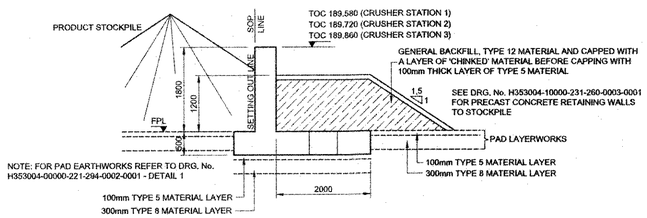
TYPE 8 (CRUSHER RUN 150mm MINUS):
THE ROCKFILL MUST BE PLACED IN LIFTS NOT EXCEEDING 500mm. THE PLACEMENT SHALL AVOID SEGREGATION AND NESTING OF COARSE PARTICLES. IT SHALL BE COMPACTED BY MINIMUM 5 PASSES OF A MINIMUM 15 TON VIBRATORY ROLLER WITH VIBRATIONS IN THE RANGE OF 1200 TO 1500 vpm AND THE ROLLER SPEED OF ABOUT 2mph (3.2km/h). EACH LIFT MUST BE "PROOF-ROLLED" PRIOR TO PLACING THE SUBSEQUENT LIFT.

TYPE 12 (RUN OF QUARRY):
THE ROCKFILL, IF USED, MUST BE PLACED IN LIFTS NOT EXCEEDING 1000mm. THE ROCKFILL SHALL BE COMPACTED BY MINIMUM 5 PASSES OF A MINIMUM 15 TON VIBRATORY ROLLER WITH VIBRATIONS IN THE RANGE OF 1200 TO 1500 vpm AND THE ROLLER SPEED OF ABOUT 2mph (3.2km/h). ALTERNATIVE COMPACTORS SUCH AS HEAVY LOADED RUBBER TIRED HAUL TRUCKS CAN ONLY BE USED AS PER A WRITTEN APPROVAL FROM THE ENGINEER.



TYPICAL ELEVATION ON CRUSHER LOADING RAMP

SCALE 1:100



TYPICAL ELEVATION ON STOCKPILE RETAINING WALL

SCALE 1:50

DRAWING No.	DRAWING TITLE
H353004-00000-221-294-0008-0001	STANDARD DRAWINGS - TYPICAL PAD, DITCH AND BERM SECTIONS
H353004-00000-221-294-0006-0001	STANDARD DRAWINGS - EARTHWORKS AND DRAINAGE DETAILS
H353004-10000-221-272-0006-0001	CRUSHER PAD - LAYOUT PLAN
H353004-41000-231-260-0002-0001	PRIMARY CRUSHER FEED RAMP - CONCRETE ARRANGEMENT AND DETAILS
H353004-19000-231-260-0001-0003	PRIMARY CRUSHER AREA - RETAINING WALL DETAILS
H353004-19000-231-260-0001-0001	PRIMARY JAW CRUSHER FOUNDATIONS - ARRANGEMENT AND DETAILS

REFERENCE DRAWINGS

PERMIT TO PRACTICE
HATCH LTD.
Signature
Date
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

REGISTERED PROFESSIONAL ENGINEER — R. A. HALIM — LICENSEE — 2019-08-03 — NWT/NU

REG. PROFESSIONAL

FOR CONSTRUCTION

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No.	DESCRIPTION	BY	CHK'D	DATE
1	EDC NOTE REMOVED	JM	FH	02/08/2018
0	APPROVED FOR CONSTRUCTION	IHB	FH	13/04/2018

REVISIONS

HATCH

DRAFTSPERSON	I BARNARD	NR	01/08/2018
DESIGNER	I BARNARD	NR	01/08/2018
CHECKER	F HUGO		2018-08-03
DESIGN COORD.	R GOOSEN		2018-08-03
RESP. ENG.	R HALIM		2018-08-03
LEAD DISC. ENG.	A GROBBELAAR		2018-08-03
AREA LEAD	T ATIBA		
ENG. MANAGER	D STANGER		
AREA MANAGER	T ATIBA		2018-08-03

DRAWING APPROVAL STATUS: Approved for Construction

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

MINE SITE
CRUSHER PAD
CRUSHER RAMP & WALLS SETTING OUT

SCALE 1:500 OR AS NOTED | DWG. No. H353004-10000-221-272-0007-0001 | REV 1

SHEET SIZE: E

$USERNAMES
$FILES
$FILES
$TIMES

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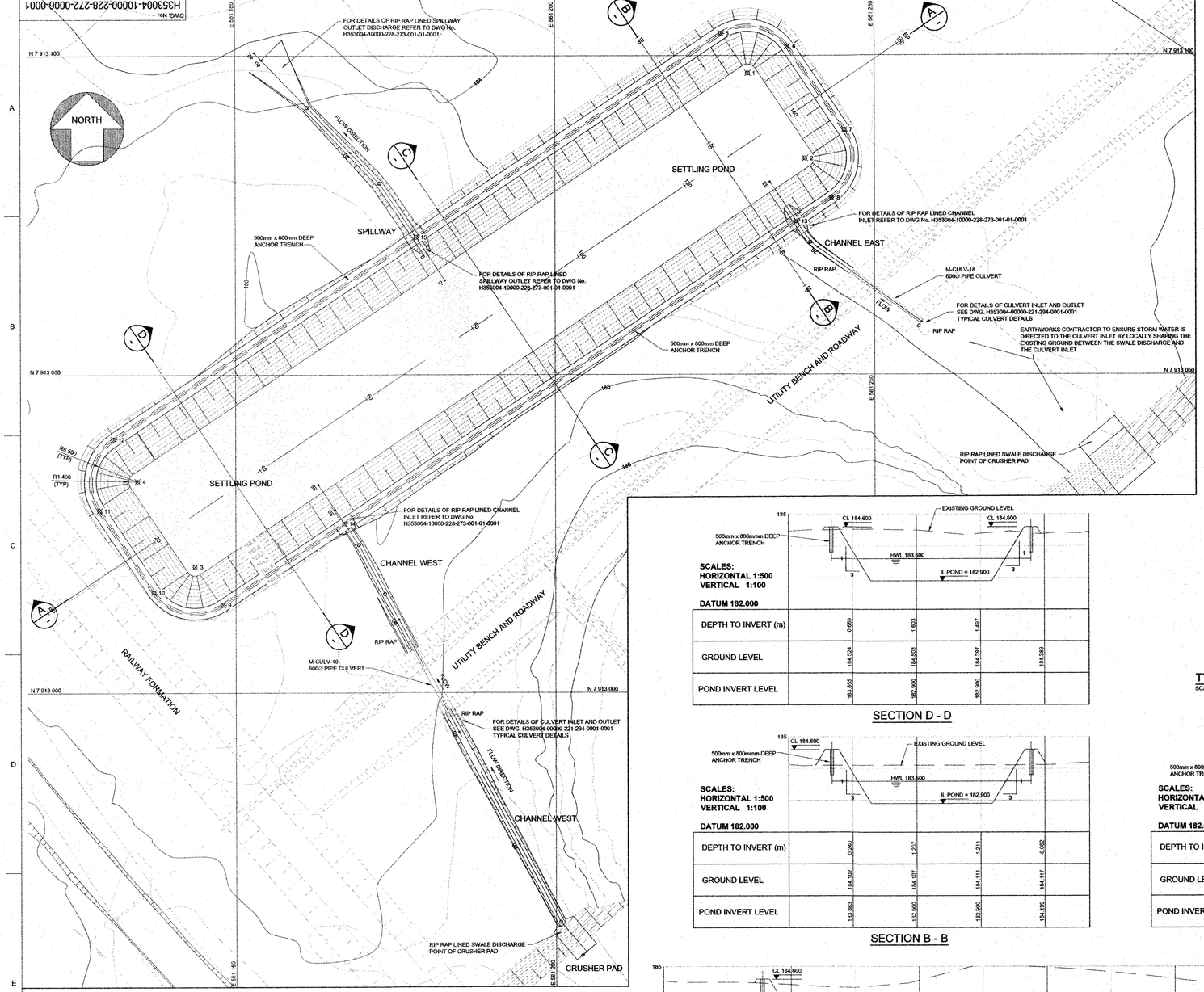
DWG. No. H353004-10000-228-272-0006-0001



PLAN ON CRUSHER PAD SETTLING POND

SCALE: 1:250

SCALES:
HORIZONTAL 1:500
VERTICAL 1:100

DATUM 182.000

| | | |

DWG. No. H353004-10000-228-273-0001-0001

SCALES:
HORIZONTAL 1:500
VERTICAL 1:100

DATUM 182.000

INVERT LEVELS (m)	184.200	184.148	184.086	184.010	
GROUND LEVELS ON CL (m)			184.148		
DEPTH TO TRENCH	0.003	0.000	0.061	0.145	
DISTANCE (m)	0.000	13.483	20	28.010	33
VERTICAL PROFILE GRADES	-0.38%		-0.95%		

EAST CHANNEL - PROFILE

PLAN ON SETTLING POND EAST CHANNEL INLET
SCALE 1:50

SECTION A - A
SCALE 1:50

KEY PLAN

SECTION B - B
SCALE 1:50

NOTES:

1. LIDAR SURVEY PROVIDED BY PHOTSAT (2016).
2. CO-ORDINATE GRID IS SHOWN IN UTM (NAD83), ZONE 17 AND IS IN METERS.
3. CONTOURS ARE IN METERS. THE CONTOUR INTERVAL IS 0.5m.
4. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE NOTED.
5. THE POND IS DESIGNED TO BE OPERATED EMPTY.
6. IT IS ASSUMED THAT ALL RUN OFF COLLECTED BY THE SETTLING POND IS NON-ACID GENERATING AND CAN BE DISCHARGED TO THE ENVIRONMENT ONCE THE REQUIREMENTS OF BIM ENVIRONMENTAL DESIGN CRITERIA HAS BEEN ACHIEVED. WATER TO BE DISCHARGED TO AN APPROVED POINT, IN ACCORDANCE WITH THE CLIENT'S (BIM) ENVIROMENTAL REQUIREMENTS.
7. THE INSTALLATION OF THE GEOMEMBRANE (ENVIRO LINER 6000HD) IS TO BE IN STRICT ACCORDANCE WITH THE SPECIALIST PROVIDERS SPECIFICATIONS.

LEGEND:

CL	CREST LEVEL
IL	INVERT LEVEL
HWL	HIGH WATER LEVEL
FBL	FREE BOARD LEVEL
— - — -	TYPE 4 GEO-MEMBRANE (ENVIRO LINER 6000 HD) OR SIMILAR APPROVED
— — — —	NON WOVEN GEO-TEXTILE (LAYFIELD LP7) OR SIMILAR APPROVED

SCALES:
HORIZONTAL 1:500
VERTICAL 1:100

DATUM 182.000

INVERT LEVELS (m)		187.127	184.866	184.814	184.741	184.667	184.600		
GROUND LEVELS ON CL (m)	185.095	185.100	185.067	185.105	185.128	184.767	184.765	184.771	184.812
DEPTH TO TRENCH	-2.027		0.201	0.290	0.387	0.099	0.165		
DISTANCE (m)	0	1.466	5.987	20	40	60	78.356	80	85
VERTICAL PROFILE GRADES	-50.02%		-0.37%						

WEST CHANNEL - PROFILE

PLAN ON SETTLING POND WEST CHANNEL INLET
SCALE 1:50

SECTION C - C
SCALE 1:50

SECTION D - D
SCALE 1:25

SCALES:
HORIZONTAL 1:500
VERTICAL 1:100

DATUM 182.000

INVERT LEVELS (m)		183.900	183.900	183.857	183.797	183.792
GROUND LEVELS ON CL (m)		184.414		184.218	183.798	
DEPTH TO TRENCH		0.514	0.494	0.361	0.001	0.000
DISTANCE (m)	-5	0.000	5.614	20	40	41.636
VERTICAL PROFILE GRADES		0.00%	-0.30%			

SPILLWAY OUTLET - PROFILE

PLAN ON SETTLING POND SPILLWAY OUTLET
SCALE 1:50

SECTION E - E
SCALE 1:25

PLAN ON SPILLWAY OUTLET DISCHARGE
SCALE 1:100

DETAIL 1 - POND LINER ANCHOR TRENCH
SCALE 1:25

DETAIL 2 - POND LINER
SCALE 1:10

DETAIL 3 - TRENCH LINER
SCALE 1:10

PERMIT TO PRACTICE
HATCH LTD.
Signature
Date 2018-08-03
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

REFERENCE DRAWINGS

DRAWING No.	DRAWING TITLE
H353004-00000-221-294-0006-0001	STANDARD DRAWING - EARTHWORKS AND DRAINAGE DETAILS
H353004-10000-221-271-0001-0001	UTILITY BENCH AT CRUSHER PAD - PLAN AND PROFILE
H353004-10000-228-272-0006-0001	CRUSHER PAD SETTLING POND - PLAN AND PROFILES
H353004-10000-221-272-0006-0001	CRUSHER PAD - LAYOUT PLAN

REG. PROFESSIONAL: REGISTERED PROFESSIONAL ENGINEER, L1247, R. A. HALIM, LICENSEE, 2018-08-03, NWT/NU

FOR CONSTRUCTION

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REVISIONS

No.	DESCRIPTION	BY	CHK'D	DATE
1	EDC NOTE REMOVED	JM	FH	02/08/2018
0	APPROVED FOR CONSTRUCTION	IHB	FH	01/06/2018

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	I BARNARD	NR	01/08/2018
DESIGNER	I BARNARD	NR	01/08/2018
CHECKER	F HUGO		2018-08-03
DESIGN COORD.	R GOOSEN		2018-08-03
RESP. ENG.	R HALIM		2018-08-03
LEAD DISC. ENG.	A GROBBELAAR		2018-08-03
AREA LEAD	T ATIBA		
ENG. MANAGER	D STANGER		
AREA MANAGER	T ATIBA		2018-08-03

DRAWING APPROVAL STATUS: Approved for Construction

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

MINE SITE
CRUSHER PAD SETTLING POND
DETAILS

SCALE 1:500 OR AS NOTED | DWG. No. H353004-10000-228-273-0001-0001 | REV 1

SHEET SIZE: E

ATTACHMENT 11

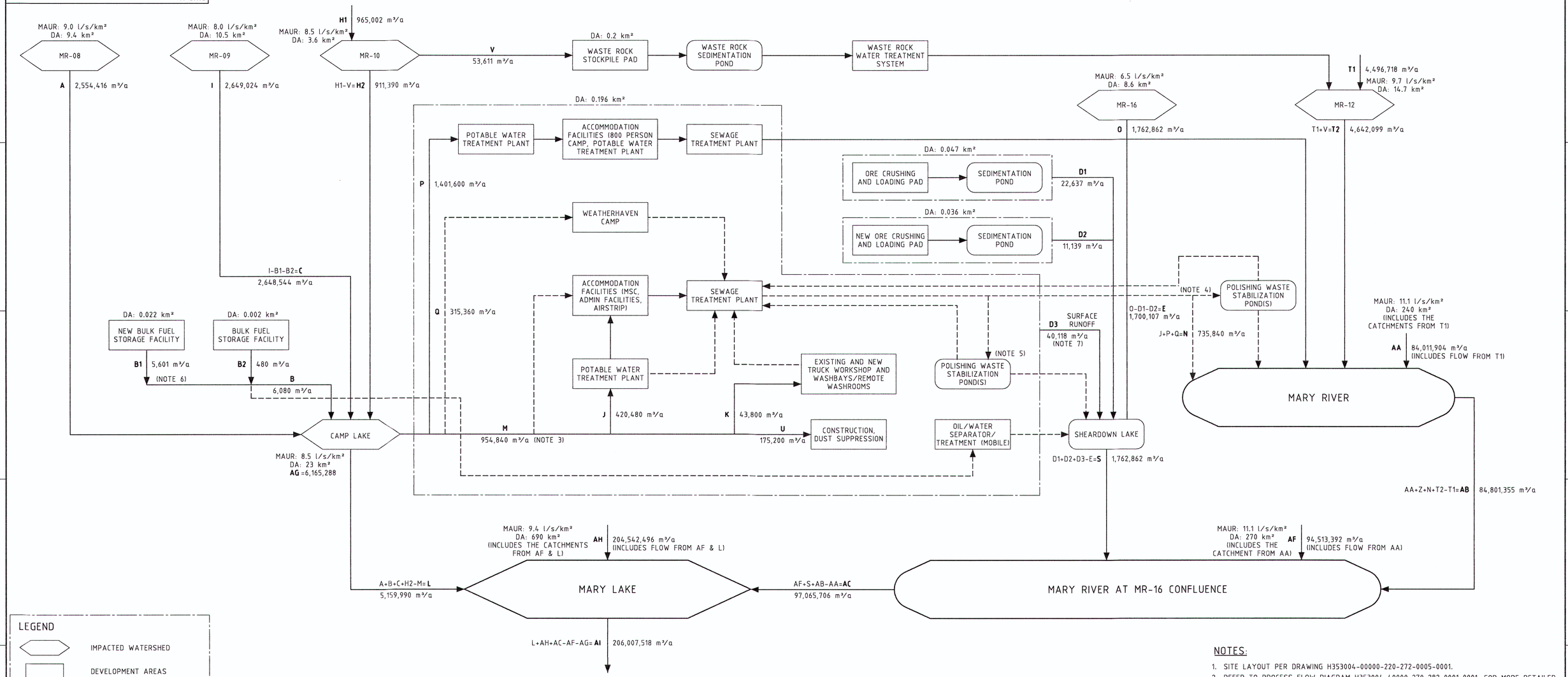
UPDATED BLOCK FLOW DIAGRAMS

11.1 Mine Site Water Balance
11.2 Mine Site Water and Sewage Process Flow Diagram
11.3 Port Site Water Balance
11.4 Port Site Water and Sewage Process Flow Diagram
11.5 Ore Staging Water Balance

ATTACHMENT 11.1

MINE SITE WATER BALANCE

DWG. No. H353004-10000-270-252-0002-0001



LEGEND

- IMPACTED WATERSHED
- DEVELOPMENT AREAS
- DEVELOPMENT AREAS SUBJECT TO APPROVAL
- STORMWATER PONDS
- CONTINUOUS OR WATERSHED FLOW
- INTERMITTENT FLOW
- A/AA 100,000 — ANNUAL VOLUME (m³/a)
- MAUR — MEAN ANNUAL UNIT RUNOFF (l/s/km²)
- MSC — MINE SITE COMPLEX

NOTES:

1. SITE LAYOUT PER DRAWING H353004-00000-220-272-0005-0001.
2. REFER TO PROCESS FLOW DIAGRAM H353004-40000-270-282-0001-0001, FOR MORE DETAILED WATER SUPPLY AND WASTE WATER TREATMENT.
3. RAW WATER SUPPLY FLOW RATE CAMP LAKE IS EQUAL TO OR LESS THAN TYPE A WATER LICENCE 2AM-MRY1325 FLOW RATE LIMIT OF 657.5m³/day (240,000m³/year) TOTAL.
4. USE OF POLISHING WASTE STABILIZATION POND PRIOR TO MARY RIVER DISCHARGE WILL OCCUR ON A CONTINGENCY BASIS ONLY, IN THE EVENT OF OFF-SPEC TREATED SEWAGE EFFLUENT.
5. USE OF POLISHING WASTE STABILIZATION POND AND SHEARDOWN LAKE DISCHARGE WILL OCCUR ON A CONTINGENCY BASIS ONLY, SHOULD CAPACITY BE EXCEEDED THROUGH THE SEWAGE TREATMENT SYSTEM DISCHARGING TO MARY RIVER.
6. BULK FUEL STORAGE AREA RUNOFF DRAINED TO ENVIRONMENT IF QUALITY SATISFIES DISCHARGE REQUIREMENTS; OTHERWISE IS CONVEYED TO MOBILE OIL/WATER SEPARATOR FOR TREATMENT PRIOR TO DISCHARGE.
7. PLANT SITE RECEIVES ONLY PRECIPITATION-RUNOFF AND NO SURFACE WATER RUNOFF FROM SURROUNDING AREAS.
8. REFER ERP SURFACE WATER AND AQUATIC ECOSYSTEM MANAGEMENT FROM H349000-1000-07-126-0005, REV 1.

PERMIT TO PRACTICE
HATCH LTD.
Signature RJ.
Date 2018-09-14
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

REGISTERED PROFESSIONAL ENGINEER — PR JIM — LICENSEE — 2018-09-14 — NT/NU

FOR USE

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No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR USE	HV	PC	12-09-2018

REVISIONS

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	H VINCENT	NR	24-08-2018
DESIGNER		NR	
CHECKER	P CHERRY		2018-09-13
DESIGN COORD.	R GOOSEN		2018-09-14
RESP. ENG.	P JIM	RJ.	2018-09-14
LEAD DISC. ENG.	P CHERRY		2018-09-13
AREA LEAD	T ATIBA		
ENG. MANAGER	D STANGER		2018-9-14
AREA MANAGER	T ATIBA		2018-09-13

DRAWING APPROVAL STATUS: Approved for Use

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

MINE SITE
AREA WATER BALANCE
BLOCK FLOW DIAGRAM

DRAWING No.	DRAWING TITLE
H349000-4000-10-002-0002	MINE SITE - WATER BALANCE - BLOCK FLOW DIAGRAM

REFERENCE DRAWINGS

REG. PROFESSIONAL

SCALE NTS OR AS NOTED

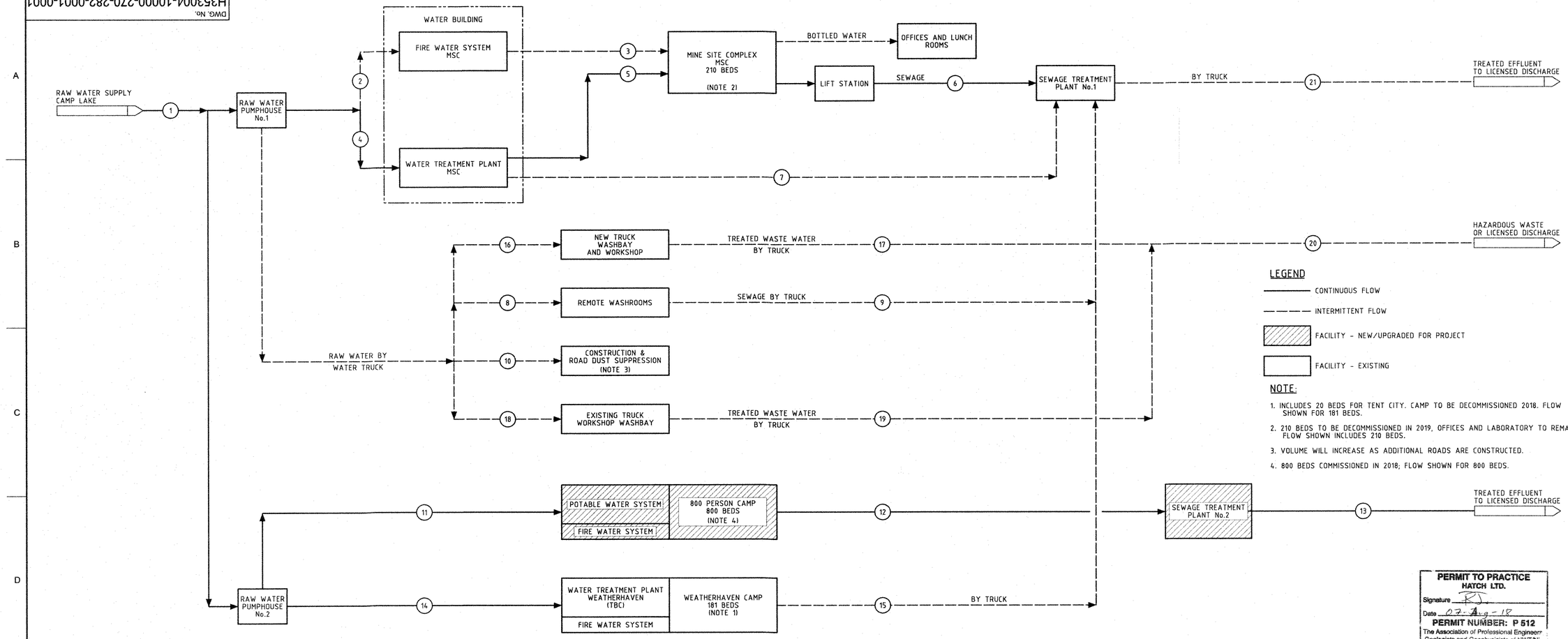
DWG. No. H353004-10000-270-252-0002-0001 REV 0

SHEET SIZE: D

ATTACHMENT 11.2

MINE SITE WATER AND SEWAGE PROCESS FLOW DIAGRAM

DWG. No. H353004-10000-270-282-0001-0001



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Date 07-Aug-18
PERMIT NUMBER: P 512
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Stream No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Stream Description	RAW WATER FROM CAMP LAKE	RAW WATER TO FIRE TANKS	FIRE WATER TO MSC	RAW WATER TO MSC WTP	POTABLE WATER TO MSC	SEWAGE FROM MSC	POTABLE WATER TO STP # 1	RW TO REMOTE WASHROOMS	SEWAGE FRM REMOTE WASHROOMS	CONST. & ROAD DUST	RAW WATER TO 800 PERSON CAMP	SEWAGE TO 800 PERSON CAMP STP # 2	TREATED EFFLUENT DISCHARGE FROM STP # 2	RAW WATER TO W.HAVEN CAMP	SEWAGE FROM W.HAVEN CAMP	RW TO NEW TRUCK WASHBAY	EFFLUENT FROM NEW TRUCK WASHBAY	RW TO EXISTING TRUCK WASHBAY	EFFLUENT FROM EXISTING TRUCK WASHBAY	WASTE WATER TO LICENSED DISCHARGE OR HAZ WASTE DISPOSAL	TREATED EFFLUENT DISCHARGE FROM STP # 1	TOTAL TREATED EFFL. DISCHARGE (13+21)
Fluid	RAW WATER	RAW WATER	RAW WATER	RAW WATER	POT. WATER	SEWAGE	POT. WATER	RAW WATER	SEWAGE	RAW WATER	RAW WATER	SEWAGE	TREATED EFFLUENT	RAW WATER	SEWAGE	RAW WATER	EFFLUENT	RAW WATER	EFFLUENT	WASTE WATER	TREATED EFFLUENT	TREATED EFFLUENT
Units	m3/day	-	m3/hr	m3/day	m3/day	m3/day	m3/day	m3/day	m3/day	m3/day	m3/day	m3/day	m3/day	m3/day	m3/day	m3/day	m3/day	m3/day	m3/day	m3/day	m3/day	m3/day
Current Permit Limit	355.4	-	-	-	-	-	-	-	-	151.6	-	-	-	-	-						-	-
Calculated Flow (Average)	269	One off fill	113	48	42	42	6	3	3	20	160	160	160	36	36	1	1	1	1	2	87	247
Calculated Flow (Maximum)	331	One off fill	113	60	53	53	7	3	3	21	200	200	200	45	45	1	1	1	1	2	108	308

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H353004-10000-221-282-0001	MINE WATER & SEWAGE PFD - SUPERCEDED BY THIS DRAWING

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DESIGNER		NR	
CHECKER	P CHERRY		2018-08-07
DESIGN COORD.	R GOOSEN		2018-08-07
RESP. ENG.	P JIM		2018-08-07
LEAD DISC. ENG.	P CHERRY		2018-08-07
AREA LEAD	T ATIBA		
ENG. MANAGER	D STANGER		7 Aug 18
AREA MANAGER	T ATIBA		7 Aug 18

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BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

MINE SITE
WATER AND SEWAGE
PROCESS FLOW DIAGRAM

SCALE: NTS OR AS NOTED | DWG. No.: H353004-10000-270-282-0001-0001 | REV: 0 | SHEET SIZE: D

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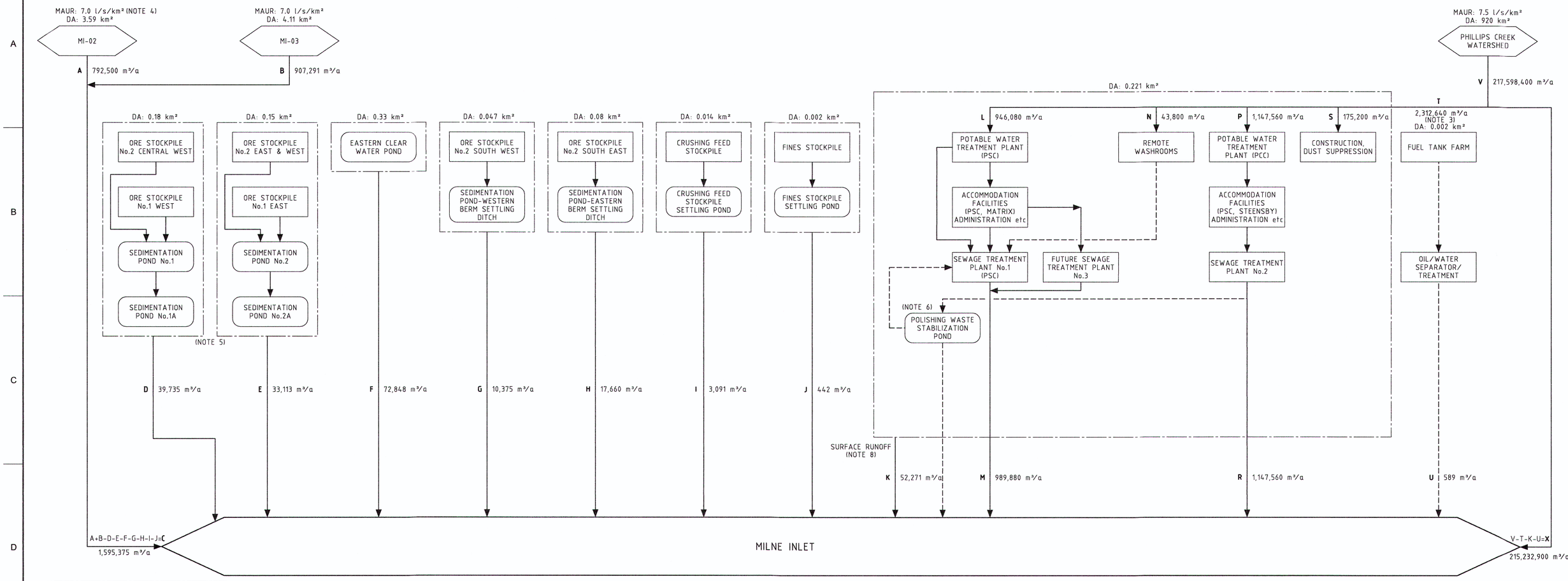
ATTACHMENT 11.3

PORT SITE WATER BALANCE

DWG. No. H353004-40000-270-252-0002-0001



LEGEND

- IMPACTED WATERSHED
- DEVELOPMENT AREAS
- DEVELOPMENT AREAS SUBJECT TO APPROVAL
- STORMWATER PONDS
- CONTINUOUS OR WATERSHED FLOW
- INTERMITTENT FLOW
- A/AA 100,000 — ANNUAL VOLUME (m³/a)
- MAUR — MEAN ANNUAL UNIT RUNOFF (l/s/km²)
- PSC — PORT SITE COMPLEX
- PCC — PORT CONSTRUCTION CAMP

NOTES:

1. SITE LAYOUT PER DRAWING H353004-00000-220-272-0001-0001, REV 3.
2. REFER TO PROCESS FLOW DIAGRAM H353004-40000-270-282-0001-0001, FOR MORE DETAILED WATER SUPPLY AND WASTE WATER TREATMENT.
3. RAW WATER SUPPLY FLOW RATE FROM PHILIPS CREEK (SUMMER) & KM32 LAKE (WINTER/SUMMER) ARE CURRENTLY EQUAL TO OR LESS THAN TYPE A WATER LICENCE 2AM-MRY1325 FLOW RATE LIMIT OF 68.5m³/day (25,000m³/year) PLUS TYPE B WATER LICENCE 8BC-MRY-1416 FLOW RATE LIMIT OF 299m³/day (109,135m³/year) TOTAL.
4. MAUR IN WATERSHEDS MI-02 AND MI-03 LIKELY RANGE BETWEEN 5 AND 7.5 l/s/km². PART OF THE MI-03 NATURAL CATCHMENT WILL BE USED FOR PROPOSED INFRASTRUCTURE CONSTRUCTION.
5. ORE STOCKPILE AND SEDIMENTATION POND CONSTRUCTION SUBJECT TO APPROVAL. ORE STOCKPILES RECEIVE ONLY PRECIPITATION AND NO SURFACE WATER RUNOFF FROM SURROUNDING AREAS.
6. USE OF POLISHING WASTE STABILIZATION POND WILL OCCUR ON A CONTINGENCY BASIS ONLY, SHOULD OFF-SPEC TREATED SEWAGE EFFLUENT BE PRODUCED.
7. PLANT SITE RECEIVES ONLY PRECIPITATION-RUNOFF AND NO SURFACE WATER RUNOFF FROM SURROUNDING AREAS.
8. REFER ERP SURFACE WATER AND AQUATIC ECOSYSTEM MANAGEMENT FROM H349000-1000-07-126-0005, REV 1 FOR CATCHMENT AREA INFORMATION.

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CHECKER	P CHERRY		2018-09-13
DESIGN COORD.	R GOOSEN		2018-09-14
RESP. ENG.	P JIM	PJ	2018-09-14
LEAD DISC. ENG.	P CHERRY		2018-09-13
AREA LEAD	T ATIBA		
ENG. MANAGER	D STANGER		2018-09-14
AREA MANAGER	T ATIBA		2018-09-13

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BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

PORT SITE
AREA WATER BALANCE
BLOCK FLOW DIAGRAM

DRAWING No.	DRAWING TITLE
H349000-2000-10-002-0002	PORT SITE - WATER BALANCE - BLOCK FLOW DIAGRAM

REFERENCE DRAWINGS | REG. PROFESSIONAL | REVISIONS

SCALE: NTS OR AS NOTED | DWG. No. H353004-40000-270-252-0002-0001 | REV 0

SHEET SIZE: D

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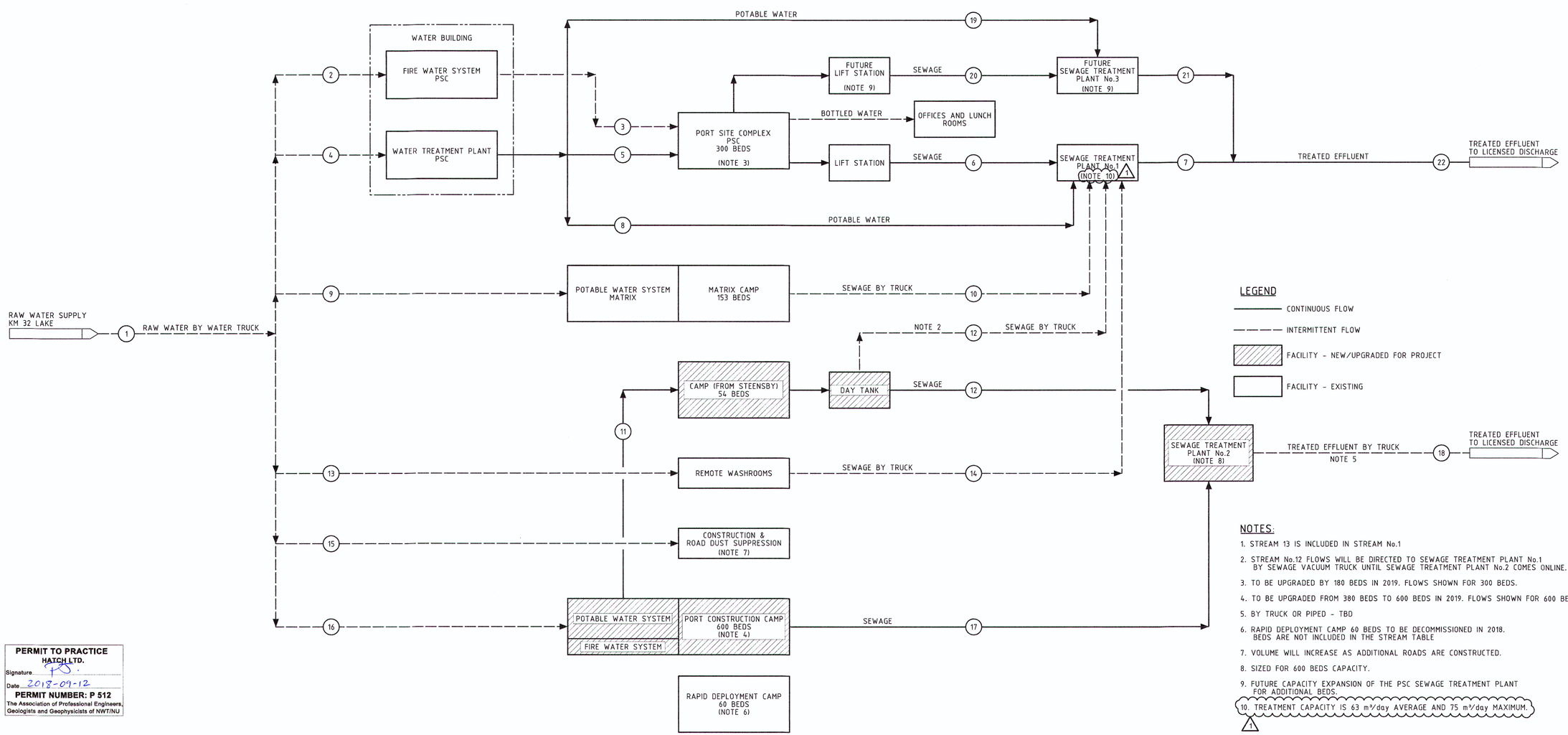
ATTACHMENT 11.4

PORT SITE WATER AND SEWAGE PROCESS FLOW DIAGRAM

DWG. No. H353004-40000-270-282-0001-0001



NOTES:

1. STREAM 13 IS INCLUDED IN STREAM No.1
2. STREAM No.12 FLOWS WILL BE DIRECTED TO SEWAGE TREATMENT PLANT No.1 BY SEWAGE VACUUM TRUCK UNTIL SEWAGE TREATMENT PLANT No.2 COMES ONLINE.
3. TO BE UPGRADED BY 180 BEDS IN 2019. FLOWS SHOWN FOR 300 BEDS.
4. TO BE UPGRADED FROM 380 BEDS TO 600 BEDS IN 2019. FLOWS SHOWN FOR 600 BEDS
5. BY TRUCK OR PIPED - TBD
6. RAPID DEPLOYMENT CAMP 60 BEDS TO BE DECOMMISSIONED IN 2018. BEDS ARE NOT INCLUDED IN THE STREAM TABLE
7. VOLUME WILL INCREASE AS ADDITIONAL ROADS ARE CONSTRUCTED.
8. SIZED FOR 600 BEDS CAPACITY.
9. FUTURE CAPACITY EXPANSION OF THE PSC SEWAGE TREATMENT PLANT FOR ADDITIONAL BEDS.
10. TREATMENT CAPACITY IS 63 m³/day AVERAGE AND 75 m³/day MAXIMUM. (1)

Stream No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Stream Description	RAW WATER FROM KM32 LAKE	RAW WATER TO FIRE TANKS	FIRE WATER TO PSC	RAW WATER TO PSC	POTABLE WATER TO PSC	SEWAGE FROM PSC	TREATED EFFLUENT FROM STP # 1	POTABLE WATER TO STP #1	RAW WATER TO MATRIX	SEWAGE FROM MATRIX	POTABLE WATER TO STEENSBY CAMP	SEWAGE FROM STEENSBY CAMP	RAW WATER TO WASHROOMS	SEWAGE FROM WASHROOMS	CONST. & ROAD DUST	RAW WATER TO CONSTRUCTION CAMP	SEWAGE FROM CONSTRUCTION CAMP	TREATED EFF. FROM STP # 2	POTABLE WATER TO STP #3	SEWAGE FROM EXPANDED SECTION OF PSC	TREATED EFFLUENT FROM FUTURE STP # 3	TREATED EFFLUENT FROM STP # 1 AND # 3 TO ENVIRONMENT
Fluid	RAW WATER	RAW WATER	RAW WATER	RAW WATER	POTABLE WATER	SEWAGE	TREATED EFFLUENT	POTABLE WATER	RAW WATER	SEWAGE	POTABLE WATER	SEWAGE	RAW WATER	SEWAGE	RAW WATER	RAW WATER	SEWAGE	TREATED EFFLUENT	POTABLE WATER	SEWAGE	TREATED EFFLUENT	TREATED EFFLUENT
Units	m³/day	m³/day	m³/hour	m³/day	m³/day	m³/day	m³/day	m³/day	m³/day	m³/day	m³/day	m³/day	m³/day	m³/day	m³/day	m³/day	m³/day	m³/day	m³/day	m³/day	m³/day	m³/day
Current Permit Limit	367.5	-	-	-	-	-	-	-	-	-	-	-	-	-	Note 1	-	-	-	-	-	-	-
Calculated Flow (Average)	258	One off fill	113	72	60	21	63 (1)	6	31	31	11	11	5	5	20	131	120	131	6	39	45	108 (1)
Calculated Flow (Maximum)	317	One off fill	113	89	75	25	75	7	38	38	14	14	5	5	21	164	150	164	7	50	57	132

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0	APPROVED FOR USE	HV	PC	07-08-2018

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	H VINCENT	NR	06-06-2018
DESIGNER		NR	
CHECKER	P CHERRY		2018-09-07
DESIGN COORD.	R GOOSEN		2018-09-07
RESP. ENG.	P JIM		2018-09-12
LEAD DISC. ENG.	P CHERRY		2018-09-07
AREA LEAD	T ATIBA		
ENG. MANAGER	D STANGER		2018-09-12
AREA MANAGER	T ATIBA		2018-09-13

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Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

PORT SITE
WATER AND SEWAGE
PROCESS FLOW DIAGRAM

REFERENCE DRAWINGS		REG. PROFESSIONAL
DRAWING No.	DRAWING TITLE	
H353004-40000-221-282-0001	MILNE PORT WATER & SEWAGE PFD - SUPERCEDED BY THIS DRAWING	

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DWG. No. H353004-40000-270-282-0001-0001
REV 1
SHEET SIZE: D

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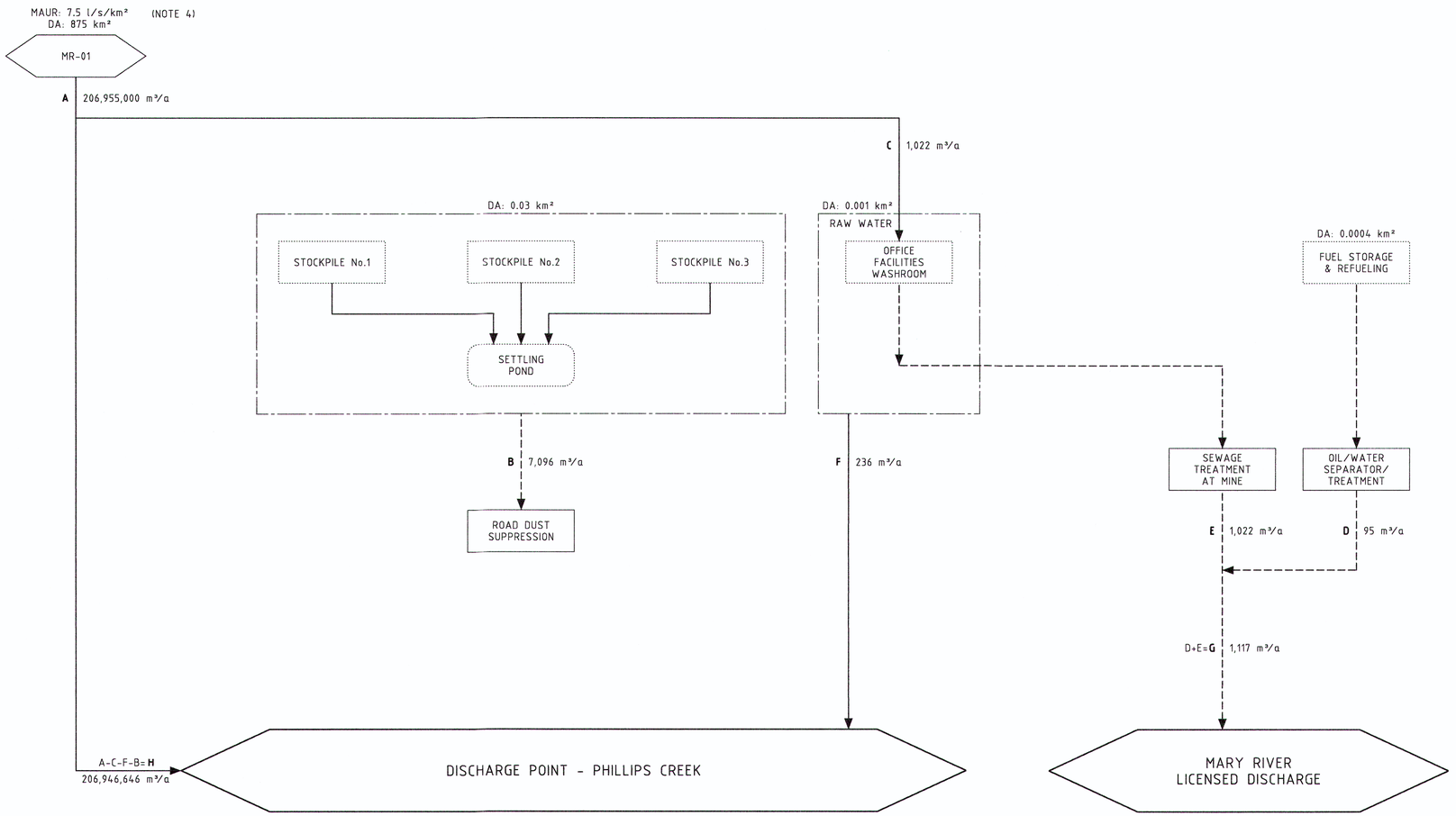
ATTACHMENT 11.5

ORE STAGING WATER BALANCE

DWG. No. H353004-30000-270-252-0001-0001



LEGEND

- IMPACTED WATERSHED
- DEVELOPMENT AREAS
- DEVELOPMENT AREAS SUBJECT TO APPROVAL
- STORMWATER PONDS
- CONTINUOUS OR WATERSHED FLOW
- INTERMITTENT FLOW
- A/AA 100,000 — ANNUAL VOLUME (m³/a)
- MAUR — MEAN ANNUAL UNIT RUNOFF (l/s/km²)

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NOTES:

1. SITE LAYOUT PER DRAWING H353004-30000-224-271-0029-0001, REV 0.
2. FLOW 'C' IS BASED ON 6 PERSONS/DAY AT THE OFFICE FACILITIES USING 50 l/day AND 250 trucks/day OF ORE USING 10 l PER TRUCK LOAD PER DAY.
3. MAUR IN WATERSHED MR-01 IS LIKELY IN THE RANGE BETWEEN 5 AND 7.5 l/s/km².
4. ORE STOCKPILE AND SETTLING POND CONSTRUCTION SUBJECT TO APPROVAL. ORE STOCKPILES RECEIVE ONLY PRECIPITATION AND NO SURFACE WATER RUNOFF FROM SURROUNDING AREAS.
5. PLANT SITE RECEIVES ONLY PRECIPITATION-RUNOFF AND NO SURFACE WATER RUNOFF FROM SURROUNDING AREAS.
6. REFER ERP SURFACE WATER AND AQUATIC ECOSYSTEM MANAGEMENT FROM H349000-1000-07-126-0005, REV 1 FOR CATCHMENT AREA INFORMATION.

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ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	H VINCENT	NR	24-08-2018
DESIGNER		NR	
CHECKER	P CHERRY		2018-09-13
DESIGN COORD.	R GOOSEN		2018-09-14
RESP. ENG.	P JIM	RJ.	2018-09-14
LEAD DISC. ENG.	P CHERRY		2018-09-13
AREA LEAD	F v BILJON		
ENG. MANAGER	D STANGER		2018-9-14
AREA MANAGER	F PITTMAN		2018-09-17

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BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

ORE STAGING RAIL SITE
AREA WATER BALANCE
BLOCK FLOW DIAGRAM

SCALE: NTS OR AS NOTED
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REV: 0

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REFERENCE DRAWINGS
REG. PROFESSIONAL
REVISIONS

ATTACHMENT 12

MINE AND PORT SITE GEOTECHNICAL REPORTS

12.1 Mine Site Factual Geotechnical Report
12.2 Port Site Geotechnical Recommendations
12.3 Ore Dock Factual Geotechnical Report
12.4 Ore Dock Geophysics Report

ATTACHMENT 12.1

MINE SITE FACTUAL GEOTECHNICAL REPORT

Baffinland Iron Mines Corporation
Mary River Expansion Project

2018 Mine Site Geotechnical Investigation Report

HATCH PARALLEL REVIEW – Internal and Client		
HATCH	***Signature***	***Date***
Port Area Lead		
Rail Area Lead		
PEng Reviewer (NAPEG)		
Construction		
Other		
Other		
BIM	***Signature***	***Date***
Port Area Manager		
Mine / Rail Area Manager		
Environmental		
Permitting		
Operations		
Other		
Other		

Review Grade *(check applicable box below)*		
C1	**C2**	**C3**
Proceed to next submission & status	*Proceed with exceptions as noted to next submission & status*	*Do not proceed. Revise as noted & resubmit*
Client Rep.		*Date:*

			Yang, Michael Digitally signed by Yang, Michael Date: 2018.09.13 13:47:48-04'00'			
2018-09-13	A	Internal/Client Review	M. Yang	K. Ho	W. Hoyle	
Date	**Rev.**	**Status**	**Prepared By**	**Checked By**	**Approved By**	**Approved By**
						Client

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DISCLAIMER

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Any use of this report by the Client is subject to the terms and conditions provided in the ArcelorMittal General Service Agreement, dated November 14, 2014, including the limitations on liability set out therein. Without limiting the foregoing, Hatch explicitly disclaims all responsibility for losses, claims, expenses or damages, if any, suffered by a third party as a result of any reliance on this Report, including for any decisions made or actions made by such a third party and based on this Report ("Claims"), and such third party's use or review of the Report shall constitute its agreement to waive all such Claims and release Hatch in respect thereof.

This report is meant to be read, and sections should not be read or relied upon out of context. While it is believed that the information contained herein is reliable under the conditions and subject to the limitations set forth herein, this Report is based in part on information not within the control of Hatch and Hatch therefore cannot and does not guarantee the accuracy of such information based in whole or in part on information not within the control of Hatch. The comments in it reflect Hatch's professional judgment in light of the information available to it at the time of preparation.

This report contains the expression of the professional opinion of Hatch exercising reasonable care, skill and judgment and based upon information available at the time of preparation. Hatch has conducted this investigation in accordance with the methodology outlined herein. It is important to note that the methods of evaluation employed, while aimed at minimizing the risk of unidentified problems, cannot guarantee their absence. The quality of the information, conclusions and estimates contained herein is consistent with the intended level of accuracy as set out in this report, as well as the circumstances and constraints under which this report was prepared.

Client's Signature:

Name:

Title:

Date:

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Geotechnical Investigation Safety Plan

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1. Introduction

Baffinland Iron Mines LP (BIM) currently operates the Mary River iron ore mine in Nunavut, Canada. BIM plans to increase the production to 12Mtpa, shipping the output through Milne Port. This will be achieved by upgrading the mine fleet, constructing a 110 km long rail line from the mine site to the port, building a new crushing and screening facility at the port, construction of larger ore stockpiles and building a second ore dock for ship loading.

In order to support the increased mine fleet, construction equipment and subsequent fuel consumption, an additional Tank Farm and Truck workshop is planned for the Mary River mine site. Hatch Ltd. (Hatch) was retained by BIM to conduct geotechnical drilling investigations for the design of a new truck workshop and tank farm at the Mine Site. The drilling program included one phase executed from June 15 to June 28, 2018.

This report summarizes the result of the geotechnical investigation for the truck workshop, tank farm, and associated infrastructure. The site program, borehole log reports, photographs and laboratory testing results are detailed in the following sections.

1.1 Previous Investigations

Geotechnical investigation programs have previously been conducted at the Mary River mine site, Steensby Inlet port structure, and the Milne Inlet port site, the Tote Road, as well as offshore investigations at Milne Port.

These previous programs were conducted in 2006, 2007, and 2008 by Knight Piésold Consulting Ltd. (Knight Piésold), in 2010 by AMEC Earth and Environmental (AMEC), and in 2011, and 2013-2014 and by Hatch. Relevant information from these investigations has been included in this report.

1.2 Local Topology and Geology

The site of the proposed truck workshop and tank farm is located within the Mary River Mine Site. The proposed truck workshop is to be located southeast of the Mine Site Complex (MSC) and the proposed tank farm is to be located northwest of the MSC and the existing tank farm. The geology of this area generally includes glacio-fluvial sand underlain by glacial till followed by a sandstone or granite bedrock.

2. Geotechnical Investigation

2.1 General

The drilling supervision, field core logging and sampling for the 2018 investigation program was carried out by Hatch. Boart Longyear Ltd. (Boart Longyear) was selected as the drilling contractor. The Hatch field personnel and the drilling contractor mobilized to site on June 15, 2018. The field investigation was completed on June 28, 2018.

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2.2 Borehole Locations

A summary of the as-drilled borehole locations for the Truck Workshop and Tank Farm is shown in Table 2-1. All coordinates are located within Zone 17 of the Universal Transverse Mercator (UTM) Grid. The horizontal datum for this project is the North American Datum 1983 (NAD 83). The as-drilled borehole location plan is provided in Appendix A.

The prefix BH represents Borehole, while 18 refers to 2018, the year of the investigation. The two letters following the dash symbol (-) categorizes the borehole location as Truck Workshop (TW) or Tank Farm (TF).

Table 2-1: Truck Workshop and Tank Farm Borehole Locations

Borehole Number	Easting (m)	Northing (m)	Depth (m)	Ground elevation (masl)
BH18-TW-01	561,477	7,913,189	25.9	195.17
BH18-TW-02	561,532	7,913,229	25.9	N/A
BH18-TF-01	561,154	7,913,396	25.9	188.22
BH18-TF-02	560,988	7,913,441	25.9	186.42
BH18-TF-03	561,094	7,913,477	25.9	187.82
BH18-TF-04	561,002	7,913,499	25.9	187.16
BH18-TF-05	561,203	7,913,478	24.4	188.10
BH18-TF-7N	561,064	7,913,438	12.4	187.00*
BH18-TF-8N	561,166	7,913,449	12.2	189.00*

**Approximate elevations sourced from topographical maps*

2.3 Drilling and Sampling Methodology

The geotechnical boreholes were developed using a BL100 Mini Sonic Drilling rig manufactured and operated by Boart Longyear, shown in Figure 1. The boreholes were advanced by vibration of the drill string at a high frequency in addition to rotary motion, and pressure by the drilling head (vibracore). Casing, size H, was advanced with the vibracore to keep the hole open between runs. Sonic drilling does not require water at shallow depths in the overburden.

When using vibracore drilling in overburden, a 3 m drilling rod was advanced 1.5 m into the ground for each run. The bottom 1.5 m was collected into a 4 inch split PVC pipe as shown in Figure 2. Soil collected above the bottom 1.5 m, if encountered, was disposed to ensure the collected sample was not contaminated by surface soil caved-in accumulated at the bottom of the drilled hole. Soil sample were photographed in the PVC split. Once the material in the split was photographed and sampled, the splits were secured using caps and aluminum tape, and stored in a shipping container at the Milne Port site.

Where encountered, bedrock was cored using a HQ-3 triple tube wireline core barrel, which required the use of water and casing. In addition, rock coring required the installation of a high-speed rotary head on the drilling rig every time there was a switch from sonic drilling in soil to rock coring.

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Figure 2-1: Boart Longyear Mini Sonic Drilling Rig

Figure 2-2: Sample Collected in a PVC Split using a Mini Sonic Drilling Rig

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The Hatch field supervisor documented the materials encountered, and determined in situ testing and sampling requirements. When ice was encountered in the borehole, it was documented and classified according to ASTM D4083. The description of soils as detailed in the geotechnical borehole reports are based on field visual classification and confirmatory laboratory testing in accordance with the explanatory notes included with these reports.

The detailed geotechnical borehole drilling reports are contained in the attached Appendix B and should be referenced for a complete description of soil materials and the in situ testing and sampling performed. Appendix B also contains a set of explanatory notes detailing terminology used in the borehole reports. Additional observations such as testing and sampling procedures, percent recovery, water loss/gain, and mechanical heating of samples were recorded, along with time of observation. Photographs of samples collected during the drilling investigation are contained in Appendix C.

2.4 Safety Management Plan

Safety management was a key consideration during the planning process for the geotechnical investigations. A safety management plan was prepared by Hatch and reviewed by BIM and Boart Longyear. A Job Hazard Analysis (JHA), identifying the hazards associated with the work and the controls that were to be used, was developed by Hatch and BIM and reviewed by Boart Longyear. This JHA was reviewed on a periodic basis and when work conditions changed and updated accordingly. A notification procedure was prepared by BIM specifically for the drilling activities in remote areas. A copy of both the final JHA and the notification procedure is presented in Appendix G.

2.5 Laboratory Testing

2.5.1 Soil Testing

All samples were shipped to the Hatch geotechnical laboratory in Niagara Falls, Ontario. Representative samples were selected for testing including moisture content and particle size distribution in accordance with the standard listed in Table 2-2. Full laboratory test results are presented in Appendix D and laboratory results are summarized in Appendix F.

Table 2-2: Standards Used for the Current Geotechnical Investigation

Name	Standard
Standard Test methods for Laboratory Determination of Water Content of Soil and Rock by Mass	ASTM D2216
Standard Test Methods for Particle-Size Distribution of Soils using Sieve Analysis	ASTM D6913
Standard Test Method for Particle Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis	ASTM D7928

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3. Results of Field Investigations

3.1 Mine Site Boreholes

A total of 9 boreholes were drilled at the Mine Site to support design of the proposed truck workshop and tank farm. Fence diagrams have been made for select boreholes and are presented in Appendix E.

3.1.1 Truck Workshop Area

The subsurface beneath the footprint of truck workshop has been mapped as layers of sand and gravel (typically till), sand, and ice, along with some cobbles and silt. The boreholes for this area are summarized in Table 3-1.

Table 3-1: Summary of Boreholes in Truck Workshop Areas

Borehole ID (Infrastructure)	Depth Material was Encountered (m)						
	Fill	Sand with Cobbles	Ice with Soil	Topsoil	Sand and Gravel	Sand	Silt and Sand
BH18-TW-01	0 – 2.6	2.6 – 15.2	15.2 – 15.8		15.8 – 25.2	25.2 – 25.9*	
BH18-TW-02				0 – 0.1	0.1 – 13.3	13.3 – 18.3 20.9 – 25.9*	18.3 – 20.9

* Indicates termination depth

3.1.1.1 Sand and Gravel / Sand with Cobbles

Both boreholes contain a layer of this material directly below the uppermost layer of either fill or topsoil. BH18-TW-01 also contained a second layer of this material that was separated from the first layer by a layer of ice. In general, the soil material was made up of a mix of sand and gravel, containing sections of cobbles, and trace silt. It was brown to grey in colour, sub-rounded to sub-angular, and is likely a layer of till.

3.1.1.2 Sand

Both boreholes contained sand as the lowermost layer, ranging from 0.7 m to 5 m. BH18-TW-02 also contains a second layer of sand overlying the first layer, separated by a layer of silt and sand. In general the material encountered was poorly graded sand, and was brown to grey in colour.

3.1.1.3 Ice with Soil

Ice with soil was encountered as an inferred layer in BH18-TW-01 in the truck workshop area where 0.6 m was encountered at 15.2 m depth.

3.1.2 Tank Farm Area

Additional tanks are proposed for the Mine Site, northwest of the existing tank farm. Seven boreholes were developed for the tank farm. The results of the boreholes are summarized in Table 3-2.

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Table 3-2: Summary of Boreholes in Tank Area

Borehole ID (Infrastructure)	Depth Material was Encountered (m)					
	Topsoil	Sand and Gravel to Gravelly Sand	Ice to Ice with Soil	Sand	Sandy Silt to Silty Clay	Cobbles
BH18-TF-01		0.0 – 4.9 11.1 – 16.2	4.9 – 6.0 9.1 – 10.6	6.0 – 9.1 10.6 – 11.1 16.2 – 25.9*		
BH18-TF-02		0.0 – 5.4 12.1 – 18.3 19.8 – 22.9	5.4 – 7.2 11.7 – 12.1	7.2 – 11.7 18.3 – 19.50 22.9 – 25.9*		19.5 – 19.8
BH18-TF-03	1.4 – 1.5	0.0 – 1.4 1.5 – 13.2 13.7 – 16.2		13.2 – 13.7 16.2 – 25.9*		
BH18-TF-04		0.0 – 5.7 7.8 – 9.1	5.7 – 6.2 7.4 – 7.8	6.2 – 7.4 9.1 – 9.6 15.2 – 25.9*	9.6 – 15.2	
BH18-TF-05	0.0 – 0.1	1.4 – 5.0		5.0 – 9.1 12.2 – 24.4*	9.1 – 12.2	0.1 – 1.4
BH18-TF-7N		0.0 – 6.1 7.6 – 12.4*	6.6 – 7.6	6.1 – 6.6		
BH18-TF-8N	0.5 – 4.6	0.0 – 0.5 5.8 – 12.2*	4.6 – 5.8			

* Denotes termination depth

3.1.2.1 *Sand and Gravel to Gravelly Sand*

In most boreholes the uppermost soil encountered was sand and gravel to gravelly sand. This material tends to contain trace to some cobbles with increased depth. This material is likely a fill within the first 2 m and a till throughout the rest of the borehole.

3.1.2.2 *Ice or Ice and Soil*

A layer or two of ice or ice and soil was encountered in five out of seven boreholes. The ice layers range from 0.4 m to 1.8 m in thickness and contain clear, hard ice.

3.1.2.3 *Sand*

Sand was encountered in the lowermost soil of five out of seven boreholes as well as between layers of ice or ice and soil. The sand tends to be poorly graded and contains traces of silt and gravel.

3.2 Laboratory Testing

Select soil samples collected during the investigations were tested to confirm the field classification of the soil. These test results have been included in the borehole reports contained in Appendix B. For full test results please see Appendix D and Appendix E for the grain size and moisture content results, respectively.

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4. Recommendations

4.1 Tank Farm Pad

The design and dimensions of the Tank Farm Pad and Fuel Tanks are sourced from Tank Farm drawings provided in transmittal H353004-TR-02071-CA01 and River Mine Site Fuel Storage Facility Project Memo (H353004-10000-240-210-0001, Rev. 0) respectively.

Due to the similarities between the subsurface conditions and pad designs between the existing Milne Port Tank Farm and proposed Mine Tank Farm, the Milne Port Tank Farm Pad Geotechnical Design memo (H349000-2000-15-220-001, Rev. A) recommendations will be applied to the Mine Tank Farm Pad Design. The subsurface of the existing Milne Port Tank Farm Pad consists of mostly sand containing varying amounts of gravel and silt. This soil is comparable to subsurface conditions beneath the proposed Mine Tank Farm Pad footprint, consisting of sand and gravel (till) overlaying thin layers of clear hard ice, followed by sand.

The following are the results and recommendations regarding the proposed granular fill pad:

- A combination of the equations and parameters found in the Milne Port Tank Farm Pad Geotechnical Design Memo (H349000-2000-15-220-0001, Rev. A), Geotechnical Design Basis report (H353004-00000-229-210-0001, Rev. 0) and Mary River Mine Site Fuel Storage Facility Project Memo (H353004-10000-240-210-0001, Rev. 0) was used in the proposed Mine Tank Farm Pad foundation bearing capacity calculations. The maximum surcharge on top of native material is less than 250 kPa with the height of fuel tank equal to 18.15 m. The calculations showed that the allowable bearing capacity is higher than the surcharge, using a maximum thickness of 2.16 m for the granular pad. Changes to the dimensions of the proposed fuel tanks or tank farm pads should be accompanied by bearing capacity calculations using the updated values.
- The transient thermal analysis conducted on the existing Milne Port Tank Farm pad resulted in recommendations of increasing the total pad thickness to 2.0 m from 1.95 m, and the extension of the edges of the granular pad a minimum of 2 m beyond the edge of the tanks to reduce the risk of differential settlement. The presence of thin ice layer underneath the proposed Mine Tank Farm Pad highlights the importance of minimizing the disturbance of the subsurface, therefore the recommendations for the existing Milne Port Tank Farm Pad presented above will be applied to the Mine Tank Farm Pad. The cross section of the pad in Figure 4-1 summarizes the recommendations for the proposed Mine Tank Farm Pad.

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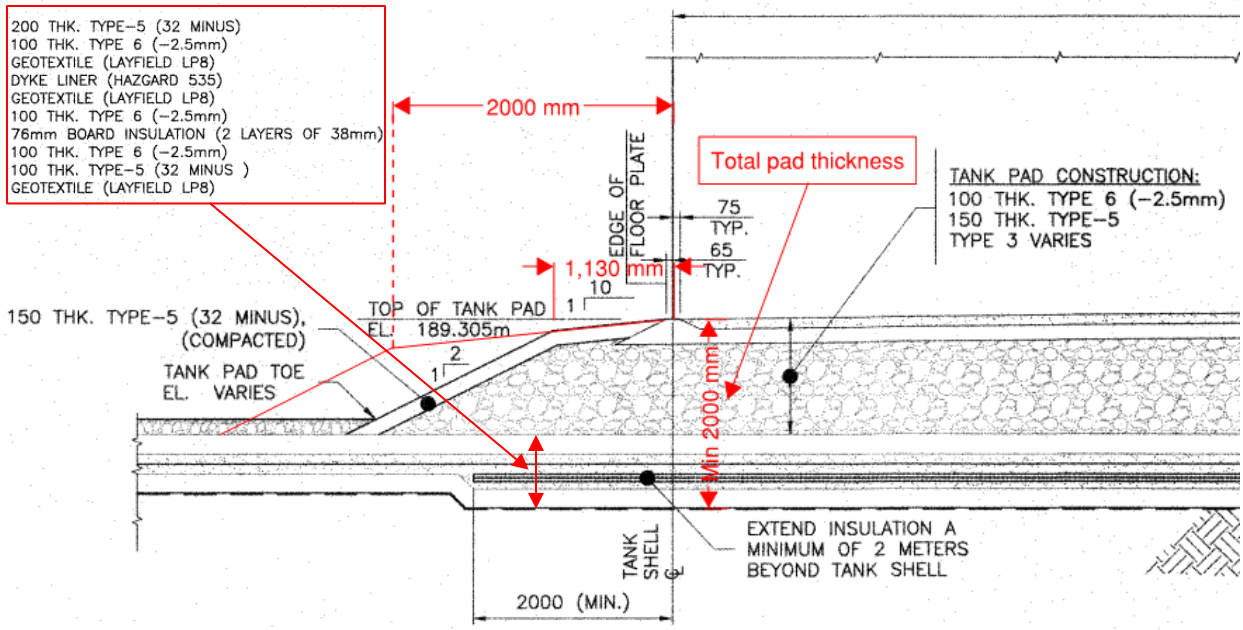

Figure 4-1: Recommendations for Tank Farm Pad at Mary River Mine Site (recommendations are highlighted in red)

- The Milne Port Tank Farm Pad memo recommended the removal of the insulation layer near the bottom of the pad. However the presence of hard ice beneath the proposed Mine Tank Farm Pad increases the risk of differential settlement, and the specified 76 mm board insulation should be kept in place. Any changes to the insulation should be verified for subsurface disturbance using a transient thermal analysis modelling program.
- The specifications for the granular fill materials and fill placement shall conform to the Hatch standards titled “Quarried Fill Materials Requirements” (H353004-00000-280-078-0002, Rev. 0) and “Placement of Fill” (H353004-00000-221-078-0001, Rev. 0), respectively.

4.2 Truck Workshop

The design and dimensions of the proposed Mine Truck Workshop Pad are sourced from Truck Workshop drawings titled “MINE TRUCK WORKSHOP PAD EARTHWORKS CROSS SECTIONS” and “MINE TRUCK WORKSHOP PAD LAYOUT PLAN” with document numbers H353004-10000-221-273-0001-0001 and H353004-10000-221-272-0005-0001, respectively. As all design and loading information was not available during the preparation of this report, assumptions were made based on the Geotechnical Criteria for Building Foundations specification (H353004-00000-229-078-0001). Any assumptions made are stated below.

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The following are the results and recommendations regarding the proposed granular fill pad:

- The design of the granular pad beneath the slab on grade for the truck workshop follows the recommendations outlined in Geotechnical Criteria for Building Foundations specification document, additional details can be found in the aforementioned specification.
- Based on the Geotechnical Criteria for Building Foundations specification, a modulus of 30 MPa and 20MPa should be utilised for the Mine Site and Milne Port site, respectively. This is based on a maximum effective base width of 2.0 m.
- While the earthworks cross sections drawing does not indicate the use of footings for the truck workshop foundation, the Geotechnical Criteria for Building Foundations specification provides ultimate and allowable bearing capacity figures for square and rectangular footings with footing widths from 1 m to 4 m and a strip footing with footing widths from 1 m to 3 m, all over 400 mm of granular engineered fill. Any designs with footing widths, or required bearing capacities outside of the plotted range requires additional calculation or modelling.
- The insulation and compacted granular fill beneath the concrete slab on grade follows the insulation requirements defined in the Geotechnical Criteria for Building Foundations specification. The requirement states 100 mm thick rigid underneath the concrete, and 150 mm thick insulation below the engineered fill pad. It should be noted the insulation requirements covers for standard temperatures encountered in buildings (10°C to 23°C). Thermal modelling is recommended if the truck workshop will experience elevated temperatures to determine the risk for subsurface disturbance.
- The specifications for the granular fill materials and fill placement shall conform to the Hatch standards titled “Quarried Fill Materials Requirements” (H353004-00000-280-078-0002, Rev. 0) and “Placement of Fill” (H353004-00000-221-078-0001, Rev. 0) respectively.

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Appendix A

Borehole Location Plan

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DWG. No. H353004-10000-229-230-0006

LEGEND:

- EXISTING BOREHOLE
- BOREHOLE FOR TANK FARM
- BOREHOLE FOR TRUCK WORKSHOP

TRUE NORTH

N +7 913 600

N +7 913 400

N +7 913 200

N +7 913 000

E +561 000

E +561 200

E +561 400

MBC 001

MRL-2008-07

BH18-TF-04

BH18-TF-03

TP-MSI-2008-05

BH18-TF-05

MSI-2008-05

BH18-TF-02

MBC 003

BH18-TF-7N

BH18-TF-8N

MSI-2008-06

TP-MSI-2008-06

EXISTING TOTE ROAD

MBC 002

BH18-TF-01

MRL-2008-10

MR-PGS-001

MTF 001

BH18-TW-02

MR-MEM-001

MR-MEM-002

BH18-TW-01

MTF 003

MTF 002

MR-PGS-007

MR-PGS-008

MR-PGS-009

RAILWAY LINE

SERVICE ROAD

DRAIN

DRAIN

0 20 40 60 80 100m 200m

SCALE : 1:2500

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CHECKER	H GHIABI		31/08/2018	
DESIGN COORD.	M YANG		31/08/2018	
RESP. ENG.	H GHIABI		31/08/2018	
LEAD DISC. ENG.	H GHIABI		31/08/2018	
AREA MANAGER	D STANGER		31/08/2018	
PROJ. MANAGER	S PERRY		31/08/2018	
CLIENT				

No.	DESCRIPTION	BY	CHK'D	DATE
A	ISSUED WITH GEOTECHNICAL REPORT	RP		31/08/2018

DRAWING APPROVAL STATUS: Client Review

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

MINE SITE
BOREHOLE
LAYOUT

DRAWING No.	DRAWING TITLE
REFERENCE DRAWINGS	

NAME
SIGNATURE
ENG REG NUMBER
REVISION DATE
ORIGINAL DATE
REG. PROFESSIONAL

SCALE 1:2500 OR AS NOTED

DWG. No. H353004-10000-229-230-0006

REV A

SHEET SIZE: E

$USERNAME$
$DATE$
$FILES$
$TIMES$

Appendix B

Borehole Reports

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List of Abbreviations and Terms Used in the Borehole Reports

(Sheet 1)

General

Elevations
Elevations are referenced to datum indicated.

Depth
All depths are given in meters (feet) measured from the ground surface unless otherwise noted.

Sample Recovery
Indicates the length retained in millimeters (inches) in a split spoon sampler or percentage recovery of sample retained in the core barrel sampler.

Sample Number
Samples are numbered consecutively in the order in which they were obtained or attempted in the borehole.

Sample Type
The first letter describes the sampling method and the second, the shipping container.

Sampling Method

A – Split Tube	E – Auger
B – Thin Wall Tube	F – Wash
C – Piston Sampler	G – Shovel Grab Sample
D – Core Barrel	K – Slotted Sampler

Shipping Container

O – Tube	U – Not Recovered
P – Water Content Tin	X – Plastic & PVC Sleeve (Sonic)
Q – Jar	Y – Core Box
S – Plastic Bag	Z – Discarded

Abbreviations
N/A – Not applicable
N/E – Not encountered
N/O – Not observed

Soil

Soil Description, Label and Symbol
Soil description under the "Description" column conforms generally, but not rigorously, to the Unified Soils Classification System. For a given soil unit, defined by depth boundaries, the descriptive text constitutes the definitive soil unit description and takes precedence over both the brief label and the symbol used to graphically represent the soil unit.

Grain Size

Clay		<0.002 mm
Silt	0.002 –	0.075 mm
Sand	0.075 –	4.75 mm
Fine	0.075 –	0.42 mm
Medium	0.42 –	2.00 mm
Course	2.00 –	4.75 mm
Gravel	4.75 –	75 mm
Fine	4.75 –	19.00 mm
Coarse	19.00 –	75.00mm
Cobbles	75 –	300 mm
Boulder		>300 mm

Relative Quantities

Term	*Example*	*(%)*
Trace	Trace sand	1 – 10
Some	Some sand	10 – 20
With (adjective)	With Sand (Sandy)	20 – 35
And	And sand	>35
Noun	Sand	>50

Standard Penetration Test (SPT)
The test is carried out in accordance with ASTM D-1586 and the 'N' value corresponds to the sum of the number of blows required by a 63.5-kg (140-lb) hammer, dropped 760 mm (30 in.), to drive a 50-mm (2-in.) diameter split tube sampler the second and third 150 mm (6 in.) of penetration.

Density (Granular Soils)

	N(SPT)
Very loose	0 – 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very dense	>50

Consistency (Cohesive Soils)

	N(SPT)
Very soft	<2
Soft	2 – 4
Firm	4 – 8
Stiff	8 – 15
Very stiff	15 – 30
Hard	>30

Plasticity/Compressibility

		Liquid Limit (%)
Low plasticity clays	Low compressibility silts	<30
Medium plasticity clays	Medium compressibility silts	30 – 50
High plasticity clays	High compressibility silts	>50

Dilatancy
None - No visible change, during shaking or squeezing
Slow - Water appears slowly on surface of specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid - Water appears quickly on the surface of specimen during shaking and disappears quickly upon squeezing.

Sensitivity

Insensitive	<2
Low	2 – 4
Medium	4 – 8
High	8 – 16
Quick	>16

List of Abbreviations and Terms Used in the Borehole Reports

(Sheet 2)

Rock

Core Recovery
Sum of lengths of rock core recovered from a core run, divided by the length of the core run and expressed as a percentage.

RQD (Rock Quality Designation)
Sum of lengths of hard, sound pieces of rock core equal to or greater than 100 mm from a core run, divided by the length of the core run and expressed as a percentage. Measured along centerline of core. Core fractured by drilling is considered intact. RQD normally quoted for N-size core.

RQD (%) Rock Quality

90	-	100	Excellent
75	-	90	Good
50	-	75	Fair
25	-	50	Poor
0	-	25	Very Poor

Grain Size

Term	*Grain Size*
Very coarse-grained	>60 mm
Coarse-grained	2 mm - 60 mm
Medium-grained	60 μm - 2 mm
Fine-grained	2 μm - 60 μm
Very fine-grained	< 2 μm

Bedding

Term	*Bed Thickness*			
Very thickly bedded		>2 m		>6.50 ft
Thickly bedded	600 mm -	2 m	2.00 -	6.50 ft
Medium bedded	200 mm -	600 mm	0.65 -	2.00 ft
Thinly bedded	60 mm -	200 mm	0.20 -	0.65 ft
Very thinly bedded	20 mm -	60 mm	0.06 -	0.20 ft
Laminated	6 mm -	20 mm	0.02 -	0.06 ft
Thinly laminated		<6 mm		<0.02 ft

Discontinuity Frequency
Expressed as the number of discontinuities per meter or discontinuities per foot. Excludes drill-induced fractures and fragmented zones.

Discontinuity Spacing

Term	*Average Spacing*			
Extremely widely spaced		>6 m		>20.00 ft
Very widely spaced	2 m -	6 m	6.50 -	20.00 ft
Widely spaced	600 mm -	2 m	2.00 -	6.50 ft
Moderately spaced	200 mm -	600 mm	0.65 -	2.00 ft
Closely spaced	60 mm -	200 mm	0.20 -	0.65 ft
Very closely spaced	20 mm -	60 mm	0.06 -	0.20 ft
Extremely closely spaced		<20 mm		<0.06 ft

Note: Excludes drill-induced fractures and fragmented rock.

Broken Zone
Zone of full diameter core of very low RQD which may include some drill-induced fractures.

Fragmented Zone
Zone where core is less than full diameter and RQD = 0.

Strength

Term	*Description*	*Unconfined Compressive Strength (MPa)*	*(psi)*
Extremely weak rock	Indented by thumbnail	0.25 – 1.0	36 – 145
Very weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	1.0 – 5.0	145 – 725
Weak rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	5.0 – 25	725 – 3625
Medium strong rock	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer to facture it	25 – 50	3625 –7250
Strong rock	Specimen requires more than one blow of geological hammer to fracture it	50 – 100	7250 – 14500
Very strong rock	Specimen requires many blows of geological hammer to fracture it	100 – 250	14500 – 36250
Extremely strong rock	Specimen can only be chipped with geological hammer	>250	>36250

Weathering

Term	*Description*
Fresh	No Visible sign of rock material weathering
Faintly weathered	Discoloration on major discontinuity surfaces.
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker than in its fresh condition.
Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones.
Highly weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

BASIS FOR SOIL DESCRIPTION

(Based on AS1726-1993 - Geotechnical Site Investigations, with modifications)

GRAPHIC SYMBOLS FOR SOILS

GRAVEL – poorly graded -

well graded -

SAND – poorly graded -

well graded -

SILT – of low plasticity -

of high plasticity -

CLAY – of low plasticity -

of high plasticity -

ICE -

COBBLES AND BOULDERS -

ORGANIC/ PEATY SOIL -

FILL/ MADE GROUND -

Composite soil types are presented using combined symbols, eg. **Gravelly Sandy CLAY**

GROUNDWATER OBSERVATIONS

Permanent Water Level

Temporary Water Level

Inflow into Pit or Borehole

Outflow/ Water Loss in Borehole

Slow Inflow/ Seepage into Pit or Borehole

SAMPLE TYPES

Disturbed bag sample

Bulk Disturbed (>20kg)

Hollow Stem Auger Core

Auger Flight Cuttings

Standard Penetration Test (SPT), with Disturbed Split-Spoon Sample

SPT (no recovery)

Thin walled "undisturbed" push tube sample eg. U60, U100 etc

Sample attempted with no recovery

HATCHCANADA2015 DRAFT.GLB GrfcText SOIL DESCRIPTION - 3 BAFFINLAND BOREHOLES 2016 - TJ.GPJ <<DrawingFile>> 17/02/2017 15:13

BASIS FOR ROCK DESCRIPTION

(Based on AS1726-1993 - Geotechnical Site Investigations, with modifications)

GRAPHIC SYMBOLS FOR SOILS

GRAVEL – poorly graded -

GRAVEL – well graded -

SAND – poorly graded -

SAND – well graded -

SILT – of low plasticity -

SILT – of high plasticity -

CLAY – of low plasticity -

CLAY – of high plasticity -

FINE GRAINED TAILINGS -

COBBLES AND BOULDERS -

ORGANIC/ PEATY SOIL -

FILL/ MADE GROUND -

Composite soil types are presented using combined symbols, eg. **Gravelly Sandy CLAY**

GRAPHIC SYMBOLS FOR ROCKS

SEDIMENTARY

SHALE

CLAYSTONE

SILTSTONE

SANDSTONE

CONGLOMERATE

BRECCIA

CORE LOSS

CARBONATE

LIMESTONE

Calcareous CLAYSTONE

Calcareous SILTSTONE

CALCARENITE

CALCIRUDITE

CALCRETE

EVAPORITES

GYPSUM

IGNEOUS

COARSE GRAINED

MEDIUM GRAINED

FINE GRAINED

DOLERITE

METAMORPHIC

COARSE GRAINED

MEDIUM GRAINED

FINE GRAINED

Additional rock graphics may be added for specific projects.

GROUNDWATER OBSERVATIONS

Permanent Water Level

Temporary Water Level

Inflow into Pit or Borehole

Outflow/ Water Loss in Borehole

Slow Inflow/ Seepage into Pit or Borehole

SAMPLE TYPES

Disturbed bag sample

Bulk Disturbed (>20kg)

Hollow Stem Auger Core

Auger Flight Cuttings

Standard Penetration Test (SPT), with Disturbed Split-Spoon Sample

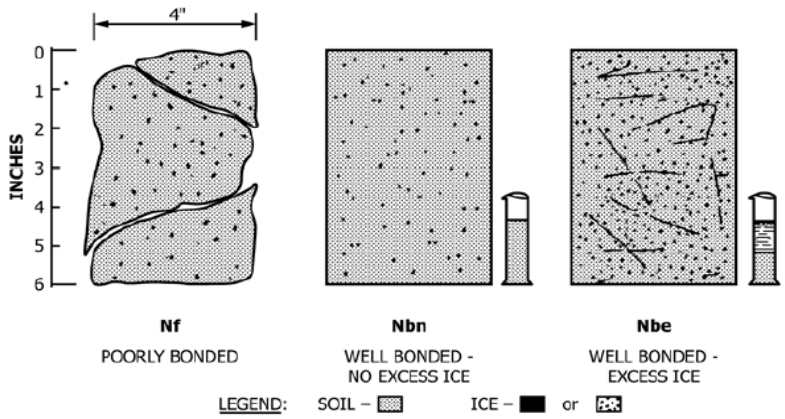
SPT (no recovery)

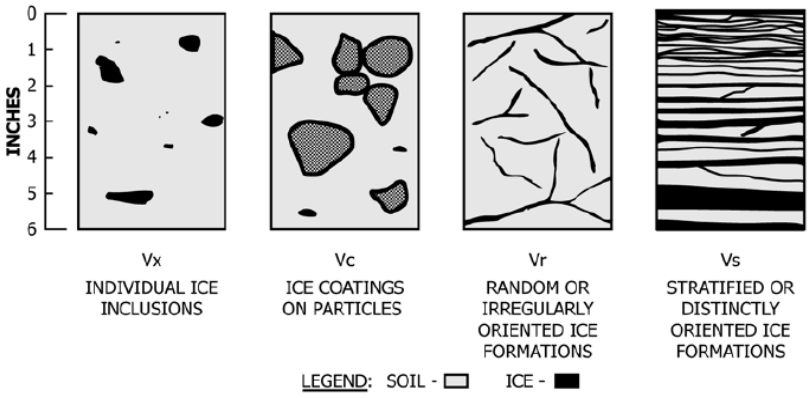
Thin walled "undisturbed" push tube sample eg. U60, U100 etc

Sample attempted with no recovery

HATCH LIBRARY DEVELOPMENT COPY.GLB GrfcText ROCK SYMBOLS GINT LOGS MR 2018 GEOTECHNICAL INVESTIGATION - V7.GPJ <<DrawingFile>> 29/08/2018 12:00

Symbol	Description
Nf	Poorly bonded with no visible excess ice
Nbn	Well bonded with no visible excess ice
Nbe	Well bonded with excess cie
Vx	Individual ice inclusions
Vc	Ice coatings on particles
Vr	Random or Irregularly oriented ice formations
Vs	Stratified or distrinctly oriented ice formations





BOREHOLE REPORT

BH18-TF-01
Sheet 1 of 3

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Southeast Corner of Tank Farm

Project No.: H353004
Datum: NAD83
Platform:

Easting: 561,154.0 m
Northing: 7,913,396.0 m
Surface Elevation: 188.00 m
Bottom Elevation: 162.10 m
Total Depth: 25.9 m
Logged By: MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 6/25/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	187.0	1.0				FILL: Sand and gravel, some boulders to cobbles, well graded, medium grained, light brown.	Non - frozen										
	186.0	2.0				TILL: Silty gravelly sand to silty sandy gravel, fine to medium grained, dark grey, dense to very dense.	Nbn inferred										
	185.0	3.0				3.30 m - 3.50 m: Cobble to potential boulders.				●	7						
	184.0	4.0															
	183.0	5.0				ICE and SOIL: Clear to grey, granular, hard, 20% - 30% soil.	I+S										
	182.0	6.0				SAND: Poorly graded, medium to fine grained, grey to light brown. 6.10 m - 7.60 m: High moisture content.	Nbn - Vx										
	181.0	7.0								●	45						
	180.0	8.0				8.05 m - 8.30 m: Boulder inferred 8.40 m - 9.10 m: Becoming gravelly, sub-angular to sub-rounded, 30 mm - 50 mm.	Vs - clear hard ice										
	179.0	9.0				ICE: clear, granular, becoming strong at 9.90 m.	ICE										
	178.0	10.0															

Notes:

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BOREHOLE REPORT

BH18-TF-01
Sheet 2 of 3

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Southeast Corner of Tank Farm

Project No.: H353004
Datum: NAD83
Platform:

Easting: 561,154.0 m
Northing: 7,913,396.0 m
Surface Elevation: 188.00 m
Bottom Elevation: 162.10 m
Total Depth: 25.9 m
Logged By: MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 6/25/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	177.0	11.0				ICE and SOIL: Sand, medium to fine grained, brown, hard, clear ice, granular.	I+S										
						TILL: Sand, some gravel, light brown, wet / moist sand.	Nbn assumed										
	176.0	12.0				TILL: Sand and gravel to sandy silty gravel, trace to some cobbles, grey, medium to fine grained, dense, sub-angular to sub-rounded gravel. 11.10 m - 11.90 m: Boulder with sand, some gravel in between.	Nbn assumed										
						NO RECOVERY											
	175.0	13.0				TILL: Sand and gravel to sandy silty gravel, trace to some cobbles. 13.0 m - 13.40 m: Core disturbance.											
	174.0	14.0				13.85 m - 14.00 m: Sandstone boulder. 14.60 m - 14.80 m: Becoming wet.											
	173.0	15.0									11						
	172.0	16.0				SAND, trace SILT: Organic sand band 3 mm thick, sand continues below.	Nbn										
	171.0	17.0				SAND and SILT: Statified, layers of light greenish grey siltstone, yellowish grey, fine sand.	Nbn Vs Nbn Vs				20						
	170.0	18.0				SAND: Poorly graded, medium to fine grained, light grey to yellowish grey, dense to very dense, with very dense layers, similar consistency to sandstone. 18.75 m - 18.85 m: Statified silt and sand layers bounded by organic sand.	Nbn										
	169.0	19.0															
	168.0	20.0				19.80 m - 20.60 m: Very hard band of											

Notes:

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BOREHOLE REPORT

BH18-TF-01

Sheet 3 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Southeast Corner of Tank Farm

Project No.: H353004

Datum: NAD83

Platform:

Easting: 561,154.0 m

Northing: 7,913,396.0 m

Surface Elevation: 188.00 m

Bottom Elevation: 162.10 m

Total Depth: 25.9 m

Logged By: MY

Reviewed By:

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 6/25/2018

Driller: Brent McAndrew

Hole Diameter (mm): 100

Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 25 50	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						sand, possible sandstone. SAND: Poorly graded, medium to fine grained, light grey to yellowish grey, dense to very dense, with very dense layers, similar consistency to sandstone. *(Continued)*	Nbn *(Continued)*										
	167.0	21.0				20.70 m: Organic smelling sand, grey, 2 mm.											
	166.0	22.0				22.30 m - 22.60 m: Wet.											
	165.0	23.0				23.40 m - 23.90 m: Compact moist sand.	Nbn										
	164.0	24.0															
	163.0	25.0				25.50 m: Becoming dense and dry.											
	162.0	26.0				To Target Depth. **Drillhole BH18-TF-01 terminated at 25.9m.**											
	161.0	27.0															
	160.0	28.0															
	159.0	29.0															
	158.0	30.0															

Notes:

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BOREHOLE REPORT

BH18-TF-02

Sheet 1 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Southwest Corner of Tank Farm

Project No.: H353004

Datum: NAD83

Platform:

Easting: 560,988.0 m

Northing: 7,913,441.0 m

Surface Elevation: 186.00 m

Bottom Elevation: 160.10 m

Total Depth: 25.9 m

Logged By: MY

Reviewed By:

Contractor: Boart Longyear

Driller: Brent McAndrew

Rig Type/ Mounting: MiniSonic Rig

Hole Diameter (mm): 100

Date Logged: 6/24/2018

Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	185.0	1.0				SAND and GRAVEL: Medium grained, light brown.	Non - frozen				2						
	184.0	2.0				TILL: Silty gravelly sand to sand and gravel, fine grained, grey to light brown, dense to very dense, 1.50 m - 1.65 m: Boulder. 1.80 m - 2.30 m: Boulder.	Nbn Inferred										
	183.0	3.0				3.00 m - 3.15 m: Cobble. 3.20 m - 3.80 m: Boulder.											
	182.0	4.0									9						
	181.0	5.0				5.10 m: Becoming moist.											
	180.0	6.0				ICE and SOIL / ICE: Grey, hard, granular, clear ice lenses.	ICE										
						ICE and SOIL: Stratified with sand, fine grained, grey to brown, 1 mm - 5 mm thick hard ice.	Vs										
	179.0	7.0				ICE: Clear to grey, hard, granular to clear.	Ice										
						TILL: Silty gravelly sand.	Vs Nbn										
	178.0	8.0									10						
	177.0	9.0				SAND: Poorly graded, medium to fine grained, brown. 9.40 m - 9.60 m: Wet.											
	176.0	10.0															

Notes:

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BOREHOLE REPORT

BH18-TF-02
Sheet 2 of 3

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Southwest Corner of Tank Farm

Project No.: H353004
Datum: NAD83
Platform:

Easting: 560,988.0 m
Northing: 7,913,441.0 m
Surface Elevation: 186.00 m
Bottom Elevation: 160.10 m
Total Depth: 25.9 m
Logged By: MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 6/24/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	175.0	11.0				SAND: Poorly graded, medium to fine grained, brown. *(Continued)*											
	174.0	12.0				ICE: Granular with clear lenses, hard.	ICE										
	173.0	13.0				TILL: Sand and gravel to silty gravelly sand, trace to some cobbles, grey to light brown.	Nbn Inferred				9						
	172.0	14.0															
	171.0	15.0				15.20 m: Becomes grey, very dense.											
	170.0	16.0				15.75 m - 16.00 m: Boulder inferred.											
	169.0	17.0				16.90 m: Becoming cobbley.											
	168.0	18.0															
	167.0	19.0				SAND: Medium grained, light brown. 18.80 m - 19.30 m: Becoming gravelly.	Nbn Inferred										
	166.0	20.0				COBBLE	Nbn Inferred										

Notes:

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BOREHOLE REPORT

BH18-TF-02
Sheet 3 of 3

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Southwest Corner of Tank Farm

Project No.: H353004
Datum: NAD83
Platform:

Easting: 560,988.0 m
Northing: 7,913,441.0 m
Surface Elevation: 186.00 m
Bottom Elevation: 160.10 m
Total Depth: 25.9 m
Logged By: MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 6/24/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	165.0	21.0				SILTY GRAVELLY SAND: Light reddish brown, dense. *(Continued)* 20.70 m - 20.90 m: Inferred boulder. 20.90 m - 21.03 m: Grey, loose sand. Boulder from 21.30 m - 21.65 m, and 22.40 m - 22.60 m (Inferred).	Nbn Inferred *(Continued)*				7						
	164.0	22.0															
	163.0	23.0				SAND: Poorly graded, medium grained, light grey to yellowish brown.	Nbn										
	162.0	24.0															
	161.0	25.0															
	160.0	26.0				To Target Depth. **Drillhole BH18-TF-02 terminated at 25.9m.**											
	159.0	27.0															
	158.0	28.0															
	157.0	29.0															
	156.0	30.0															

Notes:

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BOREHOLE REPORT

BH18-TF-03

Sheet 1 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Center North Corner of Tank Farm

Project No.: H353004

Datum: NAD83

Platform:

Easting: 561,094.0 m

Northing: 7,913,477.0 m

Surface Elevation: 188.00 m

Bottom Elevation: 162.10 m

Total Depth: 25.9 m

Logged By: MY

Reviewed By:

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 6/21/2018

Driller: Brent McAndrew

Hole Diameter (mm): 100

Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	187.0	1.0				SAND and GRAVEL (FILL): Grey to red grains, sub-rounded to angular.	Non - frozen										
						Possible Reworked Topsoil											
	186.0	2.0				TILL: Sand and gravel to gravelly sand and silt, trace cobbles, medium to coarse grained, greyish brown. 2.00 m: Moist, and loose to dry, and dense	Nf assumed										
	185.0	3.0															
	184.0	4.0															
	183.0	5.0				4.60 m - 4.95 m: Possible rock powder or finer sand / silt. 4.95 m - 5.15 m: Inferred boulder.	Nbn Inferred										
	182.0	6.0				5.90 m - 6.05 m: Inferred boulder. 6.10 m: Becomes dense to very dense.											
	181.0	7.0															
	180.0	8.0									8						
	179.0	9.0				8.60 m - 9.05 m: Boulder. 9.10 m - 9.80 m: Wet, possible ice and soil, less than 20% ice.	I+S possible										
	178.0	10.0				9.80 m - 10.50 m: Boulder, brownish											

Notes:

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HATCH BOREHOLE REPORT

BH18-TF-03
Sheet 2 of 3

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Center North Corner of Tank Farm

Project No.: H353004
Datum: NAD83
Platform:

Easting: 561,094.0 m
Northing: 7,913,477.0 m
Surface Elevation: 188.00 m
Bottom Elevation: 162.10 m
Total Depth: 25.9 m
Logged By: MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 6/21/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	177.0	11.0				grey sand and gravel after. TILL: Sand and gravel to gravelly sand and silt, trace cobbles, medium to coarse grained, greyish brown. *(Continued)*	Nf assumed *(Continued)* Nf										
	176.0	12.0															
	175.0	13.0					Vc										
						SAND: Poorly graded, medium to fine grained, light brown.	Nbn				21						
	174.0	14.0				TILL: Sand and gravel, trace cobbles, coarse grained, light brownish grey to light grey. 14.40 m - 14.90 m: Boulder, grey.	Vv				9						
	173.0	15.0				15.20 m - 15.70 m: Moist to wet.	Vc										
	172.0	16.0				SAND to SILTY SAND, some GRAVEL: Poorly graded, yellowish brown to light grey, medium to fine grained.	Nbn inferred										
	171.0	17.0									11						
	170.0	18.0				17.80 m - 18.00 m: Very hard sand pieces, weathered sandstone or compacted sand, some clevage.	Nbn inferred										
	169.0	19.0															
	168.0	20.0															

Notes:

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BOREHOLE REPORT

BH18-TF-03

Sheet 3 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Center North Corner of Tank Farm

Project No.: H353004

Datum: NAD83

Platform:

Easting: 561,094.0 m

Northing: 7,913,477.0 m

Surface Elevation: 188.00 m

Bottom Elevation: 162.10 m

Total Depth: 25.9 m

Logged By: MY

Reviewed By:

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 6/21/2018

Driller: Brent McAndrew

Hole Diameter (mm): 100

Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 25 50	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	167.0	21.0				SAND to SILTY SAND, some GRAVEL: Poorly graded, yellowish brown to light grey, medium to fine grained. *(Continued)*	Nbn inferred *(Continued)*										
	166.0	22.0															
	165.0	23.0					Nbn										
	164.0	24.0															
	163.0	25.0															
	162.0	26.0				To Target Depth. **Drillhole BH18-TF-03 terminated at 25.9m.**											
	161.0	27.0															
	160.0	28.0															
	159.0	29.0															
	158.0	30.0															

Notes:

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HATCH BOREHOLE REPORT

BH18-TF-04

Sheet 1 of 3

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Northwest Corner of Tank Farm

Project No.: H353004
Datum: NAD83
Platform:

Easting: 561,002.0 m
Northing: 7,913,499.0 m
Surface Elevation: 187.00 m
Bottom Elevation: 161.10 m
Total Depth: 25.9 m
Logged By: MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 6/23/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	187.0	0.0				GRAVELLY SAND (FILL): Brown.	Non - frozen										
	186.0	1.0				TILL: Sand and gravel, some silt, medium to coarse grained, reddish brown.	Non - frozen				6						
						1.05 m - 1.20 m: Cobble / boulder.											
						1.70 m - 2.10 m: Boulder.	Nbn inferred										
	185.0	2.0															
						2.70 m - 3.00 m: Very dense.											
	184.0	3.0				3.00 m - 3.85 m: Boulder, red, white, and black banding.											
	183.0	4.0															
						4.60 m: Becoming moist.	Nf										
	182.0	5.0					Vs possible										
	181.0	6.0				ICE with SOIL: Layers of grey ice, soil matrix, circular grains very hard, 1 mm - 5 mm pellets of ice.	I+S										
						SAND: Grey, medium to coarse grained, sub-angular to sub-rounded, pellet styled ice to clear lenses, 1 mm - 2 mm, approx. 40% ice.	Vs										
	180.0	7.0															
						ICE and SOIL: Grey to clear ice, sand grains, 1mm, red to grey, subrounded.	I+S										
	179.0	8.0				SAND and GRAVEL: Coarse grained, red to black.	Nbn				12						
							Vs										
							Vc										
	178.0	9.0				SAND: Poorly graded, medium to fine grained, light brownish grey.	Nbn										
	177.0	10.0				SANDY SILT, trace GRAVEL: Fine grained, orangy brown.	Nbn										

Notes:

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HATCH BOREHOLE REPORT

BH18-TF-04
Sheet 2 of 3

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Northwest Corner of Tank Farm

Project No.: H353004
Datum: NAD83
Platform:

Easting: 561,002.0 m
Northing: 7,913,499.0 m
Surface Elevation: 187.00 m
Bottom Elevation: 161.10 m
Total Depth: 25.9 m
Logged By: MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 6/23/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 25 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	176.0	11.0				SANDY SILT, trace GRAVEL: Fine grained, orangy brown. *(Continued)*	Nbn *(Continued)*										
							Vs				32						
							Nbn										
	175.0	12.0															
	174.0	13.0				13.20 m - 13.70 m: 120 mm of ice, small grains of ice.	Vs										
						13.70 m - 13.85 m: Ice.	ICE										
	173.0	14.0															
	172.0	15.0				SAND: poorly graded, compact to very dense, orange to light grey to white.	Nbn										
	171.0	16.0															
	170.0	17.0															
	169.0	18.0															
	168.0	19.0				18.90 m: Becoming medium grained.											
	167.0	20.0				19.80 m - 20.00 m: Bands of sand, grey											

Notes:

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BOREHOLE REPORT

BH18-TF-04

Sheet 3 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Northwest Corner of Tank Farm

Project No.: H353004

Datum: NAD83

Platform:

Easting: 561,002.0 m

Northing: 7,913,499.0 m

Surface Elevation: 187.00 m

Bottom Elevation: 161.10 m

Total Depth: 25.9 m

Logged By: MY

Reviewed By:

Contractor: Boart Longyear

Driller: Brent McAndrew

Rig Type/ Mounting: MiniSonic Rig

Hole Diameter (mm): 100

Date Logged: 6/23/2018

Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 / 25 / 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						organics, very dense sand. SAND: poorly graded, compact to very dense, orange to light grey to white. *(Continued)*	Nbn *(Continued)*										
	166.0	21.0															
	165.0	22.0				22.00 m: Sand, grey, hard.											
	164.0	23.0															
	163.0	24.0															
	162.0	25.0				25.00 m: Becoming silty.					12						
	161.0	26.0				To Target Depth. **Drillhole BH18-TF-04 terminated at 25.9m.**											
	160.0	27.0															
	159.0	28.0															
	158.0	29.0															
	157.0	30.0															

Notes:

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BOREHOLE REPORT

BH18-TF-05
Sheet 1 of 3

Client: Baffinland Iron Mine
Project No.: H353004
Project: Mary River Expansion Study
Datum: NAD83
Location: Outside Northeast Corner of Tank Farm
Platform:

Easting: 561,203.0 m
Northing: 7,913,478.0 m
Surface Elevation: 188.00 m
Bottom Elevation: 163.60 m
Total Depth: 24.4 m
Logged By: MY
Reviewed By:

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 6/18/2018
Driller: Brent McAndrew
Hole Diameter (mm): 100
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 / 25 / 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	188.0	0.0				ORGANIC TOPSOIL	Non - frozen										
						Possible TILL: Mainly boulder fragments and cobbles with rock dust, grey, sub-rounded, 6 cm - 9 cm cobbles.												
	187.0	1.0				TILL: Sand and gravel, trace to some cobbles, medium to coarse grained, grey to light brown.	Possible Nf										
	186.0	2.0															
	185.0	3.0															
	184.0	4.0					Nf										
	183.0	5.0				5.00 m: Slow transition from till to sand.											
						SAND, trace COBBLES: Poorly graded, light brown, cobbles at 5.20 m, 5.40 m, and 6.00 m.											
	182.0	6.0				6.10 m - 6.70 m: Trace gravel.											
	181.0	7.0					Nbn / Nf										
	180.0	8.0					Nbn										
	179.0	9.0															
						SILTY CLAY: Poorly graded, yellowish brown, black layers.	Nbn / Vs										
	178.0	10.0															

Notes:

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BOREHOLE REPORT

BH18-TF-05
Sheet 2 of 3

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Outside Northeast Corner of Tank Farm

Project No.: H353004
Datum: NAD83
Platform:

Easting: 561,203.0 m
Northing: 7,913,478.0 m
Surface Elevation: 188.00 m
Bottom Elevation: 163.60 m
Total Depth: 24.4 m
Logged By: MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 6/18/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	177.0	11.0				SILTY CLAY: Poorly graded, yellowish brown, black layers. *(Continued)*	Nbn / Vs *(Continued)*										
	176.0	12.0				12.05 m: Dark stratified layer.	Nbn										
						SAND: Poorly graded, medium grained, light brown.	Nbn										
	175.0	13.0				13.60 m: Thin silt band (possible clay), darker grey.											
	174.0	14.0				14.75 m - 14.80 m: Dark organics in sand, black / dark grey.											
	173.0	15.0				15.00 m: Starting to change to silty sand then silt.											
						NO RECOVERY	Nbn										
	172.0	16.0				SAND with SILT: Poorly graded, medium to fine grained, grey to dark grey, possible sandstone pieces approx every 20 cm, hard frozen sand embedded in sand with silt.											
	171.0	17.0															
	170.0	18.0															
	169.0	19.0				18.60 m: Grey organic layer, 6 cm thick, very dense compacted.											
	168.0	20.0															

Notes:

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BOREHOLE REPORT

BH18-TF-05

Sheet 3 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Outside Northeast Corner of Tank Farm

Project No.: H353004

Datum: NAD83

Platform:

Easting: 561,203.0 m

Northing: 7,913,478.0 m

Surface Elevation: 188.00 m

Bottom Elevation: 163.60 m

Total Depth: 24.4 m

Logged By: MY

Reviewed By:

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 6/18/2018

Driller: Brent McAndrew

Hole Diameter (mm): 100

Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 25 50	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	167.0	21.0				SAND with SILT: Poorly graded, medium to fine grained, grey to dark grey, possible sandstone pieces approx every 20 cm, hard frozen sand embedded in sand with silt. *(Continued)*	Nbn *(Continued)*										
	166.0	22.0															
	165.0	23.0									11						
	164.0	24.0															
	163.0	25.0				To Target Depth. **Drillhole BH18-TF-05 terminated at 24.4m.**											
	162.0	26.0															
	161.0	27.0															
	160.0	28.0															
	159.0	29.0															
	158.0	30.0															

Notes:

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HATCH BOREHOLE REPORT

BH18-TF-7N

Sheet 1 of 2

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: South of Tank Farm

Project No.: H353004

Datum: NAD83

Platform:

Easting: 561,064.0 m

Northing: 7,913,438.0 m

Surface Elevation: 187.00 m

Bottom Elevation: 174.55 m

Total Depth: 12.5 m

Logged By: MY

Reviewed By:

Contractor: Boart Longyear

Driller: Brent McAndrew

Rig Type/ Mounting: MiniSonic Rig

Hole Diameter (mm): 100

Date Logged: 6/26/2018

Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	186.0	1.0				SAND and GRAVEL, trace COBBLES (FILL): Light grey, loose. 0.30 m: Dark sandy layer, 30 mm thick, possible organic over fill 1.50 m - 3.00 m: Boulder fragments and dust, gravel pieces in between.	Non - frozen										
	185.0	2.0															
	184.0	3.0				TILL: Sand and gravel, trace cobbles, medium to fine grained, grey to brownish grey, dense to very dense.	Nbn inferred										
	183.0	4.0															
	182.0	5.0				TILL: Sand and gravel to gravelly silty sand, reddish brown, moist to wet, sub-rounded to sub-angular, elongated to 'round'.	Nbn possible Vs				10						
	181.0	6.0				SAND, trace to some SILT: Poorly graded, stratified, brown.	Nbn possible				26						
	180.0	7.0				ICE: clear, granular, strong with clear grains, 1 mm - 5 mm.	ICE										
	179.0	8.0				TILL: Sand and gravel to silty gravelly sand, trace to some cobbles, coarse grained, grey to light brown, moist. 7.90 m: Dry, medium to fine sand below.	Nbn				10						
	178.0	9.0															
	177.0	10.0															

Notes:

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BOREHOLE REPORT

BH18-TF-7N

Sheet 2 of 2

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: South of Tank Farm

Project No.: H353004

Datum: NAD83

Platform:

Easting: 561,064.0 m

Northing: 7,913,438.0 m

Surface Elevation: 187.00 m

Bottom Elevation: 174.55 m

Total Depth: 12.5 m

Logged By: MY

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 6/26/2018

Driller: Brent McAndrew

Hole Diameter (mm): 100

Date Reviewed:

Reviewed By:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	176.0	11.0				TILL: Sand and gravel to silty gravelly sand, trace to some cobbles, coarse grained, grey to light brown, moist. *(Continued)* 10.45 m: Boulder, dark grey with white gneissic banding.	Nbn *(Continued)*										
	175.0	12.0				11.90 m - 12.20 m: Boulder and pieces, moist to wet.											
	174.0	13.0				To Target Depth. **Drillhole BH18-TF-7N terminated at 12.5m.**											
	173.0	14.0															
	172.0	15.0															
	171.0	16.0															
	170.0	17.0															
	169.0	18.0															
	168.0	19.0															
	167.0	20.0															

Notes:

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BOREHOLE REPORT

BH18-TF-8N

Sheet 1 of 2

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: East End of Tank Farm

Project No.: H353004

Datum: NAD83

Platform:

Easting: 561,166.0 m

Northing: 7,913,449.0 m

Surface Elevation: 189.00 m

Bottom Elevation: 176.80 m

Total Depth: 12.2 m

Logged By: MY

Reviewed By:

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 6/26/2018

Driller: Brent McAndrew

Hole Diameter (mm): 100

Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	188.0	1.0				FILL: Grey, angular, crushed.	Non - frozen										
						TILL: Sand and gravel to gravelly silty sand, trace cobbles, well graded, medium to fine grained, grey.	Nbn / Nf				4						
	187.0	2.0															
	186.0	3.0															
	185.0	4.0															
						ICE and SOIL: Sand, fine to coarse grained, grey with red grains, 30% - 40% soil, granular, clear, hard ice, 1 mm - 5 mm grains.	I+S										
	184.0	5.0															
	183.0	6.0				TILL: Gravelly sand to silty sand, some gravel, trace to some cobbles, medium to fine sand, yellowish grey, sub-rounded to sub-angular.	Nf / Nbn										
	182.0	7.0									6						
						7.60 m - 7.80 m: Moist to wet.											
	181.0	8.0															
	180.0	9.0															
	179.0	10.0															

Notes:

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BOREHOLE REPORT

BH18-TF-8N

Sheet 2 of 2

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: East End of Tank Farm

Project No.: H353004

Datum: NAD83

Platform:

Easting: 561,166.0 m

Northing: 7,913,449.0 m

Surface Elevation: 189.00 m

Bottom Elevation: 176.80 m

Total Depth: 12.2 m

Logged By: MY

Reviewed By:

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 6/26/2018

Driller: Brent McAndrew

Hole Diameter (mm): 100

Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 25 50	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	178.0	11.0				TILL: Gravelly sand to silty sand, some gravel, trace to some cobbles, medium to fine sand, yellowish grey, sub-rounded to sub-angular. *(Continued)* 10.50 m - 10.70 m: Moist. 11.20 m - 11.80 m: Moist.	Nf / Nbn *(Continued)* Nbn / Nf										
	177.0	12.0				To Target Depth. **Drillhole BH18-TF-8N terminated at 12.2m.**											
	176.0	13.0															
	175.0	14.0															
	174.0	15.0															
	173.0	16.0															
	172.0	17.0															
	171.0	18.0															
	170.0	19.0															
	169.0	20.0															

Notes:

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BOREHOLE REPORT

BH18-TW-01
Sheet 1 of 3

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Southwest of Truck Workshop

Project No.: H353004
Datum: NAD83
Platform:

Easting: 561,477.0 m
Northing: 7,913,189.0 m
Surface Elevation: 195.00 m
Bottom Elevation: 169.10 m
Total Depth: 25.9 m
Logged By: MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 6/16/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	194.0	1.0				SANDY GRAVEL, some COBBLES (FILL): Brown, sub-rounded to sub-angular gravel and cobbles.	Non - frozen										
	193.0	2.0				BOULDER: Inferred rock dust.											
	192.0	3.0				SAND, some GRAVEL: Possible fill, light brown, sub-rounded. SAND and GRAVEL: Black, grey to red gravel, sub-rounded to sub-angular. SAND with COBBLES, some SILT, some GRAVEL: Fine grained, greyish brown.					10						
	191.0	4.0				4.60 m - 4.70 m: Grey, melt water (snow).											
	190.0	5.0				5.00 m - 5.20 m, 5.60 m, 6.00m: Cobbles.											
	189.0	6.0															
	188.0	7.0				6.70 m, 6.90 m, 6.70m: Cobbles.											
	187.0	8.0				7.60 m - 8.30 m: Boulder. 8.00 m - 8.30 m: Crushed dust.											
	186.0	9.0				9.10 m: Boulder, dust, pulverized, water mixed in.											
	185.0	10.0															

Notes:

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BOREHOLE REPORT

BH18-TW-01

Sheet 2 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Southwest of Truck Workshop

Project No.: H353004

Datum: NAD83

Platform:

Easting: 561,477.0 m

Northing: 7,913,189.0 m

Surface Elevation: 195.00 m

Bottom Elevation: 169.10 m

Total Depth: 25.9 m

Logged By: MY

Reviewed By:

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 6/16/2018

Driller: Brent McAndrew

Hole Diameter (mm): 100

Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	184.0	11.0				SAND with COBBLES, some SILT, some GRAVEL: Fine grained, greyish brown. *(Continued)*											
						COBBLES and BOULDERS: Grey, sub-angular. Cobbles at 10.70 m, 10.90 m, and 11.00 m. 11.45 m - 12.20 m: Inferred boulder.											
	183.0	12.0															
	182.0	13.0				SAND: Poorly graded, medium to coarse grained, light brown, sub-angular grains.	Nbn				23						
	181.0	14.0				SAND with GRAVEL, some COBBLES, trace SILT: Well graded, grey, organic smell.	Nf inferred										
	180.0	15.0				COBBLES: Pulverized, grey, yellow, sulphur smelling layer at 14.50 m, sub-rounded. 14.60 m - 14.70 m: Inferred boulder.	Vs										
	179.0	16.0				SAND and GRAVEL, some COBBLES: Greyish brown, red cobbles, sub-angular to sub-rounded.											
						ICE with SOIL (inferred). Ice at 15.85 m.					10						
	178.0	17.0				SILTY GRAVELLY SAND, some COBBLES: Medium to coarse grained sand, grey, sub-rounded. 17.70 m: Becoming reddish brown.	Nf inferred										
	177.0	18.0															
	176.0	19.0				SAND and GRAVEL, trace COBBLES: Fine to coarse grained, brownish grey, sub-rounded to sub-angular sand. 18.50 m: Becoming dry. 19.60 m, 19.80 m - 19.90m: Cobbles.											
	175.0	20.0															

Notes:

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BOREHOLE REPORT

BH18-TW-01
Sheet 3 of 3

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Southwest of Truck Workshop

Project No.: H353004
Datum: NAD83
Platform:

Easting: 561,477.0 m
Northing: 7,913,189.0 m
Surface Elevation: 195.00 m
Bottom Elevation: 169.10 m
Total Depth: 25.9 m
Logged By: MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 6/16/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	174.0	21.0				SAND and GRAVEL, trace COBBLES: Fine to coarse grained, brownish grey, sub-rounded to sub-angular sand. *(Continued)*											
	173.0	22.0															
	172.0	23.0				22.70 m - 22.90 m: Thin layer of organic material bounded by coarse sand.					8						
	171.0	24.0				24.15 m - 24.40 m: Moist.											
	170.0	25.0				SAND: Poorly graded, light brown, sub-rounded to sub-angular.	Nbn										
	169.0	26.0				To Target Depth. **Drillhole BH18-TW-01 terminated at 25.9m.**											
	168.0	27.0															
	167.0	28.0															
	166.0	29.0															
	165.0	30.0															

Notes:

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BOREHOLE REPORT

BH18-TW-02

Sheet 1 of 3

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Northeast of Truck Workshop

Project No.: H353004
Datum: NAD83
Platform:

Easting: 561,532.0 m
Northing: 7,913,229.0 m
Surface Elevation: 200.00 m
Bottom Elevation: 174.10 m
Total Depth: 25.9 m
Logged By: MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 6/20/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	200.0	0.0				TOPSOIL: Organic	Non - frozen										
						TILL: Sand with gravel, light brown transition to grey.											
	199.0	1.0				0.70 m: Some cobbles (0.30 m, 0.60 m), 80 mm - 130 mm, grey to red gravel and sand.											
							Possible Nf / Nbn										
	198.0	2.0				2.00 m: Cobble.											
	197.0	3.0															
						3.45 m - 3.60 m: Compacted / very dense.	Nf / Nbn										
	196.0	4.0				3.85 m: Becoming wet (surface run-off down the hole).											
						4.60 m, 5.00 m: Cobbles (100 mm), sub-angular to sub-rounded.	Nf / Nbn inferred										
	195.0	5.0															
	194.0	6.0				6.10 m: Some cobbles to becoming cobbley.											
	193.0	7.0				7.30 m: Trace silt, moist to wet.					11						
						7.60 m - 7.90 m: Boulder.											
	192.0	8.0				TILL: Sand and gravel, trace cobbles, medium to coarse grained, brownish grey, sub-angular to sub-rounded.											
	191.0	9.0				9.10 m - 10.30 m: Possible traces silt.											
	190.0	10.0															

Notes:

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BOREHOLE REPORT

BH18-TW-02
Sheet 2 of 3

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Northeast of Truck Workshop

Project No.: H353004
Datum: NAD83
Platform:

Easting: 561,532.0 m
Northing: 7,913,229.0 m
Surface Elevation: 200.00 m
Bottom Elevation: 174.10 m
Total Depth: 25.9 m
Logged By: MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 6/20/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	189.0	11.0				TILL: Sand and gravel, trace cobbles, medium to coarse grained, brownish grey, sub-angular to sub-rounded. *(Continued)*	Nbn / Nf										
	188.0	12.0				12.20 m: Poorly graded, wet to melted.	Nbn										
	187.0	13.0				SAND: Poorly graded, medium to fine grained, yellowish brown to light grey / white.											
	186.0	14.0															
	185.0	15.0															
	184.0	16.0															
	183.0	17.0					Vs										
	182.0	18.0															
	181.0	19.0				SILT and SAND to SILT, trace SAND: Poorly graded, light brown.	Nbn				18						
	180.0	20.0															

Notes:

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BOREHOLE REPORT

BH18-TW-02
Sheet 3 of 3

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Northeast of Truck Workshop

Project No.: H353004
Datum: NAD83
Platform:

Easting: 561,532.0 m
Northing: 7,913,229.0 m
Surface Elevation: 200.00 m
Bottom Elevation: 174.10 m
Total Depth: 25.9 m
Logged By: MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 6/20/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 25 50	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SILT and SAND to SILT, trace SAND: Poorly graded, light brown. *(Continued)*	Nbn *(Continued)*										
	179.0	21.0				SAND: Poorly graded, medium grained, greenish brown, dark band at 21.20 m.											
	178.0	22.0															
	177.0	23.0															
	176.0	24.0															
	175.0	25.0															
	174.0	26.0				To Target Depth. **Drillhole BH18-TW-02 terminated at 25.9m.**											
	173.0	27.0															
	172.0	28.0															
	171.0	29.0															
	170.0	30.0															

Notes:

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Appendix C

Sample Photographs

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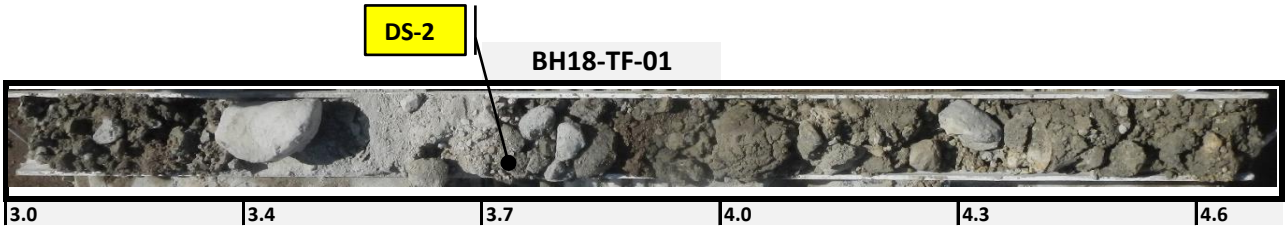
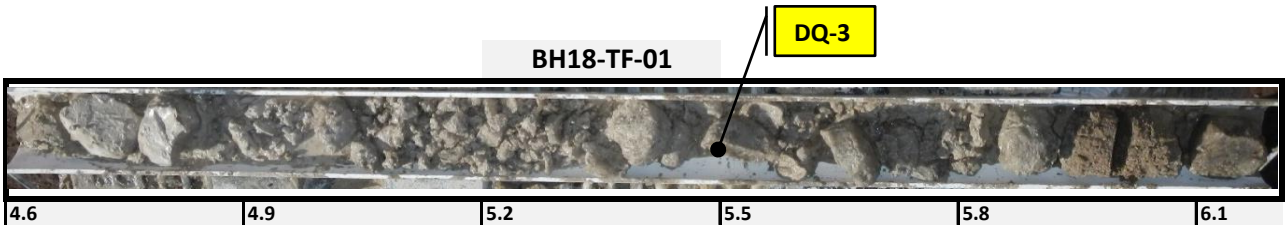
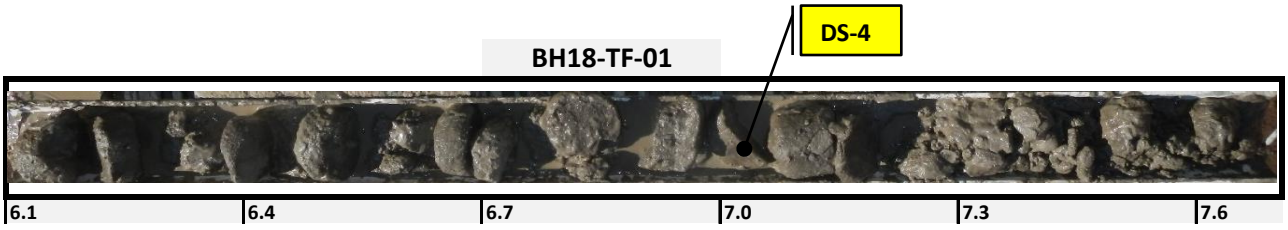
HATCH

Sample Photographs

Borehole Name:	BH18-TF-01	Mary River Expansion Study Stage 2
Location:	17 W 561154 7913396	2018 Geotechnical Investigation
Completion Date:	June 25, 2018	Baffinland Iron Mines







HATCH

Sample Photographs

Borehole Name:	BH18-TF-01	Mary River Expansion Study Stage 2
Location:	17 W 561154 7913396	
Completion Date:	June 25, 2018	Baffinland Iron Mines

DQ-5

BH18-TF-01

9.1 | 9.4 | 9.8 | 10.1 | 10.4 | 10.7

BH18-TF-01

10.7 | 11.0 | 11.3 | 11.6 | 11.9 | 12.2

DS-6

BH18-TF-01

12.2 | 12.5 | 12.8 | 13.1 | 13.4 | 13.7

BH18-TF-01

13.7 | 14.0 | 14.3 | 14.6 | 14.9 | 15.2

DS-7

BH18-TF-01

15.2 | 15.5 | 15.8 | 16.2 | 16.5 | 16.8

DS-8

BH18-TF-01

16.8 | 17.1 | 17.4 | 17.7 | 18.0 | 18.3

HATCH

Sample Photographs

Borehole Name:	BH18-TF-01	Mary River Expansion Study Stage 2
Location:	17 W 561154 7913396	
Completion Date:	June 25, 2018	Baffinland Iron Mines

DS-9

BH18-TF-01

18.3 | 18.6 | 18.9 | 19.2 | 19.5 | 19.8

BH18-TF-01

19.8 | 20.1 | 20.4 | 20.7 | 21.0 | 21.3

BH18-TF-01

21.3 | 21.6 | 21.9 | 22.3 | 22.6 | 22.9

DS-10

BH18-TF-01

22.9 | 23.2 | 23.5 | 23.8 | 24.1 | 24.4

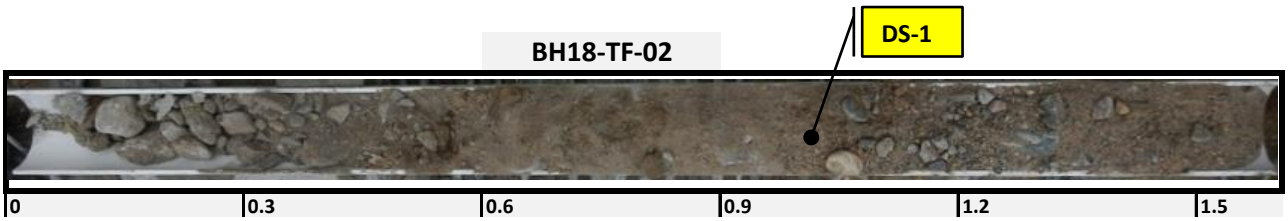
BH18-TF-01

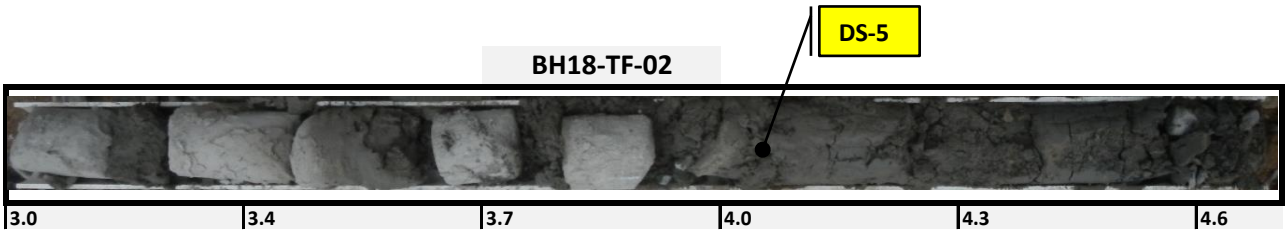
24.4 | 24.7 | 25.0 | 25.3 | 25.6 | 25.9

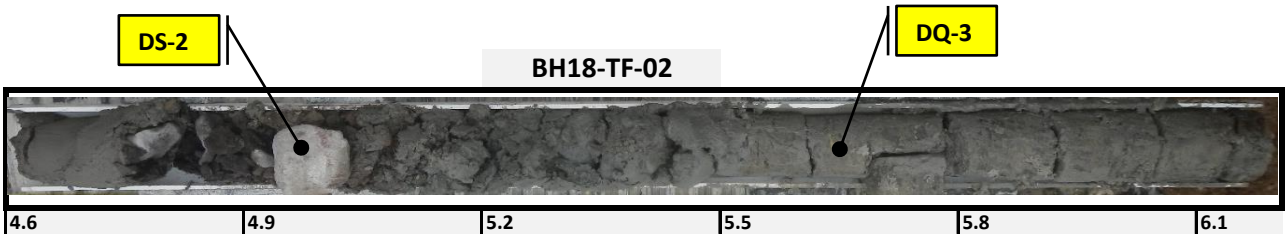
HATCH

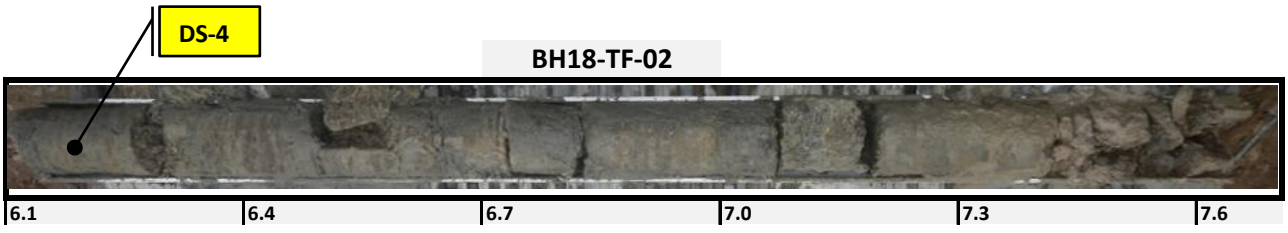
Sample Photographs

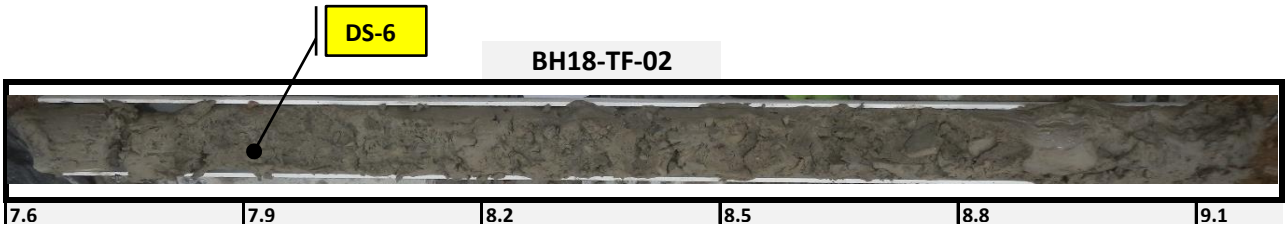
Borehole Name:	BH18-TF-02	Mary River Expansion Study Stage 2
Location:	17 W 560988 7913441	2018 Geotechnical Investigation
Completion Date:	June 24, 2018	Baffinland Iron Mines











HATCH

Sample Photographs

Borehole Name:	BH18-TF-02	Mary River Expansion Study Stage 2
Location:	17 W 560988 7913441	
Completion Date:	June 24, 2018	Baffinland Iron Mines

BH18-TF-02

9.1 | 9.4 | 9.8 | 10.1 | 10.4 | 10.7

DS-7 DQ-8

BH18-TF-02

10.7 | 11.0 | 11.3 | 11.6 | 11.9 | 12.2

DS-9

BH18-TF-02

12.2 | 12.5 | 12.8 | 13.1 | 13.4 | 13.7

BH18-TF-02

13.7 | 14.0 | 14.3 | 14.6 | 14.9 | 15.2

DS-10

BH18-TF-02

15.2 | 15.5 | 15.8 | 16.2 | 16.5 | 16.8

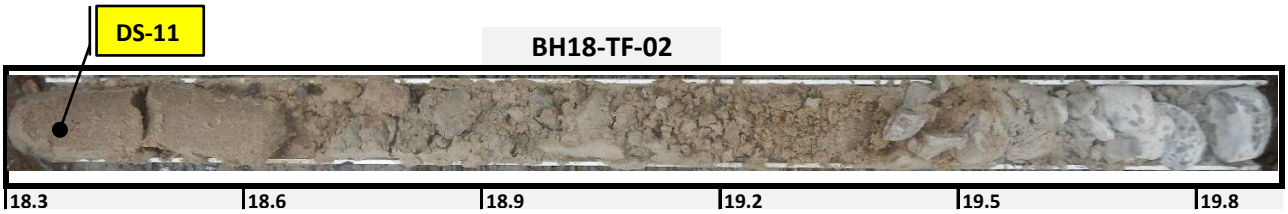
BH18-TF-02

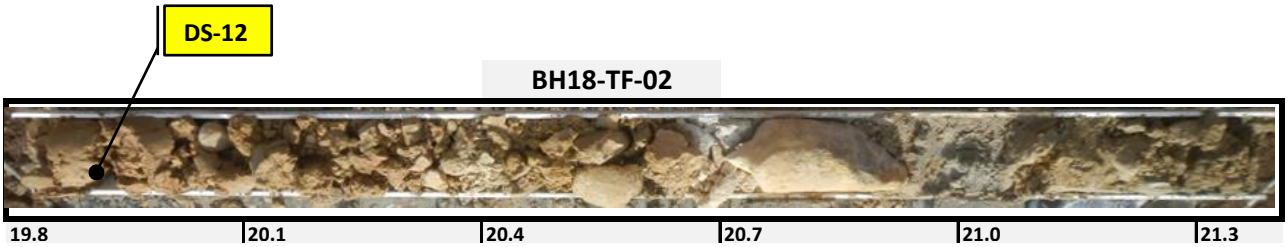
16.8 | 17.1 | 17.4 | 17.7 | 18.0 | 18.3

HATCH

Sample Photographs

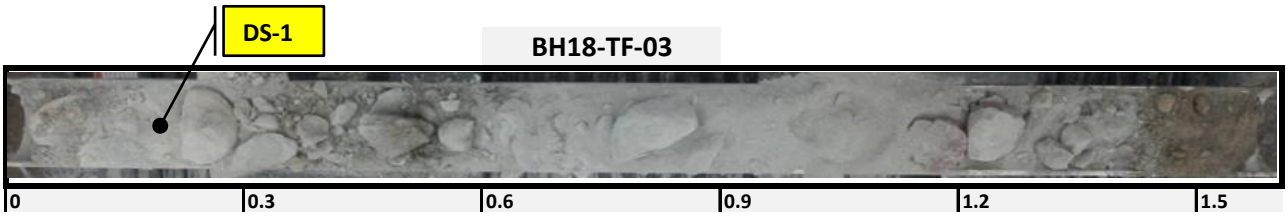
Borehole Name:	BH18-TF-02	Mary River Expansion Study Stage 2
Location:	17 W 560988 7913441	
Completion Date:	June 24, 2018	Baffinland Iron Mines

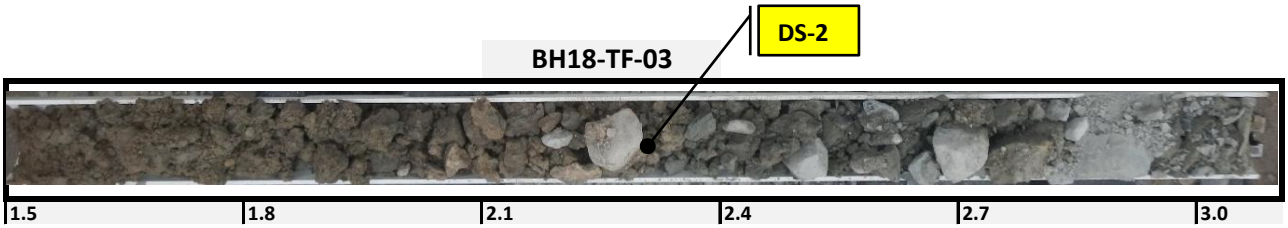


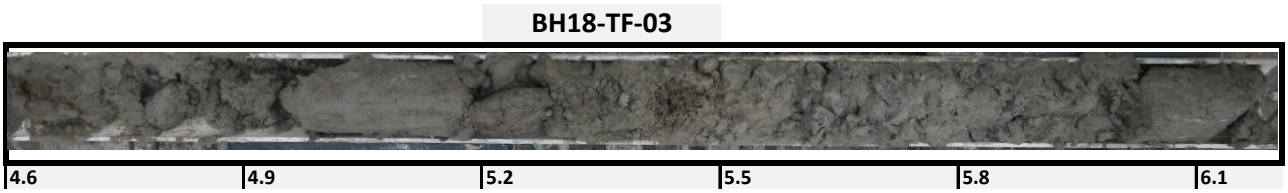


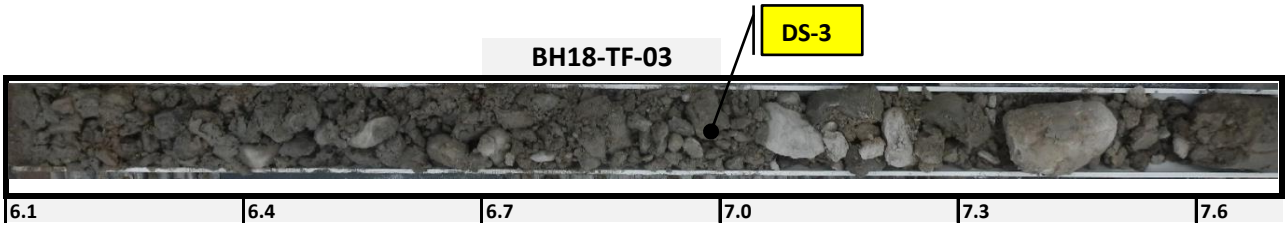
Sample Photographs

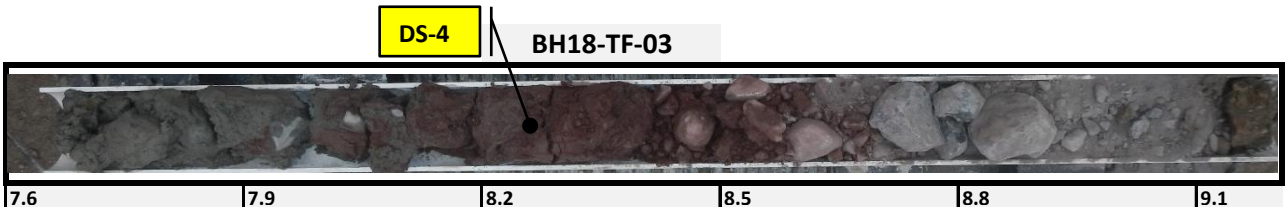
Borehole Name:	BH18-TF-03	Mary River Expansion Study Stage 2
Location:	17 W 561094 7913477	2018 Geotechnical Investigation
Completion Date:	June 22, 2018	Baffinland Iron Mines







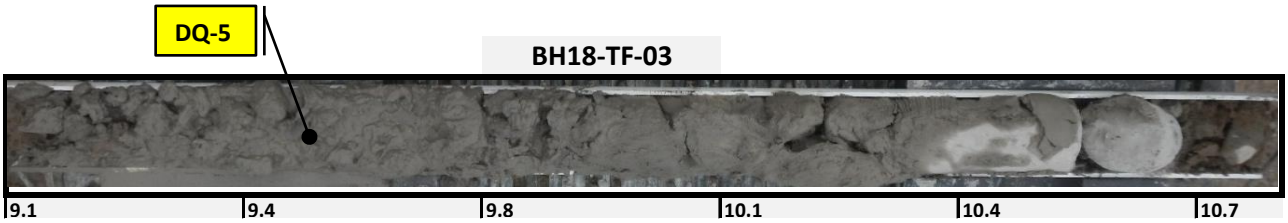


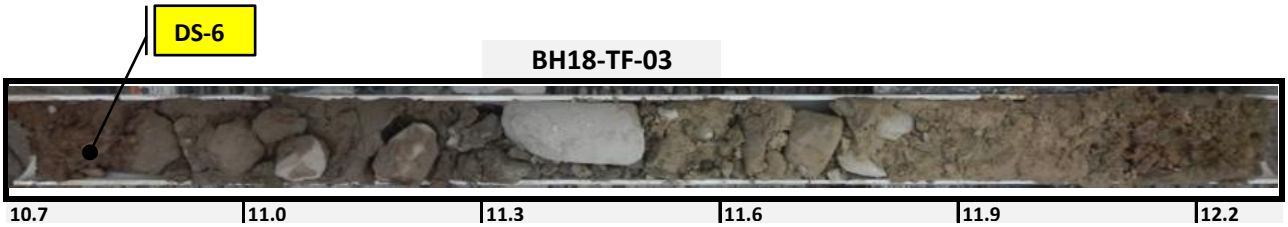


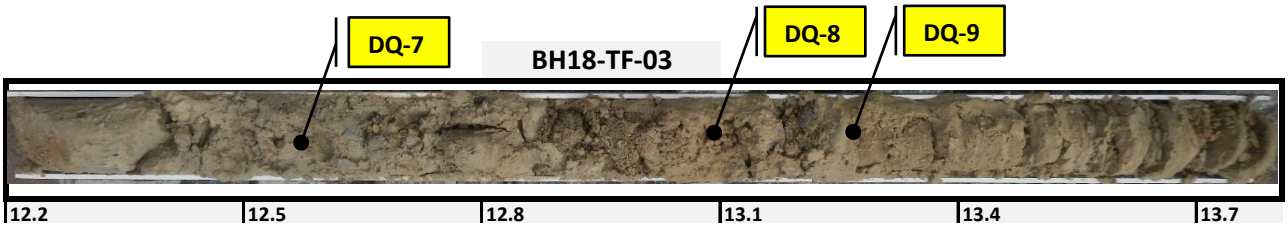
HATCH

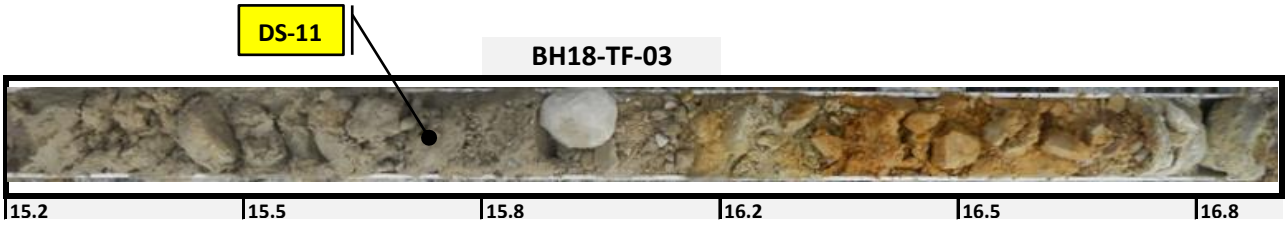
Sample Photographs

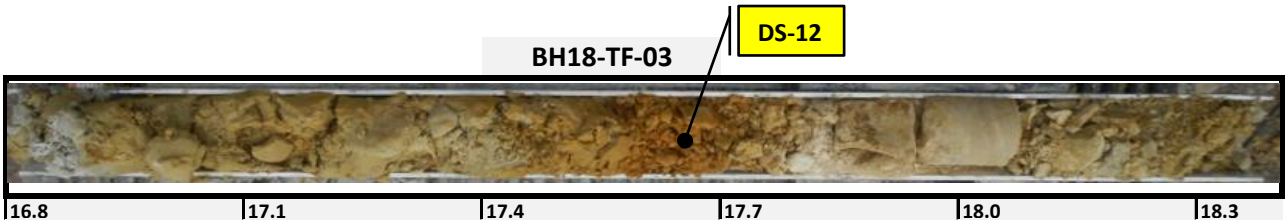
Borehole Name:	BH18-TF-03	Mary River Expansion Study Stage 2
Location:	17 W 561094 7913477	
Completion Date:	June 22, 2018	Baffinland Iron Mines











HATCH

Sample Photographs

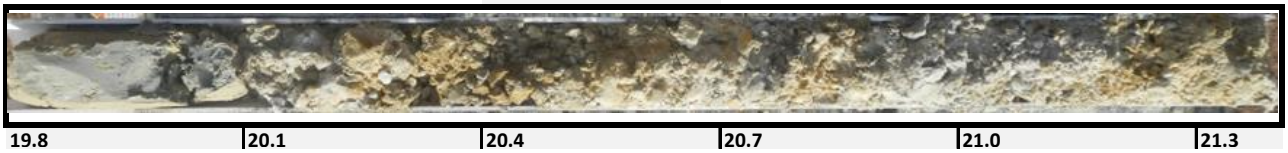
Borehole Name:	BH18-TF-03	Mary River Expansion Study Stage 2
Location:	17 W 561094 7913477	
Completion Date:	June 22, 2018	Baffinland Iron Mines

DS-13

BH18-TF-03

18.3 | 18.6 | 18.9 | 19.2 | 19.5 | 19.8

BH18-TF-03



19.8 | 20.1 | 20.4 | 20.7 | 21.0 | 21.3

BH18-TF-03

21.3 | 21.6 | 21.9 | 22.3 | 22.6 | 22.9

BH18-TF-03

22.9 | 23.2 | 23.5 | 23.8 | 24.1 | 24.4

DS-14

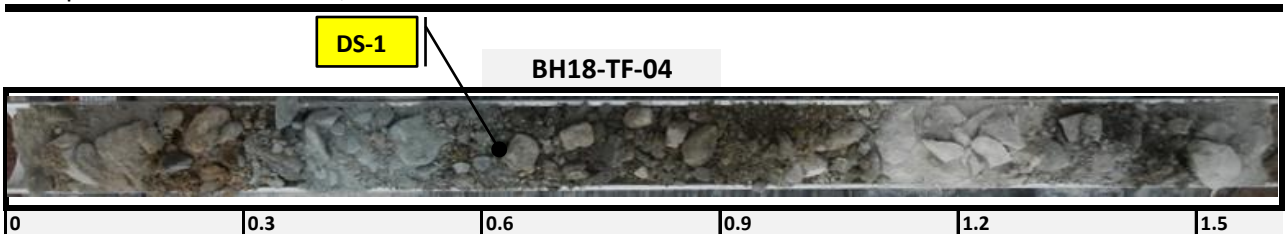
BH18-TF-03

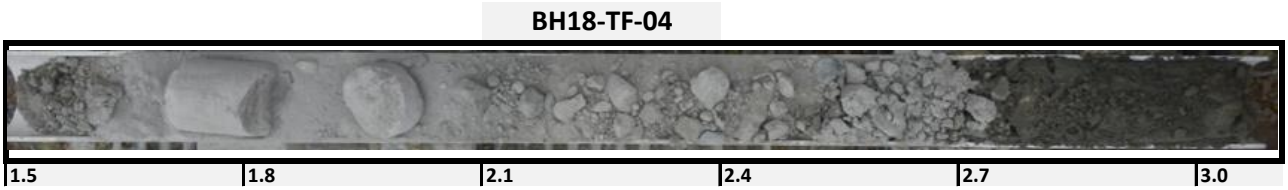
24.4 | 24.7 | 25.0 | 25.3 | 25.6 | 25.9

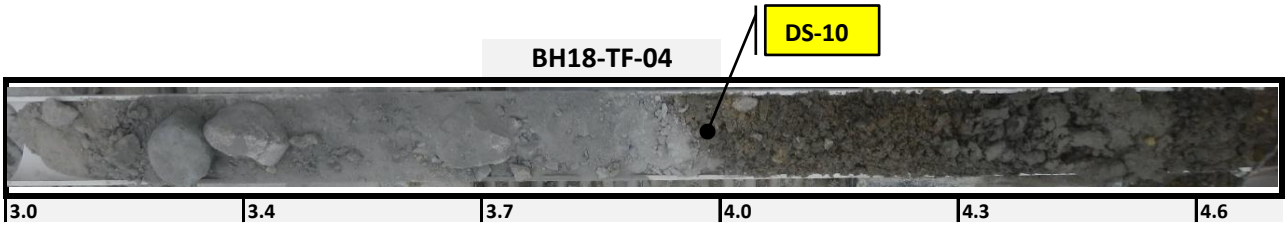
HATCH

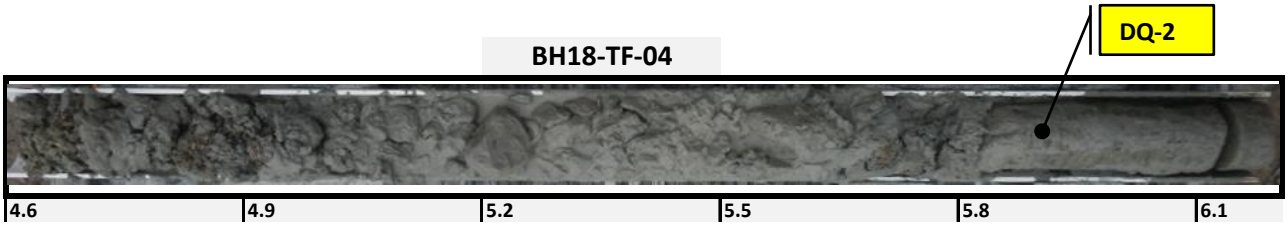
Sample Photographs

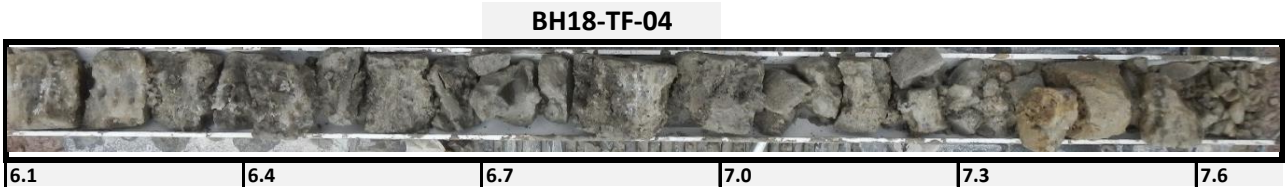
Borehole Name:	BH18-TF-04	Mary River Expansion Study Stage 2
Location:	17 W 561002 7913499	2018 Geotechnical Investigation
Completion Date:	June 24, 2018	Baffinland Iron Mines

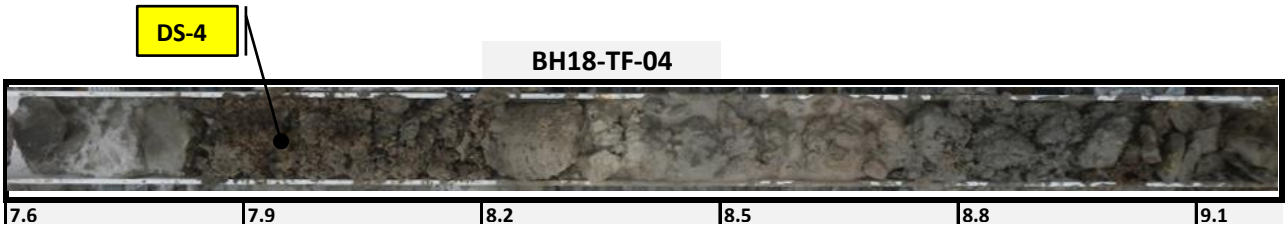








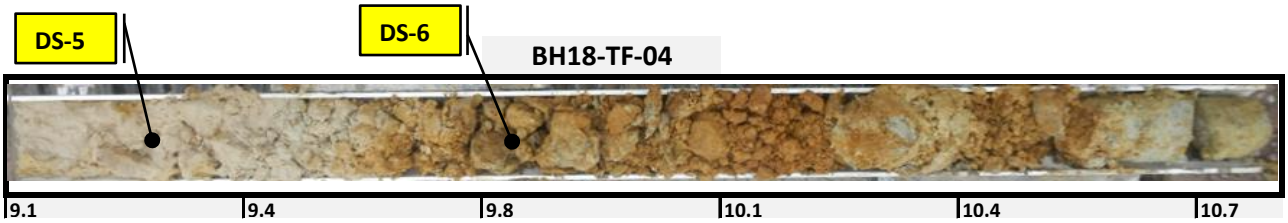


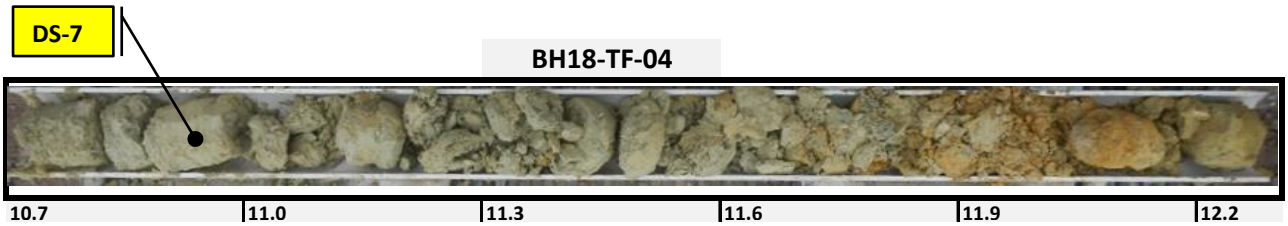


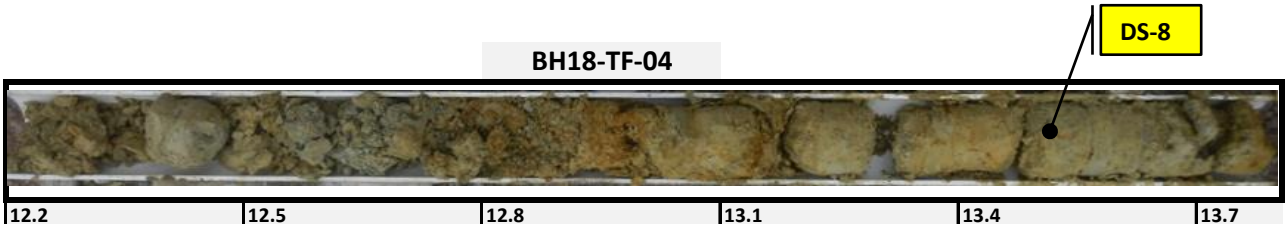
HATCH

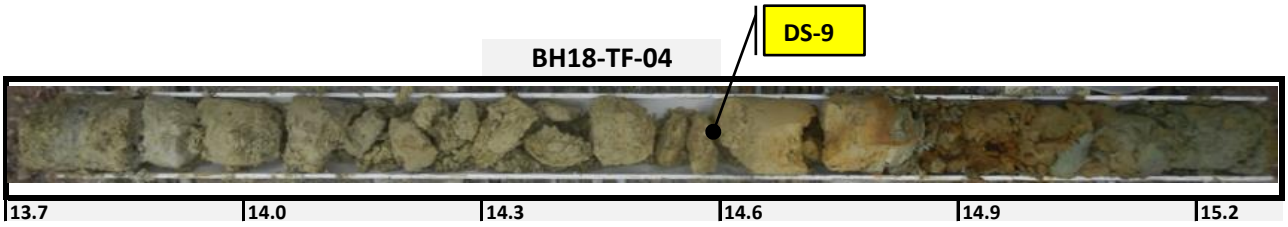
Sample Photographs

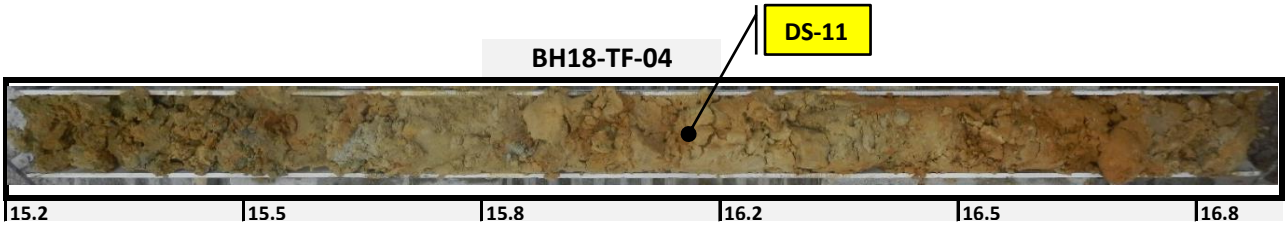
Borehole Name:	BH18-TF-04	Mary River Expansion Study Stage 2
Location:	17 W 561002 7913499	
Completion Date:	June 24, 2018	Baffinland Iron Mines

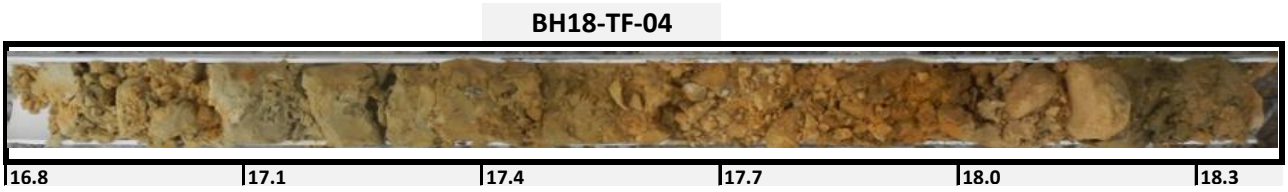












HATCH

Sample Photographs

Borehole Name:	BH18-TF-04	Mary River Expansion Study Stage 2
Location:	17 W 561002 7913499	
Completion Date:	June 24, 2018	Baffinland Iron Mines

BH18-TF-04

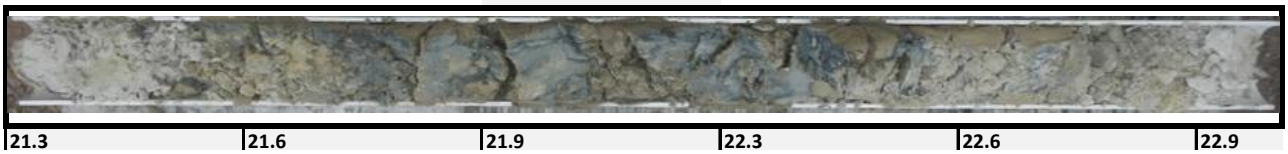
18.3 | 18.6 | 18.9 | 19.2 | 19.5 | 19.8

DS-12

BH18-TF-04

19.8 | 20.1 | 20.4 | 20.7 | 21.0 | 21.3

BH18-TF-04



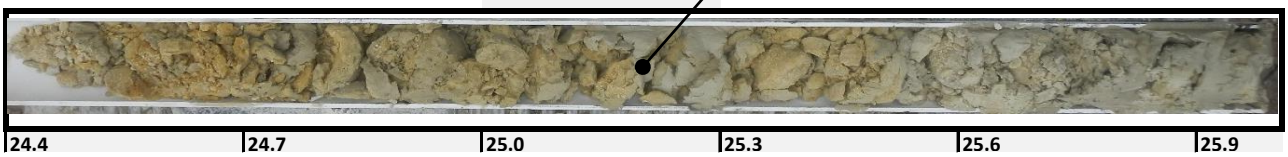
21.3 | 21.6 | 21.9 | 22.3 | 22.6 | 22.9

BH18-TF-04

22.9 | 23.2 | 23.5 | 23.8 | 24.1 | 24.4

DS-13

BH18-TF-04



24.4 | 24.7 | 25.0 | 25.3 | 25.6 | 25.9

HATCH

Sample Photographs

Borehole Name:	BH18-TF-05	Mary River Expansion Study Stage 2
Location:	17 W 561203 7913478	2018 Geotechnical Investigation
Completion Date:	June 20, 2018	Baffinland Iron Mines

BH18-TF-05

0	0.3	0.6	0.9	1.2	1.5

BH18-TF-05

1.5	1.8	2.1	2.4	2.7	3.0

BH18-TF-05

3.0	3.4	3.7	4.0	4.3	4.6

BH18-TF-05

4.6	4.9	5.2	5.5	5.8	6.1

BH18-TF-05

6.1	6.4	6.7	7.0	7.3	7.6

BH18-TF-05

7.6	7.9	8.2	8.5	8.8	9.1

HATCH

Sample Photographs

Borehole Name:	BH18-TF-05	Mary River Expansion Study Stage 2
Location:	17 W 561203 7913478	
Completion Date:	June 20, 2018	Baffinland Iron Mines

BH18-TF-05

9.1 | 9.4 | 9.8 | 10.1 | 10.4 | 10.7

BH18-TF-05

10.7 | 11.0 | 11.3 | 11.6 | 11.9 | 12.2

BH18-TF-05

12.2 | 12.5 | 12.8 | 13.1 | 13.4 | 13.7

BH18-TF-05

13.7 | 14.0 | 14.3 | 14.6 | 14.9 | 15.2

BH18-TF-05

15.2 | 15.5 | 15.8 | 16.2 | 16.5 | 16.8

BH18-TF-05

16.8 | 17.1 | 17.4 | 17.7 | 18.0 | 18.3

HATCH

Sample Photographs

Borehole Name:	BH18-TF-05	Mary River Expansion Study Stage 2
Location:	17 W 561203 7913478	
Completion Date:	June 20, 2018	Baffinland Iron Mines

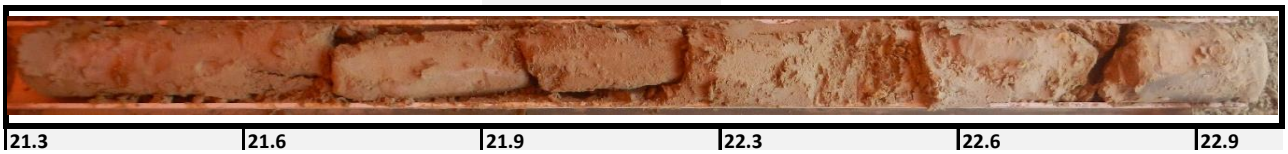
BH18-TF-05

18.3 | 18.6 | 18.9 | 19.2 | 19.5 | 19.8

BH18-TF-05

19.8 | 20.1 | 20.4 | 20.7 | 21.0 | 21.3

BH18-TF-05



21.3 | 21.6 | 21.9 | 22.3 | 22.6 | 22.9

DS-13

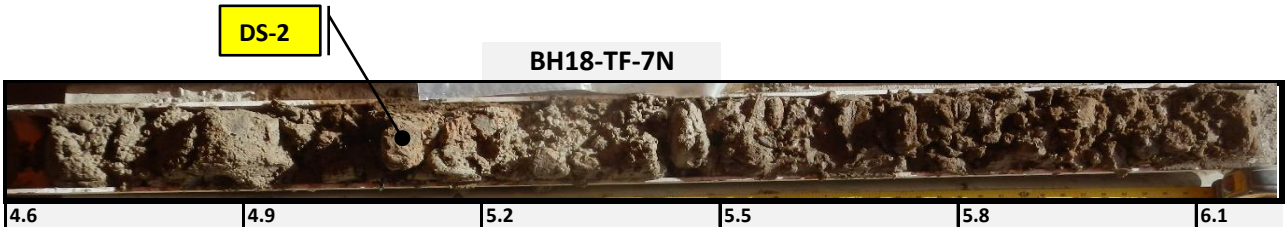
BH18-TF-05

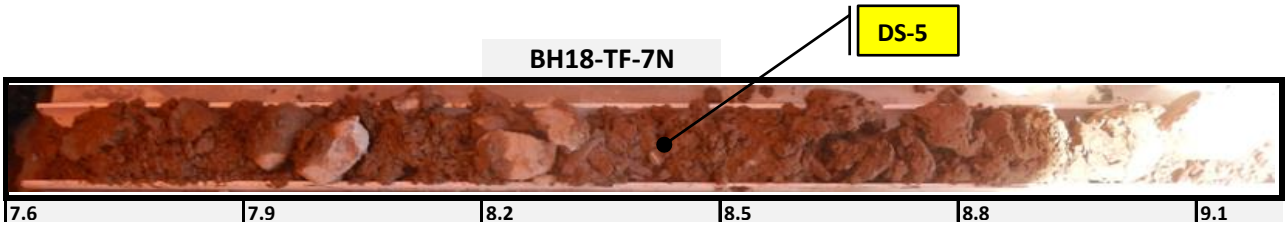
22.9 | 23.2 | 23.5 | 23.8 | 24.1 | 24.4

HATCH

Sample Photographs

Borehole Name:	BH18-TF-7N	Mary River Expansion Study Stage 2
Location:	17 W 561064 7913438	2018 Geotechnical Investigation
Completion Date:	June 26, 2018	Baffinland Iron Mines





HATCH

Sample Photographs

Borehole Name:	BH18-TF-7N	Mary River Expansion Study Stage 2
Location:	17 W 561064 7913438	
Completion Date:	June 26, 2018	Baffinland Iron Mines

BH18-TF-7N

9.1 | 9.4 | 9.8 | 10.1 | 10.4 | 10.7

DS-6

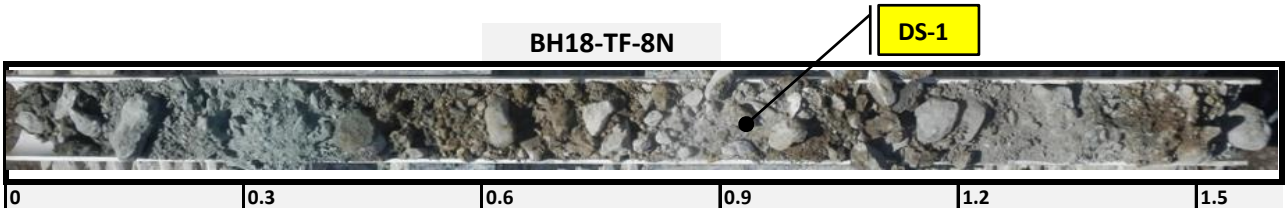
BH18-TF-7N

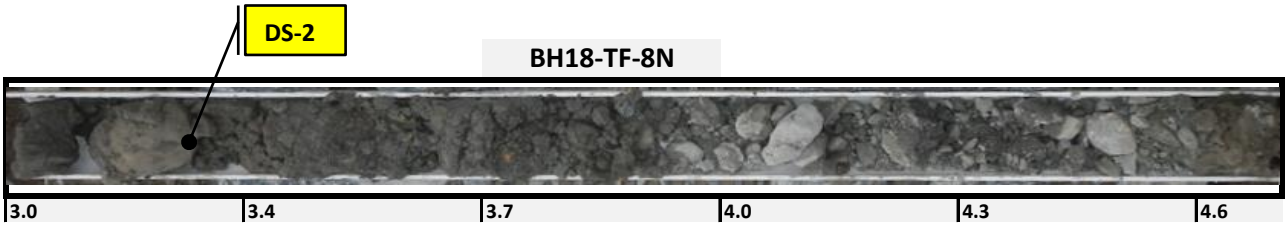
10.7 | 11.0 | 11.3 | 11.6 | 11.9 | 12.2

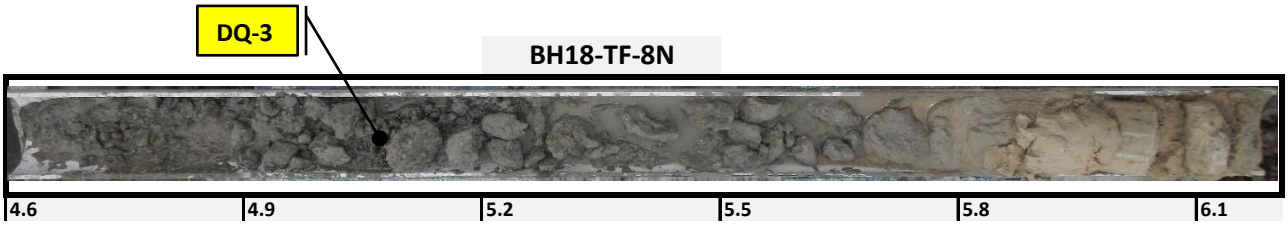
HATCH

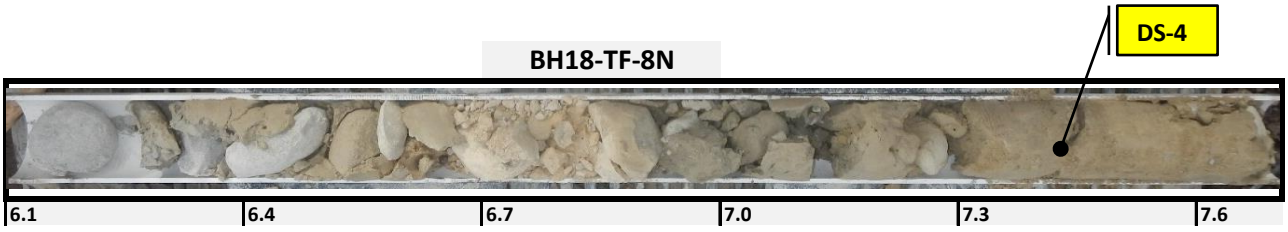
Sample Photographs

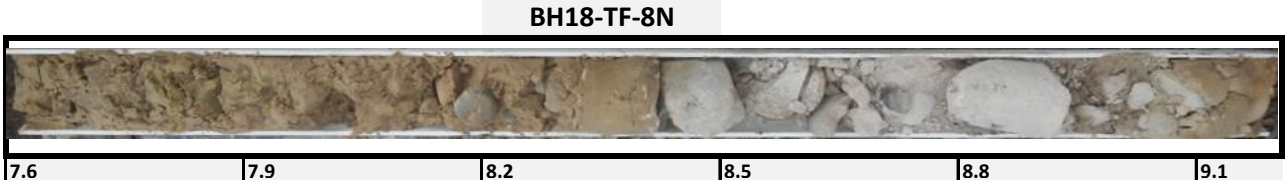
Borehole Name:	BH18-TF-8N	Mary River Expansion Study Stage 2
Location:	17 W 561166 7913449	2018 Geotechnical Investigation
Completion Date:	June 27, 2018	Baffinland Iron Mines











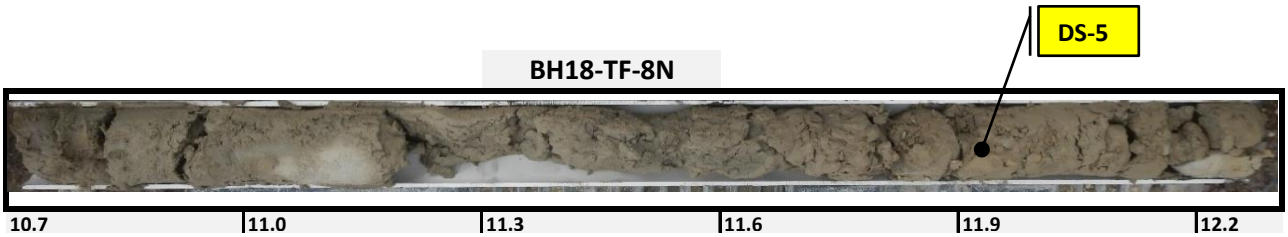
HATCH

Sample Photographs

Borehole Name:	BH18-TF-8N	Mary River Expansion Study Stage 2
Location:	17 W 561166 7913449	
Completion Date:	June 27, 2018	Baffinland Iron Mines

BH18-TF-8N

BH18-TF-8N



HATCH

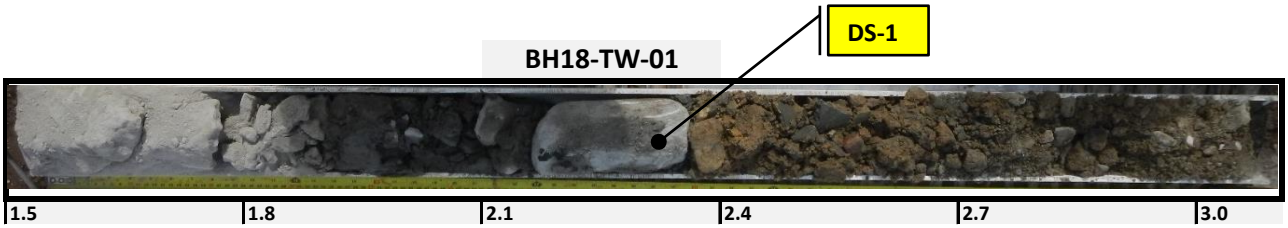
Sample Photographs

Borehole Name:	BH18-TW-01	Mary River Expansion Study Stage 2
Location:	17 W 561477 7913189	2018 Geotechnical Investigation
Completion Date:	June 17, 2018	Baffinland Iron Mines

BH18-TW-01

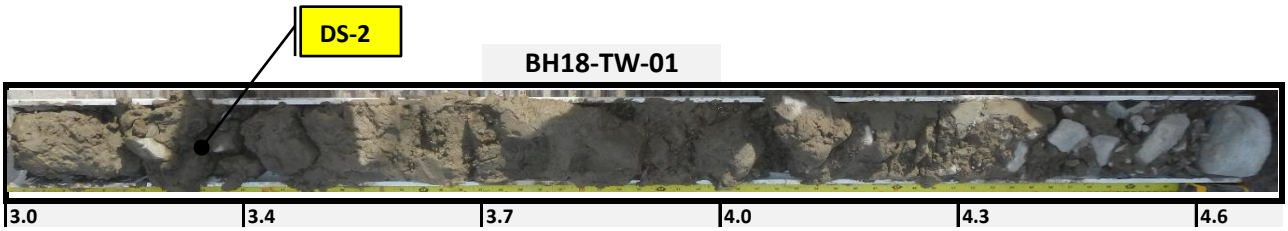
0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH18-TW-01



1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH18-TW-01



3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

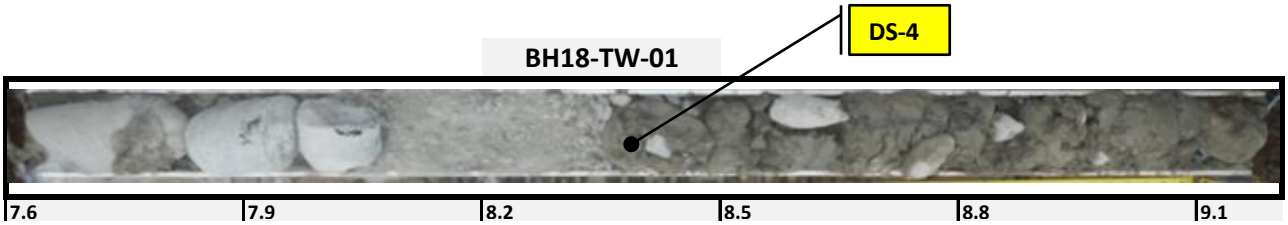
BH18-TW-01

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH18-TW-01

6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

BH18-TW-01

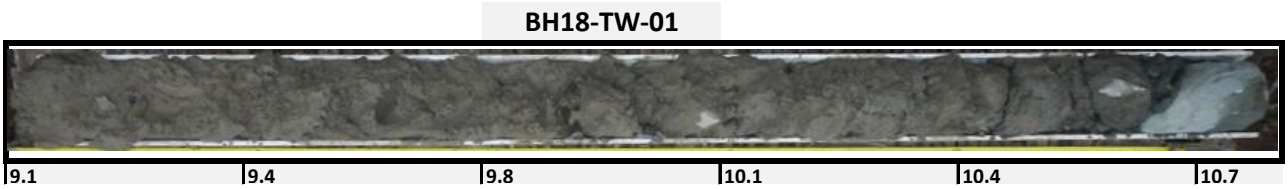


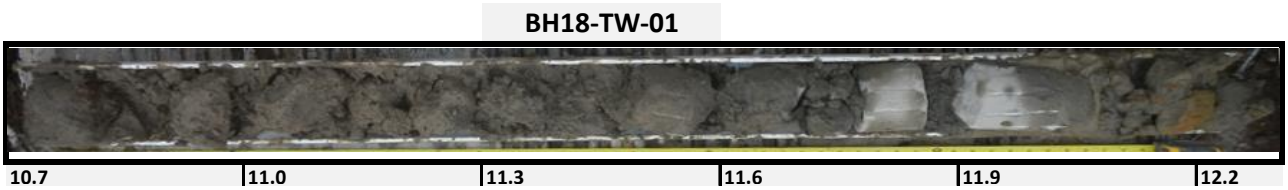
7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

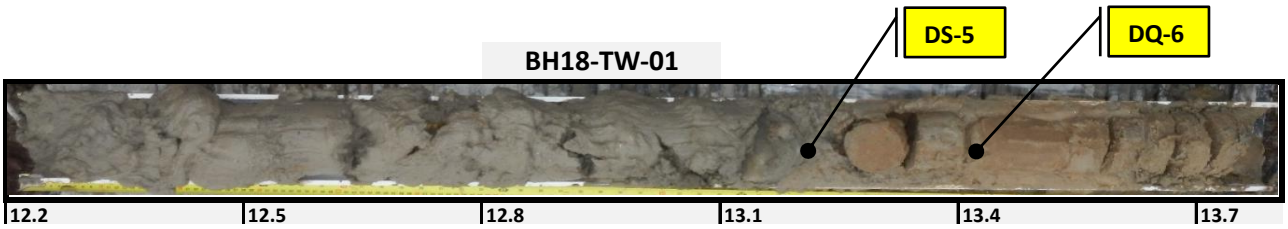
HATCH

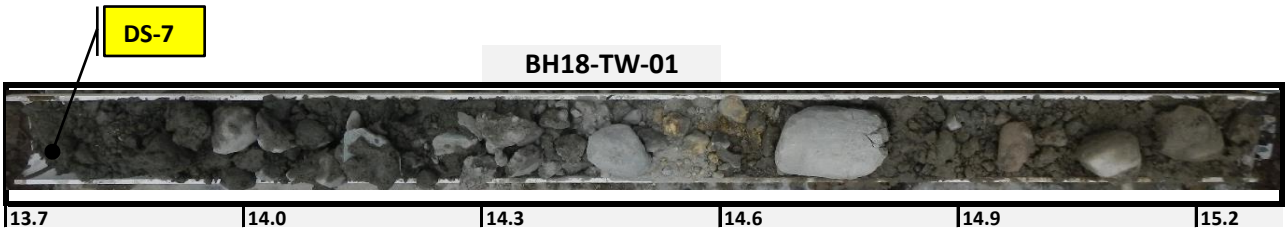
Sample Photographs

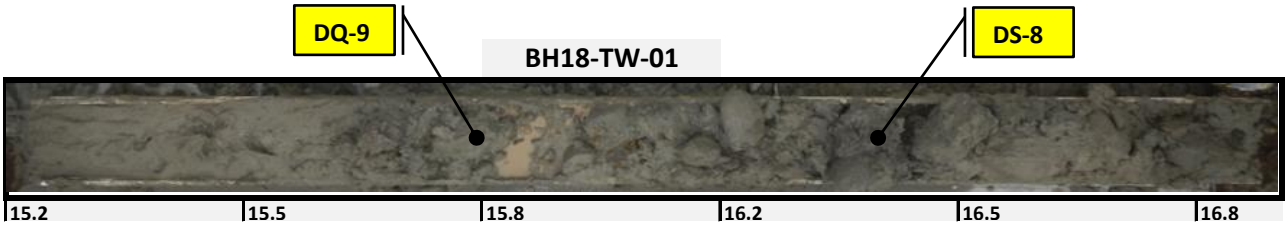
Borehole Name:	BH18-TW-01	Mary River Expansion Study Stage 2
Location:	17 W 561477 7913189	
Completion Date:	June 17, 2018	Baffinland Iron Mines

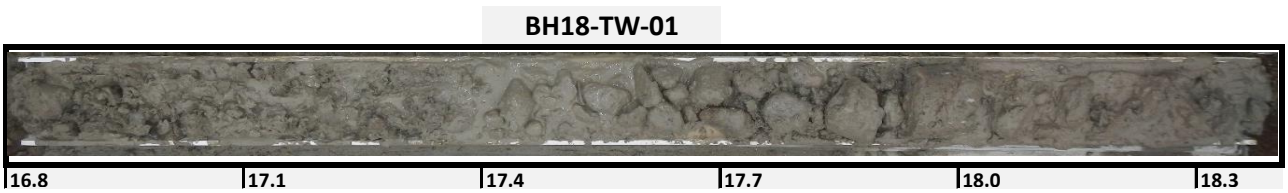








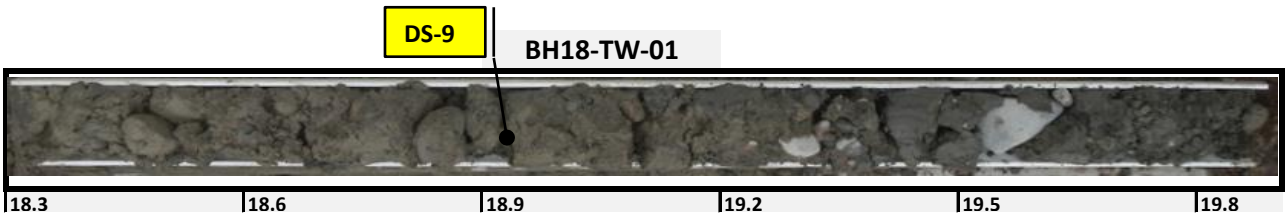


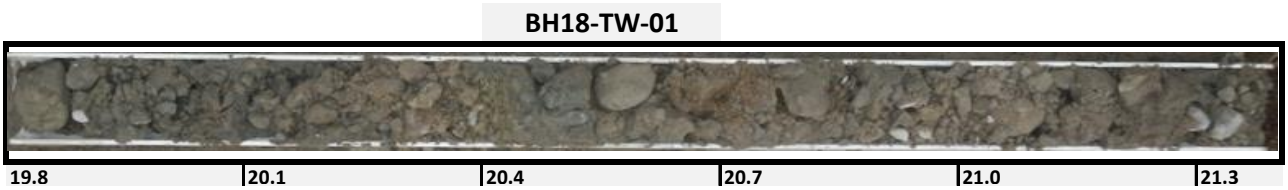


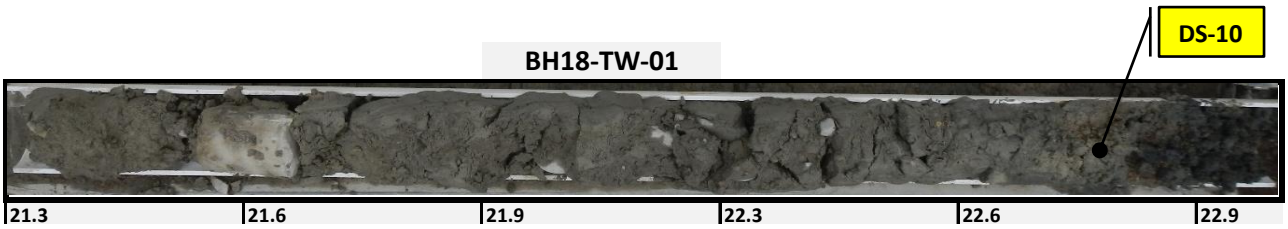
HATCH

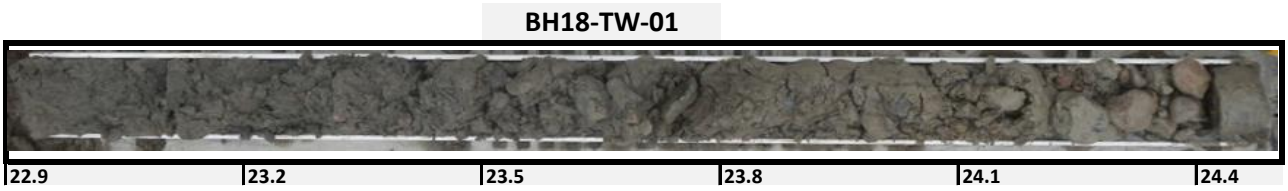
Sample Photographs

Borehole Name:	BH18-TW-01	Mary River Expansion Study Stage 2
Location:	17 W 561477 7913189	
Completion Date:	June 17, 2018	Baffinland Iron Mines









HATCH

Sample Photographs

Borehole Name:	BH18-TW-02	Mary River Expansion Study Stage 2
Location:	17 W 561532 7913229	2018 Geotechnical Investigation
Completion Date:	June 17, 2018	Baffinland Iron Mines

BH18-TW-02

DS-1

BH18-TW-02

BH18-TW-02

BH18-TW-02

DS-2

BH18-TW-02

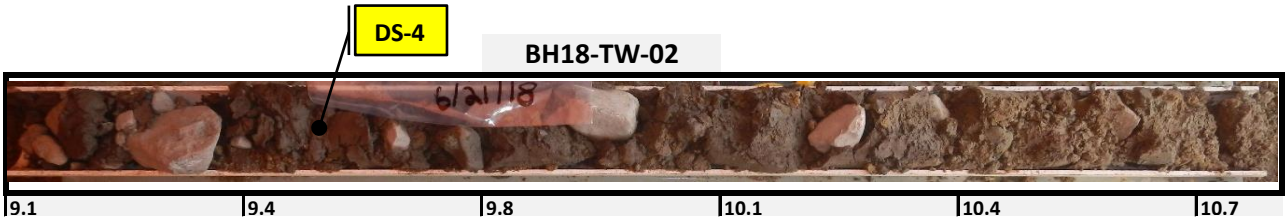
DS-3

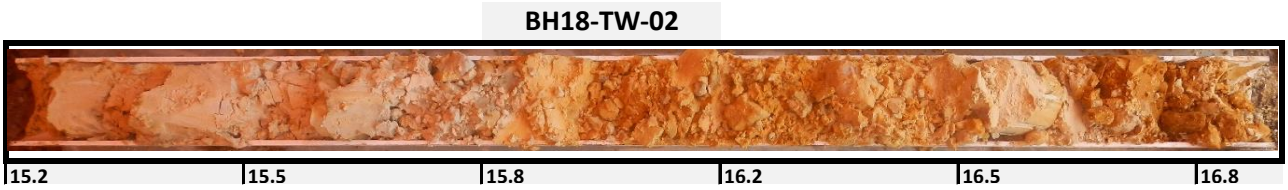
BH18-TW-02

HATCH

Sample Photographs

Borehole Name:	BH18-TW-02	Mary River Expansion Study Stage 2
Location:	17 W 561532 7913229	
Completion Date:	June 17, 2018	Baffinland Iron Mines

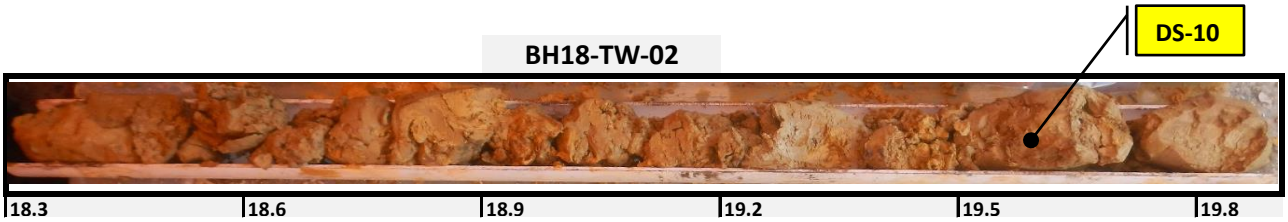


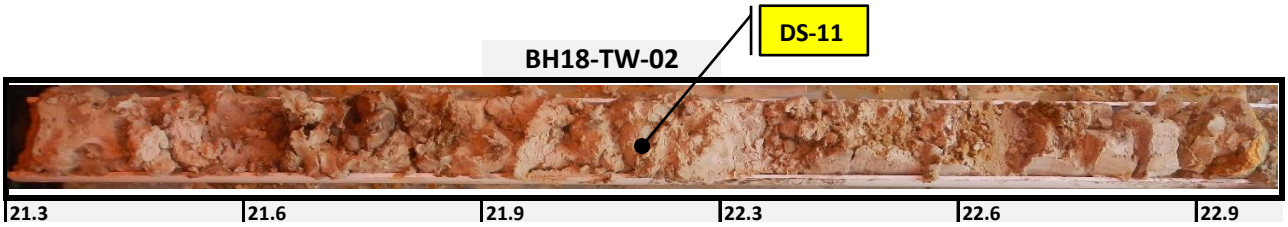


HATCH

Sample Photographs

Borehole Name:	BH18-TW-02	Mary River Expansion Study Stage 2
Location:	17 W 561532 7913229	
Completion Date:	June 17, 2018	Baffinland Iron Mines





Appendix D

Laboratory Test Reports

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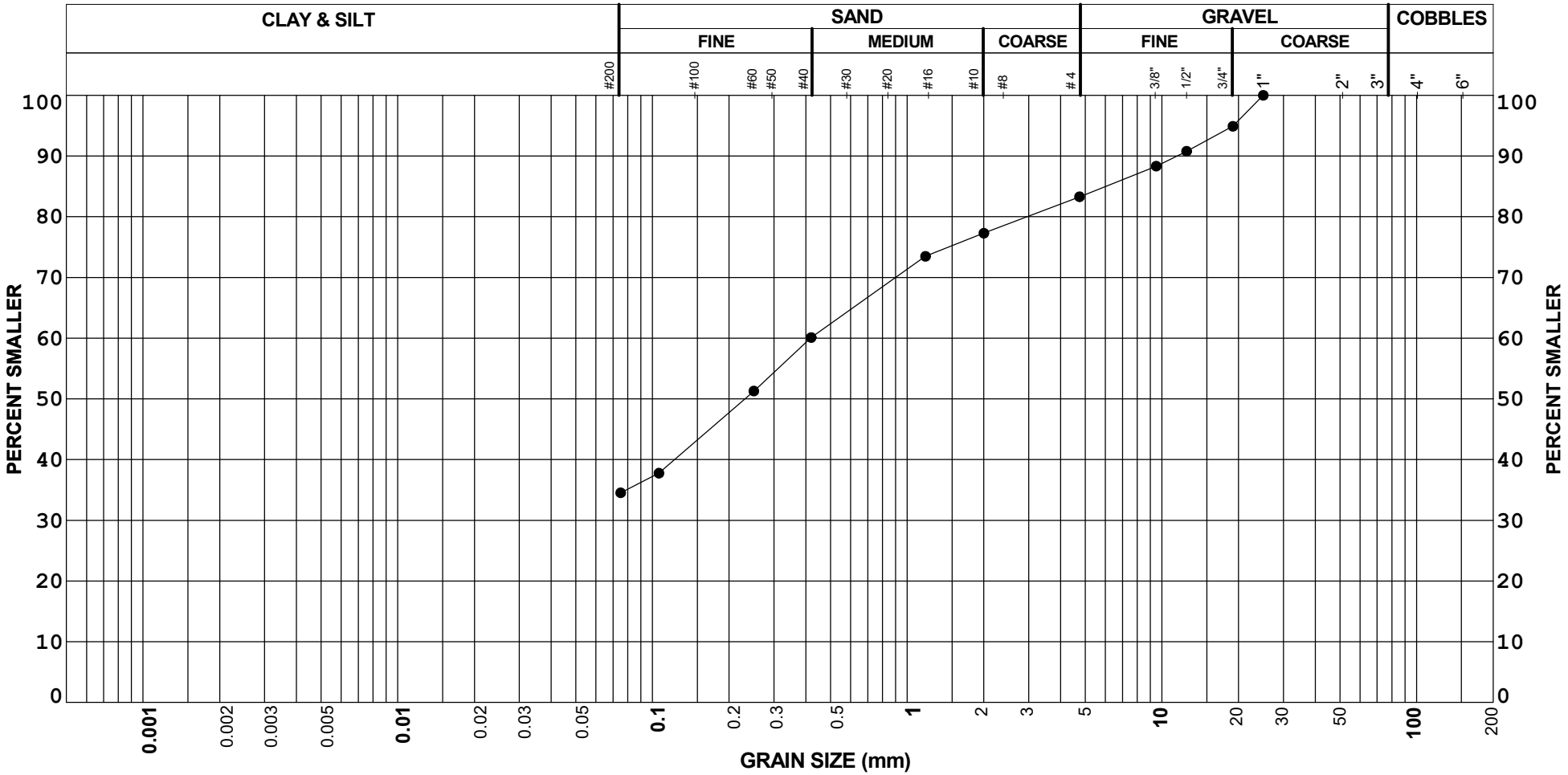
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-01	DS-2	3.70	17	48	35		

REMARKS:

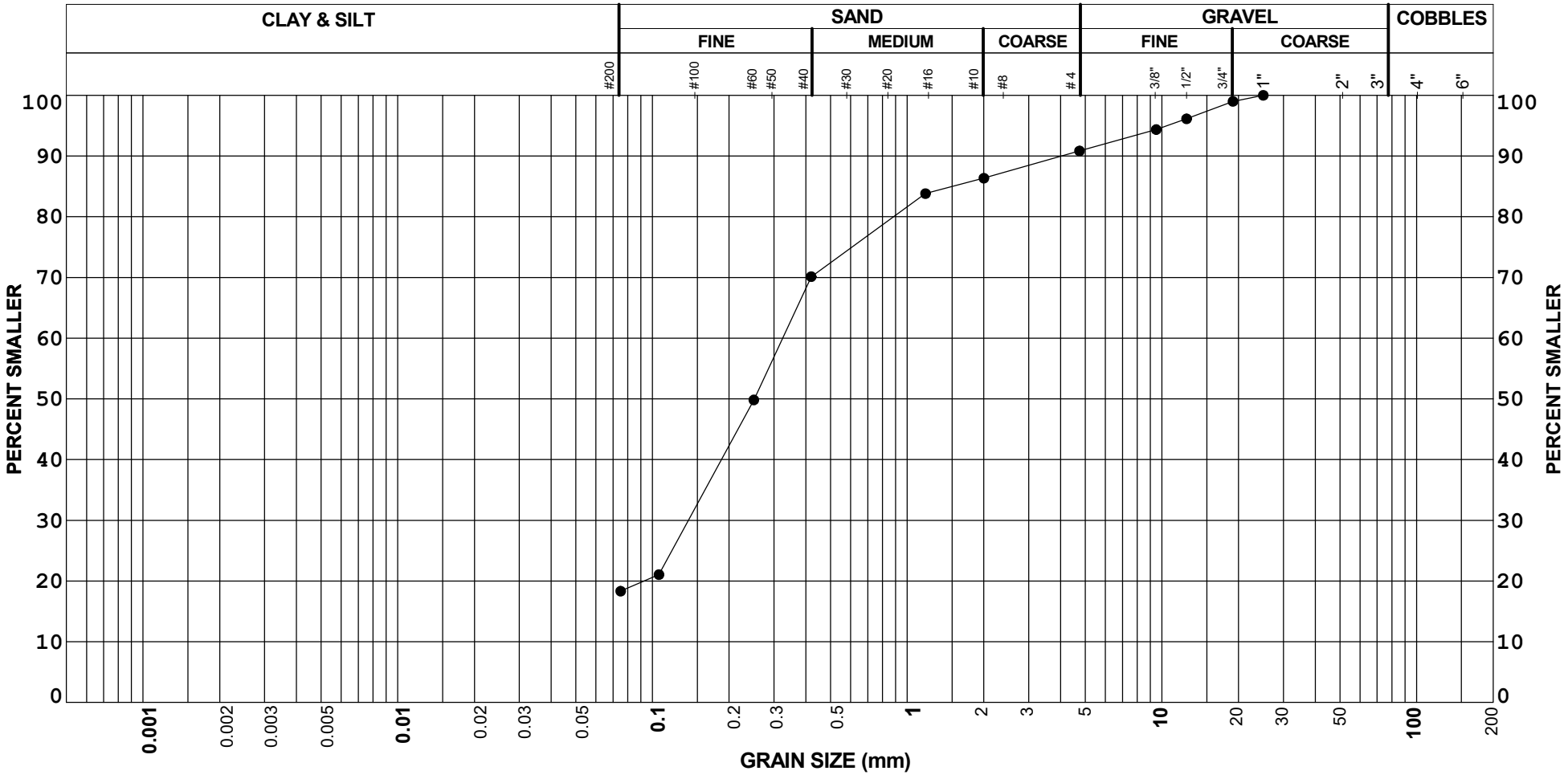
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-01	DS-4	7.00	9	73	18		

REMARKS:

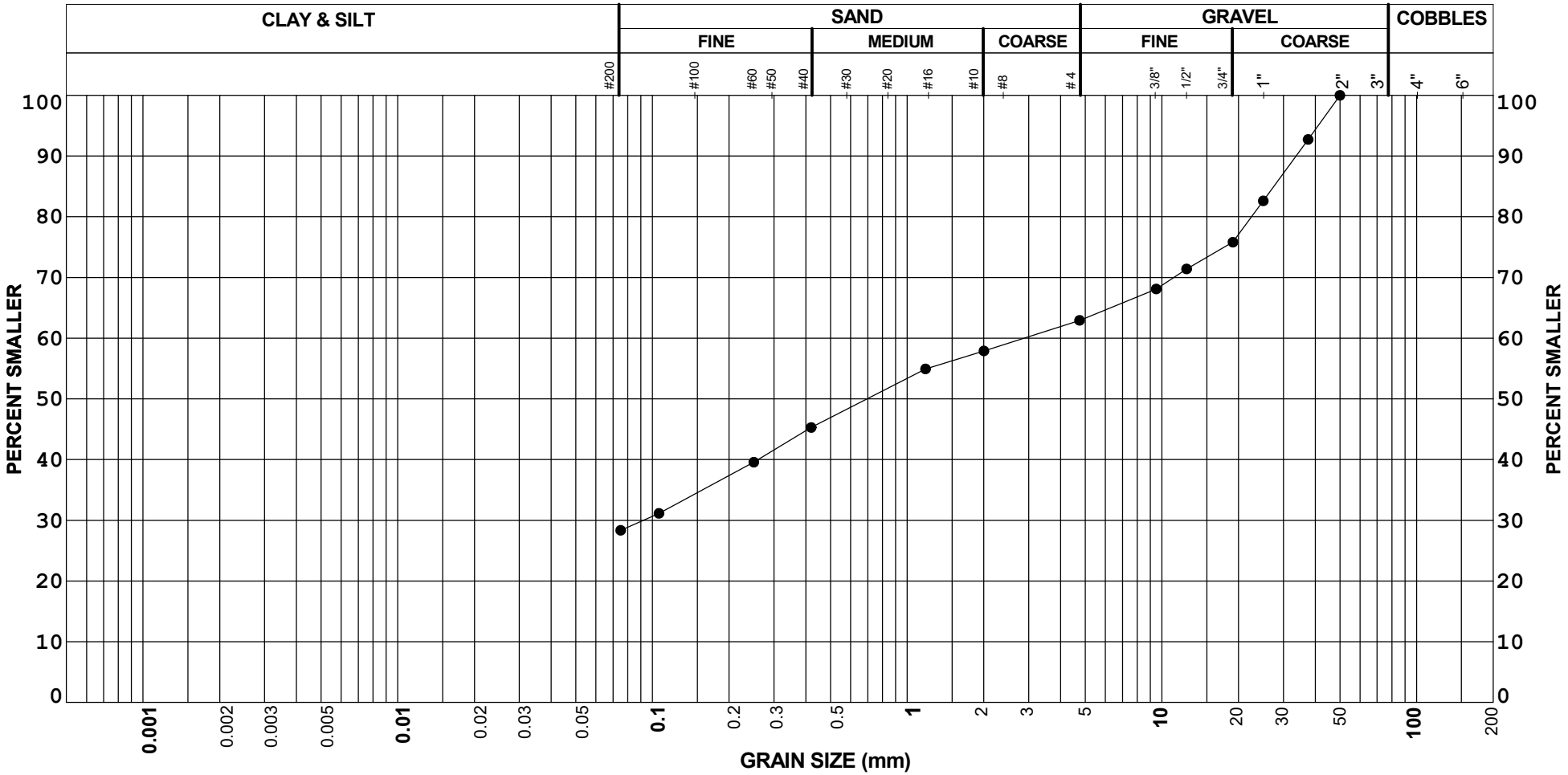
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-01	DS-7	15.50	37	35	28		

REMARKS:

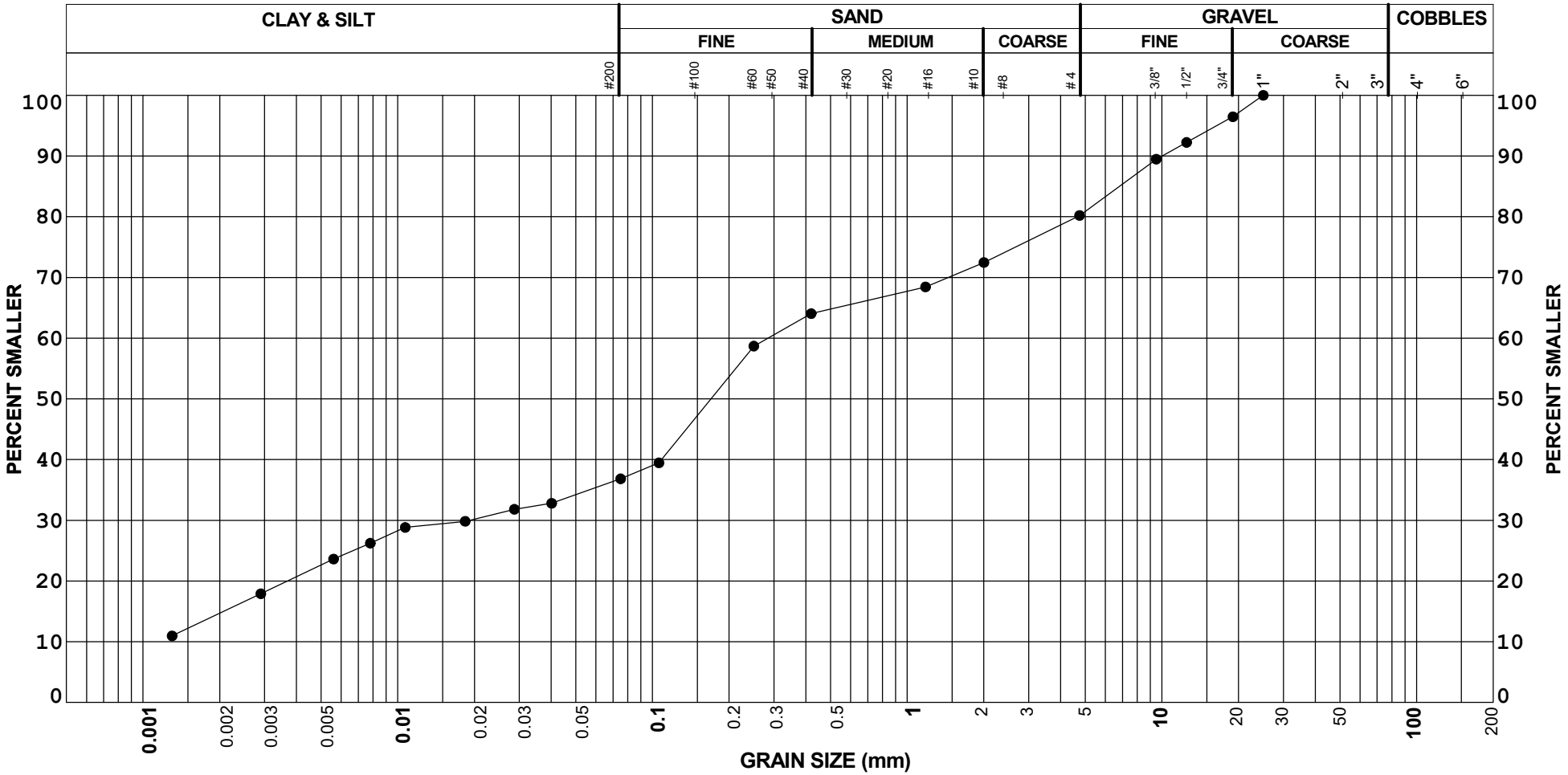
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-01	DS-8	17.25	20	43	37		

REMARKS:

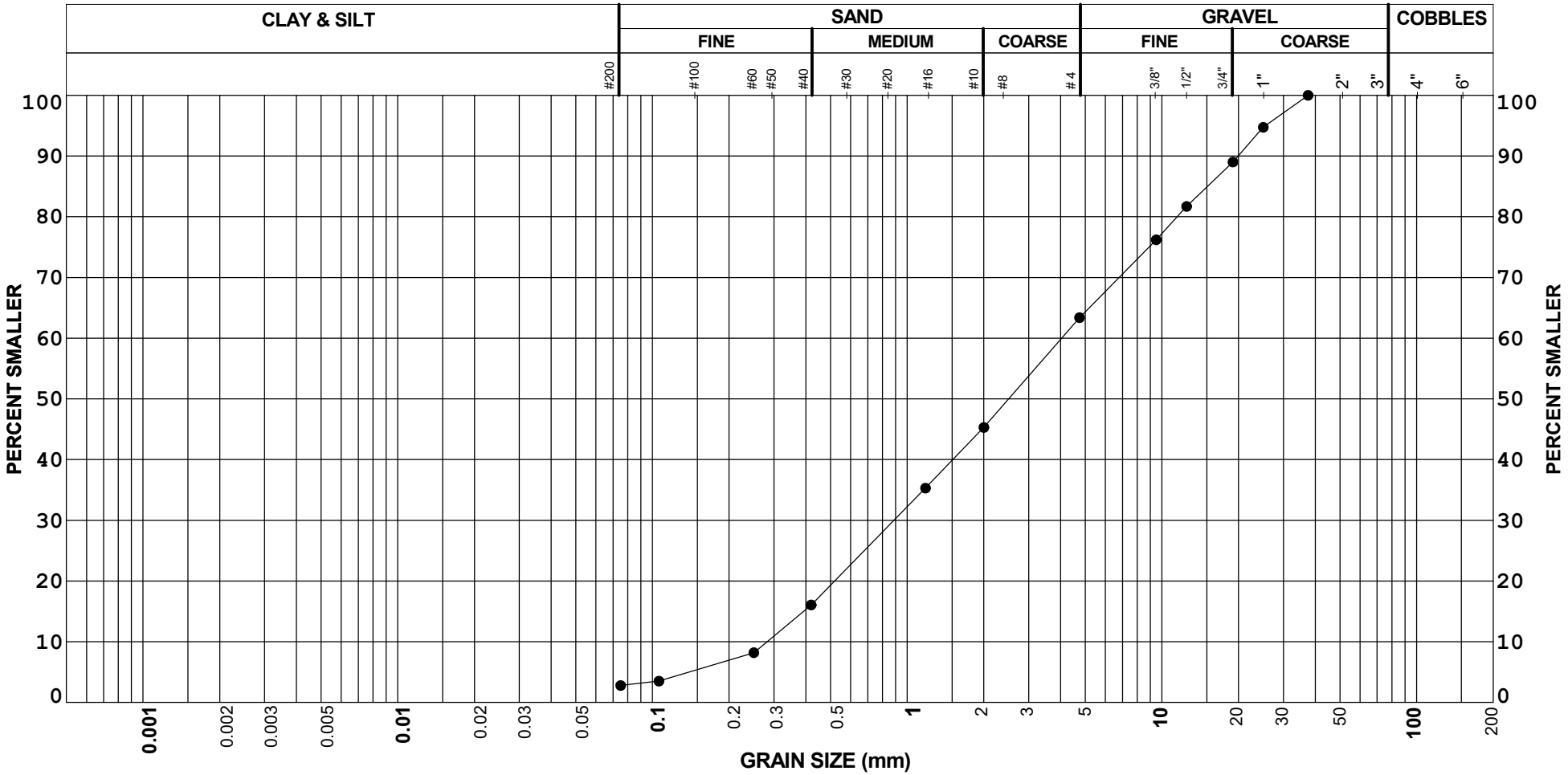
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-02	DS-1	1.00	37	60	3		

REMARKS:

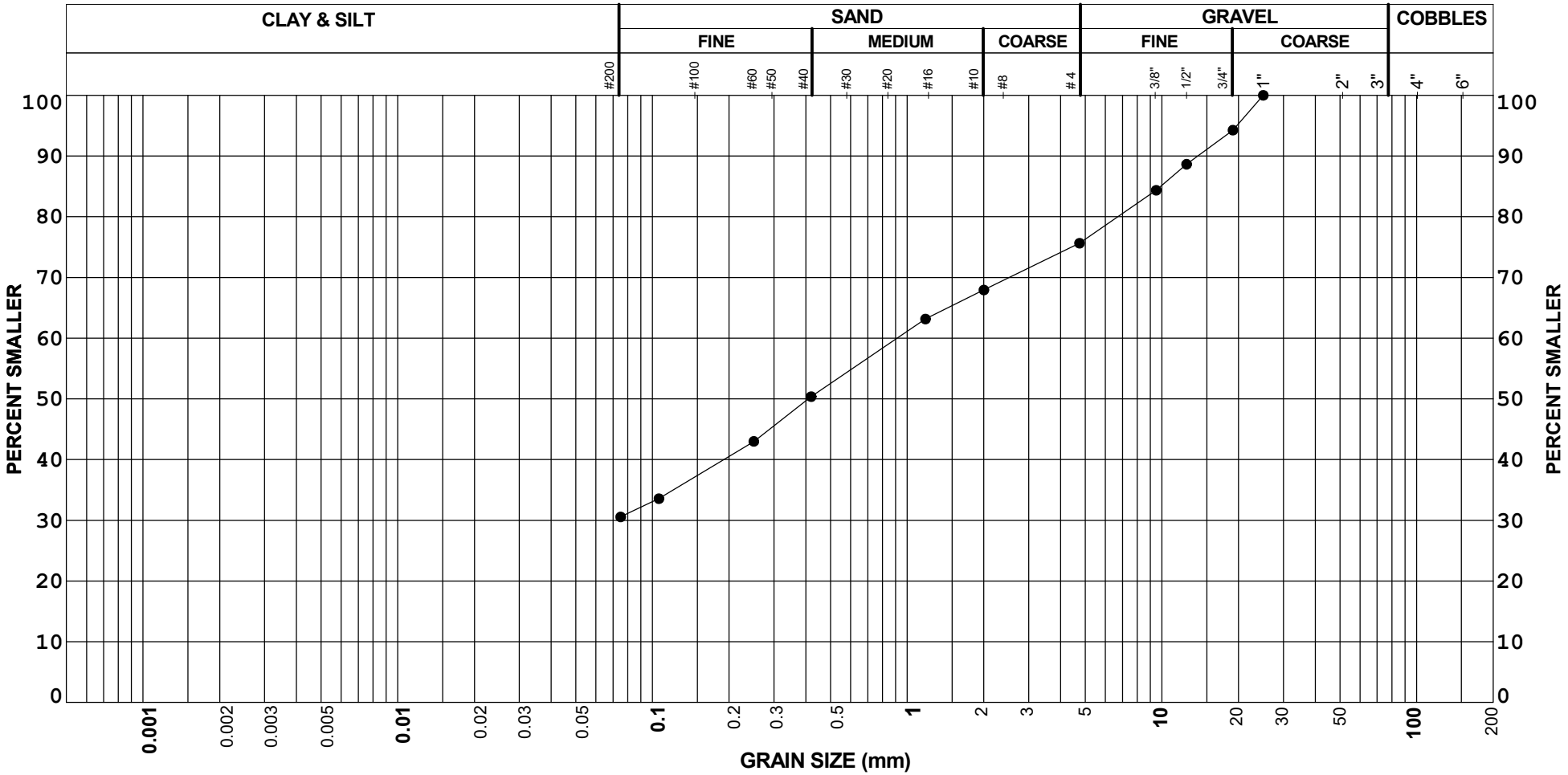
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-02	DS-5	4.00	24	45	31		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

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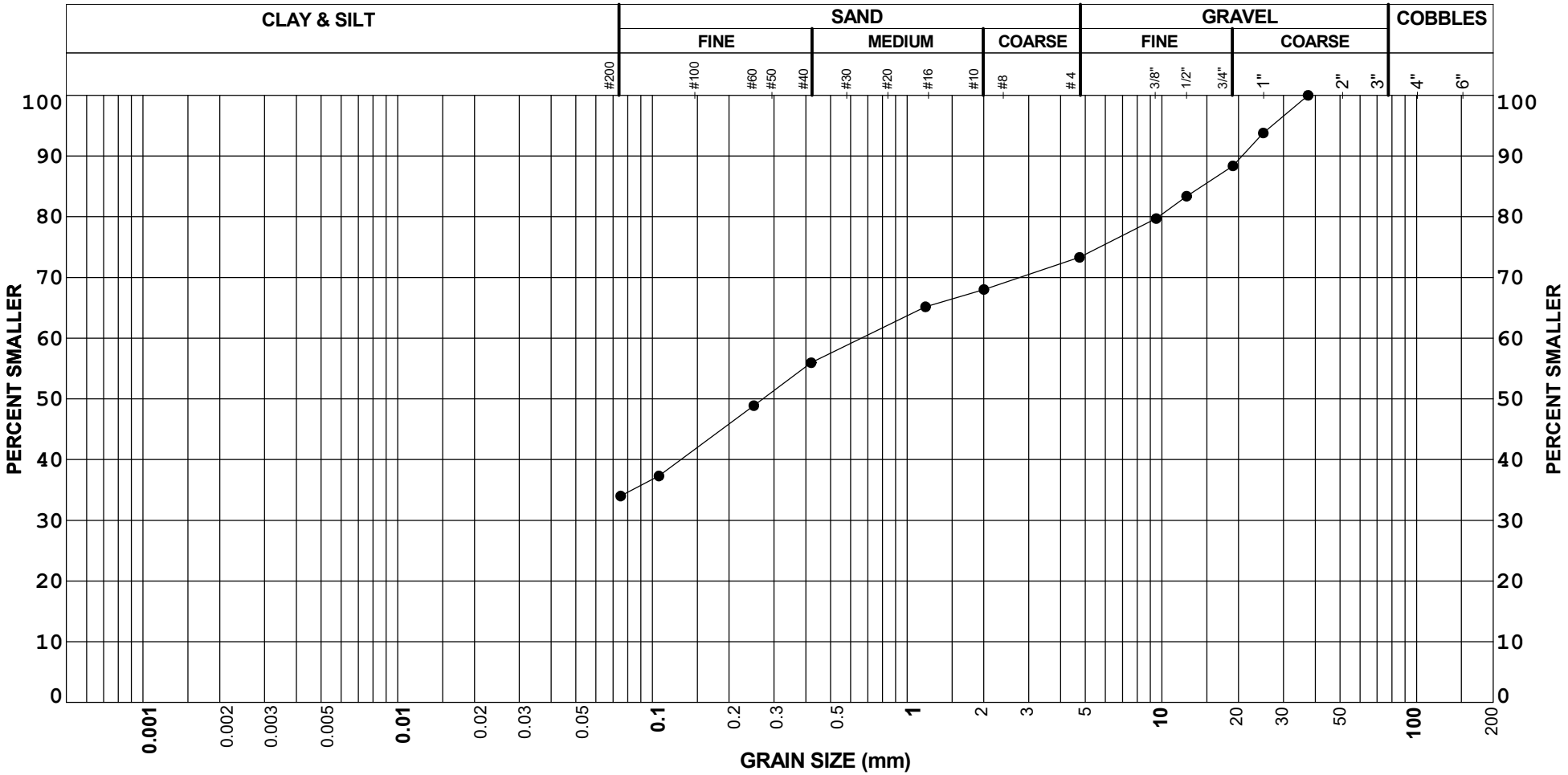
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-02	DS-6	7.90	27	39	34		

REMARKS:

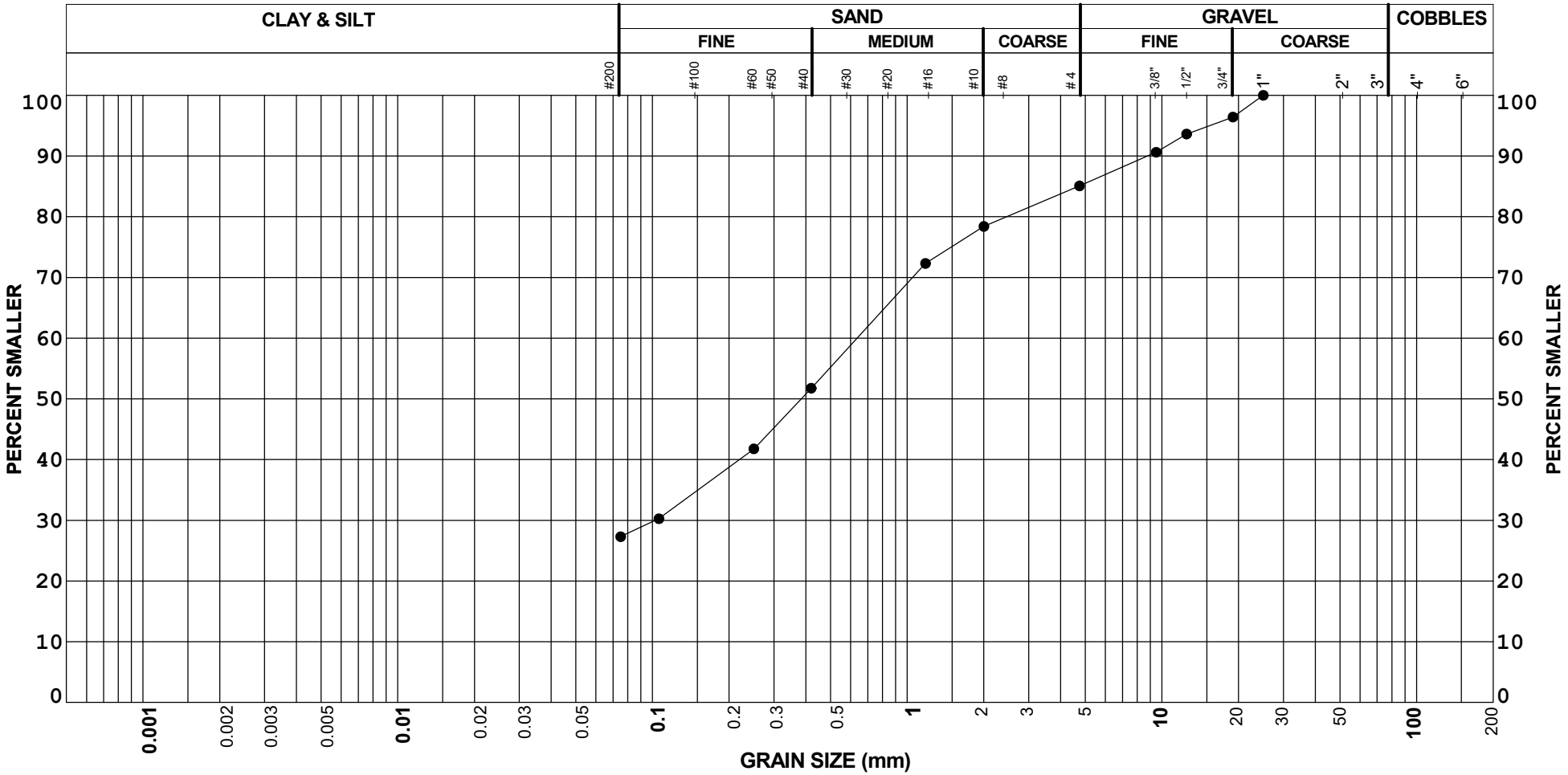
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-02	DS-9	13.20	15	58	27		

REMARKS:

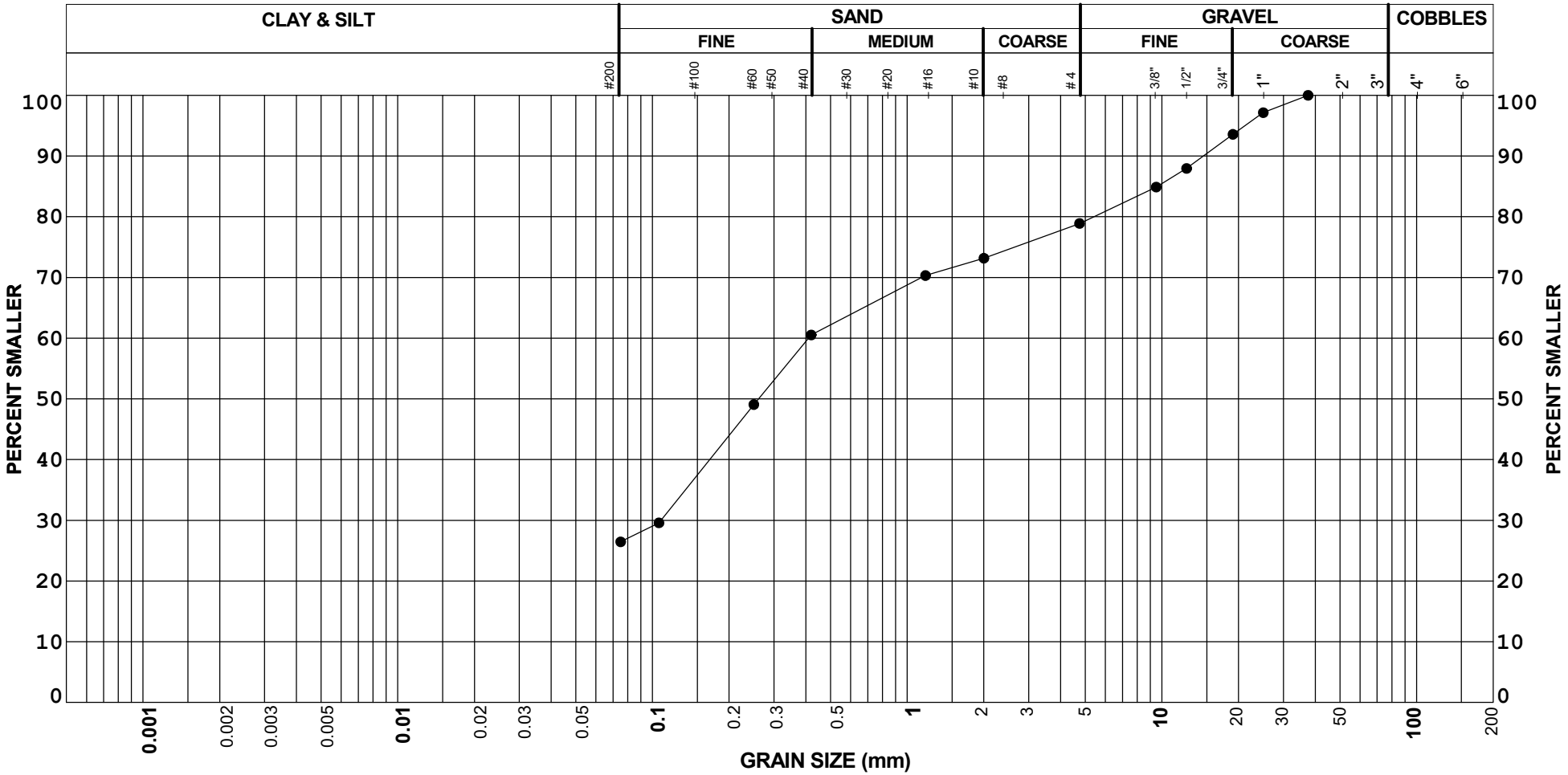
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-02	DS-12	19.90	21	53	26		

REMARKS:

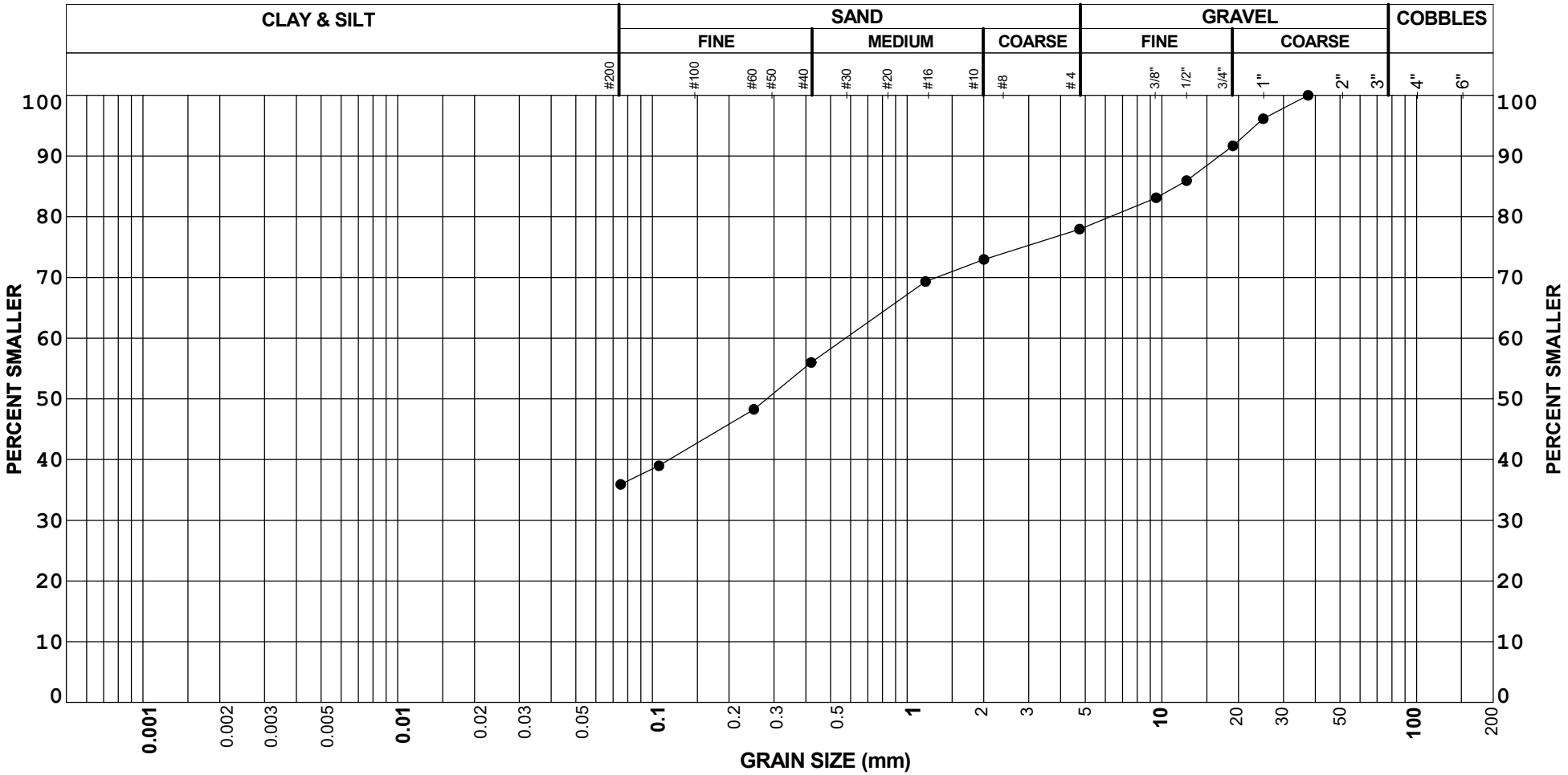
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-03	DS-4	8.20	22	42	36		

REMARKS:

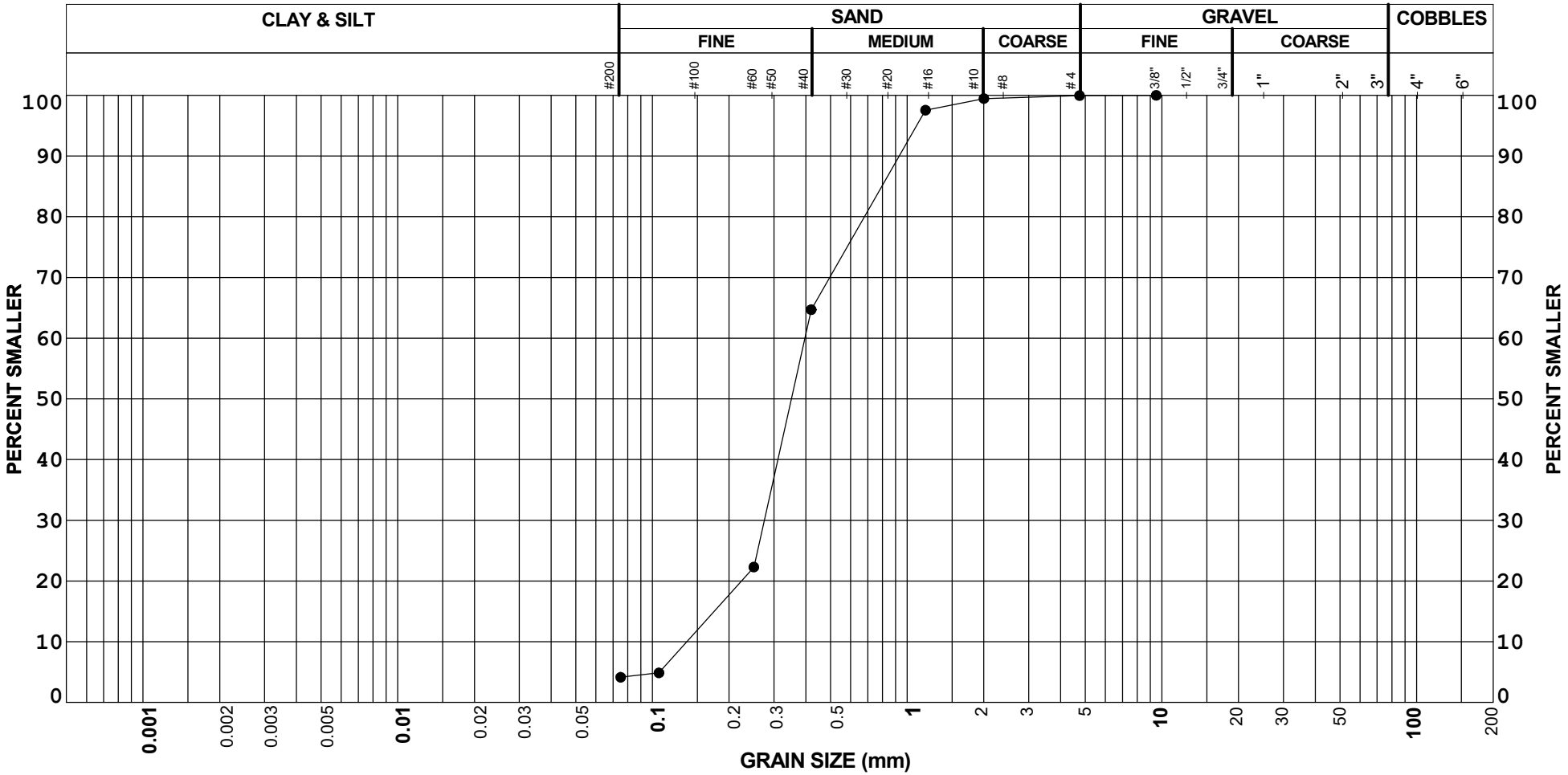
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-03	DQ-9	13.20	0	96	4		

REMARKS:

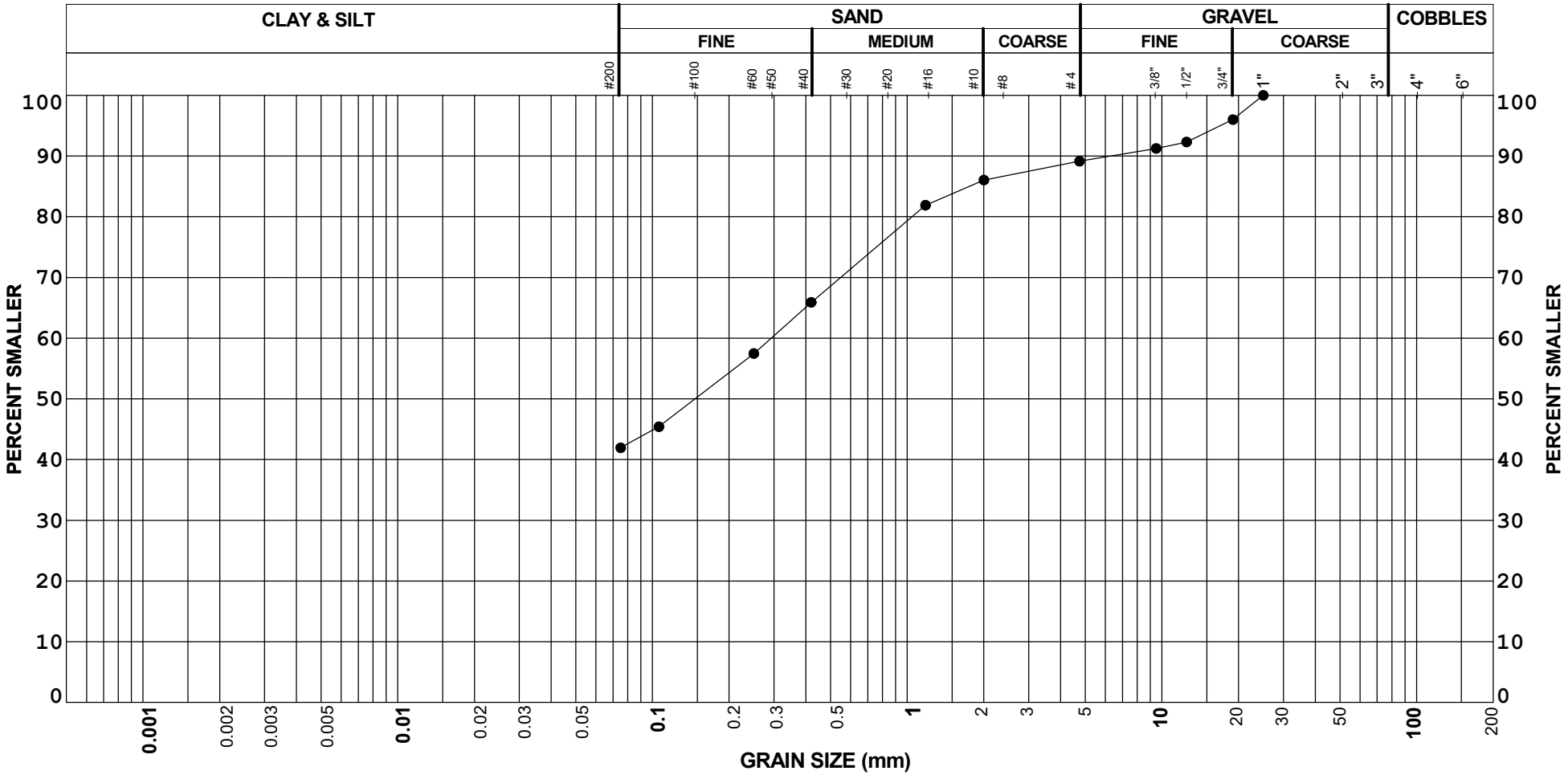
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-03	DS-10	14.10	11	47	42		

REMARKS:

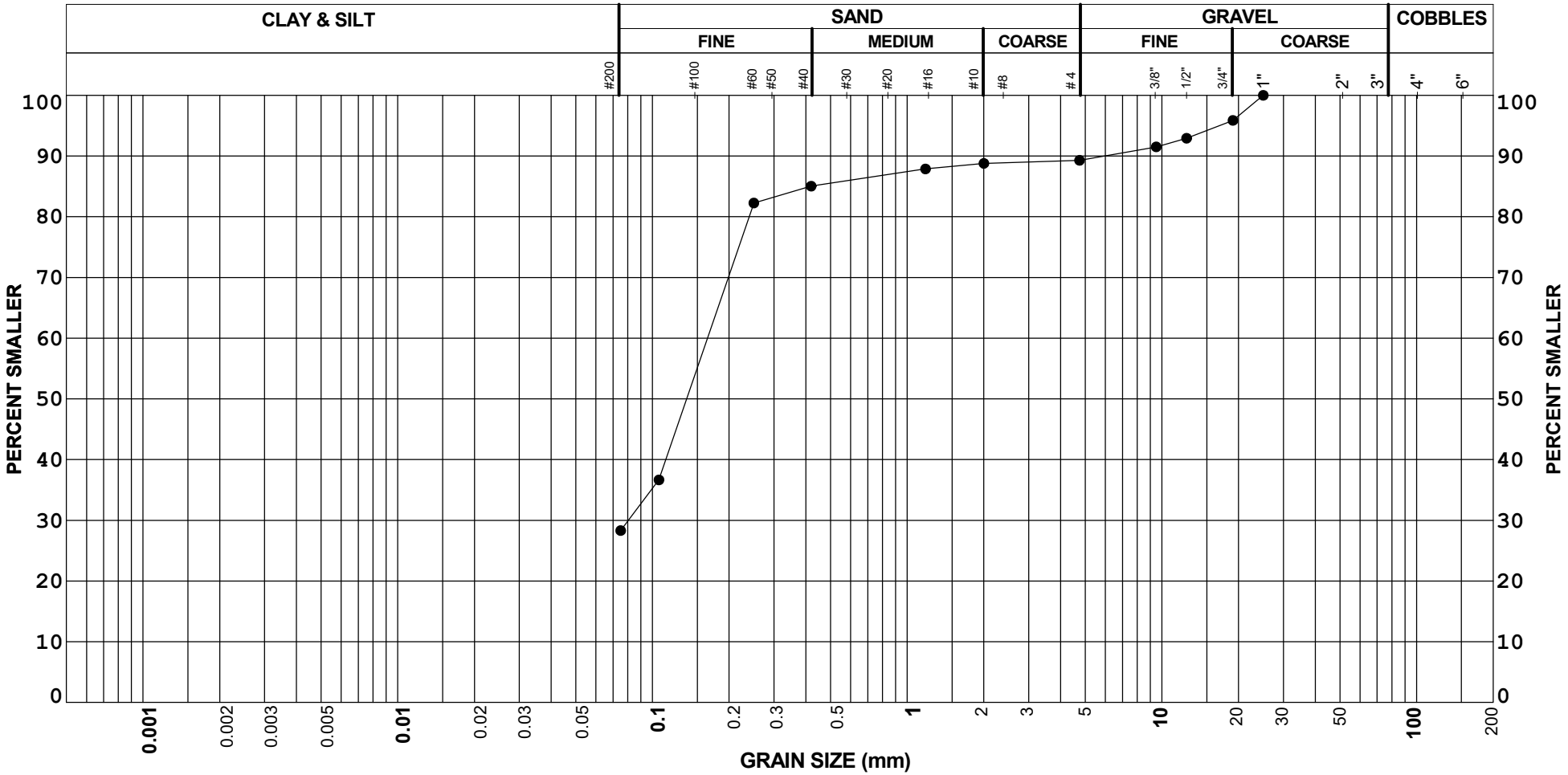
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-03	DS-12	17.50	11	61	28		

REMARKS:

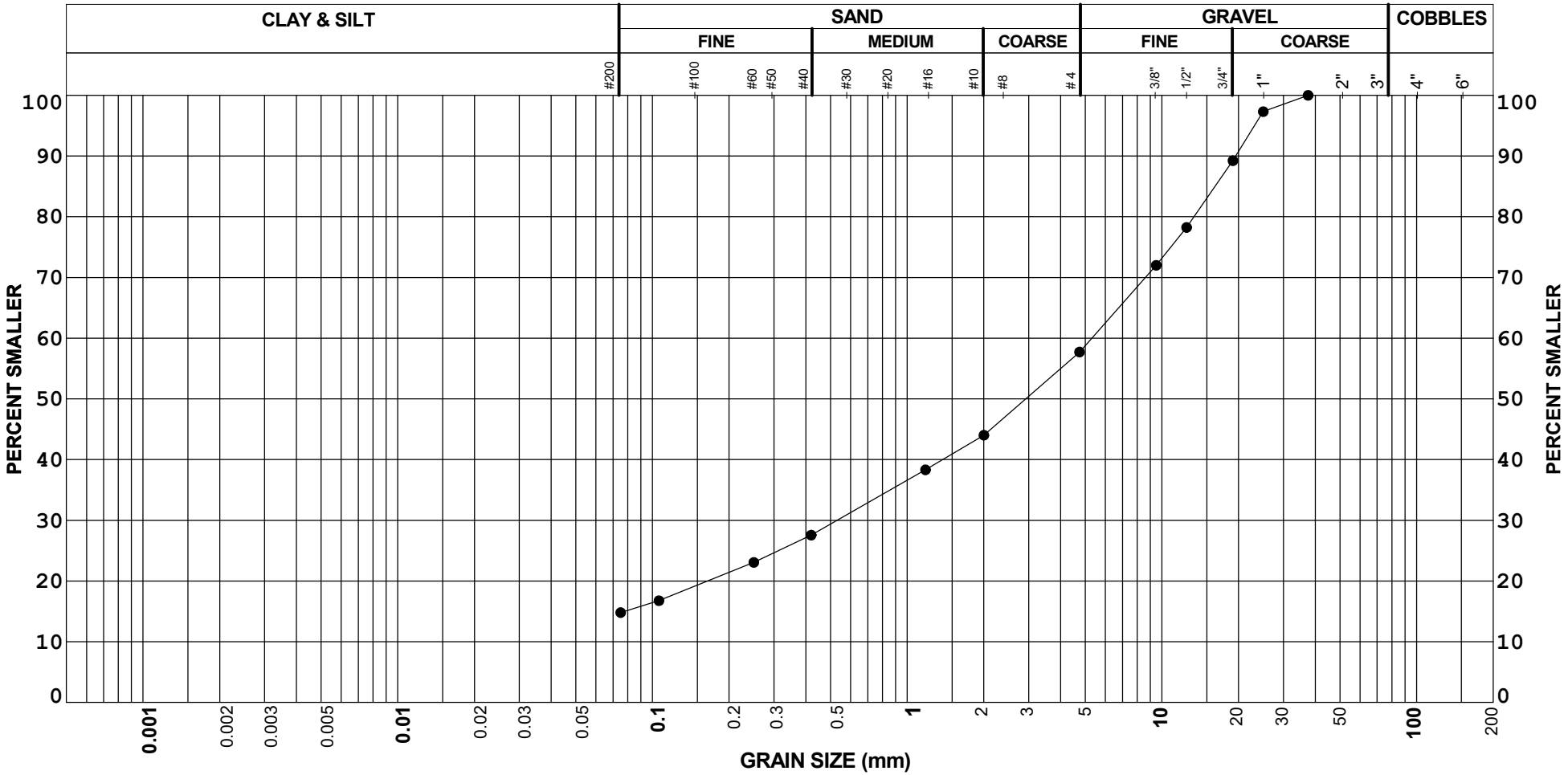
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-04	DS-1	0.60	42	43	15		

REMARKS:

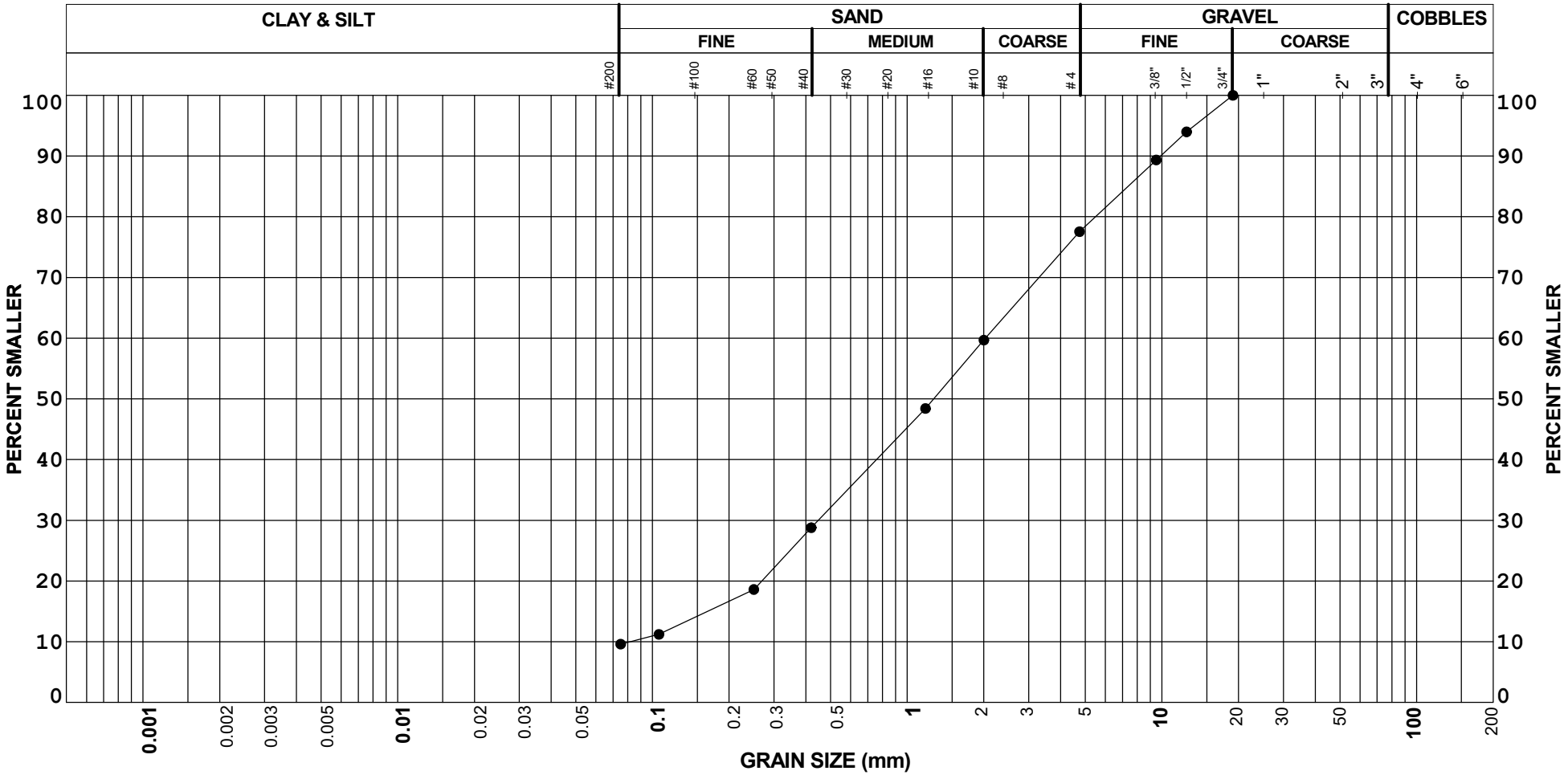
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-04	DS-4	7.90	22	68	10		

REMARKS:

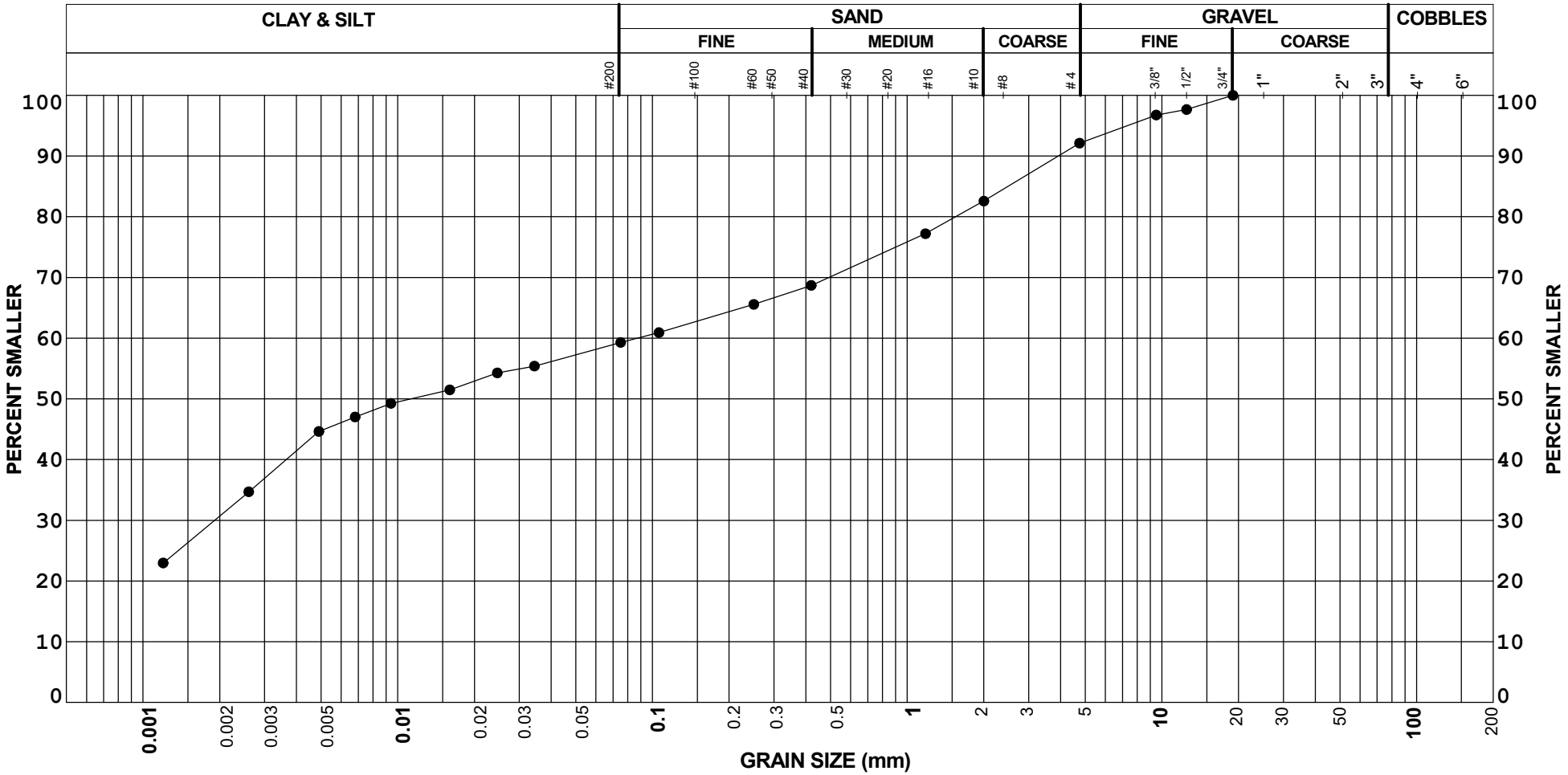
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-04	DS-7	10.90	8	33	59		

REMARKS:

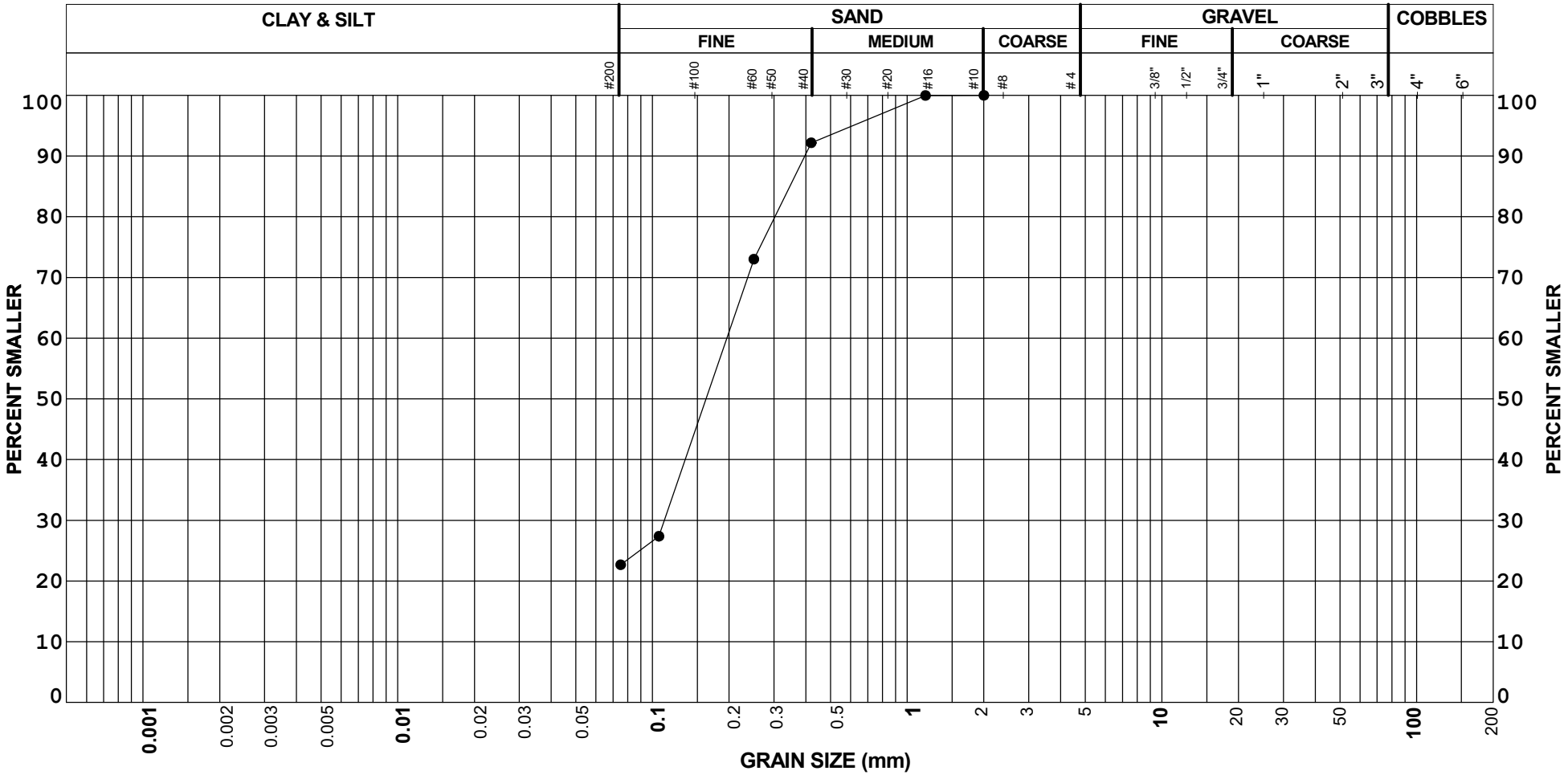
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-04	DS-13	25.00	0	77	23		

REMARKS:

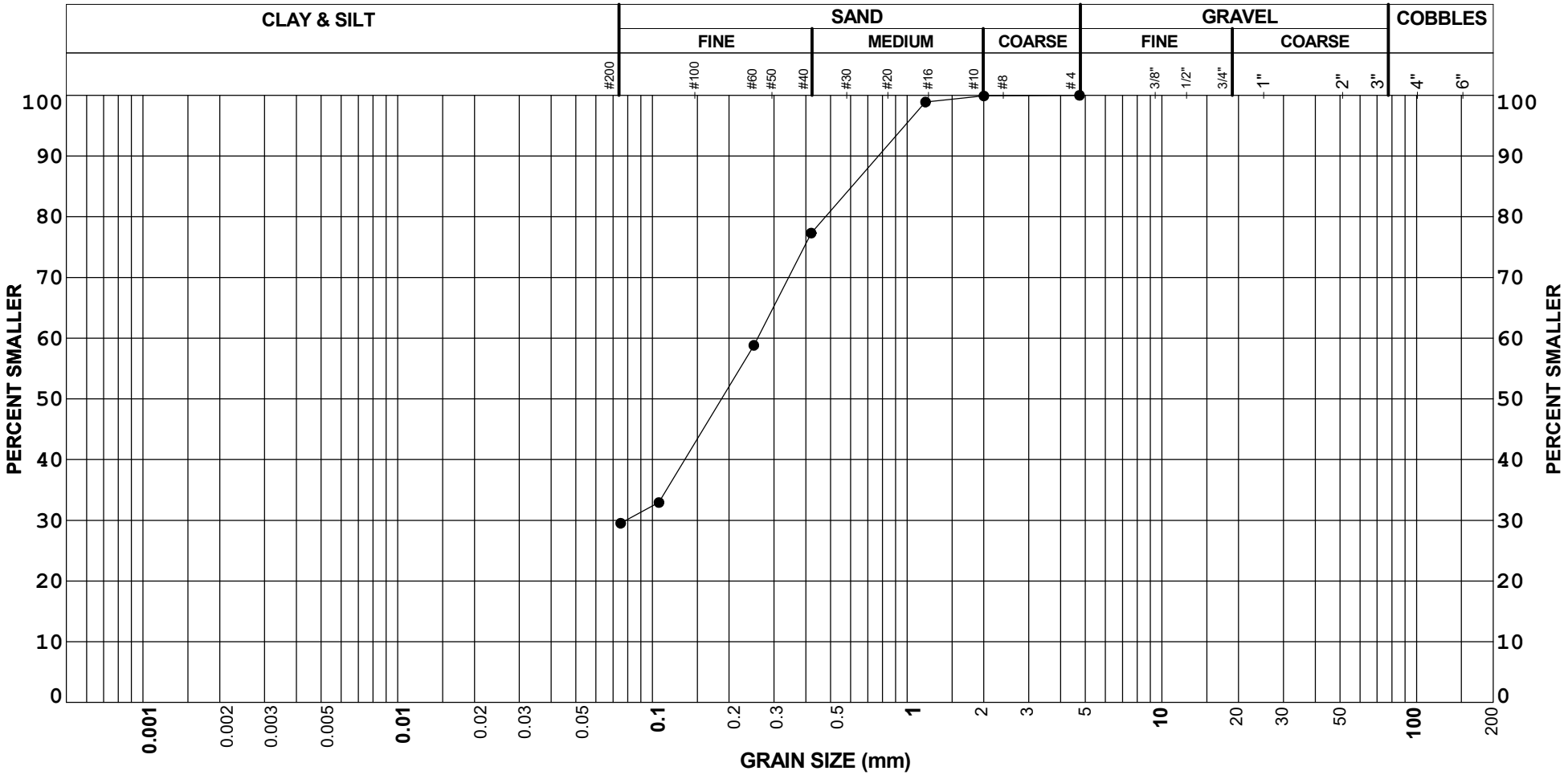
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



REMARKS:

BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-05	DS-13	23.20	0	70	30		

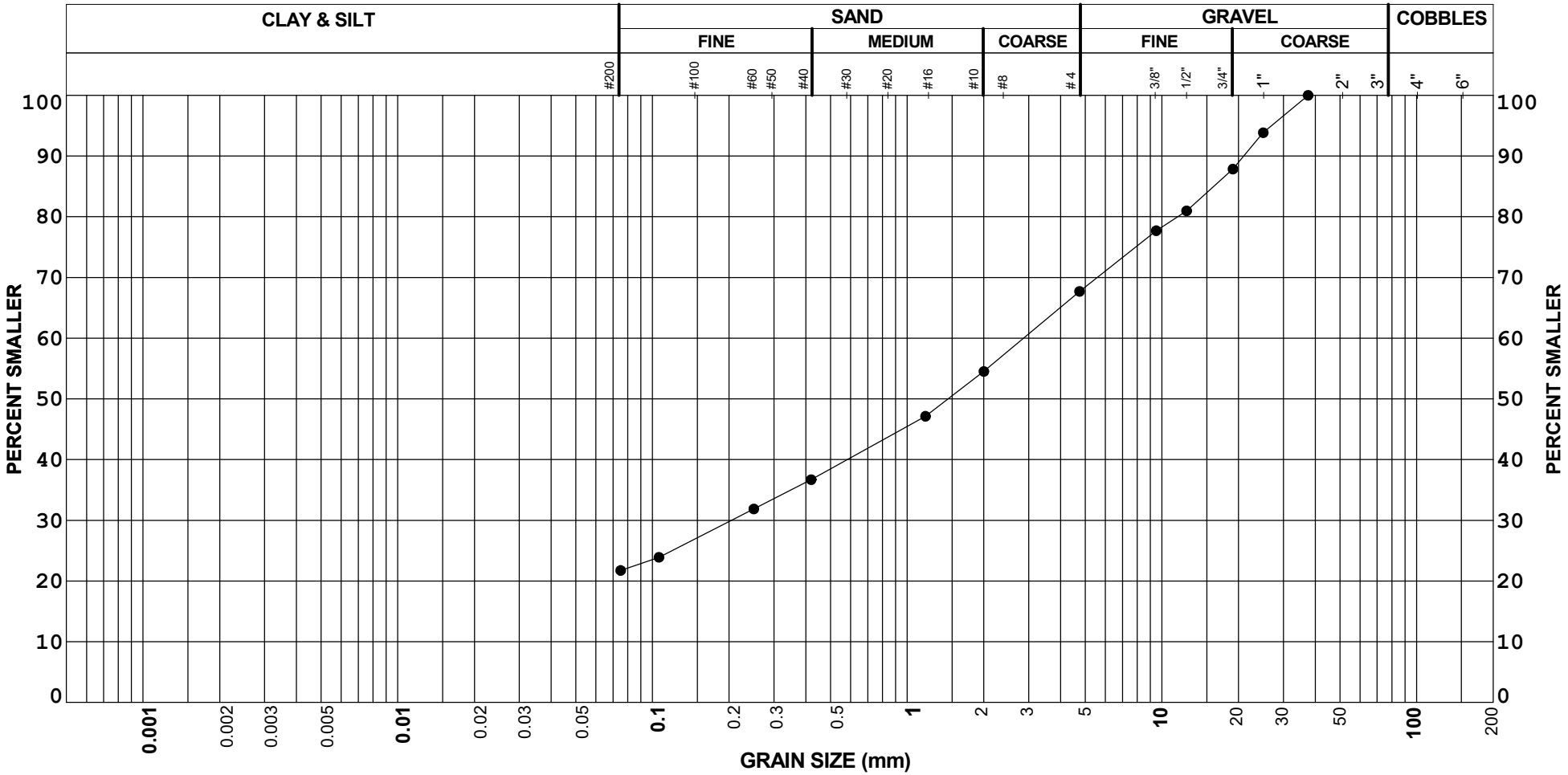
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-7N	DS-2	5.10	32	46	22		

REMARKS:

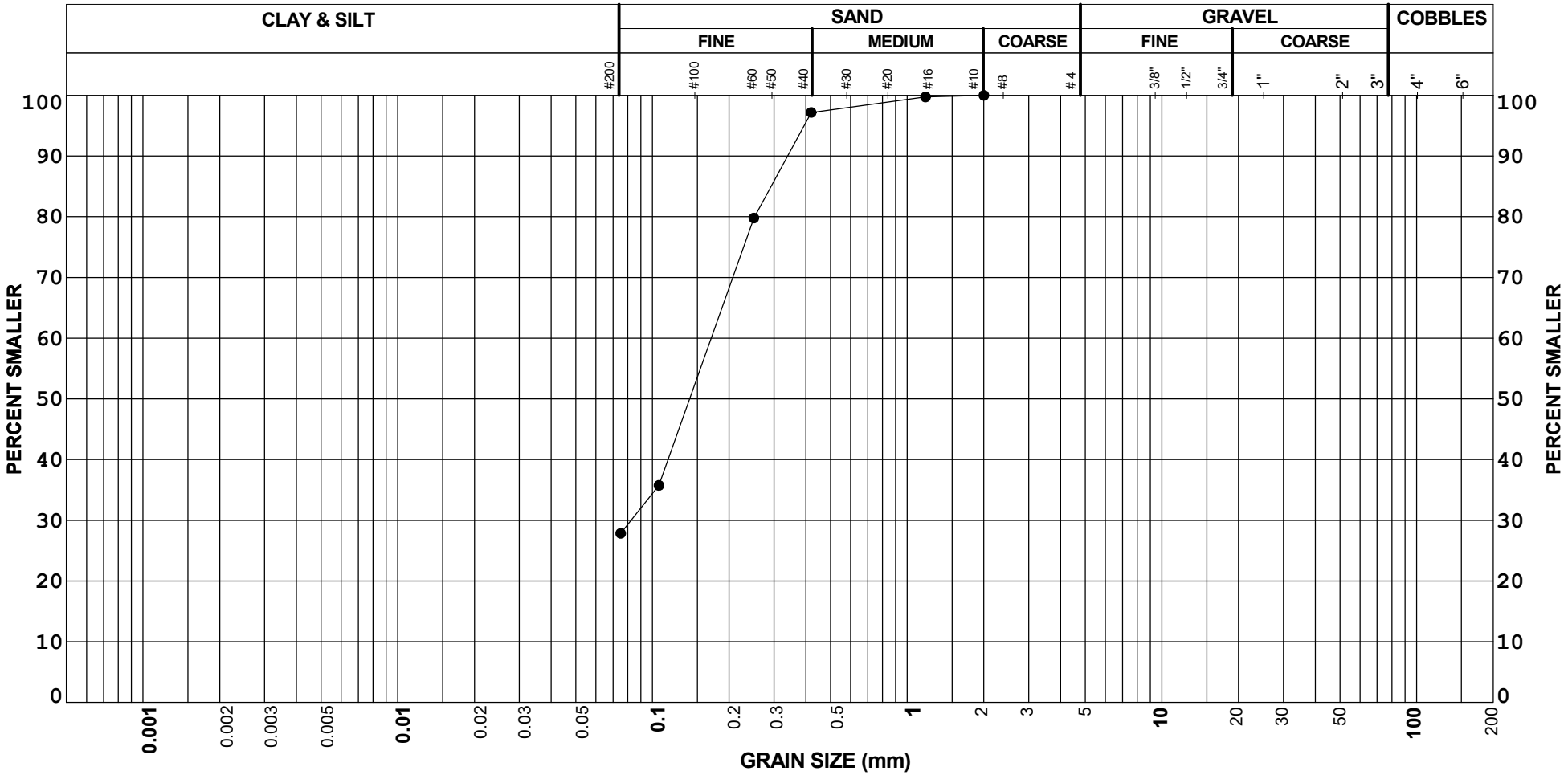
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-7N	DS-3	6.40	0	72	28		

REMARKS:

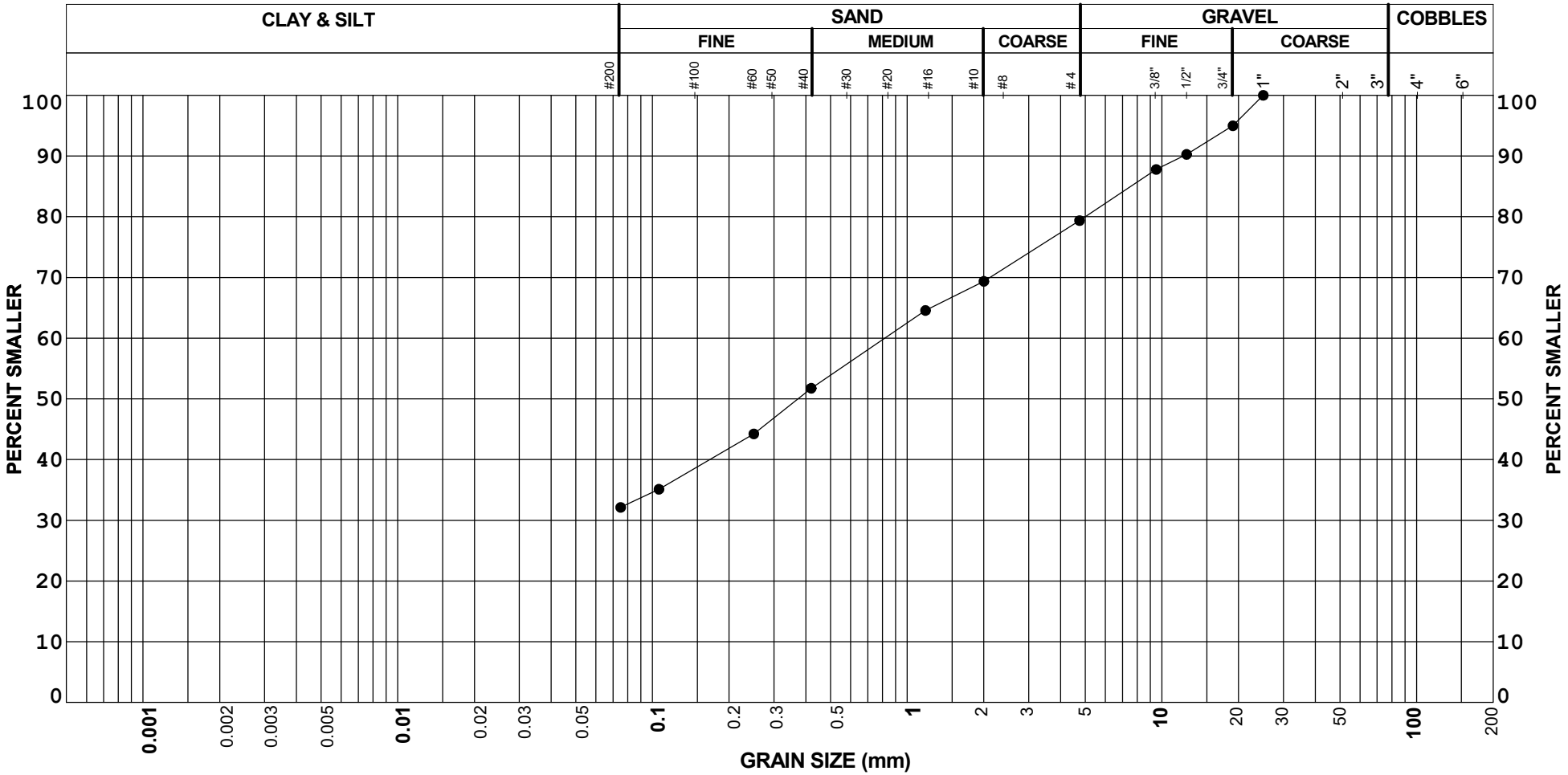
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-7N	DS-5	8.30	21	47	32		

REMARKS:

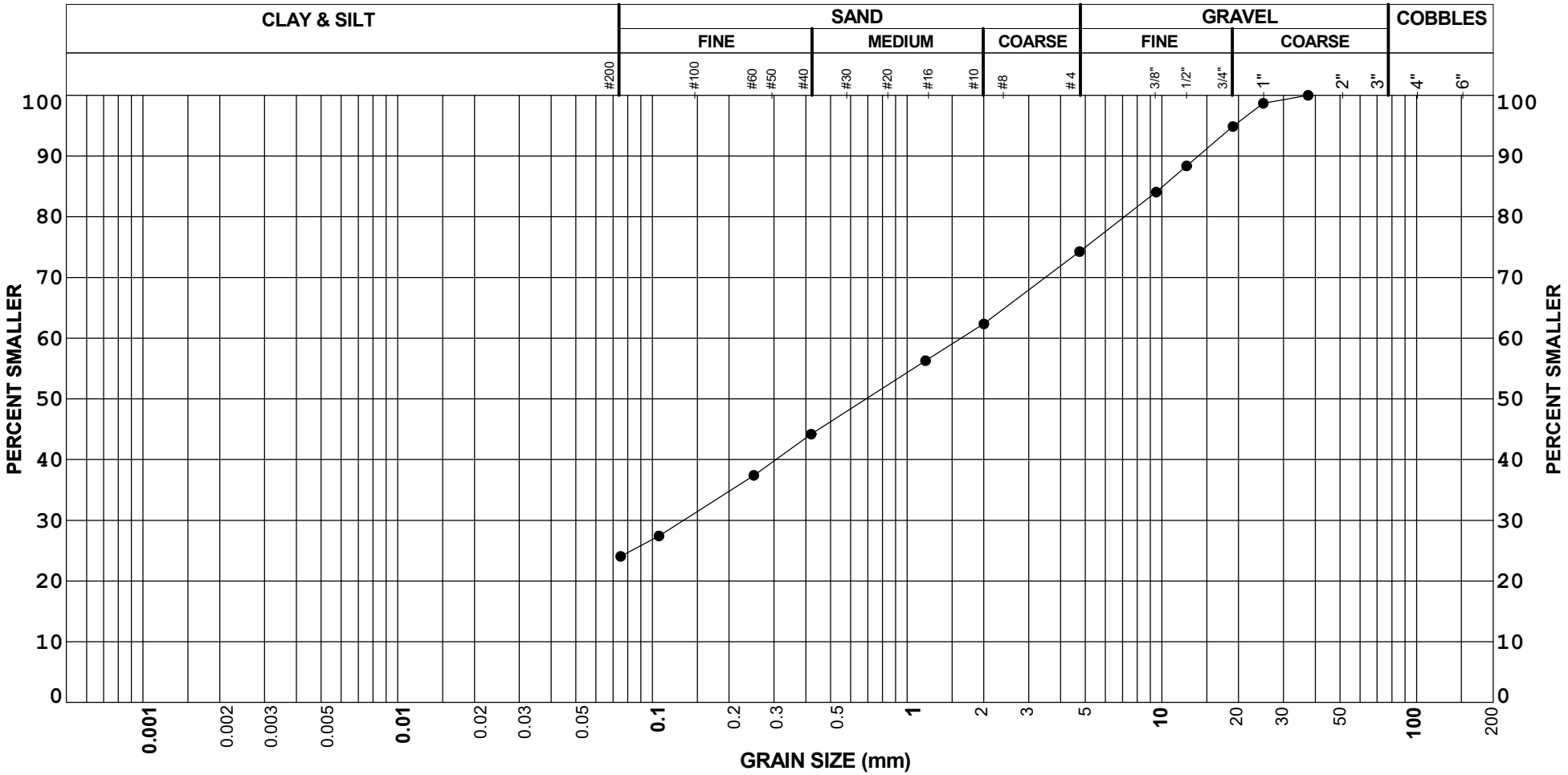
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-8N	DS-1	0.90	26	50	24		

REMARKS:

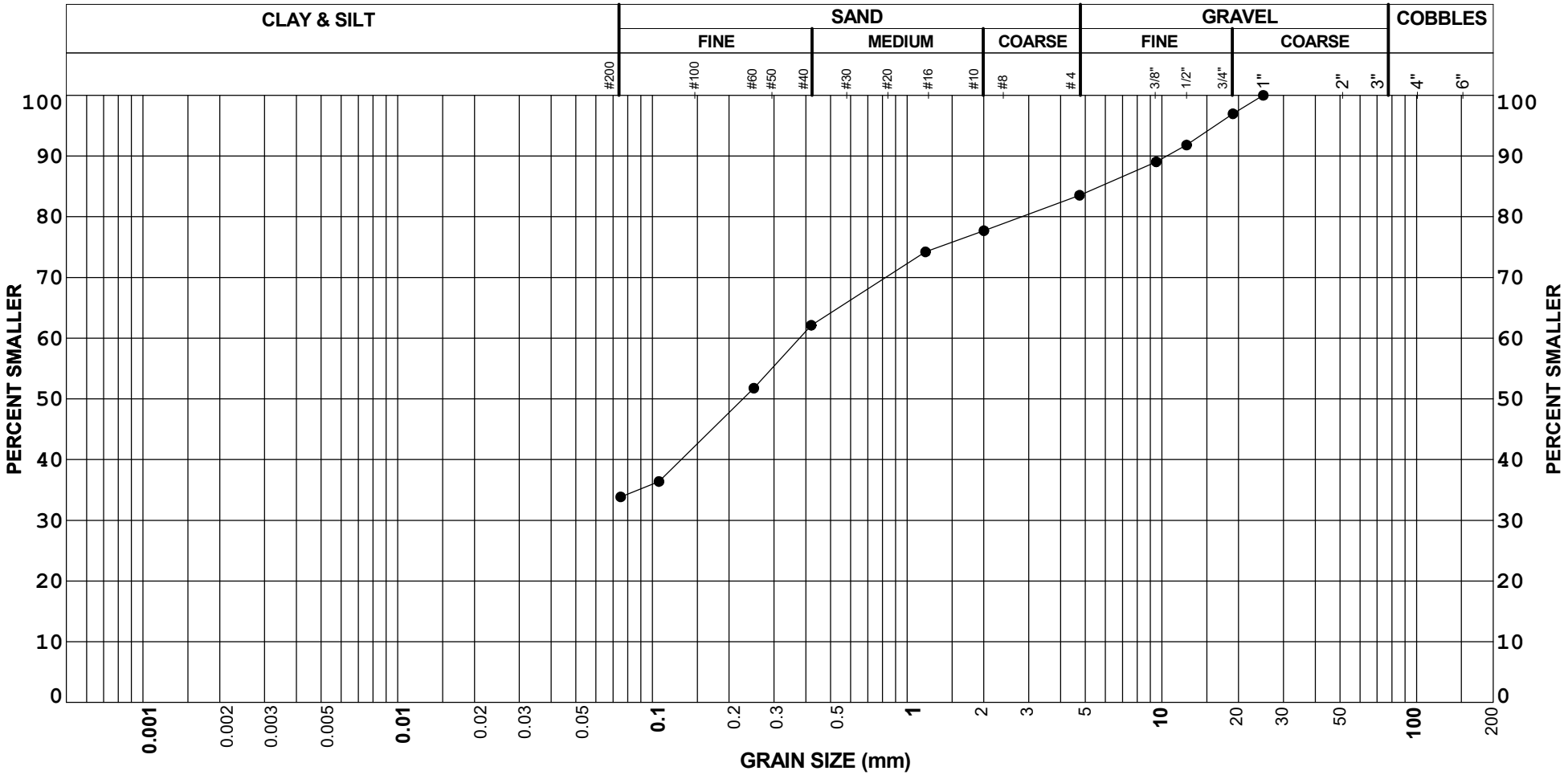
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



REMARKS:

BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TF-8N	DS-4	7.35	16	50	34		

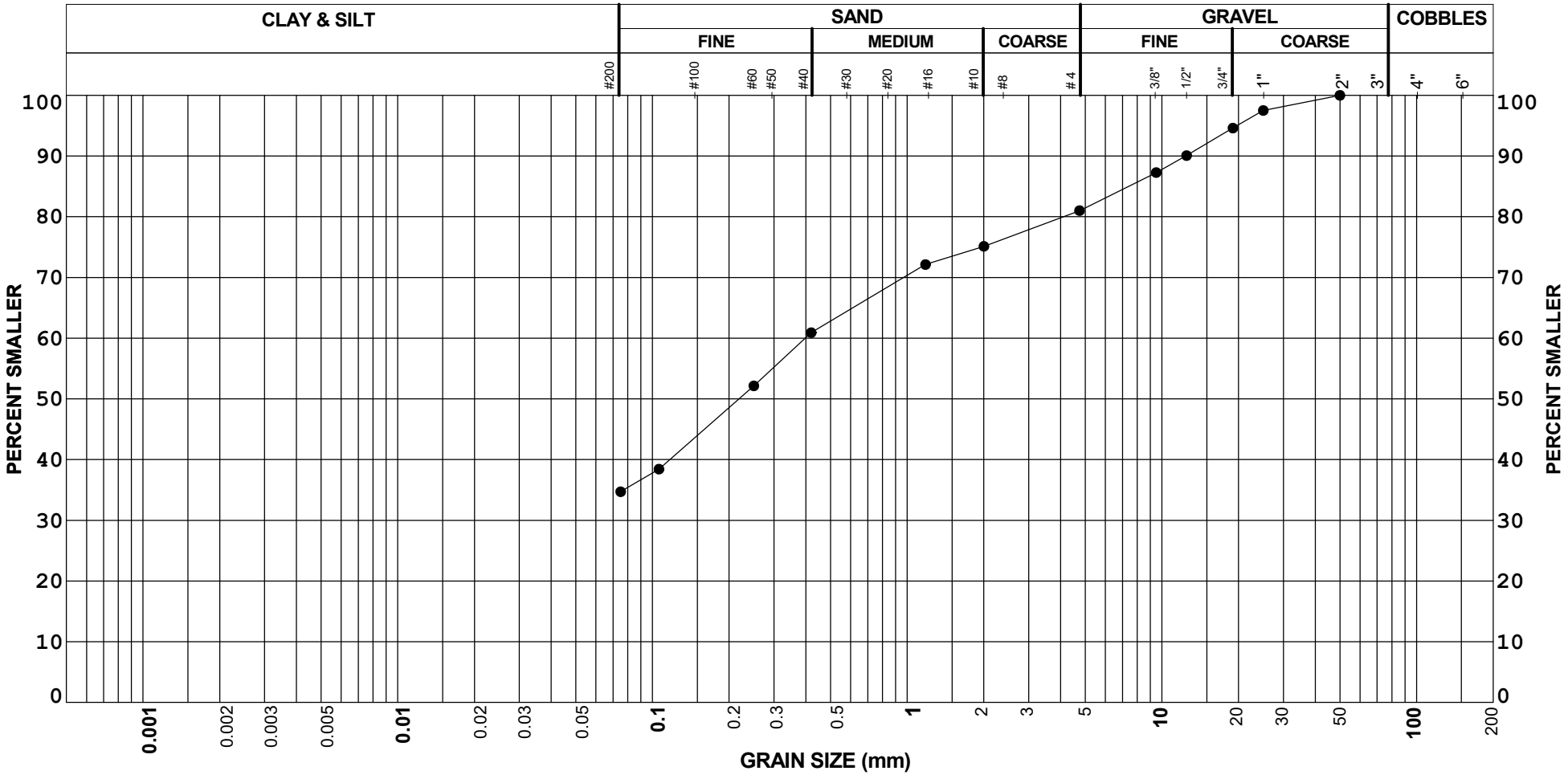
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TW-01	DS-2	3.20	19	46	35		

REMARKS:

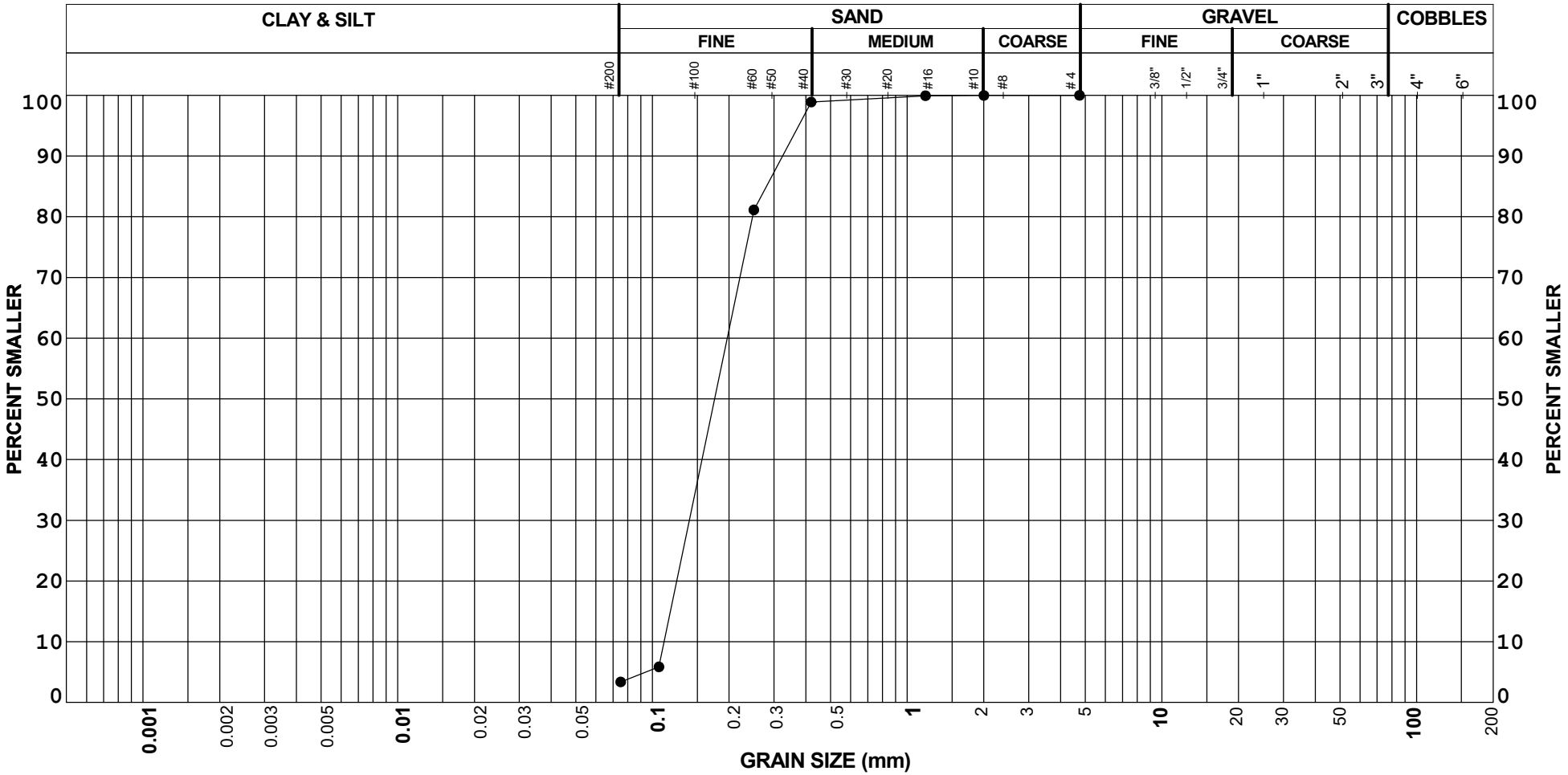
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TW-01	DS-6	13.30	0	97	3		

REMARKS:

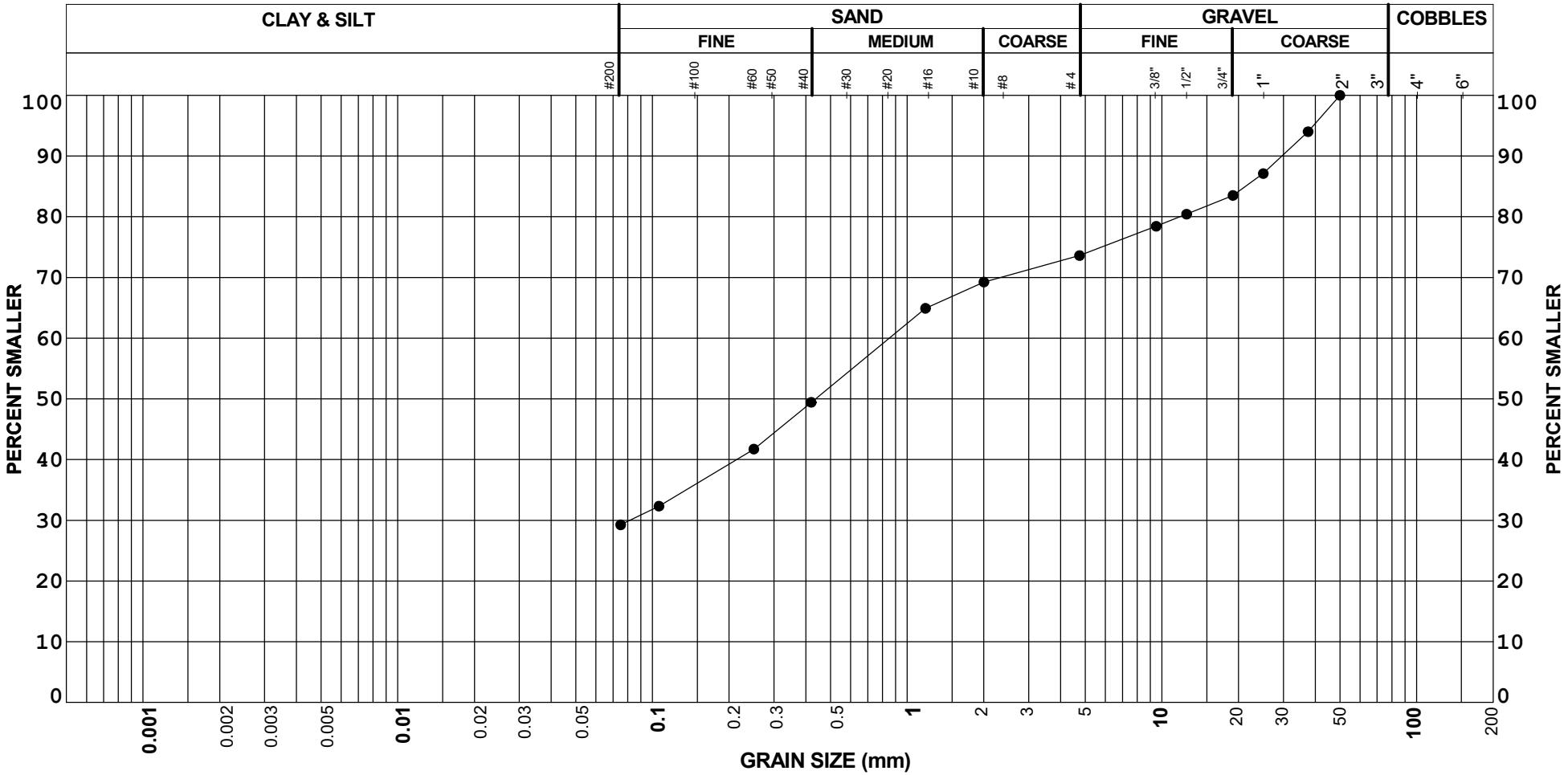
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TW-01	DS-8	16.10	26	45	29		

REMARKS:

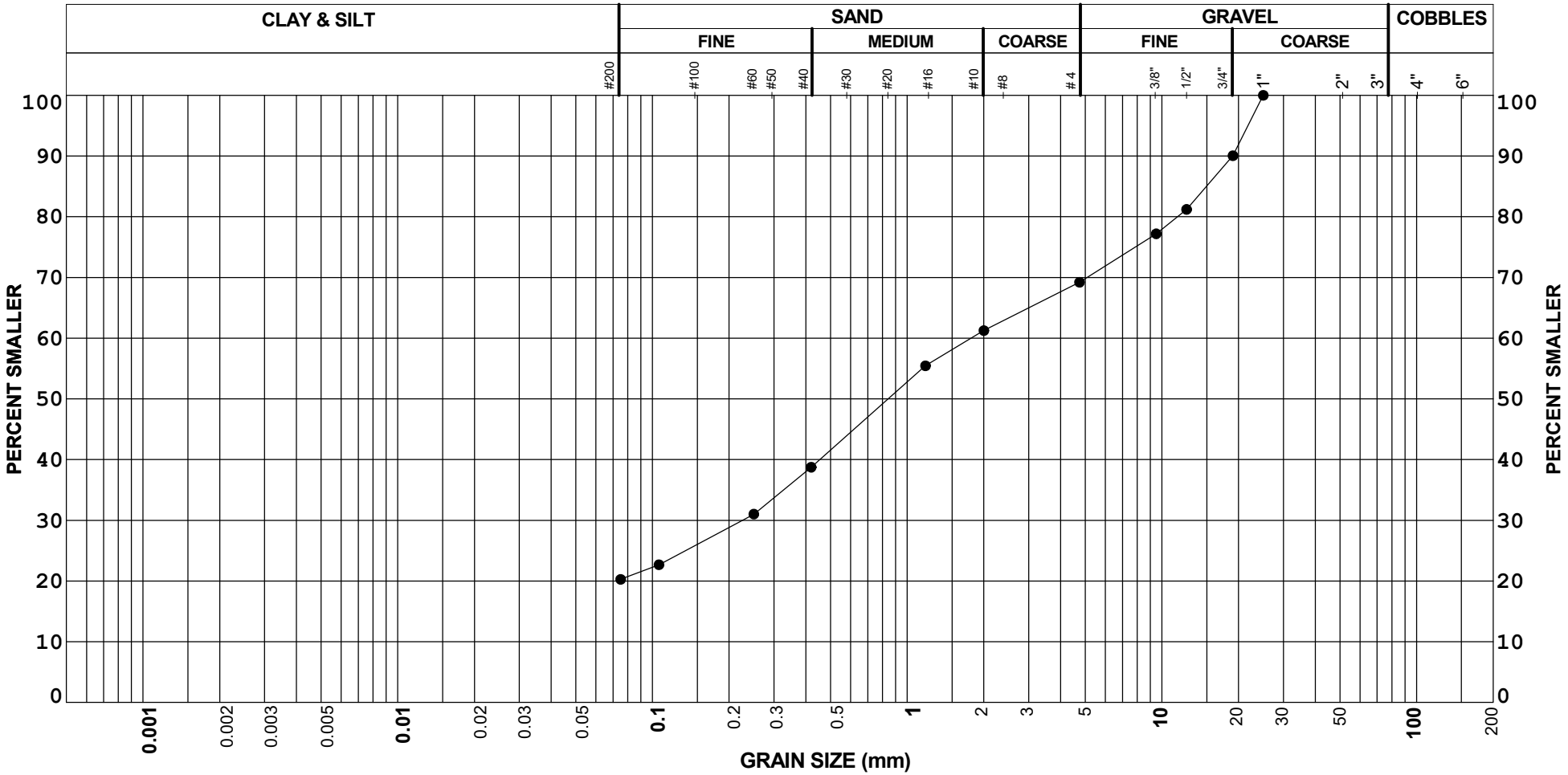
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TW-01	DS-11	22.70	31	49	20		

REMARKS:

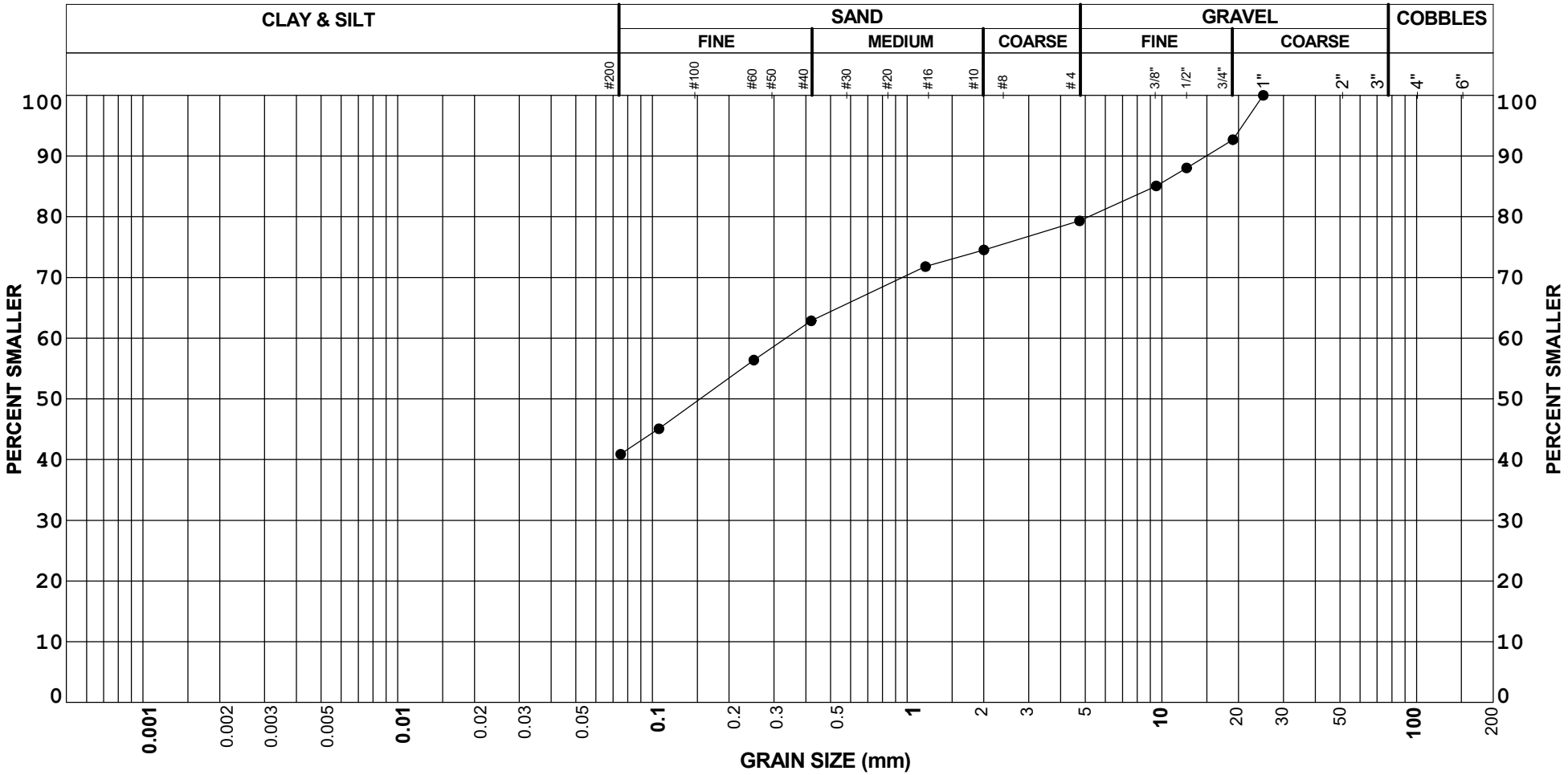
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TW-02	DS-2	7.30	21	38	41		

REMARKS:

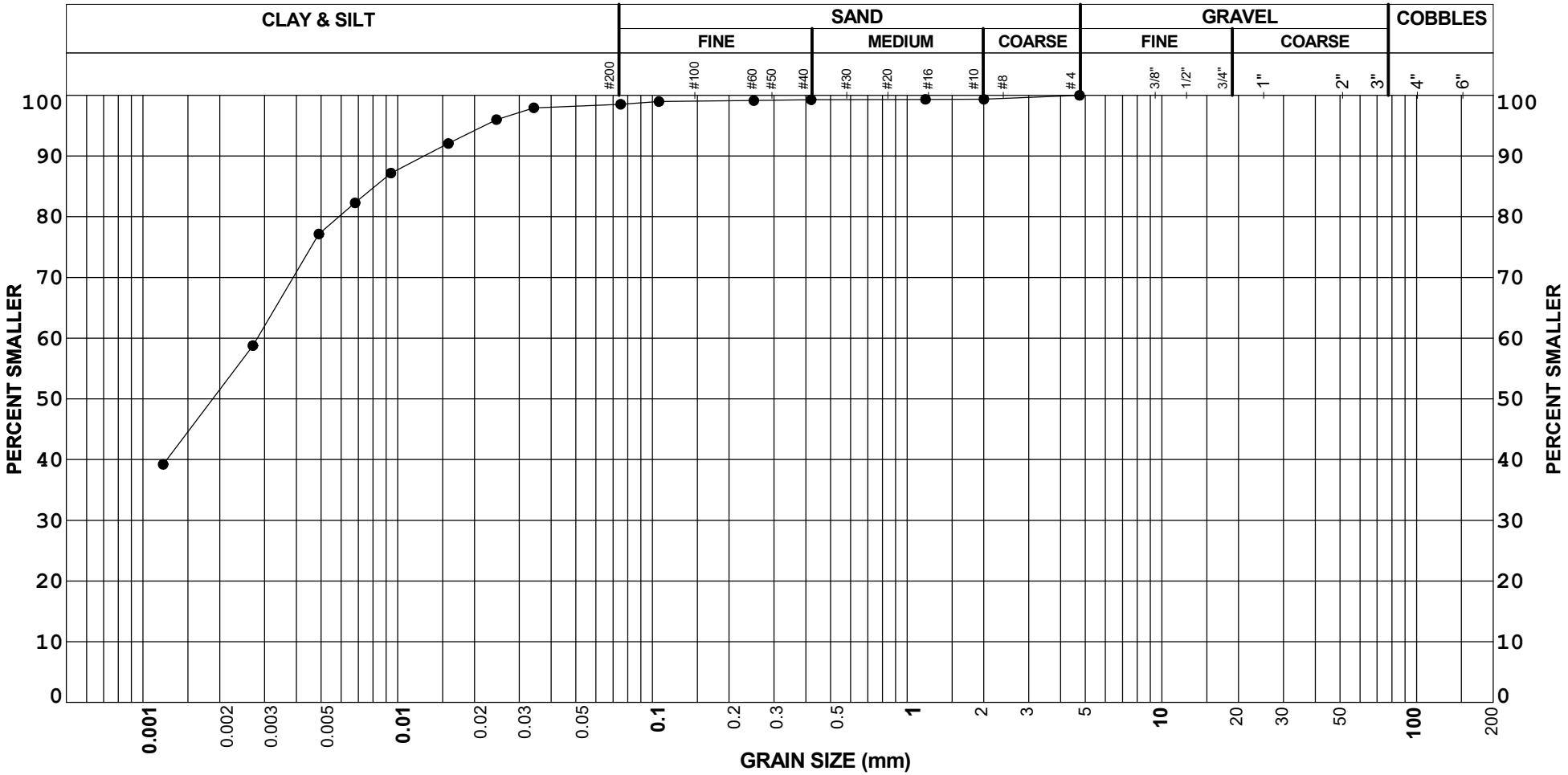
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH18-TW-02	DS-10	19.50	0	1	99		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mine

HATCH

Project

Pore Water Extraction and Determination of Soluble Salt Content of Soils by Refractometer

ASTM D4542-15

HATCH Geotechnical Laboratory

Date:	August 15. 2018	Baffinland Iron Mines
Project Number:	H/353004	2275 Upper Middle Rd, Oakville Ontario.
Project:	**Mary River Expansion Project**	**Attention: M. Yang**

Sample	**As Listed Below**
Source	**Proposed New Truck Shop and Tank Farm Locations, Boreholes noted in table.**

Borehole	Sample	Depth m	Salinity PPT	Notes
NA	NA	NA	0.0	Distilled Water
BH18-TF-1	DQ3	5.4 - 5.6	0.0	Water with silt
BH18-TF-1	DQ5	9.5 - 9.8	0.0	Water with silt
BH18-TF-2	DQ3	5.6 - 6.0	0.0	Water with silt
BH18-TF-2	DS4	6.1 - 6.5	0.0	Water with silt
BH18-TF-2	DQ8	11.85 - 12.0	0.0	Water with silt
NA	NA	NA	0.0	Distilled Water
BH18-TF-4	DQ2	5.9 - 6.0	0.0	Water with silt
BH18-TF-4	DS4	7.9 - 8.15	0.0	Soil (silt)
BH18-TF-4	DQ8	13.5 - 13.6	2.0	Soil (silt and sand)
BH18-TF-7N	DS3	6.4 - 6.6	0.0	Soil (silt and sand)
BH18-TF-7N	DQ4	6.95 - 7.15	0.0	Water with silt
BH18-TF-8N	DQ3	5.0 - 5.4	0.0	Water with silt
BH18-TW-2	DQ9	18.2 - 18.3	0.0	Water with silt
NA	NA	NA	0.0	Distilled Water

Comments: Tested with EXTECH Model RF20 Refractometer with automatic temperature compensation.

Reported by: R. Serluca. Lab Manager, Aug. 15, 2018

Name, Title, Date

Reviewed by: M. Yang. EIT Aug.16 ,2018

Name. Title. Date

Notice: the test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

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Appendix E

Fence Diagrams

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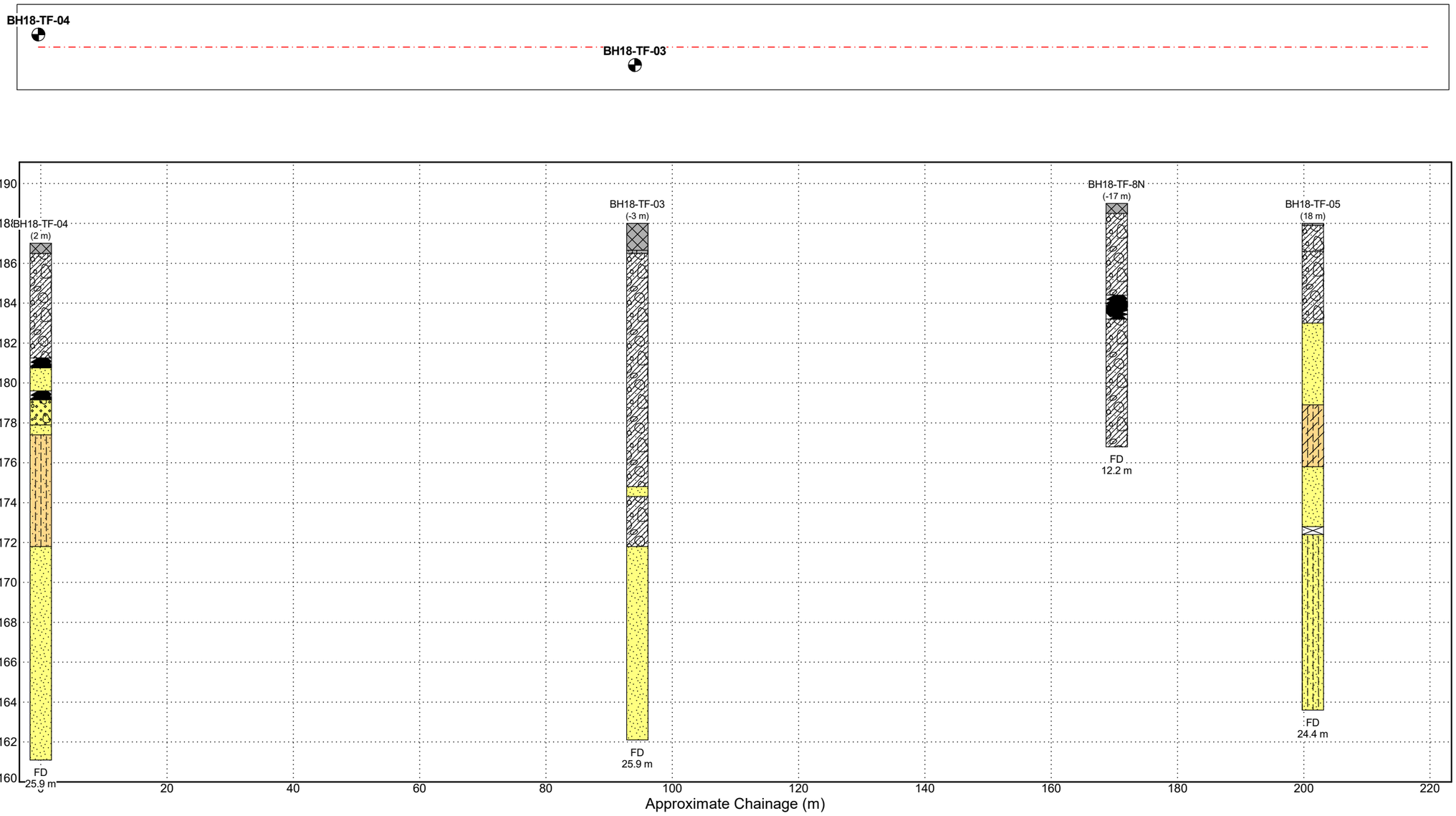


MAP KEY

- BH03 — INVESTIGATION ON SECTION
- TP03 — INVESTIGATION OFF SECTION
- SECTION LINES

POST LEGEND

Borehole Number
(Baseline Offset m)

N SPT value

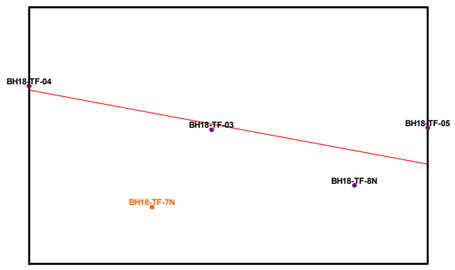
Final Depth m

STRATAGRAPHIC BOUNDARIES

MATERIAL GRAPHICS

- FILL (made ground)
- Topsoil
- Glacial TILL
- Poorly-graded SAND
- Ice
- Well-graded Gravelly SAND
- Sandy SILT
- Low Plasticity Silty CLAY to Clayey SILT
- Core Loss
- Silty SAND

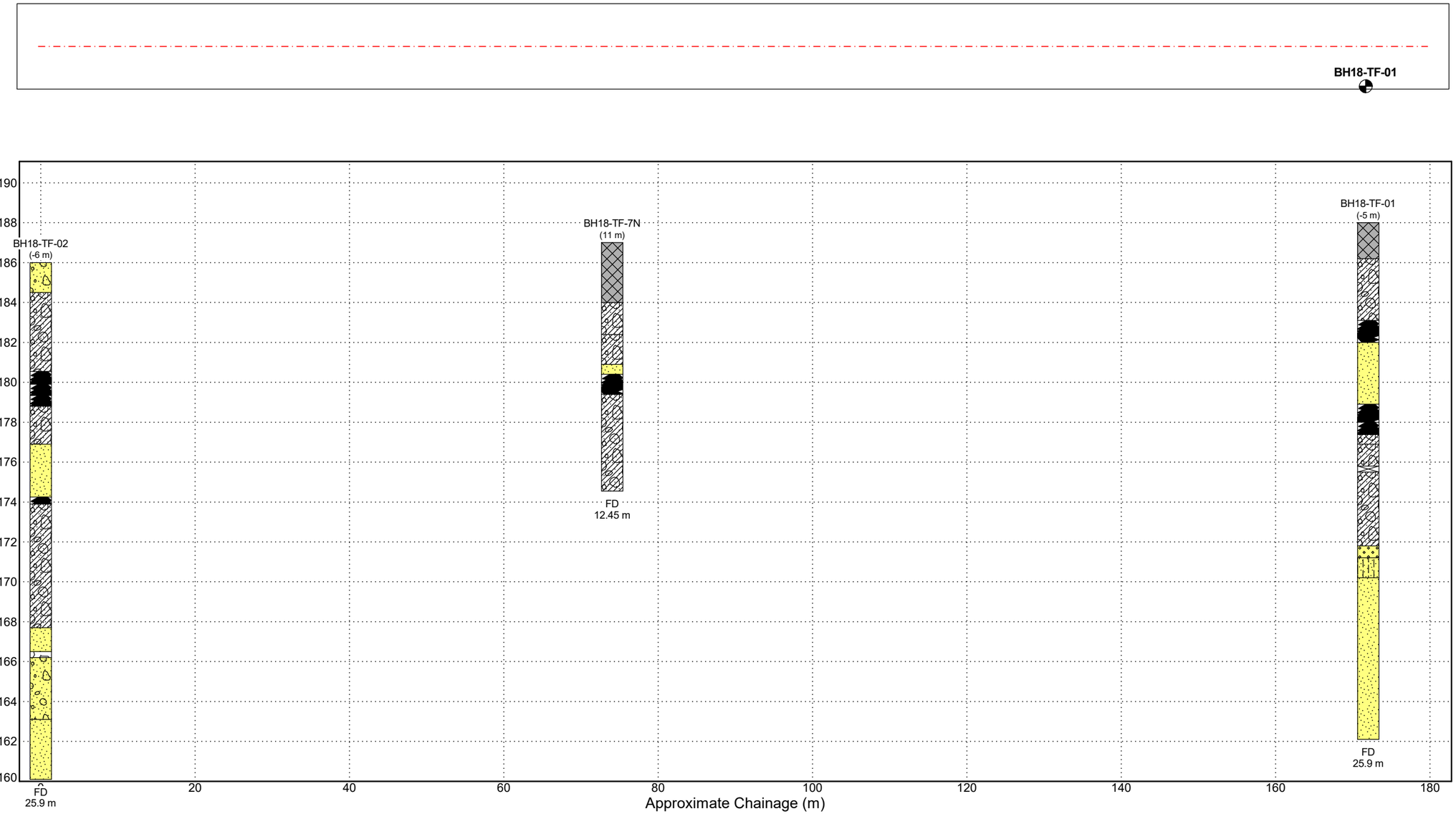
SITE MAP



H 1:677
0 5 10 15 20 25m
V 1:214
0 2 4 6 8 10m
Coord.System: "NAD83" Zone 17 Height Datum: NAD83

HATCH

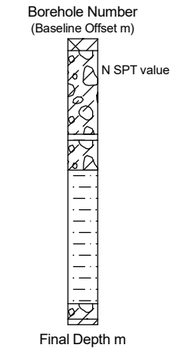
CLIENT Baffinland Iron Mine		PROJECT Mary River Expansion Study	
DRAWN CL	DATE 8/24/2018	TITLE TANK FARM NORTH SIDE	
CHECKED	DATE		
SCALE H 1:677 V 1:214 VE=3X		PROJECT No H353004	FIGURE No E3



MAP KEY

- BH03 — INVESTIGATION ON SECTION
- TP03 — INVESTIGATION OFF SECTION
- SECTION LINES

POST LEGEND

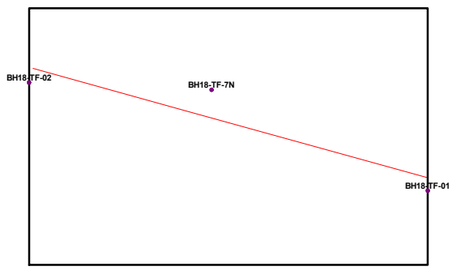


STRATAGRAPHIC BOUNDARIES

MATERIAL GRAPHICS

- FILL (made ground)
- Well-graded SAND
- Glacial TILL
- Silty SAND
- Ice
- Poorly-graded Gravelly SAND
- Poorly-graded SAND
- BOULDERS
- Core Loss

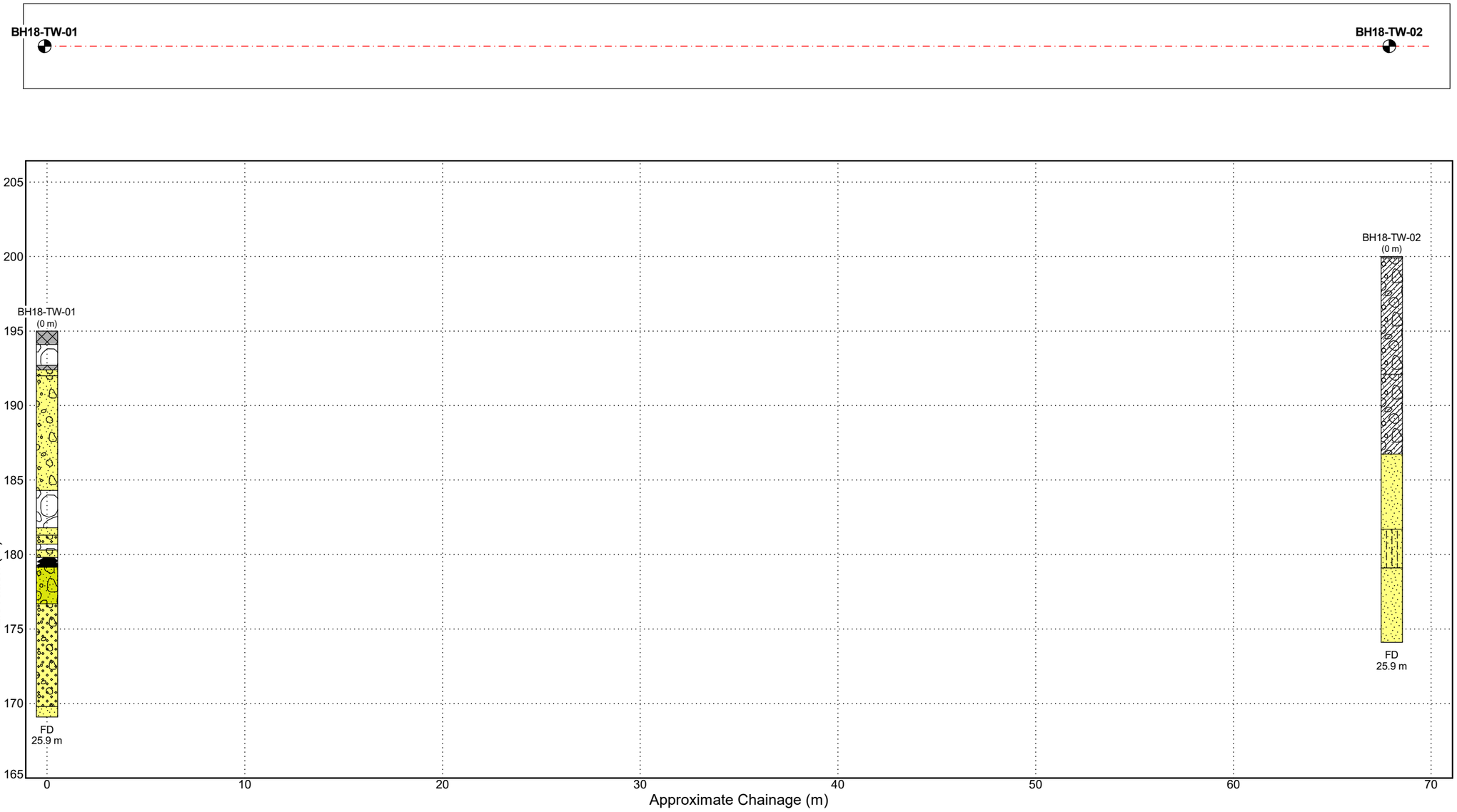
SITE MAP



H 1:554
0 5 10 15 20 25m
V 1:214
0 2 4 6 8 10m
Coord.System: "NAD83" Zone 17 Height Datum: NAD83

HATCH

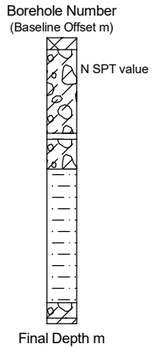
CLIENT Baffinland Iron Mine		PROJECT Mary River Expansion Study	
DRAWN CL	DATE 8/24/2018	TITLE TANK FARM SOUTH SIDE	
CHECKED	DATE		
SCALE H 1:554 V 1:214 VE=3X		PROJECT No H353004	FIGURE No E2



MAP KEY

- BH03 — INVESTIGATION ON SECTION
- TP03 — INVESTIGATION OFF SECTION
- SECTION LINES

POST LEGEND

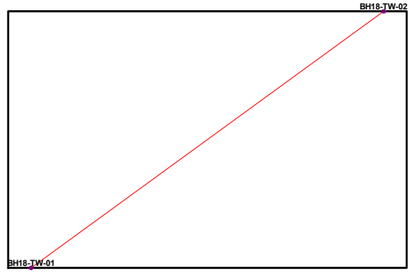


STRATAGRAPHIC BOUNDARIES

MATERIAL GRAPHICS

- FILL (made ground)
- Ice
- BOULDERS
- Poorly-graded Sandy GRAVEL
- Poorly-graded Gravelly SAND
- Topsoil
- Poorly-graded SAND
- Glacial TILL
- Well-graded Gravelly SAND
- Silty SAND

SITE MAP



H 1:215
0 2 4 6 8 10m
V 1:286
0 2 4 6 8 10m
Coord.System: "NAD83" Zone 17 Height Datum: NAD83

HATCH

CLIENT Baffinland Iron Mine		PROJECT Mary River Expansion Study	
DRAWN CL	DATE 8/24/2018	TITLE TRUCK WORKSHOP	
CHECKED	DATE		
SCALE H 1:215 V 1:286 VE=1X		PROJECT No H353004	FIGURE No E1

Appendix F

Summary of Laboratory Results

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Borehole No.	Sample No.	Depth	Moisture Content	Gravel (%)	Sand (%)	Fines (%)
BH18-TF-01	DS-1	0.9				
	DS-2	3.7	7	17	48	35
	DQ-3	5.4				
	DS-4	7.0	45	9	73	18
	DQ-5	9.5				
	DS-6	12.9				
	DS-7	15.5	11	37	35	28
	DS-8	17.3	20	20	43	37
	DS-9	19.1				
	DS-10	23.5				
BH18-TF-02	DS-1	1.0	2	37	60	3
	DS-5	4.0	9	24	45	31
	DS-2	4.9				
	DQ-3	5.6				
	DS-4	6.1				
	DS-6	7.9	10	27	39	34
	DS-7	11.0				
	DQ-8	11.9				
	DS-9	13.2	9	15	58	27
	DS-10	15.2				
	DS-11	18.3				
	DS-12	19.9	7	21	53	26
BH18-TF-03	DS-1	0.2				
	DS-2	2.3				
	DS-3	6.4				
	DS-4	8.2	8	22	42	36
	DQ-5	9.5				
	DS-6	10.7				
	DQ-7	12.5				
	DQ-8	12.9				
	DQ-9	13.2	21	0	96	4
	DS-10	14.1	9	11	47	42
	DS-11	15.6				
	DS-12	17.5	11	11	61	28
	DS-13	18.6				
	DS-14	25.0				
BH18-TF-04	DS-1	0.6	6	42	43	15
	DS-10	3.9				
	DQ-2	5.9				
	DS-4	7.9	12	22	68	10
	DS-5	9.2				
	DS-6	9.8				
	DS-7	10.9	32	8	33	59
	DS-9	14.6				
	DQ-8	13.5				
	DS-11	16.0				
	DS-12	20.1				
	DS-13	25.0	12	0	77	23
BH18-TF-05	DS-13	23.2	11	0	70	30

Borehole No.	Sample No.	Depth	Moisture Content	Gravel (%)	Sand (%)	Fines (%)
BH18-TF-7N	DS-1	0.5				
	DS-2	5.1	10	32	46	22
	DS-3	6.4	26	0	72	28
	DQ-4	7.0				
	DS-5	8.3	10	21	47	32
	DS-6	10.8				
BH18-TF-8N	DS-1	0.9	4	26	50	24
	DS-2	3.3				
	DQ-3	5.0				
	DS-4	7.4	6	16	50	34
	DS-5	11.9				
BH18-TW-01	DS-1	2.3				
	DS-2	3.2	10	19	46	35
	DQ-3	4.6				
	DS-4	8.3				
	DS-5	13.2				
	DQ-6	13.3	23	0	97	3
	DS-7	13.7				
	DQ-9	15.8				
	DS-8	16.1	10	26	45	29
	DS-9	18.9				
	DS-10	22.7	8	31	49	20
	DQ-12	24.4				
	DQ-13	25.5				
	DS-14	25.6				
BH18-TW-02	DS-1	2.1				
	DS-2	7.3	11	21	38	41
	DS-3	8.2				
	DS-4	9.5				
	DS-5	11.4				
	DQ-6	12.4				
	DQ-7	13.5				
	DS-8	17.4				
	DQ-9	18.2				
	DS-10	19.5	18	0	1	99
	DS-11	22.0				
	DS-12	25.3				

Appendix G

Geotechnical Investigation Safety Plan

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1. Introduction

A geotechnical field investigation is underway to gather subsurface data for the 12 Mtpa mine expansion prefeasibility study, which includes an offshore (on ice) investigation for the proposed Ore Dock No. 2. This job hazard analysis (JHA) presents an assessment of the hazards and control measures to reduce the likelihood or consequence of the hazards in order to carry out the offshore investigation program. There are a total of 10 proposed boreholes for the dock area including 5 sonic boreholes and 5 Piezocone (CPTu) test holes.

Job Hazard Analysis Form

PROJECT/TASK: ZG003 Geotechnical Marine Drilling Milne Inlet		**Department: Projects Boart Longyear**				**JOB No.:ZG003**			
SUPERVISOR: Emile Beauchamp		**LOCATION: Future Ore Dock Milne Inlet**				**DATE: March 12 ,2017**			
JOB STEP Break the job into steps. Listing work which may be hazardous.	**HAZARDS** List the hazard or type of harm identified with each step.	**Inherent**			**CONTROL MEASURE** List the necessary control measures to be followed to eliminate/reduce the identified hazards.	**Residual**			**ACTION** Person who will ensure this happens
		Consequence	**Likelihood**	**Risk Ranking**		**Consequence**	**Likelihood**	**Risk Ranking**	
1. Pre-job JHA Review.	Missing critical items on the JHA that can lead to an incident	3	2	5	Conduct a pre-job JHA review with Safety and critical team members All workers will have the opportunity to identify changes needed Any changes will be added to this document	1	1	2	Marlon Coakley/Warren Hoyle
2. Workers to complete FLRA card in the field at location prior to starting work.	Additional hazards in the area that may not have been identified on the JHA and daily changes that may pose additional danger to the health and safety of workers, the environment and property	3	3	6	Look at immediate work area for hazards that may exist, not identified on the JHA. Have other workers in the group sign off on the FLHA	1	1	2	All workers
3. Load Weights – The number and types of vehicles and equipment and their maximum gross weights	Not knowing load calculations will run the risk of breaking through the ice.	5	3	8	All equipment and material shall have posted GVW or gross equipment weight or maximum pull back loads available for use with load-ice thickness tables and shall follow the Ice Safety Plan. Refer to Attachment B for minimum ice thickness required for the drilling operations and Attachment C for further guidelines regarding Ice Safety	4	2	6	Warren Hoyle

4. General Site	Ice Conditions – Slip falls Ice Conditions – Adequate load bearing capacity Inadequate lighting Interaction with a Polar Bear Cold Whiteout conditions Emergency Procedures	3	2	5	Construct a working platform for outside of drill shack to store drill steel and allow the use of salt Use of traction aids on work boots will be required for work on ice surfaces. Apply salt to drill shack decks Engineered Assessment of minimum ice thickness as referenced in Attachment B for ice thickness required for the drilling operations and Attachment C for further guidelines regarding Ice Safety Place delineators in the snow marking access from the drilling location to the shoreline Existing Baffinland procedure “Safely Working On Fresh And Salt Water Ice” shall be followed Polar Bear Monitor will be available at all times Employees will have appropriate PPE including clothing available for safely working in -40 C and windy conditions Worksite location is approximately 300 meters from the shoreline. No work will be conducted in whiteout conditions and a safety shelter will be available immediately adjacent to the work area Site emergency procedures will be provided and reviewed at site	2	1	3	All Crew

5. Working around water and sea ice	Water may appear to be completely frozen over, but not enough to support persons Falling in water Equipment breaking through ice Workers unaware of potential dangerous conditions	5 5 4 3	1 1 2 1	6 6 6 4	Ice thickness to be assessed before walking on ice as per BIM Policy. Initial ice profiling will be conducted with an ice auger Floatation suit will be used for the initial ice profiling using an ice auger. Survival Bag (sleeping bag) will be available to reduce the risk of hyperthermia Follow the BIM Working On Ice Procedure (BAF-PH1-320-PRO-005, Rev 0, March 1, 2016) All workers will be required to complete the Alberta Working Safely on Ice Procedure online training	2	1	3	Marlon Coakley/Warren Hoyle
6. Drill testing for ice thickness	Water may appear to be completely frozen over, but not enough to support persons. Large ice cracks or crevices Falling in water Strains/Sprains Slipping on ice Drilling ice with power auger Changes in ice conditions	3	4	7	Traction aids will be used for any ice work Ice thickness to be assessed before walking on ice Floatation suits will be worn by workers while ice auguring, the worker is to be tethered to a primary rescue worker at a distance of 30m Snow must be removed at the hole location so ice can be examined for quality as described in the Ice field guide. Hand shovelling may be necessary If crevices/ cracks greater than 50% of the ice thickness are present, repairs must be made if there is risk of falling through ice into deep water	2	2	4	Warren Hoyle / Marlon Coakley

					Ice thickness for a person to walk on must be a minimum 13 cm. **STOP** all work if this condition is not met and return to shore. Be aware when using power ice auger that auger bit could bind or jam, have secure footing and grip on auger The ice auger hole spacing will be 20 m along the centreline access and the grid established in the designated work area. Secondary test holes will be augured at 10 m spacing within 250 m of the shoreline, if required based on the variable ice thickness Complete daily inspections of ice surfaces and record on ice log inspection sheet				
7. Access from Land to Sea Ice Snow removal equipment, drill rig and access vehicles are to be used for borehole access	Long distances to walk Exposure to cold White Out conditions Risk of falling under sea ice along the shoreline	4	1	5	Proper warm winter wear to be used Sat phones and digital radio use. Rig mats to be used to bridge over the fractured ice transition area if the transition between sea ice and shoreline needs leveling Buddy system is important to verify presence of frost bite or other cold related concerns **Vehicle operators and passengers are not to wear seat belts when working on ice**	1	1	2	All workers

8. Refueling of equipment	Fuel spills Regulatory or social impacts Spills into water bodies	3	2	5	Use of duck ponds with any refueling Have sufficient spill cleanup supplies on hand to respond to potential spills Maximize space between refueling vehicle	3	1	4	All workers
9. Extreme weather exposure when working outdoors or driving to and from the Borehole Location	Stranded work crew in white out conditions Cold emergencies or cold injuries Mechanical equipment failure	4	2	6	BIM has a procedure that is designed for white out conditions – it would be announced on the radio An emergency shelter to be used when in the Marine Drilling areas Emergency Shelter: Heated wooden shack (7' 8" by 7' 8") set on platform with skis Crews to radio from Hatch leads Buddy system to watch out for fellow workers who may not realize they are developing frost bite Workers to dress in arctic gear and layered clothing Proper PPE required Equipment check list Review Tidal charts on a daily basis Workers to take warm up breaks to stay warm and alert At toolbox review weather forecast with crew and prepare accordingly	2	1	3	All workers

10. Chemical handling- No unusual chemicals other than equipment needs are anticipated to be used.	Spills, leaks Chemical splash Chemical exposure	2	2	4	All products to be stored in secondary containment MSDS to supplied to BIM for review MSDS books to be accessible at the work front MSDS training and WHMIS training completed before arriving to site PPE will be followed as per MSDS recommendations as will first aid and environmental responses Spills response training and supplies to be kept with the equipment	1	1	2	Boart Longyear
11. Waste management and Wildlife Encounters	Risk of wildlife encounters due to improper waste controls Regulatory non compliance	3	2	5	Crews will collect waste daily and transport it back to camp Crews will follow BIM waste management guidelines No placing or storing of food in the back of pickup trucks Secure all small tools and PPE as foxes may carry away small articles from the site	2	2	4	All workers
12. Ecological and Cultural sensitive areas	Risk of causing damage to archeological areas Destroying vegetation Sensitive wildlife and marine life areas Regulatory and reputation damage	3	3	6	Crews have been instructed that there will be **NO** entry to the area east of the sealift ramp Crews are not to build or alter any inukshuk's or other rock formations on the tundra Permits will be required for the work	2	2	4	All personnel

13. Assemble Drill on skid platform skid and construct four walls and roofs	General hazards associated with drill assembly Inadequate communication between Boart Longyear and Site Services / mobile equipment operators	2	2	4	FLRA to be complete by Boart Longyear supervisor prior to executing work Boart Longyear Drilling operations SOPs to be followed including Boart Longyear Procedure 4001	1	1	2	Warren Hoyle / Marlon Coakley
14. Auguring holes in ice for sonic drilling and CPT work	Large ice cracks or crevices Falling in water Strains/Sprains Slipping on ice Drilling ice with power auger Changes in ice conditions	3	3	6	Wear traction aids for any ice work PFDs to be worn by workers while ice auguring during the sonic drilling and CPT operations Snow must be removed at the hole location so ice can be examined for quality. Hand shovelling may be necessary Be aware when using power ice auger that auger bit could bind or jam, have secure footing and grip on auger Complete daily inspections of ice surfaces and record on ice log inspection sheet All holes must be marked using an orange spray paint Any hole in ice over 30 cm in diameter must have a physical barrier around the hole	3	2	5	
15. Working around rotating equipment	Entanglement injuries	3	2	5	All equipment guards to be in place and in good working condition No loose clothing or drawstrings that can get pulled into rotating equipment Long hair must be contained to prevent entanglement into rotating equipment	2	1	3	All workers

					If any maintenance is required then energy isolation procedures to be followed				
16. Isolation of energy sources	Potential energy release that causes injury	3	2	5	All crews will follow the BIM Zero Energy State (ZES) procedure Crews to be given the BIM ZES training on site and fully understand the BIM requirements	1	1	2	Boart Longyear Crews BIM H&S
17. Working on equipment	Slip and trip hazards around railings, stairs and uneven ground.	2	2	4	Rails are installed around deck and to be properly maintained in good condition Stairs to be used on equipment A head cage will be used to reduce chance of contact with the rotating head Estops to be in good working order and easily accessible FLRA to be completed daily to review hazards All crews will follow the BIM Zero Energy State (ZES) procedure	1	1	2	Boart Longyear crew
18. Ice monitoring during drilling activities	Excessive deflection in ice	4	3	7	Hatch geotechs crew will monitor ice conditions during drilling including cracks around the work area, monitor freeboard in drilled holes for signs of ice deflection	2	2	4	All crew

19. Spotter activities	Equipment could come in contact with Spotter	4	2	6	Spotter to maintain eye contact with driver Spotter to review FLRA Agreed hand signals to be used with drivers in conjunction with BIM spotter procedure Agreed hand signals will be documented on the FLRA Drivers to immediately stop if the Spotter is out of eye contact	1	1	2	Boart Longyear crew
20. Manual lifting	Pinch point, back injuries, muscle and joint sprains and strains	2	3	5	Work in pairs, FLRA reviews Work with a buddy on heavy or awkward lifts Use proper lifting techniques 100 pound pipes to be handled by two workers	1	1	2	All crew
21. Working with pressure systems	Pressurized water and hydraulic fluids are used on drill and support equipment	3	2	5	Pre operational inspection Follow all safe work procedures. ZES when maintenance is required.	1	1	2	Boart Longyear crew
22. Falling objects	Potential exists for falling of drill rod and casing falling from overhead	3	2	5	Rigging and slinging training required when working with suspended loads and overhead hazards Perform FLRA	1	1	2	Boart Longyear Hatch Geotec EHS techs
23. High noise and vibration areas on the rigs	Hearing damage	2	2	4	Hearing protection is required by use of ear plugs or muffs.	2	1	3	Boart Longyear Hatch Geotec EHS techs

24. Housekeeping	Potential exists for poor housekeeping causing slip/trips and other hazards	3	2	5	Daily site assessments and toolbox meetings by drillers and site supervisors BIM EHS techs to perform daily inspections	2	2	4	All Crew
25. Fatigue	Potential exists for crew fatigue	2	2	4	Fit for duty confirmation required for all employees, daily FLRA reviews Micro breaks to stretch Proper rest during off shift period	1	1	2	All Crew
26. Working at night or 24 hour darkness	Higher risk of injury due to poor visibility	3	3	6	Hi-vis work gear to be used Use of flashlight and headlamp Workers to stay within 10 meters (30 feet) of the worksites at any time Use of wobble lights and light tower Emergency shelter	1	1	2	All Crew
27. Hot work - welding	Fire risk Burn injuries Welders Flash	2	2	4	Hot work training Use of hot work permits and JHA for any Hot Work Fire Watch required Proper PPE Welding training required	1	1	2	Boart Longyear crew

28. Rescue Plan	Rough terrain Further injuries to casualty during transit. Snow storm, white out conditions. Darkness	3	3	6	The track unit will be used to pull the survival shack (survival shack is 7' 8" x 7' 8" square) on platform with skis. When an incident has occurred, the Geotechnical Engineer must call a Code 1. Provide first aid treatment to the injured person until MRT arrives on site MRT will be dispatched to the location. MRT will transport the casualty. Visibility (whiteout conditions) will hinder rescue time, rescuers will have to wait out the storm, or until the whiteout conditions have subsided.	2	2	4	Marlon Coakley/ Warren Hoyle
29. Cleanup and Demob	Unfrozen open holes Complacency	3	3	6	All drill holes must be filled in with water and snow upon completion of drilling operations A Hatch site representative will confirm safe conditions upon demob All debris must be removed from ice surface and disposed off site per waste management plan BIM safety and environment representatives to attend a post project closeout inspection to document the completion of the clean-up	2	2	4	Boart Longyear

Comments:

Score	CONSEQUENCE		
	People	Plant	Environment
5 – Very High/ Catastrophic	Multiple Fatalities.	Greater than $10 Million Loss	Catastrophe, destruction of sensitive environment, worldwide attention. Likely EPA prosecution. More than 30 days delay.
4 – High/ Major	Fatality or Permanent Disabilities.	$1 Million to $10 Million Loss	Disaster, high levels of media attention, high cost of clean-up. Offsite environmental harm; more than 10 days delay.
3 – Moderate	Major Injuries – Incapacitations or requiring time of work.	$100 Thousand to $1 Million Loss	Major spills, onsite release, substantial environmental nuisance, more than 1day delay. (Leads to additional resources call out i.e. SES).
2 – Low/ Minor	Significant Injuries – Medical Treatments, non-permanent injury.	$10 Thousand to $100 Thousand Loss	Significant spills. (Leads to a call out of Site Emergency Response Group).
1 – Very Low/ Insignificant	Minor Injuries – First Aid Treatments (cuts/bruises).	Less than $10 Thousand Loss	Low environmental impact. Minor Spills less than 80 Litres.

Score	LIKELIHOOD
5 – Almost Certain	The event is expected to occur in most circumstances. Likely to occur frequently - More than 1 per year.
4 – Likely/ Probable	The event will probably occur in most circumstances. Likely to occur several times – 1 per year.
3 – Moderate/ Occasional	The event should occur at some time. Likely to occur at some time – 1 per 5 years.
2 – Remote/ Unlikely	The event could occur at some time. Unlikely but possible. 1 per 10 years.
1 – Rare/ Very Unlikely	The event may occur only in exceptional circumstances. Assumed it may not be experienced. 1 per 100 years.

Job Hazard Analysis Attendees: Darryl Finlay, Marlon Coakley, Warren Hoyle, Usman Khan, Alex Boissonneault

	Name	Signature	Date
Written by:	Marlon Coakley	Marlon Coakley	Mar 20/2017
Reviewed by:	Warren Hoyle (Hatch)	Warren Hoyle	March 20, 2017
	Darryl Finlay (BIM Safety Coordinator)		March 20, 2017

Risk Rating = Consequence + Likelihood

Consequence	Risk Rating				
5	6	7	8	9	10
4	5	6	7	8	9
3	4	5	6	7	8
2	3	4	5	6	7

Risk Rating - Definitions

Risk Rating	Definitions	*Action Required*
8 - 10	Intolerable	Task not to start till the risk is eliminated or reduced. Bring to the immediate attention of management. Formal assessment required. MUST reduce the risk as a matter of priority.
7	High	Bring to the immediate attention of management. Task not to start till the risk is eliminated or reduced. Further Assessment required. MUST reduce the risk as a matter of priority.
6	Significant Risk	Bring to the attention of supervision. Review risks and ensure that they are reduced to as low as reasonably practicable. To be dealt with as soon as possible, preferably before the task commences. Introduce some form of hardware to control risk.
5	Moderate Risk	Needs to be controlled but not necessarily immediately, an action plan to control the risk should be drawn up. Review effectiveness of controls. Ensure responsibilities for

1	2	3	4	5	6
	1	2	3	4	5
	Likelihood				

		control are specified.
2-4	Low Risk	If practical reduce the risk. Ensure personnel are competent to do the task. Manage by routing procedure. Monitor for change

A JHA considers a variety of activities/tasks involved in a job scope and analyses the key hazards (sources of harm) and their consequences (types of harm) eg. Sources of harm – lifting a heavy pipe - manual handling. Types of harm – Back strain.

Main Points – On how to write a JHA.

1. Define the task – what is to be done.
2. Review previous JHA if any – have we done it before?
3. Identify the steps – what is to be done.
4. Identify the hazards of each step.
5. Identify who or what could be harmed.
6. Give the task a risk rating – Consequence + Frequency
7. Develop solutions to eliminate or control hazards in each step.
8. Review the risk rating after the control system has been implemented.
9. If risk rating unacceptable review the solutions till risk rating acceptable.
10. Agree who will implement the control system.
11. Document the JHA and discuss with the relevant personnel.

Hierarchy of Hazard Management – Control Measures

These steps outline what should be planned for when deciding what control measures are to be put in place. Whenever possible the highest step should be used first and then progress down the list.

1. Eliminate the hazard.
2. Substitution.
3. Reducing the frequency of a hazardous task.
4. Enclosing the hazard.
5. Additional procedures.
6. Additional supervision.
7. Additional training.
8. Instructions / information.
9. Some personal protective equipment.

Attachment A – BIM Working on Ice Procedure

Baffinland Iron Mines Corporation

Working on Ice Procedure

BAF-PH1-320-PRO-0055

Rev 0

Prepared By: Shawn Parry
Department: Road Maintenance
Title: Manager
Date: February 9, 2017
Signature:

Approved By: Sylvain Proulx
Title: Chief Operating Officer
Date: February 9, 2017
Signature:

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DOCUMENT REVISION RECORD

Issue Date MM/DD/YY	Revision	Prepared By	Approved By	Issue Purpose
01/19/17	1	S.P.	R.G.	use

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1 PURPOSE AND SCOPE

Baffinland Iron Mines Corporation is committed to taking the necessary steps to ensure that work performed on ice of lakes, rivers, streams or the ocean is conducted in a safe, efficient and environmentally compliant manner.

This procedure is not intended to provide instructions for large scale ice operations such as ice road construction and operation. For large scale ice operations, refer to "Best Practice for Building and Working Safely on Ice Covers in Alberta (Work Safe Alberta)".

2 DEFINITIONS

2.1 BAFFINLAND CLASSIFICATIONS FOR WORKING ON ICE

Class A Job – The ice is between 15 centimetres and 38 centimetres thick and the load weight, including people on the ice will be 4,536 kilograms or less.

Class B Job – The ice is more than 38 centimetres thick and the load weight, including people, is greater than 4,536 kilograms but less than 63,000 kilograms.

Class C Job – The job requirements cannot be met by either Class A or B guidelines.

See section 4, Protocols for a discussion of Class A, B and C requirements.

3 RESPONSIBILITIES

The following roles have specific accountabilities that must be met to ensure that any work on ice is conducted in a safe and environmentally responsible manner.

3.1 CHIEF OPERATING OFFICER OR GENERAL MANAGER, OPERATIONS

The Chief Operating Officer or General Manager, Operations must review and approve any Class C job for working on ice.

3.2 DEPARTMENT MANAGER/SUPERINTENDENT

The Department Manager and Superintendent are responsible to ensure their department supervisors are aware of and comply with this procedure. The manager and superintendent are also responsible to validate the terms and conditions of the JHA are implemented.

3.3 DEPARTMENT SUPERVISOR

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The Supervisor is responsible for supervising the work/tasks in accordance with this procedure and the terms and conditions of the JHA. Specifically, the supervisor is responsible for:

- Notify the department manager and superintendent of the requirement to work on ice and send each a copy of the completed JHA.
- Ensure a geographically specific JHA is completed and implemented, prior to starting work.
- Notify the MRT Trainer and have them participate in the JHA.
- Ensuring that workers have reviewed and understand the JHA, prior to starting work.
- Supervise the work and act as the main point of contact for workers working on ice.

3.4 Worker

The worker, is responsible for the following:

- Review, sign and comply with the terms and conditions of the JHA.
- Promptly reporting to their supervisor, any safety concerns or incidents that occur while working on ice.

3.5 Safety Superintendent or Coordinator

The Safety Superintendent or Coordinator will facilitate the working on ice JHA process.

3.6 Mine Rescue Team Trainer or Delegate

The Mine Rescue Team Trainer or delegate is responsible to work with the supervisor to develop the rescue plan component of the JHA.

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4 PROTOCOL

4.1 CLASS A JOB

The following table provides requirements for performing work on ice under Class A conditions. The JHA must meet the following conditions;

Equipment Example	Weight (kilograms)	Minimum Ice Thickness (centimetres)	Ice Integrity
1 or 2 people and their tools and equipment	Up to 272	15	Solid ice that is free of cracks, water and slush
Snowmobile and rider	Up to 363	20	Solid ice that is free of cracks, water and slush
2 snowmobiles and riders	Up to 726	25	Solid ice that is free of cracks, water and slush
Pickup truck or other mobile equipment, cargo and driver/passengers	Up to 4536	38	Solid ice that is free of cracks, water and slush

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4.2 Class B Job

The ice is greater than 38 centimetres thick and the load weight, including people, is greater than 4536 kilograms but less than 63, 000 kilograms.

Ice Thickness Calculation	Weight and Ice Thickness	Ice Integrity
The Golds formula found in Section 5 must be applied to calculate the safe ice thickness. The calculation, including safe ice thickness must be documented in or attached to the working on ice JHA.	The combined weight of the load, including equipment and people is greater than 4536 kilograms but less than 63, 000 kilograms and the ice is 38 centimetres thick or greater	Solid ice that is free of cracks, water and slush

4.3 Class C Job

The job requirements cannot be met by either Class A or B guidelines. The assistance of a professional engineer recognized as an authority on ice covers, must be consulted and their guidance documented in or attached to, the JHA.

5 Golds Ice Weight Bearing Capacity Formula

GOLD'S FORMULA
All guidelines currently in use in Canada are based on a technical paper published by Dr. Lorne Gold in 1971 entitled "Use of Ice Covers for Transportation". Gold's Formula is;

$P = A \times h^2$
Where:

- **P** is the allowable load in kilograms
- **A** is a parameter that depends on the strength of the ice
- **h** is the effective thickness of good quality ice (cm)

Gold suggested a range of A-values for lake ice that corresponds to a range of safe ice thicknesses for a given load or a range of acceptable loads for a given ice thickness. Baffinland has adopted Golds "Tolerable Risk" value for ice quality, therefore the A value in Golds formula will be four (4) when calculating ice thickness for a Baffinland Class B job.

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Gold's formula A value of 4 is most commonly used for normal operations with moving vehicles. When equipment will be working in the same spot (stationary) for more than 2 hours, the value for A in Golds formula, must be reduced to two (2).

Two examples using the Golds Formula for a Class B job:

What is the weight capacity of good quality ice that is 60 cm thick?
Capacity (in Kgs) = A x h^2
Capacity (in Kgs) = 4 x (60x60)
Capacity (in Kgs) = 4 x 3600
Capacity = 14400 Kgs

The weight bearing capacity of good quality ice that is 60 cm thick is up to 14400 kilograms.

What is the weight bearing capacity of good quality ice that is 60 cm thick and the load will be stationary for 2 hours or more?
Capacity (in Kgs) = A x h^2
Capacity (in Kgs) = 2 x (60x60)
Capacity (in Kgs) = 2 x 3600
Capacity = 7200 Kgs

7, 200 kgs is the weight bearing capacity of good quality ice that is 60 cm thick and the load will be stationary for 2 hours or more.

5.1 Working on Ice frozen to the bottom (River, Lake – etc.)

When Ice thickness measurements determine the ice has frozen to the bottom in the area of travel and work, the ice may be considered as safe provided the ice quality is routinely monitored and remains solid and free of slush and water.

6 Working on Ice JHA and Work Planning Meeting

Working on ice may be divided into two parts;
1. initial measurement of ice thickness
2. working on the ice

Both parts require a JHA.

A work planning meeting must be held prior to any work on ice. This meeting will be based on review of the completed JHA. All individuals participating in the work must present and review their work instructions, roles and responsibilities. The following points will be covered

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in the JHA and will be covered as part of the topics of discussion during the "planning meeting":

- A description of the work to be done – with sufficient detail for individuals to understand their role
- Potential hazards associated with the work
- Personal safety equipment
- Specific safety procedures for working on ice
- Rescue procedures and necessary equipment
- Individual job tasks
- Communications and hand signals to be used
- Load (i.e. equipment, personnel) weight and distribution on ice during work
- Ice assessment – thickness and condition

JHA safety and emergency response considerations;

- Measuring ice thickness should always be a two person operation.
- Initial ice measurement must be done with a PFD and the lead tester on a tether to the second person who is a safe distance behind.
- Self-recovery is not the primary means of rescue, it's the second person and the tether.
- The MRT will provide a backup rescue plan.

7 MEASURING AND RECORDING ICE THICKNESS

The task of ice thickness measurements may be the subject of a separate JHA or may be included in the working on ice JHA.

Ice thickness is the primary measurement required to determine the safe working load that can be put on the ice (allowable load bearing capacity). Manual measurements are made by cutting a hole in the ice cover with an auger, a saw or an ice chisel and then directly measuring the ice thickness. Measurements are made in a prescribed spacing or pattern to provide sufficient coverage and verify the thickness of the ice cover.

It must be mentioned that in all cases of manual ice thickness measurements it is the absolute minimum thickness measured in all holes that must be used. Not an average or any other measurement.

It is imperative that a systematic procedure be implemented to document all ice thickness measurements. Measurement locations should be taken either with a Global Positioning System (GPS) receiver or marked with stakes, or other reliable system so that these locations can be tracked in future measurements or identified for repairs. This information is a key element in the monitoring control plan.

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These records are vital to reconcile any ice failures that may occur. These records must be maintained in a log that is specific to recording ice thickness. See Appendix #1 - Ice Thickness Measurement Log

Suitable equipment and personal protective equipment (PPE) must be prescribed for the work. Initial testing should be conducted by at least two trained crew members travelling separately over the ice. The work could be carried out by travelling:

- On foot, by snowmobile or by amphibious vehicle.
- While testing, the crew should also be checking the ice for cracks and noting the snow load.
- If vehicles are used, two separate vehicles must be used at all times and must be separated at safe distance unless ice conditions are known.

7.1 Test Hole Spacing

Rivers

If GPR is used, test holes are only required for calibration and for mapping of thin areas. Recommend 30 meters between test holes along alternate edges. Look for thin areas caused by river current.

Lakes

If GPR is used, test holes are only required for calibration. If within 250 metres of shore: 30 meters between test holes along centre line. If more than 250 metres from shore: 250 metres between test holes along centre line

Note – these recommendations indicate normal test hole spacing. Good judgement based on field experience must be used when varying from these recommendations. In thin ice areas the suggested spacing should be reduced to determine their extent and severity.

8 REFERENCES AND RECORDS

- Baffinland Job Hazard Analysis Procedure BAF-PH1-810-PRO-0016r1
- Baffinland Iron Mines Corporation– Emergency Response Plan (BAF-PH1-830-P16-0007)
- Best Practice for Building and Working Safely on Ice Covers in Alberta (Work Safe Alberta)
- NWT Transportations Guide to Ice Road Construction

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Appendix #1
Ice Thickness Measurement Log

Date:		Location:
Completed by:		Signature:
Weather Conditions, including temperature:		
Test Hole #	Ice Thickness	Notes on test hole – clear solid ice cracking, water – etc.
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
Names of other participants		Signature of other participants

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Attachment B – On Ice Platform for Geotechnical Drilling

On-Ice Platforms for Geotechnical Drilling at Steensby Island

2013-04-09	0	Approved for Use	V. Tatone	D. Wolek	S. Perry	D. Matthews
DATE	**REV.**	**STATUS**	**PREPARED BY**	**CHECKED BY**	**APPROVED BY**	**APPROVED BY**

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Appendix B

Consideration of Bearing Capacity of Ice for Geotechnical Drilling Program

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1. Purpose

1.1 This Procedure identifies minimum safe work practices for the set-up and maintenance of on-ice platforms to be used to support geotechnical drill rigs for near shore work at Steensby Island.

NOTE: This Procedure does not replace safe work procedures for working on ice.

2. Scope

2.1 This Procedure applies to all locations where on-ice platforms are required for near shore work at Steensby Island.

3. Roles and Responsibilities

3.1 Construction Manager

3.1.1 The Construction Manager shall be accountable for ensuring full implementation and compliance with the requirements of this Procedure.

3.2 Contractor's Line Managers

3.2.1 Contractor's Line Managers shall have the following accountabilities:

- Conduct risk assessments for tasks associated with this Procedure and ensure the implementation of controls
- Ensure equipment is used and processes are applied in accordance with this Procedure

3.3 Site Health and Safety Manager

3.3.1 The Site Health and Safety Manager shall have the following accountabilities:

- Audit and monitor compliance with this Procedure
- Identify remedial corrective actions required to meet this Procedure

3.4 Supervisors

3.4.1 Supervisors shall have the following accountabilities:

- Ensure the application of this Procedure
- Responsibility for details of construction of the platforms
- Ensure that a JHA/FLRA is developed for tasks associated with this Procedure

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- Ensure that employees review and sign the JHA/FLRA prior to task commencement
- Responsibility for removal of the ice platforms

3.5 Employees

3.5.1 All employees shall have the following accountabilities:

- Ensure they follow this Procedure
- Ensure that JHA/FLRA developed for tasks associated with this Procedure are followed

4. Definitions

4.1 Solid Ice

4.1.1 Stable sheet of solid ice, thickness adequate to safely support the operation. The solid ice may be subject to movement due to tides.

4.2 Sea Ice

4.2.1 Sea ice is any form of ice that is found at sea and has originated from the freezing of sea water.

4.3 Rafted Ice or Raft Ice

4.3.1 Ice in cakes or sheets overlapping or piled on one another. This is a body of near shore ice segments fused together and formed during fall freeze-up. The surface of suitable rafted ice should be reasonably flat and elevation at or near high tide. This rafted ice is a stable entity. Rafted ice that moves with the tides shall be regarded as unstable.

4.4 Ice Platform

4.4.1 A platform constructed on the rafted ice by flooding with salt water and including embedded rig mats.

4.5 Rig Mat

4.5.1 A portable platform used to support equipment used in construction and resource based activity including drill rigs.

4.6 Drill Rig

4.6.1 A track mounted drill rig used for geotechnical investigations.

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5. Procedure

5.1 Specific Requirements for Ice Platforms

5.1.1 The rafted ice must be stable and fused to act as a homogeneous mass. Appropriate ice profiling and/or direct measurement of ice thickness is required.

5.1.2 Do not attempt to construct an ice platform in locations where sea ice is pushed up onto the rafted ice to a height exceeding 2 m.

5.1.3 The solid ice adjacent to the ice platform must be stable during tidal influence and capable of safely supporting the gravity loads imposed by the operation, including at the edge of the ice sheet. Appropriate ice profiling and/or direct measurement of ice thickness is required.

5.1.4 The zone of discontinuity between the solid and rafted ice must not be open water at any time and must be sufficiently narrow so that the rig mats will safely support the movement of equipment and personnel across this zone. No work is to be performed over this zone of discontinuity. Appropriate ice profiling and/or direct measurement of ice thickness is required.

5.1.5 The ice platform shall be constructed by alternate overlapping layers of rig mats and flooding with salt water until a suitable work space is created over the rafted ice. Profile the ice with an ice profiler or measure ice thickness using a mechanical ice auger prior to any flooding.

5.1.6 The rig mats shall be constructed of steel frames and timber cross beams. The rig mats shall be strong enough to bridge across the zone of discontinuity. Note that the attached sketch is conceptual only. The number of rig mats must be determined on site. It is anticipated that the number of available rig mats will not be more than six.

5.1.7 The rig mats shall be adequately connected by mechanical means to be determined at site.

5.1.8 The platform must be sufficiently long and wide to permit a clearance of at least two metres on each side of the equipment and supplies.

5.1.9 The platforms must be removed by means established by the supervisor.

6. References

Nunavut General Safety Regulations, R.R.N.W.T. 1990.

Nunavut Mine Health and Safety Regulations, R-125-95.

Safe Work Procedure – Working on Ice (HS-SWP-092).

END OF SECTION

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Appendix A

Illustrations

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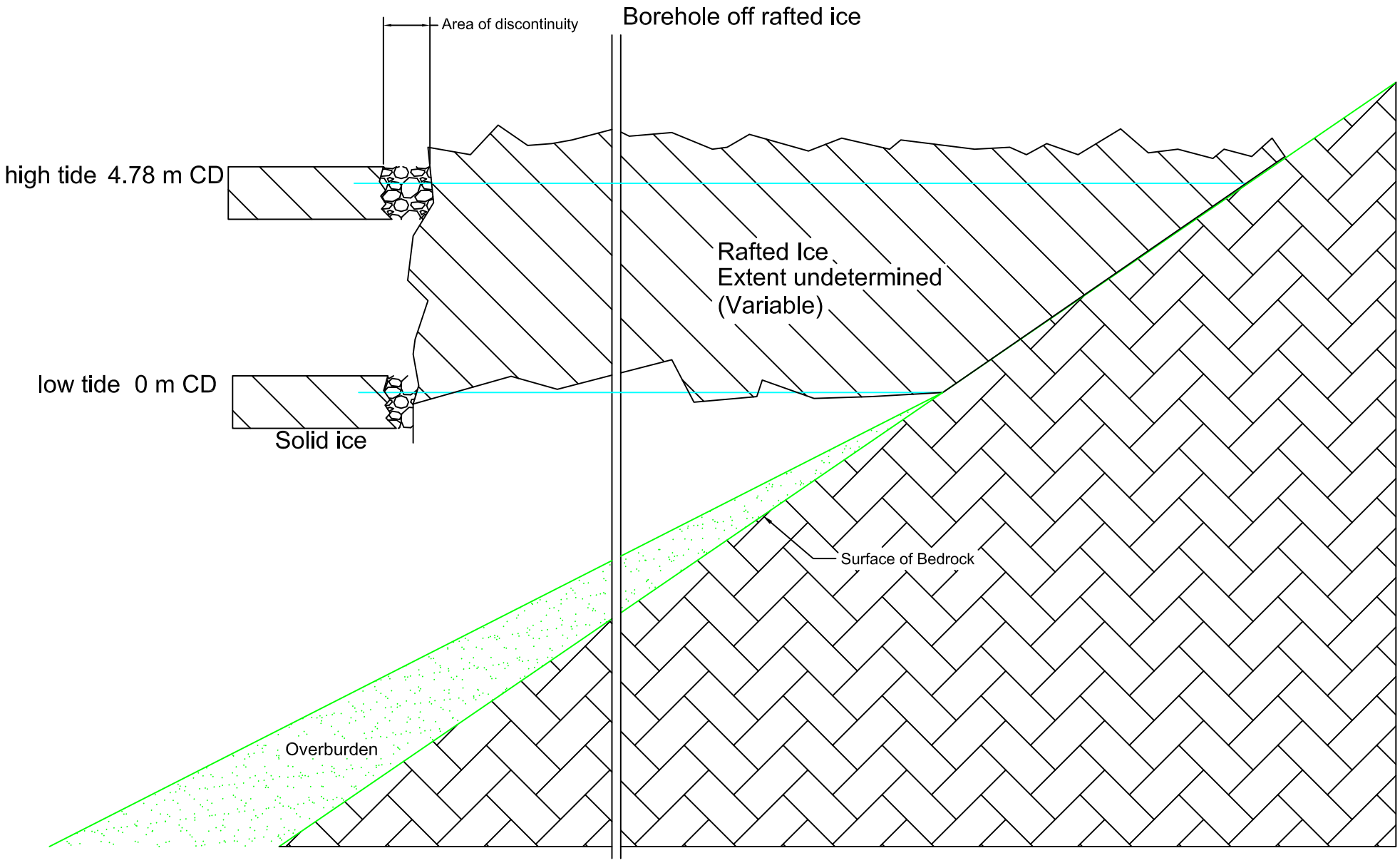
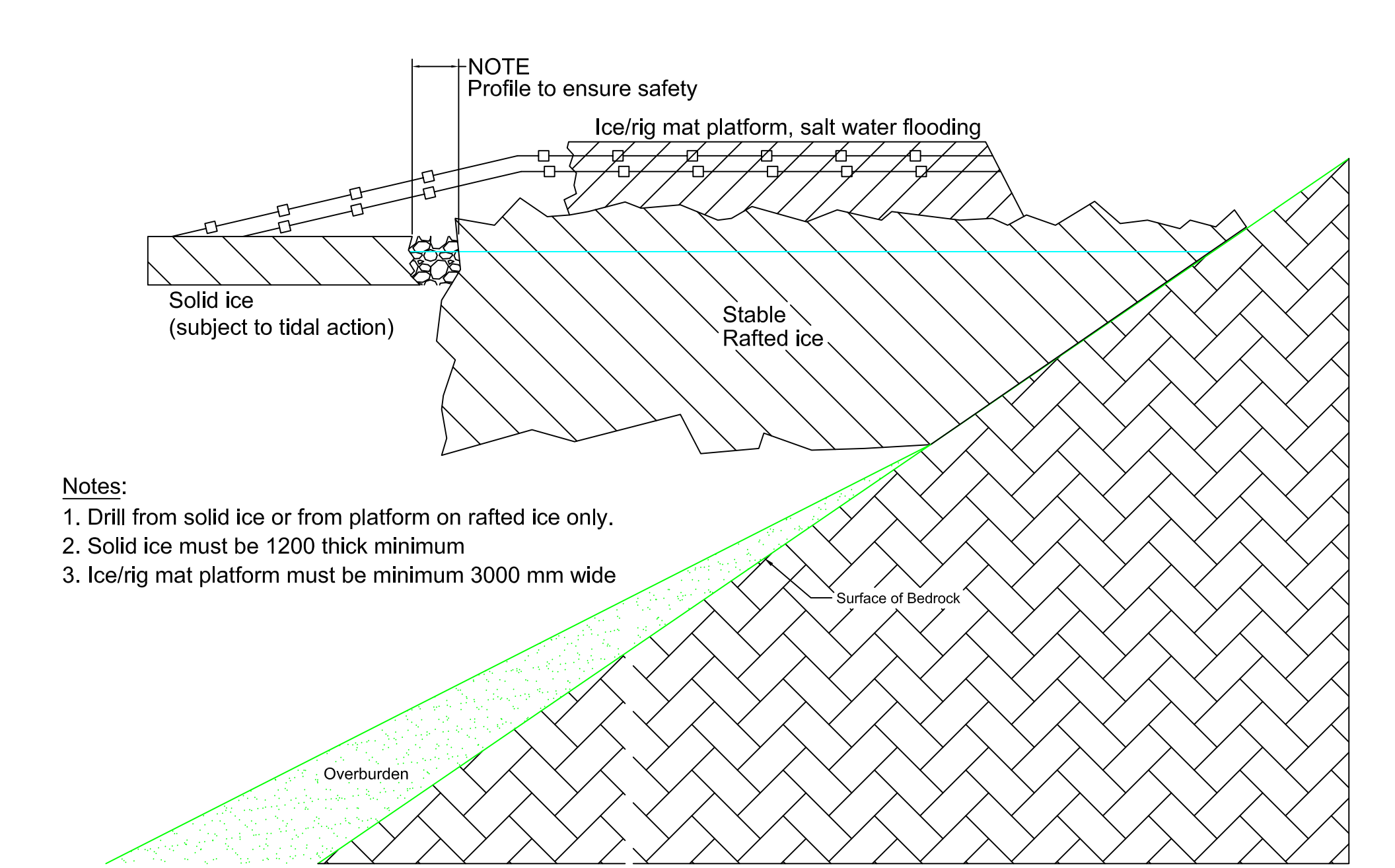


Dredged Depth -23 m CD

ORE DOCK
NEARSHORE CROSS SECTION



Notes:

1. Drill from solid ice or from platform on rafted ice only.
2. Solid ice must be 1200 thick minimum
3. Ice/rig mat platform must be minimum 3000 mm wide

ORE DOCK
ICE PLATFORM CONCEPT

Appendix B

Consideration of Bearing Capacity of Ice for Geotechnical Drilling Program

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Project Memo

December 14, 2011

TO: K. Skebo FROM: B. Gill

cc: S. Hinchberger
R. MacCrimmon

Baffinland Iron Mines Corporation
Mary River Project

Consideration of Bearing Capacity of Ice for Geotechnical Drilling Program

1. Introduction

The purpose of this note is to consider the ice features that may affect the execution of a planned geotechnical drilling program in a safe and effective manner. The program will be conducted during April and May in the proposed mine and marine facilities areas of the Baffinland project on northern Baffin Island. This note addresses primarily the bearing capacity of the ice cover for supporting the drilling program vehicles and equipment.

1.1 Air Temperatures and Ice Thickness

The air temperatures over the period from 1971 to 2000 for Hall Beach to the southwest and Pond Inlet to the northeast for April and May are as follows:

Table 1-1: Air Temperatures

	Hall Beach		Pond Inlet	
	April	**May**	**April**	**May**
Daily Average	-20.4	-9.0	-22.1	-9.9
Daily Maximum	-15.2	-4.8	-17.7	-5.8
Daily Minimum	-25.6	-13.2	-26.5	-13.9

Thus it is seen that the air temperature is well below freezing for the period and ice will continue to grow. Ice thickness data for Hall Beach show that in most years, the thickness reaches to 2 m or greater by May. The minimum thickness for May over 50 years is approximately 1.5 m. This is a significant thickness that is capable of supporting very heavy loads.

1.2 The Bearing Capacity of Ice

The guidelines in Canada for determining safe working loads for operations on ice are based on work by Dr. L. Gold of the National Research Council (see for example, "A Field Guide to Ice Construction Safety" by NWT Department of Transportation, November, 2007 and "Best Practice for Building and Working Safely on Ice Covers in Alberta by Work Safe Alberta, Government of Alberta, October, 2009). Dr. Gold published his paper "Use of Ice Covers for Transportation" in 1971. His formula, which says that the safe working load is a function of the ice thickness squared, is $P = Ah^2$ where A is a parameter that is related to the ice strength and h is the ice

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thickness. The value of A may vary depending on the degree of risk one is willing to take and the offsetting precautionary and response measures that are implemented in a given case. For the current case in which the ice thickness is large, the ice is static, and the equipment loads are relatively modest in relation to the ice bearing capacity, one could assume a low risk factor, and the subsequent calculated minimum ice thickness for the planned equipment weight would be relatively high, but still well below the thickness in April and May. In the Alberta and NWT documents referred to above, the former document uses a range of values for 'A' from 3.5 to 7 and suggests hazard control measures appropriate to each level, whereas the latter document uses a single value of 4 for 'A'. Both of these documents are concerned with freshwater lake and river ice.

Using a value of 4 for 'A' and an ice thickness of 200 cm results in an allowable load of 160 tonnes or more than 12 times the weight of a Cat 950 loader. The ratio would be presumably even greater in the case of a drill rig. In the same manner, the minimum (freshwater) ice thickness that a stationary or slowly moving 950 loader weighing about 13,000 kg would require is 57 cm.

The allowable load in the case of sea ice would be less than that for an equivalent thickness of freshwater ice because of the lower strength (under the same temperature conditions) that results from brine inclusions in the sea ice. A reasonable understanding of this derating can be obtained by comparing the flexural strengths of the two types of ice. For a salinity of 8 ppt (parts per thousand) for arctic sea ice at an average ice temperature of -20 deg C, the resulting flexural strength is about 65 percent of the strength of freshwater ice at the same temperature. The minimum sea ice thickness for a 950 loader would then be about 70 cm. This is 35 percent of the expected ice thickness at the project site during the drilling period.

The rate of movement of the equipment is not expected to be a significant factor, unlike in the case of transport vehicles moving at speed on ice covers over relatively shallow water. The speeds in the present case will not be sufficient to cause any dynamic effects that could lead to a magnification in deflection of the ice cover. According to field studies reported in the above-referenced Alberta Government document, a vehicle would have to travel at 50 km/h over ice 1 m thick in 15 m of water to cause such effects.

1.3 Potential Hazard Control

As noted, the large ice thickness in relation to the minimums required to safely carry the loads and the static nature of the ice cover in the present case mean that this is a low-risk operation in terms of potential ice bearing problems. An appropriate hazard control procedure would entail prior ice measurements to confirm the anticipated thickness in the working areas, measurements thereafter if any uncertainties exist with respect to ice thickness, monitoring the ice quality (e.g. cracks, effects of warming, water on the ice, etc), and checking for deflection of the ice cover as time of equipment in one location increases (this can be done by observing the water level in boreholes).

An overall ice safety plan should be implemented, including orientation and instruction for employees and contractors and routine daily observations to ensure rules of working on an ice cover are followed.

BG:vl

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Internal Memo

H352034

March 18, 2017

To: Warren Hoyle

From: Usman Khan

cc: Marlon Coakley
Alex Boissonneault
Sean Hinchberger
Tyler Bruce
Sven Heiner

Baffinland Iron Mines
Mary River Expansion Study Stage 2

Minimum Ice Thickness for Offshore Drilling at Milne Port 2017

1. Introduction

Hatch Ltd. (Hatch) was retained by Baffinland Iron Mines to conduct an offshore, on-ice, geotechnical drilling investigation at the Milne Port Site. This investigation is scheduled for the period of mid to late March 2017. In order to mitigate risk relating to ice breakthrough, the investigation team reviewed ice strength evaluation completed for a similar offshore investigation at the Steensby site in 2011.

2. Allowable Ice Loading

2.1 Moving Loads

The 2011 evaluation of ice thickness utilized Gold's formula to calculate the allowable weight for a variable ice thickness. Gold's formula is based on literature that utilizes data collected from ice breakthroughs and forms an empirical relationship to predict the allowable bearing capacity of ice.

$$P = Ah^2$$

P = Allowable load in kilograms

A = Constant which depends on the quality of the ice, the geometry of the load and the factor of safety appropriate

h = Effective thickness of the ice in centimeters

Further literature review suggests using a value of 4 as a conservative estimate for freshwater ice. Government of Alberta and Northwest territories both recommend using a factor of 4.

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It is noted that a factor of 4 is used for freshwater ice and does not account for the reduction of flexural strength in sea ice due to the presence of brine. A reduction factor of 0.65 is applied per Hatch project memo entitled, “On-Ice Platforms for Geotechnical Drilling at Steensby Island” (Document # H349000-HS-SWP-165).

Table 2-1: Maximum Allowable Load On Sea Ice

Ice Thickness (cm)	Load (kg)	Load (lb)		Ice Thickness (cm)	Load (kg)	Load (lb)
5	60	150		105	28,660	63,200
10	260	580		110	31,460	69,360
15	580	1,290		115	34,380	75,810
20	1,040	2,300		120	37,440	82,550
25	1,620	3,590		125	40,620	89,570
30	2,340	5,160		130	43,940	96,880
35	3,180	7,030		135	47,380	104,470
40	4,160	9,180		140	50,960	112,350
45	5,260	11,610		145	54,660	120,520
50	6,500	14,340		150	58,500	128,980
55	7,860	17,340		155	62,460	137,720
60	9,360	20,640		160	66,560	146,740
65	10,980	24,220		165	70,780	156,060
70	12,740	28,090		170	75,140	165,660
75	14,620	32,250		175	79,620	175,550
80	16,640	36,690		180	84,240	185,720
85	18,780	41,420		185	88,980	196,180
90	21,060	46,430		190	93,860	206,930
95	23,460	51,740		195	98,860	217,970
100	26,000	57,330		200	104,000	229,290

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2.2 Static Loads

Gold's formula is adequate for calculating the allowable bearing capacity for moving loads on ice but it does not propose a relationship between allowable loads and ice thickness for static loads. To ensure ice safety for a static load operation, a literature review was completed. It was concluded that the deflection in ice must be monitored throughout the drilling operation and loading must be removed in case of excessive deflections. Ice cover should not exceed the freeboard elevation to ensure safety of the drilling crew.

3. Monitoring During Drilling Activities

A hole will be augured through ice within 5 m of the point of maximum load. The depth of water in the hole will be monitored throughout the duration of the drilling investigation at each borehole location. Drilling will be terminated if sea water is observed flowing through the top of the augured hole. Ref 3 provides further details regarding the bearing capacity of ice covers under static loads.

4. References

1. W, Gold. L. (n.d.). Field study on the load bearing capacity of ice covers. National Research Council Canada, 61(5), 3-7. Retrieved March 18, 2017, from http://nparc.cisti-icist.nrc-cnrc.gc.ca/eng/view/object/?id=e7d278d9-808a-4959-b9f7-27320d757afd
2. KINGERYW, . D., KLICKD, . W., DYKINSJ., E. Sea ice engineering summary report-Project ICEWAY. U.S. Naval Civ. Eng. Lab.Port Hueneme, Calif., Tech. Rep. R-189.
3. Frederking, R. M. W., and L. W. Gold. "The Bearing Capacity of Ice Covers under Static Loads." Canadian Journal of Civil Engineering 3.2 (1976): 288-93. Web Accessed March 18, 2017.

UK:UK
Attachment(s)/Enclosure

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ATTACHMENT 12.2

PORT SITE GEOTECHNICAL RECOMMENDATIONS

Baffinland Iron Mines Corporation
Mary River Expansion Study - Stage II

Preliminary Geotechnical Recommendation for Infrastructures at Milne Inlet

2017-01-10	1	Approved for Use	M. Buykx	J. Cleland	J. Cleland	M. Weaver
2016-09-01	0	Approved for Use	G. Liang	K.S. Ho	J. Cleland	M. Weaver
Date	**Rev.**	**Status**	**Prepared By**	**Checked By**	**Approved By**	**Approved By**
			HATCH			**Client**

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1. Introduction

Baffinland Iron Mines Corporation (BIM) currently operates the Mary River iron ore mine in Nunavut, Canada. BIM plans to increase the production rate of the mine from current 4.2 million tonnes per annum (Mtpa) to 12Mtpa, shipping the output through Milne Port. This will be achieved by upgrading the mine fleet, constructing a 105 km long rail line from the mine site to the port, building a new crushing and screening facility at the port, construction of larger ore stockpiles and building a second ore dock and ship loader.

This report summarizes preliminary geotechnical recommendations for different types of foundation of infrastructures at Milne Inlet (the Site) based on the existing geotechnical investigation data, as part of the Mary River Expansion Study – Stage II. It should be noted that the site layout is not finalized; the structural loadings and the site specific geotechnical investigation data are not available at this time. The recommendations for foundation design provided in this report are preliminary. Detailed geotechnical engineering assessment (i.e. geotechnical investigation, temperature measurements, thermal analysis, bearing capacity and settlement analyses of foundations) will be required to confirm their performance and optimize the preliminary design in the next design stages. Detailed geotechnical recommendations and construction considerations are not discussed in this report.

2. Scope of Work

The geotechnical assessment summarized in this report was developed to support the pre feasibility study for the foundation design of infrastructures at Milne Inlet and for the Railway Bridges. Figure 2-1 shows the preliminary layout of the proposed infrastructures at this design stage. Table 2–1 summarizes the preliminary infrastructure list.

Table 2–1: Summary of Preliminary Infrastructures List at Milne Inlet and Railroad Bridges [1]

No.	Proposed Infrastructures
1	Rail car rotary tipper building
2	Ship loaders
3	Elevated conveyors
4	Bridges foundations for railroad
5	Conveyor transfer towers and drive houses
6	Ground level yard conveyor and stacker/reclaimer
7	Crushing and screening buildings
8	Rail workshop

Note ([1]) - the infrastructure lists are preliminary, which will be updated based on the final layout design.

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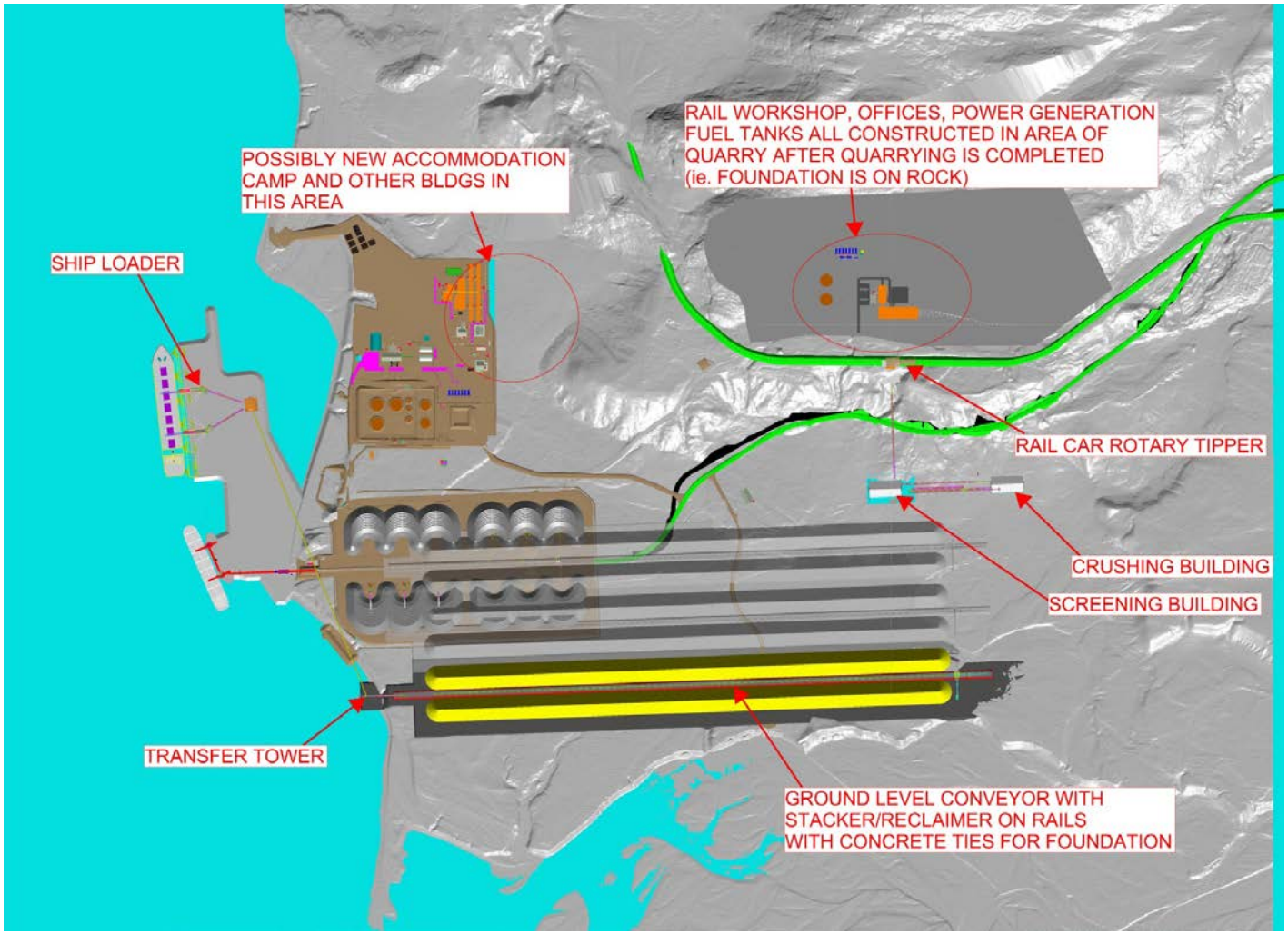

Figure 2-1: Preliminary Layout of Infrastructures at Milne Inlet (For Reference Only)

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3. Reference Document

The preliminary geotechnical recommendation for the infrastructure foundation design at Milne Inlet provided in this report are based on the following information and investigation:

- AMEC Earth & Environmental, 2010. Geotechnical, Geochemical and Quarry Sourcing Investigation (Draft). Project No. TC101510. Dec. 2010.
- Knight Piesold Consulting Ltd. (KP) report “Mine Site Infrastructure, Pit Overburden and Waste Dumps – 2006 Site Investigation Summary Report”, (Ref. No. NB102-00181/3-2), February 28, 2007.
- Knight Piesold Consulting Ltd. (KP) report “Mine Site Infrastructure, Pit Overburden and Waste Dumps – 2007 Site Investigations and Foundations Recommendations Summary Report”, (Ref. No. NB102-00181/8-2), December 14, 2007.
- Knight Piesold Consulting Ltd. (KP) boreholes (PMT-001, PMBC-002, PMPL-002, PMTF-001, PMSD-001 and BS-001) advanced at Milne Inlet in May 2007.
- Knight Piesold, July 2007, Bulk Sampling Program Road Upgrade Design Summary (REF. NO. NB102-00181/10-1).
- Knight Piesold, 2008, “Mine site infrastructure, pit overburden and waste dumps – 2008 site investigations summary report” (ref NB102-181/24-1), May 4, 2010.
- Knight Piesold, Feb 2009, Bulk Sampling Program Milne Inlet Tote Road Construction Summary, (REF. NO. NB102-181/13-2).
- Thurber, 2011, “2011 Onshore Geotechnical Investigations Summary of Results”, (ref. 19-1605-126), Nov 10, 2011.
- Thurber 2011 report “Initial Geotechnical Recommendations Mary River Mine Site Facilities” (ref 19-1605-126), Nov 7, 2011.
- EBA Engineering Consultants Ltd. (EBA) memo “Foundation Recommendations, Mary River Mine Site Infrastructure”, (File: E14101009.003), September 9, 2010.
- EBA 2008, Mary Rive- Pile Foundations Revision C, E14101009.001.
- Hatch Ltd. H337697-0000-15-124-0004.Geotechnical Data Report –Infrastructure. April 5, 2012.
- Hatch 2013, Geotechnical Design Criteria, H349000-1000-15-122-0001, Rev 0.

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4. Regional Geology

Regional geologic mapping is available for the project site from Milne Inlet follow the route of Tote Road (Scott and de Kemp, 1998), which can be used for preliminary design:

- Approximately the first 20 km of the Tote Road from Milne Inlet passes through Precambrian terrane.
- The middle 73 km of the road travels across relatively flat lying Paleozoic rocks.
- The final 14 km of the road to the Mary River mine site passes through Precambrian terrane near the boundary with the Paleozoic units.

The detailed regional geology was described in AMEC 2010 geotechnical Investigation Report (AMEC TC101510, 2010).

5. Geotechnical Data Summary

5.1 Subsoil Conditions

In general, the overburden soils encountered at Milne Port consist of glacial alluvial deposits of cohesionless soils consisting of sand, sand and gravel, and gravel, containing frequent cobbles and boulders. A thin layer of organics at the ground surface is encountered in some locations. The glacial alluvial deposits are found at the ground surface to a depth of 42 m. An average of 9% passing 0.075 mm size (silt and clay content) was recorded in particle size tests from this area. Bedrock has not been encountered at the Site within the low lying area located at the base of the rock ridge.

Vegetation is sparse and consists primarily of a variety of mosses and grasses in areas where surface moisture is present during the thaw season. No shrubs or trees exist in the area and no peat deposits have been observed. Top soil and existing roots shall be removed to a minimum of 150 mm, if required.

The Site is underlain by permafrost, except below large bodies of water where water depths exceed 3 or 4 m. No sub-surface (ground) ice has been observed at the Milne Port site based on the previous geotechnical investigation campaigns. However significant ground ice was found in a deep excavation near the new ore dock and ground ice has been found in the vicinity of the existing Water Building; settlement due to thawing of ground ice is believed to be occurring under the Water Building and the Sewage Treatment Plant.

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5.2 Foundation Type and Bearing Capacity

The anticipated foundation option for the infrastructures of Milne Inlet could be summarized in Table 5–1.

Table 5–1: Summary of Preliminary Infrastructures and Foundation Options

No.	Proposed Infrastructures	Potential Foundation Option
1	Rail car rotary tipper building	Shallow foundation (on rock); or Adfreeze pile (on permafrost)
2	Ship loaders	Adfreeze pile
3	Elevated conveyors	Adfreeze pile or shallow foundation
4	Bridges foundations for railroad	Adfreeze pile
5	Conveyor transfer towers and drive houses	Adfreeze pile
6	Ground level yard conveyor and stacker/reclaimer	Rockfill Embankment with shallow foundation
7	Crushing and screening buildings	Shallow foundation
8	Rail workshop	Shallow foundation (possibly on rock)

It should be noted that the above proposed foundation options should be reviewed based on ground investigation results during the next design phase.

5.2.1 Shallow Footings

The following types of shallow foundations are considered applicable for infrastructures at Milne Inlet for pre feasibility design stage.

- Square footing (Footing Length (L)/width (B) =1, with B=1 m to 4 m).
- Rectangular footing (L/B=3, with B =1 m to 4 m).
- Strip Footing (L/B>10, with B=1 m to 3 m).

5.2.2 Bearing Capacity

The allowable bearing capacity of different types of shallow foundation are estimated based on the following assumption.

- The existing subgrade soil is assumed non ice-rich permafrost in this preliminary design stage. It should be noted that, for footing placed on ice-rich soil, the serviceability of the foundation should be checked for secondary creep.
- The proposed shallow foundations at Milne port will be constructed on an engineered fill (granular pad) with a minimum thickness of 400 mm of Non Frost Susceptible (NFS) material. There will be no embedment considered for the foundations at this stage.
- An internal friction angle of 32° and a cohesion of zero are assumed for the soil shear strength parameters. Soil bulk density is assumed 20 kN/m^3.
- The engineered fill is placed and compacted to meet required specifications. Surface drainage is maintained to prevent formation of ice lenses.
- Bearing capacity is estimated based on the generalized foundation equation described in the Canadian Foundation Engineering Manual, 4th Edition.

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- A factor of safety of 2.5 applied to the ultimate bearing capacity.

The estimated bearing capacities for different types of shallow foundation are shown in the design charts listed as follows:

- Bearing capacity for square footing: Figure 5-1.
- Bearing capacity for rectangular footing: Figure 5-2.
- Bearing capacity for strip footing: Figure 5-3.

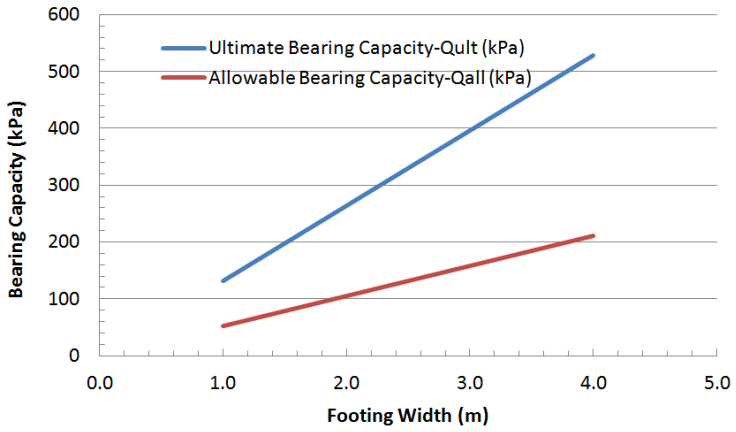

Figure 5-1: Bearing Capacity for Square Footing on 400 mm Granular Engineered Fill (L/B=1 with B =1 m to 4 m)

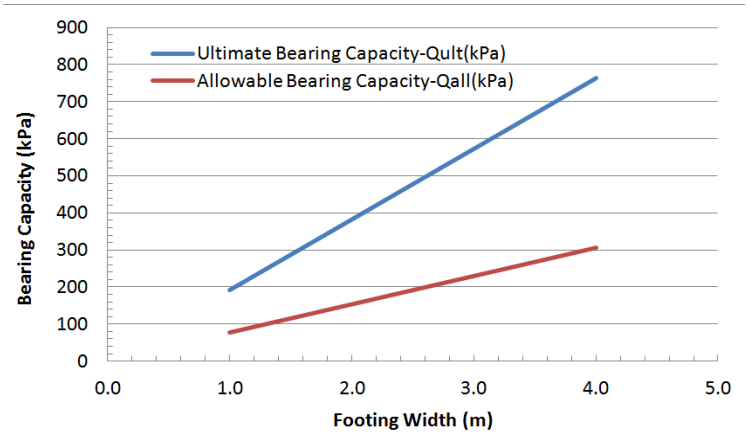

Figure 5-2: Bearing Capacity for Rectangular Footing on 400 mm Granular Engineered Fill (L/B=3 with B =1 m to 4 m)

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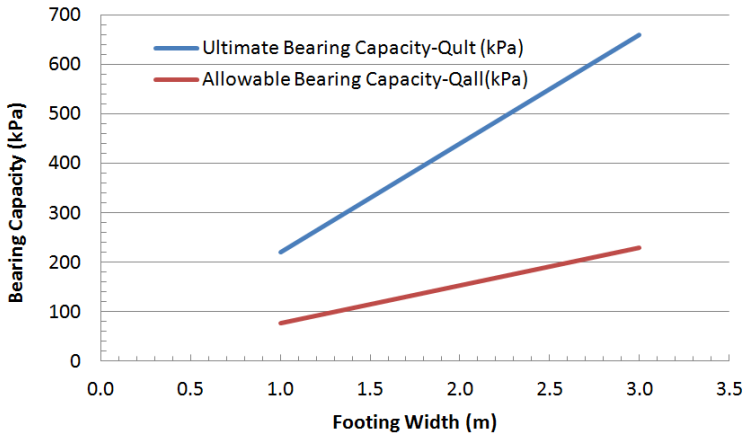

Figure 5-3: Bearing Capacity for Strip Footing on 400 mm Granular Engineered Fill (L/B>10 with B =1 m to 3 m)

5.2.3 Modulus of Subgrade Reaction

5.2.3.1 Building Foundations

Considering the soil conditions at Milne Inlet sites, the modulus of subgrade reaction recommended by Knight Piesold (2007) are considered suitable. Table 5–2 provides the modulus of subgrade reaction for foundations with different widths.

Table 5–2: The Modulus of Subgrade Reaction

Foundation Width (m)	Modulus of Subgrade Reaction (MPa/m)
1.0	66.0
1.5	44.0
2.0	33.0
2.5	26.0
3.0	22.0
3.5	19.0
4.0	16.5

5.2.3.2 Slab on Grade

The building slab at Milne port site will accept loads from heavy loaders, bulldozers, or haul trucks. No stockpile loads are anticipated on slabs. Therefore the maximum effective width of slabs below the trucks are assumed less than 2 m. A modulus of subgrade reaction for slabs on grades can be selected similar to building foundations with a width of 2 m.

Based on the latest field observation, significant ground ice was found in a deep excavation near the new ore dock and ground ice has been found in the vicinity of the existing Water Building, foundation settlement due to thawing of ground ice should be limited by design measures. As such, thermal insulation is recommended for the Milne port buildings. The modulus of subgrade reaction of 20 MPa/m is recommended for preliminary design.

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5.2.4 *Sliding Friction Angles*

All the foundations will be founded on granular pad, not on native soils. Consequently the following friction angles and coefficients can be used for sliding of the foundations on granular pad, based on Canadian Foundation Engineering Manual (2006):

- 30° (friction coefficient: 0.58) for cast-in-place concrete.
- 24° (friction coefficient: 0.45) for precast concrete.

5.2.5 *Thermal Insulation Design Consideration*

Based on the test pits advanced during the 2010 investigation of borrow areas close to Milne Inlet, AMEC reported that the thickness of the active zone is anticipated to be between 2 m and 2.5 m. Thurber also indicated that, based on the results of geotechnical investigations carried out in 2006, 2007, 2008 and 2011 in the entire Mary River site, the depth of annual thaw ranges from 0.5 m in poorly drained areas to about 3 m in well drained areas.

For preliminary thermal insulation design at Milne Inlet Site, the following assumptions are applied:

- The temperatures of the heated structures are assumed constant throughout the year. The internal temperature is in a range of at +5°C (lower bound) to +22°C (upper bound).
- The ground temperature below 15m deep from the existing ground surface is -10°C (assumption based on the data from the thermistors installed at the Mine site)

The preliminary thermal insulation recommendations are summarized as follows:

- For the structures with an internal temperature of +5°C, an insulation layer of 125 mm thick is recommended to be placed below the granular fill and the native ground will remain frozen.
- For the structures with an internal temperature of +22°C, the following two insulation configurations are recommended:
  - 250 mm thick insulation layer to be placed below the granular fill.
  - The granular fill will be sandwiched between two insulation layers each with a thickness of 125 mm.

Hatch recommends that thermal analysis shall be carried out for the detail design to confirm the preliminary thermal design and to optimize the thermal insulation configuration, based on the site specific geotechnical investigation data and designed building internal temperatures.

5.3 Embankment Berm for Rail Stacker and Reclaimer Machine

Rail stacker and reclaimer machines are proposed to handle iron ore stockpile at Milne Inlet. Embankment berms for stacker and reclaimer machines are normally subjected to large static and dynamic machine loadings. The stability of these berms and acceptable deformation of machine foundations under working loads are of paramount importance to ensure a safe and cost effective mining operation.

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The preliminary geotechnical recommendations for the embankment berm at Milne Inlet are summarized as the following:

- The embankment berm consists of a 200 cm thick compacted rock-fill (Type 8) material underlain a stiff geotextile on the existing ground. The side slope is 1.5H:1V. The maximum height of embankment depends on the design grade at the project site.
- The allowable capacity of the proposed compacted rock-fill embankment is 200 kPa.

It should be noted that the detailed geotechnical engineering assessment shall be carried out to confirm the preliminary design when the design loading and the site specific geotechnical data are available. The geotechnical engineering assessment consists of the following but not limited to:

- Bearing capacity.
- Embankment stability (local and global) under machine loadings.
- Design of geosynthetic reinforcements.
- Foundation deformation under machine loadings.

5.4 Deep Foundations

5.4.1 Adfreeze Piles

Pile foundations in permafrost soil can normally be selected from adfreeze or rock-socketed piles depending on the characteristics of the site and bedrock depth. Since the bedrock depth at the Milne Port site and Railway bridge locations has not been established, for preliminary design stage, only the adfreeze pile option will be studied. In addition, it is assumed that steel pipe piles with nominal diameters ranging from 4” to 12” could be utilized in this project.

5.4.2 Pile Capacity

The capacity of the adfreeze piles can be calculated using the following equation:

$$P_a + W = \tau a \ . \pi . d . L \text{ (for compression)} \quad [5\text{-}1]$$

and,

$$P_a - W = \tau_a . \pi . d . L \text{ (for tension)} \quad [5\text{-}2]$$

where:

P_a= allowable pile capacity (kN)

W= weight of pile (kN)

d= pile diameter (m)

L= pile embedment length (m) in permafrost (i.e. ignore embedment in active layer)

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Also, based on the equation presented in literature for secondary creep, τ_a (kPa) which is the adfreeze shaft stress can be determined using the following:

$$\tau_a = \left[\frac{\frac{\dot{u}_a}{a}(n-1)}{3^{(n+1)/2}.B}\right]^{\frac{1}{n}} \quad [5\text{-}3]$$

where:

$\dot{u}_a$= allowable settlement rate (mm/year)

a = pile radius (mm)

B = creep parameter (kPa-n/year)

n = creep parameter (unitless)

It is assumed that the allowable settlement rate is 2 mm/year in the calculations. The creep parameter (n) is also assumed to be equal to 3. Furthermore, with the assumptions of non-saline porewater/ice and an average ground temperature of -5 C, the creep parameter (B) is estimated at 10^{-8} kPa^{-3}/year.

The pile capacity calculation is carried out for pipe piles with diameters of 4”, 6”, 8”, 10” and 12” with embedment lengths ranging between 2 m and 20 m. It is of note that the embedment length corresponds to the length within the permafrost layer (ignoring the length of the pile within the active layer). The allowable pile axial capacities (geotechnical) under compression and uplift (tension) are plotted in Figure 5–4. It should be noted that the weights of the piles (W) have to be be taken into consideration in calculation of the allowable pile capacities in both compression and tension.

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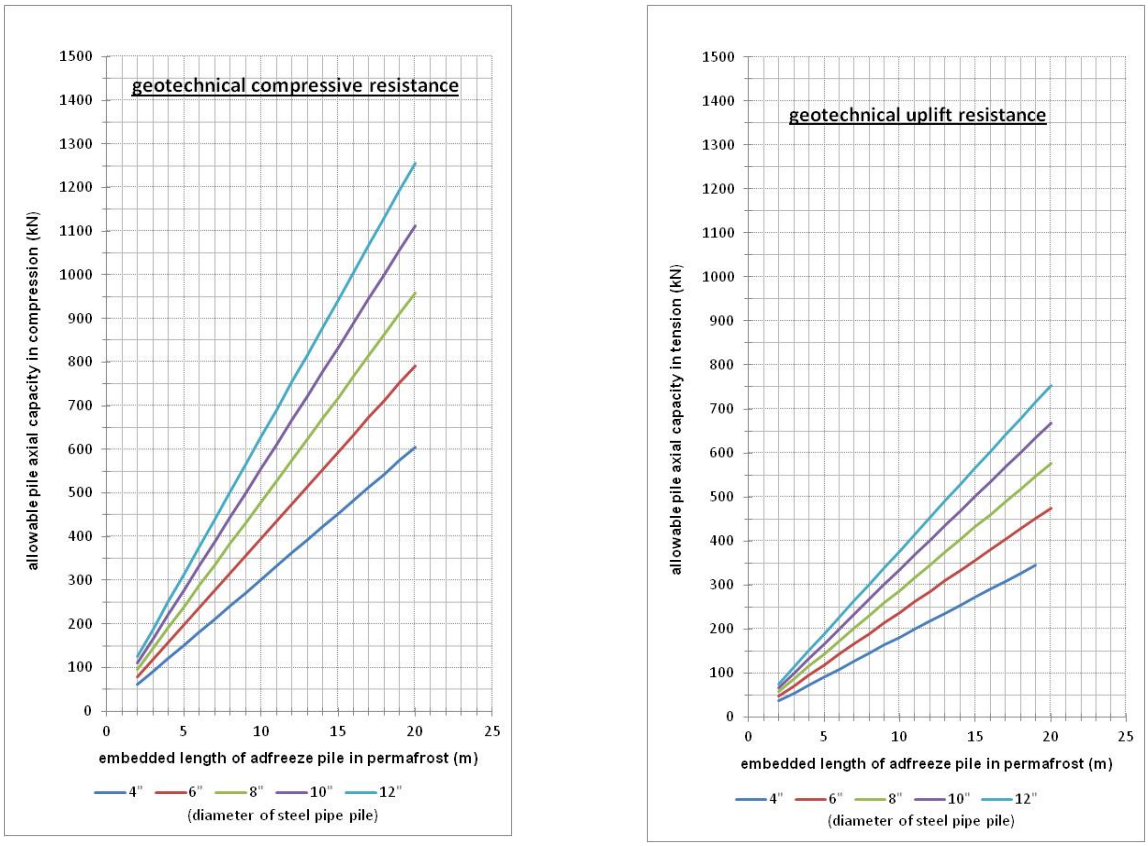

Figure 5–4: Plots of Geotechnical Axial Resistance with Embedded Length of Adfreeze Piles

In order to avoid frost heave, the length of the pile in the active layer should be wrapped with polyethylene film to break the adfreeze bond in the active layer.

It should be noted that Figure 5–4 presents the preliminary geotechnical capacities of adfreeze pile. The structural capacity of the steel pipe pile should be checked by a structural engineer.

6. References

1) Corps of Engineers, U.S. Army. Description and Classification of Frozen Soils. August 1966.

2) Andersland, B.A., Ladanyi, B., 2004, “Frozen Ground Engineering”, Second Edition, ASCE, John Wiley and Sons, Inc.

3) International Permafrost Association, 2005, “Glossary of Permafrost”, The Arctic Institute of North America, The University of Calgary.

4) Canadian Geotechnical Society, 2006, “Canadian Foundation Engineering Manual”, Forth Edition.

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ATTACHMENT 12.3

ORE DOCK FACTUAL GEOTECHNICAL REPORT

Report

Baffinland Iron Mines Corporation
Mary River Expansion Project

2017 Milne Port Ore Dock No. 2
Geotechnical Factual Data Report

2017-10-03	0	Approved for Use	U Khan / A Boissonneault	W Hoyle	S Heiner	M Weaver
Date	**Rev.**	**Status**	**Prepared By**	**Checked By**	**Approved By**	**Approved By**
			HATCH			**Client**

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This report contains the expression of the professional opinion of Hatch, based upon information available at the time of preparation. Hatch has conducted this investigation in accordance with the methodology outlined herein. It is important to note that the methods of evaluation employed, while aimed at minimizing the risk of unidentified problems, cannot guarantee their absence. The quality of the information, conclusions and estimates contained herein is consistent with the intended level of accuracy as set out in this report, as well as the circumstances and constraints under which this report was prepared.

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Waiver, Release and Indemnification

To: Hatch Ltd. together with its affiliates, the "Consultant"

Re: 2017 Milne Ore Dock No. 2 Geotechnical Factual Data Report (and together with any subsequent revisions thereof, the "Report") dated October 03, 2017 prepared by the Consultant for Baffinland Iron Mines Corporation (the "Client"), in respect of the drilling, soil sampling at the proposed Ore Dock 2 and laboratory testing of samples.

The undersigned hereby:

(a) acknowledges that it wishes to receive a copy of the Report from the Client and that a condition precedent to the provision of the Report to the undersigned is that it sign and deliver to the Consultant this Waiver, Release and Indemnification; and

(b) irrevocably and unconditionally:

(i) waives, releases and disclaims any and all suits, actions, proceedings, claims and any other rights (whether in tort, contract or otherwise and whether past, present or future) that it has or may have against or in relation to the Consultant in respect of or in connection with the Report;

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Dated: [insert current date]

[INSERT NAME OF REPORT RECIPIENT]

By:_____

Name:

Title:

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1. Introduction

Baffinland Iron Mines LP (BIM) currently operates the Mary River iron ore mine in Nunavut, Canada. BIM plans to increase the mine production to 12 Mtpa, shipping the output through the Milne Port. This will be achieved by upgrading the mine fleet, constructing a 105 km long rail line from the mine site to the port, building a new crushing and screening facility at the port, construction of larger ore stockpiles and building a secondary dock for ship loading.

Hatch Ltd. (Hatch) was retained by BIM to conduct geotechnical investigations for an additional ore dock (Ore Dock No. 2) at the Milne Port Site.

This report presents (i) sonic borehole data at the proposed Ore Dock No. 2 location including the visual observations and laboratory test results for particle size distribution and soil behavior type and (ii) piezocone penetration test (CPTu) data. In addition, sample photographs are appended providing visual records of the soil cores.

1.1 Previous Investigations

Geotechnical investigation programs have previously been conducted at the Mary River mine site, Steensby Inlet port structure, and the Milne Inlet port site, the Tote Road, as well as offshore investigations for Ore Dock No. 1 at Milne Port.

These previous programs were conducted in 2006, 2007, and 2008 by Knight Piésold Consulting Ltd. (Knight Piésold), in 2010 by AMEC Earth and Environmental (AMEC) in 2011 by Thurber Engineering (Thurber), and in 2013 and 2014 by Hatch.

For the 2013-2014 investigation, offshore boreholes were drilled at the Milne Port for Ore Dock No. 1. The soil thermal resistivity was tested, and a geophysical survey consisting of seismic refraction, seismic resonance, and Multichannel Analysis of Surface Waves were conducted. Information from the 2013-2014 investigation undertaken by Hatch for the Milne Port has been used in this report when relevant.

1.2 Pre-Investigation Activities

1.2.1 Safety Management Plan

Safety management was a key consideration during the planning process for the geotechnical investigations. A safety management plan was prepared by Hatch and reviewed and approved by BIM and Boart Longyear Ltd. (Boart Longyear). As part of the execution plan for the Milne Port Offshore Investigation, a Job Hazard Analysis (JHA); appended as Appendix E; was developed by Hatch and BIM and reviewed by Boart Longyear. All site personnel reviewed and signed off on the JHA. This JHA was reviewed on a periodic basis and updated when there were changes to the conditions or the work activities.

1.2.2 Ice Thickness Assessment

As required by the JHA, an ice assessment plan was prepared to test the thickness of the ice sheet and assess it before mobilizing equipment on the ice, to ensure the ice was sufficiently

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strong to support the drill rig and associated equipment and personnel. The target thickness was more than 1.5 m of ice.

The ice thickness assessment consisted of auguring test holes through the ice on a grid pattern at the drilling location; 34 of the 46 planned auger holes were drilled to confirm the ice thickness. The 12 remaining holes were located mostly in an area of ground ice (full ice column to the seabed) and did not require detailed delineation as found during the ice augering program. The test holes were augured using a 20 cm (8 in) diameter gas-powered auger operated by two Boart-Longyear workers. Once the hole was augured, a Hatch field engineer measured the thickness of the sea ice, the depth of freeboard as well as the height of the snow cover on the ice. The completed ice assessment and UTM Coordinates of the test holes can be found in Appendix H.

2. Geotechnical Investigation

2.1 General

The drilling supervision, material logging and sampling was carried out by Hatch Boart Longyear was selected as the drilling contractor and ConeTec Inc. (ConeTec) was selected as the contractor to perform piezocone penetration tests, (piezocone soundings). The Hatch field personnel and the contractor mobilized to the site on March 7, 2017. The field investigations for the Milne Port Ore Dock No. 2 offshore program were completed between March 8, 2017 and April 7, 2017.

A total of six boreholes were developed ranging from a depth of 24.4 m to 42.7 m below the sea bed. In addition, eight piezocone soundings were performed with depths ranging from 20.5 to 39.5 m.

Soil samples were collected on site and shipped to the Hatch geotechnical laboratory in Niagara Falls for additional visual examination. Representative samples were selected for further laboratory testing (See Section 2.5 for more detail).

This report provides information for the proposed Milne Port Ore Dock No. 2 seabed area approximately 300 m from the shoreline. Land based drilling was completed for the Milne Port infrastructure and results are presented in the report entitled, “2016 Milne Port Geotechnical Investigation Factual Data Report (H353034-1000-229-230-0002, Rev. 2, October 03, 2017)”.

2.2 Sonic Borehole and CPTu Sounding Locations

The surveyed location of the sonic borehole and the borehole depths are provided in Table 2-1. The CPTu surveyed locations and total depths are summarized in Table 2-2. All coordinates are located within Zone 17 of the Universal Transverse Mercator (UTM) Grid. The horizontal datum for this project is the North American Datum 1983 (NAD 83).
The as-built borehole location plan is provided in Appendix A.

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In the naming convention, the prefix BH represents Borehole and CPT represents Piezocone sounding, while 17 refers to 2017, the year of the investigation. The first letter following the dash symbol (-) categorizes the borehole location as the proposed Ore Dock No. 2 (D).

Table 2-1: Milne Port Borehole Locations and Depths

Borehole Number	Easting (m)	Northing (m)	Depth (m)
BH17-D001	503,644	7,976,666	27.4
BH17-D002	503,764	7,976,680	27.4
BH17-D003	503,608	7,976,710	30.5
BH17-D004	503,701	7,976,728	42.7
BH17-D005	503,786	7,976,738	31.1
BH17-D006	503,678	7,976,797	24.4

Table 2-2: Milne Port CPTu Locations and Depths

Borehole Number	Easting (m)	Northing (m)	Depth (m)
CPT17-D001	503,607	7,976,718	32.8
CPT17-D002	503,705	7,976,728	39.5
CPT17-D003	503,785	7,976,758	30.4
CPT17-D004	503,646	7,976,768	32.1
CPT17-D005	503,736	7,976,781	25.1
CPT17-D006	503,808	7,976,808	20.6
CPT17-D007	503,767	7,976,684	30.2
CPT17-D008	503,636	7,976,651	30.0

2.3 Drilling and Sampling Methodology for Boreholes

The geotechnical boreholes were drilled using a BL100 Mini Sonic Drilling rig owned and operated by Boart Longyear. The boreholes were advanced using vibration of the drill string at a high frequency in addition to rotary motion, and pressure by the drilling head.

A 178 mm (7 in.) casing was lowered to approximately 3 m above the seabed and suspended using a collar seated on the ice around the borehole. A 152 mm (6 in.) casing was then lowered to the seabed surface and an HQ rod (89 mm OD) was used for the sonic drilling with seawater. Figure 1 shows the offshore drilling setup including the drilling rig, drill shack, survival shack, drilling rods/casings rack and a light tower. Other major equipment included a tracked utility vehicle, skid steer, generator sets, frost fighters and pickup trucks.

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Figure 1: 2017 Offshore Drilling Setup

In order to collect soil samples, a 3 m drilling rod was advanced 1.5 m into the seabed for each run. The bottom 1.5 m was collected into a 4 in. split PVC pipe, and the top 1.5 m was collected in a second 4 in. split PVC pipe. Both samples from the 3 m run were inspected by the field supervisor.

The Hatch field supervisor documented the materials encountered, and determined in situ testing and sampling requirements. Samples were typically taken at 2 m to 4 m spacing. The description of soils as detailed in the geotechnical borehole reports are based on field visual classification and confirmatory laboratory testing in accordance with the explanatory notes included with these reports.

The detailed geotechnical borehole drilling reports are contained in the attached Appendix B and should be referenced for a complete description of soil materials and the in situ testing and sampling performed. Appendix B also contains a set of explanatory notes detailing terminology used in the borehole reports. Additional observations such as testing and sampling procedures, percent recovery, water loss/gain, and mechanical heating of samples were recorded, along with time of observation. Photographs of samples collected during the drilling investigation are contained in Appendix C.

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2.4 Methodology for Performing Piezocone Soundings

The piezocone soundings were completed by ConeTec using the Boart Longyear drilling rig, CPTu equipment and a ramset (Figure 2). The piezocone soundings were undertaken as per ASTM D5778. The ramset used the hydraulic system of the drilling rig to push an instrumented cone under the seabed. The drilling rig was secured in place using heavy duty steel chains and titanium ice studs to prevent it from lifting.

Figure 2: Ramset used for Pushing Cones through the Seabed

The cone was pushed through the soil at 2.5 cm/s and data was collected electronically in real time by an onsite data acquisition system as shown in Figure 3. Tip resistance, sleeve friction and pore-water pressure was recoded at 2.5 cm intervals. The Soil Behaviour Type (SBT) chart by Robertson and Campanella (1986) was used to characterize the soil type i.e., Sand, Silty Sand, etc.

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Figure 3: Data Acquisition System for Piezocone Testing

A total of 8 piezocone soundings were completed for the offshore investigation. Piezocone testing characterizes the soil based on its behaviour type as opposed to the particle size distribution. Soil behavior is deduced based on the friction ratio.

$$Friction\ Ratio = \frac{Sleeve\ Friction}{Tip\ Resistance} \times 100$$

According to Robertson and Campanella's SBT chart, finer grained soils tend to have a high friction ratio (i.e., high sleeve friction, low tip resistance) while coarser grained soils tend to have a lower friction ratio (i.e., low sleeve friction, high tip resistance). Overburden stress and pore-water pressure data can be used to correct soil classifications acquired from piezocone testing.

See Appendix F for detailed information regarding the CPTu test results.

2.5 Laboratory Testing

All soil samples were shipped to the Hatch geotechnical laboratory in Niagara Falls, a Canadian Council of Independent Laboratories (CCIL) certified laboratory (see Appendix G for the certification document). Discussion of the lab results is included in Section 3 of this report, with full laboratory test results in Appendix D.

Table 2-3: Laboratory Testing Standards from 2017 Investigation

Name	Standard
Standard Test Methods for Particle-Size Distribution of Soils Using Sieve Analysis	ASTM D6913
Standard Test Method for Particle Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis	ASTM D7928
Direct Shear Tests of Soils Under Conolidated Drained Conditions	ASTM D3080

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3. Results of Investigation

3.1 Milne Port Offshore Boreholes

A total of six (6) boreholes were drilled offshore at Milne Port to support design of the proposed Ore Dock No. 2 at Milne Port. The boreholes were arranged into three categories based on the depth to seabed; the shallow water (closest to shoreline), the mid-depth holes, and the deep water (farthest from shoreline). Fence diagrams of select borehole sections are presented in Appendix I.

The materials encountered during the investigation typically consisted of silt and sand, sand or gravelly sand. In the shallow and deep boreholes these layers were found inter layered without a consistent trend of coarsening or fining with depth, when all the boreholes are considered. In general, it was noted that there was a tendency for coarser deposits to have a brown to reddish brown colour whereas finer deposits tended to be coloured grey to dark grey, see Figure 4.

Figure 4: Transition from Gravelly Sand to Silt in BH17-D002

The recorded elevations for the boreholes were determined from the surveyed drilling position on the sea ice and the depth to the sea bed; the depths noted refer to depth below the sea bed. Total drilling depths were corrected for the tidal effects.

3.1.1.1 Silt and Sand

A soil comprising a mix of silt and sand was encountered at the surface, where there was recovery, in the mid-depth boreholes. Layers of silt and sand were also noted in the mid-depth boreholes beneath the surface layer of sand, and also at depth. The silt and sand was noted to occur in either grey to dark grey, generally comprised of fine sand, see Figure 5, or a reddish brown, which tended to have coarse sand.

Figure 5: Dark Grey Silt and Sand Encountered Below 4.6 m in BH17-D001

3.1.1.2 Sand

Sand was encountered at surface in the shallow and deep borehole locations. The sand was typically fine to coarse grained when encountered in the upper 10 m of the boreholes, and tended to be finer at depth. Sand was generally light grey to brown. Sand was intersected for the full depth of the deep borehole BH17-D006. Examples of the sand encountered in the investigation are presented in Figure 6 through Figure 8.

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Figure 6: Fine Sand from BH17-D003

Figure 7: Grey Sand from the Sea Bed, BH17-D001

Figure 8: Reddish Brown Sand Encountered in BH17-D001

3.1.1.3 Gravelly Sand

The gravelly sand layer (also referred to as Sand with Gravel in the borehole logs) was encountered in both shallow and one mid-depth borehole. Typically the gravelly sand was well graded, and where described the gravel was noted to be rounded to subangular. The gravelly sand was brown to reddish brown in most cases, as seen in Figure 9.

Figure 9: Gravelly Sand from BH17-D005

3.1.2 Shallow Water Boreholes

The two boreholes drilled in shallow water are BH17-D001 and BH17-D002. The recorded elevations are -2.38 m and -3.25 respectively. The materials encountered in these boreholes are summarized in Table 3-1. Generally BH17-D001 intersected alternating sand and gravelly sand below 7.6 m, and BH17-D002 encountered gravelly sand below 8.5 m.

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Table 3-1: Summary of Material Encountered in Shallow Boreholes

Borehole Number	Depth Material Encountered		
	Silt and Sand	Sand	Gravelly Sand
BH17-D001	4.3 – 7.6	0 – 4.3; 9.7 – 17.1; 18.3 – 21.9; 24.4 – 27.4*	17.1 – 18.3; 22.9 – 24.4
BH17-D002	4.6 – 8.5	0 – 3.0; 12.8 – 13.7	8.5 – 12.8; 13.7 – 27.4

* Denotes termination depth

3.1.3 Mid-Depth Boreholes

BH17-D003, BH17-D004 and BH17-D005 were drilled at an elevation of -15.3 m, -16.6 m and -19.5 m, respectively. The materials intersected in these boreholes is summarized in Table 3-2.

Table 3-2: Summary of Materials Encountered in Mid-Depth Boreholes

Borehole Number	Depth Material Encountered		
	Silt and Sand or Silty Sand	Sand	Gravelly Sand
BH17-D003	3.0 – 6.1; 21.3 – 21.9; 27.4 – 30.5*	1.5 – 3.0; 6.1 – 9.1; 10.7 – 11.3; 22.9 – 23.5; 24.4 – 25.0; 25.9 – 27.4*	15.2 – 15.8; 16.8 – 17.4; 18.3 – 18.9;
BH17-D004	0 – 1.5; 3.0 – 4.6; 25.9 – 33.5	4.6 – 18.3; 19.8 – 25.9; 33.5 – 42.7*	
BH17-D005	0 – 2.1; 6.7 – 9.1; 19.3 – 21.3	12.2 – 15.2; 16.5 – 19.3; 21.3 – 31.1*	

* Denotes termination depth

Gravelly sand was encountered in BH17-D003 between 15.2 m and 18.9 m, core loss during the investigation prevented full definition of this strata. While drilling, soil samples were retrieved using a core barrel with a flapper bit to ensure good sample recovery. In BH17-D003, the flapper drilling bit was lost at a depth of 9.1 m below the seabed. This resulted in poor sample recovery. A Standard Penetration Test (SPT) was carried out every 1.5 m to recover split spoon samples. A replacement drill bit was used for drilling between a depth of 29.9 m to the end of borehole.

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3.1.4 *Deep Water Boreholes*

The sole deep water borehole, BH17-D006, was located on the sea bed with a collar elevation of -29.8 m. Unlike the other boreholes, neither silty material or gravelly material was intersected, see Table 3-3. An example of the sand from BH17-D006 is presented in Figure 10.

Table 3-3: Summary of Materials Encountered in Deep Borehole

Borehole Number	Depth Material Encountered		
	Silt and Sand or Silty Sand	Sand	Gravelly Sand
BH17-D006	Not Encountered	0 – 24.4*	Not Encountered

Figure 10: Sand from BH17-D006

3.1.5 *Influence of Drilling Methods on SPT N-Values*

Various drilling methods have been used at the Milne Port Site to investigate the seabed subsurface conditions. The rotary wash boring (rotary) method was primarily used with sea water as the drilling fluid during the 2013 investigations associated with the Ore Dock No. 1. There were difficulties encountered during the borehole advancement including sand binding around the rods and heaving into the drill rods. As a result of these difficulties, New Zam D mud was added to the sea water in order to mitigate these issues. This was only partly successful, while there was an improvement in production, some SPT values were considered to be invalid due to soil disturbance.

During the 2014 investigations, bentonite was added to the New Zam D mud mixture. This combination appeared to stabilize the borehole conditions resulting in a more consistent SPT blow count.

In order to maximize drilling production, a Mini Sonic Drilling rig was selected in 2017. However, the sonic drilling method involves advancement of the casing in conjunction with the core barrel, as well as the use of sea water as the drilling fluid and there was concern that this drilling technique might cause soil disturbance prior to conducting SPT. Disturbance of the in-situ conditions would likely result in a lower SPT N-value than would have been measured without the disturbance. Figures provided in Appendix J show a comparison of N-Values recorded in 2013, 2014 and 2017.

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In contrast, piezocone sounding do not require advancement of drill casing and a core barrel past the surface layer of the seabed, reducing the chances of disturbance of the in-situ conditions. Accordingly, piezocone testing was undertaken as part of the 2017 investigation in order to provide the in-situ density data to supplement the material classification and sample collection undertaken in the boreholes. Down hole seismic profiling was carried out at two boreholes locations.

3.2 Piezocone Sounding Results

The piezocone data attached in Appendix F provides a general interpretation of the tip resistance, sleeve friction and pore water pressure during each sounding. The piezocone sounding plots, provided by Conetec, include inferred phi and SPT values as well as inferred soil types based on the soils Soil Behaviour Type (SBT) chart. Soil samples were collected using the sonic core barrel and SPT split spoon to supplement and confirm piezocone test results with field classification and laboratory testing.

The piezocone test data requires further review by a qualified geotechnical engineer for selection of the design parameters and safety factors. A summary of the inferred materials, based on the SBT, from each of the piezocone soundings is presented below.

3.2.1.1 CPT17-D001

CPT17-D001 was performed at the BH17-D003 location. The SBT indicates a silty sand in the upper 12 m, changing to sand with trace to some gravel below 12 m depth.

3.2.1.2 CPT17-D002

CPT17-D002 was performed at the same location at BH17-D004. The SBT indicates silt and sand for the top 6 m, alternating layers of sand and silty sand between 6 m and 16 m, and sand below 16 m from the seabed surface.

3.2.1.3 CPT17-D003

CPT17-D003 was performed slightly north of BH17-D005. Based on the SBT the soil type is silt and sand at the top 5m and 19 m to 21 m below the seabed. Alternating bands of sand and silty sand are indicated between 5 m and 11 m below seabed. The soil behaves like sand 11 m to 19 m and from 21 m to the end of the borehole.

3.2.1.4 CPT17-D004, CPT17-D005 and CPT17-D006

CPT17-D004, CPT17-D005 and CPT17-D006 were drilled along a line slightly south of BH17-D006. The SBT indicates alternating layers of sand and silty sand for the top 10 to 15 m below the seabed. The CPTu testing showed a 1 m thick layer of sandy silt at a depth of 17 m and 27 m, respectively, below the seabed.

3.2.1.5 CPT17-D007

CPT17-D007 was performed at the same location as BH17-D002. Based on the SBT, the soil behaves as silty sand in the upper 10 m below the seabed and indicates gravelly sand 15 m below seabed.

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3.2.1.6 CPT17-D008

CPT17-D008 was performed close to borehole BH17-D001. Based on the SBT, the top 7 m of the test location is predominantly silty sand. Soil behaviour indicates sand from 7 m to 13 m, and alternating layers of sand and gravelly sand 13 m below the seabed.

3.3 Laboratory Test Results

Laboratory testing on select soil samples was undertaken to confirm the site classification of the material. The results of the classification tests are presented in Table 3-4 with full laboratory results presented in Appendix D. Results of the classification tests are also presented on the borehole reports in Appendix B.

Table 3-4: Summary of Particle Size Distribution Testing

Borehole ID	Depth (m)	Sample	Percent Gravel	Percent Sand	Percent Fines
BH17-D001	0.90	DS1	3	89	8
	7.00	DS4	3	41	57
	14.50	DS9	1	95	4
	17.70	DS11	60	39	1
BH17-D002	0.00	DS1	5	91	4
	5.20	DS3	2	46	52
	8.50	DS5	31	67	1
	15.70	DS9	28	68	3
	17.50	DS10	27	66	8
	25.90	DS13	32	66	2
BH17-D003	5.20	DS2	3	40	57
	15.20	AS6	35	63	1
	21.30	AS9	5	56	39
	30.20	DS14	1	78	23
BH17-D004	7.60	AS5	2	94	4
	18.00	DS10	1	96	3
	29.30	DS16	2	49	49
	38.70	DS20	8	91	1
	42.10	DS21	0	98	2
BH17-D005	0.00	DS1	8	54	38
	7.00	DS3	10	55	35
	12.80	DS5	5	92	3
	21.00	DS9	1	41	58
	25.30	DS12	1	80	20
	28.00	DS13	0	96	4

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Borehole ID	Depth (m)	Sample	Percent Gravel	Percent Sand	Percent Fines
BH17-D006	0.00	AS1	3	79	18
	2.10	DS2	0	99	1
	11.60	DS8	3	95	2
	15.80	DS11	0	82	18

Representative samples were selected for direct shear testing. Samples were remolded and compacted to in situ conditions. The inferred values of peak and residual internal friction angles, based on the direct shear testing, are presented. The test reports should be reviewed by a qualified engineer to select the appropriate design values based on these results and in consideration with the other information gathered during the investigations. The results of the direct shear testing are summarized with the Laboratory Test Reports in Appendix D.

Table 3-5: Summary of Direct Shear Testing on Borehole Samples

Borehole ID	Depth (m)	Sample	Peak m	Residual m
BH17-D003	5.2 – 5.5	DS2	34.6°	32.3°
BH17-D004	18.0 – 18.3	DS10	42.9°	31.6°
BH17-D005	0.0 – 0.3	DS1	39.4°	36.7°
BH17-D005	12.8 – 13.1	DS5	37.8°	31.9°
BH17-D005	30.5 – 31.1	DS14	35.9°	33.3°

4. Summary of Geotechnical Findings

A summary of geotechnical findings for the 2017 Ore Dock No. 2 investigations is provided below:

- The most common soil intersected in the investigations was a sand, varying from fine grained with trace to some silt, to fine to coarse grained with trace gravel.
- Layers of silt and sand were intersected in the shallow and mid-depth boreholes; gravelly sand was encountered in both shallow boreholes and one mid-depth borehole.
- The soil primarily consists of sand with trace silt and gravel. Layers of silt and sand were observed at a depth of 0 m, 4.6 m, 21 m and 26 m. Layers of sand and some gravel were observed in the shallow boreholes at various depths between 8 m and 25 m below seabed.
- There is a linear increase with depth in the pore water pressure, as measured by the piezocone soundings, indicating clean sand. This notwithstanding, interbedded silt was noted with in the sand sequence in several locations and layers of silt and sand were encountered.

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- Seismic data indicates an increase in shear velocity with depth.
- No bedrock was encountered during the 2017 Ore Dock No. 2 investigation.
- No permafrost or frozen soils were encountered during the 2017 offshore investigation.

5. References

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Hatch Ltd. H349000-1000-15-122-0001. Geotechnical Design Criteria. Aug 08, 2013.

Hatch Ltd. H349000-2200-15-124-0002. Milne Ore Dock Geotechnical Investigation Factual Report. Feb 21, 2014.

Hatch Ltd. H352034-1000-229-230-0002. 2016 Milne Port Geotechnical Investigation Factual Report.

Robertson.P,K., Campanella, RG, Gillespie, D., and Greig, J., 1986. Use of Piezometer Cone data. In-Situ ’86 Use of In-situ testing in Geotechnical Engineering, GSP 6, ASCE, Reston, VA, Specialty Publication, pp 1263-1280.

ASTM D5778 Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils.

Hatch Ltd. H349000-2200-015-124-0002. 2014 Milne Ore Dock Geotechnical Investigation Factual Report.

Youd et al., 1998 Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluations of Liquefaction Resistance of Soils, Journal of Geotechnical and Geoenvironmental Engineering, Salt Lake City, UT.

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Appendix A

Borehole Location Plan

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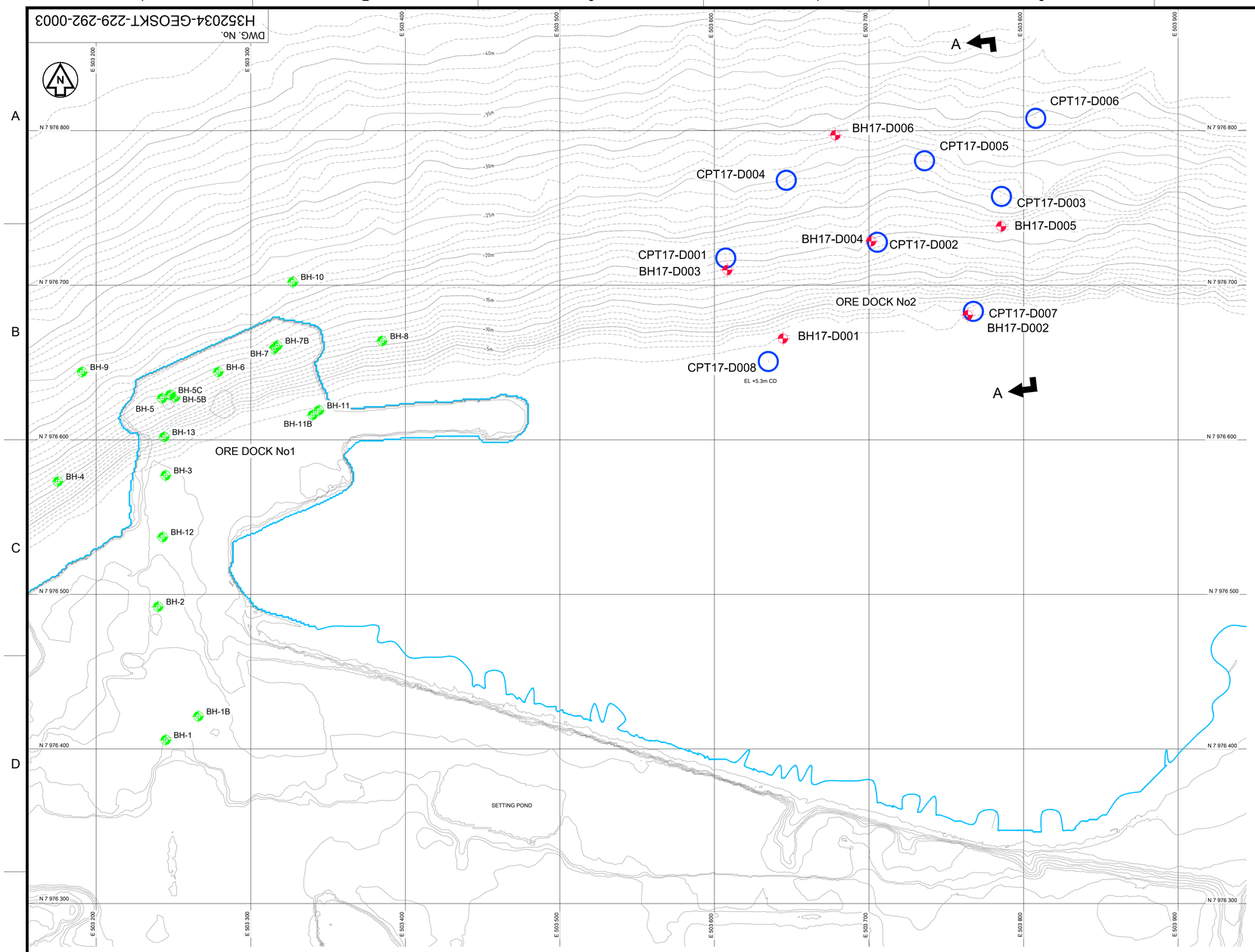
DWG. No. H352034-GEOSKT-229-292-0003



NOTES:

1. *COORDINATE GRID IS UTM, NAD 83, ZONE 17*
2. *INFORMATION FOR BATHAMETRY IS A COMBINATION OF LOGISTEC STEVEDORING INC. AND M&S.*
3. *THE CHART DATUM HAS BEEN ASSUMED TO BE 1.2 METRES BELOW CGVD 28 (0.0m CHART DATUM = -1.2m GEODETIC DATUM)*
4. *ELEVATIONS ARE BASED ON CHART DATUM*
5. *DIMENSIONS AND ELEVATIONS ARE SHOWN IN METERS*
6. *ELEVATIONS MEASURED AT THE TIME OF BOREHOLE COMPLETION (SEE BOREHOLE REPORTS) .*

LEGEND

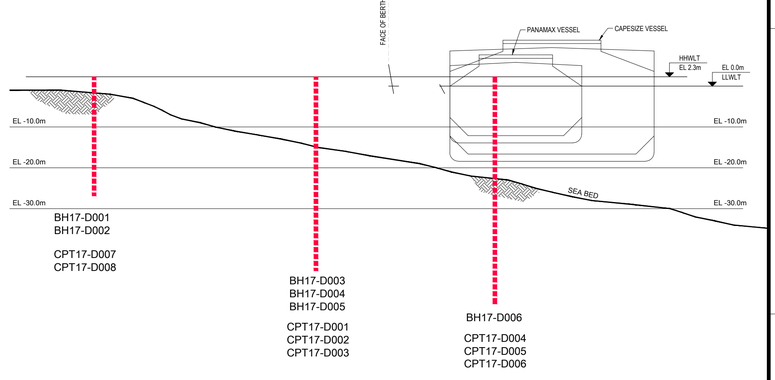
- 2017 GEOTECHNICAL INVESTIGATION SONIC BOREHOLE LOCATION
- 2017 GEOTECHNICAL INVESTIGATION PIEZOCONE PENETRATION TEST (CPTu) LOCATION
- 2013 GEOTECHNICAL INVESTIGATION BOREHOLE LOCATION

BH LOCATIONS (AS-BUILT)

POINT #	EASTING	NORTHING	DEPTH
BH17-D001	503644.4	7976665.6	27.4
BH17-D002	503763.9	7976680.7	27.4
BH17-D003	503608.4	7976709.9	30.5
BH17-D004	503701.4	7976728.5	42.2
BH17-D005	503785.6	7976738.1	31.1
BH17-D006	503678.2	7976797.1	24.4

CPT LOCATIONS (AS-BUILT)

POINT #	EASTING	NORTHING	DEPTH
CPT17-D001	503607.4	7976717.6	32.8
CPT17-D002	503705.3	7976728.1	39.5
CPT17-D003	503785.4	7976757.7	30.4
CPT17-D004	503646.4	7976768.1	32.1
CPT17-D005	503736.1	7976780.8	25.1
CPT17-D006	503807.6	7976808.4	20.5
CPT17-D007	503767.5	7976683.6	30.2
CPT17-D008	503635.0	7976650.8	30.0



PLAN

0 30 60 90 120 150 METRES

SCALE 1:1500

SECTION A-A

0 15 30 45 60 75 METRES

SCALE 1:750

DESIGN SHOWN IS A HATCH CONCEPT DESIGN
CONTRACTOR TO PROVIDE HIS OWN DESIGN

DRAWING No.	DRAWING TITLE
REFERENCE DRAWINGS	

NAME
SIGNATURE
ENG REG NUMBER
REVISION DATE
ORIGINAL DATE
REGISTERED PROFESSIONAL

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No.	DESCRIPTION	BY	CHK'D	DATE
C	AS BUILT BOREHOLE & CPTu	W.H.	S.H.	19/05/2017
B	NUMBER OF BH REVISED, CPT ADDED	W.H.	S.H.	27/01/2017
A	CLIENT REVIEW	W.H.	S.H.	20/01/2017

REVISIONS

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	D PARKES	NR	20/01/2017
DESIGNER		NR	
CHECKER			
DESIGN COORD.	W HOYLE		
RESP. ENG.			
LEAD DISC. ENG.	S HINCHBERGER		
ENG. MANAGER			
PROJ. MANAGER	S HEINER		

DRAWING APPROVAL STATUS: Record Document

Baffinland

BAFFINLAND EXPANSION 12 MTPA MINE OPTION
PRE FEASIBILITY STUDY

PORT SITE - ORE DOCK No. 2
2017 GEOTECHNICAL INVESTIGATIONS
BOREHOLE AND CPTu LOCATIONS

SCALE	DWG. No.	REV
1:50,000 OR AS NOTED	H352034-GEOSKT-229-292-0003	1

$USERNAME$ $TIME$
$XREFS$
$PLTES$

Appendix B

Borehole Reports

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List of Abbreviations and Terms Used in the Borehole Reports

(Sheet 1)

General

Elevations
Elevations are referenced to datum indicated.

Depth
All depths are given in meters (feet) measured from the ground surface unless otherwise noted.

Sample Recovery
Indicates the length retained in millimeters (inches) in a split spoon sampler or percentage recovery of sample retained in the core barrel sampler.

Sample Number
Samples are numbered consecutively in the order in which they were obtained or attempted in the borehole.

Sample Type
The first letter describes the sampling method and the second, the shipping container.

Sampling Method

A – Split Tube	E – Auger
B – Thin Wall Tube	F – Wash
C – Piston Sampler	G – Shovel Grab Sample
D – Core Barrel	K – Slotted Sampler

Shipping Container

O – Tube	U – Not Recovered
P – Water Content Tin	X – Plastic & PVC Sleeve (Sonic)
Q – Jar	Y – Core Box
S – Plastic Bag	Z – Discarded

Abbreviations
N/A – Not applicable
N/E – Not encountered
N/O – Not observed

Soil

Soil Description, Label and Symbol
Soil description under the "Description" column conforms generally, but not rigorously, to the Unified Soils Classification System. For a given soil unit, defined by depth boundaries, the descriptive text constitutes the definitive soil unit description and takes precedence over both the brief label and the symbol used to graphically represent the soil unit.

Grain Size

Clay		<0.002 mm
Silt	0.002 –	0.075 mm
Sand	0.075 –	4.75 mm
Fine	0.075 –	0.42 mm
Medium	0.42 –	2.00 mm
Course	2.00 –	4.75 mm
Gravel	4.75 –	75 mm
Fine	4.75 –	19.00 mm
Coarse	19.00 –	75.00mm
Cobbles	75 –	300 mm
Boulder		>300 mm

Relative Quantities

Term	*Example*	*(%)*
Trace	Trace sand	1 – 10
Some	Some sand	10 – 20
With (adjective)	With Sand (Sandy)	20 – 35
And	And sand	>35
Noun	Sand	>50

Standard Penetration Test (SPT)
The test is carried out in accordance with ASTM D-1586 and the 'N' value corresponds to the sum of the number of blows required by a 63.5-kg (140-lb) hammer, dropped 760 mm (30 in.), to drive a 50-mm (2-in.) diameter split tube sampler the second and third 150 mm (6 in.) of penetration.

Density (Granular Soils)

	N(SPT)
Very loose	0 – 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very dense	>50

Consistency (Cohesive Soils)

	N(SPT)
Very soft	<2
Soft	2 – 4
Firm	4 – 8
Stiff	8 – 15
Very stiff	15 – 30
Hard	>30

Plasticity/Compressibility

		Liquid Limit (%)
Low plasticity clays	Low compressibility silts	<30
Medium plasticity clays	Medium compressibility silts	30 – 50
High plasticity clays	High compressibility silts	>50

Dilatancy
None - No visible change, during shaking or squeezing
Slow - Water appears slowly on surface of specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid - Water appears quickly on the surface of specimen during shaking and disappears quickly upon squeezing.

Sensitivity

Insensitive	<2
Low	2 – 4
Medium	4 – 8
High	8 – 16
Quick	>16

BASIS FOR SOIL DESCRIPTION

(Based on AS1726-1993 - Geotechnical Site Investigations, with modifications)

GRAPHIC SYMBOLS FOR SOILS

GRAVEL – poorly graded -

well graded -

SAND – poorly graded -

well graded -

SILT – of low plasticity -

of high plasticity -

CLAY – of low plasticity -

of high plasticity -

ICE -

COBBLES AND BOULDERS -

ORGANIC/ PEATY SOIL -

FILL/ MADE GROUND -

Composite soil types are presented using combined symbols, eg. **Gravelly Sandy CLAY**

GROUNDWATER OBSERVATIONS

Permanent Water Level

Temporary Water Level

Inflow into Pit or Borehole

Outflow/ Water Loss in Borehole

Slow Inflow/ Seepage into Pit or Borehole

SAMPLE TYPES

Disturbed bag sample

Bulk Disturbed (>20kg)

Hollow Stem Auger Core

Auger Flight Cuttings

Standard Penetration Test (SPT), with Disturbed Split-Spoon Sample

SPT (no recovery)

Thin walled "undisturbed" push tube sample eg. U60, U100 etc

Sample attempted with no recovery

HATCHCANADA2015 DRAFT.GLB GrfcText SOIL DESCRIPTION - 3 BAFFINLAND BOREHOLES 2016 - TJ.GPJ <<DrawingFile>> 17/02/2017 15:13

BOREHOLE REPORT

BH17-D001
Sheet 1 of 6

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,644.4 m
Northing: 7,976,665.6 m
Surface Elevation: -2.38 m
Bottom Elevation: -29.78 m
Total Depth: 27.4 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/31/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-2.9	0.5				SAND, trace SILT, trace GRAVEL: Grey, medium grained, poorly graded sand; fine gravel											
	-3.4	1.0								DS1 taken from .90-1.20m.		3	89	8			
	-3.9	1.5															
	-4.4	2.0															
	-4.9	2.5															
	-5.4	3.0						100%		AS2 taken from 3.00-3.60m. N= 7							
	-5.9	3.5															
	-6.4	4.0															
	-6.9	4.5				SILT and SAND, trace GRAVEL: Reddish brown, coarse grained sand, well graded, rounded to subangular gravel											
	-7.4	5.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:21

HATCH BOREHOLE REPORT

BH17-D001
Sheet 2 of 6

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,644.4 m
Northing: 7,976,665.6 m
Surface Elevation: -2.38 m
Bottom Elevation: -29.78 m
Total Depth: 27.4 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/31/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-7.9	5.5				SILT and SAND, trace GRAVEL: Reddish brown, coarse grained sand, well graded, rounded to subangular gravel *(Continued)*				DS3 taken from 5.20-5.50m.							
	-8.4	6.0															
	-8.9	6.5															
	-9.4	7.0								DS4 taken from 7.00-7.30m.		3	41	57			
	-9.9	7.5				No core recovered											
	-10.4	8.0															
	-10.9	8.5															
	-11.4	9.0						0%		AS5 taken from 9.10-9.70m. N= 2							
	-11.9	9.5															
	-12.4	10.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:21

BOREHOLE REPORT

BH17-D001
Sheet 3 of 6

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,644.4 m
Northing: 7,976,665.6 m
Surface Elevation: -2.38 m
Bottom Elevation: -29.78 m
Total Depth: 27.4 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/31/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-12.9	10.5				SAND, trace GRAVEL: Grey to light brown, fine to coarse grained sand; rounded to subrounded, well graded gravel *(Continued)*				DS6 taken from 10.10-10.40m.							
	-13.4	11.0								DS7 taken from 11.30-11.60m.							
	-13.9	11.5															
	-14.4	12.0															
	-14.9	12.5								DS8 taken from 12.50-12.80m.							
	-15.4	13.0															
	-15.9	13.5															
	-16.4	14.0															
	-16.9	14.5				SAND, trace SILT, trace GRAVEL: Grey to light brown, fine to medium grained sand; rounded				DS9 taken from 14.50-14.90m.		1	95	4			
	-17.4	15.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:21

BOREHOLE REPORT

BH17-D001
Sheet 4 of 6

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,644.4 m
Northing: 7,976,665.6 m
Surface Elevation: -2.38 m
Bottom Elevation: -29.78 m
Total Depth: 27.4 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/31/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-17.9	15.5				SAND, trace GRAVEL: Fine to coarse grained sand; fine, rounded, poorly graded gravel		75%		AS10 taken from 15.20-15.80m. N= 3							
	-18.4	16.0															
	-18.9	16.5															
	-19.4	17.0															
	-19.9	17.5				GRAVEL with SAND and trace SILT: Light brown to reddish brown; rounded well graded gravel; fine to coarse grained sand				DS11 taken from 17.70-18.30m.		60	39	1			
	-20.4	18.0															
	-20.9	18.5				SAND, trace GRAVEL: Light brown to reddish brown, fine to coarse grained sand; rounded to subrounded gravel											
	-21.4	19.0								DS12 taken from 19.20-19.50m.							
	-21.9	19.5															
	-22.4	20.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:21

BOREHOLE REPORT

BH17-D001
Sheet 5 of 6

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,644.4 m
Northing: 7,976,665.6 m
Surface Elevation: -2.38 m
Bottom Elevation: -29.78 m
Total Depth: 27.4 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/31/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-22.9	20.5				SAND, trace GRAVEL: Brownish Grey, fine to coarse grained sand; rounded to subrounded gravel *(Continued)*				DS13 taken from 20.40-20.70m.							
	-23.4	21.0															
	-23.9	21.5						100%		AS14 taken from 21.30-21.90m. N= 9							
	-24.4	22.0				No core recovered											
	-24.9	22.5															
	-25.4	23.0				SAND, with GRAVEL: Grey to light brown, fine to coarse grained sand; rounded to subrounded, well graded gravel											
	-25.9	23.5								DS15 taken from 23.50-23.80m.							
	-26.4	24.0															
	-26.9	24.5				SAND, trace GRAVEL: Grey to light brown, fine to medium grained sand											
	-27.4	25.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

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BOREHOLE REPORT

BH17-D001

Sheet 6 of 6

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,644.4 m

Northing: 7,976,665.6 m

Surface Elevation: -2.38 m

Bottom Elevation: -29.78 m

Total Depth: 27.4 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/31/2017

Logged By: UK/AB

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-27.9	25.5				SAND, trace GRAVEL: Grey to light brown, fine to medium grained sand *(Continued)*				DS16 taken from 25.00-25.30m.							
	-28.4	26.0															
	-28.9	26.5				SAND, some SILT, trace GRAVEL: Light brown to dark grey, fine grained sand; rounded, poorly graded gravel				DS17 taken from 26.50-26.80m.							
	-29.4	27.0															
	-29.9	27.5				To Target Depth. **Drillhole BH17-D001 terminated at 27.4m.**											
	-30.4	28.0															
	-30.9	28.5															
	-31.4	29.0															
	-31.9	29.5															
	-32.4	30.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:21

BOREHOLE REPORT

BH17-D002

Sheet 1 of 6

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,763.9 m

Northing: 7,976,680.7 m

Surface Elevation: -3.25 m

Bottom Elevation: -30.65 m

Total Depth: 27.4 m

Logged By: UK/AB

Reviewed By: WH/CH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/21/2017

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-3.8	0.5				SAND, trace GRAVEL, trace SILT: Grey, fine to coarse grained sand; poorly graded gravel				DS1 taken from .00-.30m.		5	91	4			
	-4.3	1.0															
	-4.8	1.5															
	-5.3	2.0								DS2 taken from 2.00-2.20m.							
	-5.8	2.5															
	-6.3	3.0				No core recovered											
	-6.8	3.5															
	-7.3	4.0															
	-7.8	4.5															
	-8.3	5.0				SILT and SAND, trace GRAVEL: Grey, fine grained sand; fine gravel											

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:21

BOREHOLE REPORT

BH17-D002
Sheet 2 of 6

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,763.9 m
Northing: 7,976,680.7 m
Surface Elevation: -3.25 m
Bottom Elevation: -30.65 m
Total Depth: 27.4 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/21/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-8.8	5.5				SILT and SAND, trace GRAVEL: Grey, fine grained sand; fine gravel *(Continued)*				DS3 taken from 5.20-5.50m.		2	46	52			
	-9.3	6.0						50%		AS4 taken from 6.10-6.70m. N= 8							
	-9.8	6.5															
	-10.3	7.0															
	-10.8	7.5															
	-11.3	8.0															
	-11.8	8.5				SAND, with GRAVEL: Brown, fine to coarse grained sand; fine to coarse gravel				DS5 taken from 8.50-8.80m.		31	67	1			
	-12.3	9.0															
	-12.8	9.5															
	-13.3	10.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:21

BOREHOLE REPORT

BH17-D002

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,763.9 m

Northing: 7,976,680.7 m

Surface Elevation: -3.25 m

Bottom Elevation: -30.65 m

Total Depth: 27.4 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/21/2017

Logged By: UK/AB

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-13.8	10.5				SAND, with GRAVEL: Brown, fine to coarse grained sand; fine to coarse gravel *(Continued)*											
	-14.3	11.0						100%		AS6 taken from 10.70-11.30m. N= 8							
	-14.8	11.5															
	-15.3	12.0								DS7 taken from 11.90-12.20m.							
	-15.8	12.5															
	-16.3	13.0				SAND: Grey, fine grained, poorly graded				DS8 taken from 13.10-13.40m.							
	-16.8	13.5															
	-17.3	14.0				SAND, with GRAVEL: Brown, fine to coarse grained, well graded sand; fine to coarse, well graded gravel											
	-17.8	14.5															
	-18.3	15.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:21

HATCH BOREHOLE REPORT

BH17-D002

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,763.9 m

Northing: 7,976,680.7 m

Surface Elevation: -3.25 m

Bottom Elevation: -30.65 m

Total Depth: 27.4 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/21/2017

Logged By: UK/AB

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-18.8	15.5				SAND, with GRAVEL: Brown, fine to coarse grained, well graded sand; fine to coarse, well graded gravel *(Continued)*											
										DS9 taken from 15.70-16.00m.		28	68	3			
	-19.3	16.0				SAND with GRAVEL, trace SILT: Brown, fine to coarse grained, well graded sand; fine well graded gravel											
	-19.8	16.5															
	-20.3	17.0															
	-20.8	17.5								DS10 taken from 17.50-17.80m.		27	66	8			
	-21.3	18.0															
	-21.8	18.5															
	-22.3	19.0															
	-22.8	19.5															
	-23.3	20.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:21

BOREHOLE REPORT

BH17-D002
Sheet 5 of 6

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,763.9 m
Northing: 7,976,680.7 m
Surface Elevation: -3.25 m
Bottom Elevation: -30.65 m
Total Depth: 27.4 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/21/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-23.8	20.5				SAND with GRAVEL, trace SILT: Brown, fine to coarse grained, well graded sand; fine well graded gravel *(Continued)*				DS11 taken from 20.40-20.70m.							
	-24.3	21.0															
	-24.8	21.5															
	-25.3	22.0															
	-25.8	22.5															
	-26.3	23.0				SAND with GRAVEL, trace SILT: Light brown, fine to coarse grained sand, fine to coarse gravel											
	-26.8	23.5								DS12 taken from 23.60-23.90m.							
	-27.3	24.0															
	-27.8	24.5															
	-28.3	25.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:21

BOREHOLE REPORT

BH17-D002

Sheet 6 of 6

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,763.9 m

Northing: 7,976,680.7 m

Surface Elevation: -3.25 m

Bottom Elevation: -30.65 m

Total Depth: 27.4 m

Logged By: UK/AB

Reviewed By: WH/CH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/21/2017

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND with GRAVEL, trace SILT: Light brown, fine to coarse grained sand, fine to coarse gravel *(Continued)*											
	-28.8	25.5															
						SAND with GRAVEL, trace SILT: Fine to coarse grained sand, rounded gravel, poorly graded				DS13 taken from 25.90-26.70m.		32	66	2			
	-29.3	26.0															
	-29.8	26.5															
	-30.3	27.0															
	-30.8	27.5				To Target Depth. **Drillhole BH17-D002 terminated at 27.4m.**											
	-31.3	28.0															
	-31.8	28.5															
	-32.3	29.0															
	-32.8	29.5															
	-33.3	30.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:21

BOREHOLE REPORT

BH17-D003

Sheet 1 of 7

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,608.4 m

Northing: 7,976,709.9 m

Surface Elevation: -15.34 m

Bottom Elevation: -45.84 m

Total Depth: 30.5 m

Logged By: UK/AB

Reviewed By: WH/CH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/29/2017

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-15.8	0.5				No Core Recovered											
	-16.3	1.0															
	-16.8	1.5				SAND, trace Silt: Grey, fine to coarse grained sand, loose, poorly graded		100 %		AS1 taken from 1.50-2.10m. N= 1							
	-17.3	2.0															
	-17.8	2.5															
	-18.3	3.0				No core recovered											
	-18.8	3.5															
	-19.3	4.0															
	-19.8	4.5															
	-20.3	5.0				SILT and SAND, trace GRAVEL: Dark grey, black mottling, organics; fine grained sand; fine angular gravel											

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D003
Sheet 2 of 7

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,608.4 m
Northing: 7,976,709.9 m
Surface Elevation: -15.34 m
Bottom Elevation: -45.84 m
Total Depth: 30.5 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/29/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-20.8	5.5				SILT and SAND, trace GRAVEL: Dark grey, black mottling, organics; fine grained sand; fine angular gravel *(Continued)*				DS2 taken from 5.20-5.30m.		3	40	57			
	-21.3	6.0															
	-21.8	6.5				SAND, trace GRAVEL, trace COBBLES: Reddish brown, medium to coarse grained, poorly graded sand; angular gravel, and subroundded cobbles.											
	-22.3	7.0								DS3 taken from 7.00-7.30m.							
	-22.8	7.5															
	-23.3	8.0				SAND: Reddish brown, medium to coarse grained, poorly graded		0%		AS4 taken from 7.60-8.20m. N= 7							
	-23.8	8.5															
	-24.3	9.0															
	-24.8	9.5				No Core Recovered											
	-25.3	10.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D003

Sheet 3 of 7

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,608.4 m

Northing: 7,976,709.9 m

Surface Elevation: -15.34 m

Bottom Elevation: -45.84 m

Total Depth: 30.5 m

Logged By: UK/AB

Reviewed By: WH/CH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/29/2017

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-25.8	10.5				No Core Recovered *(Continued)*											
	-26.3	11.0				SAND, trace Gravel: Grey, fine to medium grained sand, loose, poorly graded, subangular gravel		100%		AS5 taken from 10.70-11.30m. N= 9							
	-26.8	11.5				No Core Recovered											
	-27.3	12.0						0%		taken from 12.20-12.80m. N= 8							
	-27.8	12.5															
	-28.3	13.0															
	-28.8	13.5						0%		taken from 13.70-14.30m. N= 4							
	-29.3	14.0															
	-29.8	14.5															
	-30.3	15.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D003

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,608.4 m

Northing: 7,976,709.9 m

Surface Elevation: -15.34 m

Bottom Elevation: -45.84 m

Total Depth: 30.5 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/29/2017

Logged By: UK/AB

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						No Core Recovered *(Continued)*											
	-30.8	15.5				Gravelly SAND, trace SILT: Reddish brown to grey, coarse to medium grained sand; rounded to subrounded gravel		50%		AS6 taken from 15.20-15.80m. N= 6		35	63	1			
	-31.3	16.0				No core recovered											
	-31.8	16.5															
	-32.3	17.0				SAND, with Gravel: Coarse grained sand; rounded to subangular coarse gravel, well graded		17%		AS7 taken from 16.80-17.40m. N= 10							
	-32.8	17.5				No Core Recovered											
	-33.3	18.0															
	-33.8	18.5				SAND, with Gravel: Coarse grained sand; coarse, rounded to subangular gravel		50%		AS8 taken from 18.30-18.90m. N= 9							
	-34.3	19.0				No Core Recovered											
	-34.8	19.5															
	-35.3	20.0						0%		taken from 19.80-20.40m. N= 5							

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D003
Sheet 5 of 7

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,608.4 m
Northing: 7,976,709.9 m
Surface Elevation: -15.34 m
Bottom Elevation: -45.84 m
Total Depth: 30.5 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/29/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-35.8	20.5				No Core Recovered *(Continued)*											
	-36.3	21.0															
	-36.8	21.5				SILT and SAND, trace GRAVEL: Grey, medium to fine grained sand; fine grained, poorly graded gravel		50%		AS9 taken from 21.30-21.90m. N= 10		5	56	39			
	-37.3	22.0				No Core Recovered											
	-37.8	22.5															
	-38.3	23.0				SAND, trace GRAVEL: Grey to light brown, fine grained sand; poorly graded, rounded to subangular gravel		100%		AS10 taken from 22.90-23.50m. N= 35							
	-38.8	23.5				No Core Recovered											
	-39.3	24.0															
	-39.8	24.5				SAND, trace GRAVEL: Grey to light brown, fine to medium grained sand, rounded to subrounded, poorly graded gravel		50%		AS11 taken from 24.40-25.00m. N= 26							
	-40.3	25.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D003

Sheet 6 of 7

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,608.4 m

Northing: 7,976,709.9 m

Surface Elevation: -15.34 m

Bottom Elevation: -45.84 m

Total Depth: 30.5 m

Logged By: UK/AB

Reviewed By: WH/CH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/29/2017

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-40.8	25.5				No Core Recovered											
	-41.3	26.0				SAND, trace GRAVEL: Grey to light brown, fine to medium grained sand; rounded, poorly graded gravel		50%		AS12 taken from 25.90-26.50m. N= 23							
	-41.8	26.5															
	-42.3	27.0															
	-42.8	27.5				SAND with SILT, trace GRAVEL: Grey to light brown, fine grained sand; rounded, poorly graded gravel											
	-43.3	28.0								DS13 taken from 28.00-28.30m.							
	-43.8	28.5															
	-44.3	29.0															
	-44.8	29.5															
	-45.3	30.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D003

Sheet 7 of 7

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,608.4 m

Northing: 7,976,709.9 m

Surface Elevation: -15.34 m

Bottom Elevation: -45.84 m

Total Depth: 30.5 m

Logged By: UK/AB

Reviewed By: WH/CH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/29/2017

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND with SILT, trace GRAVEL: Grey to light brown, fine grained sand; rounded, poorly graded gravel *(Continued)*				DS14 taken from 30.20-30.50m.		1	76	23			
	-45.8	30.5				To Target Depth. **Drillhole BH17-D003 terminated at 30.5m.**											
	-46.3	31.0															
	-46.8	31.5															
	-47.3	32.0															
	-47.8	32.5															
	-48.3	33.0															
	-48.8	33.5															
	-49.3	34.0															
	-49.8	34.5															
	-50.3	35.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D004

Sheet 1 of 9

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,701.4 m

Northing: 7,976,728.5 m

Surface Elevation: -16.59 m

Bottom Elevation: -59.29 m

Total Depth: 42.7 m

Logged By: UK/AB

Reviewed By: WH/CH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/26/2017

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-17.1	0.5				SAND and SILT: Dark grey to black, fine grained sand, trace of organics, black mottling											
	-17.6	1.0								DS1 taken from .90-1.20m.							
	-18.1	1.5				No core recovered											
	-18.6	2.0															
	-19.1	2.5															
	-19.6	3.0				SAND and SILT, some GRAVEL: Dark grey, black mottling, fine grained sand; fine to coarse, rounded to subangular gravel				DS2 taken from 3.20-3.40m.							
	-20.1	3.5															
	-20.6	4.0															
	-21.1	4.5								DS3 taken from 4.30-4.60m.							
	-21.6	5.0				SAND, some SILT, some GRAVEL: Light brown, fine to coarse grained, well graded sand; multi-coloured, fine to coarse, rounded to subangular gravel				DS4 taken from 4.70-5.00m.							

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D004
Sheet 2 of 9

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,701.4 m
Northing: 7,976,728.5 m
Surface Elevation: -16.59 m
Bottom Elevation: -59.29 m
Total Depth: 42.7 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/26/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-22.1	5.5				SAND, some SILT, some GRAVEL: Light brown, fine to coarse grained, well graded sand; multi-coloured, fine to coarse, rounded to subangular gravel *(Continued)*											
	-22.6	6.0				SAND, trace GRAVEL, trace SILT: Brown, fine to coarse grained sand; multi-coloured, well graded, rounded to subrounded gravel											
	-23.1	6.5															
	-23.6	7.0															
	-24.1	7.5				SAND, trace SILT, trace GRAVEL: Brown, coarse grained, poorly graded sand; multi-coloured, angular gravel		100%		AS5 taken from 7.60-8.20m. N= 6		2	94	4			
	-24.6	8.0															
	-25.1	8.5															
	-25.6	9.0								DS6 taken from 8.80-9.10m.							
	-26.1	9.5															
	-26.6	10.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D004

Sheet 3 of 9

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,701.4 m

Northing: 7,976,728.5 m

Surface Elevation: -16.59 m

Bottom Elevation: -59.29 m

Total Depth: 42.7 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/26/2017

Logged By: UK/AB

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, trace SILT, trace GRAVEL: Brown, coarse grained, poorly graded sand; multi-coloured, angular gravel *(Continued)*											
	-27.1	10.5															
	-27.6	11.0								DS7 taken from 11.00-11.30m.							
	-28.1	11.5															
	-28.6	12.0															
	-29.1	12.5															
	-29.6	13.0															
	-30.1	13.5															
						SAND, trace GRAVEL, trace SILT: Reddish brown, medium to coarse grained sand; angular well graded gravel		100%		AS8 taken from 13.70-14.30m. N= 11							
	-30.6	14.0															
	-31.1	14.5															
	-31.6	15.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D004

Sheet 4 of 9

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,701.4 m

Northing: 7,976,728.5 m

Surface Elevation: -16.59 m

Bottom Elevation: -59.29 m

Total Depth: 42.7 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/26/2017

Logged By: UK/AB

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-32.1	15.5				SAND, trace GRAVEL, trace SILT: Reddish brown, medium to coarse grained sand; angular well graded gravel *(Continued)*				DS9 taken from 15.50-15.80m.							
	-32.6	16.0															
	-33.1	16.5															
	-33.6	17.0															
	-34.1	17.5															
	-34.6	18.0								DS10 taken from 18.00-18.30m.		1	96	3			
	-35.1	18.5				No core recovered											
	-35.6	19.0															
	-36.1	19.5															
	-36.6	20.0						100%		AS11 taken from 19.80-20.40m. N= 35							

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D004
Sheet 5 of 9

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,701.4 m
Northing: 7,976,728.5 m
Surface Elevation: -16.59 m
Bottom Elevation: -59.29 m
Total Depth: 42.7 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/26/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-37.1	20.5				SAND, trace Gravel: Reddish brown, medium to coarse grained sand; well graded, angular gravel *(Continued)*											
	-37.6	21.0															
	-38.1	21.5															
	-38.6	22.0															
	-39.1	22.5															
	-39.6	23.0				SAND, trace SILT: Grey, fine grained, poorly graded sand											
	-40.1	23.5															
	-40.6	24.0								DS12 taken from 23.80-24.10m.							
	-41.1	24.5															
	-41.6	25.0				24.70 m to 25.30 m: Some silt, mottled black, fine organics											

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D004
Sheet 6 of 9

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,701.4 m
Northing: 7,976,728.5 m
Surface Elevation: -16.59 m
Bottom Elevation: -59.29 m
Total Depth: 42.7 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/26/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-42.1	25.5				SAND, trace SILT: Grey, fine grained, poorly graded sand *(Continued)*				DS13 taken from 25.00-25.30m.							
	-42.6	26.0				SILT and SAND, trace GRAVEL: Brown, fine to medium grained, well graded sand		100%		AS14 taken from 25.90-26.50m. N= 9							
	-43.1	26.5															
	-43.6	27.0															
	-44.1	27.5															
	-44.6	28.0															
	-45.1	28.5								DS15 taken from 28.30-28.60m.							
	-45.6	29.0				SAND and SILT, trace GRAVEL: Brown, fine to coarse grained, well graded sand; multi-coloured, rounded gravel											
	-46.1	29.5								DS16 taken from 29.30-29.60m.		2	49	49			
	-46.6	30.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D004
Sheet 7 of 9

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,701.4 m
Northing: 7,976,728.5 m
Surface Elevation: -16.59 m
Bottom Elevation: -59.29 m
Total Depth: 42.7 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/26/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-47.1	30.5				SAND and SILT, trace GRAVEL: Brown, fine to coarse grained, well graded sand; multi-coloured, rounded gravel *(Continued)*											
	-47.6	31.0															
	-48.1	31.5															
	-48.6	32.0						100%		AS17 taken from 32.00-32.60m. N= 5							
	-49.1	32.5															
	-49.6	33.0															
	-50.1	33.5				SAND, some GRAVEL: Brown, coarse grained poorly graded sand; multi-coloured, rounded to subangular gravel											
	-50.6	34.0															
	-51.1	34.5								DS18 taken from 34.40-34.70m.							
	-51.6	35.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D004
Sheet 8 of 9

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,701.4 m
Northing: 7,976,728.5 m
Surface Elevation: -16.59 m
Bottom Elevation: -59.29 m
Total Depth: 42.7 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/26/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-52.1	35.5				SAND, trace GRAVEL, trace SILT: Brown, coarse grained sand; poorly graded, fine, subangular gravel											
	-52.6	36.0															
	-53.1	36.5				SAND, some SILT: Dark grey, fine grained, well graded sand											
	-53.6	37.0															
										DS19 taken from 37.20-37.50m.							
	-54.1	37.5															
	-54.6	38.0				SAND, trace Gravel, trace SILT: Brown, coarse grained sand; fine, multi-coloured, rounded to subangular, well graded gravel												
	-55.1	38.5															
										DS20 taken from 38.70-39.00m.		8	91	1			
	-55.6	39.0															
	-56.1	39.5															
	-56.6	40.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D004

Sheet 9 of 9

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,701.4 m

Northing: 7,976,728.5 m

Surface Elevation: -16.59 m

Bottom Elevation: -59.29 m

Total Depth: 42.7 m

Logged By: UK/AB

Reviewed By: WH/CH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/26/2017

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-57.1	40.5				SAND, trace Gravel, trace SILT: Brown, coarse grained sand; fine, multi-coloured, rounded to subangular, well graded gravel *(Continued)*											
	-57.6	41.0															
	-58.1	41.5				SAND, trace SILT: Brown, coarse grained sand; well graded, multi-coloured gravel											
	-58.6	42.0								DS21 taken from 42.10-42.40m.		0	98	2			
	-59.1	42.5															
	-59.6	43.0				To Target Depth. **Drillhole BH17-D004 terminated at 42.7m.**											
	-60.1	43.5															
	-60.6	44.0															
	-61.1	44.5															
	-61.6	45.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D005
Sheet 1 of 7

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,785.6 m
Northing: 7,976,738.1 m
Surface Elevation: -19.50 m
Bottom Elevation: -50.60 m
Total Depth: 31.1 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/24/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-20.0	0.5				SILT and SAND, trace GRAVEL: Dark brown to black, fine to coarse grained sand; fine, poorly graded gravel			DS1	DS1 taken from .00-.30m.		8	54	38			
	-20.5	1.0															
	-21.0	1.5							AS2	AS2 taken from 1.50-2.10m.							
	-21.5	2.0				No core recovered											
	-22.0	2.5															
	-22.5	3.0															
	-23.0	3.5															
	-23.5	4.0															
	-24.0	4.5															
	-24.5	5.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D005
Sheet 2 of 7

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,785.6 m
Northing: 7,976,738.1 m
Surface Elevation: -19.50 m
Bottom Elevation: -50.60 m
Total Depth: 31.1 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/24/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-25.0	5.5				No core recovered *(Continued)*											
	-25.5	6.0															
	-26.0	6.5															
	-26.5	7.0				SAND with SILT, trace GRAVEL: Brown, fine to coarse grained sand; well graded, rounded gravel				DS3 taken from 7.00-7.30m.		10	55	35			
	-27.0	7.5															
	-27.5	8.0															
	-28.0	8.5															
	-28.5	9.0															
	-29.0	9.5				No core recovered		100%		AS4 taken from 9.10-9.70m. N= 30							
	-29.5	10.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D005
Sheet 3 of 7

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,785.6 m
Northing: 7,976,738.1 m
Surface Elevation: -19.50 m
Bottom Elevation: -50.60 m
Total Depth: 31.1 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/24/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-30.0	10.5				No core recovered *(Continued)*											
	-30.5	11.0															
	-31.0	11.5															
	-31.5	12.0															
	-32.0	12.5				SAND, trace GRAVEL, trace SILT: Grey, coarse grained, poorly graded, angular sand				DS5 taken from 12.80-13.10m.		5	92	3			
	-32.5	13.0															
	-33.0	13.5															
	-33.5	14.0															
	-34.0	14.5								DS6 taken from 14.30-14.50m.							
	-34.5	15.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D005
Sheet 4 of 7

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,785.6 m
Northing: 7,976,738.1 m
Surface Elevation: -19.50 m
Bottom Elevation: -50.60 m
Total Depth: 31.1 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/24/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-35.0	15.5				No core recovered											
	-35.5	16.0															
	-36.0	16.5				SAND, some GRAVEL: Coarse grained sand; rounded to subangular coarse gravel				DS7 taken from 16.50-16.80m.							
	-36.5	17.0															
	-37.0	17.5															
	-37.5	18.0															
	-38.0	18.5				SAND, some SILT: Brown, fine grained, poorly graded											
	-38.5	19.0								DS8 taken from 18.90-19.20m.							
	-39.0	19.5				SILT and SAND, trace GRAVEL: Brown to Grey, medium to coarse grained, poorly graded sand; fine gravel											
	-39.5	20.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D005

Sheet 5 of 7

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,785.6 m

Northing: 7,976,738.1 m

Surface Elevation: -19.50 m

Bottom Elevation: -50.60 m

Total Depth: 31.1 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/24/2017

Logged By: UK/AB

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-40.0	20.5				SILT and SAND, trace GRAVEL: Brown to Grey, medium to coarse grained, poorly graded sand; fine gravel *(Continued)*											
	-40.5	21.0								DS9 taken from 21.00-21.30m.		1	41	58			
	-41.0	21.5				SAND, some SILT, trace GRAVEL: Light brown, fine to coarse grained sand, well graded, multi-coloured, rounded to subangular gravel											
	-41.5	22.0								DS10 taken from 21.90-22.30m.							
	-42.0	22.5															
	-42.5	23.0				SAND, some SILT: Light brown, well graded, medium to coarse grained sand											
	-43.0	23.5															
	-43.5	24.0				24.00 m to 24.40 m: Trace gravel, multi-coloured				DS11 taken from 24.10-24.40m.							
	-44.0	24.5															
	-44.5	25.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D005

Sheet 6 of 7

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,785.6 m

Northing: 7,976,738.1 m

Surface Elevation: -19.50 m

Bottom Elevation: -50.60 m

Total Depth: 31.1 m

Logged By: UK/AB

Reviewed By: WH/CH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/24/2017

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-45.0	25.5				SAND, some SILT: Light brown, well graded, medium to coarse grained sand *(Continued)*											
										DS12 taken from 25.30-25.60m.		1	80	20			
	-45.5	26.0															
	-46.0	26.5															
	-46.5	27.0															
	-47.0	27.5				SAND, trace SILT: Light brown, fine to coarse grained, well graded sand											
	-47.5	28.0								DS13 taken from 28.00-28.30m.		0	96	4			
	-48.0	28.5															
	-48.5	29.0															
	-49.0	29.5															
	-49.5	30.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D005

Sheet 7 of 7

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,785.6 m

Northing: 7,976,738.1 m

Surface Elevation: -19.50 m

Bottom Elevation: -50.60 m

Total Depth: 31.1 m

Logged By: UK/AB

Reviewed By: WH/CH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/24/2017

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-50.0	30.5				SAND, trace SILT: Light brown, fine to coarse grained, well graded sand *(Continued)*		100%		AS14 taken from 30.50-31.10m. N= 2							
	-50.5	31.0				To Target Depth. **Drillhole BH17-D005 terminated at 31.1m.**											
	-51.0	31.5															
	-51.5	32.0															
	-52.0	32.5															
	-52.5	33.0															
	-53.0	33.5															
	-53.5	34.0															
	-54.0	34.5															
	-54.5	35.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D006

Sheet 1 of 5

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,678.2 m

Northing: 7,976,797.1 m

Surface Elevation: -29.84 m

Bottom Elevation: -54.24 m

Total Depth: 24.4 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/1/2017

Logged By: UK/MR

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-30.3	0.5				SAND, some SILT, trace Gravel: Light brown to dark grey, fine grained sand; rounded gravel; organic silt		100%		AS1 taken from .00-.60m. N= 5		3	79	18			
	-31.8	2.0				SAND, trace SILT: Grey to light brown, fine to coarse grained, well graded sand				DS2 taken from 2.10-2.40m.		0	99	1			
	-33.8	4.0								DS3 taken from 3.70-4.00m.							
	-34.8	5.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D006

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,678.2 m

Northing: 7,976,797.1 m

Surface Elevation: -29.84 m

Bottom Elevation: -54.24 m

Total Depth: 24.4 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/1/2017

Logged By: UK/MR

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-35.3	5.5				SAND, trace SILT: Grey to light brown, fine to coarse grained, well graded sand *(Continued)*				DS4 taken from 5.50-5.80m.							
	-35.8	6.0				SAND, trace GRAVEL: Grey to light brown, fine to medium grained sand; rounded, well graded gravel		100%		AS5 taken from 6.10-6.70m. N= 4							
	-36.3	6.5															
	-36.8	7.0															
	-37.3	7.5				SAND, trace GRAVEL, trace SILT: Grey to light brown, fine to medium grained sand; rounded, poorly graded gravel				DS6 taken from 7.90-8.20m.							
	-37.8	8.0															
	-38.3	8.5															
	-38.8	9.0															
	-39.3	9.5															
	-39.8	10.0								DS7 taken from 9.80-10.10m.		3	95	2			

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D006

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,678.2 m

Northing: 7,976,797.1 m

Surface Elevation: -29.84 m

Bottom Elevation: -54.24 m

Total Depth: 24.4 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/1/2017

Logged By: UK/MR

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-40.3	10.5				SAND, trace GRAVEL, trace SILT: Grey to light brown, fine to medium grained sand; rounded, poorly graded gravel *(Continued)*											
	-40.8	11.0				SAND, trace SILT, trace GRAVEL: Grey to light brown, fine to coarse grained sand, rounded to subrounded well graded gravel											
	-41.3	11.5								DS8 taken from 11.60-11.90m.		3	95	2			
	-41.8	12.0															
								42%		AS9 taken from 12.20-12.80m. N= 4							
	-42.3	12.5															
	-42.8	13.0															
	-43.3	13.5															
	-43.8	14.0								DS10 taken from 14.00-14.30m.							
	-44.3	14.5															
	-44.8	15.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D006

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,678.2 m

Northing: 7,976,797.1 m

Surface Elevation: -29.84 m

Bottom Elevation: -54.24 m

Total Depth: 24.4 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/1/2017

Logged By: UK/MR

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-45.3	15.5				SAND, some SILT: Dark grey, fine to medium grained, poorly graded sand; organic silt											
										DS11 taken from 15.80-16.20m.		0	82	18			
	-45.8	16.0															
	-46.3	16.5															
	-46.8	17.0															
	-47.3	17.5															
										DS12 taken from 17.70-18.00m.							
	-47.8	18.0															
						SAND: Light brown, fine to medium grained											
	-48.3	18.5															
										DS13 taken from 18.90-19.20m.							
	-48.8	19.0															
	-49.3	19.5															
	-49.8	20.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

BOREHOLE REPORT

BH17-D006

Sheet 5 of 5

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,678.2 m

Northing: 7,976,797.1 m

Surface Elevation: -29.84 m

Bottom Elevation: -54.24 m

Total Depth: 24.4 m

Logged By: UK/MR

Reviewed By: WH/CH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/1/2017

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND: Light brown, fine to medium grained *(Continued)*											
	-50.3	20.5								DS14 taken from 20.40-20.70m.							
	-50.8	21.0															
	-51.3	21.5															
	-51.8	22.0				Thin silt seams below 22.0m				DS15 taken from 21.90-22.30m.							
	-52.3	22.5															
	-52.8	23.0															
	-53.3	23.5								DS16 taken from 23.50-23.80m.							
	-53.8	24.0															
	-54.3	24.5				To Target Depth. **Drillhole BH17-D006 terminated at 24.4m.**											
	-54.8	25.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

Appendix C

Sample Photographs

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HATCH

Sample Photographs

Borehole Name:	BH17-D001	Mary River Expansion Study Stage 2
Location:	17 W 503644 7976665	2017 Geotechnical Investigation
Completion Date:	April 1, 2017	Baffinland Iron Mines

BH17-D001

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH17-D001

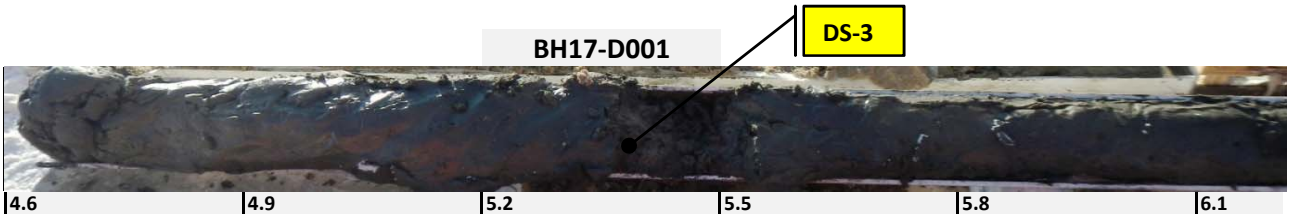
SAMPLE PHOTO NOT TAKEN

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH17-D001

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH17-D001



4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH17-D001

6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

BH17-D001

NO RECOVERY IN CORE BARREL

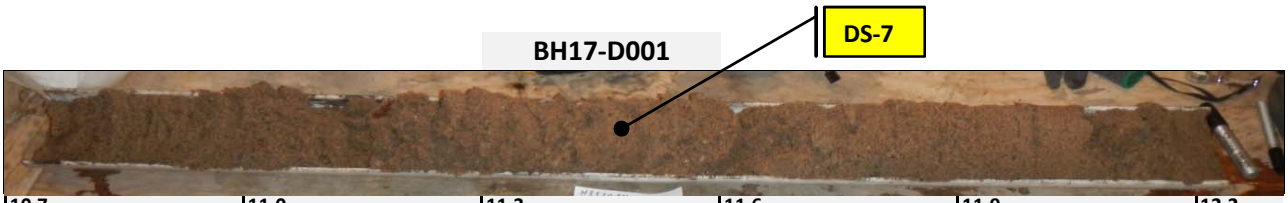
7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

HATCH

Sample Photographs

Borehole Name:	BH17-D001	Mary River Expansion Study Stage 2
Location:	17 W 503644 7976665	
Completion Date:	April 1, 2017	Baffinland Iron Mines

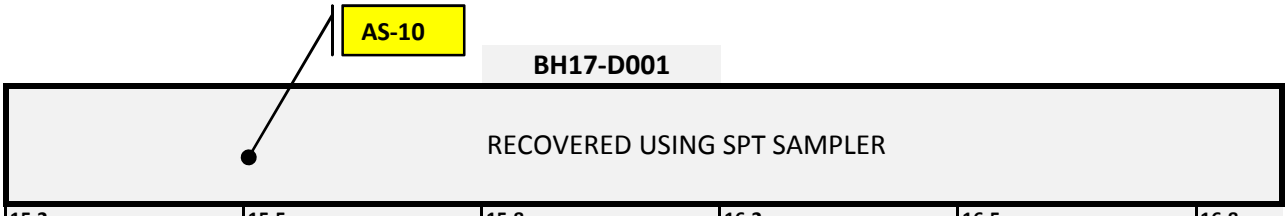
9.1	9.4	9.8	10.1	10.4	10.7



10.7	11.0	11.3	11.6	11.9	12.2

12.2	12.5	12.8	13.1	13.4	13.7

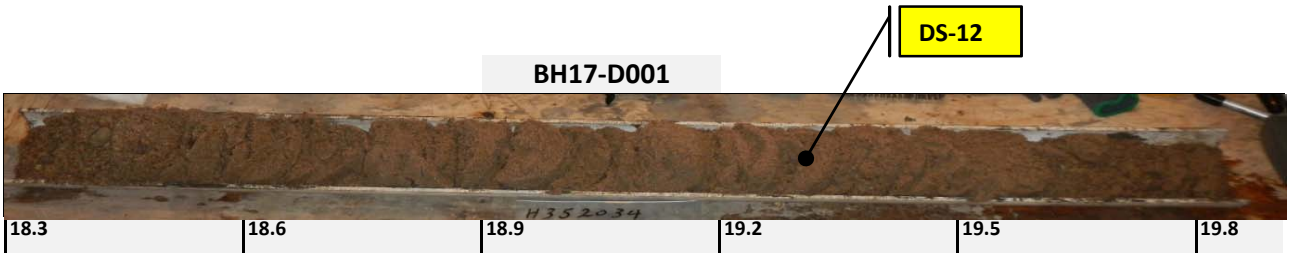
13.7	14.0	14.3	14.6	14.9	15.2

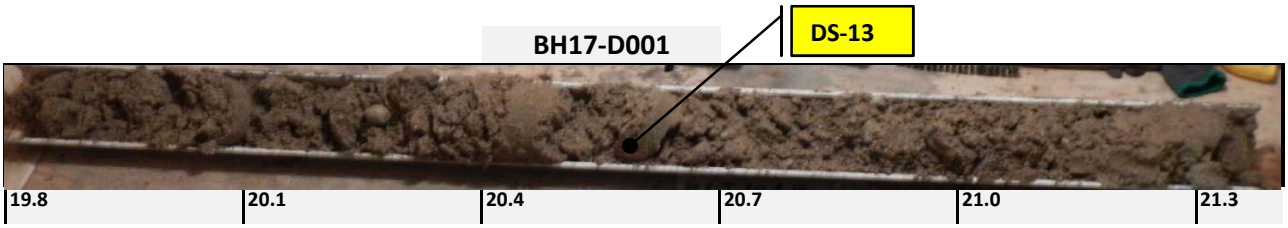


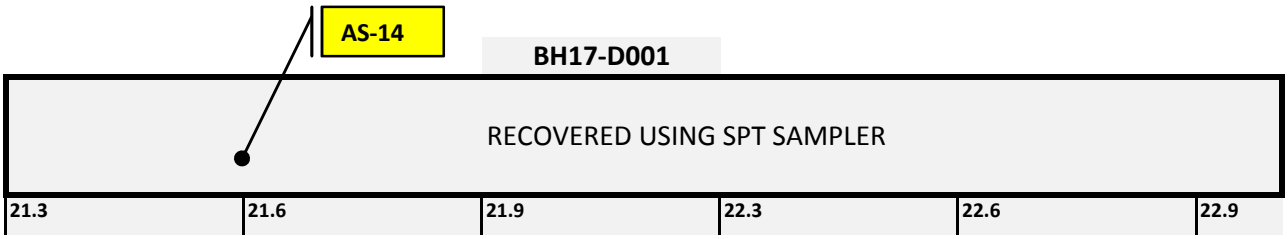
15.2	15.5	15.8	16.2	16.5	16.8

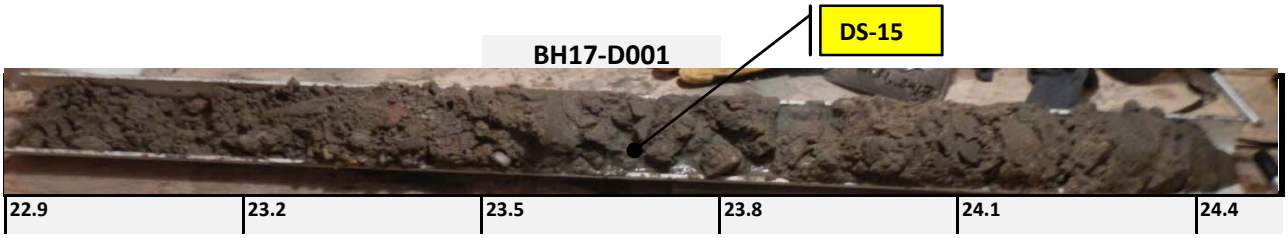
Sample Photographs

Borehole Name:	BH17-D001	Mary River Expansion Study Stage 2
Location:	17 W 503644 7976665	
Completion Date:	April 1, 2017	Baffinland Iron Mines



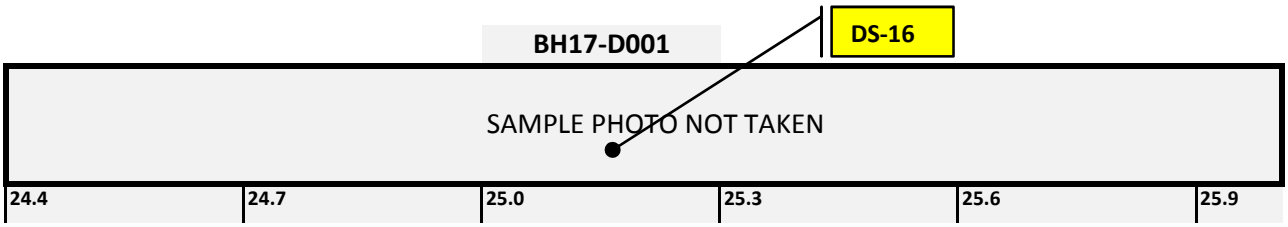


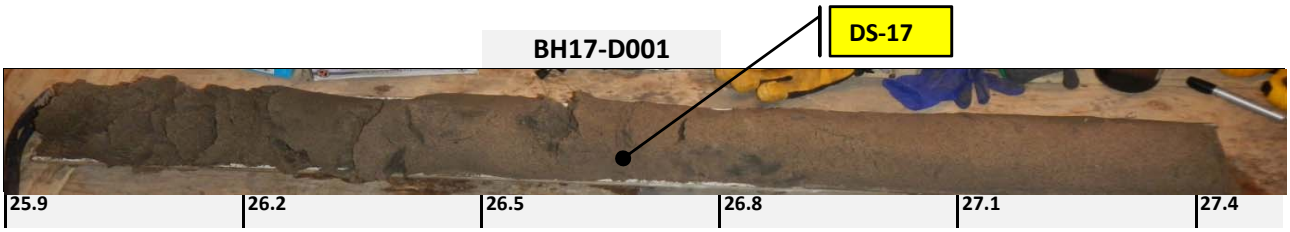




Sample Photographs

Borehole Name:	BH17-D001	Mary River Expansion Study Stage 2
Location:	17 W 503644 7976665	
Completion Date:	April 1, 2017	Baffinland Iron Mines

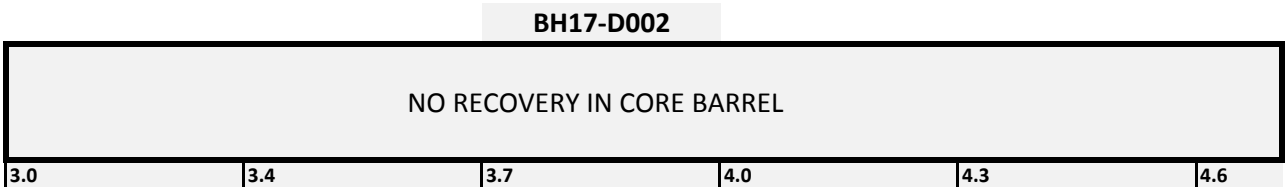




HATCH

Sample Photographs

Borehole Name:	BH17-D002	Mary River Expansion Study Stage 2
Location:	17 W 503764 7976681	
Completion Date:	March 24, 2017	Baffinland Iron Mines



HATCH

Sample Photographs

Borehole Name:	BH17-D002	Mary River Expansion Study Stage 2
Location:	17 W 503764 7976681	
Completion Date:	March 24, 2017	Baffinland Iron Mines

HATCH

Sample Photographs

Borehole Name:	BH17-D002	Mary River Expansion Study Stage 2
Location:	17 W 503764 7976681	
Completion Date:	March 24, 2017	Baffinland Iron Mines

BH17-D002

DS-10

16.8	17.1	17.4	17.7	18.0	18.3

BH17-D002

18.3	18.6	18.9	19.2	19.5	19.8

BH17-D002

DS-11

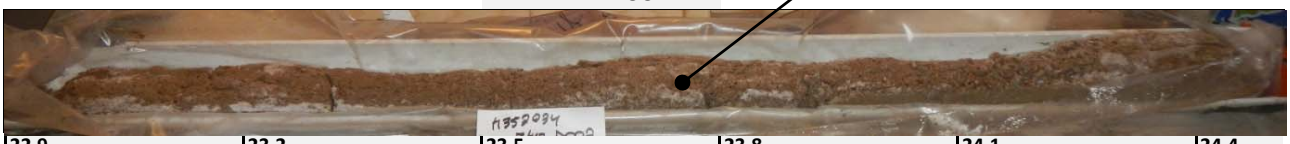
19.8	20.1	20.4	20.7	21.0	21.3

BH17-D002

21.3	21.6	21.9	22.3	22.6	22.9

BH17-D002

DS-12



22.9	23.2	23.5	23.8	24.1	24.4

HATCH

Sample Photographs

Borehole Name:	BH17-D002	Mary River Expansion Study Stage 2
Location:	17 W 503764 7976681	
Completion Date:	March 24, 2017	Baffinland Iron Mines

BH17-D002

24.4 | 24.7 | 25.0 | 25.3 | 25.6 | 25.9

DS-13

BH17-D002

25.9 | 26.2 | 26.5 | 26.8 | 27.1 | 27.4

HATCH

Sample Photographs

Borehole Name:	BH17-D003	Mary River Expansion Study Stage 2
Location:	17 W 503608 7976710	2017 Geotechnical Investigation
Completion Date:	March 31, 2017	Baffinland Iron Mines

BH17-D003

NO RECOVERY IN CORE BARREL

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

AS-1

BH17-D003

RECOVERED USING SPT SAMPLER

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH17-D003

NO RECOVERY IN CORE BARREL

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

DS-2

BH17-D003

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

DS-3

BH17-D003

6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

AS-4

BH17-D003

RECOVERED USING SPT SAMPLER

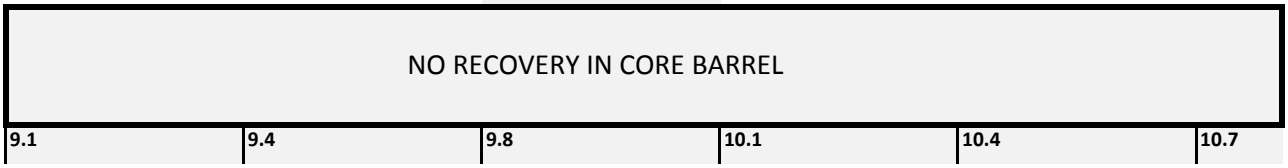
7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

HATCH

Sample Photographs

Borehole Name:	BH17-D003	Mary River Expansion Study Stage 2
Location:	17 W 503608 7976710	
Completion Date:	March 31, 2017	Baffinland Iron Mines

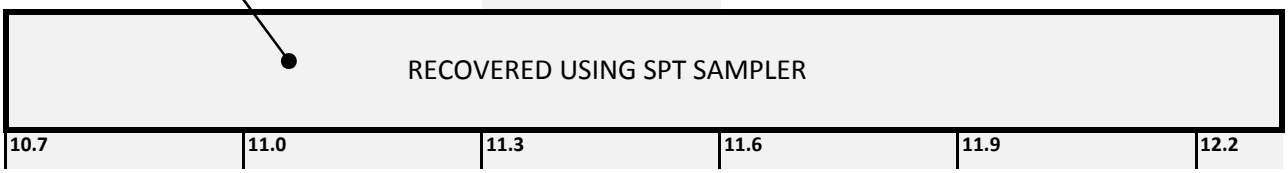
BH17-D003



9.1	9.4	9.8	10.1	10.4	10.7

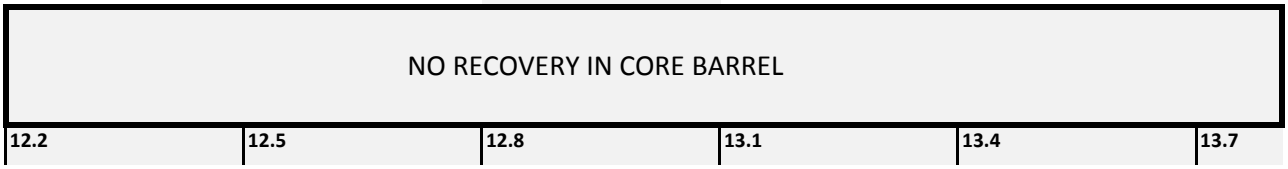
AS-5

BH17-D003



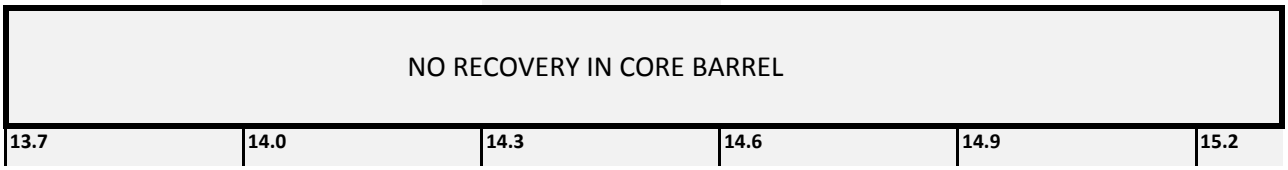
10.7	11.0	11.3	11.6	11.9	12.2

BH17-D003



12.2	12.5	12.8	13.1	13.4	13.7

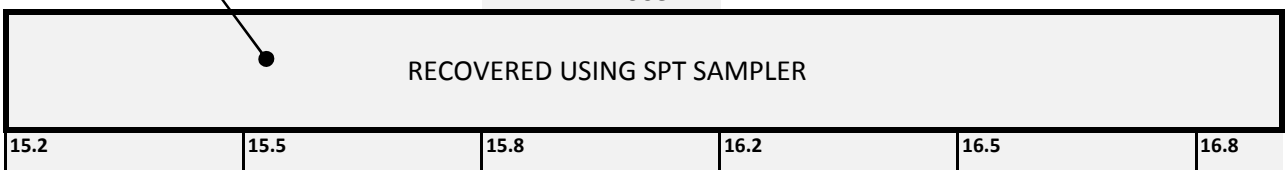
BH17-D003



13.7	14.0	14.3	14.6	14.9	15.2

AS-6

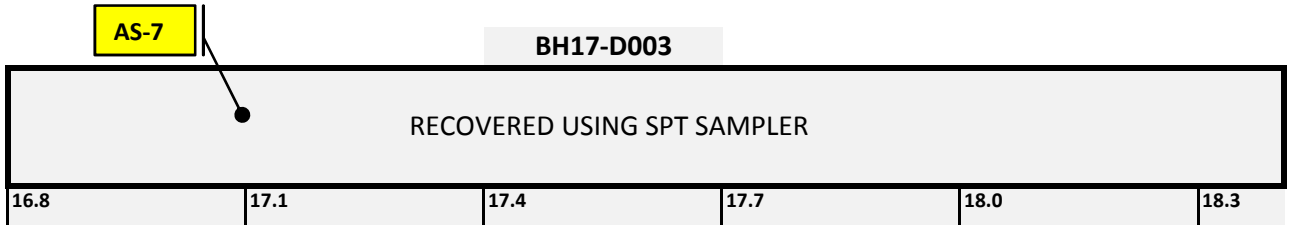
BH17-D003

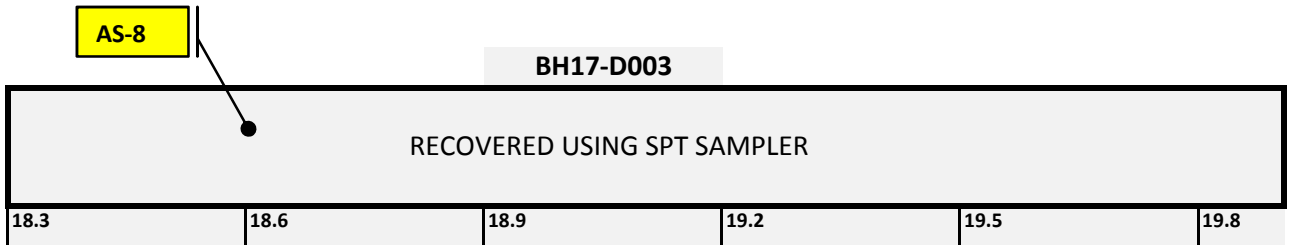


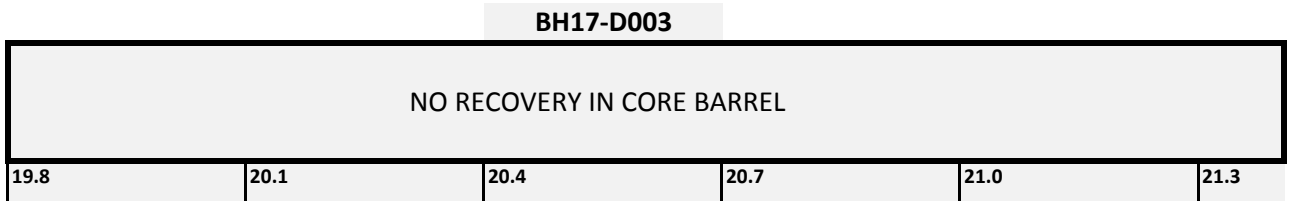
15.2	15.5	15.8	16.2	16.5	16.8

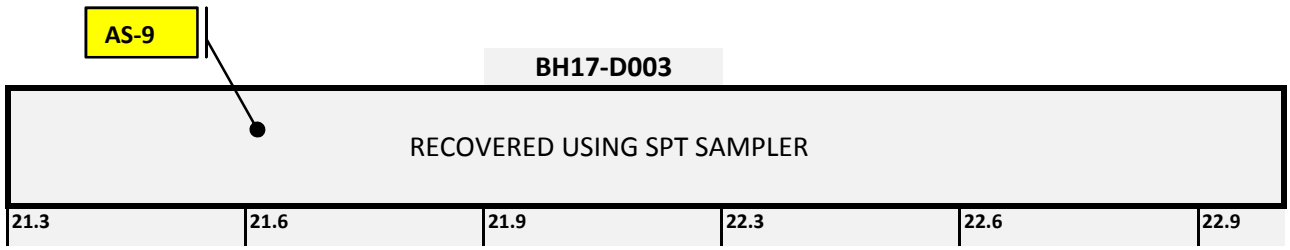
Sample Photographs

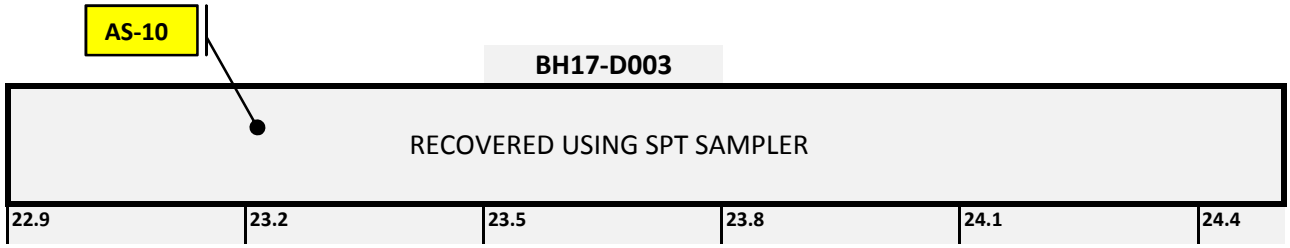
Borehole Name:	BH17-D003	Mary River Expansion Study Stage 2
Location:	17 W 503608 7976710	
Completion Date:	March 31, 2017	Baffinland Iron Mines







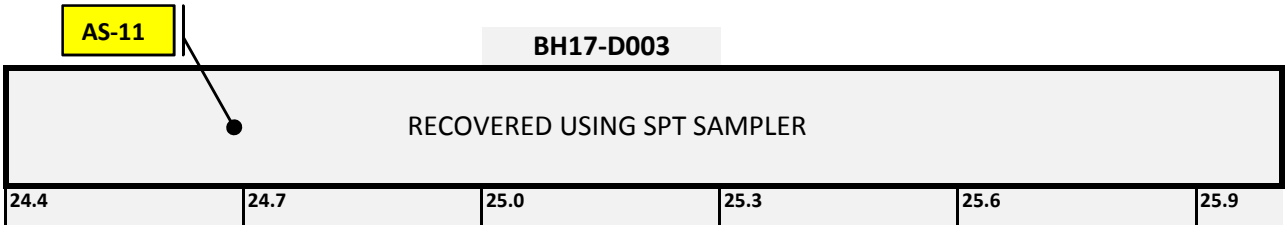


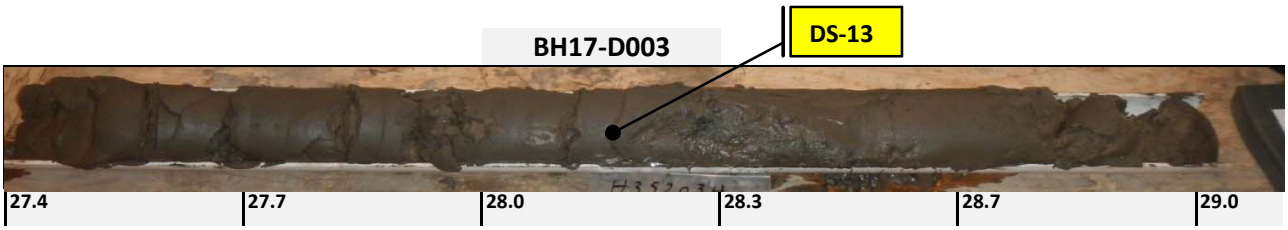


HATCH

Sample Photographs

Borehole Name:	BH17-D003	Mary River Expansion Study Stage 2
Location:	17 W 503608 7976710	
Completion Date:	March 31, 2017	Baffinland Iron Mines

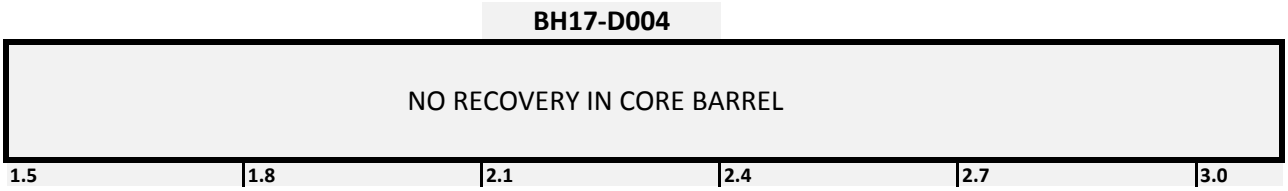




HATCH

Sample Photographs

Borehole Name:	BH17-D004	Mary River Expansion Study Stage 2
Location:	17 W 503701 7976728	
Completion Date:	March 28, 2017	Baffinland Iron Mines



Sample Photographs

Borehole Name:	BH17-D004	Mary River Expansion Study Stage 2
Location:	17 W 503701 7976728	
Completion Date:	March 28, 2017	Baffinland Iron Mines

BH17-D004

9.1 | 9.4 | 9.8 | 10.1 | 10.4 | 10.7

10.7 | 11.0 | 11.3 | 11.6 | 11.9 | 12.2

BH17-D004

12.2 | 12.5 | 12.8 | 13.1 | 13.4 | 13.7

13.7 | 14.0 | 14.3 | 14.6 | 14.9 | 15.2

15.2 | 15.5 | 15.8 | 16.2 | 16.5 | 16.8

HATCH

Sample Photographs

Borehole Name:	BH17-D004	Mary River Expansion Study Stage 2
Location:	17 W 503701 7976728	
Completion Date:	March 28, 2017	Baffinland Iron Mines

BH17-D004

DS-10

16.8	17.1	17.4	17.7	18.0	18.3

BH17-D004

NO RECOVERY IN CORE BARREL

18.3	18.6	18.9	19.2	19.5	19.8

AS-11

BH17-D004

19.8	20.1	20.4	20.7	21.0	21.3

BH17-D004

21.3	21.6	21.9	22.3	22.6	22.9

DS-12

BH17-D004

22.9	23.2	23.5	23.8	24.1	24.4

HATCH

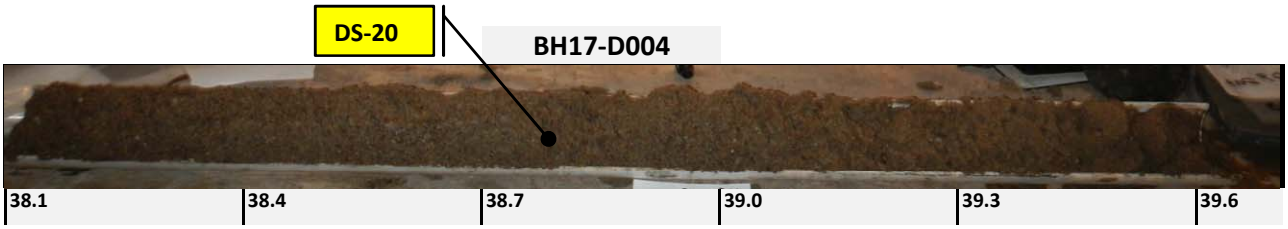
Sample Photographs

Borehole Name:	BH17-D004	Mary River Expansion Study Stage 2
Location:	17 W 503701 7976728	
Completion Date:	March 28, 2017	Baffinland Iron Mines

HATCH

Sample Photographs

Borehole Name:	BH17-D004	Mary River Expansion Study Stage 2
Location:	17 W 503701 7976728	
Completion Date:	March 28, 2017	Baffinland Iron Mines



HATCH

Sample Photographs

Borehole Name:	BH17-D004	Mary River Expansion Study Stage 2
Location:	17 W 503701 7976728	
Completion Date:	March 28, 2017	Baffinland Iron Mines

BH17-D004

39.6	39.9	40.2	40.5	40.8	41.1

BH17-D004

41.1	41.5	41.8	42.1	42.4	42.7

HATCH

Sample Photographs

Borehole Name:	BH17-D005	Mary River Expansion Study Stage 2
Location:	17 W 503786 7976738	
Completion Date:	March 26, 2017	Baffinland Iron Mines

BH17-D005

DS-1

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

BH17-D005

AS-2

RECOVERED USING SPT SAMPLER

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH17-D005

NO RECOVERY IN CORE BARREL

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH17-D005

NO RECOVERY IN CORE BARREL

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH17-D005

DS-3

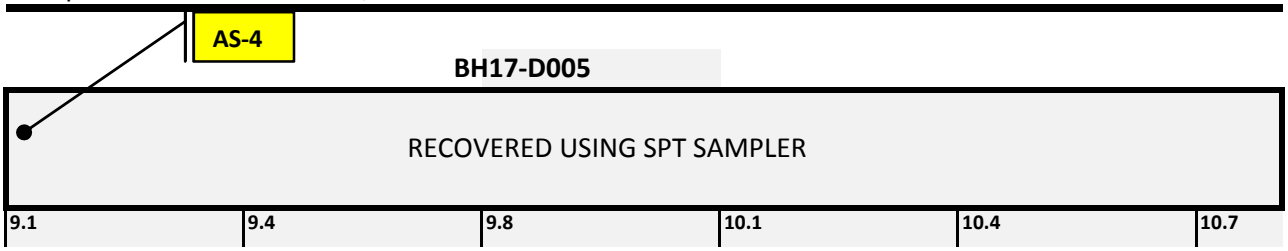
6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6

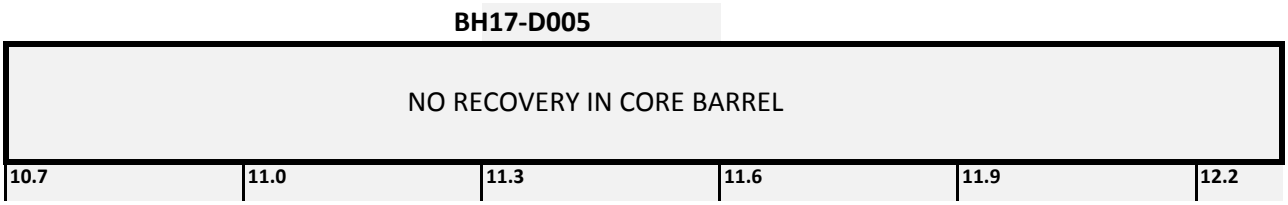
BH17-D005

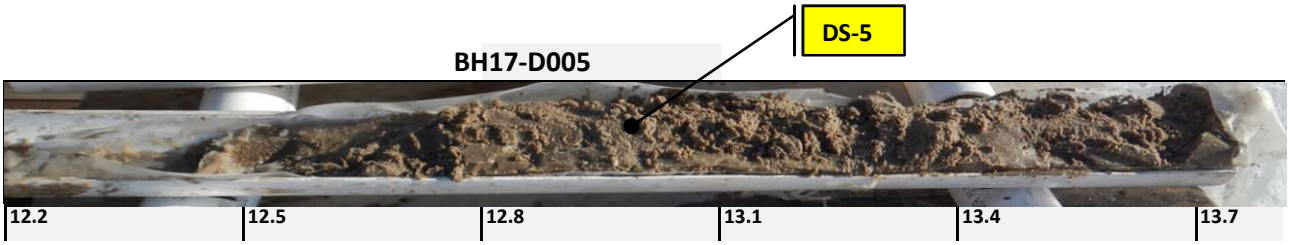
7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

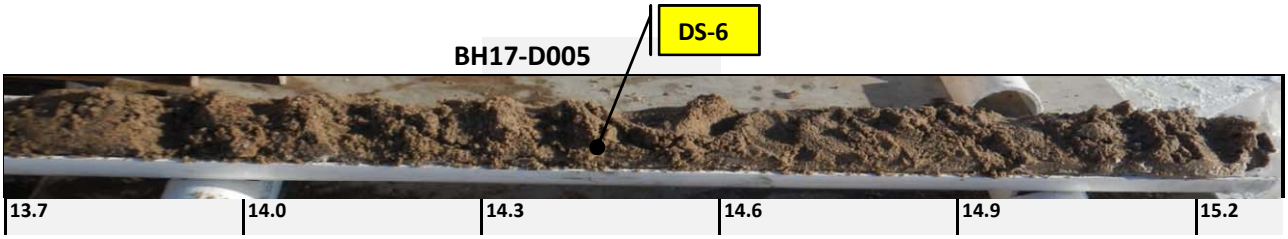
Sample Photographs

Borehole Name:	BH17-D005	Mary River Expansion Study Stage 2
Location:	17 W 503786 7976738	
Completion Date:	March 26, 2017	Baffinland Iron Mines









HATCH

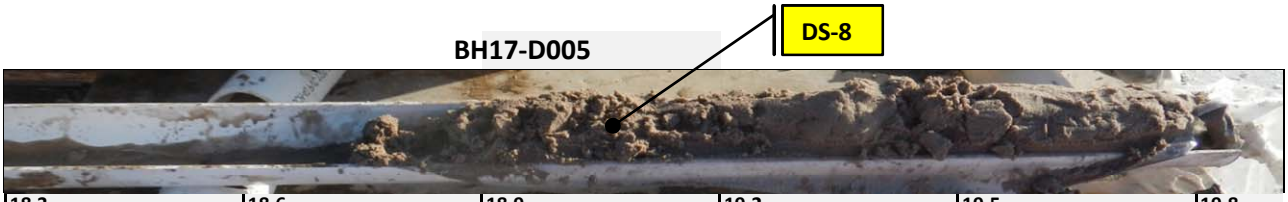
Sample Photographs

Borehole Name:	BH17-D005	Mary River Expansion Study Stage 2
Location:	17 W 503786 7976738	
Completion Date:	March 26, 2017	Baffinland Iron Mines

BH17-D005

16.8 | 17.1 | 17.4 | 17.7 | 18.0 | 18.3

BH17-D005

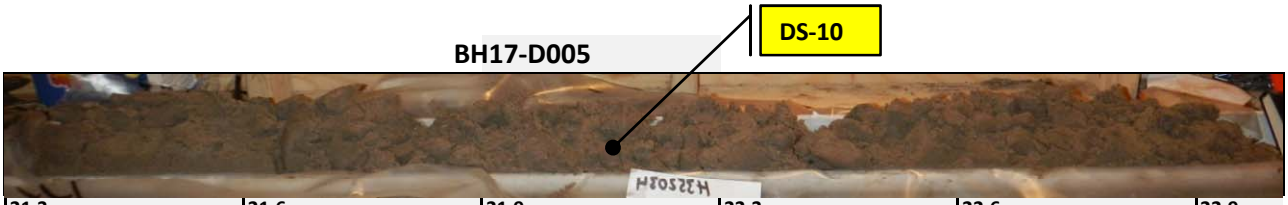


18.3 | 18.6 | 18.9 | 19.2 | 19.5 | 19.8

BH17-D005

19.8 | 20.1 | 20.4 | 20.7 | 21.0 | 21.3

BH17-D005



21.3 | 21.6 | 21.9 | 22.3 | 22.6 | 22.9

BH17-D005

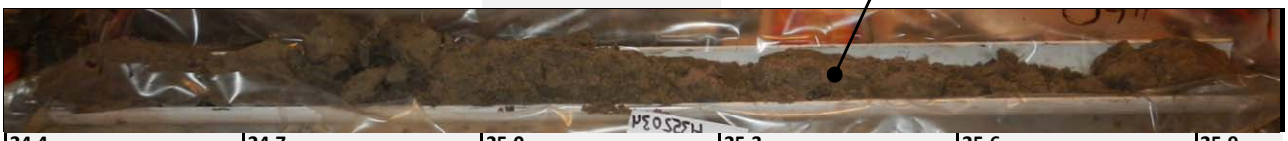
22.9 | 23.2 | 23.5 | 23.8 | 24.1 | 24.4

Sample Photographs

Borehole Name:	BH17-D005	Mary River Expansion Study Stage 2
Location:	17 W 503786 7976738	
Completion Date:	March 26, 2017	Baffinland Iron Mines

BH17-D005

DS-12



24.4	24.7	25.0	25.3	25.6	25.9

BH17-D005

25.9	26.2	26.5	26.8	27.1	27.4

BH17-D005

DS-13

27.4	27.7	28.0	28.3	28.7	29.0

BH17-D005

29.0	29.3	29.6	29.9	30.2	30.5

AS-14

BH17-D005

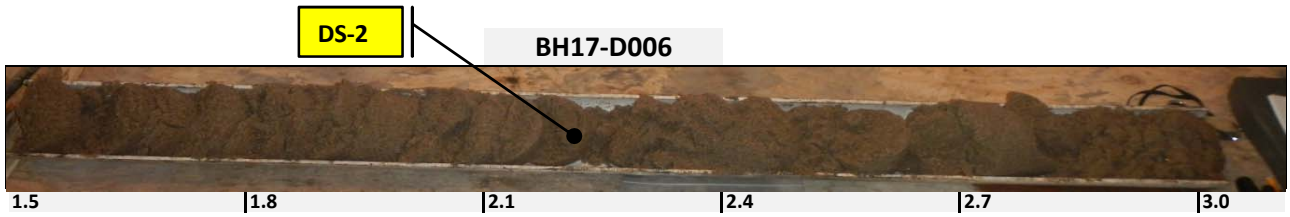
RECOVERED USING SPT SAMPLER

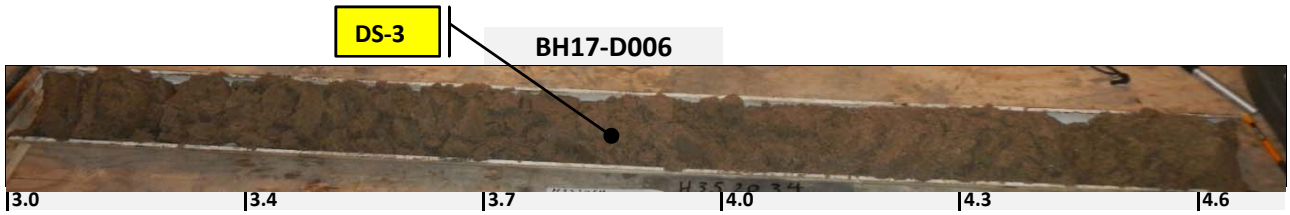
30.5	30.8	31.1	31.4	31.7	32.0

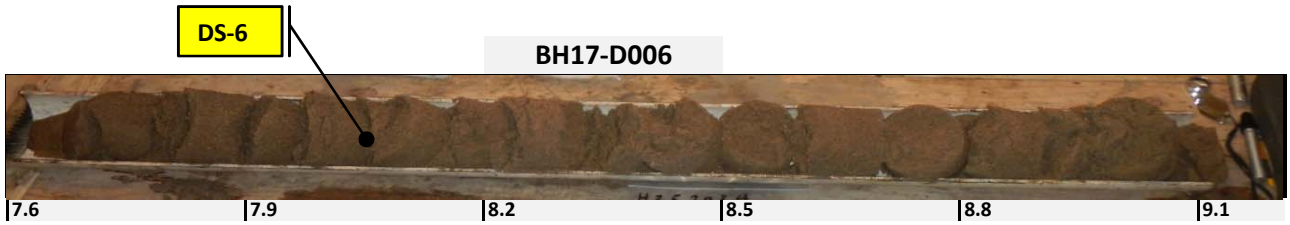
HATCH

Sample Photographs

Borehole Name:	BH17-D006	Mary River Expansion Study Stage 2
Location:	17 W 503678 7976797	2017 Geotechnical Investigation
Completion Date:	April 2, 2017	Baffinland Iron Mines



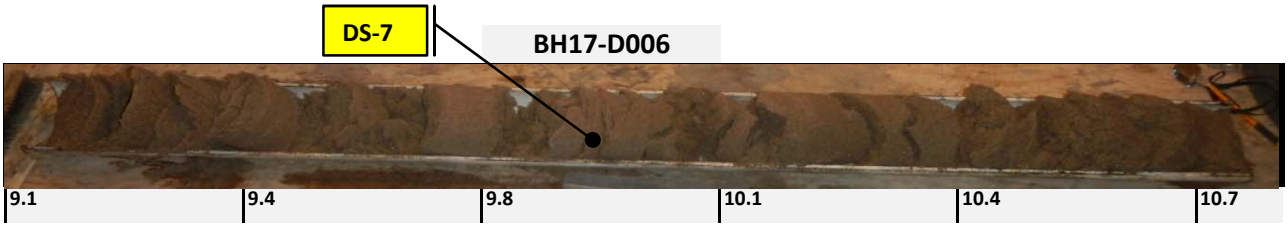


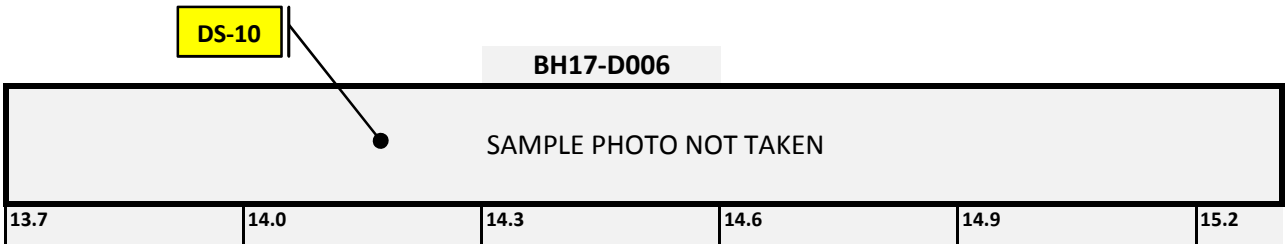


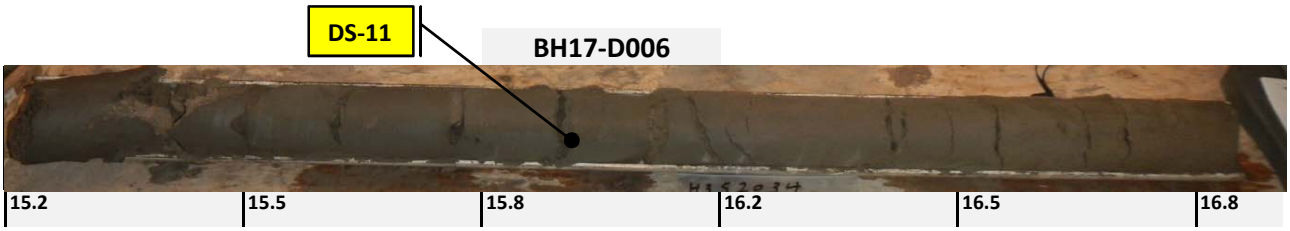
HATCH

Sample Photographs

Borehole Name:	BH17-D006	Mary River Expansion Study Stage 2
Location:	17 W 503678 7976797	
Completion Date:	April 2, 2017	Baffinland Iron Mines



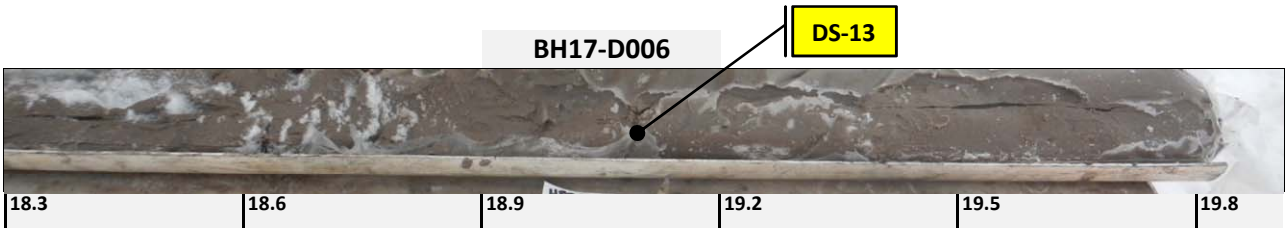


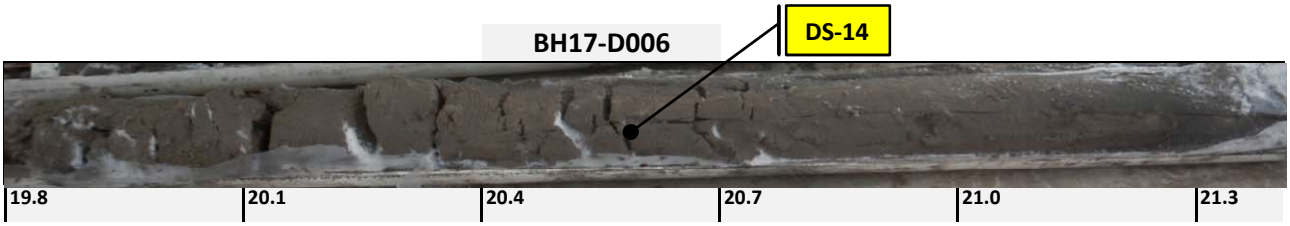


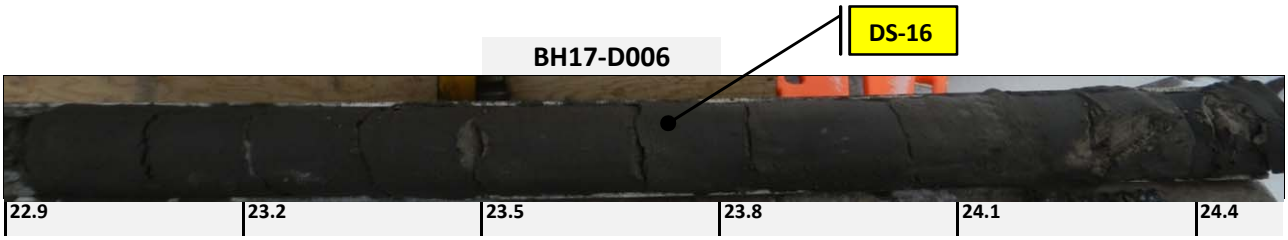
HATCH

Sample Photographs

Borehole Name:	BH17-D006	Mary River Expansion Study Stage 2
Location:	17 W 503678 7976797	
Completion Date:	April 2, 2017	Baffinland Iron Mines







Appendix D

Laboratory Test Reports

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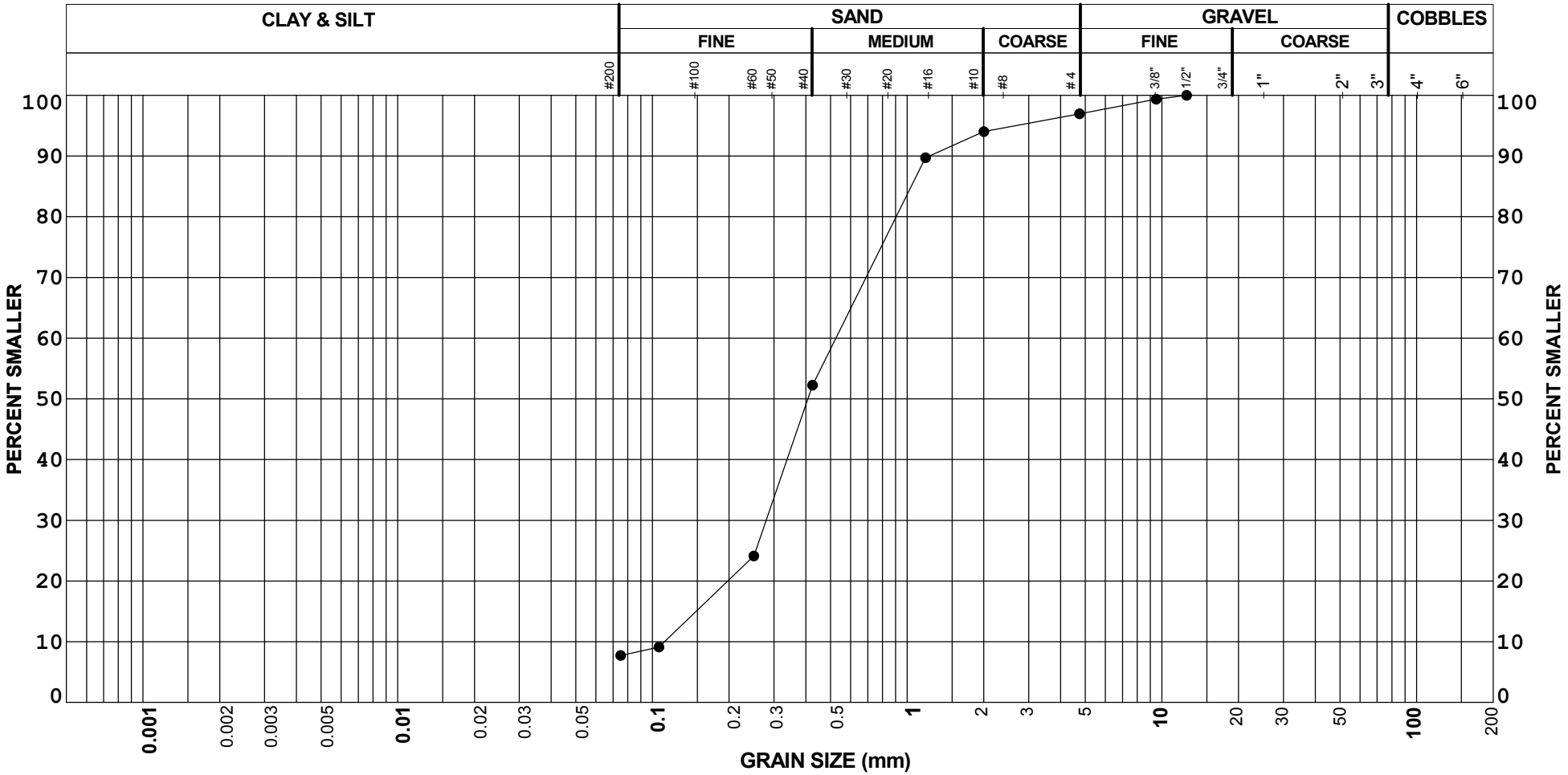
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D001	DS1	0.90	3	89	8		

REMARKS:

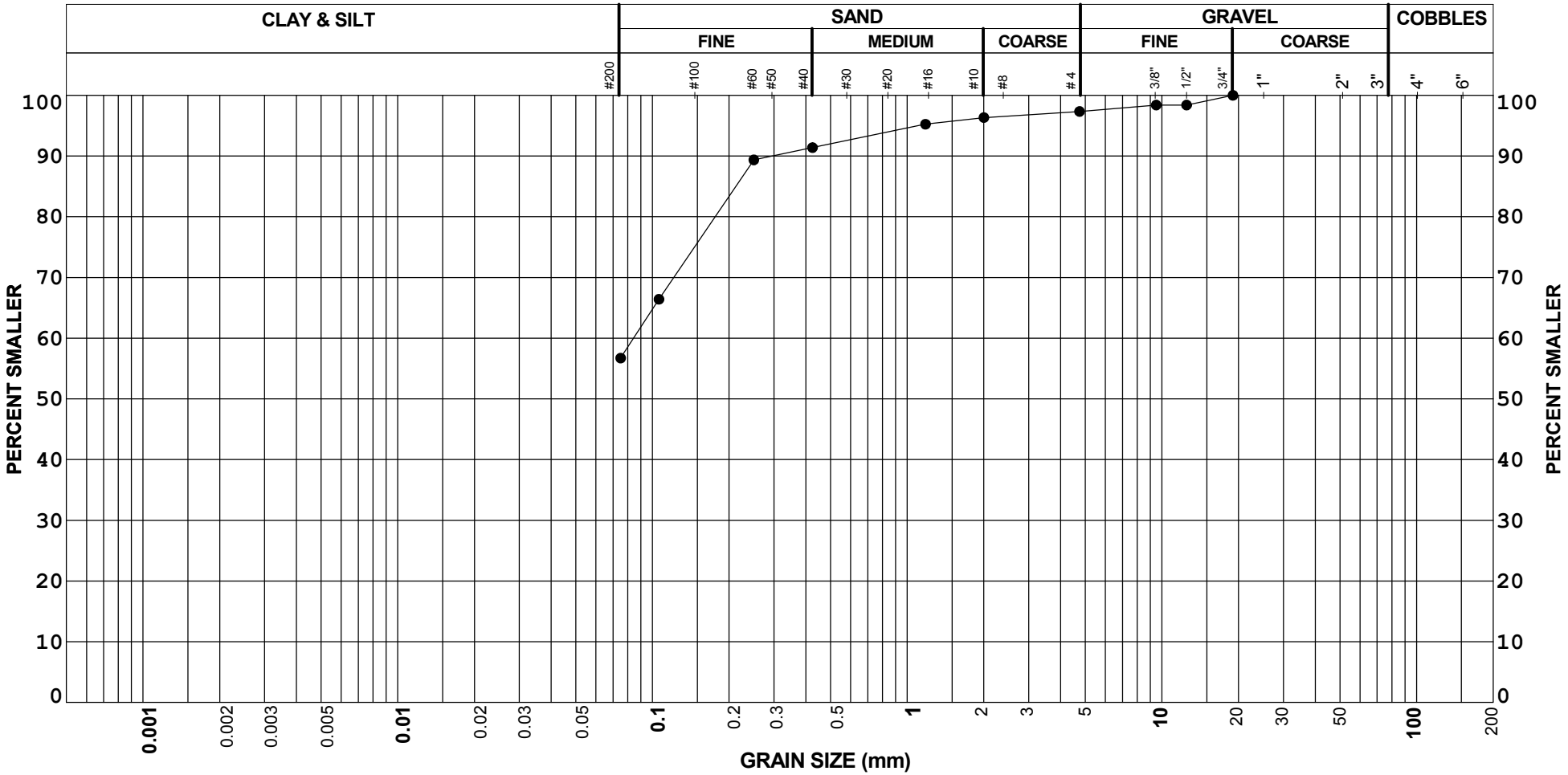
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D001	DS4	7.00	3	41	57		

REMARKS:

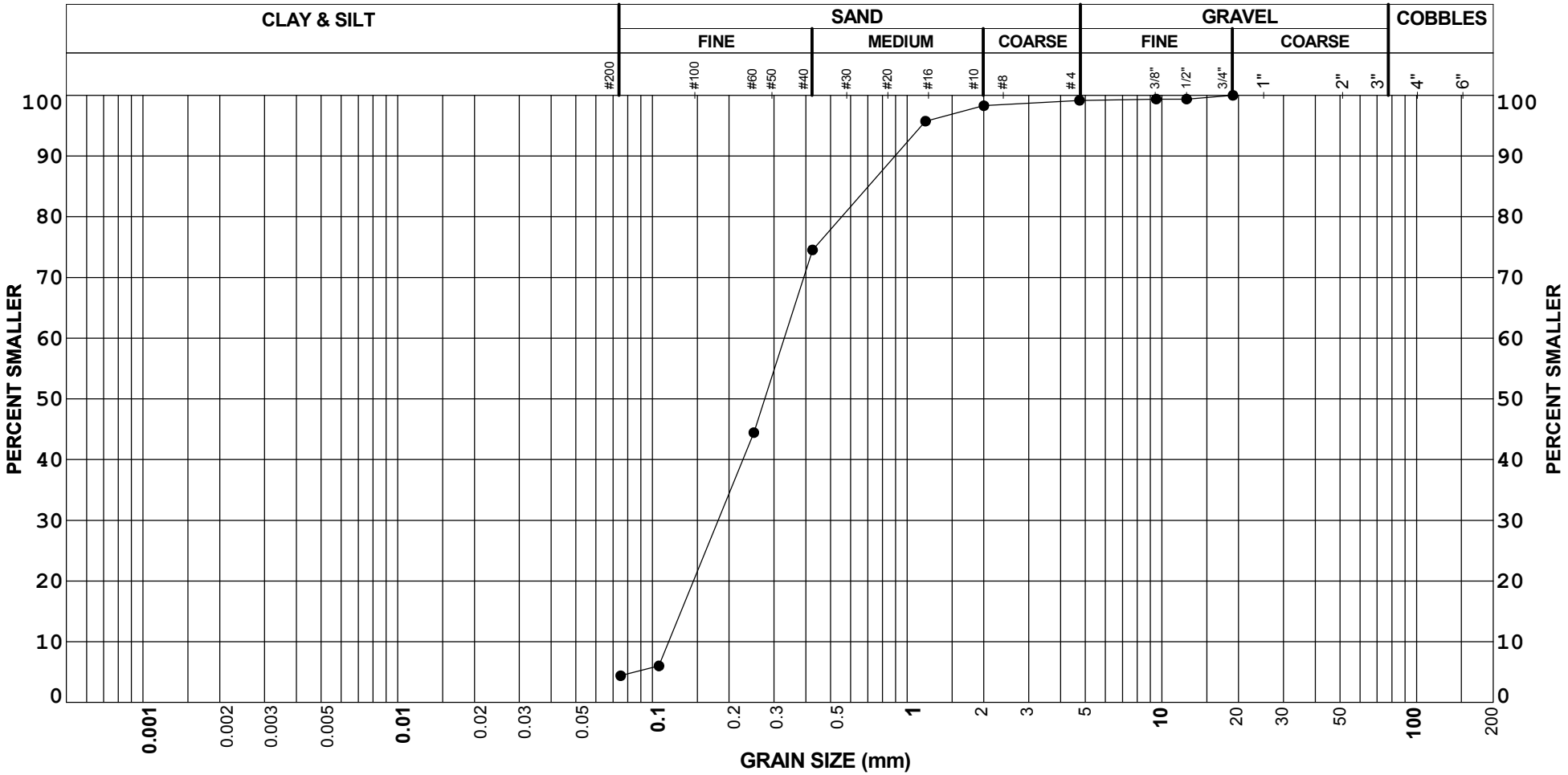
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D001	DS9	14.50	1	95	4		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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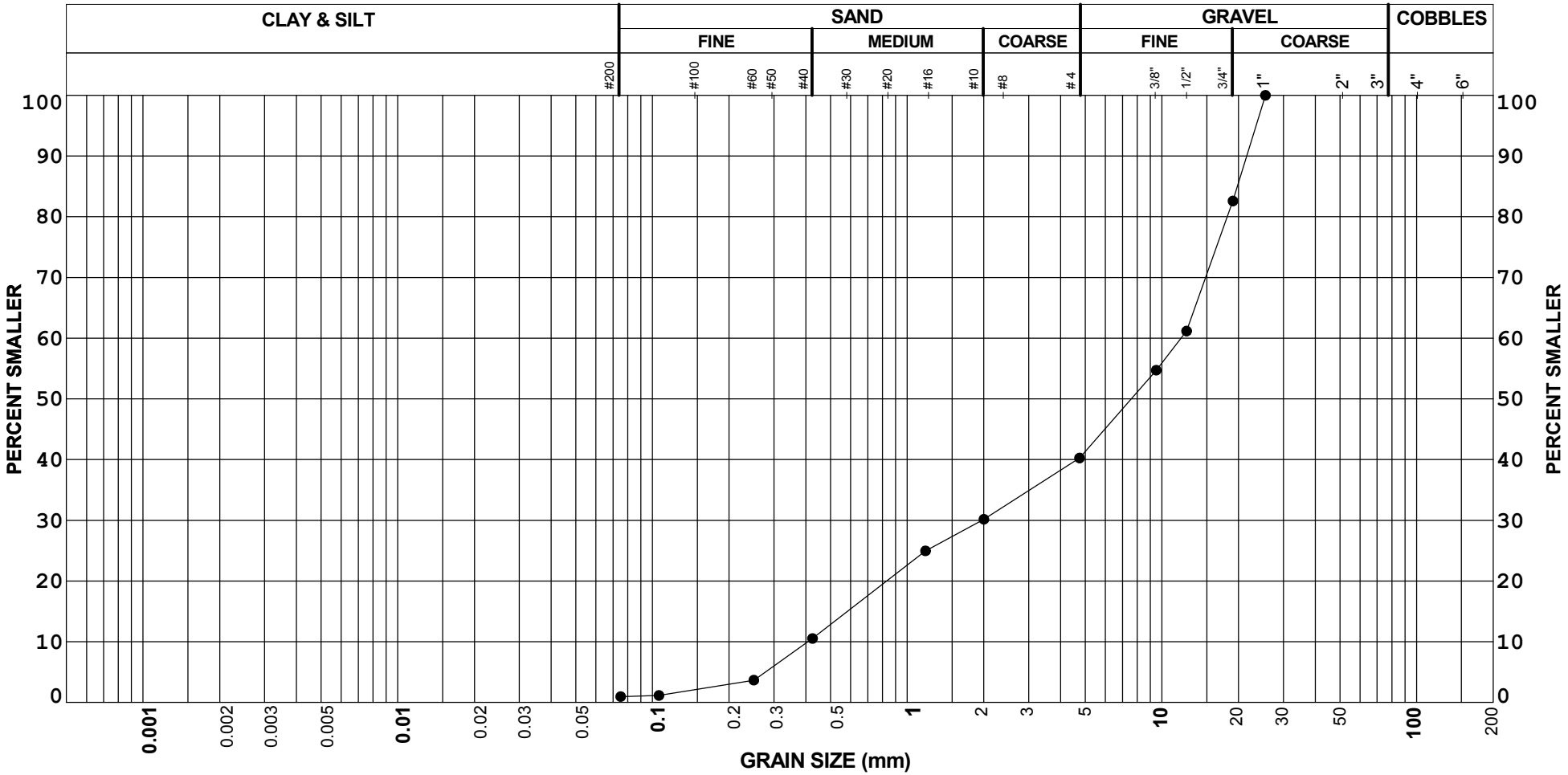
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D001	DS11	17.70	60	39	1		

REMARKS:

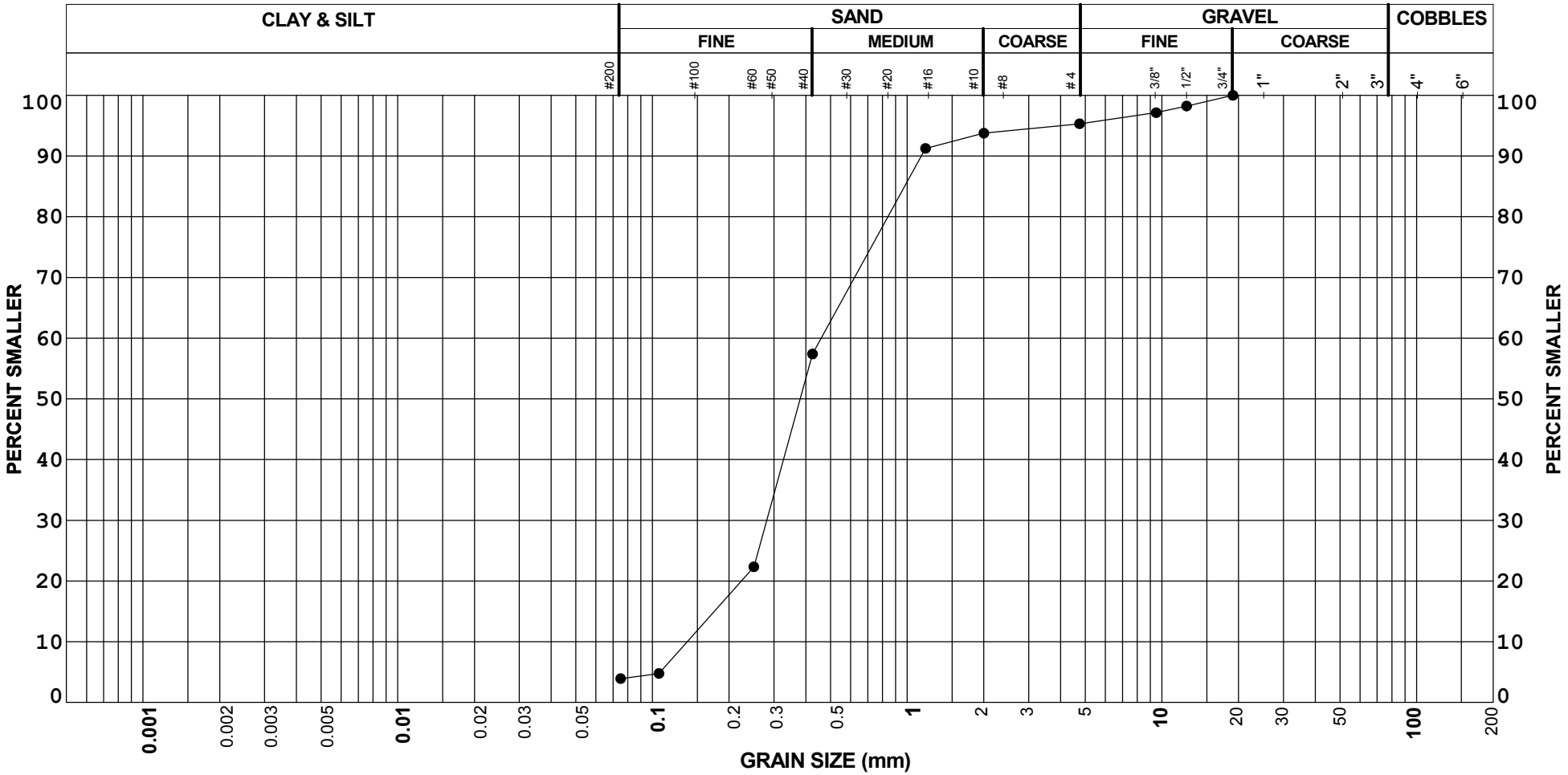
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



REMARKS:

BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D002	DS1	0.00	5	91	4		

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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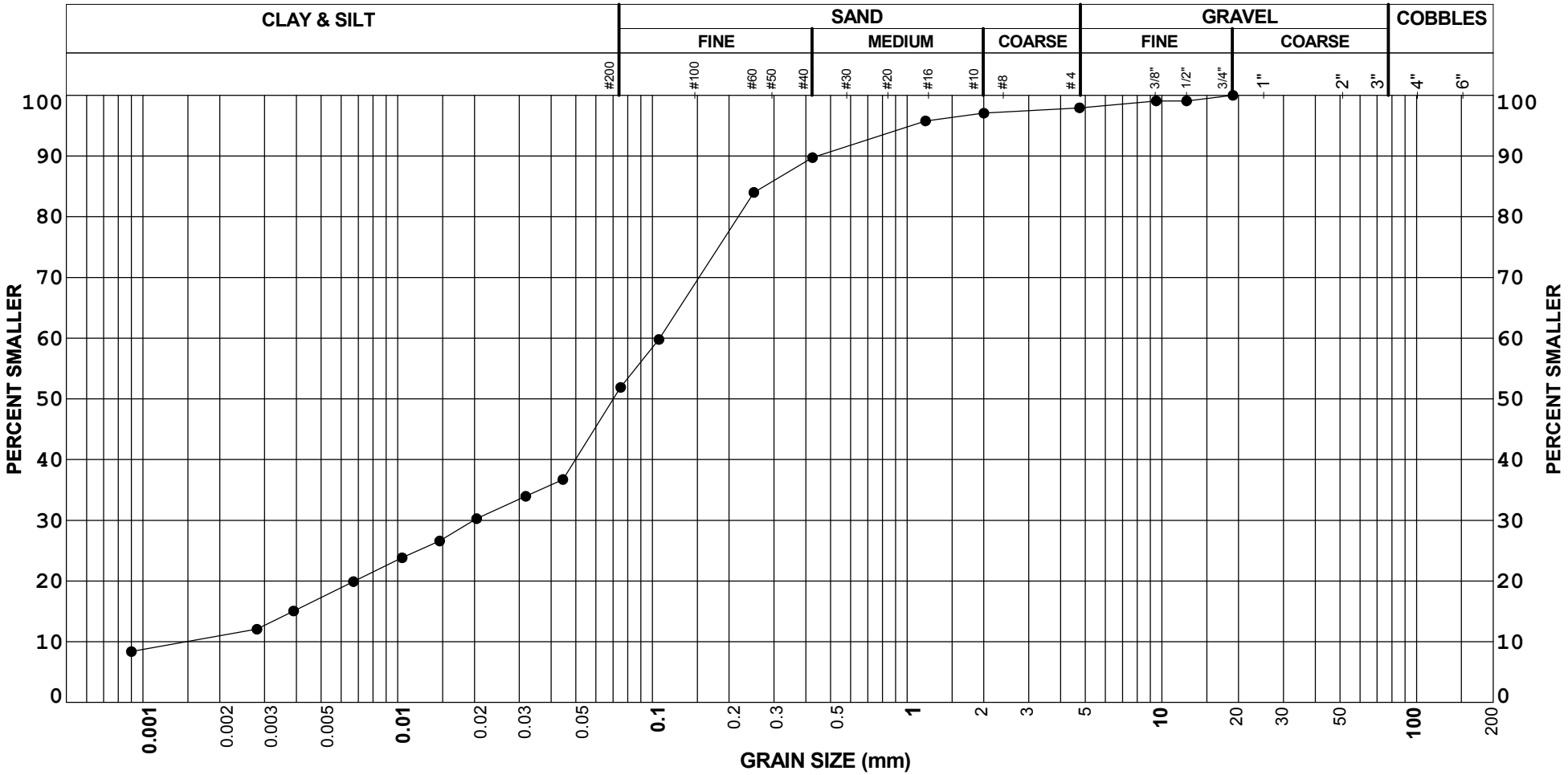
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D002	DS3	5.20	2	46	52		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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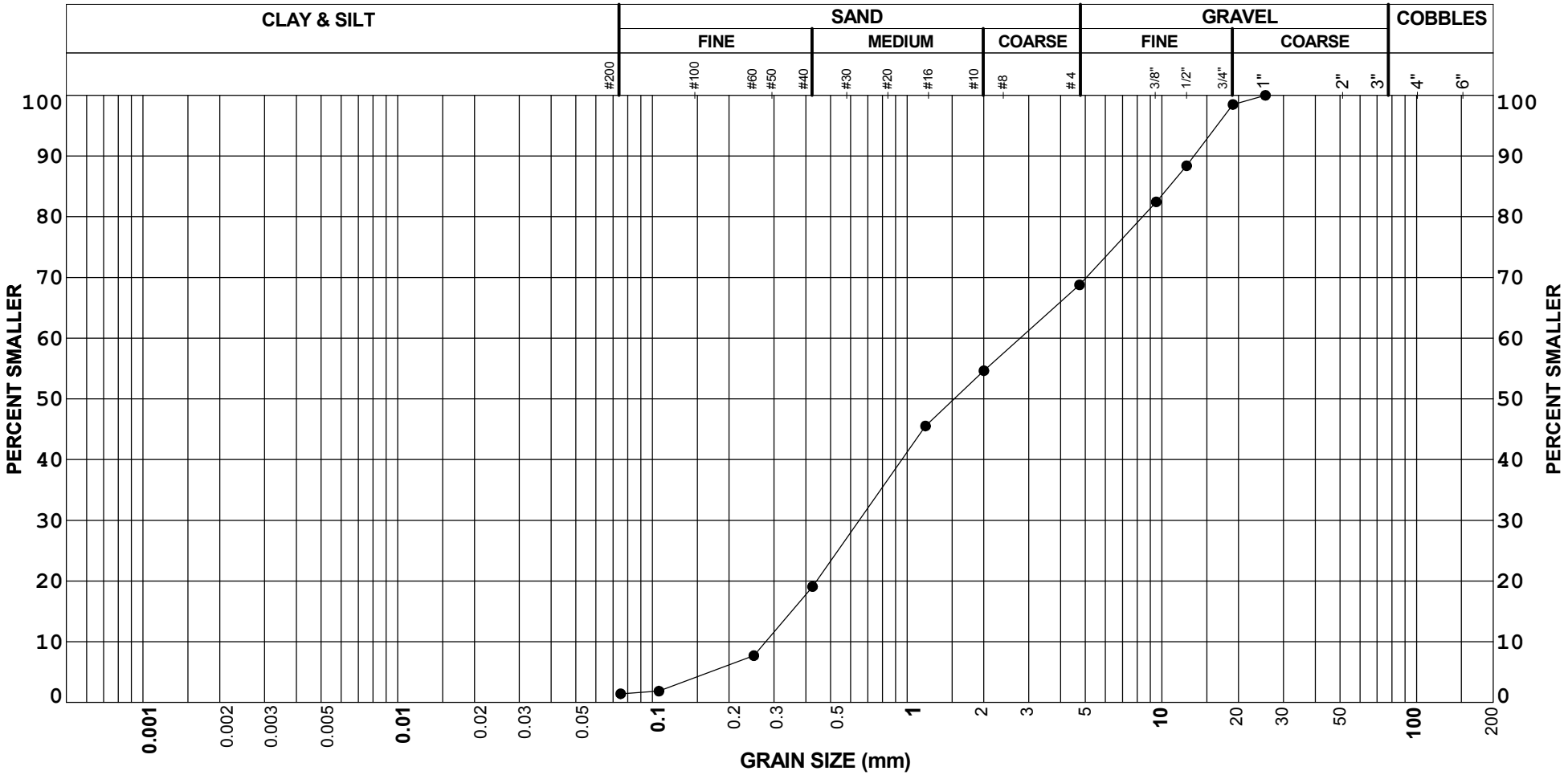
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D002	DS5	8.50	31	67	1		

REMARKS:

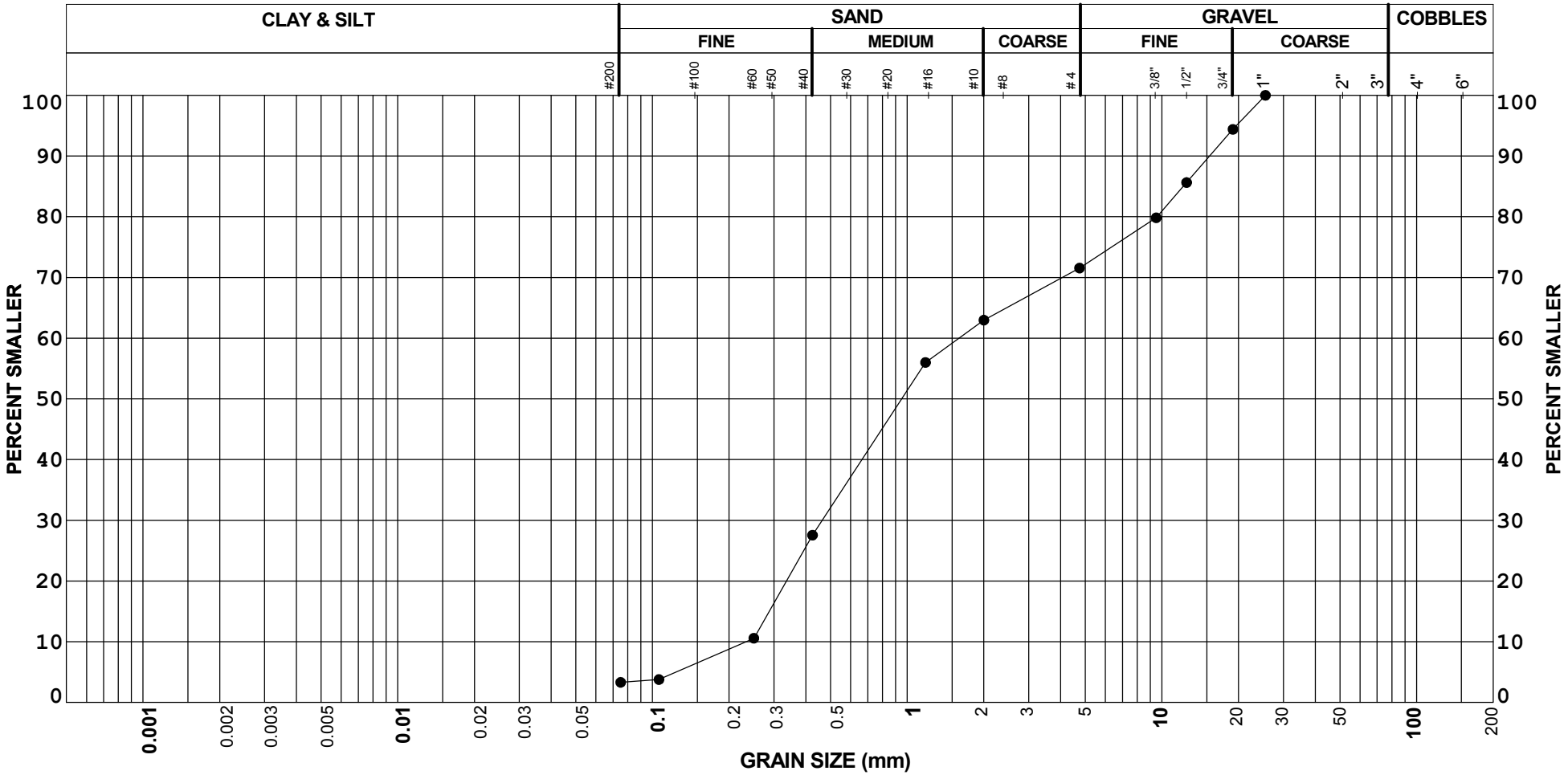
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D002	DS9	15.70	28	68	3		

REMARKS:

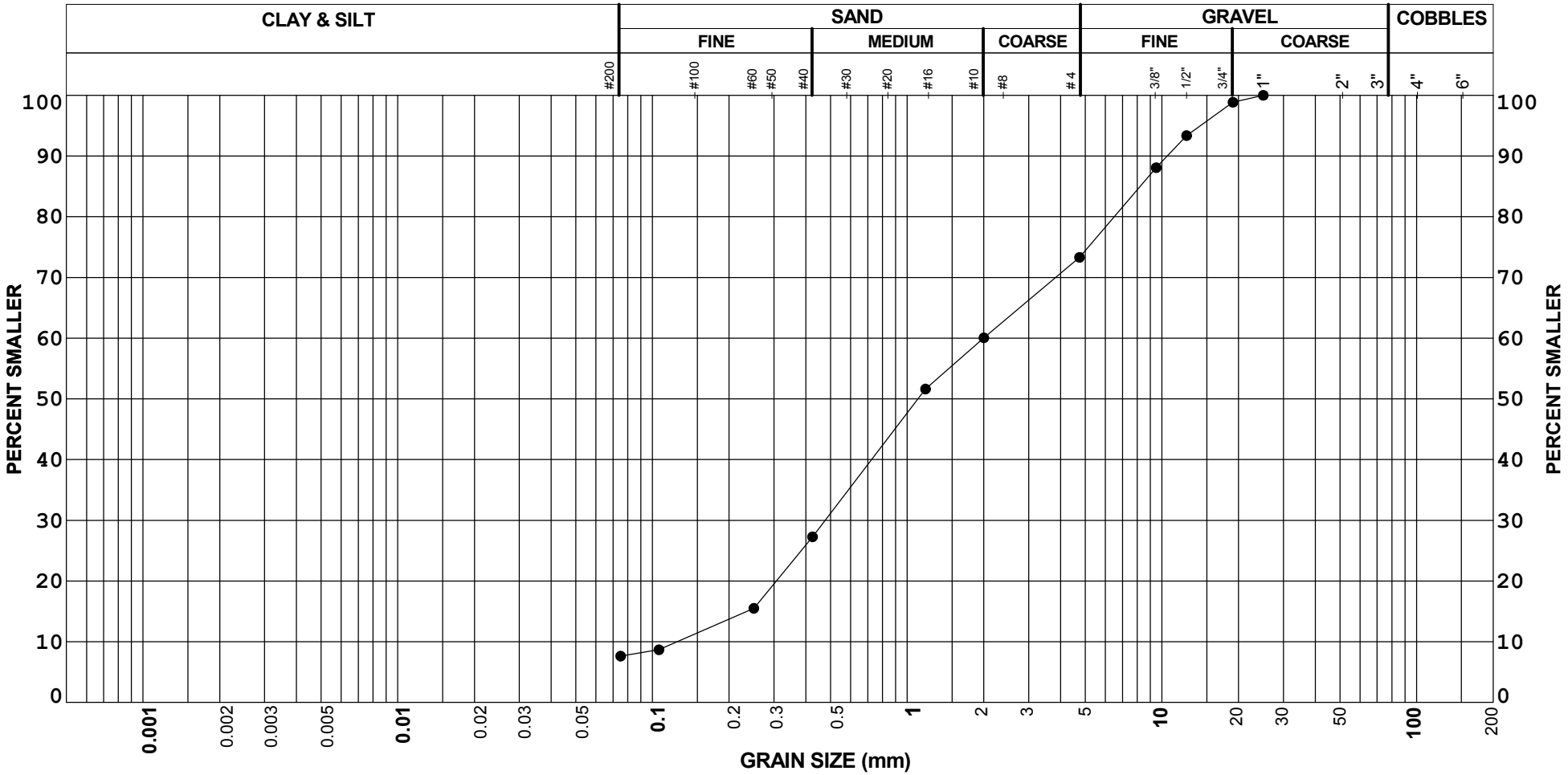
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D002	DS10	17.50	27	66	8		

REMARKS:

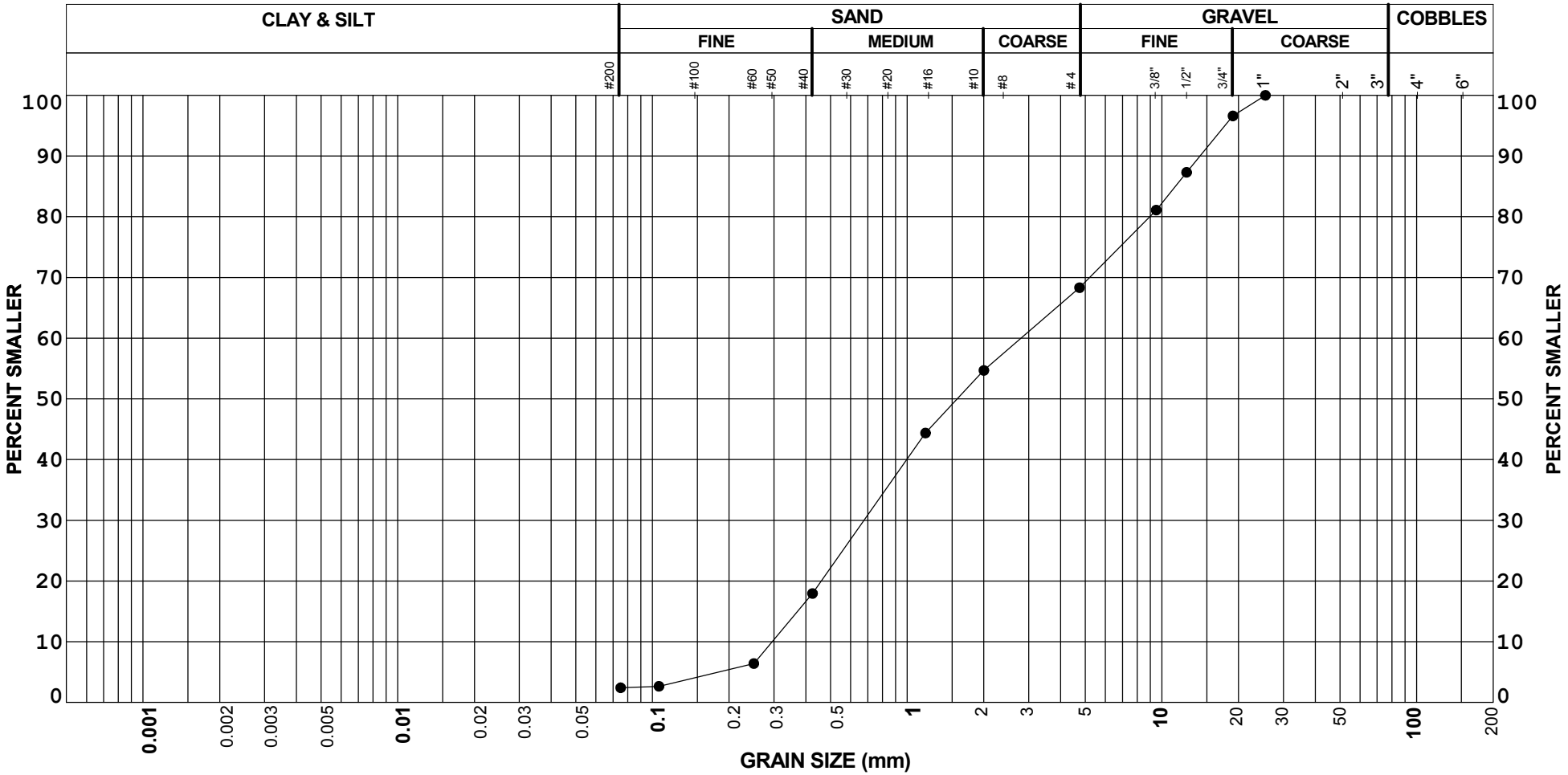
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D002	DS13	25.90	32	66	2		

REMARKS:

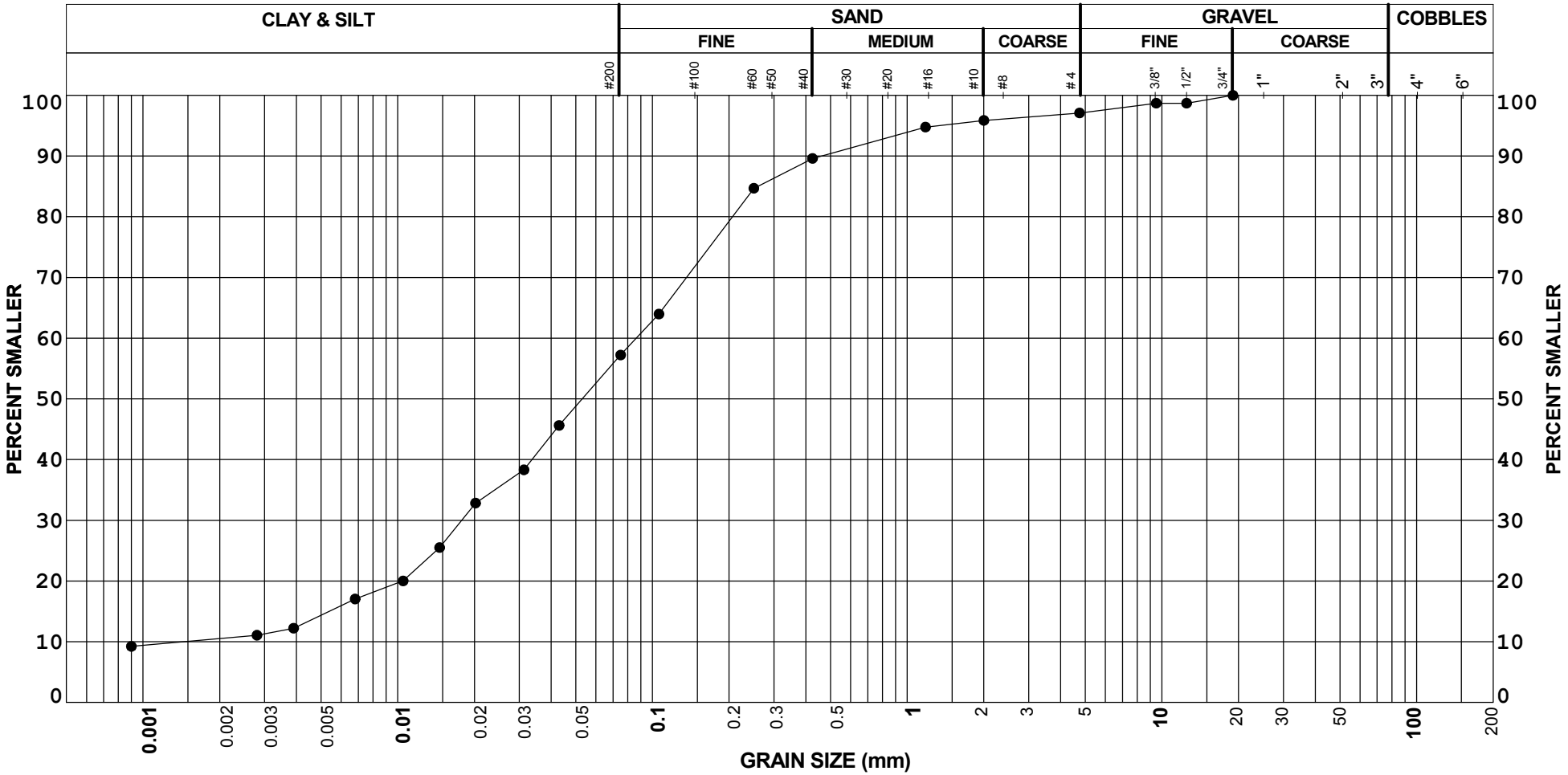
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D003	DS2	5.20	3	40	57		

REMARKS:

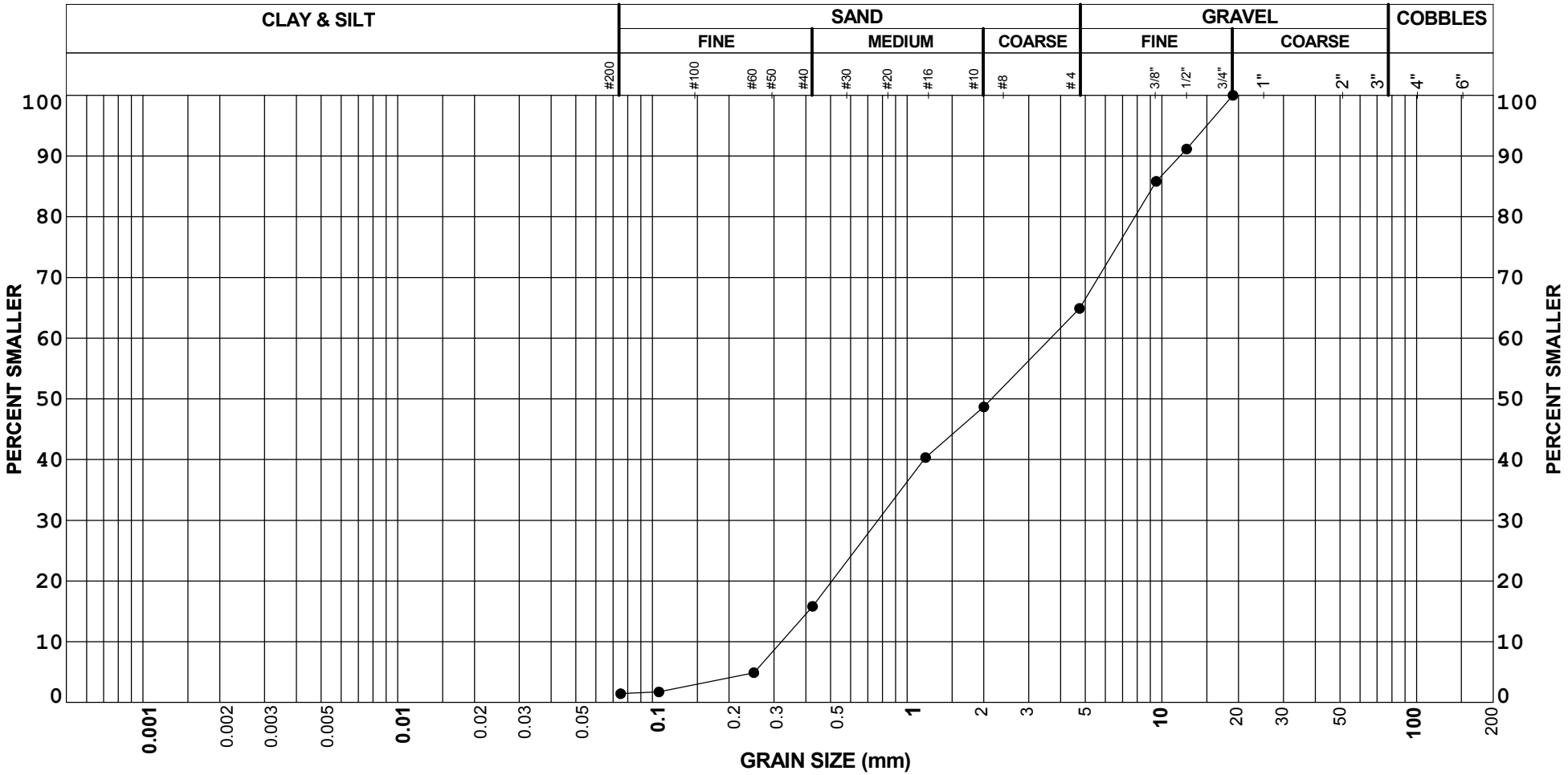
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D003	AS6	15.20	35	63	1		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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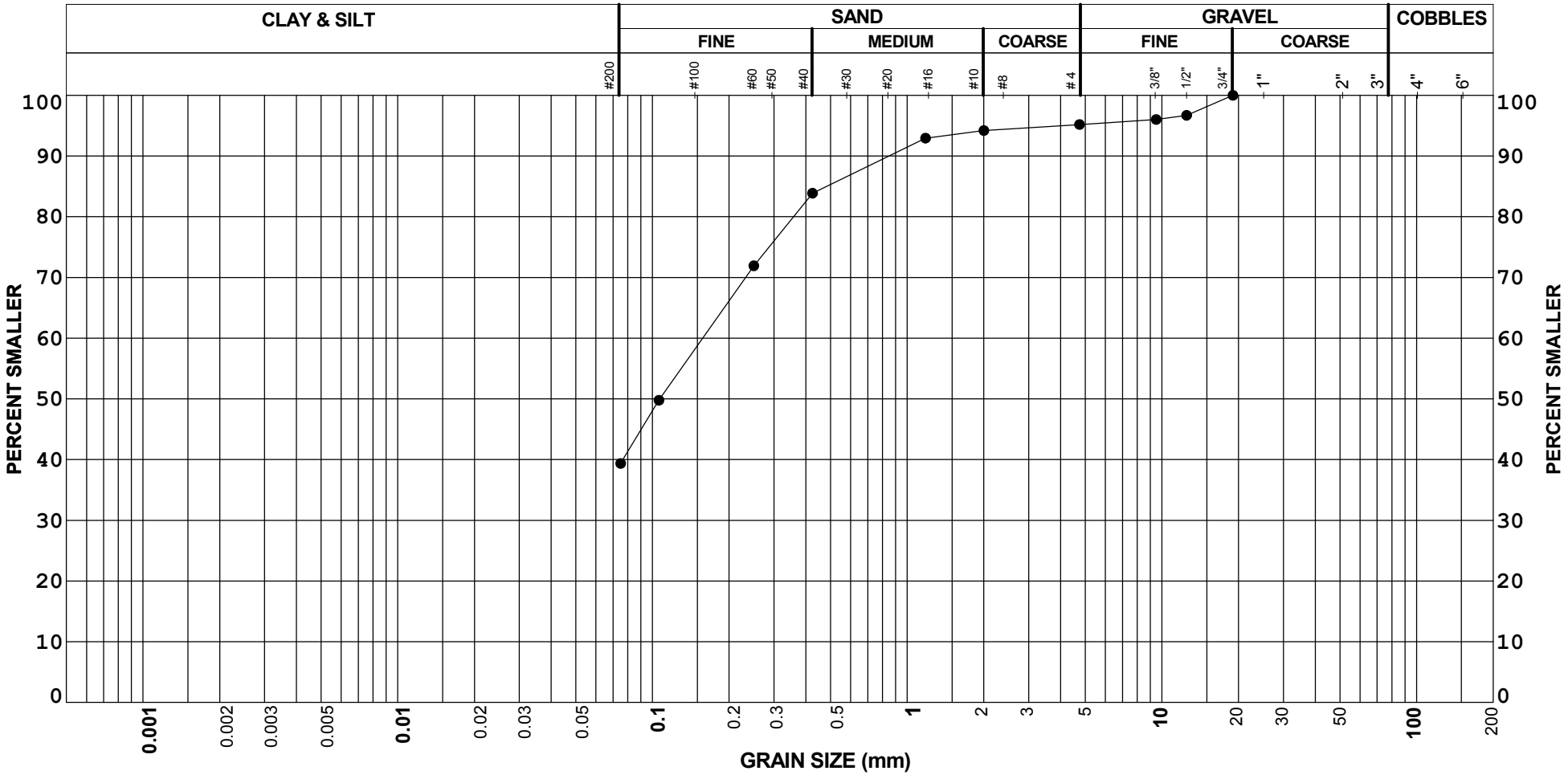
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



REMARKS:

BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D003	AS9	21.30	5	56	39		

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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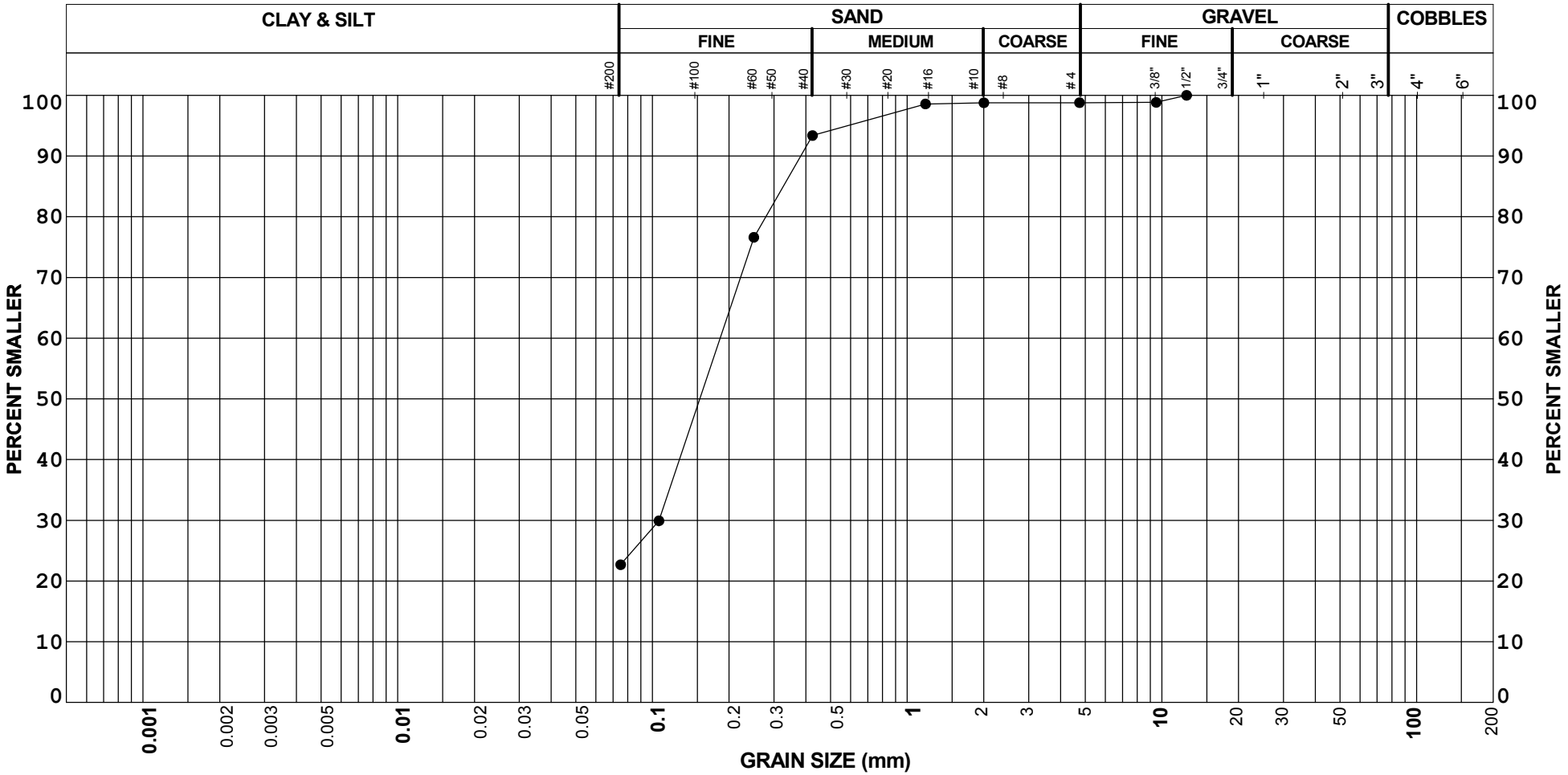
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D003	DS14	30.20	1	76	23		

REMARKS:

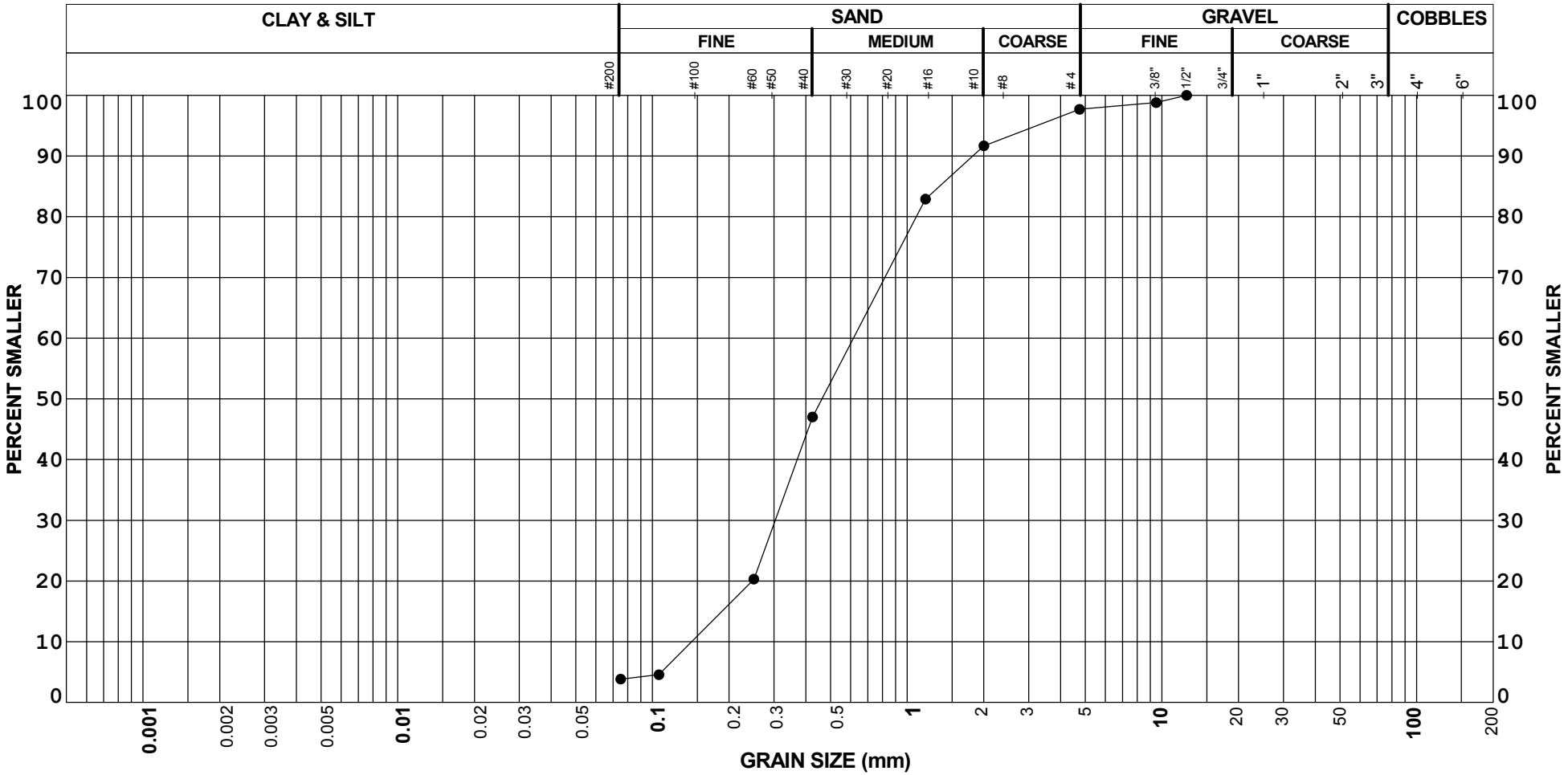
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D004	AS5	7.60	2	94	4		

REMARKS:

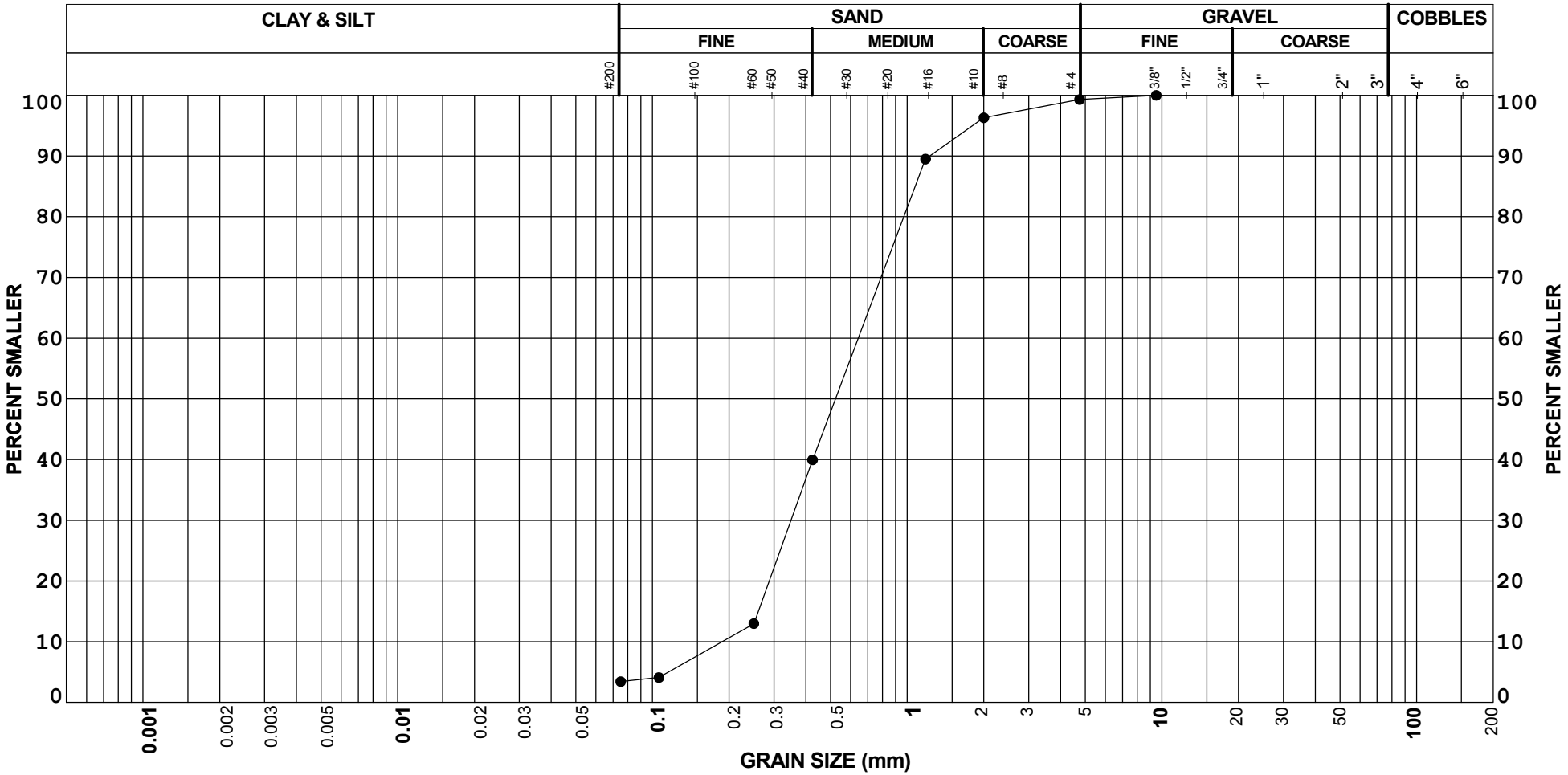
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D004	DS10	18.00	1	96	3		

REMARKS:

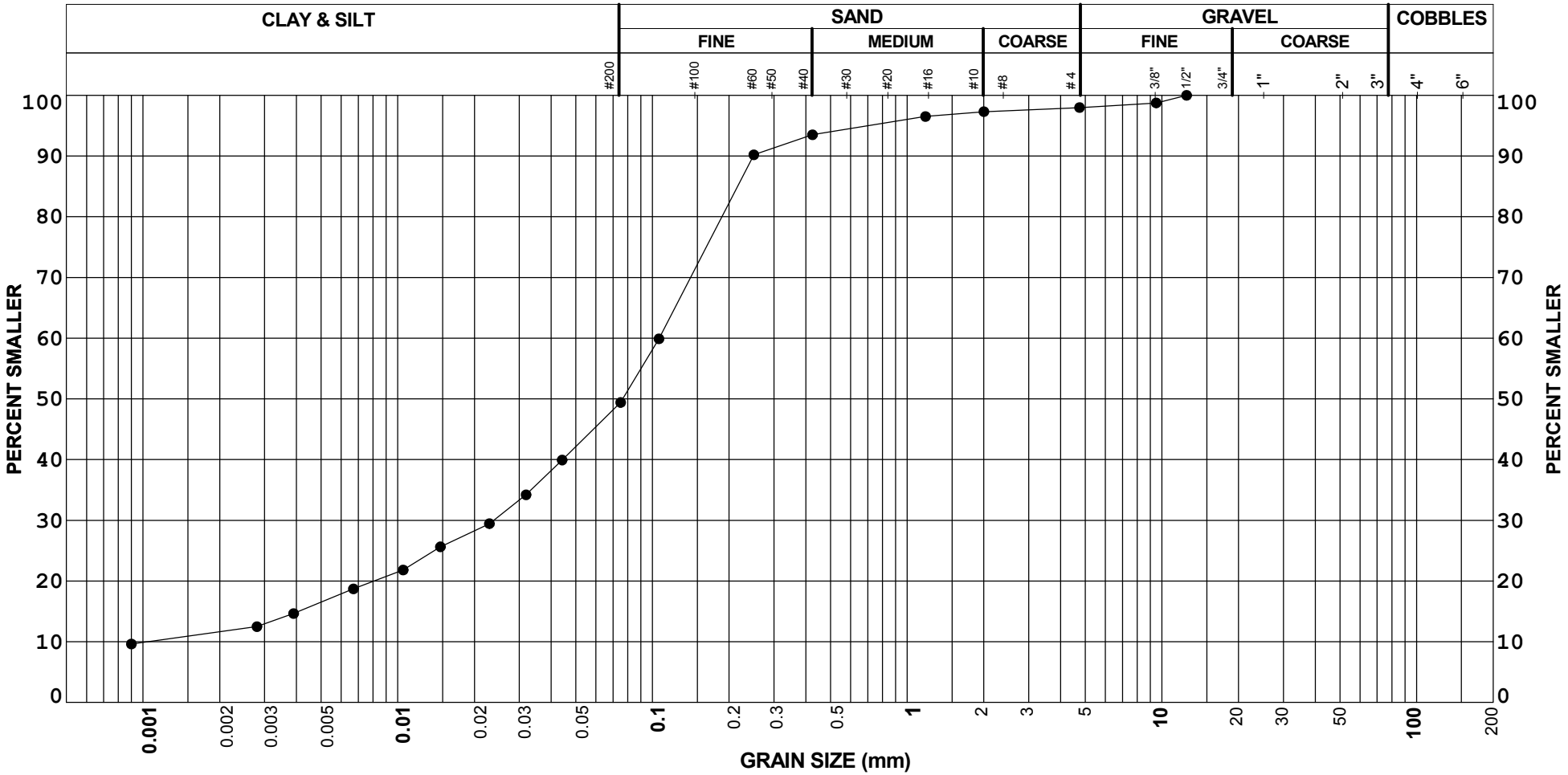
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D004	DS16	29.30	2	49	49		

REMARKS:

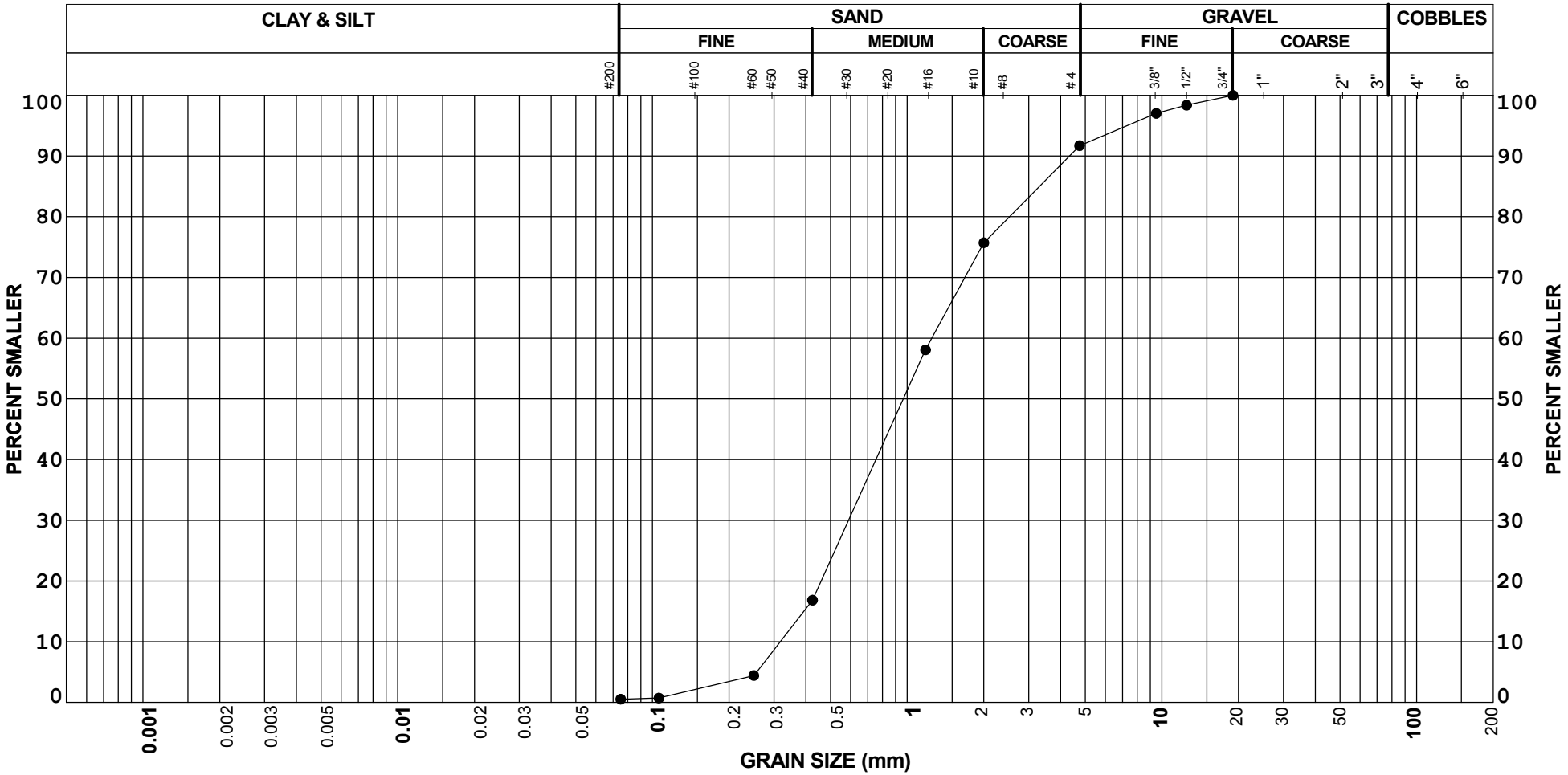
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



REMARKS:

BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D004	DS20	38.70	8	91	1		

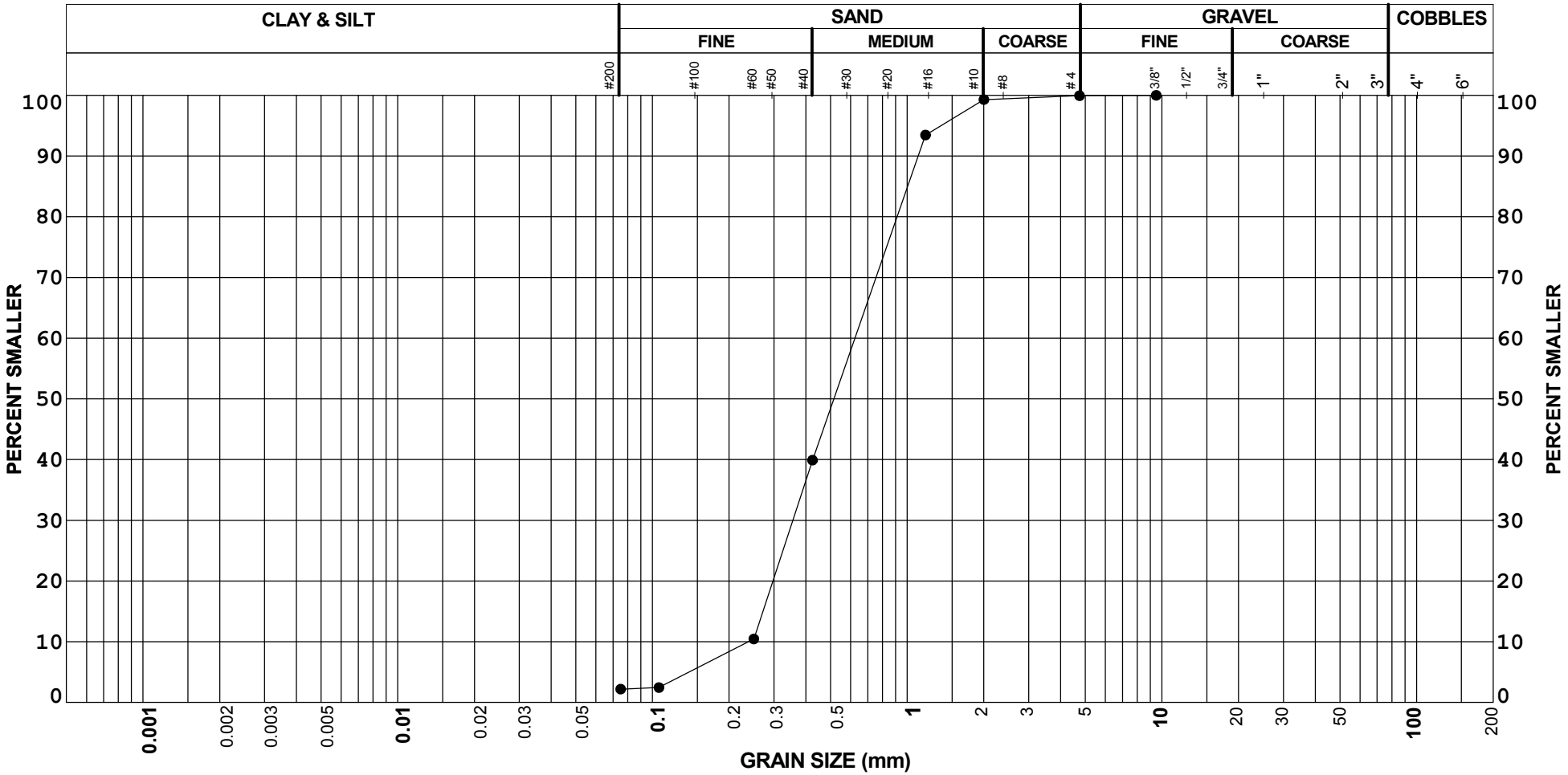
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D004	DS21	42.10	0	98	2		

REMARKS:

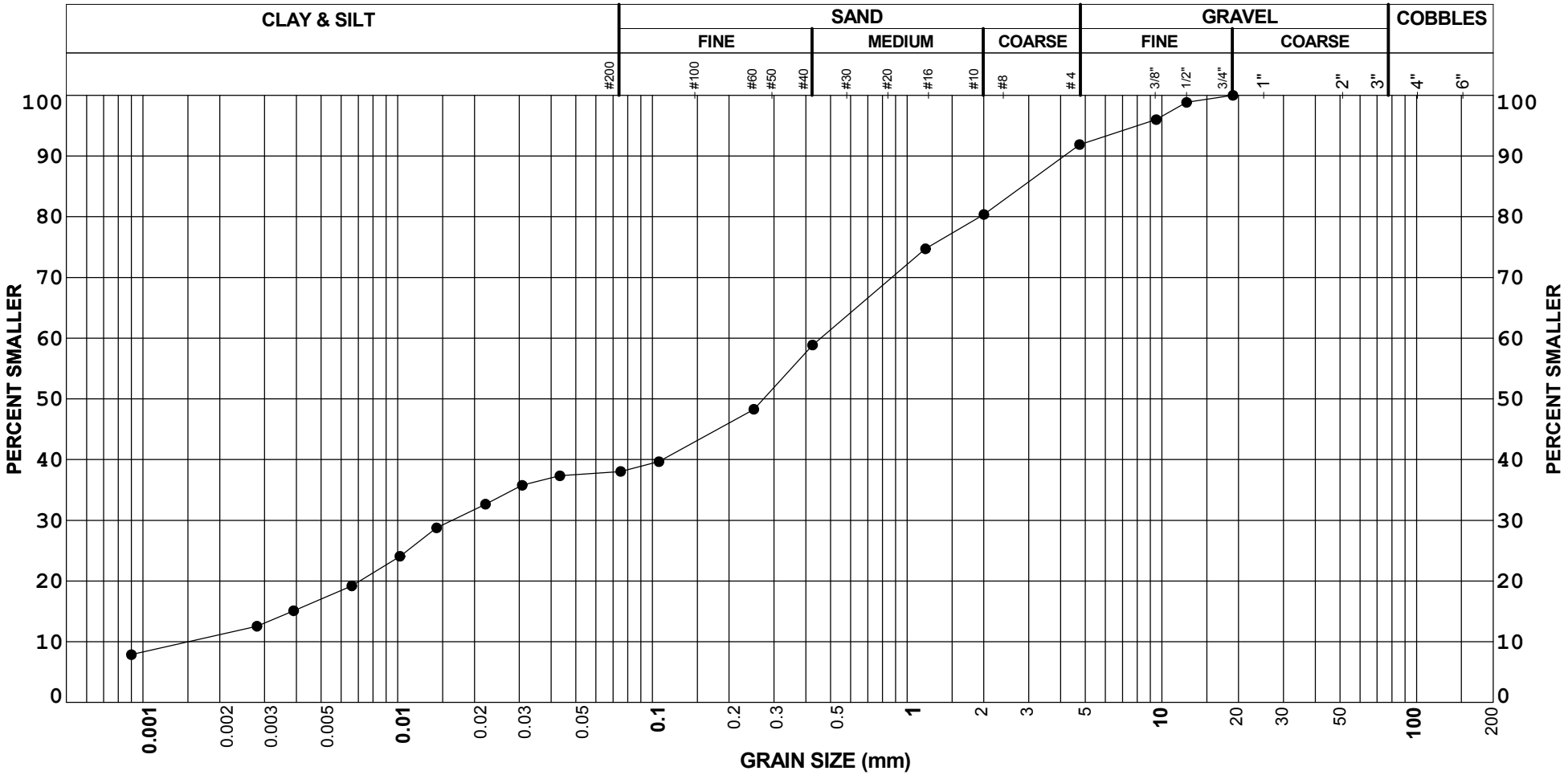
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D005	DS1	0.00	8	54	38		

REMARKS:

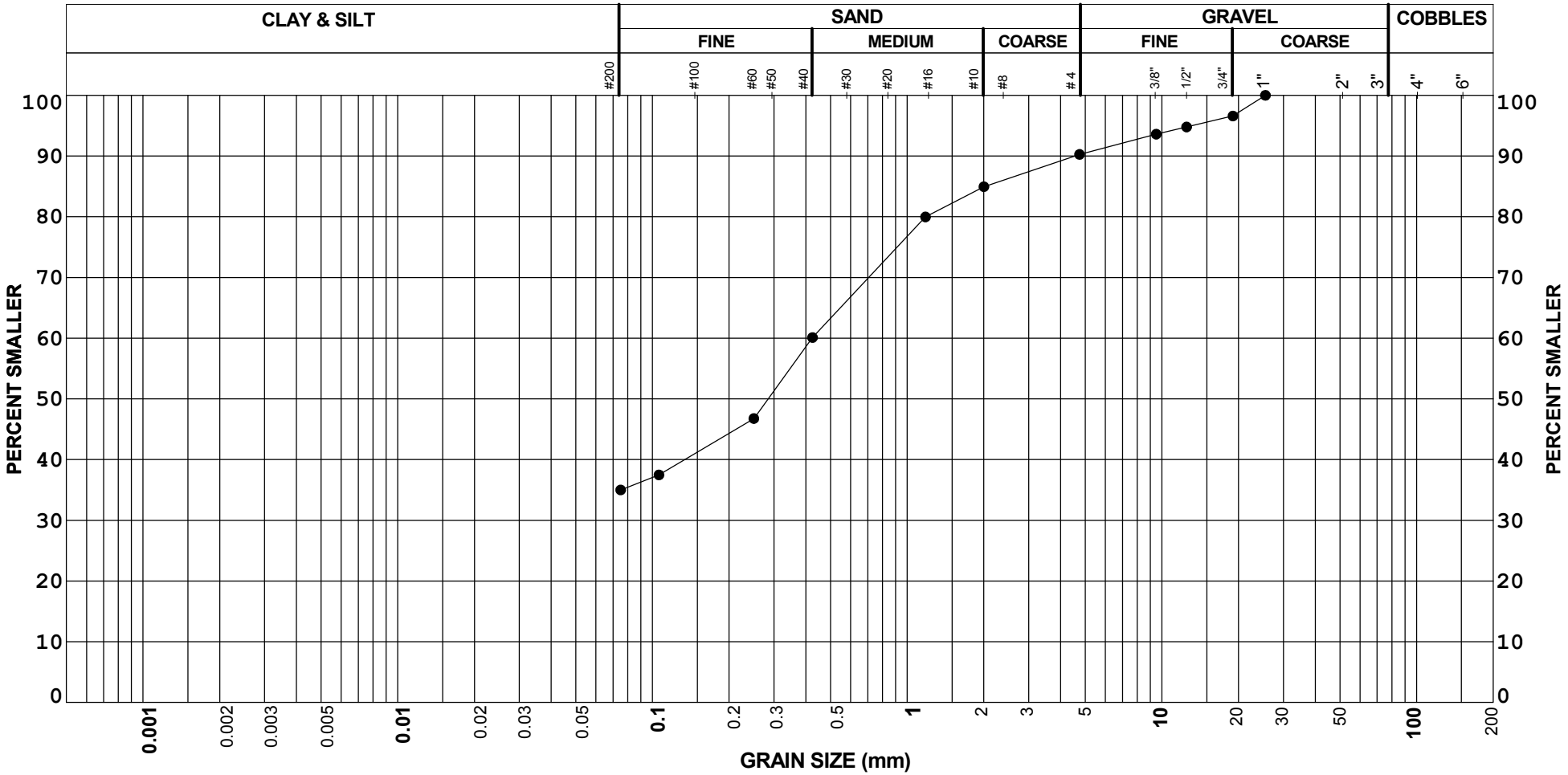
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D005	DS3	7.00	10	55	35		

REMARKS:

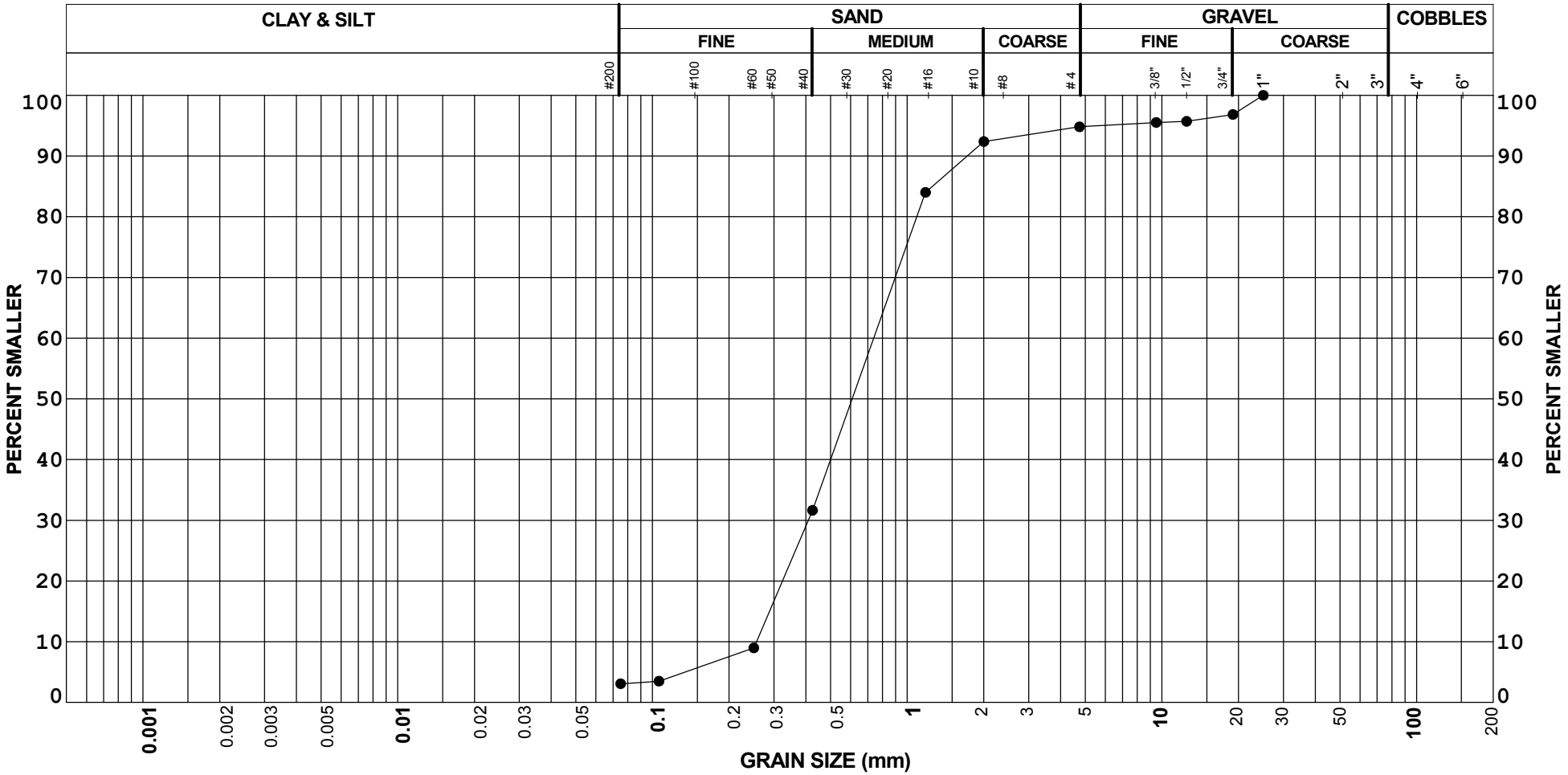
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



REMARKS:

BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D005	DS5	12.80	5	92	3		

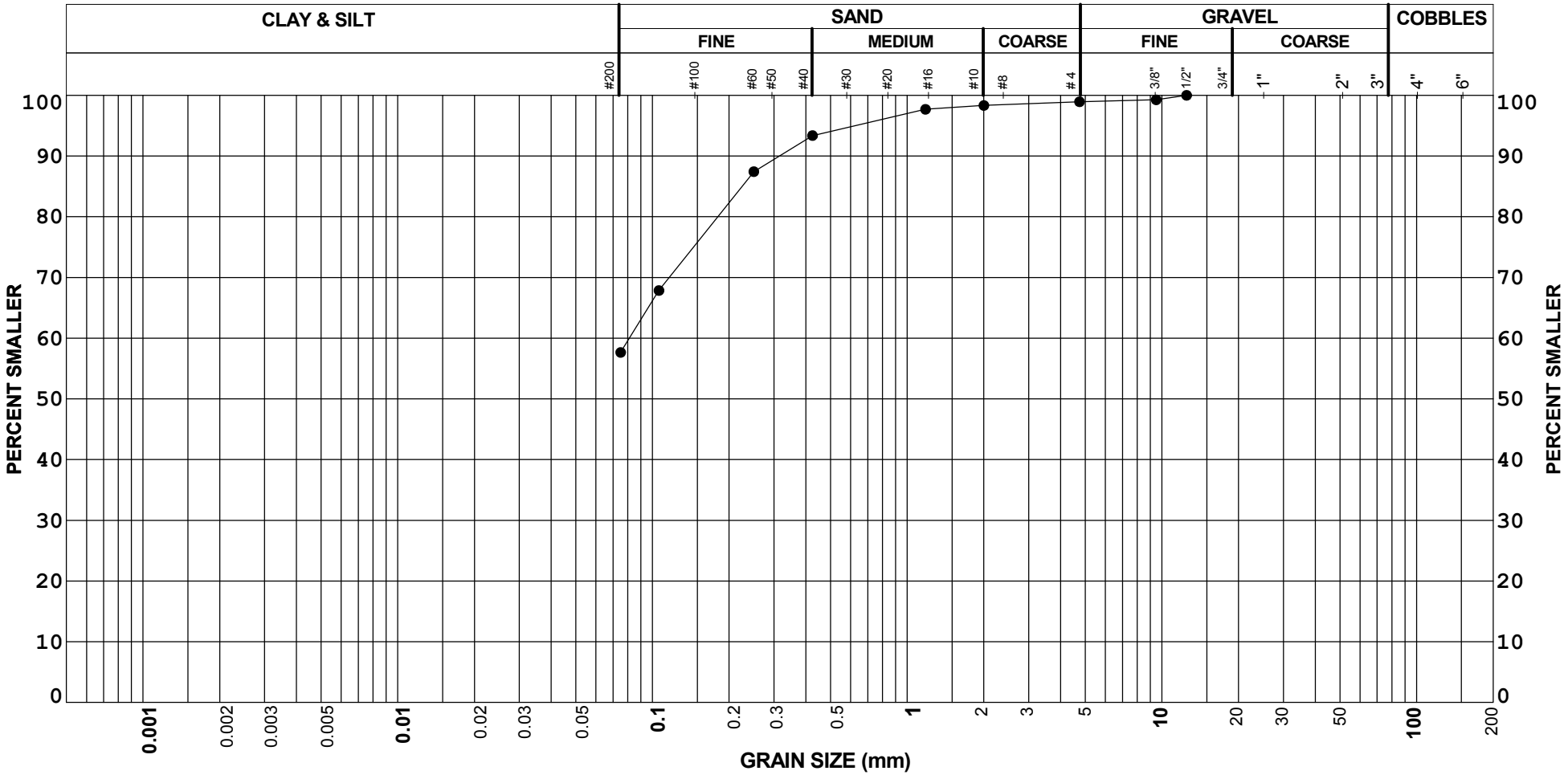
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D005	DS9	21.00	1	41	58		

REMARKS:

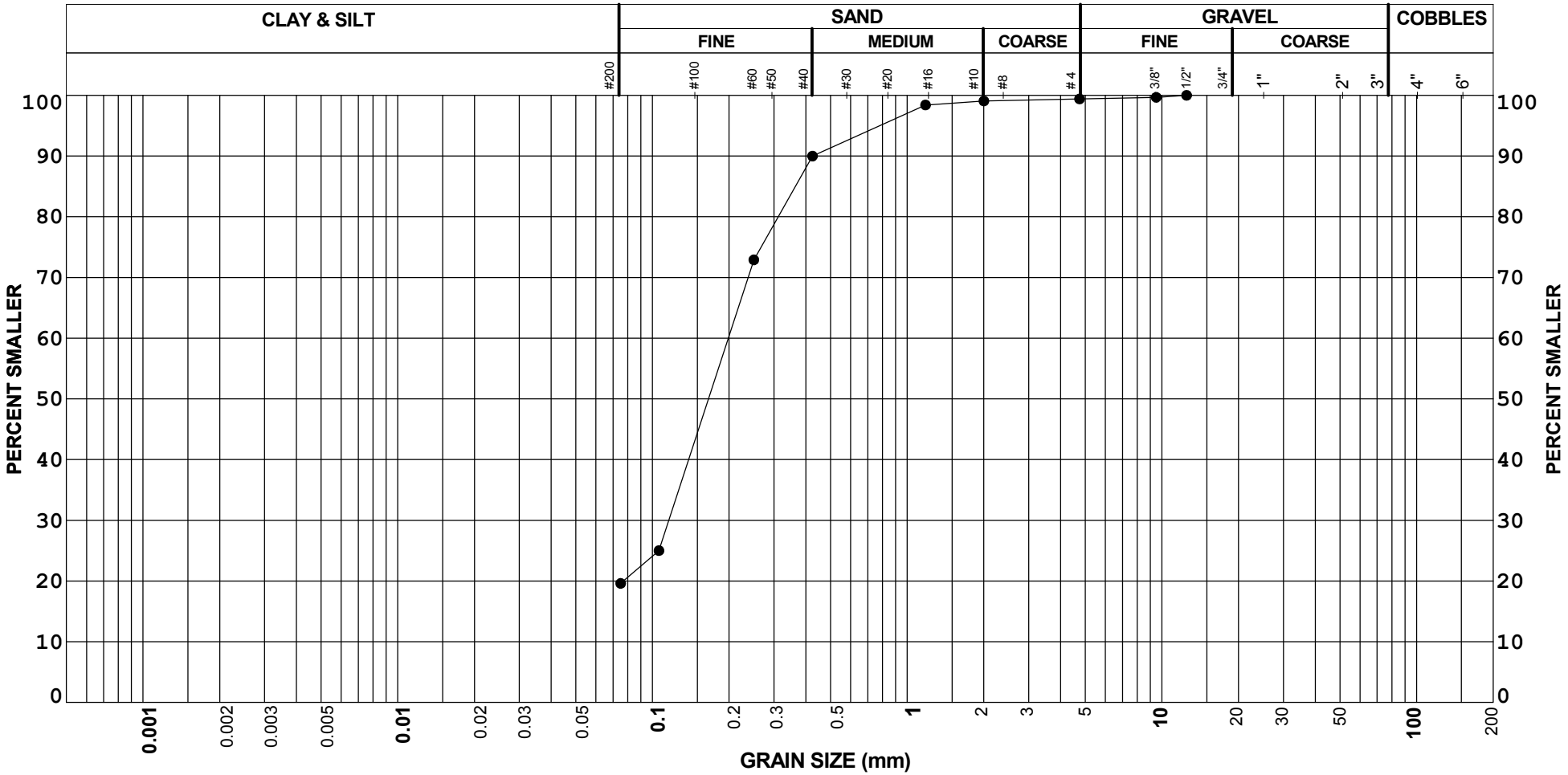
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D005	DS12	25.30	1	80	20		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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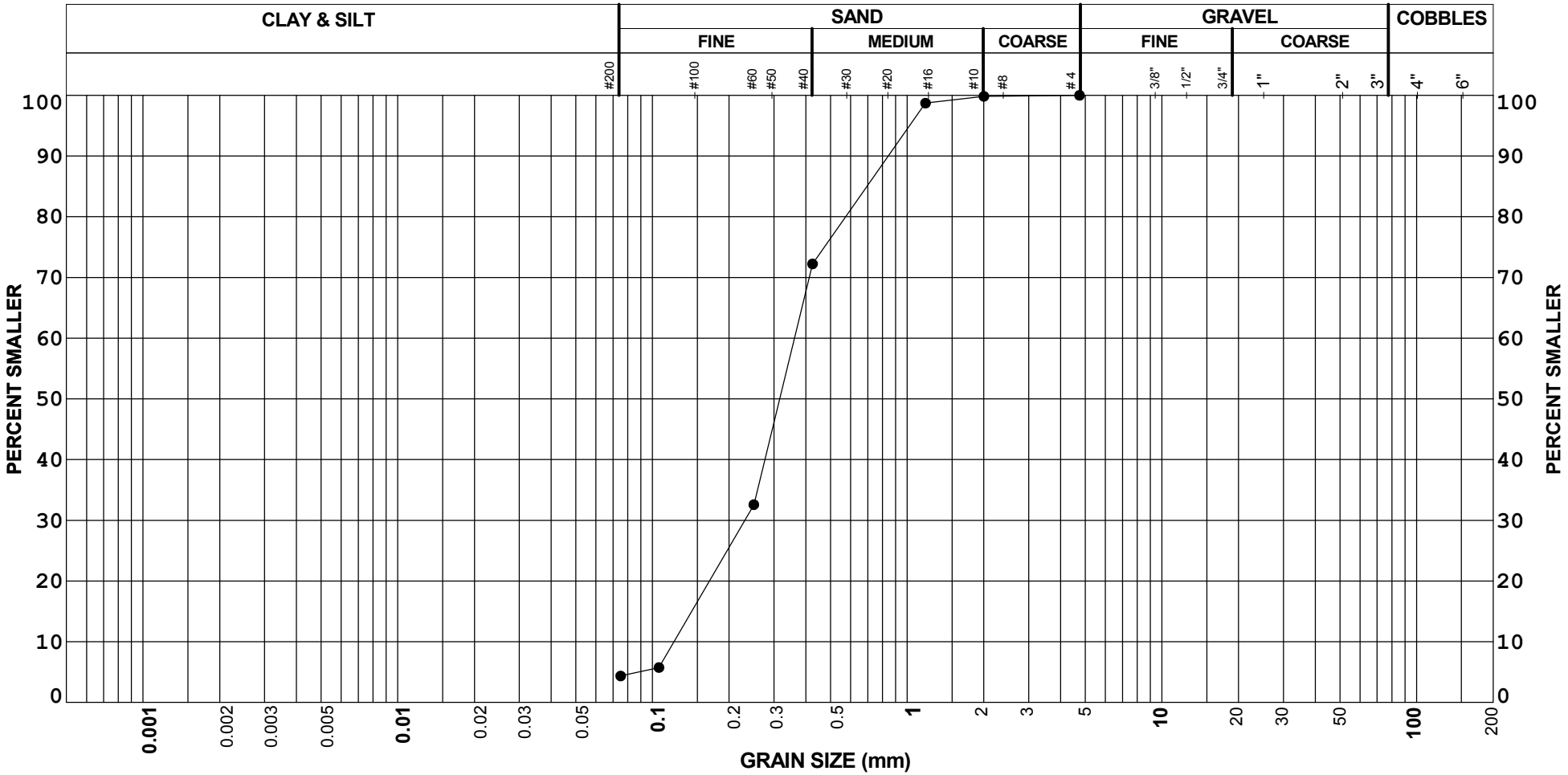
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D005	DS13	28.00	0	96	4		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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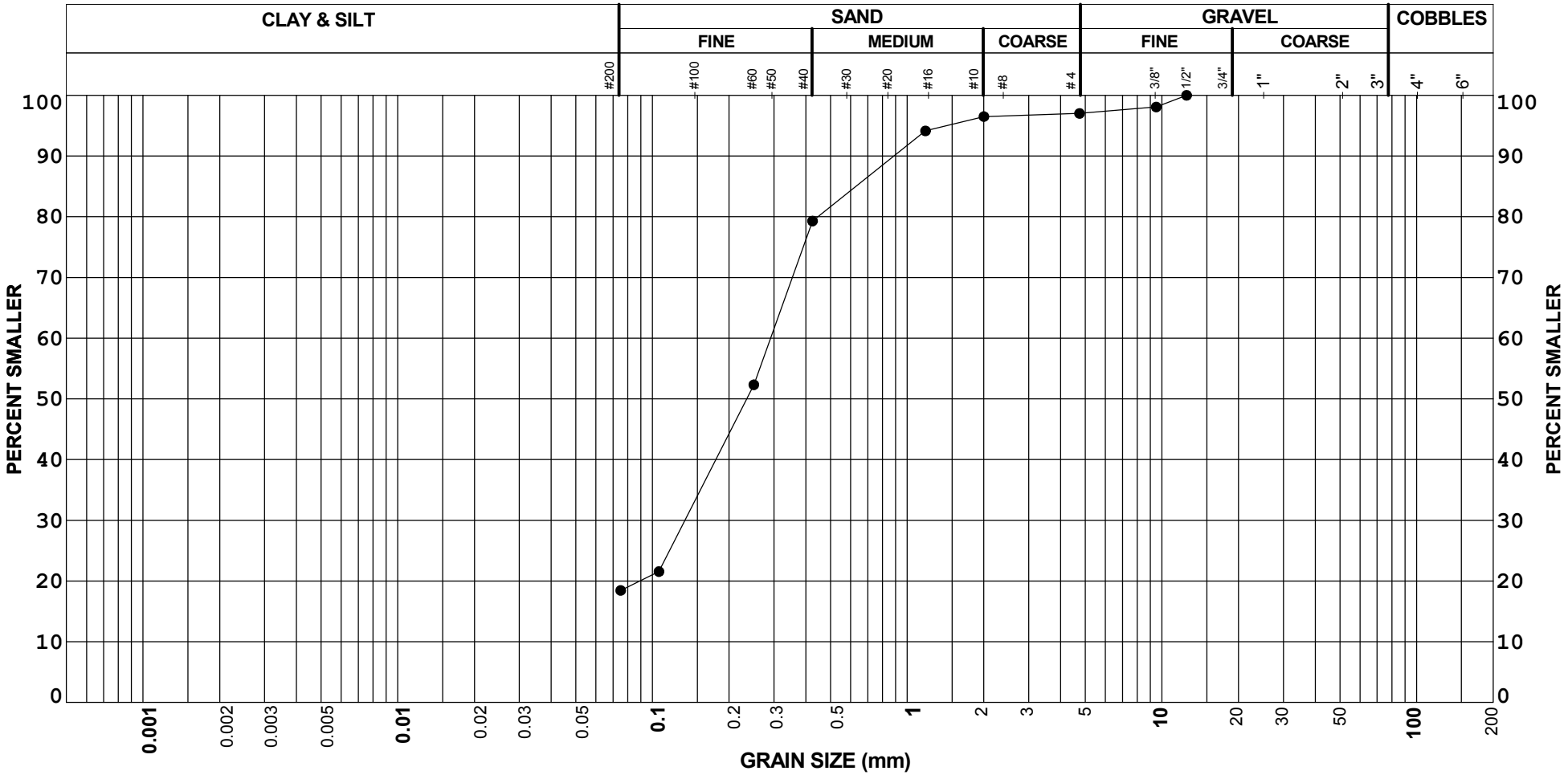

BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D006	AS1	0.00	3	79	18		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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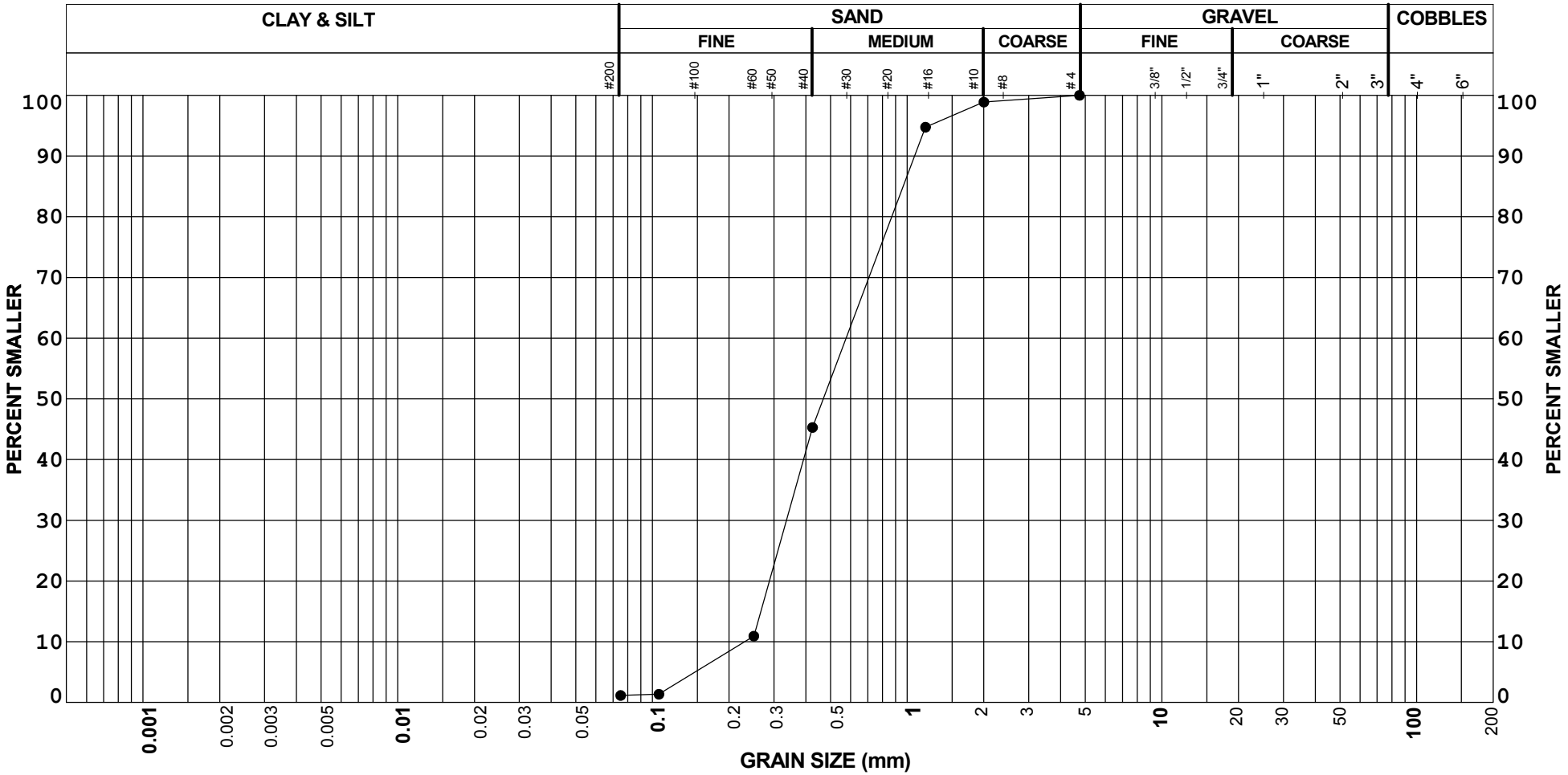
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D006	DS2	2.10	0	99	1		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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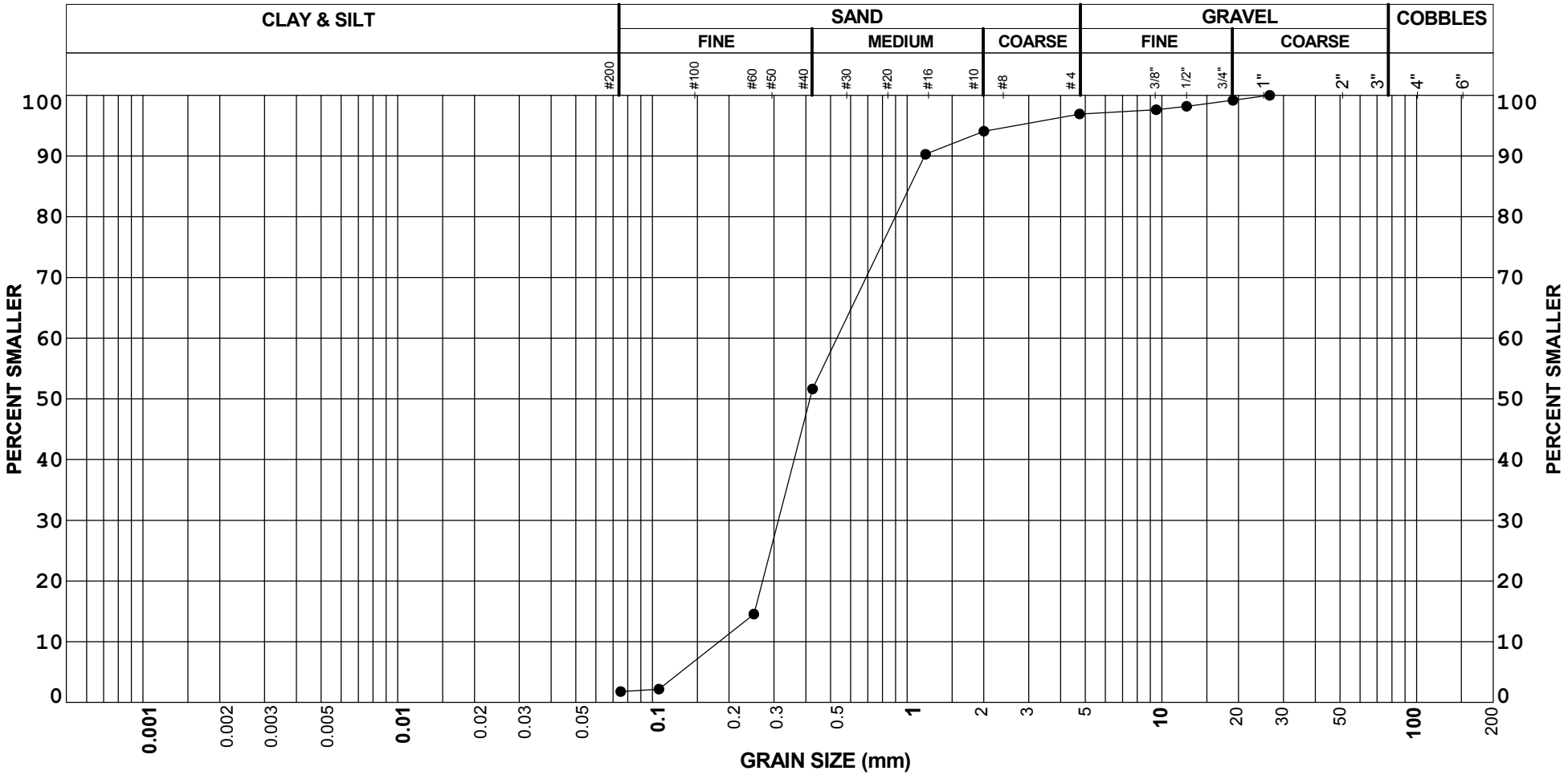
Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D006	DS8	11.60	3	95	2		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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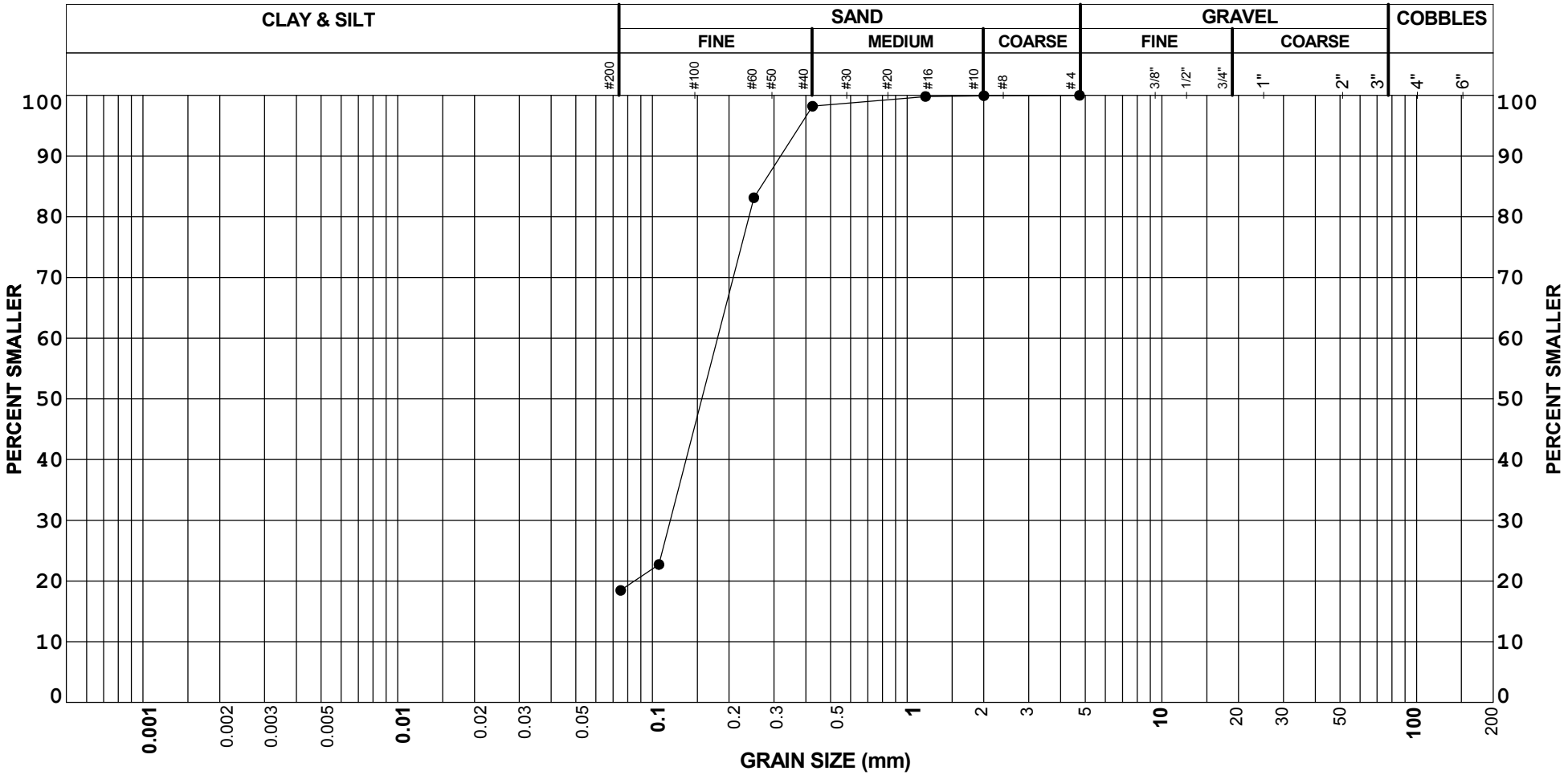
UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D006	DS11	15.80	0	82	18		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

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Project

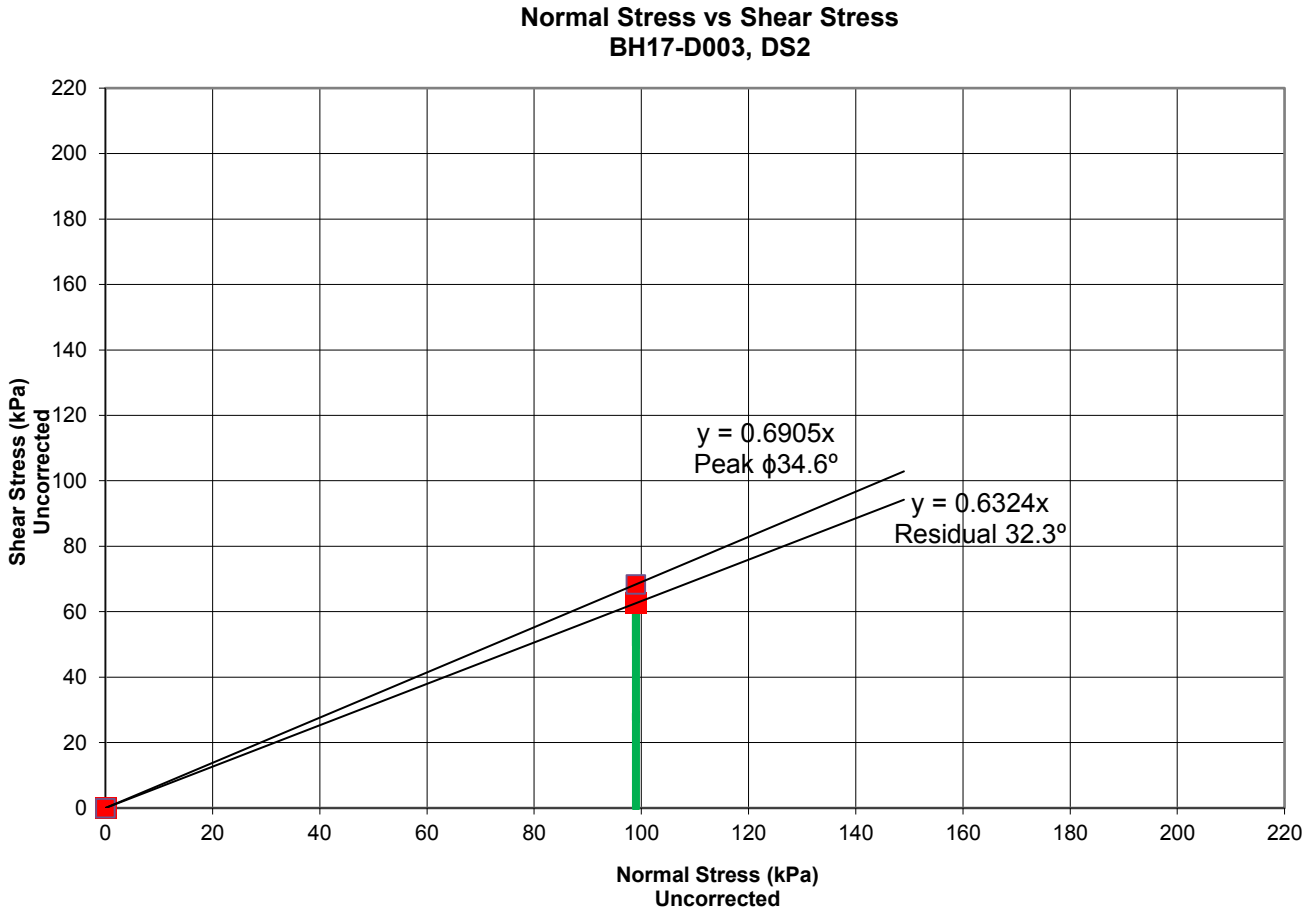
Direct Shear Test of Soils Under Consolidated Drained Conditions

HATCH Geotechnical Laboratory

ASTM D 3080/3080M- 11

Date:	May 19, 2017	Baffinland Iron Mines
Project Number:	H/352034	2275 Upper Middle Rd, Oakville Ont.
Project:	**Mary River Expansion Study Stage 2**	**Attention: Matt Weaver**

Sample	**DS2 from 5.2 m to 5.5 m**
Source	**Milne Port Borehole BH17-D003**



Comments:

Reported by: R.Serluca, Lab Tech, May 23, 2017

Name, Title, Date

Reviewed by: C. Hannon, May 2017

Name, Title, Date

Notice: the test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

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100 kPa Test	Before Test	After Consolidation	After Test
Length and Width (cm)	5.986	********	5.986
Height (cm)	2.950	2.988	********
Area (cm2)	35.832	35.832	35.832
Volume (cm3)	105.705	107.067	********
Tare+Wet Samp. (gm)	2478.700	********	********
Tare (gm)	2247.300	********	********
Wet Weight (gm)	231.400	232.762	********
Water Content (%)	12.176	********	12.577
Tare	46.980	********	47.780
Tare+ Wet Soil	164.630	********	274.690
Tare+ Dry Soil	151.860	********	249.340
Dry Weight (gm)	206.283	********	********
Dry Density (kg/m3)	1951.500	********	********
Wet Density (kg/m3)	2189.112	2173.989	********
Specific Gravity (cm3)	2.700		********
Vol.of Solids (cm3)	76.302	********	********
Void Ratio	1.385	********	********
Deg.of Saturation (%)	85.422	********	********
Height of Solids (cm)	2.13	********	********

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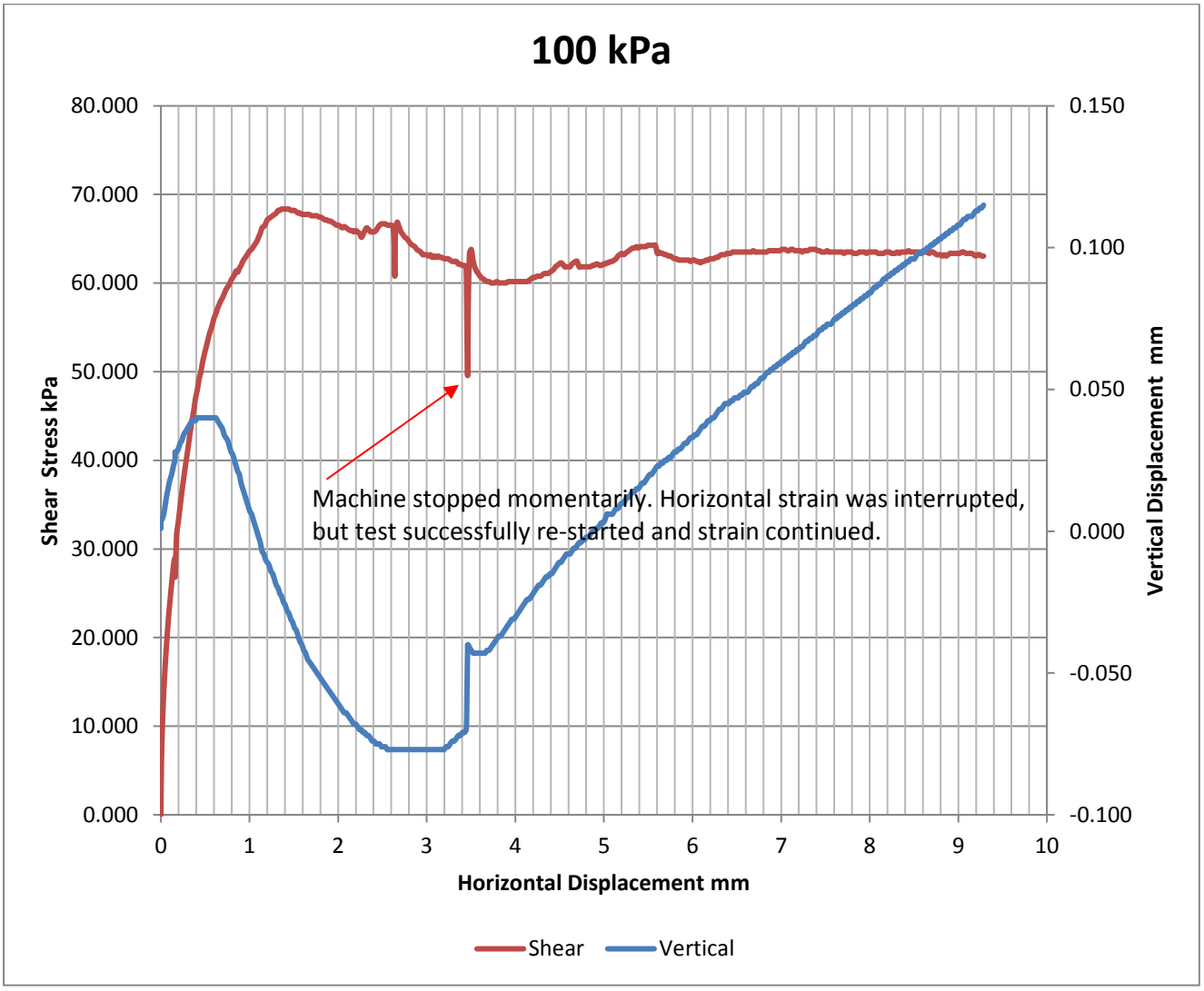

TEST NOTES.

1. Test carried out as per ASTM D3080 remolded and compacted.
2. Test specimen was split from total sample, portion passing 4.75 mm sieve.
3. Test carried out on Shear Machine #1.
4. Shear Rate 0.0043 cm per minute.
5. Value for Specific Gravity is assumed.
6. Peak PHI values are based on highest shear stress to normal stress ratio achieved during the test.
7. Residual PHI was taken at 6 mm train for all 5 samples in test suite.
8. Test data not corrected for area change during shearing as per ASTM.

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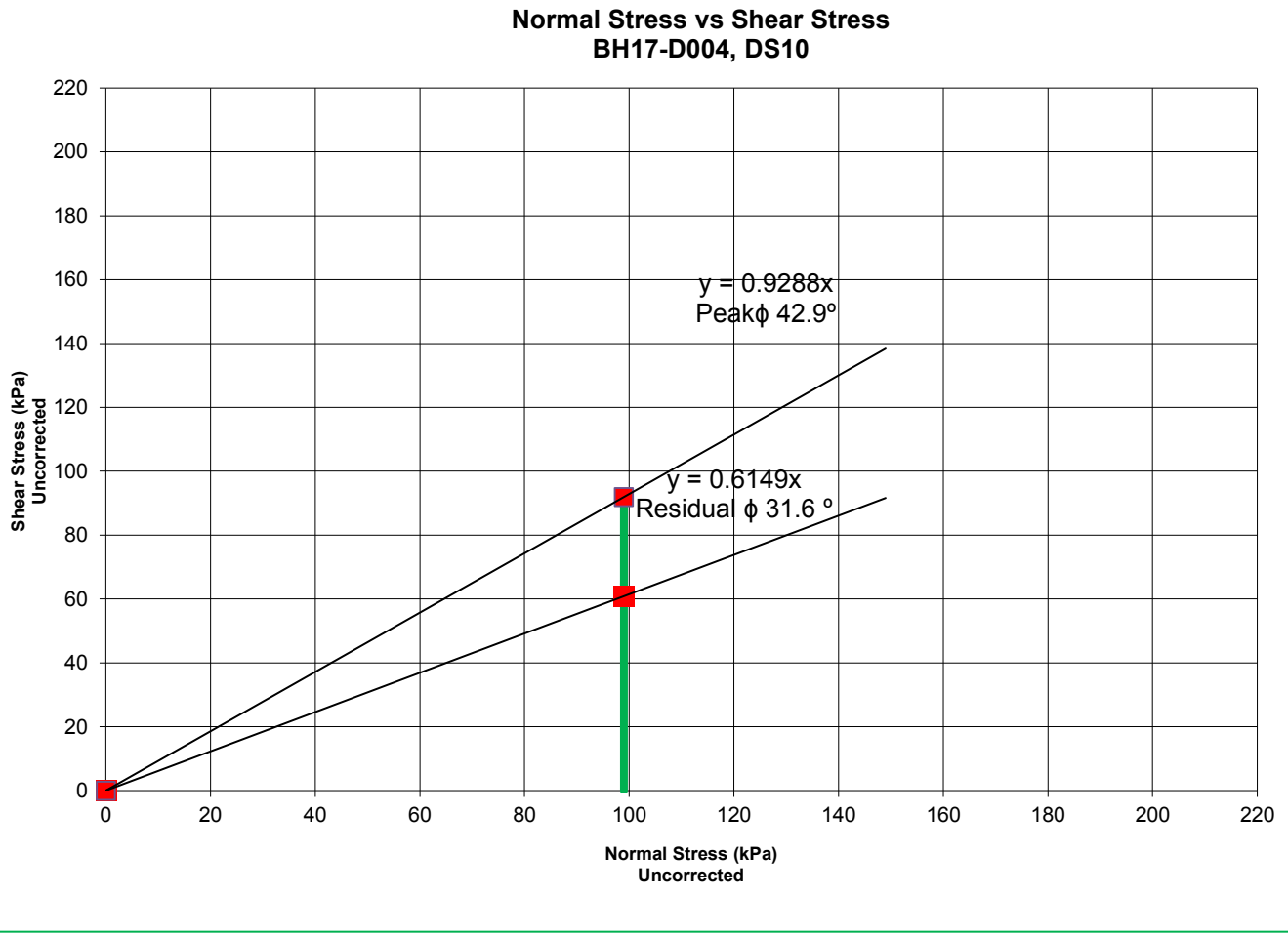
Direct Shear Test of Soils Under Consolidated Drained Conditions

HATCH Geotechnical Laboratory

ASTM D 3080/3080M- 11

Date:	May 19, 2017	Baffinland Iron Mines
Project Number:	H/352034	2275 Upper Middle Rd, Oakville Ont.
Project:	**Mary River Expansion Study Stage 2**	**Attention: Matt Weaver**

Sample	**DS10 from 18.0 m to 18.3 m**
Source	**Milne Port Borehole BH17-D004**



Comments:

Reported by: R.Serluca, Lab Tech, May 23, 2017

Name, Title, Date

Reviewed by: C. Hannon, May 2017

Name, Title, Date

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100 kPa Test	Before Test	After Consolidation	After Test
Length and Width (cm)	5.986	********	5.986
Height (cm)	2.988	2.988	********
Area (cm2)	35.832	35.832	35.832
Volume (cm3)	107.067	107.067	********
Tare+Wet Samp. (gm)	2467.600	********	********
Tare (gm)	2243.100	********	********
Wet Weight (gm)	224.500	224.500	********
Water Content (%)	15.532	********	15.278
Tare	47.650	********	47.650
Tare+ Wet Soil	99.420	********	248.050
Tare+ Dry Soil	92.460	********	221.490
Dry Weight (gm)	194.318	********	********
Dry Density (kg/m3)	1814.927	********	********
Wet Density (kg/m3)	2096.826	2096.826	********
Specific Gravity (cm3)	2.700		********
Vol.of Solids (cm3)	71.876	********	********
Void Ratio	1.490	********	********
Deg.of Saturation (%)	85.767	********	********
Height of Solids (cm)	2.01	********	********

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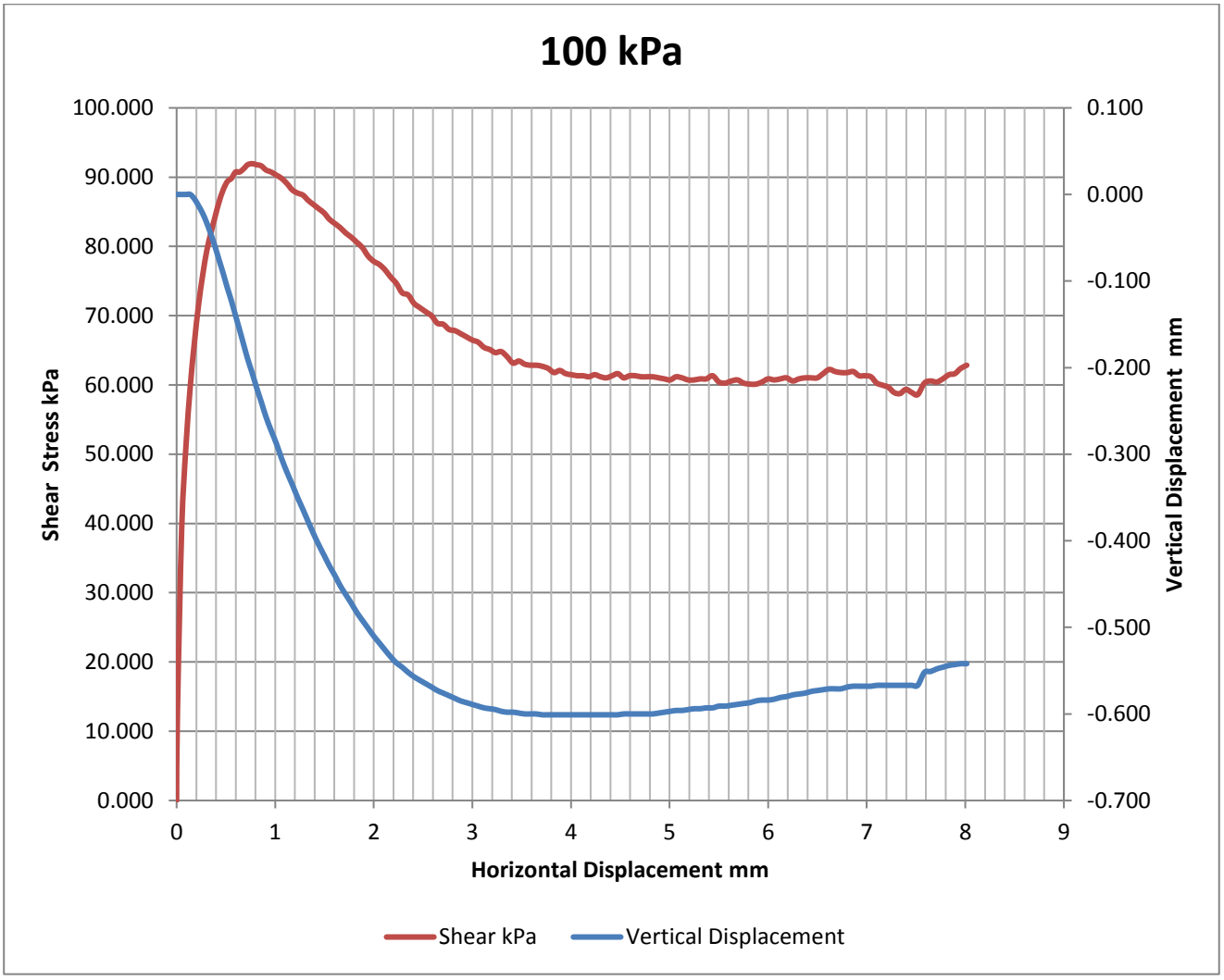

TEST NOTES.

1. Test carried out as per ASTM D3080 remolded and compacted.
2. Test specimen was split from total sample, portion passing 4.75 mm sieve.
3. Test carried out on Shear Machine #1.
4. Shear Rate 0.0114 cm per minute.
5. Value for Specific Gravity is assumed.
6. Peak PHI values are based on highest shear stress to normal stress ratio achieved during the test.
7. Residual PHI was taken at 6 mm train for all 5 samples in test suite.
8. Test data not corrected for area change during shearing as per ASTM.

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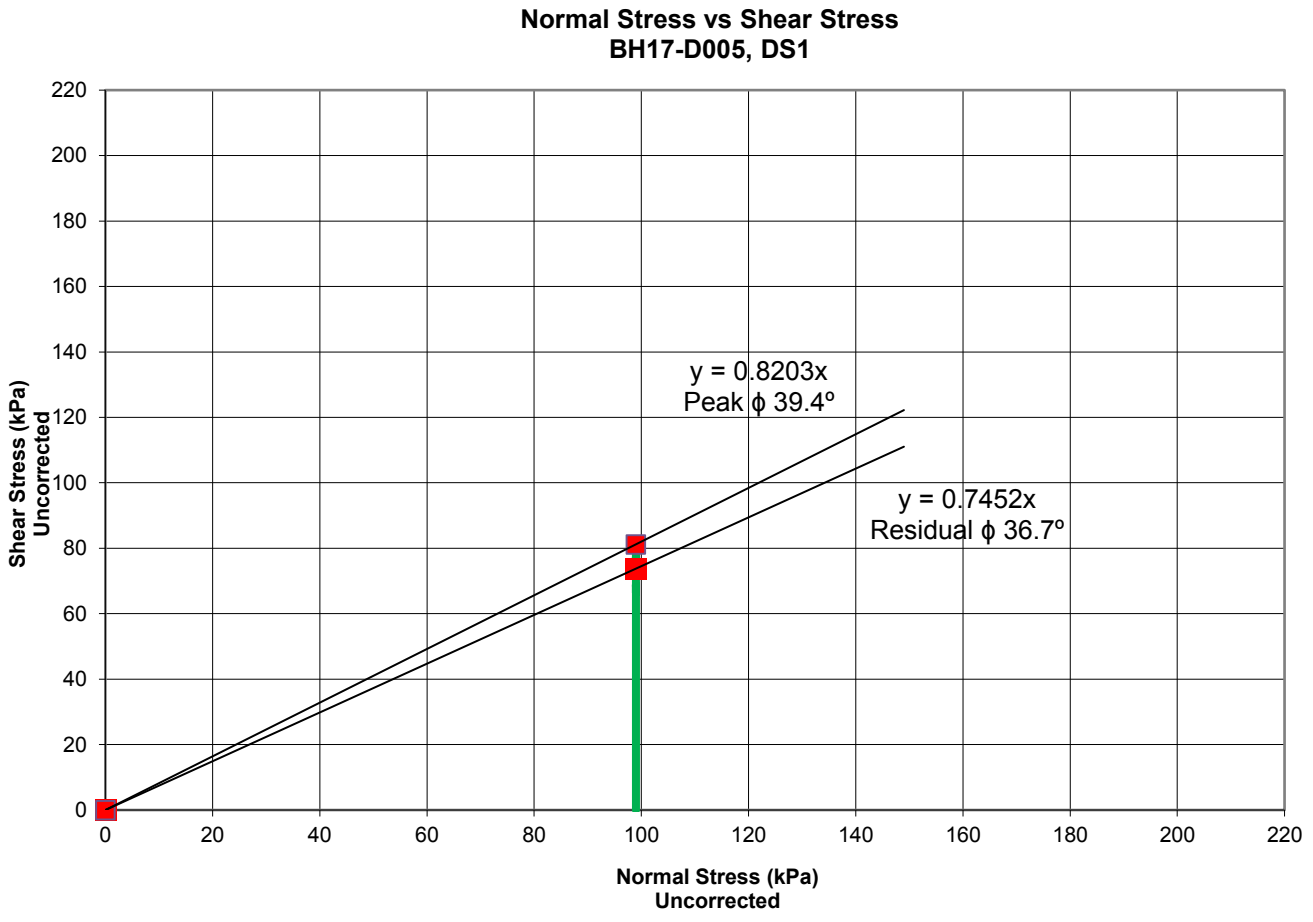
Direct Shear Test of Soils Under Consolidated Drained Conditions

HATCH Geotechnical Laboratory

ASTM D 3080/3080M- 11

Date:	May 29, 2017	Baffinland Iron Mines
Project Number:	H/352034	2275 Upper Middle Rd, Oakville Ont.
Project:	**Mary River Expansion Study Stage 2**	**Attention: Matt Weaver**

Sample	**DS1 from 0.0 m to 0.3 m**
Source	**Milne Port Borehole BH17-D005**



Comments:

Reported by: R.Serluca, Lab Tech, May 23, 2017

Name, Title, Date

Reviewed by: C. Hannon, May 2017

Name, Title, Date

Notice: the test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

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100 kPa Test	Before Test	After Consolidation	After Test
Length and Width (cm)	5.986	********	5.986
Height (cm)	2.950	2.796	********
Area (cm2)	35.832	35.832	35.832
Volume (cm3)	105.705	100.183	********
Tare+Wet Samp. (gm)	2479.200	********	********
Tare (gm)	2246.000	********	********
Wet Weight (gm)	233.200	227.678	********
Water Content (%)	13.106	********	15.508
Tare	48.180	********	48.640
Tare+ Wet Soil	166.840	********	273.880
Tare+ Dry Soil	153.090	********	243.640
Dry Weight (gm)	206.177	********	********
Dry Density (kg/m3)	1950.499	********	********
Wet Density (kg/m3)	2206.140	2272.618	********
Specific Gravity (cm3)	2.700		********
Vol.of Solids (cm3)	76.263	********	********
Void Ratio	1.386	********	********
Deg.of Saturation (%)	91.782	********	********
Height of Solids (cm)	2.13	********	********

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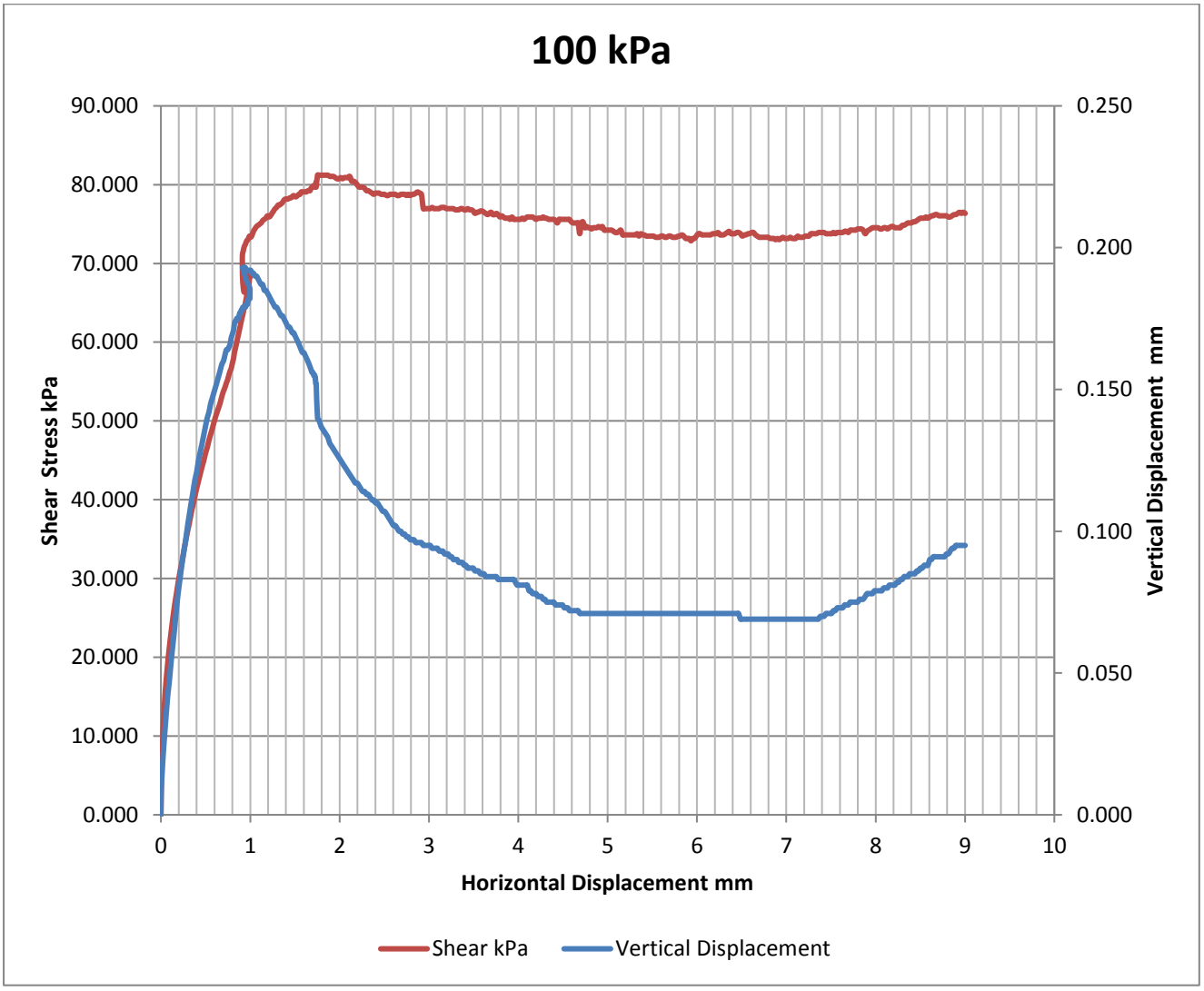

TEST NOTES.

1. Test carried out as per ASTM D3080 remolded and compacted.
2. Test specimen was split from total sample, portion passing 4.75 mm sieve.
3. Test carried out on Shear Machine #1.
4. Shear Rate 0.0043 cm per minute.
5. Value for Specific Gravity is assumed.
6. Peak PHI values are based on highest shear stress to normal stress ratio achieved during the test.
7. Residual PHI was taken at 6 mm train for all 5 samples in test suite.
8. Test data not corrected for area change during shearing as per ASTM.

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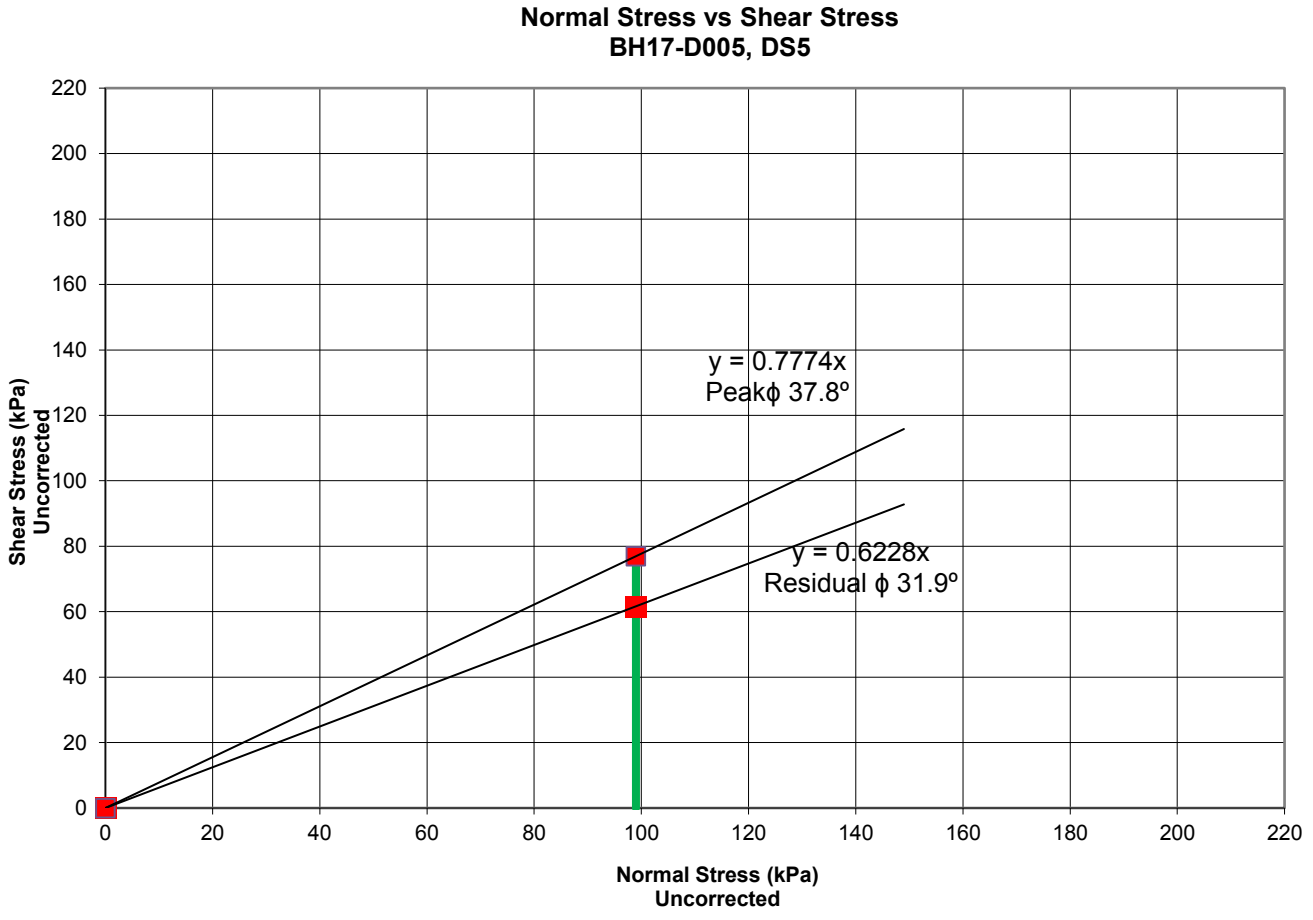
Direct Shear Test of Soils Under Consolidated Drained Conditions

HATCH Geotechnical Laboratory

ASTM D 3080/3080M- 11

Date:	June 1, 2017	Baffinland Iron Mines
Project Number:	H/352034	2275 Upper Middle Rd, Oakville Ont.
Project:	**Mary River Expansion Study Stage 2**	**Attention: Matt Weaver**

Sample	**DS5 from 12.8 m to 13.1 m**
Source	**Milne Port Borehole BH17-D005**



Comments:

Reported by: R.Serluca, Lab Tech, May 23, 2017

Name, Title, Date

Reviewed by: C. Hannon, May 2017

Name, Title, Date

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100 kPa Test	Before Test	After Consolidation	After Test
Length and Width (cm)	5.986	********	5.986
Height (cm)	2.950	2.887	********
Area (cm2)	35.832	35.832	35.832
Volume (cm3)	105.705	103.448	********
Tare+Wet Samp. (gm)	2443.500	********	********
Tare (gm)	2247.200	********	********
Wet Weight (gm)	196.300	194.043	********
Water Content (%)	7.175	********	17.599
Tare	47.680	********	46.970
Tare+ Wet Soil	146.570	********	238.080
Tare+ Dry Soil	139.950	********	209.480
Dry Weight (gm)	183.159	********	********
Dry Density (kg/m3)	1732.738	********	********
Wet Density (kg/m3)	1857.055	1875.758	********
Specific Gravity (cm3)	2.700		********
Vol.of Solids (cm3)	67.749	********	********
Void Ratio	1.560	********	********
Deg.of Saturation (%)	34.621	********	********
Height of Solids (cm)	1.89	********	********

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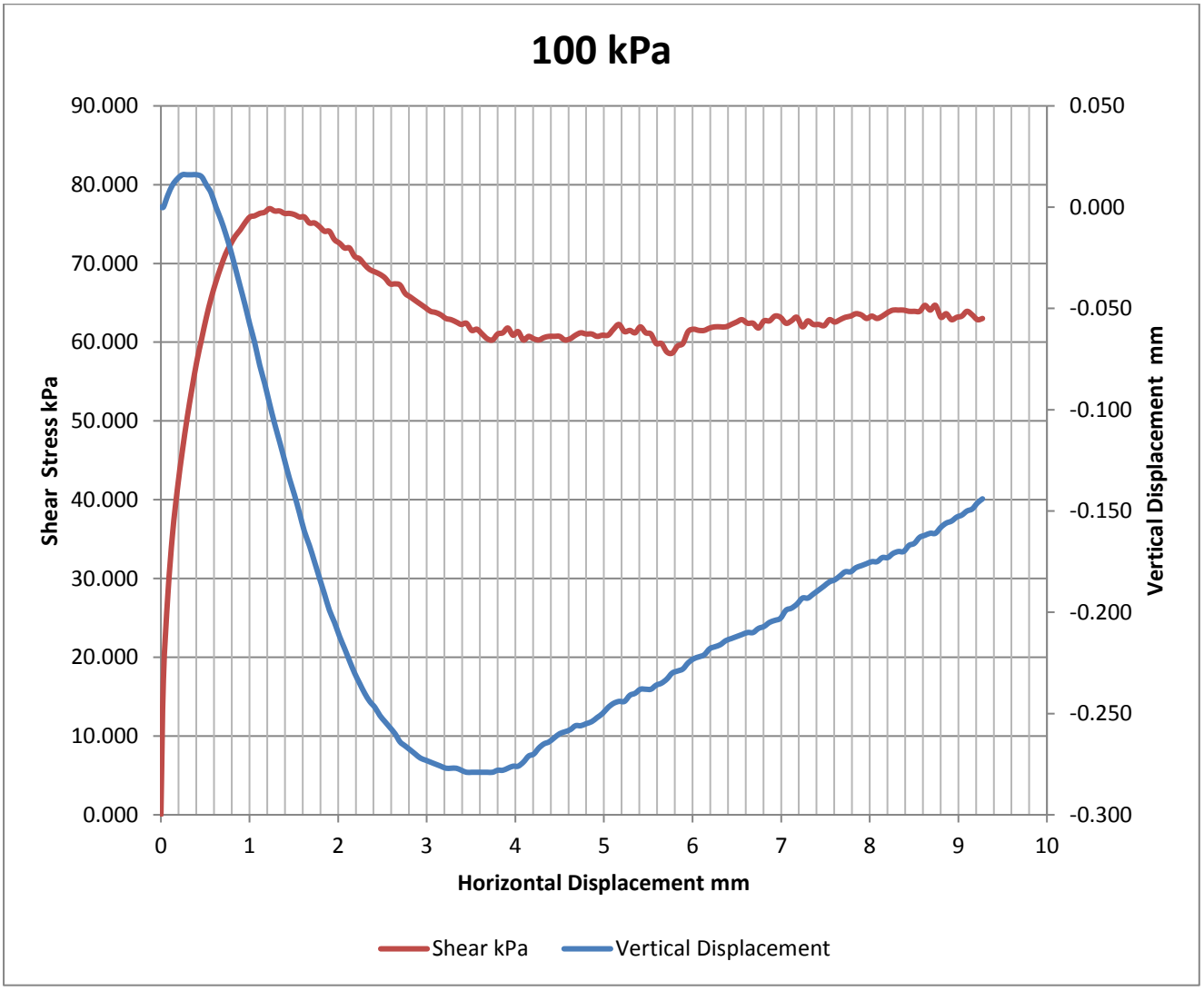

TEST NOTES.

1. Test carried out as per ASTM D3080 remolded and compacted.
2. Test specimen was split from total sample, portion passing 4.75 mm sieve.
3. Test carried out on Shear Machine #1.
4. Shear Rate 0.0117 cm per minute.
5. Value for Specific Gravity is assumed.
6. Peak PHI values are based on highest shear stress to normal stress ratio achieved during the test.
7. Residual PHI was taken at 6 mm train for all 5 samples in test suite.
8. Test data not corrected for area change during shearing as per ASTM.

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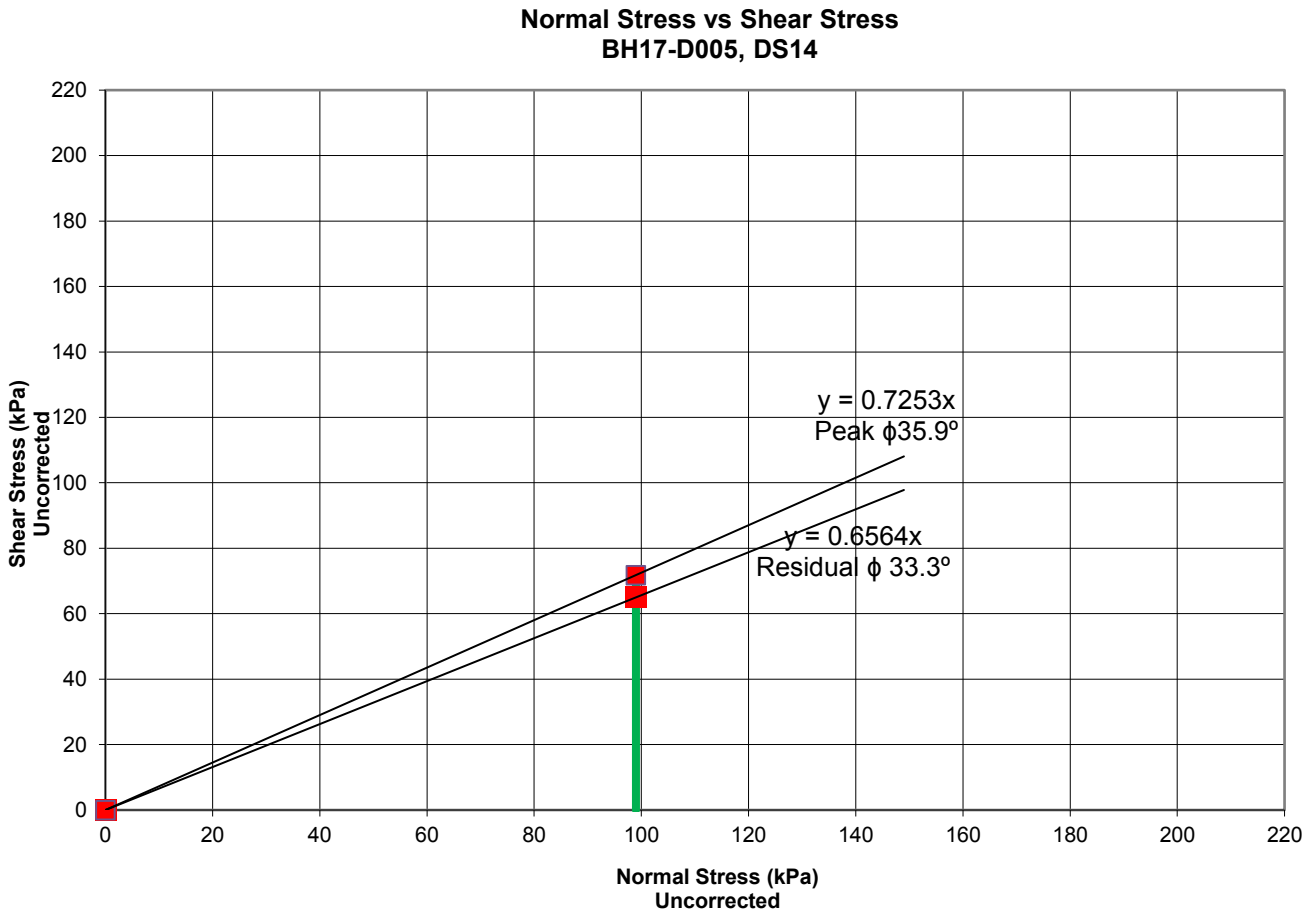
Direct Shear Test of Soils Under Consolidated Drained Conditions

HATCH Geotechnical Laboratory

ASTM D 3080/3080M- 11

Date:	May 31, 2017	Baffinland Iron Mines
Project Number:	H/352034	2275 Upper Middle Rd, Oakville Ont.
Project:	**Mary River Expansion Study Stage 2**	**Attention: Matt Weaver**

Sample	**DS14 from 30.5 m to 31.1 m**
Source	**Milne Port Borehole BH17-D005**



Comments:

Reported by: R.Serluca, Lab Tech, May 23, 2017

Name, Title, Date

Reviewed by: C. Hannon, May 2017

Name, Title, Date

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100 kPa Test	Before Test	After Consolidation	After Test
Length and Width (cm)	5.986	********	5.986
Height (cm)	2.950	2.913	********
Area (cm2)	35.832	35.832	35.832
Volume (cm3)	105.705	104.368	********
Tare+Wet Samp. (gm)	2463.000	********	********
Tare (gm)	2246.700	********	********
Wet Weight (gm)	216.300	214.963	********
Water Content (%)	10.557	********	15.945
Tare	47.070	********	47.290
Tare+ Wet Soil	117.760	********	254.170
Tare+ Dry Soil	111.010	********	225.720
Dry Weight (gm)	195.646	********	********
Dry Density (kg/m3)	1850.869	********	********
Wet Density (kg/m3)	2046.261	2059.660	********
Specific Gravity (cm3)	2.700		********
Vol.of Solids (cm3)	72.367	********	********
Void Ratio	1.461	********	********
Deg.of Saturation (%)	61.954	********	********
Height of Solids (cm)	2.02	********	********

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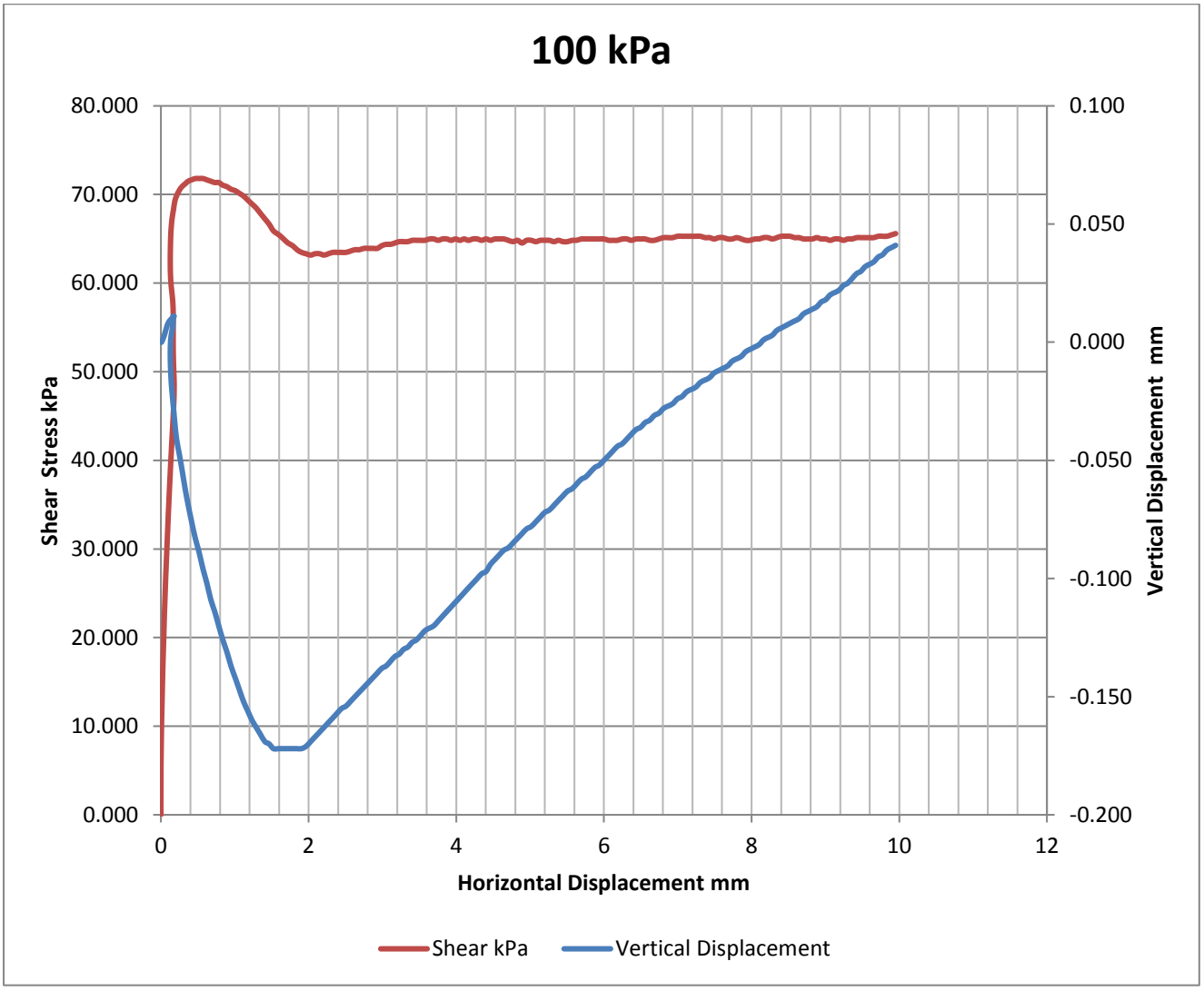

TEST NOTES.

1. Test carried out as per ASTM D3080 remolded and compacted.
2. Test specimen was split from total sample, portion passing 4.75 mm sieve.
3. Test carried out on Shear Machine #1.
4. Shear Rate 0.0116 cm per minute.
5. Value for Specific Gravity is assumed.
6. Peak PHI values are based on highest shear stress to normal stress ratio achieved during the test.
7. Residual PHI was taken at 6 mm train for all 5 samples in test suite.
8. Test data not corrected for area change during shearing as per ASTM.

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Appendix E

Geotechnical Investigation Job Hazard Analysis

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1. Introduction

A geotechnical field investigation is underway to gather subsurface data for the 12 Mtpa mine expansion prefeasibility study, which includes an offshore (on ice) investigation for the proposed Ore Dock No. 2. This job hazard analysis (JHA) presents an assessment of the hazards and control measures to reduce the likelihood or consequence of the hazards in order to carry out the offshore investigation program. There are a total of 10 proposed boreholes for the dock area including 5 sonic boreholes and 5 Piezocone (CPTu) test holes.

Job Hazard Analysis Form

PROJECT/TASK: ZG003 Geotechnical Marine Drilling Milne Inlet		**Department: Projects Boart Longyear**				**JOB No.:ZG003**			
SUPERVISOR: Emile Beauchamp		**LOCATION: Future Ore Dock Milne Inlet**				**DATE: March 12 ,2017**			
JOB STEP Break the job into steps. Listing work which may be hazardous.	**HAZARDS** List the hazard or type of harm identified with each step.	**Inherent**			**CONTROL MEASURE** List the necessary control measures to be followed to eliminate/reduce the identified hazards.	**Residual**			**ACTION** Person who will ensure this happens
		Consequence	**Likelihood**	**Risk Ranking**		**Consequence**	**Likelihood**	**Risk Ranking**	
1. Pre-job JHA Review.	Missing critical items on the JHA that can lead to an incident	3	2	5	Conduct a pre-job JHA review with Safety and critical team members All workers will have the opportunity to identify changes needed Any changes will be added to this document	1	1	2	Marlon Coakley/Warren Hoyle
2. Workers to complete FLRA card in the field at location prior to starting work.	Additional hazards in the area that may not have been identified on the JHA and daily changes that may pose additional danger to the health and safety of workers, the environment and property	3	3	6	Look at immediate work area for hazards that may exist, not identified on the JHA. Have other workers in the group sign off on the FLHA	1	1	2	All workers
3. Load Weights – The number and types of vehicles and equipment and their maximum gross weights	Not knowing load calculations will run the risk of breaking through the ice.	5	3	8	All equipment and material shall have posted GVW or gross equipment weight or maximum pull back loads available for use with load-ice thickness tables and shall follow the Ice Safety Plan. Refer to Attachment B for minimum ice thickness required for the drilling operations and Attachment C for further guidelines regarding Ice Safety	4	2	6	Warren Hoyle

4. General Site	Ice Conditions – Slip falls Ice Conditions – Adequate load bearing capacity Inadequate lighting Interaction with a Polar Bear Cold Whiteout conditions Emergency Procedures	3	2	5	Construct a working platform for outside of drill shack to store drill steel and allow the use of salt Use of traction aids on work boots will be required for work on ice surfaces. Apply salt to drill shack decks Engineered Assessment of minimum ice thickness as referenced in Attachment B for ice thickness required for the drilling operations and Attachment C for further guidelines regarding Ice Safety Place delineators in the snow marking access from the drilling location to the shoreline Existing Baffinland procedure “Safely Working On Fresh And Salt Water Ice” shall be followed Polar Bear Monitor will be available at all times Employees will have appropriate PPE including clothing available for safely working in -40 C and windy conditions Worksite location is approximately 300 meters from the shoreline. No work will be conducted in whiteout conditions and a safety shelter will be available immediately adjacent to the work area Site emergency procedures will be provided and reviewed at site	2	1	3	All Crew

5. Working around water and sea ice	Water may appear to be completely frozen over, but not enough to support persons Falling in water Equipment breaking through ice Workers unaware of potential dangerous conditions	5 5 4 3	1 1 2 1	6 6 6 4	Ice thickness to be assessed before walking on ice as per BIM Policy. Initial ice profiling will be conducted with an ice auger Floatation suit will be used for the initial ice profiling using an ice auger. Survival Bag (sleeping bag) will be available to reduce the risk of hyperthermia Follow the BIM Working On Ice Procedure (BAF-PH1-320-PRO-005, Rev 0, March 1, 2016) All workers will be required to complete the Alberta Working Safely on Ice Procedure online training	2	1	3	Marlon Coakley/Warren Hoyle
6. Drill testing for ice thickness	Water may appear to be completely frozen over, but not enough to support persons. Large ice cracks or crevices Falling in water Strains/Sprains Slipping on ice Drilling ice with power auger Changes in ice conditions	3	4	7	Traction aids will be used for any ice work Ice thickness to be assessed before walking on ice Floatation suits will be worn by workers while ice auguring, the worker is to be tethered to a primary rescue worker at a distance of 30m Snow must be removed at the hole location so ice can be examined for quality as described in the Ice field guide. Hand shovelling may be necessary If crevices/ cracks greater than 50% of the ice thickness are present, repairs must be made if there is risk of falling through ice into deep water	2	2	4	Warren Hoyle / Marlon Coakley

					Ice thickness for a person to walk on must be a minimum 13 cm. **STOP** all work if this condition is not met and return to shore. Be aware when using power ice auger that auger bit could bind or jam, have secure footing and grip on auger The ice auger hole spacing will be 20 m along the centreline access and the grid established in the designated work area. Secondary test holes will be augured at 10 m spacing within 250 m of the shoreline, if required based on the variable ice thickness Complete daily inspections of ice surfaces and record on ice log inspection sheet				
7. Access from Land to Sea Ice Snow removal equipment, drill rig and access vehicles are to be used for borehole access	Long distances to walk Exposure to cold White Out conditions Risk of falling under sea ice along the shoreline	4	1	5	Proper warm winter wear to be used Sat phones and digital radio use. Rig mats to be used to bridge over the fractured ice transition area if the transition between sea ice and shoreline needs leveling Buddy system is important to verify presence of frost bite or other cold related concerns **Vehicle operators and passengers are not to wear seat belts when working on ice**	1	1	2	All workers

8. Refueling of equipment	Fuel spills Regulatory or social impacts Spills into water bodies	3	2	5	Use of duck ponds with any refueling Have sufficient spill cleanup supplies on hand to respond to potential spills Maximize space between refueling vehicle	3	1	4	All workers
9. Extreme weather exposure when working outdoors or driving to and from the Borehole Location	Stranded work crew in white out conditions Cold emergencies or cold injuries Mechanical equipment failure	4	2	6	BIM has a procedure that is designed for white out conditions – it would be announced on the radio An emergency shelter to be used when in the Marine Drilling areas Emergency Shelter: Heated wooden shack (7' 8" by 7' 8") set on platform with skis Crews to radio from Hatch leads Buddy system to watch out for fellow workers who may not realize they are developing frost bite Workers to dress in arctic gear and layered clothing Proper PPE required Equipment check list Review Tidal charts on a daily basis Workers to take warm up breaks to stay warm and alert At toolbox review weather forecast with crew and prepare accordingly	2	1	3	All workers

10. Chemical handling- No unusual chemicals other than equipment needs are anticipated to be used.	Spills, leaks Chemical splash Chemical exposure	2	2	4	All products to be stored in secondary containment MSDS to supplied to BIM for review MSDS books to be accessible at the work front MSDS training and WHMIS training completed before arriving to site PPE will be followed as per MSDS recommendations as will first aid and environmental responses Spills response training and supplies to be kept with the equipment	1	1	2	Boart Longyear
11. Waste management and Wildlife Encounters	Risk of wildlife encounters due to improper waste controls Regulatory non compliance	3	2	5	Crews will collect waste daily and transport it back to camp Crews will follow BIM waste management guidelines No placing or storing of food in the back of pickup trucks Secure all small tools and PPE as foxes may carry away small articles from the site	2	2	4	All workers
12. Ecological and Cultural sensitive areas	Risk of causing damage to archeological areas Destroying vegetation Sensitive wildlife and marine life areas Regulatory and reputation damage	3	3	6	Crews have been instructed that there will be **NO** entry to the area east of the sealift ramp Crews are not to build or alter any inukshuk's or other rock formations on the tundra Permits will be required for the work	2	2	4	All personnel

13. Assemble Drill on skid platform skid and construct four walls and roofs	General hazards associated with drill assembly Inadequate communication between Boart Longyear and Site Services / mobile equipment operators	2	2	4	FLRA to be complete by Boart Longyear supervisor prior to executing work Boart Longyear Drilling operations SOPs to be followed including Boart Longyear Procedure 4001	1	1	2	Warren Hoyle / Marlon Coakley
14. Auguring holes in ice for sonic drilling and CPT work	Large ice cracks or crevices Falling in water Strains/Sprains Slipping on ice Drilling ice with power auger Changes in ice conditions	3	3	6	Wear traction aids for any ice work PFDs to be worn by workers while ice auguring during the sonic drilling and CPT operations Snow must be removed at the hole location so ice can be examined for quality. Hand shovelling may be necessary Be aware when using power ice auger that auger bit could bind or jam, have secure footing and grip on auger Complete daily inspections of ice surfaces and record on ice log inspection sheet All holes must be marked using an orange spray paint Any hole in ice over 30 cm in diameter must have a physical barrier around the hole	3	2	5	
15. Working around rotating equipment	Entanglement injuries	3	2	5	All equipment guards to be in place and in good working condition No loose clothing or drawstrings that can get pulled into rotating equipment Long hair must be contained to prevent entanglement into rotating equipment	2	1	3	All workers

					If any maintenance is required then energy isolation procedures to be followed				
16. Isolation of energy sources	Potential energy release that causes injury	3	2	5	All crews will follow the BIM Zero Energy State (ZES) procedure Crews to be given the BIM ZES training on site and fully understand the BIM requirements	1	1	2	Boart Longyear Crews BIM H&S
17. Working on equipment	Slip and trip hazards around railings, stairs and uneven ground.	2	2	4	Rails are installed around deck and to be properly maintained in good condition Stairs to be used on equipment A head cage will be used to reduce chance of contact with the rotating head Estops to be in good working order and easily accessible FLRA to be completed daily to review hazards All crews will follow the BIM Zero Energy State (ZES) procedure	1	1	2	Boart Longyear crew
18. Ice monitoring during drilling activities	Excessive deflection in ice	4	3	7	Hatch geotechs crew will monitor ice conditions during drilling including cracks around the work area, monitor freeboard in drilled holes for signs of ice deflection	2	2	4	All crew

19. Spotter activities	Equipment could come in contact with Spotter	4	2	6	Spotter to maintain eye contact with driver Spotter to review FLRA Agreed hand signals to be used with drivers in conjunction with BIM spotter procedure Agreed hand signals will be documented on the FLRA Drivers to immediately stop if the Spotter is out of eye contact	1	1	2	Boart Longyear crew
20. Manual lifting	Pinch point, back injuries, muscle and joint sprains and strains	2	3	5	Work in pairs, FLRA reviews Work with a buddy on heavy or awkward lifts Use proper lifting techniques 100 pound pipes to be handled by two workers	1	1	2	All crew
21. Working with pressure systems	Pressurized water and hydraulic fluids are used on drill and support equipment	3	2	5	Pre operational inspection Follow all safe work procedures. ZES when maintenance is required.	1	1	2	Boart Longyear crew
22. Falling objects	Potential exists for falling of drill rod and casing falling from overhead	3	2	5	Rigging and slinging training required when working with suspended loads and overhead hazards Perform FLRA	1	1	2	Boart Longyear Hatch Geotec EHS techs
23. High noise and vibration areas on the rigs	Hearing damage	2	2	4	Hearing protection is required by use of ear plugs or muffs.	2	1	3	Boart Longyear Hatch Geotec EHS techs

24. Housekeeping	Potential exists for poor housekeeping causing slip/trips and other hazards	3	2	5	Daily site assessments and toolbox meetings by drillers and site supervisors BIM EHS techs to perform daily inspections	2	2	4	All Crew
25. Fatigue	Potential exists for crew fatigue	2	2	4	Fit for duty confirmation required for all employees, daily FLRA reviews Micro breaks to stretch Proper rest during off shift period	1	1	2	All Crew
26. Working at night or 24 hour darkness	Higher risk of injury due to poor visibility	3	3	6	Hi-vis work gear to be used Use of flashlight and headlamp Workers to stay within 10 meters (30 feet) of the worksites at any time Use of wobble lights and light tower Emergency shelter	1	1	2	All Crew
27. Hot work - welding	Fire risk Burn injuries Welders Flash	2	2	4	Hot work training Use of hot work permits and JHA for any Hot Work Fire Watch required Proper PPE Welding training required	1	1	2	Boart Longyear crew

28. Rescue Plan	Rough terrain Further injuries to casualty during transit. Snow storm, white out conditions. Darkness	3	3	6	The track unit will be used to pull the survival shack (survival shack is 7' 8" x 7' 8" square) on platform with skis. When an incident has occurred, the Geotechnical Engineer must call a Code 1. Provide first aid treatment to the injured person until MRT arrives on site MRT will be dispatched to the location. MRT will transport the casualty. Visibility (whiteout conditions) will hinder rescue time, rescuers will have to wait out the storm, or until the whiteout conditions have subsided.	2	2	4	Marlon Coakley/ Warren Hoyle
29. Cleanup and Demob	Unfrozen open holes Complacency	3	3	6	All drill holes must be filled in with water and snow upon completion of drilling operations A Hatch site representative will confirm safe conditions upon demob All debris must be removed from ice surface and disposed off site per waste management plan BIM safety and environment representatives to attend a post project closeout inspection to document the completion of the clean-up	2	2	4	Boart Longyear

Comments:

Score	CONSEQUENCE		
	People	Plant	Environment
5 – Very High/ Catastrophic	Multiple Fatalities.	Greater than $10 Million Loss	Catastrophe, destruction of sensitive environment, worldwide attention. Likely EPA prosecution. More than 30 days delay.
4 – High/ Major	Fatality or Permanent Disabilities.	$1 Million to $10 Million Loss	Disaster, high levels of media attention, high cost of clean-up. Offsite environmental harm; more than 10 days delay.
3 – Moderate	Major Injuries – Incapacitations or requiring time of work.	$100 Thousand to $1 Million Loss	Major spills, onsite release, substantial environmental nuisance, more than 1day delay. (Leads to additional resources call out i.e. SES).
2 – Low/ Minor	Significant Injuries – Medical Treatments, non-permanent injury.	$10 Thousand to $100 Thousand Loss	Significant spills. (Leads to a call out of Site Emergency Response Group).
1 – Very Low/ Insignificant	Minor Injuries – First Aid Treatments (cuts/bruises).	Less than $10 Thousand Loss	Low environmental impact. Minor Spills less than 80 Litres.

Score	LIKELIHOOD
5 – Almost Certain	The event is expected to occur in most circumstances. Likely to occur frequently - More than 1 per year.
4 – Likely/ Probable	The event will probably occur in most circumstances. Likely to occur several times – 1 per year.
3 – Moderate/ Occasional	The event should occur at some time. Likely to occur at some time – 1 per 5 years.
2 – Remote/ Unlikely	The event could occur at some time. Unlikely but possible. 1 per 10 years.
1 – Rare/ Very Unlikely	The event may occur only in exceptional circumstances. Assumed it may not be experienced. 1 per 100 years.

Job Hazard Analysis Attendees: Darryl Finlay, Marlon Coakley, Warren Hoyle, Usman Khan, Alex Boissonneault

	Name	Signature	Date
Written by:	Marlon Coakley	Marlon Coakley	Mar 20/2017
Reviewed by:	Warren Hoyle (Hatch)	Warren Hoyle	March 20, 2017
	Darryl Finlay (BIM Safety Coordinator)		March 20, 2017

Risk Rating = Consequence + Likelihood

Consequence	Risk Rating				
5	6	7	8	9	10
4	5	6	7	8	9
3	4	5	6	7	8
2	3	4	5	6	7

Risk Rating - Definitions

Risk Rating	Definitions	*Action Required*
8 - 10	Intolerable	Task not to start till the risk is eliminated or reduced. Bring to the immediate attention of management. Formal assessment required. MUST reduce the risk as a matter of priority.
7	High	Bring to the immediate attention of management. Task not to start till the risk is eliminated or reduced. Further Assessment required. MUST reduce the risk as a matter of priority.
6	Significant Risk	Bring to the attention of supervision. Review risks and ensure that they are reduced to as low as reasonably practicable. To be dealt with as soon as possible, preferably before the task commences. Introduce some form of hardware to control risk.
5	Moderate Risk	Needs to be controlled but not necessarily immediately, an action plan to control the risk should be drawn up. Review effectiveness of controls. Ensure responsibilities for

1	2	3	4	5	6
	1	2	3	4	5
	Likelihood				

		control are specified.
2-4	Low Risk	If practical reduce the risk. Ensure personnel are competent to do the task. Manage by routing procedure. Monitor for change

A JHA considers a variety of activities/tasks involved in a job scope and analyses the key hazards (sources of harm) and their consequences (types of harm) eg. Sources of harm – lifting a heavy pipe - manual handling. Types of harm – Back strain.

Main Points – On how to write a JHA.

1. Define the task – what is to be done.
2. Review previous JHA if any – have we done it before?
3. Identify the steps – what is to be done.
4. Identify the hazards of each step.
5. Identify who or what could be harmed.
6. Give the task a risk rating – Consequence + Frequency
7. Develop solutions to eliminate or control hazards in each step.
8. Review the risk rating after the control system has been implemented.
9. If risk rating unacceptable review the solutions till risk rating acceptable.
10. Agree who will implement the control system.
11. Document the JHA and discuss with the relevant personnel.

Hierarchy of Hazard Management – Control Measures

These steps outline what should be planned for when deciding what control measures are to be put in place. Whenever possible the highest step should be used first and then progress down the list.

1. Eliminate the hazard.
2. Substitution.
3. Reducing the frequency of a hazardous task.
4. Enclosing the hazard.
5. Additional procedures.
6. Additional supervision.
7. Additional training.
8. Instructions / information.
9. Some personal protective equipment.

Worker / Visitor review	Signature
Warren Hoyle	March 19/2017
Marlon Coakley	March 19/2017
Usman Khan	
Alex Boissonneault	March 19, 2017
Emile Beauchamp	March 19/2017
Samuel Flynn	March 19/2017
Ruben Gross	March 19/2017
Justin Gross	March 19/2017
Chris Entz	March 19/2017
Doug Roach	
Robbie Jordan	

Enclosed:

Attachment A – BIM Working on Ice Procedure
Attachment B – On Ice Platform for Geotechnical Drilling
Attachment C – Best Practice for Building and Working Safely on Ice Covers in Alberta
Attachment D – Ice Thickness Assessment
Attachment E – Ice Assessment Drawing

Attachment A – BIM Working on Ice Procedure

Baffinland Iron Mines Corporation

Working on Ice Procedure

BAF-PH1-320-PRO-0055

Rev 0

Prepared By: Shawn Parry
Department: Road Maintenance
Title: Manager
Date: February 9, 2017
Signature:

Approved By: Sylvain Proulx
Title: Chief Operating Officer
Date: February 9, 2017
Signature:

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1 PURPOSE AND SCOPE

Baffinland Iron Mines Corporation is committed to taking the necessary steps to ensure that work performed on ice of lakes, rivers, streams or the ocean is conducted in a safe, efficient and environmentally compliant manner.

This procedure is not intended to provide instructions for large scale ice operations such as ice road construction and operation. For large scale ice operations, refer to "Best Practice for Building and Working Safely on Ice Covers in Alberta (Work Safe Alberta)".

2 DEFINITIONS

2.1 BAFFINLAND CLASSIFICATIONS FOR WORKING ON ICE

Class A Job – The ice is between 15 centimetres and 38 centimetres thick and the load weight, including people on the ice will be 4,536 kilograms or less.

Class B Job – The ice is more than 38 centimetres thick and the load weight, including people, is greater than 4,536 kilograms but less than 63,000 kilograms.

Class C Job – The job requirements cannot be met by either Class A or B guidelines.

See section 4, Protocols for a discussion of Class A, B and C requirements.

3 RESPONSIBILITIES

The following roles have specific accountabilities that must be met to ensure that any work on ice is conducted in a safe and environmentally responsible manner.

3.1 CHIEF OPERATING OFFICER OR GENERAL MANAGER, OPERATIONS

The Chief Operating Officer or General Manager, Operations must review and approve any Class C job for working on ice.

3.2 DEPARTMENT MANAGER/SUPERINTENDENT

The Department Manager and Superintendent are responsible to ensure their department supervisors are aware of and comply with this procedure. The manager and superintendent are also responsible to validate the terms and conditions of the JHA are implemented.

3.3 DEPARTMENT SUPERVISOR

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The Supervisor is responsible for supervising the work/tasks in accordance with this procedure and the terms and conditions of the JHA. Specifically, the supervisor is responsible for:

- Notify the department manager and superintendent of the requirement to work on ice and send each a copy of the completed JHA.
- Ensure a geographically specific JHA is completed and implemented, prior to starting work.
- Notify the MRT Trainer and have them participate in the JHA.
- Ensuring that workers have reviewed and understand the JHA, prior to starting work.
- Supervise the work and act as the main point of contact for workers working on ice.

3.4 Worker

The worker, is responsible for the following:

- Review, sign and comply with the terms and conditions of the JHA.
- Promptly reporting to their supervisor, any safety concerns or incidents that occur while working on ice.

3.5 Safety Superintendent or Coordinator

The Safety Superintendent or Coordinator will facilitate the working on ice JHA process.

3.6 Mine Rescue Team Trainer or Delegate

The Mine Rescue Team Trainer or delegate is responsible to work with the supervisor to develop the rescue plan component of the JHA.

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4 PROTOCOL

4.1 CLASS A JOB

The following table provides requirements for performing work on ice under Class A conditions. The JHA must meet the following conditions;

Equipment Example	Weight (kilograms)	Minimum Ice Thickness (centimetres)	Ice Integrity
1 or 2 people and their tools and equipment	Up to 272	15	Solid ice that is free of cracks, water and slush
Snowmobile and rider	Up to 363	20	Solid ice that is free of cracks, water and slush
2 snowmobiles and riders	Up to 726	25	Solid ice that is free of cracks, water and slush
Pickup truck or other mobile equipment, cargo and driver/passengers	Up to 4536	38	Solid ice that is free of cracks, water and slush

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4.2 Class B Job

The ice is greater than 38 centimetres thick and the load weight, including people, is greater than 4536 kilograms but less than 63, 000 kilograms.

Ice Thickness Calculation	Weight and Ice Thickness	Ice Integrity
The Golds formula found in Section 5 must be applied to calculate the safe ice thickness. The calculation, including safe ice thickness must be documented in or attached to the working on ice JHA.	The combined weight of the load, including equipment and people is greater than 4536 kilograms but less than 63, 000 kilograms and the ice is 38 centimetres thick or greater	Solid ice that is free of cracks, water and slush

4.3 Class C Job

The job requirements cannot be met by either Class A or B guidelines. The assistance of a professional engineer recognized as an authority on ice covers, must be consulted and their guidance documented in or attached to, the JHA.

5 Golds Ice Weight Bearing Capacity Formula

GOLD'S FORMULA
All guidelines currently in use in Canada are based on a technical paper published by Dr. Lorne Gold in 1971 entitled "Use of Ice Covers for Transportation". Gold's Formula is;

$P = A \times h^2$
Where:

- **P** is the allowable load in kilograms
- **A** is a parameter that depends on the strength of the ice
- **h** is the effective thickness of good quality ice (cm)

Gold suggested a range of A-values for lake ice that corresponds to a range of safe ice thicknesses for a given load or a range of acceptable loads for a given ice thickness. Baffinland has adopted Golds "Tolerable Risk" value for ice quality, therefore the A value in Golds formula will be four (4) when calculating ice thickness for a Baffinland Class B job.

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Gold's formula A value of 4 is most commonly used for normal operations with moving vehicles. When equipment will be working in the same spot (stationary) for more than 2 hours, the value for A in Golds formula, must be reduced to two (2).

Two examples using the Golds Formula for a Class B job:

What is the weight capacity of good quality ice that is 60 cm thick?
Capacity (in Kgs) = A x h^2
Capacity (in Kgs) = 4 x (60x60)
Capacity (in Kgs) = 4 x 3600
Capacity = 14400 Kgs

The weight bearing capacity of good quality ice that is 60 cm thick is up to 14400 kilograms.

What is the weight bearing capacity of good quality ice that is 60 cm thick and the load will be stationary for 2 hours or more?
Capacity (in Kgs) = A x h^2
Capacity (in Kgs) = 2 x (60x60)
Capacity (in Kgs) = 2 x 3600
Capacity = 7200 Kgs

7, 200 kgs is the weight bearing capacity of good quality ice that is 60 cm thick and the load will be stationary for 2 hours or more.

5.1 Working on Ice frozen to the bottom (River, Lake – etc.)

When Ice thickness measurements determine the ice has frozen to the bottom in the area of travel and work, the ice may be considered as safe provided the ice quality is routinely monitored and remains solid and free of slush and water.

6 Working on Ice JHA and Work Planning Meeting

Working on ice may be divided into two parts;
1. initial measurement of ice thickness
2. working on the ice

Both parts require a JHA.

A work planning meeting must be held prior to any work on ice. This meeting will be based on review of the completed JHA. All individuals participating in the work must present and review their work instructions, roles and responsibilities. The following points will be covered

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in the JHA and will be covered as part of the topics of discussion during the "planning meeting":

- A description of the work to be done – with sufficient detail for individuals to understand their role
- Potential hazards associated with the work
- Personal safety equipment
- Specific safety procedures for working on ice
- Rescue procedures and necessary equipment
- Individual job tasks
- Communications and hand signals to be used
- Load (i.e. equipment, personnel) weight and distribution on ice during work
- Ice assessment – thickness and condition

JHA safety and emergency response considerations;

- Measuring ice thickness should always be a two person operation.
- Initial ice measurement must be done with a PFD and the lead tester on a tether to the second person who is a safe distance behind.
- Self-recovery is not the primary means of rescue, it's the second person and the tether.
- The MRT will provide a backup rescue plan.

7 MEASURING AND RECORDING ICE THICKNESS

The task of ice thickness measurements may be the subject of a separate JHA or may be included in the working on ice JHA.

Ice thickness is the primary measurement required to determine the safe working load that can be put on the ice (allowable load bearing capacity). Manual measurements are made by cutting a hole in the ice cover with an auger, a saw or an ice chisel and then directly measuring the ice thickness. Measurements are made in a prescribed spacing or pattern to provide sufficient coverage and verify the thickness of the ice cover.

It must be mentioned that in all cases of manual ice thickness measurements it is the absolute minimum thickness measured in all holes that must be used. Not an average or any other measurement.

It is imperative that a systematic procedure be implemented to document all ice thickness measurements. Measurement locations should be taken either with a Global Positioning System (GPS) receiver or marked with stakes, or other reliable system so that these locations can be tracked in future measurements or identified for repairs. This information is a key element in the monitoring control plan.

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These records are vital to reconcile any ice failures that may occur. These records must be maintained in a log that is specific to recording ice thickness. See Appendix #1 - Ice Thickness Measurement Log

Suitable equipment and personal protective equipment (PPE) must be prescribed for the work. Initial testing should be conducted by at least two trained crew members travelling separately over the ice. The work could be carried out by travelling:

- On foot, by snowmobile or by amphibious vehicle.
- While testing, the crew should also be checking the ice for cracks and noting the snow load.
- If vehicles are used, two separate vehicles must be used at all times and must be separated at safe distance unless ice conditions are known.

7.1 Test Hole Spacing

Rivers

If GPR is used, test holes are only required for calibration and for mapping of thin areas. Recommend 30 meters between test holes along alternate edges. Look for thin areas caused by river current.

Lakes

If GPR is used, test holes are only required for calibration. If within 250 metres of shore: 30 meters between test holes along centre line. If more than 250 metres from shore: 250 metres between test holes along centre line

Note – these recommendations indicate normal test hole spacing. Good judgement based on field experience must be used when varying from these recommendations. In thin ice areas the suggested spacing should be reduced to determine their extent and severity.

8 REFERENCES AND RECORDS

- Baffinland Job Hazard Analysis Procedure BAF-PH1-810-PRO-0016r1
- Baffinland Iron Mines Corporation– Emergency Response Plan (BAF-PH1-830-P16-0007)
- Best Practice for Building and Working Safely on Ice Covers in Alberta (Work Safe Alberta)
- NWT Transportations Guide to Ice Road Construction

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Note: This is an UNCONTROLLED COPY. All staff members are responsible to ensure the latest revision is used.

Appendix #1
Ice Thickness Measurement Log

Date:		Location:
Completed by:		Signature:
Weather Conditions, including temperature:		
Test Hole #	Ice Thickness	Notes on test hole – clear solid ice cracking, water – etc.
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
Names of other participants		Signature of other participants

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Attachment B – On Ice Platform for Geotechnical Drilling

On-Ice Platforms for Geotechnical Drilling at Steensby Island

2013-04-09	0	Approved for Use	V. Tatone	D. Wolek	S. Perry	D. Matthews
DATE	**REV.**	**STATUS**	**PREPARED BY**	**CHECKED BY**	**APPROVED BY**	**APPROVED BY**

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Consideration of Bearing Capacity of Ice for Geotechnical Drilling Program

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1. Purpose

1.1 This Procedure identifies minimum safe work practices for the set-up and maintenance of on-ice platforms to be used to support geotechnical drill rigs for near shore work at Steensby Island.

NOTE: This Procedure does not replace safe work procedures for working on ice.

2. Scope

2.1 This Procedure applies to all locations where on-ice platforms are required for near shore work at Steensby Island.

3. Roles and Responsibilities

3.1 Construction Manager

3.1.1 The Construction Manager shall be accountable for ensuring full implementation and compliance with the requirements of this Procedure.

3.2 Contractor's Line Managers

3.2.1 Contractor's Line Managers shall have the following accountabilities:

- Conduct risk assessments for tasks associated with this Procedure and ensure the implementation of controls
- Ensure equipment is used and processes are applied in accordance with this Procedure

3.3 Site Health and Safety Manager

3.3.1 The Site Health and Safety Manager shall have the following accountabilities:

- Audit and monitor compliance with this Procedure
- Identify remedial corrective actions required to meet this Procedure

3.4 Supervisors

3.4.1 Supervisors shall have the following accountabilities:

- Ensure the application of this Procedure
- Responsibility for details of construction of the platforms
- Ensure that a JHA/FLRA is developed for tasks associated with this Procedure

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- Ensure that employees review and sign the JHA/FLRA prior to task commencement
- Responsibility for removal of the ice platforms

3.5 Employees

3.5.1 All employees shall have the following accountabilities:

- Ensure they follow this Procedure
- Ensure that JHA/FLRA developed for tasks associated with this Procedure are followed

4. Definitions

4.1 Solid Ice

4.1.1 Stable sheet of solid ice, thickness adequate to safely support the operation. The solid ice may be subject to movement due to tides.

4.2 Sea Ice

4.2.1 Sea ice is any form of ice that is found at sea and has originated from the freezing of sea water.

4.3 Rafted Ice or Raft Ice

4.3.1 Ice in cakes or sheets overlapping or piled on one another. This is a body of near shore ice segments fused together and formed during fall freeze-up. The surface of suitable rafted ice should be reasonably flat and elevation at or near high tide. This rafted ice is a stable entity. Rafted ice that moves with the tides shall be regarded as unstable.

4.4 Ice Platform

4.4.1 A platform constructed on the rafted ice by flooding with salt water and including embedded rig mats.

4.5 Rig Mat

4.5.1 A portable platform used to support equipment used in construction and resource based activity including drill rigs.

4.6 Drill Rig

4.6.1 A track mounted drill rig used for geotechnical investigations.

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5. Procedure

5.1 Specific Requirements for Ice Platforms

5.1.1 The rafted ice must be stable and fused to act as a homogeneous mass. Appropriate ice profiling and/or direct measurement of ice thickness is required.

5.1.2 Do not attempt to construct an ice platform in locations where sea ice is pushed up onto the rafted ice to a height exceeding 2 m.

5.1.3 The solid ice adjacent to the ice platform must be stable during tidal influence and capable of safely supporting the gravity loads imposed by the operation, including at the edge of the ice sheet. Appropriate ice profiling and/or direct measurement of ice thickness is required.

5.1.4 The zone of discontinuity between the solid and rafted ice must not be open water at any time and must be sufficiently narrow so that the rig mats will safely support the movement of equipment and personnel across this zone. No work is to be performed over this zone of discontinuity. Appropriate ice profiling and/or direct measurement of ice thickness is required.

5.1.5 The ice platform shall be constructed by alternate overlapping layers of rig mats and flooding with salt water until a suitable work space is created over the rafted ice. Profile the ice with an ice profiler or measure ice thickness using a mechanical ice auger prior to any flooding.

5.1.6 The rig mats shall be constructed of steel frames and timber cross beams. The rig mats shall be strong enough to bridge across the zone of discontinuity. Note that the attached sketch is conceptual only. The number of rig mats must be determined on site. It is anticipated that the number of available rig mats will not be more than six.

5.1.7 The rig mats shall be adequately connected by mechanical means to be determined at site.

5.1.8 The platform must be sufficiently long and wide to permit a clearance of at least two metres on each side of the equipment and supplies.

5.1.9 The platforms must be removed by means established by the supervisor.

6. References

Nunavut General Safety Regulations, R.R.N.W.T. 1990.

Nunavut Mine Health and Safety Regulations, R-125-95.

Safe Work Procedure – Working on Ice (HS-SWP-092).

END OF SECTION

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Appendix A

Illustrations

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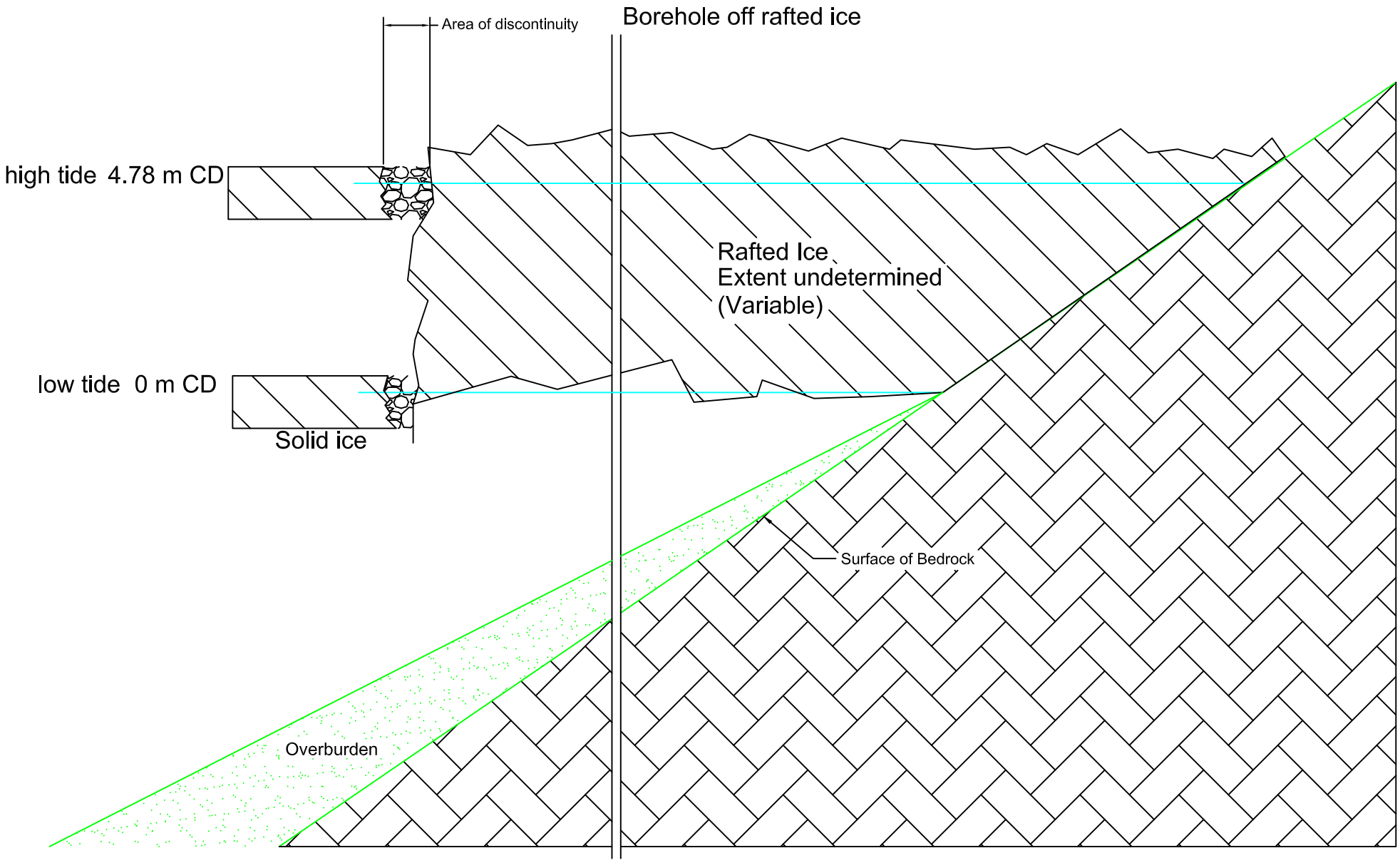
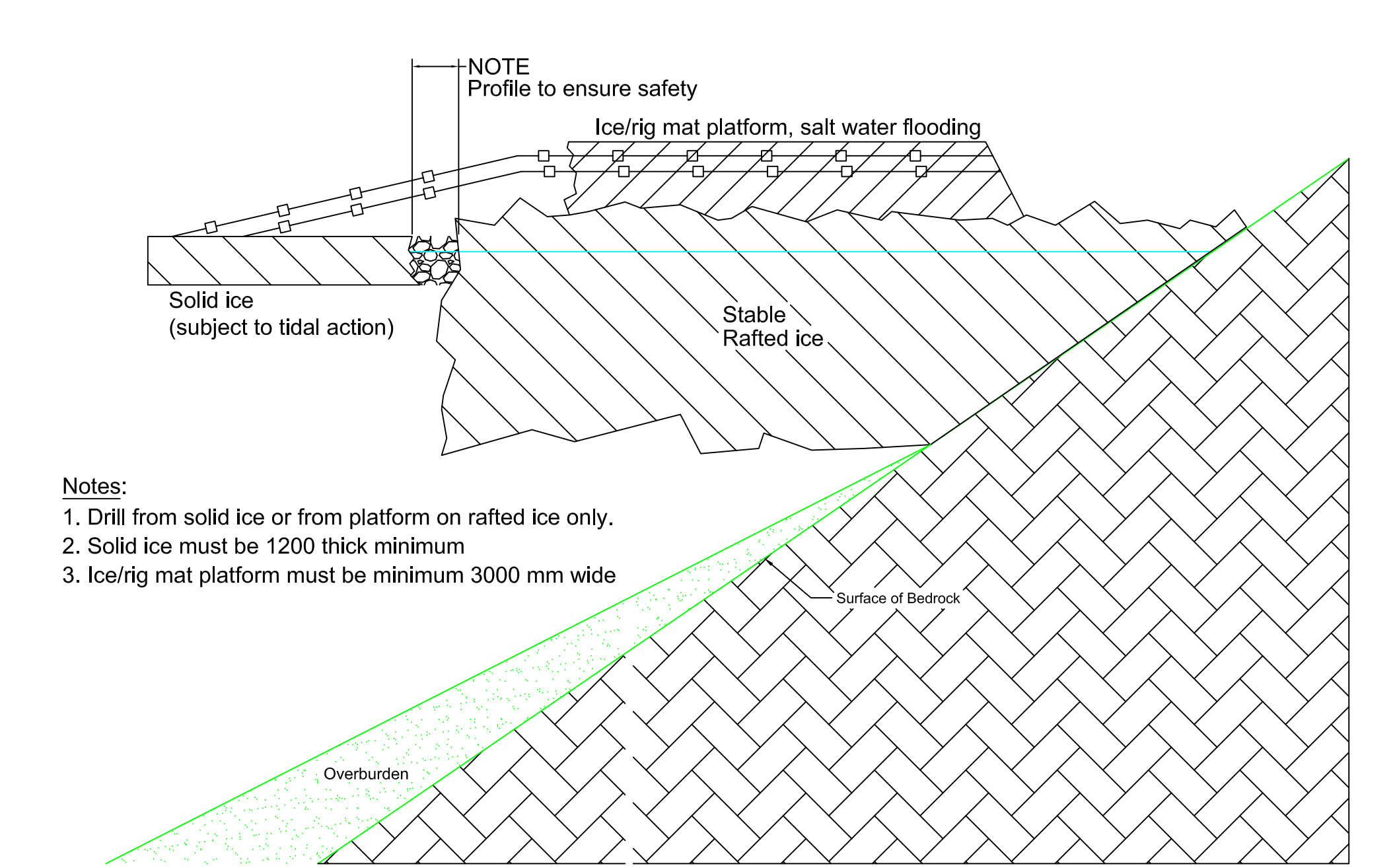


Dredged Depth -23 m CD

ORE DOCK
NEARSHORE CROSS SECTION



Notes:

1. Drill from solid ice or from platform on rafted ice only.
2. Solid ice must be 1200 thick minimum
3. Ice/rig mat platform must be minimum 3000 mm wide

ORE DOCK
ICE PLATFORM CONCEPT

Appendix B

Consideration of Bearing Capacity of Ice for Geotechnical Drilling Program

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Project Memo

December 14, 2011

TO: K. Skebo FROM: B. Gill

cc: S. Hinchberger
R. MacCrimmon

Baffinland Iron Mines Corporation
Mary River Project

Consideration of Bearing Capacity of Ice for Geotechnical Drilling Program

1. Introduction

The purpose of this note is to consider the ice features that may affect the execution of a planned geotechnical drilling program in a safe and effective manner. The program will be conducted during April and May in the proposed mine and marine facilities areas of the Baffinland project on northern Baffin Island. This note addresses primarily the bearing capacity of the ice cover for supporting the drilling program vehicles and equipment.

1.1 Air Temperatures and Ice Thickness

The air temperatures over the period from 1971 to 2000 for Hall Beach to the southwest and Pond Inlet to the northeast for April and May are as follows:

Table 1-1: Air Temperatures

	Hall Beach		Pond Inlet	
	April	**May**	**April**	**May**
Daily Average	-20.4	-9.0	-22.1	-9.9
Daily Maximum	-15.2	-4.8	-17.7	-5.8
Daily Minimum	-25.6	-13.2	-26.5	-13.9

Thus it is seen that the air temperature is well below freezing for the period and ice will continue to grow. Ice thickness data for Hall Beach show that in most years, the thickness reaches to 2 m or greater by May. The minimum thickness for May over 50 years is approximately 1.5 m. This is a significant thickness that is capable of supporting very heavy loads.

1.2 The Bearing Capacity of Ice

The guidelines in Canada for determining safe working loads for operations on ice are based on work by Dr. L. Gold of the National Research Council (see for example, "A Field Guide to Ice Construction Safety" by NWT Department of Transportation, November, 2007 and "Best Practice for Building and Working Safely on Ice Covers in Alberta by Work Safe Alberta, Government of Alberta, October, 2009). Dr. Gold published his paper "Use of Ice Covers for Transportation" in 1971. His formula, which says that the safe working load is a function of the ice thickness squared, is $P = Ah^2$ where A is a parameter that is related to the ice strength and h is the ice

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thickness. The value of A may vary depending on the degree of risk one is willing to take and the offsetting precautionary and response measures that are implemented in a given case. For the current case in which the ice thickness is large, the ice is static, and the equipment loads are relatively modest in relation to the ice bearing capacity, one could assume a low risk factor, and the subsequent calculated minimum ice thickness for the planned equipment weight would be relatively high, but still well below the thickness in April and May. In the Alberta and NWT documents referred to above, the former document uses a range of values for 'A' from 3.5 to 7 and suggests hazard control measures appropriate to each level, whereas the latter document uses a single value of 4 for 'A'. Both of these documents are concerned with freshwater lake and river ice.

Using a value of 4 for 'A' and an ice thickness of 200 cm results in an allowable load of 160 tonnes or more than 12 times the weight of a Cat 950 loader. The ratio would be presumably even greater in the case of a drill rig. In the same manner, the minimum (freshwater) ice thickness that a stationary or slowly moving 950 loader weighing about 13,000 kg would require is 57 cm.

The allowable load in the case of sea ice would be less than that for an equivalent thickness of freshwater ice because of the lower strength (under the same temperature conditions) that results from brine inclusions in the sea ice. A reasonable understanding of this derating can be obtained by comparing the flexural strengths of the two types of ice. For a salinity of 8 ppt (parts per thousand) for arctic sea ice at an average ice temperature of -20 deg C, the resulting flexural strength is about 65 percent of the strength of freshwater ice at the same temperature. The minimum sea ice thickness for a 950 loader would then be about 70 cm. This is 35 percent of the expected ice thickness at the project site during the drilling period.

The rate of movement of the equipment is not expected to be a significant factor, unlike in the case of transport vehicles moving at speed on ice covers over relatively shallow water. The speeds in the present case will not be sufficient to cause any dynamic effects that could lead to a magnification in deflection of the ice cover. According to field studies reported in the above-referenced Alberta Government document, a vehicle would have to travel at 50 km/h over ice 1 m thick in 15 m of water to cause such effects.

1.3 Potential Hazard Control

As noted, the large ice thickness in relation to the minimums required to safely carry the loads and the static nature of the ice cover in the present case mean that this is a low-risk operation in terms of potential ice bearing problems. An appropriate hazard control procedure would entail prior ice measurements to confirm the anticipated thickness in the working areas, measurements thereafter if any uncertainties exist with respect to ice thickness, monitoring the ice quality (e.g. cracks, effects of warming, water on the ice, etc), and checking for deflection of the ice cover as time of equipment in one location increases (this can be done by observing the water level in boreholes).

An overall ice safety plan should be implemented, including orientation and instruction for employees and contractors and routine daily observations to ensure rules of working on an ice cover are followed.

BG:vl

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Internal Memo

H352034

March 18, 2017

To: Warren Hoyle

From: Usman Khan

cc: Marlon Coakley
Alex Boissonneault
Sean Hinchberger
Tyler Bruce
Sven Heiner

Baffinland Iron Mines
Mary River Expansion Study Stage 2

Minimum Ice Thickness for Offshore Drilling at Milne Port 2017

1. Introduction

Hatch Ltd. (Hatch) was retained by Baffinland Iron Mines to conduct an offshore, on-ice, geotechnical drilling investigation at the Milne Port Site. This investigation is scheduled for the period of mid to late March 2017. In order to mitigate risk relating to ice breakthrough, the investigation team reviewed ice strength evaluation completed for a similar offshore investigation at the Steensby site in 2011.

2. Allowable Ice Loading

2.1 Moving Loads

The 2011 evaluation of ice thickness utilized Gold's formula to calculate the allowable weight for a variable ice thickness. Gold's formula is based on literature that utilizes data collected from ice breakthroughs and forms an empirical relationship to predict the allowable bearing capacity of ice.

$$P = Ah^2$$

P = Allowable load in kilograms

A = Constant which depends on the quality of the ice, the geometry of the load and the factor of safety appropriate

h = Effective thickness of the ice in centimeters

Further literature review suggests using a value of 4 as a conservative estimate for freshwater ice. Government of Alberta and Northwest territories both recommend using a factor of 4.

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It is noted that a factor of 4 is used for freshwater ice and does not account for the reduction of flexural strength in sea ice due to the presence of brine. A reduction factor of 0.65 is applied per Hatch project memo entitled, “On-Ice Platforms for Geotechnical Drilling at Steensby Island” (Document # H349000-HS-SWP-165).

Table 2-1: Maximum Allowable Load On Sea Ice

Ice Thickness (cm)	Load (kg)	Load (lb)		Ice Thickness (cm)	Load (kg)	Load (lb)
5	60	150		105	28,660	63,200
10	260	580		110	31,460	69,360
15	580	1,290		115	34,380	75,810
20	1,040	2,300		120	37,440	82,550
25	1,620	3,590		125	40,620	89,570
30	2,340	5,160		130	43,940	96,880
35	3,180	7,030		135	47,380	104,470
40	4,160	9,180		140	50,960	112,350
45	5,260	11,610		145	54,660	120,520
50	6,500	14,340		150	58,500	128,980
55	7,860	17,340		155	62,460	137,720
60	9,360	20,640		160	66,560	146,740
65	10,980	24,220		165	70,780	156,060
70	12,740	28,090		170	75,140	165,660
75	14,620	32,250		175	79,620	175,550
80	16,640	36,690		180	84,240	185,720
85	18,780	41,420		185	88,980	196,180
90	21,060	46,430		190	93,860	206,930
95	23,460	51,740		195	98,860	217,970
100	26,000	57,330		200	104,000	229,290

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2.2 Static Loads

Gold's formula is adequate for calculating the allowable bearing capacity for moving loads on ice but it does not propose a relationship between allowable loads and ice thickness for static loads. To ensure ice safety for a static load operation, a literature review was completed. It was concluded that the deflection in ice must be monitored throughout the drilling operation and loading must be removed in case of excessive deflections. Ice cover should not exceed the freeboard elevation to ensure safety of the drilling crew.

3. Monitoring During Drilling Activities

A hole will be augured through ice within 5 m of the point of maximum load. The depth of water in the hole will be monitored throughout the duration of the drilling investigation at each borehole location. Drilling will be terminated if sea water is observed flowing through the top of the augured hole. Ref 3 provides further details regarding the bearing capacity of ice covers under static loads.

4. References

1. W, Gold. L. (n.d.). Field study on the load bearing capacity of ice covers. National Research Council Canada, 61(5), 3-7. Retrieved March 18, 2017, from http://nparc.cisti-icist.nrc-cnrc.gc.ca/eng/view/object/?id=e7d278d9-808a-4959-b9f7-27320d757afd
2. KINGERYW, . D., KLICKD, . W., DYKINSJ., E. Sea ice engineering summary report-Project ICEWAY. U.S. Naval Civ. Eng. Lab.Port Hueneme, Calif., Tech. Rep. R-189.
3. Frederking, R. M. W., and L. W. Gold. "The Bearing Capacity of Ice Covers under Static Loads." Canadian Journal of Civil Engineering 3.2 (1976): 288-93. Web Accessed March 18, 2017.

UK:UK
Attachment(s)/Enclosure

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Appendix F

ConeTec Report

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PRESENTATION OF SITE INVESTIGATION RESULTS

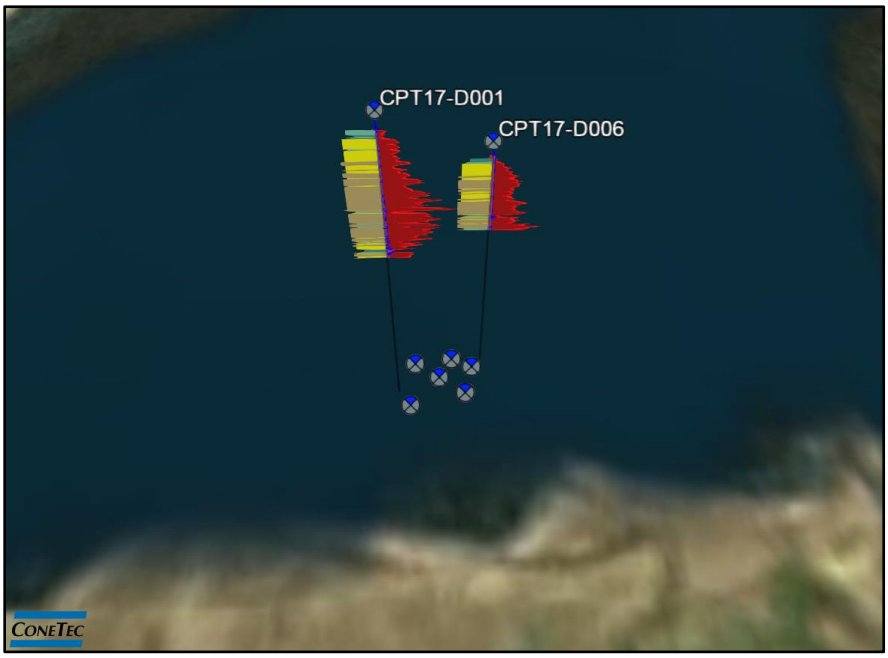
Milne Port Expansion

Prepared for:

Baffinland Iron Mines Corporation

ConeTec Job No: 17-05010

Project Start Date: 22-Mar-2017
Project End Date: 09-Apr-2017
Report Date: 13-Apr-2017
Revised Date: 21-Apr-2017



Prepared by:

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CONETEC

Introduction

The enclosed report presents the results of the site investigation program conducted by ConeTec Investigations Ltd. for Baffinland Iron Mines Corporation at Milne Inlet, Baffin Island, Nunavut. The program consisted of six cone penetration tests (CPT) and two seismic cone penetration tests (SCPT) carried out under the direction of Hatch Ltd.

Project Information

Project	
Client	Baffinland Iron Mines Corporation
Project	Milne Port Expansion
ConeTec project number	17-05010

A map from Google earth including the CPT and SCPT test locations is presented below.

Rig Description	Deployment System	Test Type
Boart LS100	Portable	CPT, SCPT

Coordinates		
Test Type	Collection Method	EPSG Number
CPT, SCPT	ConeTec Trimble Survey (RTK)	26917

Cone Penetration Test (CPT)	
Depth reference	Depths are referenced to the existing mudline at the time of each test.
Tip and sleeve data offset	0.1 meter This has been accounted for in the CPT data files.
Additional plots	Advanced CPT plots with Ic, Phi, and N1(60) and SCPT plots have been included.

Cone Penetrometers Used for this Project						
Cone Description	Cone Number	Cross Sectional Area (cm^2)	Sleeve Area (cm^2)	Tip Capacity (bar)	Sleeve Capacity (bar)	Pore Pressure Capacity (psi)
338:T1500F15U500	338	15	225	1500	15	500
374:T1500F15U500	374	15	225	1500	15	500
The CPT summary indicates which cone was used for each sounding.						

Interpretation Tables	
Additional information	The Soil Behaviour Type (SBT) classification chart (Robertson et al., 1986 presented by Lunne, Robertson and Powell, 1997) was used to classify the soil for this project. A detailed set of calculated CPT parameters were generated and are provided in Excel format files in the release folder. The calculated CPT parameters are based on values of corrected tip (q_t), sleeve friction (f_s) and pore pressure (u_2). Soils were classified as either drained or undrained based on the Soil Behaviour Type (SBT) classification chart (Robertson et al., 1986 presented by Lunne, Robertson and Powell, 1997). Calculations for both drained and undrained parameters were included for materials that classified as silt (zone 6).

Survey	
Tidal Fluctuations	As requested by Hatch Ltd., a survey grid was setup to monitor ice movement due to tidal fluctuation throughout the drill program. The grid was laid out around the proposed drilling area using six survey points in a 200m by 100m grid. ½ inch steel pins was installed at each point by drilling out a section of ice and freezing the rod in place. The pins were surveyed repeatedly throughout a 12-hour period to determine if the ebb and flow of the tide was moving the ice laterally. After installation they were then surveyed every couple of days.
Surveying Methodology	Due to the lack of compatibility with the onsite base station, a second base station broadcasting in the 450MHz band had to be setup to support the drill program surveying. An observed control point was surveyed in by the BIM

	surveyor onsite in datum NAD83 using an ellipsoid model. Our base station was permanently setup over the surveyed point with a vertical offset of 1.32m to the bottom of the R8 base. An existing control point, KM002, was surveyed for quality control. A second control point, PRJCNTRL, was surveyed in to allow for easy quality control when restarting the base station.
Depth Control	Significant tidal fluctuations between two and seven feet were observed on the ice throughout the drill program. Constant monitoring of the elevation of the ice was required while conducting the cone penetration tests (CPTs) to ensure the depth was correct throughout the sounding. At the beginning of the CPT, the Northing, Easting, and Elevation of the sounding was recorded along with a dip tape measurement to the sea floor. The dip tape measurement was subtracted from the ice elevation to get the sea floor elevation. Throughout the CPT, the elevation of ice was monitored and compared to the initial measurement to get an accurate depth at the end of every meter.
Ice Cracks and Survey Grid	There were large cracks in the ice near the drilling pad. They appeared to open and close as the tide went up and down. The Northing and Easting coordinates of the grid were surveyed using a continuous topo. The survey grid coordinates are not presented as part of this report.

Limitations

This report has been prepared for the exclusive use of Baffinland Iron Mines Corporation (Client) and Hatch Ltd. for the project titled “Milne Port Expansion”. The report’s contents may not be relied upon by any other party without the express written permission of ConeTec Investigations Ltd. (ConeTec). ConeTec has provided site investigation services, prepared the factual data reporting, and provided geotechnical parameter calculations consistent with current best practices. No other warranty, expressed or implied, is made.

The information presented in the report document and the accompanying data set pertain to the specific project, site conditions and objectives described to ConeTec by the Client and Hatch Ltd. In order to properly understand the factual data, assumptions and calculations, reference must be made to the documents provided and their accompanying data sets, in their entirety.

The cone penetration tests (CPTu) are conducted using an integrated electronic piezocone penetrometer and data acquisition system manufactured by Adara Systems Ltd. of Richmond, British Columbia, Canada.

ConeTec's piezocone penetrometers are compression type designs in which the tip and friction sleeve load cells are independent and have separate load capacities. The piezocones use strain gauged load cells for tip and sleeve friction and a strain gauged diaphragm type transducer for recording pore pressure. The piezocones also have a platinum resistive temperature device (RTD) for monitoring the temperature of the sensors, an accelerometer type dual axis inclinometer and a geophone sensor for recording seismic signals. All signals are amplified down hole within the cone body and the analog signals are sent to the surface through a shielded cable.

ConeTec penetrometers are manufactured with various tip, friction and pore pressure capacities in both 10 cm^2 and 15 cm^2 tip base area configurations in order to maximize signal resolution for various soil conditions. The specific piezocone used for each test is described in the CPT summary table presented in the first Appendix. The 15 cm^2 penetrometers do not require friction reducers as they have a diameter larger than the deployment rods. The 10 cm^2 piezocones use a friction reducer consisting of a rod adapter extension behind the main cone body with an enlarged cross sectional area (typically 44 mm diameter over a length of 32 mm with tapered leading and trailing edges) located at a distance of 585 mm above the cone tip.

The penetrometers are designed with equal end area friction sleeves, a net end area ratio of 0.8 and cone tips with a 60 degree apex angle.

All ConeTec piezocones can record pore pressure at various locations. Unless otherwise noted, the pore pressure filter is located directly behind the cone tip in the "u_2" position (ASTM Type 2). The filter is 6 mm thick, made of porous plastic (polyethylene) having an average pore size of 125 microns (90-160 microns). The function of the filter is to allow rapid movements of extremely small volumes of water needed to activate the pressure transducer while preventing soil ingress or blockage.

The piezocone penetrometers are manufactured with dimensions, tolerances and sensor characteristics that are in general accordance with the current ASTM D5778 standard. ConeTec's calibration criteria also meets or exceeds those of the current ASTM D5778 standard. An illustration of the piezocone penetrometer is presented in Figure CPTu.

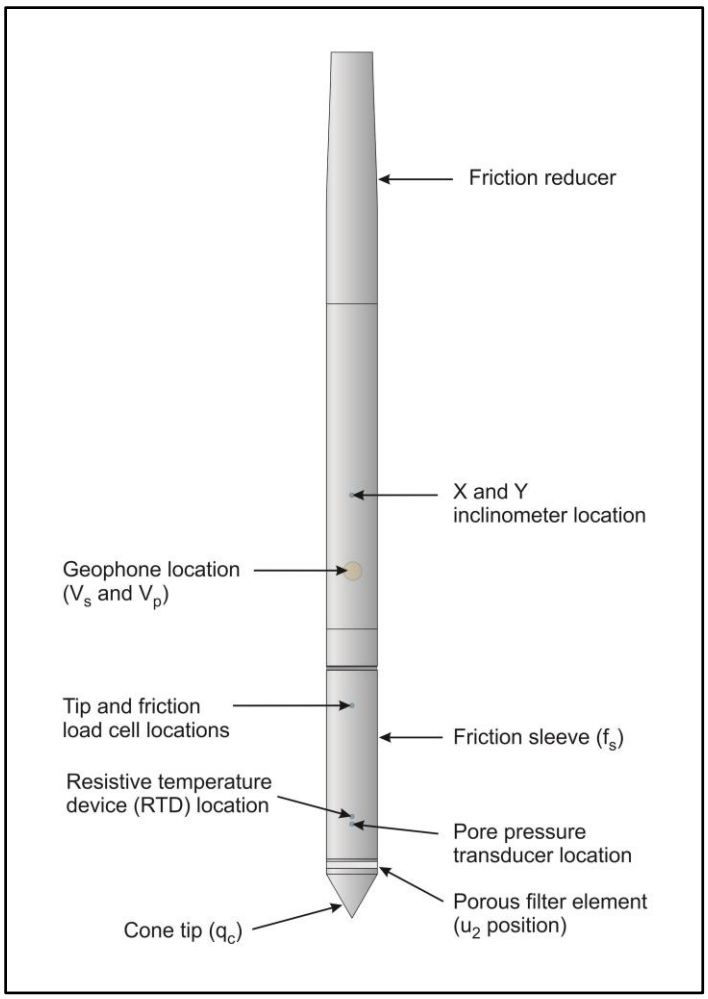

Figure CPTu. Piezocone Penetrometer (15 cm^2)

The ConeTec data acquisition systems consist of a Windows based computer and a signal conditioner and power supply interface box with a 16 bit (or greater) analog to digital (A/D) converter. The data is recorded at fixed depth increments using a depth wheel attached to the push cylinders or by using a spring loaded rubber depth wheel that is held against the cone rods. The typical recording intervals are either 2.5 cm or 5.0 cm depending on project requirements; custom recording intervals are possible. The system displays the CPTu data in real time and records the following parameters to a storage media during penetration:

- Depth
- Uncorrected tip resistance (q_c)
- Sleeve friction (f_s)
- Dynamic pore pressure (u)
- Additional sensors such as resistivity, passive gamma, ultra violet induced fluorescence, if applicable

All testing is performed in accordance to ConeTec's CPT operating procedures which are in general accordance with the current ASTM D5778 standard.

Prior to the start of a CPTu sounding a suitable cone is selected, the cone and data acquisition system are powered on, the pore pressure system is saturated with either glycerine or silicone oil and the baseline readings are recorded with the cone hanging freely in a vertical position.

The CPTu is conducted at a steady rate of 2 cm/s, within acceptable tolerances. Typically one meter length rods with an outer diameter of 1.5 inches are added to advance the cone to the sounding termination depth. After cone retraction final baselines are recorded.

Additional information pertaining to ConeTec's cone penetration testing procedures:

- Each filter is saturated in silicone oil or glycerine under vacuum pressure prior to use
- Recorded baselines are checked with an independent multi-meter
- Baseline readings are compared to previous readings
- Soundings are terminated at the client's target depth or at a depth where an obstruction is encountered, excessive rod flex occurs, excessive inclination occurs, equipment damage is likely to take place, or a dangerous working environment arises
- Differences between initial and final baselines are calculated to ensure zero load offsets have not occurred and to ensure compliance with ASTM standards

The interpretation of piezocone data for this report is based on the corrected tip resistance (q_t), sleeve friction (f_s) and pore water pressure (u). The interpretation of soil type is based on the correlations developed by Robertson (1990) and Robertson (2009). It should be noted that it is not always possible to accurately identify a soil type based on these parameters. In these situations, experience, judgment and an assessment of other parameters may be used to infer soil behaviour type.

The recorded tip resistance (q_c) is the total force acting on the piezocone tip divided by its base area. The tip resistance is corrected for pore pressure effects and termed corrected tip resistance (q_t) according to the following expression presented in Robertson et al, 1986:

$$q_t = q_c + (1\text{-}a) \bullet u_2$$

where: q_t is the corrected tip resistance
q_c is the recorded tip resistance
u_2 is the recorded dynamic pore pressure behind the tip (u_2 position)
a is the Net Area Ratio for the piezocone (0.8 for ConeTec probes)

The sleeve friction (f_s) is the frictional force on the sleeve divided by its surface area. As all ConeTec piezocones have equal end area friction sleeves, pore pressure corrections to the sleeve data are not required.

The dynamic pore pressure (u) is a measure of the pore pressures generated during cone penetration. To record equilibrium pore pressure, the penetration must be stopped to allow the dynamic pore pressures to stabilize. The rate at which this occurs is predominantly a function of the permeability of the soil and the diameter of the cone.

The friction ratio (Rf) is a calculated parameter. It is defined as the ratio of sleeve friction to the tip resistance expressed as a percentage. Generally, saturated cohesive soils have low tip resistance, high

friction ratios and generate large excess pore water pressures. Cohesionless soils have higher tip resistances, lower friction ratios and do not generate significant excess pore water pressure.

A summary of the CPTu soundings along with test details and individual plots are provided in the appendices. A set of interpretation files were generated for each sounding based on published correlations and are provided in Excel format in the data release folder. Information regarding the interpretation methods used is also included in the data release folder.

For additional information on CPTu interpretations, refer to Robertson et al. (1986), Lunne et al. (1997), Robertson (2009), Mayne (2013, 2014) and Mayne and Peuchen (2012).

Shear wave velocity testing is performed in conjunction with the piezocone penetration test (SCPTu) in order to collect interval velocities. For some projects seismic compression wave (Vp) velocity is also determined.

ConeTec's piezocone penetrometers are manufactured with a horizontally active geophone (28 hertz) that is rigidly mounted in the body of the cone penetrometer, 0.2 meters behind the cone tip.

Shear waves are typically generated by using an impact hammer horizontally striking a beam that is held in place by a normal load. In some instances an auger source or an imbedded impulsive source maybe used for both shear waves and compression waves. The hammer and beam act as a contact trigger that triggers the recording of the seismic wave traces. For impulsive devices an accelerometer trigger may be used. The traces are recorded using an up-hole integrated digital oscilloscope which is part of the SCPTu data acquisition system. An illustration of the shear wave testing configuration is presented in Figure SCPTu-1.

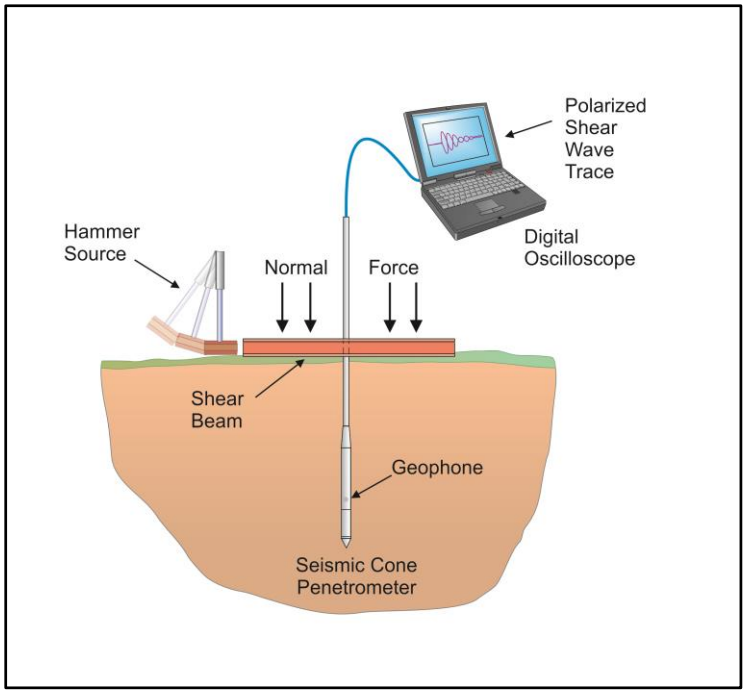

Figure SCPTu-1. Illustration of the SCPTu system

All testing is performed in accordance to ConeTec's SCPTu operating procedures.

Prior to the start of a SCPTu sounding, the procedures described in the Cone Penetration Test section are followed. In addition, the active axis of the geophone is aligned parallel to the beam (or source) and the horizontal offset between the cone and the source is measured and recorded.

Prior to recording seismic waves at each test depth, cone penetration is stopped and the rods are decoupled from the rig to avoid transmission of rig energy down the rods. Multiple wave traces are recorded for quality control purposes. After reviewing wave traces for consistency the cone is pushed to the next test depth (typically one meter intervals or as requested by the client). Figure SCPTu-2 presents an illustration of a SCPTu test.

For additional information on seismic cone penetration testing refer to Robertson et.al. (1986).

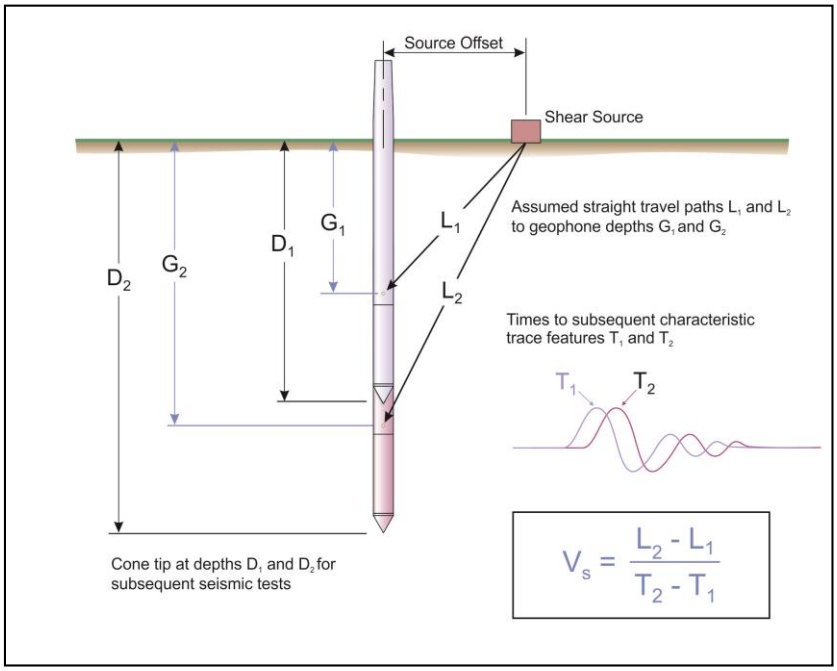

Figure SCPTu-2. Illustration of a seismic cone penetration test

Calculation of the interval velocities are performed by visually picking a common feature (e.g. the first characteristic peak, trough, or crossover) on all of the recorded wave sets and taking the difference in ray path divided by the time difference between subsequent features. Ray path is defined as the straight line distance from the seismic source to the geophone, accounting for beam offset, source depth and geophone offset from the cone tip.

The average shear wave velocity to a depth of 30 meters (V_{s30}) has been calculated and provided for all applicable soundings using an equation presented in Crow et al., 2012.

$$V_{s30} = \frac{total\ thickness\ of\ all\ layers\ (30m)}{\sum(layer\ traveltimes)}$$

The layer travel times refers to the travel times propagating in the vertical direction, not the measured travel times from an offset source.

Tabular results and SCPTu plots are presented in the relevant appendix.

The cone penetration test is halted at specific depths to carry out pore pressure dissipation (PPD) tests, shown in Figure PPD-1. For each dissipation test the cone and rods are decoupled from the rig and the data acquisition system measures and records the variation of the pore pressure (u) with time (t).

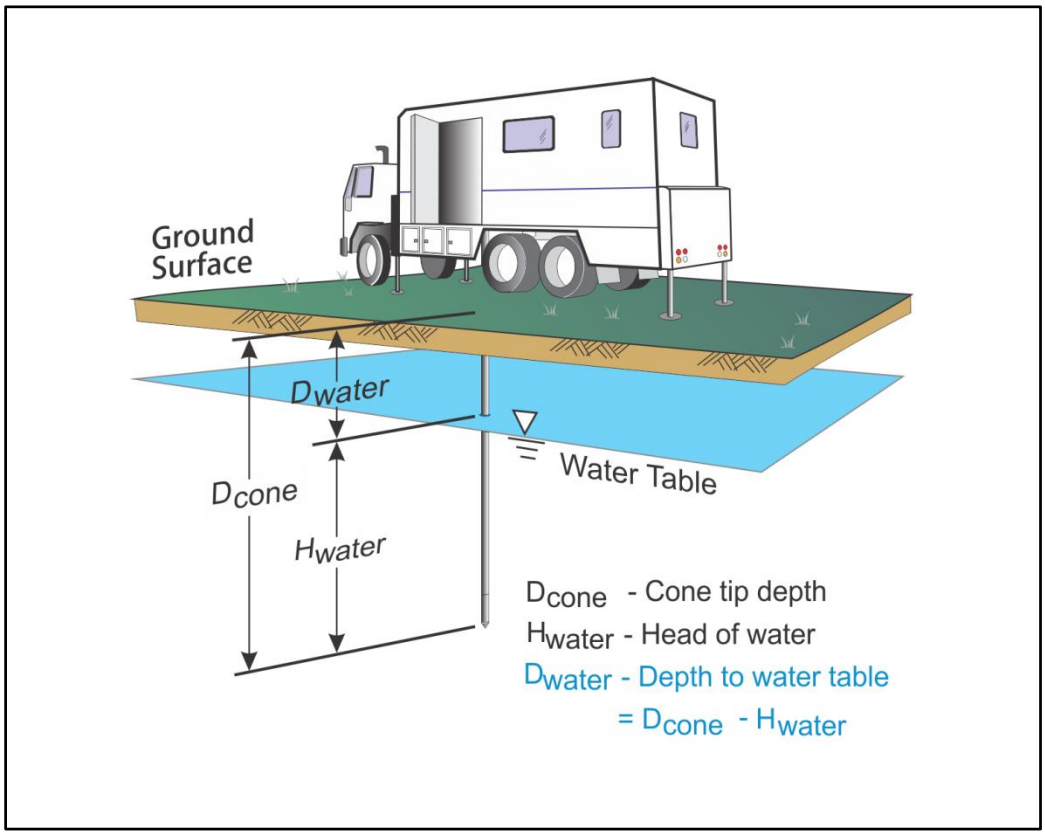

Figure PPD-1. Pore pressure dissipation test setup

Pore pressure dissipation data can be interpreted to provide estimates of ground water conditions, permeability, consolidation characteristics and soil behaviour.

The typical shapes of dissipation curves shown in Figure PPD-2 are very useful in assessing soil type, drainage, in situ pore pressure and soil properties. A flat curve that stabilizes quickly is typical of a freely draining sand. Undrained soils such as clays will typically show positive excess pore pressure and have long dissipation times. Dilative soils will often exhibit dynamic pore pressures below equilibrium that then rise over time. Overconsolidated fine-grained soils will often exhibit an initial dilatory response where there is an initial rise in pore pressure before reaching a peak and dissipating.

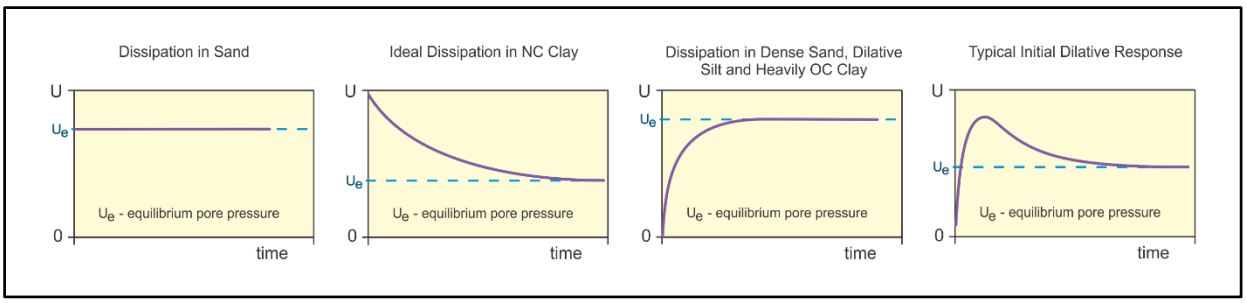

Figure PPD-2. Pore pressure dissipation curve examples

In order to interpret the equilibrium pore pressure (u_{eq}) and the apparent phreatic surface, the pore pressure should be monitored until such time as there is no variation in pore pressure with time as shown for each curve of Figure PPD-2.

In fine grained deposits the point at which 100% of the excess pore pressure has dissipated is known as t_{100}. In some cases this can take an excessive amount of time and it may be impractical to take the dissipation to t_{100}. A theoretical analysis of pore pressure dissipations by Teh and Houlsby (1991) showed that a single curve relating degree of dissipation versus theoretical time factor (T*) may be used to calculate the coefficient of consolidation (c_h) at various degrees of dissipation resulting in the expression for c_h shown below.

$$c_h = \frac{T^* \cdot a^2 \cdot \sqrt{I_r}}{t}$$

Where:

T* is the dimensionless time factor (Table Time Factor)
a is the radius of the cone
I_r is the rigidity index
t is the time at the degree of consolidation

Table Time Factor. T* versus degree of dissipation (Teh and Houlsby, 1991)

Degree of Dissipation (%)	20	30	40	50	60	70	80
T* (u_2)	0.038	0.078	0.142	0.245	0.439	0.804	1.60

The coefficient of consolidation is typically analyzed using the time (t_{50}) corresponding to a degree of dissipation of 50% (u_{50}). In order to determine t_{50}, dissipation tests must be taken to a pressure less than u_{50}. The u_{50} value is half way between the initial maximum pore pressure and the equilibrium pore pressure value, known as u_{100}. To estimate u_{50}, both the initial maximum pore pressure and u_{100} must be known or estimated. Other degrees of dissipations may be considered, particularly for extremely long dissipations.

At any specific degree of dissipation the equilibrium pore pressure (u at t_{100}) must be estimated at the depth of interest. The equilibrium value may be determined from one or more sources such as measuring the value directly (u_{100}), estimating it from other dissipations in the same profile, estimating the phreatic surface and assuming hydrostatic conditions, from nearby soundings, from client provided information, from site observations and/or past experience, or from other site instrumentation.

For calculations of c_h (Teh and Houlsby, 1991), t_{50} values are estimated from the corresponding pore pressure dissipation curve and a rigidity index (I_r) is assumed. For curves having an initial dilatory response in which an initial rise in pore pressure occurs before reaching a peak, the relative time from the peak value is used in determining t_{50}. In cases where the time to peak is excessive, t_{50} values are not calculated.

Due to possible inherent uncertainties in estimating I_r, the equilibrium pore pressure and the effect of an initial dilatory response on calculating t_{50}, other methods should be applied to confirm the results for c_h.

Additional published methods for estimating the coefficient of consolidation from a piezocone test are described in Burns and Mayne (1998, 2002), Jones and Van Zyl (1981), Robertson et al. (1992) and Sully et al. (1999).

A summary of the pore pressure dissipation tests and dissipation plots are presented in the relevant appendix.

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Sully, J.P., Robertson, P.K., Campanella, R.G. and Woeller, D.J., 1999, "An approach to evaluation of field CPTU dissipation data in overconsolidated fine-grained soils", Canadian Geotechnical Journal, 36(2): 369-381.

Teh, C.I., and Houlsby, G.T., 1991, “An analytical study of the cone penetration test in clay”, Geotechnique, 41(1): 17-34.

The following appendices listed below are included in the report:

- Cone Penetration Test Summary and Standard Cone Penetration Test Plots
- Advanced Cone Penetration Test Plots with Ic, Phi, and N1(60)
- Seismic Cone Penetration Test Tabular Results
- Seismic Cone Penetration Test Plots
- Pore Pressure Dissipation Summary and Pore Pressure Dissipation Plots

Cone Penetration Test Summary and Standard Cone Penetration Test Plots

CONETEC

Job No: 17-05010
Client: Baffinland Iron Mines Corporation
Project: Milne Port Expansion
Start Date: 03-Apr-2017
End Date: 07-Apr-2017

CONE PENETRATION TEST SUMMARY

Sounding ID	File Name	Date	Cone	Assumed Phreatic Surface[1] (m)	Final Depth[2] (m)	Northing[3] (m)	Easting (m)	Elevation (m)	Refer to Notation Number
CPT17-D001	17-05010_CPD001	05-Apr-2017	338:T1500F15U500	-17.6	32.750	7976717.62	503607.38	-16.97	
SCPT17-D002	17-05010_SPD002	05-Apr-2017	338:T1500F15U500	-16.9	39.475	7976728.05	503705.30	-16.12	
CPT17-D003	17-05010_CPD003	06-Apr-2017	338:T1500F15U500	-23.2	30.425	7976757.71	503785.39	-22.68	
SCPT17-D004	17-05010_SPD004	04-Apr-2017	338:T1500F15U500	-27.3	32.050	7976768.10	503646.44	-26.59	
CPT17-D005	17-05010_CPD005	03-Apr-2017	338:T1500F15U500	-26.0	25.125	7976780.84	503736.09	-24.98	
CPT17-D006	17-05010_CPD006	06-Apr-2017	374:T1500F15U500	-32.0	20.575	7976808.43	503807.55	-31.32	
CPT17-D007	17-05010_CPD007	07-Apr-2017	374:T1500F15U501	-4.7	30.200	7976683.63	503767.46	-4.23	
CPT17-D008	17-05010_CPD008	07-Apr-2017	374:T1500F15U502	-1.4	30.000	7976650.76	503635.99	-1.80	

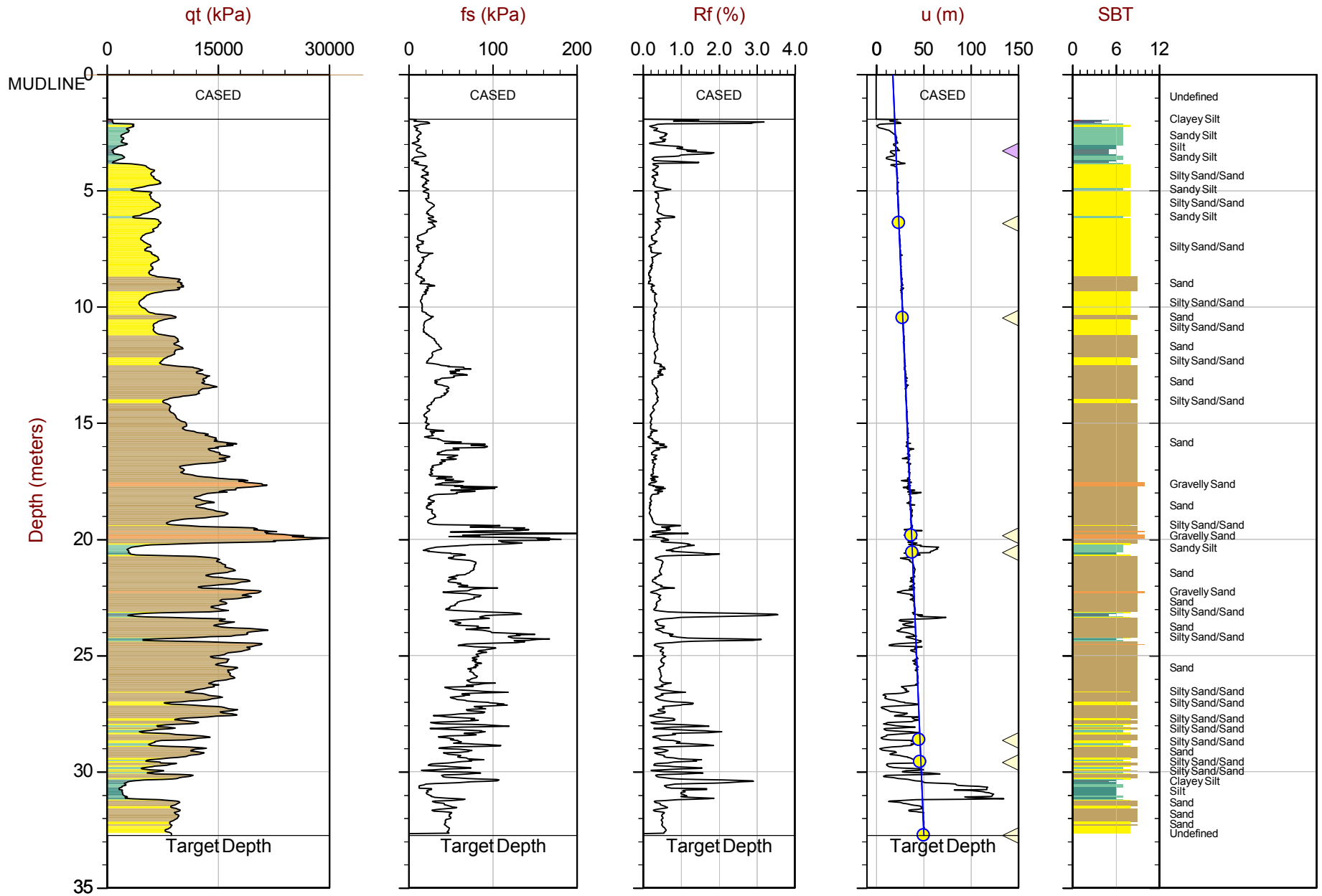
1. The assumed phreatic surface was based on pore pressure dissipation tests. Hydrostatic conditions were assumed for the interpretation tables.
2. Depth is referenced from the mudline at the time of testing.
3. Coordinates and elevations were acquired using ConeTec Trimble Survey in datum NAD 83 / UTM Zone 17 North. Elevation is of the mudline at the time of testing.

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-05 09:17
Site: Milne Port Expansion

Sounding: CPT17-D001
Cone: 338:T1500F15U500



Max Depth: 32.750 m / 107.45 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_CPD001.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976717.62m E: 503607.38m Elev: -16.97m

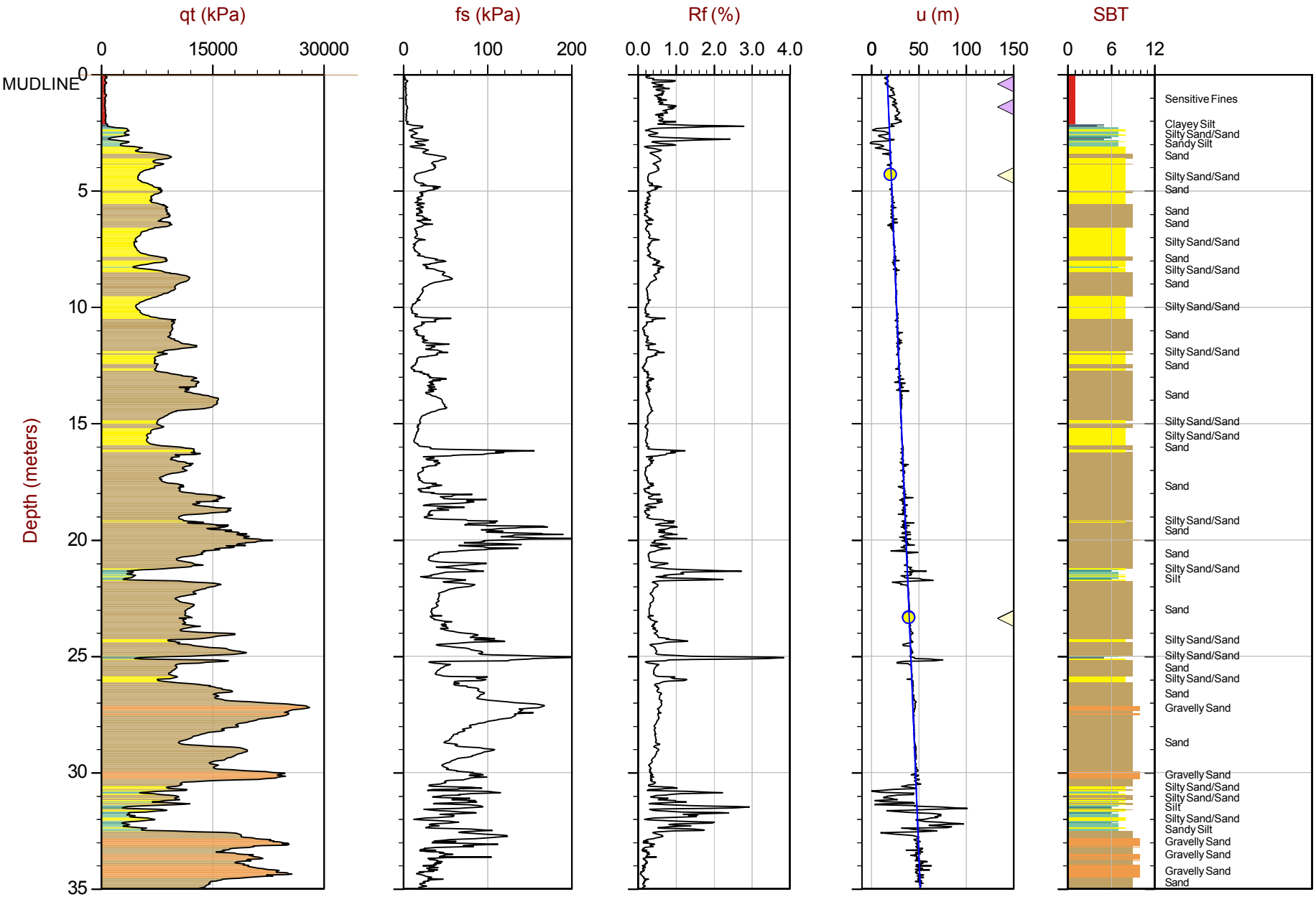
Equilibrium Pore Pressure (Ueq)
Dissipation, Ueq not achieved
Dissipation, Ueq achieved
Hydrostatic Line

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-05 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500



Max Depth: 39.475 m / 129.51 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_SPD002.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976728.05m E: 503705.30m Elev: -16.12m

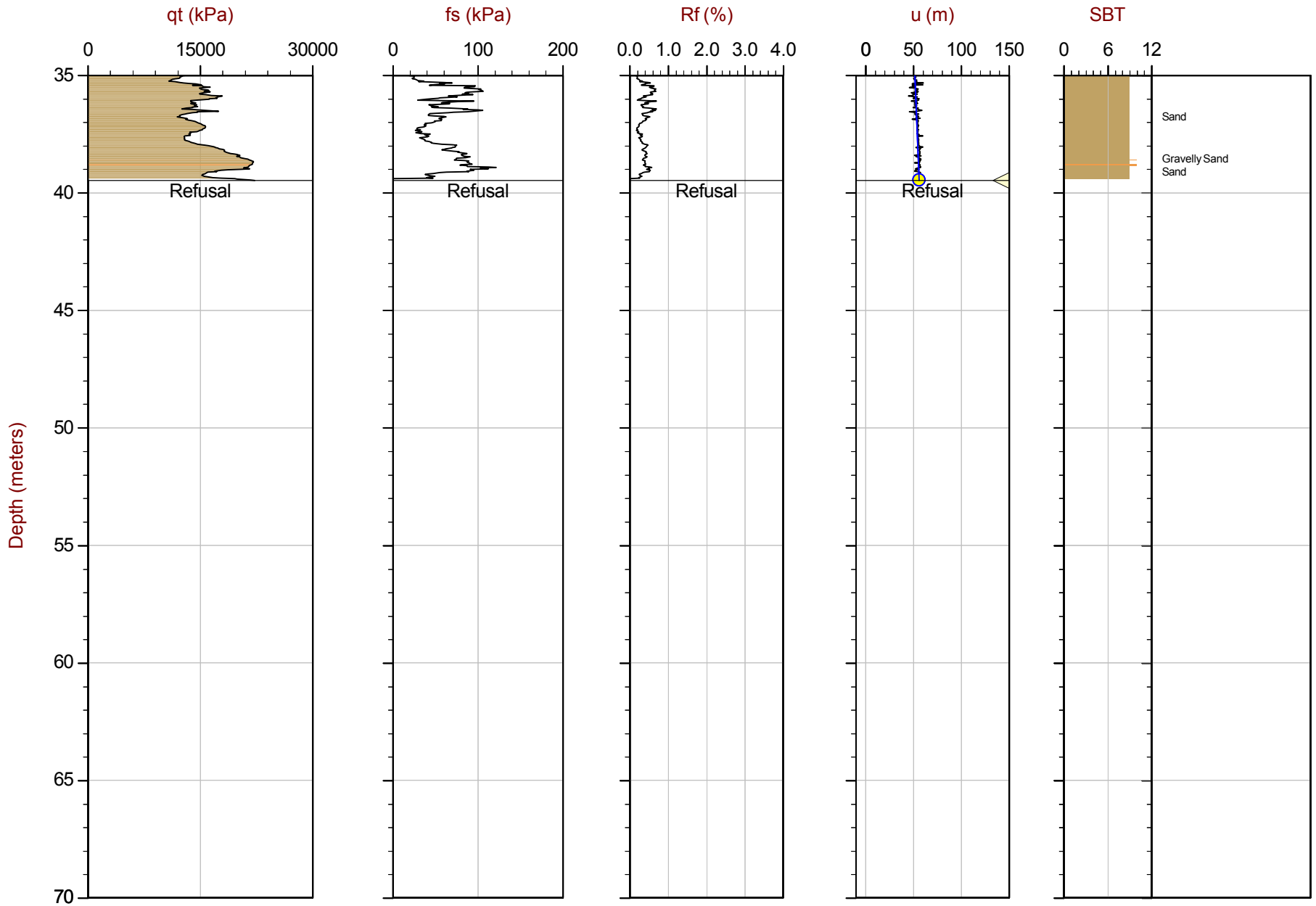
Equilibrium Pore Pressure (Ueq)
Dissipation, Ueq not achieved
Dissipation, Ueq achieved
Hydrostatic Line

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-05 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500



Max Depth: 39.475 m / 129.51 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_SPD002.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976728.05m E: 503705.30m Elev: -16.12m

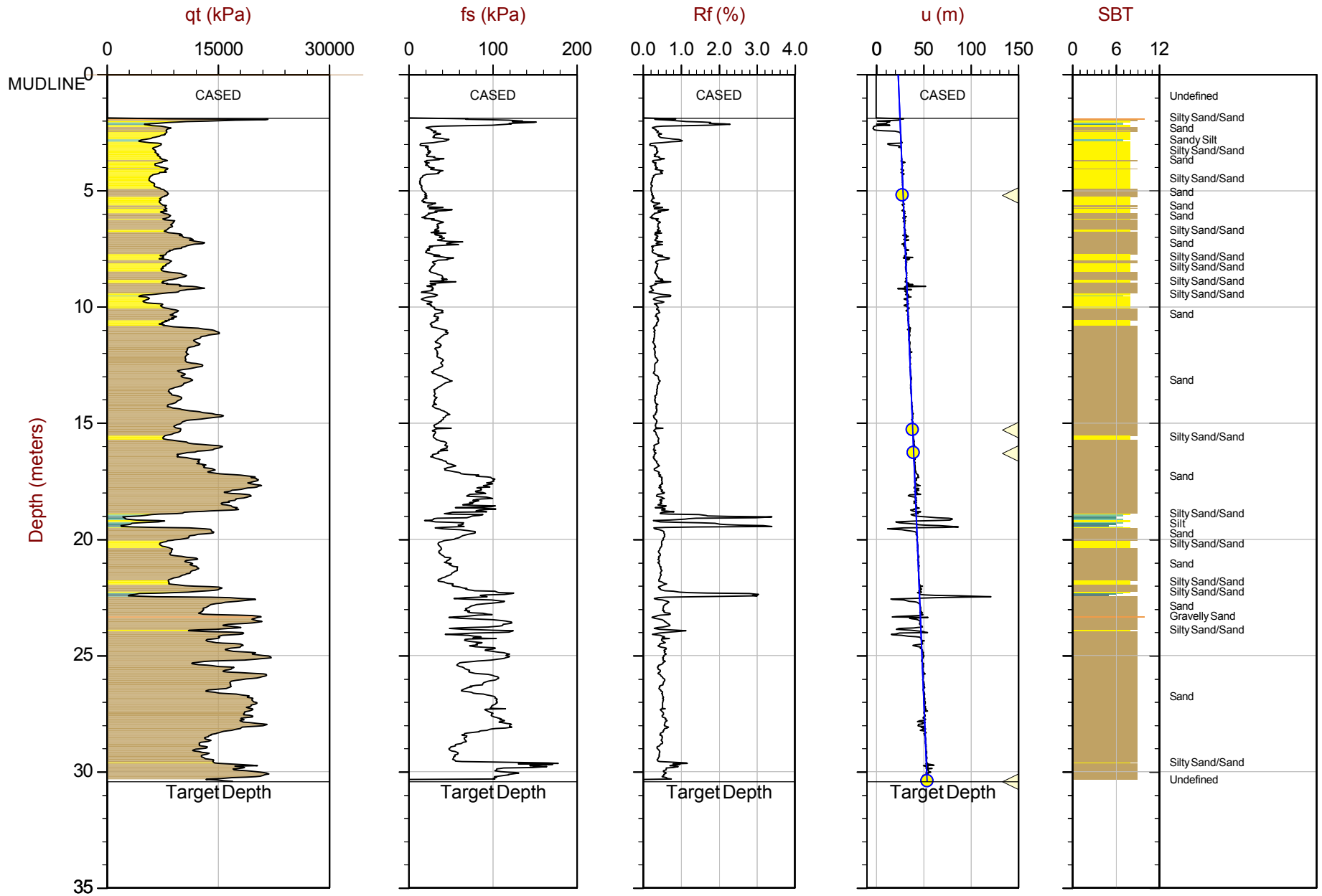
Equilibrium Pore Pressure (Ueq)
Dissipation, Ueq not achieved
Dissipation, Ueq achieved
Hydrostatic Line

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-06 13:34
Site: Milne Port Expansion

Sounding: CPT17-D003
Cone: 338:T1500F15U500



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Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_CPD003.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976757.71m E: 503785.39m Elev: -22.68m

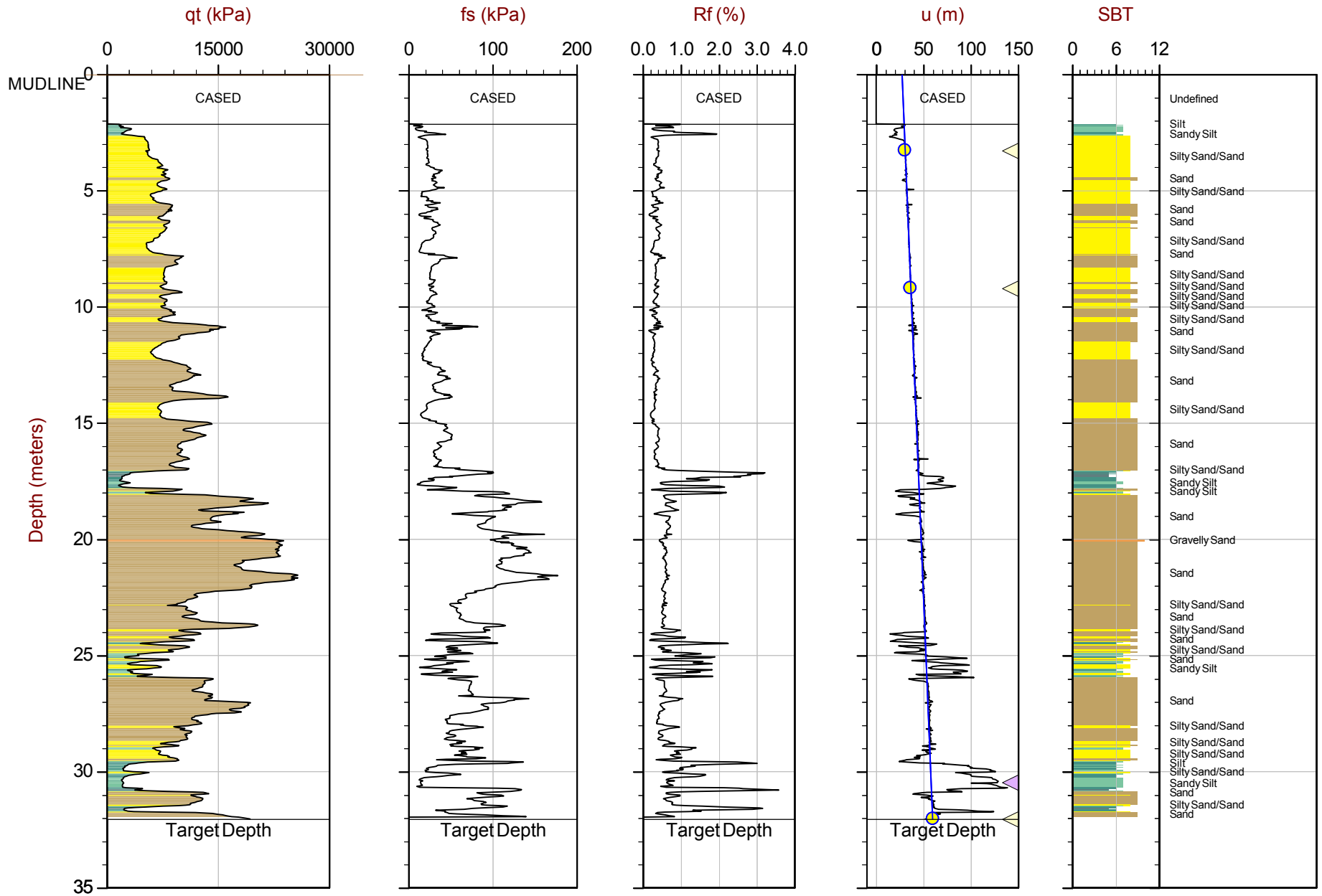
Equilibrium Pore Pressure (Ueq)
Dissipation, Ueq not achieved
Dissipation, Ueq achieved
Hydrostatic Line

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-04 16:44
Site: Milne Port Expansion

Sounding: SCPT17-D004
Cone: 338:T1500F15U500



Max Depth: 32.050 m / 105.15 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_SPD004.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976768.10m E: 503646.44m Elev: -26.59m

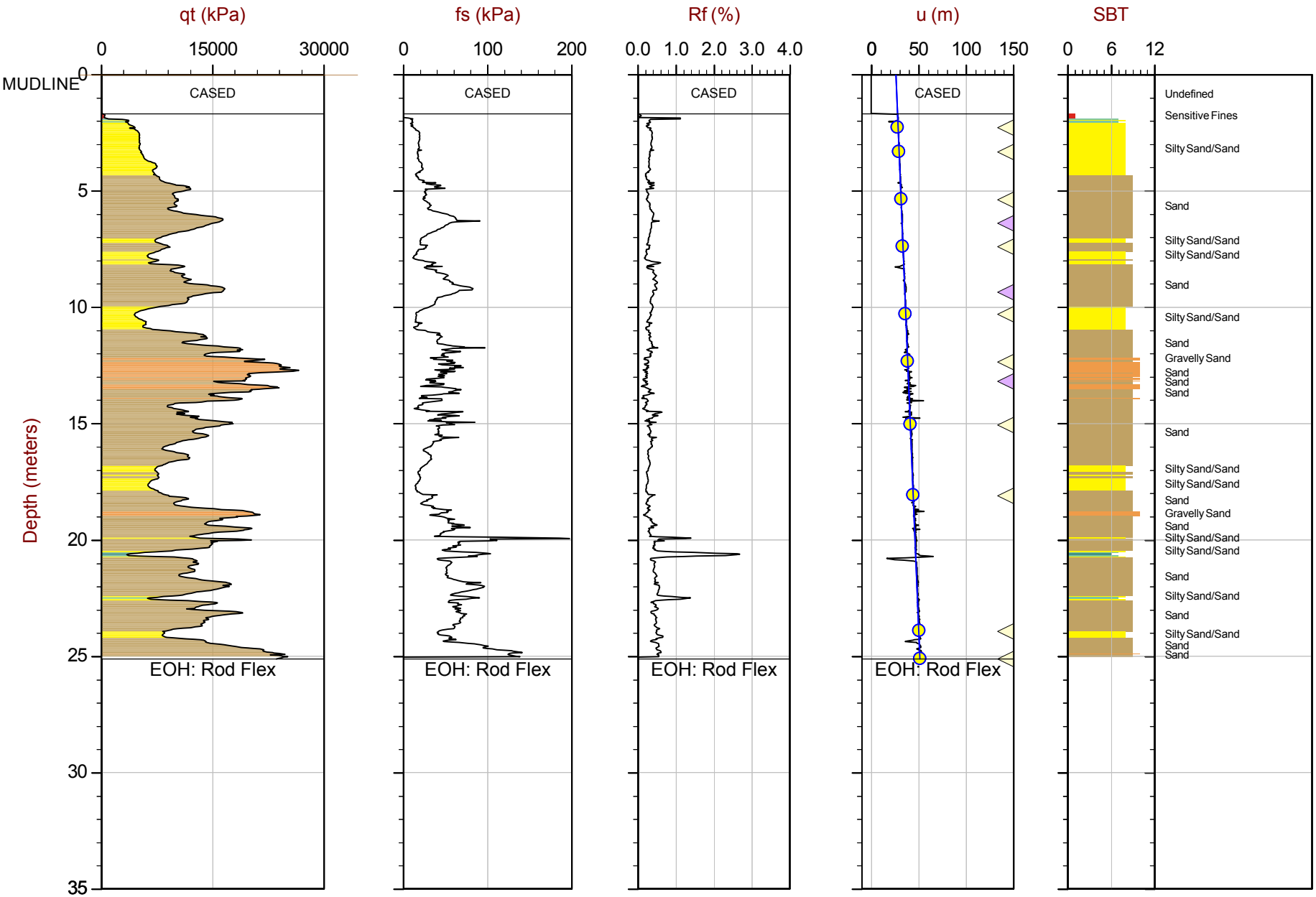
Equilibrium Pore Pressure (Ueq)
Dissipation, Ueq not achieved
Dissipation, Ueq achieved
Hydrostatic Line

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-03 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500



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Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_CPD005.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976780.84m E: 503736.09m Elev: -24.98m

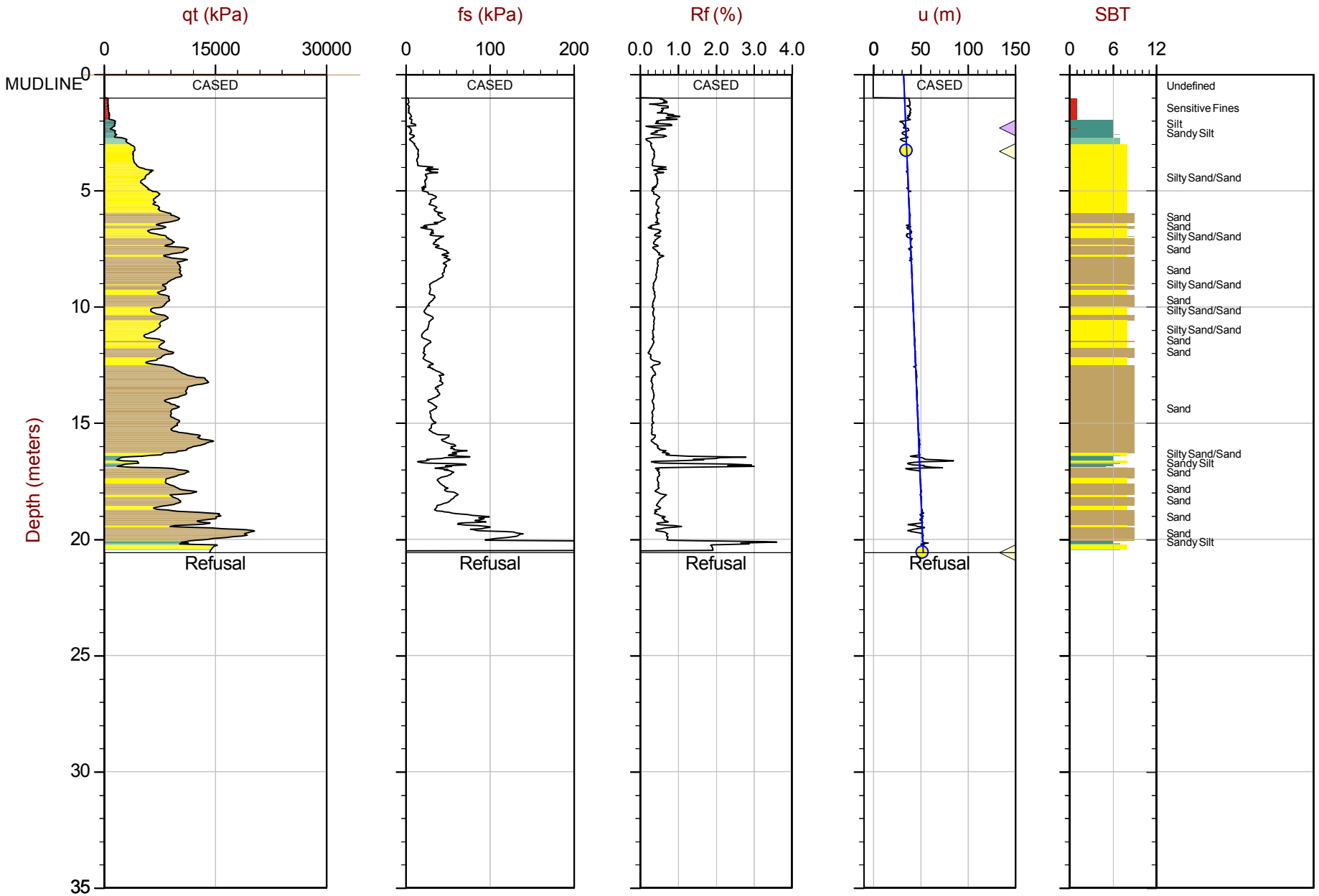
Equilibrium Pore Pressure (Ueq)
Dissipation, Ueq not achieved
Dissipation, Ueq achieved
Hydrostatic Line

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-06 23:59
Site: Milne Port Expansion

Sounding: CPT17-D006
Cone: 374:T1500F15U500



Max Depth: 20.575 m / 67.50 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_CPD006.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976808.43m E: 503807.55m Elev: -31.32m

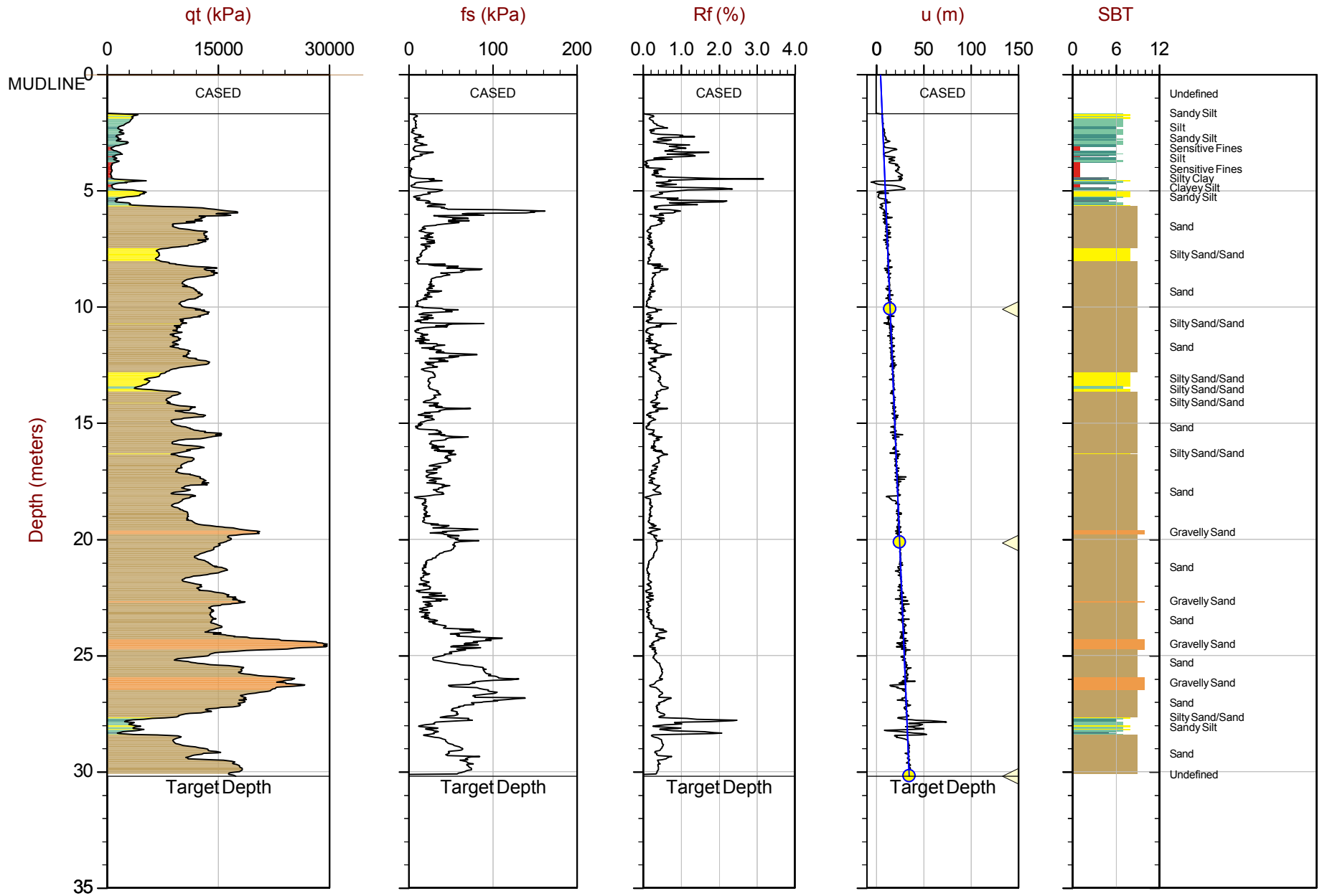
Equilibrium Pore Pressure (Ueq)
Dissipation, Ueq not achieved
Dissipation, Ueq achieved
Hydrostatic Line

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-07 11:27
Site: Milne Port Expansion

Sounding: CPT17-D007
Cone: 374:T1500F15U500



Max Depth: 30.200 m / 99.08 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_CPD007.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976683.63m E: 503767.46m Elev: -4.23m

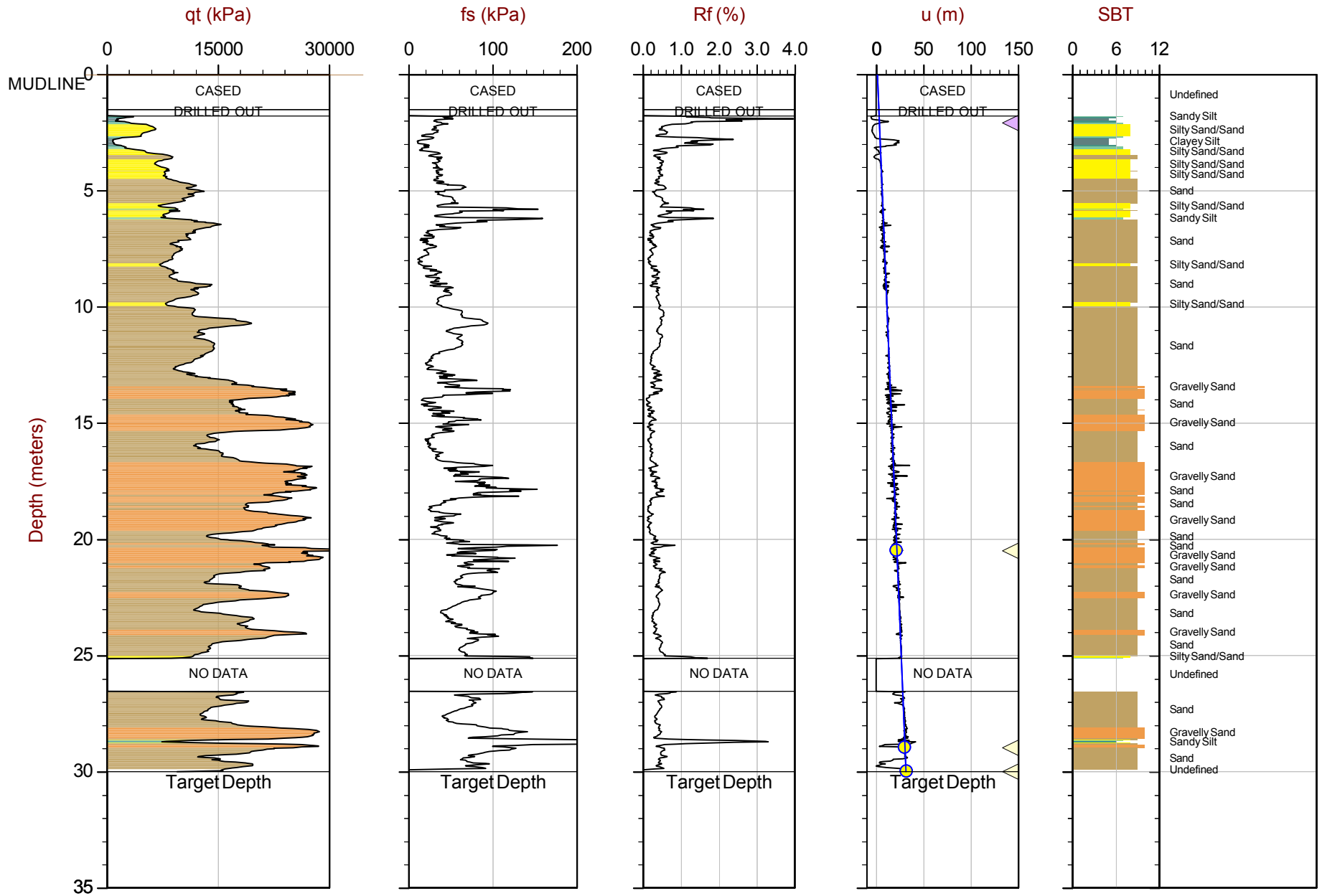
Equilibrium Pore Pressure (Ueq)
Dissipation, Ueq not achieved
Dissipation, Ueq achieved
Hydrostatic Line

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-07 16:47
Site: Milne Port Expansion

Sounding: CPT17-D008
Cone: 374:T1500F15U500



Max Depth: 30.000 m / 98.42 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_CPD008.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976650.76m E: 503635.99m Elev: -1.80m

Equilibrium Pore Pressure (Ueq)
Dissipation, Ueq not achieved
Dissipation, Ueq achieved
Hydrostatic Line

Advanced Cone Penetration Test Plots with Ic, Phi, and N1(60)

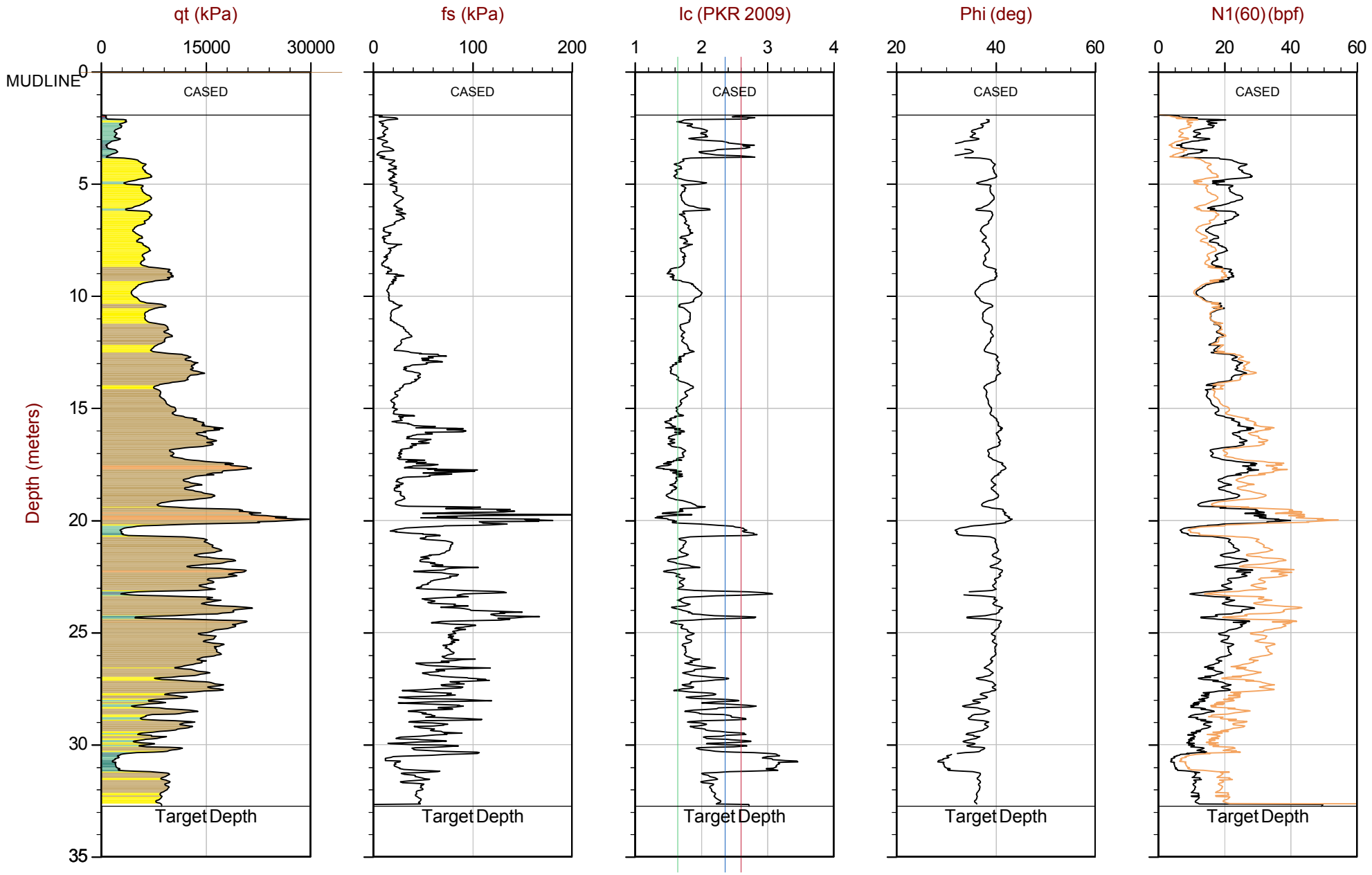
CONETEC

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-05 09:17
Site: Milne Port Expansion

Sounding: CPT17-D001
Cone: 338:T1500F15U500



Max Depth: 32.750 m / 107.45 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point
N(60) (bpf)

File: 17-05010_CPD001.COR
Unit Wt: SBT (R&C1986)

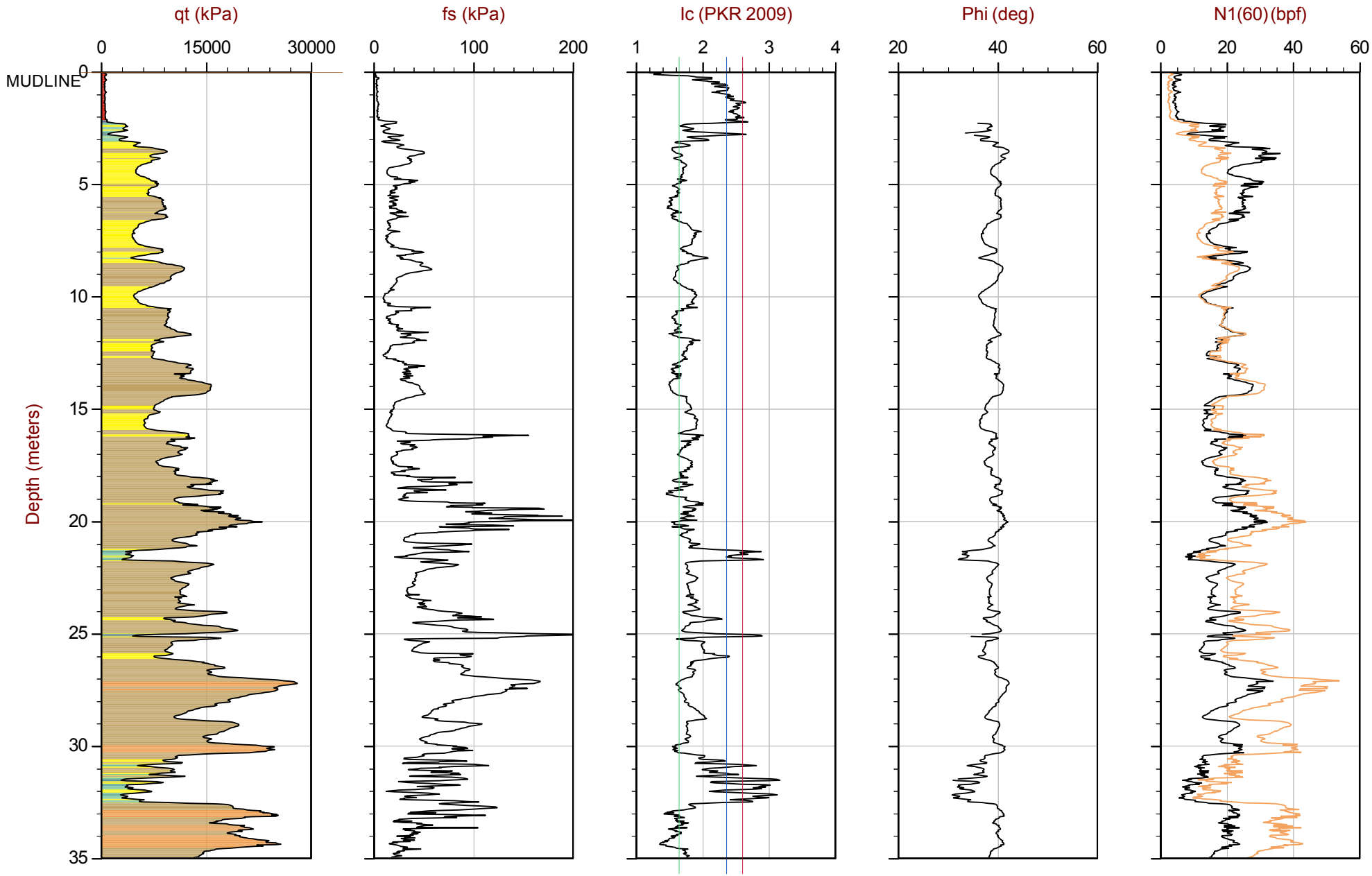
SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976717.62m E: 503607.38m Elev: -16.97m

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-05 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500



Max Depth: 39.475 m / 129.51 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point
N(60) (bpf)

File: 17-05010_SPD002.COR
Unit Wt: SBT (R&C1986)

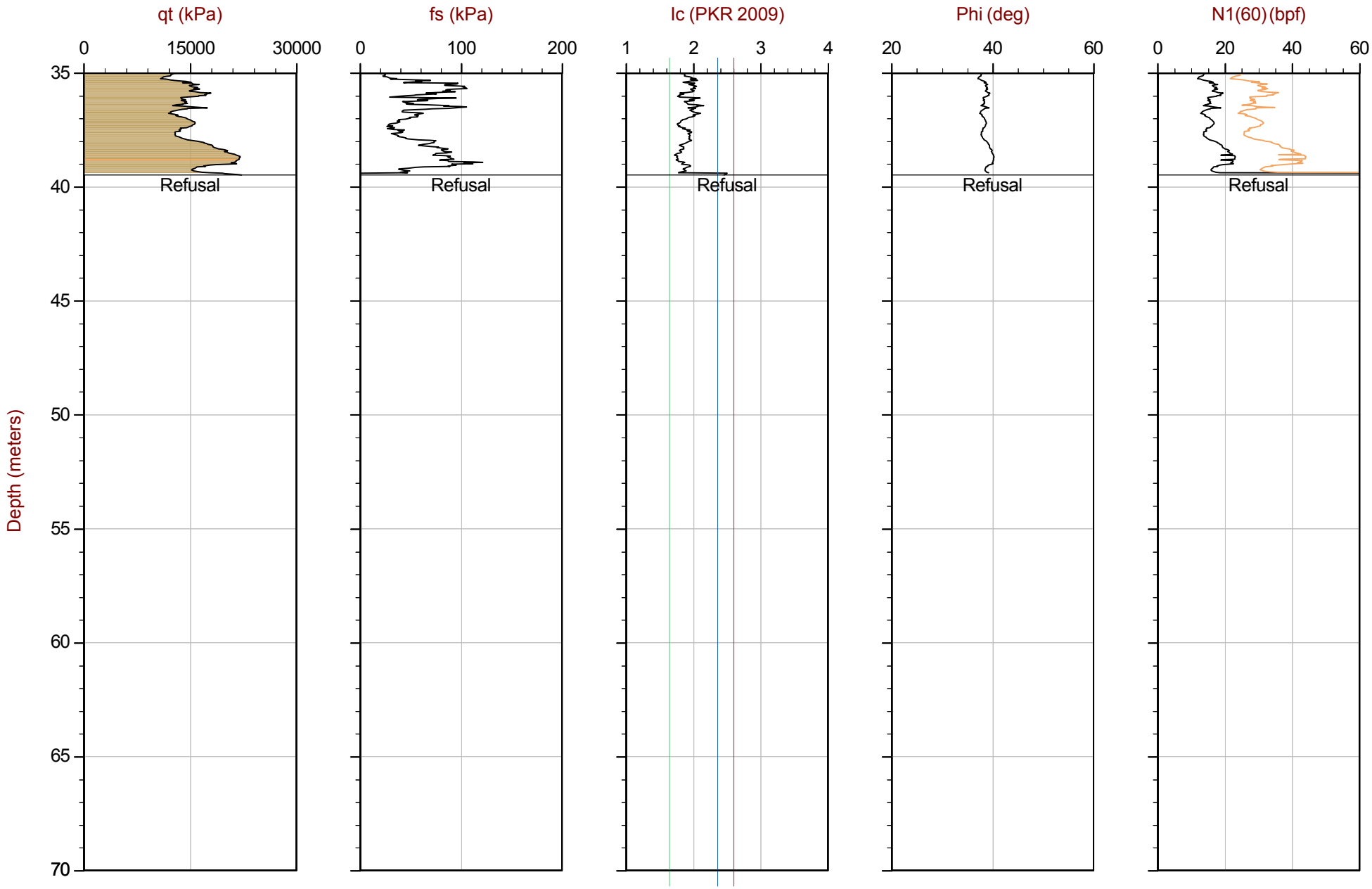
SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976728.05m E: 503705.30m Elev: -16.12m

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-05 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500



Max Depth: 39.475 m / 129.51 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point
N(60) (bpf)

File: 17-05010_SPD002.COR
Unit Wt: SBT (R&C1986)

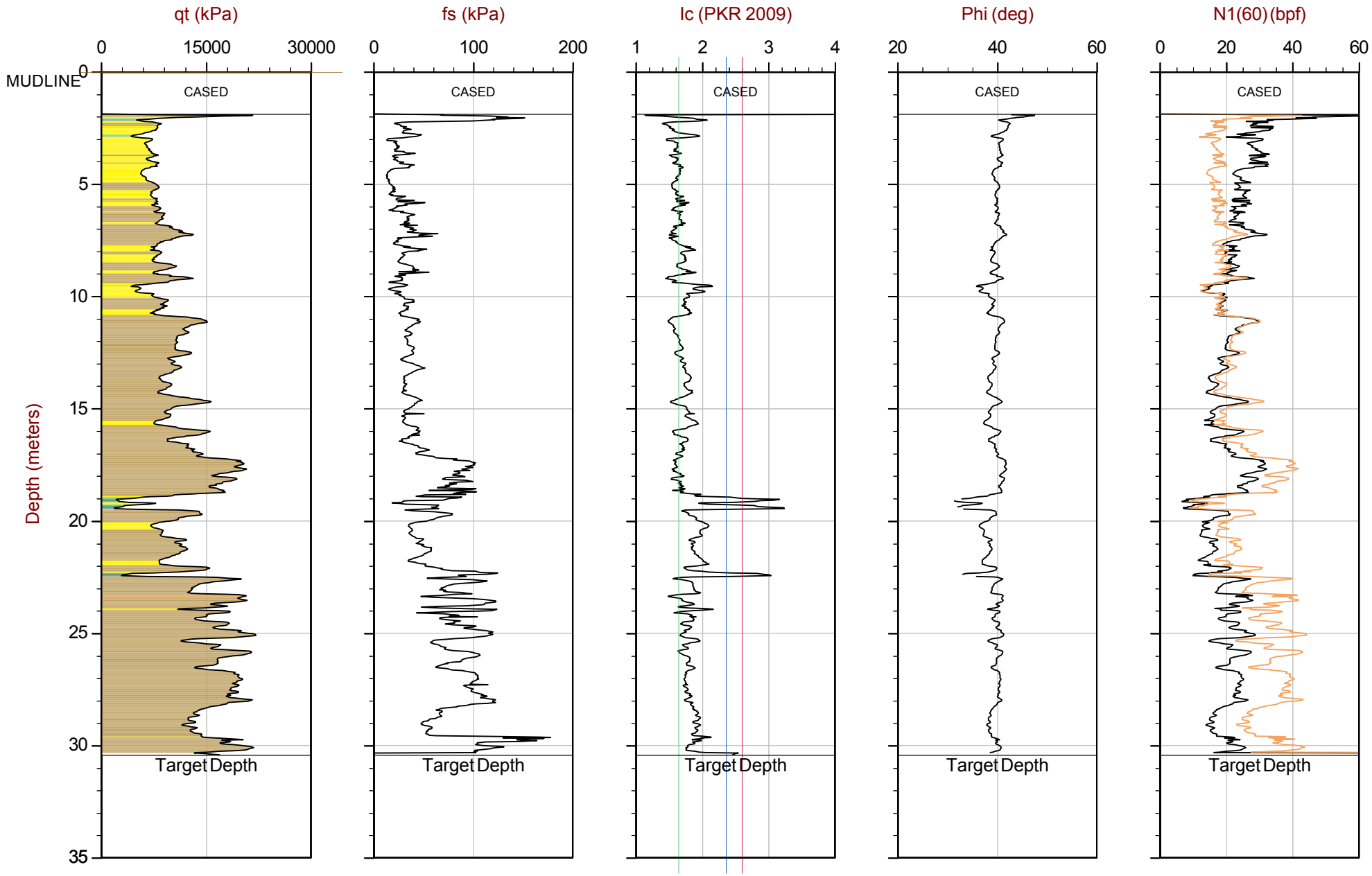
SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976728.05m E: 503705.30m Elev: -16.12m

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-06 13:34
Site: Milne Port Expansion

Sounding: CPT17-D003
Cone: 338:T1500F15U500



Max Depth: 30.425 m / 99.82 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point
N(60) (bpf)

File: 17-05010_CPD003.COR
Unit Wt: SBT (R&C1986)

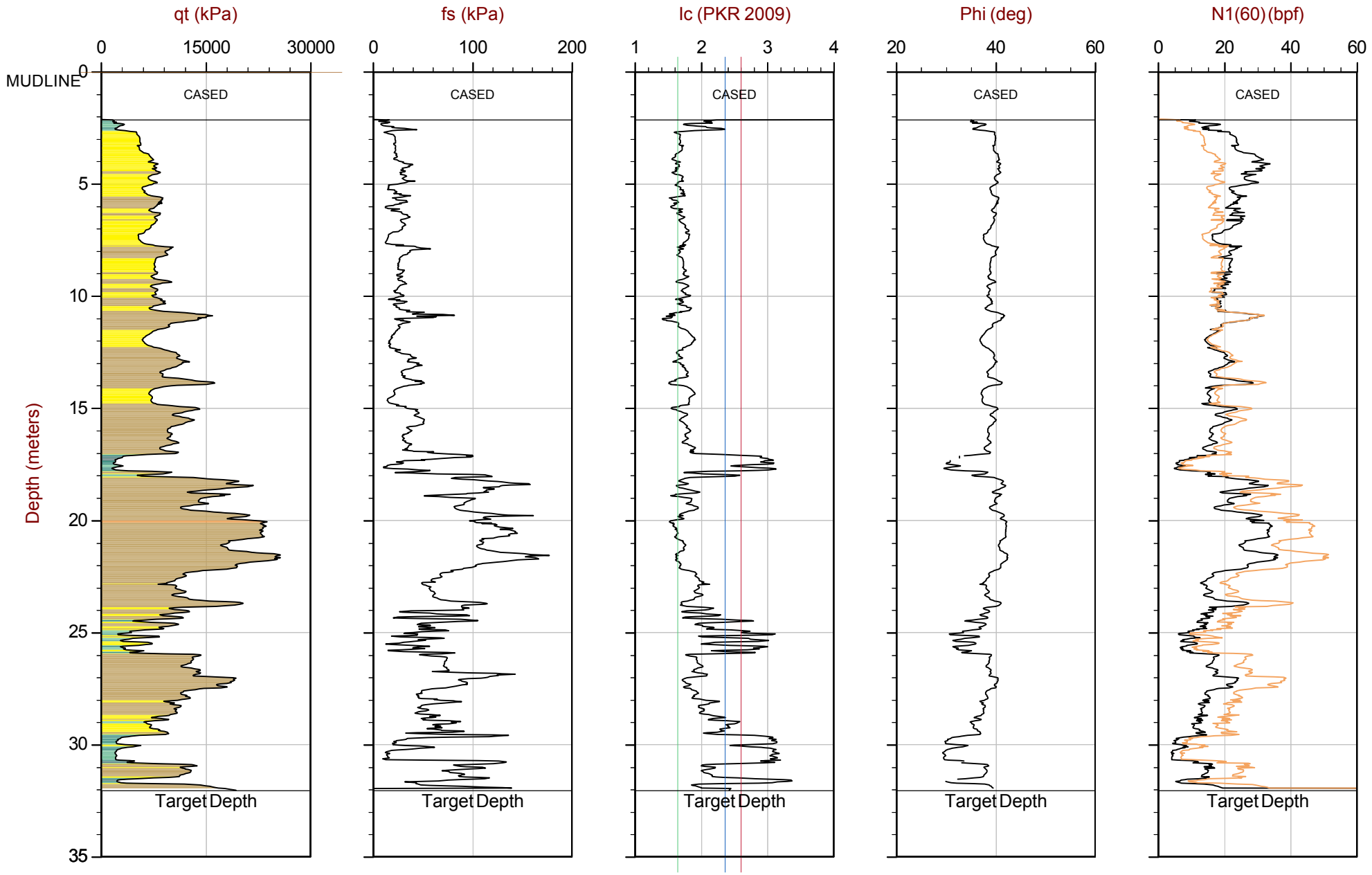
SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976757.71m E: 503785.39m Elev: -22.68m

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-04 16:44
Site: Milne Port Expansion

Sounding: SCPT17-D004
Cone: 338:T1500F15U500



Max Depth: 32.050 m / 105.15 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point
N(60) (bpf)

File: 17-05010_SPD004.COR
Unit Wt: SBT (R&C1986)

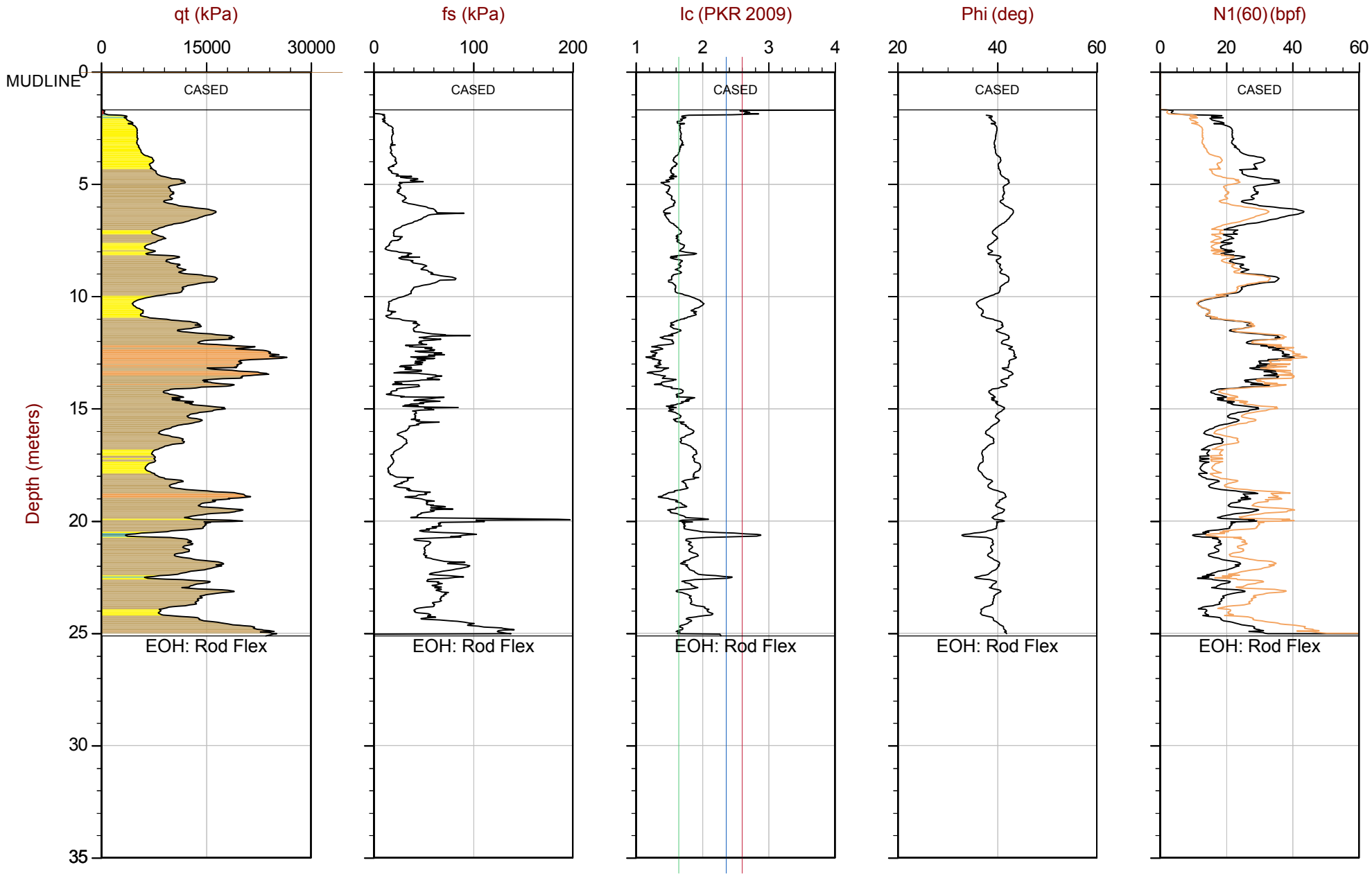
SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976768.10m E: 503646.44m Elev: -26.59m

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-03 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500



Max Depth: 25.125 m / 82.43 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point
N(60) (bpf)

File: 17-05010_CPD005.COR
Unit Wt: SBT (R&C1986)

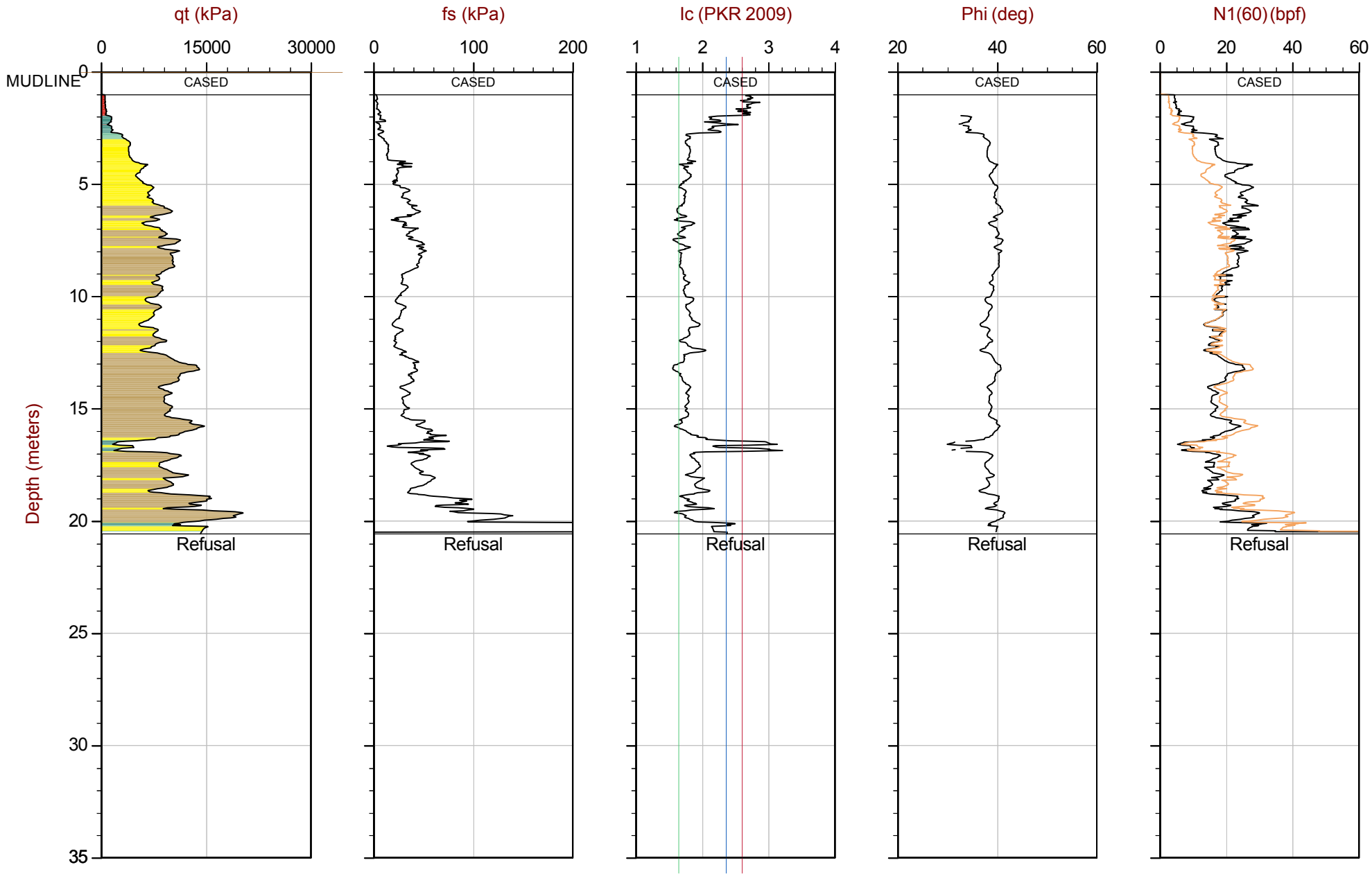
SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976780.84m E: 503736.09m Elev: -24.98m

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-06 23:59
Site: Milne Port Expansion

Sounding: CPT17-D006
Cone: 374:T1500F15U500



Max Depth: 20.575 m / 67.50 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point
N(60) (bpf)

File: 17-05010_CPD006.COR
Unit Wt: SBT (R&C1986)

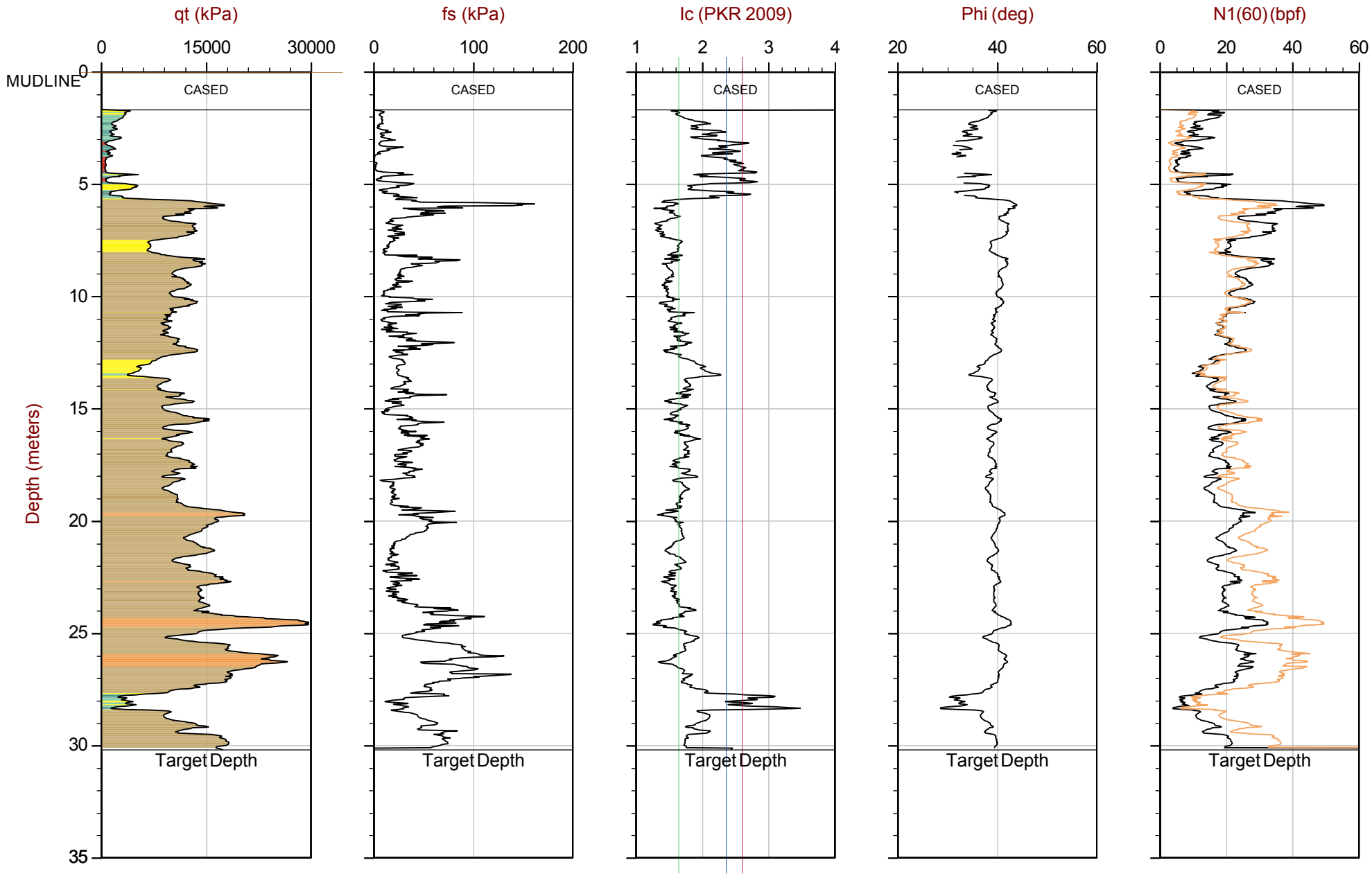
SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976808.43m E: 503807.55m Elev: -31.32m

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-07 11:27
Site: Milne Port Expansion

Sounding: CPT17-D007
Cone: 374:T1500F15U500



Max Depth: 30.200 m / 99.08 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point
N(60) (bpf)

File: 17-05010_CPD007.COR
Unit Wt: SBT (R&C1986)

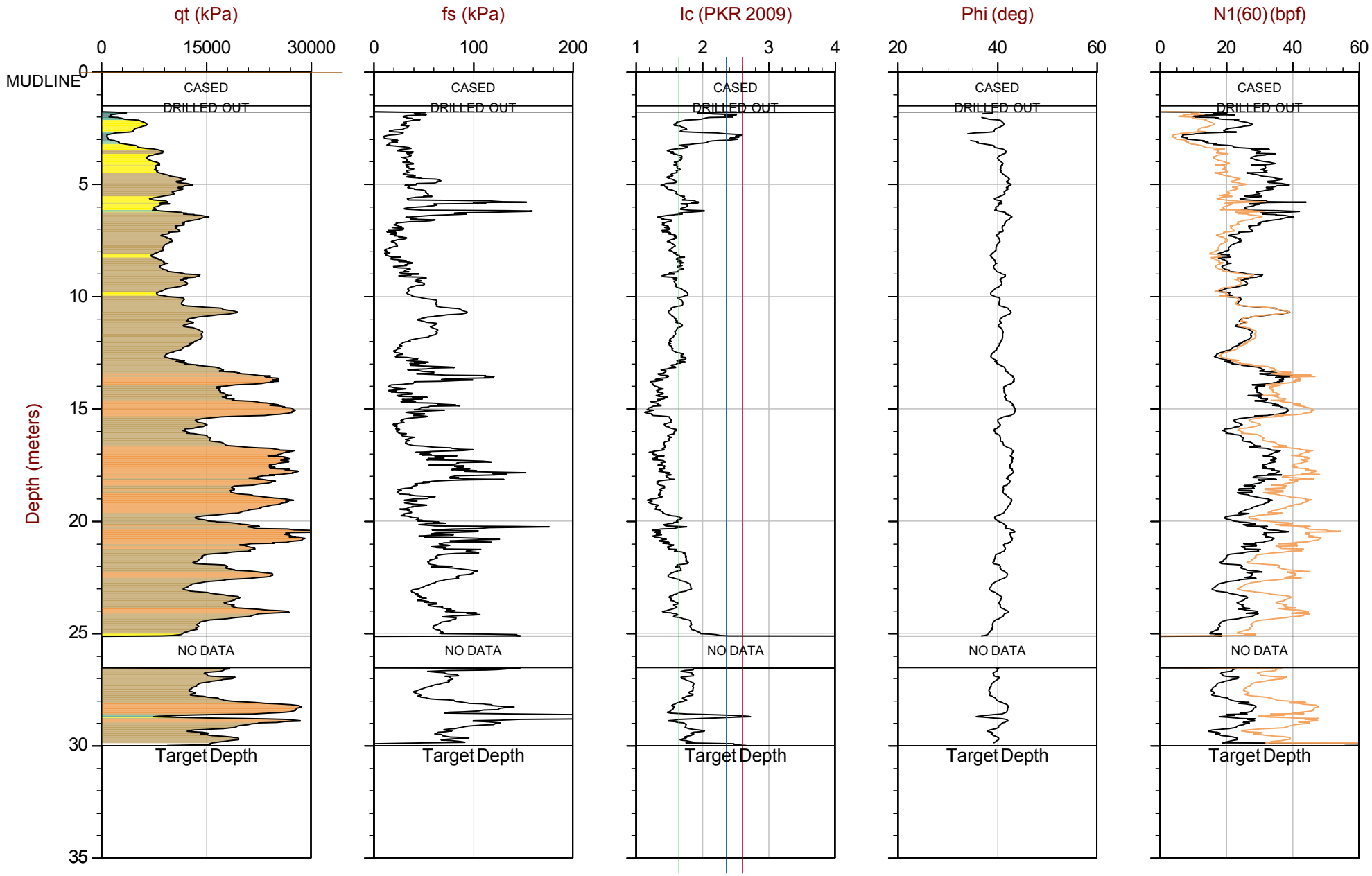
SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976683.63m E: 503767.46m Elev: -4.23m

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-07 16:47
Site: Milne Port Expansion

Sounding: CPT17-D008
Cone: 374:T1500F15U500



Max Depth: 30.000 m / 98.42 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point
N(60) (bpf)

File: 17-05010_CPD008.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976650.76m E: 503635.99m Elev: -1.80m

Seismic Cone Penetration Test Tabular Results

CONETEC

Job No: 17-05010
Client: Baffinland Iron Mines Corporation
Project: Milne Port Expansion
Sounding ID: SCPT17-D002
Date: 05-Apr-2017

Seismic Source: Auto-seismic
Source Offset (m): 4.30
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
3.38	3.18	5.35			
5.38	5.18	6.73	1.38	8.94	155
6.35	6.15	7.50	0.77	4.62	167
7.40	7.20	8.39	0.88	5.00	177
8.38	8.18	9.24	0.86	4.38	195
9.40	9.20	10.16	0.91	5.21	175
10.38	10.18	11.05	0.90	4.78	187
11.38	11.18	11.98	0.93	5.35	173
12.40	12.20	12.94	0.96	4.82	198
13.43	13.23	13.91	0.98	4.81	203
14.43	14.23	14.87	0.95	4.70	203
15.43	15.23	15.83	0.96	4.39	219
16.43	16.23	16.79	0.96	4.40	219
17.40	17.20	17.73	0.94	4.13	228
18.45	18.25	18.75	1.02	4.54	225
19.40	19.20	19.68	0.93	3.87	239
20.35	20.15	20.60	0.93	3.91	238
21.35	21.15	21.58	0.98	4.50	217
22.35	22.15	22.56	0.98	4.44	221
23.35	23.15	23.55	0.98	4.67	210
24.27	24.07	24.45	0.91	4.13	219
25.30	25.10	25.47	1.01	4.00	254
26.27	26.07	26.42	0.96	3.80	252

Job No:	17-05010
Client:	Baffinland Iron Mines Corporation
Project:	Milne Port Expansion
Sounding ID:	SCPT17-D002
Date:	05-Apr-2017

Seismic Source:	Auto-seismic
Source Offset (m):	4.30
Source Depth (m):	0.00
Geophone Offset (m):	0.20

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
27.32	27.12	27.46	1.04	4.08	254
28.38	28.18	28.51	1.05	3.93	267
29.43	29.23	29.54	1.04	4.08	254
30.40	30.20	30.50	0.96	3.54	271
31.40	31.20	31.49	0.99	3.55	279
32.38	32.18	32.47	0.97	3.59	270
33.38	33.18	33.46	0.99	3.56	279
34.40	34.20	34.47	1.01	3.63	279
35.40	35.20	35.46	0.99	3.60	276
36.40	36.20	36.45	0.99	3.75	265
37.40	37.20	37.45	0.99	3.87	257
38.40	38.20	38.44	0.99	3.81	261
39.40	39.20	39.44	0.99	3.81	261

Job No:	17-05010
Client:	Baffinland Iron Mines Corporation
Project:	Milne Port Expansion
Sounding ID:	SCPT17-D004
Date:	04-Apr-2017

Seismic Source:	Auto-seismic
Source Offset (m):	3.40
Source Depth (m):	0.00
Geophone Offset (m):	0.20

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
4.30	4.10	5.33			
5.30	5.10	6.13	0.80	4.48	179
6.20	6.00	6.90	0.77	3.86	198
7.20	7.00	7.78	0.89	3.86	229
8.20	8.00	8.69	0.91	4.17	218
9.20	9.00	9.62	0.93	4.33	214
10.95	10.75	11.27	1.65	7.11	233
11.93	11.73	12.21	0.94	3.87	243
12.93	12.73	13.18	0.96	4.33	223
13.95	13.75	14.16	0.99	4.10	241
14.88	14.68	15.07	0.90	3.75	241
15.88	15.68	16.04	0.98	4.50	217
16.88	16.68	17.02	0.98	4.05	242
17.85	17.65	17.97	0.95	4.80	198
18.85	18.65	18.96	0.98	3.75	262
19.88	19.68	19.97	1.01	4.21	241
20.90	20.70	20.98	1.01	3.94	255
21.82	21.62	21.89	0.91	3.18	286
22.82	22.62	22.87	0.99	3.63	272
23.85	23.65	23.89	1.02	4.39	232
24.80	24.60	24.83	0.94	3.63	259
25.80	25.60	25.82	0.99	4.09	242
26.80	26.60	26.82	0.99	3.63	273

Job No:	17-05010
Client:	Baffinland Iron Mines Corporation
Project:	Milne Port Expansion
Sounding ID:	SCPT17-D004
Date:	04-Apr-2017

Seismic Source:	Auto-seismic
Source Offset (m):	3.40
Source Depth (m):	0.00
Geophone Offset (m):	0.20

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
27.82	27.62	27.83	1.01	3.63	278
28.82	28.62	28.82	0.99	3.94	252
29.82	29.62	29.81	0.99	3.79	262
30.77	30.57	30.76	0.94	3.48	271
31.80	31.60	31.78	1.02	3.79	270
32.05	31.85	32.03	0.25	0.91	274

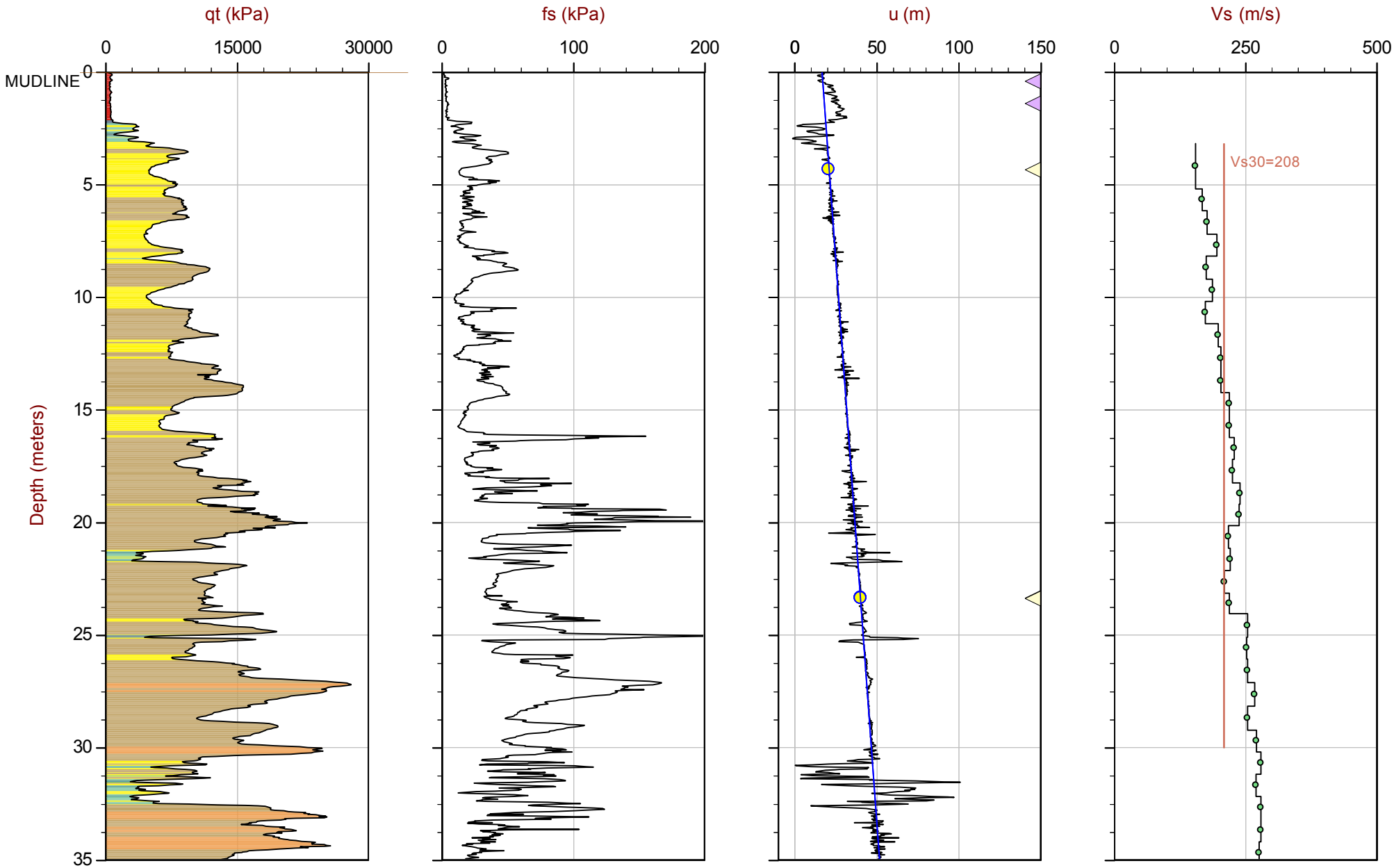
Seismic Cone Penetration Test Plots

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-05 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500



Max Depth: 39.475 m / 129.51 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_SPD002.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976728.05m E: 503705.30m Elev: -16.12m

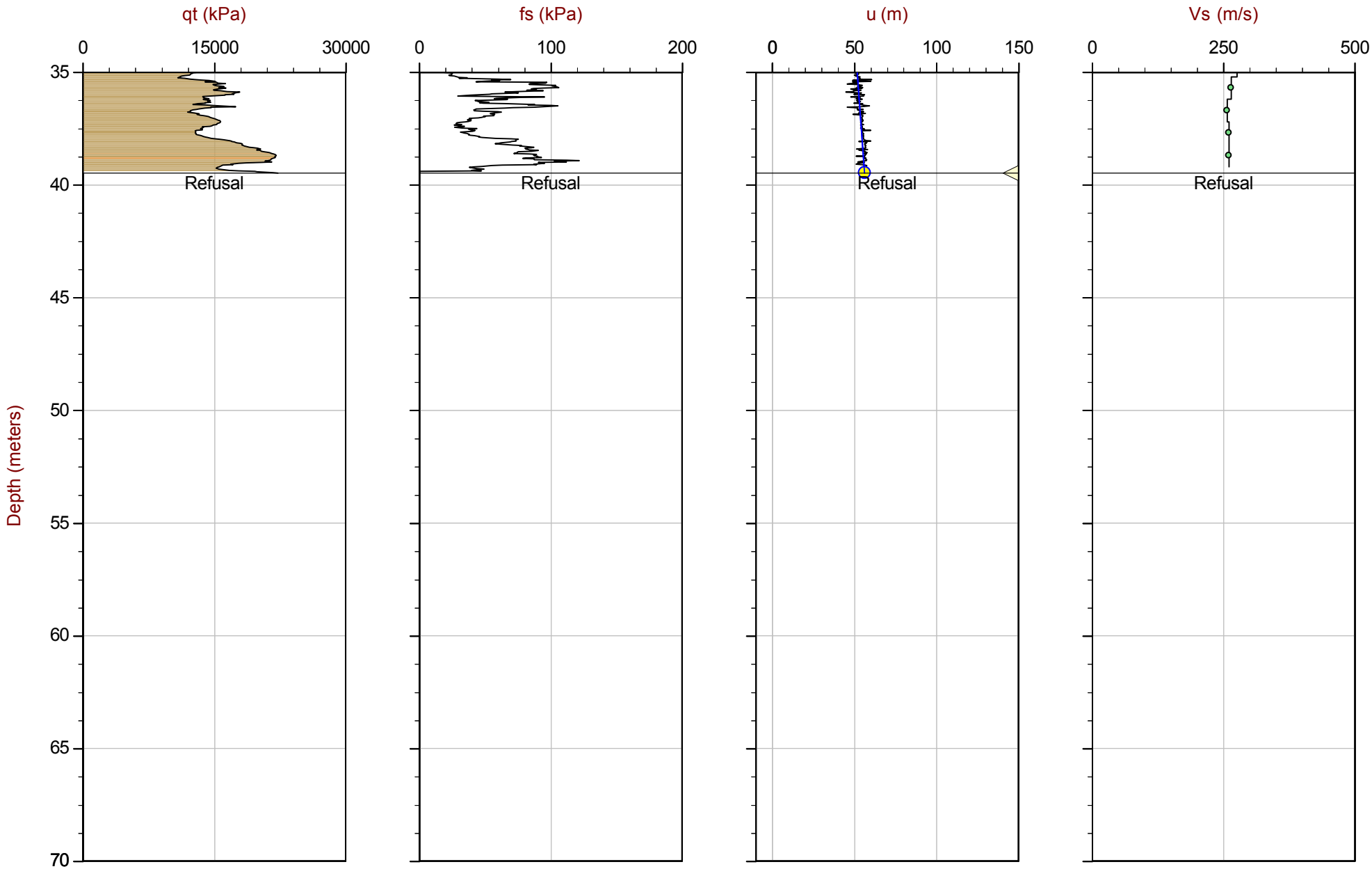
Equilibrium Pore Pressure (Ueq)
Dissipation, Ueq not achieved
Dissipation, Ueq achieved
Hydrostatic Line

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-05 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500



Max Depth: 39.475 m / 129.51 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_SPD002.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976728.05m E: 503705.30m Elev: -16.12m

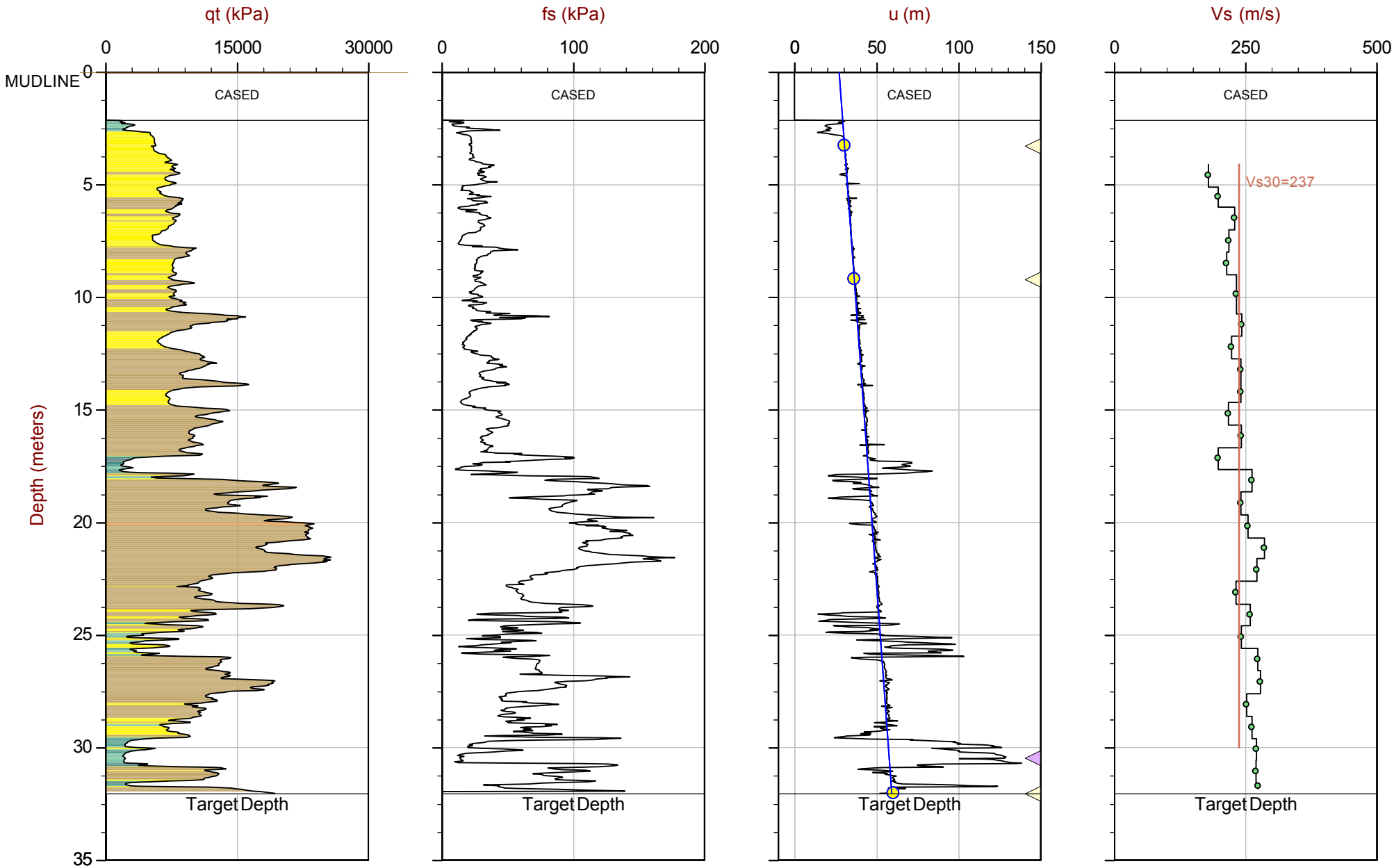
Equilibrium Pore Pressure (Ueq)
Dissipation, Ueq not achieved
Dissipation, Ueq achieved
Hydrostatic Line

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-04 16:44
Site: Milne Port Expansion

Sounding: SCPT17-D004
Cone: 338:T1500F15U500



Max Depth: 32.050 m / 105.15 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_SPD004.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976768.10m E: 503646.44m Elev: -26.59m

Equilibrium Pore Pressure (Ueq)
Dissipation, Ueq not achieved
Dissipation, Ueq achieved
Hydrostatic Line

Pore Pressure Dissipation Summary and
Pore Pressure Dissipation Plots

Job No:	17-05010
Client:	Baffinland Iron Mines Corporation
Project:	Milne Port Expansion
Start Date:	03-Apr-2017
End Date:	07-Apr-2017

CPTu PORE PRESSURE DISSIPATION SUMMARY

Sounding ID	File Name	Cone Area (cm^2)	Duration (s)	Test Depth (m)	Estimated Equilibrium Pore Pressure U_{eq} (m)	Calculated Phreatic Surface (m)
CPT17-D001	17-05010_CPD001	15	260	3.275	Not Achieved	
CPT17-D001	17-05010_CPD001	15	95	6.400	24.0	-17.6
CPT17-D001	17-05010_CPD001	15	300	10.475	28.1	-17.6
CPT17-D001	17-05010_CPD001	15	100	19.850	37.5	-17.6
CPT17-D001	17-05010_CPD001	15	400	20.575	38.5	-17.9
CPT17-D001	17-05010_CPD001	15	95	28.650	45.6	-16.9
CPT17-D001	17-05010_CPD001	15	150	29.600	46.7	-17.1
CPT17-D001	17-05010_CPD001	15	400	32.750	50.4	-17.7
SCPT17-D002	17-05010_SPD002	15	105	0.400	Not Achieved	
SCPT17-D002	17-05010_SPD002	15	110	1.375	Not Achieved	
SCPT17-D002	17-05010_SPD002	15	150	4.325	20.7	-16.4
SCPT17-D002	17-05010_SPD002	15	600	23.350	40.2	-16.9
SCPT17-D002	17-05010_SPD002	15	275	23.375	40.4	-17.0
SCPT17-D002	17-05010_SPD002	15	200	39.475	56.6	-17.1
CPT17-D003	17-05010_CPD003	15	110	5.200	28.2	-23.0
CPT17-D003	17-05010_CPD003	15	400	15.300	38.5	-23.2
CPT17-D003	17-05010_CPD003	15	105	16.300	39.6	-23.3
CPT17-D003	17-05010_CPD003	15	1200	30.425	54.1	-23.7
SCPT17-D004	17-05010_SPD004	15	95	3.275	30.4	-27.1
SCPT17-D004	17-05010_SPD004	15	300	9.200	36.5	-27.3
SCPT17-D004	17-05010_SPD004	15	600	30.475	Not Achieved	
SCPT17-D004	17-05010_SPD004	15	300	32.050	60.3	-28.2
CPT17-D005	17-05010_CPD005	15	1340	2.275	28.3	-26.0
CPT17-D005	17-05010_CPD005	15	110	3.325	29.5	-26.2
CPT17-D005	17-05010_CPD005	15	95	5.375	31.8	-26.4
CPT17-D005	17-05010_CPD005	15	145	6.375	Not Achieved	
CPT17-D005	17-05010_CPD005	15	110	7.400	33.5	-26.1
CPT17-D005	17-05010_CPD005	15	125	9.350	Not Achieved	
CPT17-D005	17-05010_CPD005	15	300	10.300	36.5	-26.2

Job No:	17-05010
Client:	Baffinland Iron Mines Corporation
Project:	Milne Port Expansion
Start Date:	03-Apr-2017
End Date:	07-Apr-2017

CPTu PORE PRESSURE DISSIPATION SUMMARY

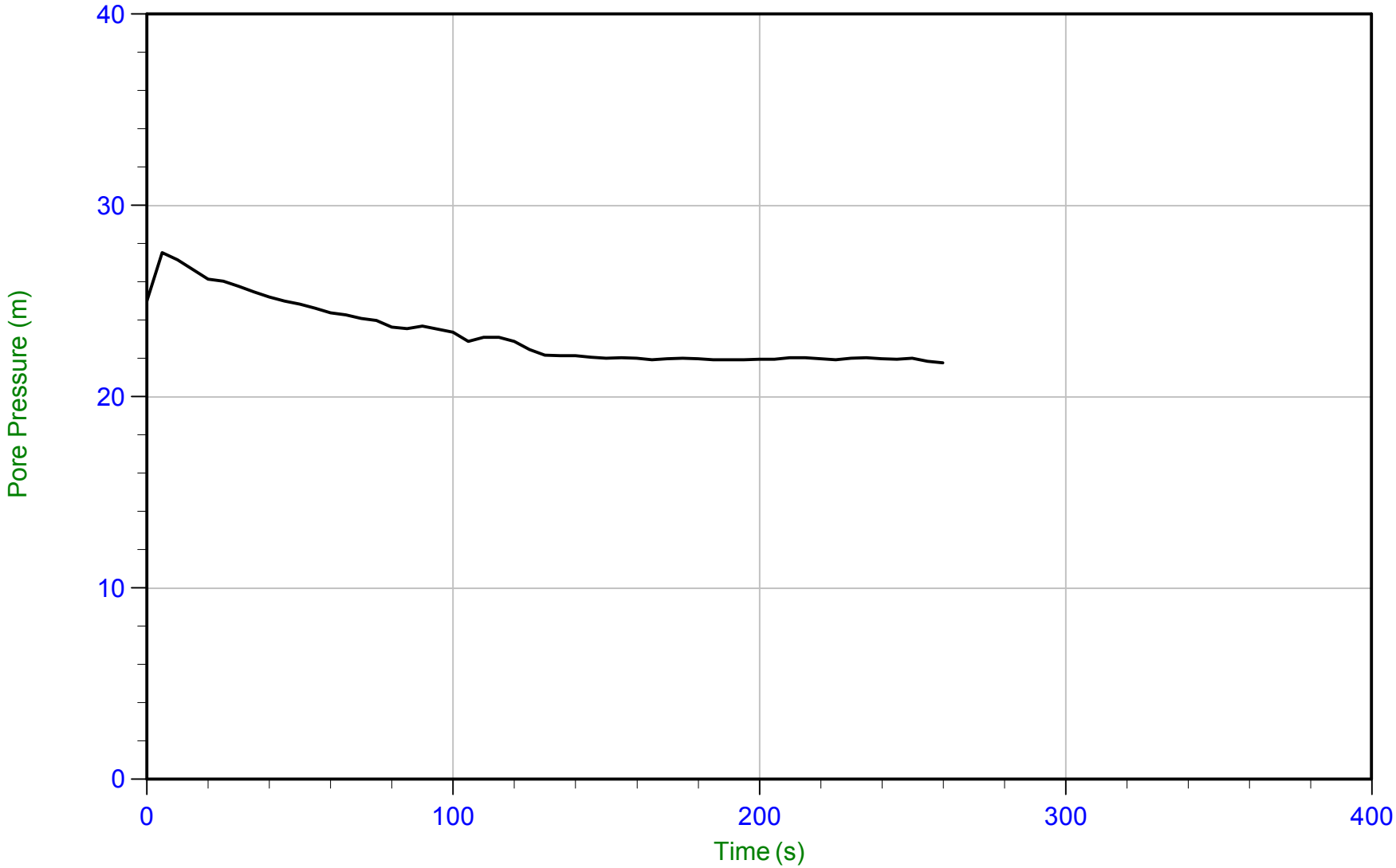
Sounding ID	File Name	Cone Area (cm^2)	Duration (s)	Test Depth (m)	Estimated Equilibrium Pore Pressure U_{eq} (m)	Calculated Phreatic Surface (m)
CPT17-D005	17-05010_CPD005	15	1460	12.350	38.8	-26.4
CPT17-D005	17-05010_CPD005	15	275	13.175	Not Achieved	
CPT17-D005	17-05010_CPD005	15	305	15.050	41.7	-26.6
CPT17-D005	17-05010_CPD005	15	165	18.100	44.7	-26.6
CPT17-D005	17-05010_CPD005	15	130	23.925	50.7	-26.8
CPT17-D005	17-05010_CPD005	15	300	25.125	51.9	-26.8
CPT17-D006	17-05010_CPD006	15	105	2.300	Not Achieved	
CPT17-D006	17-05010_CPD006	15	2100	3.300	35.3	-32.0
CPT17-D006	17-05010_CPD006	15	300	20.575	52.4	-31.8
CPT17-D007	17-05010_CPD007	15	200	10.100	14.8	-4.7
CPT17-D007	17-05010_CPD007	15	200	20.150	25.1	-5.0
CPT17-D007	17-05010_CPD007	15	200	30.200	35.5	-5.3
CPT17-D008	17-05010_CPD008	15	180	2.075	Not Achieved	
CPT17-D008	17-05010_CPD008	15	200	20.500	21.9	-1.4
CPT17-D008	17-05010_CPD008	15	120	28.975	30.4	-1.4
CPT17-D008	17-05010_CPD008	15	405	30.000	32.2	-2.2

CONETEC

Baffinland

Job No: 17-05010
Date: 04/05/2017 09:17
Site: Milne Port Expansion

Sounding: CPT17-D001
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD001.PPF
Depth: 3.275 m / 10.745 ft
Duration: 260.0 s

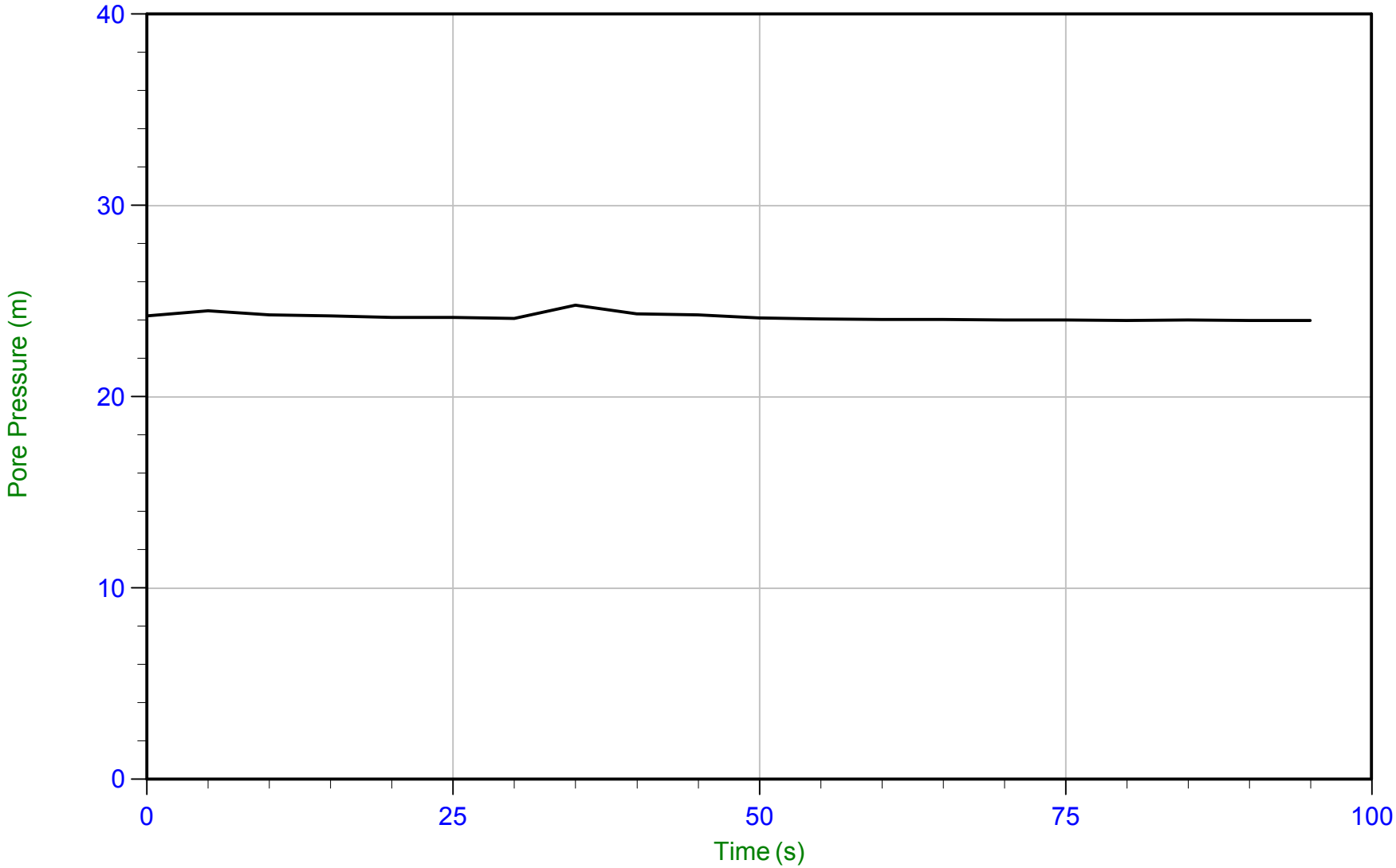
U Min: 21.8 m
U Max: 27.5 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/05/2017 09:17
Site: Milne Port Expansion

Sounding: CPT17-D001
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD001.PPF
Depth: 6.400 m / 20.997 ft
Duration: 95.0 s

U Min: 24.0 m
U Max: 24.8 m

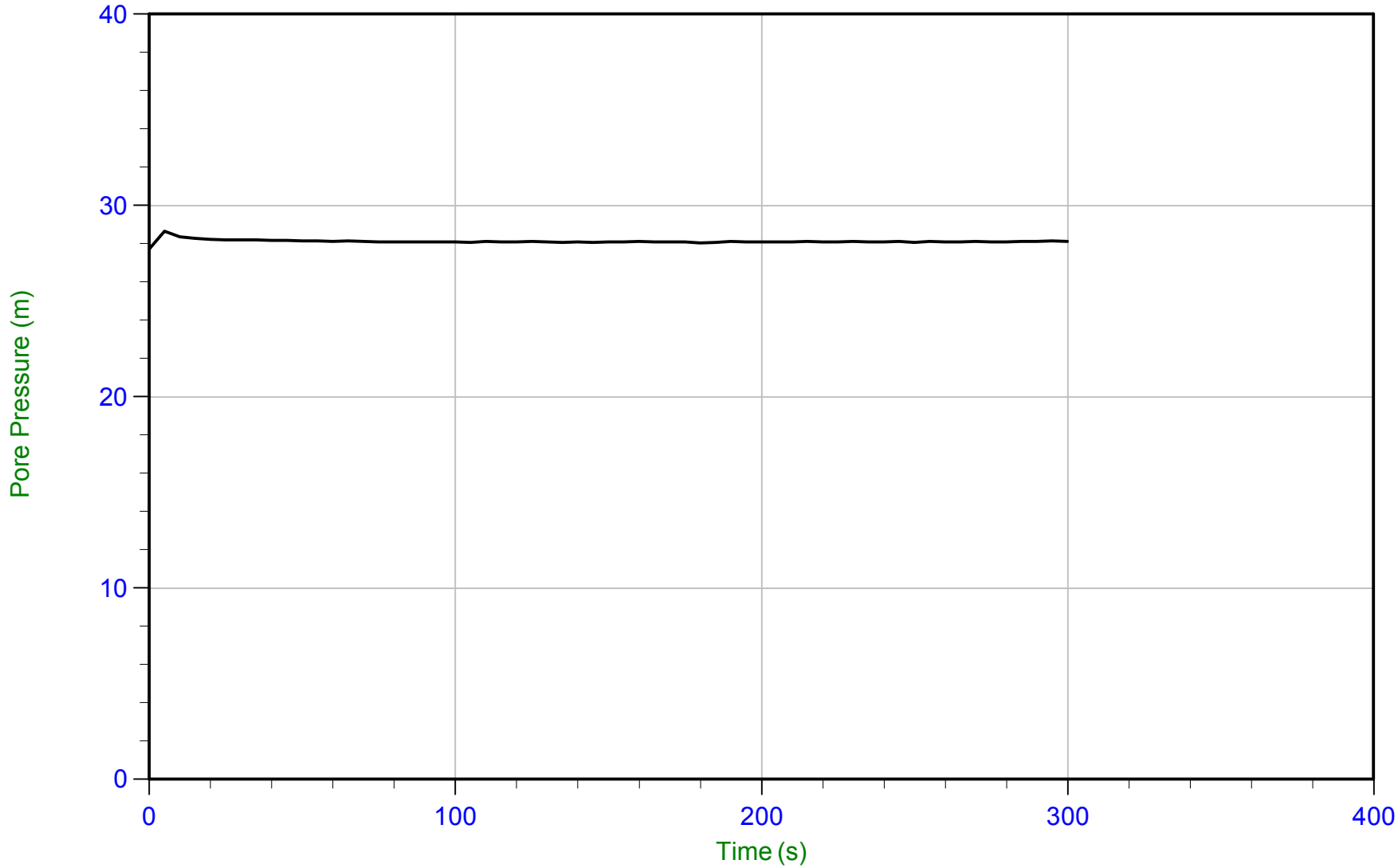
WT: -17.600 m / -57.742 ft
Ueq: 24.0 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/05/2017 09:17
Site: Milne Port Expansion

Sounding: CPT17-D001
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD001.PPF
Depth: 10.475 m / 34.366 ft
Duration: 300.0 s

U Min: 27.7 m
U Max: 28.6 m

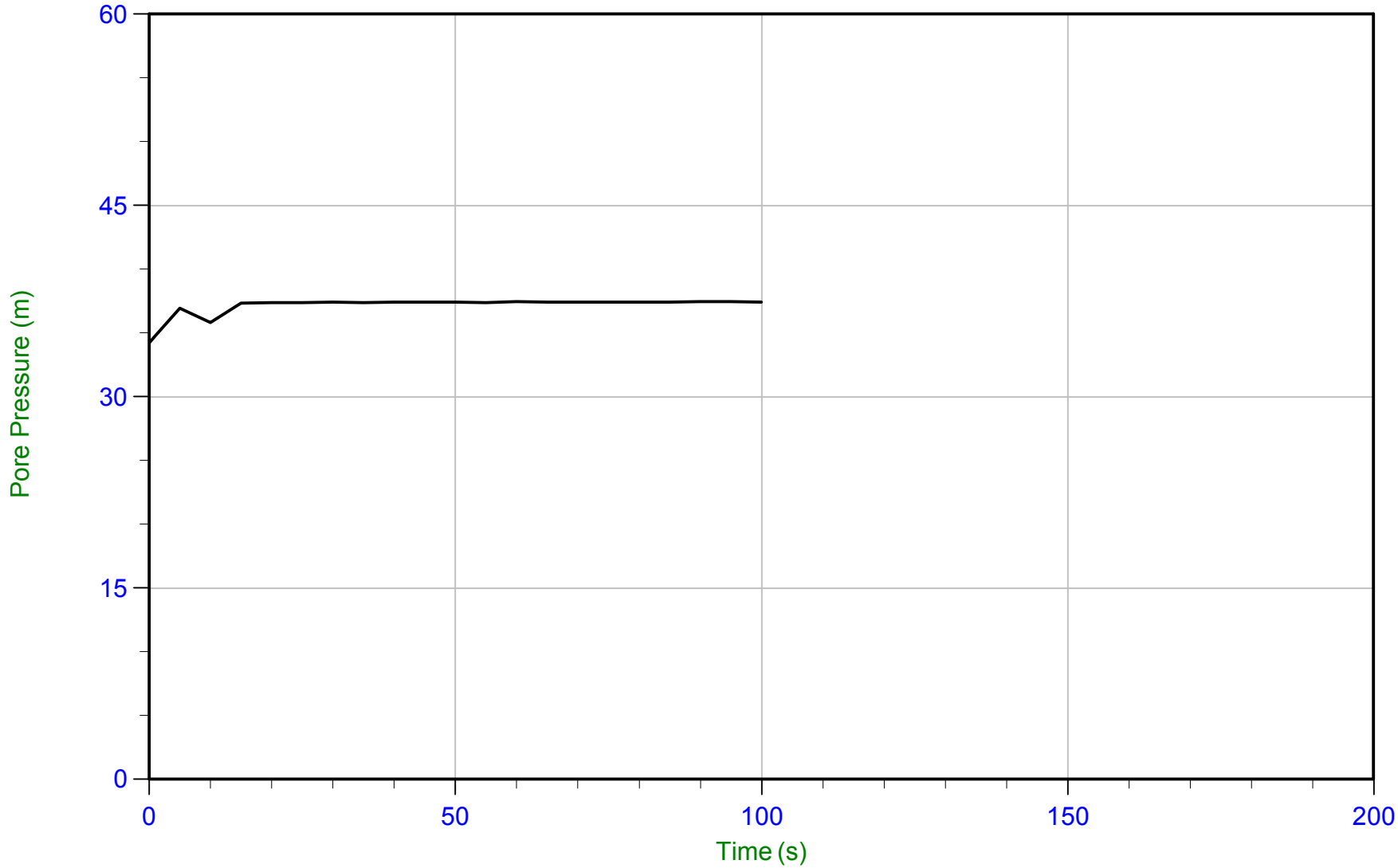
WT: -17.646 m / -57.893 ft
Ueq: 28.1 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/05/2017 09:17
Site: Milne Port Expansion

Sounding: CPT17-D001
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD001.PPF
Depth: 19.850 m / 65.124 ft
Duration: 100.0 s

U Min: 34.2 m
U Max: 37.5 m

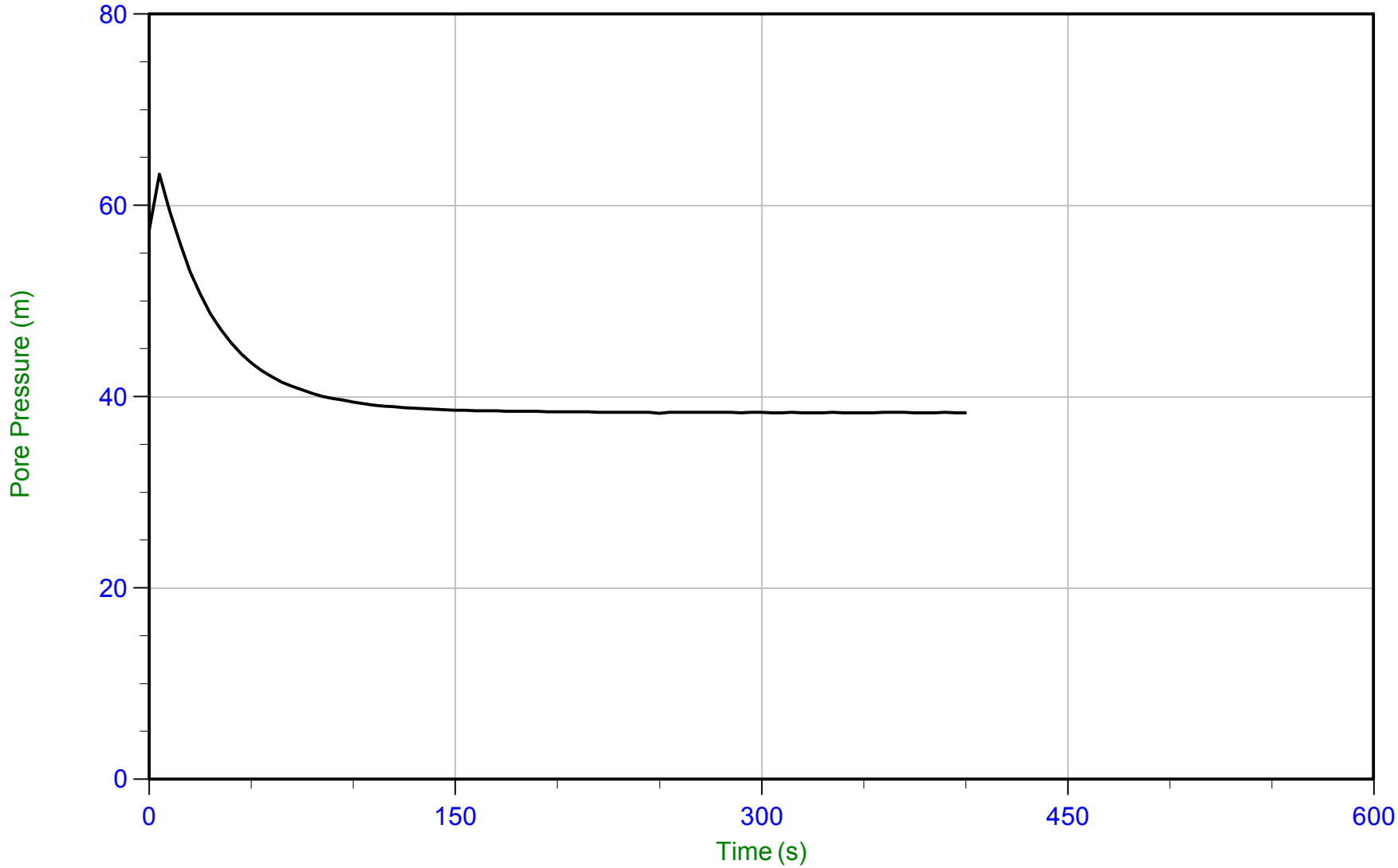
WT: -17.605 m / -57.758 ft
Ueq: 37.5 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/05/2017 09:17
Site: Milne Port Expansion

Sounding: CPT17-D001
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD001.PPF
Depth: 20.575 m / 67.502 ft
Duration: 400.0 s

U Min: 38.3 m
U Max: 63.3 m

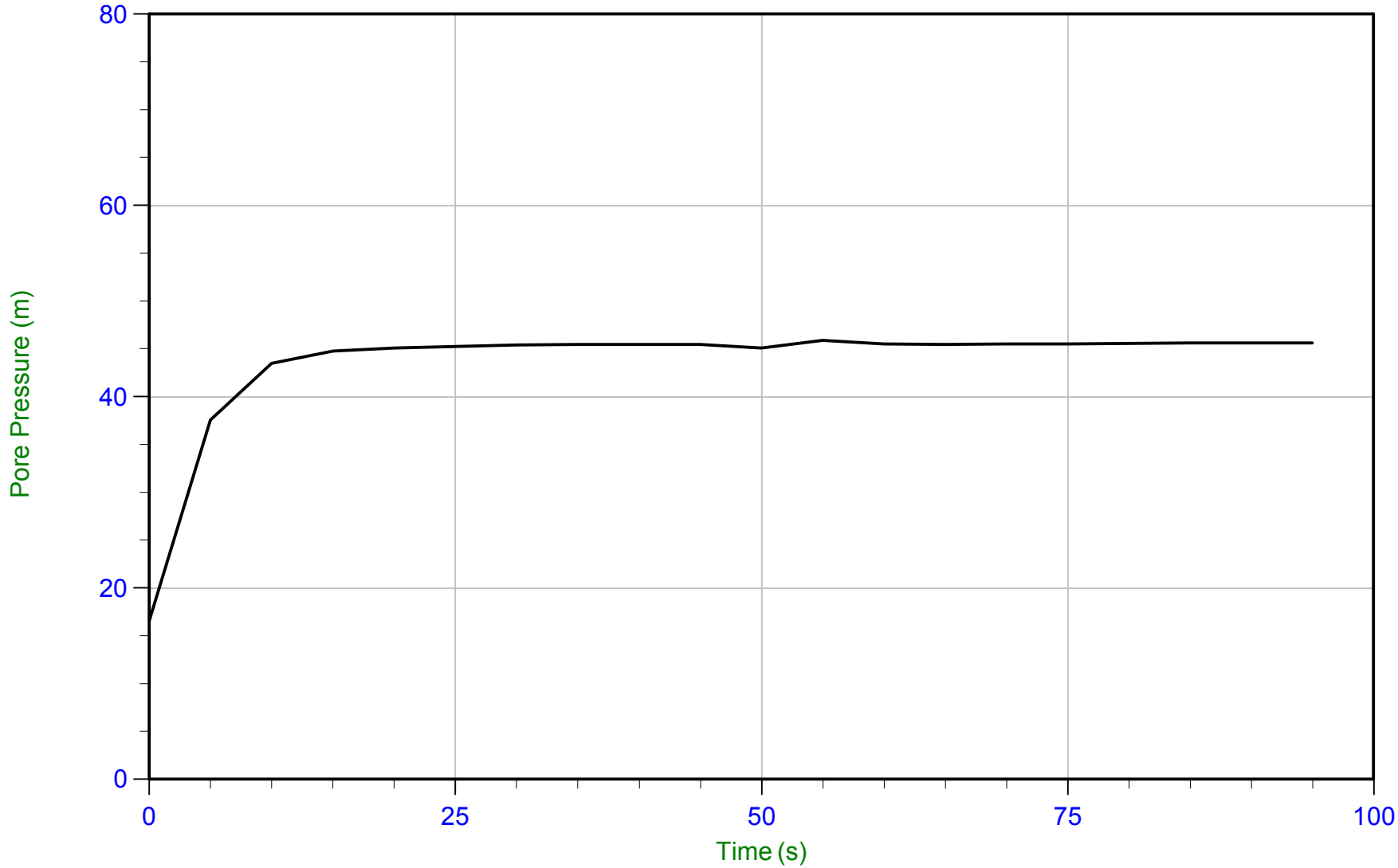
WT: -17.890 m / -58.694 ft
Ueq: 38.5 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/05/2017 09:17
Site: Milne Port Expansion

Sounding: CPT17-D001
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD001.PPF
Depth: 28.650 m / 93.995 ft
Duration: 95.0 s

U Min: 16.6 m
U Max: 45.9 m

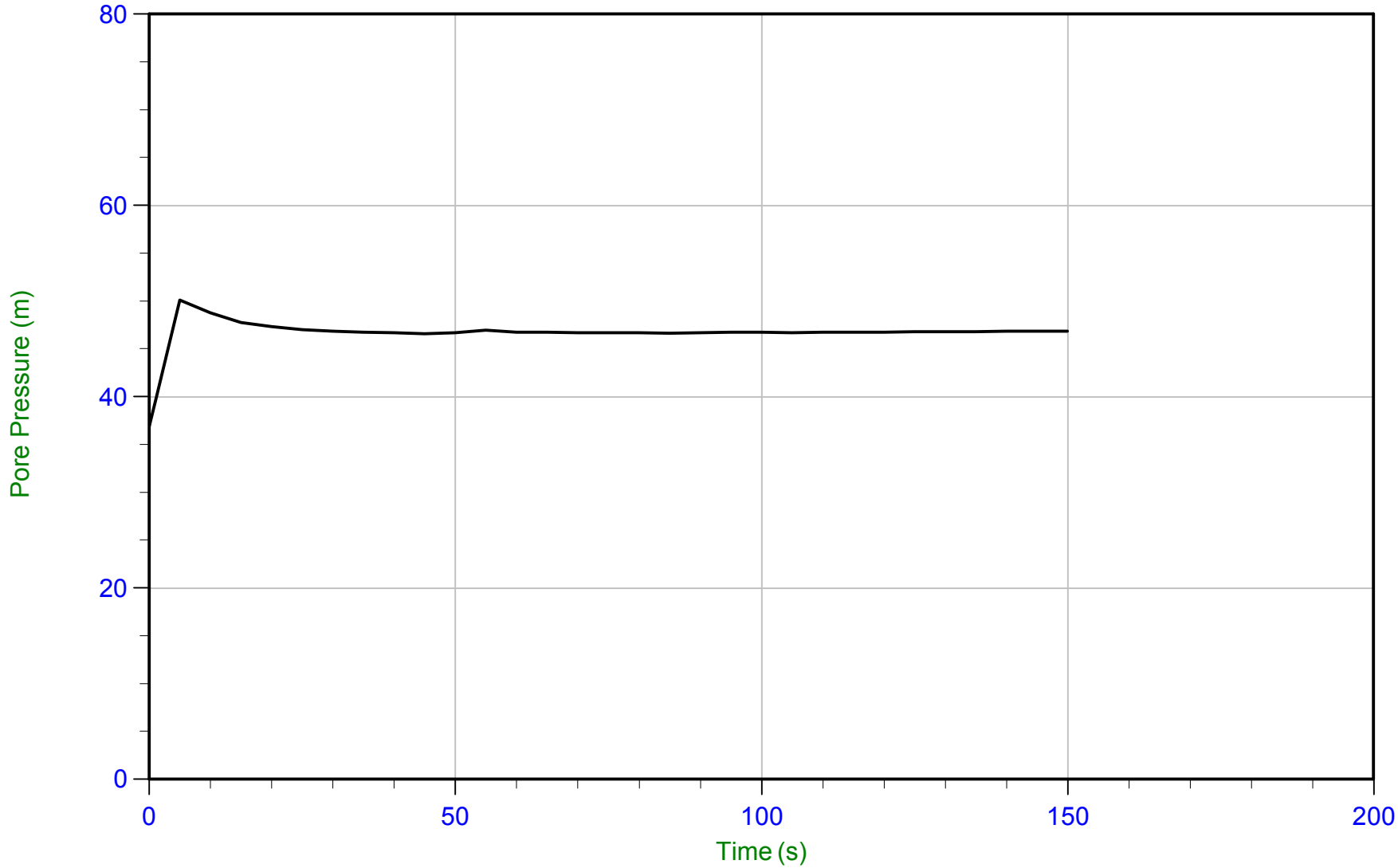
WT: -16.926 m / -55.531 ft
Ueq: 45.6 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/05/2017 09:17
Site: Milne Port Expansion

Sounding: CPT17-D001
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD001.PPF
Depth: 29.600 m / 97.112 ft
Duration: 150.0 s

U Min: 36.9 m
U Max: 50.1 m

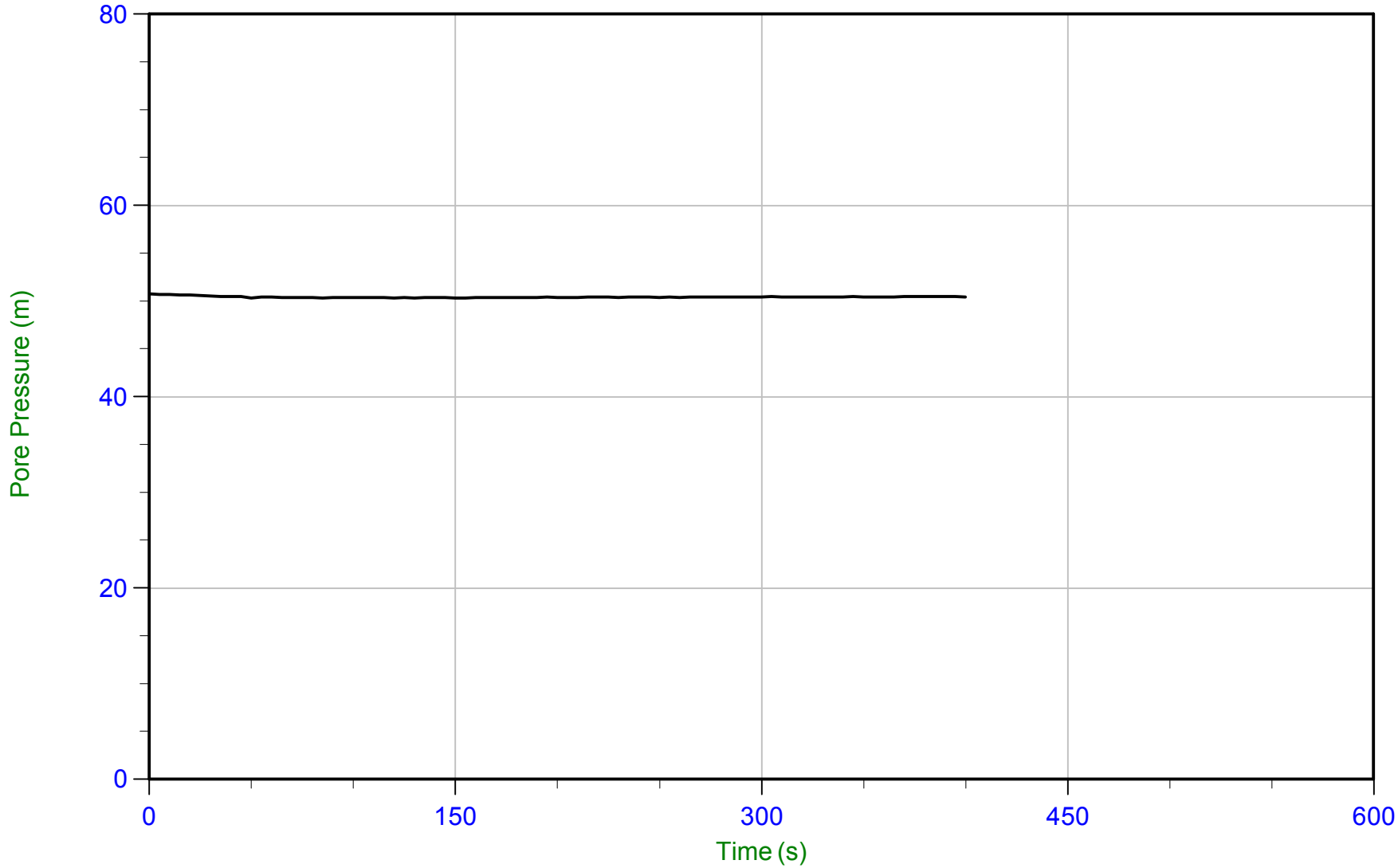
WT: -17.107 m / -56.125 ft
Ueq: 46.7 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/05/2017 09:17
Site: Milne Port Expansion

Sounding: CPT17-D001
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD001.PPF
Depth: 32.750 m / 107.446 ft
Duration: 400.0 s

U Min: 50.3 m
U Max: 50.7 m

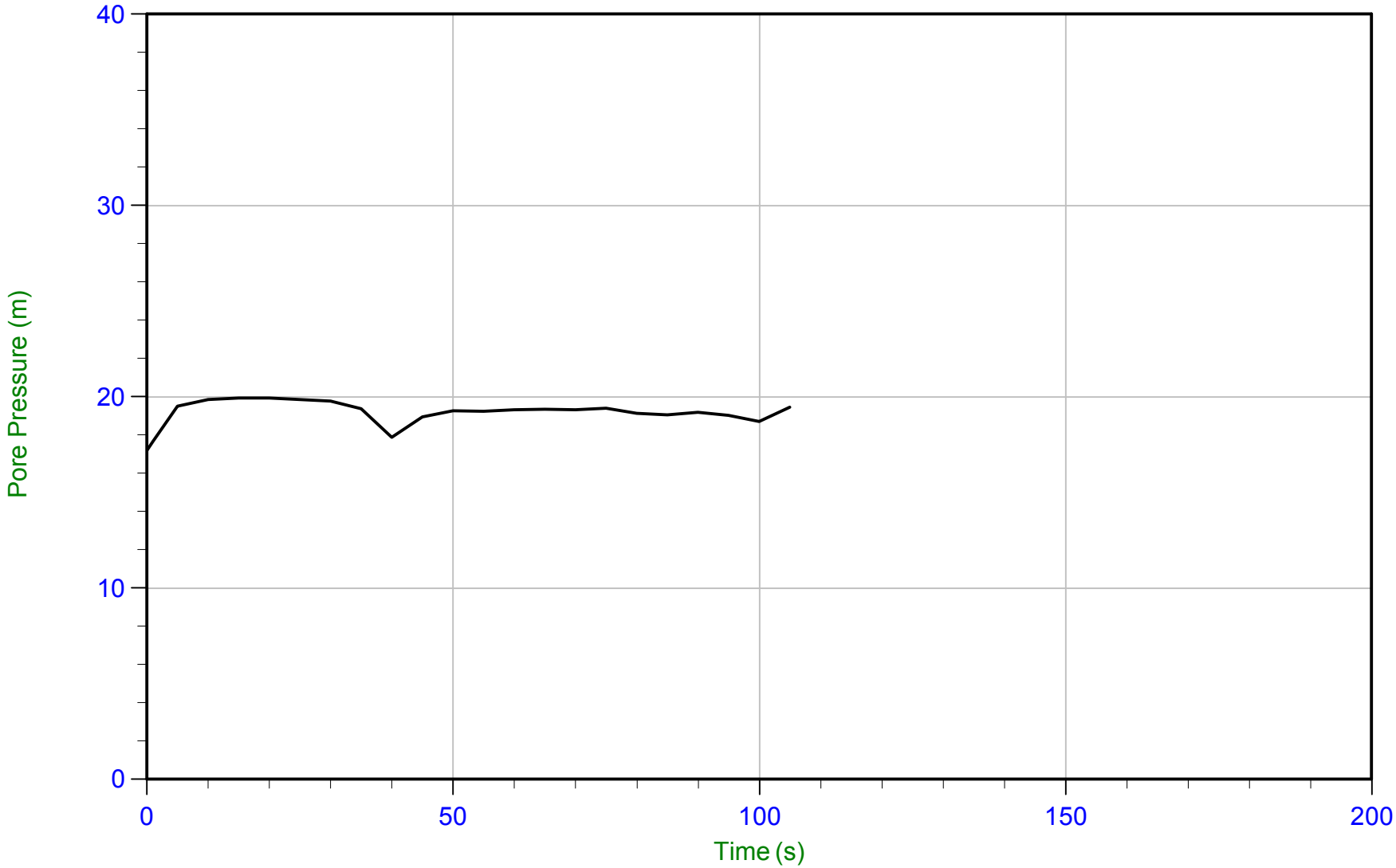
WT: -17.674 m / -57.985 ft
Ueq: 50.4 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/05/2017 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_SPD002.PPF
Depth: 0.400 m / 1.312 ft
Duration: 105.0 s

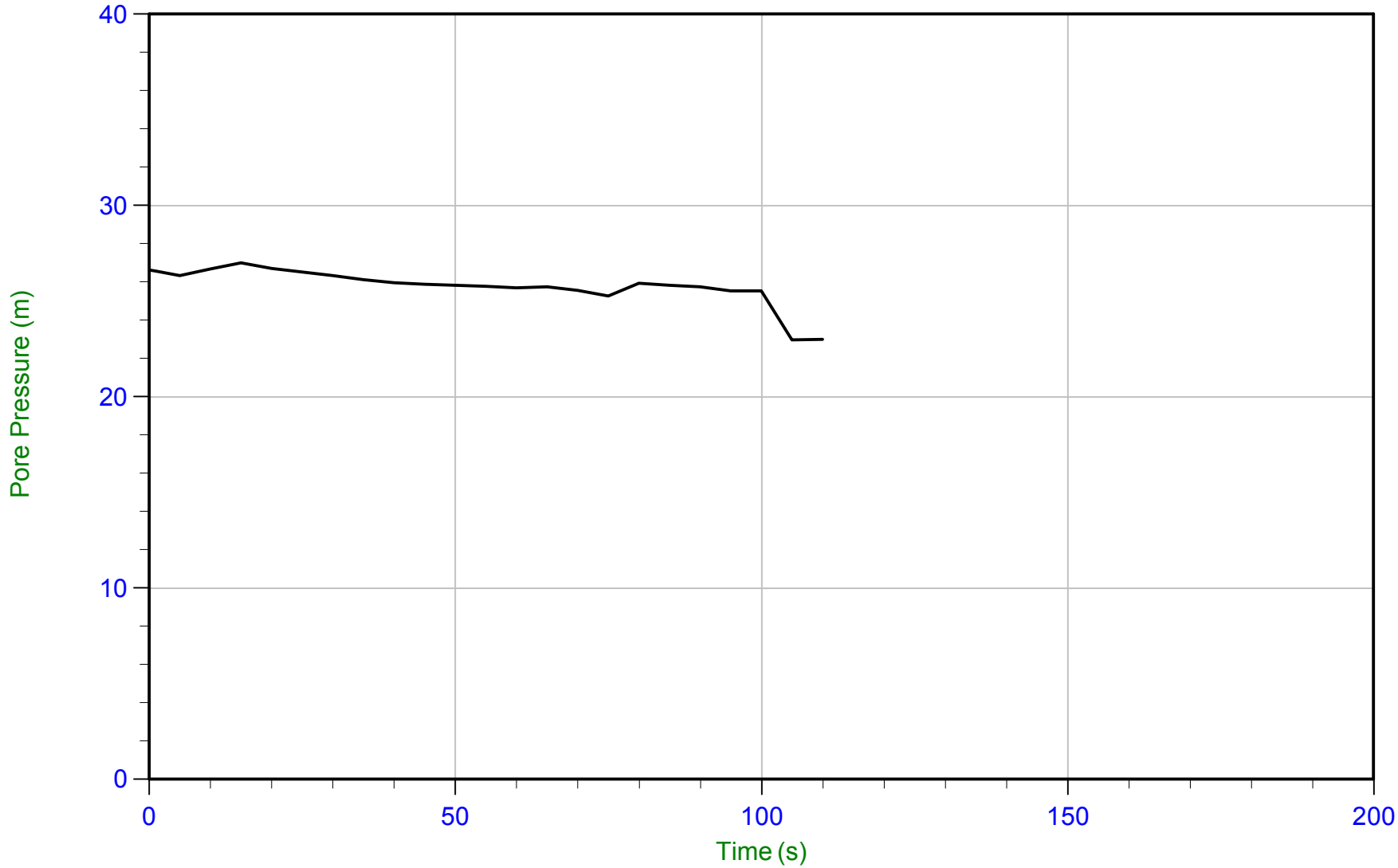
U Min: 17.2 m
U Max: 19.9 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/05/2017 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_SPD002.PPF
Depth: 1.375 m / 4.511 ft
Duration: 110.0 s

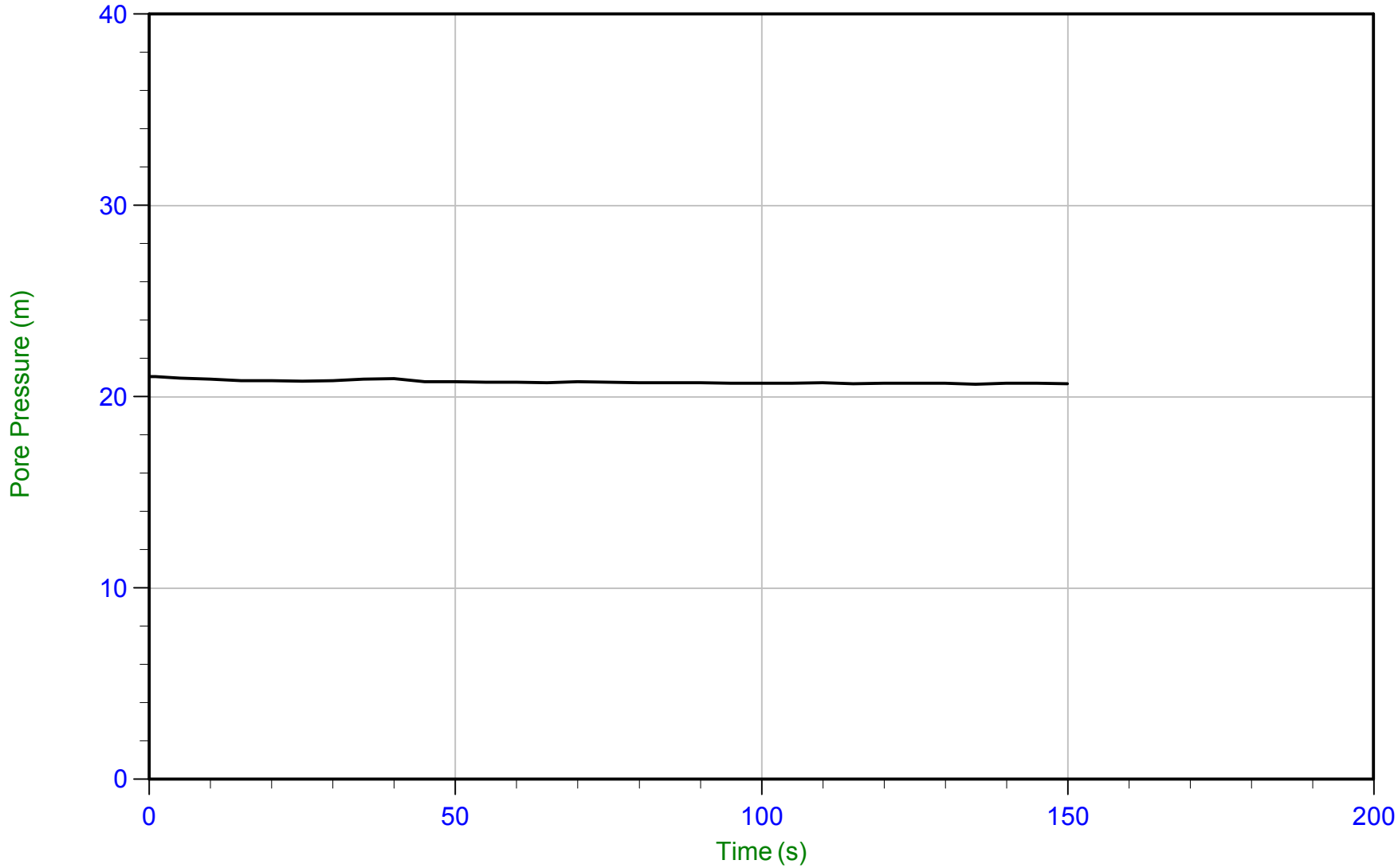
U Min: 23.0 m
U Max: 27.0 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/05/2017 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_SPD002.PPF
Depth: 4.325 m / 14.189 ft
Duration: 150.0 s

U Min: 20.7 m
U Max: 21.1 m

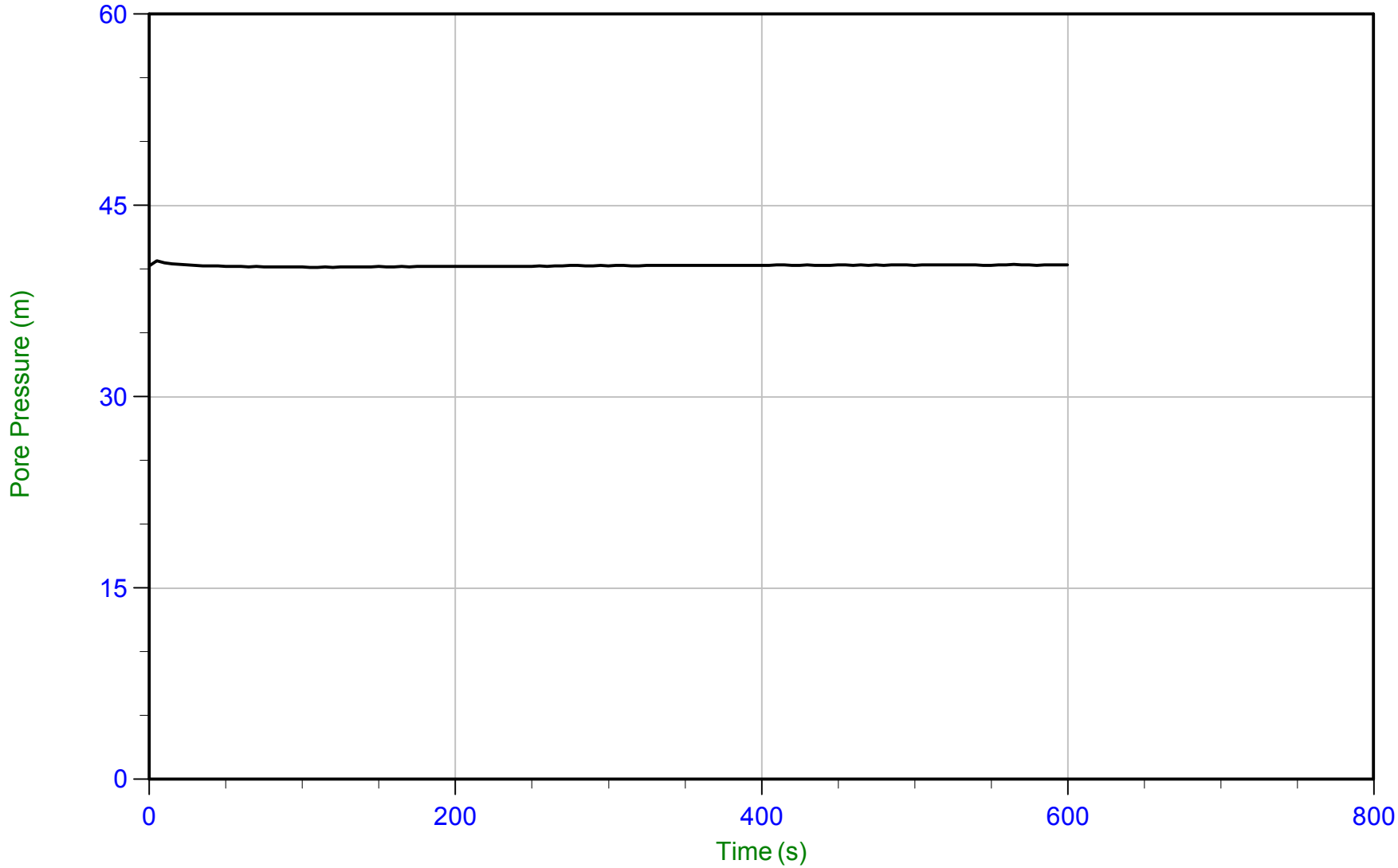
WT: -16.362 m / -53.680 ft
Ueq: 20.7 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/05/2017 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_SPD002.PPF
Depth: 23.350 m / 76.607 ft
Duration: 600.0 s

U Min: 40.1 m
U Max: 40.6 m

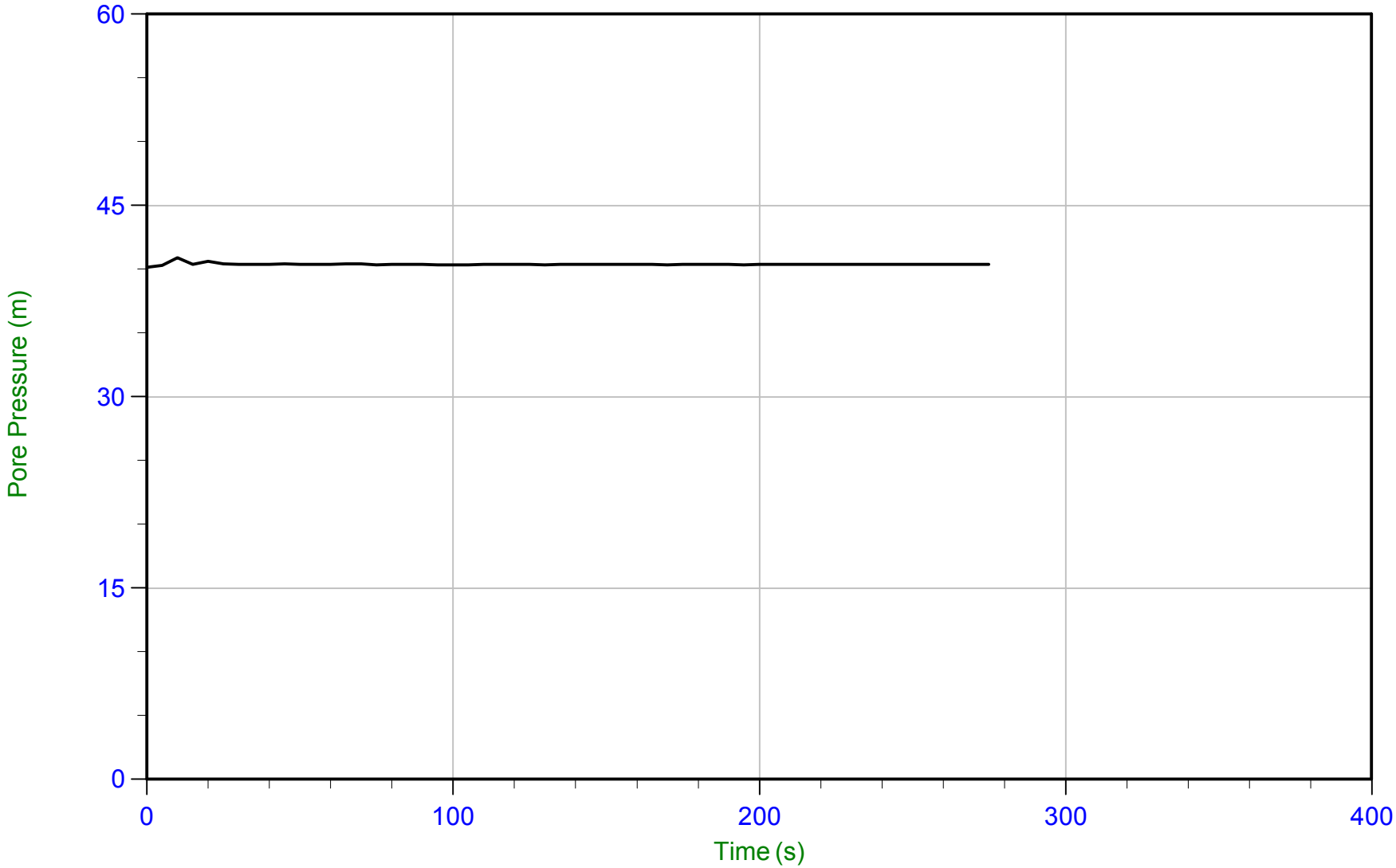
WT: -16.892 m / -55.419 ft
Ueq: 40.2 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/05/2017 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_SPD002.PPF
Depth: 23.375 m / 76.689 ft
Duration: 275.0 s

U Min: 40.2 m
U Max: 40.9 m

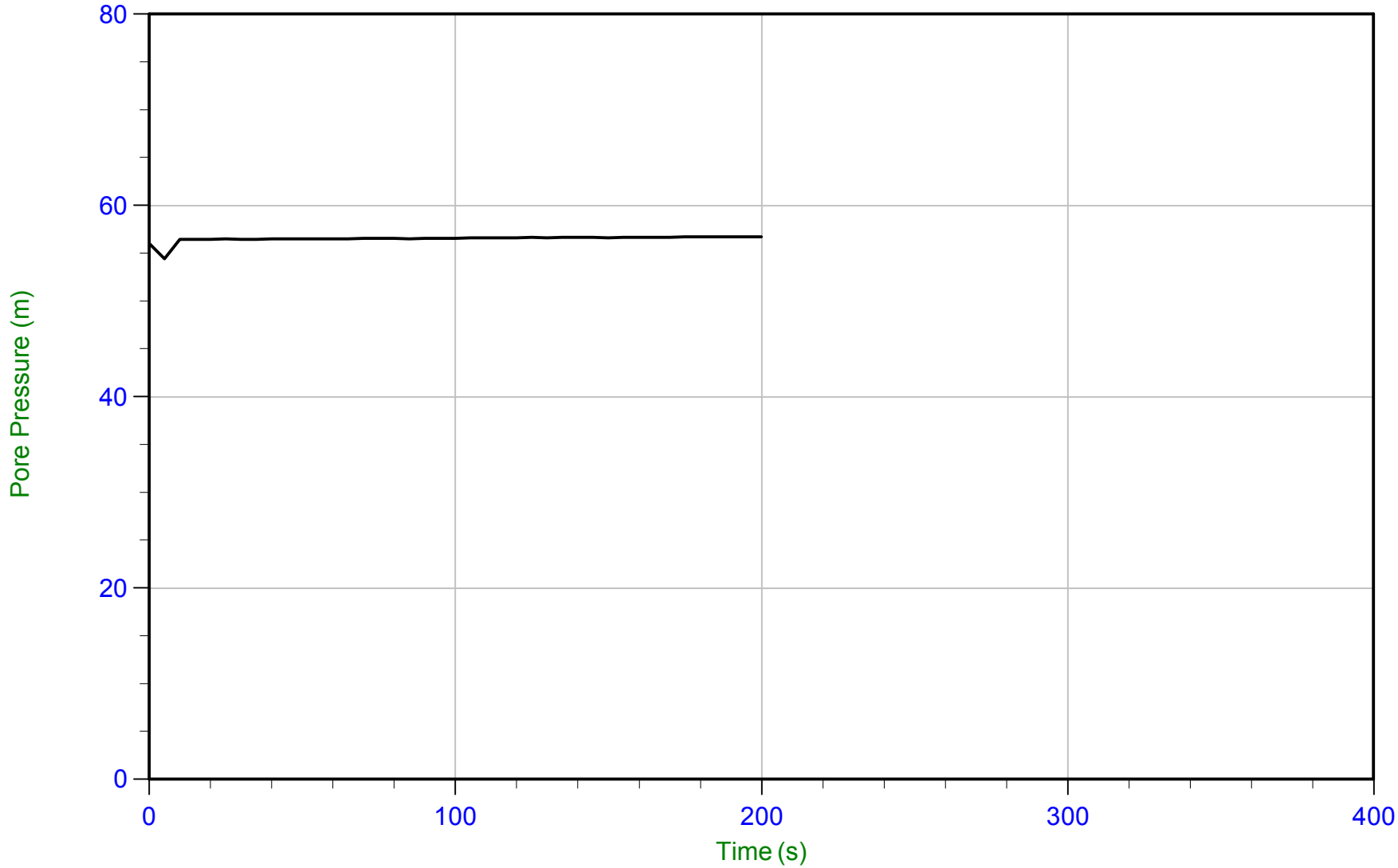
WT: -16.989 m / -55.738 ft
Ueq: 40.4 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/05/2017 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_SPD002.PPF
Depth: 39.475 m / 129.510 ft
Duration: 200.0 s

U Min: 54.4 m
U Max: 56.7 m

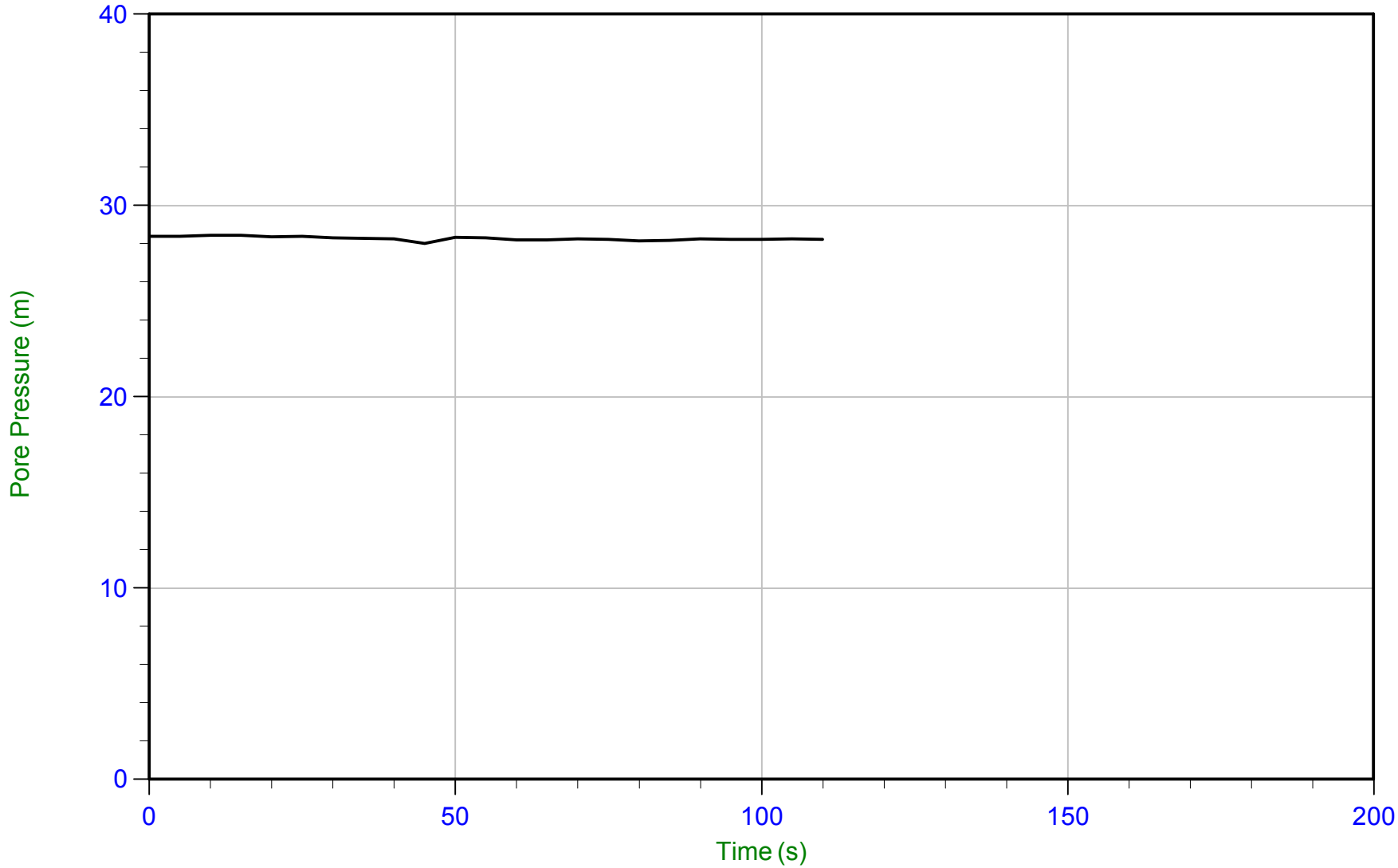
WT: -17.091 m / -56.072 ft
Ueq: 56.6 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/06/2017 13:34
Site: Milne Port Expansion

Sounding: CPT17-D003
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD003.PPF
Depth: 5.200 m / 17.060 ft
Duration: 110.0 s

U Min: 28.0 m
U Max: 28.4 m

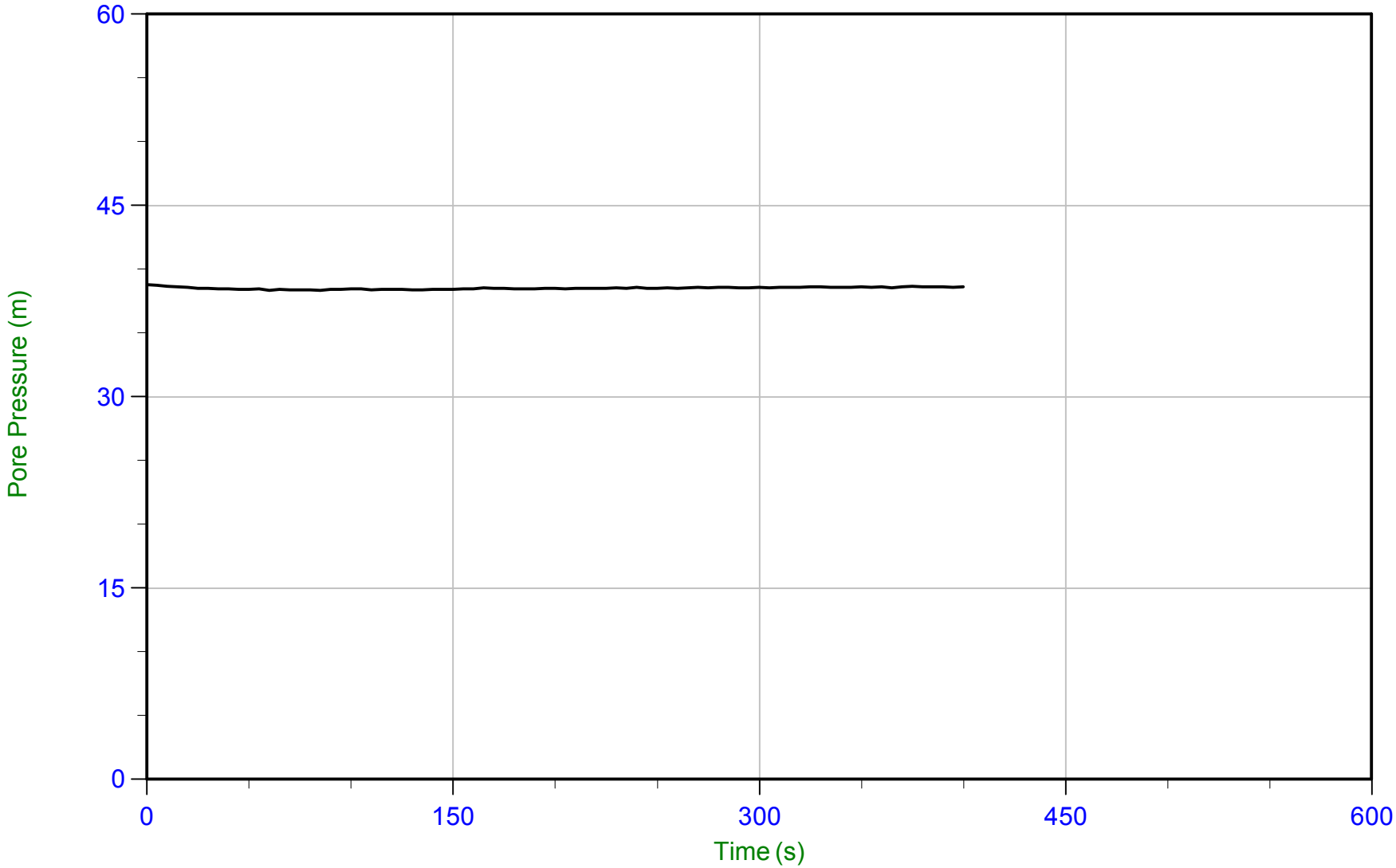
WT: -23.002 m / -75.465 ft
Ueq: 28.2 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/06/2017 13:34
Site: Milne Port Expansion

Sounding: CPT17-D003
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD003.PPF
Depth: 15.300 m / 50.196 ft
Duration: 400.0 s

U Min: 38.3 m
U Max: 38.8 m

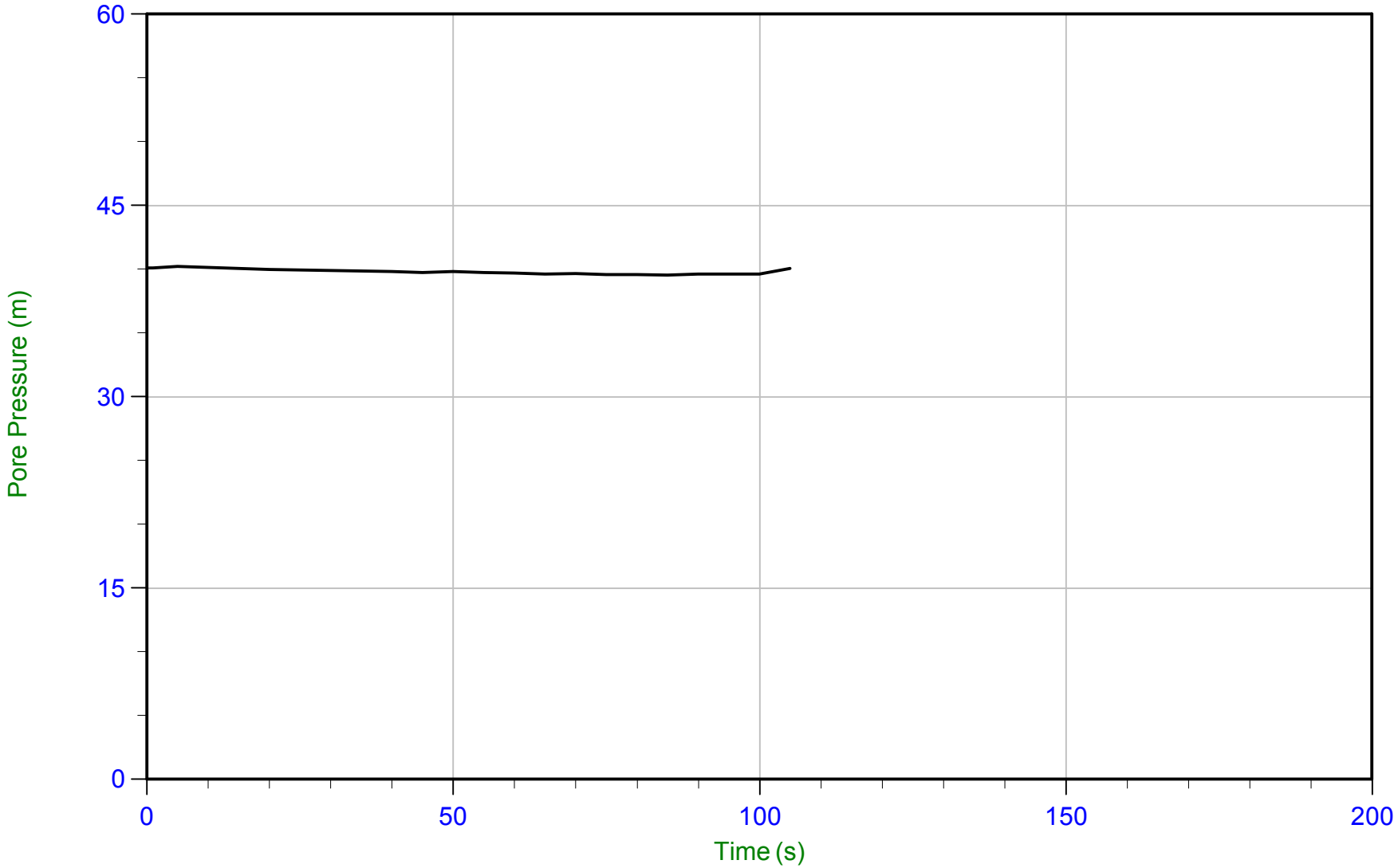
WT: -23.245 m / -76.262 ft
Ueq: 38.5 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/06/2017 13:34
Site: Milne Port Expansion

Sounding: CPT17-D003
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD003.PPF
Depth: 16.300 m / 53.477 ft
Duration: 105.0 s

U Min: 39.5 m
U Max: 40.2 m

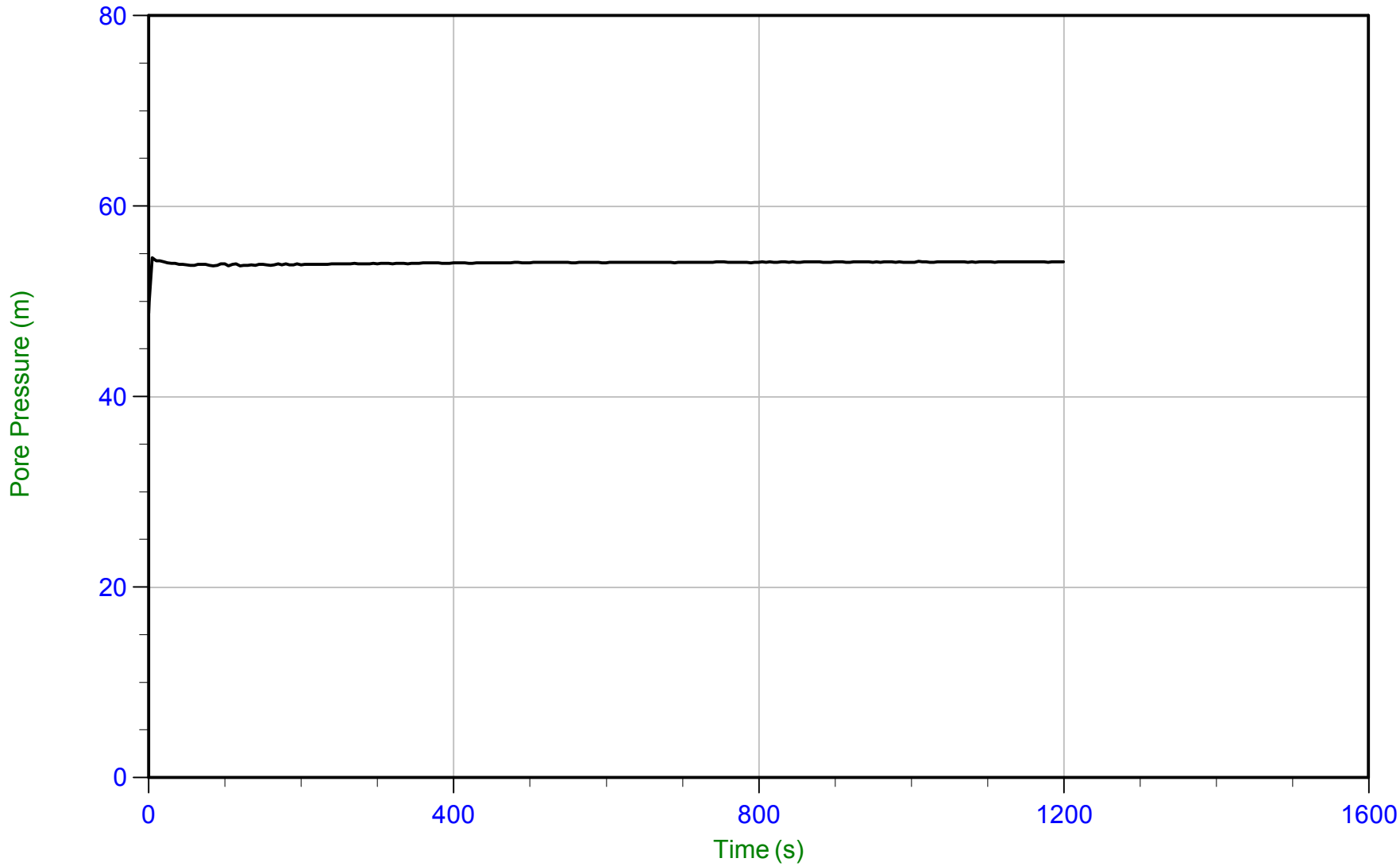
WT: -23.336 m / -76.561 ft
Ueq: 39.6 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/06/2017 13:34
Site: Milne Port Expansion

Sounding: CPT17-D003
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD003.PPF
Depth: 30.425 m / 99.818 ft
Duration: 1200.0 s

U Min: 48.8 m
U Max: 54.6 m

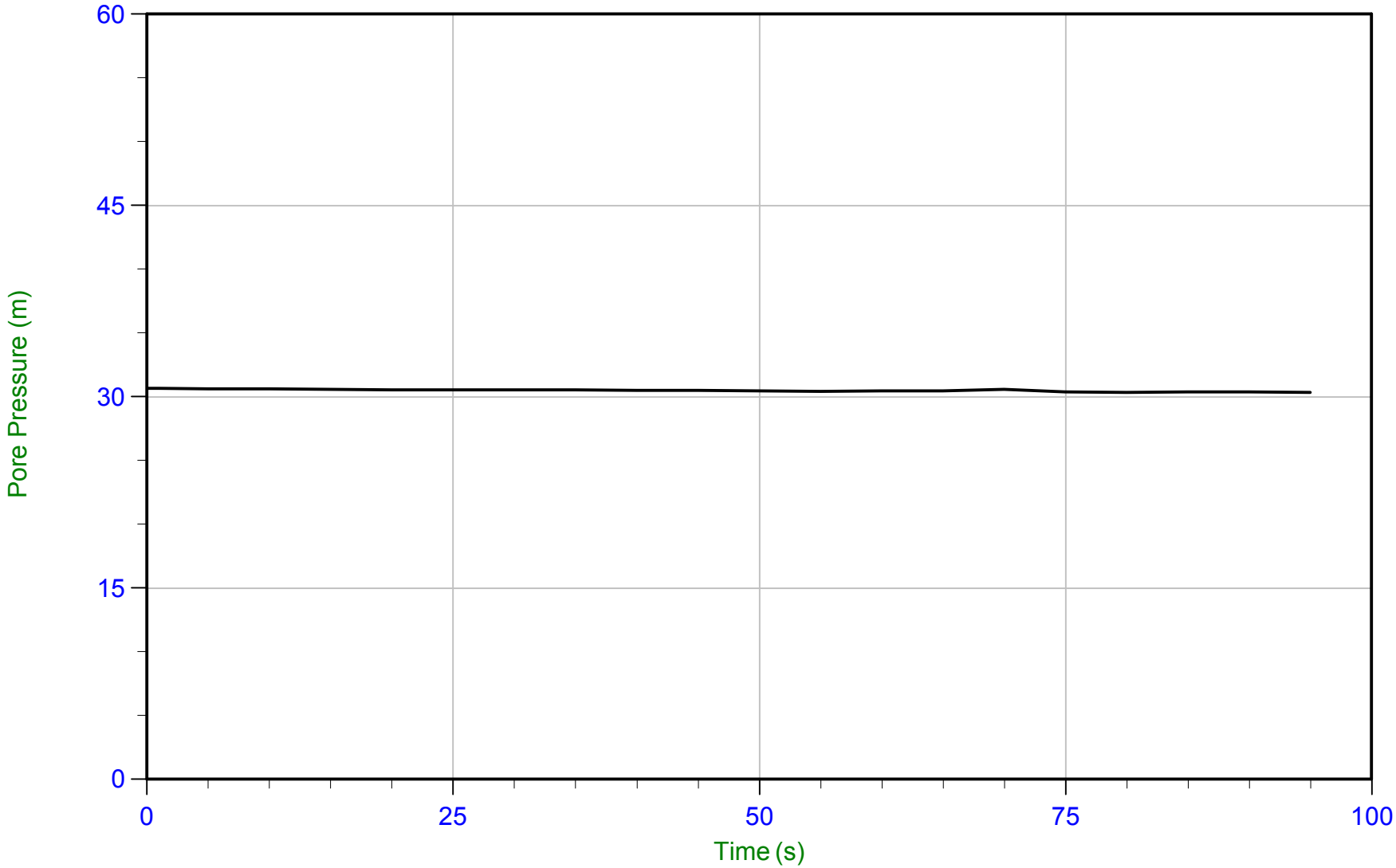
WT: -23.716 m / -77.807 ft
Ueq: 54.1 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/04/2017 16:44
Site: Milne Port Expansion

Sounding: SCPT17-D004
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_SPD004.PPF
Depth: 3.275 m / 10.745 ft
Duration: 95.0 s

U Min: 30.3 m
U Max: 30.7 m

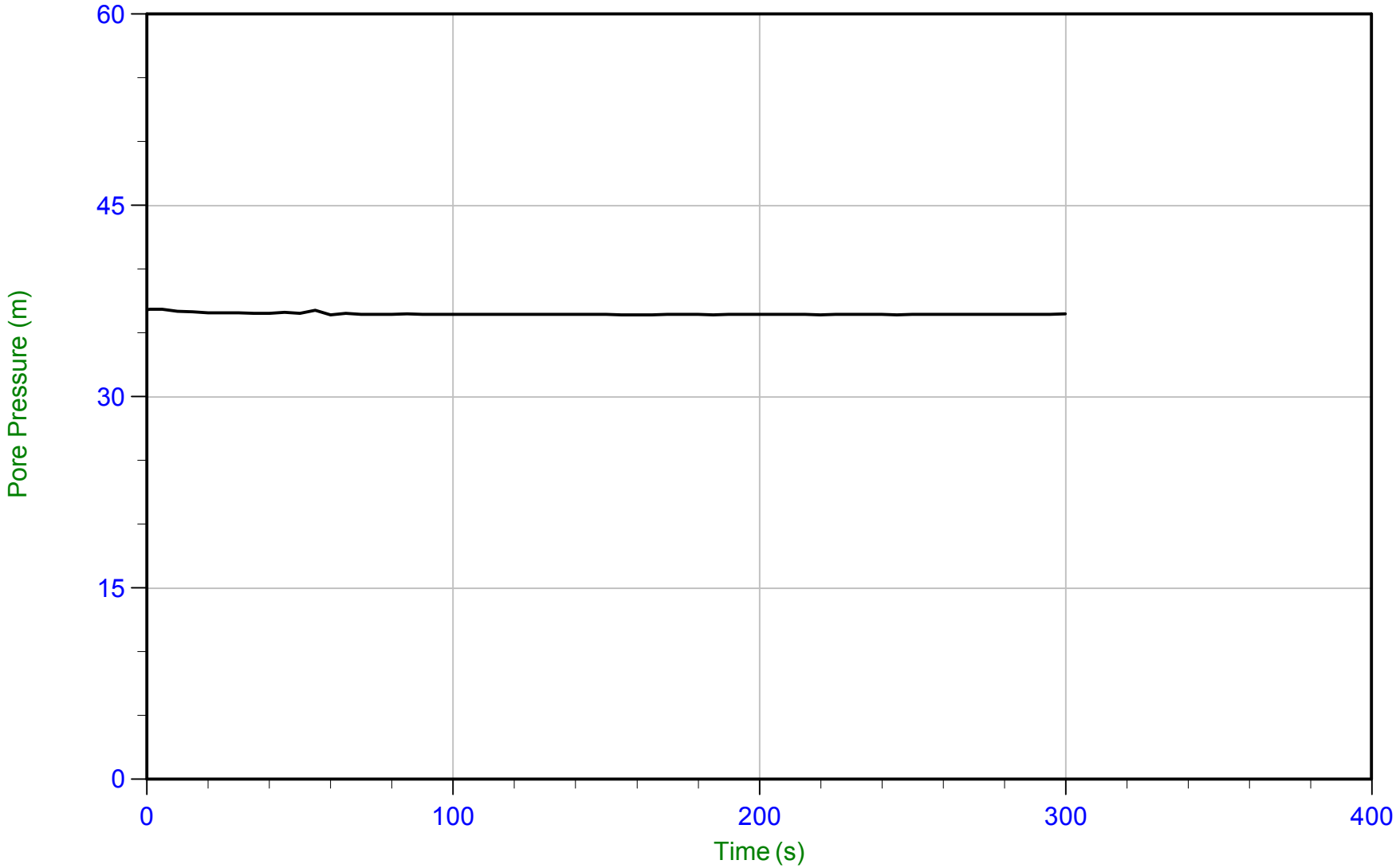
WT: -27.149 m / -89.070 ft
Ueq: 30.4 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/04/2017 16:44
Site: Milne Port Expansion

Sounding: SCPT17-D004
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_SPD004.PPF
Depth: 9.200 m / 30.183 ft
Duration: 300.0 s

U Min: 36.4 m
U Max: 36.9 m

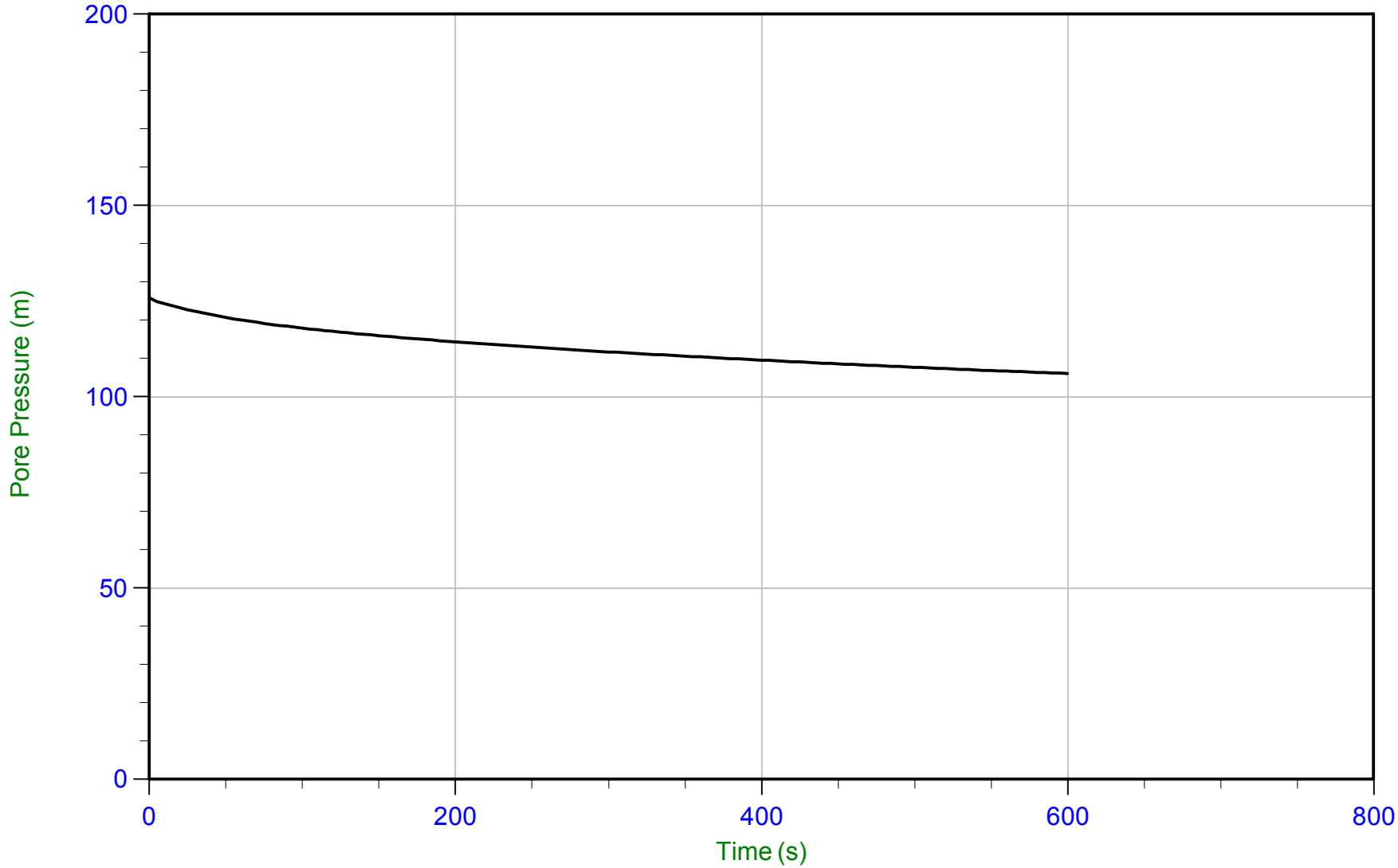
WT: -27.285 m / -89.517 ft
Ueq: 36.5 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/04/2017 16:44
Site: Milne Port Expansion

Sounding: SCPT17-D004
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_SPD004.PPF
Depth: 30.475 m / 99.982 ft
Duration: 600.0 s

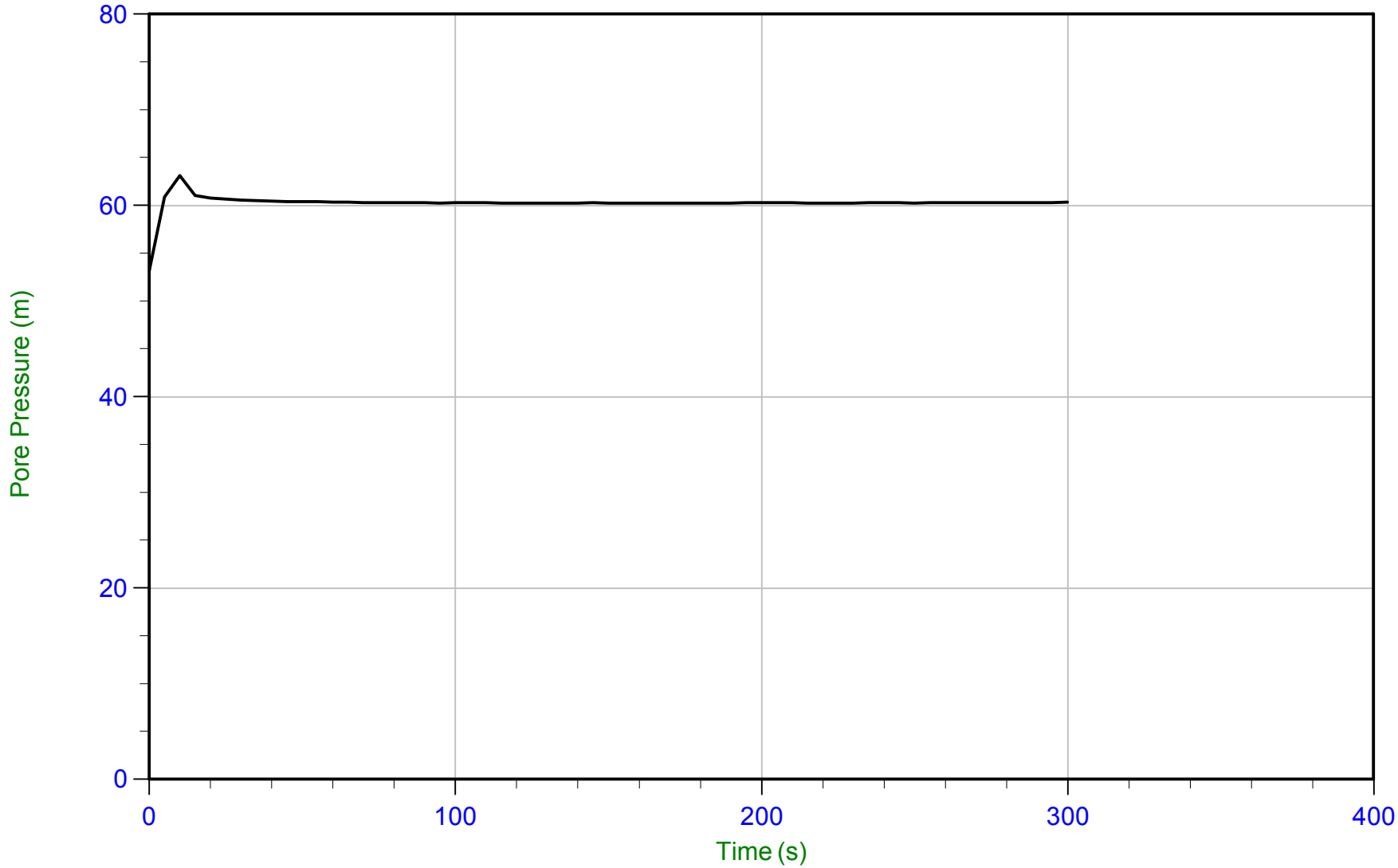
U Min: 106.1 m
U Max: 125.8 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/04/2017 16:44
Site: Milne Port Expansion

Sounding: SCPT17-D004
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_SPD004.PPF
Depth: 32.050 m / 105.150 ft
Duration: 300.0 s

U Min: 53.2 m
U Max: 63.1 m

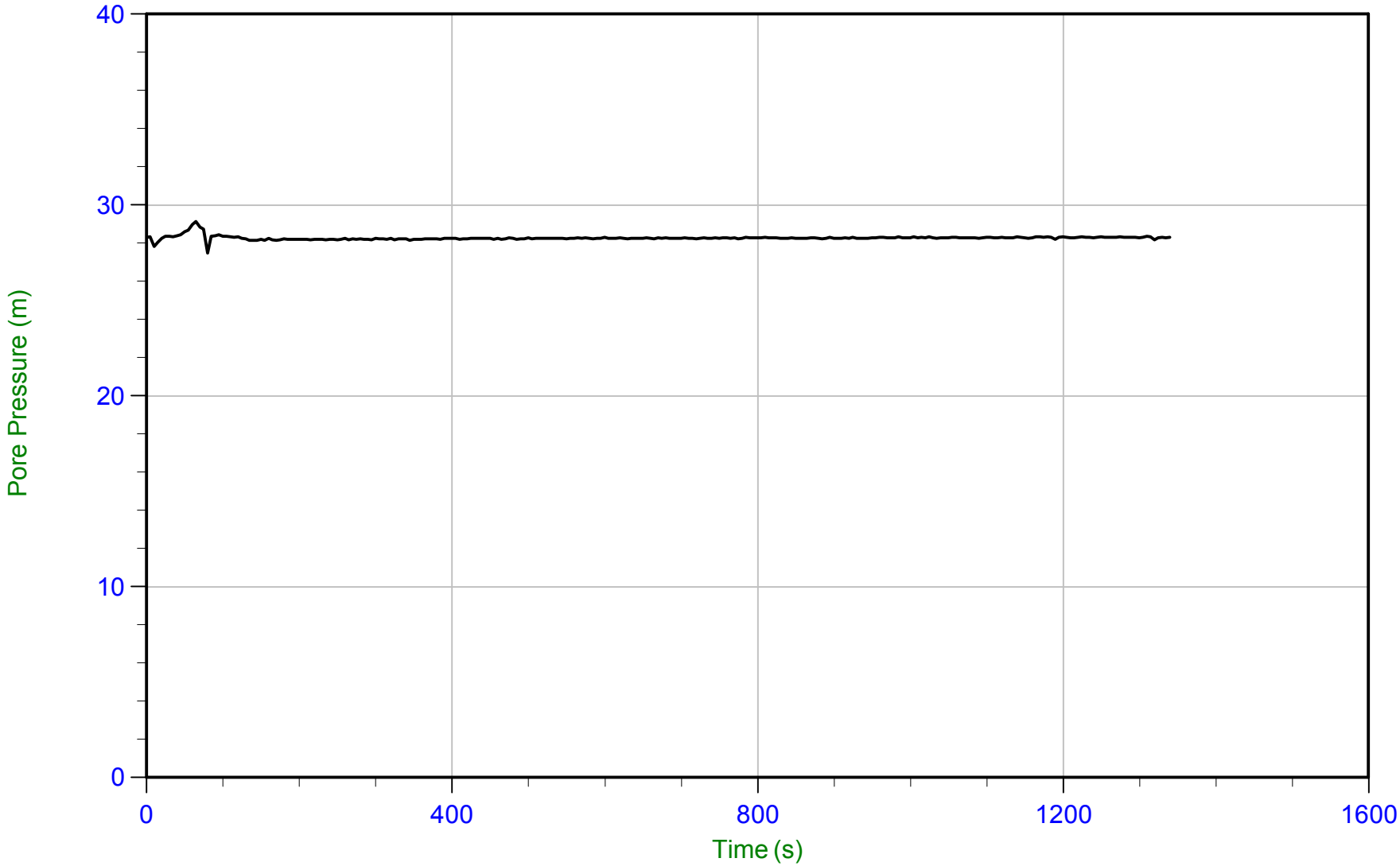
WT: -28.233 m / -92.627 ft
Ueq: 60.3 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 2.275 m / 7.464 ft
Duration: 1340.0 s

U Min: 27.5 m
U Max: 29.1 m

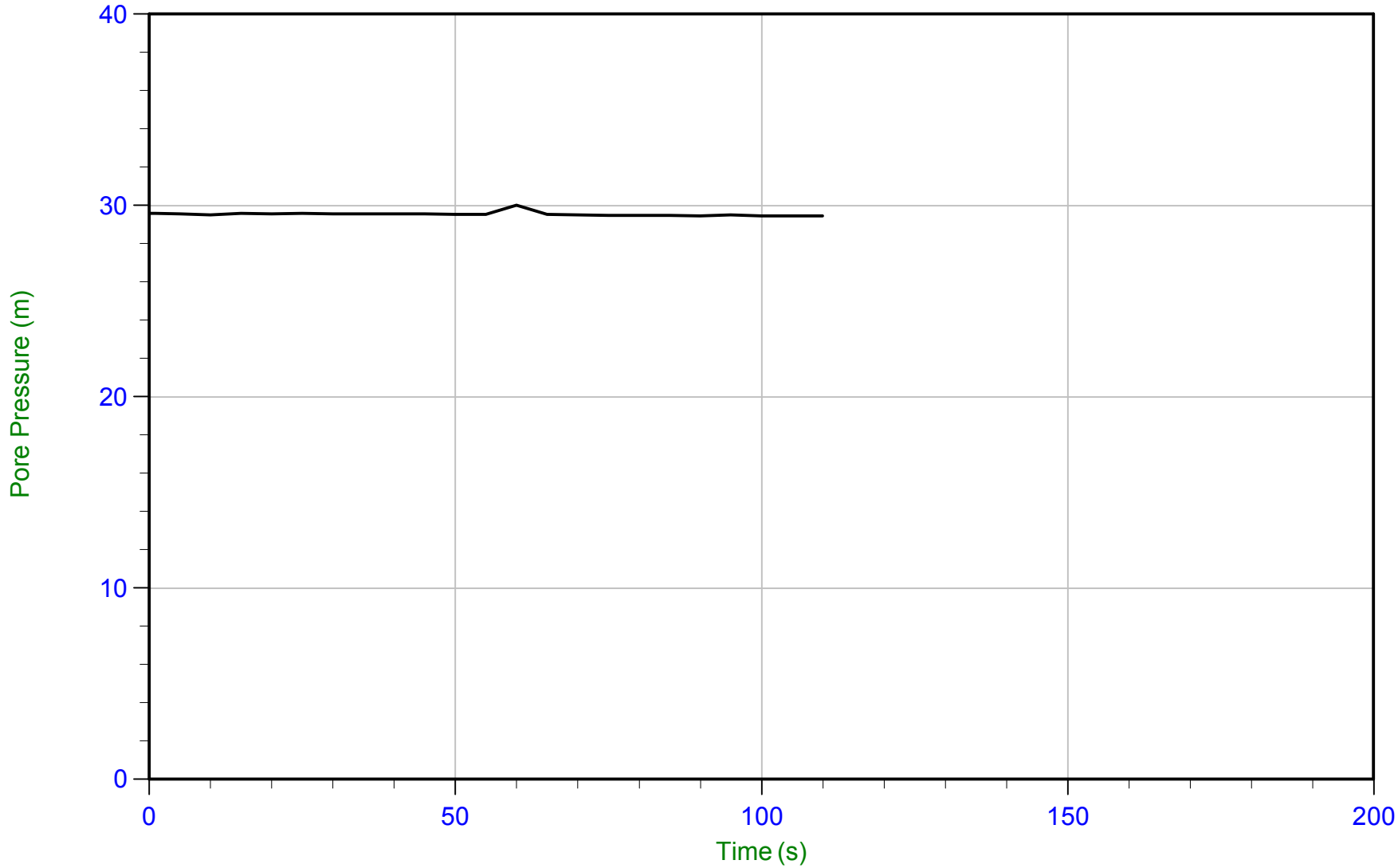
WT: -26.008 m / -85.327 ft
Ueq: 28.3 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 3.325 m / 10.909 ft
Duration: 110.0 s

U Min: 29.4 m
U Max: 30.0 m

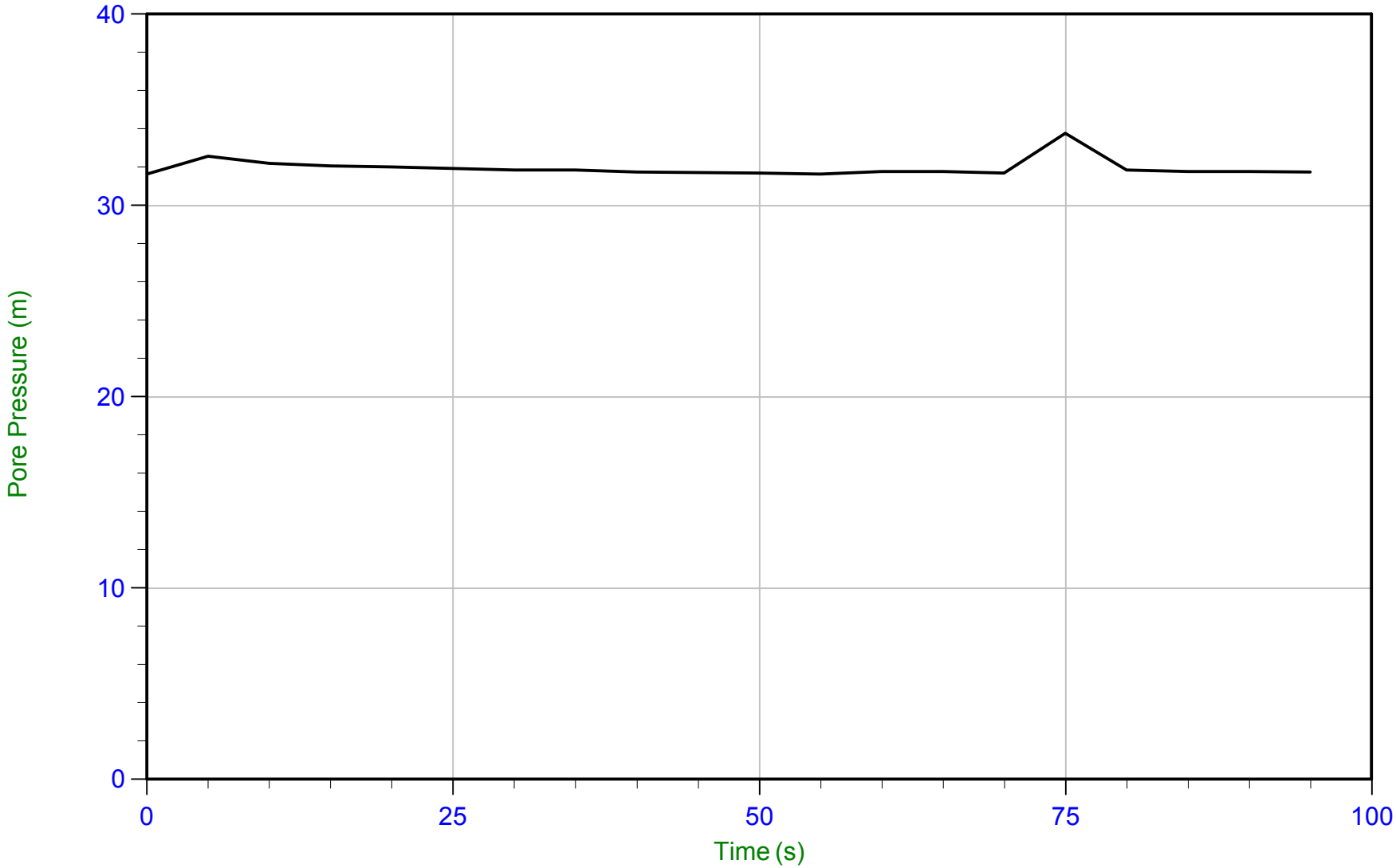
WT: -26.170 m / -85.859 ft
Ueq: 29.5 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 5.375 m / 17.634 ft
Duration: 95.0 s

U Min: 31.6 m
U Max: 33.8 m

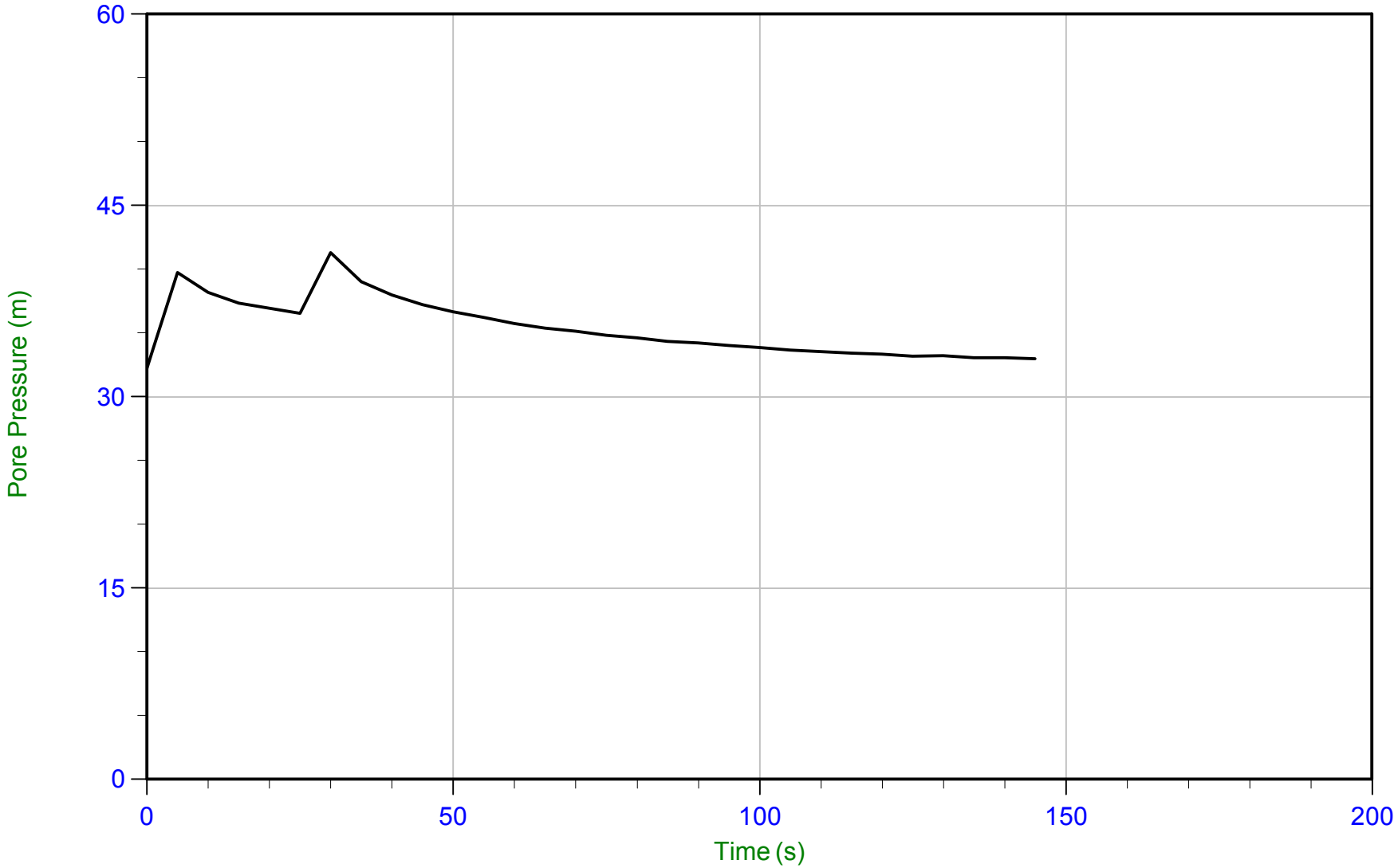
WT: -26.383 m / -86.557 ft
Ueq: 31.8 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 6.375 m / 20.915 ft
Duration: 145.0 s

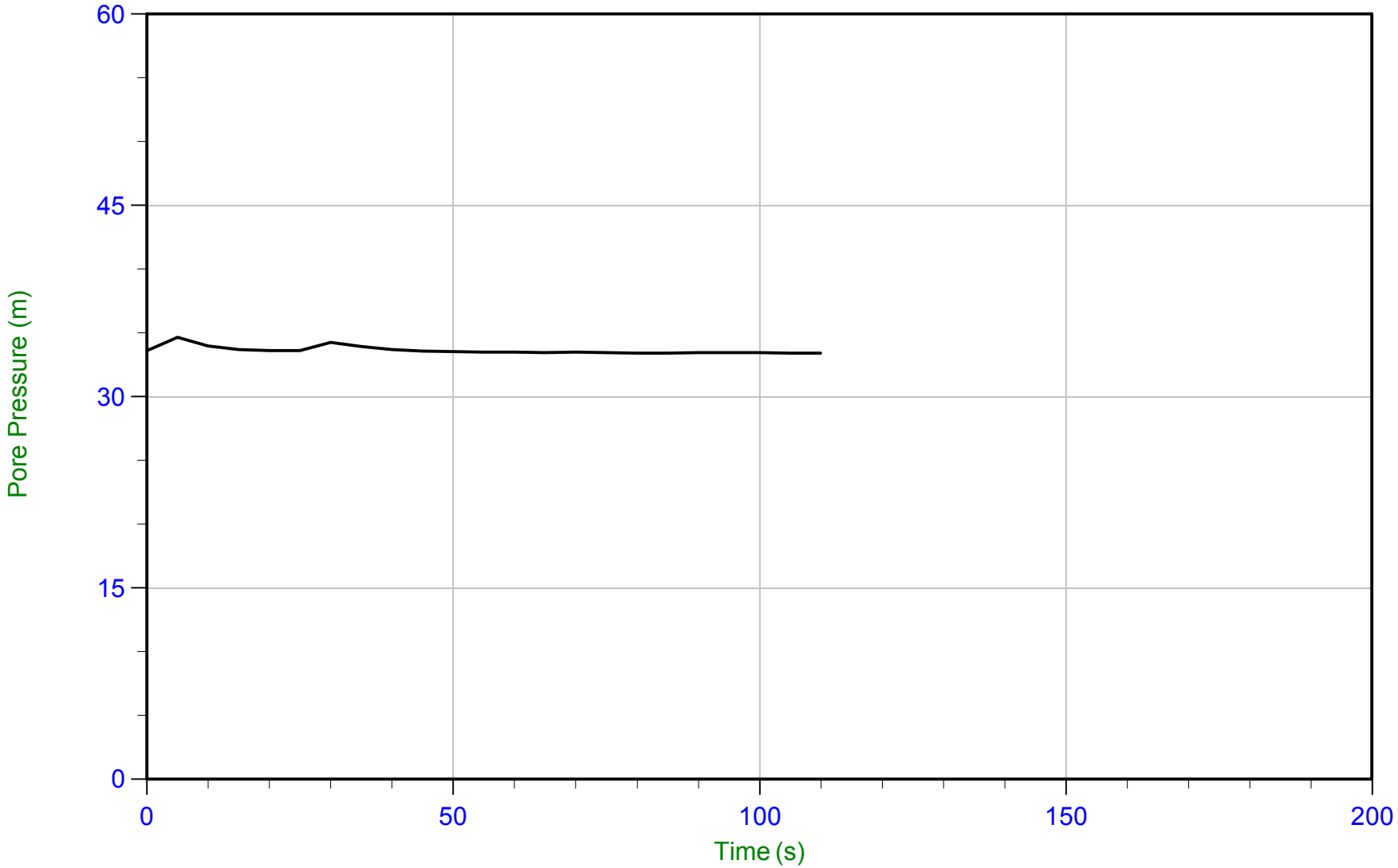
U Min: 32.2 m
U Max: 41.3 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 7.400 m / 24.278 ft
Duration: 110.0 s

U Min: 33.4 m
U Max: 34.6 m

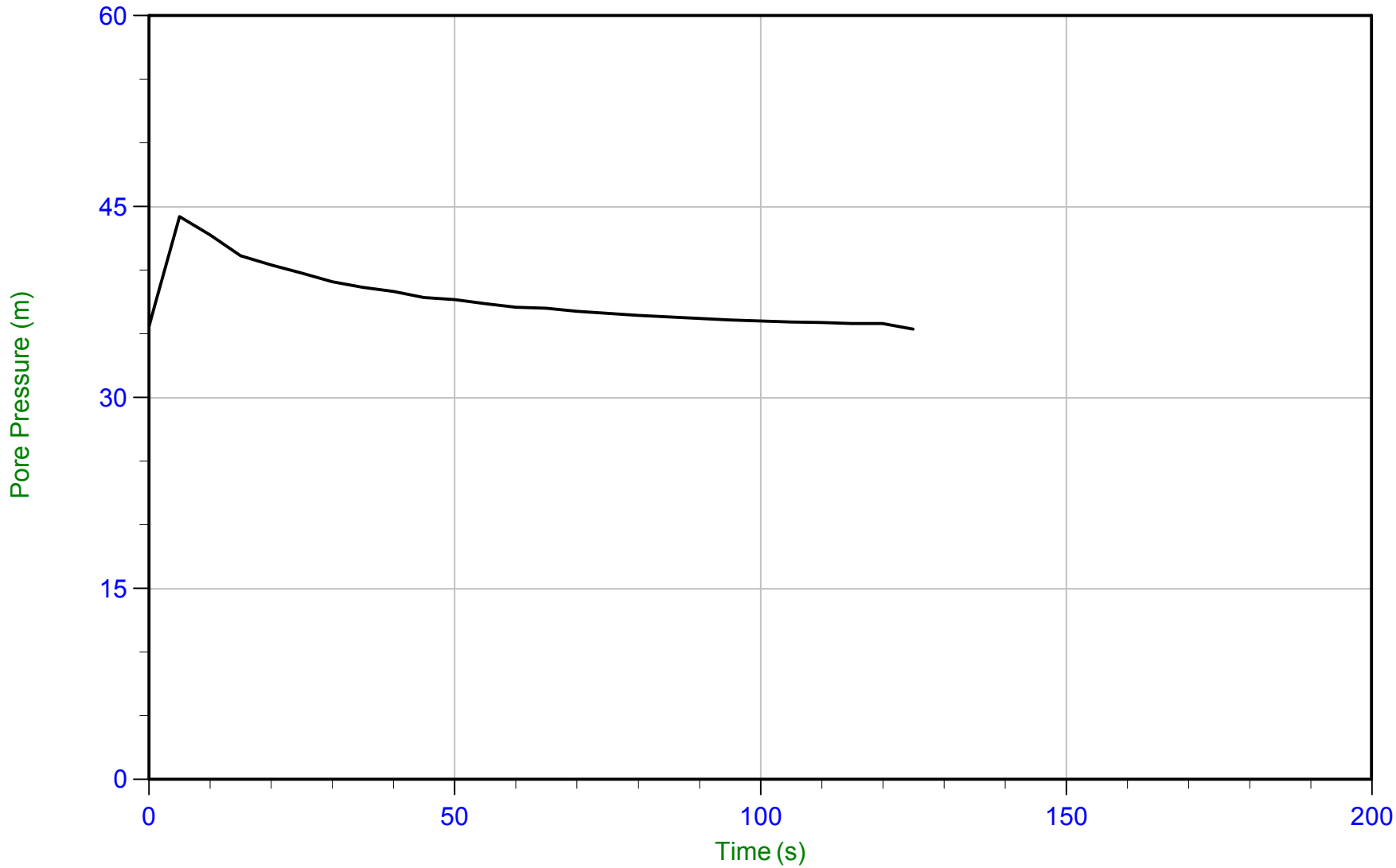
WT: -26.055 m / -85.481 ft
Ueq: 33.5 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 9.350 m / 30.675 ft
Duration: 125.0 s

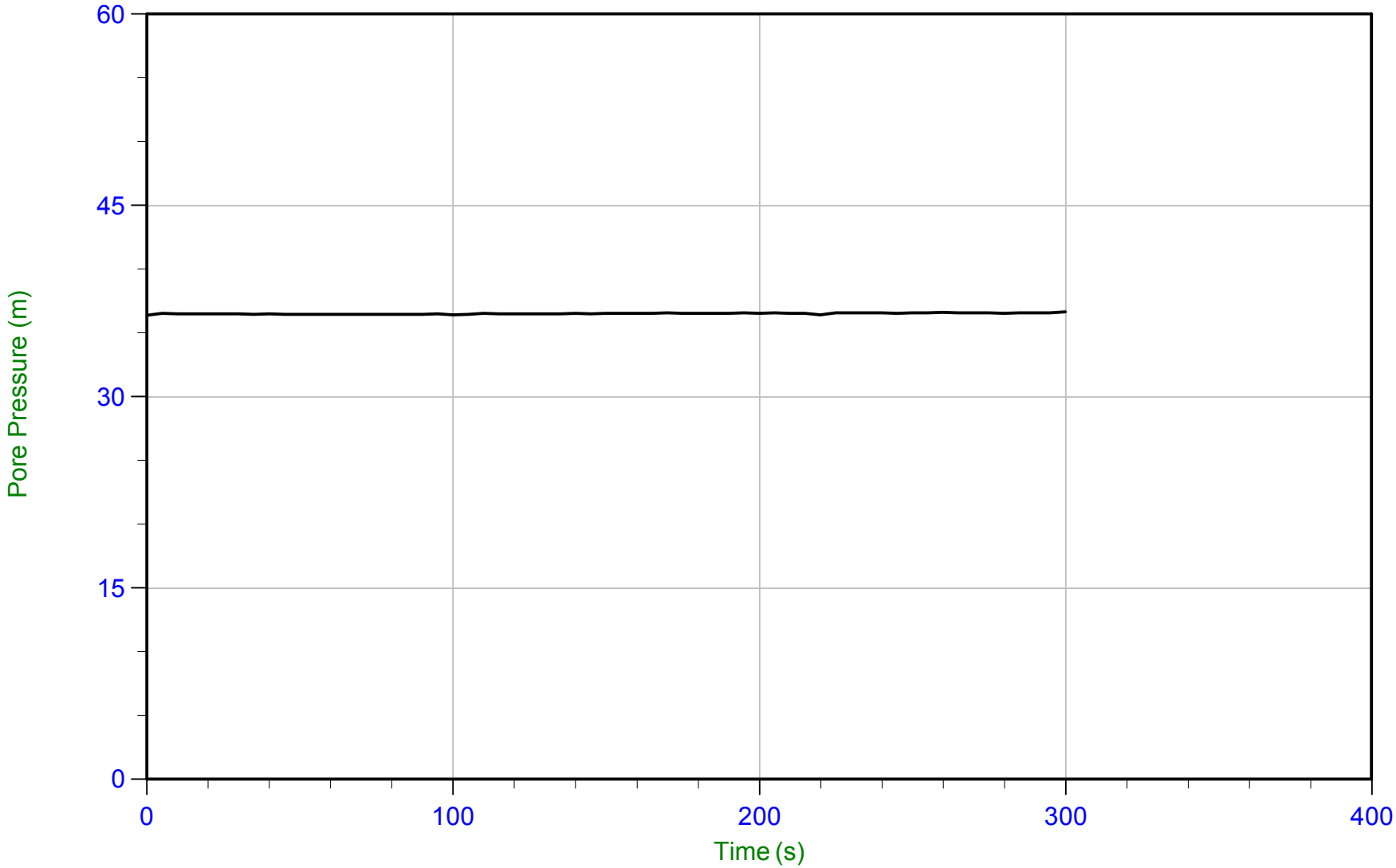
U Min: 35.4 m
U Max: 44.2 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 10.300 m / 33.792 ft
Duration: 300.0 s

U Min: 36.4 m
U Max: 36.6 m

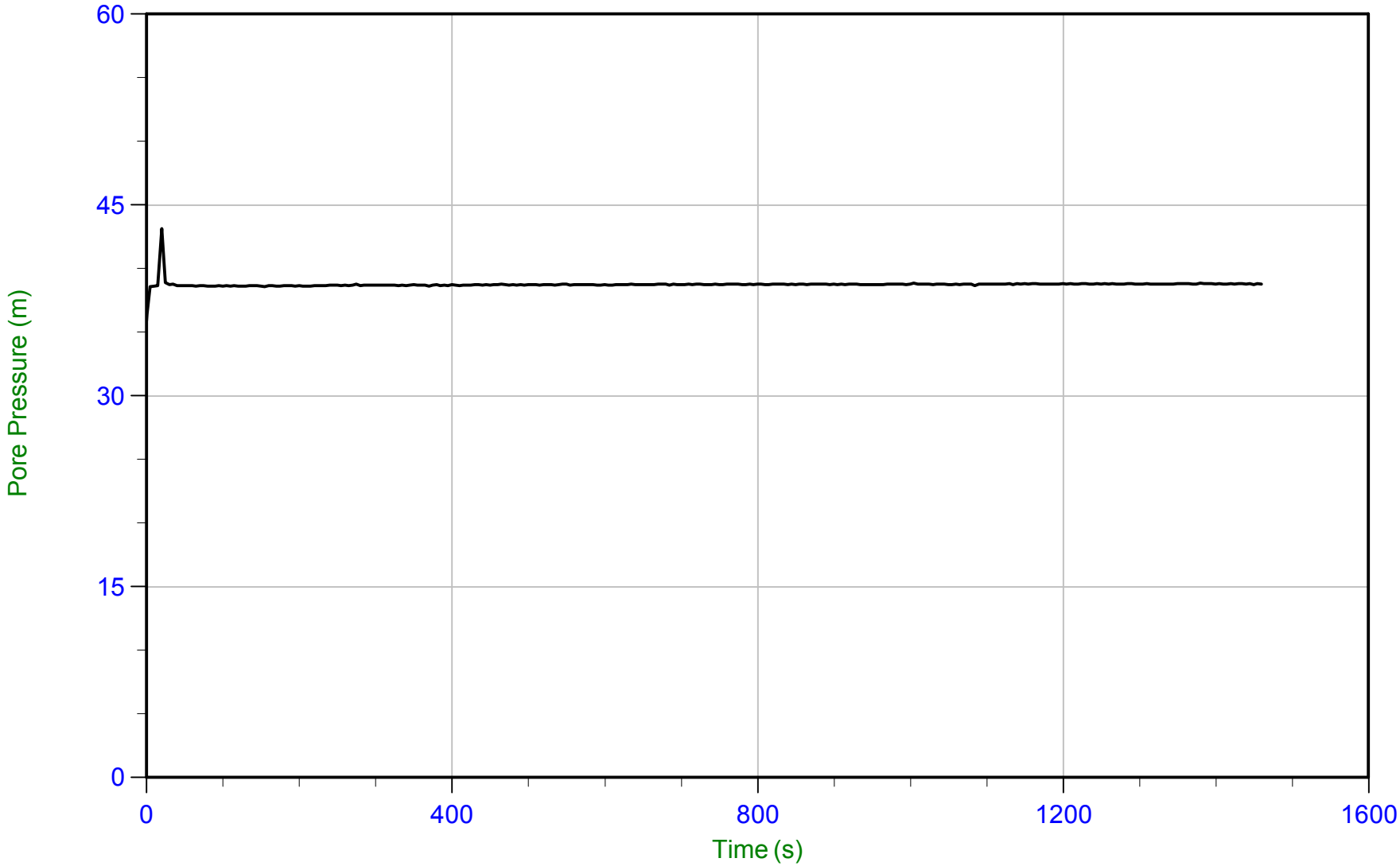
WT: -26.185 m / -85.908 ft
Ueq: 36.5 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 12.350 m / 40.518 ft
Duration: 1460.0 s

U Min: 35.9 m
U Max: 43.1 m

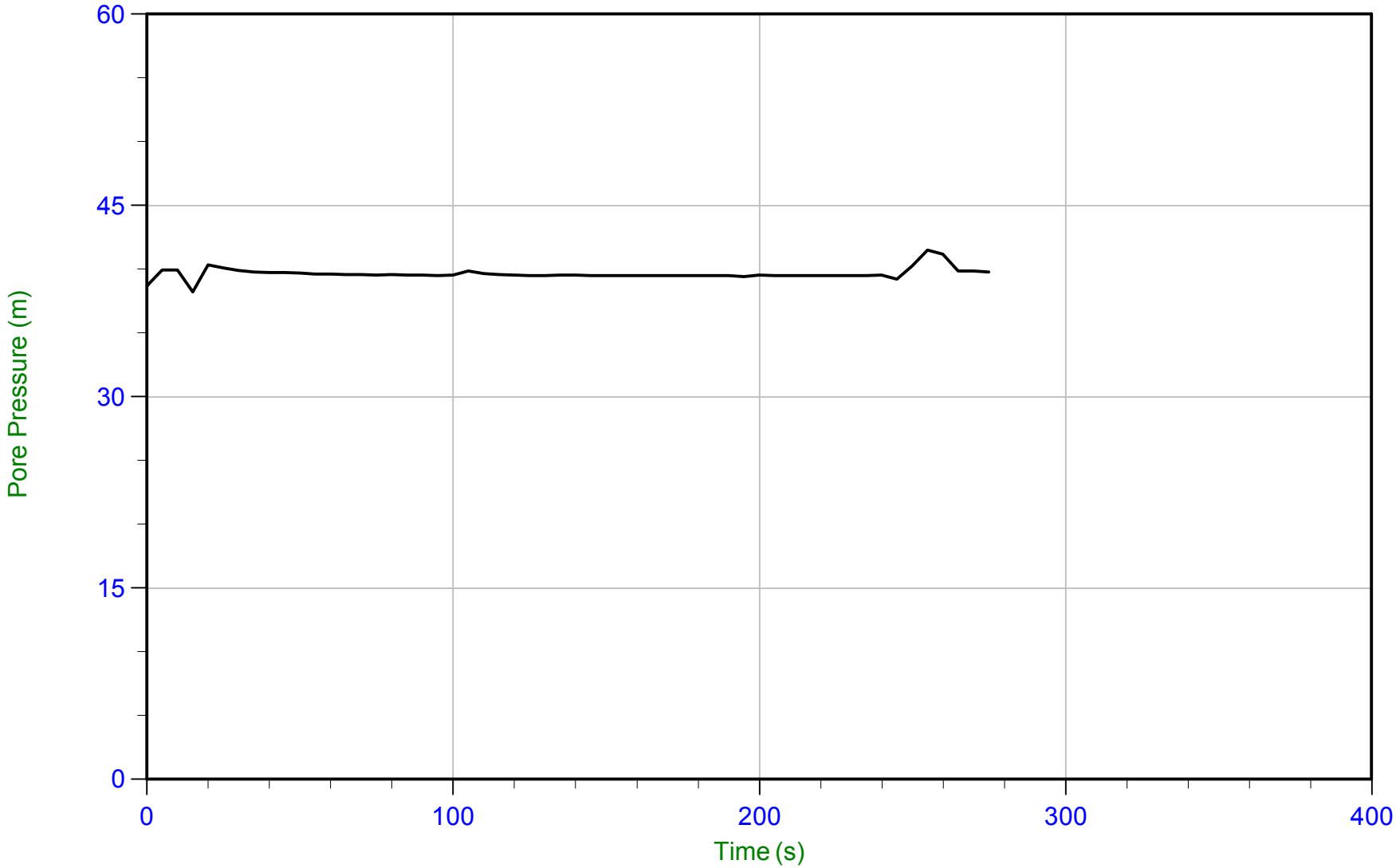
WT: -26.438 m / -86.738 ft
Ueq: 38.8 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 13.175 m / 43.225 ft
Duration: 275.0 s

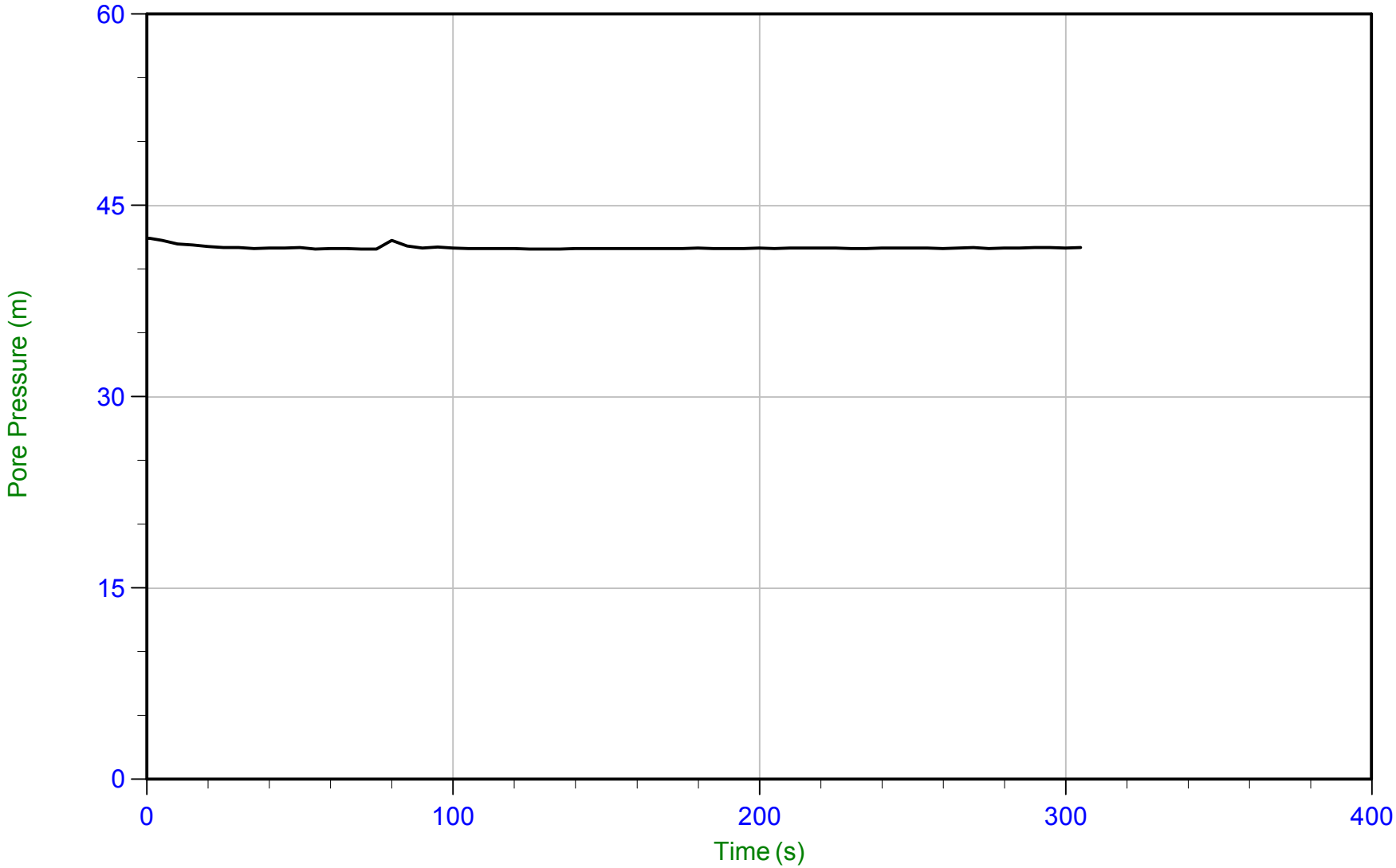
U Min: 38.2 m
U Max: 41.5 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 15.050 m / 49.376 ft
Duration: 305.0 s

U Min: 41.6 m
U Max: 42.4 m

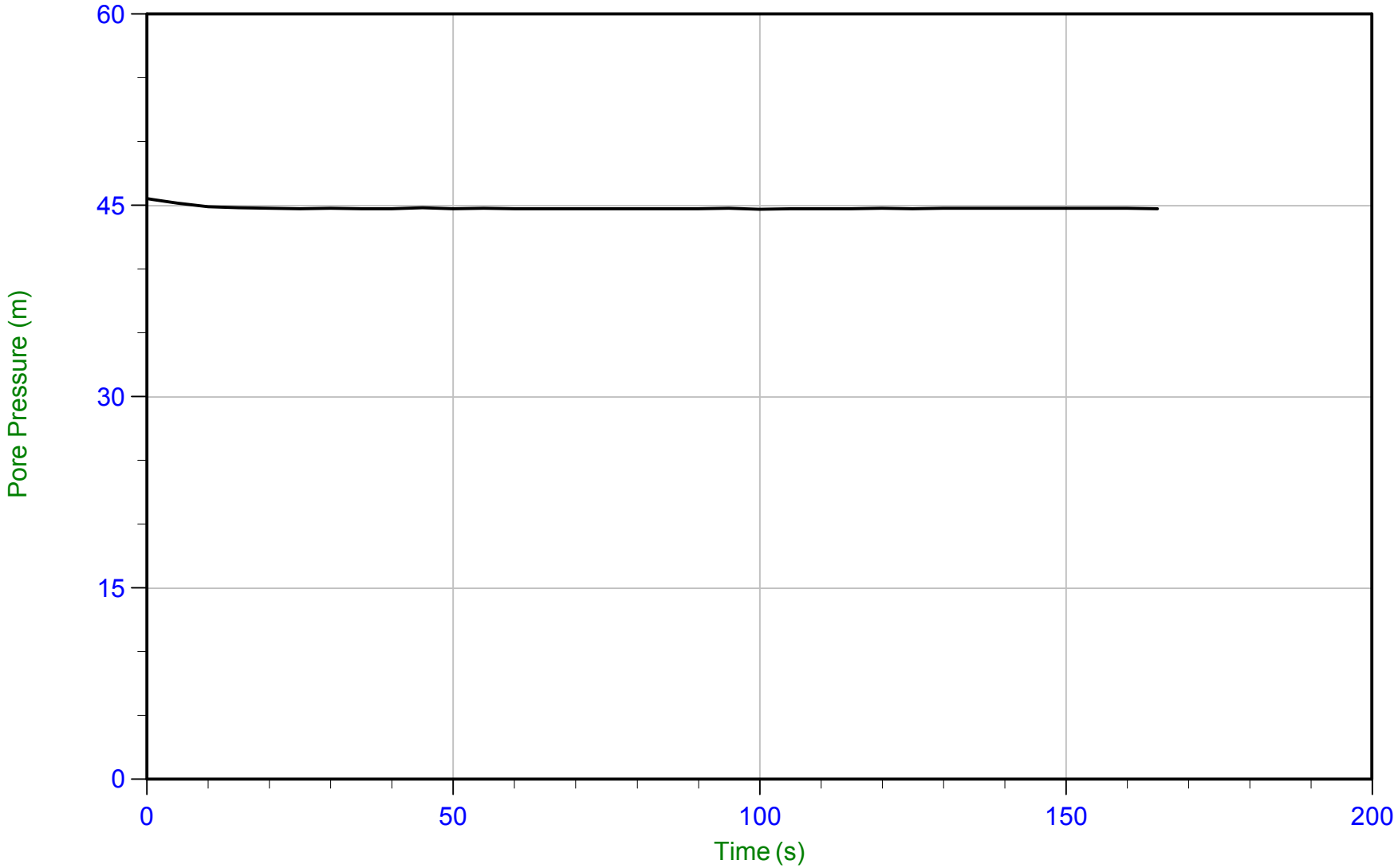
WT: -26.647 m / -87.423 ft
Ueq: 41.7 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 18.100 m / 59.382 ft
Duration: 165.0 s

U Min: 44.7 m
U Max: 45.5 m

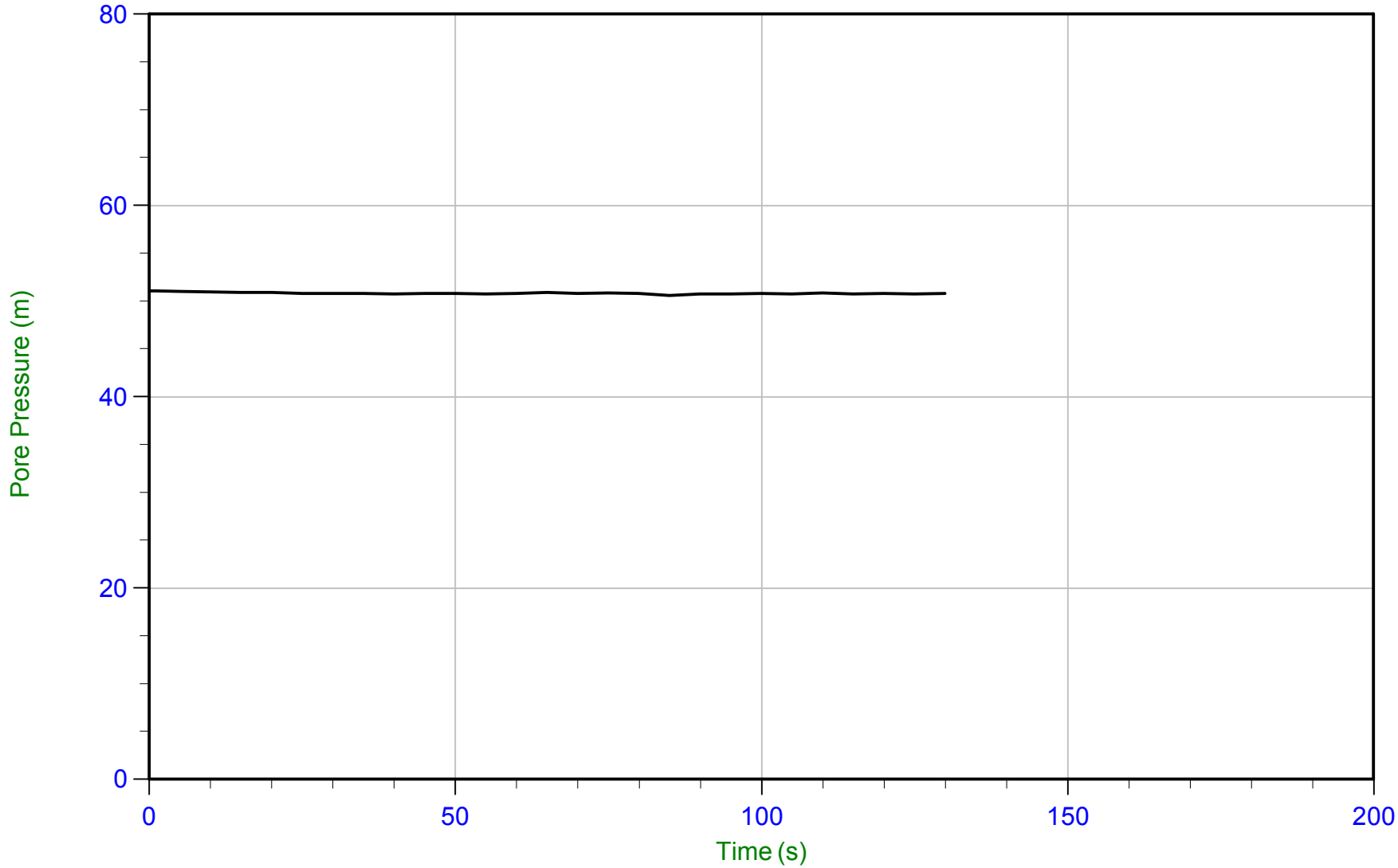
WT: -26.627 m / -87.358 ft
Ueq: 44.7 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 23.925 m / 78.493 ft
Duration: 130.0 s

U Min: 50.6 m
U Max: 51.1 m

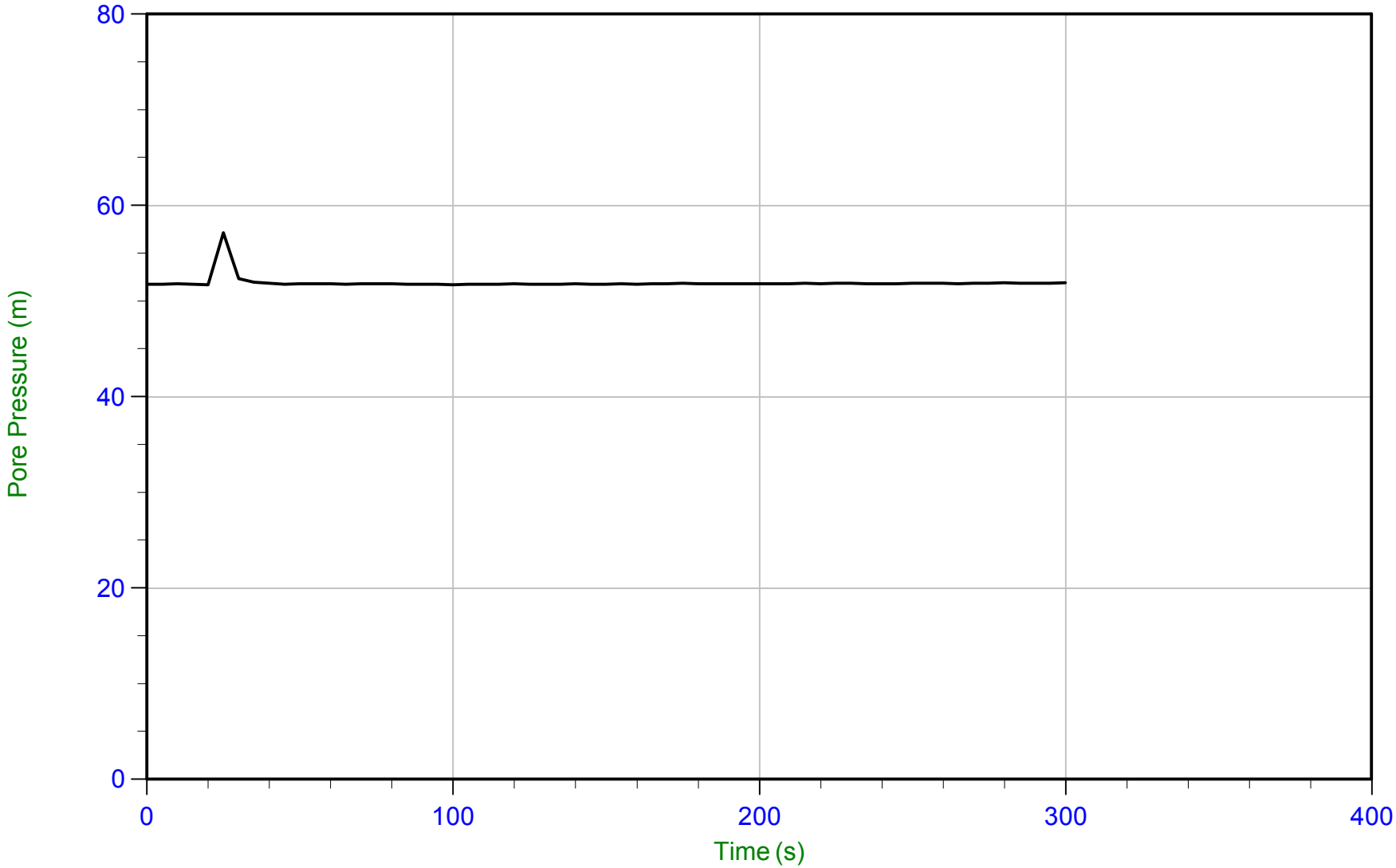
WT: -26.822 m / -87.998 ft
Ueq: 50.7 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 25.125 m / 82.430 ft
Duration: 300.0 s

U Min: 51.7 m
U Max: 57.2 m

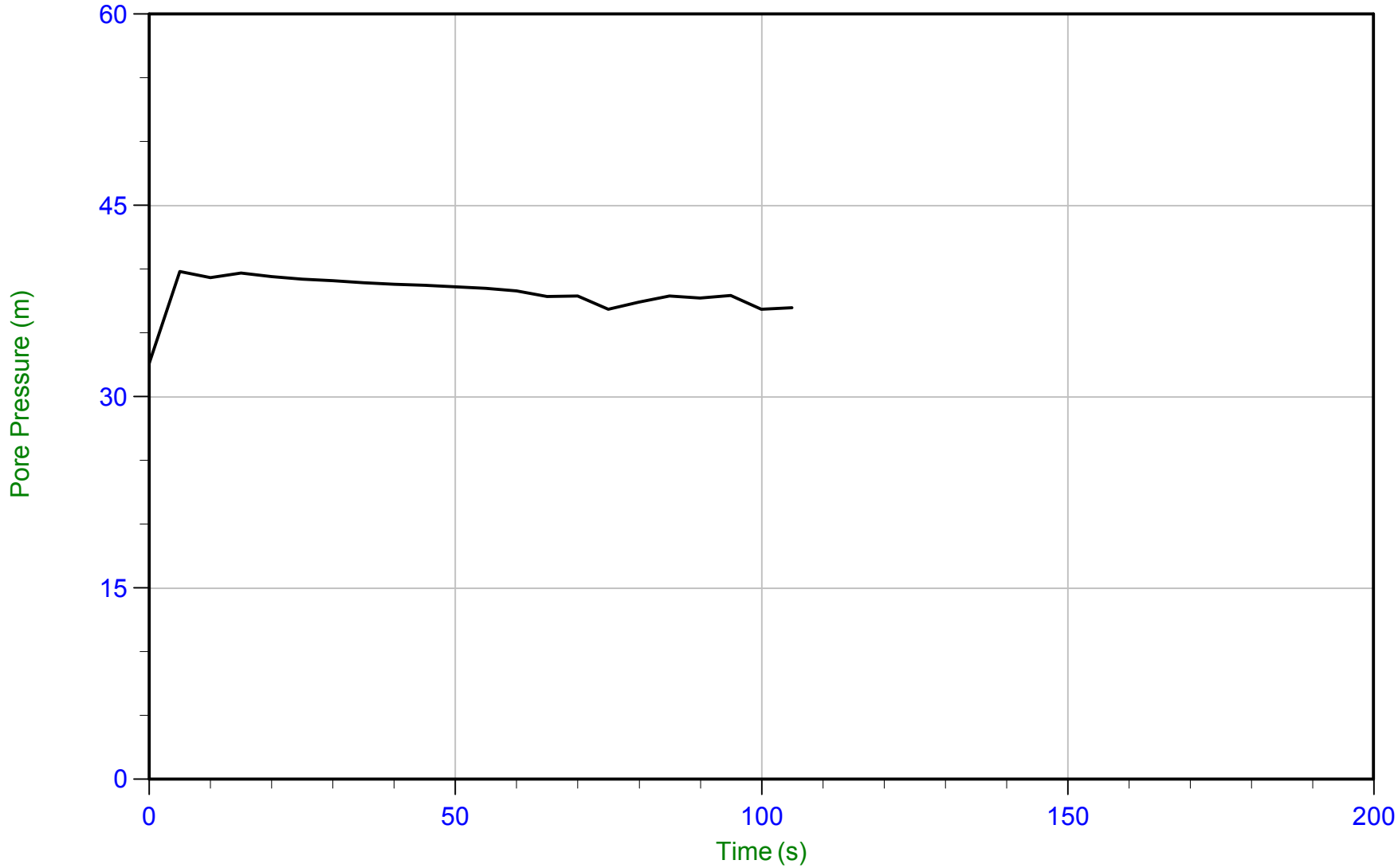
WT: -26.754 m / -87.775 ft
Ueq: 51.9 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/06/2017 23:59
Site: Milne Port Expansion

Sounding: CPT17-D006
Cone: 374:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD006.PPF
Depth: 2.300 m / 7.546 ft
Duration: 105.0 s

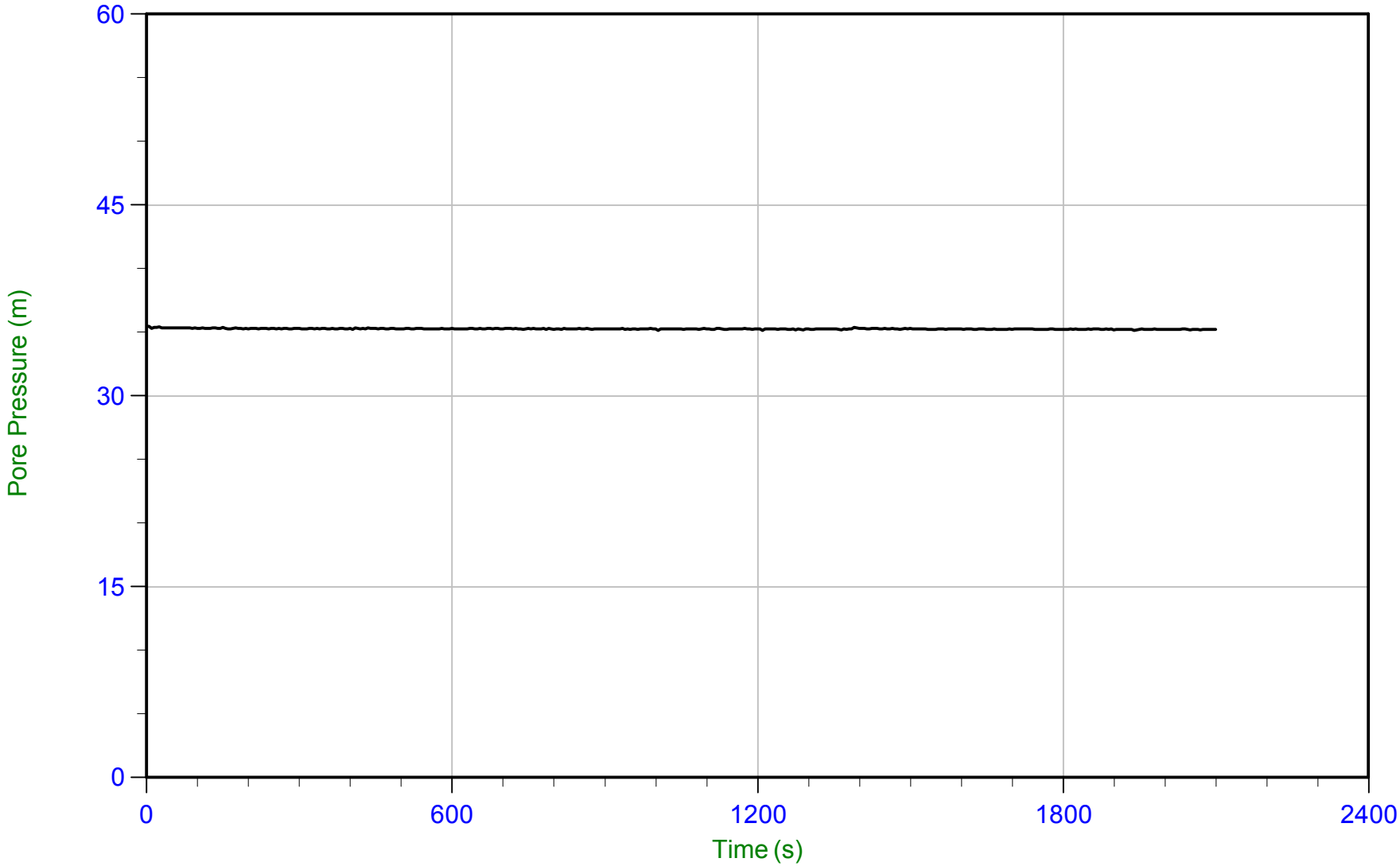
U Min: 32.6 m
U Max: 39.8 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/06/2017 23:59
Site: Milne Port Expansion

Sounding: CPT17-D006
Cone: 374:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD006.PPF
Depth: 3.300 m / 10.827 ft
Duration: 2100.0 s

U Min: 35.1 m
U Max: 35.4 m

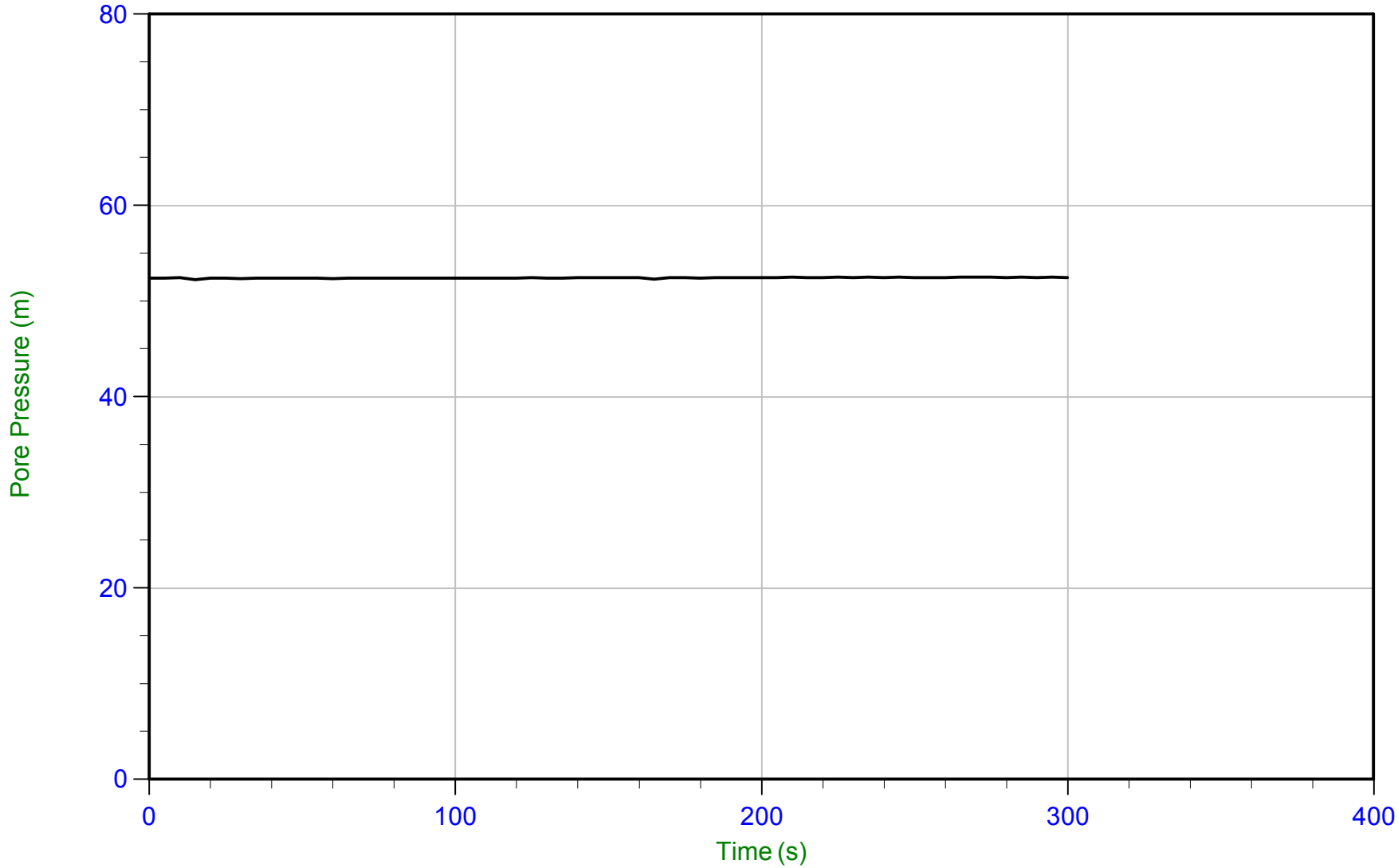
WT: -31.973 m / -104.897 ft
Ueq: 35.3 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/06/2017 23:59
Site: Milne Port Expansion

Sounding: CPT17-D006
Cone: 374:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD006.PPF
Depth: 20.575 m / 67.502 ft
Duration: 300.0 s

U Min: 52.2 m
U Max: 52.5 m

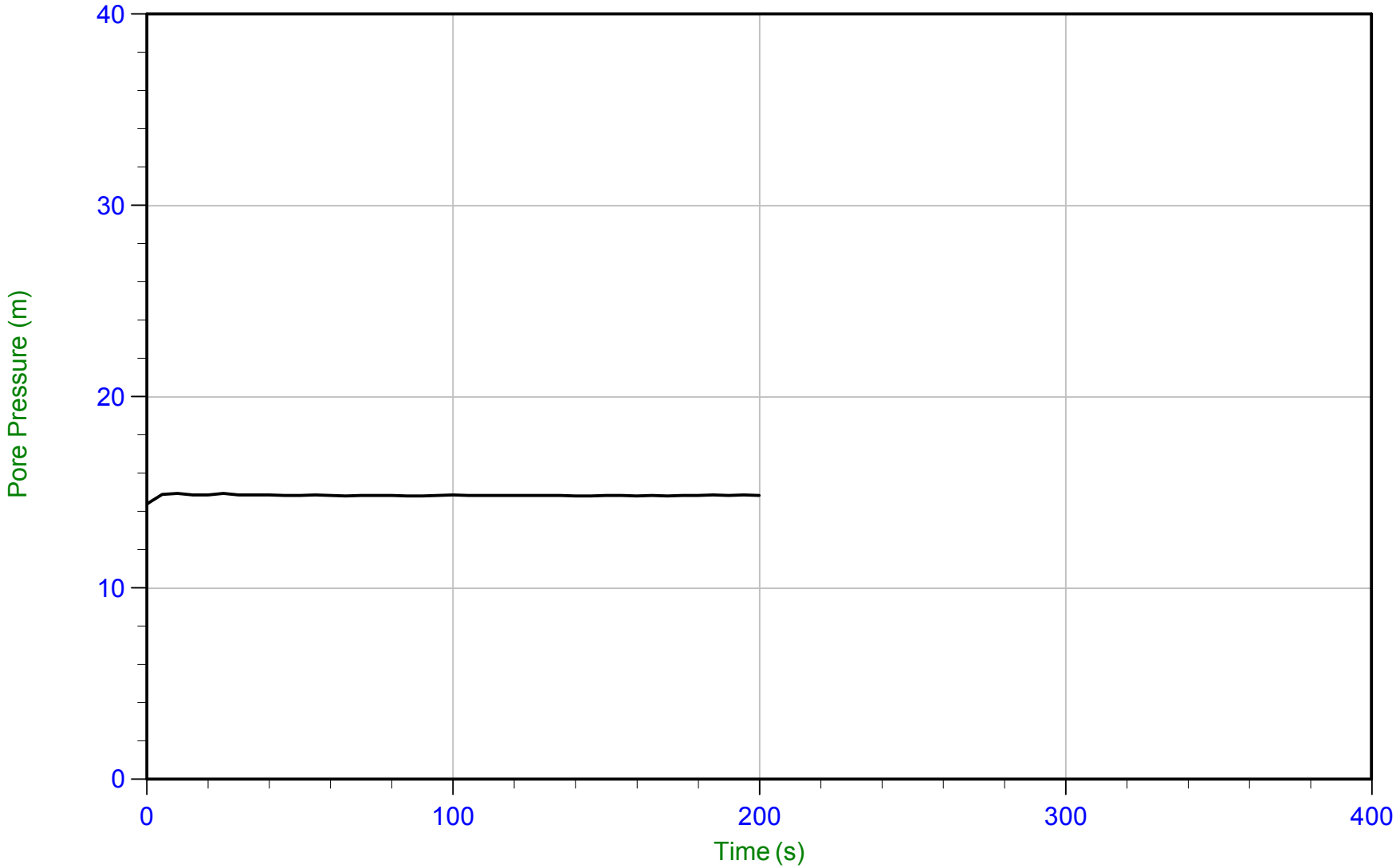
WT: -31.789 m / -104.293 ft
Ueq: 52.4 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/07/2017 11:27
Site: Milne Port Expansion

Sounding: CPT17-D007
Cone: 374:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD007.PPF
Depth: 10.100 m / 33.136 ft
Duration: 200.0 s

U Min: 14.4 m
U Max: 15.0 m

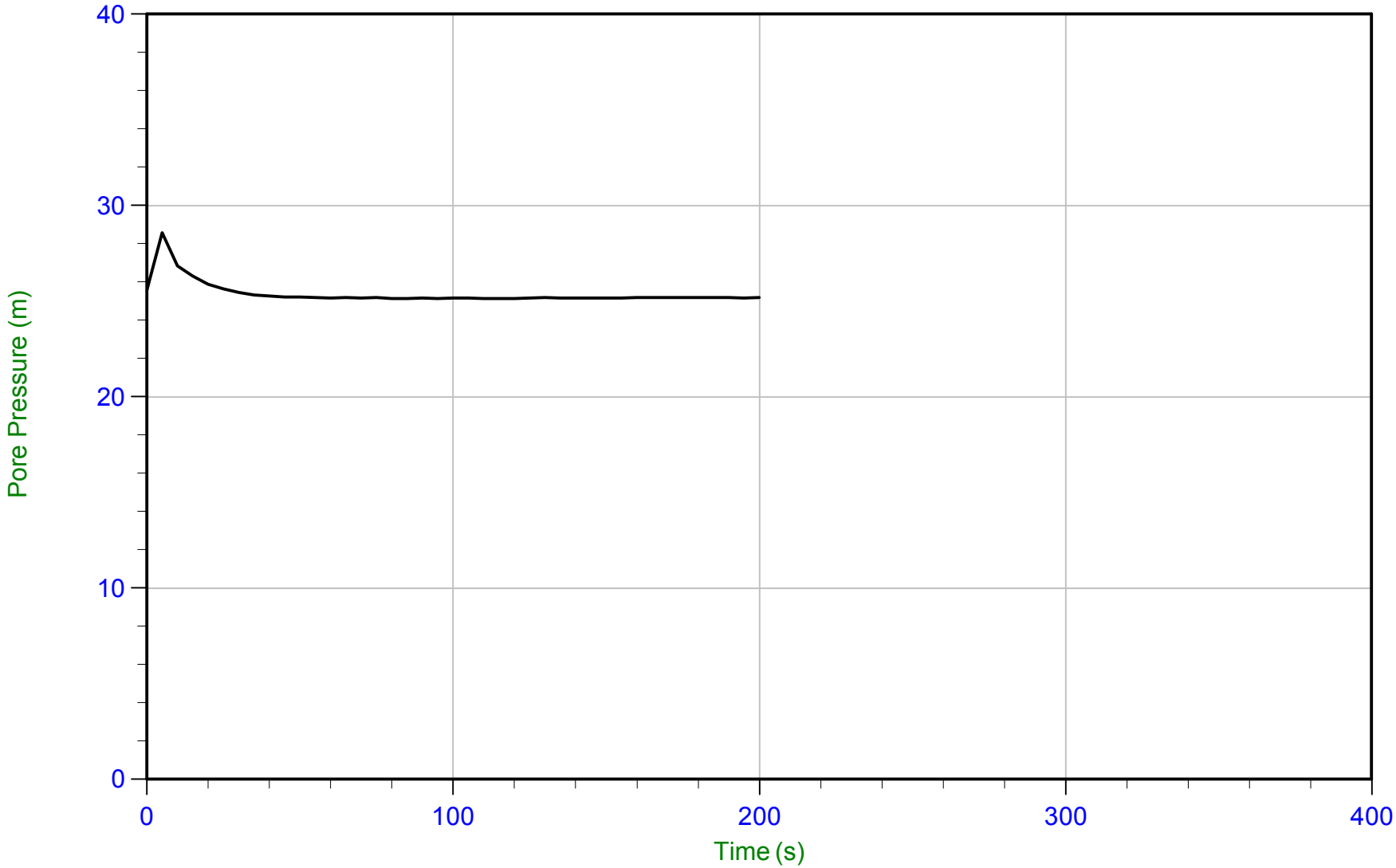
WT: -4.688 m / -15.380 ft
Ueq: 14.8 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/07/2017 11:27
Site: Milne Port Expansion

Sounding: CPT17-D007
Cone: 374:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD007.PPF
Depth: 20.150 m / 66.108 ft
Duration: 200.0 s

U Min: 25.1 m
U Max: 28.6 m

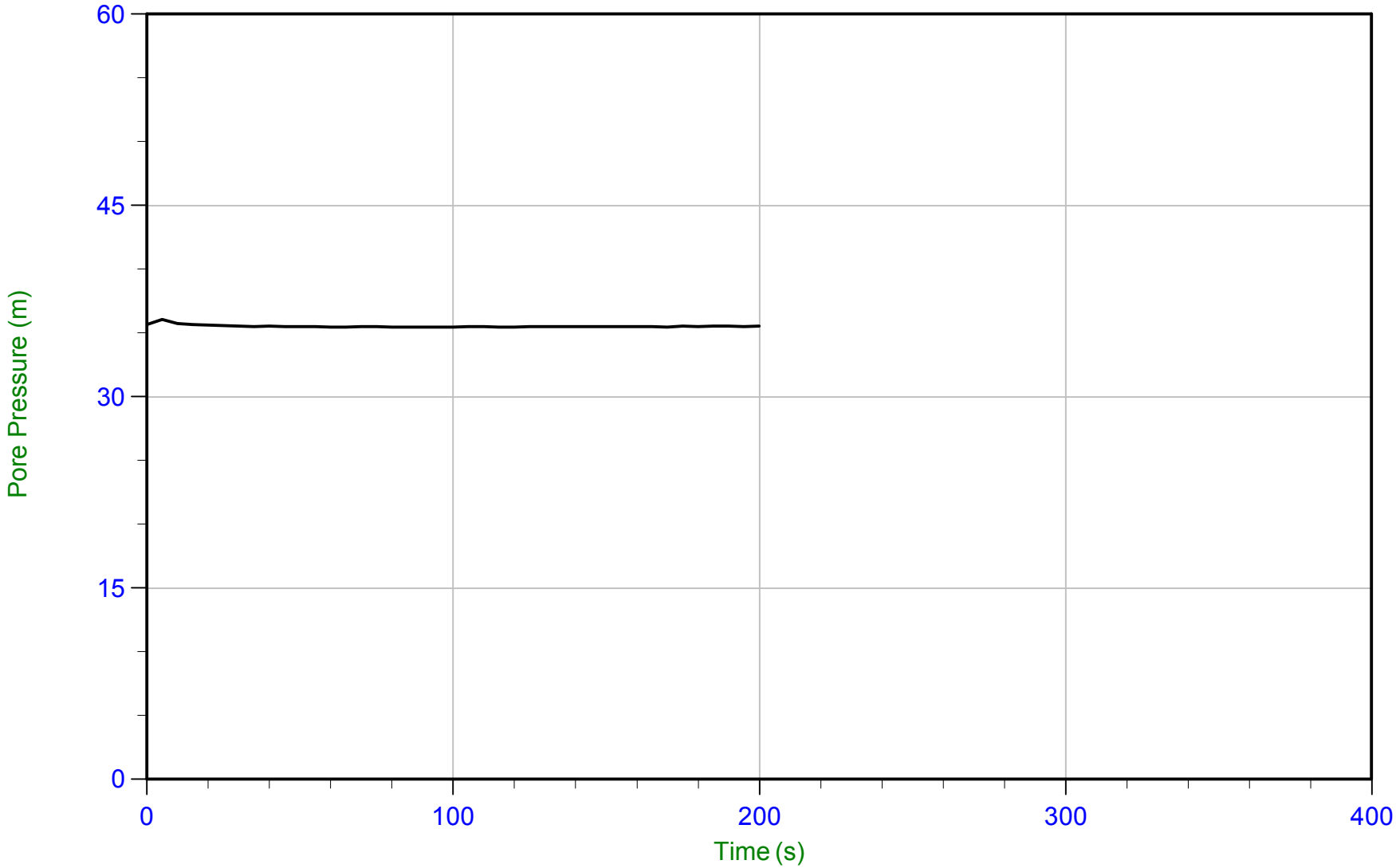
WT: -4.981 m / -16.342 ft
Ueq: 25.1 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/07/2017 11:27
Site: Milne Port Expansion

Sounding: CPT17-D007
Cone: 374:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD007.PPF
Depth: 30.200 m / 99.080 ft
Duration: 200.0 s

U Min: 35.5 m
U Max: 36.0 m

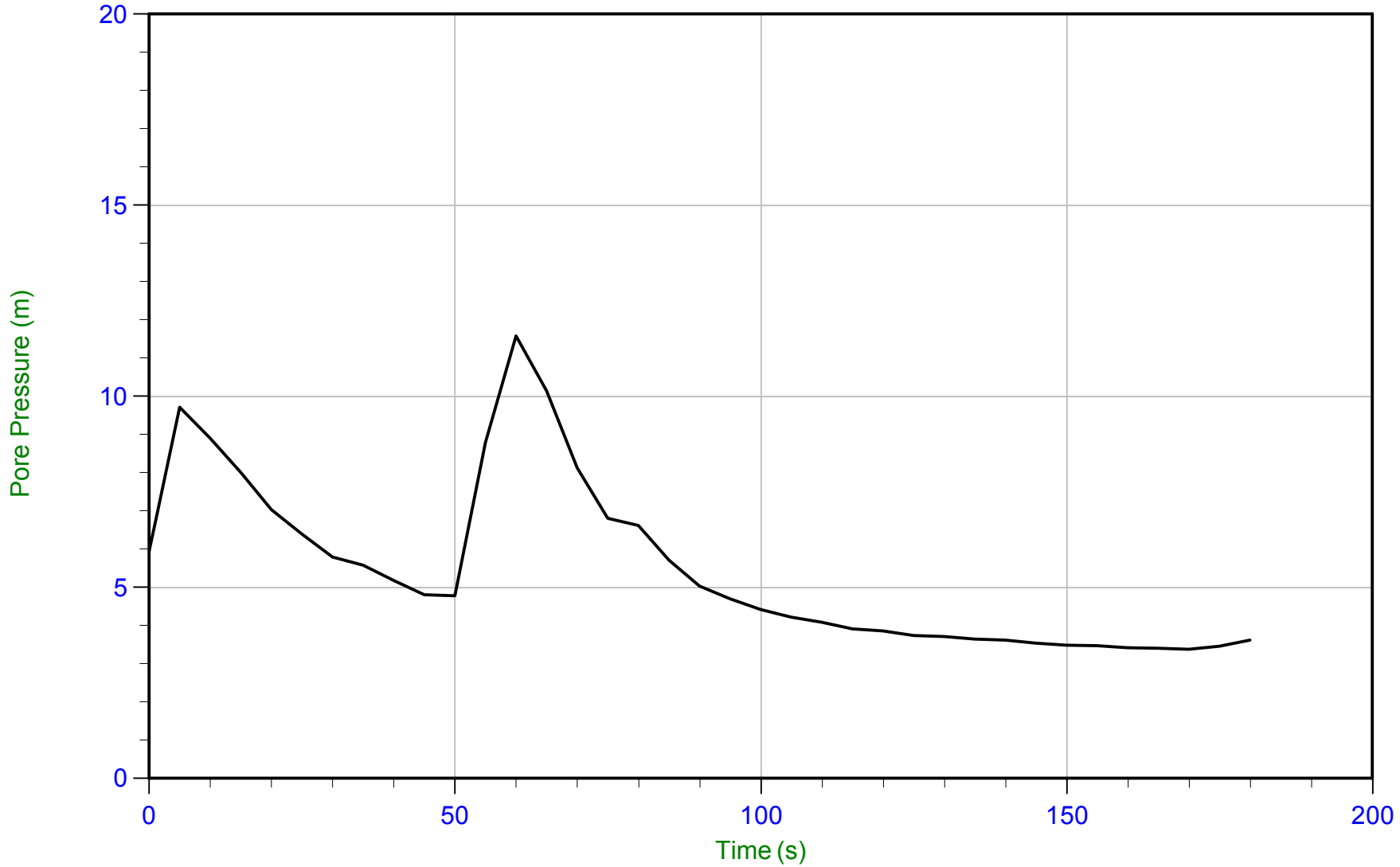
WT: -5.315 m / -17.437 ft
Ueq: 35.5 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/07/2017 16:47
Site: Milne Port Expansion

Sounding: CPT17-D008
Cone: 374:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD008.PPF
Depth: 2.075 m / 6.808 ft
Duration: 180.0 s

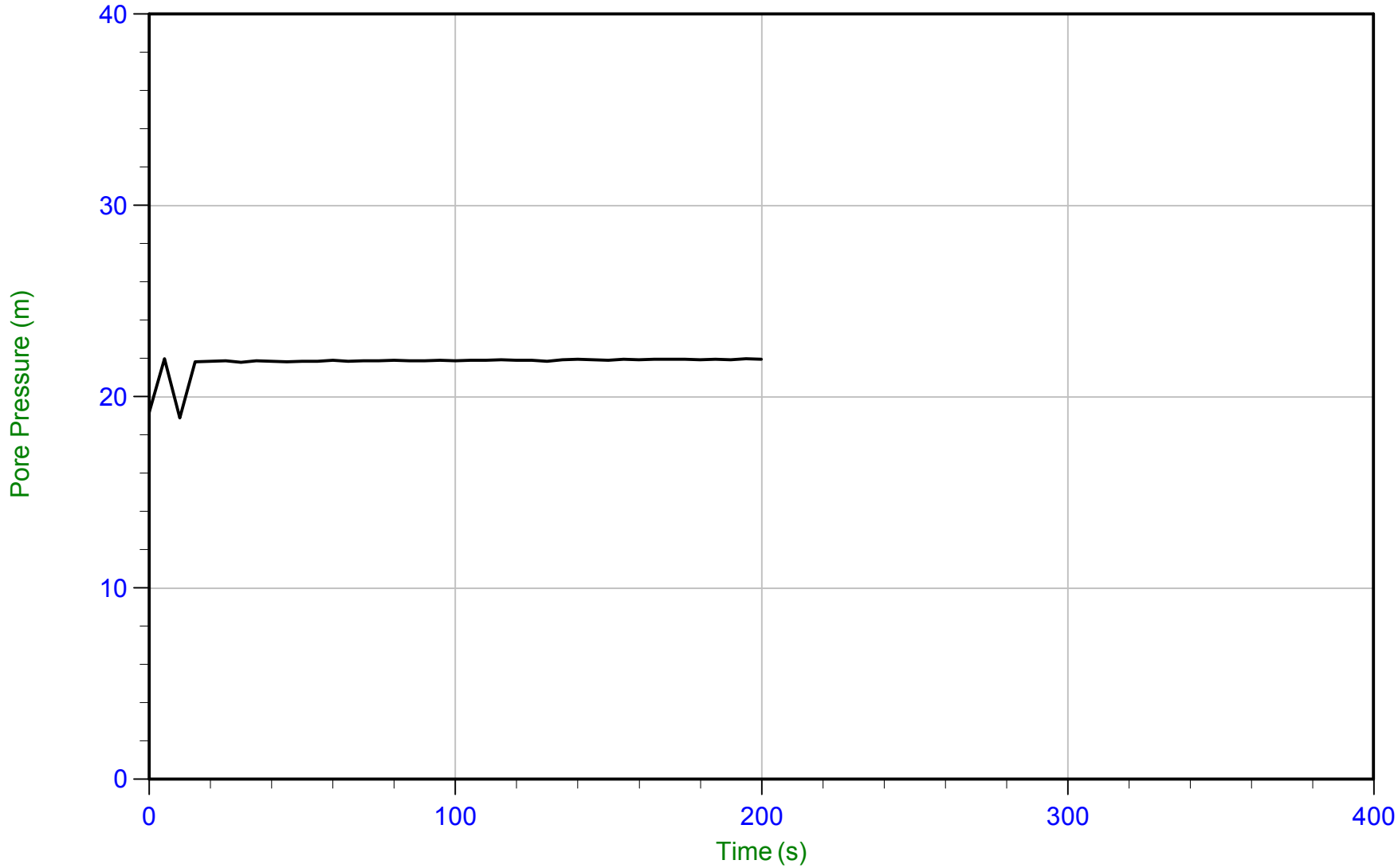
U Min: 3.4 m
U Max: 11.6 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/07/2017 16:47
Site: Milne Port Expansion

Sounding: CPT17-D008
Cone: 374:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD008.PPF
Depth: 20.500 m / 67.256 ft
Duration: 200.0 s

U Min: 18.9 m
U Max: 22.0 m

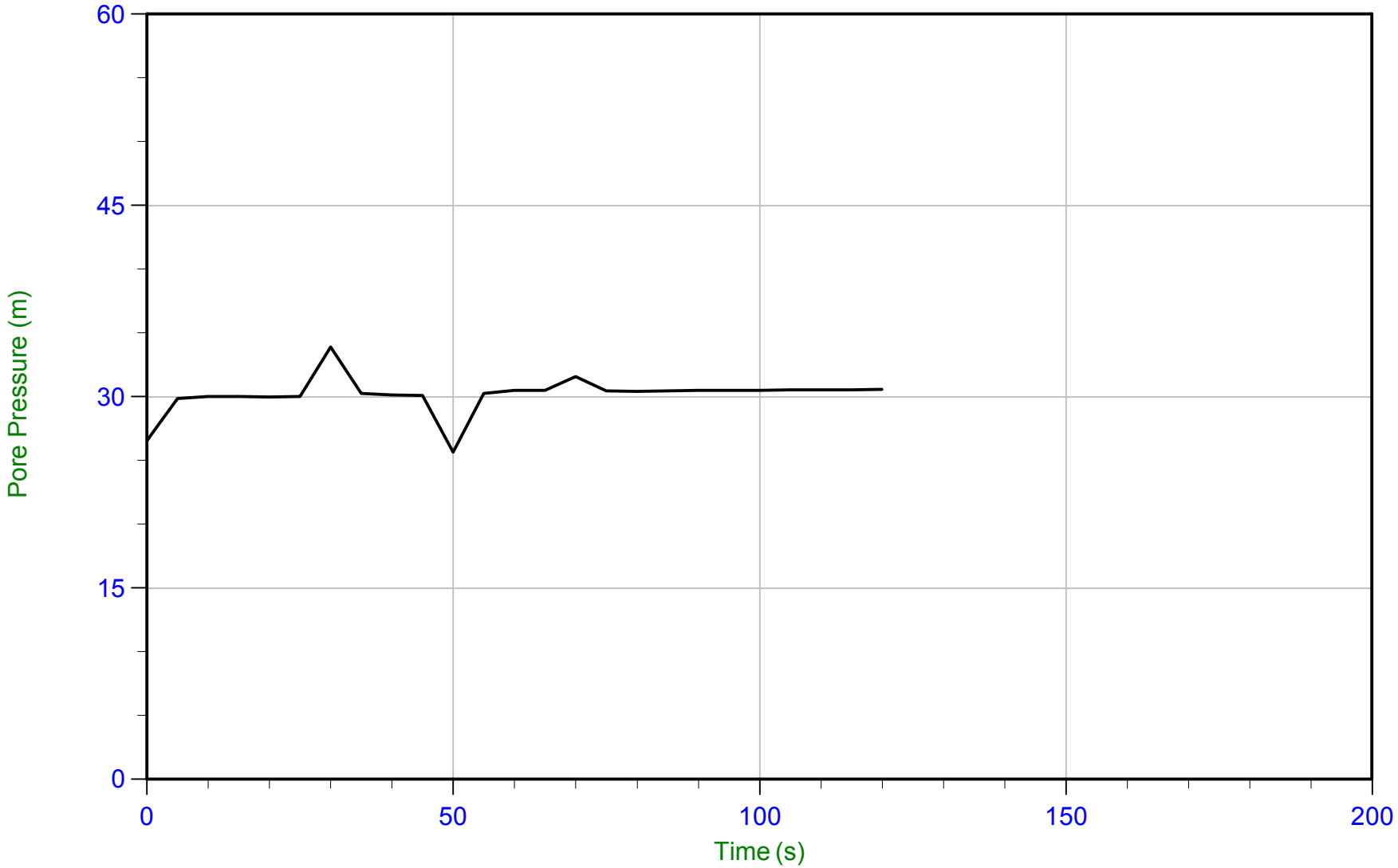
WT: -1.399 m / -4.590 ft
Ueq: 21.9 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/07/2017 16:47
Site: Milne Port Expansion

Sounding: CPT17-D008
Cone: 374:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD008.PPF
Depth: 28.975 m / 95.061 ft
Duration: 120.0 s

U Min: 25.6 m
U Max: 33.9 m

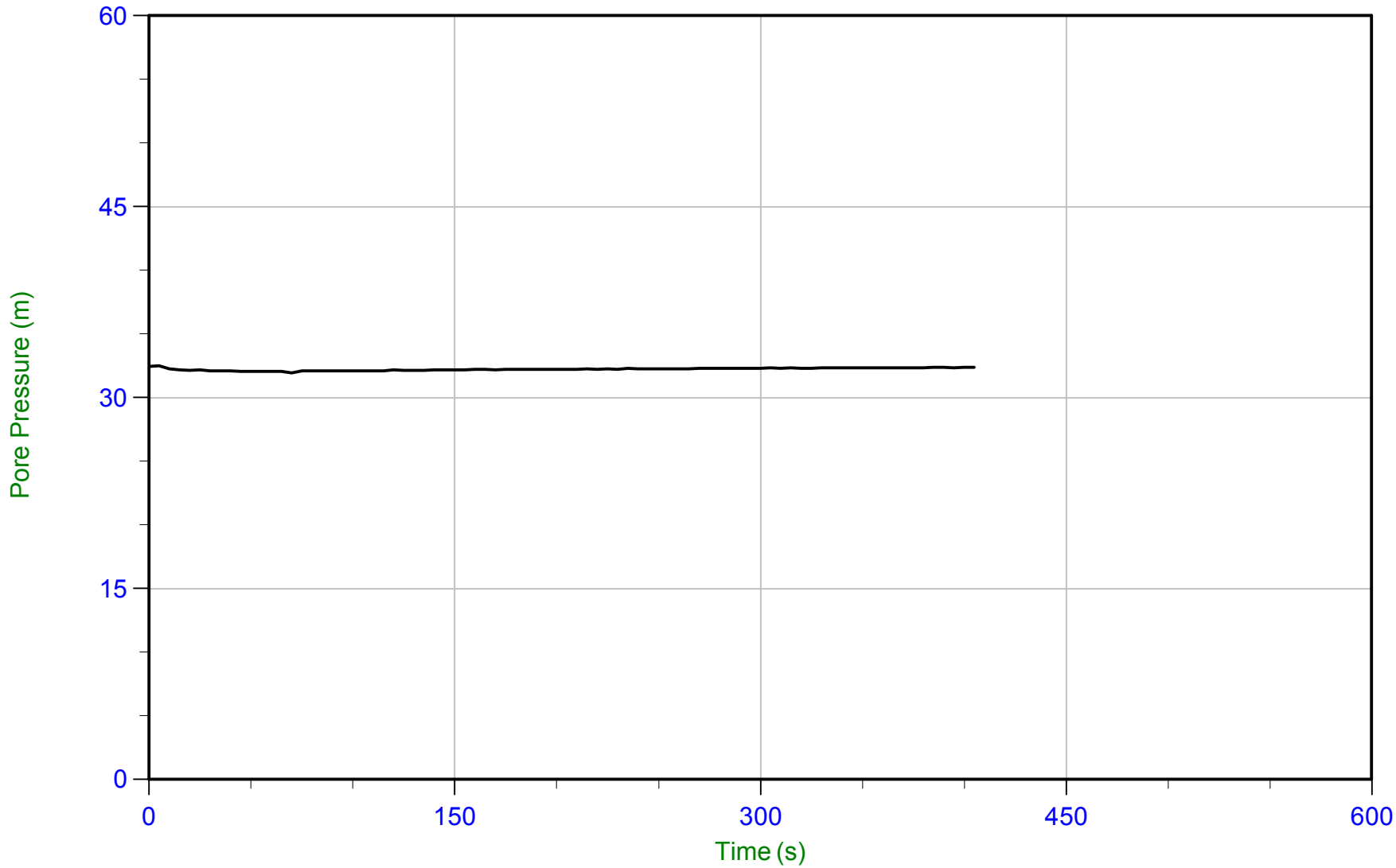
WT: -1.449 m / -4.754 ft
Ueq: 30.4 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/07/2017 16:47
Site: Milne Port Expansion

Sounding: CPT17-D008
Cone: 374:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD008.PPF
Depth: 30.000 m / 98.424 ft
Duration: 405.0 s

U Min: 32.0 m
U Max: 32.5 m

WT: -2.242 m / -7.356 ft
Ueq: 32.2 m

Appendix G

Laboratory Certificate

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Canadian Council of Independent Laboratories

CERTIFICATE OF CONFORMANCE

AGGREGATE LABORATORY CERTIFICATION

This is to certify that

Hatch

Located at:

Niagara Falls ON

Has met the Standardization and Interlaboratory Testing Requirements of the CCIL/OSSGA AGGREGATE LABORATORY CERTIFICATION PROGRAM and has qualified under the following categories and test methods:

AGGREGATE QUALITY CONTROL LABORATORY (TYPE C)

LS-600/C-702; LS-601/C-117; LS-602/C-136; LS-607; LS-608; LS-621

AGGREGATE PHYSICAL PROPERTY LABORATORY (TYPE D)

LS-623/D698; LS-702/D422; LS-703,704/D4318; LS-705/D854; LS-709/D2434

GIB MCINTEE, P. ENG.
CHAIRMAN, CERTIFICATION PROGRAM ADMINISTRATION COMMITTEE

May 1, 2016 - April 30, 2017

Date

GORDON H. LEAMAN, P. ENG.
PRESIDENT

Appendix H

Ice Thickness Assessment

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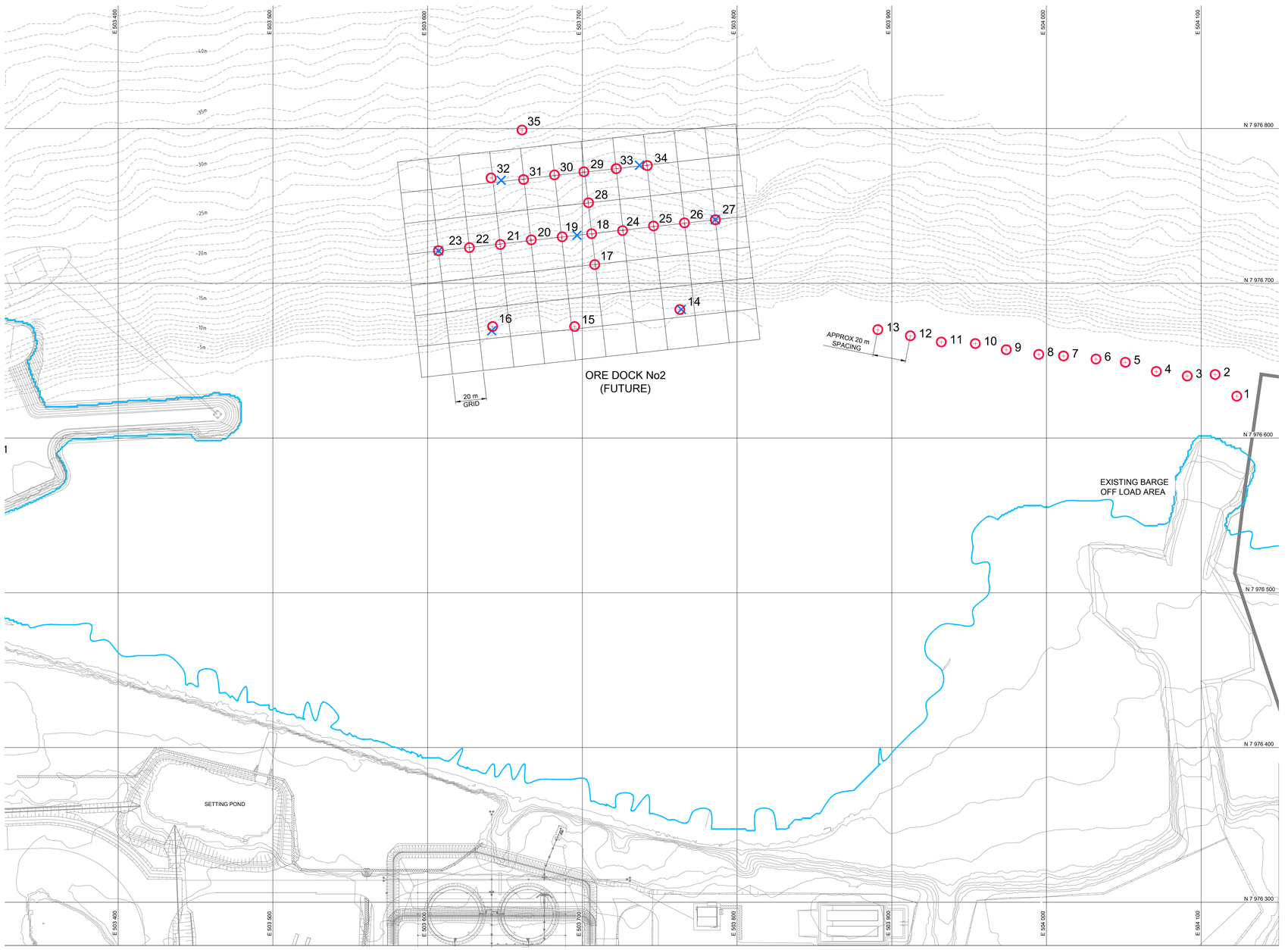
DWG. No. H352034-GEOSKT-229-292-0007

NOTES:

1. *COORDINATE GRID IS UTM, NAD 83, ZONE 17*
2. *INFORMATION FOR BATHAMETRY IS A COMBINATION OF LOGISTEC STEVEDORING INC. AND M&S.*
3. *THE CHART DATUM HAS BEEN ASSUMED TO BE 1.2 METRES BELOW CGVD 28 (0.0m CHART DATUM = -1.2m GEODETIC DATUM)*
4. *ELEVATIONS ARE BASED ON CHART DATUM*
5. *DIMENSIONS AND ELEVATIONS ARE SHOWN IN METERS*

LEGEND

- GEOTECHNICAL INVESTIGATION LOCATION
- AUGER HOLE LOCATION FOR OFFSHORE ICE ASSESSMENT (20 METERS SPACING, MAXIMUM)



PLAN

0 30 60 90 120 150 METRES

SCALE 1:1500

DESIGN SHOWN IS A HATCH CONCEPT DESIGN
CONTRACTOR TO PROVIDE HIS OWN DESIGN

DRAWING No.	DRAWING TITLE
REFERENCE DRAWINGS	

NAME
SIGNATURE
ENG REG NUMBER
REVISION DATE
ORIGINAL DATE
REGISTERED PROFESSIONAL

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No.	DESCRIPTION	BY	CHK'D	DATE
-	-	-	-	-

REVISIONS

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	D PARKES	NR	16/03/2017
DESIGNER		NR	
CHECKER			
DESIGN COORD.	W HOYLE		
RESP. ENG.			
LEAD DISC. ENG.	S HINCHBERGER		
ENG. MANAGER			
PROJ. MANAGER	S HEINER		

DRAWING APPROVAL STATUS: CLIENT REVIEW

Baffinland

BAFFINLAND EXPANSION 12 MTPA MINE OPTION PRE FEASIBILITY STUDY

PORT SITE - ORE DOCK No. 2 OFF SHORE ICE ASSESSMENT AUGER HOLE LOCATIONS

SCALE	DWG. No.	REV
1:50,000 OR AS NOTED	H352034-GEOSKT-229-292-0007	B

$USERNAMES $DATES $FILES $TIMES

Appendix I

Fence Diagrams

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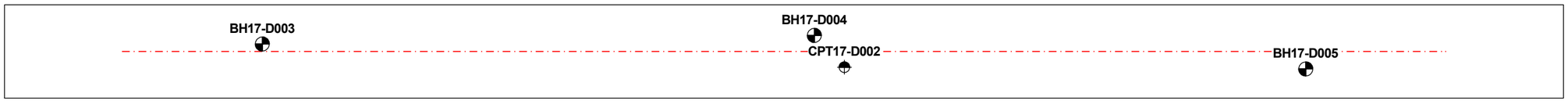
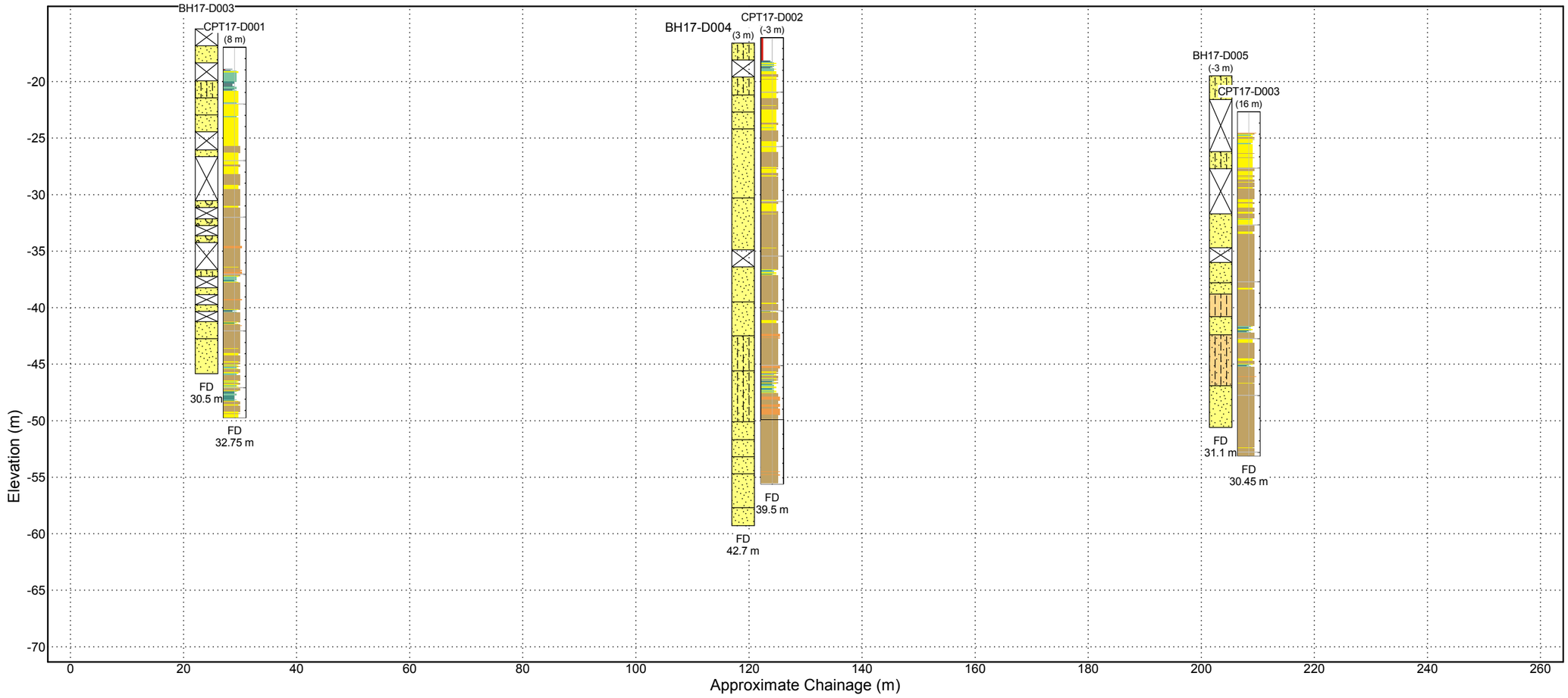
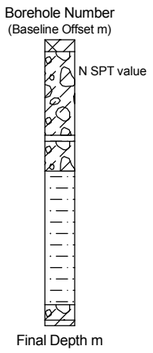




MAP KEY

- BH03 — INVESTIGATION ON SECTION
- TP03 — INVESTIGATION OFF SECTION
- SECTION LINES

POST LEGEND



STRATAGRAPHIC BOUNDARIES

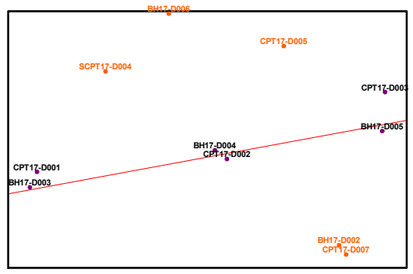
MATERIAL GRAPHICS

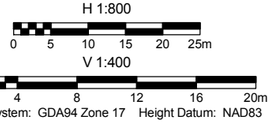
- Core Loss
- Sandy SILT
- Poorly-graded SAND
- Silty SAND
- Poorly-graded Gravelly SAND
- SILT

SBT GRAPHICS

- SAND
- Silty SAND
- Gravelly SAND
- Sandy SILT
- SILT

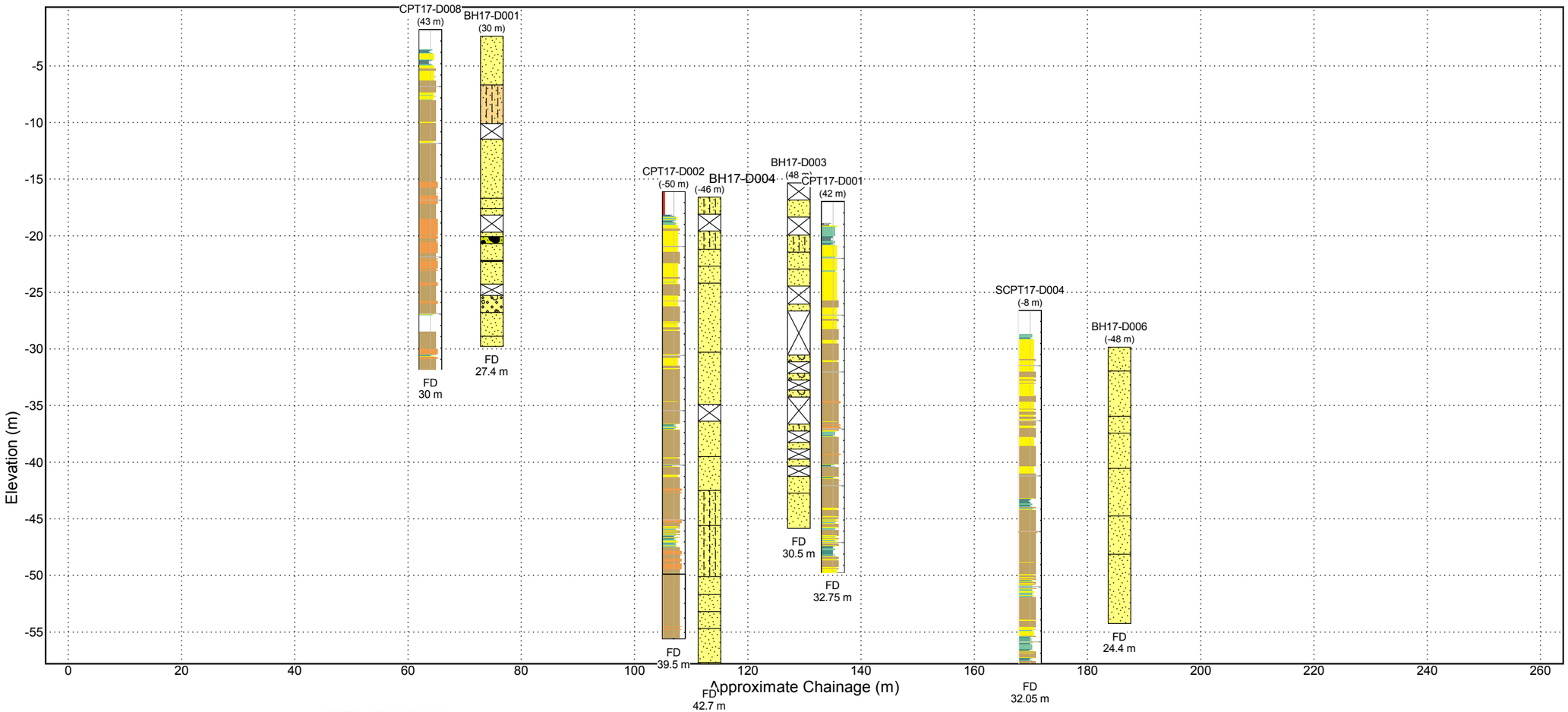
SITE MAP





HATCH

CLIENT Baffinland Iron Mines		PROJECT Marry River Expansion Study Stage 2	
DRAWN JCH	DATE 4/28/2017	TITLE Ore Dock No. 2 Area West-East Section	
CHECKED WH	DATE 5/18/2017		
SCALE H 1:800 V 1:400 VE=2X		PROJECT No H352034	FIGURE No I.1



MAP KEY

- BH03 — INVESTIGATION ON SECTION
- TP03 — INVESTIGATION OFF SECTION
- SECTION LINES

POST LEGEND

Borehole Number
(Baseline Offset m)

N SPT value

Final Depth m

STRATAGRAPHIC BOUNDARIES

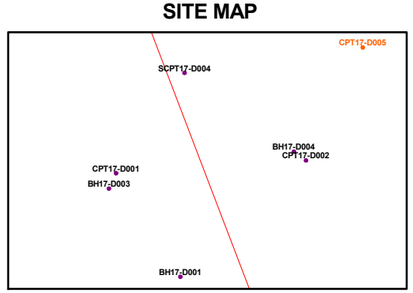
MATERIAL GRAPHICS

- Poorly-graded SAND
- Silty SAND
- Sandy SILT
- Poorly-graded Gravelly SAND
- Core Loss
- Well-graded Sandy GRAVEL
- Well-graded Gravelly SAND

SBT GRAPHICS

- SAND
- Silty SAND
- Gravelly SAND
- Sandy SILT
- SILT

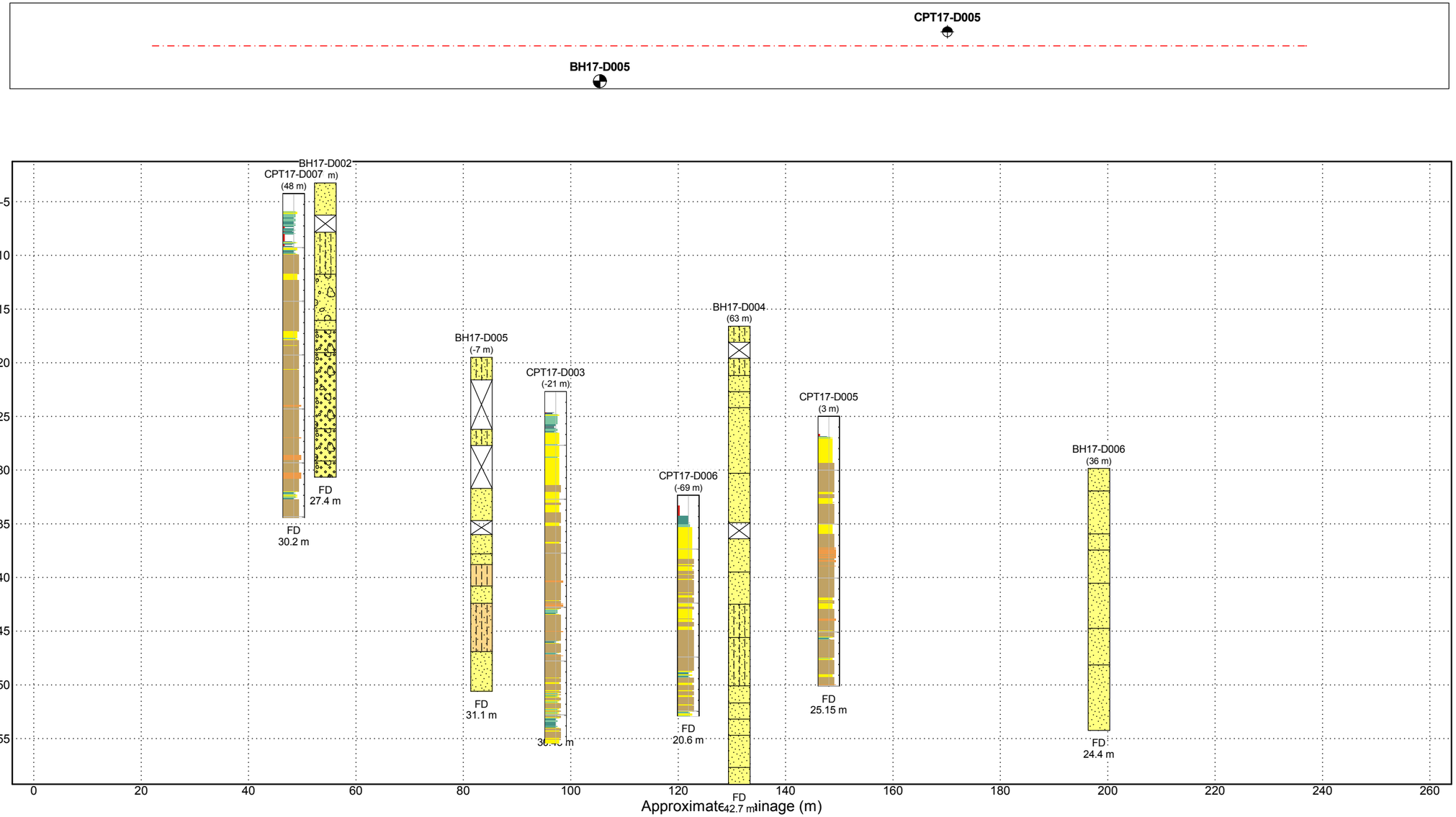
SITE MAP



H 1:800
0 5 10 15 20 25m
V 1:400
0 4 8 12 16 20m
Coord.System: GDA94 Zone 17 Height Datum: NAD83

HATCH

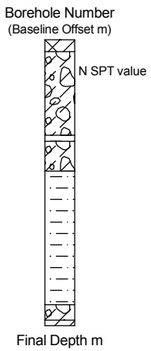
CLIENT Baffinland Iron Mines		PROJECT Marry River Expansion Study Stage 2	
DRAWN JCH	DATE 4/28/2017	TITLE Ore Dock No. 2 Area South-North Section (West Side)	
CHECKED WH	DATE 5/18/2017		
SCALE H 1:800 V 1:400 VE=2X		PROJECT No H352034	FIGURE No I.2



MAP KEY

- BH03 — INVESTIGATION ON SECTION
- TP03 — INVESTIGATION OFF SECTION
- SECTION LINES

POST LEGEND



STRATAGRAPHIC BOUNDARIES

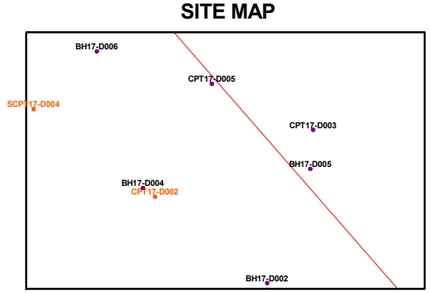
MATERIAL GRAPHICS

- Poorly-graded SAND
- Core Loss
- Silty SAND
- Poorly-graded Gravelly SAND
- Well-graded Gravelly SAND
- SILT
- Sandy SILT

SBT GRAPHICS

- SAND
- Silty SAND
- Gravelly SAND
- Sandy SILT
- SILT

SITE MAP



H 1:800
0 5 10 15 20 25m
V 1:400
0 4 8 12 16 20m
Coord.System: GDA94 Zone 17 Height Datum: NAD83

HATCH

CLIENT Baffinland Iron Mines		PROJECT Marry River Expansion Study Stage 2	
DRAWN JCH	DATE 4/28/2017	TITLE Ore Dock No. 2 Area South-North Section (East Side)	
CHECKED WH	DATE 5/18/2017		
SCALE H 1:800 V 1:400 VE=2X		PROJECT No H352034	FIGURE No I.3

Appendix J

Influence of Drilling Method on Standard Penetration Testing

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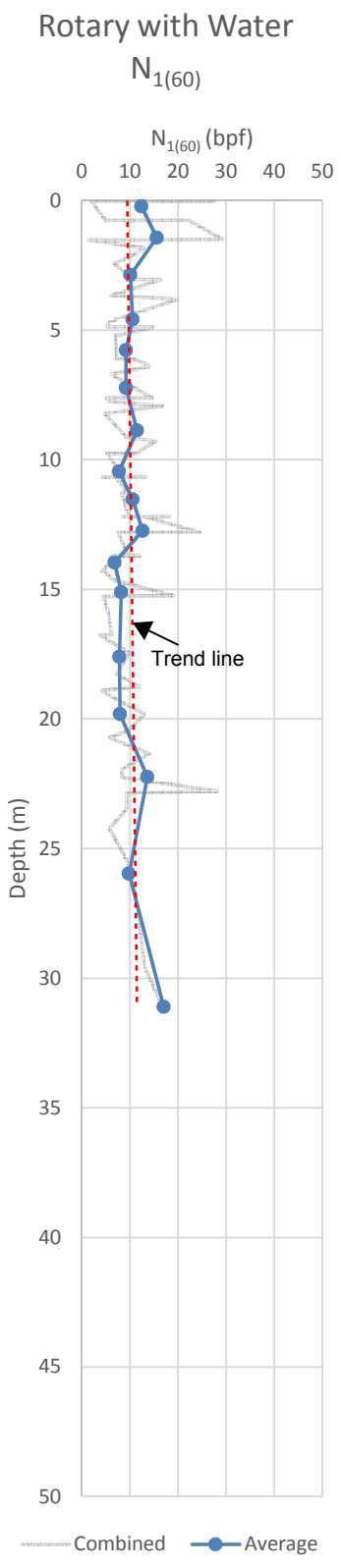
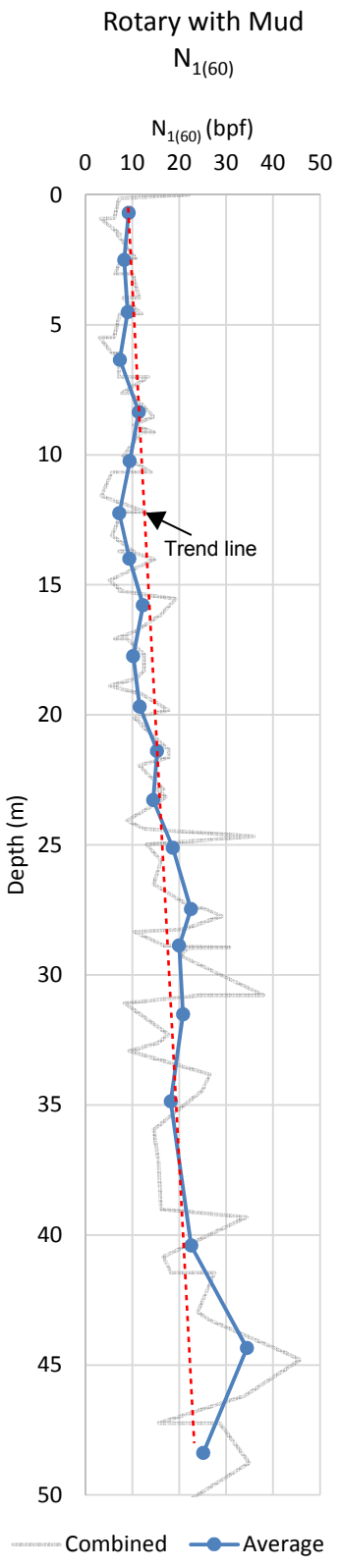
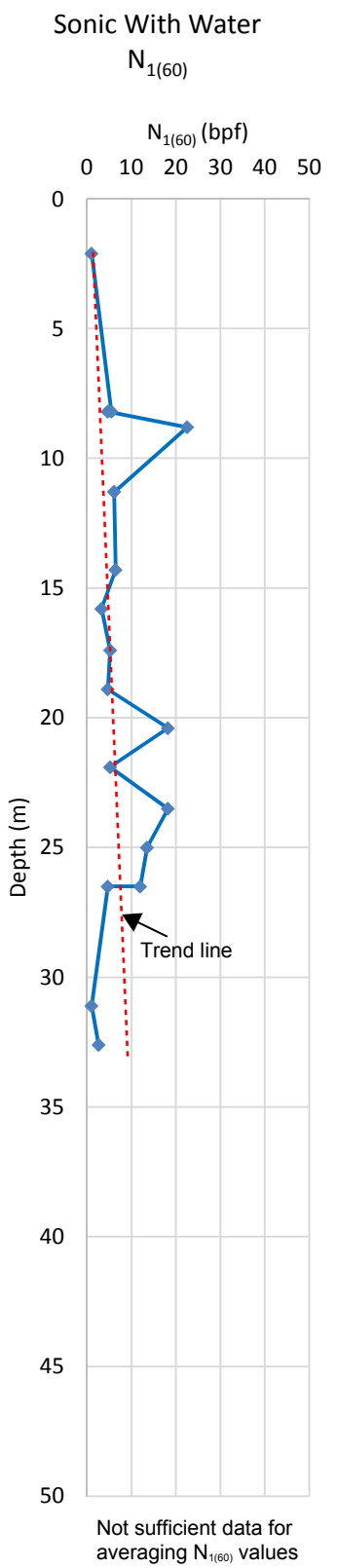
Influence of Drilling Methods on SPT $N_{1(60)}$ values



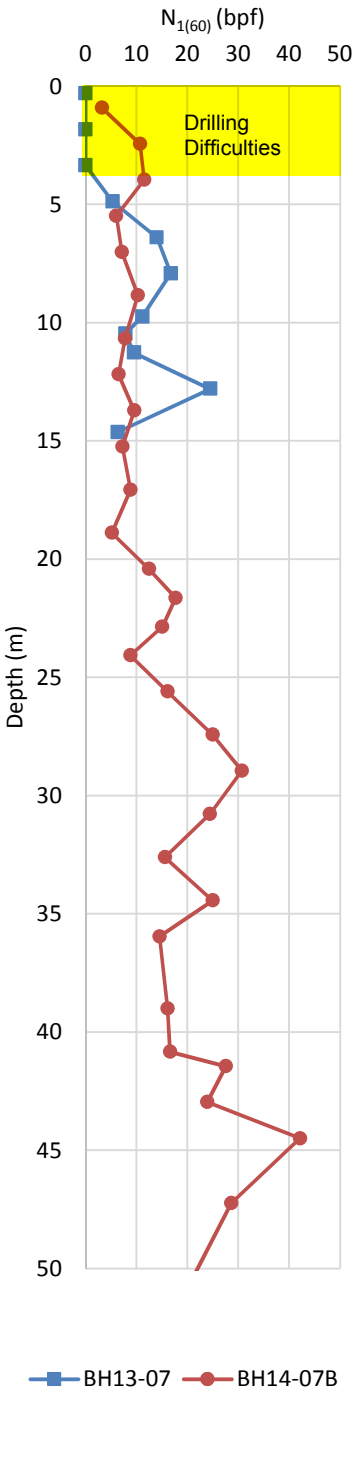




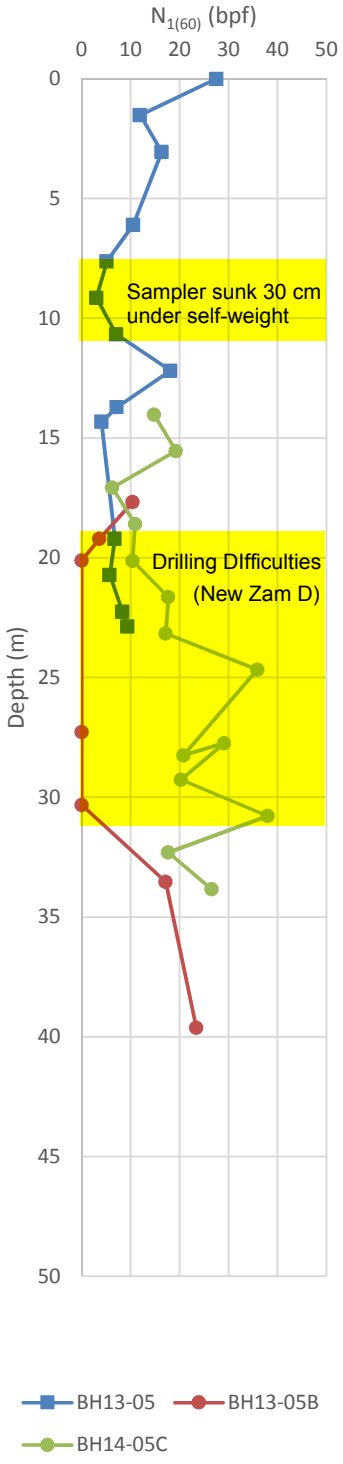
Notes:
Diamond Rotary with water includes data from BH13-03, BH13-05, BH13-07, BH13-08, BH13-09 and BH13-011
Diamond Rotary with Mud includes data from BH14-05C, BH14-06, BH14-07B, BH14-12 and BH14-13
Sonic with Water includes data from BH17-D001, BH17-D002, BH17-D003, BH17-D004, BH17-D005 and BH17-D006.

HATCH

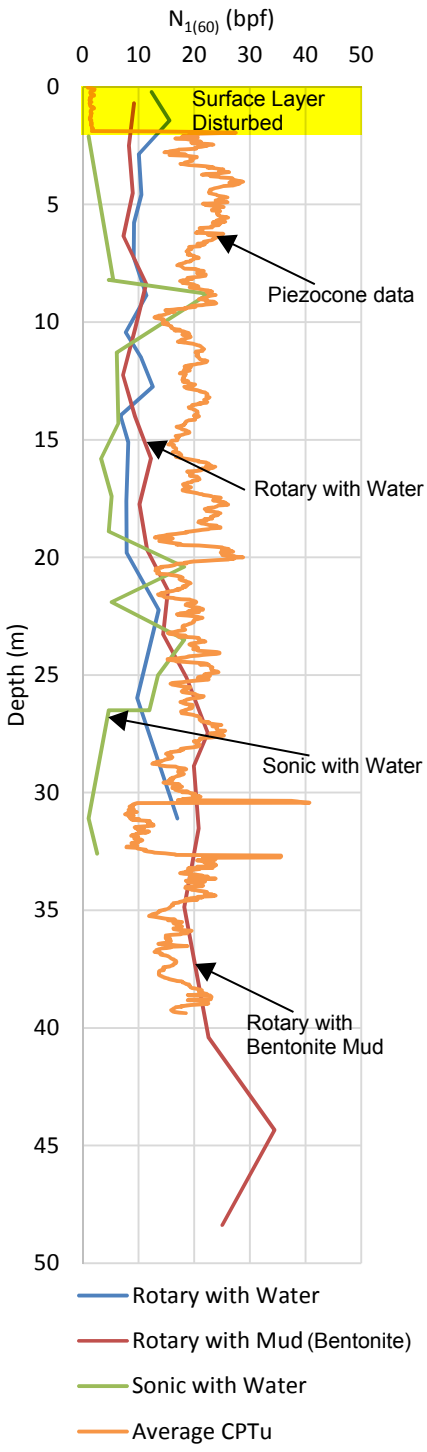
BH13-07
Water vs. Mud
$N_{1(60)}$ Comparison



BH13-05
Water vs. Mud
$N_{1(60)}$ Comparison



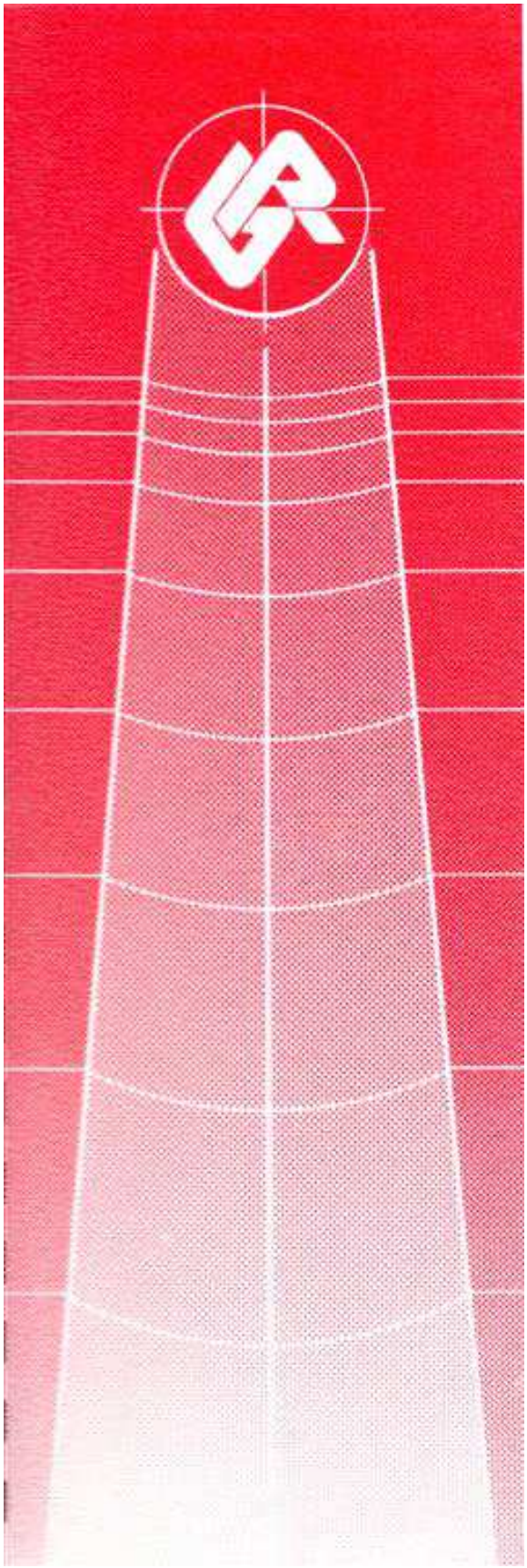
$N_{1(60)}$ Comparison
Drilling Methods



Notes:
BH13-05B was drilled with New Zam D Mud Only
BH14-05C and BH14-07B were drilled with New Zam D Mud and Bentonite
CPTu was averaged using data from CPT-D001, CPT-D002 and CPT-D003

ATTACHMENT 12.4

ORE DOCK GEOPHYSICS REPORT



GEOPHYSICAL SEISMIC SURVEY FOR A PROPOSED FIXED DOCK, MARY RIVER PROJECT, MILNE INLET, NUNAVUT

Presented to:
Baffinland Iron Mines Corporation
2275 Upper Middle Road East, Suite 300,
Oakville, Ontario
L6H 0C3

Presented by:
Geophysics GPR International Inc.
6741 Columbus Road. Unit 14
Mississauga, Ontario
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February 2014 T13615

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1. Introduction

Geophysics GPR International Inc. was requested by Baffinland Iron Mines Corporation to carry out a geophysical survey to aid in projection and planning of a proposed fixed dock for the Mary River Project, Milne Inlet, Nunavut. The aim of the investigation was to map the depth to bedrock and provide details of the overburden material.

Seismic profiles were collected approximately parallel with the shoreline as well as lines going from land perpendicularly out to sea (Figure 1). The start and end of line coordinates are outlined in Table 1.

Table 1: Profile Line UTM Coordinates and Chainage

Profile	UTM Start		UTM End		Chainage Start	Chainage End
A-A'	503251E	7976390N	503238E	7976742N	0+000	0+352.5
B-B'	503325E	7976422N	503312E	7976774N	0+000	0+352.5
C-C'	503091E	7976600N	503415E	7976740N	0+000	0+352.5
D-D'	503105E	7976568N	503430E	7976707N	0+000	0+352.5
E-E'	503114E	7976547N	503439E	7976686N	0+000	0+352.5

Geophysics GPR field personnel involved in this project and the dates that they were on-site are outlined in Table 2.

Employee	Title	Dates On-Site
Cameron Coatsworth	Field Supervisor	Nov. 26 to Dec. 5, 2013
Benoit Maille	Senior Tech	Nov. 26 to Dec. 5, 2013
Nicolas Beaulieu	Geophysicist	Nov. 26 to Dec. 5, 2013

Table 2: Geophysics GPR Field Personnel

The seismic reflection, refraction, TISAR and shear-wave velocity analysis methods were applied to collect the data along the alignments shown in Figure 1. Approximately 1.76 km of profiled data were collected.

The following report describes the survey design, the principles of the seismic methods, the methodology for interpreting the data and finally a culmination of the results in the form of interpreted bedrock profiles.

Figure 1: Approximate seismic profile orientations, Milne Inlet, Nunavut

2. Methodology

2.1. Positioning, Topography and Units of Measurement

The locations of the seismic profiles were oriented to encompass the area and to align with the design of the proposed fixed dock location.

The positioning data (northing and easting) were collected by Monteith & Sutherland Limited at the start and end of each line as well as every 15 m along the lines.

The GPS coordinates and field observations were then converted to project chainage based on site plans provided by Baffinland and Hatch.

The geophones were installed on the ice surface. The elevation of the geophones varied with the tides. Ice elevation data provided by Monteith & Sutherland Limited from December 2nd and 3rd indicate a range of approximate 0.9 m to -1.1 m over the course of the survey day. An average elevation of the geophones on the ice has been assumed to be 0 m.

The topography for the land portions of the Line A and B has been estimated using field observations and borehole elevation data.

All geophysical measurements were collected in SI units.

2.2. Seismic Methods

Seismic methods for geologic mapping involve measuring/recording the response of vibration sensors. Multiple techniques and methodologies are available for analysis of the data depending on the ultimate goal of the investigation. The profiles were collected using a standard stationary geophone arrangement. Several different seismic sources were applied including; propelled elastic generator (PEG) hammer, buffalo gun and explosives. After initial testing, it was determined that the buffalo gun and explosives were the most suitable sources for this particular site.

Several essentially independent techniques were used to analysis the resulting data; namely, seismic reflection, seismic refraction, TISAR and surface wave analysis.

Each of the seismic techniques has strengths and weaknesses primarily related to the depth of interest and local geology. After initial testing, it was determined that the seismic reflection method was likely going to be the primary methodology supplemented with seismic refraction and TISAR and surface wave analysis.

2.2.1. Seismic Reflection

Basic Theory

The seismic reflection method relies on measuring the transit time of an acoustic energy wave that travels from the energy source location to a reflective event (i.e. change in acoustic impedance) and back to a receiver (geophone). The fastest seismic waves are the compressional (P) or acoustic waves. Figure 2 is a basic geometric layout for reflection ray paths.

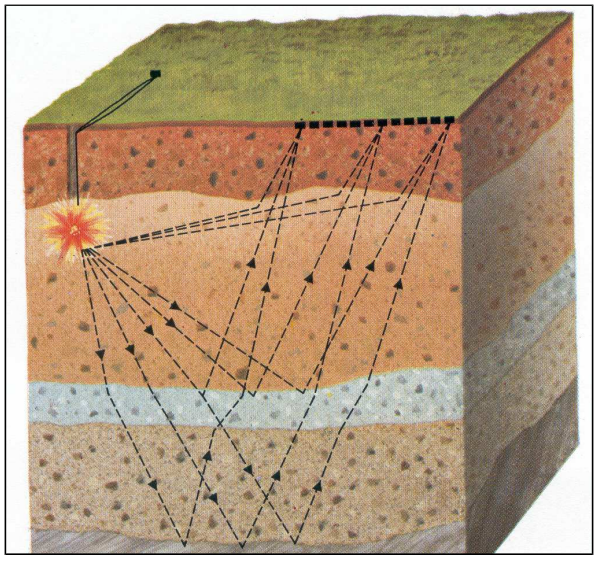


Figure 2: Simple Geometry of reflected pulse ray paths

Survey Design

A seismic spread consisted of 48 vibration monitoring devices (geophones) connected in line (spread) to a seismograph (ABEM Terraloc Pro) by connector cables. A seismic pulse (shot) is generated at a known location relative to the spread with a trigger system linked with the seismograph to begin the recording of the time-arrivals of the various seismic waves (shot record).

This investigation used 48 – 4.5 Hz geophones with a spacing between geophones of 7.5 m for a total individual profile length of 352.5 m.

The spacing between shots was 15 m with the shot inline with the seismic spread. Typically single shots were taken for each shot record, stacking was not needed to improve the signal to noise ratio.

The combination of geophone spacing and shot interval used for this investigation results in a varied-fold data set. Where fold refers to the multiplicity of the common-midpoint data. The highest fold was in the middle of the spread and decreased toward the ends.

The fold may be less for some shot gathers depending on geometry and individual geophone trace quality.

The seismic sources selected for this survey were devices called a “buffalo gun” and a “propelled elastic generator” (PEG). The “buffalo gun” was designed to fire a 12-gauge shotgun shell into a 5 cm diameter hole drilled through the ice. The PEG is a weight drop accelerated by elastic bands. The PEG was determined to be inadequate. It could not generate enough energy to transmit to the depths required of the geology. The “buffalo gun” source was determined to be the best option due to the prohibited use of explosives for the marine portion of this site.

Processing of Reflection Data

There are some common processing steps for every reflection data-set. These are purely mathematical or systematic steps that account for site conditions. There are also processing steps that serve to enhance the appearance of reflectors. Some of the more common steps include the removal of traces that are unusually noisy (trace kills) or correction of topography (statics corrections). In the processing sequence used for this project, there is flexibility in the order and the settings used in some optional processing steps.

It is important to note that there is no one correct processing sequence, as the processing steps and sequence are dependent on the geology and method of data collection. The following is a list of the processing steps and the order in which they were applied for this project.

1) Input seg2 data
2) time cut to 600 ms
3) trace editing (remove noisy traces)
4) Interpolation of removed traces
5) Gain correction
6) Filtering (bandpass and frequency-wave number)
7) Velocity Analysis
8) Normal move-out corrections
9) Common mid-point (CMP) Stacking
10) Time to depth conversion
11) Visual gain adjustments, horizontal filtering and contouring

Interpretation Method and Accuracy of Results

The reflection profile is essentially an image which must be interpreted. Without corroborating data, the true source or nature of a reflector can only be assumed. Interpretation of the data involves identifying reflectors and assigning a geologic context to them.

The two main sources of uncertainty in the results of a seismic reflection survey are in the velocity analysis and the assigning of reflectors to given geologic units.

2.2.2. Seismic Refraction

Basic Theory

The seismic refraction method relies on measuring the transit time of the wave that takes the shortest time to travel from the shot-point to each geophone. The fastest seismic waves are the compressional (P) or acoustic waves, where displaced particles oscillate in the direction of wave propagation. The energy that follows this first arrival, such as reflected waves, transverse (S) waves and resonance, is not considered under routine seismic refraction interpretation. Figure 3 illustrates the basic operating principle for refraction surveys.

Survey Design

The seismic spread setup utilized for seismic reflection was also used for seismic refraction. The seismic source was mainly buffalo gun. Explosives were used for the end and far shots on the land portion of the Line A and Line B.

This investigation used 48 – 4.5 Hz geophones with a spacing between geophones of 7.5 m for a total individual profile length of 352.5 m.

Typically, seven or more shots are executed per seismic spread; three to five shots within the profile to obtain the lateral velocity variation in the overburden and two shots on either side of the spread to provide the true velocity of the bedrock surface. The spacing between shots was generally every 45 m with the shot inline with the seismic spread. Typically single shots were taken for each shot record, stacking was not needed to improve the signal to noise ratio.

Interpretation Method and Accuracy of Results

Interpretation of the seismic data was primarily done using the critical distance method. Ideally, the Hawkins' method is the preferred method as it allows the computation of the rock depth to every geophone, information on the thickness of the various overburden layers, depth to bedrock and rock quality. At this particular site, the depth of the rock was greater than expected, performing a full Hawkins' interpretation would have required the use of explosives in the water which was not permissible. Accordingly the critical distance and partial Hawkins' method were employed.

A full description of the strengths and limitations of the refraction seismic method is presented in Appendix A.

The seismic refraction method typically allows the determination of the bedrock profile with a precision of 10% or better for depths greater than 10 m and a precision of 1 m for depths less than 10 m. The precision in the determination of rock velocities is plus or minus 3%.

The two most significant problem areas for refraction mapping are the “hidden” layer and effect of velocity inversions.

A “hidden” layer or “blind zone” is a stratigraphic layer that is not possible to discern from the arrival time data due to insufficient velocity variation or thickness. The unknown presence of a hidden layer has the effect of making the interpreted bedrock depth too shallow. The presence of a “hidden” layer is typically revealed through borehole or test-pit data and calculations can be made to compensate for the presence of such a layer.

Velocity inversions occur when the velocity does not increase with depth. The velocity inversion can result from the presence of a low or high velocity layer. Refractions from low-velocity layers cannot be determined from the arrival time data. The unknown presence of a low velocity layer has the effect of making the interpreted depths deeper than actual depths.

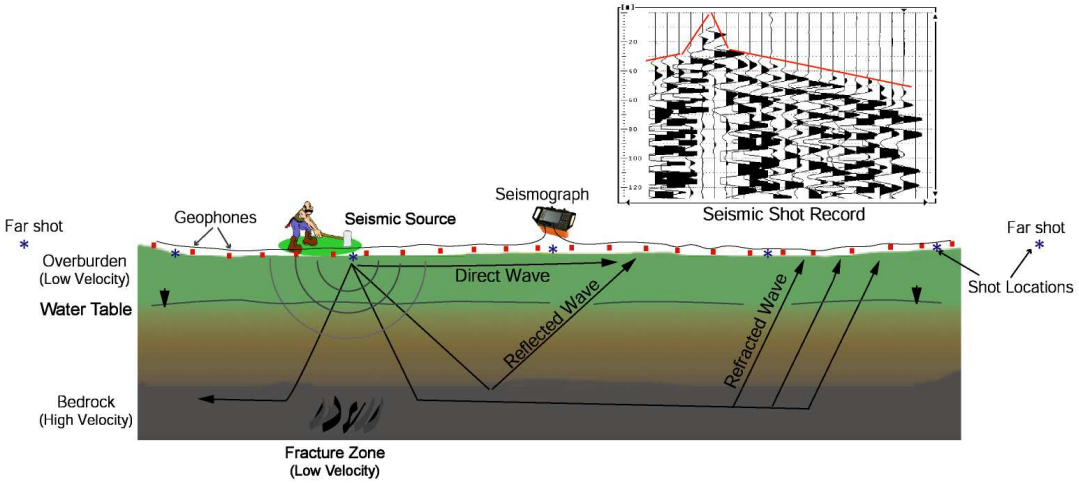


Figure 3: Seismic Refraction Operating Principle

2.2.3. Seismic Resonance (TISAR)

Basic Theory

The seismic resonance, or *TISAR (Testing & Imaging using Seismic Acoustic Resonance),* method is based on the frequency analysis of seismic records. It considers the seismic resonance within the signal. The method was originally developed for geological sub-surface profiling (1 to 15 m deep); however it has been shown to be effective for ranges smaller than 0.1 m for testing of concrete/asphalt structures, as well as for deep (100 m) geological investigations. Figure 4 is a combination figure showing

applications for the method and a small sample of an output that is interpreted for geologic contacts.

The method uses the information from an induced seismic signal in the frequency domain instead of the direct time domain as with classic seismic reflection. For both methods, however, the principal physical parameter involved remains the acoustic impedance contrast, which is the product of the seismic velocity and the volumetric mass of the investigated materials. At the interface between two materials with different acoustic impedance, the seismic signal is partially reflected back to the surface. Under specific conditions, the repetition of such reflections leads to the build-up of a resonance signal, whose frequency is related to the depth of the interface and the seismic velocity of the upper material. The resonance frequency is inversely proportional to the reflection time. The first advantage of the use of frequencies instead of reflection times is the amplitude and the repetitive signal, which is less sensitive to the ambient noise and produces a resolution that increases with shallow depths. The second advantage of using resonance frequencies is the ability to resolve very thin layers (contrary to standard reflection).

Survey Design

The seismic spread setup utilized for seismic reflection and seismic refraction was also used for TISAR. A buffalo gun was used as the primary energy source. The buffalo gun was a good energy source for the resonance survey. The TISAR data was primarily used to supplement the reflection data in the shallow on-land portions.

Interpretation Method and Accuracy of Results

The seismic resonance method requires adequate geological models and seismic velocities. These parameters are typically derived from seismic refraction measurements. The accuracy of the depths of TISAR reflectors is related to the accuracy of the layer velocities and thicknesses of the geological model. It may be possible that velocities vary by approximately 10% or more resulting in a similar variation in depth to a given reflector. Layer thicknesses estimated in the model could vary by a few metres resulting in variations of 20 to 30% in the resonance reflector depth. Resonance has the advantage of a vertical resolution that cannot be obtained from conventional seismic methods.

TISAR resonators can occur from geologic contacts, fractures and/or voids. As with seismic reflection and ground penetrating radar, the true nature/source of the resonators cannot be certain. Interpretation involves identifying trends in the relative amplitude of resonators.

The use of the word “relative” is the operative word. The vibration response of each geophone is normalized to itself and then a gain curve is applied to the entire geophone spread to compensate for the decrease in signal amplitude with depth (this is similar to ground radar). The gain curves are kept similar between profiles; however, changes in near surface geology and the resulting geophone coupling and hammer signal amplitude and frequency requires individual adjustment of the gain curves for each profile. Accordingly, discretion must be used when comparing the relative amplitudes of the resonators between profiles and depths.

The same colour palette (blue through violet) has been applied in all the data sets presented in this report. The TISAR values are unitless. The blue has "relatively" little or no acoustic impedance contrast when compared to the red within an entire data set. A geologic contact such as a fracture should appear in yellow to red unless there is a stronger contact such as a larger void within the data set in which case a subtle stratigraphic contact may not be visible.

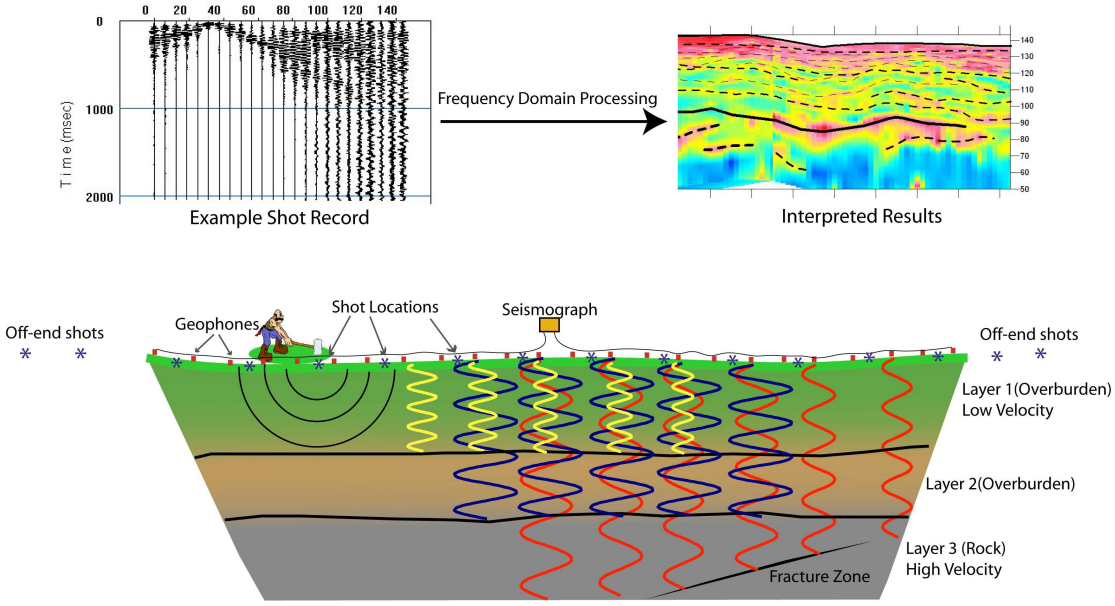


Figure 4: TISAR operating principle.

2.2.4. Multichannel Analysis of Surface Waves (MASW)

Basic Theory

The Multi-channel Analysis of Surface Waves (MASW) is a seismic method used to evaluate the shear-wave velocities of subsurface materials through the analysis of the dispersion properties of Rayleigh surface waves ("ground roll"). The dispersion properties are measured as a change in phase velocity with frequency. Surface wave energy will decay exponentially with depth. Lower frequency surface waves will travel deeper and thus be more influenced by deeper velocity layering than the shallow higher frequency waves. Inversion of the Rayleigh wave dispersion curve yields a shear-wave (V_s) velocity depth profile (sounding). Figure 5 outlines the basic operating procedure for the MASW method. Figure 6 is an example image of a typical MASW record and resulting 1D V_s model. A more detailed description of the method can be found in the paper *Multi-channel Analysis of Surface Waves*, Park, C.B., Miller, R.D. and Xia, J. Geophysics, Vol. 64, No. 3 (May-June 1999); P. 800–808.

Survey Design

The geometry of an MASW survey is similar to that of a seismic refraction investigation (i.e. 12 or more geophones in a linear array). The fundamental principle involves intentionally generating an acoustic wave at the surface and digitally recording the surface waves from the moment of source impact with a linear series of geophones on the surface. This is referred to as an "active source" method. Unlike the reflection method, which produces a data point beneath each geophone, the shear-wave depth profile is the average of the bulk area within the entirety of the geophone spread.

Interpretation Method and Accuracy of Results

The main processing sequence involves plotting, picking, and 1-D inversion of the MASW shot records using the SeisimagerSW™ software package. The results of the inversion process are inherently non-unique and the final model must be judged geologically realistic. The inversion modelling also assumes that all layering is flat/horizontal and laterally uniform.

Typically the accuracy of the shear-wave velocities modelled from the MASW method is on the order of +/- 10 to 15% for overburden material. The estimated error is typically higher for shear-wave velocities within rock formations.

At this particular site, the geology was not ideal for MASW soundings. The permafrost, ice and water layers will complicate the dispersion images. The method also assumes that the geology is laterally homogenous. The most suitable profile for MASW analysis was SL-E as the water depth was relatively shallow and uniform; however, analysis of the dispersion images for SL-D and SL-C appear to yield reasonable results. Ideally for marine MASW surveys, the geophones/hydrophones are placed on or as close as possible to the sea-floor.

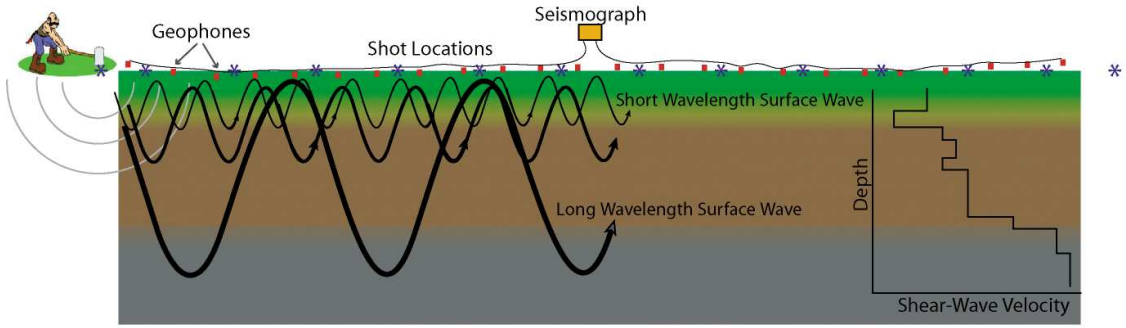
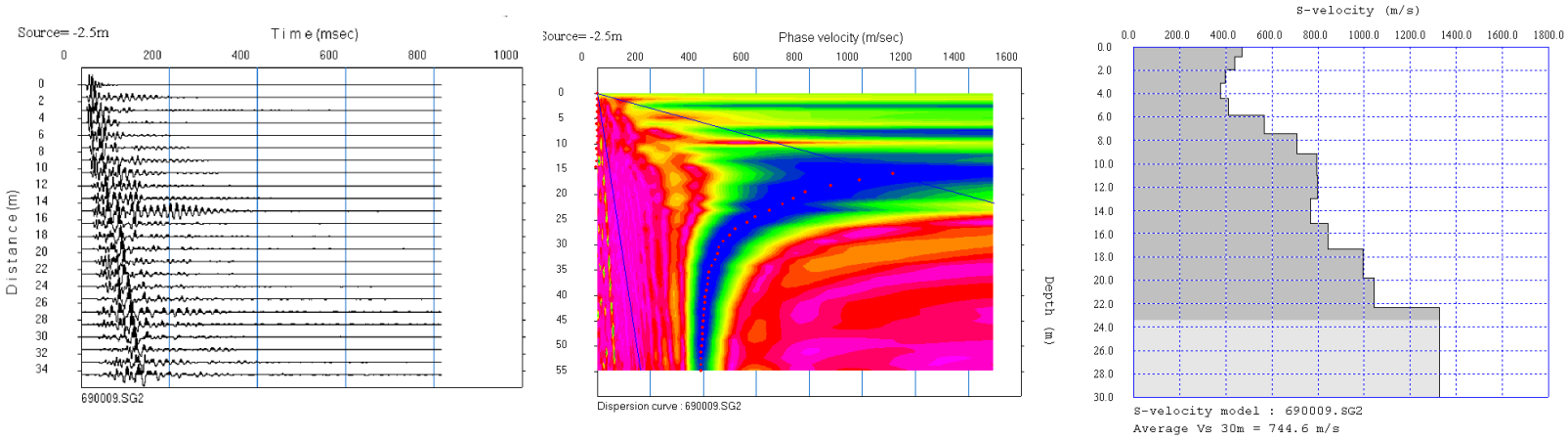


Figure 5: MASW Operating Principle



Raw Seismic Shot Record

Phase Velocity-Frequency Transformation indicating Dispersion Curve

1D Shear-Wave Velocity Profile from Inversion of Dispersion Curve

Figure 6: Example of a typical MASW shot record, phase velocity/frequency curve and resulting 1D shear-wave velocity model.

3. Results

The combined results of the seismic reflection, refraction, TISAR and MASW interpretations are presented in Appendix C in the form of interpreted cross-sections (Drawing T13615_A1). The interpreted contacts are based on the combined results of the shear-wave modelling, reflection images, critical distance calculations and borehole data.

The overall quality of the seismic records was very good.

Initial testing indicated that the seismic reflection method was most suitable to this particular site.

The primary objective of the survey was to identify the top of rock. It has been represented by a thick red line from the reflection interpretation and a magenta line based on the refraction analysis. Additional overburden contacts interpreted from the reflection and TISAR images are indicated by blue and grey lines respectively.

S-wave velocities can be used as an indicator of overburden types and bedrock competence. Appendix A contains a table of soil and rock classification based on S-wave velocities. MASW shear-wave data were analyzed for SL-C, SL-D and SL-E. The shear-wave models have been overlain on the cross-sections of drawing T13615_A1. As discussed above, the conditions for MASW analysis were not ideal at this particular site. The S-wave velocities determined through the MASW method are modelled velocities as opposed to true velocities measured using standard in-situ measuring methodology. The modelled velocities are typically within +/-10 to 15% of the true velocities of the overburden material; however, the added complications of the ice/water layers and multiple dispersion modes likely increase this error for this particular survey.

The seismic reflection and resonance (TISAR) data are primarily imaging tools. Alone, the methods do not provide indications of the material type. In addition, a velocity must be applied to convert the vertical scale of the images to a depth scale. The velocity can be estimated by correlation with borehole data. Interpretation of the data involves visually identifying reflector trends and corroborating with borehole data.

Interpretation of the seismic reflection data has identified 6 layers based on relatively stronger reflectors. These 6 layers have very good correlation at the intersection points of the seismic lines. The identification of the layers does not necessarily indicate uniform material within the layer. Gradual changes or thin layers may not generate a clear detectable reflection.

Relatively weaker reflectors have also been identified. The correlation of the weaker reflectors between the seismic profiles has not been systemically analyzed.

Comparison with the borehole logs suggest the following summaries for the defined overburden layers:

Layer 1: Layer 1 the upper most layer and represents materials from the sea floor to an elevation of approximately -10 m (onshore) to -32 m (offshore at SL-C). Offshore, in the vicinity of Line C, and based on borehole BH-13-09, this layer is interpreted as loose silty sand. Towards the shore there appears to be an increase in coarser grained materials; however the layer remains loose (BH-13-05 and MASW data). At the shoreline, boreholes indicate that this layer is fully (BH-13-01) to partially frozen (BH-13-02).

MASW S-wave velocities were modelled to be between 175 to 250 m/s for this layer.

Layer 2: Layer 2 is defined by a strong upper reflector. Borehole 13-09, along SL-C, suggests that this layer is characterized by compact silt and sand. Boreholes along SL-D indicate the layer is dominated by relatively uniform compact sand. Boreholes along SL-E indicate predominately compact sand (BH-13-08) with some silt and gravel layers (BH-14-13 and BH-13-11).

MASW S-wave velocities were modelled to be between 175 to 275 m/s for this layer.

Layer 3: The top of Layer 3 is best defined along SL-D.

BH-14-07b indicates primarily sand with some gravel and silt layers. The SPT N-Values are higher than the overlying layers.

BH-14-06 indicates more silt content than BH-14-07b.

BH-14-05C indicates primarily dense to very dense sand with some silt layers. As with BH-14-07b, the SPT N-Values are higher than the overlying layers.

BH-13-05b indicates very loose sand. This conflicts with the nearby BH-14-05C.

BH-13-09 intersects with the top of Layer 3 on SL-C. There is no sample logging; however, the DCPT indicates an increase (followed by a decrease) in blows near the top of Layer 3.

BH-14-13 along SL-E extends into the top of this layer and indicates sand and gravel for the upper 7 m.

No boreholes on-shore extend to this layer.

MASW S-wave velocities were modelled to be between 250 to 375 m/s for this layer.

Layer 4: The top of layer 4 is well defined along SL-C; however there are no boreholes that extend to it along the line nor along SL-E. Along SL-D BH-13-05B, BH-14-05C, BH-14-06 and BH-14-07B extend into this interpreted layer at an elevation of approximately -53 m. The boreholes indicate primarily dense to very dense sand.

MASW S-wave velocities were modelled to be between 400 to 460 m/s for this layer.

No on-shore boreholes extended into this interpreted layer.

Layer 5: A single borehole (BH-14-07b) extends to the top of Layer 5 at an elevation of -66 m. The borehole indicates dense sand with trace silt, less dense than the material immediately overlying it.

MASW S-wave velocities were modelled to be between 460 to 600 m/s for this layer.

Layer 6: MASW S-wave velocities were modelled to be between 525 to 760 m/s for this layer indicating the potential for dense sediments.

No boreholes extend to layer 6.

4. Conclusions & Recommendations

A total of approximately 1.76 km of seismic data were collected along five profiles in the vicinity of the proposed fixed dock, Mary River Project, Milne Inlet, Nunavut (Figure 1).

The data are presented in the form of cross-sectional figures in drawing T13615_A1.

Bedrock depths have been interpreted from a combination of seismic reflection and refraction data. The interpreted bedrock elevation ranged from approximately 90 to 140 m below sea-level. There was no borehole data available to corroborate the bedrock depth. P-wave velocities in the order of 3900 to 5100 m/s suggest the bedrock is competent.

Interpretation of the reflection data identifies 6 overburden layers overlying the bedrock based on relatively stronger, continuous reflectors. Borehole data for 16 boreholes were provided by Hatch Ltd. to aid in the interpretation of the seismic data. Brief descriptions of the bulk layer properties based on borehole data have been provided above. The reader is referred to the geotechnical report by Hatch Ltd. for the analysis of borehole and geotechnical data.

Interpretation of the TISAR data identifies a number of resonators that could represent geologic overburden contacts. In general the TISAR method provides a higher resolution than the seismic reflection method. The TISAR contacts are interpreted to represent the various sand/gravel contacts identified in the borehole logs. As mentioned above, the TISAR data requires an accurate velocity model. At this particular site, due to the permafrost, assumptions had to be made regarding the velocity model. Variations in the thickness or seismic velocity of the permafrost layers will have a large effective in the overall accuracy of the interpreted results.

The velocity model, and thus interpreted images, for the on-shore portions are likely less accurate than the off-shore profiles. This is due to the irregularly/discontinuous frozen soil as indicated in BH-13-01/b, BH-13-02 and BH-14-12. The combined TISAR and reflection images for SL-A and SL-B do suggest however, that the geologic layers interpreted off-shore, can be interpreted continuing on-shore.

Line SL-E was the most suitable data set for MASW processing due to the shallow water and unfrozen sediments. The frozen ground on/near the shore created a large velocity inversion and contrast at surface, which does not allow adequate frequency dispersion. The water was shallow for SL-E and the sediments unfrozen. Lines SL-C and SL-D had deep water and unfrozen sediments. The overall accuracy of the shear-wave velocity measurements is not certain due to water depths and ice.

Shear strength data can be more reliably measured in marine conditions using data collected with hydrophones on or near the water bottom and a seismic source such as an air gun. On-shore, intrusive, e.g. downhole, methods can accurately measure the shear-wave velocity beneath the permafrost.

Processing and interpretation of the seismic data was performed by Ben McClement, P.Eng. and Olivier Létourneau. This report has been written by Milan Situm, P.Geo. and reviewed by Ben McClement, P.Eng.

Ben McClement, P.Eng.
Geophysicist

Milan Situm, P.Geo.
Manager

APPENDIX A

SEISMIC EQUIPMENT AND METHODOLOGY FACT SHEETS

TERRALOC PRO FEATURES

Terraloc Pro - Your guarantee for high-quality fieldwork

A STAND-ALONE SEISMOGRAPH, RUGGED FOR DEMANDING ENVIRONMENTS: A self-contained instrument, designed to cope with rough field conditions.

VERSATILE & FUTURE-PROOF: You don't know what your next job will demand, with the Terraloc Pro you are equipped to successfully take on a wide range of seismic surveys.

SAVES VALUABLE FIELD TIME: Terraloc Pro offers built-in diagnostics and remote management as well as vendor assisted support over the net.

HIGH QUALITY DATA: Don't compromise, return from the field with superior data, Terraloc Pro delivers top class performance.

SECURE INVESTMENT: Terraloc Pro is a product for the future, it allows for add-on of new functionality and seamless expansion.

The ABEM Terraloc line of seismographs has a long and well-known reputation for ease of use and reliability under the toughest field conditions. With this brand new Terraloc Pro instrument, ABEM has stretched the specification and incorporated several new features. Well working software functionality has been inherited from its predecessor in order to save time and effort for the user. All together, this new instrument is a high quality product, designed to meet demanding field requirements.

A

General

No. of channels	12, 24 and 48
Additional channels	Easily obtained by linking two or more units together
Up-hole channel	Yes, 2 additional independent
Sampling rate (selectable)	100 sps – 50 ksps (20 µs - 10 ms)
Record length (selectable)	Up to 480 k samples / ch. equivalent to: 5,1 ms - 80 min
Pre-trig record (selectable)	0 – 100 % of record length
Delay time	Up to 2 minutes
Stacking	32 bits, up to 999 impacts
Unstack	Remove last shot from stack
Trigger inputs	Trigger coil, make/break, geophone, TTL
A/D converter resolution	24 bits
Dynamic range	(theoretical / measured) 144 dB / >120 dB
Input voltage range (selectable)	0,5 Vpp, 5 Vpp, 12,5 Vpp
Input gain (selectable)	0 dB, 12 dB, 24 dB, 36 dB, 48 dB
Input impedance (selectable)	3 kΩ, 20 kΩ, 20 MΩ
Frequency range	DC to 20 kHz
Total harmonic distortion	0,0005%
Crosstalk	-120 dB
Noise monitor	Amplitude
Anti-alias filters	Set automatically based on sampling rate
Connectors	NK-27 / KPT 55
GPS	Yes

Post recording features

Digital filters	Band-, low-, high- pass band-reject, remove DC offset
Spectrum analysis	Any single trace, FFT analysis
Velocity Analysis	On-screen analysis of refractor velocity
First arrivals picking	Automatic or manual Times can be saved with record
Pre-stack correlation	Yes, cross correlation with reference or any other ch.

Processor, RAM and hard disk

Processor	Low power Intel Atom, 1,6 GHz
Operating System	Windows XP Pro
Internal RAM	2GB (DDR SO-DIMM module)
Hard disk capacity	100 GB or greater
Display	8,4" Active TFT LCD, full colour, daylight visible, 800x600 res.
External display port	VGA output
I / O port	3 x USB 2.0 ports
Network interfaces	1 x IEEE 802.3 TP-10/100/1000 RJ-45 IP 67 2 x TP-10/100 KPT 08 WLAN antenna

Power	10 – 34 V DC external power 12 V internal battery
Power consumption	30/60 W (man/acq)
Ambient temp (operating)	-20 to + 55 °C
Ambient temp (storage)	-30 to + 70 °C
Casing	Rugged Al alloy, meets IEC IP 66
Weight, 24 channels	10 kg
Weight, 48 channels	11 kg
Dimensions (W x L x H)	39 x 21 x 32 cm

To order, please specify

Terraloc Pro, 12 CHANNEL UNIT	33 7000 12
Terraloc Pro, 24 CHANNEL UNIT	33 7000 14
Terraloc Pro, 48 CHANNEL UNIT	33 7000 16

Each unit includes:

- Terraloc Pro instrument (of chosen type)
- Reference manual
- Trigger cable 250 m on reel, Office power supply (charger), Trigger coil, Accessories & Tools kit
- Windows XP compatible USB keyboard and mouse
- Software SeisTW and sample records
- Transport case (plywood)

Field Accessories (ordered separately)

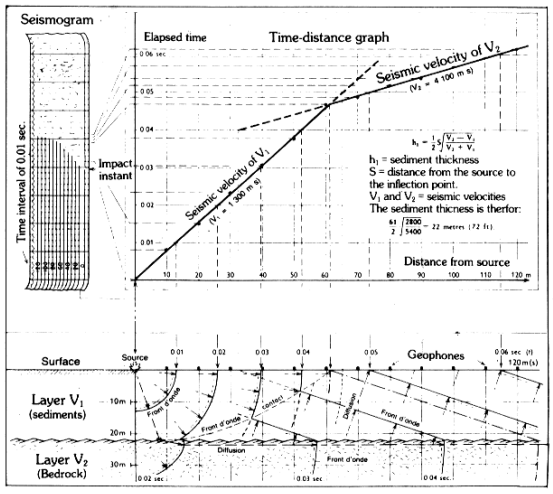
Seismic cable 24 take-outs at 5 m	36 0001 96
Extension cable 160 m (for 24 take-out cable)	36 0001 97
Seismic cable 12 take-outs at 12.5 m	36 0001 26
Extension cable, 160 m (for 12 take-out cable)	36 0001 28
(other cable configurations also available)	
Portable reel	38 3001 52
10 Hz vertical geophone	39 1000 61
10 Hz horizontal geophone	39 1000 93
4.5 Hz vertical geophone	39 1000 63
4.5 Hz horizontal geophone	39 1000 64
4.5 Hz 3-D geophone	39 1000 85
100 Hz vertical geophone (land)	39 1000 77
100 Hz vertical geophone (marsh)	39 1000 78
Shock plate	33 0010 18
Hi-voltage CB 20 VA shotbox	39 9000 23

GEOPHYSICS G P R INTERNATIONAL INC.

SEISMIC REFRACTION

Seismic refraction consists of recording the length of time taken for an artificially provoked surface vibration to propagate through the earth. By processing the data, the seismic velocities and depths of the underlying rock layers can be determined. These velocities are characteristic of the nature and quality of the bedrock; a fissured, fractured or sheared rock will be characterized by reduced seismic velocities.

The method is generally used to obtain a better geological analysis of the sub-surface and to determine the following characteristics: the quality, profile and depth of bedrock, its nature, degree of alteration and any other physical contrasts. Seismic refraction ensures that maximum information may be gained from geological field work, and that direct investment costs (drilling, excavation), will be reduced.



PRINCIPLE OF SEISMIC REFRACTION

FEATURES

- Precise determination of soil thickness .
- Precise determination of the seismic velocities (rock type and quality).
- Localization and identification of geological units.
- Detailed analysis of soil.
- Year-round use.
- Sea and land surveys (above and below ground).
- Great accessibility possible to rough terrain and remote regions.

AREAS OF APPLICATION

Civil Engineering/Mining Exploration - Exploitation/Petroleum and Gas Sectors/ Geotechnology/Geology/ Hydrology.

- Identification of faults, fractures, shear zones.
- Detection of rock differences (veins, dykes, cavities, etc.).
- Determination of rock topography.
- Evaluation of volume of soil present or to be excavated.
- Excellent complement to geological mapping.
- Recognition of geophysical anomalies such as VLF, gravimetry, etc.
- Drill site selection, better target identification.
- Evaluation of the size, thickness and condition of surface shafts (mining exploitation).
- Mass Rock Quality Determination (MRQD).
- Detection of rock irregularities and breaks.
- Hydrogeology (detection of water tables, veins, reservoirs).
- Excellent complement to any geological analysis.

AREAS OF APPLICATION

Civil Engineering/Mining Exploration - Exploitation/Petroleum and Gas Sectors/ Geotechnology/Geology/ Hydrology.

- Identification of faults, fractures, shear zones.
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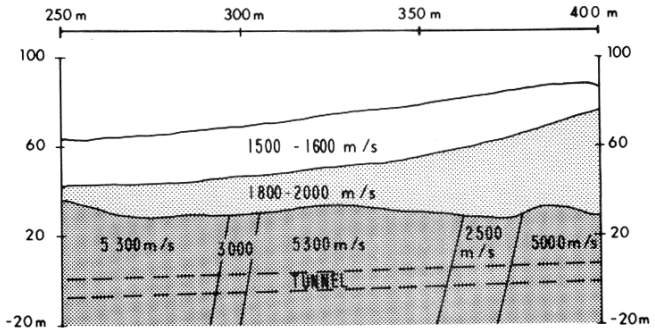
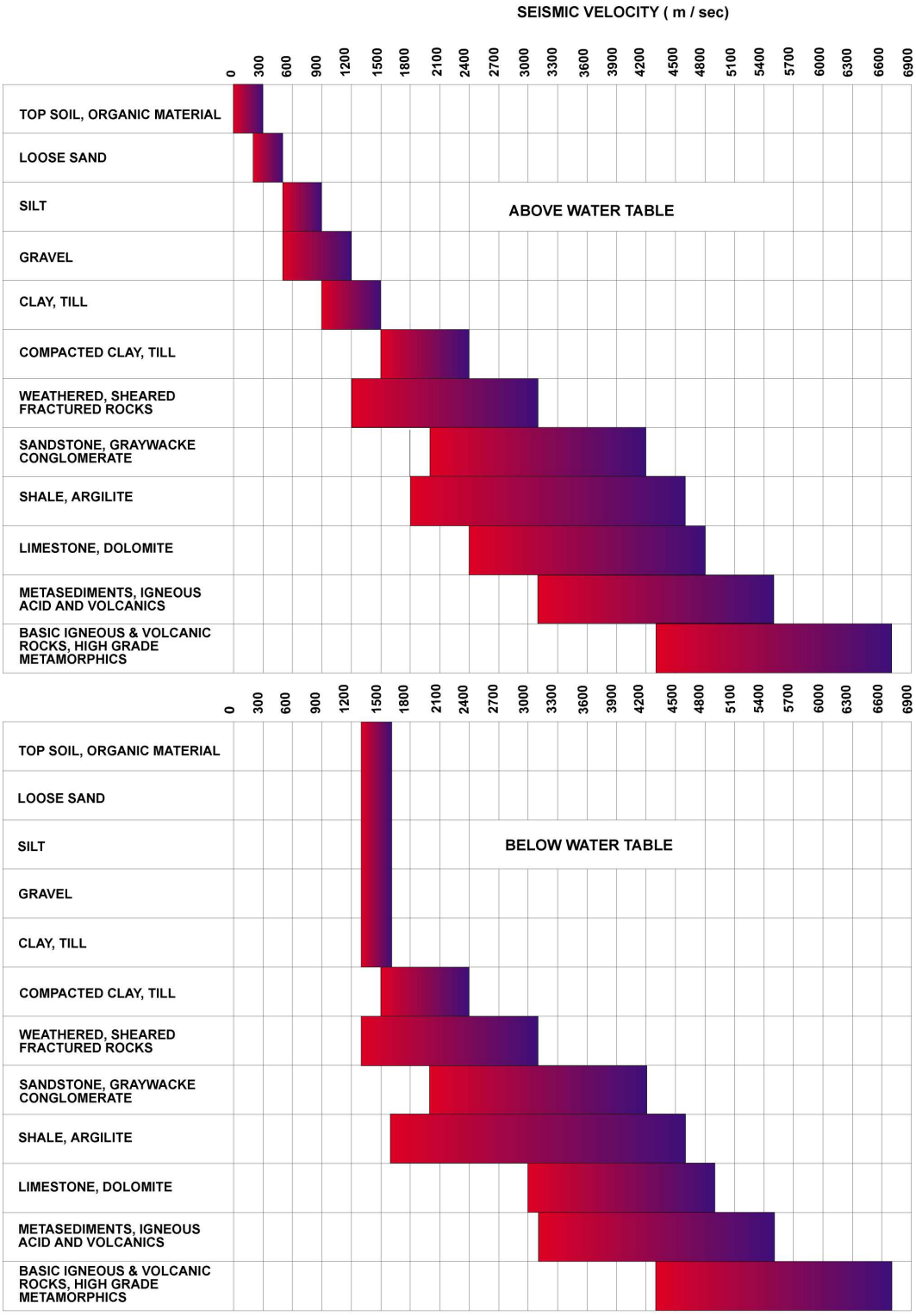


Interpretation results of a seismic profile

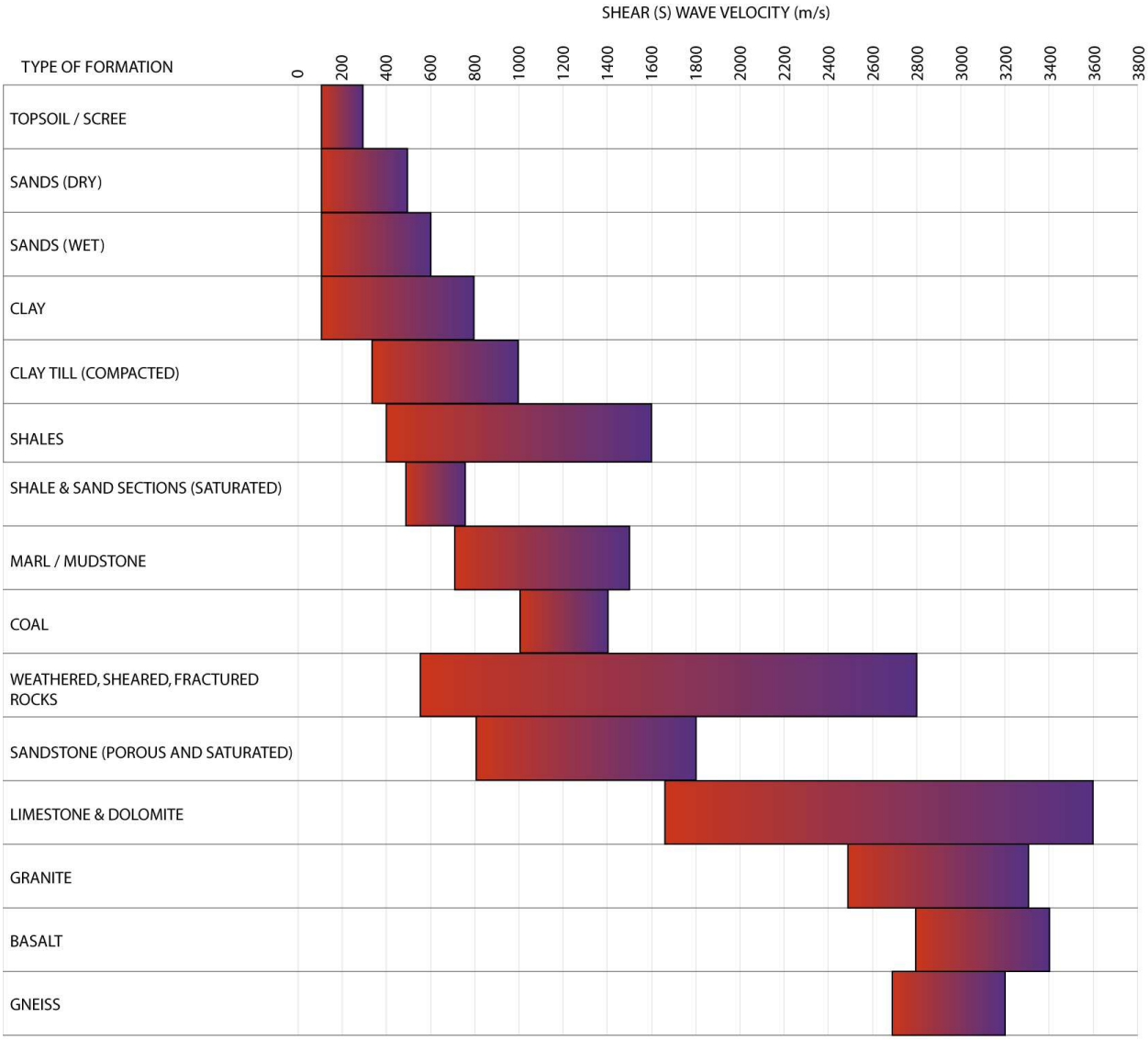
ADDITIONAL REMARKS

Geophysics GPR International Inc. has been recognized for the past fifteen years as a leader in both the application and the development of seismic methods. Seismic refraction is currently used in both civil and mining engineering; the use of lighter high-performance equipment and better tomographical interpretation of the results have contributed to its growing popularity.

GEOPHYSICS G P R INTERNATIONAL INC.



SOIL AND ROCK CLASSIFICATION
BASED ON SEISMIC VELOCITIES



Typical rock velocities, Based on Bourbie, Coussy and Zinszner, Acoustics of Porous Media, 1987
with modifications by Geophysics GPR. Rev A.1 July 2011

APPENDIX B

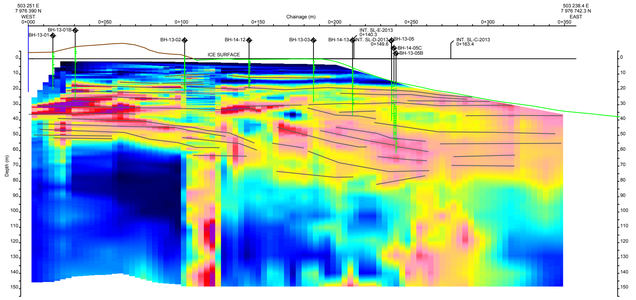
SITE PHOTOS

Photo 1: Seismic line setup with buffalo gun

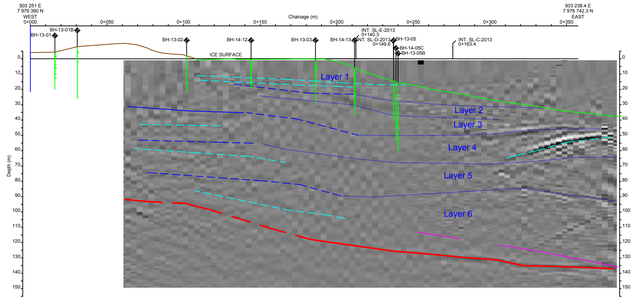
Photo 2: Seismic line setup, with seismograph shelter

APPENDIX C

DRAWING T13615_A1



SL-A-2013
(TISAR)



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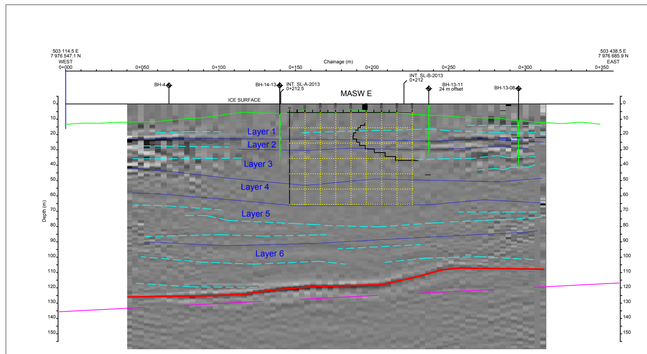
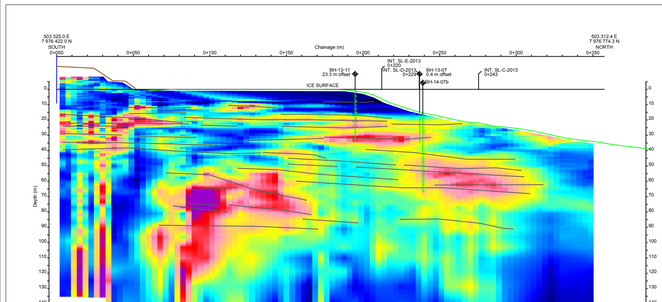
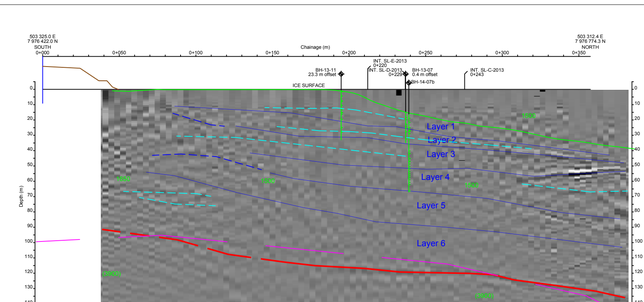
(Reflection and Refraction)



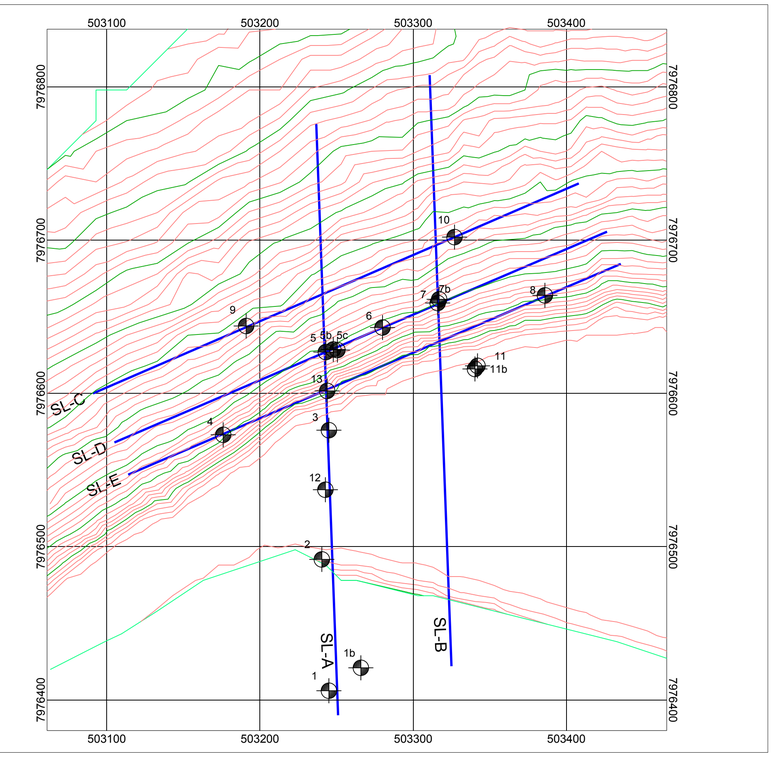
SL-E-2013
(Reflection and Refraction)



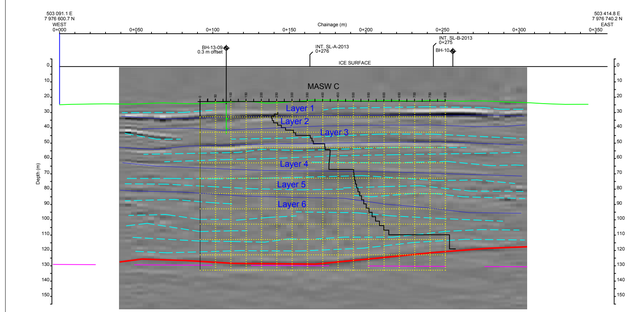
SL-B-2013
(TISAR)



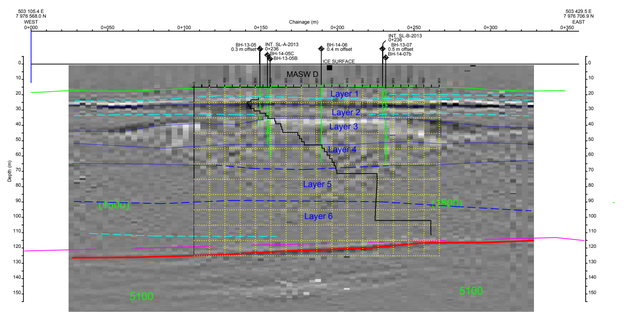
SL-B-2013
(Reflection and Refraction)



PLAN VIEW MAP WITH BATHYMETRY CONTOURS



SL-C-2013
(Reflection and Refraction)



SL-D-2013
(Reflection and Refraction)

LEGEND

- Interpreted Bedrock from Reflection data
- Interpreted Bedrock from Refraction data
- Interpreted Overburden Reflector (stronger)
- Interpreted Overburden Reflector (weaker)
- (1500) Seismic Refraction Velocity
- Interpreted Overburden Resonator (TISAR)
- Bathymetry Profile
- Topography Profile
- Geotechnical Borehole (Hatch)

No	NOTES
1	THE GEOPHYSICAL SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. DECEMBER, 2013
2	COORDINATE SYSTEM: NAD83 UTM ZONE 17N
3	BATHYMETRY DATA, AND BOREHOLE DATA PROVIDED BY HATCH LTD.
4	REFER TO THE FULL REPORT FOR A DISCUSSION OF METHODLOGY, RESULTS, ACCURICIES AND LIMITATIONS
5	
6	

No	DATE	MODIFICATIONS
1	Feb 10, 2014	Minor adjustments to layer interpretation at intersection points of lines Added interpretation for weaker seismic reflectors and MASW S-wave Profiles
2	Feb 28, 2014	Minor formating/labeling changes

GPR
APP.

GEOPHYSICS GPR INTERNATIONAL INC.

DESSINÉ PAR / DRAWN BY	RBM
VERIFIÉ PAR / CHECKED BY	B.McClement, P. Eng.
APPROUVÉ PAR / APPROVED BY	M. Situm, P. Geo.
# CONTRAT / CONTRACT #	T-13615
DATE	February 28, 2014
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T13615_A1

CLIENT / CLIENT
BAFFINLAND IRON MINES CORP.

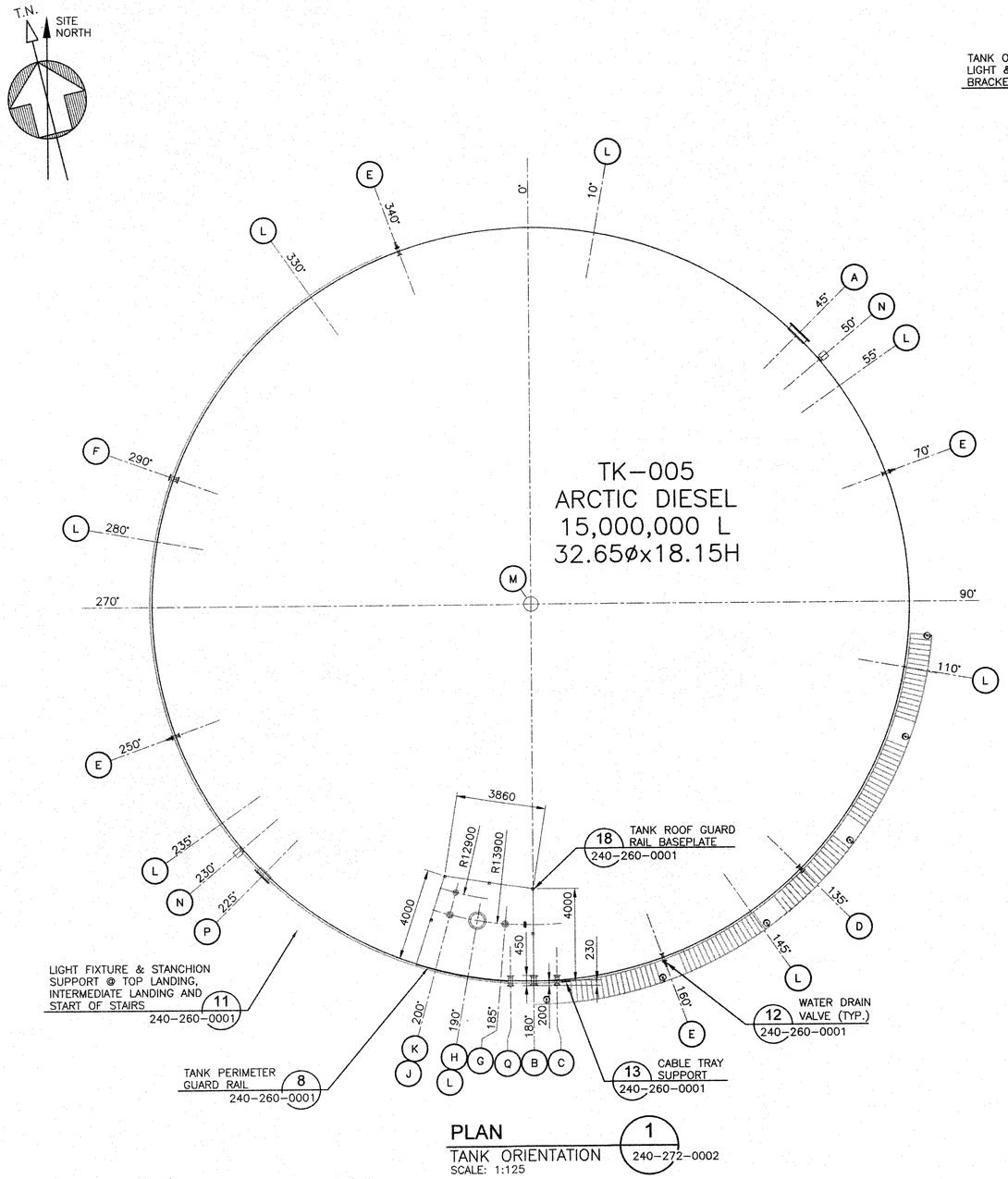
PROJET / PROJECT
MARY RIVER PROJECT
MILNE INLET, NUNAVUT

TITRE / TITLE
GEOPHYSICAL SEISMIC INVESTIGATION
INTERPRETED SEISMIC PROFILES

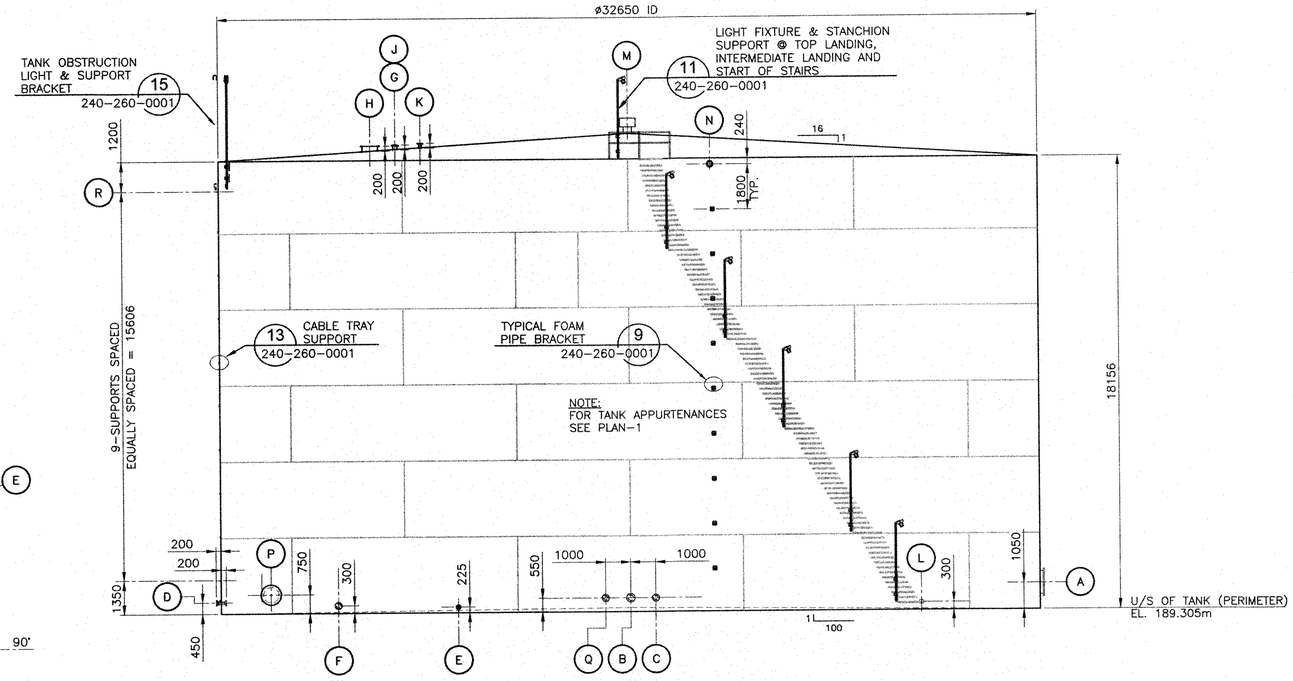
ATTACHMENT 13

FUEL TANK DRAWINGS

DWG. No. H353004-10000-240-270-0001-0001



PLAN
TANK ORIENTATION 1 240-272-0002
SCALE: 1:125



ELEVATION
TANK ORIENTATION 1 –
SCALE: 1:125

TANK APPURTENANCES

ITEM	NO.	SERVICE	SIZE	RATING	TYPE	REMARKS	REFERENCE DETAIL
A	1	SHELL MANWAY	915 (36")	API 650	FF	API 650 FIG. 5-7A	DET. 1, DWG: 240-260-0001
B	1	TANK SUCTION	203 (8")	CLASS 150	RF WELD NECK	DOUBLE FLANGED /W 25mm SW HALF COUPLING ON EXTERIOR NOZZLE	N/A
C	1	TANK FILL	150 (6")	CLASS 150	RF WELD NECK	DOUBLE FLANGED /W 25mm SW HALF COUPLING ON EXTERIOR NOZZLE	N/A
D	1	SPARE SHELL NOZZLE	100 (4")	CLASS 150	RF WELD NECK	DOUBLE FLANGED	N/A
E	4	WATER DRAIN NOZZLE	75 (3")	CLASS 150	RF WELD NECK	FLANGED	DET. 12, DWG: 240-260-0001
F	1	SPARE SHELL NOZZLE	150 (6")	CLASS 150	RF WELD NECK	FLANGED w/ BLIND FLANGE	N/A
G	1	GAUGE HATCH	150 (6")	CLASS 150	RF SLIP ON	FLANGED	DET. 3, DWG: 240-260-0001
H	1	ROOF MANWAY c/w EMERGENCY VENT	610 (24")	API 650	FF	C/W COVER	DET. 5, DWG: 240-260-0001
J	1	RADAR GAUGE	150 (6")	CLASS 150	RF SLIP ON	SINGLE FLANGE	DET. 2, DWG: 240-260-0001
K	1	ROOF NOZZLE (OVERFILL PROBE)	100 (4")	CLASS 150	RF SLIP ON	BLIND FLANGED	DET. 4, DWG: 240-260-0001
L	8	GROUNDING LUGS					DET. 7, DWG: 240-260-0001
M	1	ROOF VENT	305ø (12")		NOZZLE	–	DET. 6, DWG: 240-260-0001
N	2	FOAM CONNECTION NOZZLE	150 (6")		STUD PAD	STUD PAD	DET. 10, DWG: 240-260-0001
P	1	SHELL MANWAY	610 (24")	API 650	FF	API 650 FIG. 5-7A	DET. 1, DWG: 240-260-0001
Q	1	TANK DRAW DOWN	150 (6")	CLASS 150	RF	DOUBLE FLANGED	DET. 14 DWG: 240-260-0001
R	10	CABLE TRAY SUPPORT					DET. 13 DWG: 240-260-0001

PERMIT TO PRACTICE
HATCH LTD.
Signature
Date 18/07/25
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

ISSUED FOR CONSTRUCTION

THIS DRAWING WAS PREPARED BY HATCH LTD. ("HATCH") FOR THE EXCLUSIVE USE OF BAFFINLAND IRON MINES LP ("CLIENT") AND ITS USE IS SUBJECT TO THE TERMS AND CONDITIONS OF THE CONTRACT BETWEEN HATCH AND THE CLIENT, INCLUDING ANY LIMITATIONS ON LIABILITY CONTAINED THEREIN. THIS DRAWING AND ITS CONTENTS REMAIN THE INTELLECTUAL PROPERTY OF HATCH SUBJECT TO CLIENT'S ROYALTY-FREE, IRREVOCABLE, PERPETUAL AND NON-EXCLUSIVE LICENSE TO USE AND REPRODUCE THE DRAWING FOR PURPOSES CONNECTED WITH THE PROJECT, INCLUDING THE CONSTRUCTION, COMPLETION, MAINTENANCE, EXTENSION, REINSTATEMENT AND REPAIR OF THE PROJECT. THIS DRAWING, AND THE INFORMATION CONTAINED HEREIN, SHALL BE TREATED AS CONFIDENTIAL FOR ALL OTHER PURPOSES AND SHALL NOT BE MODIFIED WITHOUT THE WRITTEN CONSENT OF HATCH.

No.	DESCRIPTION	BY	CHK'D	DATE
0	ISSUED FOR CONSTRUCTION	SJM	MMI	18-07-25
A	ISSUED FOR PARALLEL REVIEW	SJM	MMI	18-07-20

REVISIONS

REGISTERED PROFESSIONAL ENGINEER F.E. BUTTS LICENSE P.512 NT/NU

REG. PROFESSIONAL

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	H. P. CURRIE	NR	18-07-04
DESIGNER	K. MacLEAN	NR	18-07-04
CHECKER	M. MacINTYRE	Michael MacIntyre	18/07/25
DESIGN COORD.	M. MacINTYRE	Michael MacIntyre	18/07/25
RESP. ENG.	F. BUTTS		18/07/25
LEAD DISC. ENG.	K. MacLEAN		18/07/25
ENG. MANAGER	D. STANGER		18/7/25
PROJ. MANAGER			
CLIENT	T. ATIBA		18/7/25

DRAWING APPROVAL STATUS: Approved for Construction

HATCH

Baffinland

MARY RIVER EXPANSION PROJECT
BAFFINLAND IRON MINES LP

MINE SITE
FUEL SYSTEM
15,000,000L ARCTIC DIESEL TANK

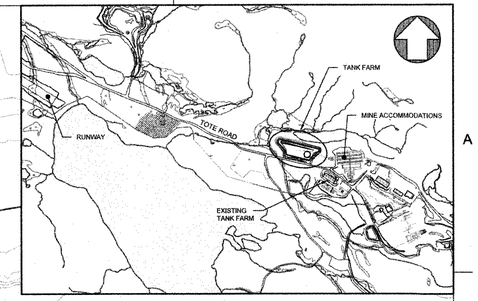
DRAWING No.	DRAWING TITLE
H353004-10000-240-260-0001-0001	FUEL SYSTEM TYPICAL VERTICAL TANK DETAILS

REFERENCE DRAWINGS

SCALE	DWG. No.	REV
AS NOTED OR AS NOTED	H353004-10000-240-270-0001-0001	0

SHEET SIZE: A1

DWG. No. H353004-10000-220-272-0009-0001



KEYPLAN
NTS

LAYOUT & GRADING POINTS 1 220-272-0010-0001

3 DYKE SUMP 220-273-0004

3 DYKE SUMP 220-273-0004

TOP OF DYKE EL. 190.100m
TOE OF DYKE EL. 188.300m

TOE OF SLOPE

ACCESS ROAD (6m WIDE)

HIGH POINT

600mm WIDE SWALE
3:1 SIDE SLOPE

600mm WIDE SWALE
3:1 SIDE SLOPE

FUTURE TANK PAD
TOE OF SLOPE
SUB-LINER INSULATION IS ONLY SCOPE TO BE CURRENTLY EXECUTED

FUTURE TANK PAD
TOE OF SLOPE
SUB-LINER INSULATION IS ONLY SCOPE TO BE CURRENTLY EXECUTED

EXISTING ELECTRICAL

FUTURE TANK PAD

FUTURE TANK PAD

TANK PAD

1 TANK PAD 220-273-0004

5.0m WIDE SERVICE RAMP

600mm WIDE SWALE
2H:1V SIDE SLOPE

RELOCATED FUEL MODULE

TOTE ROAD

G 220-273-0003

F 220-273-0002

E 220-273-0002

A 220-273-0001

B 220-273-0001

C 220-273-0001

D 220-273-0001

SCALE: 1:400
0m 10m 20m 30m

1 PLAN
DYKE GRADING
SCALE: 1:400

PERMIT TO PRACTICE
HATCH LTD.
Signature
Date 15/07/25
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

REFERENCE DRAWINGS	
DRAWING No.	DRAWING TITLE
H353004-10000-220-272-0010-0001	MINE SITE TANK FARM LAYOUT & GRADING POINTS
H353004-10000-220-273-0004-0001	MINE SITE DYKE SECTIONS & DETAILS
H353004-10000-220-273-0003-0001	MINE SITE TANK FARM DYKE SECTION G
H353004-10000-220-273-0002-0001	MINE SITE TANK FARM DYKE SECTIONS E & F
H353004-10000-220-273-0001-0001	MINE SITE TANK FARM DYKE SECTIONS A TO D

REG. PROFESSIONAL

R.E. BUTTS
LICENSED PROFESSIONAL ENGINEER
NT/NU

ISSUED FOR CONSTRUCTION

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No.	DESCRIPTION	BY	CHK'D	DATE
0	ISSUED FOR CONSTRUCTION	SCS	MMI	18/07/25
A	ISSUED FOR REVIEW	SS	MMI	18-07-19

REVISIONS

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	S. SKINNER	NR	18-07-06
DESIGNER	K. MacLEAN	NR	18-07-06
CHECKER	M. MacINTYRE	Michael MacIntyre	18/07/25
DESIGN COORD.	M. MacINTYRE	Michael MacIntyre	18/07/25
RESP. ENG.	F. BUTTS		15/07/25
LEAD DISC. ENG.	K. MacLEAN		15/07/25
ENG. MANAGER	D. STANGER		15/7/25
PROJ. MANAGER			
CLIENT	T. ATIBA		18/7/25

DRAWING APPROVAL STATUS: Approved for Construction

Baffinland

MARY RIVER EXPANSION PROJECT
BAFFINLAND IRON MINES LP

MINE SITE
TANK FARM GRADING
PLAN

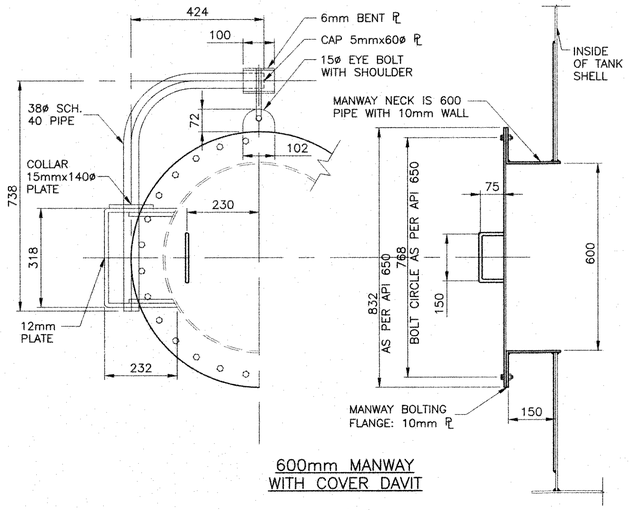
SCALE 1:400 OR AS NOTED

DWG. No. H353004-10000-220-272-0009-0001

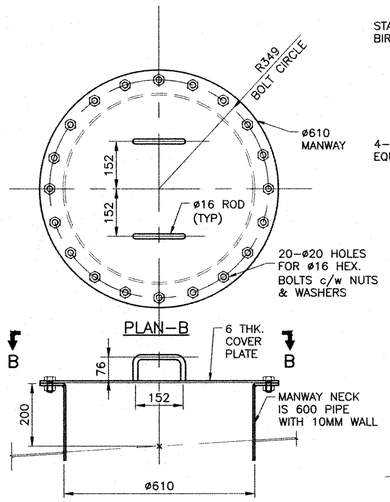
REV 0

SHEET SIZE: A1

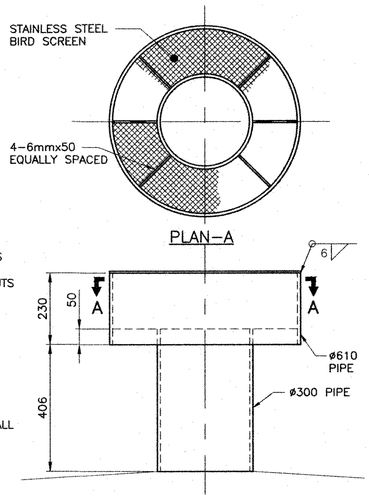
DWG. No. H353004-10000-240-260-0001-0001



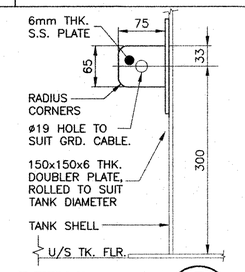
600mm MANWAY WITH COVER DAVIT



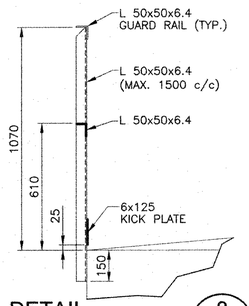
DETAIL 5 — ROOF MANWAY c/w EMERGENCY VENT (240-270-0001)
SCALE: 1:10



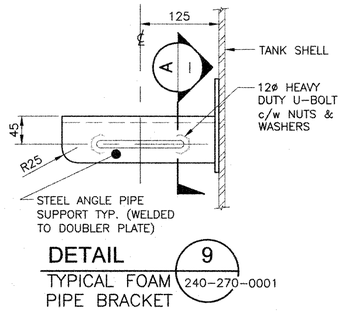
DETAIL 6 — ROOF VENT (240-270-0001)
SCALE: 1:10



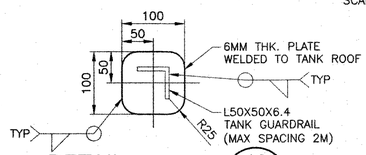
DETAIL 7 — GROUND LUG (240-270-0001 / 260-272-0007)
SCALE: 1:5



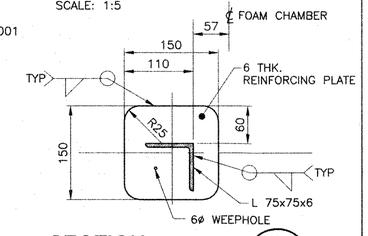
DETAIL 8 — TANK PERIMETER GUARD RAIL (240-270-0001)
SCALE: 1:15



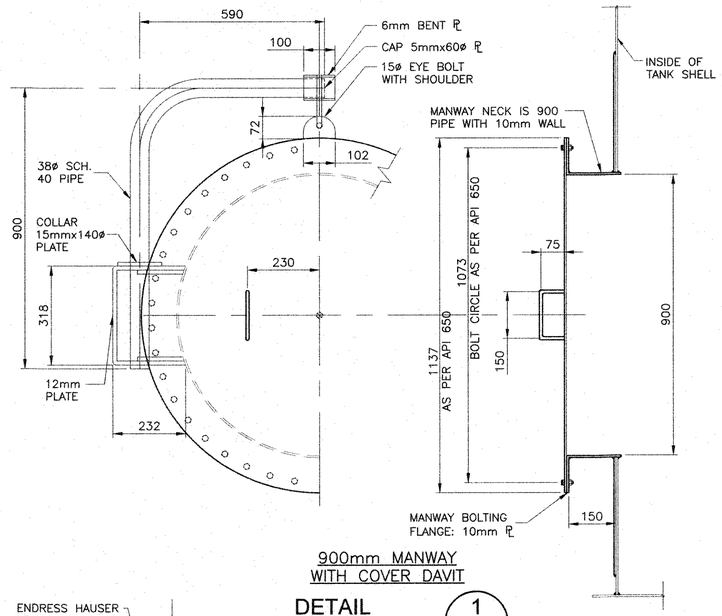
DETAIL 9 — TYPICAL FOAM PIPE BRACKET (240-270-0001)
SCALE: 1:5



DETAIL 18 — TANK ROOF GUARD RAIL BASEPLATE (240-270-0001)
SCALE: 1:5

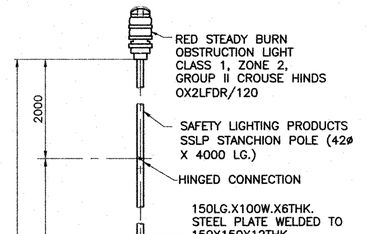


SECTION A — MOUNTING PLATE (–)
SCALE: 1:5

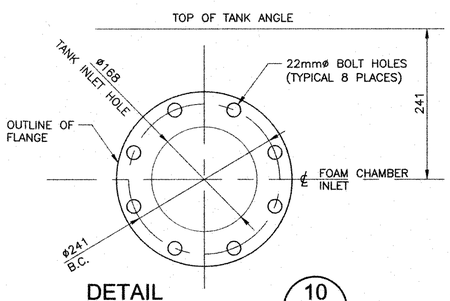


900mm MANWAY WITH COVER DAVIT

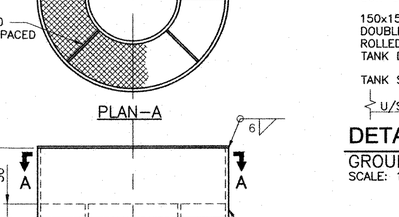
DETAIL 1 — SHELL MANWAYS (240-270-0001)
SCALE: 1:10



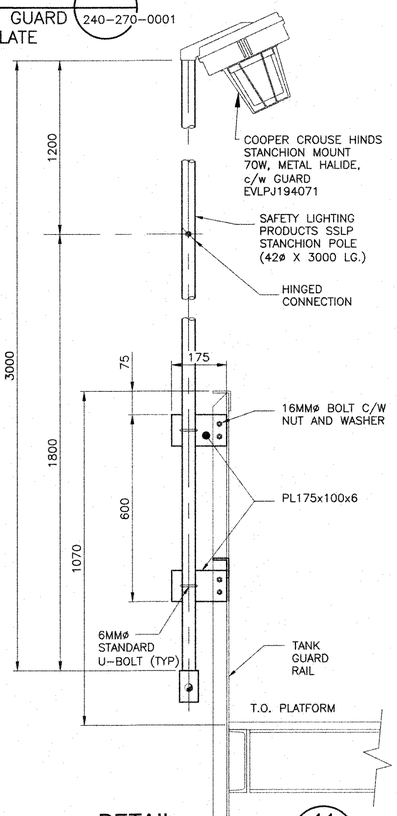
DETAIL 15 — TANK OBSTRUCTION LIGHT & SUPPORT BRACKET (240-270-0001 / 260-272-0007)
SCALE: 1:20



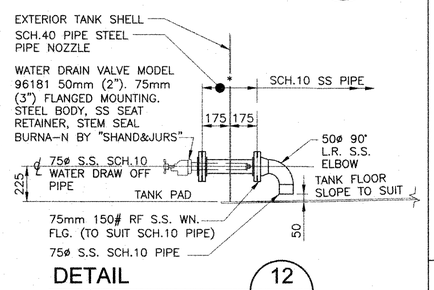
DETAIL 10 — FOAM INLET OPENING (240-270-0001)
SCALE: 1:5



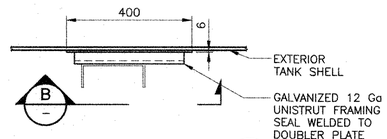
DETAIL 14 — TANK DRAW DOWN (240-270-0001)
SCALE: 1:20



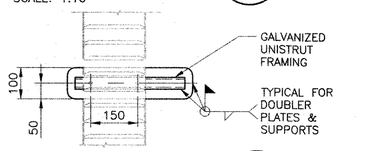
DETAIL 11 — LIGHT FIXTURE & STANCHION SUPPORT (240-270-0001 / 260-272-0007)
SCALE: 1:10



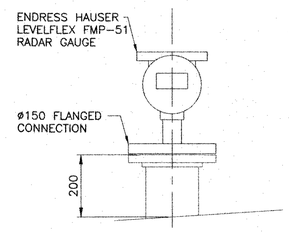
DETAIL 12 — WATER DRAIN VALVE (240-270-0001)
SCALE: 1:20



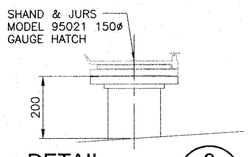
DETAIL 13 — CABLE TRAY SUPPORT (240-270-0001)
SCALE: 1:10



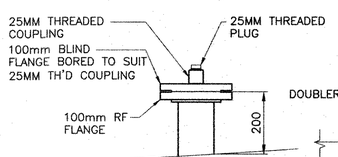
ELEVATION B — MOUNTING BRACKET (–)
SCALE: 1:10



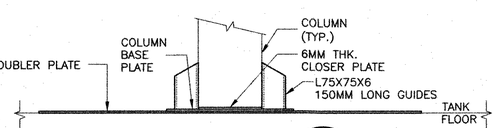
DETAIL 2 — RADAR GAUGE (240-270-0001)
SCALE: 1:10



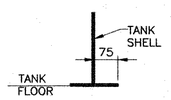
DETAIL 3 — GAUGE HATCH (240-270-0001)
SCALE: 1:10



DETAIL 4 — OVERFILL PROBE (240-270-0001)
SCALE: 1:10



DETAIL 16 — COLUMN TO TANK FLOOR CONNECTION (–)
SCALE: 1:10



DETAIL 17 — ANNULAR RING OR FLOOR PLATE EXTENSION (–)
SCALE: 1:10

PERMIT TO PRACTICE
HATCH LTD.
Signature
Date 15/07/25
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

REGISTERED PROFESSIONAL ENGINEERS F.E BUTTS LICENSE NT/NU

ISSUED FOR CONSTRUCTION

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REFERENCE DRAWINGS	
DRAWING No.	DRAWING TITLE
H353004-10000-260-272-0007-0001	TANK FARM GROUNDING PLAN
H353004-10000-240-270-0001-0001	FUEL SYSTEM 15,000,000L ARCTIC DIESEL TANK

REG. PROFESSIONAL

REVISIONS				
No.	DESCRIPTION	BY	CHK'D	DATE
0	ISSUED FOR CONSTRUCTION	SJM	MMI	18107125
A	ISSUED FOR PARALLEL REVIEW	SJM	MMI	18-07-20

HATCH

DRAWING APPROVAL STATUS: Approved for Construction			
ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	H. P. CURRIE	NR	18-07-04
DESIGNER	K. MacLEAN	NR	18-07-04
CHECKER	M. MacINTYRE	Michael MacIntyre	18107125
DESIGN COORD.	M. MacINTYRE	Michael MacIntyre	18107125
RESP. ENG.	F. BUTTS		15/07/25
LEAD DISC. ENG.	K. MacLEAN		19/07/25
ENG. MANAGER	D. STANGER		19/7/25
PROJ. MANAGER			
CLIENT	T. ATIBA		18/7/25

Baffinland

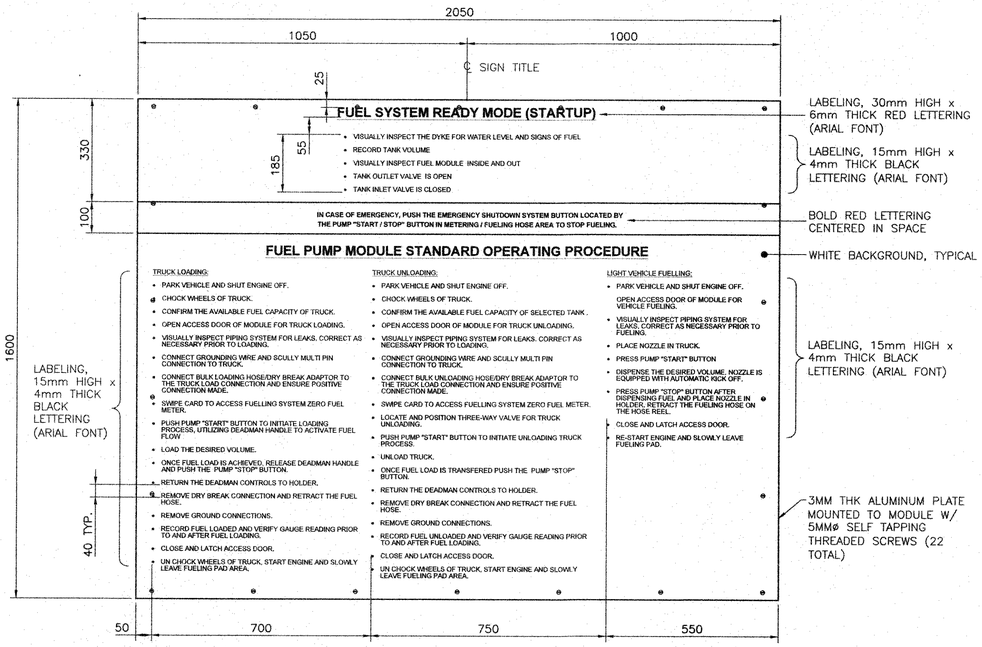
MARY RIVER EXPANSION PROJECT
BAFFINLAND IRON MINES LP

MINE SITE
FUEL SYSTEM
TYPICAL VERTICAL TANK DETAILS

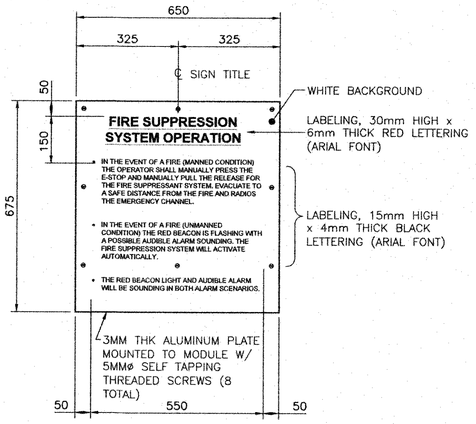
SCALE	DWG. No.	REV
AS NOTED OR AS NOTED	H353004-10000-240-260-0001-0001	0

SHEET SIZE: A1

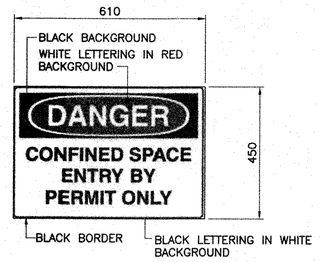
DWG. No. H353004-10000-240-260-0004-0001



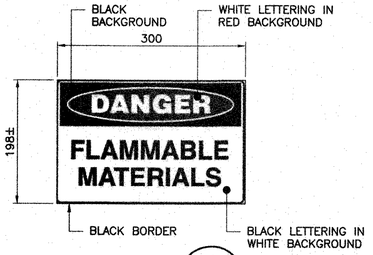
DETAIL 1 — 240-260-0003
FUEL PUMP MODULE STANDARD OPERATING PROCEDURE SIGN
SCALE: 1:10



DETAIL 2 — 240-260-0003
SYSTEM FIRE PROCEDURE SIGN – FUELING MODULE
SCALE: 1:10



DETAIL 3 — 240-260-0002
CONFINED SPACE ENTRY SIGN
(2 REQUIRED – 1 PER TANK MAN WAY)
SCALE: 1:10

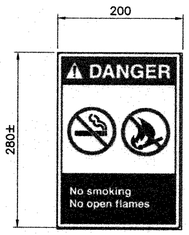


DETAIL 4 — 240-260-0002
FLAMMABLE STORAGE SIGN
(4 REQUIRED)
SCALE: 1:5

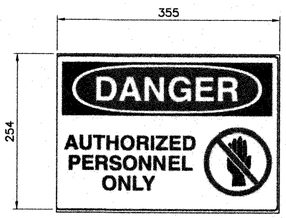
SPECIFICATION AND INSTALLATION NOTES:

1. SIGNS ARE TO BE CONSTRUCTED OF PERMANENT 4 MIL SELF-STICK VINYL FOR ADHESION TO EXISTING PIPING AND EQUIPMENT.
2. ALL EQUIPMENT AND PRODUCT IDENTIFICATIONS TO BE FIELD LOCATED UNLESS OTHERWISE NOTED.
3. MARKINGS SHALL BE LOCATED SO THEY CAN BE EASILY READ AND UNOBSTRUCTED BY EQUIPMENT, ACCESS STAIRS & PLATFORMS, RELIEF PIPING, ETC.
4. MARKINGS SHALL BE VISIBLE FROM THE POINT OF NORMAL APPROACH.
5. PIPE MARKINGS SHALL BE PLACED NEAR VALVES, PRODUCT LINE DESIGNATIONS AND CHANGES IN PIPE DIRECTION AND AT SPACING AS INDICATED.
6. ALL PRODUCT IDENTIFICATION LETTERING AND LABELS SHALL BE VINYL STICK-ON.
7. SAMPLE LETTERING/LABELS SHALL BE PROVIDED FOR OWNER REVIEW/APPROVAL.
8. REFERENCE CODES FOR VALVE TAG SHAPES AND COLOR CODING AS PER PETROLEUM PRODUCTS DISTRIBUTION SYSTEMS 151930:
   - NATIONAL FIRE CODE OF CANADA 2010.
   - CPPI RECOMMENDED PRACTICE 2009.
9. ALL IDENTIFYING LETTERS SHALL BE UPPER CASE ARIAL FONT OR SIMILAR.
10. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE NOTED.

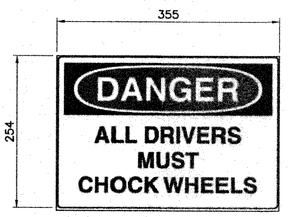
DETAIL 5 — 240-260-0003
FIRE EXTINGUISHER SIGN
SCALE: 1:5



DETAIL 6 — 240-260-0002
NO SMOKING OR OPEN FLAME
SCALE: 1:5



DETAIL 7 — 240-260-0002
AUTHORIZED PERSONNEL SIGN
SCALE: 1:5



DETAIL 8 — 240-260-0003
CHOCK WHEELS SIGN
SCALE: 1:5

PERMIT TO PRACTICE
HATCH LTD.
Signature
Date 15/07/25
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

DRAWING No.	DRAWING TITLE
H353004-10000-240-260-0003-0001	MINE SITE TANK FARM MODULE & PIPING SIGNAGE
H353004-10000-240-260-0002-0001	MINE SITE TANK FARM TK-005 ARCTIC DIESEL TANK SIGNAGE

REFERENCE DRAWINGS

REGISTERED PROFESSIONAL ENGINEER — F.E. BUTTS — LICENSEE — NT/NU

REG. PROFESSIONAL

ISSUED FOR CONSTRUCTION

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No.	DESCRIPTION	BY	CHK'D	DATE
0	ISSUED FOR CONSTRUCTION	SJM	MMI	18/07/25
A	ISSUED FOR PARALLEL REVIEW	SJM	MMI	18-07-20

REVISIONS

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	S. J. McNEIL	NR	18-07-06
DESIGNER	K. MacLEAN	NR	18-07-06
CHECKER	M. MacINTYRE	Michael MacIntyre	18/07/25
DESIGN COORD.	M. MacINTYRE	Michael MacIntyre	18/07/25
RESP. ENG.	F. BUTTS		15/07/25
LEAD DISC. ENG.	F. BUTTS		15/07/25
ENG. MANAGER	D. STANGER		15/7/25
PROJ. MANAGER			
CLIENT	T. ATIBA		18/7/25

DRAWING APPROVAL STATUS: Approved for Construction

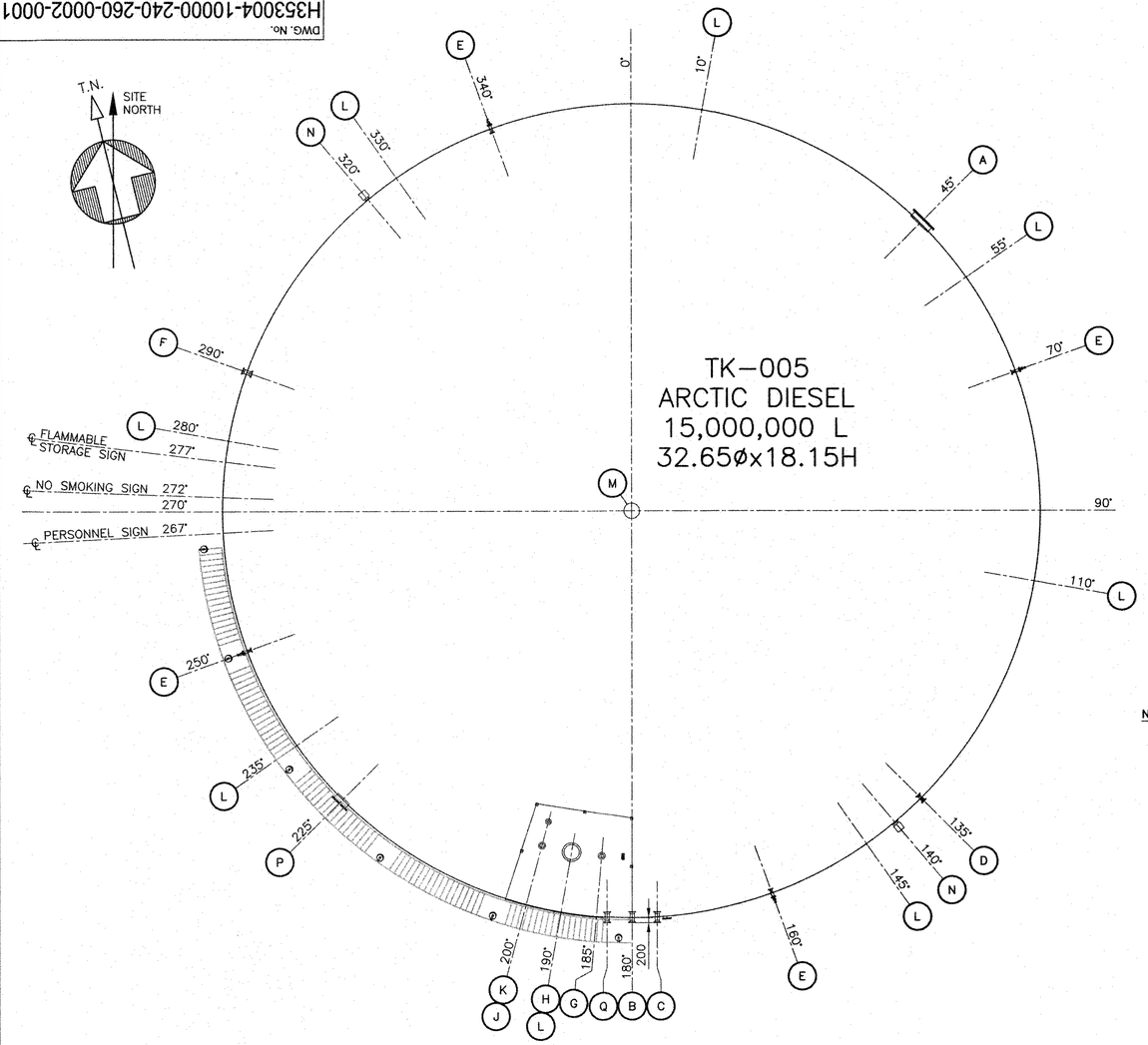
Baffinland

MARY RIVER EXPANSION PROJECT
BAFFINLAND IRON MINES LP

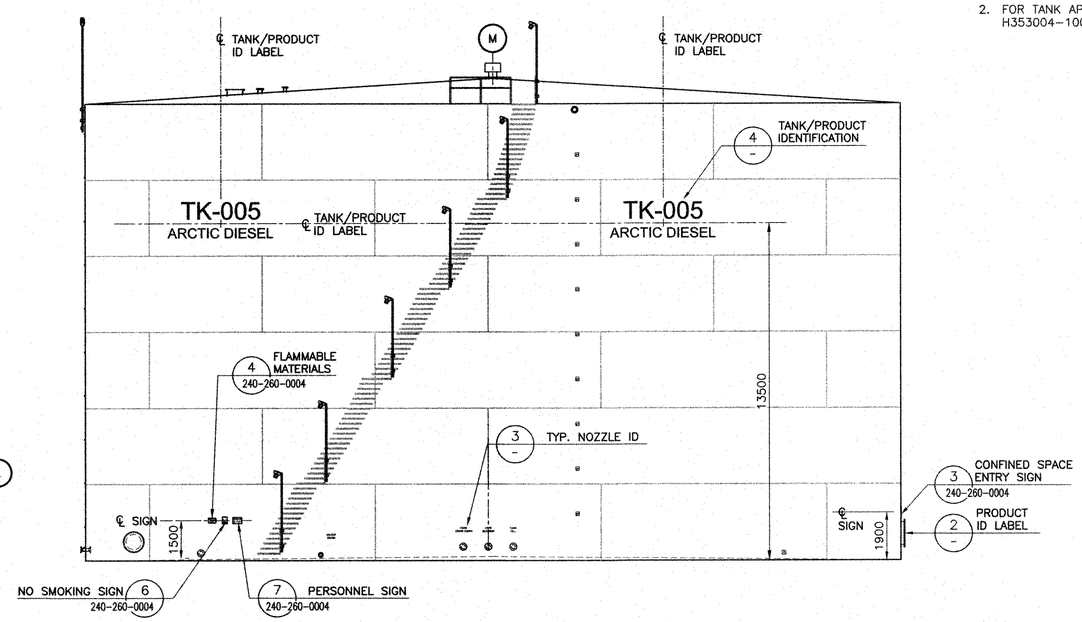
MINE SITE
TANK FARM
OPERATING PROCEDURES SIGNAGE

SCALE: AS NOTED OR AS NOTED
DWG. No. H353004-10000-240-260-0004-0001
REV 0
SHEET SIZE: A1

DWG. No. H353004-10000-240-260-0002-0001



PLAN
TANK ORIENTATION
SCALE: 1:125
1
240–272–0004



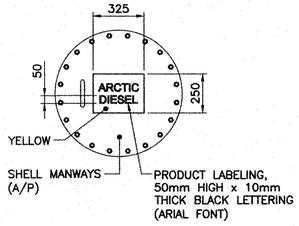
ELEVATION
TANK ORIENTATION
SCALE: 1:125
1
240–272–0004

NOTES:

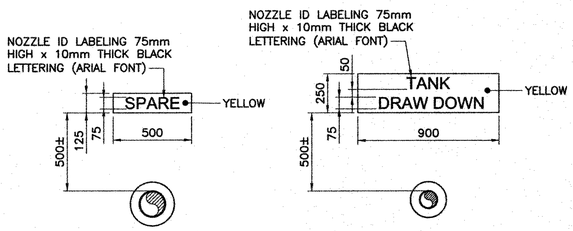
1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE NOTED.
2. FOR TANK APPURTENANCES SEE DRAWING H353004–10000–240–270–0001–0001.

TANK NOZZLE IDENTIFICATION CHART

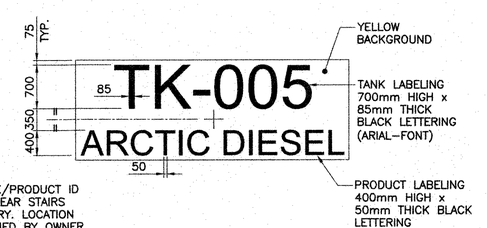
IDENTIFICATION LABEL	NOZZLE LOCATION	TEXT SIZE (MM)	TEXT COLOR	APPURTENANCE ITEM
MANWAY	SHELL	75x10	YELLOW	A/P
TANK SUCTION	SHELL	75x10	YELLOW	B
TANK FILL	SHELL	75x10	YELLOW	C
SPARE	SHELL	75x10	YELLOW	D
WATER DRAIN	SHELL	75x10	YELLOW	E
SPARE	SHELL	75x10	YELLOW	F
GAUGE HATCH	ROOF	75x10	YELLOW	G
MANWAY	ROOF	75x10	YELLOW	H
RADAR GAUGE	ROOF	75x10	YELLOW	J
OVERFILL PROBE	ROOF	75x10	YELLOW	K
ROOF VENT	ROOF	75x10	YELLOW	M
FOAM CONNECTION	SHELL	75x10	YELLOW	N
TANK DRAW DOWN	SHELL	75x10	YELLOW	Q



DETAIL
PRODUCT ID LABEL
SCALE: 1:20
2



DETAIL
TYP. NOZZLE ID
SCALE: 1:20
3



NOTE:
ADJUST TANK/PRODUCT ID LABEL TO CLEAR STAIRS AS NECESSARY. LOCATION TO BE VERIFIED BY OWNER.

DETAIL
TANK/PRODUCT ID
SCALE: .1:50
4

PERMIT TO PRACTICE
HATCH LTD.
Signature
Date 18/07/25
PERMIT NUMBER: P 512
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

DRAWING No.	DRAWING TITLE
H353004-10000-240-272-0004-0001	MINE SITE TANK FARM SITE SIGNAGE
H353004-10000-240-270-0001-0001	MINE SITE FUEL SYSTEM 15,000,000L DIESEL STORAGE TANK
H353004-10000-240-260-0004-0001	MINE SITE TANK FARM OPERATING PROCEDURES SIGNAGE

REFERENCE DRAWINGS

REGISTERED PROFESSIONAL ENGINEER — F.E. BUTTS — LICENSEE — NT/NU

ISSUED FOR CONSTRUCTION

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No.	DESCRIPTION	BY	CHK'D	DATE
0	ISSUED FOR CONSTRUCTION	SJM	MMI	18/07/25
A	ISSUED FOR PARALLEL REVIEW	SJM	MMI	18-07-20

REVISIONS

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	S. J. McNEIL	NR	18-07-04
DESIGNER	K. MacLEAN	NR	18-07-04
CHECKER	M. MacINTYRE	Michael MacIntyre	18/07/25
DESIGN COORD.	M. MacINTYRE	Michael MacIntyre	18/07/25
RESP. ENG.	F. BUTTS		18/07/25
LEAD DISC. ENG.	F. BUTTS		18/07/25
ENG. MANAGER	D. STANGER		18/7/25
PROJ. MANAGER			
CLIENT	T. ATIBA		18/7/25

DRAWING APPROVAL STATUS: Approved for Construction

Baffinland

MARY RIVER EXPANSION PROJECT
BAFFINLAND IRON MINES LP

MINE SITE
TANK FARM
TK-005 ARCTIC DIESEL TANK SIGNAGE

SCALE	DWG. No.	REV
AS NOTED OR AS NOTED	H353004-10000-240-260-0002-0001	0

SHEET SIZE: A1

ATTACHMENT 14

COMPLIANCE REPORT

Knight Piésold CONSULTING

TABLE 14.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325
COMPLIANCE ASSESSMENT

Print Sep/28/18 14:27:40

Clause	Condition Details	Compliance Assessment July 3, 2018[1]	Compliance Status Sept 17, 2018[2]
Part A: Scope, Definitions, and Enforcement			
1		N/A	
2		N/A	
3		N/A	
Part B: General Conditions			
1	This Amended Licence incorporates the entire scope of Type "B" Water Licences Nos. 8BCMRY1314 and 8BC-MRY1416, issued to the Mary River Project for construction and site preparation work; specific elements of the scope of Type "B" Licence No. 2BB-MRY1114 (currently replaced by Licence No 2BE-MRY1421), issued to the Project for the Exploration and Bulk Sample Programs; most of the scope of the Existing Type "A" Water Licence No. 2AM-MRY1325, and most of the scope of Amendment No.1 Application, which includes the Early Revenue Phase (ERP) activities and facilities. To the extent that any required reports, studies or plans having not yet been received and accepted or approved by the Board, the requirements associated with such documents are now brought forward under this Amended Licence.	N/A	
2	In the event of a conflict amongst the Type "B" Licences, the Existing Licence and the Amended Licence referred to in Part B, Item 1, the terms and conditions of the Amended Licence will prevail unless otherwise advised by the Board in writing.	N/A	
3	The amount of Water use fees shall be determined and payment of those fees shall be made in accordance with section 12 of the Regulations.	In compliance	
4	The Licensee shall file an Annual Report with the Board no later than the 31st of March in the year following the calendar year being reported. The Annual Report shall be developed in accordance with Schedule B.	In compliance	
5	The Licensee shall maintain a copy of this Licence at the sites of operation at all times, in English, Inuktitut, and French.	In compliance	
6	Any communication with respect to this Licence shall be made in writing to the attention of:	In compliance	
	Manager of Licensing Nunavut Water Board P. O. Box 119 Gjoa Haven, NU X0B 1J0 Telephone: (867) 360-6338 Fax: (867) 360-6369 Email: licensing@nwb-oen.ca		
7	Any notice made to an Inspector shall be made in writing to the attention of:	In compliance	
	Water Resources Officer Nunavut District, Nunavut Region P.O. Box 100 Iqaluit, NU X0A 0H0 Telephone: (867) 975-4295 Fax: (867) 979-6445		
8	The Licensee shall submit one (1) paper copy and one (1) electronic copy of all reports, studies, and plans to the Board or as otherwise requested by the Board in writing. Reports and/or studies submitted to the Board by the Licensee shall include an executive summary in English, Inuktitut, and French.	In compliance	
9	This Licence is assignable as provided in section 44 of the Act.	In compliance	
10	The Licensee shall notify the NWB of any major or significant changes in development plans, phase, or conditions associated with the Project, including commencement of the full Operations Phase and other phases associated with the Project, at least sixty (60) days prior to carrying such changes.	In compliance	
11	The Licensee shall post signs in the appropriate areas to inform the public of the location of infrastructure and/or facilities designed to contain, withhold, divert or retain Water and/or Waste. All signs must be in English, Inuktitut, and French.	Not compliant	In compliance
12	The Licensee shall, for all Plans submitted under this Licence, include a proposed timetable for implementation. Plans submitted for approval/acceptance, cannot be undertaken without subsequent written Board approval and/or direction. The Board may alter or modify a Plan if necessary to achieve the objectives of the Licence or other regulatory instruments. For plans submitted for Board approval, the Board will notify the Licensee in writing of the Board's approval, rejection, or alteration of the Plan. Plans or drawings submitted to the Board for review and/or comments do not necessarily require Board approval prior to implementation; however, the Board may request revisions to those Plans, as required.	In compliance	
13	In the event that a Plan submitted for approval is not approved by the Board, the Licensee shall provide a revised version of the Plan to the Board for review within thirty (30) days of notification by the Board or within the timeframe specified in the Board's notification.	In compliance	

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14	The Licensee shall, for all Plans submitted for approval under this Licence, implement the Plan as approved by the Board in writing. The Board has approved under this Licence or carried forward from the Existing Licence the following Plans for implementation under the relevant sections in the Amendment Licence:	In compliance	
a	*Emergency Response Plan* (BAF-PH1-840-P16-0002, Rev 0), March 3, 2015;	In compliance	
b	*Spill Contingency Plan* (BAF-PH1-840-P16-0036, Rev 1), March 16, 2015;	In compliance	
c	*Surface Water and Aquatic Ecosystems Management Plan* (BAF-PH1-830-P16-0026, Rev 3);	In compliance	
d	*Fresh Water Supply, Sewage and Wastewater Management Plan* (BAF-PH1-830-P16-0010, Rev 3), March 19, 2015;	In compliance	
e	*Waste Management Plan* (BAF-PH1-830-P16-0028, Rev 3), March 20, 2015;	In compliance	
f	*Life-of Mine Waste Rock Management Plan* (BAF-PH1-830-P16-0031, Rev 0), April 30, 2014;	In compliance	
g	Baffinland Iron Mines Corporation Mary River Project Attachment 5: Environmental Monitoring Plan (EMP) Appendix 10D-12, dated January 2012;	In compliance	
h	*Environmental Protection Plan* (BAF-PH1-830-P16-0008, Rev 0), July 15, 2014;	In compliance	
i	*Borrow Pit and Quarry Management Plan* (BAF-PH1-830-P16-0004, Rev 0), March 20, 2014;	In compliance	
j	Baffinland Iron Mines Corporation Mary River Project Operations and Management Plan Milne Inlet Quarry (Q1), dated January 12, 2012;	In compliance	
k	Baffinland Iron Mines Corporation Mary River Project Operations and Management Plan Mary River Mine Site Quarry (QMR2) dated January 12, 2012;	In compliance	
l	Baffinland Iron Mines Corporation Mary River Project Operations and Management Plan Steensby Inlet Quarry (QS2), dated January 12, 2012;	In compliance	
m	Baffinland Iron Mines Corporation Mary River Project Quarry Operations and Management Plan: Quarry Q7 + 500, dated January 11, 2012;	In compliance	
n	Baffinland Iron Mines Corporation Mary River Project Quarry Operations and Management Plan: Quarry Q133 +500, dated January 11, 2012;	In compliance	
o	Baffinland Iron Mines Corporation Mary River Project Quarry Operations and Management Plan: Quarry Q77 +200, dated February 2012;	In compliance	
p	Preliminary Mine Closure and Reclamation Plan Appendix 10G, dated February 2012;	In compliance	
q	*Hazardous Materials and Hazardous Waste Management Plan* (BAF-PH1-830-P16-0011, Rev 3), March 20, 2015	In compliance	
r	Aquatic Effects Monitoring Program Framework, dated February 2013.	In compliance	
s	*Phase 1 Waste Rock Management Plan* (BAF-PH1-830-P16-0029, Rev 0), April 30, 2014;	In compliance	
15	Every Plan to be carried out pursuant to the terms and conditions of this Licence shall become a part of this Licence, and any additional terms and condition imposed upon approval of a Plan by the Board shall become part of this Licence. All terms and conditions of the Licence should be contemplated in the development of a Plan where appropriate.	In compliance	
16	The Licence shall refer to the Schedules attached to this Licence for instructive details and interpretive guidance regarding requirements associated with specific terms and conditions included in the main body of the Licence. If the Board subsequently determines that an item included in a Schedule requires revision in order to better reflect the intent and objectives of the Licence, the Board may at its discretion and upon providing written notice to the Licensee and interested parties, revise the Schedule accordingly. Unless the Board directs otherwise, such revision may not necessarily be construed as an “amendment” to the Licence.	In compliance	
17	The Licensee shall review the Plans or Manuals referred to in this Licence as required by changes in operation and/or technology and modify the Plans or Manuals accordingly. Revisions to the Plans or Manuals are to be submitted in the form of Addenda to be included with the Annual Report required by Part B, Item 4, complete with a revisions list detailing where significant content changes are made.	In compliance	
18	The Licensee shall confirm that all document(s) or correspondence submitted by the Licensee to the Board is received and acknowledged by the Manager of Licensing.	In compliance	
19	The expiry or cancellation of this Licence does not relieve the Licensee from any obligation imposed by the Licence, or any other regulatory requirement.	N/A	

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Clause	Condition Details	Compliance Assessment July 3, 2018[1]	Compliance Status Sept 17, 2018[2]
Part C: Conditions Applying to Security			
1	Subject to the conditions set out in Part C, Items 2 and 3, the Licensee shall furnish and maintain security with the Minister in the form that is satisfactory to the Minister or that is in accordance with the applicable regulations, in the following amounts:	In compliance	
a	within thirty (30) days following notification by the Board, the Licensee shall post with the Minister and the Qikiqtani Inuit Association, additional financial security to that already posted under the Licence in the amount and form as determined by the Annual Security Review process referred to in Part C, Item 1(b), or Part C, Item 1(c), and/or based on the written notification from the Board and stipulations included the section pertaining to reclamation in the Board's Reasons for Decision for the Amended Licence;	In compliance	
b	for each subsequent year, the amount of financial security to be held under this Part shall be reviewed by the Board in accordance with the requirements of Schedule C and adjusted to reflect the results of the Annual Security Review conducted in accordance with Schedule C; and	In compliance	
c	the Board may waive the requirements to hold the Annual Security Review referred to in Part C, Item 1(b) provided that adequate rationale is given to stakeholders and interested parties in advance of doing so including the determination that the Project's scope proposed for a particular year may result in only negligible changes to the amount of financial security already posted and create no unsecured environmental risk or liabilities to the public and stakeholders.	N/A	
2	Where the Licensee files evidence, in writing with the Board and with notice to the Minister and the Qikiqtani Inuit Association that the Licensee has furnished and maintained security with the Qikiqtani Inuit Association in an amount that the Qikiqtani Inuit Association confirms is sufficient to secure the mine closure and reclamation costs (including cumulative and legacy liabilities) estimated for the upcoming year to be required for the portion of the Project located on Inuit-owned lands, the Board may reduce the amount of security required to be held under Part C, Item 1. The Board shall ensure that the reduced amount of security furnished under Part C, Item1 is equal to the estimated anticipated mine closure and reclamation costs (including cumulative and legacy liabilities) for the portion of the Project located on Crown-owned lands for the upcoming year.	N/A	
3	In addition to the Annual Security Review set out in Schedule C, the Licensee may, at any time, submit to the Board for consideration and approval, a request to change the amount of security outlined in Part C, Item 1. The submission shall include supporting evidence to justify the request, and the Minister and the Qikiqtani Inuit Association will be consulted by the Board during the Board's consideration of this request.	N/A	
4	The security furnished and maintained with the Minister, under Part C, Item 1, shall be maintained until such time as it is fully or in part refunded by the Minister pursuant to section 76(5) of the Act. This clause shall survive the expiry of this Licence or renewals thereof and until full and final reclamation has been completed to the satisfaction of the Minister.	In compliance	
5	In the event that the amount of security required to be held under Part C, Item 1 is reduced on the basis of evidence that the Licensee has furnished and maintained security with the Qikiqtani Inuit Association as set out under Part C, Item 2, the Licensee is required to provide the Board and the Minister with sixty (60) days written notice prior to any material change affecting the security arrangements between the Licensee and the Qikiqtani Inuit Association, including, but not limited to the form of security, quantum of security or terms associated with holding, accessing or releasing the security.	N/A	
6	If the Board determines it to be necessary, or upon the request of the Licensee, the Minister or the Qikiqtani Inuit Association, the Board may issue further directions under this Part with respect to the amount of security to be furnished and maintained under the Licence.	N/A	
Part D: Conditions Applying to Construction and Operations			
1	All final design and construction drawings shall be stamped and signed by a Professional Engineer.	In compliance	
2	The Licensee shall submit to the Board for review and acceptance, at least sixty (60) days prior to construction or in a timeframe otherwise approved by the Board in writing, final design and for-construction drawings, stamped and signed by a Professional Engineer, for all infrastructure and/or facilities designed to contain, withhold, divert or retain Water and/or Waste, as authorized under the Licence.	In compliance	
3	Quarrying activities shall be conducted in accordance with all applicable legislation, guidelines and industry standards including the Northern Land Use Guidelines, Pits and Quarries (INAC, 2009).	In compliance	
4	The Licensee shall implement sediment and erosion control measures, as required, prior to and during all Phases of the Mary River Project to prevent and/or minimize sediment loading into Water.	In compliance	

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Clause	Condition Details	Compliance Assessment July 3, 2018[1]	Compliance Status Sept 17, 2018[2]
5	The Board has approved, with the issuance of the Amended Licence or the carried forward from the Existing Licence, the following Plans:	In compliance	
a	*Borrow Pit and Quarry Management Plan* (BAF-PH1-830-P16-0004, Rev 0), March 20, 2014;	In compliance	
b	*Baffinland Iron Mines Corporation Mary River Project Operations and Management Plan Milne Inlet Quarry (Q1)* , dated January 12, 2012;	In compliance	
c	*Baffinland Iron Mines Corporation Mary River Project Operations and Management Plan Mary River Mine Site Quarry (QMR2),* dated January 12, 2012;	In compliance	
d	*Baffinland Iron Mines Corporation Mary River Project Operations and Management Plan Steensby Inlet Quarry (QS2)* , dated January 12, 2012;	In compliance	
e	*Baffinland Iron Mines Corporation Mary River Project Quarry Operations and Management Plan: Quarry Q7 + 500* , dated January 11, 2012;	In compliance	
f	*Baffinland Iron Mines Corporation Mary River Project Quarry Operations and Management Plan: Quarry Q133 +500* , dated January 11, 2012;	In compliance	
g	*Baffinland Iron Mines Corporation Mary River Project Quarry Operations and Management Plan: Quarry Q77 +200* , dated February 2012; and	In compliance	
h	*Phase 1 Waste Rock Management Plan* (BAF-PH1-830-P16-0029, Rev 0), April 30, 2014.	In compliance	
6	The Licensee shall submit to the Board for review, an addendum to the Plan referred to in Part D, Item ~~6a~~ 5a for any quarry site selected for future development that the plan does not adequately address. If the content of the existing quarry plan referred to under Part D, Item ~~6a~~, 5a does not adequately address the proposed activities for the management requirements of the selected Quarry site, the Licensee shall submit to the Board for approval, a site-specific Quarry management plan.	In compliance	
7	The Licensee shall inspect daily, the areas of the Mary River Project site affected activities during the Construction, Operations and other phase of the project, including the Early Revenue Phase, for signs of erosion.	In compliance	
8	The Licensee shall implement preventive and mitigation measures to prevent any Wastes associated with the undertaking from entering any Water bodies.	In compliance	
9	The Licensee shall locate equipment storage areas on gravel, sand or other durable land, at a distance of at least thirty-one (31) metres above the ordinary High Water Mark of any Water body in order to minimize impacts on surface drainage and Water quality.	In compliance	
10	The Licensee shall minimize disturbance to terrain, permafrost and drainage during movement of contractors' equipment and personnel around the site, including the railway corridor, during all phases of the Project.	In compliance	
11	The Licensee shall not store material on the surface of frozen streams or lakes except what is required for immediate use.	In compliance	
12	The Licensee shall use fill material for construction from approved sources that have been demonstrated by appropriate geochemical analyses to not possess Acid-Generating and Metal Leaching properties.	Not compliant	In compliance
13	The Licensee shall maintain a minimum thirty-one (31) metre undisturbed buffer zone between the periphery of Quarry sites and the ordinary High Water Mark of any Water body unless otherwise approved by the Board in writing. The Licensee shall not excavate and/or remove material from any Quarry beyond a depth of one (1) meter above the ordinary High Water Mark or above the groundwater table, to prevent the potential contamination of groundwater unless otherwise approved by the Board in writing. The Licensee shall construct and operate the Mine Site and associated infrastructure and facilities in accordance with all applicable legislation and industry standards.	In compliance	
14	All surface runoff from Quarry activities associated with the Project, where flow may directly or indirectly enter a Water body, shall be sampled Weekly and not exceed the Effluent quality limits under Part D, Item 15.	In compliance	
15	All surface runoff during all phases of the Project, where flow may directly or indirectly enter a Water body, shall be sampled Weekly and not exceed the following Effluent quality limits:	In compliance	
16	The Licensee shall supervise and field check through an appropriately qualified Engineer, all construction of Engineered Structures in such a manner that the Project specification can be enforced, and where required, the quality control measures followed.	In compliance	
17	The Licensee shall submit a Construction Summary Report to the Board, within ninety (90) days following the completion of any structure designed to contain, withhold, divert or retain Waters or Wastes, as authorized by the Board. The construction summary report shall be prepared by an Engineer(s) in accordance with Schedule D, Item 1.	In compliance	
18	The Licensee shall conduct inspections of earthworks and geological and hydrological regimes of the Project Biannually during the summer or as otherwise approved by the Board in writing. The inspection shall be conducted by a Geotechnical Engineer and the inspection report shall be submitted to the Board within sixty (60) days of the inspection, including a cover letter from the Licensee outlining an implementation plan to respond to the Engineer's recommendations.	In compliance	

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Clause	Condition Details	Compliance Assessment July 3, 2018[1]	Compliance Status Sept 17, 2018[2]
19	The Licensee shall prevent any chemicals, fuel or Wastes associated with the undertaking from entering any Water body.	Not compliant	In compliance
20	The Licensee shall not erect camps or store material on the surface of frozen streams or lakes including the immediate banks except what is for immediate use. Camps shall be located such that impact on surface drainage is minimized.	Not compliant	In compliance
21	The Licensee shall undertake necessary corrective measures to mitigate impact on surface drainage resulting from the Licensee's activities.	In compliance	
22	For the purposes of culvert and bridge installations, the Licensee shall not encroach on the natural channel width by the placement of abutments, footings or armoring below the ordinary High Water Mark.	In compliance	
23	The Licensee shall construct and operate all infrastructure and Facilities authorized by the Board that are designed to contain, withhold, divert or retain Water and/or Waste, in accordance with all applicable legislation and industry standards.	Not compliant	In compliance
24	The Licensee shall construct and operate the Bulk Fuel Storage Facilities in accordance with all applicable legislation and industry standards, including:	Not compliant	In compliance
a	CCME *Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products* (2003); and		
b	National Fire Code of Canada (2010).		
25	The Licensee shall prevent the deposition of debris or sediment from entering into or onto any Water body, with respect to the construction of access roads, site laydown pads and areas or other earthworks. These materials shall be disposed of at a distance of at least thirty-one (31) metres from the ordinary High Water Mark in such a manner that they do not enter the Water.	In compliance	
Part E: Conditions Applying to Water Use and Management			
1	The Board has approved the Plan entitled Fresh Water Supply, Sewage and Wastewater Management Plan (BAF-PH1-830-P16-0010, Rev 3), March 19, 2015, submitted as additional information with the 2014 Annual Report.	In compliance	
2	The Board has approved the Plan entitled Surface Water and Aquatic Ecosystems Management Plan (BAF-PH1-830-P16-0026, Rev 3), submitted as additional information with the 2014 Annual Report.	In compliance	
3	The Licensee shall obtain all fresh Water for domestic camp use and industrial purposes, during the Construction Phase of the Project, in amounts and from the sources described in Table 2, or from sources otherwise approved by the Board in writing. In addition to the source-specific limits prescribed in Table 2, the Licensee is authorized to use up to one thousand eight hundred and eighty-eight (1,888) cubic metres of Water per day, to a maximum of six hundred and eighty-nine thousand (689,000) cubic metres of Water annually, during the Construction Phase of the Project.	In compliance	
4	Licensee shall provide notice to the Board, as required under Part B, Item 10, in advance of using fresh Water for domestic camp use and industrial purposes during the Operations Phase of the Project in amounts and from the sources described in Table 3, or from sources otherwise approved by the Board in writing. In addition to the source-specific limits prescribed in the Table 3, the Licensee is authorized to withdraw up to nine hundred and sixty-seven (967) cubic metres of water per day, to a maximum of three hundred and fifty-three thousand (353,000) cubic metres of Water annually, during the Operations Phase of the Project.	In compliance	
5	The Licensee may recycle water and use reclaimed water from the various Treatment Facilities, surface water management ponds and embankment dams and approved discharge locations under the licence if such waters meet appropriate discharge criteria for those facilities.	In compliance	
6	The Licensee shall equip all Water intake hoses with screens of an appropriate mesh size, consistent with the requirements of Fisheries and Ocean (DFO) Canada's *Freshwater Intake End-of-Pipe Fish Screen Guidelines* (1995), to prevent the entrainment of fish and control withdraw of Water at rates such that fish do not become impinged on the screen.	In compliance	
7	The Licensee shall document separately the use of Waters on, in or flowing through Inuit owned lands and Crown Lands as required under Part I, Item 7 in the Licence.	In compliance	
8	Streams or Water Bodies cannot be used as a Water source unless authorized and approved by the Board in writing.	In compliance	
9	The Licensee shall notify the Inspector and the Board at least ten (10) days in advance of using Water from any sources not identified in the Application or requiring approval as per Part E, Item 8.	In compliance	
10	The Licensee shall update or revise annually following the commencement of the Operations Phase and/or the Early Revenue Phase, the Project Block-flow Diagram Water Supply Balance information for the various Project sites provided with the Application, and submit the revisions, for review by the Board, with the Annual Report under Part B, Item 4.	In compliance	
11	The Licensee shall carry out weekly inspections of all structures designed to contain, withhold, divert or retain Waters or Wastes during periods of flow and maintain records of the inspections and findings, for review upon the request by the Board or an Inspector.	In compliance	

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Clause	Condition Details	Compliance Assessment July 3, 2018[1]	Compliance Status Sept 17, 2018[2]
12	The Licensee shall not remove any material from below the ordinary High Water Mark of any water body unless authorized.	In compliance	
13	The Licensee shall not cause erosion to the banks of any body of Water and shall provide necessary controls to prevent such erosion.	In compliance	
14	The Licensee shall, where the use of Water of a sufficient volume would likely result in the drawdown of the source Water body involved or dewatering of the specific Water body is anticipated, submit the following for the approval of the Board in writing:	In compliance	
a	the volume of Water required;	In compliance	
b	a hydrological overview of the Water body;	In compliance	
c	details of impact; and	In compliance	
d	Proposed mitigation measures.	In compliance	
15	The Licensee shall, for winter-lake and stream crossings, including ice bridges, construct entirely of water, ice or snow and minimize disturbance by locating ice bridges in an area that requires the minimum approach grading and the shortest crossing route. Stream crossings shall be removed or the ice notched prior to spring break-up.	In compliance	
16	The Licensee shall not utilize any equipment or vehicles in the course of this undertaking unless the ground surface is in a state capable of fully supporting the equipment or vehicles without rutting or gouging. Overland travel of equipment or vehicles shall cease if rutting occurs.	In compliance	
17	The Licensee shall designate an area for the deposition of excavated and stockpiled materials that is at least thirty-one (31) metres above the ordinary High Water Mark of any water body.	In compliance	
18	The Licensee shall not cut any stream bank or remove any material from below the ordinary High Water Mark of any Water body.	In compliance	
19	The Licensee shall undertake appropriate corrective measures to mitigate impacts on surface drainage resulting from the Licensee's operations.	Not compliant	Partially compliant
20	The Licensee shall limit any in-stream activity, as much as possible, to low Water periods. In-stream activity is prohibited during fish migration.	In compliance	
21	The Licensee shall locate stream crossings to minimize approach grades. Approaches shall be stabilized during construction and upon completion of Project activities, to control runoff, erosion and subsequent siltation to any Water body.	In compliance	
22	The Licensee shall not permit machinery to travel up the stream bed and fording of any Water body is to be kept to a minimum and limited to one area. Equipment used should be well cleaned and free of oil and grease and maintained free of fluid leaks.	In compliance	
23	The Licensee shall provide to the Board for review, for-construction design drawings for stream culverts, bridges and any other structures, which may impact the quantity, quality and flow of water, at least thirty (30) days prior to construction.	In compliance	
24	The Licensee shall submit to the Board for review, at least thirty (30) days prior to implementation, copies of separate Blasting Management Plans developed for the mining operation, tunnelling of the railway and blasting near water bodies as committed to during the Public Hearing.	In compliance	
25	The Licensee is authorized to withdraw up to 1,500 m3 / day to a maximum of 547,500 m3 annually of Water specifically for use in dust suppression or control along the Tote Road during the Early Revenue Phase (ERP) of the Project. Water for dust suppression or control shall be obtained from the sources in accordance with thresholds established in Table 2-3.	In compliance	
26	The Licensee shall obtain authorization from the Board in writing prior to using Water authorized under Part E, Item 25, for purposes other than that authorized in Part E, Item 25.	In compliance	
Part F: Conditions Applying to Waste Disposal and Management			
1	The Board has approved, the Plan entitled Waste Management Plan (BAF-PH1-830-P16-0028, Rev 3), March 20, 2015, submitted as additional information with the 2014 Annual Report.	In compliance	
2	The Board has approved the Plans entitled Phase 1 Waste Rock Management Plan (BAFPH1-830-P16-0029, Rev 0), April 30, 2014, and Life-of Mine Waste Rock Management Plan (BAF-PH1-830-P16-0031, Rev 0), April 30, 2014, submitted as additional information with the 2014 Annual report.	In compliance	
3	Future updates to the Plans referenced in Part F, Item 2 should include or address changes pertaining to the following:	In compliance	
a	Updates to the on-going Waste Rock Characterization Program (including the further refinement of acid rock drainage and metal leaching aspects of the foot wall and hanging wall;	In compliance	
b	Any additional details on the segregation of potentially acid generating waste rock;	In compliance	
c	Update to the geochemical modeling;	In compliance	
d	Update on pit water quality predictions;	In compliance	
e	Results of ongoing humidity cell kinetic test-work;	In compliance	
f	The incorporation of on-site test pile program results with respect to ARD/ML and impacts to modeling results; and	In compliance	
g	Waste Rock Storage Facilities with consideration for climate change.	In compliance	
4	The Board has approved the Plan entitled Hazardous Materials and Hazardous Waste Management Plan (BAF-PH1-830-P16-0011, Rev 3), March 20, 2015, submitted as additional information with the 2014 Annual Report.	Not compliant	In compliance

TABLE 14.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325
COMPLIANCE ASSESSMENT

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Clause	Condition Details	Compliance Assessment July 3, 2018[1]	Compliance Status Sept 17, 2018[2]
5	The Licensee shall locate areas designated for Waste disposal at a minimum distance of thirty-one (31) metres from the ordinary High Water Mark of any Water body such that the quality, quantity or flow of Water is not impaired, unless otherwise approved by the Board in writing.	In compliance	
6	The Licensee is authorized to dispose of all acceptable food waste, paper waste and untreated wood products in an Incinerator System;	In compliance	
7	The Licensee shall test the bottom ash generated by all Incinerator Systems, by using the acceptable test procedures for analyzing residuals, prior to being disposed of at any Landfill Facility. If the composition of the ash makes it unsuitable for disposal at the Landfill facilities, the Licensee shall direct the Waste to an appropriate facility for disposal. The records of analytical results and volumes of ash shall be maintained and provided to an Inspector or the Board upon request.	In compliance	
8	The Licensee shall not open burn plastics, wood treated with preservatives, electric wire, Styrofoam, asbestos or painted wood, to prevent the deposition of waste materials of incomplete combustion and/or leachate from contaminated ash residual, from impacting any surrounding Waters, unless otherwise approved by the Board in writing.	In compliance	
9	The Licensee shall treat oily water and wastewater generated by the Project at the Oily Water/Wastewater Treatment Facilities authorized under the scope of the Licence.	In compliance	
10	The Licensee shall submit to the Board and the Inspector, thirty (30) days prior to the removal and transfer of Waste, a declaration of authorization from any Hamlet community receiving Waste from the Project, which clearly states that authorization has been granted for the deposit of Waste by the Licensee at the Hamlet's appropriately licensed facilities.	In compliance	
11	The Licensee shall provide at least ten (10) days' notice to the Inspector prior to planned Discharges from any Waste Management Facility, Oily Water/Wastewater Treatment Facilities, Sewage Treatment Facilities, and any other relevant facilities associated with the Project. The notice shall include the estimated volume proposed for Discharge and the location and description of the receiving environment.	In compliance	
12	The Licensee shall, unless otherwise approved by the Board in writing, discharge Effluent at a distance of least thirty-one (31) metres above the Ordinary High Water Mark of any Water body, where direct flow into the Water body is not possible, such that surface erosion is minimized and no additional impacts are created.	In compliance	
13	The Licensee shall remove any Waste generated from temporary and permanent shelters along the Tote Road and along the railway corridor for treatment at appropriately licenced Waste Management Facilities.	In compliance	
14	The Licensee shall direct all Sewage generated from the relevant Project sites to the Sewage Treatment Facilities or as otherwise approved by the Board in writing.	In compliance	
15	The Licensee shall treat all Sewage waste generated at the Ravn River and Mid-Rail camps and Sewage generated at the Cockburn North and Cockburn South camps at either the Mine Site Sewage Treatment Facility or the Steensby Port Sewage Treatment Facility, unless otherwise approved by the Board in writing.	In compliance	
16	The Licensee shall provide to the Board for review, at least sixty (60) days prior to installation, detailed specifications and operational requirements for the Sewage storage tanks proposed for the Railway camps.	In compliance	
17	All discharge from the Sewage Treatment Facilities including the Polishing Waste Stabilization Ponds directly into fresh Water bodies at Monitoring Stations MP-01, MP-01a, MP-MRY-04, MP-MRY-04a, MS-01, MS-01a, MS-MRY-04, MS-MRY-04a, and/or from monitoring stations as otherwise approved by the Board in writing, must not exceed the following Effluent quality limits:	Not compliant	In compliance
18	All discharge from the Sewage Treatment Facilities including the Polishing Waste Stabilization Ponds at Monitoring Stations SP-01, SP-01a, and/or from monitoring stations as otherwise approved by the Board in writing, directly into the ocean or to ditches flowing into the ocean shall not exceed the following Effluent quality limits:	Not compliant	In compliance
19	Sludge generated from the Sewage Treatment Facilities or any other facilities shall be confirmed to be non-hazardous and the results provided to the Board for review prior to disposal at any Landfill Facility or as otherwise approved by the Board in writing.	In compliance	
20	All discharge from the Oily Water/Wastewater Treatment Facilities at Monitoring Stations MP-02, MS-02, SP-02, and/or from monitoring stations as otherwise approved by the Board in writing, must not exceed the following Effluent quality limits:	In compliance	
21	All discharge from the Landfill Facilities at Monitoring Stations MS-MRY-13a, MS- MRY-13b and SP-08, and/or from monitoring stations as otherwise approved by the Board in writing must not exceed the following Effluent quality limits:	In compliance	
22	All discharge from the Bulk Fuel Storage Facilities at Monitoring Stations MP-03, MPMRY-7, MS-03, MS-04, MS-MRY-6, SP-04 and SP-05 and/or from monitoring stations as otherwise approved by the Board in writing, must not exceed the following Effluent quality limits:	Not compliant	In compliance
23	All discharge from the Landfarm Facilities at Monitoring Stations MP-04, MS-05 and SP-06, and/or from monitoring stations as otherwise approved by the Board in writing, must not exceed the following Effluent quality limits:	In compliance	

TABLE 14.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325
COMPLIANCE ASSESSMENT

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Clause	Condition Details	Compliance Assessment July 3, 2018[1]	Compliance Status Sept 17, 2018[2]
24	All Discharge from the Bulk Sample Open Pit, Bulk Sample Weathered Ore Stockpile, Bulk Sample Processing Stockpile Area and Bulk Sample Stockpile Area Seepage and runoff from the at Milne Inlet at Monitoring Stations MS-MRY-09, MS-MRY-10, MS-MRY-11, MP-MRY-12 and/or monitoring stations as otherwise approved by the Board shall not exceed the following Effluent quality limits:	In compliance	
25	All discharge from the Ponds associated with the Run of Mine Ore Stockpile, Ore Stockpile, West and East Sediment Ponds at Monitoring stations MS-06+, MS-07, MS-08, MS-09 and SP-07 and/or from monitoring stations as otherwise approved by the Board in writing shall not exceed the Effluent quality limits of Part F, Item ~~25~~ 24.	Not compliant	In compliance
26	All Contact Water and surface runoff from the site Drainage and Surface Water Management Systems where flow may directly or indirectly enter a Water body, shall be sampled Weekly during the Operations Phase and/or Early Revenue Phase of the Project and must not exceed the following Effluent quality limits:	In compliance	
27	The Licensee shall incorporate best management practices including ditches, diversions, sumps and berms where necessary to minimize or prevent surface runoff from entering nearby Water bodies from Quarry and borrow pit sites.	In compliance	
28	The Licensee shall remove from the project site, all Hazardous Wastes generated through the course of the Construction, Operations, and Early Revenue Phases, for disposal at an approved Waste Disposal Facility.	In compliance	
29	The Licensee shall maintain records of all Waste backhauled from the Mary River Project and confirmation of proper disposal through the use of Waste manifest tracking systems and registration with the Government of Nunavut – Department of Environment. These records shall be made available upon request, to an Inspector or the Board.	In compliance	
Part G: Conditions Applying to Modifications			
1	The Licensee may, without written consent from the Board, carry out Modifications provided that such Modifications are consistent with the terms of this Licence and the following requirements are met:	In compliance	
a	The Licensee has notified the Board in writing of such proposed Modifications at least sixty (60) days prior to beginning the Modifications;	In compliance	
b	Such Modifications do not place the Licensee in contravention of the Licence or the Act;	In compliance	
c	Such Modifications are consistent with the NIRB Project Certificate;	In compliance	
d	The Board has not, within sixty (60) days following notification of the proposed Modifications, informed the Licensee that review of the proposal will require more than sixty (60) days; and	In compliance	
e	The Board has not rejected the proposed Modifications.	In compliance	
2	Modifications for which any of the conditions referred to in Part G, Item 1 have not been met can be carried out only with written approval from the Board.	In compliance	
3	Applications for modifications shall contain:	In compliance	
a	A description of the facilities and/or works to be constructed;	In compliance	
b	The proposed location of the structure(s);	In compliance	
c	Identification of any potential impacts to the receiving environment;	In compliance	
d	A description of any monitoring required, including sampling locations, parameters measured and frequencies of sampling;	In compliance	
e	Schedule for construction;	In compliance	
f	Drawings of engineered structures stamped by a Professional Engineer; and	In compliance	
g	Proposed sediment and erosion control measures.	In compliance	
4	The Licensee shall provide as-built plans and drawings of the Modifications referred to in this Licence within ninety (90) days of completion of the Modification. These plans and drawings shall be stamped by an Engineer.	In compliance	
Part H: Conditions Applying to Emergency Response and Contingency Planning			
1	The Board has approved the Plans entitled *Spill Contingency Plan* (BAF-PH1-840-P16-0036, Rev 1), March 16, 2015, and *Emergency Response Plan* (BAF-PH1-840-P16-0002, Rev 0), March 3, 2015, submitted as additional information with the 2014 Annual Report.	In compliance	
2	The Licensee shall prevent any chemicals, petroleum products or wastes associated with the project from entering water. All sumps and fuel caches shall be located at a distance of at least thirty-one (31) metres from the ordinary High Water Mark of any adjacent water body and inspected on a regular basis.	In compliance	
3	The Licensee shall provide secondary containment for fuel and chemical storage as required by applicable standards and acceptable industry practice.	Not compliant	In compliance
4	The Licensee shall perform weekly inspections of fuel containment facilities for leaks and settlement and shall keep a written log of inspections to be made available to an Inspector upon request.	In compliance	
5	The Licensee shall maintain and service any equipment in designated areas and shall implement special procedures (such as the use of drip pans) to manage Waste and contain potential spills.	In compliance	
6	If the Licensee provides notification under Part J, Item 13, the Licensee shall submit to the Board, an Addendum to the Emergency Response Plan and the Spill Contingency Plan, detailing the changes in operations, personnel, responsibilities, availability of equipment and access to the site for assistance.	In compliance	

TABLE 14.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325
COMPLIANCE ASSESSMENT

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Clause	Condition Details	Compliance Assessment July 3, 2018[1]	Compliance Status Sept 17, 2018[2]
7	The Licensee shall keep a copy of the Emergency Response Plan and the Spill Contingency Plan at each site of operations.	In compliance	
8	The Licensee shall conduct emergency maintenance and servicing on equipment, in designated areas, and shall implement measures to collect motor fluids and other Waste and prevent and contain spills.	In compliance	
9	If during the period of this Licence, an unauthorized Discharge of Waste and/or Effluent occurs, or if such a Discharge is foreseeable, the Licensee shall:	In compliance	
a	Employ as required, the Emergency Response Plan and the Spill Contingency Plan;	In compliance	
b	Report the incident immediately via the 24-Hour Spill Reporting Line (867) 920-8130 and to the Inspector at (867) 975-4295; and	In compliance	
c	For each spill occurrence, submit a detailed report to the Inspector, no later than thirty (30) days after initially reporting the event, which includes the amount and type of spilled product, the GPS location of the spill, and the measures taken to contain, clean up and restore the spill site.	In compliance	
10	The Licensee shall, in addition to Part H, Item 9, regardless of the quantity of release of a harmful substance, report to the NWT/NU Spill Line if the release is near or into a Water body.	In compliance	
11	The Licensee shall implement measures to prevent or minimize any chemicals, petroleum products or wastes associated with the project from entering Water. All sumps and fuel caches shall be located at a distance of at least thirty-one (31) meters from the ordinary High Water Mark of any adjacent Water body and inspected on a regular basis.	In compliance	
Part I: Conditions Applying to General and Aquatic Effects Monitoring			
1	The Board has approved with the issuance of the Licence, for the Construction Phase of the Project, the plan entitled *Aquatic Effects Monitoring Program (AEMP) Framework* , dated February 2013, applicable during the Construction Phase of the Project.	In compliance	
2	The Licensee shall submit to the Board, for approval in writing, at least sixty (60) days following approval of this Amendment, a revised version of the Plan entitled *Aquatic Effects Management Plan* (BAF-PH1-830-P16-0039, Rev 0), June 27, 2014, that addresses the relevant comments received from intervening parties during the review period for the Plan. The Plan under this condition, once approved, will supersede the Plan referenced in Part I, Item 1.	In compliance	
3	The Board has approved, with the issuance of the licence, the Plan entitled Environmental Protection Plan Appendix BAF-PH1-830-P16-0008, Rev 0), July 15, 2014, submitted as additional information with the 2014 Annual Report.	In compliance	
4	The Board has approved with the issuance of the licence, the Plan entitled Baffinland Iron Mines Corporation Mary River Project Attachment: 5 Environmental Monitoring Plan Appendix 10D-12, dated January 2012. The Plan referred to in Part I, Item 2 will supersede the Plan under this condition, once approved.	In compliance	
5	The Licensee shall undertake the Monitoring Program as stipulated in Schedule I.	In compliance	
6	The Licensee shall confirm the locations and GPS coordinates for all Monitoring stations referred to in Schedule I, and any additional monitoring stations that may be required, with an Inspector.	In compliance	
7	The Licensee shall provide the GPS co-ordinates (in degrees, minutes and seconds of latitude and longitude) of all locations where sources of Water are utilized for all purposes. The Licensee shall report these coordinates to the Inspector prior to the use of Water.	In compliance	
8	The Licensee shall determine the GPS co-ordinates (in degrees, minutes and seconds of latitude and longitude) of all locations of temporary and permanent storage and/or deposit of Wastes associated with the Mary River Project. The Licensee shall report these coordinates to the Inspector prior to depositing Waste.	In compliance	
9	The Licensee shall install and maintain flow meters or other such devices, or implement suitable methods required for the measuring of Water and Waste volumes, to be operated and maintained to the satisfaction of an Inspector.	In compliance	
10	The Licensee shall install and maintain signs that identify the Monitoring Stations, posted in English, Inuktitut, and French.	In compliance	
11	The Licensee shall measure and record the following in cubic metres or as otherwise stated:	In compliance	
a	The volume of fresh Water obtained from all Water sources associated with the Project. Water quantities from sources in, on or flowing through Crown Lands and those through Inuit-owned lands are to be provided separately;	In compliance	
b	The volume, source, and end use of reclaim or recycled water used for any purposes under this licence;	In compliance	
c	The volume of Sewage sludge removed from the Sewage Treatment Facilities;	In compliance	
d	Tonnes of mineralized and un-mineralized waste rock stored at the end of the calendar year being reported; and	In compliance	
e	Tonnes of ore stored at the Project sites at the end of the calendar year and the tonnes of ore shipped annually in relationship to the Project.	In compliance	

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TABLE 14.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325
COMPLIANCE ASSESSMENT

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Clause	Condition Details	Compliance Assessment July 3, 2018[1]	Compliance Status Sept 17, 2018[2]
12	The Licensee shall undertake a geotechnical inspection of all engineered facilities designed to contain Water or Waste, to be carried out bi-annually by a Geotechnical Engineer, between the months of July and September. The inspection shall be conducted in accordance with the Canadian Dam Safety Guidelines, where applicable and including the following:	In compliance	
a	Pit walls	In compliance	
b	Quarries	In compliance	
c	Landfills	In compliance	
d	Landfarms	In compliance	
e	Bulk Fuel Storage Facilities	In compliance	
f	Sediment Ponds	In compliance	
g	Collection ponds	In compliance	
h	Polishing Waste Stabilization Ponds	In compliance	
13	The Licensee shall submit to the Board, within sixty (60) days of completion of the geotechnical inspection referred to in Part I, Item 12, a Geotechnical Engineer's Report that shall include a cover letter from the Licensee outlining an implementation plan to address the recommendations of the Geotechnical Engineer.	In compliance	
14	The Licensee shall monitor and report to an Inspector, Seepage from all facilities designed to contain, withhold, divert or retain Water or Wastes and submit the results and an interpretation of the Seepage monitoring carried out, in the Annual Report required under Part B, Item 4.	In compliance	
15	The Licensee shall obtain a digital photographic record of all the watercourse crossings before, during, and after the completion of construction as required under Schedule D, Item 1.	In compliance	
16	The Licensee shall submit to an Analyst for approval, within six (6) months of the Licence issuance, an updated Quality Assurance / Quality Control Plan that includes sampling and analysis requirements and addresses additional monitoring required under the ERP and/or changes to the Project. This Plan shall be developed in accordance with the 1996 *Quality Assurance (QA) and Quality Control (QC) Guidelines for Use by Class "A" Licensees in Meeting SNP Requirements and for Submission of a QA / QC Plan* (INAC).	In compliance	
17	If the Analyst does not approve the Plan referred to in Part I, Item 16, the Licensee shall revise the Plan and resubmit to the Analyst for approval.	In compliance	
18	The Licensee shall annually review the approved Quality Assurance/Quality Control plan and modify it as necessary. Proposed modifications shall be submitted to an Analyst for approval.	In compliance	
19	All sampling, sample preservation and analyses shall be conducted in accordance with methods prescribed in the most current edition of *Standard Methods for the Examination of Water and Wastewater* , or by other such methods approved by an Analyst.	In compliance	
20	All compliance analyses shall be performed in a Canadian Association for Environmental Analytical Laboratories (CAEAL) accredited laboratory according to ISO/IEC Standard 17025. The accreditation shall be current and in good standing.	In compliance	
21	The Licensee shall submit to the Board, within thirty (30) days following the month being reported, a Monthly Monitoring Report. The Report shall include:	In compliance	
a	All data and information required by this Part and generated by the Monitoring Program in the tables of Schedule I;	In compliance	
b	An assessment of data to identify areas of non-compliance with regulated discharge parameters referred to in Part F;	In compliance	
22	The License shall, with the assistance of an Inspector, establish additional Monitoring Stations, as may be required to effectively and adequately monitor surface runoff from the Mary River Project site(s) or discharge from Site Drainage and Surface Water Management System water associated with the Mary River Project. Within thirty (30) days of establishment of additional Monitoring Stations, the Licensee shall inform the Board and the Inspector.	In compliance	
23	The Licensee shall monitor runoff and/or discharge from borrow pits and rock Quarry sites, on a monthly basis, for the following parameters:	In compliance	
a	Total Suspend Solid (TSS)	Not compliant	In compliance
b	Oil and Grease	In compliance	
c	Ammonia (total NH3-N)	In compliance	
d	Nitrate (total NO3-N)	In compliance	
e	pH	In compliance	
f	Conductivity; and	In compliance	
g	Demonstrate to be non-acutely toxic.	In compliance	
24	The Licensee shall, in addition to Part I, Item 23, during periods of flow and following a major precipitation event, conduct opportunistic monitoring on a monthly basis on any observed flows related to Effluent quality limits under Part D, Item 15 and the monitoring requirements as established under Part I, Item 23, for any flows originating from borrow pits or rock quarries.	In compliance	

TABLE 14.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325
COMPLIANCE ASSESSMENT

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Clause	Condition Details	Compliance Assessment July 3, 2018[1]	Compliance Status Sept 17, 2018[2]
25	The Licensee shall monitor surface runoff and/or discharge of the monitoring stations downstream of construction areas at Milne Port Site and the Mary River Mine Site as indicated in Tables 13 and 14 of Schedule I, to comply with Effluent quality limits under Part D, Item 15.	In compliance	
26	An Inspector may impose additional monitoring requirements.	In compliance	
27	The Licensee shall include in the Annual Report, required under Part B, Item 4, all monitoring results and information required by this Part.	In compliance	
28	The NWB can modify the Monitoring Program as set out in Schedule I without a public Hearing. Requests for changes to the Monitoring Program should be forwarded to the NWB in writing, and should include the justification for the change.	In compliance	
Part J: Conditions Applying to Abandonment, Reclamation and Closure			
1	The Board has approved, with the issuance of the Licence, the Plan entitled Baffinland Iron Mines Corporation Mary River Project Preliminary Mine Closure and Reclamation Plan Appendix 10G dated February 2012 as part of the Application.	In compliance	
2	The Licensee shall to submit to the Board for Approval in writing, within sixty (60) days following approval of this Amendment, a revised version of the Plan entitled Interim Closure and Reclamation Plan (BAF-PH1-830-P16-0012, Rev 3), March 19, 2015, that addresses the relevant comments and recommendations provided by intervening parties during the review period. The Plan under this section will supersede the Plan referred to in Part J, Item 1 once approved and must address all mine related components including the following:	In compliance	
a	Detailed description, including maps and other visual representations, of the preconstruction conditions for each site, accompanied by a detailed description of the proposed final landscape, with emphasis on the reclamation of surface drainage over the restored area;	In compliance	
b	A description of how progressive reclamation will be employed and monitored throughout the life of the mine, plus reclamation scheduling and coordination of activities with the overall sequence of the project; details of reclamation scheduling and procedures for coordinating reclamation activities within the overall mining sequence and materials balance;	In compliance	
c	Implications of any updated water balance and water quality model prediction results and any adaptive management measures that may be required;	In compliance	
d	An evaluation of closure and reclamation measures for each mine component, including the goals, objectives, closure criteria and the rationale for selection of the preferred measures;	In compliance	
e	A comprehensive assessment of materials suitability, including geochemical and physical characterization and a schedule of availability for reclamation needs. Particular attention shall be given to cover materials, including maps showing sources and stockpile locations of all reclamation construction materials;	In compliance	
f	An assessment and description of any required post-closure treatment for pit water that is not acceptable for discharge, taking into consideration further studies completed and updated modeling information;	In compliance	
g	Contingency measures for all reclamation components including action thresholds that are linked to the monitoring programs;	In compliance	
h	Monitoring programs to assess reclamation performance and environmental conditions including monitoring locations for surface water and Ground Water, parameters;	In compliance	
i	Monitoring schedules and overall timeframes;	In compliance	
j	QA/QC procedures for managing the demolition landfill and other waste disposal areas;	In compliance	
k	A list of non-salvageable materials and disposal locations;	In compliance	
l	Rock storage facility closure design plans and sections including the types of material placed and volumes;	In compliance	
m	Protocol for the disposal of any contaminated soil;	In compliance	
n	An assessment of the long-term physical stability of all remaining project components;	In compliance	
o	A revised closure and reclamation cost estimate; and	In compliance	
p	A detailed implementation schedule for completion of reclamation work	In compliance	
3	The Licensee shall, on an annual basis, provide an annual work plan and updated estimate of anticipated mine closure and reclamation costs for the upcoming year, shall in accordance with the requirements of Schedule J.	In compliance	
4	The Licensee shall submit to the Board, for approval in writing, at least twelve (12) months prior to the expected end of the mining life of the Project, a Final Closure and Reclamation Plan. The plan shall incorporate revisions, which reflect the pending closed status of the mine, and include:	N/A	
a	Soil Quality Remediation Objectives along with CCME Guidelines and the Government of Nunavut Environmental Guideline for Site Remediation;	N/A	
b	Environmental Site Assessment plans in accordance Canadian Standards Association (CSA) criteria; and	N/A	
c	An evaluation of the Human Health and Ecological Risk Assessment required for the associated closure options.	N/A	

TABLE 14.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325
COMPLIANCE ASSESSMENT

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Clause	Condition Details	Compliance Assessment July 3, 2018[1]	Compliance Status Sept 17, 2018[2]
5	The Licensee shall remediate hydrocarbon contaminated soils associated with the Project's bladder tank farms and treat to meet the appropriate remedial objectives consistent with the use of the remediated soil as well as the requirements of the Government of Nunavut Guidelines, or as otherwise approved by the Board in writing.	N/A	
6	The Licensee shall provide to the Board, for approval in writing, at least sixty (60) days prior to commencing reclamation activities at any bulk (fuel bladder) storage facility impacted by hydrocarbon contamination, a remediation action plan that meets at minimum, the objectives as outlined in the Government of Nunavut's Environmental Guideline for Site Remediation, 2010. The use of reclaimed soils for the purpose of back fill or general site grading may be carried out only upon consultation and approval by the Government of Nunavut, Department of Environment and an Inspector.	N/A	
7	The Licensee shall backfill and restore, to the satisfaction of an Inspector, all sumps to the pre-existing natural contours of the land.	N/A	
8	The Licensee shall, unless otherwise identified within the approved Plan under Part J, Item 1, and/or Part J, Item 2 remove all Culverts and open the natural drainage channel. In carrying out this activity, measures shall be implemented to minimize erosion and sedimentation.	N/A	
9	The Licensee shall contour and stabilize all disturbed areas to a pre-disturbed state upon completion of work.	N/A	
10	In order to promote growth of vegetation and the needed microclimate for seed deposition, all disturbed surfaces shall be prepared by ripping, grading, or scarifying the surface to conform to the natural topography.	N/A	
11	The Licensee shall implement progressive reclamation including re-vegetation as soon as practically possible and shall update all Plans to reflect such measures.	N/A	
12	Areas that have been contaminated by hydrocarbons from normal fuel transfer procedures shall be reclaimed to meet objectives as outlined in the Government of Nunavut's Environmental Guideline for Site Remediation (2010). The use of reclaimed soils for the purpose of back fill or general site grading may be carried out only upon consultation and approval by the Government of Nunavut, Department of Environment and an Inspector.	N/A	
13	The Licensee shall notify the Board in writing, at least sixty (60) days prior to entering into a Care and Maintenance Phase.	N/A	
14	Within thirty (30) days of the Licensee providing the Board with notification of the Licensee's intention to enter into Care and Maintenance, the Licensee shall provide the Board with a Care and Maintenance Plan that details the Licensee's plans for maintaining compliance with the Terms and Conditions of the Licence.	N/A	
15	The Licensee shall remove from the site, all infrastructure and site materials, including but not limited to, all fuel caches, drums, barrels, buildings and contents, docks, water pumps and lines, material and equipment prior to the expiry of this Licence.	N/A	
16	The Licensee shall notify the Board in writing, at least sixty (60) days prior to any intent to achieve Recognized Closed Mine status.	N/A	

I:\1\02\00181\45\A\Report\2 - Water Licence Amendment Application TSD\Rev 4\Attachment 14 - Compliance Report\[180926-2AM-MRY1325-Att-14-Compliance-Assessment (final).xlsx]Table

NOTES:

1. BASED ON AN INTERNAL COMPLIANCE ASSESSMENT FROM SITE AND USING THE 2017 QIA/NWB ANNUAL REPORT FOR OPERATIONS AND A MAY 2018 INAC INSPECTION REPORT.

2. BASED ON THE STATUS OF ACTIONS TAKEN TO ADDRESS NON-COMPLIANCE, AS OF SEPTEMBER 17, 2018. SEE TABLE 14.2 FOR FURTHER DETAILS.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
4	26SEP'18	ISSUED WITH REPORT NB102-181/45-2	AMH	RAC

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TABLE 14.2

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325
STATUS OF RESOLUTION OF NON-COMPLIANCE ITEMS

Print Sep/28/18 14:46:52

Clause	Condition Details	Description of Non-compliance	Status of Resolution (Sept 17, 2018)
Part B: General Conditions			
11	The Licensee shall post signs in the appropriate areas to inform the public of the location of infrastructure and/or facilities designed to contain, withhold, divert or retain Water and/or Waste. All signs must be in English, Inuktitut, and French.	Signs were not posted as required.	Baffinland is in the process of posting signs in appropriate locations across the Mary River Project site. Signage has been erected in locations such as the Mary River Non-Hazardous Waste Landfill and stormwater ponds at Mary River and Milne Port. As infrastructure is constructed and/or upgraded, Baffinland will ensure appropriate signage is posted.
Part D: Conditions Applying to Construction and Operations			
12	The Licensee shall use fill material for construction from approved sources that have been demonstrated by appropriate geochemical analyses to not possess Acid-Generating and Metal Leaching properties.	Largely compliant although the May 2018 inspection report noted that the helicopter pad was topped with ore. Baffinland will remove the ore topping.	Ore topping at the helicopter pad has been removed and replaced with aggregate material. It should be noted that the previously placed ore material was potentially acid-generating (PAG), however runoff downstream of the area showed no evidence of metal leaching.
15	All surface runoff during all phases of the Project, where flow may directly or indirectly enter a Water body, shall be sampled Weekly and not exceed the following Effluent quality limits:	Partially compliant, Baffinland experienced sedimentation events at Project sites during freshet. To address the sedimentation events and ongoing sedimentation concerns at the Project, Baffinland continued to implement corrective and mitigation measures, including initiatives outlined in the Sedimentation Mitigation Action Plan, Dust Mitigation Action Plan and Tote Road Earthworks Execution Plan. In each case appropriate control measures were implemented to restore TSS levels below applicable discharge criteria.	Baffinland continues to implement corrective and mitigative measures to address sedimentation events during freshet and other runoff events. Baffinland works to ensure that sedimentation events are minimized to the greatest extent possible, and implements appropriate control measures if these events do occur. In 2018 Baffinland experienced significantly fewer sedimentation events than in 2017, demonstrating the effectiveness of the implemented mitigative measures.
19	The Licensee shall prevent any chemicals, fuel or Wastes associated with the undertaking from entering any Water body.	Largely compliant although the May 2018 inspection report noted two containers with hazardous waste were left open and 4 drums of hazardous materials were left outside of hazardous waste berms at the Mine Site. North of the batch plant at Milne Port, contaminated soil was placed in drums however the drums were not sealed or in containment. Baffinland will ensure all employees are aware of secondary containment and storage requirements for all hazardous waste and materials at the Project.	Improperly stored hazardous waste and contaminated soil that was identified in the May 2018 inspection report has been moved to proper storage and labelled appropriately. Baffinland has made a concerted effort to improve hazardous waste management procedures in 2018, continually manifesting and properly storing waste in containers for backhaul as waste was produced. In addition, volumes of non-hazardous bulky waste were significantly reduced through strategic clean up and backhaul efforts (i.e. approximately 9000 used tires were removed from site).
20	The Licensee shall not erect camps or store material on the surface of frozen streams or lakes including the immediate banks except what is for immediate use. Camps shall be located such that impact on surface drainage is minimized.	Partially compliant, Baffinland received an INAC Inspector's Direction to stop work for a new accommodations camp pad that was in the process of being constructed during the time of inspection at Milne Port, in a location that impeded the flow of an ephemeral stream. Baffinland submitted Modification No. 3a to construct a surface water diversion ditch that would redirect surface water from the ephemeral stream around the pad. Following the receipt of approval, Baffinland completed construction of the surface water diversion ditch by late October 2017.	Baffinland acted immediately in response to the INAC Inspector's Direction, removing the contractor from site and stopping work. Upon evaluation and consultation with regulators, Baffinland constructed the surface water diversion ditch described in Modification No. 3a only when approval had been granted.
23	The Licensee shall construct and operate all infrastructure and Facilities authorized by the Board that are designed to contain, withhold, divert or retain Water and/or Waste, in accordance with all applicable legislation and industry standards.	Uncontrolled seepage was observed originating from the toe of the Waste Rock Facility (WRF) pond's berm during an onsite INAC and ECCC inspection in late August 2017. This had not been previously identified in routine internal inspections and annual third party geotechnical or regulator inspections. The seepage was reported by Baffinland to relevant regulators. In the May 2018 INAC inspection report, the inspector noted several concerns at the Crusher Facility and Waste Rock Facility regarding the condition of ditches designed to convey surface water to surface water management ponds. Baffinland is actively working to correct the concerns noted in the inspection report.	Remedial work has been completed on the ditches at the Crusher Facility to provide a uniform gradient and Baffinland continues to monitor all ditches to ensure they flow as intended. Baffinland is currently working at the WRF to ensure ditches are able to convey water effectively to the surface water management pond and continues to monitor that they flow as intended. The water treatment plant at the WRF went into operation in July 2018. The water treatment plant effectively treated water from the WRF in 2018, and the emergency ditch effectively contained minor seepage from the pond. Continued improvements to the WRF are planned including those detailed in Modification Request No. 8.

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TABLE 14.2

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325
STATUS OF RESOLUTION OF NON-COMPLIANCE ITEMS

Print Sep/28/18 14:46:52

Clause	Condition Details	Description of Non-compliance	Status of Resolution (Sept 17, 2018)
24	The Licensee shall construct and operate the Bulk Fuel Storage Facilities in accordance with all applicable legislation and industry standards, including:	Largely compliant, the May 2018 inspect report noted that the secondary fuel module near the Milne Port batch plant does not appear to be properly contained as the berms creating the containment area appear to have eroded away or the facility is full of sediment. Baffinland will ensure the fuel module is properly contained.	Remedial work to ensure the secondary fuel module near the Milne Port batch plant is properly contained has been performed.
a	CCME *Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products* (2003); and		
b	National Fire Code of Canada (2010).		
25	The Licensee shall prevent the deposition of debris or sediment from entering into or onto any Water body, with respect to the construction of access roads, site laydown pads and areas or other earthworks. These materials shall be disposed of at a distance of at least thirty-one (31) metres from the ordinary High Water Mark in such a manner that they do not enter the Water.	Partially compliant, Baffinland experienced sedimentation events at Project sites during freshet. To address the sedimentation events and ongoing sedimentation concerns at the Project, Baffinland continued to implement corrective and mitigation measures, including initiatives outlined in the Sedimentation Mitigation Action Plan, Dust Mitigation Action Plan and Tote Road Earthworks Execution Plan. In each case, appropriate control measures were implemented to restore TSS levels below applicable discharge criteria.	Baffinland continues to implement corrective and mitigative measures to address sedimentation events during freshet and other runoff events. Baffinland works to ensure that sedimentation events are minimized to the greatest extent possible, and implements appropriate control measures if these events do occur. In 2018 Baffinland experienced significantly fewer sedimentation events than in 2017 demonstrating the effectiveness of implemented mitigative measures.
Part E: Conditions Applying to Water Use and Management			
19	The Licensee shall undertake appropriate corrective measures to mitigate impacts on surface drainage resulting from the Licensee's operations.	Largely compliant, however in the May 2018 inspection report, the inspector noted several concerns at the Crusher Facility and Waste Rock Facility regarding the condition of ditches designed to convey surface water to surface water management ponds. Baffinland is actively working to correct the concerns noted in the inspection report.	Remedial work has been completed on the ditches at the Crusher Facility to provide a uniform gradient and Baffinland continues to monitor all ditches to ensure they flow as intended. Baffinland is currently working at the Waste Rock Facility to ensure ditches are able to convey water effectively to the surface water management pond and continues to monitor that they flow as intended.
25	The Licensee is authorized to withdraw up to 1,500 m3 / day to a maximum of 547,500 m3 annually of Water specifically for use in dust suppression or control along the Tote Road during the Early Revenue Phase (ERP) of the Project. Water for dust suppression or control shall be obtained from the sources in accordance with thresholds established in Table 2-3.	Partially compliant, during June, July and August several exceedances of daily withdrawal water limits occurred at 4 approved dust suppression water sources. Monthly withdrawal volumes were within the approved monthly withdrawal limits during summer months. Baffinland will continue to work on improving the enforcement of daily withdrawal limits at approved water sources along the Tote Road.	Baffinland has continued to work on improving enforcement of daily withdrawal limits at approved water sources along the Tote Road. Thus far in 2018 there have been fewer exceedances of daily withdrawal limits. It should be noted that Baffinland has never exceeded the monthly or annual withdrawal limits for any water source.
Part F: Conditions Applying to Waste Disposal and Management			
4	The Board has approved the Plan entitled Hazardous Materials and Hazardous Waste Management Plan (BAF-PH1-830-P16-0011, Rev 3), March 20, 2015, submitted as additional information with the 2014 Annual Report.	Non compliant; the May 2018 INAC inspection report noted hazardous materials (paint cans, oil filters and aerosol cans) at the landfill.	Hazardous materials in the landfill were removed and disposed of as per the Hazardous Materials and Hazardous Waste Management Plan. Baffinland implemented additional measures, including worker education, restricting landfill access to select departments to improve compliance, and installation of a new permanent litter fence to improve landfill function.
17	All discharge from the Sewage Treatment Facilities including the Polishing Waste Stabilization Ponds directly into fresh Water bodies at Monitoring Stations MP-01, MP-01a, MP-MRY-04, MP-MRY-04a, MS-01, MS-01a, MS-MRY-04, MS-MRY-04a, and/or from monitoring stations as otherwise approved by the Board in writing, must not exceed the following Effluent quality limits:	Partially compliant; treated sewage effluent exceeded the discharge limit for faecal coliforms once in February 2017 at MP-01. The exceedance was a result of effluent contamination due to operator error. The operator has since been retrained on the Project's procedures for transporting sewage and treated effluent.	Thus far in 2018 there has been one (1) exceedance of phosphorus and TSS of a sample for effluent discharge criteria for treated sewage effluent reported in January 2018. Subsequent samples that month reported concentrations meeting the applicable discharge criteria.
18	All discharge from the Sewage Treatment Facilities including the Polishing Waste Stabilization Ponds at Monitoring Stations SP-01, SP-01a, and/or from monitoring stations as otherwise approved by the Board in writing, directly into the ocean or to ditches flowing into the ocean shall not exceed the following Effluent quality limits:	Partially compliant; eight instances of untreated sewage spills were reported in 2017.	Baffinland continues to improve training and procedures regarding transfers of untreated sewage. Housing maintainers and operators perform daily inspections of sewage handling facilities and storage tanks. Baffinland continually performs overhauls and rebuilds on piping and storage tanks that pose potential risk to spills. For the 800-person camp at the Mine Site that is being constructed, sewage piping and facilities have been designed using lessons learned from previous issues to reduce the potential for spills.

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TABLE 14.2

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL

APPLICATION TO AMEND TYPE A WATER LICENCE 2AM-MRY1325
STATUS OF RESOLUTION OF NON-COMPLIANCE ITEMS

Print Sep/28/18 14:46:52

Clause	Condition Details	Description of Non-compliance	Status of Resolution (Sept 17, 2018)
22	All discharge from the Bulk Fuel Storage Facilities at Monitoring Stations MP-03, MPMRY-7, MS-03, MS-04, MS-MRY-6, SP-04 and SP-05 and/or from monitoring stations as otherwise approved by the Board in writing, must not exceed the following Effluent quality limits:	Three (3) exceedances of discharge limits occurred during discharges from Project containment areas in 2017 while using the Oily Water Treatment System. Treated effluent discharged from the Mine Site MS-HWB-7 (MS-MRY-6) on July 21, 2017 exceeded the total lead limit of 0.001 mg/L (effluent concentration of 0.0016 mg/L). On August 22, 2017, treated effluent discharged from the Milne Port Landfarm Facility (MP-04A) exceeded discharge limits for TSS and total lead of 15 mg/L and 0.001 mg/L (23 mg/L TSS and 0.0012 mg/L total lead). In both instances, discharge of effluent was stopped upon receiving the results, until samples of treated effluent from the OWTS could be demonstrated compliant with the discharge limits.	Baffinland continues to monitor discharge from Bulk Fuel Storage Facilities as required. As of July 2018 there have been no reported exceedances of applicable discharge criteria from Project contaminant areas while using the oil water treatment system. Baffinland purchased a new industry-standard oily water separator to replace older systems and to allow for more effective treatment of oily water on site.
25	All discharge from the Ponds associated with the Run of Mine Ore Stockpile, Ore Stockpile, West and East Sediment Ponds at Monitoring stations MS-06+, MS-07, MS-08, MS-09 and SP-07 and/or from monitoring stations as otherwise approved by the Board in writing shall not exceed the Effluent quality limits of Part F, Item ~~25~~ 24.	Non compliant; in August 2017, runoff collected in the Waste Rock Facility Pond (WRF Pond) dropped below the discharge limits for pH. Uncontrolled seepage originating from the toe of the WRF Pond's berm was observed during an inspection by INAC and ECCC in late August 2017. The uncontrolled seepage had not been previously identified in routine internal inspections and annual third party geotechnical inspections. Non-compliant discharges (pH and TSS) occurred in August-September 2017 and were reported as NT-NU Spill Reports 17-289, 17-312, 17-328 and 17-361.	All discharges from the WRF have been in compliance with discharge limits since Baffinland commissioned a dedicated water treatment plant in July 2018. The emergency ditch is effectively capturing minor seepage from the pond. Continued improvements to the WRF are planned to address the seepage, including those detailed in Modification Request No. 8.
Part H: Conditions Applying to Emergency Response and Contingency Planning			
3	The Licensee shall provide secondary containment for fuel and chemical storage as required by applicable standards and acceptable industry practice.	Largely compliant, the May 2018 inspect report noted that the secondary fuel module near the Milne Port batch plant does not appear to be properly contained as the berms creating the containment area appear to have eroded away or the facility is full of sediment. Baffinland will ensure the fuel module is properly contained.	Remedial work to ensure the secondary fuel module near the Milne Port batch plant is properly contained have been performed.
Part I: Conditions Applying to General and Aquatic Effects Monitoring			
23	The Licensee shall monitor runoff and/or discharge from borrow pits and rock Quarry sites, on a monthly basis, for the following parameters:	Partially compliant, there were five (5) incidents in 2017 where water samples collected downstream of quarry locations exceeded the discharge limit for TSS.	Baffinland continues to implement corrective and mitigation measures to address sedimentation concerns, including silt fences, rip-rap, geotextile, silt curtains and check dams to address elevated TSS levels. Compliance is improving; as of July 2018 there have been three (3) incidents this year of water samples collected downstream of quarry locations exceeding applicable discharge criteria.
a	Total Suspend Solid (TSS)		

I:\1\02\00181\45\A\Report\2 - Water Licence Amendment Application TSD\Rev 4\Attachment 14 - Compliance Report\[180926-2AM-MRY1325-Att-14-Compliance-Assessment (final).xlsx]Table 14.2

REV	DATE	DESCRIPTION	PREP'D	RVW'D
4	26SEP'18	ISSUED WITH REPORT NB102-181/45-2	AMH	RAC

ATTACHMENT 15

CORPORATE AND FINANCIAL INFORMATION

15.1 Articles of Amalgamation
15.2 Baffinland Officers

ATTACHMENT 15.1

ARTICLES OF AMALGAMATION

For Ministry Use Only
À l'usage exclusif du ministère

Ontario Corporation Number
Numéro de la société en Ontario

1904371

Ministry of Government Services
Ontario

Ministère des Services gouvernementaux

CERTIFICATE
This is to certify that these articles are effective on

CERTIFICAT
Ceci certifie que les présents statuts entrent en vigueur le

OCTOBER 0 9 OCTOBRE, 2013

Director / Directeur
Business Corporations Act / Loi sur les sociétés par actions

ARTICLES OF AMALGAMATION
STATUTS DE FUSION

Form 4
Business Corporations Act

Formule 4
Loi sur les sociétés par actions

1. The name of the amalgamated corporation is: (Set out in BLOCK CAPITAL LETTERS)
Dénomination sociale de la société issue de la fusion: (Écrire en LETTRES MAJUSCULES SEULEMENT) :

BAFFINLAND IRON MINES CORPORATION

2. The address of the registered office is:
Adresse du siège social :

120 Adelaide Street West
Street & Number or R.R. Number & if Multi-Office Building give Room No. /
Rue et numéro ou numéro de la R.R. et, s'il s'agit d'un édifice à bureaux, numéro du bureau

Toronto — ONTARIO — M5H1T1
Name of Municipality or Post Office / Nom de la municipalité ou du bureau de poste — Postal Code/Code postal

3. Number of directors is: / Nombre d'administrateurs :

Fixed number / Nombre fixe	OR minimum and maximum / OU minimum et maximum	
	1	10

4. The director(s) is/are: / Administrateur(s) :

First name, middle names and surname / Prénom, autres prénoms et nom de famille	Address for service, giving Street & No. or R.R. No., Municipality, Province, Country and Postal Code / Domicile élu, y compris la rue et le numéro ou le numéro de la R.R., le nom de la municipalité, la province, le pays et le code postal	Resident Canadian State 'Yes' or 'No' / Résident canadien Oui/Non
See attached Exhibit "A"		

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EXHIBIT "A"

First name, initials and surname *Prénom, initiales et nom de famille*	Address for service, giving Street & No. or R.R. No., Municipality and Postal Code. *Domicile élu, y compris la rue et le numéro, le numéro de la R.R. ou le nom de la municipalité et le code postal*	Resident Canadian State Yes or No *Résident Canadien Oui/Non*
William Scotting	120 Adelaide Street West Toronto, ON M5H 1T1	No
Carole Whittall	120 Adelaide Street West Toronto, ON M5H 1T1	No
Stephen J. Wood	120 Adelaide Street West Toronto, ON M5H 1T1	Yes
John Calvert	120 Adelaide Street West Toronto, ON M5H 1T1	No
Bruce Walter	120 Adelaide Street West Toronto, ON M5H 1T1	Yes
Jowdat Waheed	120 Adelaide Street West Toronto, ON M5H 1T1	Yes

5. Method of amalgamation, check A or B
Méthode choisie pour la fusion – Cocher A ou B :

A - **Amalgamation Agreement / Convention de fusion :**

☐ The amalgamation agreement has been duly adopted by the shareholders of each of the amalgamating corporations as required by subsection 176 (4) of the *Business Corporations Act* on the date set out below.

Les actionnaires de chaque société qui fusionnne ont dûment adopté la convention de fusion conformément au paragraphe 176(4) de la *Loi sur les sociétés par actions* à la date mentionnée ci-dessous.

or
ou

B - **Amalgamation of a holding corporation and one or more of its subsidiaries or amalgamation of subsidiaries / Fusion d'une société mère avec une ou plusieurs de ses filiales ou fusion de filiales :**

☑ The amalgamation has been approved by the directors of each amalgamating corporation by a resolution as required by section 177 of the *Business Corporations Act* on the date set out below.

Les administrateurs de chaque société qui fusionne ont approuvé la fusion par voie de résolution conformément à l'article 177 de la *Loi sur les sociétés par actions* à la date mentionnée ci-dessous.

The articles of amalgamation in substance contain the provisions of the articles of incorporation of
Les statuts de fusion reprennent essentiellement les dispositions des statuts constitutifs de

1843208 Ontario Inc.

and are more particularly set out in these articles.
et sont énoncés textuellement aux présents statuts.

Names of amalgamating corporations Dénomination sociale des sociétés qui fusionnent	Ontario Corporation Number Numéro de la société en Ontario	Date of Adoption/Approval Date d'adoption ou d'approbation Year / année	Month / mois	Day / jour
1843208 Ontario Inc.	1843208	2013	10	09
Baffinland Iron Mines Corporation	658456	2013	10	09

6. Restrictions, if any, on business the corporation may carry on or on powers the corporation may exercise.
Limites, s'il y a lieu, imposées aux activités commerciales ou aux pouvoirs de la société.

None.

7. The classes and any maximum number of shares that the corporation is authorized to issue:
Catégories et nombre maximal, s'il y a lieu, d'actions que la société est autorisée à émettre :

an unlimited number of Class A Common Shares;
an unlimited number of Class B Common Shares; and
an unlimited number of Preferred Shares.

8. Rights, privileges, restrictions and conditions (if any) attaching to each class of shares and directors authority with respect to any class of shares which may be issued in series:

Droits, privilèges, restrictions et conditions, s'il y a lieu, rattachés à chaque catégorie d'actions et pouvoirs des administrateurs relatifs à chaque catégorie d'actions qui peut être émise en série :

The holders of the Class A Common Shares, Class B Common Shares and Preferred Shares shall have the rights, privileges and are subject to the restrictions and conditions set out in Appendix A attached hereto as pages 4A to 4H,

9. The issue, transfer or ownership of shares is/is not restricted and the restrictions (if any) are as follows:
L'émission, le transfert ou la propriété d'actions est/n'est pas restreint. Les restrictions, s'il y a lieu, sont les suivantes :

Shares issued by the Corporation shall not be transferred without (a) complying with any restrictions on transfer contained in any unanimous shareholders agreement; and (b) the consent of either (i) the Board evidenced by a resolution passed or signed by the directors and recorded in the books of the Corporation; or (ii) the holders of a majority in number of the outstanding voting shares of the Corporation, in each case in accordance with any unanimous shareholders agreement.

10. Other provisions, (if any):
Autres dispositions, s'il y a lieu :

Securities of the Corporation, other than shares and non-convertible debt securities, shall not be transferred without compliance with the restrictions on transfer contained in the applicable securityholders' agreement or, absent any such restrictions, without the consent of the Secretary of the Corporation.

11. The statements required by subsection 178(2) of the *Business Corporations Act* are attached as Schedule "A".
Les déclarations exigées aux termes du paragraphe 178(2) de la *Loi sur les sociétés par actions* constituent l'annexe A.

12. A copy of the amalgamation agreement or directors' resolutions (as the case may be) is/are attached as Schedule "B".
Une copie de la convention de fusion ou les résolutions des administrateurs (selon le cas) constitue(nt) l'annexe B.

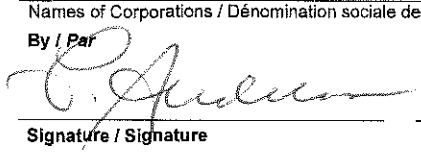
These articles are signed in duplicate.
Les présents statuts sont signés en double exemplaire.

Name and **original signature** of a director or authorized signing officer of each of the amalgamating corporations. Include the name of each corporation, the signatories name and description of office (e.g. president, secretary). **Only a director or authorized signing officer can sign on behalf of the corporation. /** Nom et **signature originale** d'un administrateur ou d'un signataire autorisé de chaque société qui fusionne. Indiquer la dénomination sociale de chaque société, le nom du signataire et sa fonction (p. ex. : président, secrétaire). **Seul un administrateur ou un dirigeant habilité peut signer au nom de la société.**

1843208 ONTARIO INC.

Names of Corporations / Dénomination sociale des sociétés

By / *Par*

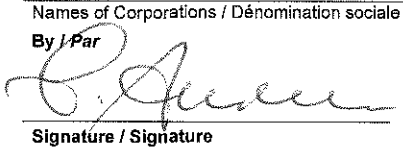


Signature / Signature	Stephanie Anderson Print name of signatory / Nom du signataire en lettres moulées	Chief Financial Officer Description of Office / Fonction

BAFFINLAND IRON MINES CORPORATION

Names of Corporations / Dénomination sociale des sociétés

By / *Par*



Signature / Signature	Stephanie Anderson Print name of signatory / Nom du signataire en lettres moulées	Chief Financial Officer Description of Office / Fonction

Names of Corporations / Dénomination sociale des sociétés

By / Par

Signature / Signature	Print name of signatory / Nom du signataire en lettres moulées	Description of Office / Fonction

Names of Corporations / Dénomination sociale des sociétés

By / Par

Signature / Signature	Print name of signatory / Nom du signataire en lettres moulées	Description of Office / Fonction

Names of Corporations / Dénomination sociale des sociétés

By / *Par*

Signature / *Signature*	Print name of signatory / Nom du signataire en lettres moulées	Description of Office / Fonction

APPENDIX A

DESCRIPTION OF SHARE CAPITAL

The rights, privileges, restrictions and conditions attached to each class of Shares are as follows:

1. DEFINITIONS

For the purposes of this Schedule A, capitalized terms used herein but not otherwise defined shall have the meanings ascribed to such terms under the USA (as defined herein), or as otherwise expressly provided below:

"**Act**" means the *Ontario Business Corporations Act*;

"**Applicable Preferred Share Redemption Amounts**" has the meaning given in section 2.5.1;

"**Conversion Date**" means the date on which the Preferred Shares will be, in accordance with the terms of the USA, converted to Common Shares;

"**holder**", "**securityholder**" or "**registered holder**" means a person who is registered on the securities register of a body corporate as the owner of securities;

"**Liquidation Event**" means either the liquidation, dissolution or winding-up of the affairs of the Corporation;

"**Operating Committee**" means the operating committee established by the shareholders of the corporation, provided that if no such committee shall exist at the relevant time, references to the "Operating Committee" shall be deemed to be a reference to the board of directors;

"**person**" means any individual, partnership, limited partnership, joint venture, syndicate, sole proprietorship, company or corporation with or without share capital, unincorporated association, trust, trustee, executor, administrator or other legal personal representative; and

"**Preferred Share Conversion Right**" has the meaning given in section 2.2.1;

"**Preferred Share Initial Issue Price**" means, with respect to each Preferred Share (subject to adjustments for stock dividends, splits, combinations and similar events), an amount in US dollars which is the US dollar equivalent of CDN$146,869.86, with such US dollar equivalent amount to be determined in accordance with section 8 hereof as of the Preferred Share Original Issue Date;

"**Preferred Share Junior Shares**" means, collectively, the Common Shares, and any other class of securities that is specifically designated as junior to the Preferred Shares;

"**Preferred Share Liquidation Preference**" has the meaning given in section 2.3.1;

"**Preferred Share Original Issue Date**" means the date the first Preferred Share is issued by the Corporation;

"**Preferred Share Redemption Date**" has the meaning given in section 2.5.3;

"**Preferred Share Redemption Election**" has the meaning given in section 2.5.1;

"**Preferred Share Redemption Notice**" has the meaning given in section 2.5.3;

"**USA**" means the Joint Venture Agreement of the Corporation, and immediately after the completion of the reorganization contemplated by section 2.1 of such Joint Venture Agreement (the "**USA Amendment Time**"), means the Shareholders Agreement between the Corporation and its shareholders, as the same may be amended, restated, revised or supplemented from time to time.

2. PREFERRED SHARES

2.1 Voting Rights.

2.1.1 Subject to section 2.1.2, the holders of the Preferred Shares as a class shall not be entitled as such to receive notice of, to attend or to vote at any meeting of the shareholders of the Corporation.

2.1.2 Subject to the provisions of the USA, the approval of the holders of Preferred Shares shall be required to add to, change or remove any rights, privilege, restriction or condition attached to the Preferred Shares. Subject to the USA, such approval may be given in such manner as may then be permitted by law. The formalities to be observed with respect to the giving of notice of any meeting in which holders of Preferred Shares are entitled to attend in accordance with this section 2.1.2 or any adjourned thereof, the quorum required therefor and the conduct thereof shall be those from time to time prescribed by the USA with respect to meetings of shareholders or, if not prescribed, as required by the Act as in force at the time of the meeting.

2.2 Conversion into Common Shares.

2.2.1 *Preferred Share Conversion Rights.* On the Conversion Date, without payment of any additional consideration, each outstanding Preferred Share shall automatically be converted into one fully-paid and non-assessable Class A Common Share or Class B Common Share, in accordance with the prior election of the applicable holder (any conversion pursuant to this Section 2.2, the "**Preferred Share Conversion Right**"), in each case, subject to the adjustments pursuant to sections 2.2.4, and 2.2.5. On the Conversion Date, the Preferred Shares so converted (the "**Converted Preferred Shares**") shall irrevocably cease to be outstanding and the corresponding fully-paid and non-assessable Class A Common Shares or Class B Common Shares, as applicable, issued, and the Corporation shall make appropriate book entries in respect of the issuance of the Common Shares upon the basis herein prescribed and in accordance with the provisions hereof for each holder of Converted Preferred Shares. Such conversion shall be deemed to have been made on the Conversion Date, and the person or persons entitled to receive the Common Shares issuable upon such conversion shall be treated for all purposes as the holder or holders of record of such Common Shares as of such date. All Converted Preferred Shares shall no longer be deemed to be outstanding, and all rights with respect to such shares, including the rights, if any, to receive notices and to vote, shall immediately cease and terminate on the Conversion Date, except only the right of the holders thereof to receive the applicable class of Common Shares in exchange therefor.

2.2.2 *Restriction on Subdivision and Consolidation.* Neither the Preferred Shares nor the Common Shares shall be subdivided, consolidated, or otherwise changed into a different number of outstanding Shares of the same class, unless, contemporaneously therewith, the other class of Shares is subdivided, consolidated, reclassified or otherwise changed in the same proportion and in the same manner. Notwithstanding the foregoing, in the event that any Common Shares are

issued, subdivided, consolidated or cancelled in accordance with Section 9.5 of the USA (or, immediately after the USA Amendment Time, Section 9.2 of the USA, a "**Section 9.2 Adjustment**"), appropriate adjustments will be made to the Preferred Shares to account for such Section 9.2 Adjustment in order to maintain the economic entitlement of the Preferred Shares.

2.2.3 *Restriction on Certain Dividends and Distributions on Common Shares*. The Corporation shall not declare or pay a dividend or other distribution payable to the holders of Common Shares in additional Common Shares, unless, contemporaneously therewith, the Corporation declares and pays a dividend or other distribution to the holders of the Preferred Shares in additional Preferred Shares in the same proportion and in the same manner. The Corporation shall not declare or pay a dividend or other distribution payable to the holders of Preferred Shares in additional Preferred Shares, unless, contemporaneously therewith, the Corporation declares and pays a dividend or other distribution to the holders of the Common Shares in additional Common Shares in the same proportion and in the same manner.

2.2.4 *Restrictions on Reclassification, Exchange, or Substitution*. If the Common Shares of the Corporation shall be changed into the same or a different number of shares of any class, whether by capital reorganization, reclassification, or otherwise (other than a subdivision or consolidation of shares or stock dividend provided for above, or a reorganization, merger, amalgamation, arrangement, consolidation, business combination or sale of assets provided for below) (a "**Structuring Change**"), then and in each such event, subject to further adjustment as provided herein, notwithstanding such Structuring Change, the Preferred Shares shall remain outstanding and shall, on the Conversion Date, convert into the kind and amount of shares or other securities or property to which the securities into which such Preferred Shares were otherwise to be converted into were changed into as a consequence of such Structuring Change.

2.2.5 *Restrictions on Merger or Reorganization, etc.* In case of any merger, amalgamation, consolidation, arrangement, reorganization or other business combination involving the Corporation and any other corporation or other entity or person (other than a Liquidation Event) (a "**Transaction**"), then in each such event, subject to further adjustment provided herein, notwithstanding such Transaction, the Preferred Shares shall remain outstanding and shall on the Conversion Date convert into the kind and number of shares or other securities or assets of the Corporation or of the successor entity resulting from such Transaction to which the securities into which such Preferred Shares were otherwise to be converted into were changed into as a consequence of such Transaction, provided that appropriate adjustments (as determined in good faith by the Operating Committee) may be made with respect to the rights of the Preferred Shares hereunder to ensure that the provisions of this section 2.2 shall thereafter be applicable, as nearly as possible, to the Preferred Shares in relation to any shares, securities or assets thereafter acquirable upon conversion of such Preferred Share (including provisions with respect to changes in and other adjustments of the Preferred Share Conversion Right).

2.2.6 *Certificate of Adjustment*. In each case of an adjustment or readjustment of the Preferred Share Conversion Right, as the case may be, or the number of applicable Common Shares or other securities issuable upon conversion of the Preferred Shares, the Corporation, at its expense, shall compute such adjustment or readjustment in accordance with the provisions hereof and prepare applicable book-entries showing such adjustment or readjustment, and shall mail a copy of such book-entry adjustments, by first class mail, postage prepaid, to each registered holder of Preferred Shares at the holder's address as shown in the Corporation's books.

2.3 Liquidation Event.

2.3.1 In the event of a Liquidation Event, with respect to each Preferred Share held by it, each holder of outstanding Preferred Shares shall be entitled to receive, in priority to any distribution of the property or assets of the Corporation to the holders of any Preferred Share Junior Shares, out of the assets of the Corporation legally available for distribution to the holders of Shares of the capital of the Corporation, an amount, in US dollars, for each such Share in cash equal to the Preferred Share Liquidation Preference on the date of the Liquidation Event. The "**Preferred Share Liquidation Preference**" on any particular date shall be calculated as follows:

> *Preferred Share Liquidation Preference on a particular date:* means the Preferred Share Initial Issue Price of said Preferred Share.

If, upon any Liquidation Event, the amount available for distribution among the holders of all outstanding Preferred Shares is insufficient to permit the payment of the Preferred Share Liquidation Preference in full, then the amount available for distribution shall be distributed among the holders of the Preferred Shares rateably in proportion to the relative Preferred Share Liquidation Preference for such holders.

2.3.2 After payment has been made in full as provided in section 2.3.1, the Corporation shall have satisfied its obligations with respect to the Preferred Share Liquidation Preference.

2.3.3 In the event of a Liquidation Event, no dividend or other distribution of any amount shall be made in respect of Preferred Share Junior Shares until the Corporation has satisfied its obligations with respect to the Preferred Share Liquidation Preference.

2.4 Restrictions on Dividends and Retirement of Shares.

2.4.1 So long as any of the Preferred Shares are outstanding, the Corporation shall not, without the approval of the holders of the Preferred Shares:

2.4.1.1 declare, pay or set apart for payment any dividends on any Preferred Share Junior Shares (other than dividends payable in Preferred Share Junior Shares); or

2.4.1.2 call for redemption, redeem, purchase or otherwise pay off or retire for value, or make any capital distributions in respect of, any Preferred Share Junior Shares.

2.5 Redemption.

2.5.1 Subject to the provisions of this section 2.5, at the election of the Corporation (a "**Preferred Share Redemption Election**"), the Corporation may, after giving a Preferred Share Redemption Notice (as defined below), redeem such number of the then outstanding Preferred Shares specified in such Preferred Share Redemption Notice, in accordance with section 2.5.4, in consideration for payment of, in US dollars, the Preferred Share Liquidation Preference applicable to each Preferred Share to be redeemed on the applicable Preferred Share Redemption Date (the "**Applicable Preferred Share Redemption Amount**").

2.5.2 Payment of the Applicable Preferred Share Redemption Amount shall be made on the relevant Preferred Share Redemption Date.

2.5.3 The Corporation shall provide each registered holder of the Preferred Shares a notice (a "**Preferred Share Redemption Notice**") in writing of the intention of the Corporation to redeem the Preferred Shares. Such notice shall set out (i) the number of Preferred Shares held by the person to whom it is addressed which are to be redeemed; (ii) the Applicable Preferred Share Redemption Amount for each share, and (iii) the date specified for redemption, which shall not be less than thirty (30) days from the date of the Preferred Share Redemption Notice and not more than sixty (60) days from the date of the Preferred Share Redemption Notice (the "**Preferred Share Redemption Date**").

2.5.4 On or after the Preferred Share Redemption Date, the Corporation shall pay or cause to be paid to or to the order of the registered holders of the applicable Preferred Shares, the Applicable Preferred Share Redemption Amount for each Preferred Share to be redeemed. Payment in respect of the Preferred Shares being redeemed shall be made by wire transfer to the respective holders thereof in lawful money of United States.

2.5.5 If any holder of Preferred Shares being redeemed in accordance with this section 2.5 fails to provide the Corporation with valid wire instructions for the deposit of the Applicable Preferred Share Redemption Amount not less than five (5) days prior to the date specified or referenced in the Preferred Share Redemption Notice, the Corporation shall have the right to deposit the monies representing the Applicable Preferred Share Redemption Amount in respect of such Preferred Shares of such holder called for redemption with any trust company in Canada named in the Preferred Share Redemption Notice, to the credit of a special account or accounts in trust for the applicable holders of such Preferred Shares, to be paid upon surrender to the applicable trust company of a statement from the Corporation that such holder is entitled to the amounts held in trust. Any such deposit shall constitute payment and satisfaction of the aggregate Applicable Preferred Share Redemption Amount of the Preferred Shares for which the deposit is made and the rights of the applicable holders of such Preferred Shares shall be limited to receiving the proportion (less any tax required or permitted by law to be deducted or withheld therefrom) of the amounts so deposited applicable to such shares, without interest thereon. Any interest allowed on such deposit shall belong to the Corporation.

2.5.6 From and after the date specified for redemption in any Preferred Share Redemption Notice, the Preferred Shares called for redemption shall cease to be entitled to any participation in any distribution of the assets of the Corporation and the holders thereof shall not be entitled to exercise any of the other rights as shareholders in respect thereof unless payment of the Applicable Preferred Share Redemption Amount shall not be made in accordance with sections 2.5.2, 2.5.4 and/or 2.5.5, in which case the rights of such holders shall remain unaffected.

2.5.7 If, pursuant to any Preferred Share Redemption Notice the Corporation calls for the redemption of all the outstanding Preferred Shares, but is not permitted by applicable law to redeem all of the Preferred Shares referenced in such Preferred Share Redemption Notice, the Corporation shall redeem only the maximum number of Preferred Shares which the Operating Committee determines the Corporation is then permitted to redeem. So long as the Operating Committee has acted in good faith in making any of the determinations referred to above as to the number of Preferred Shares which the Corporation is permitted at any one time to redeem, neither the Corporation, the Operating Committee nor the board of directors shall be liable in the event that any such determination proves to be inaccurate. The Preferred Shares referenced in any Preferred Share Redemption Notice that are not ultimately redeemed shall remain outstanding and entitled to all rights and preferences provided for herein. At any time thereafter when additional funds of the Corporation are legally available for the redemption of Preferred Shares that were originally referenced in a Preferred Share Redemption Notice but not ultimately redeemed, such

funds will be used, no later than the end of the next succeeding fiscal quarter, to redeem the balance of such Preferred Shares, or such portion thereof for which funds are legally available, on the basis set forth above.

2.5.8 Any redemption of less than all of the outstanding Preferred Shares shall be made from all holders of Preferred Shares on a pro rata basis, disregarding fractions of shares, according to the number of Preferred Shares held by each such holder and the Corporation shall make the appropriate book-entries to adjust for the number of Preferred Shares actually redeemed in accordance with this Section 2.5.

2.6 Rank.

With respect to (i) priority of redemptions, and (ii) payment of dividends and distribution of assets upon a Liquidation Event, all Preferred Shares shall rank senior to all Preferred Share Junior Shares.

3. CLASS A COMMON SHARES

3.1 Voting Rights.

Each holder of Class A Common Shares shall be entitled to receive notice of and to attend all meetings of shareholders of the Corporation and to vote thereat, except meetings at which only holders of a specified class of shares (other than Class A Common Shares) are entitled to vote. At all meetings of which notice must be given to the holders of the Class A Common Shares, each holder of Class A Common Shares shall be entitled to one (1) vote in respect of each Class A Common Share held by that holder.

3.2 Dividends.

The Class A Common Shares and the Class B Common Shares shall rank equally as to dividends. Subject to any distribution restrictions set forth in Section 18 of the USA (or, immediately after the USA Amendment Time, Section 16 of the USA), as applicable, the holders of Class A Common Shares and the Class B Common Shares shall be entitled to participate in the property, profits and surplus assets of the Corporation and, for that purpose, to receive any dividends payable in cash, in kind or by way of issuance of fully-paid shares at such times and in such manner as the Operating Committee may determine in their discretion. For the avoidance of doubt, for so long as any Preferred Shares are outstanding, no dividend shall be paid on the Class A Common Shares or the Class B Common Shares (unless such obligations are waived in whole or in part pursuant to an Extraordinary Resolution in accordance with section 18.1 of the USA (or, immediately after the USA Amendment Time, Section 16.1 of the USA)). All dividends declared in any fiscal year shall be declared and paid in equal or equivalent amounts per share on all the Class A Common Shares and all the Class B Common Shares at the time outstanding without preference or distinction.

3.3 Liquidation.

In the event of a Liquidation Event, whether voluntary of involuntary, after satisfying the Preferred Share Liquidation Preference, all remaining property and assets of the Corporation shall be paid or distributed equally to the holders of the Class A Common Shares and the Class B Common Shares in equal amounts per share, without preference or distinction.

3.4 Notice Entitlement.

The holders of the Class A Common Shares shall be entitled to receive not less than ten (10) days' notice in writing upon a proposal to change the financial year-end of the Corporation.

4. CLASS B COMMON SHARES

4.1 Voting Rights.

Each holder of Class B Common Shares shall be entitled to receive notice of and to attend all meetings of shareholders of the Corporation and to vote thereat, except meetings at which only holders of a specified class of shares (other than Class B Common Shares) are entitled to vote. At all meetings of which notice must be given to the holders of the Class B Common Shares, each holder of Class B Common Shares shall be entitled to one (1) vote in respect of each Class B Common Share held by that holder.

4.2 Dividends.

The Class A Common Shares and the Class B Common Shares shall rank equally as to dividends. Subject to any distribution restrictions set forth in Section 18 of the USA (or, immediately after the USA Amendment Time, Section 16 of the USA), as applicable, the holders of Class A Common Shares and the Class B Common Shares shall be entitled to participate in the property, profits and surplus assets of the Corporation and, for that purpose, to receive any dividends payable in cash, in kind or by way of issuance of fully-paid shares at such times and in such manner as the Operating Committee may determine in their discretion. For the avoidance of doubt, for so long as any Preferred Shares are outstanding, no dividend shall be paid on the Class B Common Shares or the Class A Common Shares (unless such obligations are waived in whole or in part pursuant to an Extraordinary Resolution in accordance with section 18.1 of the USA (or, immediately after the USA Amendment Time, Section 16 of the USA)). All dividends declared in any fiscal year shall be declared and paid in equal or equivalent amounts per share on all the Class A Common Shares and all the Class B Common Shares at the time outstanding without preference or distinction.

4.3 Liquidation.

In the event of a Liquidation Event, whether voluntary or involuntary, after satisfying the Preferred Share Liquidation Preference, all remaining property and assets of the Corporation shall be paid or distributed equally to the holders of the Class A Common Shares and the Class B Common Shares in equal amounts per share, without preference or distinction.

4.4 Notice Entitlement.

The holders of the Class B Common Shares shall be entitled to receive not less than ten (10) days' notice in writing upon a proposal to change the financial year end of the Corporation.

5. LIQUIDATION OF PROPERTY

In the event of distribution of property and assets other than cash pursuant to any provision of this Schedule A, the valuation of such property and assets shall be determined in good faith by the Operating Committee.

6. CLASS VOTE

Except as required by law, holders of Shares of any class shall not be entitled to vote separately as a class, or to exercise dissent rights under section 185 of the Act, upon a proposal to amend the articles (whether by articles of amendment or articles of amalgamation) of the Corporation to: (i) increase or decrease any maximum number of authorized Shares of such class, or increase any maximum number of authorized shares of a class having rights or privileges equal or superior to the Shares of such class; (ii) effect an exchange, reclassification or cancellation of all or part of the Shares of such class, or (iii) create a new class or series of shares equal or superior to the Shares of such class.

7. RESTRICTIONS ON SHARES

All Shares issued by the Corporation shall remain subject to the terms and conditions of the USA, including, but not limited to, any restrictions on transfer contained therein.

8. CURRENCY

Unless otherwise specified herein, all dollar amounts referenced in this Schedule A shall be in US dollars. For purposes of this Schedule A, calculation of US dollars equivalents on any day shall be based (a) on the Bank of Canada's Canada-US dollar daily noon exchange rate on the date of settlement, as such rate is reported on the Bank of Canada's website, or, if not so reported, (b) the spot selling rate for trading among banks in amounts of $1,000,000 or more as quoted by Citibank N.A. at its principal office in New York, New York at or around 3:00 p.m. on the date on which spot exchange transactions settled on such date are quoted.

SCHEDULE "A"

CANADA	)	IN THE MATTER OF the *Business Corporations Act* (Ontario) and the Articles of Amalgamation of 1843208 Ontario Inc. and Baffinland Iron Mines Corporation
PROVINCE OF ONTARIO	)	
	)	
TO WIT:	)	

Oakville

I, Stephanie Anderson, of the City of Toronto, in the Province of Ontario, hereby certify that:

1. I am the Chief Financial Officer of 1843208 Ontario Inc. and have knowledge of the matters herein declared.

2. There are reasonable grounds for believing that:

   (a) each amalgamating corporation is, and the amalgamated corporation will be, able to pay its liabilities as they become due;

   (b) the realizable value of the amalgamated corporation's assets will not be less than the aggregate of its liabilities and stated capital of all classes; and

   (c) no creditor will be prejudiced by the amalgamation.

DATED at Toronto, this 9th day of October, 2013.

Stephanie Anderson

SCHEDULE "A"

CANADA	)	IN THE MATTER OF the *Business Corporations Act* (Ontario) and the Articles of Amalgamation of 1843208 Ontario Inc. and Baffinland Iron Mines Corporation
PROVINCE OF ONTARIO	)	
	)	
	)	
	)	
TO WIT:	)	

I, Stephanie Anderson, of the City of Oakville, in the Province of Ontario, hereby certify that:

1. I am the Chief Financial Officer of Baffinland Iron Mines Corporation and have knowledge of the matters herein declared.

2. There are reasonable grounds for believing that:

   (a) each amalgamating corporation is, and the amalgamated corporation will be, able to pay its liabilities as they become due;

   (b) the realizable value of the amalgamated corporation's assets will not be less than the aggregate of its liabilities and stated capital of all classes; and

   (c) no creditor will be prejudiced by the amalgamation.

DATED at Toronto, this 9th day of October, 2013.

Stephanie Anderson

SCHEDULE "B"

"1843208 ONTARIO INC.
(the "Corporation")

RESOLUTION OF THE OPERATING COMMITTEE AND SHAREHOLDERS

RECITALS:

A. The Corporation was formed by amalgamation under the laws of Ontario by certificate and articles of amalgamation dated January 27, 2011.

B. It is desirable that the Corporation amalgamate with Baffinland Iron Mines Corporation ("**Baffinland**").

C. All the issued and outstanding shares of Baffinland are held by the Corporation.

RESOLVED THAT:

1. the amalgamation of the Corporation with Baffinland is hereby approved;

2. the by-laws of the amalgamated corporation shall be the by-laws of the Corporation, until amended or repealed;

3. (i) the shares of Baffinland shall be cancelled without any repayment of capital in respect of those shares;

   (ii) except as may be prescribed by the *Business Corporations Act* (Ontario), the articles of amalgamation shall be the same as the articles of the Corporation;

   (iii) the stated capital of Baffinland shall be added to the stated capital of the Corporation;

4. any two members of the Operating Committee or officers of the Corporation are hereby authorized to take any action and to execute any document which, in the opinion of such persons, is necessary or desirable to give effect to this resolution and to deliver all or any of those documents to the Ontario Ministry of Government Services; and"

The undersigned, Tom Paddon and Stephanie Anderson, being the President and Chief Financial Officer, respectively, of 1843208 Ontario Inc. (the "**Corporation**") hereby certify that the foregoing is a true and correct copy of a resolution passed by the Operating Committee and the shareholders of the Corporation and that such resolution is, at the date hereof, in full force and effect, unamended.

DATED this 9th day of October, 2013.

Tom Paddon

Stephanie Anderson

[Step 7.1.7 - Certified Copy of Resolution in Step 7.1.2]

SCHEDULE "B"

"BAFFINLAND IRON MINES CORPORATION
(the "Corporation")

RESOLUTION OF THE OPERATING COMMITTEE AND SOLE SHAREHOLDER

RECITALS:

A. The Corporation has been incorporated under the laws of Ontario by certificate and articles of incorporation dated March 10, 1986.

B. It is desirable that the Corporation amalgamate with 1843208 Ontario Inc. ("**Parent**").

C. The Corporation is a wholly-owned subsidiary corporation of Parent.

RESOLVED THAT:

1. the amalgamation of the Corporation with Parent is hereby approved;

2. the by-laws of the amalgamated corporation shall be the by-laws of Parent, until amended or repealed;

3. (i) the shares of the Corporation shall be cancelled without any repayment of capital in respect of those shares;

   (ii) except as may be prescribed by the *Business Corporations Act* (Ontario), the articles of amalgamation shall be the same as the articles of Parent;

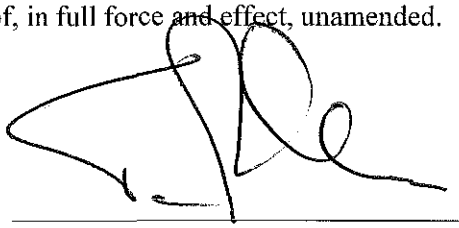
   (iii) the stated capital of the Corporation shall be added to the stated capital of Parent;

4. any two members of the Operating Committee or officers of the Corporation are hereby authorized to take any action and to execute any document which, in the opinion of such persons, is necessary or desirable to give effect to this resolution and to deliver all or any of those documents to the Ontario Ministry of Government Services; and"

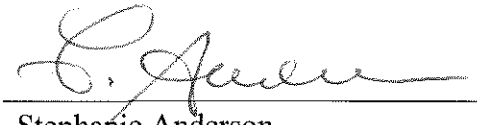
[Signature Page Follows]

The undersigned, Tom Paddon and Stephanie Anderson, being the President and Chief Financial Officer, respectively, of Baffinland Iron Mines Corporation (the "**Corporation**") hereby certify that the foregoing is a true and correct copy of a resolution passed by the Operating Committee and sole shareholder of the Corporation and that such resolution is, at the date hereof, in full force and effect, unamended.

DATED this 9th day of October, 2013.



Tom Paddon



Stephanie Anderson

ATTACHMENT 15.2

BAFFINLAND OFFICERS

As of August 1, 2018

Baffinland Iron Mines Corporation

Officers

Brian Penney	Chief Executive Officer
David Soares	Chief Financial Officer
Sylvain Proulx	Chief Operating Officer
Stephanie Anderson	Executive Vice-President, Corporate Development
Mark O'Brien	Executive Vice-President, General Counsel and Corporate Secretary
Grant Goddard	Vice-President, Sustainable Development and Human Resources
Rinaldo Stefan	Vice-President, Projects, Project Director

ATTACHMENT 16

MOBILE CAMP WATER AND SEWAGE TANK DESIGN DETAILS

1291 California Avenue, P.O. Box 1517
Brockville, ON, K6V 5Y6
T: 800.420.4056 F: 289.203.1319

Operation & Maintenance Manual 1704962 - Horizon North Wastewater Storage Tanks

Site:
Baffin Island, Nunavut

Prepared for:
Horizon North Camps & Catering
5637-67 Avenue NW
Edmonton, AB

1.0 General Documents
Safety, Quote, Packing List, Return Material Authorization

2.0 Mechanical Drawings
P&ID, Legend, System Layout

3.0 Electrical Drawings
Electrical Documents

4.0 Mechanical Components
Bill of Material

5.0 System Manuals
Manual Document List

6.0 Warranty

Section 1

General Documents

SAFETY

1.0 Introduction

This section provides general personal and environmental safety information for newterra system.

Always refer to local codes and regulations.

Specific equipment and parts safety information can be found in Section 6 of this manual.

Information and guidelines outlined in this manual **must** be followed at all times prior to system installation and during operation and maintenance.

2.0 ESSENTIAL FOR SAFE OPERATION:

1. Installation and operation of the newterra system must only be carried out by **trained and qualified** personnel.
2. All necessary **safety precautions must** be carefully exercised, including but not limited to proper use of personal protective equipment considering given working environment and conditions.
3. All **electrical installations and troubleshooting must** only be carried out by licensed electricians.
4. All **plumbing work must** only be carried out by licensed plumbers or qualified personnel.
5. Please keep in mind that trees and shrubs taller than two meters located in close proximity to the newterra system may become a safety concern at the time of installation or service.

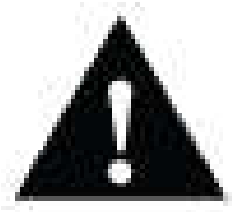
DEFINITION OF SAFETY AND WARNING SIGNS USED IN THE MANUAL

ATTENTION SYMBOL

Special attention is required to ensure compliance with instructions concerning correct operating sequences to prevent damage to the newterra system or its function.

GENERAL WARNING SIGN

This symbol accompanies all important instructions or warnings associated with risks of injury as well as possible equipment damage.



WARNING

CRITICAL WARNING SIGN

Warns against an unsafe situation or practice associated with severe injury as well as major equipment damage.

3.0 Personal Protective Equipment (PPE)

Personal protective equipment (PPE) refers to protective clothing, gloves, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury or infection. The hazards addressed by protective equipment include physical, electrical, heat, chemicals, biohazards, and airborne particulate matter. ”Protective clothing" is applied to traditional categories of clothing, and "protective gear" applies to items such as pads, guards, shields, masks, and others.

The purpose of personal protective equipment is to reduce employee exposure to hazards when engineering and administrative controls are not feasible or effective to reduce these risks to acceptable levels. PPE is needed when there are hazards present. PPE has the serious limitation that it does not eliminate the hazard at source and may result in employees being exposed to the hazard if the equipment fails.

The following list includes the minimum scope of PPE that should be available to system operators:

3.1 Head protection

Hard hats, bump caps, or helmets are types of protection that should be considered if there is a hazard of head injury. Head injuries can occur under various circumstances including as the result of a slip or fall, working in confined areas or where there are low ceilings, where there may be falling objects. Hard hats should be worn at all times when overhead work is being conducted.

3.2 Eye and Face Protection

Eye protection with side shields should be used at all times while inside the newterra system as there may be a danger of flying objects, particles, liquids, sprays or other matter entering the eyes. Protection can take many forms including:

- safety glasses,
- goggles, or
- full face protection. This should be used if handling chemicals, waste product or working around pressurized lines (air of liquid).

3.3 Foot Protection

Foot protection should be used at all times within the newterra system. Foot protection is usually in the form of steel-toed work boots, with a steel shank to protect the bottom of the foot from puncture wounds. In wet environments, steel-toed boots that are waterproof and slip-resistant may be necessary.

3.4 Hand Protection

Hand protection should be worn within the newterra system. The workplace can create many hazards for hands, whether from chemicals, cuts or burns. No single glove can provide appropriate protection for every work situation, so it is important to assess the risk for each task and select a glove that provides specialized protection.

The following is a list of gloves and their suggested appropriate application:

- Coated fabric gloves: This type of glove can provide protection against some moderate concentrated chemicals. They can be used in laboratory work provided they are strong enough to protect against the specific chemical being handled.
- Rubber, plastic or synthetic gloves: These types of glove can be used when cleaning or working with oils, solvents and other chemicals.
- Leather gloves: These should be used when welding, as the leather can resist sparks and moderate heat. The risk of cuts and abrasions also can be minimized by wearing leather gloves.
- Kevlar gloves: These have a wide variety of industrial applications. They are cut- and abrasion-resistant and provide protection against both heat and cold.
- Chemical/liquid-resistant gloves: Several types of gloves help protect against specific chemicals:
    - Butyl rubber gloves: nitric acid, sulfuric acid, hydrochloric acid and peroxide
    - Natural latex/rubber gloves: water solutions or acids, alkalis, salts, and ketones
    - Neoprene gloves: hydraulic fluids, gasoline, alcohols and organic acids
    - Nitrile rubber gloves: chlorinated solvents

3.5 Body Protection

Body protection may be required in various situations including dusty environments or when spraying liquid pesticides or handling dangerous chemicals. The hazard to be controlled will determine the type of protection that is most appropriate, for example, an apron, coveralls or a full rain suit. As a minimum, the operator should be wearing work coveralls.

3.6 Chemical and Bacterial Safety

The newterra system wastewater may contains a mixture of chemical, viable bacteria and other biological organisms, depending on the system. System wastewater may pose a number of hazards and consequently potential health risk. Immunization protects operator against infection. The use of proper hygiene measures, protective equipment, good housekeeping and common sense prevent contact with pathogens.

These measures prevent infection!

Ensure that hands are washed with an antibacterial soap and warm water and dried by disposable towels on a regular basis, especially prior eating!

Do not expose cuts or open sores to system wastewater!

Use personal protective equipment (PPE) at all times in the newterra system!

Any concern about possible infection should be brought to the attention of medical physician immediately!

3.7 Hearing Protection

Hearing protection should be worn in work environments where noise levels exceed 85 decibels – such as around blowers and air compressors. There are many types of hearing protection, including earplugs or muffs. Hearing protection that is suitable for the work environment and provides adequate noise reduction should be chosen. Disposable ear plugs or headset style are acceptable.

4.0 Electrical Safety

Power may be supplied to control panels from various sources. Even if the disconnect is in the OFF position, certain electrical components inside the panel may be energized and servicing should not be conducted unless all incoming power is disconnected. Refer to the electrical drawings in Section 3 of this manual.

Ensure that the system is properly grounded before applying power to the system. Installation and servicing is only to be performed by **qualified authorized personnel**.

4.1 Lockout Procedures

Lockout procedures must be followed prior to performing mechanical or electrical maintenance to ensure that equipment has been de-energized. All relevant local guidelines and procedures must be applied. The person who locked out the device, should be the only person to remove the lockout.

When equipment is to be locked out, employers, supervisors and workers should follow accepted lockout principles, including:

- Pre-planning for the lockout by identifying all energy sources, switches, etc.
- Where lockout is complex, a written sequence in checklist form should be prepared for equipment access, lockout/tagout, clearance, release and start-up.
- All workers affected by the lockout should be notified.
- Equipment should be shut down by normal means by turning of switches and closing valves etc.
- Equipment should be isolated from energy sources by disconnecting or blocking the sources of energy.
- Lockout and tag the energy isolating devices by padlock or some other locking device that the worker has control over as well as a tag indicating that the equipment has been shut down.
- Verify that all energy sources have been isolated by attempting to cycle the equipment prior to working on it.
- When work is completed, release equipment from lockout.
- Test equipment

5.0 Confined Spaces

“**confined space**” means a fully or partially enclosed space:

- that is not both designed and constructed for continuous human occupancy, and
- in which atmospheric hazards may occur because of its construction, location or contents or because of work that is done in it.

If you have a space that is fully or partially enclosed, the two conditions – (a) and (b) above – must both apply before the space can be considered a "confined space".

"**atmospheric hazards**" means:

- the accumulation of flammable, combustible or explosive agents,
- an oxygen content in the atmosphere that is less than 19.5 per cent or more than 23 per cent by volume, or
- the accumulation of atmospheric contaminants, including gases, vapours, fumes, dusts or mists, that could,

- result in acute health effects that pose an immediate threat to life, or
- interfere with a person's ability to escape unaided from a confined space.

Follow local laws and regulations with respect to entering a confined space.

If a workplace includes a confined space that workers may enter to perform work, it is highly recommended that written program for the confined space is developed and maintained in accordance with this local regulations and policies before a worker enters the confined space.

A confined space program is a written document that would include: a method for recognizing each confined space to which the program applies; a method for assessing the hazards to which workers may be exposed; a method for the development of confined space entry plans; a method for training workers; and, an entry permit system.

Most newterra systems do not have confined spaces; however, you must consult your local Health and Safety Coordinator for clarification.

6.0 Fire Safety

Exposed hot surfaces can create potential burn/ignition hazards. Blowers and air compressors compress ambient air, causing heat to be generated. This heat can bring the temperature of the air compressor head and blower piping to a level that can cause burns to exposed flesh.

Follow local laws and regulations with respect to Fire Safety and regulations.

6.0 Responsibility for Safety

6.1 Management/Supervisors

Management is responsible for providing a safe working environment. This is accomplished partly by:

- Ensuring that all facilities and equipment are built and maintained in accordance with the appropriate safety standards
- Providing adequate funds for equipment, system maintenance and establish a safety training program (if applicable)
- Supplying easy accessible eyewash, fire extinguishers, first-aid stations and proper personal protective equipment (PPE) for personnel servicing the newterra system (if not provided as part of the system).

6.2 Worker

- To develop a positive and professional attitude towards safety.
- To avoid mistakes caused by indifference to safety, poor work habits, lack of attentiveness, rushing the job, failure to observe established safety procedures and poor physical condition.

Remember the "ABC" of accident prevention:

ALWAYS BE CAREFUL!!!

In addition to ***"being careful"*****,** it is the responsibility of all workers to:

- Work in accordance with established safety procedures
- Follow the established safety rules
- Wear appropriate personal protective equipment (PPE)
- Report all accidents, no matter how minor
- Report potential safety hazards
- Participate in safety programs

6.3 Plant Safety – Simple Rules to Follow

Common sense plays a very important part in the safe operation of any type of plant!

- Wear the appropriate personal protective equipment at all times.
- Keep walkways clear of snow and ice, and loose objects such as pails, shovels, tools, etc.
- Clean up spills of oil, grease, chemicals, or other substances immediately.
- Keep all tools and similar equipment clean, in good condition, and properly stored when not in use.
- Replace all manhole covers, access trap doors, etc. as soon as possible. Erect a safety barrier if it is necessary to leave the opening uncovered.

- Use the proper tools when removing or replacing a manhole cover.
- Wear a safety belt whenever there is the possibility of falling even a short distance, or when working over water.
- Lock out and tag electrical equipment before working on it or the associated equipment.
- Ensure that moving machinery is properly guarded. Wear ear protection in noisy environments.
- Ensure that fire-fighting equipment is in good working condition.

6.4 Hazard Warning Signs/Symbols

Below is a sample of possible hazard warning signs/symbols that may be provided with the newterra system. It is recommended that the operator become familiar with the warning signs in the system.

7.0 First aid

First aid is emergency care given immediately to an injured person. The purpose of first aid is to minimize injury and future disability. In serious cases, first aid may be necessary to keep the victim alive.

It often consists of a one-time, short-term treatment and requires little technology or training to administer. First aid can include cleaning minor cuts, scrapes, or scratches; treating a minor burn; applying bandages and dressings; drinking fluids to relieve heat stress, etc.

Operators must know the location of emergency telephone number(s), First Aid Kits, emergency eye wash stations and first aid attendant(s).

In over 98% of locations in the United States and Canada, dialing "9-1-1" from any telephone will link the caller to an emergency dispatch office—called a Public-Safety Answering Point (PSAP) by the telecom industry—which can send emergency responders to the caller's location in an emergency. In approximately 96 percent of the U.S., the Enhanced 9-1-1 system automatically pairs caller numbers with a physical address.

Follow local laws and regulations with respect to First Aid procedures and reporting.

7.2 CPR Poster

CPR for an Adult or Child

1

- Check the scene to ensure it is safe. If it is safe to do so, check the person and the person's ABCs (Airway, Breathing, Circulation).
- Call EMS/9-1-1 and get an AED or have someone else do this.

2

- Place the heel of one hand on the middle of the chest. Place the other hand on top.
- Do 30 compressions. Push hard, push fast.

3

- Open the airway by tilting the head back and lifting the chin. Pinch the nostrils closed and give 2 breaths.
- Repeat the cycle of 30 compressions and 2 breaths.
- Continue CPR until an AED arrives or more advanced care takes over.

The information on this poster does not replace formal First Aid & CPR training.

To find a Red Cross First Aid course in your area scan the QR code, or:
redcross.ca/firstaid |1.877.356.3226

CANADIAN RED CROSS

10/10

MECHANICAL TEST RECORD								
Device Name:	**H-7901A**			Manufacturer:	**MARKEL**			
Device Model #:	**HLA1224036007.024**			Device Serial #:				
Motor Manufacturer:				Area Classification Tag Checked:				
Motor Model #:				Motor Serial #:				
WATTAGE	**7.5K**	Voltage:	**240**	Frame:		RPM:		
Phase:	**3**	Current:	**18.00**	SF:		ENCL.:		
Factory Test:				Field Test:				
L1	L2	L3		L1	L2	L3		
16.0	**16.2**	**16.2**	Amps				Amps	
L1/L2	L2/L3	L3/L1		L1/L2	L2/L3	L3/L1		
229	**230**	**229**	Vac				Vac	

Device Name:	**H-7902A**			Manufacturer:	**MARKEL**			
Device Model #:	**HLA1624036010.024**			Device Serial #:				
Motor Manufacturer:				Area Classification Tag Checked:				
Motor Model #:				Motor Serial #:				
WATTAGE	**10K**	Voltage:	**240**	Frame:		RPM:		
Phase:	**3**	Current:	**21.40**	SF:		ENCL.:		
Factory Test:				Field Test:				
L1	L2	L3		L1	L2	L3		
22.0	**22.0**	**22.3**	Amps				Amps	
L1/L2	L2/L3	L3/L1		L1/L2	L2/L3	L3/L1		
229	**230**	**229**	Vac				Vac	

Device Name:	**H-7901B**			Manufacturer:	**MARKEL**			
Device Model #:	**HLA1224036007.024**			Device Serial #:				
Motor Manufacturer:				Area Classification Tag Checked:				
Motor Model #:				Motor Serial #:				
WATTAGE	**7.5K**	Voltage:	**240**	Frame:		RPM:		
Phase:	**3**	Current:	**18.00**	SF:		ENCL.:		
Factory Test:				Field Test:				
L1	L2	L3		L1	L2	L3		
16.2	**16.0**	**16.5**	Amps				Amps	
L1/L2	L2/L3	L3/L1		L1/L2	L2/L3	L3/L1		
229	**230**	**229**	Vac				Vac	

Device Name:	**H-7902B**			Manufacturer:	**MARKEL**			
Device Model #:	**HLA1624036010.024**			Device Serial #:				
Motor Manufacturer:				Area Classification Tag Checked:				
Motor Model #:				Motor Serial #:				
WATTAGE	**10K**	Voltage:	**240**	Frame:		RPM:		
Phase:	**3**	Current:	**21.40**	SF:		ENCL.:		
Factory Test:				Field Test:				
L1	L2	L3		L1	L2	L3		
22.3	**22.5**	**22.5**	Amps				Amps	
L1/L2	L2/L3	L3/L1		L1/L2	L2/L3	L3/L1		
229	**230**	**229**	Vac				Vac	

4428 Manila Road SE
Calgary, AB T2G 4B7
showard@newterra.com | www.newterra.com

September 1st, 2017

Patrice Demers |Manager, Purchasing
Horizon North Logistics Inc., Camps & Catering

5637 67th Avenue, Edmonton AB T6B 2R8
(Office) 780-395-7305
(Cell) 780-446-5614
(Toll Free) 866-305-6565
www.horizonnorth.ca

Re: **Quote for Wastewater storage tank / Quote # 1704962R0**

Dear Patrice Demers,

We are pleased to provide you with a firm price quote for a **newterra** WW storage system for the storage of sewage. The **newterra** WW system is designed specifically for decentralized remote camp applications.

As your preferred vendor and global water technology partner we will endeavor to engineer the best solutions for your customers incorporating the **newterra** technology. We trust that, as you review this proposal, you will find the information provided to be helpful in your decision making process. Should you require further information, please do not hesitate to contact us.

Yours truly,

Steve Howard
Vice President Western Operations
403.651.8094 | showard@newterra.com

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SCOPE OF SUPPLY:

Storage System

- Four (4) storage tanks
  - HDPE construction
  - Inlet and outlet isolation valves
  - Total approximate volume of 6,400 gal
  - Each tank Sealed and vented to exterior

System Enclosures – Modified Shipping Containers

cMET certified, built to NEC standards with all wiring complete and all equipment pre-piped factory tested and mounted in enclosure.

One (1) used 40’ high-cube modified shipping containers with the following standard features:

- Exterior paint
- Class 1 Div. 2 Heaters
- Lifting eyes on upper corners
- Insulated walls and ceiling
- Insulated floor
- Barn-style rear double doors

Control System Module:

- Branch circuit protection with circuit breakers for heaters
- Wired and installed
- Factory tested prior to shipping

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PRICE BREAKDOWN:

Equipment Purchase Cost:	$ 65,000.00 each
Estimated Equipment Freight to Montreal:	$ 2000.00 each
Sales Tax on Equipment:	Not Included
Total System Purchase Cost:	**$ 67,000.00 each**

DELIVERY: The system would be ready for shipment from Brockville Ontario by September 11, 2017

CURRENCY: All prices are quoted in CAN dollars.

PAYMENT TERMS:

- 50% due immediately on purchase order
- 50% due 15 days from ready shipment

CLIENT'S SCOPE OF SUPPLY AND WORK:

- Delivery of raw sewage to the **newterra** WWR system;
- Permitting;
- Grease trap to control entry of oil and greasy material to the **newterra** WWR system. Fat, oil and grease levels entering the newterra MBR system must be less than 30 mg/L to ensure the system functions as designed and to prevent overflow clogging;
- Firm, level base for the containers;
- Piping hookups to and from the **newterra** WWR system;
- Electrical power supply to our electrical distribution panel @ 3Ph 20KW
- Lightning, grounding, etc. ;
- Potable water supply to the plant site for plant hydraulic test during startup;
- Wastewater testing;
- Anything not mentioned in "Scope of Supply" above.

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Project Packing List

PMProjNum **1704962**

Horizon North Wastewater Storage Tanks

Shipping Notes:

Tag	Part Number	Part Description	Req	EngMemo
			Rec	
			PO #	Line
7900	24612	Container, 40' x 8' x 9'6", Once Use, High Cu	2	---
-	ea	30,480kg rated, Forklift Pockets, CSC Plate,	0	
	Type: I	ABS/BV/LR Certs. Steel Checkerplate ---	1704962-0003	1
8900	11328	Disconnect, 3ph, CH362RB	2	---
DISC	ea	60A,CSA,600V,Nema 3R,fusible disconnect	2	
	Type: P	---	1704962-0010	1
8900	38783	Disconnect, Square D, CH361RB	2	---
DISC	ea	30A, CSA, 600V, Nema 3R,fusible disconne	2	
	Type: P	---	1704962-0010	2
8900	E1200	Fuse, GLD TRS30R	18	---
DISC	ea	30A 600V Time Delay	18	
	Type: P	Class R ---	1704962-0010	3
8900	E1202	Fuse, GLD TRS40R	18	---
DISC	ea	40A 600V Time Delay	18	
	Type: P	Class R ---	1704962-0010	4

newterra Return Material Authorization (RMA)

For in warranty issues there are two possible RMA procedures.
1. System will be down during warranty assessment. Raise an RMA through **newterra™** and we will have the equipment sent for warranty assessment. Depending on the outcome of the warranty assessment you will either receive refurbished or replacement equipment, or, if it is deemed not covered by warranty, you will have to purchase new equipment.
2. System will be running during warranty assessment. Raise an RMA through **newterra** and we will have the equipment sent for warranty assessment. Purchase new equipment. Depending on the outcome of the warranty assessment you will either receive a credit for the purchase amount, or, if it is deemed not covered by warranty, no further action will be taken.

Return Policy and Instructions

Please note only goods that have been authorized by newterra for return will be accepted. Returned goods that do not follow this procedure will not be accepted.

Contact newterra requesting a return of the product.
Include a brief description of the problem and what action is required, ie repair, warranty, incorrect item etc.

Get RMA form and RMA number from newterra.
Upon receiving authorization from **newterra** to return goods, **newterra** will provide you a RMA number, and fax/email you an RMA form that must be completed and signed.

Complete and sign the RMA form and include form with items being returned.
The RMA form (completed and signed by customer) must accompany the goods being returned.

Ship returned items prepaid on your courier account.
Shipment from customer to **newterra** shall be prepaid at customer's expense. Collect shipments will not be accepted. Replaced or repaired items will be shipped back to customer at customer's expense.

Restocking Policy

Only unused items, in 'like new' condition in original packing (if applicable) can be returned for credit.
All credits are subject to our satisfactory examination of the returned items. All items returned must be clean and free of product. Restocking charges are applicable and will be reviewed on a case by case basis.

Exchange Policy

In cases where an incorrect item was shipped, or an item was damaged in transit please notify **newterra** immediately for instructions for return and /or exchange.

Evaluation Policy

Items returned for repair which are no longer under warranty may be subject to a $200 evaluation fee.

newterra Return Material Authorization (RMA)

1325 California Avenue
P.O. Box 1517
Brockville, Ontario
Canada, K6V 5Y6

Ph. 1-800-420-4056
Fax 613-345-7633

Date Issued: _____

RMA Number: _____ Project Number: _____

newterra Contact: _____

Customer Name: _____

Customer Contact: _____

Customer Ph.: _____

Customer Fax: _____

Parts free of 'product': _____

newterra Part Number/s, Description/s and quantity to be returned:

Part #	Description	Quantity

Reason for return: _____

Print name: _____

Signature: _____

Title: _____

Date: _____

Sheet to be filled out by customer and returned with returned items.

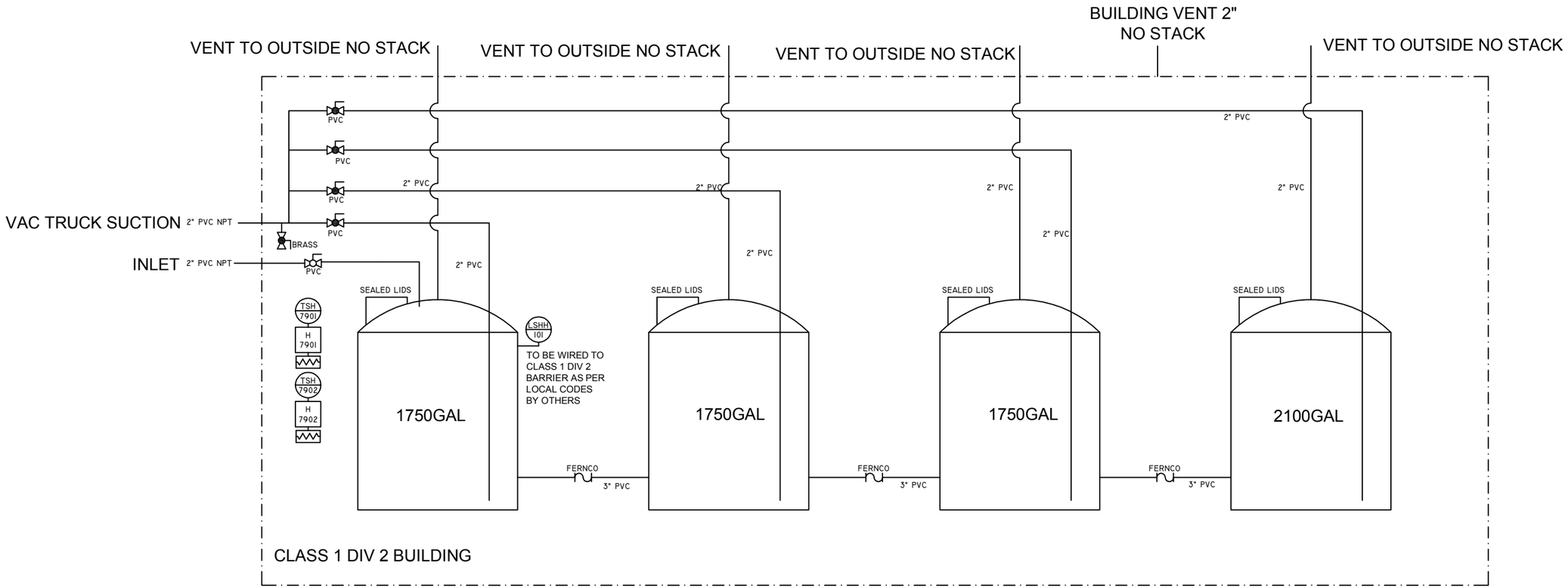
newterra®
clean water. modular solutions. simple.™

Section 2

Mechanical Drawings

HEATER 7901
1799K25
McMaster Carr
240v 3p 7.5KW

HEATER 7902
1799K27
McMaster Carr
240v 3p 10KW



WIRING AND SPECIAL PROJECT NOTES
IS INPUT WIRING TO BE WIRED FOR INDOORS, ACCORDING NEC FOR HAZARDOUS LOCATIONS.
WIRING TO BE CLASS 1 DIVISION 2, AS PER THE NEC.

NOTES
- MATERIALS OF VALVES AND FITTINGS TO BE THE SAME AS THE DESCRIPTION AT THE LINE. IF THERE IS A TRANSITION FROM PVC TO STEEL, THE VALVE SHOULD BE BRASS.
- THERE ARE NO SPECIAL PIPING REQUIREMENTS OTHER THAN WHAT IS EXPLAINED ON THE DIAGRAM.
- - PVC PIPE MAY BE SUBSTITUTED WITH EQUAL-SIZED PVC HOSE WHERE A FLEXIBLE CONNECTION IS PREFERRED.
- DO NOT DRILL AND TAP HOLES IN PIPE WHEN PRESSURES ARE OVER 15 PSIG.

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PHONE:
(800) 420-4056

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LEVEL	REVISION	DATE (mm/dd/yy)	BY
C	AS BUILT	08/09/17	JJK
B	PRODUCTION	06/09/17	JJK
A	FOR SUBMITTAL	05/09/17	JJK

PROJECT NUMBER 1704962

TITLE AND LOCATION WASTEWATER STORAGE

CUSTOMER HORIZON NORTH

DRAWN BY | DATE | SHEET 1 | SHEETS 1

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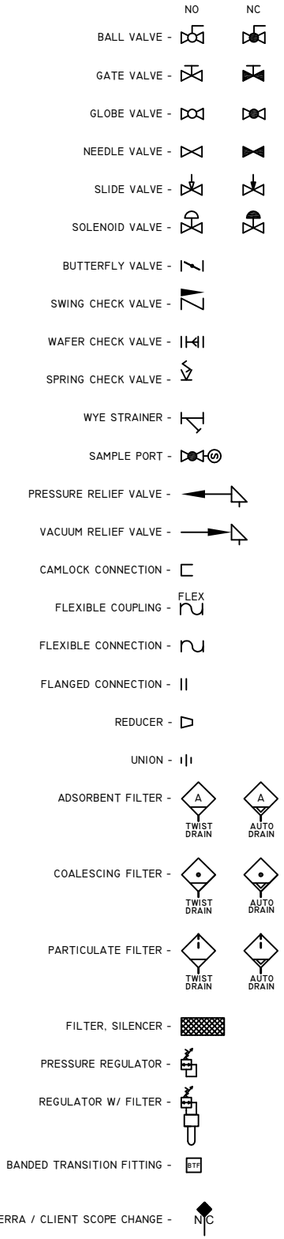
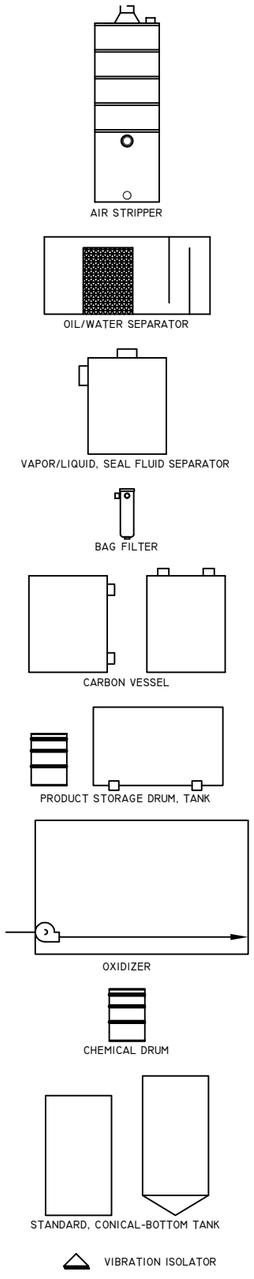
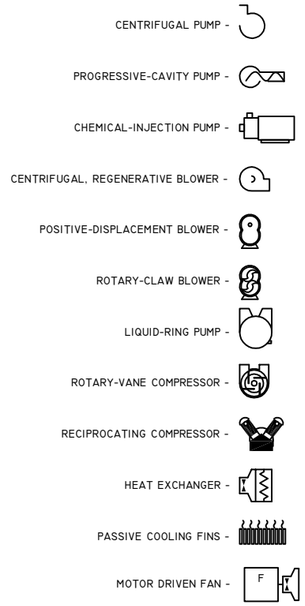
VALVES AND PIPING



EQUIPMENT



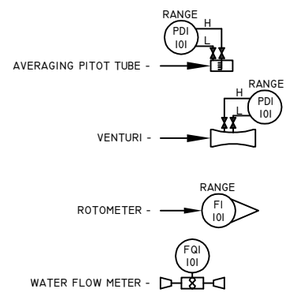
EQUIPMENT



EQUIPMENT

AS - AIR STRIPPER
BLD - BUILDING, TRAILER OR SKID
FLT - FILTER VESSEL
LPC - LIQUID-PHASE CARBON VESSEL
MFD - MANIFOLD
OWS - OIL/WATER SEPARATOR
OX - OXIDIZER
PST - PRODUCT STORAGE TANK
SOS - SEAL OIL SEPARATOR
SWS - SEAL WATER SEPARATOR
TNK - TANK
VLS - VAPOR/LIQUID SEPARATOR
VPC - VAPOR-PHASE CARBON VESSEL

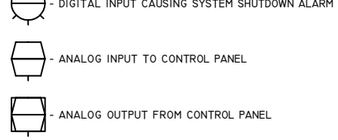
FLOW MEASUREMENT



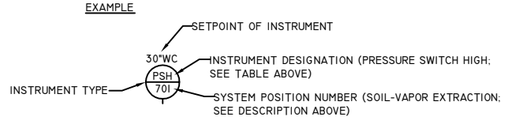
INSTRUMENT DESIGNATION

	INPUT	1ST MODIFIER	2ND MODIFIER	3RD MODIFIER	OUTPUT	1ST MODIFIER	
A			ALARM				A
B						BLOWER	B
C	CYCLE					COMPRESSOR	C
D		DIFFERENTIAL				AIR DRYER	D
E							E
F	FLOW					FAN	F
G	GAS (LEL)		GAUGE				G
H				HIGH	HAND	HEATER	H
I	CURRENT		INDICATOR				I
J							J
K							K
L	LEVEL			LOW			L
M					MOTORIZED		M
N							N
O							O
P	PRESSURE				PNEUMATIC	PUMP	P
Q		QUANTITY					Q
R							R
S	SPEED		SWITCH		SOLENOID		S
T	TEMPERATURE		TRANSMITTER				T
U							U
V						VALVE	V
W							W
X							X
Y							Y
Z	POSITION						Z

INSTRUMENT IDENTIFICATION



EXAMPLE



SYSTEM POSITION DESIGNATION

100 - VACUUM INLET MANIFOLD
300 - INLET HEAT EXCHANGER
400 - VAPOR/LIQUID SEPARATOR
500 - VAPOR/LIQUID SEPARATOR - 2
700 - SOIL-VAPOR EXTRACTION
1000 - LIQUID-RING PUMP
1300 - SVE HEAT EXCHANGER
1600 - VAPOR-PHASE CARBON
1900 - OXIDIZER
2200 - AIR SPARGE
2500 - SPARGE HEAT EXCHANGER
2800 - SPARGE OUTLET MANIFOLD
3100 - AIR COMPRESSOR
3400 - COMPRESSED-AIR OUTLET MANIFOLD
3700 - PNEUMATIC WELL PUMPS
4000 - SUBMERSIBLE WELL PUMPS
4300 - SURFACE-MOUNT WELL PUMPS
4600 - GROUNDWATER INLET MANIFOLD
4900 - OIL/WATER SEPARATOR
5200 - PRODUCT STORAGE TANK
5500 - INLET TANK
5800 - UPSTREAM BAG FILTER
6100 - CHEMICAL INJECTION
6400 - AIR STRIPPER
6700 - PRE-CARBON BAG FILTER
7000 - LIQUID-PHASE CARBON
7100 - PRE-MEDIA BAG FILTER
7200 - ACTIVATED ALUMINA
7300 - DISCHARGE TANK
7400 - POST-TREATMENT BAG FILTER
7600 - REINJECTION
7900 - BUILDING,TRAILER OR SKID
8200 - CONTROL PANEL
8500 - ELECTRICAL PARTS
9900 - EXTRAS

NOTES
- WATER FLOW METERS: PROVIDE 10 DIA. OF STRAIGHT PIPE BEFORE AND 5 DIA. OF STRAIGHT PIPE AFTER METERS. ENSURE THAT THROTTLING VALVES ARE NOT DIRECTLY IN LINE WITH METERS.
- AIR FLOW METERS: PROVIDE 8 DIA. OF STRAIGHT PIPE BEFORE AND 3 DIA. OF STRAIGHT PIPE AFTER METERS, AVOID TEES AND ELBOWS BEFORE AND AFTER METERS.
- MATERIALS OF VALVES AND FITTINGS TO BE THE SAME AS THE DESCRIPTION AT THE LINE. IF THERE IS A TRANSITION FROM PVC TO STEEL, THE VALVE SHOULD BE BRASS.
- THERE ARE NO SPECIAL PIPING REQUIREMENTS OTHER THAN WHAT IS EXPLAINED ON THE DIAGRAM.
- WHEN PVC HOSE IS SPECIFIED, ALWAYS USE VACUUM HOSE; USE GREEN HOSE FOR PRESSURES LESS THAN 60PSI; USE TANK TRUCK HOSE FOR PRESSURES BETWEEN 60PSI AND 150PSI.
- PVC PIPE MAY BE SUBSTITUTED WITH EQUAL-SIZED PVC HOSE WHERE A FLEXIBLE CONNECTION IS PREFERRED.
- DO NOT DRILL AND TAP HOLES IN PIPE WHEN PRESSURES ARE OVER 15 PSIG.
- DO NOT USE PVC PIPE ON AIR LINES OVER 5 PSIG.

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(800) 420-4056

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LEVEL	REVISION	DATE (mm/dd/yy)	BY

PROJECT NUMBER	CUSTOMER
TITLE AND LOCATION	
DRAWN BY	DATE / SHEET / SHEETS

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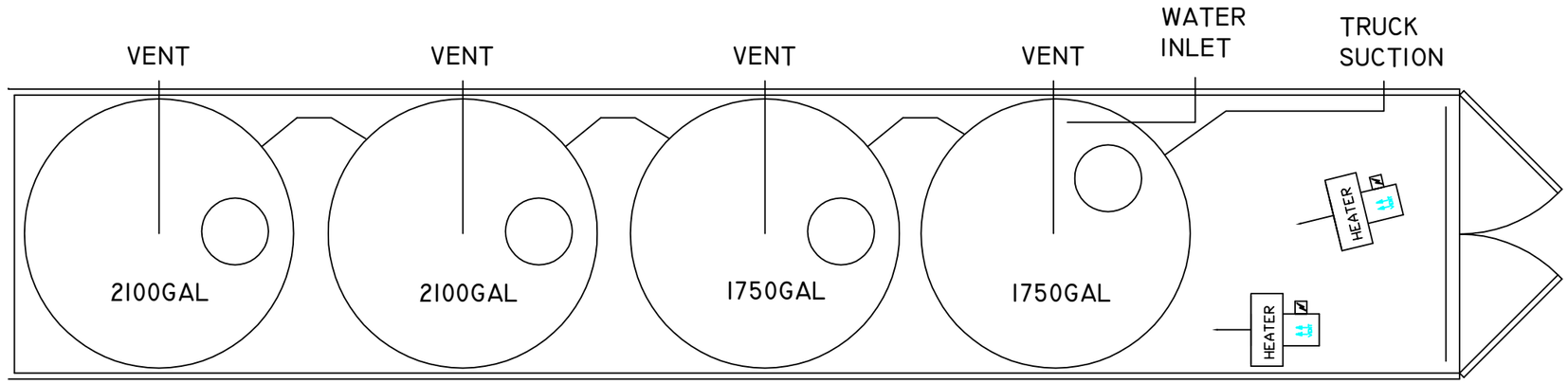

40' SHIPPING CONTAINER

WALLS
- 2" SPRAY FOAM INSULATION
- NO PLYWOOD WALLS OR FRAMING

FLOOR
- 4" SPRAY FOAM INSULATION

CEILING
- 3" SPRAY FOAM INSULATION

NOTES

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LEVEL	REVISION	DATE (mm/dd/yy)	BY
C	AS BUILT	08/09/17	JJK
B	PRODUCTION	07/09/17	JJK
A	SUBMITTAL	05/09/17	JJK

PROJECT NUMBER: 1704962

TITLE AND LOCATION: WASTEWATER TANKS

CUSTOMER: HORIZON NORTH

DRAWN BY | DATE | SHEET: 1 | SHEETS: 1

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Section 3

Electrical Drawings

1704962

WASTE WATER STORAGE
HORIZON NORTH

newterra®

ELECTRICAL DRAWING PACKAGE

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ELEC-All Electrical Drawings

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NOTES:

1291 CALIFORNIA AVE.
BROCKVILLE ONTARIO
CANADA K6V 5Y6

PHONE: 1-800-420-4056
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C	AS BUILTS	12/09/2017	ccliffe
B	FOR PRODUCTION	08/09/2017	ccliffe
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PROJ. NO: 1704962

TITLE AND LOCATION: DRAWING LIST

CUSTOMER: HORIZON NORTH WASTE WATER STORAGE

SCALE	SHEET	SHEETS
NTS	2	9

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ELECTRICAL SPECIFICATIONS	
VOLTAGE	240V
PHASE	3
FREQUENCY	60Hz
FULL LOAD AMPS	45A
MAIN DISCONNECT SIZE	NONE - BY CUSTOMER
MAIN OVERCURRENT PROTECTION RATING	NONE - BY CUSTOMER
SCCR SYMMETRICAL (kAMPS)	10
SYSTEM APPROVAL AND CLASSIFICATION	cMETus CL1 DIV 2
PANEL APPROVAL AND CLASSIFICATION	cMET TO UL698A
ELECTRICAL INSTALL SPECIFICATIONS	CLASS 1 DIV 2 STANDARD

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TITLE AND LOCATION: SPECIFICATIONS

CUSTOMER: HORIZON NORTH WASTE WATER STORAGE

SCALE	SHEET	SHEETS
NTS	3	9

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FLOW SWITCH, NORMALLY CLOSED

FLOW SWITCH, NORMALLY OPEN

FLOAT SWITCH, NORMALLY CLOSED

FLOAT SWITCH, NORMALLY OPEN

LIMIT SWITCH, NORMALLY CLOSED

LIMIT SWITCH, NORMALLY OPEN

PRESSURE SWITCH, CHANGE OVER CONTACTS

PRESSURE SWITCH, NORMALLY CLOSED OPENS ON PRESSURE INCREASE

PRESSURE SWITCH, NORMALLY OPEN CLOSES ON PRESSURE INCREASE

TEMPERATURE SWITCH, CHANGE OVER CONTACTS

TEMPERATURE SWITCH, NORMALLY CLOSED OPENS ON TEMPERATURE INCREASE

TEMPERATURE SWITCH, NORMALLY OPEN CLOSES ON TEMPERATURE INCREASE

METAL OXIDE VARISTOR
MOV

DIODE

TANDEM TERMINAL BLOCK

PANEL TERMINAL BLOCK

JUNCTION BOX TERMINAL BLOCK

CUSTOMER TERMINAL BLOCK

FUSED TERMINAL BLOCK

TERMINALS THAT ARE JUMPERED TOGETHER HAVE THEIR JUMPERS SHOWN ON THE TERMINAL STRIP LAYOUTS

TOGGLE SWITCH, NORMALLY OPEN

TEMPERATURE SWITCH, NORMALLY OPEN CLOSES ON TEMPERATURE INCREASE

PUSH BUTTON, NORMALLY CLOSED

PUSH BUTTON, NORMALLY OPEN

TEMPERATURE SWITCH, NORMALLY OPEN CLOSES ON TEMPERATURE INCREASE

SELECTOR SWITCH, 2 POSITION
2 NORMALLY OPEN

H A

SELECTOR SWITCH, 3 POSITION
2 NORMALLY OPEN

PILOT LIGHT, PUSH-TO-TEST
X=COLOUR

X

PILOT LIGHT, X=COLOUR

A - AMBER
B - BLUE
G - GREEN
R - RED
W - WHITE

BEACON LIGHT
X=COLOR

CONTACT, NORMALLY CLOSED

CONTACT, NORMALLY OPEN

TIME DELAY CONTACT, INSTANTANEOUS OPEN
TIMED CLOSED ON DE-ENERGIZE

TIME DELAY CONTACT, INSTANTANEOUS CLOSE
TIMED OPEN ON DE-ENERGIZE

TIME DELAY CONTACT, INSTANTANEOUS OPEN
TIMED CLOSE ON ENERGIZE

TIME DELAY CONTACT, INSTANTANEOUS CLOSE
TIMED OPEN ON ENERGIZE

COIL - RELAY, CONTACTOR
TIMER, MOTOR STARTER

ANNUNCIATOR, HORN

ANNUNCIATOR, BUZZER

BATTERY

TRANSMITTER, 2 WIRE
LOOP POWERED

INTRINSICALLY SAFE BARRIERS
(NOT TO SCALE)

4 CHANNEL DISCRETE

IN1
IN2
IN3
IN4

2 CHANNEL ANALOG

IN1
IN2

PANEL METER
AM=AMMETER
VM=VOLT METER

AM

ETM

ELAPSED TIME METER

CURRENT TRANSFORMER

GROUND

INSTRUMENTATION GROUND

SOLENOID

CURRENT SWITCH

FUSED DISCONNECT
X=AMP RATING

FUSE, X=AMP RATING

CIRCUIT BREAKER
X=AMP RATING

COMBINATION STARTER
X-X AMP=CURRENT RANGE

CONTACTOR

DISTRIBUTION BLOCK

M

3 PHASE MOTOR

HTR

3 PHASE HEATER

RECEPTACLE, SINGLE OUTLET

RECEPTACLE, DUPLEX

HV
LV

TRANSFORMER
CONTROL POWER
(NOT REPRESENTATIVE OF ALL TYPES)

HV
LV

TRANSFORMER
DISTRIBUTION/LIGHTING
(NOT REPRESENTATIVE OF ALL TYPES)

24V
72Watt

DC POWER SUPPLY
(NOT REPRESENTATIVE OF ALL TYPES)
(NOT TO SCALE)

REACTOR

CR0917C

0704B		0917F	
0926B		0919E	
0913F		0919F	
0913E		0925E	

CROSS REFERENCE TABLE

R/L1
S/L2
T/L3
Line Voltage
GND
U/T1
V/T2
W/T3
Motor
GND

VARIABLE FREQUENCY DRIVE
(NOT REPRESENTATIVE
OF ALL TYPES)
(NOT TO SCALE)

CONNECTION MADE BY JUMPER BAR

GENERAL PUROSE WIRING EXTERNAL TO PANEL

CL1DIV2 WIRING EXTERNAL TO PANEL

WIRING BY OTHERS EXTERNAL TO PANEL

USA 3 PHASE
POWER WIRING COLOR CODE

480V	208/230V (HIGH LEG)
PHASE A - BROWN	PHASE A - BLACK
PHASE B - ORANGE	PHASE B - RED(ORG)
PHASE C - YELLOW	PHASE C - BLUE

CANADIAN 3 PHASE
POWER WIRING COLOUR CODE

PHASE A - RED
PHASE B - BLACK
PHASE C - BLUE

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PROJ. NO: 1704962

CUSTOMER: HORIZON NORTH WASTE WATER STORAGE

TITLE AND LOCATION: ELECTRICAL LEGEND

SCALE	SHEET	SHEETS
NTS	4	9

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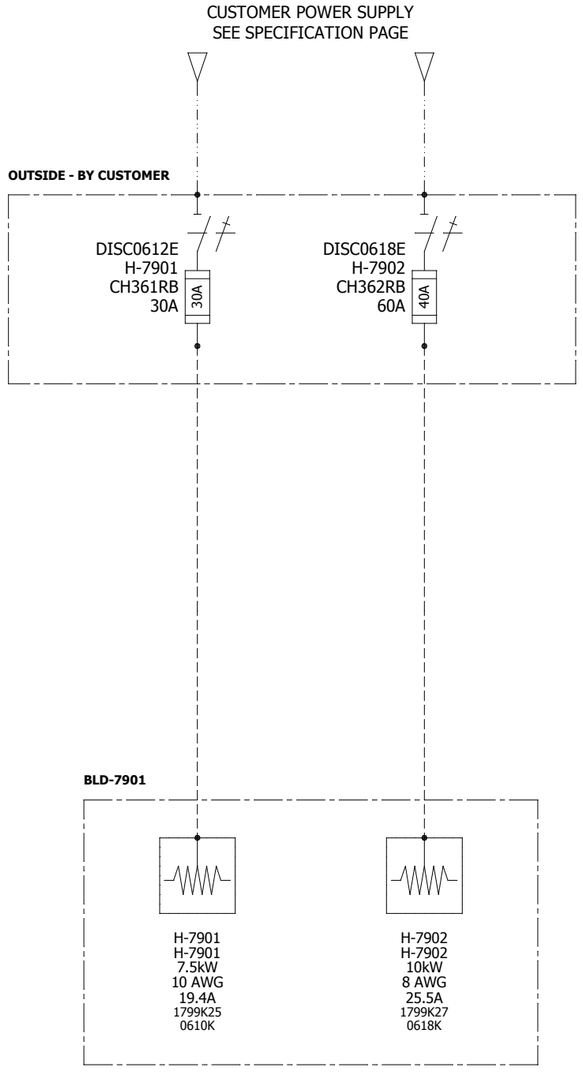

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TITLE AND LOCATION: SINGLE LINE DIAGRAM

MCP

CUSTOMER: HORIZON NORTH WASTE WATER STORAGE

SCALE	SHEET	SHEETS
NTS	5	9

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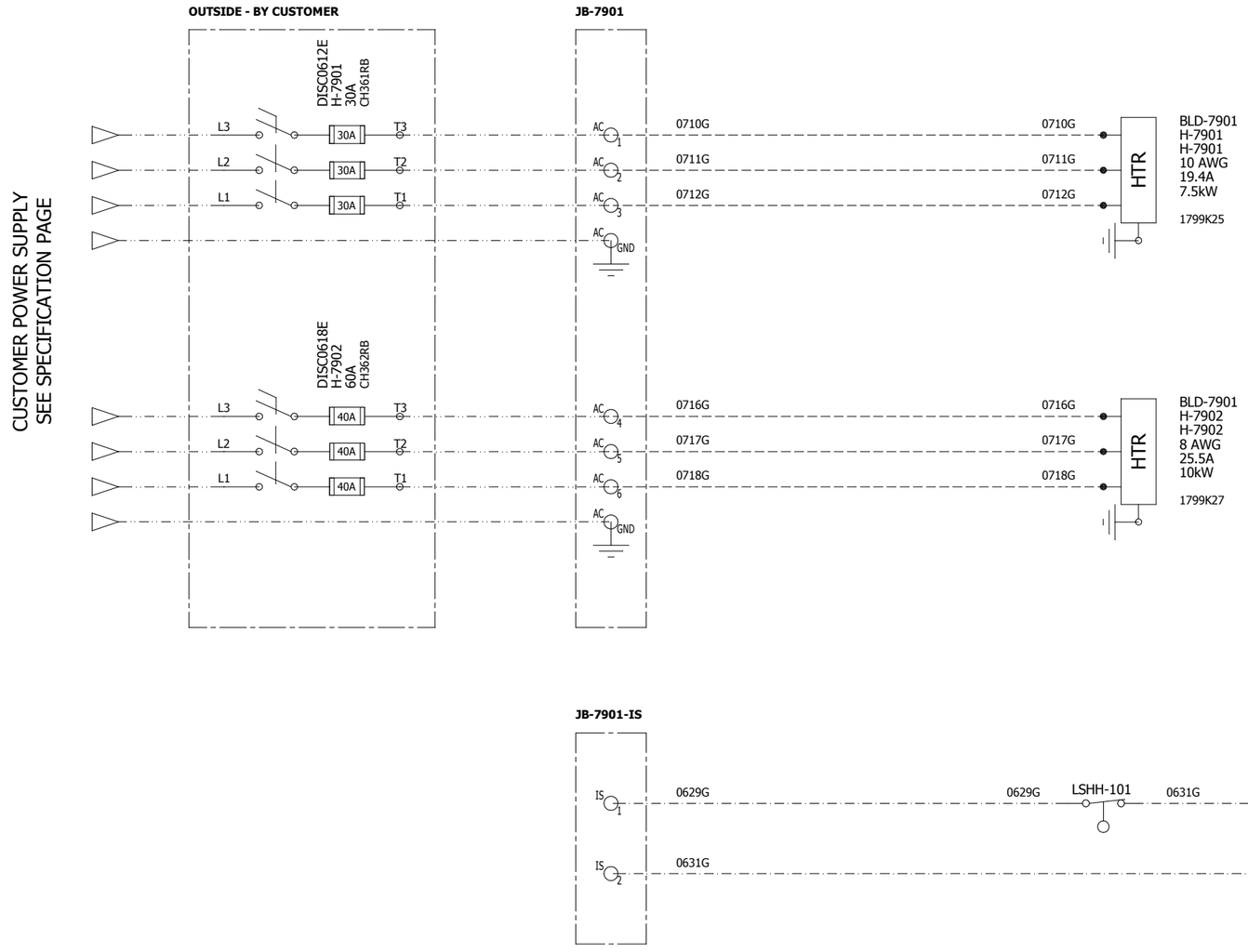

CONTROL WIRING LEGEND

BLACK:	POWER
RED:	120VAC CONTROL
WHITE:	NEUTRAL
BLUE:	+24VDC & IS WIRING
BLU/WHT:	0VDC
YELLOW:	INTERLOCKS

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TITLE AND LOCATION: POWER DISTRIBUTION

MCP

CUSTOMER: HORIZON NORTH WASTE WATER STORAGE

SCALE	SHEET	SHEETS
NTS	6	9

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JB-7901

Quantity	APES Number	Manufacturer	Part Number	Description	TAG
1	19168	Phoenix Contact	801733	Steel mounting rail; 35x7,5 mm, 1 mm thick; perforated	JB-7901
2	23745	Phoenix Contact	800886	End Bracket - DIN Rail	JB-7901
6	28365	Phoenix Contact	3036110	Terminal, PHX 3036110, ST 10, Grey, Spring Cage, 24 - 8 AWG	AC-1 , AC-2 , AC-3 , AC-4 , AC-5 , AC-6
2	28366	Phoenix Contact	3036644	Terminal, PHX 3036644, D-ST 10, End cover for ST 10 terminal	JB-7901
2	28446	Phoenix Contact	3030433	Terminal, PHX 3030433, D-ST 6, End cover for ST 6 terminal	JB-7901
2	28447	Phoenix Contact	3031500	TERMINAL, GROUND, 24-10AWG, ST6-PE	AC-GND
1	38220	Hammond Mfg	EJ1084	Junction Box, 10" x 8" x 4", Hammond EJ1084 with Back Panel and Hinged ...	JB-7901

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PROJ. NO: 1704962

TITLE AND LOCATION: BILL OF MATERIAL - ELECTRICAL
PAGE 1/3

CUSTOMER: HORIZON NORTH
WASTE WATER STORAGE

SCALE	SHEET	SHEETS
NTS	7	9

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JB-7901-IS

Quantity	APES Number	Manufacturer	Part Number	Description	TAG
1	19168	Phoenix Contact	801733	Steel mounting rail; 35x7,5 mm, 1 mm thick; perforated	JB-7901-IS
2	23738	Phoenix Contact	3031377	Terminal, Blue, 28-12AWG, 30A, 600V	IS-1 , IS-2
1	23742	Phoenix Contact	3030420	End Plate - 30A Feed Thru	JB-7901-IS
2	23745	Phoenix Contact	800886	End Bracket - DIN Rail	JB-7901-IS
1	37975	Hammond Mfg	EJ664	Junction Box, 6" x 6" x 4", Hammond EJ664 with Back Panel and Hinged Li...	JB-7901-IS

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TITLE AND LOCATION: BILL OF MATERIAL - ELECTRICAL PAGE 2/3

CUSTOMER: HORIZON NORTH WASTE WATER STORAGE

SCALE	SHEET	SHEETS
NTS	8	9

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OUTSIDE - BY CUSTOMER

Quantity	APES Number	Manufacturer	Part Number	Description	TAG
1	11328	Schneider Electric	CH362RB	Disconnect,3ph, CH362RB60A,CSA,600V,Nema 3R,fusible disconnect	DISC0618E
1	38783	Schneider Electric	CH361RB	Disconnect,3ph, CH361RB 30A,CSA,600V,Nema 3R,fusible disconnect	DISC0612E
9	E1200	Ferraz Shawmut	TRS30R	Fuse, GLD TRS30R 30A 600V Time Delay	DISC0612E
9	E1202	Ferraz Shawmut	TRS40R	Fuse, GLD TRS40R 40A 600V Time Delay	DISC0618E

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TITLE AND LOCATION: BILL OF MATERIAL - ELECTRICAL PAGE 3/3

CUSTOMER: HORIZON NORTH WASTE WATER STORAGE

SCALE	SHEET	SHEETS
NTS	9	9

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Section 4

Mechanical Components

Project As-Built Document

08-Sep-17

1704962 **Horizon North Wastewater Sto**

Customer: Patrice Demers Horizon North Camps & Catering

System SIte Specifications

Elevation: 0 ft
Max Temp 0 deg F
Min Temp: 0 deg F
Noise Target:
Gas Required:
Water Required:
Telephone Reqd:
Building:

System Electrical Specifications

Voltage:
Main Disconnect
Panel Approval: Class
System Approval: Class
Panel Type:
Telemetry:
Autodialer:
EMonitor: Server:

System SVE (First Blower)

0 @ 0
Blower Disch Temp: 0 deg F
Inlet Legs: 0
Disch Press: 0 in wc
Water Flowrate: 0 gpm
Heat xchg Disch: 0 deg F

System SVE (Second Blower)

0 @ 0
Blower Disch Temp: 0 deg F
Inlet Legs: 0
Disch Press: 0 in wc
Water Flowrate: 0 gpm
Heat xchg Disch: 0 deg F

Air Sparge

0 @ 0 psi
Sparge Disch Temp: 0 deg F
Disch Legs: 0
Heat xchg Disch: 0 deg F

Other Specifications

Other Inlet Liquid Flow: 0 gpm
Disch Flow: 0 gpm @ 0 psi
AirTreatment:
Water_Treatment:
Stripper Airflow: 0 cfm
Stripper Dsn Flow: 0 gpm
OWS_Dsn_Flow: 0 gpm

Contaminants

Other Information May be Presented Below

Connection Info:

Shipping Information

Valport Maritime Services Inc
950 Boulevard Gérard-Cadieux

Salaberry-de-Valle Quebec
Canada J6T 6L4

Reducer, Bushing, Galv, 3" x 2" Hex Reducer, Bushing, Galv, 3" x 2"	Part: Qty: Mfg: Mfg Part:	10019 1
Valve, Ball, Brass, 3/4", 150# NPT, Teflon seats, 600 PSI WOG Valve, Ball, Brass, 3/4", 150#	Part: Qty: Mfg: Mfg Part:	10095 1 Kitz
Tee, Galv, 2" 1 Tee, Galv, 2"	Part: Qty: Mfg: Mfg Part:	10136 2
Plug, Galv, 2", Square Drive Plug, Galv, 2", Square Drive	Part: Qty: Mfg: Mfg Part:	10137 1
Plug, Galv, 2", Square Drive Plug, Galv, 2", Square Drive	Part: Qty: Mfg: Mfg Part:	10137 1
Pipe, PVC 40, 2" 10ft Length, 40-020G Pipe, PVC 40, 2"	Part: Qty: Mfg: Mfg Part:	10154 20
Pipe, PVC 40, 2" 10ft Length, 40-020G Pipe, PVC 40, 2"	Part: Qty: Mfg: Mfg Part:	10154 30
Pipe, PVC 40, 2" 10ft Length, 40-020G Pipe, PVC 40, 2"	Part: Qty: Mfg: Mfg Part:	10154 10
Pipe, PVC 40, 2" 10ft Length, 40-020G Pipe, PVC 40, 2"	Part: Qty: Mfg: Mfg Part:	10154 10
Pipe, PVC 40, 2" 10ft Length, 40-020G Pipe, PVC 40, 2"	Part: Qty: Mfg: Mfg Part:	10154 20
Nipple, PVC 80, 2" x 8" Nipple, PVC 80, 2" x 8"	Part: Qty: Mfg: Mfg Part:	10366 6

Cement Solvent, PVC, 711, quart	Part:	10384
	Qty:	1
	Mfg:	
Cement Solvent, PVC, 711, quart	Mfg Part:	
Valve, Ball, Brass, 1/2", 150#	Part:	10538
NPT, Teflon seats, 600 PSI WOG	Qty:	2
	Mfg:	
Valve, Ball, Brass, 1/2", 150#	Mfg Part:	
Nipple, Galv, 1/2" x Close	Part:	10619
	Qty:	2
	Mfg:	
Nipple, Galv, 1/2" x Close	Mfg Part:	
Coupling, PVC 80, 3", SxS, 829-030G	Part:	10729
	Qty:	2
	Mfg:	
Coupling, PVC 80, 3", SxS, 829-030G	Mfg Part:	
Plug, Galv, 1-1/2", Square Drive	Part:	10804
	Qty:	2
	Mfg:	
Plug, Galv, 1-1/2", Square Drive	Mfg Part:	
Reducer, Bushing, Galv, 4" x 3"	Part:	10811
Hex	Qty:	1
	Mfg:	
Reducer, Bushing, Galv, 4" x 3"	Mfg Part:	
Nipple, KC, Plated, 3/4"	Part:	12235
	Qty:	1
	Mfg:	
Nipple, KC, Plated, 3/4"	Mfg Part:	
Paint, Roller, 3106.081 (6) sleeve	Part:	12925
10mm	Qty:	1
	Mfg:	
Paint, Roller, 3106.081 (6) sleeve	Mfg Part:	
Washer, Master seal 3/8", 685-004, (100 per box)	Part:	13368
	Qty:	100
	Mfg:	
Washer, Master seal 3/8", 685-004, (100 per box)	Mfg Part:	
Strut, Slotted, 1-5/8" x 1-5/8"	Part:	15297
TB A1200HS10PGC	Qty:	20
	Mfg:	
Strut, Slotted, 1-5/8" x 1-5/8"	Mfg Part:	
Strut, Slotted, 1-5/8" x 1-5/8"	Part:	15297
TB A1200HS10PGC	Qty:	20
	Mfg:	
Strut, Slotted, 1-5/8" x 1-5/8"	Mfg Part:	
Strut, Slotted, 1-5/8" x 1-5/8"	Part:	15297
TB A1200HS10PGC	Qty:	20
	Mfg:	
Strut, Slotted, 1-5/8" x 1-5/8"	Mfg Part:	

Strut, Slotted, 1-5/8" x 1-5/8" TB A1200HS10PGC Strut, Slotted, 1-5/8" x 1-5/8"	Part: Qty: Mfg: Mfg Part:	15297 20
Strut, Slotted, 1-5/8" x 1-5/8" TB A1200HS10PGC Strut, Slotted, 1-5/8" x 1-5/8"	Part: Qty: Mfg: Mfg Part:	15297 20
Strut, Vinyl End Covers, 1-5/8" TB A804NEOPWH Strut, Vinyl End Covers, 1-5/8"	Part: Qty: Mfg: Mfg Part:	15318 25
Strut, Twirl Nuts, 3/8" TN228 ZN Strut, Twirl Nuts, 3/8"	Part: Qty: Mfg: Mfg Part:	15323 100
Strut, Angle, 5 Hole 90 deg Fitting - Gusset 3-1/2" x 4-1/8" Strut, Angle, 5 Hole 90 deg Fitting - Gusset	Part: Qty: Mfg: Mfg Part:	15324 6
Strut, Angle, 4 Hole 90 deg Corner 3-1/2" x 4-1/8" Strut, Angle, 4 Hole 90 deg Corner	Part: Qty: Mfg: Mfg Part:	15391 25
Plug, PVC 40, 2", MPT 450-020G Plug, PVC 40, 2", MPT	Part: Qty: Mfg: Mfg Part:	15500 1
Hole Saw, 3-1/2" Hole Saw, 3-1/2"	Part: Qty: Mfg: Mfg Part:	15935 1
Reducer, Bushing, Black, 2" x 1-1/2" Hex Reducer, Bushing, Black, 2" x 1-1/2"	Part: Qty: Mfg: Mfg Part:	16450 2
Plug, Galv, 1/2", Square Drive Plug, Galv, 1/2", Square Drive	Part: Qty: Mfg: Mfg Part:	17440 10
Hose Barb, Brass, 1/4" x 1/4", NPT x Hose, 125-4B 1 Hose Barb, Brass, 1/4" x 1/4", NPT x Hose, 125-4B	Part: Qty: Mfg: Mfg Part:	18070 1
Reinforced, Adapter, PVC 80, Female, 2", Spig x T Steel Reinforced, 878-020SR Reinforced, Adapter, PVC 80, Female, 2", Spig x T	Part: Qty: Mfg: Mfg Part:	19282 2

Plug, Black, 1-1/2"	Part:	21375
	Qty:	2
	Mfg:	
Plug, Black, 1-1/2"	Mfg Part:	
Gloves, Polyethelene Knit, Large Polyurethane dipped palm, Cut Level 3	Part:	21913
	Qty:	2
	Mfg:	
Gloves, Polyethelene Knit, Large	Mfg Part:	
Gloves, Polyethelene Knit, Large Polyurethane dipped palm, Cut Level 3	Part:	21913
	Qty:	1
	Mfg:	
Gloves, Polyethelene Knit, Large	Mfg Part:	
Gloves, Polyethelene Knit, X-Large Polyurethane dipped palm, Cut Level 3	Part:	21914
	Qty:	1
	Mfg:	
Gloves, Polyethelene Knit, X-Large	Mfg Part:	
Coupling, PVC 40, 2", SxS, 429-020G	Part:	22488
	Qty:	2
	Mfg:	
Coupling, PVC 40, 2", SxS, 429-020G	Mfg Part:	
Elbow, 90deg, PVC 40, 2", SxS, 406-020G	Part:	22489
	Qty:	8
	Mfg:	
Elbow, 90deg, PVC 40, 2", SxS, 406-020G	Mfg Part:	
Plug, PVC 40, 3", MPT 450-030G	Part:	23421
	Qty:	1
	Mfg:	
Plug, PVC 40, 3", MPT	Mfg Part:	
Nut, hex, 3/8"-16, zinc plated	Part:	23676
	Qty:	50
	Mfg:	
Nut, hex, 3/8"-16, zinc plated	Mfg Part:	
Washer, BS, Flat, 3/8", Plated	Part:	23678
	Qty:	100
	Mfg:	
Washer, BS, Flat, 3/8", Plated	Mfg Part:	
Washer, BS, Flat, 3/8", Plated	Part:	23678
	Qty:	100
	Mfg:	
Washer, BS, Flat, 3/8", Plated	Mfg Part:	
Washer, BS, Lock, Spring, 3/8", Plated	Part:	23679
	Qty:	50
	Mfg:	
Washer, BS, Lock, Spring, 3/8", Plated	Mfg Part:	
Washer, BS, Lock, Spring, 3/8", Plated	Part:	23679
	Qty:	20
	Mfg:	
Washer, BS, Lock, Spring, 3/8", Plated	Mfg Part:	

Lubricant, Super Lube, Cartridge, 14.5 oz PTFE	Part:	23726
	Qty:	1
	Mfg:	
Lubricant, Super Lube, Cartridge, 14.5 oz PTFE	Mfg Part:	
Tape, Silver Duct, 2" (2"x60yrd) 3M 3939	Part:	23771
	Qty:	1
	Mfg:	
Tape, Silver Duct, 2" (2"x60yrd) 3M 3939	Mfg Part:	
Cleaner, Citris, Llyods 51120, 20oz	Part:	23781
	Qty:	1
	Mfg:	
Cleaner, Citris, Llyods 51120, 20oz	Mfg Part:	
Blade, Sawzall, "THE TORCH", 14T, 9", 5PK	Part:	23785
	Qty:	1
	Mfg:	
Blade, Sawzall, "THE TORCH", 14T, 9", 5PK	Mfg Part:	
Respirator, Mask, Disposable, N95	Part:	23829
M1-5-8210	Qty:	2
RESPIRATOR: N95 PARTICULATE DUST MASK	Mfg:	
Respirator, Mask, Disposable, N95	Mfg Part:	
Screw, Hex Head Cap, NC, GR5, Plated, 5/16-18x1-1/4"	Part:	23837
	Qty:	8
	Mfg:	
Screw, Hex Head Cap, NC, GR5, Plated, 5/16-18x1-1/4"	Mfg Part:	
Screw, Hex Head Cap, NC, GR5, Plated, 3/8-16x3"	Part:	23861
	Qty:	2
	Mfg:	
Screw, Hex Head Cap, NC, GR5, Plated, 3/8-16x3"	Mfg Part:	
Screw, Hex Head Cap, NC, GR5, Plated, 3/8-16x3"	Part:	23861
	Qty:	50
	Mfg:	
Screw, Hex Head Cap, NC, GR5, Plated, 3/8-16x3"	Mfg Part:	
Cement, PVC, Electrical	Part:	25399
250 ML	Qty:	1
	Mfg:	
Cement, PVC, Electrical	Mfg Part:	
Screw, Hex Head Cap, NC, GR5, Plated, 5/16-18x1"	Part:	25594
	Qty:	8
	Mfg:	
Screw, Hex Head Cap, NC, GR5, Plated, 5/16-18x1"	Mfg Part:	
Washer, SS, Flat, 1/4"	Part:	25670
	Qty:	16
	Mfg:	
Washer, SS, Flat, 1/4"	Mfg Part:	
Junction Box, 10" x 8" x 4",	Part:	27232
box only requires backplate to be ordered	Qty:	1
	Mfg:	
Junction Box, 10" x 8" x 4",	Mfg Part:	

Bit, Power Drive, #2 x Square	Part:	29383
	Qty:	1
	Mfg:	
Bit, Power Drive, #2 x Square	Mfg Part:	
Screw, Hex Head Cap, NC, GR5, Plated, 3/8-16x2-1/2"	Part:	29747
	Qty:	2
	Mfg:	
Screw, Hex Head Cap, NC, GR5, Plated, 3/8-16x2-1/2"	Mfg Part:	
Screw, Hex Head Cap, 1/4-20 x 3", SS **XFR**	Part:	35629
	Qty:	8
	Mfg:	
Screw, Hex Head Cap, 1/4-20 x 3", SS **XFR**	Mfg Part:	
Washer, SS, Lock, 1/4" **XFR**	Part:	35892
	Qty:	8
	Mfg:	
Washer, SS, Lock, 1/4" **XFR**	Mfg Part:	
Junction Box, 6" x 6" x 4", Hammond EJ664 with Back Panel and Hinged Lid, NEMA 4	Part:	37975
	Qty:	1
	Mfg:	
Junction Box, 6" x 6" x 4", Hammond EJ664	Mfg Part:	
Coupling, Galv, 2"	Part:	P1016
	Qty:	2
	Mfg:	
Coupling, Galv, 2"	Mfg Part:	
Reducer, Bushing, Galv, 1/2" x 1/4" Hex	Part:	P1018
	Qty:	1
	Mfg:	
Reducer, Bushing, Galv, 1/2" x 1/4"	Mfg Part:	
Reducer, Bushing, Galv, 2" x 1/2" Hex	Part:	P1021
	Qty:	2
	Mfg:	
Reducer, Bushing, Galv, 2" x 1/2"	Mfg Part:	
Reducer, Bushing, Galv, 3" x 1-1/2" Hex	Part:	P1022
	Qty:	1
	Mfg:	
Reducer, Bushing, Galv, 3" x 1-1/2"	Mfg Part:	
Adapter, Tank, PVC, 2", Threaded, 871-020 Bulkhead Fitting	Part:	P1040
	Qty:	1
	Mfg:	
Adapter, Tank, PVC, 2", Threaded, 871-020	Mfg Part:	
Reducer, Bushing, Galv, 2" x 1-1/2" Hex	Part:	P1053
	Qty:	1
	Mfg:	
Reducer, Bushing, Galv, 2" x 1-1/2"	Mfg Part:	
Pipe, PVC 80, 3" 10 ft. 80-030	Part:	P1101
	Qty:	10
	Mfg:	
Pipe, PVC 80, 3" 10 ft.	Mfg Part:	

Plug, ABS, 4", 21-4APG	Part:	P1109
	Qty:	4
	Mfg:	
Plug, ABS, 4", 21-4APG	Mfg Part:	
Nipple, Galv, 2" x 6"	Part:	P1141
	Qty:	4
	Mfg:	
Nipple, Galv, 2" x 6"	Mfg Part:	
Elbow, 90deg, PVC 80, 2", SxS, 806-020G	Part:	P1144
	Qty:	16
	Mfg:	
Elbow, 90deg, PVC 80, 2", SxS, 806-020G	Mfg Part:	
Coupling, PVC 80, 2", SxS, 829-020G	Part:	P1145
	Qty:	4
	Mfg:	
Coupling, PVC 80, 2", SxS, 829-020G	Mfg Part:	
Coupling, PVC 80, 2", SxS, 829-020G	Part:	P1145
	Qty:	2
	Mfg:	
Coupling, PVC 80, 2", SxS, 829-020G	Mfg Part:	
Coupling, PVC 80, 2", SxS, 829-020G	Part:	P1145
	Qty:	4
	Mfg:	
Coupling, PVC 80, 2", SxS, 829-020G	Mfg Part:	
Tee, PVC 80, 2", SxSxS, 801-020G	Part:	P1156
	Qty:	8
	Mfg:	
Tee, PVC 80, 2", SxSxS, 801-020G	Mfg Part:	
Adapter, Tank, PVC, 3", Threaded, 871-030	Part:	P1167
Bulkhead Fitting	Qty:	6
	Mfg:	
Adapter, Tank, PVC, 3", Threaded, 871-030	Mfg Part:	
Nipple, PVC 80, 3" x 8"	Part:	P1168
	Qty:	8
	Mfg:	
Nipple, PVC 80, 3" x 8"	Mfg Part:	
Pipe, PVC 80, 2"	Part:	P1190
80-020	Qty:	20
	Mfg:	
Pipe, PVC 80, 2"	Mfg Part:	
Pipe, PVC 80, 2"	Part:	P1190
80-020	Qty:	10
	Mfg:	
Pipe, PVC 80, 2"	Mfg Part:	
Pipe, PVC 80, 2"	Part:	P1190
80-020	Qty:	20
	Mfg:	
Pipe, PVC 80, 2"	Mfg Part:	

Pipe, PVC 80, 2" 80-020 Pipe, PVC 80, 2"	Part: Qty: Mfg: Mfg Part:	P1190 30
Pipe, PVC 80, 2" 80-020 Pipe, PVC 80, 2"	Part: Qty: Mfg: Mfg Part:	P1190 40
Reducer, Bushing, Black, 4" x 2" Hex Reducer, Bushing, Black, 4" x 2"	Part: Qty: Mfg: Mfg Part:	P1198 2

-

Nipple, PVC 80, 2" x 8" ---	Part: Qty: Mfg: Mfg Part:	10366 10 887-080
Flexible Coupling, 3" x 3" ---	Part: Qty: Mfg: Mfg Part:	10383 6 5633
Elbow, 45deg, PVC 80, 3", SxS, 817-030G ---	Part: Qty: Mfg: Mfg Part:	10767 12 817-030
Reinforced, Adapter, PVC 80, Female, 2", FNPTxS Fitting, transition, socket x Fipt SS ---	Part: Qty: Mfg: Mfg Part:	17054 4 835-020SR
Tank, Lid, Non Vented 16" replacement lid ---	Part: Qty: Mfg: Mfg Part:	23430 8 norwesco 60365
Tank, Gasket, For 16" Lid Ethafoam ---	Part: Qty: Mfg: Mfg Part:	24326 10 norwesco 62941
Tank, Closed Top, Cylindrical, 2100 gal, Norwesco - no drain 87dia 89 tall, 1.9sg, Heavy Walled, blue 40241 ---	Part: Qty: Mfg: Mfg Part:	26009 4 40241
Tank, Closed Top, Cylindrical, HDPE, 1700 gal, Norwesco 89 dia 72" tall Heavy Wall , 1.9sg - No Drain, bl 40012 ---	Part: Qty: Mfg: Mfg Part:	26010 4 40012 - No Botto
Valve, Ball, PVC, 2", True-Union, FPM O-rings SOC ends included ---	Part: Qty: Mfg: Mfg Part:	37662 10 K15-020VS

Adapter, Tank, PVC, 2", Threaded, 871-020 Bulkhead Fitting ---	Part: Qty: Mfg: Mfg Part:	P1040 20 8172E-020
Adapter, Tank, PVC, 3", Threaded, 871-030 Bulkhead Fitting ---	Part: Qty: Mfg: Mfg Part:	P1167 12 8172E-030

ls

Strain Relief, Connector, PVC, 1/2" TSRC10 None	Part: Qty: Mfg: Mfg Part:	16884 2 TSRC10
Switch, Level, Mech Float, Narrow Angle, N.C., YEL N/C, Yellow float None	Part: Qty: Mfg: Mfg Part:	19279 2 PY2CW4000
Switch, Level, Tether Weight Cast Iron fits PB20W4000 None	Part: Qty: Mfg: Mfg Part:	21552 2
Level Switch Assembly -	Part: Qty: Mfg: Mfg Part:	38185 2 -
Adapter, Tank, PVC, 1/2", Threaded, 871-005 Bulkhead Fitting None	Part: Qty: Mfg: Mfg Part:	P1166 2 8172E-005

Building

Module Code: 7900

Strut, Clamp, 2" EMT/RIGID ERC SK325I Strut, Clamp, 2" EMT/RIGID	Part: Qty: Mfg: Mfg Part:	15304 50

-

Container, 40' x 8' x 9'6", Once Use, High Cube, Steel Floor 30,480kg rated, Forklift Pockets, CSC Plate, ISO ABS/BV/LR Certs. Steel Checkerplate ---	Part: Qty: Mfg: Mfg Part:	24612 2
Insulation, Container, Complete interior insulation, Blown Spray Foam 40ft Containers 3in ceiling	Part: Qty: Mfg: Mfg Part:	25403 2
Paint, Hempatex Hi Build 46410, Black Hempel Colour Code 19990 priced per Gallon - sold in 5 gallon pails ---	Part: Qty: Mfg: Mfg Part:	28979 5

bld

Junction Box, 6" x 6" x 4", Hammond EJ664 with Back Panel and Hinged Lid, NEMA 4 ---	Part: Qty: Mfg: Mfg Part:	37975 2 HAM EJ664

Decal

Label, Misc. As per detailed specification below. Decals per document: 1704962 Port Shipping Label - Newterra.pdf 4 decals. 2 decals of each page.	Part: Qty: Mfg: Mfg Part:	35332 4

Freight

Estimated Freight to jobsite - address as provided Outbound ---	Part: Qty: Mfg: Mfg Part:	25793 2 x

H-7901

Misc Part, McMaster-Carr 1799K27 Hazardous Location Wall-Mount Large-Space Heater, 240V AC, 34100 Btu/hr.	Part: Qty: Mfg: Mfg Part:	21362 2 1799K27

H-7902

McMaster-Carr, Misc, Catalog Part	Part:	22858
See Description	Qty:	2
	Mfg:	
1799K25 Hazardous Location Wall-Mount Large-Space Heater, 240V AC, 25600 Btu/hr	Mfg Part:	1799K25

JB

Module Code: 8200

JB

Terminal, PHX 3031487, ST 6	Part:	28445
Grey, Spring Cage, 24-10 AWG	Qty:	12
	Mfg:	
---	Mfg Part:	3031487
Terminal, PHX 3031500, ST 6-PE	Part:	28447
Ground, Spring Cage, 24-10 AWG	Qty:	4
	Mfg:	
---	Mfg Part:	PHX 3031500
Junction Box, 10" x 8" x 4", Hammond EJ1084	Part:	38220
with Back Panel and Hinged Lid, NEMA 4	Qty:	2
	Mfg:	
---	Mfg Part:	HAM EJ1084

MPP

Breaker, Techna, JTEC4893C30	Part:	17715
480/277V 30 AMP 3P C Trip Curve	Qty:	1
10k SCCR	Mfg:	Fusetek
---	Mfg Part:	JTEC4893C30
Breaker, Techna, JTEC4893C40	Part:	17717
240V 40 AMP 3P C Trip Cuve	Qty:	1
10k SCCR	Mfg:	Fusetek
---	Mfg Part:	JTEC4893C40

Disconnects

Module Code: 8900

DISC

Disconnect, 3ph, CH362RB	Part:	11328
60A,CSA,600V,Nema 3R,fusible disconnect	Qty:	2
	Mfg:	Square D
---	Mfg Part:	SQD CH362RB
Disconnect, Square D, CH361RB	Part:	38783
30A, CSA, 600V, Nema 3R,fusible disconnect	Qty:	2
	Mfg:	
---	Mfg Part:	SQD CH361RB
Fuse, GLD TRS30R	Part:	E1200
30A 600V Time Delay	Qty:	18
Class R	Mfg:	Ferraz Shawmut
---	Mfg Part:	GLD TRS30R
Fuse, GLD TRS40R	Part:	E1202
40A 600V Time Delay	Qty:	18
Class R	Mfg:	Ferraz Shawmut
---	Mfg Part:	GLD TRS40R

Section 5

System Manuals

Manual Document List

PMProjNum **1704962**

Horizon North Wastewater Storage Tanks

Part Number	Part Description	
Tag		

Module: *100*

19279 Switch, Level, Mech Float, Narrow Angle, N.C., YEL Manucturer:

ls ManDoc: \\mlee-nas\DATA\Library\Gems\Manuals\Series M Float Switch Manual.pdf

Module: *7900*

21362 Misc Part, McMaster-Carr Manucturer:

Merkel HLA12

22858 McMaster-Carr, Misc, Catalog Part Manucturer:

H-7902 ManDoc:

Merkel HLA16

Warrick®
Series M Mechanical Tilt Float Switch
Installation and Operation Bulletin

Specifications

Cord	16 gauge, 2 or 3 conductor SJOW, Oil Resistant CPE
Contact Rating	13 amp @ 120/240 VAC, 1/2hp
Contact Design	SPST, Normally Open or Normally Closed, Common with N.O. & N.C. (Form C)
Temperature Rating	32°F (0°C) to 194°F (90°C) Dry and 140°F (60°C) Water Resistant
Overall Weight	1.0 lbs. (not including weight)
Tether Method	Tie-wrap nylon, weight: 2.5 lbs.
Approvals	U.L. Recognized, CSA Certified

Installation

Tether Tie-Wrap (Fig 1)
Attach cord, using a tie-wrap, to a stationary structure. This is known as the tether point, it will determine the pumping range. The farther the float is placed from the tether point, the greater the pumping range. The minimum distance that the float should be placed from the tether point is 3 inches.

Tether-Weight (Fig 2)
Place tension-brand over the cord before installation. Place the weight at the desired position and secure with the tension-band. This position will determine the pumping range. The farther the float is placed from the tether point, the greater the pumping range. The minimum distance that the float should be placed from the tether point is 3 inches.

Determine tether point using charts below as a reference

Notes:
1. To Prevent Motor Burnout - In a pumpdown application make sure the turn-off level is at least 2 inches above the intake of the submersible pump.

2. Securing Tether Points - Make sure levels are correct and that floats are free from any obstructions before securing tether points.

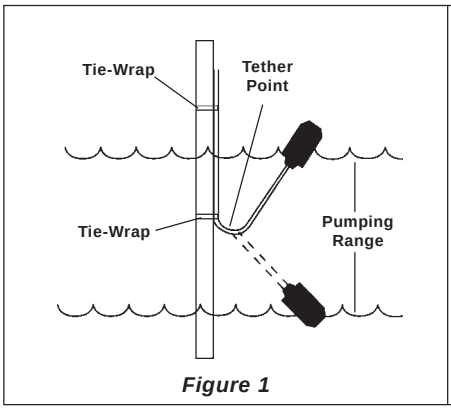


Figure 1

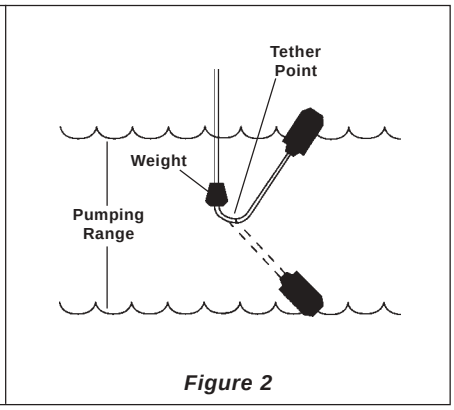
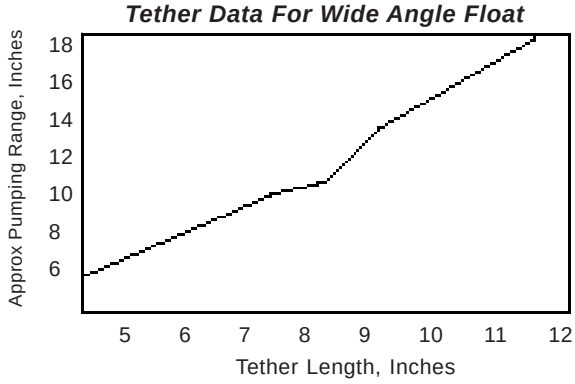
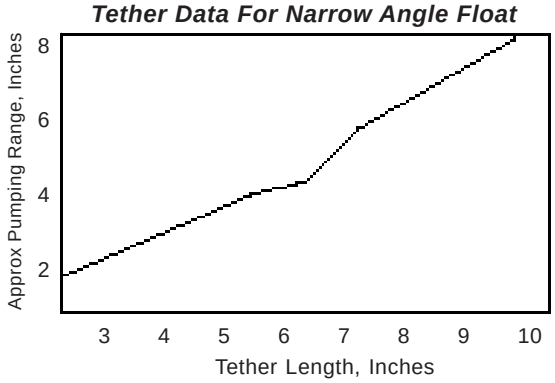


Figure 2

Tether Data For Wide Angle Float

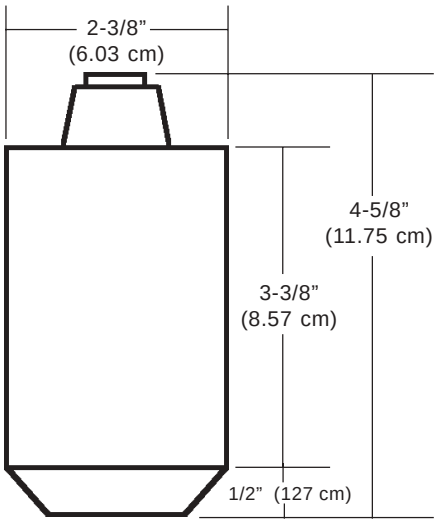


Tether Data For Narrow Angle Float

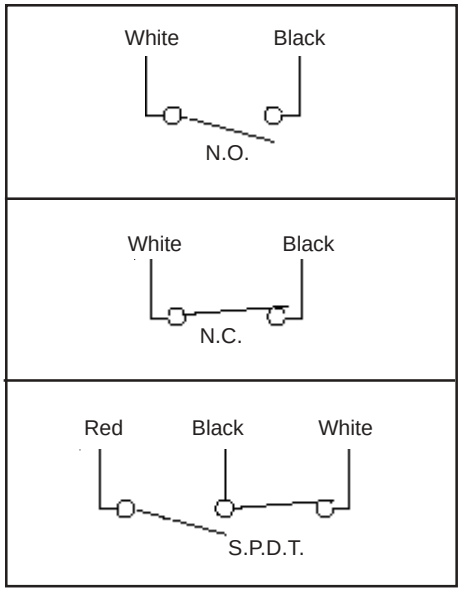


Notes:
1. Narrow angle pumping range is approximately 2 In. to 8 In.
2. Wide angle pumping range is approximately 5 In. to 18 In.

Dimensions



Contact Configurations



Important Points:

- Gems products must be maintained and installed in strict accordance with the National Electrical Code and the applicable Gems Product Instruction Bulletin that covers installation, operation and proper maintenance. Failure to observe this information may result in serious injury or damages.
- For hazardous area applications involving such things as, but not limited to, ignitable mixtures, combustible dust and flammable materials, use an appropriate explosionproof enclosure or intrinsically safe interface device.
- Please adhere to the pressure and temperature limitations shown throughout this catalog for our level and flow sensors. These limitations must not be exceeded. These pressures and temperatures take into consideration possible system surge pressures/temperatures and their frequencies.
- Selection of materials for compatibility with the media is critical to the life and operation of Gems products. Take care in the proper selection of materials of construction, testing is required.
- NSF-approved sensors are made of materials approved for potable water applica tions according to Standard 61.
- Stainless steel is generally regarded as safe by NSF and FDA.
- Life expectancy of switch contacts varies with application. Contact Gems if life cycle testing is required.
- Ambient temperature changes do affect switch set points, since the gravity of a liquid can vary with temperature.
- Our sensors have been designed to resist shock and vibration. However, shock and vibration should be minimized.
- Filter liquid media containing particulate and/or debris to ensure the proper operation of our products.
- Electrical entries and mounting points in an enclosed tank may require liquid/vapor sealing.
- Our sensors must not be field-repaired.
- Physical damage sustained by product may render it unserviceable.

Return Policy

Returns are accepted on stock items up to 30 days from date of order. You must contact our Returns Department for a Return Authorization (RA) number. Return the goods - freight prepaid - in the original container and include original packing slip. C. O. D. returns are not accepted. Gems reserves the right to apply restocking charges.

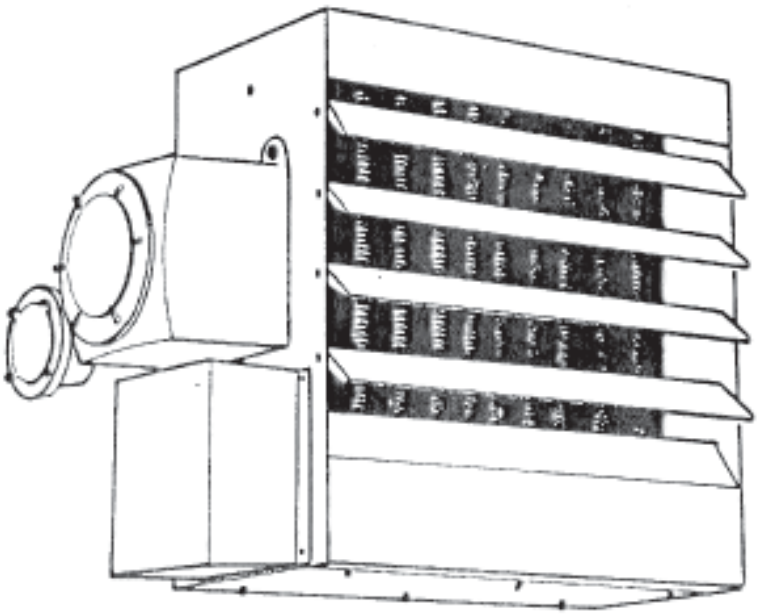
Tel: 860-793-4357
Fax: 860-793-4563

Gems Sensors Inc.
One Cowles Road
Plainville, CT 06062-1198
Tel: 860-793-4579
Fax: 860-793-4580

INSTALLATION, PARTS, SERVICE & MAINTENANCE MANUAL FOR HLA SERIES HEATER

Electric Air Heaters for Hazardous Locations

Divisions 1 & 2
Class I Group C, D - Class II, Groups E, F & G



Models covered by this manual:

HLA12 - 3, 5 AND 7.5 KW
HLA16 - 10 KW
HLA20 - 15, 20 AND 25 KW

WARNING!

READ ALL WARNINGS AND NOTICES.

FORM: 9627 - D

WARNING

To prevent ignition of hazardous atmospheres adhere to the following:

1. Read and follow the instructions in this manual.

2. The HLA Series electric unit heaters have been listed by the Underwriters Laboratories and have a maximum operating temperature of 165°C. DO NOT install heaters where the marked operating tempera ture exceeds the ignition temperature of the hazardous atmosphere.

3. Before opening any enclosure, first disconnect the heater from the power supply.

4. It is absolutely essential that the high-limit thermostat provided in the heater be left in operation. Never bypass the high-limit from the contactor coil circuit. When installing an external control thermostat, con nect it to the terminal block provided in the control box. Refer to “INSTALLATION - ELECTRICAL” for more details.

5. Operate heater only while permanently mounted in an upright position. See “INSTALLATION - MECHANI CAL” for tilt limits.

6. To operate correctly, the heater must be kept clean. When operating in a dirty environment, requlary clean the finned tubes, fan and fan guard, and motor cooling fan, if provided.

7. If any fluid leakage occurs, withdraw the heater from service and have it repaired. See “REPAIR AND REPLACEMENT PROCEDURES - HEAT EXCHANGER CORE” for details.

8. Never operate the heater with all or any louvers fully closed. Set all louvers to similar angles to obtain required air flow direction. Stops have been provided in the cabinet side walls to limit the amount to which the louvers may be closed. DO NOT OVERRIDE THESE STOPS.

9. Do not operate in atmosphere corrosive to steel and aluminum.

10. During installation, ensure that the 1” plastic protector cap in the control box is discarded and replaced with either an incoming conduit or the remaining 1” explosion-proof plug not being used. Do not operate the heater without proper explosion-proof plugs installed in all unused threaded openings.

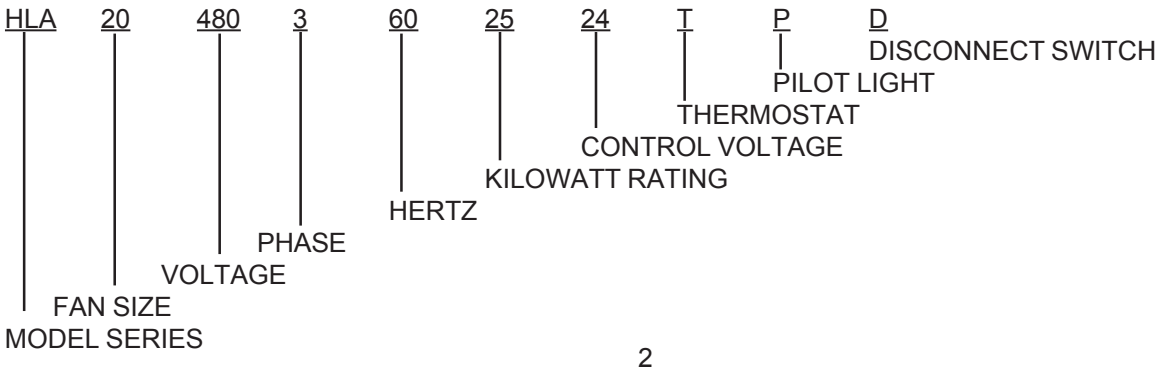
WARRANTY WILL BE VOIDED IF THESE WARNINGS ARE NOT ADHERED TO.

INTRODUCTION

APPROVED SERVICE USES

HLA Series Electric Air Heaters for Hazardous Locations are U.L. listed for use in hazardous locations Divi- sions 1 and 2, Class 1, Group C, D and Class II, Groups E, F and G. For details of the particular hazardous environments having the potential for explosion, refer to articles 500 through 516 of the National Electrical Code.

MODEL CODING



DESCRIPTION

The HLA Series heaters use a permanently sealed, liquid-to-air finned tube heat exchanger core. This consists of a bottom tank containing three immersion type heating elements and two rows of finned heat exchanger tubes welded between the bottom tank and a top header tank. A specific mixture of ethylene glycol to water mixture is placed in the heater core to act as the heat transfer fluid. Heat is transferred to the fluid mixture by the heating elements causing vigorous convective vapor circulation and condensation within the heater core, ensuring even heat distribution. The ethylene glycol provides freeze damage protection to -49°F (-45°C). An electric motor driven fan blows air over the finned tubes to transfer heat to the air flow, thus heating the area.

Over temperature protection is effected by a manual reset capillary type high-limit rated for 6,000 cycles of reliable service, which is housed in a thermowell tube next to the heating elements. Overpressure arising from excessive external temperature is relieved by a pressure relief valve provided in the top heater tank.

The heater core assembly is contained in a sturdy steel cabinet which also carries the controls, motor and fan assembly. A narrow gap safety fan guard is provided to shield all moving parts. Adjustable louvers are provided to allow directional control of the airflow.

All electrical power is carried by copper conductor wires enclosed in rigid metal conduits. Only within the enclosures are wires exposed to permit connection to terminals.

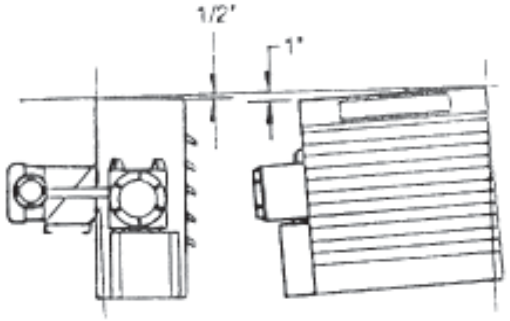
NOTE - In order to provide the highest possible outlet air temperatures, yet operate safely in hazardous atmospheres, these heaters operate in a narrow temperature band between normal operating temperature and that temperature at which the high-limit control shuts off to limit maximum temperature. It is probable therefore, that the heater will not operate continuously should ambient temperatures exceed 104°F (40°C).

INSTALLATION

MECHANICAL

The HLA series heaters are designed for use only while permanently mounted in an upright position. The supporting assembly must ensure that the heater is installed such that it operates in an upright attitude. The maximum out of plane attitude shall not exceed the values indicated in the following sketch.

To insure proper heating of floor surfaces, observe the following recommended maximum mounting heights (to



Maximum tilt allowed during operation (applicable front to back and side to side in either direction). Heater must be permanently mounted.

Max Mtg. Height from Floor:	HLA12	HLA16	HLA20
	8 ft.	10 ft.	13 ft.

The heater should be installed to allow clearances for services access and air circulation as follows:

Back	-	2” from motor
Front	-	84” HLA20, 72” HLA12 & HLA16
Right Side	-	1”
Left Side	-	30” from control box
Top	-	0”
Bottom	-	Cabinet height plus 6” (Optional - for easier core removal)

To permit removal of the heater core assembly from a suspended heater, leave space beneath the heater at least equal the cabinet height plus 6". Installations with less than specified clearances from the heater bottom make it necessary to dismount the entire unit should core removal be required.

It is essential that the supporting assembly be of adequate strength to suspend the heaters. See "Specifications" for heater weights. Adequate stiffness should be provided to ensure that unwanted vibrations or movements of the complete system do not occur. Such vibrations or movement could be induced by electric motor start-up, or be transmitted to the heater from the structure to which it is mounted, as in mobile installations. Where heaters are installed in applications that are of a relocatable or transportable nature (such as drilling rigs) design the mounting structure to withstand all probable load conditions. Such load conditions should recognize abuse situations such as truck off-loading impacts. The heaters should be suspended from the supporting assembly by two 5/8 NC bolts fitted with lock washers.

ELECTRICAL

The HLA heaters have been designed for explosion proof service, with single and three-phase inputs of 208, 240, 480 or 600 volts. They meet stringent U.L. requirements. However, it is essential that correct installation procedures be followed to eliminate all potential hazards ariging from faulty installation.

Follow these instructions:

1. Should it be deemed desirable to install a room temperature control thermostat, refer to the appropriate electrical wiring diagram and follow these steps:

   Remove the jumper wire from the small terminal block marked C1-C2 located in control enclosure. Connect the external thermostat to these terminals. The external thermostat will then be connected in series with the heater high limit and correct operation of the heater will result.

   Any room thermostat used with these heaters must be of an explosion-proof type, open on temperature rise, suitable with control voltage selected.

WARNING

   It is imperative that the high-limit (in the heater core junction box enclosure) remain connected in series with the room thermostat, the secondary output of the control transformer and the contactor coil. Under no circumstances are the heaters to be operated with the high-limit disabled or disconnected.

2. Proper installation of the heater requires that an adequate grounding conductor be connected to the ground terminal. This terminal is marked and is located in the control enclosure.

3. Avoid placing conduit runs directly beneath the heater in a way that would prevent removal of the heater core assembly.

4. On all 3-phase heaters, it is necessary to verify that the fan is rotating in the proper direction. If air delivery is not from the front of the heater, exhange any 2 input wires at the contactor. Do not needlessly remove the electric motor conduit box cover. In the event that the motor cover is removed, ensure that it is securely tightened when replaced.

5. Use only an approved explosion-proof means of wiring such as mineral insulated cable or copper conduc tors in rigid conduit to make connections to the heater.

6. External electric circuit breaker protection is required. See "TECHNICAL DATA" table and follow code recommendations. Check nameplate for voltage and amperage.

7. Follow all applicable electrical and building codes related to the intended use of the heater. Similarly, any National, State or Local codes must be observed and adhered to.

8. When doing any work on a heater, including the initial electrical connection, disconnect the electrical current at the main switch. Where possible lock the switch in the off (open) position and/or tag WARNING to prevent shock hazards.

9. Refer to the appropriate wiring diagram to ensure that all connections are as required and securely fastened.

10. Ensure conductions are of appropriate gauge size. Size all input conductors according to accepted standards consistent with the temperature rating of the wire being used. Use minimum 90°C rated wire. Minimum size for the thermostat circuit is 16 - AWG (90oC). Use copper conductors.

11. Ensure that input conductors and conduit have adequate strain relief at installation.

12. Confirm that the electrical power supply is compatible with the nameplate rating of the heater to be connected.

13. Before application of electrical power, recheck all connections to ensure compliance with the wiring diagram and any code requirements. Remove any foreign objects from the control box and reinstall cover lid tightly. Make certain that all three conduit box covers are securely in place.

MAINTENANCE RECOMMENDATIONS

CAUTION - Before undertaking any maintenance, disconnect the heater from the electrical power source. If possible, lock the main power switch in the off (open) position and/or tag to prevent shock hazards.

ELECTRICAL

Annually inspect all terminal connections, contactor and visible insulation for damage, looseness, fraying, etc. as applicable. Retighten any loose terminals and replace or repair damaged or deteriorated insulation. If contactor contacts are badly pitted, welded together or burned, replace the contactor. Check all explosion -proof conduit for visible damage and tightness. Contact TPI for replacement parts.

If reduced heat output is suspected, verify the condition of the heating elements by using an amperage meter to check the current draw of each input line. All input lines should draw approximately equal current which should agree with nameplate rating. If they do not, one or more of the heating elements could be burned out. See "REPAIR AND REPLACEMENT PROCEDURES".

The electric motor is permanently lubricated and thermally protected. Check for smooth and quiet running at all inspections. Check shaft for bearing play. Replace motor if excessive bearing play is detected. Contact TPI for replacement parts.

MECHANICAL

Explosion-proof conduit boxes are designed with threaded joints and metal-to-metal contact at lid and cover joints to prevent an explosion. Do not attempt to install gasket materials of any type at these joints. A light coating of anti-seize compound is applied to the threads to prevent seizing.

Annually check the tightness of all visible bolts or nuts, in particular the support structure bolts and nuts. Similarly check the electric motor mounting bolts and nuts.

Periodically, depending on environmental service condition, check the cleanliness of motor, fan and heater core fins. Clean if required by air jet. Check louvers for tightness and equal angle settings. Check motor and fan for smooth running. Any unusual noise or vibration must be investigated and rectified.

REPAIR AND REPLACE PROCEDURES

CAUTION - Before undertaking any maintenance, disconnect the heater from the electrical power source. If possible, lock the main power switch in the off (open) position and/or tag to prevent shock hazards.

Should problems arise requiring repair or replacement of any major component, the following procedures should be followed where applicable:

HEAT EXCHANGER CORE

(Including HEAT TRANSFER FLUID, HEATING ELEMENTS and PRESSURE RELIEF VALVE)

The HLA Series heater core assemblies have been deliberately designed to permit only limited field service. Repair and overhaul is intended to only be by complete replacement of the core assembly with either a new or factory reconditioned core assembly. Such new ore reconditioned core assemblies will be supplied with heating elements, pressure relief valve, the correct amount of fluid and a new high-limit. Each core assembly will have been factory assembled, inspected and electrically tested for correct heat output and proper operation of the high-limit. Because of the equipment and test procedures required to test core assemblies, it is not practical for cores to be field serviced. Incorrect field service procedures may render a heater potentially hazardous.

The only core assembly field service work sanctioned by the manufacturer is replacement of the capillary high-limit and cleaning.

To remove the heater core from the heater cabinet proceed as follows:

1. First remove all threaded and screw-attached sheet metal covers from the control box side of the heater. Then remove the bottom cover.

2. Remove all 5 wires from within the conduit between the upper and lower boxes.

3. The heater core assembly is secured by three 5/16 diameter x 1/2 capscrews; two on one side and one above the aluminum control box enclosure. Before removing these screws assistance will be required to support the weight of the core.

4. With a second person to support the weight of the core assembly, remove the three 5/16 diameter x 1/2 capscrews and have the helper carefully lower the heater core assembly from the cabinet.

HEAT TRANSFER FLUID

The heater cores are partially filled with an ethylene glycol/water solution similar to that used in automotive applications. Oral ingestion of this solution could prove fatal since ETHYLENE GLYCOL IS POISONOUS. Should ingestion occur, seek medical attention immediately.

Field service of the core assembly with respect to refilling it with fluid is not permissible. A new or factory reconditioned core assembly must be used and shall be provided by the manufacturer or one of its agents.

HEATING ELEMENTS

In the event of failure of the heating elements it will be necessary to replace the core assembly with a new or reconditioned unit.

PRESSURE RELIEF VALVE

The pressure relief valve is factory installed and pressure tested. Contact the manufacturer or authorized service agent should suspected problems occur.

ELECTRIC MOTOR

Remove the cover lid on the motor junction box and disconnect all the wires. Carefully loosen the union between the motor and control box enclosures. Loosen and remove the motor mounting bolts and fan guard bolts, being careful not to damage the fan blades. Note the relative axial position of the fan hub on the motor shaft and remove the motor mounting bolts and fan guard bolts, being careful not to damage the fan blades. Note the relative axial position of the fan blades. Note the relative axial position of the fan hub on the motor shaft and remove the fan.

To replace the motor, fan guard and fan assembly, reverse the above procedure. Position the fan on the shaft to the previously noted position. It is helpful to leave the motor bolts loose while connecting the union. The back of each fan blade should be about 3/4" from the inside of the fan guard. When everything is in place, make certain all fasteners are secure and that the conduits have at least 5 threads engaged. Manually spin the fan blade with a screwdriver before application of power to make certain it does not foul the cabinet or fan guard.

HIGH-LIMIT

The high-limit is rated for operation of 6,000 cycles. Experience indicates that nuisance tripping is generally not the fault of the high-limit but is usually caused by excessive input voltage, high ambient temperatures, or an excessively dirty heater core. The high-limit is unlikely to cause any difficulty, but if it should, follow these procedures:

Gain access to the high-limit by removing the sheet metal cover from the cabinet and the threaded aluminum cover from the core junction box. Once inside, pull off the two wires attached to the high-limit. Remove the two screws that retain the capillary high-limit and withdraw it by pulling.

To replace the high-limit, reverse the above procedure. Reconnect the thermostat wires on terminals. DO NOT OMIT THIS OPERATION AND DO NOT BYPASS.

Never use any replacement high-limit other than one supplied by the manufacturer as the heaters may be rendered potentially hazardous.

CONTROL TRANSFORMER

HLA heaters are provided with multi-tap primary transformers on 208, 240 and 480 volt models. If replacement is necessary, select the voltage tap compatible with the line voltage of the unit and cap off all unused taps. All 600 volt units are furnished with non selectable dedicated primaries.

NOTE: Transformers secondaries should not be sparked or shorted as they may be provided with embedded over current protection.

CONTACTOR

A contactor should be replaced if excessive pitting or burning of the contact points is found, or if the coil has burned out. (Note-the contactor is rated for 100,000 cycles of operation at it full rated capacity).

REPLACEMENT PROCEDURES - CONTROLS

BEFORE OPENING ANY ENCLOSURE, DISCONNECT HEATER FROM POWER SUPPLY.

Remove top plate located in control enclosure, by removing three (3) No. 8 screws. One of the screws also retains the grounding lug. Associated wiring must be removed from control block, fuse block, and contactor. Remove three (3) screws that retain the contactor mounting plate. Remove contactor mounting plate, which will have two standoff posts and contactor assembled as a unit. The contactor can be replaced if necessary, at this time.

If transformer or thermostat is to be replaced, remove three (3) screws retaining the plate on which they are mounted. Both parts will be removed together. If a thermostat is provided, the operating shaft must be withdrawn through its clearance hole or shaft hub screw loosened to free assembly. Transformer can now be replaced.

To replace thermostat, loosen bulb retaining clamps, and remove capillary plug retaining ring located on outside of enclosure. Withdraw thermostat and its capillary bulb through enclosure opening. Thermostat may be replaced at this time. When reassembling thermostat, retaining rings should be firmly seated in capillary plug seal grooves on both sides of enclosure wall. Inside retaining ring should be placed on seal plug before passing capillary bulb through enclosure opening provided. To prevent any possible shorting of terminals, route thermostat capillary close to lower enclosure wall. Refer to wiring diagram covering your model. For reassembly reverse the order to above procedure.

RATINGS

MODEL	VOLTS	PHASE	MOTOR KW	MOTOR HP	A MOTOR	A HEATER	A LINE	MINIMUM CIRCUIT A	MAXIMUM FUSE A	SUPPLY CONNECTIONS WIRE SIZE NO. AWG.
HLA 12	208	1	3	1/4	1.9	14.4	16.3	20.4	25	10
			5	1/4	1.9	24.0	26.0	32.5	35	8
			7 1/2	1/4	1.9	36.1	38.0	47.5	50	8
HLA12	240	1	3	1/4	2.3	12.5	14.8	18.5	20	12
			5	1/4	2.3	20.8	23.1	28.9	30	10
			7 1/2	1/4	2.3	31.3	33.6	42.0	45	8
HLA12	208	3	3	1/4	1.5	8.3	9.8	12.3	15	14
			5	1/4	1.5	13.9	15.4	19.2	20	12
			7 1/2	1/4	1.5	20.8	22.3	27.9	30	10
HLA12	240	3	3	1/4	1.4	7.2	8.6	10.8	15	14
			5	1/4	1.4	12.0	13.4	16.8	20	12
			7 1/2	1/4	1.4	18.0	19.4	24.3	25	10
HLA12	480	3	3	1/4	0.7	3.6	4.3	5.4	15	14
			5	1/4	0.7	6.0	6.7	8.4	15	14
			7 1/2	1/4	0.7	9.0	9.7	12.1	15	14
HLA12	600	3	3	1/4	0.6	2.9	3.5	4.4	15	14
			5	1/4	0.6	4.8	5.4	6.8	15	14
			7 1/2	1/4	0.6	7.2	7.8	9.8	15	14
HLA16	208	3	10	1/4	1.5	27.8	29.3	36.6	40	8
HLA16	240	3	10	1/4	1.4	24.1	25.5	31.8	35	8
HLA16	480	3	10	1/4	0.7	12	12.7	15.9	20	12
HLA16	600	3	10	1/4	0.6	9.6	10.2	12.8	15	14
HLA16	240	1	10	1/4	2.3	41.7	44	55	60	6
HLA16	208	3	15	1/2	1.9	41.6	43.3	54.4	60	6
HLA20	240	3	15	1/2	2.0	36.1	38.1	47.6	50	8
HLA20	480	3	15	1/2	1.0	18.0	19.0	23.3	25	10
			20	1/2	1.0	24.1	25.1	31.3	35	8
			25	1/2	1.0	30.1	31.1	38.8	40	8
HLA20	600	3	15	1/2	0.8	14.4	15.2	19.0	20	12
			20	1/2	0.8	19.2	20.1	25.1	30	10
			25	1/2	0.8	24.1	24.9	31.1	35	8

REPLACEMENT PARTS LIST HLA

ITEM	QTY	3, 5, 7.5 KW	10 KW	15, 20, 25 KW	DESCRIPTION
1	1	70667-001	70667-002	70667-003	CABINET WELDMENT
2	3	62022-001			LOUVER
2			62022-002		LOUVER
2				62022-003	LOUVER
3	4	62023-001	62023-002	62023-003	MOTOR SUPPORT
4	5	51634-001	51634-002	51634-003	BOTTOM COVER
5	1	70671-001	70671-002	70671-003	FAN GUARD
6	1	62003-001	62003-002	62003-003	FAN GUARD
7	1	51510-004	51510-005	51510-006	HIGH LIMIT CONTROL
8	1	52823-001	52823-002	52823-003	CONDUIT MOTOR 3/4
9	1	52823-001	52823-002	52823-004	CONDUIT JUNCTION BOX 3/4
10	1	PROVIDE MODEL NUMBER			

Heat Exchanger Complete with relief valve, elements, fluid charge, slip-joint and element enclosure cover.

COMMON TO ALL SIZES PARTS LIST		
ITEM	PART NUMBER	DESCRIPTION
11	58027-036	CONTACTOR, 50 AMP 3 POLE 24 VOLT COIL
11	58027-037	CONTACTOR, 50 AMP 3 POLE 120 VOLT COIL
11	58027-038	CONTACTOR, 50 AMP 3 POLE 208/240 VOLT COIL
12	51704-001	TRANSFORMER 208/240/480 VOLT PRIMARY 24 VOLT SECONDARY
12	51512-001	TRANSFORMER 208/240/480 VOLT PRIMARY 120 VOLT SECONDARY
12	51704-002	TRANSFORMER 600 VOLT PRIMARY 24 VOLT SECONDARY
13	51511-002	FUSE BLOCK 2 POLE
14	43810-003	FUSE 3.0 AMP TIME DELAY
14	43810-002	FUSE 4/10 AMP TIME DELAY
14	43810-001	FUSE 2/10 AMP TIME DELAY
15 (3.5, 7.5, 10KW)	62034-001	MOTOR, 1/4 HP 208/240/480 VOLT SINGLE PHASE
16 (3.5, 7.5, 10KW)	62034-002	MOTOR, 1/4 HP 208/240/480 VOLT SINGLE PHASE
17 (3.5, 7.5, 10KW)	62034-003	MOTOR, 1/4 HP 600 VOLT THREE PHASE
15 (15, 20, 25KW)	62034-004	MOTOR, 1/2 HP 208/240/480 VOLT THREE PHASE
16 (15, 20, 25KW)	62034-005	MOTOR, 1/2 HP 600 VOLT THREE PHASE
16	62024-001	ELEMENT ENCLOSURE COVER
17	62032-001	ELEMENT ENCLOSURE (EXPLOSION PROOF) THREADED COVER
18	41352-001	CAUTION PLATE
19	70672-003	CONTROL BOX EXPLOSION PROOF (PROVISIONS FOR THERMOSTAT OPTION)
20	62031-002	CONTROL BOX EXPLOSION PROOF COVER
21	51637-001	THERMOSTAT (STAINLESS STEEL CAPILLARY)
22	43633-001	THERMOSTAT RETAINING RING (2 REQUIRED)
23	41341-001	THERMOSTAT SHAFT ASSEMBLY
24	43758-001	3/4" CONDUIT UNION FEMALE (MOTOR)
25	43755-001	3/4" CONDUIT UNION MALE (JUNCTION BOX)
26	51638-001	3/4" SLIP-JOINT FITTING (JUNCTION BOX TO ELEMENT ENCLOSURE)
27	43672-001	DRIVE SCREW #6 X 3/16"
28	62034-000	MOTOR JUNCTION BOX (EXPLOSION PROOF)

TERMS AND WARRANTY

RETURNED MERCHANDISE

Goods may not be returned without the company's written permission. All transportation costs for returned goods must be paid by the customer:

FREIGHT DAMAGE CLAIMS

Title to goods shipped passes to the consignee upon delivery by the company to the carrier. All claims for shortages or damage must be made to the carrier by the consignee. In case of concealed damage it is important that such damage be reported to the delivering carrier within one week.

WARRANTY
LIMITED WARRANTY TO OWNER
TPI CORPORATION
EFFECTIVE MAY 1, 1977

The warranty herein set forth is in lieu of all other warranties expressed or implied, and shall not apply to any accessory not part of the product.

TPI Corporation, hereafter referred to as the company of Johnson City, Tennessee 37602, warrants its products to the owner against defects in material and workmanship for a (12) month period under normal use and services following date of manufacture or installation when proof of such is provided to seller.

This warranty requires that the owner, or his agent install the equipment in accordance with the National Electrical Code, any other applicable heating or electrical codes and the manufacturer's installation instructions. It further requires that he perform reasonable and necessary maintenance on the unit. The company is not liable for abuse or misuse of product as may be finally determined by inspection by the company.

The obligation of the manufacturer, under the terms of this warranty, shall be to supply a new part, or the repair of defective part at the company's option with no costs to owener for the new or repaired part. Such parts are to be returned to the factory, or such other location as the company may desinate at the ovner's expense. This warranty does not obligate the manufacturer to bear the cost of labor in replacing any assembly, unit or component part therof, nor does the company assume any liability for secondary charges, expenses for installing or removal, or any other consequential losses, freight or damages. The company's maximum liability shall not in any case exceed the list price for the product claimed to be defective.

IN CASE OF PRODUCT FAILURE

It shall be the obligation of the owner to furnish to the company within the designated warranty period, the following information:

1. Model number and date of manufacture of product involved.

2. Complete description of the problem encountered with product.

Upon receipt of the above, the company will reply to the owner within a period not to exceed fifteen (15) working days, the action to be taken by owner.

When requested, it shall be the obligation of the owner to return the defective part to the company within thirty (30) days after its removal, or otherwise to follow instructions from the company.

HAZARDOUS LOCATIONS DEFINITIONS

HAZARDOUS LOCATIONS - Areas where the possibility of explosion or fire exists because of the presence of flammable gases, vapors, or dust etc.

DIVISION 1 - Locations where the hazard is expected to be present during normal production operations, or during frequent maintenance and repair activities.

DIVISION II - Locations where the hazards would only exist as a result of an accident or other abnormal event such as a rupture or spillage.

CLASS I - Areas wheresufficient quantities of flammable gases or vaports exist in the air to be explosive or ignitable.

- Offshore and land based drilling rigs, petroleum exploration and testing facilities.
- Petroleum refineries, gasoline storage and dispensing areas.
- Industrial firms that use flammable liguids in dip tanks for parts cleaning or other operations.
- Petrochemical companies that manufacture chemicals from gas and oil.
- Dry cleaning plants where vapors from cleaning fluids can be present.
- Artcraft hangars and fuel servicing areas.
- Utility gas plants and operations involving storage and handling of liquefied petroleum gas or natural gas.

GROUP D - Gases or vapors with specific explosive characteristics grouped together including:

Acetone	Cyclohexane	Iso Butyl Alcohol	Propane
Acrylonitrile	Decane	Isooctane	Propylene
Ammonia	Ethano	Isoprene	Propyl Acetate
Amyl Acetate	Ethylene Dicholoride	Methane	Styrene
Amyl Alcohol	Ethyl Acetate	Methanol	Toluene
Benzene	Ethyl Alcohol	Methyl Acetate	Vinyl Acetate
Blast Furnace Gas	Ethyl Methyl Keytone	Methyl Alcohol	Vinyl Chloride
Buta - 1:3 Diene	Ethyl Nitrite	Naphtha	Xylene
Butane	Heptane	Natural Gas	
Butyl Acetate	Hexane	N-Butyl Alcohol	
Carbon Monazite		Pentane	

CLASS II - Areas which are made hazardous by the existence of combustible dusts.

- Coal preparation plants and other carbon handling or processing areas
- Grain elevators, flour and feed mills.
- Plants that manufacture, use or store magnesium or aluminum powders.
- Plants that have chemical or metallurgical processes, producers of plastics, medicines and fireworks, etc.
- Producers of starch or candies.
- Spice grinding plants, surgar plants and cocoa plants.

GROUP E - Powdered metals such as aluminum and magnesium, and other metal dusts with similar characteristics.

GROUP F - Dusts such as carbon black, coke, and coal dust.

GROUP G -Dusts, including flour, starch, spices and grain dust.

BASIC MOUNTING KIT/WALL MOUNTING KIT
INSTRUCTION SHEET

NOTE: Check that your heater model number corresponds to the model number shown on the mounting kit carton.

WARNING: IF INSTALLED ON A STRUCTURE THAT IS TO BE TRANSPORTED, PROVIDE ADDITIONAL TEMPORARY SUPPORT FOR THE HEATER DURING TRANSIT.

THE SUSPENDED WEIGHT ON THE ARM ASSEMBLY SHOULD NOT EXCEED 250 LB (114KG.)

REFER TO HEATER INSTALLATION MANUAL FOR MOUNTING SPECIFICATIONS AND CONDITIONS.

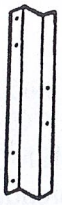
INSTALLER REQUIRED TO SUPPLY:

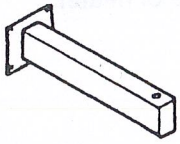
A method to fasten the two Z Sections ① to the supporting wall. This kit required at least four (4) 3/8" diameter, grade 5 bolts. However, any method providing the same or greater strength may be used.

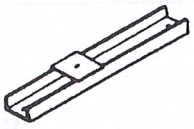
A method to fasten the ARM ASSEMBLY ② to the supporting structure. Four (4) 3/8" diameter, grade 5 bolts are suggested, however, any method providing the same or greater strength may be used.

CONTENTS:

Item	Part No.	Quantity	Description
①	51666-001	2	Z SECTION, SUPPORT
②	62036-002	1	ARM ASSEMBLY, MOUNTING
③	62037-001 HLA 12 62037-002 HLA 16 62037-003 HLA 20	1	ATTACHMENT, ASSEMBLY
④	93480-004	4	3/8 UNC Nut
⑤	1766	4	3/8 UNC x 1 Bolt
⑥	43567-001	4	3/8 Lock Washer
⑦	43566-002	2	5/8 UNC x 1 1/4 Bolt
⑧	43567-002	2	5/8 Lock Washer
⑨	43566-001	1	5/8 UNC x 4 1/2 Bolt
⑩	43625-003	1	5/8 Flat Washer





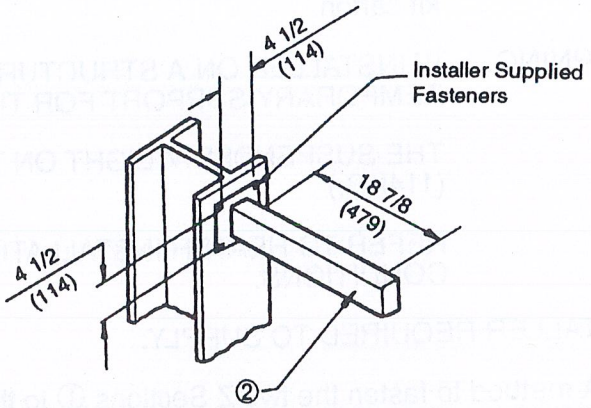


BASIC MOUNTING KIT INSTALLATION

Note: Dimensions are in inches (mm)

STEP 1

Fasten the ARM ASSEMBLY②to a surface or structure that will support the heater's weight using the installer supplied fastening method.

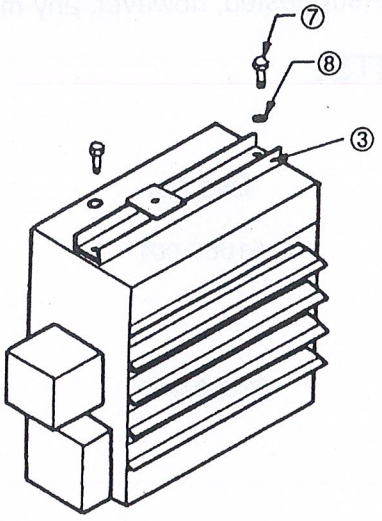


STEP 2

Bolt ATTACHMENT ASSEMBLY ③ to the heater using 5/8 UNC x 1 1/4 bolts and lock washers.

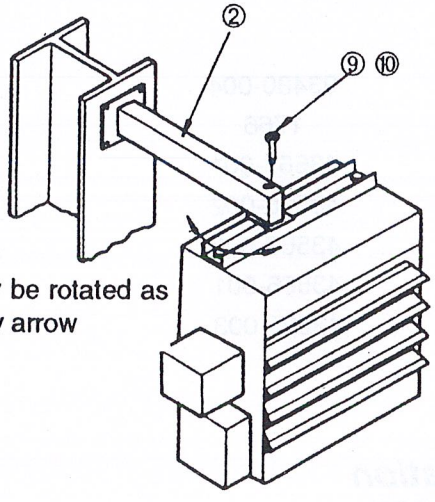
NOTES:

1) HL Series electric heaters use an ATTACHMENT ASSEMBLY ③ with an offset threaded hole. The ATTACHMENT ASSEMBLY ③ must be placed with the threaded hole closest to the control box side of heater.



STEP 3

Lift heater into place and fasten it to the ARM ASSEMBLY ② using a 5/8 UNC x 4 1/2 bolt. This step will require more than one person due to the weight of the heater. Refer to the heater installation manual for weight.



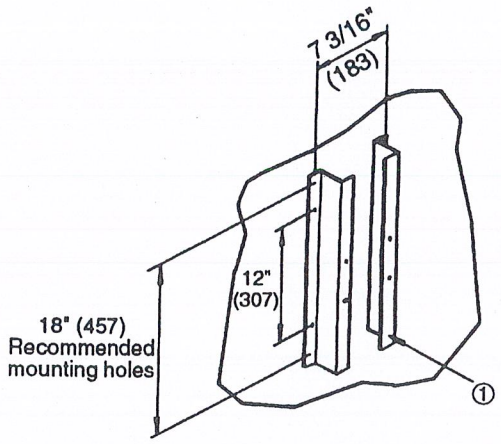
Heater may be rotated as indicated by arrow

WALL MOUNTING KIT INSTALLATION

NOTE: Dimensions are in inches (mm)

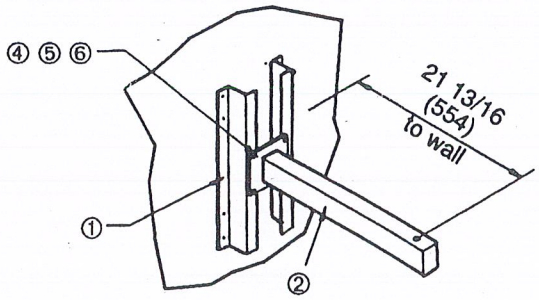
STEP 1

Fasten the Z SECTIONS ① to a wall that will support the heater's weight using installer supplied fasteners.



STEP 2

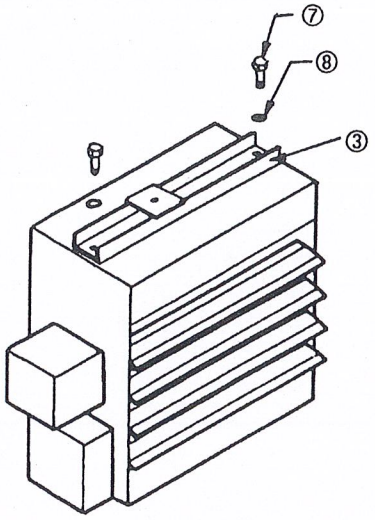
Bolt the ARM ASSEMBLY ② to the Z SECTIONS ① using 3/8 UNC x 1 bolts, lockwashers and nuts.



STEP 3

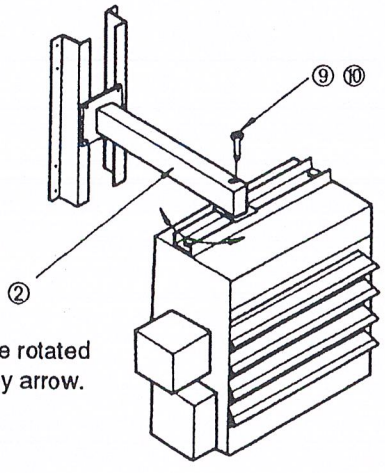
Bolt ATTACHMENT ASSEMBLY ③ to the heater using 3/8 UNC x 1 1/4 bolts and lock washers.

1) HL Series electric heaters use an ATTACHMENT ASSEMBLY ③ with an offset threaded hole. The ATTACHMENT ASSEMBLY ③ must be placed with the threaded hole closest tot he control box side of heater.



STEP 4

Lift heater into place and fasten it to the ARM ASSEMBLY ② using a 5/8 UNC x 4 1/2 bolt. This step will require more than one person due to the weight of the heater. Refer to the heater installation manual for weight.



Heater may be rotated as indicated by arrow.

Section 6

Warranty

4428 Manila Road SE
Calgary, AB T2G 4B7
showard@newterra.com | www.newterra.com

WARRANTY AND PERFORMANCE GUARANTEE

General Warranty Statement

1. **newterra** warrants and guarantees products of its manufacture against defective workmanship or material for a period of one year from the date of successful commissioning or eighteen months from the date of shipment from the factory, whichever comes earlier.
2. This warranty is expressly and strictly limited to replacing, without charge, any part or parts which prove to **newterra**'s satisfaction upon examination, to have been defective in design, material, and workmanship, and which have not been neglected, abused or misapplied, and provided that the buyer gives **newterra** immediate written notice upon discovery of any claimed defect.
3. During the warranty period, parts will be shipped with the instructions to replace, which can be further elaborated over the telephone; visit of our technician can be covered under the service agreement; otherwise, actual charges will be quoted to the owner at that time, if required.
4. All components are designed in accordance with the local/national governing building code(s).
5. All wastewater components meet the specified guideline and standards.

Warranty Exclusions

1. Warranty coverage does not include:
   - Freight, labour, travel, and living expenses associated with parts replacement
   - Normal wear & tear for items such as lubrication, fan belts, and cleaning of the equipment
2. In the event that the customer, or any contractor employed by the customer, contracts an outside company other than **newterra** for modification of plant equipment, without knowledge of **newterra**, the warranty in that case may become null & void.

Conditions of Warranty

1. **newterra** highly recommends that the system be started up by a **newterra** factory trained technician to ensure the correct installation and trouble-free startup. The start-up checklist provided in the manual must be completed and returned to the Product Support Department at **newterra** to validate your equipment warranty, which begins on the date of shipment from the factory.

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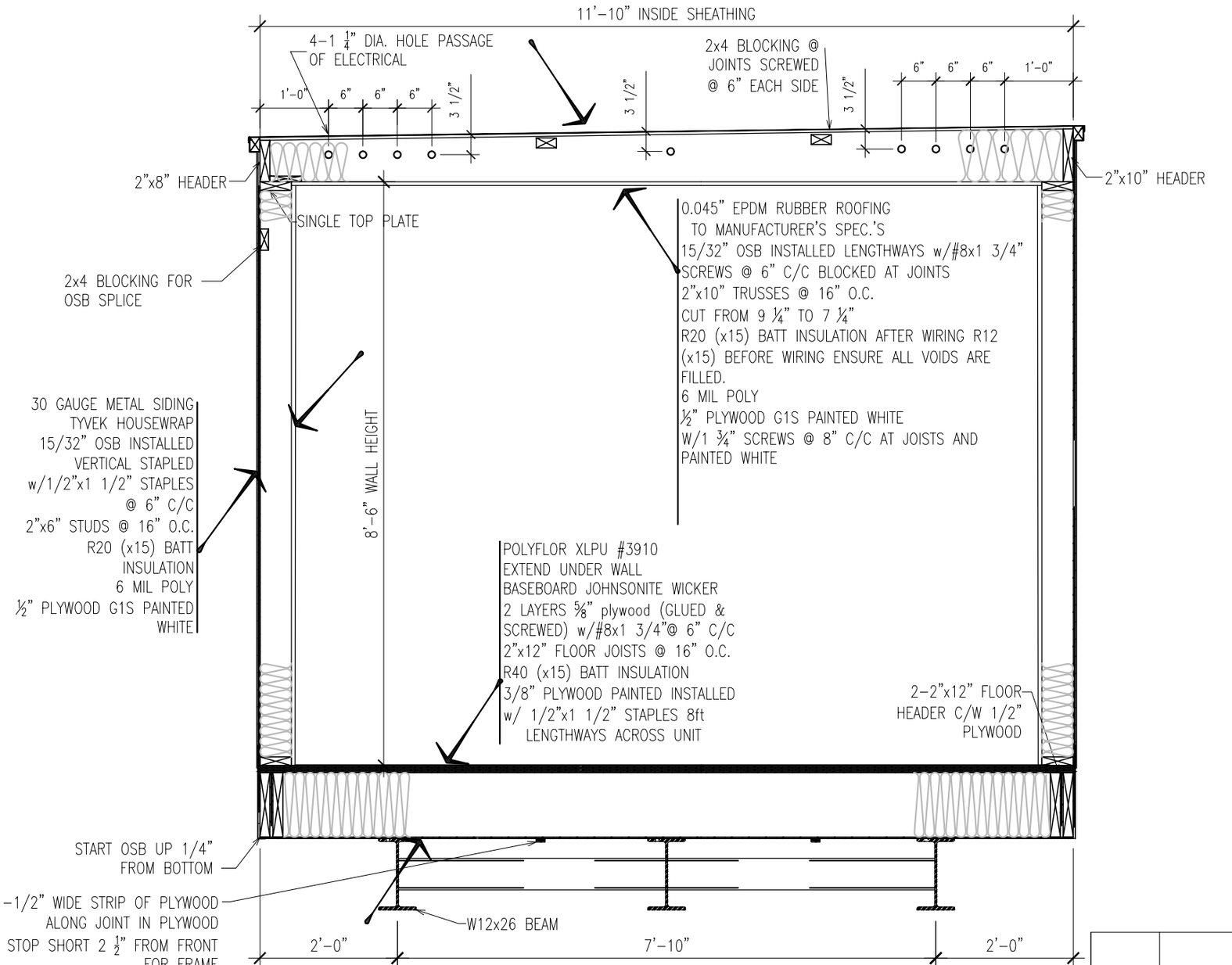

A / A-5 CROSS SECTION SCALE: 1/2" = 1'-0"

REV.	DESCRIPTION	DATE
0	FOR APPROVAL	JUN 2018

A-5 OF 7

Drawing Title: CROSS SECTION

Date: JUN 2018

Drawn By: NH

Scale: AS NOTED

Project Title: 50' x 12' HORIZON NORTH
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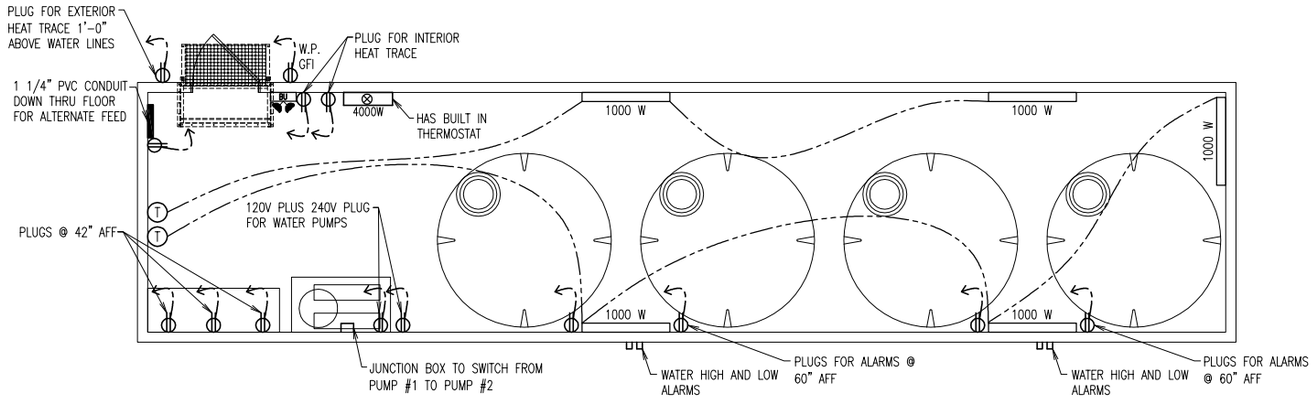
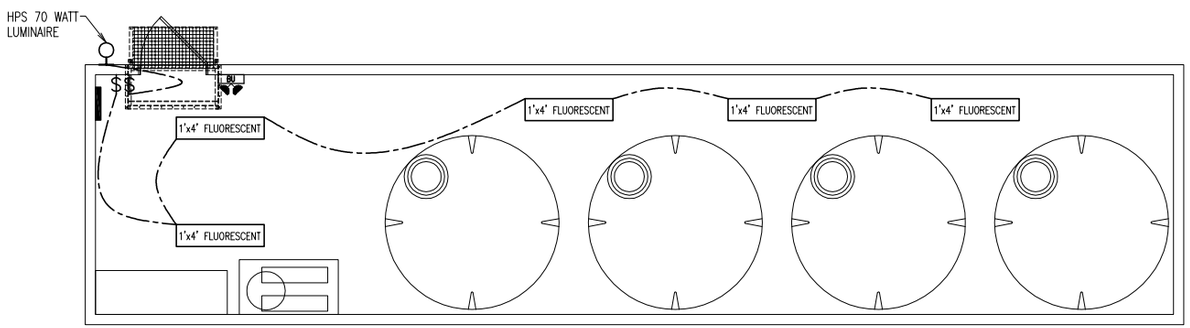


POWER & HEAT LAYOUT

SCALE: 1/8" = 1'-0"



LIGHTING LAYOUT

SCALE: 1/8" = 1'-0"

LEGEND

LIGHTING

	FLOURESCENT LUMINAIRE.
	FIXTURE MOUNTING. CEILING MOUNTED, SURFACE.
	EXTERIOR HPS 70W LUMINAIRE. WALL, SURFACE MOUNTED.
$	SINGLE POLE SWITCH, (TOGGLE TYPE) WALL, FLUSH MOUNTED, 120VAC–15 A MOUNTED AT 48" AFF

GENERAL

	NMB 14/2 WIRING FOR LIGHTS AND RECEPTACLES
	NMB 12/2 WIRING FOR 20 AMP RECEPTACLES
	NMB 12/2 WIRING FOR HEAT
	NMB CABLES ARE ALLOWED IN 90°F AMBIENT TEMP. THE CURRENT CARRYING CAPACITY IS FROM NEC 60°F TABLE FOR BEING EMBEDDED IN THERMAL INSULATION
GFCI	GROUND FAULT INTERRUPTER TYPE.
AFF	ABOVE FINISHED FLOOR.
34"	MOUNTING HEIGHT OF ITEM CENTER LINE AFF. 16" U/N 54" FOR A/C UNITS 50" AT DRAWING TABLE 50" AT 33" HIGH COUNTERTOP 44" AT KITCHEN COUNTER 80" EXIT/EMERG LIGHT

POWER

	DUPLEX RECEPTACLE, WALL, FLUSH MOUNTED. 120VAC–15A.
	DUPLEX RECEPTACLE, WALL, FLUSH MOUNTED. 120VAC–20A.
TELCO 2	TELEPHONE/DATA 2 PORT OUTLET.
1000	BASEBOARD HEATER, WALL, SURFACE MOUNTED 6" AFF.. 1000 DENOTES WATTAGE.
T	THERMOSTAT, ELECTRIC, WALL MOUNTED 48" AFF
STANDARD	WALL HEATER, WALL, SURFACE MOUNTED STANDARD DENOTES WATTAGE.

REV.	DESCRIPTION	DATE
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E-1 OF 1

Drawing Title: ELECTRICAL LAYOUT

Date: JUN 2018

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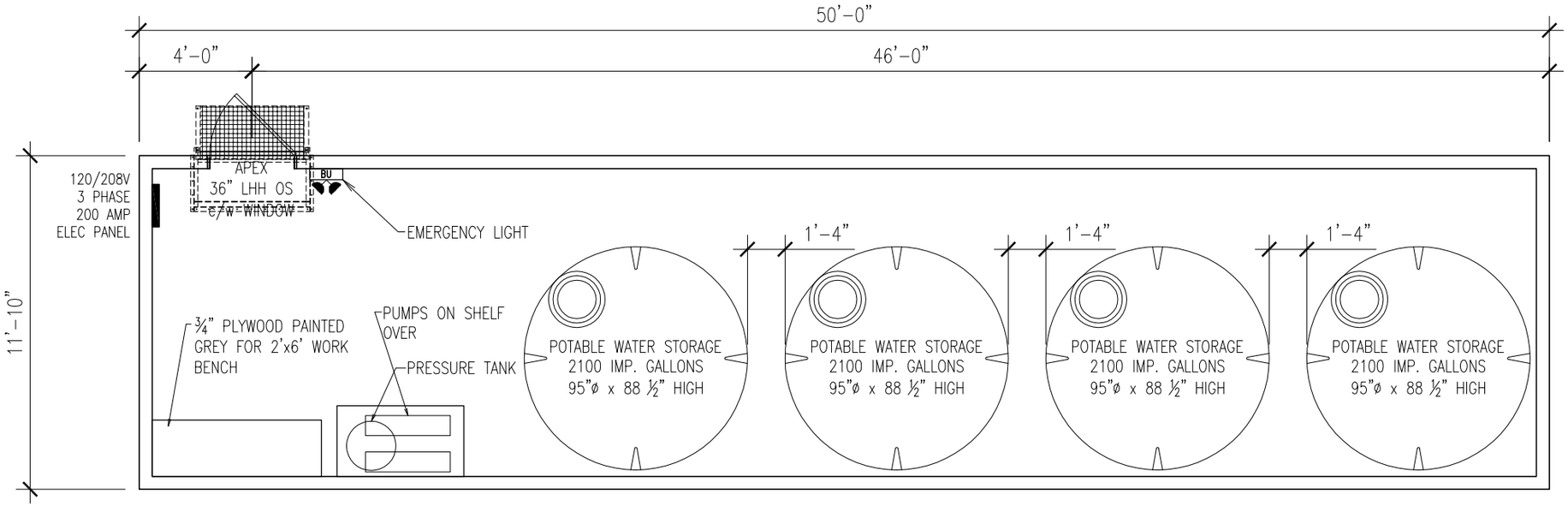

FLOOR PLAN

SCALE: 1/8" = 1'-0"

- 2–2x6 HEADER TYPICAL AT DOORS
- RSO OF ALL EXTERIOR DOORS (FROM APEX) 37 7/8"x82 11/16" U/N. DOORS C/W PANIC HARDWARE AND DOOR CLOSURE
- 6'–6" LONG EAVES TROUGH OVER EACH EXTERIOR DOOR
- SOLD UNT INSTALL "MANUFACTURED BY ALANTRA LEASING" DECAL
- INSTALL INTERIOR SHEATHING AT 1/4" ABOVE FLOOR AND SILICONE ALONG BOTTOM
- INSTALL PVC TRIM BLOCKS UNDER INTERIOR CASINGS AND CORNER TRIM
- INSTALL METAL ROOF ANCHORS IN SHOP

0	FOR APPROVAL	JUN 2018
REV.	DESCRIPTION	DATE

A-1 OF 7

Drawing Title: FLOOR PLAN

Date: JUN 2018

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Project Title: 50' x 12' HORIZON NORTH
SERIAL #: AL18-1349

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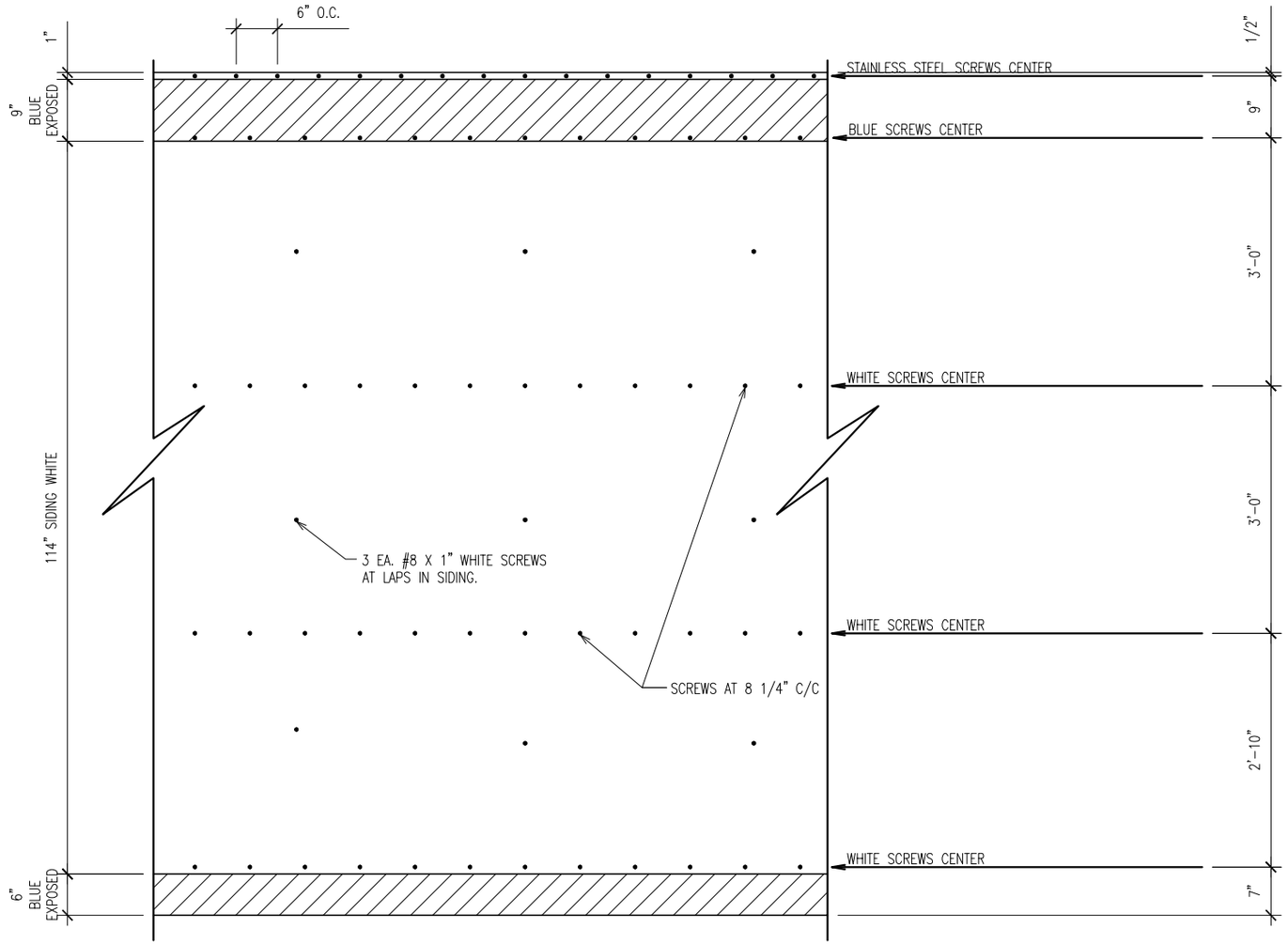

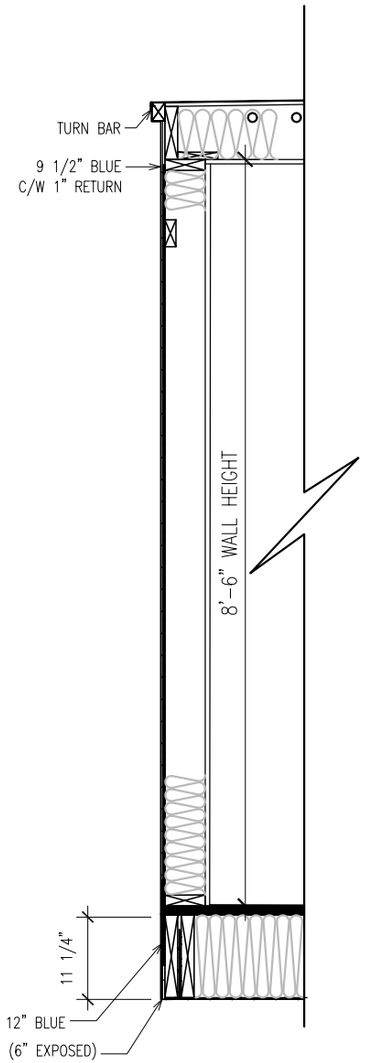

SIDING ELEVATION & SECTION SCALE: 1/2" = 1'-0"

- INSTALL SIDING SO THAT LAPS IN SIDING FACE TOWARDS THE REAR OF THE TRAILER

PROVIDE COLORS

REV.	DESCRIPTION	DATE
0	FOR APPROVAL	JUN 2018

A-7 OF 7

Drawing Title: SIDING PLAN

Date: JUN 2018

Drawn By: NH

Scale: AS NOTED

Project Title: 50' x 12' HORIZON NORTH
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ATTACHMENT 17

LANDFARM MANUAL

Baffinland Iron Mines Corporation

Landfarm Operation Maintenance and Monitoring Manual

BAF-PH1-320-T07-0005

Rev 0

Prepared By: Trevor Myers
Department: Environmental
Title: Environmental Superintendent
Date: March 18, 2015
Signature:

Approved By: Bikash Paul
Department: Site Services
Title: Site Services - Manager
Date: March 18, 2015
Signature: for

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DOCUMENT REVISION RECORD

Issue Date MM/DD/YY	Revision	Prepared By	Approved By	Issue Purpose
03/18/15	0	TM	BP	Use

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Attachment A – Site User Rules

Attachment B – Landfarming: Basic Processes and Principles

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1 PURPOSE AND SCOPE

The purpose of this manual is to outline and prescribe Standard Operating Procedures to ensure that Baffinland Iron Mine's Milne Port landfarm facility is operated in an efficient manner that is consistent with Baffinland's commitments to health, safety and environmental protection.

This manual has been designed to be used as a field reference document and training manual for classroom and self-instruction purposes. All employees with accountabilities and responsibilities as outlined in this manual are expected to be familiar with its use and location at the site. This manual contains the basic knowledge regarding responsibilities, environmental protection measures and regulations, safety practices and overall procedures for operating the Milne Port landfarm facility.

2 REQUIREMENTS

2.1 HAZARDS AND ADDITIONAL PERSONAL PROTECTIVE EQUIPMENT (PPE)

The following section provides the hazards, personal protective equipment (PPE), and safety and environmental equipment requirements associated with landfarm facility operation and maintenance activities.

2.1.1 HAZARDS

There are numerous hazards associated with the operation and maintenance of the landfarm. They include:

- Equipment collision or rollover
- Flying dust and small particles
- Petroleum hydrocarbon (PHC) vapor inhalation
- Spills

2.1.2 PERSONAL PROTECTIVE EQUIPMENT (PPE)

- Wear Standard P.P.E. - Safety glasses, hard hat, safety boots and reflective vest[1].
- Optional - Respirator fitted with an organic vapor cartridge(s) when dealing with heavily contaminated soils or when unusually high levels of hydrocarbon vapor may be present.

2.1.3 SAFETY AND ENVIRONMENTAL EQUIPMENT

- Spill kits (at landfarm and on mobile equipment)
- Radio Communication
- Optional - Gas monitor (for air quality testing)

[1] PPE is not required for operators inside enclosed cabs of heavy equipment.

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2.2 Training, Qualifications and/or Certification

Any operator who may be working at the landfarm shall complete the documented training in this procedure and demonstrate their understanding of their responsibilities, and of the hazards and controls. Verification of training will be kept by the Training Department.

3 RESPONSIBILITES

The following roles have specific accountabilities that must be met to ensure the Milne Port landfarm facility is operated in compliance with this manual. The following roles and responsibilities have been assigned to site personnel required to complete landfarm facility operations; however, this may not include all duties required to safely and successfully operate the facility.

3.1 Site Services Manager/ Superintendent

The Site Services Manager, or the Site Services Superintendent in the Manager's absence, is accountable for the overall operation of the landfarm facility. Specifically, he/she shall:

a. Implement and enforce this procedure.
b. Plan and coordinate the use of the landfarm facility to conserve space and optimize remediation efficiency;
c. Assist in the development, implementation and enforcement of landfarm specific safety protocols;
d. Meet routinely with the Site Services Supervisor(s) to maintain proper control of the site and identify existing or anticipated problems considering the following:
    i. Operational issues;
    ii. Regulatory Requirements;
    iii. Equipment issues; and
    iv. Special operating instructions; e.g., inclement weather, repairs, fertilizer addition, etc.
    e. Schedule routine work as required (e.g., snow removal, tilling and spreading, irrigation, etc.);
f. Ensure that the need for any special operating conditions are identified and planned for in advance. This may include the identification of features (e.g. stockpiles) with stakes in advance of winter and the ground freezing;
g. Coordinate a biannual summer earthworks inspection which shall be conducted by a geotechnical engineer.

3.2 Site Services Supervisor

The Site Services Supervisor, under the supervision of the Site Services Manager/Superintendent, is responsible for supervising all activities at the landfarm facility in accordance with this manual. Specifically, the Site Services Supervisor shall:

a. Implement this procedure;
b. Regularly brief the Site Services Manager/Superintendent on the status of routine operations and any potential issues;

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c. Ensure that soils under remediation are spread evenly to a soil depth determined to optimize hydrocarbon degradation rates;
d. Maintain thorough, accurate and detailed records of landfarm operations and additional requirements as determined;
e. Provide timely response to incidents and inquiries to ensure the landfarm is operated in compliance with this procedure;
f. Inspect and organize the landfarm facility layout;
g. Direct site users to the proper stockpiles or dumping area according to the incoming soils' contaminant type;
h. Perform all the duties of the landfarm Operator/Labourer in his/her absence;
i. Restrict access to landfarm facility, closing and locking gate after use or as required.

3.3 Landfarm Operator/ Labourer

The Landfarm Operator/Labourer, under the supervision of Site Services Supervisor, is responsible for executing the following tasks at the landfarm facility. Specifically the Operator/Labourer shall:

a. Be trained and experienced in operating the mobile heavy equipment necessary for the work;
b. Work in conjunction with the Site Services Supervisor in executing general facility operations according to this procedure;
c. Prepare landfarm facility for summer treatment operations prior to freshet (e.g. snow removal, etc.);
d. Apply water and/or nutrients to remediating soil under the direction of the Site Services Supervisor and the guidance of the Environment Department;
e. Inspect incoming contaminated soils and direct site users to proper stockpiles according to contaminant type; and
f. Assist the Environment Department in treating water collected in the facility sump and contaminated snow containment.
g. Report all violations of site user rules (Attachment A) to their supervisors for further action and incident reporting.

3.4 Environment Department Personnel

To ensure all employees and contractors are following the guidelines outlined in this manual, the Environment Department will conduct biweekly inspections of the Milne Port landfarm facility. In addition to conducting inspections, Environment personnel shall:

a. Provide guidance to site personnel with regards to acceptable soils at the landfarm;
b. Assist Site Services in optimizing soil remediation rates by monitoring parameters including:
    i. Soil characteristics; grain size, soil texture, bulk density, moisture content and permeability;
    ii. Residual petroleum hydrocarbon concentrations;
    iii. Soil chemistry; nutrients, salts, pH; and
    iv. Tilling frequency.
c. Sample remediating soils throughout summer treatment season to monitor remediation progression;
d. Assist Site Services in the treatment of water collected in the landfarm sump and contaminated snow containment;

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e. Identify treated soils that meet remediation objectives and are acceptable for reintroduction to the environment;
f. Liaise with regulators and stakeholders on matters related to landfarm operations (e.g. notification of planned reintroduction of remediated soil to the environment);
g. Install groundwater wells and monitor groundwater quality along the perimeter of the landfarm facility; and
h. Audit record keeping associated with landfarm facility operations.

4 DEFINITIONS

Landfarm: Bioremediation treatment facility that uses naturally occurring microorganisms (mainly aerobic) and soil aeration (tilling) to remediate soils impacted by petroleum hydrocarbon (PHC) spills.

Contact Water: All irrigation water, precipitation and snowmelt that collect within the landfarm sump.

5 PROTOCOL

5.1 Facility Design, Locations and Layout

The Milne Port landfarm facility was designed in accordance with Environment Canada's Federal Guidelines for Landfarming Petroleum Hydrocarbon Contaminated Soils to ensure both the protection of the environment and the health and safety of all personnel. It is located north of Milne Port Quarry 1 (MP-Q1) along the former Tote Road access. The facility consists of two containments, a landfarm containment and a contaminated snow containment (figure 1):

- The layout of the landfarm consists of a lined, containment area for stockpiling and remediating contaminated soils, a sump in the southwest corner for contact water collection and a ramp in the southeast corner for transporting soils in and out of the facility. It is designed to accommodate approximately 3,383 m3 of contaminated soils.
- Located on the east side of the landfarm, the contaminated snow containment is designed to store contaminated snow and ice generated from spills during the winter months. It is designed to hold 929 m3 of snow and ice (assuming a freeboard of 30 cm) and is accessed by a ramp on the south side.

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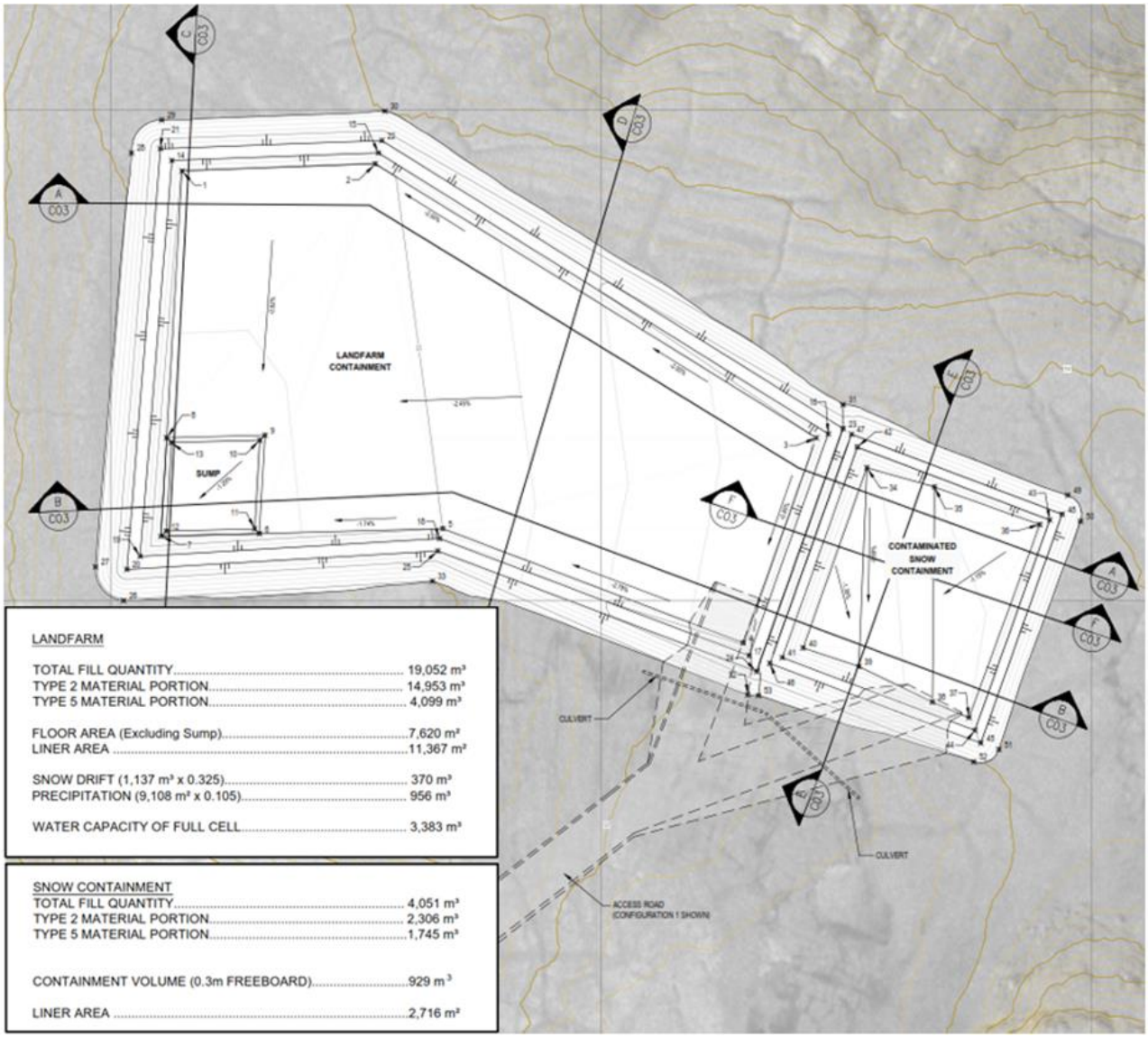

Figure 1 – Landfarm and Contaminated Snow Containment Facility

5.2 Acceptable Soil Criteria

- Impacted soils destined for the landfarm shall be inspected to ensure the material is acceptable for treatment.
- All hydrocarbon contaminated soils are accepted at the landfarm (e.g. diesel, Jet-A, hydraulic oil).

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- In case of major hydrocarbon spills or spills of unknown substance, soils should be sampled prior to being introduced in the landfarm and should meet the following chemical acceptability criteria[2] :
  - Total PHCs less than 4%;
  - Electrical conductivity <4 dS/m; sodium adsorption ratio (SAR) <6;
  - pH greater than 5 and less than 10; and
  - CCME metals up to Tier 1 values or up to natural background concentrations
- Salts contaminated soil shall not be deposited in the landfarm. They may be harmful to biodegradation in high concentrations.
- Rock fragments and cobble exceeding 100 mm (4 in.) in diameter shall not be deposited at the landfarm. They have the potential to damage the containment liner during tilling.
- Acceptable soil types and criteria shall be posted at the entrance of the facility and the unloading or stockpiling area.

5.3 Acceptable Snow Criteria

- Hydrocarbon contaminated snow and ice shall be deposited in the contaminated snow containment.
- Sewage contaminated snow and ice shall not be deposited in the snow containment. It should be deposited in the Milne Port Polishing Waste Stabilization Ponds (PWSPs).

5.4 Stockpiling

- Soils should be separated into stockpiles according to contaminant type.
- Each stockpile shall be clearly labelled with signage in order to direct trucks unloading contaminated material to the proper location at the facility.
- The Landfarm Operator/Labourer shall ensure that adequate signage and barricades are in place at the required locations at the beginning of each day and relocate signs and barricades as required at the end of each day.

5.5 Cell Development, Soil Thickness and Tilling

- **Cell development:** Soil should be tilled as it is spread, continuing until all of the intended soil has been deposited to ensure that the material is well-mixed and aerated.
- **Soil thickness:** Remediating soil should have an approximate soil depth of 30 cm (12 in.) and should maintain a 2 m (6 ½ ft.) perimeter from the inside toe of the berm.

[2] These characteristics detail the optimal chemical composition of suitable landfill soils and will be used as a guideline in determining treatability of soils generated by spills.

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- **Optimum soil condition:** Landfarm soil should be loose and moist. During the summer treatment season, the soils should be tilled every week. Optimizing the moisture content will enhance biodegradation and avoid dust generation.
- **Dry soil:** Very dry soils should not be tilled. The landfarm should be irrigated prior to tilling to increase the soil moisture content to 40% to 85% of the soils' water-holding capacity.
- **Wet soil:** Soils that are too wet should not be tilled. Passing equipment over wet or saturated soils could compact the material, reducing aeration and overall microbial activity. If soils appear muddy, or stick to the tracks of the tilling equipment, the soils are too wet to process.
- **Tilling equipment:** All tilling should be done with a plow pulled by a tracked skid steer to reduce soil compaction and optimize soil aeration. To avoid unnecessary soil compaction, only tilling equipment shall be permitted on remediating soil plots while actively tilling.

5.6 Water Management and Monitoring

5.6.1 Irrigation and Routine Operation

- **Sump water:** Contact water that accumulates in the sump from precipitation or snowmelt may be recycled as irrigation water to increase soil moisture or to supress dust within the landfarm area during dry periods.
- **Sheen:** Recycled water from the sump should not contain any PHC sheen. If a sheen is observed it should be removed with absorbents or avoided by drawing water from beneath the water surface.
- **External water requirements:** As per the Type A Water License No. 2AM-MRY1325, Part E, Item 5, MBR effluent or treated water from the Milne Port PWSP may be used to irrigate dry soil, if such waters meet their respective appropriate discharge criteria. Consumption of fresh water should be avoided.

5.6.2 Water Treatment and Discharge Criteria

- The level of contact water within the landfarm sump shall be monitored and maintained within the determined range during the summer months to maintain adequate freeboard and avoid flooding the soils undergoing treatment.
- Contact water should be drained prior to freeze-up in September.
- All water from the landfarm sump and contaminated snow containment pond shall be sampled and analysed prior to discharge to ensure the water quality meets the landfarm discharge criteria outlined in Baffinland's Type A Water License No. 2AM-MRY1325, Part F, Item 24, Table 9.
- All water that does not meet discharge criteria shall be treated using the onsite mobile Oily Water Treatment System (OWTS). All water sampling shall be conducted in accordance with Baffinland's Surface Water Sampling QA/QC Plan.

5.6.3 Groundwater Monitoring

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- Groundwater monitoring wells shall be installed around the perimeter of the landfarm facility to ensure the structural integrity of the facility's containment liner throughout facility operations.
- Groundwater wells shall be sampled at a minimum of once annually, between mid-August and mid-September when groundwater monitoring becomes possible.
- All sampling groundwater sampling shall be conducted in accordance with Baffinland's Surface Water Sampling QA/QC Plan.

5.7 Soil Management and Monitoring

5.7.1 Remediation Objectives

- Remediation objectives for impacted soils shall be determined by the source of contamination and the subsequent use of the remediated soils.
- Tier 1 criteria for PHC and metals parameters will be used as a minimum to determine soil remediation objectives, as outlined in the Government of Nunavut Environmental Guideline for Site Remediation (2009), as per Baffinland's Type A Water Licence No. 2AM-MRY1325, Part J, Item 6.
- Analysis of additional parameters will depend on the source of contamination.

5.7.2 Soil Sampling and Analysis

- At the beginning of each summer treatment season, soils shall be evaluated for optimal nutrient, moisture and pH conditions.
- Soil sampling should be conducted throughout the treatment season to characterize soil additions from recent spills and monitor the progression of PHC degradation in soils undergoing remediation.
- Parameters may include soil bulk density, salts, moisture content, field capacity, and nutrients.
- All soil samples shall be collected using best industry practices and in accordance with the principles outlined in Baffinland's Surface Water Sampling QA/QC Plan.

5.7.3

- Any transport of soils out of the landfarm shall be preapproved by the Environment Department.
- The use of remediated soil for back fill or general site grading may be carried out only upon consultation and approval by the Government of Nunavut, Department of Environment and an Inspector, as per Baffinland's Type A Water License No: 2AM-MRY1325, Part J, Item 6.

5.7.4 Winter Management and Freshet Preparation

- **Winter management:** Contaminated soil can be stockpiled up to 5 m (5 yd.) to minimize the amount of contact precipitation.

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- **Freshet preparation:** Snow and ice accumulated within the landfarm that has not come in contact with the underlying contaminated soil can be removed and placed outside the landfarm facility to melt.
- Approximately 10 cm (4 in.) of contact snow cover should remain on all surfaces during the snow removal process.
- If the landfarm soils are disturbed, contact snow should remain in the landfarm area and be deposited in the sump to melt.
- Snow accumulation within the sump area should be removed to within 10 cm (4 in.) of the ice surface.

5.8 Summary of Inspections and Reporting

Table 6.1 summarizes the documentation and due diligence required to ensure compliance throughout the landfarm operations. All site personnel responsible for completing landfarm facility operations shall be familiar with documentation and reporting requirements.

Table 6.1 – Monitoring Summary and Documentation

Item	Purpose	Responsible Party	Frequency	Type of Record(s)
General Operations	Record keeping of treatment operations	Site Services and Environment	Ongoing	• A working log detailing the following: - Dates, volumes (m^3) and source of soils entering and exiting facility - Start and end date of soils under remediation - Dates and volumes of contact water treated, discharged and recycled - Dates, volumes and source of soil amendment additions (e.g. wastewater effluent, fertilizer) • A current layout sketch identifying origin and contaminant type of remediating soils and stockpiles • Photographic record.
Soil Sampling	Characterization and acceptance at landfarm	Environment	As required (e.g. major spill, spill of unknown substance)	• Soils origin and associated spill report. • Field notes detailing sampling methodology, soil texture, moisture content, odor and suspected contaminants. • Laboratory-issued analysis reports including QA/QC and chain of custody. • Documentation of fate of rejected soils. • Record of any treatability tests done.

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Item	Purpose	Responsible Party	Frequency	Type of Record(s)
Soil Sampling	Remediation Progress Monitoring Determination of amendment additions	Environment	Monthly during the frost-free months	• Field notes detailing sampling methodology, sample location and depth, soil texture, moisture content and odor. • Photographic record. • Laboratory-issued reports including QA/QC and chain of custody. • Summary tabulation of results. • Analysis of percent removal of PHC constituent treated and treatment time.
Soil Sampling	Verification of remediation	Environment	Once per year at the end of the season Otherwise, as circumstances require	• Field notes and sketch detailing sampling methodology, sample location and depth, soil texture, moisture content and odor. • Photographic record. • Laboratory-issued reports including QA/QC and chain of custody. • Summary tabulation of results. • Analysis of percent removal of PHC constituent treated and treatment time. • Documentation of fate of treated soils including date and volume (m^3).

Contact and Contaminated Water Sampling	Conformity to Water License requirements
	
	Remediation Progress Monitoring
		Environment	Monthly, or as required	• Document notification to Inspector (written notification at least 10 days prior to discharge).
				• Field notes detailing:
				  • Discharge start and stop times
				  • Date and time of samples taken
				  • Daily discharge volumes (m^3)
				  • Photographic record of OWTS setup
				• Laboratory-issued reports including QA/QC, chain of custodies and summary tabulation of results.

Groundwater Monitoring and Sampling	Groundwater quality assessment	Environment	At least once per year	• Laboratory-issued reports including QA/QC, chain of custodies and summary tabulation of results • Field notes detailing sampling methodology, date and time of sampling, depth of active layer, weather and condition of wells. • Trend analysis (after a minimum of four years of data, if applicable).
Construction Summary Report	As-built and construction report as per Water License.	Projects	Submit to Nunavut Water Board within 90 days of completion of construction	• Construction field notes and observations. • Record and as-built drawings. • Monitoring well installation details. • Summary of any geotechnical testing, compaction, moisture content, particle size analysis.

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Item	Purpose	Responsible Party	Frequency	Type of Record(s)
Site Safety Inspections	Hazards identification	Health and Safety	Weekly	• Any unsafe condition/near-miss/incident reports and records. • Any unsafe conditions reported by workers must be reported to the Safety Department immediately for prompt action.
Geotechnical Inspection	Earthworks integrity and maintenance requirements identification	Site Services Engineering Consultants	Biannually during the summer	• Inspection of geotechnical performance of facility. • Berm performance with emphasis on observations of cracking or any signs of instability • Document recommendations of any repair/maintenance work. • Record of any repair work made to the facility.

6 REFERENCES AND RECORDS

- Government of Nunavut. Department of Sustainable Development. Environmental Protection Service. Environmental Guideline for Contaminated Site Remediation. March 2009.
- Environment Canada. Federal Contaminated Sites Action Plan (FCSAP): Federal Guidelines for Landfarming Petroleum Hydrocarbon Contaminated Soils. ISBN no. 978-1-100-22284-4. Cat. No. En14-19/3-2013E-PDF. 2013.
- Nunavut Water Board - Type A Water Licence No: 2AM-MRY1325
- EBA. Preliminary Hydrocarbon Impacted Soils Storage and Landfarm Facility – Operations, Maintenance and Monitoring Plan. EBA File No. E14101092. Milne Inlet, September 2011.
- EBA. Laboratory Biotreatability Study to Evaluate Biodegradation of Petroleum Hydrocarbons. SiREM Ref: TL0307B. Milne Inlet, July 2012.
- Waste Management Plan (BAF-PH1-830-P16-0028)
- Hazardous Materials and Hazardous Waste Management Plan (BAF-PH1-830-P16-0011)

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Attachment A

Landfarm Facility User Rules

1. **RESTRICTED ACCESS – ONLY SITE SERVICES PERSONNEL ARE ALLOWED TO ENTER THIS FACILITY.**
2. **Only HYDROCARBON contaminated snow and soil are accepted at this facility.**
3. **Incinerator, hazardous and/or landfill waste are NOT accepted at this facility.**
4. **All placement of soil and contaminated snow in the facility must be preapproved by Site Services Supervisor prior to dumping.**
5. **Vehicles shall follow posted speed limits and directions to the unloading area - Unloading in other areas is strictly prohibited.**
6. **No unloading by rapid acceleration or deceleration is permitted.**
7. **All spills are to be stopped if safe to do so, and immediately reported to the Site Services Supervisor.**
8. **Personal Protective Equipment (PPE) is required to be worn at the facility.**
9. **In case of Emergency – Immediately contact the Site Services Supervisor or call a Code 1, if necessary, providing your location, your name and the nature of the emergency.**

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Attachment B

LANDFARMING - BASIC PROCESSES AND PRINCIPLES

The Milne Port landfarm is a bioremediation treatment facility that remediates soils impacted by PHC spills and releases. Remediation is achieved by spreading contaminated soil in a thin layer (30 – 45 cm) across the landfarm area and allowing two natural processes to remove the PHCs from the soil: (1) PHC degradation by naturally occurring microorganisms; and (2) chemical volatilization.

The breakdown of PHC by aerobic microbial degradation is the dominant process of the two and results in three main end products: water, carbon dioxide and microorganism protein. The stimulation of microbial growth and activity for the removal of PHCs is accomplished primarily through the addition of air and nutrients. Microorganisms that degrade PHCs require optimal quantities of water, oxygen, and macronutrients (carbon, nitrogen, hydrogen, oxygen, sulphur, phosphorus, potassium, and magnesium), and have an ideal soil pH between 6 and 8. In addition, excessive salt compounds reduce the osmotic potential of the soil and can slow, or even halt biodegradation. Salts that are harmful to biodegradation in excessive concentrations include sodium chloride and particular fertilizer amendments.

The overall effectiveness of landfarming depends on the following three main parameters:

1. Soil characteristics; grain size, soil texture, bulk density, moisture content and permeability;
2. Type of petroleum hydrocarbon or contaminant; and
3. Climatic conditions.

Soil characteristics influence the rate of at which impacted soils remediate by affecting several factors including PHC retention, water holding capacity, surface area, permeability and bioavailability. Most soil microorganisms that breakdown PHCs in a landfarm require an aerobic environment, making remediation of soil with low permeability, such as clay, more difficult. Because of this, tilling is conducted to loosen and aerate the soils in order to enhance microbial activity.

Moreover, the type of PHCs present in impacted soils is one of the main factors that determines the amount of time required for remediation. Soils impacted by diesel and/or Jet-A remediate significantly faster than soils contaminated with hydraulic and engine oils due to the differences among the PHCs chemical composition.

Climatic conditions including rainfall, snow, wind effects and temperature also influence remedial efficiency. Rain and snow melt will change the moisture content of the treated soil which in turn can alter the activity of the microorganisms responsible for PHC degradation. In contrast, wind and low humidity have the potential to increase water evaporation and dry out remediating soil. Maintaining the moisture content of impacted soils within a range of 40% to 85% of the soil's water-holding capacity will enhance biodegradation and avoid dust generation.

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