Baffinland Iron Mines LP
Mary River Expansion Stage 3

Definitive Study Report

Section 7 – Engineering Development

2017-05-01	0	Approved for Use	N. Mason	J. Cleland	S. Heiner	BIM
Date	**Rev.**	**Status**	**Prepared By**	**Checked By**	**Approved By**	**Approved By**
HATCH						

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7. Engineering Development

7.1 Site Conditions

The following section is a summary of the site conditions experienced at both the Milne Port and Mine site. For a more detailed description refer to Appendix A7-1.

7.1.1 Temperature

Table 7-1 presents the average maximum and minimum temperatures for the Mary River site from 1971 to 2000. This information is based on a report prepared by consulting engineers Rowan Williams Davies and Irwin Inc. (RWDI). Design outdoor temperature is outlined in Table 7-2.

Table 7-1: Average Temperature 1971-2000
(Ref.: RWDI, 2011 Table 5-1.1)

Season (Months)	Mean Daily Temperature Maximum (°C)	Mean Daily Temperature Minimum (°C)
Winter (December – February)	-28.1	-35.3
Spring (March – May)	-16.6	-24.8
Summer (June – August)	9.6	3.1
Fall (September – November)	-8.4	-14.9
Annual	**-11.5**	**-18.6**

Table 7-2: Design Temperature

January, 2.5% Basis:	-43°C
January, 1% Basis:	-45°C
Winter, extreme minimum:	-54°C
July, 2.5% Basis (dry bulb):	+14°C
July, 2.5% Basis (wet bulb):	+10°C
Summer, extreme maximum:	+26°C
The Number of Degree-Days under 18ºC (1971 - 2000):	11500 for Mine Site 12000 for Milne Port

7.1.2 Rain

Rainfall can generally occur from April to November. August is the wettest month with 32.9 mm of rain. The historical data shows that the rainfall is increasing over the years at a rate of 0.24 mm/year (RWDI 2011 report). Design rainfall data is outlined in Table 7-3.

Table 7-3: Design Rainfall Data

Maximum Precipitation Month	500 mm (2005; Nanisivik station, RWDI Report)
Total annual rainfall: • Mary River Mine • Milne Inlet	 • 262 mm • 217 mm
One day rain (1/50 year): • Mary River Mine • Milne Inlet	 • 46 mm • 35 mm
15 min rainfall (1/10 year) • Mary River Mine • Milne Inlet	 • 4 mm • 3 mm

7.1.3 *Snow and Ice*

Design ground snow loads are shown in Table 7-4.

Table 7-4: Design Ground Snow Loads

Snow	Units	Mary River	Milne Inlet
Ground Snow Load (S_s) (1/50 year)	kN/m^2	2.9	2.1
Associated Rain Load (S_r) (1/50 year)	kN/m^2	0.2	0.2
Unit weight of snow, γ	kN/m^3	3.0	3.0

Ice Accretion:

- Ice thickness: 12 mm for marine structures and shiploader(s).
- Ice thickness: 50 mm for other outdoor structures.
- Ice density: 9.8 kN/m^3.

7.1.4 *Wind*

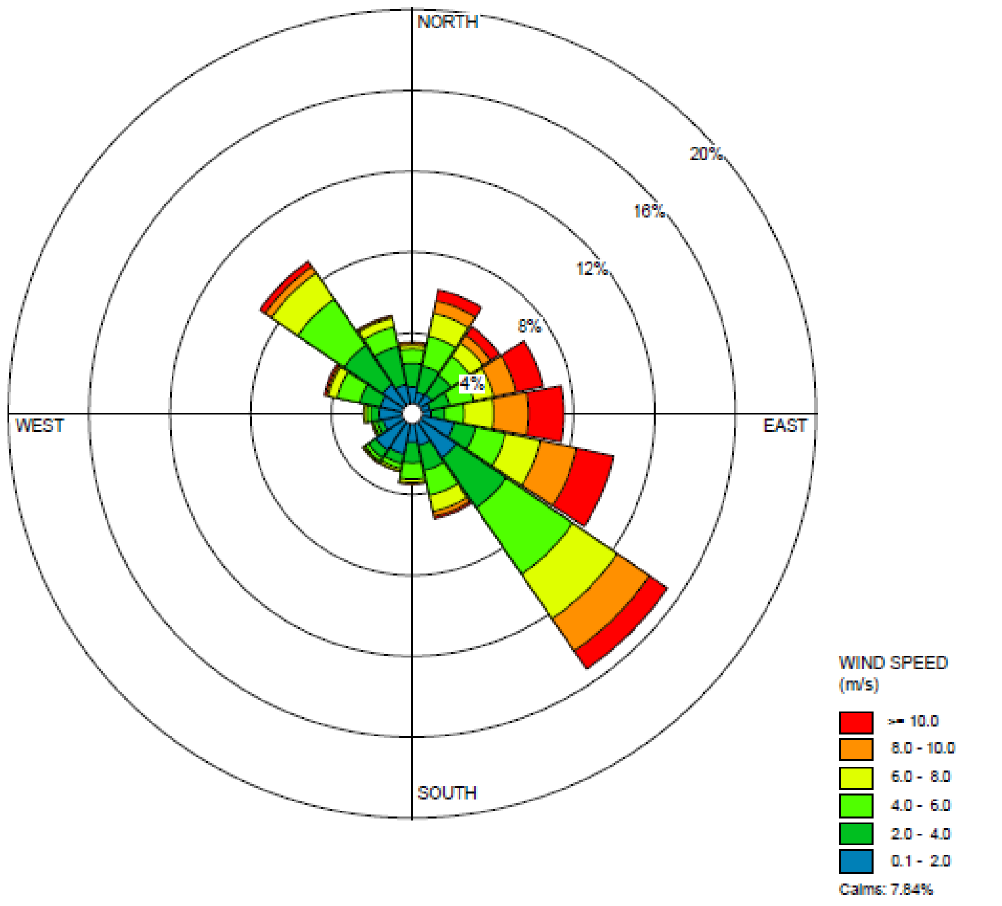
The wind rose for Milne Inlet for Open Water Season from 8/1/2016 to 10/31/2014 is shown in Figure 7-1.

The wind rose for Milne Inlet for Non-Open Water Season from 11/1/2006 to 6/16/2015 is shown in Figure 7-2.

Figure 7-3 shows the open water season wind rose at Mary River mine meteorological station from 8/1/2006 to 10/31/2014.

Figure 7-4 shows the non-open water season wind rose at Mary River mine meteorological station from /3/2006 to 6/16/2015.

WIND ROSE PLOT:	DISPLAY:
MILNE INLET MET STATION **OPEN WATER SEASON**	**Wind Speed** **Direction (blowing from)**



COMMENTS:	DATA PERIOD:	COMPANY NAME:	
Open Water Wind Conditions - August 1 to October 31	**Start Date: 8/1/2006 - 00:00** **End Date: 10/31/2014 - 23:00**	**Knight Piésold Ltd.**	
		MODELER: **SBF**	*Knight Piésold* CONSULTING
	CALM WINDS: **7.84%**	TOTAL COUNT: **7655 hrs.**	
	AVG. WIND SPEED: **4.33 m/s**	DATE: **11/9/2016**	PROJECT NO.: **NB102-181/39**

Figure 7-1: Milne Inlet Wind Rose for Open Water Season

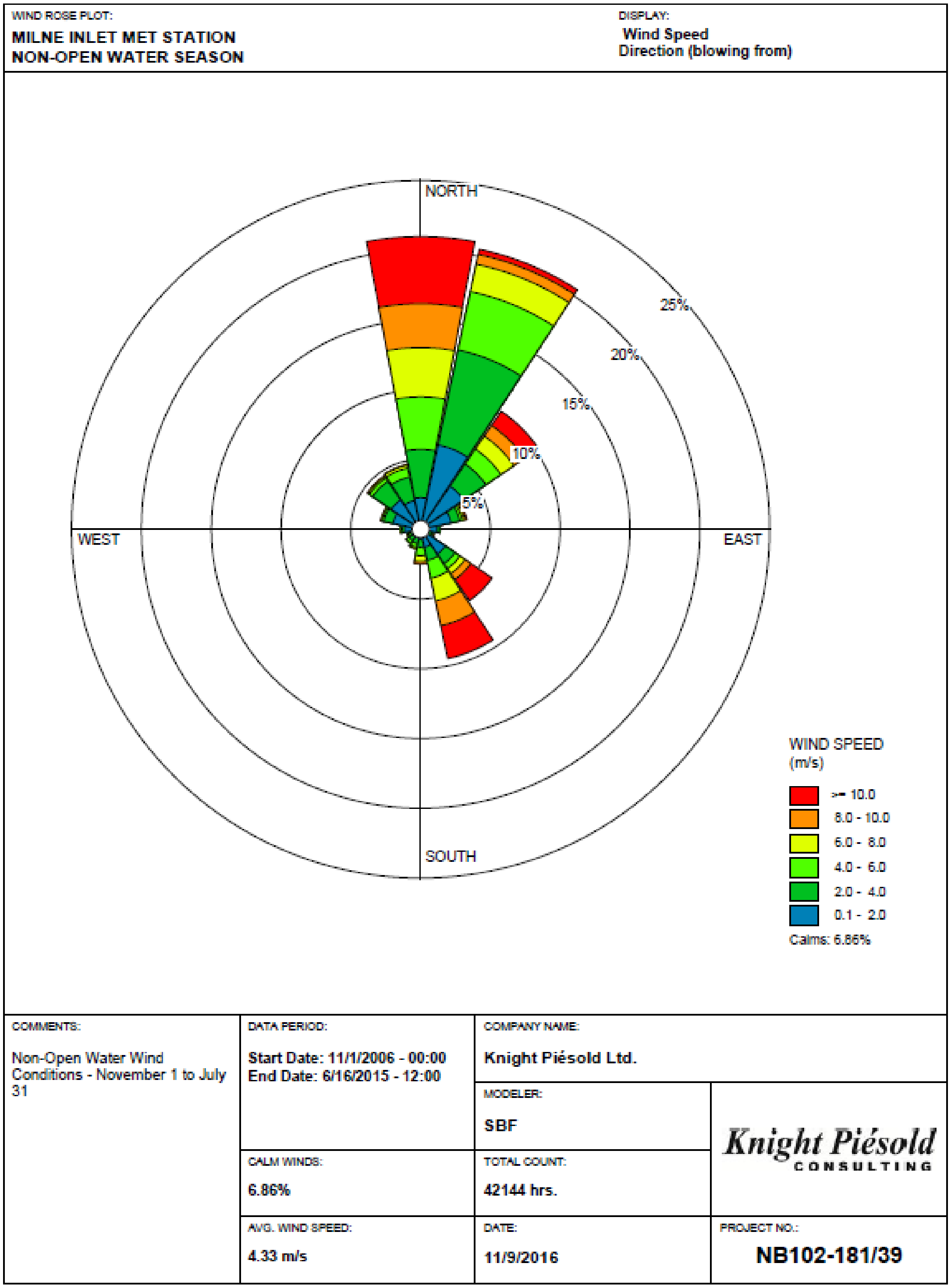


Figure 7-2: Non-Open Water Season Wind Rose at Milne Inlet

WIND ROSE PLOT:

MARY RIVER MET STATION
OPEN WATER SEASON

DISPLAY:

Wind Speed
Direction (blowing from)

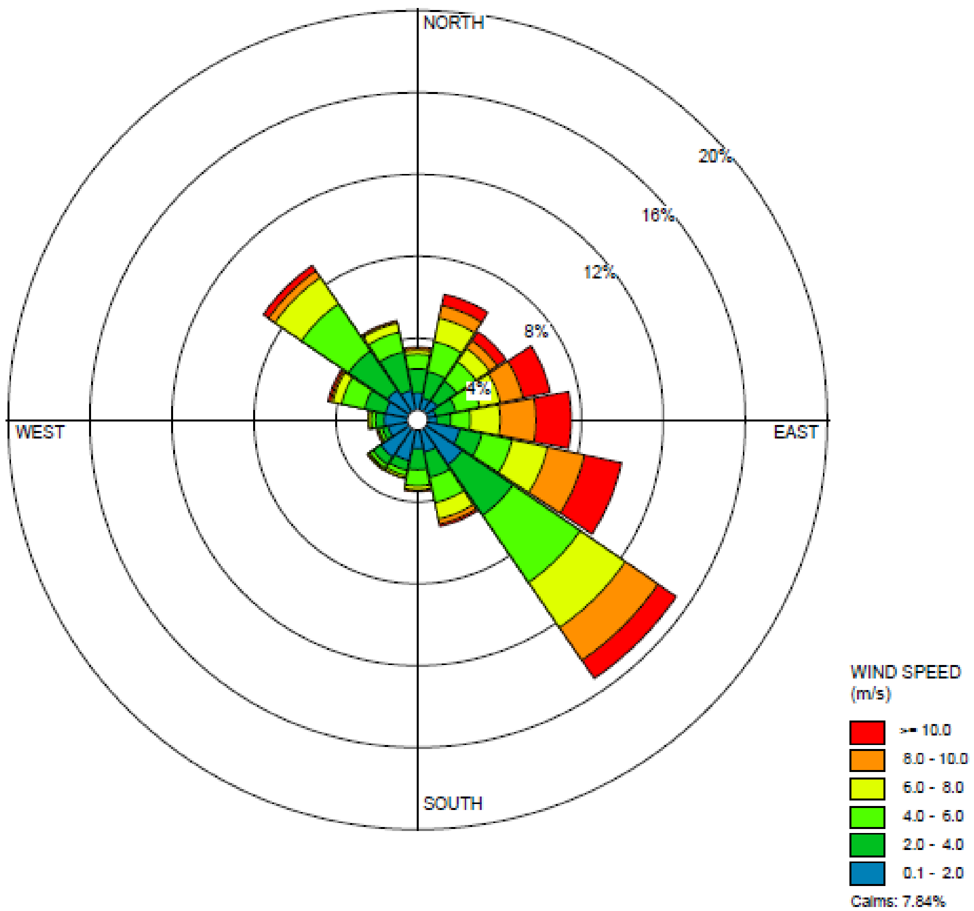


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Figure 7-3: Open Water Season Wind at Mary River Mine Station

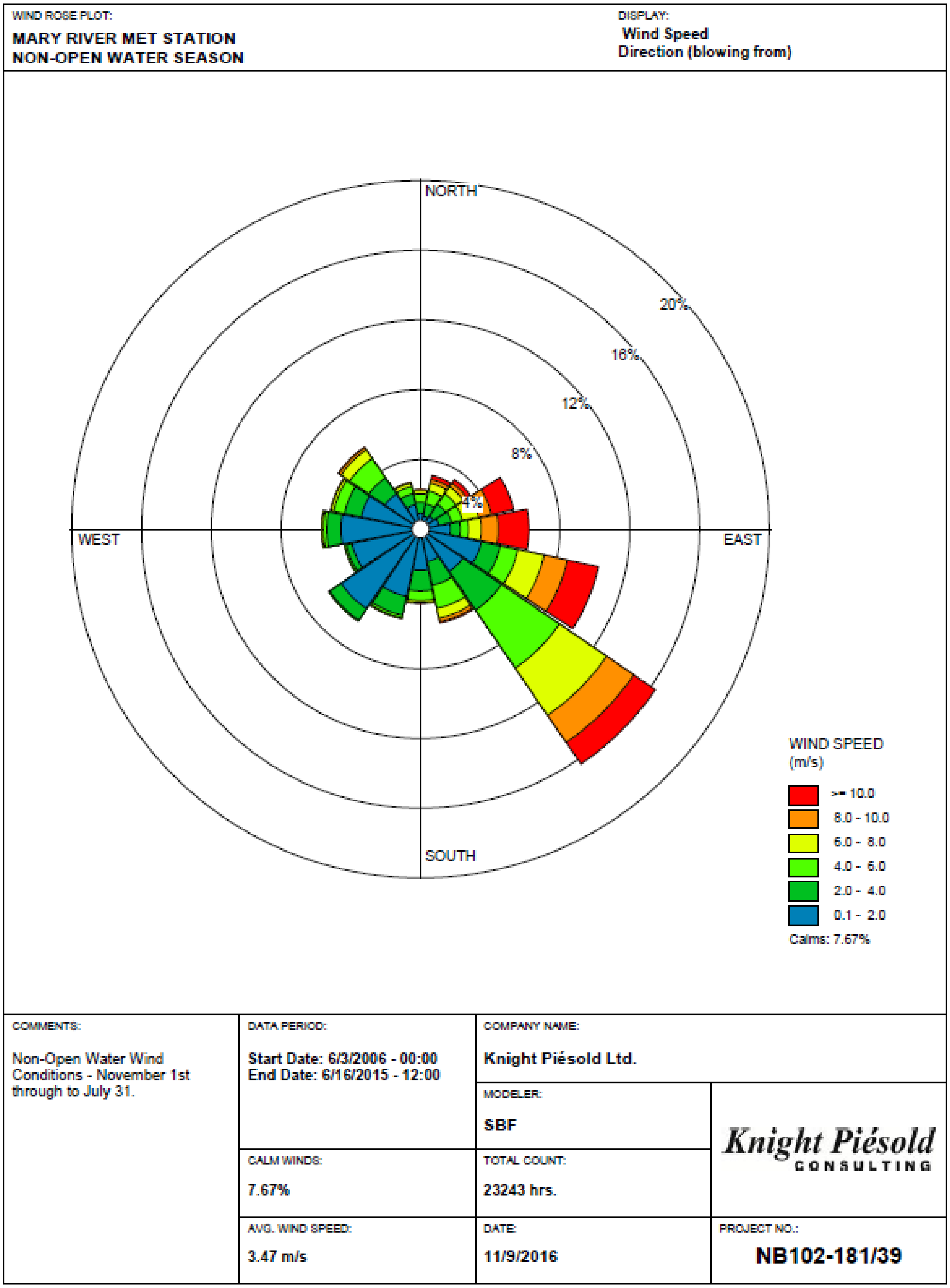

Figure 7-4: Non-Open Water Season Wind at Mary River Mine Station

7.1.5 Marine Conditions – Milne Inlet

The following provides a summary of relevant marine conditions at the Milne Inlet. For a more detailed description refer to Appendices A7-2 and A7-3.

7.1.5.1 Tides

Department of Fisheries and Oceans (DFO) provided the following tidal levels based on data recorded for a period of 2 months in 1965at Milne Inlet Station, located at 71°54' N, 80°51' W (data received March 25, 2013):

- Water: saline.
- Tides: yes, semi-diurnal.
- Highest Astronomical Tide (HAT): elevation +2.4 m CD (1.2 m GD).
- High High Water Large Tide (HHWLT): elevation +2.3 m CD (+1.1 m GD).
- High High Water Mean Tide (HHWMT): elevation +2.0 m CD (+0.8 m GD).
- Mean Water Level (MWL): elevation +1.2 m CD (0.0 m GD).
- Low Low Water Mean Tide (LLWMT): elevation +0.5 m CD (-0.7 m GD).
- Low Low Water Large Tide (LLWLT) or Lowest astronomical Tide (LAT): elevation 0.0 m CD (-1.2 m GD).

The veracity of these tidal planes should be independently established by The Design and Build Contractor (CG001 – Ore Dock), if required by establishing a tide gauge at the existing dock to confirm tidal planes at the ore dock project site.

7.1.5.2 Surge

The storm surge was calculated analytically to be 0.30 m, assuming a fetch length of 40 km and steady wind conditions of 30 m/s (Refer Appendix A7-3). Where possible, this predicted surge level is to be verified against any available water level measurements near the site or at comparable locations in the region.

7.1.5.3 Sea Level Rise

An estimated sea level rise of 0.3 m is expected along the Northeast shore of Baffin Island (refer Appendix A7-3).

7.1.5.4 Currents

Current measurements were taken at two sites over the month of September 2010 (Ref. appendix A7-3).

Currents were measured at the entrance to Milne Inlet (ADCP located at 71°59' N, 80°47' W) at a mean depth of 148 m. Measurements indicate peak speeds of 0.31 m/s at a depth of 9 m below the water surface. A maximum current speed of 0.55 m/s was calculated for the region of the water column nearer to the surface.

Currents were also measured near the Milne port (ADCP located at 71°53’ N, 80°55’ W) at a mean depth of 27 m. Measurements indicate peak speeds of 0.31 m/s at a depth of 4 m below the water surface. A maximum current speed of 0.54 m/s was calculated for the region of the water column nearer to the surface.

Due to the lack of data a safety factor 1.25 has been applied to the measured maximum currents to arrive at a design current speed. The maximum calculated design current speed is therefore 0.7 m/s. Any further quantification of current magnitudes will require execution of a hydrodynamic model validated against available measurements.

7.1.5.5 Waves

The design wave parameters were established (refer Appendix A7-2) and are shown in Table 7-5.

Table 7-5: Milne Inlet Design Wave Parameters

Return Period (years)	Significant Wave Height (m)	Peak Wave Period (s)
1	1.46	4.36
5	1.74	4.62
10	1.85	4.72
20	1.96	4.80
30	2.02	4.80
50	2.09	4.90
100	2.19	4.97

7.1.5.6 Sea Ice Thickness

Sea ice thickness values are given for both freeze-up and break-up conditions. Freeze-up is defined as the time at which a continuous and immobile ice cover forms. Breakup is the time when the ice cover begins to move downstream in a river or when open water becomes extensive at the measurement location.

The design sea ice thicknesses are shown in Table 7-6 (Refer Appendix A7-3 and A7-4).

Table 7-6: Design Sea Ice Thickness Values

Description	Value	Notes
Freeze-up	0.9 m (first year)	Note[1]
Break-up	2.05 m (first year)	

[1] Design ice thicknesses are not presented here for old ice because it was shown that the annual probability for an old ice loading event is less than 0.01.

7.2 Codes Standards and Criteria - Regulatory

The Mary River project is located in the territory of Nunavut, Canada, and falls within the jurisdiction of the Nunavut Mine Health and Safety Act. All Facilities and equipment are required to comply with:

- The National Building Code 2010.
- Nunavut Mine Health and Safety Act (S.N.W.T 1998 C.34).

- Nunavut Mine Health and Safety Regulation (R-125-95).
- Nunavut Electrical Protection Act (R.S.N.W.T. 1988 C.E-3).
- Nunavut Electrical Protection Regulation (R.R.N.W.T. 1990 C.E-21).
- National Fire Code of Canada.
- Canadian Electrical Code.
- CCME PN1326 Above Ground and Underground Storage Tank Systems.

In addition to legislated codes and standards the design has been developed generally in compliance with:

- Applicable Canadian Standards.
- Recommendations contained within the Nunavut Good Building Practice Guidelines.
- Design Criteria and standards developed for the Mary River Expansion Stage 3.

7.3 Hydrology

7.3.1 Regional Characterization and Stream Flow Estimates

Regional hydrologic characteristics and stream flow estimates for the Mary River site are summarized in the Hydrology Baseline Report (Refer Appendix A7-4):

> *Baffin Island is one of the northernmost and coldest parts of Canada and the Mary River Project is situated towards the northern end of the Island. The long duration of sub-zero temperatures in this region results in a very short runoff period that typically occurs from June through September, but may extend to late October or even early November in systems where large lakes are present. The frigid temperatures also result in very low precipitation values, from the combined effect of the low moisture carrying capacity of cold air and the scarcity of liquid water for much of the year. According to Natural Resources Canada, the mean annual total precipitation ranges from 200 to 400 mm in the Project area, classifying it as semi-arid. Processes that act to further limit water available for runoff are evaporation, transpiration and sublimation. The frigid climate and subsequent lack of significant vegetative cover combine to minimize the volume of water evaporated and transpired to very low levels. Sublimation, which is the process by which solid water changes phase directly to water vapour, occurs during the winter months and is increased by blowing snow transport which is very common in the Mary River region. Therefore, sublimation may result in a greater loss of potential runoff than either evaporation or transpiration, and has been found to result in losses of up to 50% of winter precipitation in Arctic environments (Liston and Sturm, 2004).*

As temperatures rise above freezing snow and ice melt commence. Considerable differences in the timing and volume of runoff occur between systems depending on elevation, aspect, glacial cover and lake cover. A watershed's elevation affects the timing of the onset of the summer melt, and can also affect the volume of precipitation it receives as a result of orographic influences. The aspect of a watershed can also play a role in the timing of the summer melt, and possibly in the depth, and therefore volume, of permafrost melt later in the summer. Glacial cover tends to greatly increase the volume of runoff in a watershed, especially in the late summer, relative to other catchments that receive runoff only from permafrost melt and precipitation. Finally, lake content within a watershed acts to attenuate the effects of storm and melt events, resulting in a smoothed hydrograph without the rapid changes in runoff observed in catchments without significant lake area. Lakes also provide a source of water to river systems later in the year, due to attenuation of inflows, when precipitation is falling as snow, permafrost melt has ceased, and other systems are no longer receiving input of water and are therefore drying up and/or freezing over. As a result, systems that include significant lake components tend to continue to flow later into the winter than watersheds with little or no lake volume. The presence of permafrost within the watersheds of the region, coupled with the lack of vegetative cover, also has an effect on hydrologic systems. Permafrost typically does not allow water to infiltrate the ground to any great depth, while the lack of surface vegetation results in little to no impedance or loss of runoff as it flows to the river channels. Therefore, storm driven runoff events tend to produce flashy streamflow conditions.

Five regional hydrologic stations operated by WSC were reviewed in an attempt to characterize the hydrology in the region around the Mary River Project Area. Due to the sparse hydrologic network in the Canadian Arctic, these systems are a significant distance from the Project, have records with few complete years, and are not all currently active. The five stations range in location from 640 km northwest, to 1000 km southeast of Mary River, and have drainage areas ranging from 60 km2 to 2980 km2. These systems begin to flow in late May to mid-June, with the southern watersheds melting earlier than the northern watersheds. The majority of annual runoff then typically occurs during the nival freshet in late June through July, with runoff decreasing through the late summer before freezing up again at the onset of winter. The freeze-up date is significantly different between the northern and southern sites, ranging from late September in the northern watersheds more similar in latitude to Mary River, to November and December for the sites located far to the south near Iqaluit. Mean annual unit runoff (MAUR) also differs between the northern and southern watersheds. The southern watersheds have an average MAUR of 10 l/s/km2, while the northern watersheds average 6 l/s/km^2. The mean annual peak daily unit runoff varies more randomly amongst the sites, with a low of 105 l/s/km^2 at Marcil Creek and a high of 251 l/s/km^2 on the Mecham River. Through analysis of the regional WSC streamflow stations, it is assumed that the smaller, non-lake containing watersheds in the immediate vicinity of *the Mary River Mine Site should begin to flow in early to mid-June and cease to flow in late September to early October, have MAUR values of approximately 8 to 10 l/s/km^2, and have mean annual peak daily unit runoff values ranging from approximately 100 to 400 l/s/km^2. In watersheds containing significant lake coverage, flows are expected to end later and have a lower mean annual unit runoff.*

Climate change was also discussed as it pertains to the Mary River Mine Site. It was concluded that a conservative approach should be applied to hydrologic estimates to account for potential changes in annual, seasonal and extreme flow events due to climate change.

7.3.2 Rail Hydrology Characteristics

Hydrologic characteristics for the Tote Road from Mary River to Milne Port were investigated by Knight Piesold (KP) in 2006 and are summarized in KP memorandum Hydrology for Tote Road Design (Refer Appendix A7-6). The KP hydrology work followed industry standards, and is considered valid and sufficient for the study. In 2016 KP updated the regional analyses performed previously with new data collected by WSC since 2006. Refer to Knight Piésold document in Appendix A7-8.

Utilising the Water Survey of Canada (WSC) data, KP calculated both "normal" and linear moment (L-moment) statistics on the historical peak daily flow records. From this data expected Q_{mean}, L-Stdev, L-Cv (linear moment coefficient of variance), and L-Cs (linear moment coefficient of skewness) statistics at the 10 km^2 and 1000 km^2 basin scales were derived. Peak instantaneous, rather than peak daily, flow estimates are typically required for culvert or bridge design. KP used the few WSC gauges having concurrent peak daily and peak instantaneous flow data to develop ratios of instantaneous to peak flows to drainage area. This relationship was applied to the estimates of peak daily flow values to yield final estimates of peak instantaneous flow values for a range of return periods. KP considered these relationships applicable for basins with drainage areas from 0.5 km^2 to 1000 km^2. KP recommended the Rational Equation ($Q = CIA$) for basins smaller than 0.5 km^2, using a runoff coefficient, C, of 0.90 and a rainfall intensity/corresponding to the basin's time of concentration as computed using the Kirpich Equation.

7.3.3 General

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.

The Hatch Feasibility Optimization report also recommended that the initial Steensby approach to analyze and provide for 1:200 return periods be adjusted to 1:100 year return periods after analysis showed that there wasn't a substantial change in run-off volumes – only a 10.9% reduction in design volumes.

The hydrologic analysis for the Tote road has been reviewed refer to Appendix A7-7 titled the In-Principle Review of Previous Tote Road Hydrology Assessments.

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 in Appendix A7-8.

7.3.4 Methodology

7.3.4.1 Design Peak Flows

In the Hatch report reviewing Hydrologic analysis for the Tote Road (refer Appendix 7-7) Hatch raised queries with regard to the method used to derive the design peak flows. Following the updated design peak flows by Knight Piésold, the following methodology was adopted by the project for the design of drainage structures.

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.

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.

The delineated catchments will be used in conjunction with the formulas presented as output from the Knight Piésold design peak flows update report to calculate the associated run-off flows for a 1:100 year flood.

The flow volumes calculated were then used to determine the ultimate sizing of the culvert structure in terms of number and size of barrels.

Baffinland Iron Mine will supply 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.

7.3.4.2 Flood Return Period

One in one hundred year return period.

7.3.4.3 Design Velocities

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.

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.

For flows higher than 5 m/s special treatment shall be considered on a case by case approach.

7.4 Geotechnical

7.4.1 Site Overview

A geotechnical summary for the various project areas has been developed (refer to Appendix 7-16) and a brief overview is provided in the following section. The summary is based on a combination of all the desk and field studies that have been carried out.

7.4.1.1 Milne Port

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. 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.

The entire Site is underlain by permafrost, except area's of bedrock at the Q quarry location and below large bodies of water where water depths exceed 3-4 m. Ground ice and ice lenses exist throughout the site perimeter.

7.4.1.2 Mine Site

Mary River is located on the north side of a wide valley. The valley wall on the north part of the site consists of granite bedrock overlain by glacial till which rises about 300 m above the valley floor. The glacial till varies in depth from 2 m to over 20 m deep and generally consists of sands and gravels with cobbles and boulders. The topography of the valley wall is steep and the ground surface is mainly covered with cobbles and boulders.

The valley bottom, where the mine infrastructure is located, is underlain by overburden soils that consist primarily of glacio-fluvial deposits and gravelly glacial till that are underlain by sandstone bedrock. The composition of the glacial till varies from sandy silts to sand and gravel; cobbles and boulders are common throughout the till. The glacial till varies in depth from about 1.0 m to over 26 m. The glacio-fluvial deposits generally consist of poorly graded sands and vary in depths from 3 m to over 18 m. The contact between the sandstone bedrock and the granite is located near the toe of the valley wall.

Vegetation is sparse over the entire Site and consists primarily of a variety of mosses and grasses in areas where surface moisture is present during the summer months. No shrubs or trees exist in the area and no peat deposits were observed. Organic soils, which are present in only a few poorly drained locations, are usually less than 150 mm thick.

The entire area is underlain by permafrost, except below large bodies of water where water depths exceed 3 or 4 m. The maximum annual depth of thaw in this area ranges from 0.5 to 2 m and varies significantly, depending primarily on surface drainage. Large ice lenses are found throughout the site, but are more common in the area of the airstrip.

7.4.1.3 Railway

The proposed railway alignment in preliminary design stage generally follows the existing Tote road with 10 pertinent deviations. Regional geologic mapping is available for the entire route of Tote Road (Scott and de Kemp, 1998), which can be used for railway preliminary design. In summary:

- Approximately the first 20 km of the Tote Road from Milne Inlet passes through Precambrian terrane, glaciofluvial sand and gravel terraces.
- The middle 70km spans across relatively flat lying Paleozoic rocks mainly dolomitic limestone units.
- The final 14 km of the road to the Mary River mine site traverses glaciolacustrine and glaciofluvial plains, terraces, eskers and bedrock outcrops ranging from granitic gneiss to sedimentary rocks.
- The rail line follows the Tote road alignment between Mary River Mine and the Milne Port to a large extent with 10 pertinent deviations. These deviations are required due to permafrost, the topography, and the geotechnical findings.

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. Cobbles and boulders were noted during the limited geotechnical investigation to be present within the majority of the cohesionless deposits at various depths with variable thickness.

A significant portion of the Railway alignment site is underlain by permafrost with an estimated annual thaw depth ranging from 0.5m to 2.5m.

7.4.1.4 Permafrost and Active Layer Thicknesses

The permafrost depth and active layer thicknesses are shown in Table 7-7.

Table 7-7: Permafrost Depth and Active Layer Thicknesses

Frost	Value	Addition for Global Warming[1]
Permafrost Depth	Down to Rock	
Depth of Active Layer:	0.6 – 3.0m	
• Till	1.0m	0.5m max.
• Sand and Gravel	1.5 – 2.5m	1.0m max.

[1] Global Warming allowance for 50 years can be included by adjusting values for active layer thickness.

7.4.2 Field Investigation

7.4.2.1 Previous Studies

Multiple geotechnical investigations have previously been conducted at the Mary River mine site, Steensby Inlet port site, Milne Inlet port site and along the Milne Inlet Tote Road, including:

- Knight Piesold Consulting Ltd investigation programs in 2006 (refer Appendix A7-11), 2007 (Refer Appendix A7-12), and 2008 (refer Appendix A7-13).
- AMEC Earth and Environmental investigation in 2010 (refer appendix A7-14)
- Thurber Engineering Ltd. investigation in 2011 (refer appendix A7-15).
- Hatch investigation programs and geotechnical interpretations from 2011 to 2014 (refer to Appendices A7-35 to A7-40)

7.4.2.2 2016 Expansion Project Drilling Program

Hatch was retained by BIM to conduct geotechnical drilling investigations for the design of the railway alignment spanning from Milne Port to the Mine Site and for the proposed infrastructure at Milne Port. The drilling program consists of two phases; the first phase was executed in Q4 of 2016; the second phase is currently being executed and is discussed in the following section.

Drilling supervision, field core logging and sampling was carried out by Hatch. Boart and Longyear Ltd. was selected as the drilling contractor. Hatch field personnel and the drilling contractor mobilized to site on September 28, 2016. The field investigation was completed on December 14, 2016.

A total of 113 boreholes were drilled ranging from a depth of 1.5 m to 30 m. There were 88 boreholes drilled at the proposed rail alignment, 12 boreholes drilled at the proposed rail bridge abutments, 5 boreholes drilled at proposed rail quarry locations and 15 boreholes at Milne Port.

These boreholes provide data regarding overburden depth, soil type, ground ice and type of bedrock. Approximately 590 samples were collected on site and shipped to the Hatch geotechnical laboratory in Niagara Falls for further analysis.

Due to access restrictions drilling was not completed in 2016 along the major rail alignment deviation from nominally tote road km60 to km78 or at the abutments for bridge 2.

Most quarry location boreholes were not drilled in the 2016 investigation due to weather constraints and challenges associated with location access. However:

- Representative samples of the Dolomitic limestone were recovered approximately 3 km east of the rail alignment at Km 58.
- A sample of the granitic gneiss was collected from the rail unloading area boreholes at the Milne Port.
- Diorite samples were collected from the surface near Km 103 during a site visit in September 2016.

Boreholes were drilled at Milne Port at locations of the proposed infrastructure (per the site layout at the time of drilling) including rail unloading, tanks, crusher, screening, tail pulley, reclaimer berm, reclaim tunnel and conveyors.

The data and findings from this investigation can be found in Appendix 7-9 and Appendix 7-10.

7.4.2.3 2017 Expansion Project Drilling Program

Further geotechnical drilling is currently being executed by Hatch and Boart Longyear including:

- Marine drilling program in the area of the proposed ore dock
- Boreholes along the major rail alignment deviation from nominally tote road km60 to km78
- Boreholes at the abutment locations for rail bridge 2
- Boreholes at specific locations of cut identified by the rail design and geotechnical teams.
- Ground penetrating radar investigations.

Field observations and results to date generally align with expectations.

7.4.3 Preliminary Geotechnical Recommendation for Railway Embankment

Requirements for constructing stable rail embankment along the proposed alignment were initially developed referencing previous field reports from early Tote Road investigations and were subsequently updated following a field inspection and air photo interpretation by Hatch in 2016 (refer to Appendix A7-17).

Recommendations for rail embankment by sub-grade type were established (refer to Appendix A7-18) jointly between the geotechnical and rail engineering teams including:

7.4.3.1 Railway Embankment-Section I – Cuts in Precambrian Rock

Figure *7-5* 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.
- Embankment Section 1 is recommended for the railway on bedrock in the Precambrian terrains.

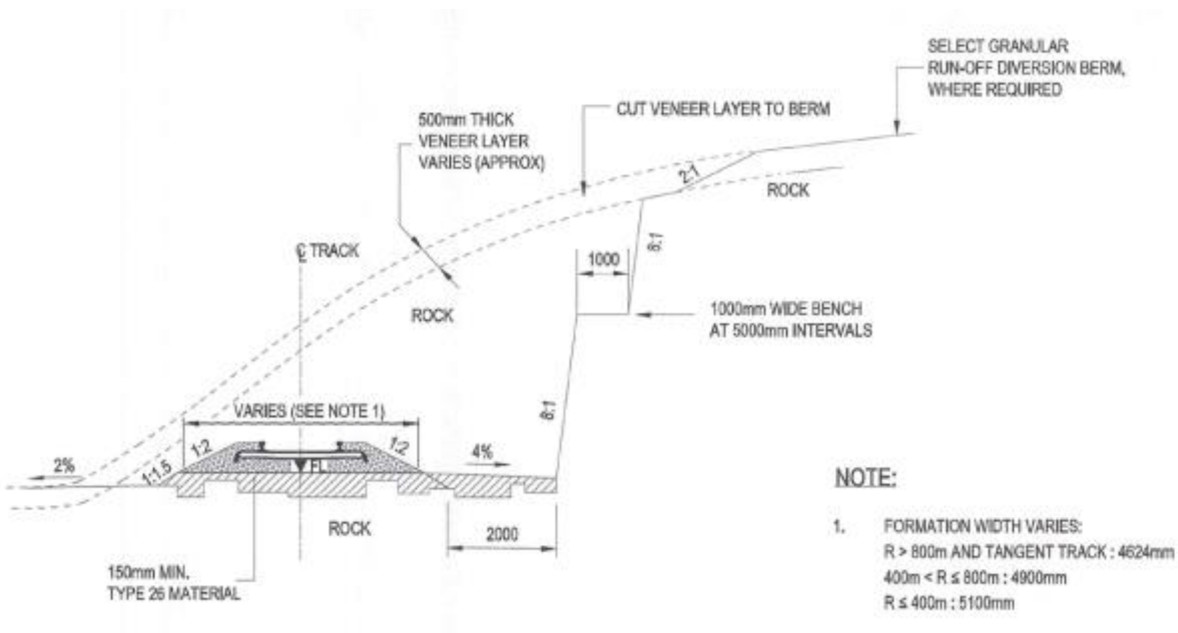

Figure 7-5: Typical Cross Section of Railway Embankment – Section I

7.4.3.2 *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 7-6, 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.

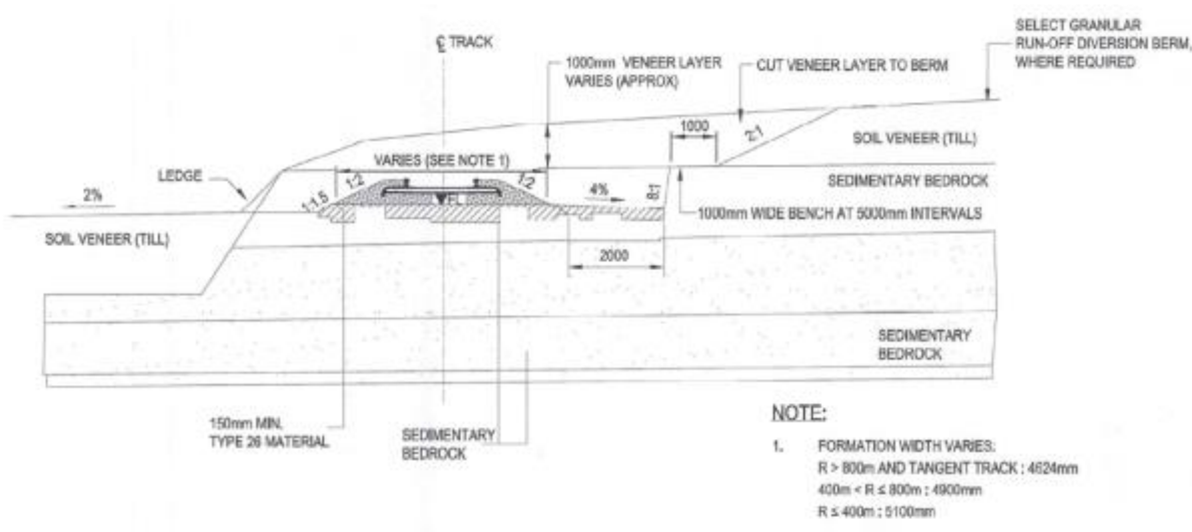

Figure 7-6: Typical Cross Section of Railway Embankment – Section II

7.4.3.3 *Railway Embankment Section III – Embankments on Permafrost Soil*

Section III is proposed for the railway on undisturbed (uncut) permafrost soil. As shown in Figure 7-7, 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.

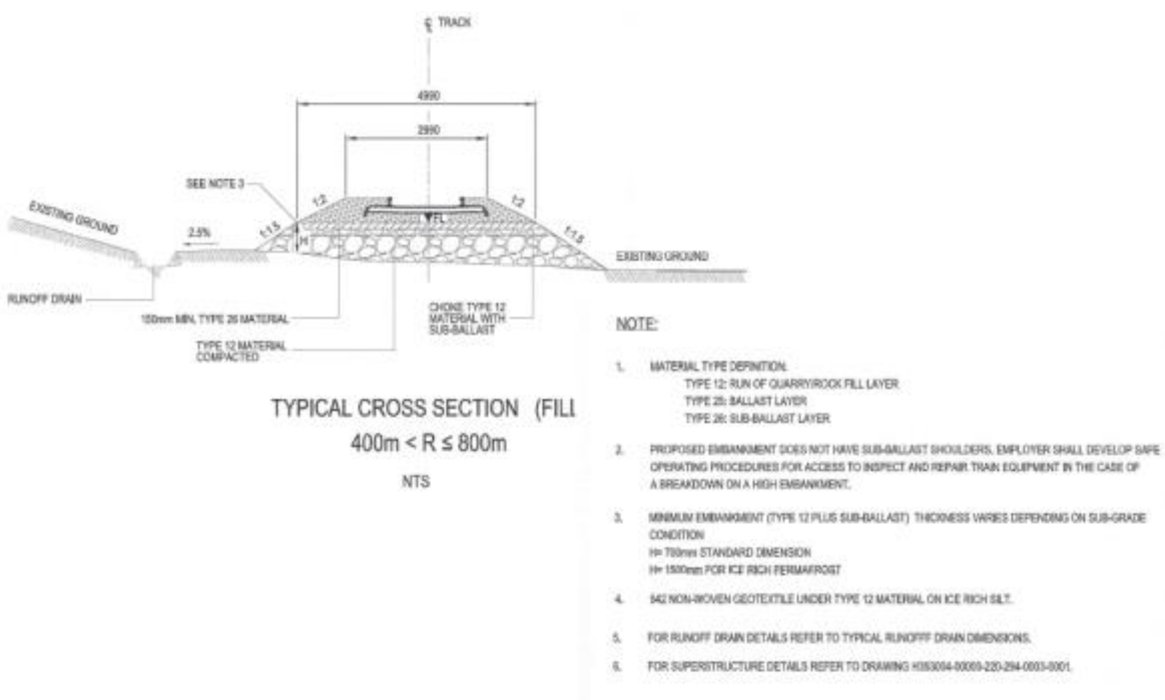

Figure 7-7: Typical Cross Section Railway Embankment on Soil – Section III

7.4.3.4 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 7-8. 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- woven geotextile (542 g/m^2) or 100mm thick rigid expanded polystyrene insulation board covered by non-woven geotextile (542 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.

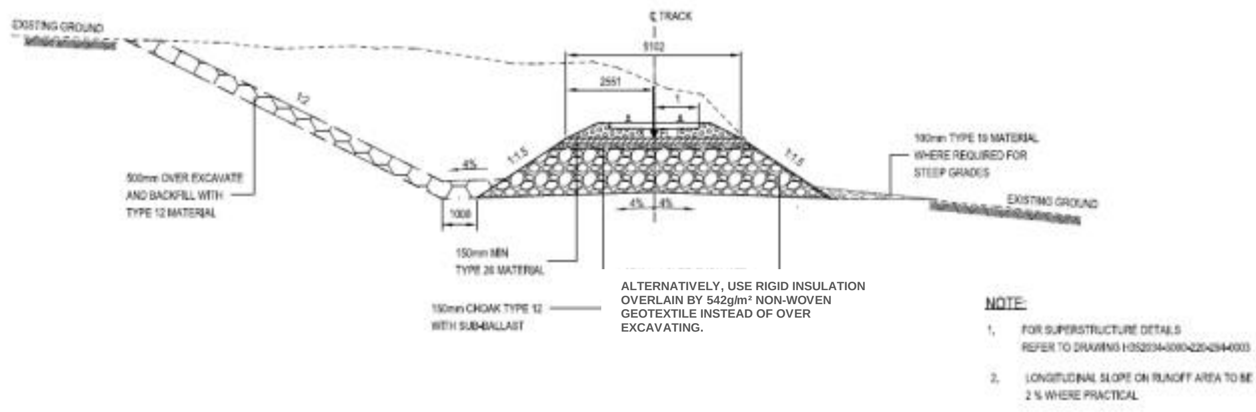

Figure 7-8: Typical Cross Section Railway Embankment in Soil Cut – Section IV

7.4.4 Preliminary Geotechnical Recommendation for Infrastructure

7.4.4.1 Overview

Geotechnical criteria for building foundations (refer Appendix A7-19) have been developed and preliminary geotechnical recommendations for different types of foundations of infrastructures at Milne Inlet, Mine Site and for the Railway Bridges have been provided (Refer Appendix A7-20).

Infrastructure foundations at Milne Port, the Mine Site and for the Rail Bridges are expected to be a combination of the following types depending on the specific requirements:

- Shallow foundation on rock.
- Shallow foundation on permafrost.
- Adfreeze pile.
- Rockfill Embankment with shallow foundation.

7.4.4.2 Shallow Footings

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.
- 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 7-9.
- Bearing capacity for rectangular footing: Figure **7-10**.
- Bearing capacity for strip footing: Figure **7-11**.

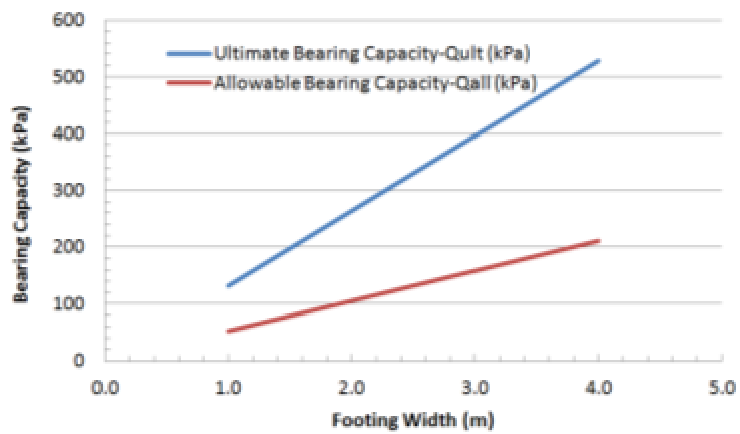

Figure 7-9: Bearing Capacity for Square Footing on 400 mm Granular Engineered Fill (L/B=1 with B=1 tm to 4 m)

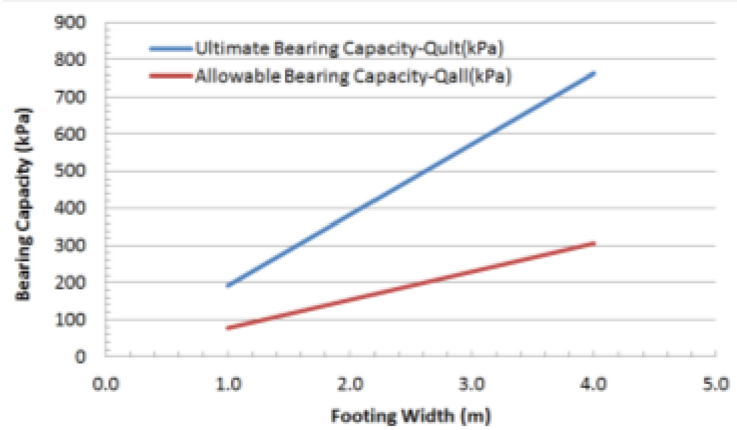

Figure 7-10: Bearing Capacity for Rectangular Footing on 400 mm Granular Engineered Fill (L/B=3 with B =1 m to 4 m)

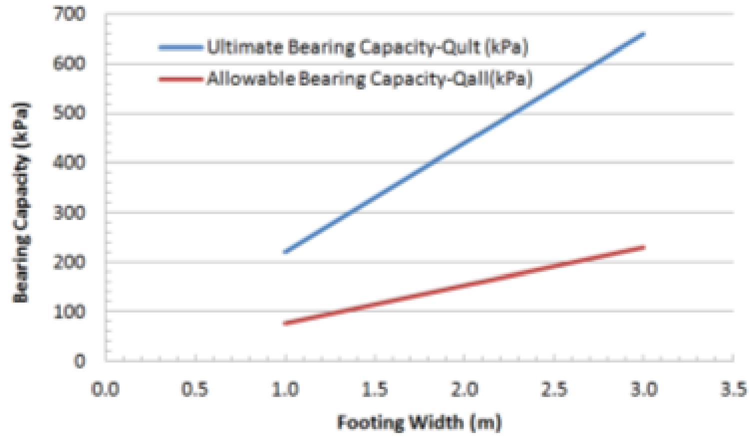

Figure 7-11: Bearing Capacity for Strip Footing on 400 mm Granular Engineered Fill (L/B>10 with B =1 m to 3 m)

Modulus of Subgrade Reaction was also investigated.

Considering the soil conditions at Milne Inlet sites, the modulus of subgrade reaction recommended by Knight Piesold (2007) are considered suitable Table 7-8 provides the modulus of subgrade reaction for foundations with different widths.

Table 7-8: 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

- Slab on Grade: The building slab at Milne port site will accept loads from mobile equipment and maintenance activities. A modulus of 30 MPa and 20 MPa should be utilised for the Mine Site and Milne Port site respectively.

7.4.4.3 *Thermal Insulation Design Consideration*

To minimize permafrost related settlement and foundation failure, the foundation strata and fill materials under footings shall be maintained in its permafrost state. Protection from heat transfer shall be included in the construction.

The engineered fill (granular pad) shall include sub-grade insulation 150mm thick below the footprint of all slab-on-grade and similar buildings. Sub-grade insulation shall be covered by 400mm of compacted engineered fill (granular pad)

Building foundations installed above grade (such as pre-cast concrete foundations blocks placed on grade) shall be installed without insulation. Excavated building foundations shall be constructed with 100mm thickness of rigid insulation below foundation, and floor slabs shall be constructed with 100mm thickness of rigid insulation directly under the concrete.

The type of insulation to be used (refer Appendix A7-21) is to consist of extruded polystyrene with the following properties:

- Compressive Strength: 414 kPa.
- Thickness: 51mm, 102mm, 150 mm.
- Size: 0.6 m by 2.4 m.
- Edges: shiplapped (square if shiplapped not available).

7.4.4.4 *Embankment Berm for Rail Stacker/Reclaimer Machine*

Embankment berms for stacker/reclaimer machine 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.

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.

7.4.4.5 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.

The pile capacity calculation has been 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).

7.5 Railway Track and Operation

The optimised 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. A Railway Design Criteria and Design Rational has been developed (refer appendix A7-22) and applies to the civil engineering and operational design of the railway system. It has been developed 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. No consideration has been made for passenger service.
- The operating speed for all trains, loaded or empty, will be 60km/h in both directions. The design speed will be 75 km/h. Operating speeds are unlikely to be adjusted upwards in the 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 design criteria and mitigating operating rules like speed restrictions will be proposed.
- The typical heavy haul Diesel Electric Locomotives (4400 HP) 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.

7.5.1 *Railway 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.

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 planned or emergency maintenance purposes on cars or locomotives. This consideration was made also due to climatic reasons in order to prevent the air pipe from freezing.

As part of the railway operations study, a rail operations static and dynamic model was defined (refer Appendix A7-23). Rolling stock fleet plan and train schedule options were developed to determine various aspects required for the export of a total of 12Mtpa iron ore. Hatch used various modelling tools for completion of the study; these include Rail Traffic Controller dynamic simulation software as well as static excel based tools developed in-house.

Table 7-9 summarizes of the findings and recommendations for the design criteria for Rail Operations.

Table 7-9: Operations

Item	Element	Design Criteria
1.	Ore Traffic	12 Mtpa (12.24 Mtpa – wet (2% moisture))
2.	Locomotive Axle Load	33 tonnes
3.	Car Axle Payload - Initially	30 tonnes
4.	Maximum Car Axle Load	32.5 tonnes
5.	Train Design Speed	75 km/h (for in train forces only)
6.	Operating Speed	60 km/h
7.	Locomotives per Train	2
8.	Cars per Train	72 up to 80
9.	Train Design Length (80)	900 m
12.	Gross Weight Loaded (72)	9750 tonnes
13.	Gross Weight Empty (72)	1974 tonnes
14.	Net Weight (72)	7776 tonnes
15.	Trainloads per day (72)	6 Loads/day

7.5.2 *Railway Alignment*

The design criteria for the rail alignment has been based on design criteria related to heavy haul railway operations and support infrastructure. The basic objective is to have the gradients as flat as possible and the radii as large as possible. To achieve these goals 3 deviations are required which take the railway outside the original lease area have been considered to divert around steep hills where the ice rich ground conditions and potentially deep excavations could not be avoided.

Table 7-10 below is summarizes the design criteria for the Railway Alignment.

Table 7-10: Railway Alignment

Item	Element	Design Criteria
	Horizontal Alignment	
1.	Minimum off-set from Tote Road	15 m
2.	Curve Radius Target	≥ 1000 m
3.	Curve Radius Minimum Target	500 m
4.	Curve Radius Absolute Minimum	230 m
5.	Transition Curves R > 300 m	80 m
6.	Transition Curves R ≤ 300 m	60 m
7.	Tangent Length between Reverse Curves	20 m
	Vertical Alignment	
1.	Vertical Curve rate of Change	0.040 m/20 m/20 m; K=100
2.	Ruling Gradient facing Loaded	1.5% (1:67)
3.	Ruling Gradient facing Empty	2.0% (1:50)
4.	Exceptional facing Empty < 775 m	3.0% (1:33)
5.	Allowed Facing Empty > 775; G>1% to follow	2.2% (1:45)
6.	Grade Compensation for G=1:X in Radius (R)	1: 20/((20/X)-(14/R)).
7.	Gradients in Passing Track	0 to 0.25%
8.	Exceptional facing Empty < 775 m	0 to 0.125%
9.	Allowed Facing Empty > 775; G>1% to follow	0 to 0.1%

7.5.3 Railway Earthworks

The earthworks design criteria for the Railway was developed from the geotechnical findings previously discussed in section 7.4 of this report. Table 7-11 below summarizes the earthworks design criteria for the Railway. Proposed construction details and shown on drawings H353004-00000-220-294-0004-0001, H353004-00000-220-294-0005-0001 and H353004-00000-220-294-0006-0001 (refer to Appendices A7-44, A7-45 and A7-46 respectively).

7.5.3.1 Elimination of the sub-ballast shoulder

The provision of a shoulder on the sub-ballast requires a wider substructure to be constructed with increase in the associated costs. Implementing this with the substructure (embankment) specified in the geotechnical requirements, an embankment constructed largely as rock fill on permafrost, requires significantly more fill.

A sub-ballast shoulder is typically constructed to provide a working area for track repair crews, a walkway alongside the train if it stops on the embankment and additional width to build-up the ballast height to locally level the track in case of embankment settlement. Elimination of the shoulder will require specific safe work procedures and operating plans to be developed and may result in increased track maintenance and repair costs, particularly if local settlement of the embankment occurs.

Following review of the options, a rail cross section which eliminates the shoulder was selected by BIM.

Typical cross-sections for main track, siding and yard tracks are shown in the sections below Figure 7-12(also refer to drawing H352034-3000-220-294-0003, Appendix A7-43).

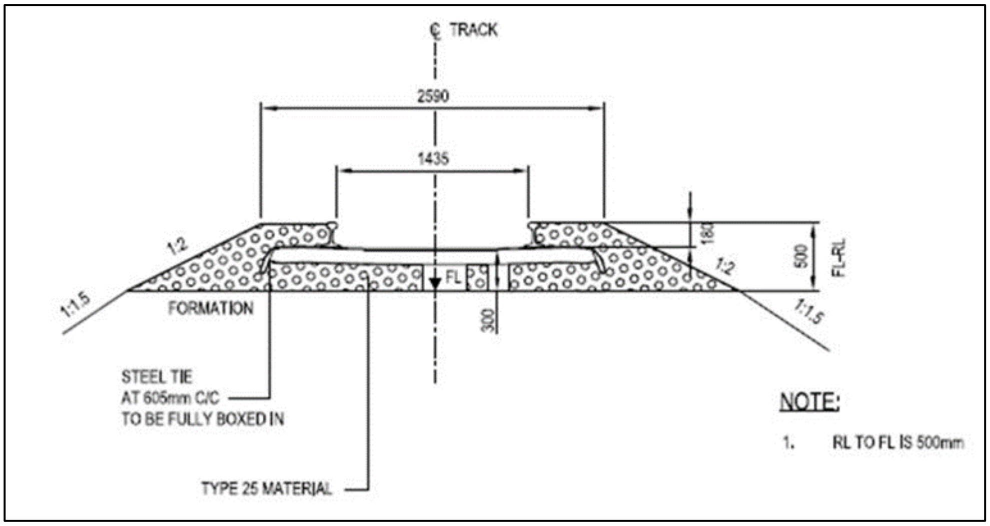

Figure 7-12: Typical Cross Section – Superstructure

The two aspects highlighted as cost reduction measures have been implemented on the project.

Table 7-11: Earthworks

Item	Element	Design Criteria
	Embankments	
1.	Typical Side Slopes	1V:1.5H
2.	Sub Ballast Layer 150 mm	Type 26 Crushed Rock
4.	2nd Layer 550 mm in Non-Susceptible & Potentially Susceptible to Ice soils, choked with Type 26	Type 12 run of quarry rock fill
5.	2nd Layer 1350mm in Moderately Susceptible & Highly Susceptible to Ice soils, choked with Type 26	Type 12 run of quarry rock fill
6.	Geotextile below 1350 mm layer	542 g/m² non-woven
	Sub-grade Cuttings	
1.	Cut side slopes in rock	1V:8H
2.	Cut side slopes ice rich soils	1V:2H (for pre feasibility)
3.	Layer Work, Geotextiles and Polystyrene Insulation	(Refer Section 6.2.2 Appendix A7-22)
4.	Grading Layer Works	(Refer Table 6-3 to 6-5 Appendix A7-22)
5.	Recovery of cut frozen ground for fills	Cut to spoil for STAGE 2 STUDY and investigate for Stage 3 Study

7.5.4 Railway Hydrology

The hydraulic characteristics were previously discussed in section 7.3 of this report. Table **7-12** below summarizes the hydrology design criteria for the Railway.

Table 7-12: Hydrology

Item	Element	Design Criteria
1.	Design Peak Flows	Extrapolated from Tote study
2.	Flood Return Period	100 years
3.	Design Flows	Q100: V = 3m/sec
4.	Hydraulic Sizing	Factored from Tote for STAGE 2 STUDY

7.5.5 Railway Bridge and Culvert Design

7.5.5.1 Rail Bridge Design Parameters

The design requirements for all bridges required along the length of the railway are as follows:

- Number of tracks = 1
- Number of service roads = 0
- Design life = 50 years

A design criteria has been developed for the Rail Bridge (refer Appendix A7-24) to guide the design of the required rail bridges. It outlines the requirements for the rail bridge with regards to the following:

- Bridge Types
- Bridge Deck Types
- Bridge Modularisation
- Bridge Geometry
- Loading of Rail Bridge Structures
- Loading Combinations

The bridge design includes the design of both the bridge superstructure and substructure.

Requirements for the bridge superstructure design have been established (refer Appendix A7-25) and outlines the requirements for the bridge superstructure with regards to the following:

- Steel Spans
- Precast Concrete Spans
- Ballast Deck Structure
- Bearings
- Drainage
- Walkways

- Access for Inspection and Maintenance

Requirements for the bridge substructure design have also been established (refer to Appendix 7-26) and outlines the requirements for the bridge substructure with regards to the following:

- Foundations
- Abutments and Piers
- Steel Towers at Piers
- Handrails and Walkways
- Access for Inspection and Maintenance

7.5.5.2 Culvert Design Parameters

In general, the major culvert structures design shall consider the following:

- Prevention of water accumulation on the sides of embankments.
- Diversion of water and ice away from the toe of the embankment.
- Provide cut-off drains or berms for dispersed flow and accumulate through appropriate culvert.
- Provide appropriate embankment protection where required.
- Provide appropriate inlet and outlet protection and treatment.
- 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 >5m/s.
- Provide oversized culvert with weirs, cut-off collars both ends and natural stones inside culverts where water velocity<5, but >4m/s.
- Provide wing walls both ends where water velocity is <4, but >3m/s.
- Provide basic inlet and outlet protection where water flow velocity is subcritical (<3m/s).

Standard culvert details based on the project criteria and hydrology requirements are shown on drawings H353004-00000-220-294-0001-0001 and H353004-00000-220-294-0002-0001 (refer to Appendices A7-41 and A7-42).

An open for an open base concrete culvert was also developed and is shown in drawing H353004-00000-220-294-0007-0001 (refer to Appendices A7-47). This option was developed to potentially reduce costs associated with crossing at fish habitat locations where a gravel stream bed is required (in lieu of partial fill inside pipe culvert).

7.5.6 Railway Track

The railway track selection for the railway 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.

Table 7-13 and Table 7-14 below provide a summary of the design criteria for the railway track.

Table 7-13: Track

Item	Element	Design Criteria
Track Superstructure – Rail		
1.	Mainline, sidings and yards	136 RE or UIC68 equivalent
2.	Mainline Joints	Welded
3.	Yard & Siding Joints	Jointed and Welded
4.	Mainline Ties	Steel H-12
5.	Yard & Siding Ties	Steel H-12
6.	Mainline Tie Spacing	605 mm
7.	Yard & Siding Tie Spacing	605 mm
8.	Curves < R400m Tie Spacing	550 mm
9.	Mainline, sidings and yards Fastenings	Pandrol “e”-clips
10.	Mainline Turnouts	AREMA No. 9 or UIC
11.	Yard Turnouts	AREMA No. 9 or UIC
Ballast		
1.	Ballast Shoulder General	300 mm
2.	Ballast Shoulder on outside of Curves < 350m	600 mm if LWR
3.	Ballast Volume	1600 m^3/km
4.	Sub Ballast Depth	150 mm
5.	Ballast cover between Sub Ballast & Tie	300 mm
6.	Ballast +Tie Height	312 mm
7.	Ballast Shoulder Slope	1:2
8.	Ballast Grading & Properties	Refer Table 9-1 and 9-2 Appendix A7-22

Table 7-14: Yards and Sidings

Item	Element	Design Criteria
Milne Tippler Yard		
1.	Loading Lines	Part of Mainline km's
2.	Departure Loop	900 m
3.	Loco Run-around Loop	347 m
4.	Loco Workshop Spur	390 m
5.	Car Workshop Spur	215 m
6.	Bad Order Car Spur	205 m
7.	Good Order Car Spur	160 m
8.	Quarry Spur and Y	400 m
9.	Cross Over	120 m
Passing Loop (km's 56.017 to 57.490)		
1.	Siding	900 m
2.	Back Track	350 m
Mary River Mine Yard		
1.	Loading Line right through to Stop Block	Part of Mainline km's
2.	Departure Siding	900 m

7.5.6.1 Use of steel ties instead of timber ties.

Installing steel ties represents a capital cost saving of approximately $22M compared to an equivalent timber tie structure (combined saving on track superstructure and substructure). The use of steel ties in cold climate heavy haul operations has not been proven and their use was rejected in previous studies due to concern about brittle facture and longevity of the ties in extreme cold conditions.

As a partial mitigation of the risk associated with using steel ties, a revised timber tie track structure was developed which, includes a steeper ballast side slope angle and results in a footprint only slightly wider than that required for steel ties. The recommendation is to construct the sub-ballast marginally wider than what would be required for a steel tie sub-structure, this allows future installation of timber ties if required.

Following review of the options, installation of steel ties with sub-ballast constructed to allow future replacement with timber was selected by BIM. For details (refer Appendix A7-27) to project memo - Rail Tie Type Trade-off for Extreme Cold Weather Heavy Haul Operations.

7.5.7 Rolling Stock

7.5.7.1 Locomotives

The locomotives will be diesel-electric locomotives in order to 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.

The locomotives are to be standard gauge configuration in order to run on 1435 mm gauge. They are to be equipped with dynamic braking capability as well as distributed power 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 an airbrake braking system.

7.5.7.2 Cars

The ore cars will 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 one side of the car and cars at the end of the train coupling to the locomotive will have couplers on both ends. This will enable the off-loading of a single car per cycle through the single cell rotary tippler.

Table 7-15 below provides a tabular summary of the Rolling Stock design criteria.

Table 7-15: Rolling Stock

Item	Element	Design Criteria
	Locomotives	
1.	Fleet Size	4+1 for exchange
2.	Locomotive Type	Diesel Electric
3.	Traction	AC Traction Motors
4.	Horsepower	4,400 Hp
5.	Special Specifications	Extreme Cold Weather
6.	Wheel Arrangment	Co-Co (two six-wheeled bogies with all axles powered, separate motor per axle)
7.	Minimum Axle load	32 tonnes/axle
8.	Maximum Axle load	32.5 tonnes/axle
9.	Maximum Length	23 m
10.	Vehicle Gauge	“Plate C” AAR S-2028 or latest AREMA Approved
11.	Loco Wheel track Gauge	Standard 1,435 mm
	Ore Cars	
1.	Fleet Size	152
2.	Car Tare Weight	22 tonnes
3.	Maximum Payload @ 32.5 t/axle	108 tonnes
4.	Coupler to Coupler Length	10.5 m (10.65m incl. Stretch)
5.	Car Width	3.2 m
6.	Maximum Car Height	7.01 m from top of rail

7.5.8 Rolling Stock Facilities

7.5.8.1 Diesel-Electric Locomotive Depot

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 which have been planned to be modular prefabricated units.

7.5.8.2 Main Workshop Facility for Diesel-Electric Locomotives

The facility must provide for minor and major repairs which must include for A, B and C shedding that will include the following activities:

- Unscheduled repairs.
- Scheduled repairs.
- Unscheduled maintenance.
- Component exchange.
- Wheel cutting.
- Minor engine repairs.
- Fueling.
- Sanding.
- Attend to driver trip report faults.
- Oil top-up on sub-systems.
- Electronic cards/modules exchange.
- Toilet servicing.

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. An extension of the locomotive workshop line is provided for on the outside of the shed to allow temporary storage space for a locomotive awaiting parts or further work.

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.

One overhead crane with a capacity of 15 tonnes must be provided to traverse both the locomotive and car workshop areas 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.

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.

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.

The locomotive maintenance facility must be able to maintain the dedicated locomotive fleet of 5 mainline diesel-electric locomotives and one shunt mobile.

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.

Office provision must also be made to accommodate the required staff levels at the depot and must link to the main shed structure.

The locomotive daily servicing and provisioning will take place on the departure siding by means of mobile fueling, sanding and maintenance equipment.

7.5.8.3 Main Workshop Facility for Iron Ore Cars

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. Designs of the car maintenance workshop have been scaled down to accommodate two ore cars per cycle in the workshop. An extension of the car workshop line outside the workshop has been provided for cars that await spares or further work.

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.
- 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 152 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.

7.5.8.4 Rolling Stock Maintenance Facility Stores and Offices

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.

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.

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.

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.

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 spate gas and cleaning agent store must be provided and these are all situated outside the main building, approximately 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.

7.5.9 Wayside Conditioning Monitoring System

The extreme characteristics associated with the Baffinland export rail corridor indicate that the provision of defect detection systems will be of significant benefit. The key characteristics identified are heavy loaded trains, relatively steep and extended gradients, extremely cold conditions and alignment through remote areas. Design criteria has been established (Refer Appendix A7-28) with regards to defect detection systems.

The defect detection systems are limited to fixed track side systems employed to primarily reduce the operational risks associated with a heavy haul operation in extreme conditions, through selective measurements and the generation of early warning alarms. The secondary use of the alarms and the data is for the enhancement of availability and reliability of rolling stock and rail infrastructure.

A typical train defect detection site will consist of; equipment apparatus room, power supply to apparatus room, a car identification tagging system, a communication link to the train control centre, and defect detection system.

Defect detection systems include:

- Wagon Identification system.
- Systems targeting wheels.
- Systems targeting axles/bearing.
- Systems targeting wagons.
- Wayside communications.

7.5.10 Train Control System

The train control system for the 110 km single track railway line will be based on Canadian Rail Operating Rules and will not have line side signals nor track circuits. Functional requirements have been developed (refer appendix A7-29) and are detailed below. The train movements are to be controlled by rail traffic controllers using an Occupancy Control System (OCS) as outlined in the Canadian Rail Operating Rules (CROR) of July 27, 2015.

The OCS rules that are of specific relevance to this form of rail traffic control are set out in subsections 301 to 3015 of the CROR. The infrastructure and systems to be designed and installed will facilitate this form of railway operation.

The system may consist of a control office located in the Milne Port area and all related telecommunications and train operational infrastructure needed to operate the required train service between the Milne Port Facility and the Mine Site Facility.

The mainline turnouts at the Milne Port, the mid-section passing loop and the departure loop at the Mine Side Facility shall be electrically driven and switched. Six switches located on the mainline shall be automated and machine driven for remote switches purposes by the locomotive driver. These switches are to have the ability to confirm to the locomotive driver, ahead of traversing the switch, the switch position. The remaining turnouts shall be hand operated sets.

The lie of any of the hand operated turnouts needed for a planned train movement is to be set and confirmed correct by local operating staff, ahead of the planned train movements being authorized over these turnouts. The train crew will be able to operate these hand operated turnouts in the absence of local operating staff.

It is proposed that hand operated derailing devices be provided at the ends of the back road that takes off from the mid-section passing loop and at the spur takeoff from the passing loop at the mine siding facility, to protect the mainline from the possible runaway of any unattended wagons staged on the back road and/or spur line.

The train control system, any other related equipment, train personnel and operational staff must be able to function in the extreme climatic conditions that occur in this corridor, namely, extended periods of darkness, intense storms with heavy snow falls, potentially strong winds, the occurrence of permafrost and periodically constrained access.

7.5.11 Road Crossings

Road and rail crossings are designs with visible waring systems only. This comprises of the relevant road and rail side signage as required by Transport Canada regulations. Due to the future decrease in the number of road vehicle trips the published regulations do not require any form of advance warning system to be installed i.e. flashing lights or gates.

7.6 Ore Dock

7.6.1 Ore Dock Elements

The ore dock shall have all necessary access and space required for the operation of the berth. All items necessary for the operation of the marine facilities and as required by the shiploader design shall be accommodated by the Ore Dock.

7.6.1.1 *Vertical Quay and Dock Area*

The main berth face will consist of structure(s) that act as combined breasting and shiploader support platform. These structure(s) will accommodate fenders to absorb the energy of the berthing vessel, provide contact points for the moored vessel and mooring line points as required.

The main berth face will be equipped with a removable fender system which will provide an impact surface against which the vessel will make contact. The fender will absorb the impact energy so as to protect the vessel and the berth.

Mooring equipment will consist of bollards (or equivalent) spaced along the main berth face so as to facilitate the spring lines for the range of design vessels.

Removable ladder(s) will be provided on the main berth face as required, extending to three (3) rungs below the lowest low water level as a minimum.

7.6.1.2 *Access Causeway*

A causeway shall be constructed to support the conveyor system and provide access for pedestrians and service vehicles from the shore to the ore dock. Access for mechanical, conveyor and electrical systems will also be provided to the ore dock.

Double lane access to the ore dock will accommodate the following vehicles:

- All terrain loader for conveyor cleanup and snow removal.
- Pickup truck.
- Fire truck.
- Maintenance Boom Truck.
- Revetment maintenance vehicle – accessible to repair armour stone on both sides of the causeway.
- Mobile crane for ongoing maintenance.
- Mobile Crane.
- Manitowoc 2250 with MAX-ER attachment (and additional counterweight, rated to 300t capacity).

7.6.1.3 *Berthing and Mooring Infrastructure*

The berthing and mooring infrastructure shall as a minimum include the following items:

- Fender assembly, complete with chains.
- Mooring assembly (Bollards / Quick Release Hooks).
- Motorized capstans.
- Walkway / stairway supports.

- Handrails.
- Adequate working and access space.
- Edge protection to prevent abrasion by mooring lines.
- Messenger rope reels.

7.6.1.4 Walkways and Quay Infrastructure

Clear pedestrian access to the walkway, stairways and ladders giving access to mooring infrastructure and the gangway shall be provided.

Walkways shall provide pedestrian access linking together all the berthing and mooring infrastructure to the quay area and shall also permit access for small-wheeled trolleys.

The walkways shall be designed for carrying the mooring lines from the vessels to the mooring assemblies and the grating level within the walkway shall not exceed a slope of 1 in 10 and there shall be no steps between walkway terminations and the connecting structures. The minimum clear width of walkways shall be 1.4m.

The structural form shall ensure that no obstructions are present on the seaward side of the walkway at a height greater than 1.2m above grating level to enable easy handing of lines. All members along the uppermost limit of the structure shall be rounded so as not to chafe or abrade lines being passed along. Ends of handrails shall be detailed so that mooring lines cannot catch on the handrail.

7.6.1.5 Access Tower / Gangway

Access Tower / Gangway are to be provided on the quay to allow boarding of personnel. The access tower / gangway design needs to take into consideration the range of design vessel sizes. The access towers / gangways and its components shall comply with national manned elevator codes, lifting appliance codes and shall meet all national working at heights requirements where applicable.

The location of the gangway shall be designed for safe access from the design vessels to the quay areas and should be located at a safe distance from any carrier mooring line or any equipment. The position shall be optimised from the "Spotting Line" with regard to the vessels to use the berthing facilities. The end steps from the gangway (i.e. on board the carrier) shall ensure safe step-down at all times on to the carrier’s main deck.

If self-levelling steps are not to be used, the maximum safe gradient of the gangway is taken as 35 degrees, unless the local authorities use a smaller angle.

7.6.2 Site Data

7.6.2.1 Bathymetry

Three sets of bathymetric data are available for Milne Inlet.

- Terra Remote Sensing Inc. (TRSI), September 15-16, 2008.

- Logistec Stevedoring, 2010.
- Monteith and Sutherland, September 9, 2011.

7.6.2.1.1 Terra Remote Sensing

The TRSI crew at Milne Inlet located a survey control pin and transferred it to a temporary marker near the waterline. The survey vessel was mobilized with the multibeam; single beam and side scan sonar systems. All bathymetric and side scan sonar survey operations were then conducted.

7.6.2.1.2 Logistec Stevedoring

Details of the survey are as follows:

- The depth was obtained with the help of an echo sounder "ODOM HYDROTRAC" with a 0.05 meter precision and was adjusted at a fix depth with a steel plate.
- The positions of the depth and the water level was obtained with a DGPS "Leica SR530" system used with the differential mode and real time (RT-K) giving a 0.02 meter precision.

7.6.2.1.3 Monteith and Sutherland

The hydrographic survey data was recorded and georeferenced to the NAD83 UTM mapping system. Water levels related to the CGVD28 datum were measured at each survey site throughout the course of each survey. The measured water levels were reduced to Chart Datum by applying the separation between CGVD28 and Chart Datum. The resulting water levels were used to reduce the soundings to Chart Datum.

7.6.2.2 Marine Conditions

Marine conditions to be considered during the design of the Ore Dock have been previously discussed in section 7.1.5 of this report.

7.6.2.3 Marine Geophysical Study

Refer to Appendix A7-48 for details of geophysical surveys conducted in the region of Mary River Dock #1.

7.6.3 Ore Dock Functional Requirements

The ore dock will serve two primary functional objectives which consist of the following:

- Provide a safe, efficient and secure deep-water berth for a range of design vessels including Panamax and Cape Size bulk ore carriers.
- Provide a means of support for the shiploaders, conveyors and associated mechanical equipment used for loading the vessel.

The design of the Ore Dock is guided by the Ore Dock Functional Specification (refer appendix A7-30) which includes the following:

7.6.3.1 *Operational and Survival Conditions*

The ore dock shall be design to withstand the following operational and survival conditions.

- **Survival:** The ore dock and associated revetments shall be designed to resist an extreme storm event with a return period of 50 years.
- **Operational Shut Down:** Extreme limiting environmental conditions during which the ore send out may be shut down and shiploaders retracted, but with the Capesize Vessel remaining moored to the ore dock. When forecast environmental conditions exceed the Capesize Vessel extreme limiting environmental conditions the Capesize Vessel will sail away and seek shelter. These limiting condition shall be determined by the Design Build Contractor (CG001 – Ore Dock).
- **Installation:** The 10 year return period storm conditions are the design limit for transportation, towing and other marine installation activities.

7.6.3.2 *Annual Operational Periods*

The ore dock will be used to load vessels from during the open water season, which is nominally expected from July 25th to October 15th of each calendar year. Consideration will be given to the possibility that BIM may consider operating beyond the open water season in the future, however this does not constitute a functional requirement.

7.6.3.3 *Ore Dock and Shiploading*

Design operating windows for ore ship loading and expected number of ships to be loaded at Milne Port is summarized in Table 7-16

Table 7-16: Ship Loading Operations Summary

Period	Dates	Ship Type	Ships Loaded Dock #1	Ships Loaded Dock #2
Early Season	Jul 25 – Aug 14	Ice Class	14x Supramax	24x Panamax
Mid-Season	Aug 15 – Sep 20	Non-ice class	22x Panamax	28x Cape Size
Late Season	Sep 21 – Oct 15	Ice Class	8x Supramax*	24x Panamax

7.6.3.4 *Arctic Shipping*

Navigation in coastal waters within Canadian jurisdiction north of latitude 60°N (which includes all shipping access to the Mary River project) is governed by the Arctic Shipping Pollution Prevention Regulations (ASPPR).

Under Canadian legislation ships may enter these waters:

- In accordance with the Zone/Date System (Z/DS) which stipulates opening and closing dates based on Type of ship (ice classification) for each of the zones into which Canadian Arctic waster are divided; or
- In accordance with the Arctic Ice Regime Shipping Systems (AIRSS). AIRSS was introduced as a more flexible system that uses the actual ice conditions to determine whether entry is allowed in an ice regime.

AIRSS provides flexibility in operations, however for general planning purposes the entry and exit dates listed in the Z/DS are recommended by Transport Canada. Entry and exit dates for Zone 13, in which Milne Inlet and Eclipse Sound are located, are listed in the Table 7-17.

Table 7-17: Permissible Vessel Entry/Exit Dates for Milne Inlet and Eclipse Sound

		Equivalent International Ship Classifications				Milne Port Entry/Exit Dates	
Canadian ASPPR Category	Equiv. Polar Class[1]	ABS Ice Strength-ening Class (A1 AMS)	Bureau Veritas Ice Class (1 3/3 E)	Det Norske Veritas Ice Class (1 A 1 ICE)	Lloyd's Register Ice Class (100 A1 LMC)	Z/DS Zone 13 Stipulated Dates	Pre Feasibility Study Basis - Dates Based on Z/DS and BIM Experience
Arctic Class 6+	PC1-2	-	-	-	-	All Year	Polar Class Vessels[4]
Arctic Class 4	PC3-4-5 operating under AIRSS[2]	-	-	-	-	Jun1-Feb15	
Arctic Class 3		-	-	-	-	Jun10-Dec31	
Arctic Class 2		-	-	-	-	Jun25-Nov22	
Arctic Class 1A		-	-	-	-	Jul15-Oct31	
Arctic Class 1		-	-	-	-	Jul15-Oct15	
Type A	PC6[3]	AA or 1A	1A Super	A or 1A	1A Super	Jun25-Oct22	Ice Class Vessels Jul 25 – Oct 15
Type B	PC7[3]	A or 1A	1A	A or 1A	1A	Jul15-Oct15	
Type C	n/a	B or 1B	1B	B or 1B	1B	Jul15-Oct10	
Type D	n/a	C or 1C	1C	C or 1C	1C	Jul30-Sep30	
Type E	n/a	n/r	n/r	n/r	n/r	Aug15-Sep20	No Ice Classification Aug 15 – Sep 20

[1] General equivalence only, refer to Transport Canada regulations for details;

[2] Specific access dates for PC3, PC4 and PC5 vessels are not defined in the regulations and have not been assessed;

[3] As an interim measure for navigation purposes, Transport Canada considers that PC 6 and 7 vessels are allowed to operate as Type A and B vessels respectively;

[4] Operation of polar class vessel constrained by permitting limits.

7.6.3.5 Design Life

The following design life is to be considered for the different components of the Ore Dock facility:

- 20 years for Ore Dock (including causeway).

The ore dock must have sufficient durability to provide the minimum specified lifespan with respect to corrosion, ice abrasion and loading.

Where this requirement cannot be reasonably met with certain vulnerable components, the design will be such as to permit ready replacement of such components (for example, fenders, ladders and any hardware components that are attached in the ice zone).

A regular inspection and maintenance program should be implemented to repair damage and deterioration as required.

7.6.3.6 *Design Vessels*

The ore dock will accommodate a range of design vessels from Panamax to Cape Size. Design vessel parameters for the new ore dock, Panamax and Cape Size are listed in Table 7-18 (refer to drawing H353004-00000-220-272-0019)

Table 7-18: Ore Dock Design Vessel Parameters

Description	Panamax	Cape Size
Tonnage (DWT)	74,000	230,000
Length Overall, LOA, m	225.0	316.0
Beam, B, m	32.5	50.0
Moulded Depth (m)	18.9	27.0
Fully Laden Draft, m	13.9	18.4 (Max 19.0)
Ballast Draft, m	7.5	9.9
Number of Hatches	7	9
Box Length, m	180	240
Box width, m	18.0	25.0

7.6.3.7 *Berth Location*

The berth location has been selected, based on the local bathymetry, to provide the minimum depth of marine structures while still providing adequate water depth at the berth face without dredging. Furthermore, the berth location has been selected to maintain a safe distance between the existing and new berth, by allowing adequate separation during berthing and avoiding the crossing of mooring lines. The orientation of the causeway has been selected to accommodate the orientation of the reclaim conveyor feeding the shiploaders. The centres point of the fenderline and causeway are located along coordinates as defined in the layout drawings listed in H353004-CG001-200-026-0002, Drawing Index. These coordinates shall be maintained for the Design-Build solutions.

7.6.3.8 *Water Depth*

An underkeel clearance of 10% of the largest vessel’s fully laden draft will be provided at the berth. The berth shall be been oriented parallel to the natural bathymetry.

Table 7-19: Minimum Water Depth

Description	Value
Maximum Design Draft	19.0 m
10% Underkeel Clearance	1.90 m
Total Depth Required	20.9 m

7.6.3.9 *Vessel Berthing Orientation*

The ore dock structure shall be arranged according to recommended principles used in the industry such as PIANC and British Standard 6349.

Vessels will predominantly berth against the ore dock on their starboard side in the open water season (summer). Alternatively vessels may berth on their port side if this is preferred by the pilots due to wind, wave, current, or ice conditions.

7.6.3.10 Navigation Criteria and Constraints

The navigational design requirements of the ore dock shall be limited to the safe and efficient berthing and de-berthing operations. The requirements generally include:

- Quay layouts.
- Mooring and Berthing Infrastructure.

The design requirements relating to the safe and efficient navigation of vessels to and from berths is excluded from the scope of this contract. The requirements generally include:

- Tug requirements and procedures.
- Anchorage.
- Aids to navigation.
- Protection zones.
- Pilot procedures.

7.6.3.11 Design Water Level

The design water level shall be calculated based on three components, namely tidal levels, surge and sea level rise. This elevation will be used for the definition of the ore dock and causeway elevations.

7.6.3.12 Deck Elevation

The deck level of the facility shall be determined based on extreme water level analysis. The average elevation of the ore dock has been set at the same level as the existing ore dock, namely: +5.3 m CD. However, the adequacy of the deck level to protect the ore dock from ice build-up and extreme storm events shall be the responsibility of the Design Build Contractor (CG001 – Ore Dock). With provision of suitable protection measures for ice build up a lower dock elevation may be selected during detailed design work, subject to award of the design build contract for the dock.

7.6.3.13 Drainage

Containment areas shall be provided around equipment especially hydraulic pumps that may give rise to contaminated liquid on the quay area. These containment areas shall be drained to individual blind sumps to permit manual removal of contaminated run-off or wash-down water during normal quay maintenance. All other areas shall be drained directly to the sea.

7.6.3.14 Site Grading

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.

Site grading shall produce a useable and easily maintainable ground surface, not subject to flooding or erosion. The rough grades and finish grades shall ensure that the final road and site grades provide suitable pedestrian and vehicular access to buildings and facilitate adequate drainage of the site.

7.6.3.15 Scour and Slope Protection

Scour protection will be provided as required at the base of the marine structures. Both propellers and bow/stern thrusters shall be considered as appropriate for the design vessels.

Slope protection along the foreshore will be designed to resist appropriate environmental conditions, with some maintenance to be required. The slope protection will be developed using the following consideration:

- Slopes to be between 1: 1.5 (V:H) and 1:2 (V:H).
- Rock armour layers will be designed for both wave and ice action criterion, ensuring that less than 5% of armour rocks are displaced for the design wave condition as well as ice action. Minor maintenance may be required from time to time.
- Causeway toe berm will be designed for an "Intermediate Damage" criterion assuming that the reshaped section will require repair/maintenance after design wave action.

All scour & slope protection work shall be done in accordance with the relevant standards and comply to the following:

- Fine grade area to be armoured to uniform, even surface. Fill depressions with suitable material and compact to provide firm bed.

7.7 Production Systems

7.7.1 Mining

Mining heavy mobile equipment required to implement the Expansion Project was carried across from the Stage 2 Study mine planning work. No further analysis of the requirements was completed.

7.7.2 Bulk Materials Handling and Processing

The purpose of the bulk materials handling and processing system is to produce and load onto ships 12 Mtpa of lump ore and fine ore product, including:

- Receive run of mine (ROM) ore (delivered by mine haul truck), process to Primary Crushed Ore and load the ore into rail cars at the Mine Site.
- Receive primary crushed ore from the rail system, unload, crush and screen the ore to produce lump and fines product, and stockpile at Milne Port

- Load all lump ore product at Ore Dock No 2 (new) onto Panamax and Cape Size ships during the prescribed loading season.
- Load all fine ore product at Ore Dock No 1 (existing) onto Supramax and Panamax ships during the prescribed loading season.

The following systems and facilities have been included in the project scope to achieve the required production:

- Primary Crushing System (including rail loading)
- Rail Unloading System
- Crushing and Screening System
- Lump Stockpile System
- Fines Stockpile System (existing stockpile and reclaim system modified)
- Ship Loading System (ore dock No 2)

The overall process is summarized in Figure 7-13 below.

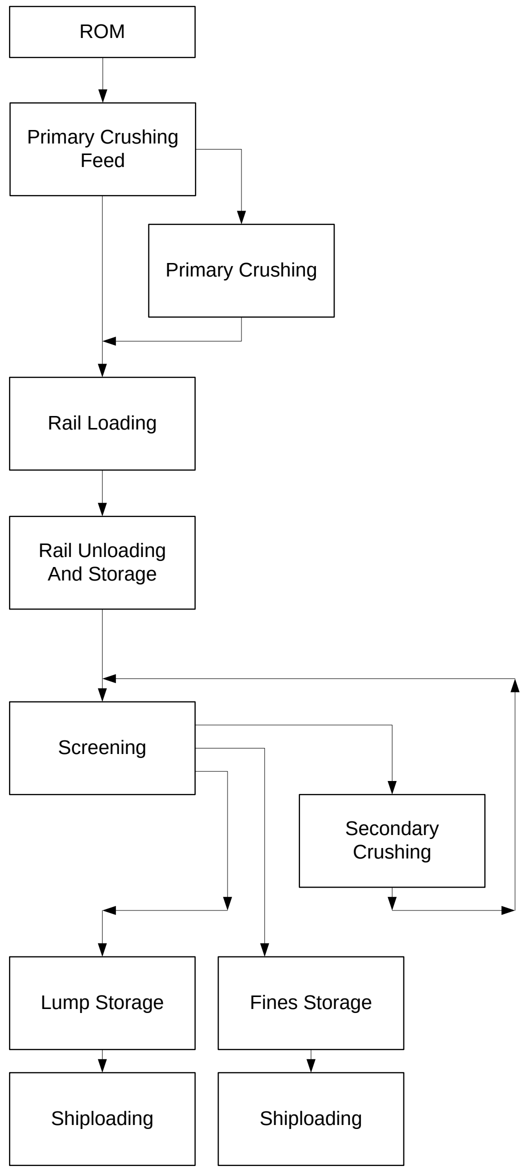

Figure 7-13: Process Block Flow Diagram

Process design development associated with the bulk materials handling systems is discussed in Section 6 – Process Definition. Engineering design of these systems for the Definitive Study was incorporated into design-build contracts PM007 Primary Crusher Upgrade and CM001 Bulk Materials Handling and Processing.

7.7.2.1 Primary Crusher System

Process assessment and preliminary design was carried out by Masaba (original equipment manufacturer of the existing mobile crushing equipment which is planned to be partially re-used for the new primary crusher system) based on ROM sizing and Primary Crushed Ore size requirements defined by Hatch.

7.7.2.2 Port Bulk Materials Handling and Processing

A comprehensive functional specification was developed and issued for bid during the Study. The specification defined the parameters for the systems at Milne Port with particular detail with regard to interfaces at Rail Unloading and Ship Loading. Proposed system design was developed by the bidders and documented in their proposals.

7.7.3 Production Mobile Equipment

Mobile equipment is required to support production at:

- Primary Crusher area to feed the primary crushers, manage the rail loading stockpile, and to load trains.
- Handling fine ore product at the Port including reclaim from the intermediate fines stockpile, transport to Stockpile No 1 (modified existing stockpile), stacking at Stockpile No 1, and reclaim for feeding ore to Ship Loader No 1.
- General stockpile management at the Port.

Mobile equipment requirements for new and significantly modified activities were assessed during the study and the equipment previously identified during the Stage 2 study were validated.

Equipment required to feed Ship Loader No 1 was assumed to be existing as there is no change to the existing operation.

7.8 Utilities and Support Infrastructure

7.8.1 Camps and Accommodation

Operations accommodation requirements were defined and incorporated into the future camp sizing.

Construction accommodation requirements were assessed during the study based on a combination of estimates by the Hatch construction management team and specific details provided by Contractor with their bids.

7.8.2 Power Generation

Each of the two principal permanent sites will have a dedicated power plant comprising reciprocal diesel engine units for primary power generation (refer Appendix 7-33 for design philosophy). Each power plant will have installed spare capacity, serving as a redundancy to ensure continuous operation during an outage of a duty generator.

Optimization of the power generation for the Expansion Project is based on the following principles:

- Assessment and benchmarking of actual operating loads and operating conditions to accurately estimate maximum load on the power plant.
- Reduced power generation redundancy especially under peak operating loads.

7.8.2.1 *Electrical Load List*

An electrical load list was develop for the Study generally based on:

- Normal and peak power demand for existing facilities and equipment, summer and winter, as advised by email from BIM Operations management
- Assumed installed power based on similar and reference equipment for all new facilities
- Power demand and diversity factors based on Hatch reference values for similar facilities

The most significant electrical power consumers for the Expansion Project are the electrically heated construction camps and the new port bulk materials handling and processing equipment (per CM001 package). Construction camp power was cross checked to Hatch reference values and the BMH equipment power was cross checked to the received CM001 bids; both systems are believed to be representative of the final configuration however both require validation when final loads are available from vendors / contractors.

7.8.2.2 *Port Site*

The currently installed generator design allows for a N+2 generator quantity design. This implies that two generators may be out of service without the requirement to shed any facility load. This design was implemented to allow for a standby generator while another generator is out of service for an extended period such as an engine rebuild.

For the new expanded port infrastructure, the generating capacity to shall be adequately sized for the maximum load envisaged during the Cape ship loading period without any additional installed capacity and redundancy on the generators. This would be referred to as N+0 installed generators at peak load.

Assessment of the average electrical loads at the Port Site has considered the following operating parameters:

- Rail car unloading:
  - Actual operating unloading trains is typically 5.3 times per day for 90 minutes each time (i.e. operates only 33% of the time otherwise idle).
- Crushing, screening and stacking:
  - Operating utilization (actual operating time divided by calendar time) approx. 70%.
- Fines ship loading rate (existing ship loader):
  - Peak rate 6 000 tph.
  - Average operating rate 4 800 tph.

    - Operating utilization (actual operating time divided by calendar time) approx. 50% of the operating period.
    - Operating period 83 days per annum.
- Lump ship loading at Ore Dock No 2 (Cape):
    - Peak rate 16 000 tph.
    - Average operating rate 12 480 tph.
    - Operating utilization (actual operating time divided by calendar time) approx. 75% of the operating period.
    - Operating period – 37 days per annum.
- Lump ship loading at Ore Dock No 2 (Panamax):
    - Peak rate 8 000 tph.
    - Average operating rate 6 640 tph.
    - Operating utilization (actual operating time divided by calendar time) approx. 50% of the operating period.
    - Operating period – 46 days per annum.

The resulting power generation configuration recommended for the Expansion Project is addition of 4x new 1350 kW generators similar to the existing and interconnected with the existing. To facilitate this interconnection and to provide the required power distribution systems a new power generation e-house (switchgear building) is also proposed.

Use of matching generators from the same manufacturer as the existing has been recommended to facilitate efficient load balancing between existing and new generators and to allow control system integration of the systems. Preliminary design of the new generation equipment and integration with the existing was carried out by Cummins and included with their PE002 budget quote package,

7.8.2.3 Mine Site

The original (currently installed) generator design allows for a N+2 generator quantity design. This implies that two generators may be out of service without the requirement to shed any facility load and was implemented to allow for a standby generator while another generator is out of service for an extended period such as an engine rebuild.

For the upgrades to the mine primary crushers and expanded mine infrastructure, the generating capacity is adequately sized for the maximum load envisaged during peak periods, with two additional generators installed as redundancy to the running generators. This would be referred to as N+2 installed generators.

For the permanent condition, no major fluctuations would occur on the demand at the mine site during summer and winter periods, barring the effect of seasonal heating loads in the accommodation camps.

Power demand is expected to peak during the construction period, given the load requirements envisaged for the construction camps which utilize electric heating systems. For this interim phase, an N+1 will be acceptable during peak winter periods of construction, with the required N+2 during normal operation.

To ensure continuous mining and primary crushing throughout the year, the following mitigation factors are considered in the event of a generator failure:

- Mobile 600V generating equipment are available on site. During abnormal events, these generators may be used to supply general facility loads by connecting the mobile generators directly to power distribution E-Houses and removing the associated E-House load from the central power generation system.

Start-up of equipment would be managed and sequenced such to minimize the peak currents drawn and limit instantaneous maximum demand on the generators.

Following review of the electrical loads no upgrade of the Mine Site power generation systems is proposed.

7.8.3 Power Distribution

Power distribution systems at the Mine and Port were assessed to match the new plant and facilities. Re-use of existing systems and equipment was utilized where possible, particularly at the Mine Site.

Modification of the Mine Site power distribution system consists of relocating and existing e-house and connecting new loads to existing e-houses. The resulting design is documented in the project Facility Description and associated engineering deliverables.

Modification and upgrade of the Port Site power distribution consist to two primary components:

- Power distribution to new support infrastructure including construction camp, PSC expansion and rail workshop. Preliminary design completed by Hatch and documented in the project Facility Description and associated engineering deliverables.
- Power distribution for the new bulk materials handling and processing systems. Initial concept design developed by Hatch and documented in the project Facility Description and associated engineering deliverables; however revised and final design is the responsibility of the CM001 contractor. The contractors final design will supersede design shown in the Study documents.

Preliminary assessment of the modified power distribution systems was completed however detail design and power systems analysis is required when final loads and the CM001 power distribution design are available.

7.8.4 Fuel Systems

7.8.4.1 Fuel Storage Analysis

Implementation of the Expansion Project will result in a change to fuel consumption particularly for power generation, mining equipment and transport (rail instead of truck). During the Study a detailed fuel consumption analysis was carried out to estimate fuel consumption during construction, ramp-up and into operations for the new configuration.

Fuel consumption estimate is based on:

- 2017 BIM operating budget, assumed to continue as-is until start-up of new plant and equipment, with future adjustments as applicable for decommissioned facilities and equipment
- Project electrical load list; for fuel required by power generation after project implementation
- Fuel for power generation to heat construction camps, benchmarked to existing facilities
- HME fuel consumption from STAGE 2 STUDY mine planning work
- Rail fuel consumption from RTC analysis based on GE locomotive performance curves
- Earthworks contractor fuel consumption as provided by EBC (lowest fuel consumption estimate of those received with CC002 and CC003 bids)
- Other facilities / equipment generally referenced from existing plant.

Based on the fuel consumption estimate two additional Arctic Diesel tanks are proposed for the Milne Port tank farm, increasing the total nominal tank farm capacity to 64 ML Arctic Diesel:

- 15 ML tank installed in the location previously identified for a future 12 ML tank.
- 3 ML tank installed at the north end of the fuel containment.

In addition to the Arctic Diesel tanks one new 750 kL Jet A-1 tank is proposed to increase the total Jet A-1 fuel storage to a total of 3 ML.

Due to only a marginal increase in fuel consumption at the Mine Site there are no changes proposed to the Mine Site fuel storage as part of the Expansion Project (however an allocation has been made in sustaining capital in recognition of the future fuel consumption increase associated with ramping up the mine equipment fleet).

7.8.4.2 *Fuel Systems Design Development*

Design of the tank farm upgrade is generally based on the existing tank farm with adjustments as required to ensure compliance with relevant Canadian codes and standards. Tanks are specified as API650 and piping to comply with applicable Canadian and ASME standards.

In addition to the tank farm upgrade the existing marine manifold building has been relocated with associated modification of the marine offload pipeline.

As part of the fuel systems work a power generation refuelling pipe system will be implemented as originally proposed during the Early Revenue Phase Project. The piping system will connect from the existing generator refuelling pump in the Arctic Diesel Fuel Module (currently unused) to the existing power generator modules.

Fuel system detail design has been included in the contract package TM001 with fuel system supply, fabrication and installation.

7.9 Infrastructure Earthworks

Design and engineering has been detailed (refer appendix 7-32) with regards to site development, road design, and stormwater management.

7.9.1 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.

Design requirements have been developed with respect to the following:

- Site Preparation.
- Earthworks.
- Site Grading.
- Infrastructure Facilities, Pads and Laydown Areas.
- Milne Port Stockpile area.
- Milne Port Design High Tide.
- Retaining walls.
- Erosion and Sediment Control.
- The software package AutoCAD Civil 3D was used to create the 3D model with which the bulk earthworks cut / fill volumes were calculated. A separate model was created for each terrace area and later integrated with the overall 3D model for the mine area. The survey information was obtained from the Lidar survey completed in August 2016. The grid of the survey points are set at $1m^2$.

- Based on the Stage 2 Study concept design and layout, each terrace / road location and its functionality was workshopped with Baffinland and the design team before being modelled. The layer works required for each terrace / road were in accordance with the Civil Design Philosophy document H353004-00000-100-146-0001-SE07.
- The bill of quantities was calculated for the various terraces and infrastructure components using the 3D modelling software. The layer works described in the Civil Design Philosophy (H353004-00000-100-146-0001-SE07) for the specific terrace / road were used to quantify the layer material quantities.

7.9.2 Road Design

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 required for operations. Permanent roads may be primary, secondary, or tertiary depending on frequency and type of traffic.

The design 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.

All road design is governed by design requirements with respect to the following:

- Road Category.
- Design Vehicles.
- Geometric Design.
- Pavement Thickness.
- Parking.
- Signage.
- Bollards.
- Shoulder Barriers.
- Utility Beams.

7.9.3 Stormwater Management System

A stormwater management system has been investigated based on design requirements with respect to the following:

- Internal Surface Drainage.
- External Surface Drainage.
- Rainfall Intensity.

- Sedimentation Ponds.
- Culverts, Roadside Ditches and Berms.
- Drainage Interceptor/Collector Berms.

Storm water drainage design was completed based on the approved Civil Design Philosophy setting out the storm water design criteria. AutoCAD Civil 3D modelling software and 3rd party software; IDAS (which integrates with the Civil 3D package) were used for calculation of the water runoff. The program uses the SWMM and rational methods to calculated runoff and the SWMM model to route the water through the identified water courses and ponds.

7.9.4 Mine Site Earthworks

The Mine bulk earthworks infrastructure design executed during the feasibility study design phase (Feasibility Study) include the development of the following:

- New terrace for the expansion of the permanent accommodation
- New terrace for the HME workshop including an access ramp to the existing terrace
- New terrace for the ROM stockpiling, crushing and train loading station
- New access road adjacent to the rail line for servicing the line as well as serving as access to the sewer outfall point
- Deviation of the Tote haul road to cross the rail and allow access to the quarry
- New terrace for the construction accommodation camp together with access to the terrace / camp
- Deviation of the routing of the potable water supply berm intersected by the new construction accommodation camp
- Laydown area for the contractor
- Storm water management for the new terrace for the product stockpile and train loading. This includes:
  - Cut-off berms (Separating clean and polluted water catchments
  - Pollution control pond
  - Culverts for cross drainage on the access road
  - Cross drainage on the deviated Tote road.

Catchments were identified based on the survey provided. Demarcation of the catchments between sedimented and clean water catchments was enabled through the placement of berms. The main new sedimented water area was identified as the new terrace for ROM stockpiling, primary crushers and train loading area. The catchment water is directed to a sedimentation control pond downstream of the terrace, see Figure 7-14. Cut-off berms on the side of the terrace convey the water to the pond which has a volume of 2.1Ml. The terrace is graded to facilitate storm water drainage to the pond.

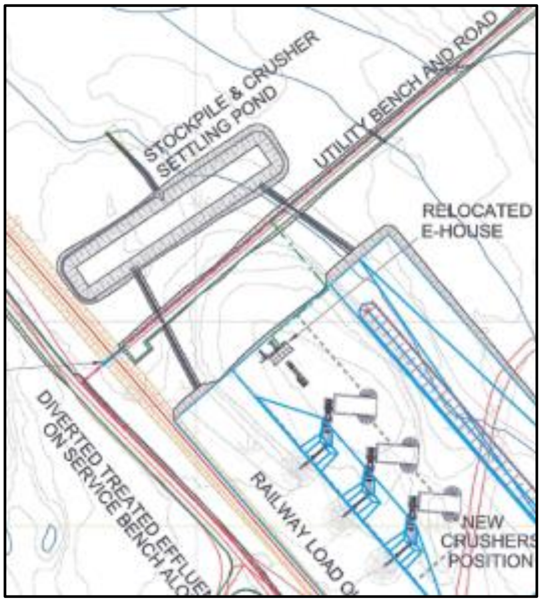

Figure 7-14: Stormwater Control Pond

Cross drainage of creeks & identified drainage points at road intersections were catered for through appropriately sized culverts and detailed according to the Civil Design Philosophy and previous Baffinland Mary River culvert details.

The drainage berm material quantities as well as the excavation volumes and general bill of materials for the pond were calculated using the 3D model. The various layer works and linings required were in accordance with the approved Civil Design Philosophy.

7.9.5 Port Site Earthworks

The Port bulk earthworks infrastructure design executed during the Stage 3 design phase includes:

- New permanent accommodation terrace
- New terrace for the Rail Locomotive workshop with an access road from the existing Tote road
- Rail Car Dumper excavation for installation of the Dumper for offloading of product
- New crushing feed stockpile terrace for the product received from the rail unloading conveyor
- New terrace for the crushing building
- New terrace for the screening building

- New terrace for the fines stockpile adjacent to the screening building
- New terrace for the transfer tower for the lump product onto the stacker reclaimer conveyor belt
- Terrace / platform for Stockpile No 2 (12 Mtpa Lump Ore) based on the pre-feasibility concept design
- Service / access road for the new Stockpile No 2 – including drainage consideration (this is regarded as polluted water)
- Layout of the Temporary Offloading Dock & road
- Stockyard No 1 (Fines product) terrace modification and access road
- Stockyard Reclaim Conveyor No 1 terrace platform for realigned conveyor belt section
- New berm for the relocated fuel offloading facility & pipe line
- New terrace for the construction accommodation camp together with access to the terrace / camp
- Storm water management for the new port facilities This includes:
  - Cut-off berms (Separating clean and polluted water catchments
  - Pollution control dams – 4 off (PCD)
  - Culverts for cross drainage on roads.

The rail dumper facility cut was designed based on the Stage 2 study phase and materials handling information obtained from contractors at the time. The excavation and development of this feature of the design will be finalised once the bulk materials handling execution contract has been awarded. This also applies to the Stockpile No 2 stacker reclaimer terrace / berm.

Storm water catchments were identified based on the survey provided. Demarcation of catchments between polluted and clean water catchments were enabled through the placement of berms to separate the contaminated water from the clean water.

At the Port, emphasis was placed on limiting the volume of clean water runoff that will naturally accumulate at the Stockpile No 2 road berm at the low point in the natural ground. The approach was to drain the natural runoff of clean water by gravity to existing creeks or rivers. In the central low point of the stockpile 2, clean water will accumulate without being able to drain naturally to the sea/ river/or creek. The stockpile road and services berm height was designed in such a manner that it can contain the yearly rain flow & runoff from the small catchment. The philosophy is that operations will have to drain the water from this “dam” that is formed by pumping the clean water to a canal or tanker and in order to dispose of it (during summer), refer to “Block Plan -Overall Layout - H363004-00000-220-272-0001-0001”.

Four polluted water dams were designed for the various identified polluted areas:

- Sedimented water run-off from the west side stockpile terrace service road (155.4 kl)
- Sedimented water run-off from the crushing fee stockpile terrace (429 kl)
- Sedimented water run-off from the fines stockpile and screening terrace (337 kl)
- Sedimented water run-off from the east side stockpile terrace service road(115 kl).

Drainage from approximately the centre of Stockpile No 2 service road is towards the existing polluted water pond. The roads are graded at a 1:800 slope to the north and south from approximately the centre of the stockpile No 2.

A new storm water containment berm was designed for the revised footprint area of Stockpile No 1 (existing stockyard). This sedimented water will link with the existing polluted water drain into the existing sedimentation water pond. (see Block Plan - Overall Layout - H353004-00000-220-272-0001-0001).

Cross drainage of creeks & identified drainage points at road intersections were catered for through appropriately sized culverts and which were detailed according to the design philosophy and previous Baffinland Mary River culvert details.

The drainage berm material quantities as well as the excavation volumes and general bill of materials for the ponds were calculated with the 3D model. The various layer works and the lining required were in accordance with the approved Civil Design Philosophy.

8. Reference Documents

Document Number	Title	Revision	Date	Appendix Number
H353004-00000-200-078-0008	Site Conditions Specification	0	2016-12-14	A7-1
H353004-CG001-200-242-0031	Metaocean Data – Standard Specification	0	2016-12-15	A7-2
H349000-2200-12-124-0004	Milne Metaocean Conditions – Milne Inlet	A	2013-10-10	A7-3
NB102-181/30-7	Hydrology Baseline Report		2012	A7-4
E349000-2200-12-124-0002	Mary River Mine Dock Site Ice Engineering Study Final Report	1	2014-02-10	A7-5
NB102-181/6-A.01	Hydrology for Tote Road Design		2006	A7-6
H352034-3000-228-030-0001	In-Principle Review of Previous Tote Road Hydrology Assessments	0	2016-08-18	A7-7
NB102-00181/39-A.01	Updated Design Peak Flow Assessment		2016-12-01	A7-8
H352034-1000-229-230-0002	2016 Milne Port Geotechnical Investigation Data Report	0	2017-02-17	A7-9
H352034-1000-229-230-0001	2016 Rail Geotechnical Investigation Factual Data Report	0	2017-02-03	A7-10
NB102-00181/3-2	Mine Site Infrastructure, Pit Overburden and Waste Dumps – 2006 Site Investigation Summary Report		2007-02-28	A7-11
NB102-00181/3-2	Mine Site Infrastructure, Pit Overburden and Waste Dumps – 2007 Site Investigations and Foundations Recommendations Summary Report		2007-12-14	A7-12
NB102-181/24-1	Mine site infrastructure, pit overburden and waste dumps – 2008 site investigations summary report		2010-05-04	A7-13
E349000-1000-00-236-0002	Geotechnical, Geochemical and Quarry Sourcing Investigation		2010-12-01	A7-14
E349000-2000-15-124-0001	Steensby Inlet and Milne inlet Port Offshore Geotechnical Investigation Summary of Results	0	2011-11-09	A7-15
H353004-00000-229-078-0002	Site Geotechnical Summary	0	2016-12-15	A7-16
H352034-1000-220-230-0001	Preliminary Geotechnical Site Investigation Report	0	2017-02-17	A7-17
H352034-3000-229-230-0001	Preliminary Geotechnical Recommendation for Railway Embankment (Between Milne Inlet and Mine Site)	2	2016-12-09	A7-18
H353004-00000-229-078-0001	Geotechnical Criteria for Building Foundations	0	2016-12-15	A7-19
H352034-3000-229-230-0002	Preliminary Geotechnical Recommendation for Infrastructures and Milne Inlet	1	2017-01-10	A7-20

Document Number	Title	Revision	Date	Appendix Number
H353004-00000-221-078-0002	Board Insulation	0	2016-12-14	A7-21
H352034-3000-200-210-0001	Railway Design Criteria and Design Rational	1	2016-11-02	A7-22
H352034-3000-200-230-0001	Rail Operations Static and Dynamic Modeling	1	2017-01-10	A7-23
H353004-CC003-230-078-0001	Rail Bridge Design Parameter Requirements	0	2016-12-13	A7-24
H353004-CC003-230-078-0003	Rail Bridge Superstructure	0	2016-12-13	A7-25
H353004-CC003-230-078-0002	Rail Bridge Substructure	0	2016-12-13	A7-26
H352034-3000-224-030-0003	Rail Tie Type Trade-off for Extreme Cold Weather Heavy Haul Operations	1	2016-12-09	A7-27
H353004-TR001-224-078-0001	Wayside Monitoring Equipment Specification	1	2017-01-26	A7-28
H353004-TR001-224-078-0002	Train control System Specification	1	2017-01-26	A7-29
H353004-CG001-200-242-0033	Ore Dock – Functional Specification	0	2016-12-14	A7-30
H353004-TM001-240-248-0001	TM001 - Fuel Storage - Fuel System Scope of Work	0	2017-02-22	A7-31
H353004-00000-200-210-0001	Civil Design Philosophy	0	2017-03-23	A7-32
H353004-00000-260-210-0001	Power Generation and Distribution Design Philosophy	0	2017-02-27	A7-33
H353004-00000-200-078-0017	Basic Electrical Requirements	0	2017-01-20	A7-34
H337697-0000-15-124-0002	Geotechnical Recommendations for Airstrip	0	2012-04-19	A7-35
H337697-0000-15-124-0004	Geotechnical Data Report - Infrastructure	C	2012-04-05	A7-36
H337697-3000-15-124-0001	2013 Geotechnical Site Investigations - Ports and Marine	A	2012-04-17	A7-37
H340960-1000-15-124-0004	Geotechnical Data Report - Infrastructure	0	2012-04-27	A7-38
H349000-2200-15-124-0003	Milne Ore Dock Geotechnical Investigation Factual Report	A	2014-02-21	A7-39
H349000-2200-15-124-0001	Ore Dock Geotechnical Design Report	0	2014-02-28	A7-40
H353004-00000-220-294-0001-0001	Rail Site Standard Drawing – Typical Cross Section Multiple Barrel Pipe Culverts	0	2016-12-07	A7-41
H353004-00000-220-294-0002-0001	Rail Site Standard Drawing – Typical Cross Section Single Barrel Pipe Culverts	0	2016-12-13	A7-42
H353004-00000-220-294-0003-0001	Rail Site Standard Drawing – Typical Cross Section Sheet 1 of 4	0	2016-12-13	A7-43
H353004-00000-220-294-0004-0001	Rail Site Standard Drawing – Typical Cross Section Sheet 2 of 4	1	2017-02-02	A7-44

Document Number	Title	Revision	Date	Appendix Number
H353004-00000-220-294-0005-0001	Rail Site Standard Drawing – Typical Cross Section Sheet 1 of 4	1	2017-02-02	A7-45
H353004-00000-220-294-0006-0001	Rail Site Standard Drawing – Typical Cross Section Sheet 1 of 4	1	2017-02-02	A7-46
H353004-00000-220-294-0007-0001	Rail Site Standard Drawing – Typical Cross Open Base Culvert	0	2017-03-22	A7-47
	Geophysical Seismic Survey for a Proposed fixed Dock, May River Project, Milne Inlet, Nunavut – Geophysics GPR International Inc. – T12615		Feb 2014	A7-48