Baffinland Iron Mines Corporation

MARY RIVER PROJECT
FINAL ENVIRONMENTAL IMPACT STATEMENT

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ATMOSPHERIC ENVIRONMENT

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PROJECT FACT SHEET

Location	• Located at Mary River, North Baffin Island. 1000 km north of Iqaluit, 160km south of Pond Inlet
Reserves	• Comprised of nine known iron ore deposits around Mary River. The current project is focused on Deposit No.1 with known reserves of 365 million tonnes estimated at >64 % iron
Construction Phase	• Construction of the project could commence as early as 2013 • Milne Port will support construction activities, receiving materials during the open water season and moving them to the Mine Site along the existing Tote Road • Construction materials will also be received at Steensby Port • 4 years to complete construction
Operational Phase Open Pit Mine Processing	• Operations will involve mining, ore crushing and screening, rail transport and marine shipping to European markets • Projected production of 18 million tonnes per year for 21 years • No secondary processing required; no tailings produced due to the high grade of ore
Rail Transport and Shipping	• A rail system will be built for year round transfer (~150 km) of ore to Steensby Inlet • A loading port constructed at Steensby Inlet will accommodate cape sized vessels • These specially designed ships will transport to the European market year round • Milne Port will be used to receive construction materials in the open water season and then very rarely to ship, during the open water season, oversized materials
Environment	• Baseline studies have been conducted by Baffinland since 2005 • Inuit Qaujimajatuqangit (traditional knowledge) information collected since 2006 • These baseline studies form the foundation for the environmental impact statement and provide information for the development of mitigation and management plans • Studies cover terrestrial environment, marine environment, freshwater environment, air quality, and resource utilization • Extensive ongoing consultation with communities and agencies • Monitoring during project activities will be important in validating predictions and mitigating potential affects
Social and Economic Benefits	• Mineral royalties will flow to NTI • Taxes will flow to governments of Nunavut and Canada • Baffinland finalizing negotiations with the Qikiqtani Inuit Association (QIA) for an Inuit Impact Benefits Agreement (IIBA) • During the four year construction period employment will peak at 2,700 people • Through the 21 years of operations about 950 people on the payroll each year
Closure and Post-Closure Phase	• Conceptual mine closure planning has been completed • Closure will ensure that the former operational footprint is both physically and chemically stable in the long term for protection of people and the natural environment • Post closure environmental monitoring will continue as long as needed to verify that reclamation has successfully met closure and reclamation objectives

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SECTION 1.0 - CLIMATE

1.1 BASELINE SUMMARY

An understanding of weather and climate in the Project area is required for design, construction and operation of facilities, including transportation corridors, for assessing effects on ambient air quality and for understanding trends in climate change. The following provides a summary of baseline meteorological conditions within the Project study area, with a detailed baseline report in Appendix 5A.

The regional study area (RSA) for climate and climate change includes the terrestrial and marine RSAs; the local study area (LSA) includes the North Baffin Region, focusing on the Project sites. Regional data exists from Environment Canada (EC) climate stations in the RSA, and to obtain more precise climate data within the LSA, Baffinland established on-site meteorological station at the exploration camp at Mary River in June 2005 and at each of Milne and Steensby ports in June 2006. Photographs and other details of the meteorological stations are provided in Appendix 5A.

EC operated a climate station at the Mary River camp (Mine Site) during summer from 1963 to 1965. A regional assessment of available data was undertaken and the following six locations were identified, reviewed and incorporated into the analysis:

- Pond Port (160 km): Pond Port is the closest station for which long-term climate data are available (1975 - 2007). The meteorological station is approximately 55 m above sea level (masl) compared with elevations at the Mary River camp (180 to 200 masl) and at the top of the deposit at Mary River (698 masl).
- Igloolik (240 km): Long-term climate data are available (1977 - 2002). The meteorological station is approximately 21 masl.
- Nanisivik (260 km): Long-term climate data are available (1976 - 2007). The meteorological station is approximately 642 masl.
- Hall Beach (290 km): Long-term climate data are available (1957 - 2007). The meteorological station is approximately 8 masl.
- Clyde River (400 km): Long-term climate data are available (1933, 1942 - 1943, and 1946 - 2007). The meteorological station is approximately 27 masl.
- Dewar Lakes (400 km): Long-term climate data are available (1958 - 1993 and 2000 - 2007). The meteorological station is approximately 527 masl.

1.1.1 Climate Setting

The North Baffin region is located within the Northern Arctic and the Arctic Cordillera Ecozones, as delineated in the National Ecological Framework for Canada. Northern Baffin Island has a semi-arid climate with relatively little precipitation. From early November to late January the region experiences near 24-hour darkness, with less than two hours of twilight. During winter months (December to April), the treeless topography and fine powdery snow produce blowing snow conditions resulting in restricted visibility. Steam fog may occur in areas of open water, but does not persist more than a few miles downwind. Ice fog is infrequent, due to the lack of moisture in the air.

Frost-free conditions occur from late June to late August. There is continuous daylight from early May to early August. July and August bring maritime influences and are usually the wettest (snow may still occur), fog increases due to arrival of moist air from southern Canada.

During September to November, temperature and the number of daylight hours start to decrease, and by mid-October the mean daily temperature is well below 0ºC. The highest snowfall typically occurs during this period. “Arctic white-out” often occurs; diffuse white clouds blend into the white snow-covered landscape, reducing visibility and increasing the likeliness of disorientation. This condition can also occur in April and May.

1.1.2 Air Temperature

Monthly mean temperatures at long-term EC climate stations range from approximately -34ºC in February at Pond Port to about 7ºC in July at Igloolik. The monthly average temperatures at Nanisivik are 0.7 -7.3ºC colder than at other stations during summer and fall. Temperatures at Pond Port are 1-5.6ºC colder than other stations during winter months.

Average annual temperatures recorded at the EC sites range from -12.8ºC at Clyde River to -16.3ºC at Pond Port. The highest annual mean temperatures generally occurred at Clyde River and the lowest at Pond Port and Nanisivik. Annual mean temperatures generally increased over the measurement period at all locations, although there is considerable year-to-year variability. The trend line plotted for Pond Port indicates that the annual mean temperature has increased by about 2.1ºC since 1975.

Data from Pond Port are most representative of temperatures at all three Baffinland stations compared to the other long-term EC stations, although there is a tendency for warmer temperatures at the Baffinland stations during summer. The Pond Port data, corrected upward by 2.4ºC during summer, are assumed to be reasonably representative of baseline conditions at Mary River Project site and to provide the best source of long-term temperature information for the Project sites.

1.1.3 Precipitation

Mean monthly precipitation at long-term EC climate stations range from 4 mm in February at Pond Port, Hall Beach and Nanisivik, to about 64 mm in August at Dewar Lakes. Variability in precipitation at the long-term EC stations ranges from about 5 mm in January to about 30 mm in August. Mean monthly precipitation reaches a maximum between August (Igloolik, Pond Port, Dewar Lakes, and Hall Beach) and October (Clyde River).

Mean annual precipitation at Pond Port is 190.8 mm, with 144.5 cm of snowfall (equivalent to 105.4 mm of rain) and 85.4 mm of rain. Historical records show that snow can occur in any month and rainfall may occur from April through November. The wettest month is August, with an average 32.9 mm of rain. October receives the most snow, an average of 32.8 cm. The lowest annual precipitation of about 74 mm occurred at Clyde River in 1958; however, the measurement techniques have become more reliable since then. The maximum annual precipitation of 500 mm occurred at Nanisivik in 2005. Data indicates that precipitation has increased slightly over the entire measurement period (about 0.24 mm/year).

Total rainfall is the only precipitation measurement available at the Project stations, and mean temperatures are typically above 0ºC from May to October. These months were used to compare the Project-measured precipitation data with measurements from the EC stations. Mary River had more rainfall in summer than all other Project stations, whereas rainfall in Milne Port and Steensby was mid-low range except for autumn months, when they were higher than at all other stations. Based on a comparison of the monthly trends, it appears that the data from Hall Beach are most representative of rainfall in Mary River, and data from Pond Port and Igloolik are most representative of rainfall from Milne Port and Steensby, respectively.

Data from Hall Beach are assumed to be reasonably representative of baseline rainfall conditions at the Mary River Project site and to provide the best source of long-term precipitation information. Likewise, an average of precipitation data from Pond Port and Igloolik are assumed to be reasonably representative of baseline conditions at both Milne Port and Steensby Port.

1.1.4 Wind-blown Snowfall

Wind-blown snow accumulates in topographic depressions, on the leeward side of ridges and buildings, and in strands of vegetation, which trap snow by reducing surface wind speeds. This accumulation presents challenges in terms of snow loads and accessibility. If wind-transported snow is not deposited in some kind of drift trap, and if a blowing-snow event is of sufficient duration (and the air remains unsaturated), then the particles can eventually sublimate away. Particle transport distance is the distance an average-sized snow/ice grain can travel before it completely sublimates. Transport distances of 2 - 3 km for a region south of Barrow, Alaska, have been calculated. As a consequence of the vigorous wind transport, a significant portion (5 % - 50 %) of the Arctic snow cover is returned to the atmosphere by sublimation of the wind-borne snow particles. The amount of solid precipitation that sublimates in the Trail Valley Creek area of the western Canadian Arctic is estimated at 20 % - 47 %.

Measurements are difficult to acquire because snow generally falls when it is windy, and precipitation gauges in windy environments significantly underestimate solid precipitation amounts.

Measurements of snow depth and snowfall are available from long-term EC stations and although they can provide an estimate, snow depth and accumulation are heavily dependent on wind distribution and sublimation of snow, which are in turn strongly influenced by local topography.

Visual observations at the Mary River Site indicate that snow drifts across the open terrain and accumulates in valleys and against obstacles, while most of the flat terrain is swept free. Some of the mountain regions have mini-glaciers, snow-covered year-round, and some of the valleys might have snow most of the year. During winter 60 % of the total land area has snow cover. From June to September, snow covers less than 5 % of the area around Mary River and Steensby, exposing dirt (for Mary River) or rock (for Steensby).

1.1.5 Evaporation

Observational evaporation data specific to the Canadian Arctic have cited annual evaporation measurements over the entire Arctic Ocean at approximately 0.4 mm/day. Climate model simulations of precipitation and evaporative fluxes in the Canadian Arctic and northern land areas have been conducted and used for Baffin Island. The Atmospheric Model Inter-comparison Project (AMIP) compiled outputs from 23 simulations, which suggest that evaporation from the Canadian Straits and Foxe Basin Watershed shows a strong seasonality, ranging from approximately 0.1 to 0.15 mm/day in winter (primarily represented by sublimation) to 0.4 to 3.4 mm/day in summer. Similar evaporation fluxes were predicted between models, with the exception of predictions for summer, when each model predicted a similar value.

Evaporation is often calculated using measurements of wind speed, solar radiation, temperature and humidity. Several methods have been developed to assess theoretical evaporation rates from these parameters, including the FAO Penman-Monteith Evapotranspiration (ET) method (FAO - Food and Agriculture Organization of the United Nations). The FAO Penman-Monteith method is recommended as the standardized method for determining reference ET from meteorological data. Evapotranspiration is the combination of two separate processes whereby water is lost either from the soil surface by evaporation and from the crop by transpiration. Five years (1982 - 1986) of meteorological data from Hall Beach were used to calculate ET using the Penman-Monteith method from March through September only.

Evapotranspiration levels are expected to be low to negligible during winter, when mean temperatures are well below the freezing point, limiting the available moisture for ET. In addition, low solar radiation during winter results in bias and errors in solar radiation observation data. Since solar radiation measurements are a component of the FAO Penman-Monteith method, ET results for these months have not been included in this analysis.

Mean daily and monthly ET values for Hall Beach for the years 1982 to 1986 are available: the mean daily ET is 0.9 mm/day, and total annual ET is 193 mm.

1.1.6 Wind Speed and Direction

Wind speed and direction are strongly affected by local influences, such as terrain. There is typically little variability in the average wind speeds on a year-to-year basis; short-term data sets from the Project stations are therefore expected to be fairly representative of average long-term conditions (or more representative than any of the EC data sets). The long-term EC data provide a better indication of extreme wind events that could possibly occur at the site.

Monthly average winds at the EC stations range from 1.8 m/s in February at Pond Port to 6.7 m/s in October at Hall Beach. Measured monthly average wind speeds at the Project stations are generally within the ranges observed from the EC stations, with the exception of Milne Port during March and summer months (June - August), which experienced higher monthly average wind speeds. This could be a function of the smaller data set at the Project stations. Wind rose plots produced for the Mary River site indicates that winds from the southeast occur most frequently (15.5 % of the time), followed by winds from the east-southeast (9 % of the time). Histograms were used to indicate the frequency of the various wind speed categories. “Light air” conditions (0.3 to 1.6 m/s) occur most frequently 26.3 % of the time, followed by calm winds (0 to 0.3 m/s) which occur 21.7 % of the time; strong breezes (10.8 to 13.9 m/s) occur 5.0 % of the time, and near-gale winds (13.9 to 17.2 m/s) occur 1.4 % of the time.

The wind rose for Milne Port indicates that winds from the northeast and south-southeast occur most frequently (nearly 1 % of the time for both directions), followed by winds from the southeast and northeast (about 11.5 and 12.0 % of the time respectively). “Light air” conditions of 0.3 to 1.6 m/s, occur most frequently (26.1 % of the time), followed by “light breezes” of 1.6 to 3.4 m/s, (18.4 % of the time). Strong breezes of 10.8 to 13.9 m/s occur 6.9 % of the time and near-gale winds of 13.9 to 17.2 m/s occur 1.9 % of the time.

The wind rose for Steensby Port indicates that winds from the northwest occur most frequently (23 % of the time), followed by winds from the southeast (nearly 12 % of the time). “Gentle breeze” conditions (3.4 to 5.5 m/s) occur most frequently at 31.5 % of the time, followed by “light breeze ” conditions (1.6 to 3.4 m/s), which occur 22.6 % of the time. Strong breezes (10.8 to 13.9 m/s) occur 4.1 % of the time and “near gale winds” (13.9 to 17.2 m/s) occur 0.9 % of the time.

The wind rose for Pond Port (2003 to October 2010) indicates that winds from the south occur most frequently (23 % of the time). "Light breezes" (1.6 to 3.4 m/s) occur most frequently at 33.8 % of the time, followed by “light air” conditions (0.3 to 1.6 m/s), which occur 30.6 % of the time. “Strong breeze” conditions (10.8 to 13.9 m/s) occur about 1 % of the time.

1.1.7 Solar Measurements

Solar radiation data are considered in the determination of atmospheric stability for air quality dispersion modelling and for theoretical evapotranspiration calculations. Mean daily global solar radiation at Hall Beach ranges from 0 in December to 23 MJ/m^2 in June. The annual rate of 9 MJ/m^2 at Hall Beach is consistent with other estimates in this region. The Atlas of Canada estimates the annual mean daily global solar radiation to be 8 - 10 MJ/m^2 for Baffin Island. The measured values at the Project stations are much higher and are therefore considered to be unreliable.

The maximum number of hours of bright sunshine occurs in May at Pond Port with 362 hours and in July at Clyde River with 279 hours.

Since the measurements from the Project stations are suspect, data from Hall Beach are expected to provide the best estimate. Data for Pond Port are expected to provide the best estimate of hours of bright sunshine.

1.1.8 Atmospheric Moisture

Relative humidity varies diurnally and seasonally; it tends to be highest at sunrise when temperatures are coolest and lowest in the late afternoon/early evening when temperatures are highest. Seasonal variability is related to temperatures and precipitation amounts.

The lowest monthly average humidity at all stations typically occurs in February or March, corresponding with the lowest precipitation and temperatures. Relative humidity data from the Project stations seem to be generally consistent with the monthly trends observed at the EC stations, although it is somewhat higher in winter and somewhat lower in summer. Again, this could be attributed to the length of the monitoring program.

The Project's relative humidity data are expected to be most representative of long-term conditions at the Project sites.

1.2 CLIMATE CHANGE FORECASTS

1.2.1 Prediction Methods

Global Climate Models (GCMs) are used to simulate potential changes in climate due to future greenhouse gas emissions, land-use changes and other driving forces. The Intergovernmental Panel on Climate Change (IPCC) has assimilated numerous emission scenarios to study the range of possible outcomes of climate on our planet. Based on the availability of model results from the most recent IPCC study (2007), scenarios A2 and B1 from the Special Report on Emissions Scenarios (SRES) were assessed. These two combined scenarios cover a wide range of potential future emissions scenarios, as A2 falls above the middle of the SRES range of future emissions and B1 falls below the middle of the range. Briefly, scenario A2 describes a more divided world characterized by high population growth and slow technological change, and scenario B1 describes an integrated and ecologically friendly world characterized by low population growth and medium technological change focusing on efficiency and dematerialization. Climate predictions from these two scenarios provide a sufficient range of possible changes in weather trends that could result from future human activity.

The Arctic Climate Impact Assessment (Arctic Council and International Arctic Science Committee, 2005), which is the first body of work to evaluate climate change across the entire Arctic region, was drawn upon to predict some of the climate change parameters in the Baffin Island area.

As with any model, GCMs are imperfect at reproducing a natural system, especially when considering the uncertainty of future emissions input into the model. Although absolute climate values from GCMs are typically not very accurate when compared to observed data, the changes in climate predicted from GCMs from a baseline period to a future period are very useful. In this assessment, GCM-predicted changes in climate were applied to the observed baseline data to develop an estimate of future climate conditions. Three future time periods were considered: 2011 - 2040, 2041 - 2070, and 2071 - 2100.

1.2.2 Historical Climate Data

Representative baseline climate parameters specific to the Mine Site are shown in Table 5-1.1. Variables include mean temperature, mean daily maximum/minimum temperature, precipitation, mean wind speed, average snow depth, and incident solar radiation. The Baseline Meteorological Report (Appendix 5A) includes a detailed discussion of historical climate conditions at the Project Site.

In a climate change assessment, it is ideal to determine trends over a long period (30 years or more). The Project meteorological stations do not contain sufficient data; therefore, climate normals from EC were used in this assessment. Data comparisons between EC and Project stations were made to determine the most representative EC station for each climate. Climate normals from 1971 to 2000 (where available) from the representative EC stations were used to develop a climate baseline. Wind speed was excepted because it is strongly affected by local influences; since there is typically very little variability in the average wind speeds on a year-to-year basis, the short-term data sets from the Project stations were used, as they are expected to be fairly representative of average long-term conditions (or at least more representative than any of the EC data sets). The mean wind speeds presented in Table 5-1.1 are taken from the Mary River Site Station, June 2005 to July 2010.

1.2.3 Global Climate Models

GCMs were used to simulate baseline climate conditions and to provide an estimate of the future predicted change in climate variables. Comparison of GCM predicted baseline conditions to actual climate normals provides an estimate of accuracy of GCM behaviour and its ability to simulate complex climate variables. If the GCM is successful in its replication of past weather trends, then, barring any uncertainties associated with future greenhouse gas emissions, a level of confidence is established when developing a future climate scenario based on GCM predicted changes.

GCM results based on the most recent IPCC study (2007) were available from several different sources. Based on the availability of climate data, two main sources were selected: the EC Canadian Climate Change Scenarios Network (CCCSN) website (http://www.cccsn.ca), and the Pacific Climate Impacts Consortium (PCIC) website (http://pacificclimate.org). The CCCSN website provided temperature, precipitation and wind speed data, and the PCIC website provided snow depth and incident solar radiation data. Five different time periods were assessed including two baseline periods, 1961 - 1990 and 1971 - 2000, and three future periods: 2011 - 2040 (2020s), 2041 - 2070 (2050s), and 2071 - 2100 (2080s). Where available, the more recent baseline data (1971 - 2000) was used in place of the 1961 - 1990 baseline period.

Table 5-1.1 Comparison of 1971 to 2000 Climate Normals to GCM-Predicted Climate Variables

Baseline	Global Climate Model	Season	Temperature			Precipitation	Wind Speed	Snow Depth	Solar Radiation
			Mean Temperature (°C)	Mean Daily Maximum Temperature (°C)	Mean Daily Minimum Temperature (°C)	Precipitation (mm/d)	Mean Wind Speed (m/s)	Average Snow Depth (m) (2)	Incident Solar Radiation (W/m^2) (2)
ENVIRONMENT CANADA CLIMATE NORMALS	See Note [1]	Winter (DJF)	-31.7	-28.1	-35.3	0.2 - 0.4	2.9	0.2 - 0.5	7
		Spring (MAM)	-20.8	-16.6	-24.8	0.3 - 0.6	3.3	0.2 - 0.6	162
		Summer (JJA)	6.4	9.6	3.1	0.9 - 1.1	4.2	0.0 - 0.1	215
		Fall (SON)	-11.7	-8.4	-14.9	0.7 - 1.0	3.7	0.1 - 0.3	39
		Annual	**-15.1**	**-11.5**	**-18.6**	**0.8 - 0.8**	**3.5**	**0.1 - 0.3**	**106**
GCM PREDICTED	CGCM3T47	Winter (DJF)	-36.7	-34.2	-39.3	0.3	1.8	0.3	2
		Spring (MAM)	-22.5	-17.9	-26.8	0.4	1.9	0.4	132
		Summer (JJA)	1.4	4.4	-1.6	0.9	1.7	0.1	177
		Fall (SON)	-13.0	-10.7	-15.4	0.8	1.9	0.2	20
		Annual	**-17.7**	**-14.6**	**-20.8**	**0.6**	**1.8**	**0.3**	**83**
	ECHAM5OM	Winter (DJF)	-28.8	N/A	N/A	0.5	1.5	N/A	4
		Spring (MAM)	-18.1	N/A	N/A	0.6	1.4	N/A	128
		Summer (JJA)	2.2	N/A	N/A	1.3	1.1	N/A	137
		Fall (SON)	-12.9	N/A	N/A	1.0	1.4	N/A	26
		Annual	**-14.4**	**N/A**	**N/A**	**0.8**	**1.4**	**N/A**	**74**
	GFDLCM2.0	Winter (DJF)	-34.9	N/A	N/A	0.3	1.3	N/A	5
		Spring (MAM)	-21.7	N/A	N/A	0.6	1.1	N/A	171
		Summer (JJA)	1.8	N/A	N/A	1.3	1.0	N/A	180
		Fall (SON)	-15.5	N/A	N/A	1.0	1.2	N/A	31
		Annual	**-17.6**	**N/A**	**N/A**	**0.8**	**1.1**	**N/A**	**98**
	HADCM3	Winter (DJF)	-37.2	N/A	N/A	0.4	2.4	N/A	5
		Spring (MAM)	-23.3	N/A	N/A	0.4	1.8	N/A	178
		Summer (JJA)	2.9	N/A	N/A	1.2	1.3	N/A	189
		Fall (SON)	-16.8	N/A	N/A	0.8	2.3	N/A	36
		Annual	**-18.6**	**N/A**	**N/A**	**0.7**	**2.0**	**N/A**	**102**
	NCARCCSM	Winter (DJF)	-33.1	N/A	N/A	0.4	N/A	N/A	4
		Spring (MAM)	-17.0	N/A	N/A	0.7	N/A	N/A	142
		Summer (JJA)	-0.1	N/A	N/A	1.1	N/A	N/A	149
		Fall (SON)	-13.7	N/A	N/A	1.1	N/A	N/A	26
		Annual	**-16.0**	**N/A**	**N/A**	**0.8**	**N/A**	**N/A**	**81**

NOTE(S):

1. MEAN, MAXIMUM, AND MINIMUM TEMPERATURE DATA BASED ON ENVIRONMENT CANADA METEOROLOGICAL STATION POND INLET MEASUREMENTS FROM 1971 - 2000. PRECIPITATION RANGES ARE FROM THREE ENVIRONMENT CANADA METEOROLOGICAL STATIONS: POND INLET, IGLOOLIK AND NANASIVIK. MEAN WIND SPEED MEASUREMENTS TAKEN FROM THE MARY RIVER SITE FROM JUNE 2005 TO JULY 2010. MEAN, MEAN DAILY MAXIMUM, AND MEAN DAILY MINIMUM SUMMER TEMPERATURES AT POND INLET FROM 1971 - 2000 WERE 4.0°C, 7.2°C, AND 0.7°C, RESPECTIVELY. A 2.4°C TEMPERATURE CORRECTION HAS BEEN APPLIED TO ACCOUNT FOR THE WARMER TEMPERATURES OBSERVED AT THE PROJECT SITE DURING THE SUMMER MONTHS.
2. GCM PREDICTED BASELINE VALUES ARE FROM THE PERIOD 1961 - 1990. SNOW DEPTH RANGES ARE FROM FOUR ENVIRONMENT CANADA METEOROLOGICAL STATIONS: POND INLET, HALL BEACH, CLYDE RIVER, AND DEWAR LAKES. HISTORICAL SOLAR RADIATION DATA WERE AVERAGED FROM GLOBAL SOLAR RADIATION MEASUREMENTS TAKEN IN HALL BEACH FROM AUGUST 1970 TO MAY 1998.

Climate data were extracted from a region covering approximately 400,000 km^2 over the northern half of Baffin Island. The area was selected to maximize the land area and minimize the grid cells over the sea.

Five different GCMs were used: CGCM3T47, ECHAM50M, GFDLCM2.0, HADCM3, and NCARCCSM. Climate variables extracted from the GCMs include mean temperature, mean daily maximum/minimum temperature (where available), precipitation, mean wind speed, average snow depth (where available), and incident solar radiation. All GCM results are reported as seasonal and annual averages.

1.2.3.1 Climate Baseline

Table 5-1.1 provides a summary of current climate conditions based on GCM results and historical climate observations from on-site and EC weather stations. Historical observations were compared to the GCM predicted baseline to validate the model. The GCMs compared reasonably well with the historical climate observations. The GCM predicted precipitation and average snow depth values were within the observed ranges for the region. Annual average temperature, mean wind speed, and solar radiation were typically under-predicted by the GCMs by an average of 2.3 °C, 1.9 m/s, and 18 W/m^2, respectively. Since this report considers the difference between the GCM predicted baseline and the future periods, and not the absolute values predicted from the GCMs, this underestimation is of little consequence.

1.2.3.2 GCM Future Climate Predictions

Tables 5-1.2, 5-1.3 and 5-1.4 contains detailed summaries of the GCM predicted change in climate along with predicted future seasonal and annual climate averages for three time periods representing the 2020s, 2050s and 2080s, respectively. The predicted future climate data in these tables were calculated by adding the GCM predicted change to the historical climate observation data. Table 5-1.5 presents a summary of the predicted future climate, providing a range of values based on all models and both SRES scenarios.

Figures 5-1.1 through 5-1.5 provide a visual representation of the predicted change in annual mean temperature, annual daily precipitation, annual mean wind speed, annual average snow depth and annual average solar radiation, respectively. Upper and lower ranges of predictions, represent the five GCM models (CGCM3T47, ECHAM50M, GFDLCM2.0, HADCM3, and NCARCCSM) as well as the two emission scenarios (A2 and B1).

1.2.3.3 Long-term Temperature Trends

A discussion of temperature trends is included in Appendix 5A and is summarized here. The trend indicates that the annual mean temperatures have increased by about 0.07°C per year at Pond Port from 1975 on. As shown in Figure 5-1.1, the GCM models predict that annual mean temperature will increase at a rate of approximately 0.03°C (lower range) and 0.08°C (upper range) over the next century. The average predicted increase of 0.055°C is relatively close to that observed at Pond Port, thus providing a level of confidence in the GCM results.

Table 5-1.2 Climate Forecasts - 2011 to 2040 (2020s)

Scenario	Model	Season	Temperature: Mean – GCM Predicted Change (°C)	Temperature: Mean – Forecast Mean (°C)	Temperature: Mean Daily Max – GCM Predicted Change (°C)	Temperature: Mean Daily Max – Forecast Mean Daily Maximum (°C)	Temperature: Mean Daily Min – GCM Predicted Change (°C)	Temperature: Mean Daily Min – Forecast Mean Daily Minimum (°C)	Precipitation – Forecast Precipitation (mm/d)	Wind – GCM Predicted Change (m/s)	Wind – Forecast Mean Wind Speed (m/s)	Snow Depth – GCM Predicted Change (m)	Snow Depth – Forecast Average Snow Depth (m)	Solar Radiation – GCM Predicted Change (W/m²)	Solar Radiation – Forecast Solar Radiation (W/m²)
A2	CGCM3T47	Winter (DJF)	1.7	-30.1	1.6	-26.5	1.7	-33.6	0.2 - 0.5	-0.05	2.9	-0.01	0.2 - 0.5	-0.1	7
		Spring (MAM)	1.3	-19.5	1.2	-15.4	1.3	-23.5	0.3 - 0.6	-0.03	3.3	0.00	0.2 - 0.6	-1.2	161
		Summer (JJA)	0.6	7.0	0.6	10.2	0.6	3.7	0.9 - 1.1	-0.13	4.1	-0.03	0.0 - 0.1	-5.8	210
		Fall (SON)	2.2	-9.5	2.1	-6.3	2.3	-12.6	0.7 - 1.1	-0.05	3.7	-0.03	0.1 - 0.2	-0.9	38
		Annual	**1.5**	**-13.6**	**1.4**	**-10.1**	**1.5**	**-17.1**	**0.8 - 0.8**	**-0.06**	**3.4**	**-0.02**	**0.1 - 0.3**	**-2.0**	**104**
	ECHAM5OM	Winter (DJF)	-0.2	-31.9	N/A	N/A	N/A	N/A	0.2 - 0.4	0.14	3.0	N/A	N/A - N/A	0.1	7
		Spring (MAM)	1.6	-19.2	N/A	N/A	N/A	N/A	0.4 - 0.7	-0.09	3.2	N/A	N/A - N/A	-5.0	157
		Summer (JJA)	0.7	7.1	N/A	N/A	N/A	N/A	0.9 - 1.1	-0.02	4.2	N/A	N/A - N/A	0.1	215
		Fall (SON)	1.7	-10.0	N/A	N/A	N/A	N/A	0.8 - 1.1	-0.01	3.7	N/A	N/A - N/A	-1.3	37
		Annual	**1.0**	**-14.1**	**N/A**	**N/A**	**N/A**	**N/A**	**0.8 - 0.8**	**0.01**	**3.5**	**N/A**	**N/A - N/A**	**-1.6**	**104**
	GFDLCM2.0	Winter (DJF)	0.8	-30.9	N/A	N/A	N/A	N/A	0.2 - 0.4	0.04	2.9	N/A	N/A - N/A	0.0	7
		Spring (MAM)	1.8	-19.0	N/A	N/A	N/A	N/A	0.4 - 0.6	0.03	3.3	N/A	N/A - N/A	-4.4	158
		Summer (JJA)	0.7	7.1	N/A	N/A	N/A	N/A	0.9 - 1.1	-0.01	4.2	N/A	N/A - N/A	-10.6	205
		Fall (SON)	1.9	-9.9	N/A	N/A	N/A	N/A	0.7 - 1.1	0.05	3.7	N/A	N/A - N/A	-1.0	38
		Annual	**1.3**	**-13.8**	**N/A**	**N/A**	**N/A**	**N/A**	**0.8 - 0.8**	**0.03**	**3.5**	**N/A**	**N/A - N/A**	**-4.0**	**102**
	HADCM3	Winter (DJF)	N/A	N/A	N/A	N/A	N/A	N/A	0.6 - 0.9	-0.14	2.8	N/A	N/A - N/A	0.0	7
		Spring (MAM)	N/A	N/A	N/A	N/A	N/A	N/A	1.0 - 1.3	-0.12	3.2	N/A	N/A - N/A	-2.6	160
		Summer (JJA)	N/A	N/A	N/A	N/A	N/A	N/A	0.4 - 0.6	0.05	4.2	N/A	N/A - N/A	-8.9	206
		Fall (SON)	N/A	N/A	N/A	N/A	N/A	N/A	0.3 - 0.7	-0.10	3.6	N/A	N/A - N/A	-1.7	37
		Annual	**1.8**	**-13.3**	**N/A**	**N/A**	**N/A**	**N/A**	**0.8 - 0.8**	**-0.08**	**3.4**	**N/A**	**N/A - N/A**	**-3.3**	**103**
	NCARCCSM	Winter (DJF)	4.2	-27.5	N/A	N/A	N/A	N/A	0.3 - 0.5	N/A	N/A	-0.01	0.2 - 0.5	-0.1	7
		Spring (MAM)	2.0	-18.8	N/A	N/A	N/A	N/A	0.4 - 0.7	N/A	N/A	0.00	0.2 - 0.6	-3.7	158
		Summer (JJA)	1.3	7.7	N/A	N/A	N/A	N/A	1.1 - 1.2	N/A	N/A	-0.02	0.0 - 0.1	-15.9	199
		Fall (SON)	3.6	-8.1	N/A	N/A	N/A	N/A	0.9 - 1.2	N/A	N/A	-0.02	0.1 - 0.3	-3.6	35
		Annual	**2.8**	**-12.3**	**N/A**	**N/A**	**N/A**	**N/A**	**0.9 - 0.9**	**N/A**	**N/A**	**-0.01**	**0.1 - 0.3**	**-5.9**	**100**
B1	CGCM3T47	Winter (DJF)	1.5	-30.3	1.5	-26.6	1.4	-33.9	0.2 - 0.4	0.24	3.1	0.00	0.2 - 0.5	-0.1	7
		Spring (MAM)	1.5	-19.3	1.3	-15.3	1.6	-23.1	0.5 - 0.8	-0.07	3.2	0.01	0.2 - 0.6	-2.8	159
		Summer (JJA)	0.6	7.0	0.6	10.2	0.6	3.7	1.1 - 1.2	-0.12	4.1	-0.03	0.0 - 0.1	-5.6	210
		Fall (SON)	2.0	-9.7	1.9	-6.5	2.1	-12.9	0.6 - 0.9	0.03	3.7	-0.02	0.1 - 0.2	-1.1	38
		Annual	**1.4**	**-13.7**	**1.4**	**-10.1**	**1.5**	**-17.1**	**0.8 - 0.8**	**0.02**	**3.5**	**-0.01**	**0.1 - 0.3**	**-2.4**	**103**
	ECHAM5OM	Winter (DJF)	1.1	-30.6	N/A	N/A	N/A	N/A	0.2 - 0.4	0.08	3.0	N/A	N/A - N/A	0.0	7
		Spring (MAM)	1.0	-19.7	N/A	N/A	N/A	N/A	0.4 - 0.7	-0.02	3.3	N/A	N/A - N/A	-5.2	157
		Summer (JJA)	0.8	7.2	N/A	N/A	N/A	N/A	0.9 - 1.0	-0.01	4.2	N/A	N/A - N/A	6.4	222
		Fall (SON)	2.2	-9.5	N/A	N/A	N/A	N/A	0.8 - 1.2	-0.04	3.7	N/A	N/A - N/A	-0.9	38
		Annual	**1.3**	**-13.8**	**N/A**	**N/A**	**N/A**	**N/A**	**0.8 - 0.8**	**0.00**	**3.5**	**N/A**	**N/A - N/A**	**0.1**	**106**
	GFDLCM2.0	Winter (DJF)	1.5	-30.2	N/A	N/A	N/A	N/A	0.3 - 0.5	-0.04	2.9	N/A	N/A - N/A	0.0	7
		Spring (MAM)	2.1	-18.6	N/A	N/A	N/A	N/A	0.3 - 0.6	-0.12	3.2	N/A	N/A - N/A	-4.6	158
		Summer (JJA)	1.0	7.4	N/A	N/A	N/A	N/A	0.9 - 1.0	0.09	4.3	N/A	N/A - N/A	-4.4	211
		Fall (SON)	2.4	-9.3	N/A	N/A	N/A	N/A	0.7 - 1.1	0.04	3.7	N/A	N/A - N/A	-0.8	38
		Annual	**1.8**	**-13.3**	**N/A**	**N/A**	**N/A**	**N/A**	**0.8 - 0.8**	**-0.01**	**3.5**	**N/A**	**N/A - N/A**	**-2.5**	**103**
	HADCM3	Winter (DJF)	2.0	-29.7	N/A	N/A	N/A	N/A	0.2 - 0.5	-0.08	2.8	N/A	N/A - N/A	0.0	7
		Spring (MAM)	2.0	-18.7	N/A	N/A	N/A	N/A	0.4 - 0.7	-0.13	3.2	N/A	N/A - N/A	-4.9	157
		Summer (JJA)	1.4	7.8	N/A	N/A	N/A	N/A	1.0 - 1.1	0.04	4.2	N/A	N/A - N/A	-5.0	210
		Fall (SON)	1.7	-10.0	N/A	N/A	N/A	N/A	0.7 - 1.0	-0.02	3.7	N/A	N/A - N/A	-1.0	38
		Annual	**1.8**	**-13.3**	**N/A**	**N/A**	**N/A**	**N/A**	**0.8 - 0.8**	**-0.05**	**3.5**	**N/A**	**N/A - N/A**	**-2.7**	**103**
	NCARCCSM	Winter (DJF)	3.1	-28.7	N/A	N/A	N/A	N/A	0.3 - 0.5	N/A	N/A	-0.01	0.2 - 0.5	0.0	7
		Spring (MAM)	1.4	-19.4	N/A	N/A	N/A	N/A	0.3 - 0.6	N/A	N/A	0.00	0.2 - 0.6	-3.7	158
		Summer (JJA)	0.9	7.3	N/A	N/A	N/A	N/A	1.1 - 1.2	N/A	N/A	-0.02	0.0 - 0.1	-14.9	201
		Fall (SON)	2.3	-9.4	N/A	N/A	N/A	N/A	0.8 - 1.2	N/A	N/A	-0.01	0.1 - 0.3	-3.5	35
		Annual	**1.9**	**-13.2**	**N/A**	**N/A**	**N/A**	**N/A**	**0.9 - 0.9**	**N/A**	**N/A**	**-0.01**	**0.1 - 0.3**	**-5.6**	**100**

NOTE(S):

1. FORECAST VALUES = HISTORICAL CLIMATE MEASUREMENTS + GLOBAL CLIMATE MODEL PREDICTED CHANGES.

Table 5-1.3 Climate Forecasts - 2041 to 2070 (2050s)

Scenario	Model	Season	Temperature – Mean: GCM Predicted Change (°C)	Temperature – Mean: Forecast Mean (°C)	Temperature – Mean Daily Max: GCM Predicted Change (°C)	Temperature – Mean Daily Max: Forecast Mean Daily Maximum (°C)	Temperature – Mean Daily Min: GCM Predicted Change (°C)	Temperature – Mean Daily Min: Forecast Mean Daily Minimum (°C)	Precipitation: Forecast Precipitation (mm/d)	Wind: GCM Predicted Change (m/s)	Wind: Forecast Mean Wind Speed (m/s)	Snow Depth: GCM Predicted Change (m)	Snow Depth: Forecast Average Snow Depth (m)	Solar Radiation: GCM Predicted Change (W/m²)	Solar Radiation: Forecast Solar Radiation (W/m²)
A2	CGCM3T47	Winter (DJF)	5.2	-26.5	5.2	-22.9	5.2	-30.1	0.3 - 0.5	0.07	3.0	0.01	0.2 - 0.5	-0.2	7
		Spring (MAM)	3.1	-17.6	2.8	-13.9	3.4	-21.3	0.4 - 0.7	-0.10	3.2	0.02	0.2 - 0.6	-5.1	157
		Summer (JJA)	1.5	7.9	1.6	11.2	1.6	4.7	1.0 - 1.2	-0.13	4.1	-0.04	0.0 - 0.1	-11.1	204
		Fall (SON)	4.5	-7.2	4.2	-4.3	4.8	-10.1	0.8 - 1.2	0.15	3.8	-0.03	0.1 - 0.2	-1.8	37
		Annual	**3.7**	**-11.4**	**3.5**	**-8.0**	**3.8**	**-14.8**	**0.9 - 0.9**	**0.00**	**3.5**	**-0.01**	**0.1 - 0.3**	**-4.6**	**101**
	ECHAM5OM	Winter (DJF)	2.9	-28.8	N/A	N/A	N/A	N/A	0.2 - 0.4	0.14	3.0	N/A	N/A - N/A	0.0	7
		Spring (MAM)	2.5	-18.3	N/A	N/A	N/A	N/A	0.4 - 0.7	0.06	3.4	N/A	N/A - N/A	-9.7	153
		Summer (JJA)	1.8	8.2	N/A	N/A	N/A	N/A	0.8 - 1.0	0.08	4.3	N/A	N/A - N/A	-0.6	215
		Fall (SON)	4.1	-7.6	N/A	N/A	N/A	N/A	0.9 - 1.2	-0.08	3.6	N/A	N/A - N/A	-3.2	35
		Annual	**2.9**	**-12.2**	**N/A**	**N/A**	**N/A**	**N/A**	**0.8 - 0.8**	**0.05**	**3.5**	**N/A**	**N/A - N/A**	**-3.4**	**102**
	GFDLCM2.0	Winter (DJF)	3.7	-28.0	N/A	N/A	N/A	N/A	0.3 - 0.5	-0.05	2.8	N/A	N/A - N/A	-0.1	7
		Spring (MAM)	3.7	-17.0	N/A	N/A	N/A	N/A	0.3 - 0.6	-0.08	3.2	N/A	N/A - N/A	-9.3	153
		Summer (JJA)	1.4	7.8	N/A	N/A	N/A	N/A	1.0 - 1.2	-0.09	4.1	N/A	N/A - N/A	-21.4	194
		Fall (SON)	4.6	-7.1	N/A	N/A	N/A	N/A	0.7 - 1.1	0.03	3.7	N/A	N/A - N/A	-1.5	37
		Annual	**3.4**	**-11.7**	**N/A**	**N/A**	**N/A**	**N/A**	**0.8 - 0.8**	**-0.04**	**3.5**	**N/A**	**N/A - N/A**	**-8.1**	**98**
	HADCM3	Winter (DJF)	N/A	N/A	N/A	N/A	N/A	N/A	0.8 - 1.1	0.07	3.0	N/A	N/A - N/A	-0.1	7
		Spring (MAM)	N/A	N/A	N/A	N/A	N/A	N/A	0.4 - 0.7	-0.09	3.2	N/A	N/A - N/A	-7.0	155
		Summer (JJA)	N/A	N/A	N/A	N/A	N/A	N/A	0.4 - 0.5	0.04	4.2	N/A	N/A - N/A	-15.0	200
		Fall (SON)	N/A	N/A	N/A	N/A	N/A	N/A	1.0 - 1.4	-0.05	3.6	N/A	N/A - N/A	-3.8	35
		Annual	**3.9**	**-11.2**	**N/A**	**N/A**	**N/A**	**N/A**	**0.9 - 0.9**	**-0.01**	**3.5**	**N/A**	**N/A - N/A**	**-6.5**	**99**
	NCARCCSM	Winter (DJF)	8.1	-23.6	N/A	N/A	N/A	N/A	0.4 - 0.6	N/A	N/A	0.00	0.2 - 0.5	-0.3	7
		Spring (MAM)	3.5	-17.3	N/A	N/A	N/A	N/A	0.4 - 0.7	N/A	N/A	0.00	0.2 - 0.6	-8.0	154
		Summer (JJA)	2.0	8.4	N/A	N/A	N/A	N/A	1.2 - 1.3	N/A	N/A	-0.03	0.0 - 0.1	-26.3	189
		Fall (SON)	6.1	-5.7	N/A	N/A	N/A	N/A	0.9 - 1.3	N/A	N/A	-0.02	0.1 - 0.2	-6.7	32
		Annual	**4.9**	**-10.2**	**N/A**	**N/A**	**N/A**	**N/A**	**1.0 - 1.0**	**N/A**	**N/A**	**-0.01**	**0.1 - 0.3**	**-10.4**	**95**
B1	CGCM3T47	Winter (DJF)	3.4	-28.3	3.5	-24.7	3.3	-32.0	0.2 - 0.5	0.08	3.0	0.02	0.2 - 0.5	-0.2	7
		Spring (MAM)	2.1	-18.7	1.9	-14.7	2.2	-22.6	0.5 - 0.8	-0.17	3.1	0.03	0.2 - 0.6	-3.3	159
		Summer (JJA)	0.7	7.1	0.7	10.3	0.8	3.9	1.1 - 1.3	0.00	4.2	-0.03	0.0 - 0.1	-9.1	206
		Fall (SON)	2.8	-9.0	2.6	-5.8	2.8	-12.1	0.6 - 1.0	0.00	3.7	-0.01	0.1 - 0.3	-1.5	37
		Annual	**2.3**	**-12.8**	**2.2**	**-9.3**	**2.3**	**-16.3**	**0.9 - 0.9**	**-0.02**	**3.5**	**0.00**	**0.1 - 0.3**	**-3.5**	**102**
	ECHAM5OM	Winter (DJF)	2.1	-29.6	N/A	N/A	N/A	N/A	0.2 - 0.5	0.06	3.0	N/A	N/A - N/A	0.1	7
		Spring (MAM)	2.4	-18.4	N/A	N/A	N/A	N/A	0.3 - 0.6	0.06	3.4	N/A	N/A - N/A	-8.4	154
		Summer (JJA)	2.1	8.5	N/A	N/A	N/A	N/A	0.9 - 1.0	-0.11	4.1	N/A	N/A - N/A	2.7	218
		Fall (SON)	3.3	-8.4	N/A	N/A	N/A	N/A	0.8 - 1.2	0.03	3.7	N/A	N/A - N/A	-2.7	36
		Annual	**2.5**	**-12.6**	**N/A**	**N/A**	**N/A**	**N/A**	**0.8 - 0.8**	**0.01**	**3.5**	**N/A**	**N/A - N/A**	**-2.1**	**104**
	GFDLCM2.0	Winter (DJF)	3.4	-28.3	N/A	N/A	N/A	N/A	0.3 - 0.5	0.00	2.9	N/A	N/A - N/A	-0.1	7
		Spring (MAM)	3.5	-17.3	N/A	N/A	N/A	N/A	0.4 - 0.7	0.00	3.3	N/A	N/A - N/A	-5.9	156
		Summer (JJA)	1.0	7.4	N/A	N/A	N/A	N/A	1.1 - 1.3	0.00	4.2	N/A	N/A - N/A	-17.4	198
		Fall (SON)	3.9	-7.9	N/A	N/A	N/A	N/A	0.8 - 1.1	0.07	3.8	N/A	N/A - N/A	-1.6	37
		Annual	**3.0**	**-12.1**	**N/A**	**N/A**	**N/A**	**N/A**	**0.9 - 0.9**	**0.02**	**3.5**	**N/A**	**N/A - N/A**	**-6.3**	**100**
	HADCM3	Winter (DJF)	3.4	-28.4	N/A	N/A	N/A	N/A	0.3 - 0.5	-0.07	2.8	N/A	N/A - N/A	-0.1	7
		Spring (MAM)	2.6	-18.2	N/A	N/A	N/A	N/A	0.4 - 0.7	-0.10	3.2	N/A	N/A - N/A	-5.8	156
		Summer (JJA)	2.2	8.6	N/A	N/A	N/A	N/A	1.0 - 1.2	0.03	4.2	N/A	N/A - N/A	-9.5	206
		Fall (SON)	3.3	-8.4	N/A	N/A	N/A	N/A	0.8 - 1.1	-0.12	3.6	N/A	N/A - N/A	-2.5	36
		Annual	**2.9**	**-12.2**	**N/A**	**N/A**	**N/A**	**N/A**	**0.9 - 0.9**	**-0.07**	**3.4**	**N/A**	**N/A - N/A**	**-4.5**	**101**
	NCARCCSM	Winter (DJF)	4.6	-27.1	N/A	N/A	N/A	N/A	0.3 - 0.5	N/A	N/A	0.00	0.2 - 0.5	-0.1	7
		Spring (MAM)	2.5	-18.3	N/A	N/A	N/A	N/A	0.4 - 0.7	N/A	N/A	0.00	0.2 - 0.6	-5.0	157
		Summer (JJA)	1.3	7.7	N/A	N/A	N/A	N/A	1.2 - 1.4	N/A	N/A	-0.03	0.0 - 0.1	-18.9	196
		Fall (SON)	4.3	-7.4	N/A	N/A	N/A	N/A	0.9 - 1.3	N/A	N/A	-0.02	0.1 - 0.3	-5.0	34
		Annual	**3.2**	**-11.9**	**N/A**	**N/A**	**N/A**	**N/A**	**1.0 - 1.0**	**N/A**	**N/A**	**-0.01**	**0.1 - 0.3**	**-7.3**	**99**

NOTE(S):

1. FORECAST VALUES = HISTORICAL CLIMATE MEASUREMENTS + GLOBAL CLIMATE MODEL PREDICTED CHANGES.

Table 5-1.4 Climate Forecasts - 2071 to 2100 (2080s)

Scenario	Model	Season	Temperature – Mean: GCM Predicted Change (°C)	Temperature – Mean: Forecast Mean (°C)	Temperature – Mean Daily Max: GCM Predicted Change (°C)	Temperature – Mean Daily Max: Forecast Mean Daily Maximum (°C)	Temperature – Mean Daily Min: GCM Predicted Change (°C)	Temperature – Mean Daily Min: Forecast Mean Daily Minimum (°C)	Precipitation: Forecast Precipitation (mm/d)	Wind: GCM Predicted Change (m/s)	Wind: Forecast Mean Wind Speed (m/s)	Snow Depth: GCM Predicted Change (m)	Snow Depth: Forecast Average Snow Depth (m)	Solar Radiation: GCM Predicted Change (W/m²)	Solar Radiation: Forecast Solar Radiation (W/m²)
A2	CGCM3T47	Winter (DJF)	8.7	-23.0	8.7	-19.4	8.6	-26.6	0.4 - 0.6	0.15	3.1	0.02	0.2 - 0.5	-0.4	7
		Spring (MAM)	4.8	-16.0	4.1	-12.5	5.2	-19.5	0.4 - 0.7	-0.12	3.2	0.05	0.3 - 0.6	-7.6	155
		Summer (JJA)	2.4	8.8	2.5	12.1	2.5	5.6	1.1 - 1.2	0.00	4.2	-0.06	0.0 - 0.1	-18.5	197
		Fall (SON)	7.1	-4.6	6.6	-1.9	7.6	-7.4	0.9 - 1.3	-0.17	3.5	-0.04	0.1 - 0.2	-2.4	36
		Annual	**5.8**	**-9.3**	**5.5**	**-6.0**	**6.0**	**-12.6**	**1.0 - 1.0**	**-0.03**	**3.5**	**-0.01**	**0.1 - 0.3**	**-7.3**	**99**
	ECHAM5OM	Winter (DJF)	7.8	-23.9	N/A	N/A	N/A	N/A	0.4 - 0.6	0.11	3.0	N/A	N/A - N/A	-0.2	7
		Spring (MAM)	5.4	-15.3	N/A	N/A	N/A	N/A	0.6 - 0.9	0.03	3.3	N/A	N/A - N/A	-20.3	142
		Summer (JJA)	3.6	10.0	N/A	N/A	N/A	N/A	0.9 - 1.0	-0.01	4.2	N/A	N/A - N/A	-0.8	215
		Fall (SON)	7.3	-4.4	N/A	N/A	N/A	N/A	1.1 - 1.5	-0.18	3.5	N/A	N/A - N/A	-6.3	32
		Annual	**6.1**	**-9.0**	**N/A**	**N/A**	**N/A**	**N/A**	**1.0 - 1.0**	**-0.01**	**3.5**	**N/A**	**N/A - N/A**	**-6.9**	**99**
	GFDLCM2.0	Winter (DJF)	6.8	-24.9	N/A	N/A	N/A	N/A	0.4 - 0.6	0.00	2.9	N/A	N/A - N/A	-0.3	7
		Spring (MAM)	5.7	-15.1	N/A	N/A	N/A	N/A	0.4 - 0.7	-0.04	3.3	N/A	N/A - N/A	-14.6	148
		Summer (JJA)	2.1	8.5	N/A	N/A	N/A	N/A	0.9 - 1.1	0.02	4.2	N/A	N/A - N/A	-37.1	178
		Fall (SON)	6.5	-5.3	N/A	N/A	N/A	N/A	0.8 - 1.2	0.07	3.8	N/A	N/A - N/A	-3.6	35
		Annual	**5.3**	**-9.8**	**N/A**	**N/A**	**N/A**	**N/A**	**0.9 - 0.9**	**0.01**	**3.5**	**N/A**	**N/A - N/A**	**-14.0**	**92**
	HADCM3	Winter (DJF)	N/A	N/A	N/A	N/A	N/A	N/A	0.4 - 0.7	-0.04	2.9	N/A	N/A - N/A	-0.2	7
		Spring (MAM)	N/A	N/A	N/A	N/A	N/A	N/A	1.0 - 1.2	-0.17	3.1	N/A	N/A - N/A	-13.4	149
		Summer (JJA)	N/A	N/A	N/A	N/A	N/A	N/A	1.0 - 1.2	0.07	4.3	N/A	N/A - N/A	-15.9	199
		Fall (SON)	N/A	N/A	N/A	N/A	N/A	N/A	0.6 - 1.0	-0.13	3.6	N/A	N/A - N/A	-7.3	31
		Annual	**6.6**	**-8.5**	**N/A**	**N/A**	**N/A**	**N/A**	**1.0 - 1.0**	**-0.07**	**3.4**	**N/A**	**N/A - N/A**	**-9.2**	**97**
	NCARCCSM	Winter (DJF)	13.5	-18.2	N/A	N/A	N/A	N/A	0.5 - 0.7	N/A	N/A	0.00	0.2 - 0.5	-0.4	7
		Spring (MAM)	6.1	-14.7	N/A	N/A	N/A	N/A	0.4 - 0.7	N/A	N/A	0.01	0.2 - 0.6	-14.0	148
		Summer (JJA)	3.3	9.7	N/A	N/A	N/A	N/A	1.5 - 1.6	N/A	N/A	-0.05	0.0 - 0.1	-40.2	175
		Fall (SON)	9.9	-1.8	N/A	N/A	N/A	N/A	1.2 - 1.5	N/A	N/A	-0.03	0.1 - 0.2	-10.5	28
		Annual	**8.2**	**-6.9**	**N/A**	**N/A**	**N/A**	**N/A**	**1.2 - 1.2**	**N/A**	**N/A**	**-0.02**	**0.1 - 0.3**	**-16.4**	**89**
B1	CGCM3T47	Winter (DJF)	4.4	-27.3	4.5	-23.7	4.4	-30.9	0.2 - 0.5	0.17	3.1	0.01	0.2 - 0.5	-0.2	7
		Spring (MAM)	2.4	-18.4	2.1	-14.5	2.5	-22.2	0.5 - 0.8	-0.02	3.3	0.01	0.2 - 0.6	-3.6	159
		Summer (JJA)	1.3	7.7	1.2	10.8	1.3	4.4	1.1 - 1.3	-0.20	4.0	-0.04	0.0 - 0.1	-11.8	204
		Fall (SON)	4.2	-7.5	3.9	-4.6	4.4	-10.5	0.6 - 0.9	0.04	3.7	-0.03	0.1 - 0.2	-1.6	37
		Annual	**3.1**	**-12.0**	**2.9**	**-8.6**	**3.2**	**-15.4**	**0.9 - 0.9**	**0.00**	**3.5**	**-0.01**	**0.1 - 0.3**	**-4.3**	**102**
	ECHAM5OM	Winter (DJF)	4.5	-27.2	N/A	N/A	N/A	N/A	0.2 - 0.5	0.15	3.0	N/A	N/A - N/A	0.0	7
		Spring (MAM)	3.8	-17.0	N/A	N/A	N/A	N/A	0.5 - 0.8	-0.02	3.3	N/A	N/A - N/A	-11.5	151
		Summer (JJA)	2.2	8.6	N/A	N/A	N/A	N/A	0.9 - 1.1	-0.04	4.2	N/A	N/A - N/A	-0.3	215
		Fall (SON)	5.1	-6.6	N/A	N/A	N/A	N/A	1.0 - 1.4	-0.12	3.6	N/A	N/A - N/A	-3.9	35
		Annual	**3.9**	**-11.2**	**N/A**	**N/A**	**N/A**	**N/A**	**0.9 - 0.9**	**-0.01**	**3.5**	**N/A**	**N/A - N/A**	**-4.0**	**102**
	GFDLCM2.0	Winter (DJF)	4.9	-26.9	N/A	N/A	N/A	N/A	0.3 - 0.5	-0.04	2.9	N/A	N/A - N/A	-0.2	7
		Spring (MAM)	4.4	-16.3	N/A	N/A	N/A	N/A	0.4 - 0.7	-0.09	3.2	N/A	N/A - N/A	-9.9	152
		Summer (JJA)	1.6	8.0	N/A	N/A	N/A	N/A	1.0 - 1.2	0.07	4.3	N/A	N/A - N/A	-24.7	191
		Fall (SON)	5.7	-6.0	N/A	N/A	N/A	N/A	0.8 - 1.2	0.09	3.8	N/A	N/A - N/A	-2.7	36
		Annual	**4.2**	**-10.9**	**N/A**	**N/A**	**N/A**	**N/A**	**0.9 - 0.9**	**0.01**	**3.5**	**N/A**	**N/A - N/A**	**-9.4**	**96**
	HADCM3	Winter (DJF)	5.0	-26.8	N/A	N/A	N/A	N/A	0.3 - 0.5	-0.07	2.8	N/A	N/A - N/A	-0.1	7
		Spring (MAM)	4.1	-16.7	N/A	N/A	N/A	N/A	0.5 - 0.8	-0.20	3.1	N/A	N/A - N/A	-9.7	152
		Summer (JJA)	2.5	8.9	N/A	N/A	N/A	N/A	1.1 - 1.2	0.02	4.2	N/A	N/A - N/A	-13.5	202
		Fall (SON)	4.3	-7.4	N/A	N/A	N/A	N/A	0.8 - 1.2	-0.07	3.6	N/A	N/A - N/A	-4.8	34
		Annual	**4.0**	**-11.1**	**N/A**	**N/A**	**N/A**	**N/A**	**0.9 - 0.9**	**-0.08**	**3.4**	**N/A**	**N/A - N/A**	**-7.0**	**99**
	NCARCCSM	Winter (DJF)	5.6	-26.1	N/A	N/A	N/A	N/A	0.3 - 0.6	N/A	N/A	0.00	0.2 - 0.5	-0.2	7
		Spring (MAM)	2.7	-18.1	N/A	N/A	N/A	N/A	0.3 - 0.6	N/A	N/A	0.00	0.2 - 0.6	-7.0	155
		Summer (JJA)	1.6	8.0	N/A	N/A	N/A	N/A	1.1 - 1.3	N/A	N/A	-0.03	0.0 - 0.1	-21.2	194
		Fall (SON)	4.8	-6.9	N/A	N/A	N/A	N/A	0.9 - 1.3	N/A	N/A	-0.02	0.1 - 0.3	-5.3	33
		Annual	**3.7**	**-11.4**	**N/A**	**N/A**	**N/A**	**N/A**	**0.9 - 0.9**	**N/A**	**N/A**	**-0.01**	**0.1 - 0.3**	**-8.5**	**97**

NOTE(S):
1. FORECAST VALUES = HISTORICAL CLIMATE MEASUREMENTS + GLOBAL CLIMATE MODEL PREDICTED CHANGES.

Table 5-1.5 Summary of Climate Forecasts

		Temperature			Precipitation	Wind	Snow Depth	Solar Radiation
	Season	Forecast Mean (°C)	Forecast Mean Daily Maximum (°C)	Forecast Mean Daily Minimum (°C)	Forecast Precipitation (mm/d)	Forecast Mean Wind Speed (m/s)	Forecast Average Snow Depth (m)	Forecast Solar Radiation (W/m^2)
2011 to 2040	Winter (DJF)	-31.9 - -27.5	-26.6 - -26.5	-33.9 - -33.6	0.2 - 0.9	2.8 - 3.1	0.2 - 0.5	7 - 7
	Spring (MAM)	-19.7 - -18.6	-15.4 - -15.3	-23.5 - -23.1	0.3 - 1.3	3.2 - 3.3	0.2 - 0.6	157 - 161
	Summer (JJA)	7.0 - 7.8	10.2 - 10.2	3.7 - 3.7	0.4 - 1.2	4.1 - 4.3	0.0 - 0.1	199 - 222
	Fall (SON)	-10.0 - -8.1	-6.5 - -6.3	-12.9 - -12.6	0.3 - 1.2	3.6 - 3.7	0.1 - 0.3	35 - 38
	Annual	**-14.1 - -12.3**	**-10.1 - -10.1**	**-17.1 - -17.1**	**0.8 - 0.9**	**3.4 - 3.5**	**0.1 - 0.3**	**100 - 106**
2041 to 2070	Winter (DJF)	-29.6 - -23.6	-24.7 - -22.9	-32.0 - -30.1	0.2 - 1.1	2.8 - 3.0	0.2 - 0.5	7 - 7
	Spring (MAM)	-17.7 - -17.0	-14.7 - -13.9	-22.6 - -21.3	0.3 - 0.8	3.1 - 3.4	0.2 - 0.6	153 - 159
	Summer (JJA)	7.1 - 8.6	10.3 - 11.2	3.9 - 4.7	0.4 - 1.4	4.1 - 4.3	0.0 - 0.1	189 - 218
	Fall (SON)	-9.0 - -5.7	-5.8 - -4.3	-12.1 - -10.1	0.6 - 1.4	3.6 - 3.8	0.1 - 0.3	32 - 37
	Annual	**-12.8 - -10.2**	**-9.3 - -8.0**	**-16.3 - -14.8**	**0.8 - 1.0**	**3.4 - 3.5**	**0.1 - 0.3**	**95 - 104**
2071 to 2100	Winter (DJF)	-27.3 - -18.2	-23.7 - -19.4	-30.9 - -26.6	0.2 - 0.7	2.8 - 3.1	0.2 - 0.5	7 - 7
	Spring (MAM)	-18.4 - -14.7	-14.5 - -12.5	-22.2 - -19.5	0.3 - 1.2	3.1 - 3.3	0.2 - 0.6	142 - 159
	Summer (JJA)	7.7 - 10.0	10.8 - 12.1	4.4 - 5.6	0.9 - 1.6	4.0 - 4.3	0.0 - 0.1	175 - 215
	Fall (SON)	-7.5 - -1.8	-4.6 - -1.9	-10.5 - -7.4	0.6 - 1.5	3.5 - 3.8	0.1 - 0.3	28 - 37
	Annual	**-12.0 - -6.9**	**-8.6 - -6.0**	**-15.4 - -12.6**	**0.9 - 1.2**	**3.4 - 3.5**	**0.1 - 0.3**	**89 - 102**

NOTE(S):

1. FORECAST VALUES = HISTORICAL CLIMATE MEASUREMENTS + GLOBAL CLIMATE MODEL PREDICTED CHANGES.

1.2.3.4 Long-term Wind Speed Trends

Wind speed is highly dependent on many factors including topography, pressure gradients, local weather conditions, etc. The GCM predicted change in annual mean wind speed, shown in Figure 5-1.3, shows inconsistencies between the predicted trends; the upper range of predictions indicates that wind speed will increase while the lower range indicates that wind speed will decrease over the next century. However, overall wind speed is predicted to change only slightly.

As wind speed is dependent on numerous factors, the GCMs ability to accurately predict changes in wind speed for future periods is questionable.

1.2.3.5 Long-term Snow Depth Trends

As shown in Figure 5-1.4, annual average snow depth is predicted to remain fairly constant over the next century.

1.2.3.6 Long-term Solar Radiation Trends

As shown in Figure 5-1.5, annual average solar radiation is predicted to decrease over the next century by approximately 3 W/m^2 (low range) to 16 W/m^2 (high range) on an annual average. Confidence in these results is achieved through studying the relationship between precipitation and solar radiation. As precipitation increases, cloud cover also increases, leading to a decrease in solar radiation. As shown in Figures 5-1.2 and 5-1.5, the increase in precipitation seems to coincide with the decrease in solar radiation.

1.2.3.7 Changes to Sea Ice Conditions

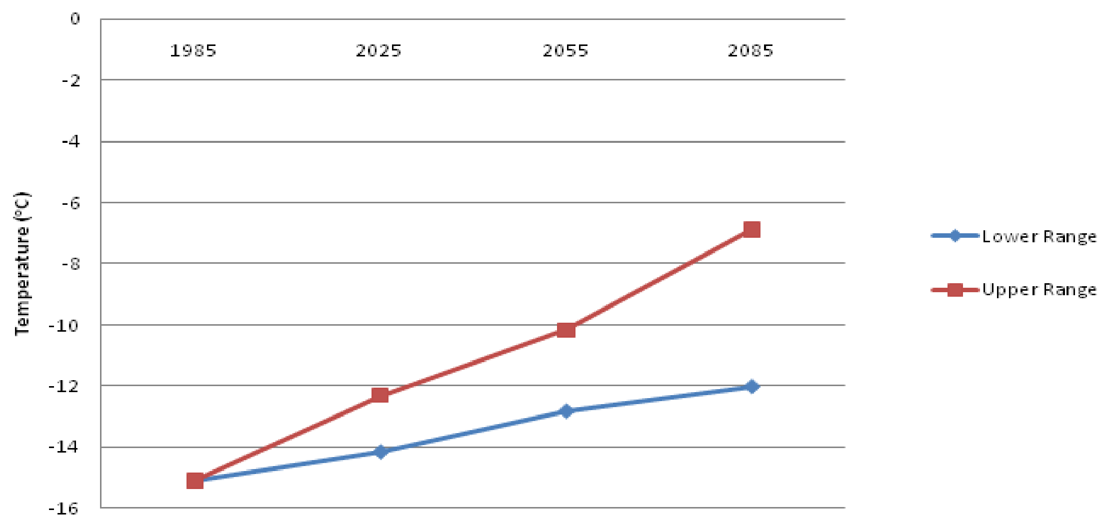
As global temperatures rise, sea ice is generally forming later and clearing earlier in the year. Current Arctic sea ice extent in March is approximately 14 million km^2 but will reduce by about 2 - 4 million km^2 by 2100. Current Arctic sea ice extent in September (when ice over is at its minimum) ranges from about 5 to 6 million km^2 (Arctic Council and International Arctic Science Committee, 2005).

The loss of sea ice could increase atmospheric humidity, cloudiness and precipitation, and decrease natural habitat used by marine mammals. Worst-case scenarios suggest that whole populations may be threatened by the changes, depending on how the animals adapt. Sea ice reduction could have a positive effect on navigation through the Northwest and Northeast Passages, and may increase commercial shipping, transportation of unprocessed mineral resources, and tourism (Arctic Council and International Arctic Science Committee, 2005). It is expected that the changes in sea ice-cover due to climate change will not significantly affect the shipping operations in the Foxe Basin (Volume 3, Appendix 3G). Appendix 3F-1 and Volume 8, Section 2, provide additional discussion on sea ice conditions.

1.2.3.8 Changes in Sea Levels

Sea level has risen about 120 m over the past 20,000 years; the current rate of sea level rise is close to 2 mm/year (Arctic Council and International Arctic Science Committee, 2005). The models used by ACIA predict that sea level in the Arctic will rise between 0.11 and 0.77 m by 2100. Tarbuck and Lutgens (2002) predict a total sea level rise of 0.49 m.

Predicted Annual Mean Daily Temperature



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

PREDICTED ANNUAL MEAN TEMPERATURE

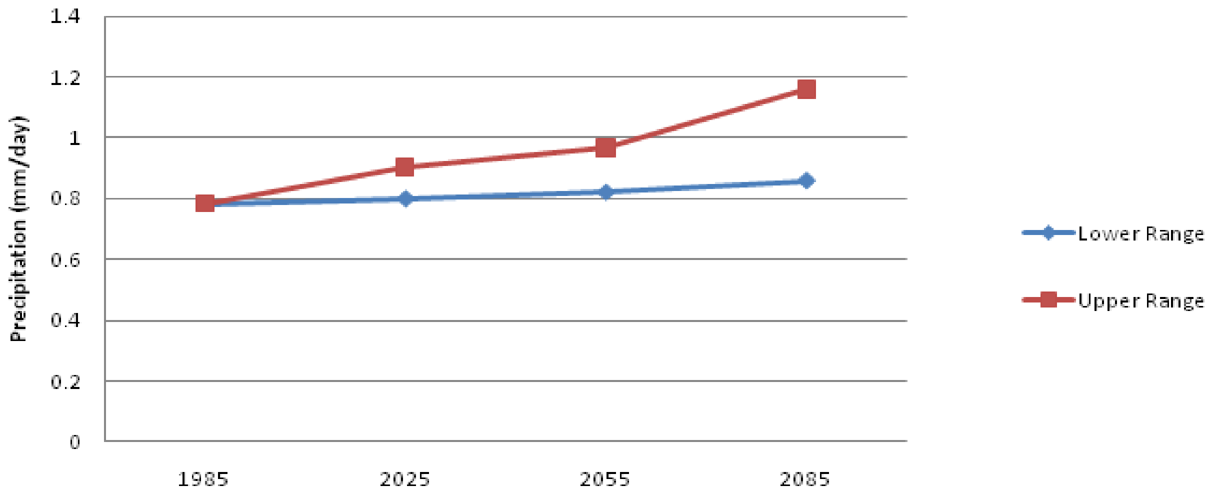
RWDI

P/A NO.	REF. NO.
NB1	1

FIGURE 5-1.1 REV #

#	DDMMM'YY	ISSUED WITH <Doc>	-	-	-
REV	2/12/2010	DESCRIPTION	PREP'D	CHK'D	APP'D

Predicted Annual Mean Daily Precipitation



#	DDMMM'Y	ISSUED WITH <Doc>	-	-	-
REV	2/12/2010	DESCRIPTION	PREP'D	CHK'D	APP'D

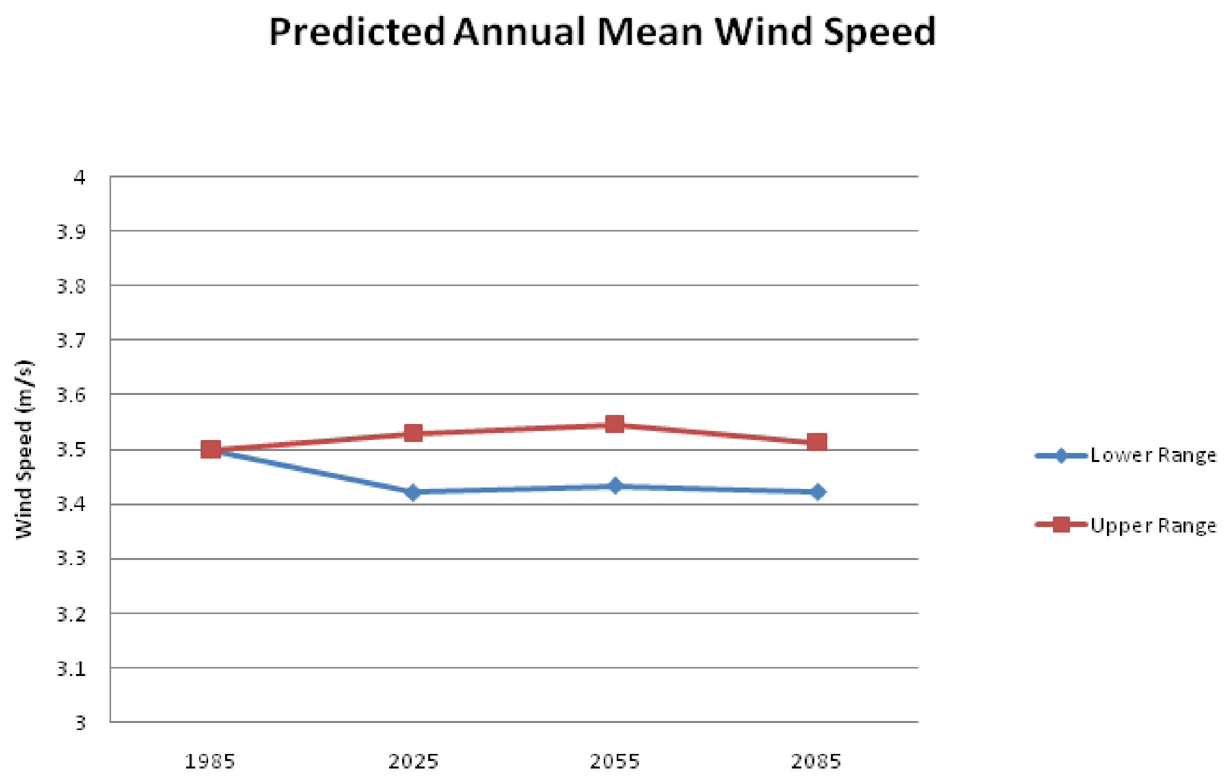
BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

PREDICTED ANNUAL MEAN DAILY PRECIPITATION

RWDI

P/A NO.	REF. NO.
NB101-1/1	1

FIGURE 5-1.2 REV #



#	DDMMM'Y	ISSUED WITH <Doc>	-	-	-
REV	2/12/2010	DESCRIPTION	PREP'D	CHK'D	APP'D

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

PREDICTED ANNUAL MEAN WIND SPEED

RWDI

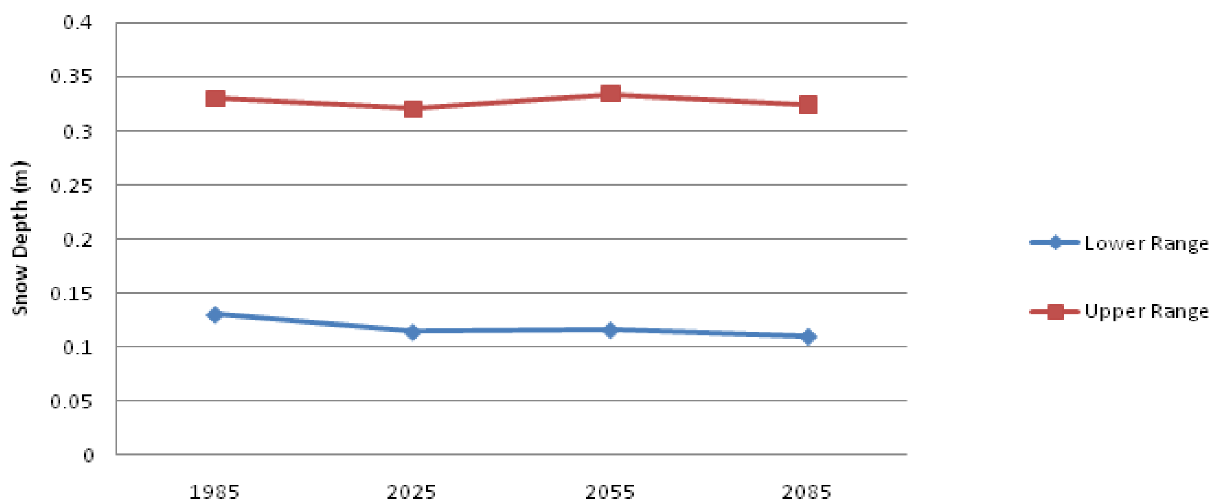
P/A NO. NB101-1/1

REF. NO. 1

FIGURE 5-1.3

REV #

Predicted Annual Average Snow Depth



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

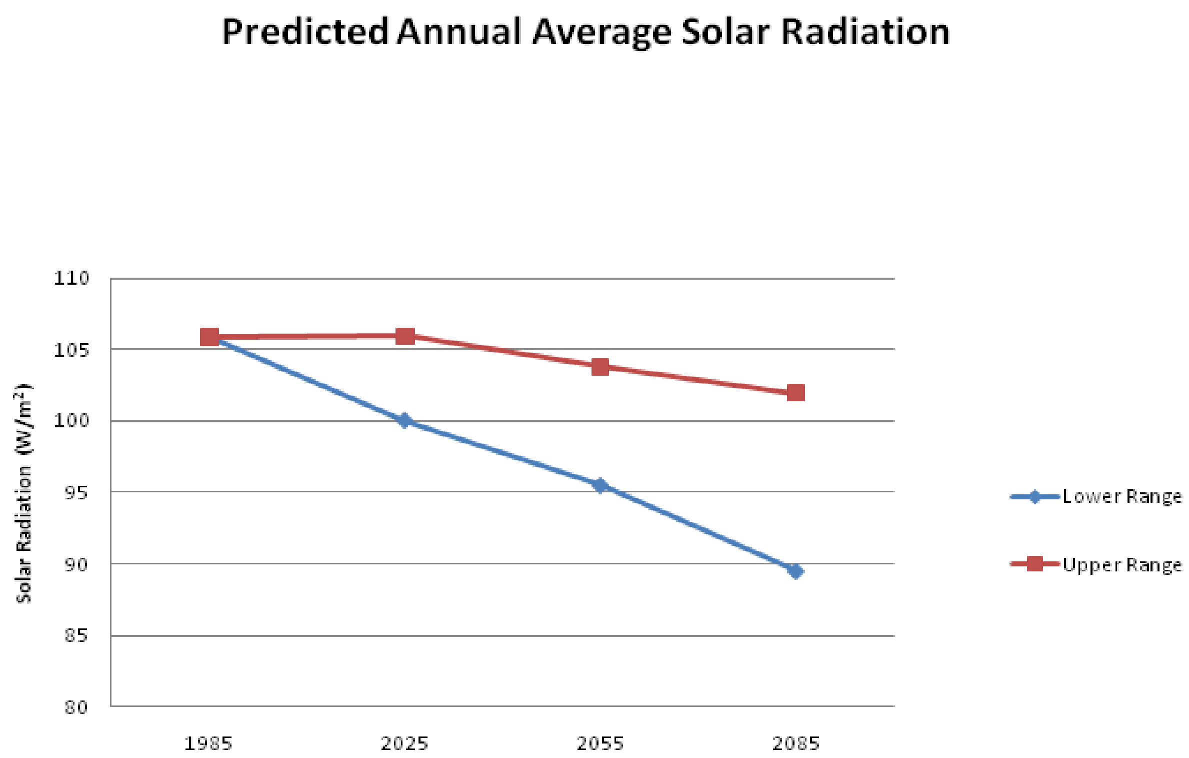
PREDICTED ANNUAL AVERAGE SNOW DEPTH

RWDI

P/A NO.	REF. NO.
NB101-1/1	1

FIGURE 5-1.4 REV #

#	DDMMM'Y	ISSUED WITH <Doc>	-	-	-
REV	2/12/2010	DESCRIPTION	PREP'D	CHK'D	APP'D



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

PREDICTED ANNUAL AVERAGE SOLAR RADIATION

RWDI

P/A NO. NB101 | REF. NO. 1

FIGURE 5-1.5 | REV #

#	DDMMM'YY	ISSUED WITH <Doc>	-	-	-
REV	2/12/2010	DESCRIPTION	PREP'D	CHK'D	APP'D

Climate change will affect sea levels at Milne Port but will not be an issue as the water in Milne Port, Eclipse Sound and Baffin Bay is very deep; this will not affect the Project. The docks, designed to accommodate tide changes and storm surges, can accommodate the predicted sea level rise. The Steensby Port facility is situated in an area of falling sea level. While Arctic sea levels are generally expected to rise, the rate of isostatic rebound in Steensby Port is greater than the rate of sea level rise.

Two studies on isostatic rebound have been done in Igloolik. The rate of rebound was estimated by carbon-dating the material on raised beaches that were once at sea level and measuring its current elevation. In a study by Dredge (1991), isostatic rebound was estimated to be occurring at a rate of 1.3 to 1.5 m per 100 years, and a study by Blackadar (1958) estimated at a rate of 1.4 m per 100 years. Natural Resources Canada modeled the vertical crustal motion using various generations of the ICE-X model (most recent is ICE-5G; Peltier, 2004). The models show that Steensby Bay has been experiencing uplift at rates of 0.6-0.7 m per 100 years over the past 500 years, based on an analysis of Peltier's ICE-5G (1.2) VM2 data.

A predicted sea level rise rate between 0.11 m and 0.77 m per year and a predicted isostatic rebound rate between 0.6 m and 1.5 m per year was used to predict the change in sea level. When considering the maximum isostatic rebound and the *minimum* sea level rise, the sea level is predicted to fall 1.39 m by the year 2100. When considering the *minimum* isostatic rebound and the maximum sea level rise, the sea level is predicted to rise by 0.17 m by the year 2100. It should be noted that Steensby Port is an area of falling sea level and will most likely continue this trend. Over the 28-year span of the project, the sea level will either fall by 0.39 m or rise by 0.05 m. The Project has accounted for this potential change and has ensured sufficient clearance along the shipping route and at the dock. As part of the Project, Baffinland has committed to install tide gauges at Steensby Port to monitor relative sea level and storm surges. In addition, continuous GPS or similar method will be installed at port sites to monitor vertical motion and constrain uplift estimates.

1.2.3.9 Climate Change Effects to Evaporation and Moisture

CICS models predict annual average evaporation around the Mary River Project to increase by up to 0.1 mm/day by 2020, 0.17 mm/day by 2050 and 0.20 mm/day by 2080 (University of Victoria, 2007). The resulting evaporations in 2020, 2050 and 2080 will be 0.50 mm/day, 0.57 mm/day and 0.60 mm/day respectively (University of Victoria, 2007).

Moisture input is defined as the difference between precipitation and evapotranspiration/sublimation (Arctic Council and International Arctic Science Committee, 2005). Current moisture input over the much of the Arctic Ocean varies between about 0.35 and 0.49 mm/day, but could be as little as 0.21 mm/day near Greenland and as much as 1.31 mm/day near the North Atlantic. Precipitation and evaporation around the Mary River Project will increase, resulting in minimal change to the overall moisture input. The annual average moisture input around the Mary River Project will stay relatively constant, approximately 0.59 mm/day, from the model-predicted baseline through all three time slices.

1.2.3.10 Climate Change Effects to Permafrost

Arctic snow cover, excluding permanently glaciated areas, varies from less than 1 million km^2 in August to 40 to 50 million km^2 in February. Models predict that changes in mean annual snow cover across the entire Arctic will range from -9 to -18 % by the 2080s; this could affect permafrost by increasing soil temperature, active layer depth and surface runoff (Arctic Council and International Arctic Science Committee, 2005).

Permafrost underlies 15-20 million km^2 (13-18 %) of exposed land area in the Northern Hemisphere (Arctic Council and International Arctic Science Committee, 2005). In the Canadian High Arctic, the zone of continuous permafrost is predicted to be reduced in area by 18, 29, and 41 % by 2030, 2050, and 2080, respectively (Arctic Council and International Arctic Science Committee, 2005). The Mary River Project will remain within the zone.

Active layer depth ranges from tens of centimetres to 2 m (Arctic Council and International Arctic Science Committee, 2005). Widespread increases in active layer depth are projected over most permafrost regions; more than 50 % are predicted for the Canadian High Arctic (Arctic Council and International Arctic Science Committee, 2005).

Permafrost is a landform sensitive to climate change (Arctic Council and International Arctic Science Committee, 2005). Effects to permafrost include changes to drainage patterns resulting from subsidence and thermokarst formation, increased sediment loadings and mass wasting on slopes. Baffinland has committed to undertake thermal modelling to determine whether the proposed design of the waste rock stockpile would maintain a suitable permafrost barrier and prevent shallow subsurface seepage to the surrounding environment.

1.2.3.11 Discussion of Uncertainty

Forecasts of climate change are inevitably imprecise because of uncertain input data and the inability of climate models to span the full range of known climate system behaviour. The major uncertainty is the assumption that the future climate system will behave in the same way that it currently does, an assumption inherent in all GCMs. Climate models are, however, our best available tools for predicting future trends as well as future changes through comparative simulations. Also, confidence in GCM predictions for individual climate variables can be achieved through the validation of past trends.

1.2.4 Extreme Events Analysis

Extreme weather event analysis is of particular interest in climate change assessments; however, these events, and the change in frequency of these events, are typically the most difficult to predict. A published statistical analysis has been used to predict the change in frequency of future extreme events. This method relies on historical data to forecast trends. As with any forecast, the further into the future the prediction, the more uncertain the result. The extreme temperature analysis is described below.

1.2.4.1 Extreme Temperature Analysis

The design of load-bearing structures such as footings is based on freeze-thaw indices. In calculating these indices, it is important to have an understanding of extreme temperature events, including return periods. A return period is the frequency with which you would expect, on average, a given maximum or minimum temperature to occur. For example, a maximum temperature of 16°C with a 2-year return period means that at that location, a 16°C temperature event can be expected to occur once every two years. Kharin *et al*. (2007) provide an extensive analysis of temperature extremes for the IPCC AR4 SRES scenarios B1, A1B, and A2. The reference period is 1981 – 2000; future scenarios were run for 2046 - 2065 and 2081 - 2100. The authors provide global maps, regional averages, and zonal averages (by latitude) of 20-year return periods. While longer return periods are desirable for many engineering applications, they point out that longer return periods would be associated with very large uncertainties because of the short 20-year model periods and the non-stationarity of the time series (quickly increasing temperatures over a few decades).

Table 5-1.6 shows predicted future changes of the 20-year return extreme minimum and maximum temperatures for the 2046 - 2065 and 2086 - 2100 periods. Shown are 50 % inter-model ranges for the zonal averages at 70°N for the SRES A1B scenario. The ranges agree with other values that are available in Kharin *et al*. (2007) from contours of global maps over northern Baffin Island and regional averages for the Arctic. For the period 2046 - 2065, temperature predictions for A1B and A2 are very similar, because until mid-century, the higher sulfate aerosol emissions of the A2 scenario offset the additional warming from higher GHG emissions than the A1B scenario. Kharin *et al*. (2007) only provide the median of the A2 scenario, which is roughly equal to the upper limit of the A1B 50 % inter-model range in 2086-2100. For the A1B scenario, the 20-year return maximum temperature in the project region is predicted to increase by about 1 to 3°C (global average 1.7°C) by 2046 - 2065 and by 2 to 4°C by 2086 - 2100. The minimum temperature is predicted to increase by about 4 to 6°C (global average 2.3°C) and 6 to 10°C, respectively.

Table 5-1.6 20-Year Return Extreme Minimum and Maximum Temperatures (in °C) Calculated from 1976-2006 Observations and Predicted Changes (in °C) for SRES A1B Emissions Scenario Relative to 1981-2000

Period	Minimum Temperature	Maximum Temperature
	Observed[1]	
1976-2006	-50.8	21.4
	Predicted Change[2]	
2046-2065	+4 to +6	+1 to +3
2081-2100	+6 to +10	+2 to +4

Notes:
[1]Values for Pond Inlet station based on a minimum least-squares best fit of a Fisher-Tippet type I distribution to annual minimum and maximum temperatures based on hourly observations.

[2]Values from figures in Kharin *et al*. (2007): based on 50 % inter-model range of 70°N zonal averages in Figure 11 in agreement with contours over northern Baffin Island in Figure 9 (top) and the Arctic regional average in Figure 12 (top).

The 20-year return maximum temperature of the 1981 - 2000 reference period over northern Baffin Island is predicted to occur roughly every 3 to 10 years during the period 2046 - 2065. This is substantially longer than the global average of 1.5 years. The 20-year return minimum temperature of the reference period 1981 - 2000 is predicted to occur basically never in northern Baffin Island and in global average after the mid-21st century.

It must be kept in mind that northern Baffin Island is located in a region of large modelling uncertainties. It is possible that estimates of extreme temperatures will change in future model runs with improvements in the sea-ice representation and the availability of longer observational time series for model calibration. For example, observations over the last one to two decades have shown quickly decreasing summer sea-ice over much of the Arctic, but not near Baffin Island. Over that period, the prevalent wind patterns have been driving sea-ice away from the East Siberian Sea and Chukchi Sea into the Canadian Archipelago. A change of wind patterns in association with continued warming in the Arctic could potentially expose sea water for a much longer time, and the positive albedo and moisture feedback might lead to much stronger regional warming in northern Baffin Island than predicted by the IPCC AR4 model runs.

1.2.5 Conclusion

The GCMs predicted an increase in temperature, precipitation and, extreme temperature events, with no significant change in wind speed or snow depth, and a decrease in solar radiation.

Sea ice is generally forming later and clearing earlier in the year as global temperatures rise. The Steensby Port facility is situated in an area of falling sea level; the rate of isostatic rebound is greater than the rate of sea level rise. Annual average evaporation around the Mary River Project is predicted to increase. The permafrost active layer depth is projected to increase by 50 %.

In general, GCM predictions replicated historical temperature and precipitation trends fairly well. Beyond these two weather variables, the confidence in future predictions tend to decrease. As well, there is greater certainty in climate predictions for the 2025 period than for the climate predictions forecasted out 100 years.

Potential climate change implications for the stability and safety of infrastructures on hydrology and permafrost have been identified as engineering hazards in Volume 9, Section 2.2.

1.3 GREENHOUSE GAS EMISSIONS ESTIMATED FOR THE PROJECT

Understanding a project's greenhouse gas (GHG) footprint is important to stakeholders. An evaluation of the Project's GHG emissions is provided in Appendix 5B. The Mining Association of Canada's (2009) categorization of GHG emissions has been adopted:

- Scope 1 emissions - direct emissions by equipment owned or controlled by the company;
- Scope 2 emissions - emissions from purchased electricity; not applicable to the Project; and
- Scope 3 emissions - emissions from related upstream and downstream activities, such as air travel and shipping.

Key facts related to the Project's GHG emissions are summarized below:

- The Project will generate about 12.4 Mt CO_2 eq of Scope 1 emissions over the life of the Project. This equates to an annual average of 0.443 Mt CO_2 eq. An additional 8.6 Mt CO_2 eq of Scope 3 emissions will be generated.
- The emissions intensity from Scope 1 emission sources is 0.0211 Mt CO_2 eq / Mt ore. This is slightly lower than another iron ore mine within Canada (the Carol Mine in Labrador, with 0.0311 Mt CO_2 eq/Mt ore). The emissions estimate for the Mary River Project is lower because of its high grade iron ore requiring no processing; the Carol Mine operates a concentrator/pellet plant.
- The Project will contribute substantially to Nunavut's overall estimated GHG emissions total. Depending on the number used for Nunavut's total emissions (several different totals were identified; see below), the Project will increase the total for Nunavut by 64 % to 123 %.
- The Project's annual GHG emissions represent 1.8 % of the current total GHG emissions from mining in Canada, 0.060 % of Canada's total emissions, and 0.001 % of Global emissions (Appendix 5B).

Several different totals have been reported for Nunavut's annual GHG emissions. Environment Canada (2010a) reports a 2008 total of 0.36 Mt CO_2 eq. The Government of Nunavut (2003) reported 0.696 Mt CO_2 eq for the year 1995, and separately reported annual totals for the years 2000, 2005, 2006 and 2007 ranging from 0.412 Mt CO_2 eq to 0.472 Mt CO_2 eq (Government of Nunavut, undated). The Nunavut (2003) source is thought to be most representative, since the resultant per capita emissions for Nunavut align quite well with estimates for the Northwest Territories and Yukon.

Because of Nunavut's small population and manufacturing base, total GHG emissions are very low. The Project would be the first major mining operation in Nunavut, so annual GHG emissions of the mine would be more than double of total territorial emissions in 2008.

On a national level, the emissions from the project are very small, and compared with global emissions they are insignificant.

1.4 AUTHORS

The climate change forecast was prepared by Nicole Vadori, P.Eng., Senior Air Quality Scientist with RWDI Air Inc. The GHG assessment was prepared by Christian Reuten, Ph.D., of RWDI. Senior review was provided by Alain Carrière, B.A., Dipl. Ecotox (Senior Project Manager) and Mike Lepage, M.Sc., ACM, CCM (Project Director) of RWDI, and Richard Cook, B.Sc. (Senior Scientist) of Knight Piésold Ltd.

SECTION 2.0 - AIR QUALITY (VEC)

The Project is in a remote location with no existing local sources of air pollutants other than exploration facilities at the Mine Site. Contaminants are primarily from industrial and urban areas in North America and Eurasia. Construction and operation of the Project will introduce new, local sources of air contaminants such as particulate matter (TSP, $PM_{10,}$ and $PM_{2.5}$), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and carbon monoxide (CO) to the project area. A reduction in air quality due to these emissions may, in the extreme, result in effects on vegetation or wildlife species, an ecosystem's structure or processes, or human health. These potential effects can result from exposure to ambient air concentrations or from accumulation in, through deposition to, the environment.

This section of the EIS identifies existing air quality conditions in the project area and describes potential effects of the Project on air quality. Potential effects associated with the operation of the mine, under reasonable worst-case operating conditions, were evaluated, and compared to ambient air quality criteria. There are several air quality guidelines specific to Nunavut. National Air Quality Objectives defined under the Canadian Environmental Protection Act (CEPA, 1999) and other criteria were considered in this assessment. The effects of potential air quality changes on other biophysical components, including wildlife, vegetation and human health, are addressed in their respective volumes of the EIS.

2.1 BASELINE SUMMARY

Historically, air quality assessments for new mining operations in the north of Canada have relied on long-term ambient quality data from monitoring stations elsewhere in the north, and site-specific monitoring has not always been conducted. For this study, some ambient monitoring was conducted to assess the background air quality where Project activities will occur. Although the air quality monitoring program provided only a brief snapshot in time, its results are more representative of site-specific background levels than long-term data from the Northwest Territories EPD monitoring stations (e.g., Yellowknife), which are located near human activities that affect the environment.

Local study areas (LSAs) were selected to illustrate the spatial distribution of concentrations and deposition patterns associated with the Project and to represent areas where air quality effects may occur. More specifically, the LSAs were defined so that air quality conditions at the border of the LSAs should be similar with or without the Project (i.e., air contaminant concentrations at the border of the LSAs are anticipated to be at ambient levels). LSAs were established at a distance of 3 km from the established Potential Development Areas (PDAs). PDAs and LSAs are shown on each of the air quality modelling figures presented in this volume.

As concentrations and deposition will tend to be largest nearest to the emissions sources and decrease with increasing distance, a larger regional study area was not specifically included. There are no industrial facilities or major sources of air emissions within 50 km that warrant a regional study of cumulative effects. Any sources beyond this distance would not affect air quality at the Project site.

Ambient air concentrations of selected contaminants were measured in the vicinity of the Mine Site over two weeks in July 2007. Monitoring results are expected to be representative of baseline air quality in the Project area, including the proposed areas of Steensby Port and Milne Port. Air contaminants monitored as part of the program included:

- total suspended particulate (TSP);
- inhalable particulate matter (PM_{10});

- total particulate deposition (dustfall);
- sulphur dioxide (SO_2);
- nitrogen dioxide (NO_2);
- ozone (O_3);
- dust deposition; and
- metals deposition.

The selection of air contaminants considered those typically associated with mining operations and anticipated Project activities. The foregoing list of contaminants was adopted in consultation with Environment Canada (Fox, 2008, Pers. Comm.). The list, as it does not include respirable particulate matter ($PM_{2.5}$) and certain products of combustion (carbon monoxide and various hydrocarbons). These contaminants were excluded from the baseline sampling as the levels were expected to be too low to be measurable. PM_{10} is considered to be an adequate surrogate for respirable particulate matter, while NO_2 and SO_2 are considered to be good markers for combustion emissions.

The July 2007 baseline ambient air quality monitoring program had two components: an active and a passive monitoring program.

- Active Monitoring Program: measured ambient concentrations of TSP. Samples were collected simultaneously from two locations near the Mine Site over 72 hours using battery-powered Airmetrics "MiniVol" samplers. Sampling time was increased from 24 hours to ensure adequate capture of particulate and to increase the accuracy of the measurements, as low particulate levels were anticipated. A DustTrack monitored particulate matter with aerodynamic diameters less than 10 µm (i.e., PM_{10}).

- Passive Sampling Program: collection of SO_2, NO_2, and O_3 samples simultaneously at two different locations near the Mine Site. Passive monitors (duplicate monitors for each contaminant) were installed at each location for 49 days. This program also involved collection of particulate deposition (dustfall), including metals at the same locations also over the same period.

Further details on the monitoring program are provided in the baseline air quality report included as Appendix 5C-1.

Although results did not vary meaningfully between samples, the maximum value was selected as the baseline concentrations to compensate for the relatively short monitoring period. Dust deposition was analyzed for metals (see Appendix 5C-1) with a combination of relatively high content in the ore and a low indicator threshold. Overall baseline results for each parameter, summarized in Tables 5-2.1, 5-2.2, and 5-2.3, are assumed to apply throughout the Project area.

In general, the measured baseline concentrations and metal deposition rates are extremely low compared to values in southern Canada.

An understanding of meteorological conditions in the Project area is necessary to air quality effects assessment. A meteorological baseline report is included in Appendix 5A, and Section 1.1 summarizes the collection of baseline meteorological data at each Project site and the incorporation of long-term meteorological data from regional EC stations. Although these data were not applied directly in the dispersion modelling assessment, they were used as a basis for comparison of the meteorological modelling results.

Table 5-2.1 Measured Baseline Concentrations

Parameter	Baseline Concentration ($\mu g/m^3$)
24-hour TSP	7.0
24-hour PM_{10}	3.8
30-day SO_2	0.262
30-day NO_2	0.188
30-day O_3	52.8

Table 5-2.2 Baseline Dustfall Deposition Rates

Parameter	Baseline Deposition Rate ($mg/100cm^2/30\text{-}day$)
Total Dustfall	0.398

Table 5-2.3 Baseline Metals Deposition Rates for Select Metals

Parameter	Baseline Deposition Rate ($\mu g/100cm^2/30\text{-}day$)
Al	26.9
Co	0.5
Cr	0.3
Fe	30.6
Mg	23.9
Mn	1.7

2.2 ISSUES SCOPING

Table 5-2.4 summarizes the key issues in terms of the Project air emissions. This assessment addresses these issues in either a quantitative or qualitative manner.

Table 5-2.4 Key Issues for Air Quality

Project Phase	Key Issue	Relevance to Project
Construction	Dust emissions and deposition	Vehicle emissions will occur from transportation of materials and workers to the site. Fugitive emissions will result from construction of roads, rail line, and other infrastructure.

Table 5-2.4 Key Issues for Air Quality (Cont'd)

Project Phase	Key Issue	Relevance to Project
Operations	Project effect on ambient SO_2 concentrations	SO_2 is a product of combustion from both stationary and mobile sources that use diesel fuel. While the project will use low sulphur and ultra-low sulphur fuels, some residual sulphur emissions will occur. At sufficiently high levels, SO_2 is known to affect the human respiratory system and also vegetation. The limiting effects, upon which standards in most jurisdictions are based, are the respiratory effects in humans. Recent evidence, for example, includes a study conducted in Hong Kong (Hedley *et al*., 2002) where a major reduction in the sulphur content of fuels has been achieved over a very short time. This has been linked to substantial reductions in health effects (e.g., childhood respiratory disease and all-age mortality). Recent time-series studies on hospital admissions for cardiac disease in Hong Kong and London produced no evidence of a threshold for health effects at 24-hour SO_2 concentrations in the range of 5-40 $\mu g/m^3$ (Wong *et al*., 2002).
	Project effect on ambient NO_2 concentrations	Oxides of nitrogen, including NO_2, are products of combustion, emitted from both stationary and mobile emission sources. The principal potential concern with NO_2 is respiratory and cardiovascular effects in humans. Animal and human experimental studies indicate that NO_2 at short-term concentrations exceeding 200 $\mu g/m^3$ will cause negative health effects. Animal toxicological studies also suggest that long-term exposure to NO_2 at concentrations above current ambient concentrations has adverse effects (WHO, 2005).
	Project effect on ambient CO concentrations	The Project will increase regional carbon monoxide (CO) emissions. Ambient CO concentrations can inhibit the blood's ability to carry oxygen to body tissues, including vital organs.
	Project effect on regional acid deposition	The Project will result in an increase of NO_x and SO_2 emissions. Ambient SO_2 and NO_x form acidifying chemicals in the atmosphere, and they are removed from the atmosphere by wet and dry removal (i.e., deposition) processes. Once removed from the atmosphere and deposited on the ground, the acidifying substances can alter the pH of soil, vegetation and surface water, which can effect the ecosystems. The deposition is represented as sulphur and nitrogen deposition and potential acid input (PAI) loads.

Table 5-2.4 Key Issues for Air Quality (Cont'd)

Project Phase	Key Issue	Relevance to Project
Operations	Project effects on ambient $PM_{2.5}$ concentrations	Respirable particulate matter ($PM_{2.5}$) is contained in dust generated by vehicle traffic and by ore processing and handling. It is also a by-product of fuel combustion. Particulates with aerodynamic diameters less than 2.5 µm ($PM_{2.5}$) are of specific interest because they are linked with adverse human health responses. The range of health effects is broad, but is predominantly to the respiratory and cardiovascular systems. Epidemiological evidence shows adverse effects of PM following both short-term and long-term exposures (WHO, 2005).
	Project effects on O_3	Exposure to ozone concentrations in excess of 160 ug/m^3 over an 8-hour averaging period is associated with physiological and inflammatory lung effects in healthy exercising young adults exposed for periods of 6.6 hours; health effects in children can result in an increase in daily mortality (WHO, 2005). O_3 is not emitted directly. In fact, NO_x emissions will reduce ambient O_3 levels due to reactions with the nitrogen oxide (NO_2) emissions. Given the northerly latitude location, the photochemical production of O_3 due to the project will be negligible and therefore is not addressed.
	Project effect on other products of combustion	In addition to the aforementioned contaminants, combustion sources will also emit various hydrocarbons (volatile organic compounds and polycyclic aromatic hydrocarbons). These substances are associated with various possible health effects in humans, depending on the level of exposure. Past experience with diesel combustion sources has indicated that the impact of these compounds is adequately addressed by using nitrogen dioxide (NO_2) as a marker for all combustion products. Therefore, hydrocarbons were not explicitly analyzed but were considered to be represented by NO_2.
	Project effect on trace contaminants from incineration	Waste incineration is a relatively small combustion source associated with the project, but can produce elevated levels of certain trace contaminants of concern, such as polycyclic aromatic hydrocarbons (PAH), dioxins and furans, acids and trace metals. This can occur if the waste stream and the incinerator are ineffectively managed. Baffinland proposes to select incinerator equipment with a proven track record, implement a waste management plan and implement ongoing training of incinerator personnel. The incinerator will also be well separated from accommodations areas and placed downwind of them with respect to the prevailing wind direction. Given that Baffinland has addressed incinerator emissions through best available mitigation measures, these trace contaminants were not explicitly analyzed.

Table 5-2.4 Key Issues for Air Quality (Cont'd)

Project Phase	Key Issue	Relevance to Project
	Project effect on fugitive dust and metal concentrations and deposition	Metals will be contained within fugitive sources of total suspended particulate (TSP) that will arise mainly from the mining, processing, handling, and storage of the iron ore. The ambient concentrations and deposition of metals was therefore evaluated in addition to dust. TSP deposition is an important consideration in the Arctic, as this process can lead to elevated levels of metals in soil and water. Although baseline air quality in the far north is more typically affected by long range transport than by Arctic sources, the Project and its activities (haul roads, rock handling, etc.) introduce the potential for metal contamination from a local source.
	Project contributions to greenhouse gas emissions	Combustion of hydrocarbons produces carbon dioxide (CO_2), a greenhouse gas. Given the interest in greenhouse gases relative to potential global warming, estimates of emissions are required. Greenhouse gas emissions and climate change issues are discussed in Section 1.3.

Both gaseous and particulate emissions can result in air contaminants (TSP, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO), which can be measured as concentrations contaminant per volume of air ($\mu g/m^3$). The Valued Ecosystem Component and key indicator is air quality, and the above air contaminants are the measurable parameters.

Due to gravitational settling and other influences, TSP can be deposited and potentially accumulate in terrestrial and aquatic systems. Here the contaminant is measured as deposition on a mass per area basis (g/m^2). Depending on the composition of the TSP, this deposition can be of no consequence to the environment. Mining and processing activities can result in the deposition of metals such as iron onto soil, vegetation and water. An evaluation of exposure potential to key vegetation and wildlife species (blueberries and caribou) and the potential for subsequent human uptake is assessed in Volume 6 Appendix 6G. Potential change to water quality resulting from dust deposition is assessed in the water quality effects assessment (Volume 7, Section 3).

2.3 AIR EMISSION SOURCES DURING CONSTRUCTION PHASE

Details of the construction activities at all three sites are provided in the Project Description (Volume 3).

A detailed emissions inventory and dispersion modelling assessment was not conducted for the Construction Phase because of its intermittent and temporary nature. Potential air quality effects were therefore assessed qualitatively based on previous testing and some ambient monitoring that was conducted August 31 to September 23, 2007, at Milne Port during the preparation for bulk sampling (Appendix 5C-2) . Activities at that time included a sealift and ancillary equipment operations including cranes, barges, a tugboat and front-end loaders; other activities included five to seven aircraft flights a day, light-duty vehicle trips, and road construction.

An overview of the ambient air quality monitoring program and a discussion of potential air quality effects from future construction activities are presented below.

Milne Port

The construction activities at Milne Port that have the potential to affect local air quality include:

- Sealift activities;
- Construction of infrastructure such as camps and laydown areas;
- Operation of the camp incinerator and power generators; and
- Construction of docks.

Mine Site

Construction activities at Mine Site that have the potential to affect local air quality include:

- Upgrade of the airstrip to accommodate Boeing 737s and similar sized aircraft;
- Preparation of laydown areas or work areas;
- Construction of temporary accommodations;
- Operation of the camp incinerator and power generators;
- Construction and operation of a concrete batch plant;
- Construction of access roads to Project infrastructure areas;
- Development of existing aggregate sources for rock, sand and gravel; and
- Pre-stripping, removal of overburden and ore extraction of about 3 Mt/a.

Mining as part of the road operation will begin approximately 18 months after the start of construction.

Railway

Activities during the construction of the railway that have the potential to affect local air quality include:

- Construction of the access road, which will run along the entire length of the railway;
- Operation of the camp incinerators and power generators;
- Crushing and screening of aggregate from within the footprint of the alignments; and
- Drilling, blasting, screening and haulage of additional aggregate from up to 63 quarry locations.

Steensby Port

Construction activities at Steensby Port that have the potential to affect local air quality include:

- Preparation of any additional laydown areas or work areas;
- Operation of the camps (land based and flotel) incinerators and power generators;
- Development of the airstrip and the access road from the port site to the airstrip;
- Construction of the railway access road;
- Construction of a concrete batch plant;
- Construction of freight and ore docks; and
- Operation of quarries and borrow sources for construction of the port, airstrip and railway.

Cut-and-fill operations will occur at the airstrip and most development areas at Steensby Port, and will consist of drilling, blasting, screening and placement.

2.4 AIR EMISSION SOURCES DURING OPERATION PHASE

These sources are summarized in the following section. The base quantities, such as equipment ratings and production rates, are provided in Appendix 5C-4.

Milne Port

Milne Port will periodically be used for resupply operations, only for supplies that cannot be delivered by rail from Steensby Port. Activity is expected to be relatively minor and infrequent, and has not been considered further in this assessment.

Milne Inlet Tote Road

The Milne Inlet Tote Road will periodically be used for resupply operations (see above). Activity is expected to be relatively minor and infrequent, and has not been considered further in this assessment.

Mine Site

- Open-pit mine operations including drilling, blasting, grading and dozing;
- Mobile engine operations in the pit, including drills, shovels, loaders, trucks, etc.;
- Mine haul roads;
- Ore stockpiles (lump and fines) including stacker/reclaimer and conveyance systems;
- Power generating station, including a series of generators operating on Arctic diesel, with boilers providing emergency backup heat; and
- Waste incineration.

A representative fixed location for these operations was considered in the modelling.

Railway

- Loading and hauling of 18 Mt/a of iron ore to Steensby; and
- Idling locomotive engines and the blow-off of iron ore from rail cars.

Steensby Port

- Ore stockpiles (lump and fines) including stacker/reclaimer and conveyance systems;
- Power generating station, including a series of generators operating on Arctic diesel, with boilers providing emergency backup heat;
- Railway activities, specifically the off-loading of railcars and idling locomotive engines;
- Shipping activities, specifically the loading and operation of "hotel" engines while ships are at the dock, as well as operation of ice management vessels (IMV's) and tug boats; and
- Waste incineration.

2.5 REGULATORY CONTEXT AND AIR QUALITY THRESHOLDS

Government health and environmental agencies have established threshold levels for chemical compounds that have potential effects to human health. These levels are effects-based levels in air, based on health, odour, vegetation, soiling, visibility, corrosion or other effects, depending on the pollutant.

There are ambient air quality guidelines for Nunavut for TSP and SO_2 (Government of Nunavut, 2002). National Air Quality Objectives, Canada-Wide Standards (CWS), and criteria from other Canadian jurisdictions were selected as the thresholds for the remaining contaminants.

The national objectives are divided into three categories, described as follows (Environment Canada, 2010b):

- "Maximum desirable level is the long-term goal for air quality and provides a basis for an anti-degradation policy for the unpolluted parts of the country, and for continuing development of control technology."
- "Maximum acceptable level is intended to provide adequate protection against effects on soil, water, vegetation, materials, visibility, personal comfort, and well-being."
- "Maximum tolerable level denotes time-based concentrations of air contaminants beyond which, due to a diminishing margin of safety, appropriate action is required without delay to protect the health of the general public."

The World Health Organization (WHO) has developed world-wide air quality guidelines for selected key contaminants of concern (WHO, 2005), based on an extensive body of scientific evidence on air pollution and its health effects. Ambient air quality guidelines from the WHO for particulate matter, NO_2, SO_2, and O_3 (WHO, 2005) are also included for reference.

Table 5-2.5 identifies and compares the federal objectives, the Northwest Territories (NWT) criteria and the Nunavut, CWS, and WHO guidelines. The criteria refer to different averaging periods to account for potential short-term acute exposures and long-term chronic exposures. On the basis of the precautionary principle, the most stringent criteria from the various Canadian jurisdictions were selected as the threshold for each contaminant indicator.

Table 5-2.5 Ambient Air Quality Criteria, Standards, and Objectives

Contaminant	Averaging Time	Federal Air Quality Objectives			CWS	Nunavut	NWT	WHO	Indicator Threshold
		Desirable	Acceptable	Tolerable					
TSP (µg/m^3)	24 hr	-	120	400	-	120	120	-	120
	Annual	60	70	-	-	60	60	-	60
PM_{10} (µg/m^3)	24 hr	-	-	-	-	-	50*	50	50
$PM_{2.5}$ (µg/m^3)	24 hr	-	-	-	30**	-	30	25	30
SO_2 (µg/m^3)	1 hr	450	900	-	-	450	450	-	450
	24 hr	150	300	800	-	150	150	20	150
	Annual	30	60	-	-	30	30	-	30
NO_2 (µg/m^3)	1 hr	-	400	1,000	-	-	-	200	400
	24 hr	-	200	300	-	-	-	-	200
	Annual	60	100	-	-	-	-	40	60
CO (µg/m^3)	1 hr	15,000	35,000	-	-	-	-	-	15,000
	8 hr	6,000	15,000	20,000	-	-	-	-	6,000
O_3 (µg/m^3)	1 hr	100	160	300	-	-	-	-	-
	8 hr	-	-	-	127***	-	127	100	-
	24 hr	30	50	-	-	-	-	-	-
	Annual	-	30	-	-	-	-	-	-

NOTE(S):

1. *Ontario Interim Ambient Air Quality Criterion (AAQC). Ontario Ministry of the Environment, September 2001.
2. ** Annual 98th percentile 24-hour concentration, averaged over 3 years.
3. *** Annual 4th highest 8-hour concentration, averaged over 3 years.

For airborne metals, the jurisdictions cited in Table 5-2.5 do not have any applicable criteria or standards. Other jurisdictions in Canada, however, have standards for these substances (e.g., Ontario). Metals with a combination of relatively high content in ore and a low indicator threshold for ambient air were selected for inclusion in this assessment. The resultant metals and the corresponding ambient air quality criteria (AAQC) for Ontario are shown in Table 5-2.6. Note that the Ontario AAQC for iron applies to metallic iron and does not apply to iron oxide, which is the prevalent form of iron in the Mary River ore deposit. In the Province of Ontario industrial facilities are required to meet these standards, but in cases of significant technical or economic barriers, facilities have been allowed to exceed these limits through site-specific control orders or, more recently, through site-specific altered standards.

Table 5-2.6 Ambient Air Quality Criteria for Metals

Contaminant	Averaging Time	Ontario AAQC	Indicator Threshold
Metallic Iron (Fe) (µg/m^3)	24 hr	4	4
Manganese (Mn) (µg/m^3)	24 hr	2.5	2.5
Arsenic (As) (µg/m^3)	24 hr	0.3	0.3
Calcium (Ca) (µg/m^3) (as calcium oxide)	24 hr	10	10
Co (Cobalt) (µg/m^3)	24 hr	0.1	0.1

Table 5-2.7 identifies dust deposition criteria for Alberta and Ontario. The basis for these criteria appear to be based on nuisance considerations. The Ontario values have been recalculated to the same units as the Alberta criteria. Dust deposition, while not indicative of effects to air quality, has been calculated for use in assessing the effects of dust on other VECs and Key Indicators such as vegetation, water quality, and wildlife.

Table 5-2.7 Dust Deposition Criteria

Averaging Time	Alberta Residential and Recreation Areas	Alberta Commercial and Industrial Areas	Ontario Ambient Air Quality Criteria	Indicator Threshold
1 Month	53 mg/100cm^2/30 d	158 mg/100cm^2/30 d	70 mg/100 cm^2/30 d	5.3 g/m^2/30 d 15.8 g/m^2/30 d
	5.3 g/m^2/30 d	15.8 g/m^2/30 d	7 g/m^2/30 d	
Annual	-	-	4.6 g/m^2/30 d	55 g/m^2/yr
	-	-	55 g/m^2/year*	

The Clean Air Strategic Alliance and the Province of Alberta have potential acid input (PAI) deposition loading criteria. These criteria refer to PAI deposition averaged over a 1° longitude by 1° latitude grid cell, which corresponds to a region about 65 km by 112 km, with a total area of 7,280 km^2. For comparison, the LSA has nominal areas of 56 km^2, 141 km^2 and 156 km^2 for Milne Port, Mine Site, and Steensby Port, respectively. The LSA average deposition can be conservatively compared to the 1° longitude by 1° latitude grid cell criteria to provide an indication of the local PAI status.

The CASA/AENV PAI deposition criteria are shown in Table 5-2.8, and the implications of exceeding them are listed as follows:

- Monitoring Load - If a grid cell deposition exceeds the monitoring load, Alberta Environment requires industry and non-industry stakeholders to discuss appropriate monitoring approaches. Monitoring loads are set below target loads to allow sufficient time for the development of a management plan before deposition levels reach target load levels.
- Target Load - Target loads are viewed as an environmental objective or regulatory instrument, similar to the ambient air quality objectives. If a grid cell deposition exceeds the target load, then an emission reduction plan will have to be developed.
- Critical Load - Critical loads identify a level of deposition that can lead to long-term harmful changes to the environment. In the event that a critical load is exceeded, an emission reduction plan will have to be developed and implemented on an accelerated schedule. Exceeding a critical load, however, does not indicate environmental damage is imminent unless it is sustained over many years.

Table 5-2.8 Thresholds for Potential Acid Input Loads

Receptor Sensitivity *	Deposition Load	Potential Acid Input (keq H^+/ha/a)
Low sensitivity	Critical	1.00
	Target	0.90
	Monitoring	0.70
Moderately sensitive	Critical	0.50
	Target	0.45
	Monitoring	0.35
Sensitive	Critical	0.25
	Target	0.22
	Monitoring	0.17

SOURCE: CASA and AENV (1999)

Note(s):

1. Refers to buffering capability of the soil. For the project site, the receptor sensitivity was determined to be moderate.

While CASA indicates these loading criteria may be used as benchmarks on a local scale (i.e., for distance scales less than the 1° longitude by 1° latitude grid cell), they are not intended to be applied on a local scale as environmental objectives or as the basis for determining the acceptability of an individual project. Values exceeding criteria loadings on a local scale indicate the potential need for management options that could include monitoring or mitigation.

In general, if the concentration or deposition level of an airborne pollutant can be maintained below its threshold, then either no health effect is observed or the effect is small enough that it presents an acceptably low risk to the population and the environment.

2.6 AIR QUALITY

2.6.1 Assessment Methodology

Overview

A standard assessment approach was used to determine air quality effects associated with Project-related activities. This approach, outlined in Table 5-2.9, included the following tasks:

- Use baseline ambient air quality monitoring to establish existing background levels;
- Identify and quantify atmospheric emission sources associated with each of the Project sites (i.e., Milne Port, Tote Road, Mine Site, Railway, Steensby Port);
- Establish local meteorological conditions to determine transport and dispersion patterns in the region;
- Use dispersion models to predict ambient concentrations and deposition patterns for the Operation Phase;
- Compare the ambient monitoring measurements (i.e., baseline conditions) and air quality predictions to the ambient air quality and deposition thresholds; and
- Identify the incremental air quality changes and assess the significance of these effects.

Table 5-2.9 Air Quality Effects Assessment Approach

Component	Description
Quantify Emission Sources	The objective of this task is to identify stack (point source) parameters (such as location, physical dimensions, gross flow conditions, and pollutant flow rates) for the Project. Fugitive sources (area and volume sources) were also characterized. This task was completed using manufacturer specifications, published emission factors, and project design information. Emissions were estimated for Milne Port, Mine Site, and Steensby Port (see Appendix 5C-4).
Terrestrial characterization	Digital terrain data were obtained to account for elevation changes in the study areas. The nature of the surface will affect the deposition of pollutants. Land surface features were obtained from satellite data. The nature of the surface was grouped according to three land-use classes: water, tundra and barren land.
Review of ambient air quality measurements	A number of ambient monitoring programs were undertaken to establish air quality conditions in the absence of the Project and to establish potential effects from activities that were not explicitly modelled as part of this assessment.
Meteorological characteristics	The CALMET preprocessor was used to generate three-dimensional meteorological fields for one year at all three sites. The one-year assessment period (2006), is consistent with other EIA applications undertaken using the CALMET/CALPUFF model system.
Model approach	The CALPUFF model was used to predict the transport, dispersion, chemical transformation, and deposition from all sources associated with the Project. The model was used to predict 1-h, 24-h and annual average concentration patterns (i.e., SO_2, NO_2, CO and $PM_{2.5}$) and annual nitrogen, sulphur, PAI and dust deposition patterns.

The assessment identifies potential changes or effects to existing air quality conditions and dust, metal and PAI deposition levels that may result from project activities. Air quality effects will depend on the magnitude of the emissions, which vary with the activities over the lifetime of the Project: construction (4 years); operation (21 years); closure and reclamation (3 years). This assessment approach described in the preceding paragraphs was applied to the Operations Phase. It was not applied to the Construction and Closure phases because of their temporary nature; however, they were assessed qualitatively.

Effects during the construction and project closure and reclamation phases were assessed qualitatively for Milne Port, the Mine Site and Steensby Port. Mitigation measures fall under one of two categories:

- Mitigation by design describes mitigations that have been built into the Project design; and
- Air Quality Specific Mitigations are those identified by the air quality effects assessment team to reduce predicted project effects.

Residual effects are those effects remaining after all appropriate mitigations have been implemented. Residual effects are evaluated based on the criteria in Table 5-2.14.

Estimation of Project Emissions

As the Project has not yet been constructed, there is no direct identification or measurements of Project emissions; therefore, the source and emission inventory was used to determine the emissions that might occur. The key components:

- Determine the activities and relevant activity levels associated with the Project;
- Determine temporal and spatial boundaries associated with these activities; and
- Apply manufacturer's data, where available, or industry-specific emission factors to the defined activities to determine the emission type and calculate emission rates.

The activities, corresponding temporal and spatial boundaries, and manufacturer's data were collected from the Development Proposal and Project engineering staff. Manufacturer's data were available for the power generators and waste incinerators. Representative manufacturer's data were also available for locomotives, ore ships, ice management vessels and tug boats.

The United States Environmental Protection Agency (US EPA) "AP-42" document (US EPA, 2008) was used to provide emission factors for the wide range of mining-related activities. An emission factor is a representative value that relates the quantity of a contaminant released into the atmosphere to an activity associated with the release of that contaminant.

The following sections of AP-42 were adopted:

- Section 11.9 (Western Surface Coal Mining) was used to estimate emissions from various mining activities;
- Section 11.19.2 (Crushed Stone Processing and Pulverized Mineral Processing) was used to estimate emissions from drilling activities;
- Section 11.24 (Metallic Mineral Processing) was used to estimate emissions from processing operations (i.e., crushing, ore handling, etc.);
- Section 13.2.2 (Unpaved Roads) was used to estimate emissions from the haul roads; and
- Section 13.2.4 (Aggregate Handling and Storage Piles) was used to estimate emissions for conveyor transfers and stacking ore onto storage piles.

In addition, the US EPA Tier II/III non-road emission standards were used to estimate the exhaust emissions from the mine fleet and truck fleet activities at the site.

A portion of the TSP concentrations predicted by the model will comprise metals such as iron, arsenic and calcium. The metal portions of the TSP will themselves be made of dust associated with general mining activities (e.g., waste and ore handling) as well as dust from ancillary operations (e.g., haul roads). As an approximate approach, and in the absence of detailed metals analyses from all dust deposition sources, metals content in the ore was applied to dust concentration results. Metal concentrations were predicted for the top five metals (those with the highest ratio of metal content to air quality thresholds) are shown in Table 5-2.10.

Table 5-2.10 Summary of Metal Analysis of Ore

Metal	Percentage of Metal in Ore (%)
Fe	72.0
Mn	2.86
As	0.08
Ca	2.0
Co	0.01

Air Dispersion Modelling

Dispersion models provides a scientific link between the emissions and the associated ambient air quality downwind of the emission source, and account for the transport, dispersion and deposition processes in relation to local terrain and meteorology. Given the importance of dispersion models for air quality effects assessments, regulatory agencies identify accepted models and provide guidance on their application (e.g., US EPA, 2005; British Columbia Ministry of Environment, 2008; Alberta Environment, 2003; Ontario Ministry of the Environment, 2009).

The CALPUFF dispersion model, which is recommended by a number of regulatory agencies, was adopted to assess emissions from the Mary River Project activities. This model has been the *de facto* standard for environment assessments at e.g., Miramar Doris North Project and High Lake Mine Project in Canada's North.

2.6.2 Potential Effects and Proposed Mitigation - Construction Phase

2.6.2.1 Milne Port

- There is a potential for the maximum 24-hour dust concentrations to exceed the indicator thresholds for TSP, PM_{10} and $PM_{2.5}$ within the immediate vicinity of traffic areas while unloading sealifts and transporting equipment. (i.e., within 100 to 200 hundred metres, depending on the activity levels). Beyond this distance, TSP levels should fall below the indicator threshold.
- SO_2 and NO_2 levels from mobile equipment are expected to be lower than the indicator thresholds during construction activities.
- Elevated dust deposition levels expected in the immediate vicinity of vehicle traffic could exceed the indicator thresholds.

Best management practices for dust control will be followed during construction. An Air Quality and Noise Abatement Management Plan is included in Appendix 10D-1. These practices may include:

- Watering of roads and/or application of approved dust suppressants, as necessary, to reduce visible plumes when temperatures are above freezing;
- Observe appropriate speed limits; and
- Concrete batch plant equipped with industry standard dust collection.

Implementing these measures should reduce the magnitude and extent of dust effects. Proposed mitigation measures are also identified in the Air Quality and Noise Abatement Management Plan (Appendix 10D-1).

2.6.2.2 Railway Construction

- The maximum 24-hour dust concentrations may exceed indicator thresholds for TSP, PM_{10} and $PM_{2.5}$ within the immediate vicinity of construction Beyond this distance, TSP levels should fall below the threshold.
- Metal concentrations are expected to be much lower than their indicator thresholds. There may be a potential for silica levels to approach or exceed indicator thresholds, depending on natural levels of silica in the soil.
- SO_2 and NO_2 levels from mobile equipment are expected to be lower than the indicator thresholds.
- Elevated dust deposition levels expected in the immediate vicinity of vehicle traffic and blasting activities could exceed indicator thresholds.

Best management practices for dust control will be followed during road and rail construction and quarry activities, where possible (Appendix 10D-1).

2.6.2.3 Mine Site

The following air quality effects are expected at the Mine Site during construction:

- There is a potential for the maximum 24-hour dust concentrations to exceed indicator thresholds for TSP, PM_{10} and $PM_{2.5}$ within several hundred metres. Beyond this distance, levels should fall below the indicator threshold.
- Metal concentrations are expected to be much lower than their respective indicator thresholds. Silica levels may approach or exceed indicator thresholds depending on natural levels of silica in the soil
- SO_2 and NO_2 levels from mobile equipment are expected to be lower than the indicator thresholds.
- Elevated dust deposition levels are expected in the immediate vicinity of vehicle traffic and could exceed the indicator thresholds.

Best management practices outlined in the previous section will be implemented during construction, where possible. In addition, crushing and sizing facilities will be enclosed and ventilated, and dust collection equipment will be installed to capture dust emissions.

2.6.2.4 Steensby Port

There is a potential for the maximum 24-hour dust concentrations to exceed the indicator thresholds for TSP, PM_{10} and $PM_{2.5}$ within several hundred metres of the vehicle traffic areas. Beyond this distance, TSP levels should fall below the indicator threshold.

- Metal concentrations in the vicinity of construction activities are expected to be much lower than their indicator thresholds. Silica levels may approach or exceed indicator thresholds, depending on natural levels of silica in the soil.
- SO_2 and NO_2 levels from mobile equipment are expected to be lower than the indicator thresholds during the construction activities.
- Elevated dust deposition levels in the immediate vicinity of vehicle traffic could exceed indicator thresholds.

Best management practices for dust control will be followed during construction activities, where possible, as discussed in the previous section.

2.6.3 Potential Effects and Proposed Mitigation - Operations

The primary emission sources from the operations phase were included in the CALPUFF model to calculate the associated air quality effects.

2.6.3.1 Mine Site

The emission inventory for the Mine Site is summarized in Table 5-2.11. The following are noted relative to these emission estimates:

- The main source of TSP, PM_{10} and $PM_{2.5}$ emissions is the dozers and graders operating in the pit, accounting for 77 %, 88 %, and 72 % of total TSP, $PM_{10,}$ and $PM_{2.5}$ emissions, respectively. These emissions were assumed to occur continuously even though precipitation can suppress dust.
- Power generation accounts for 83 % of SO_2 emissions and 70 % of NO_X emissions. Mobile equipment accounts for 86 % of the CO emissions. These combustion sources also contribute a relatively small amount to TSP, PM_{10} and $PM_{2.5}$ emissions.

Although aircraft will be a source of combustion emissions, given the intermittent nature and the short aircraft operation times, air quality effects are expected to be minimal and were therefore not assessed through dispersion modelling.

Maximum predicted concentrations are superimposed on a map centred on the Mine Site, in the following figures:

- Figure 5-2.1 Maximum 24-hour TSP Concentrations
- Figure 5-2.2 Annual TSP Deposition
- Figure 5-2.3 Maximum 24-hour PM_{10} Concentrations
- Figure 5-2.4 Maximum 24-hour $PM_{2.5}$ Concentrations
- Figure 5-2.5 Maximum 1-hour NO_2 Concentrations

These figures are described in the following sections. Concentration plots for the remaining averaging times and contaminants are provided in Part I of Appendix 5C-5. For the plots not shown, the maximum predicted CO and SO_2 concentrations and the PAI deposition levels are generally less than their respective thresholds beyond the LSA.

Table 5-2.11 Emission Sources and Estimated Annual Emissions Due to the Mine Site[1]

Source Description	TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_x	CO
In pit operations						
Blasting	10.4	5.42	0.31	0	0[2]	0
Dozing/grading/drilling	14,000	8690	577	0	0	0
Mobile equipment	3,900	1,080	118	0.02	1,040	944
Sub-total	**18,000**	**9,780**	**696**	**0.02**	**1,040**	**944**
Fines/lump stockpile	1.26	0.66	0.12	0	0	0
Sub-total	**1.26**	**0.66**	**0.12**	**0**	**0**	**0**

Table 5-2.11 Emission Sources and Estimated Annual Emissions Due to the Mine Site[1] (Cont'd)

Source Description	TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_x	CO
Stockpile emissions						
Fines/lump stockpile	1.26	0.66	0.12	0	0	0
Sub-total	**1.26**	**0.66**	**0.12**	**0**	**0**	**0**
Bulk Handling						
Stackers, Reclaimers, Conveyors	4.99	2.36	0.36	0	0	0
Sub-total	**4.99**	**2.36**	**0.36**	**0**	**0**	**0**
Railway						
Idling Locomotives	0.66	0.66	0.66	1.02	12.4	5.3
Sub-total	**0.66**	**0.66**	**0.66**	**1.02**	**12.4**	**5.3**
Point Sources						
Power Generators (3 units)	103	103	103	4.7	2,450	151
Incinerator	4.04	4.04	4.04	0.0	6.07	0.43
Sub-total	**107**	**107**	**107**	**4.7**	**2,450**	**151**
Total	**18,100**	**9,890**	**804**	**5.7**	**3,510**	**1,100**

NOTE(S):
1. Estimated annual emissions are reported in tonnes/year.
2. Blasting produces NO_X emissions but, due to the brevity and low frequency of blasts, the annual emissions are insignificant compared to those from diesel-powered equipment that run continuously. Therefore, they were not calculated.

TSP Concentrations

High TSP concentrations are predicted in the vicinity of the Mine Site, primarily due to dust generated by mobile mining equipment (dozers, graders, haul trucks). The maximum predicted 24-hour TSP concentrations are predicted to exceed the indicator threshold of 120 µg/m^3 within the LSA. Concentrations beyond the LSA are less than threshold, except for small areas to the east, northwest and southwest. These values represent maximum 24-hour concentrations under worst-case meteorological and maximum operating conditions. The annual average TSP concentrations are, for the most part, predicted to be below the applicable threshold of 60 µg/m^3 within the LSA, and exceed it only inside the potential development area (PDA) except for a few very small areas beyond the development boundary. These results are worst-case, with no dust suppression in place for the mobile equipment. When temperatures are warm enough to permit use of water or other dust suppressants, the potential maximum 24-hr TSP concentrations can be significantly reduced.

Metals Concentrations

Concentrations of metals are not shown in the concentration contour plots, but are interpreted from the plot of 24-hour TSP concentrations. Iron, based on the metals analysis of the iron ore, could account for up to 72 % of the TSP. Iron concentrations in excess of the indicator threshold of 4 µg/m^3 extend well beyond the LSA. The indicator threshold used, however, applies to metallic iron and is not directly applicable iron oxides, which would be the dominant form of iron in dust from the mining operations.

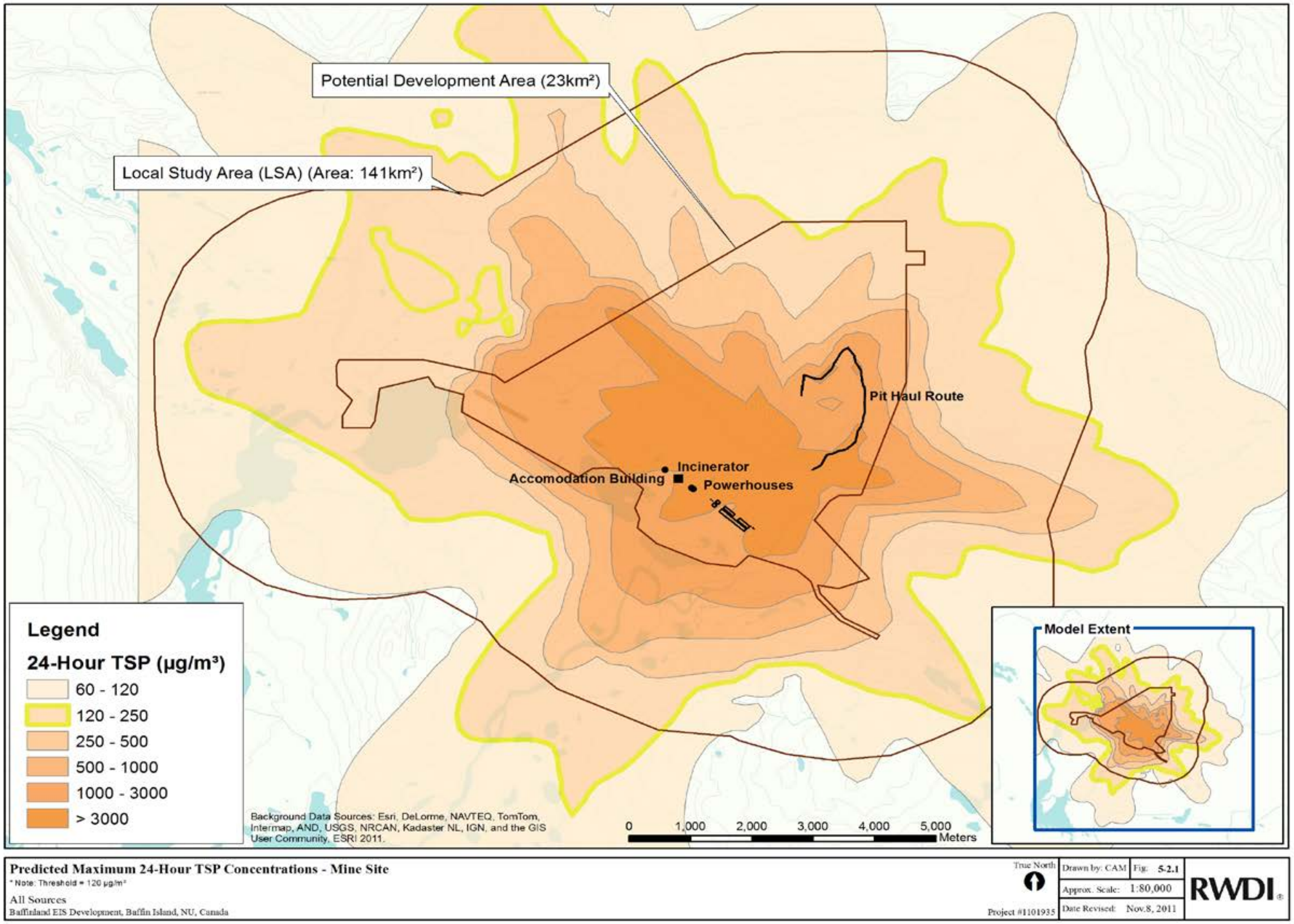


Figure 5-2.1 **Predicted Maximum 24-hour TSP Concentrations - Mine Site**

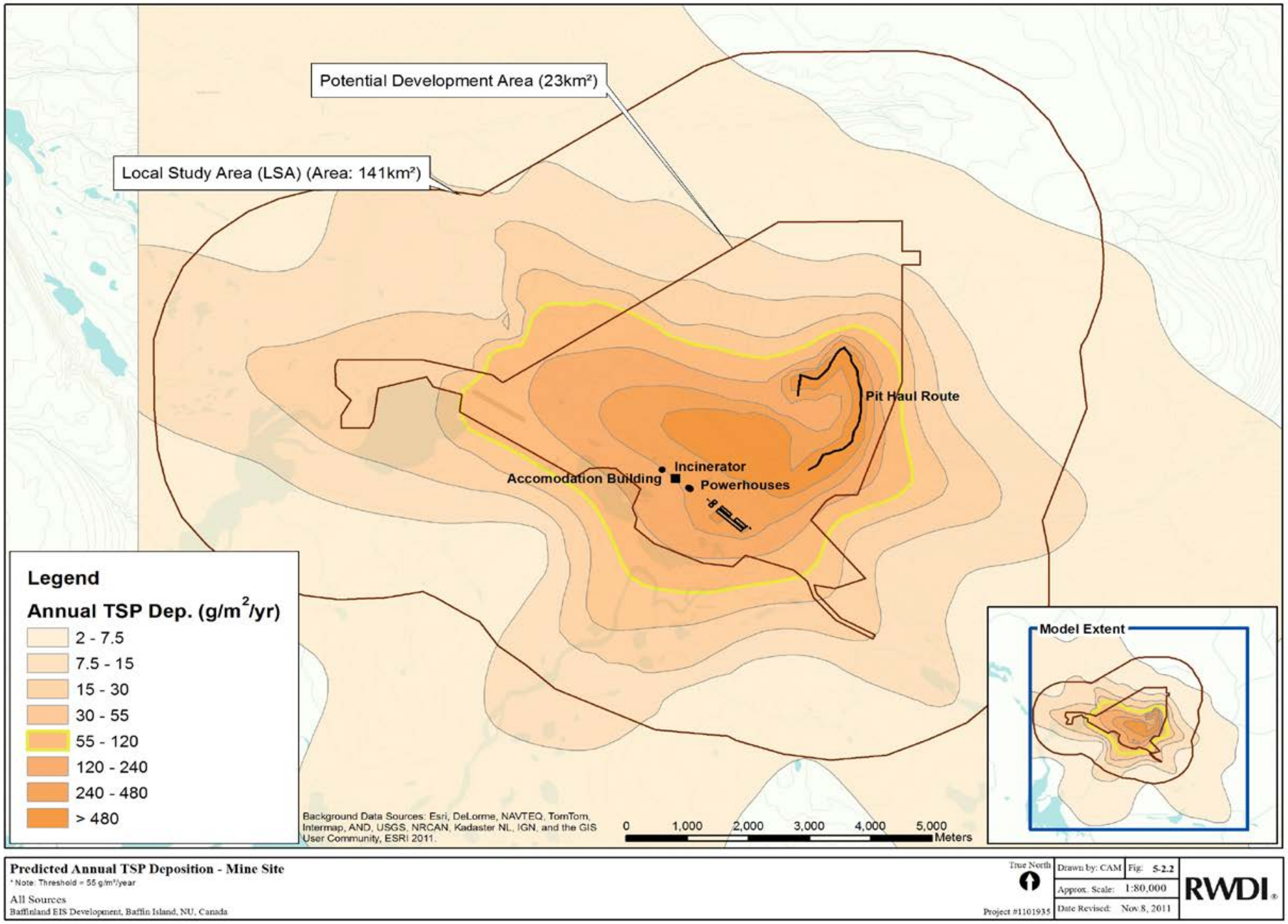


Figure 5-2.2 Predicted Annual TSP Deposition - Mine Site

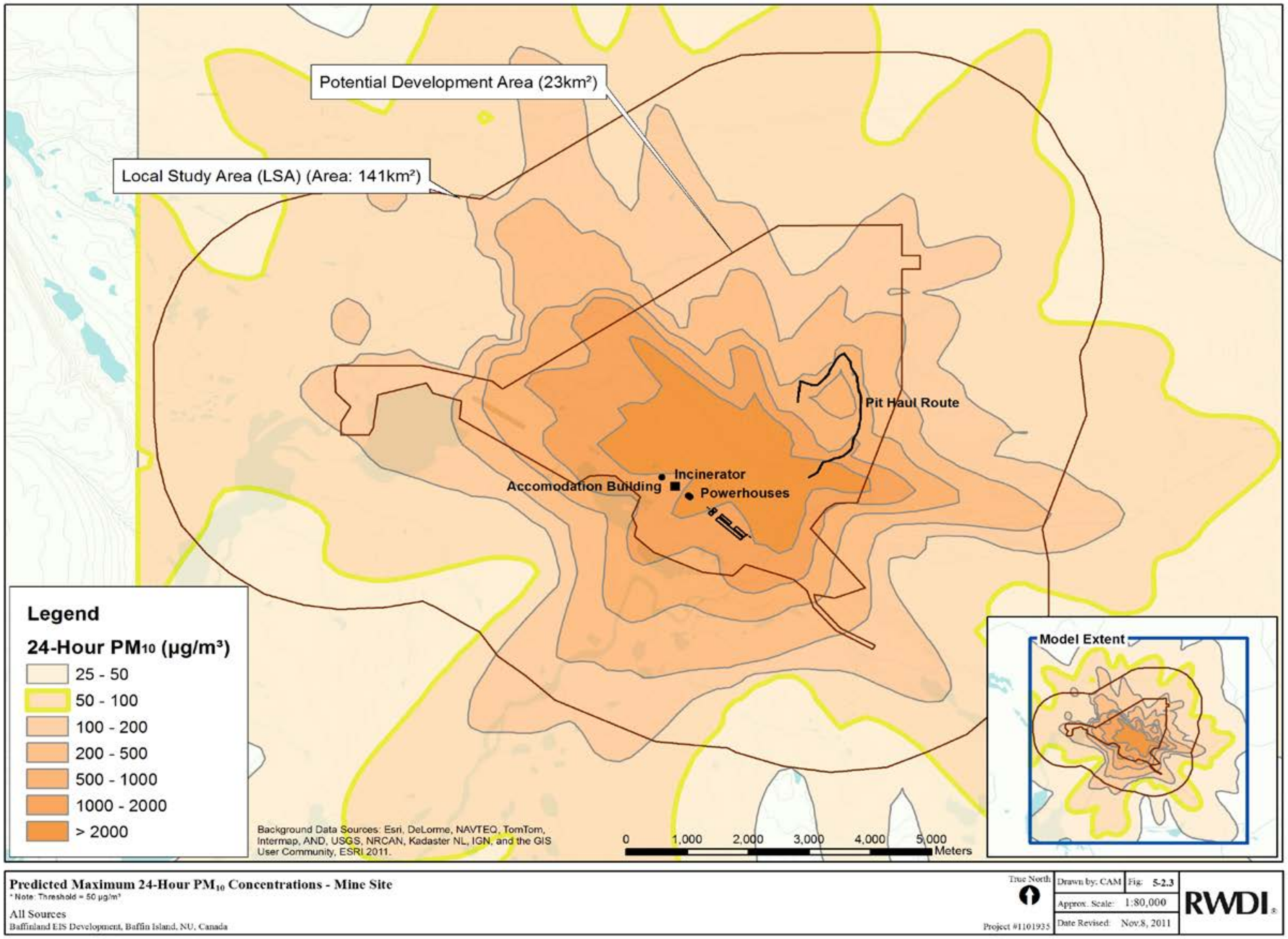


Figure 5-2.3 Predicted Maximum 24-hour PM_{10} Concentrations - Mine Site

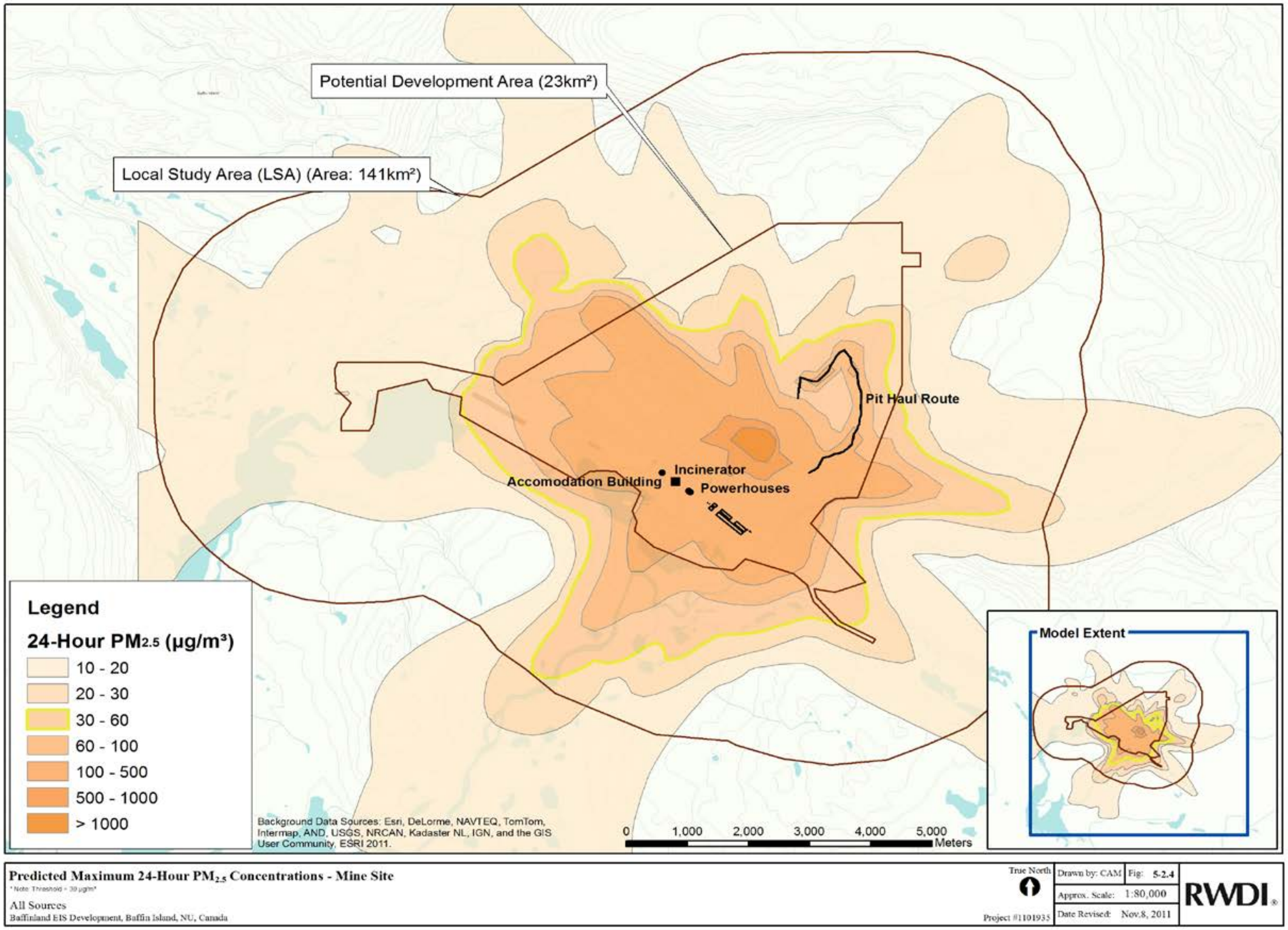


Figure 5-2.4 Predicted Maximum 24-hour $PM_{2.5}$ Concentrations - Mine Site

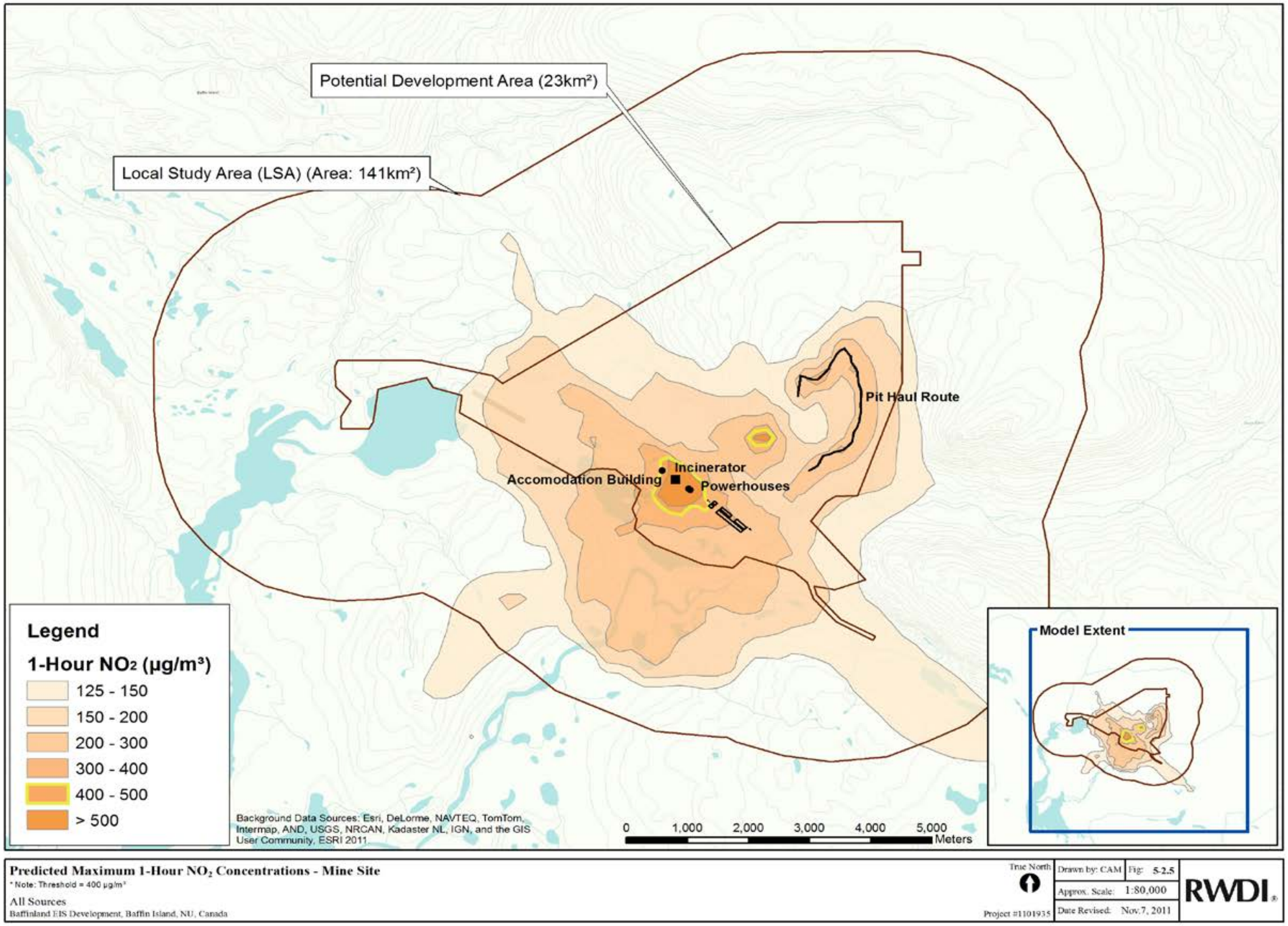


Figure 5-2.5 Predicted Maximum 1-hour NO_2 Concentrations - Mine Site

Manganese could account for up to 2.9 % of the TSP. Predicted maximum 24-hour concentrations in excess of the indicator threshold of 2.5 µg/m^3 extend somewhat beyond the LSA, as indicated in the contour plot of maximum 24-hour TSP by areas where the TSP concentration exceeds approximately 90 µg/m^3.

Arsenic could account for up to 0.08 % of the TSP. Maximum 24-hour concentrations in excess of the indicator threshold of 0.3 µg/m^3 are limited to the LSA, as indicated in the contour plot of maximum 24-hour TSP by areas where the TSP concentration exceeds approximately 375 µg/m^3.

Calcium could account for up to 2 % of the TSP. Concentrations in excess of the indicator threshold of 10 µg/m^3 (expressed as calcium oxide) are limited to a small part of the LSA outside the PDA, as indicated in the contour plot of maximum 24-hour TSP by areas where the TSP concentration exceeds approximately 500 µg/m^3..

Cobalt could account for up to 0.01 % of the TSP. Concentrations in excess of the indicator threshold of 0.1 µg/m^3 are limited mainly to the PDA, as indicated in the contour plot of maximum 24-hour TSP by areas where the TSP concentrations exceed approximately 1000 µg/m^3.

TSP Deposition

Annual TSP deposition levels are predicted to exceed the threshold of 55 g/m^2/year, generally contained within the PDA and a small part of the LSA. Outside the LSA the levels are well below the indicator threshold, but remain above baseline conditions far beyond the LSA.

PM_{10} Concentrations

High PM_{10} concentrations are predicted to occur in the vicinity of the Mine Site. The maximum predicted 24-hour PM_{10} concentrations are predicted to exceed the indicator threshold of 50 µg/m^3 within the LSA. Concentrations beyond are below threshold, except in small areas to the east, west, southeast, southwest and northeast. These values represent the maximum 24-hour concentrations under worst-case meteorological and maximum operating conditions.

$PM_{2.5}$ Concentrations

High 24-hour $PM_{2.5}$ concentrations in excess of the indicator threshold of 30 µg/m^3 are limited mainly to the PDA. The workers' accommodation building is located in an area where the threshold is exceeded, which means that $PM_{2.5}$ levels there will sometimes be undesirably high (under worst-case weather and operating conditions); however, standard air filtration techniques on the ventilation system, should be sufficient to ensure acceptable levels inside the building during these events. Concentrations beyond the LSA generally are below 10 µg/m^3, except in small zones to the east, west, northwest and southwest, where the concentrations are somewhat higher. These values represent the maximum 24-hour concentrations under worst-case meteorological and maximum operating conditions. Under more typical weather conditions, concentrations of $PM_{2.5}$ will be significantly lower.

NO_2 Concentrations

High one-hour NO_2 concentrations in excess of the indicator threshold of 400 µg/m^3 are limited to small areas inside the PDA. The worker's accommodation is currently located inside one of these areas. It is also located in a zone where the predicted maximum 24-hour NO_2 exceeds its indicator threshold of 200 µg/m^3 (shown in Appendix 5C-5). These results are based on a 30 m height for the powerhouse stacks. Additional modelling for a stack height of 40m above grade improves the results (contour plots for this case are shown in Part III of Appendix 5C-5), while further stack height increases beyond 40 m provide relatively little further improvement. Alternatively, a change to the site layout, so that the powerhouse stacks are located at least a few hundred metres northwest of the accommodation building (downwind for the prevailing winds), with the stack height remaining at 30 m, also improves the results significantly.

Concentrations beyond the LSA generally are below 125 µg/m^3, except in small zones to the southeast and southwest. These values represent the maximum one-hour concentrations under worst-case meteorological and maximum operating conditions.

For annual average NO_2, predicted concentration in excess of the indicator threshold of 60 µg/m^3 (Federal Desirable Level) occurred in the vicinity of the accommodations building, but the predicted concentrations remained within the Federal Acceptable Level of 100 µg/m^3. Therefore, the predicted annual average concentrations are considered acceptable.

Mitigation Measures

The following mitigation measures are incorporated into the design and have also been included in the air quality assessment:

- Most bulk material transfer points will be enclosed and emissions are controlled by dust collectors;
- The crusher will be enclosed and emissions are controlled by a dust collector;
- Incinerator equipment will be selected based on a proven emissions track record. A waste management plan and ongoing training of incinerator personnel will be implemented. The incinerator will also be well separated from accommodations area and placed downwind;
- Use of low-sulphur and ultra-low sulphur diesel fuels as set out in Appendix 5C-4;
- Good engineering practice in design of exhaust stacks for the power generators, and in design of the layout relative to the accommodations building, to reduce ground level concentrations; and
- Application of water or other approved dust suppressant on haul roads when the ambient temperature is warm enough to allow it.

The following adaptive management strategies will also be available for implementation, if required by monitoring:

- Wind fences to reduce erosion from stockpiles;
- Control of any remaining transfer points;
- Adjust speed limits according to conditions; and
- Reduce drop distances to the stockpiles.

These options have been identified for consideration in the Air Quality and Noise Abatement Management Plan (Appendix 10D-1).

2.6.3.2 Railway

Trains travelling between the mine site and Steensby Port will emit products of combustion and have the potential to produce airborne dust from blow-off from the open rail cars. Since the trains are in transit and only briefly present at any location along the corridor, the impact of products of combustion is considered insignificant and is not considered further. The potential for dust blow-off was considered by review of a historical study of wind losses from rail shipment of iron ore (Davies, 1974).

In the present case, over 99 % of the ore will consist of particles larger than 74 µm in diameter. The most similar types of ore in the historic study had only 96 % of the material larger than 63 µm; in other words, they contained more fines than the ore in the present case. These ore types exhibited very low wind losses in laboratory experiments, and no measurable losses in full-scale field trials. The wind losses were deemed insignificant. Based on these findings, dust generation from rail operations is expected to be limited to attrition of particles during loading of rail cars and is expected to be minimal. No significant windblown emissions are expected during transportation.

Mitigation

No mitigation measures are proposed for the railway transportation of iron ore. Dust control will focus on loading of cars at the mine and unloading of cars at Steensby Port.

2.6.3.3 Steensby Port

The emissions inventory for Steensby Port is provided in Table 5-2.12.

Maximum predicted concentrations are superimposed on a base map centred on the Steensby Port site in the following figures:

- Figure 5-2.6 Maximum 24-hour TSP Concentrations
- Figure 5-2.7 Annual TSP Deposition
- Figure 5-2.8 Maximum 24-hour PM_{10} Concentrations
- Figure 5-2.9 Maximum 24-hour $PM_{2.5}$ Concentrations
- Figure 5-2.10 Maximum 1-hour NO_2 Concentrations

These figures are described on a contaminant basis in the following sections. Concentration plots for the remaining averaging times and contaminants are provided in Part II of Appendix 5C-5. For the plots not shown, the maximum predicted CO and SO_2 concentrations and the PAI deposition levels are generally lower than their respective thresholds beyond the LSA.

TSP Concentrations

High 24-hour TSP concentrations in excess of the indicator threshold of 120 µg/m^3 are limited to a small zone within the LSA, in the vicinity of the ore stockpiles and ore dock; the principal area of activity of ice management vessels and harbour tugs is delineated by a rectangle in the contour plots. Concentrations beyond the LSA are below 30 µg/m^3. Concentrations on the mainland, referring to Baffin Island proper, are below 30 µg/m^3 beyond about 1 km from the shoreline. Concentrations over the mainland are low because of dust control – all transfer points are enclosed and are equipped with dust collectors. The values shown in the concentration contour plots represent the maximum 24-hour concentrations under worst-case meteorological and maximum operating conditions.

Metals Concentrations

Concentrations of metals are not shown in the concentration contour plots, but are interpreted from the plot of 24-hour TSP concentrations. Iron could account for up to 72 % of the TSP. Iron concentrations in excess of the indicator threshold of 4 µg/m^3 extend beyond the LSA; however, the indicator threshold used applies to metallic iron and is not directly applicable iron oxides, which will be the dominant form of iron in dust from the material handling operations.

Table 5-2.12 Emission Sources and Estimated Annual Emissions due to Steensby Port

Source Description	TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_x	CO
Stockpile emissions						
Fines/lump stockpile	0.09	0.05	0.01	0	0	0
Sub-total	**0.09**	**0.05**	**0.01**	**0**	**0**	**0**
Bulk Handling						
Stackers, reclaimers, conveyors	418	198	30	0	0	0
Sub-total	**418**	**198**	**30**	**0**	**0**	**0**
Railway						
Idling locomotives	0.66	0.66	0.66	1.02	12.4	5.26
Sub-total	**0.66**	**0.66**	**0.66**	**1.02**	**12.4**	**5.26**
Ice Management Vessels and Harbour Tugs						
IMV's and Tugs	487	487	231	23.1	3320	254
Sub-total	**487**	**487**	**231**	**23.1**	**3320**	**254**
Point Sources						
Power generators (4 units)	129	129	129	5.9	3670	189
Incinerator	2.12	2.12	2.12	0.0	3.19	0.23
Docked Ore Ship	39.7	39.7	35.5	0.07	515	39.3
Sub-total	**171**	**171**	**167**	**5.9**	**4,190**	**229**
TOTAL	**1080**	**856**	**428**	**30**	**7530**	**488**

NOTE(S):
1. ESTIMATED ANNUAL EMISSIONS ARE REPORTED IN TONNES/YEAR.

The following are noted relative to these emission estimates:

- The main sources of TSP, PM_{10} and $PM_{2.5}$ emissions are the harbour vessels, which account for 45 %, 57 %, and 54 %, respectively. The harbour vessels also account for 77 % of the SO_2, 44 % of the NO_X and 52 % of the CO emissions.
- Power generation accounts for 30 %, 20 %, 49 %, and 39 % of the $PM_{2.5}$, SO_2, NO_x and CO emissions, respectively. Other combustion related sources included the incinerator and idling locomotives.

Manganese could account for up to 2.9 % of the TSP. Concentrations in excess of the indicator threshold of 2.5 µg/m^3 are limited to the LSA, as indicated in the contour plot of maximum 24-hour TSP by areas where the TSP concentration exceeds approximately 90 µg/m^3.

Arsenic could account for up to 0.08 % of the TSP. Concentrations in excess of the indicator threshold of 0.3 µg/m^3 are limited to a very small area of the LSA, as indicated in the plot of maximum 24-hour TSP by areas where the TSP concentration exceeds approximately 375 µg/m^3. Concentrations beyond the LSA fall below about 0.05 µg/m^3.

Calcium could account for up to 2 % of the TSP. Concentrations in excess of the indicator threshold of 10 µg/m^3 (expressed as calcium oxide) are limited to a very small area of the LSA, as indicated in the plot of maximum 24-hour TSP by areas where the concentration exceeds approximately 500 µg/m^3. Concentrations beyond the LSA are below about 1 µg/m^3.

Cobalt could account for up to 0.01 % of the TSP. Concentrations in excess of the indicator threshold of 0.1 µg/m^3 are limited to a very small area of the LSA, falling to below about 0.006 µg/m^3 beyond the LSA.

PM_{10} Concentrations

High 24-hour PM_{10} concentrations in excess of the indicator threshold of 50 µg/m^3 occur over water and generally do not extend beyond the LSA. Concentrations on the mainland fall below 25 µg/m^3 beyond about 1 km from the shoreline due to the level of dust control. All transfer points are enclosed and equipped with dust collectors, which vent back into the enclosures. Values shown in the concentration contour plots represent the maximum 24-hour concentrations under worst-case meteorological and maximum operating conditions.

$PM_{2.5}$ Concentrations

High 24-hour $PM_{2.5}$ concentrations in excess of the indicator threshold of 30 µg/m^3 are limited to well within the LSA. Concentrations beyond generally are below 10 µg/m^3, except for a small zone over water to the southwest. Concentrations on the mainland are below 10 µg/m^3 beyond about 1 km from the shoreline due to the level of dust control. The values shown in the concentration contour plots represent the maximum 24-hour concentrations under worst-case meteorological and maximum operating conditions.

NO_2 Concentrations

High one-hour NO_2 concentrations in excess of the indicator threshold of 400 µg/m^3 are limited to a small zone within the PDA (near the power plant) and a small zone near the ore dock where icebreaker and tug boat activity occurs (principal area of ship activity is indicated by a rectangle in the contour plots). The accommodations building is outside these zones. Concentrations beyond the LSA are generally well below 200 µg/m^3.

NO_2 and SO_2 When an Ore Ship Leaves Port

When an ore ship is leaving Steensby Port and travelling through ice, the main engines may operate at high load. The engines are significantly larger and have higher emissions than those of the harbour vessels (i.e., the ice management vessels and tugs). When departing, the ore ship will gradually accelerate from zero to cruising speed (estimated to be 7 knots in ice). Ship departures will occur at Steensby Port approximately once every three days on average.

Baffinland will comply with future fuel regulations for ship operation. At the present, this means that ultra low sulphur fuel will be used by the harbour vessels and by the auxiliary engine that powers ore ships while they are docked. In transit, the fuel used will be low sulphur IFO 380, which currently is guaranteed to have less than 1.5 % sulphur content (going beyond current regulations applicable to shipping in the Canadian Arctic). Operating parameters associated with the ship's main engines are provided in Appendix C5-4.

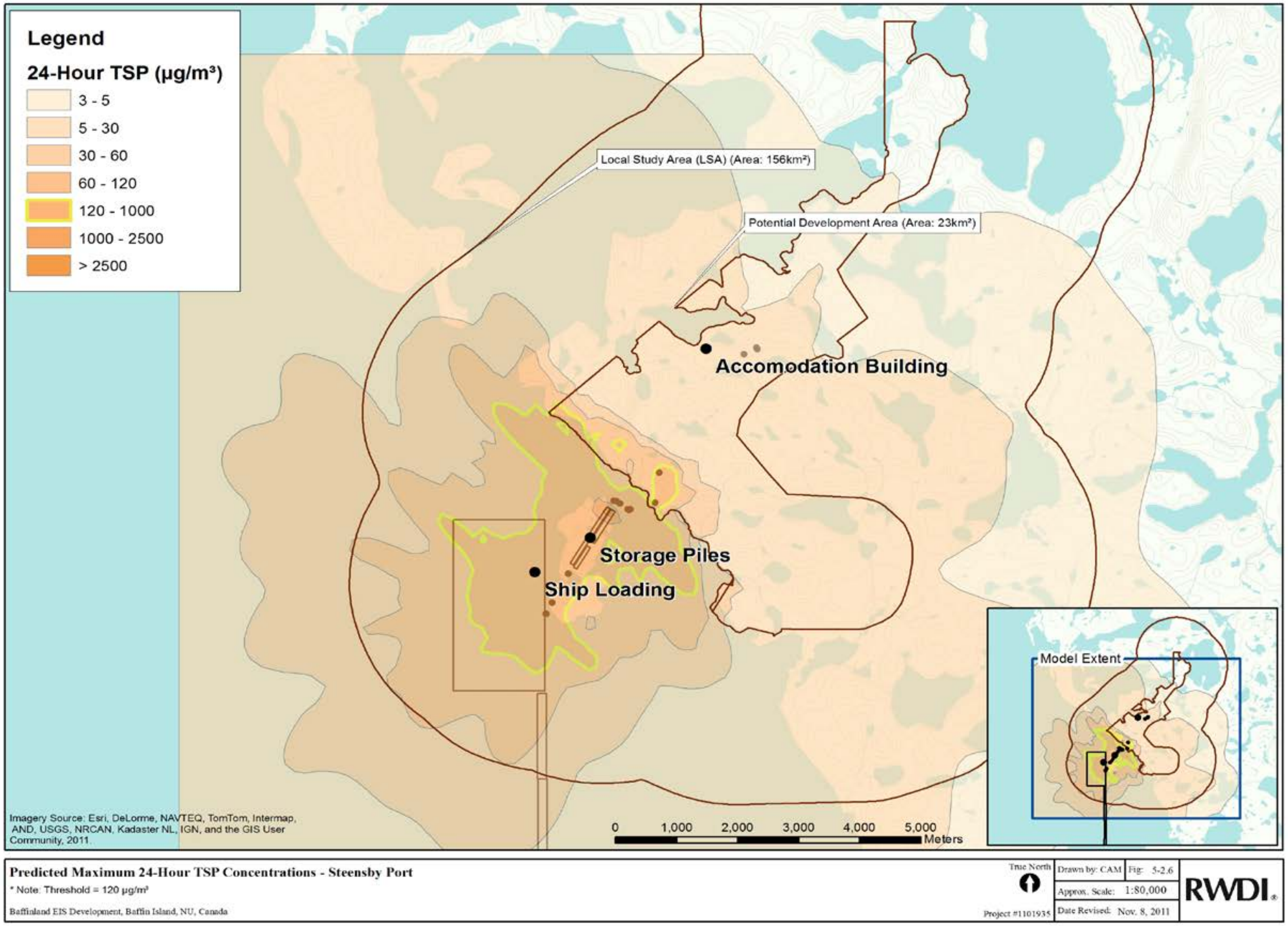


Figure 5-2.6 Predicted Maximum 24-hour TSP Concentrations - Steensby Port

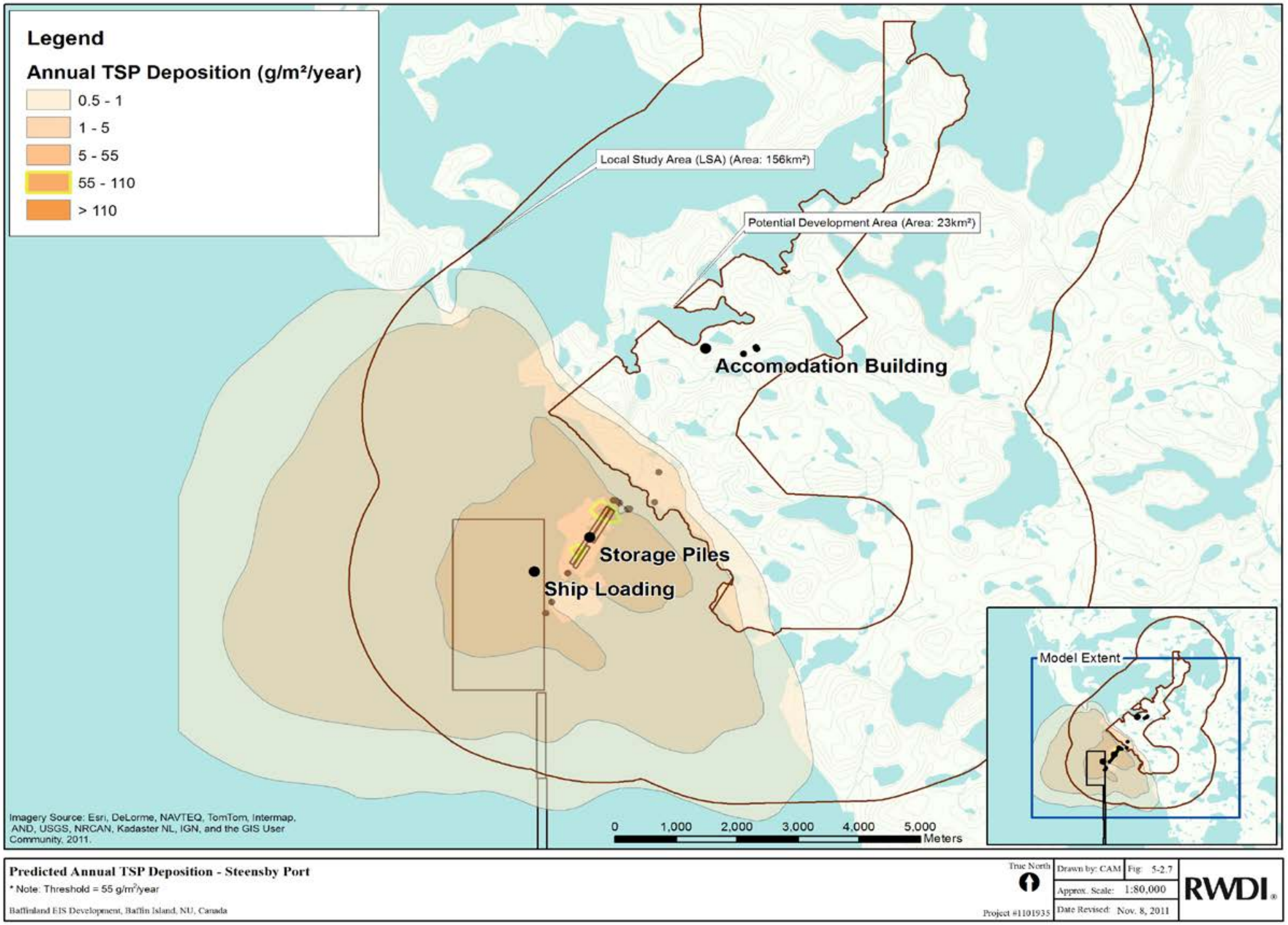


Figure 5-2.7 Predicted Annual TSP Deposition - Steensby Port

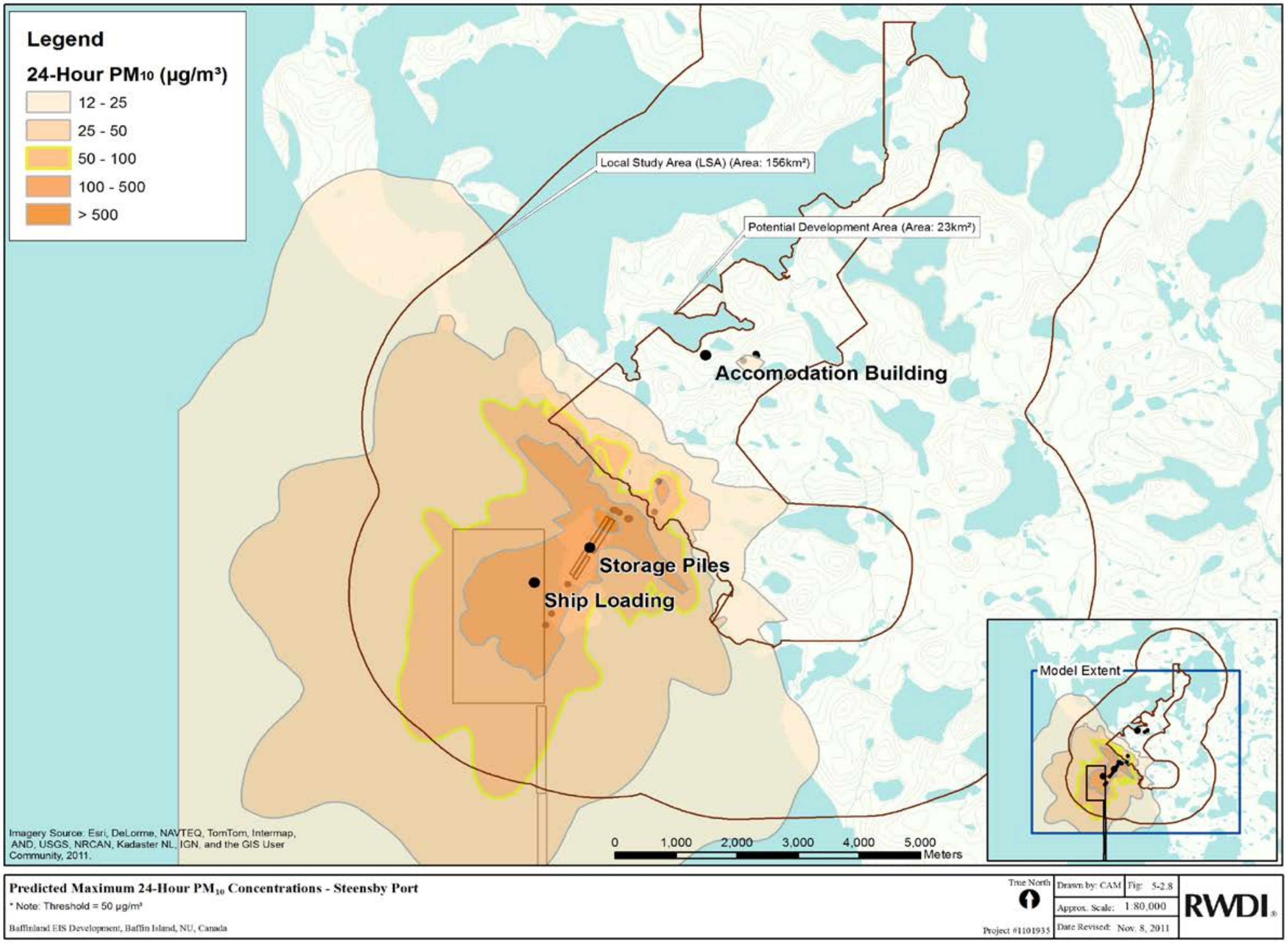


Figure 5-2.8 Predicted Maximum 24-Hour PM_{10} Concentrations - Steensby Port

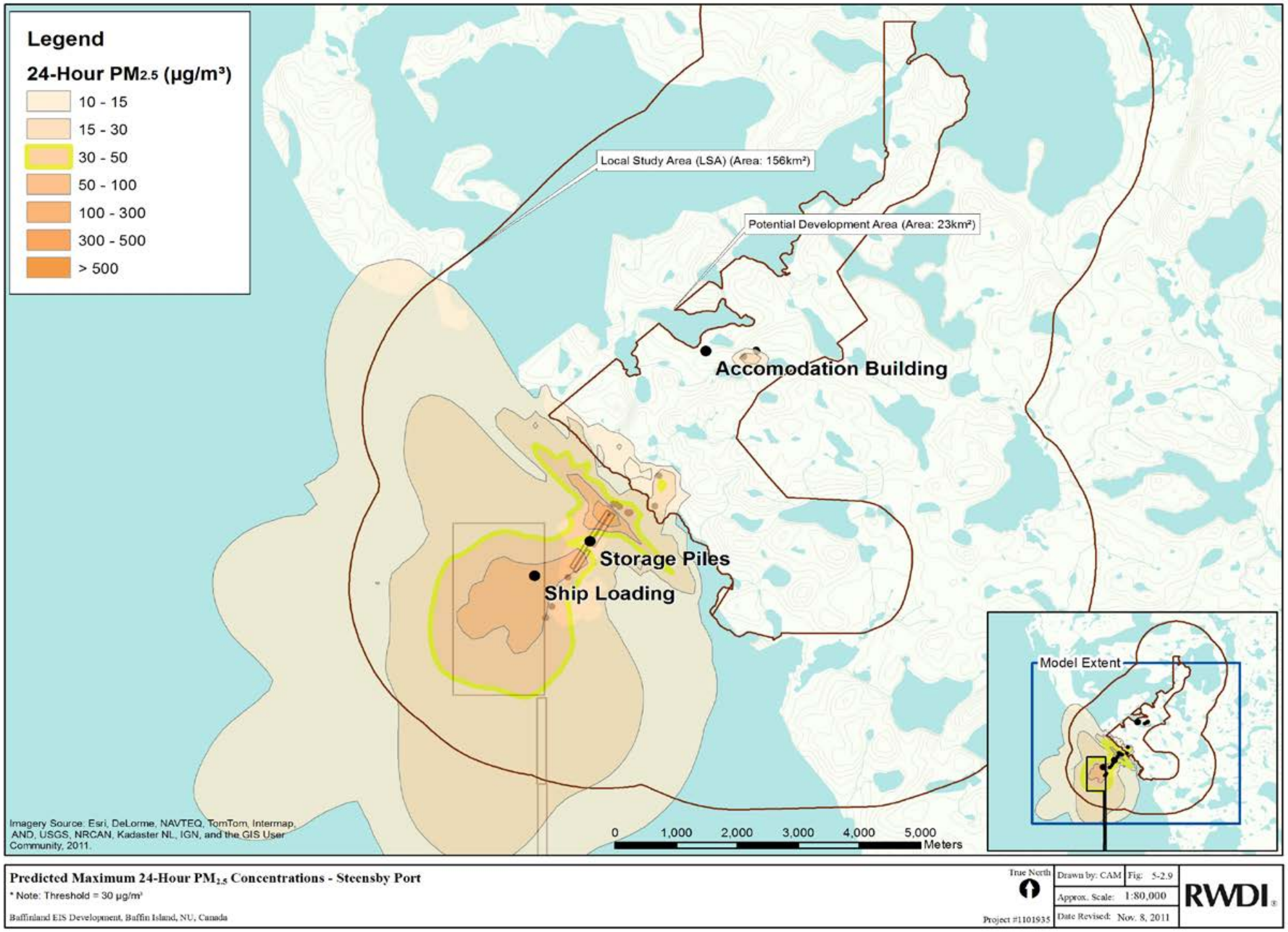


Figure 5-2.9 Predicted Maximum 24-Hour $PM_{2.5}$ Concentrations - Steensby Port

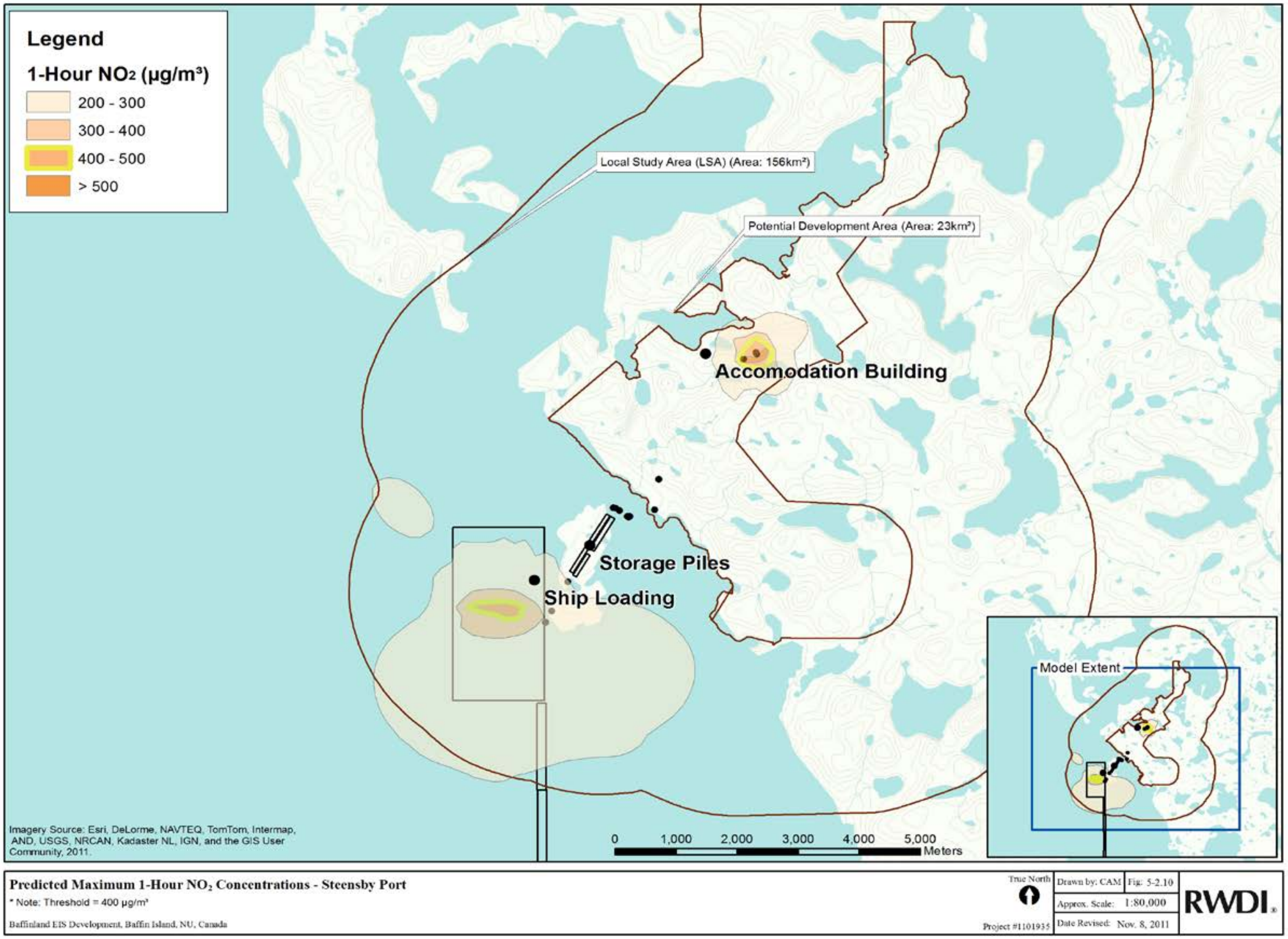


Figure 5-2.10 Predicted Maximum 1-Hour NO_2 Concentrations - Steensby Port

Plots of predicted worst-case 1-hour ground-level NO_2 and SO_2 during a ship departure are provided in Part IV of Appendix 5C-5. The predicted worst-case SO_2 levels during these events exceed the indicator threshold of 450 µg/m^3 within a distance of approximately 1 km on either side of the ship lane, in the area where the ship has not yet reach cruising speed. This impact is over water and does not extend to the main land. The zone of impact would be reduced in the event that the fuel sulphur content is actually less than the guaranteed upper bound of 1.5 %. Once the ship has reached cruising speed, the emissions are more dispersed and the predicted 1-hour SO_2 levels on either side of the ship lane no longer exceed the indicator threshold.

The predicted maximum 1-hour NO_2 levels during a ship departure remain below the indicator threshold of 400 µg/m^3, except immediately adjacent to the lane in the area where the ship begins to accelerate but is still well below cruising speed.

Mitigation Measures

The following mitigation measures are incorporated into the design and have been included in the air quality assessment:

- The rotary car dumper is enclosed and equipped with a dust collector that vents back into the building;
- Good engineering practice in design of exhaust stacks for the power generators will reduce ground level concentrations;
- Ore carriers and sealift vessels will not be permitted to operate any on-ship incinerators while docked at port; and
- Use of low sulphur and ultra low sulphur diesel fuels asset out in Appendix C5-4.

The following adaptive management strategies will also be available for implementation, if required by monitoring:

- Appropriate control at transfer points;
- Adjust speed limits according to conditions; and

These potential options have been identified for consideration in the Air Quality and Noise Abatement Management Plan (Appendix 10D-1).

2.6.4 Potential Effects and Proposed Mitigation - Closure/Post-closure

The closure and reclamation phase is discussed in Volume 3. Air quality effects will be similar to those experienced during construction. Following the closure, a post-closure environmental monitoring program will assess dust and metal deposition levels and the surfaces reclaimed.

2.6.5 Assessment of Residual Effects

Residual effects are those that remain when all mitigation options have been incorporated. The criteria identified in Table 5-2.13 were used to rate the effects on air quality of these residual effects. They are consistent with but differ slightly from the assessment criteria defined in Volume 2, Section 3, having been modified to account for the nature of air quality effects. The overall rating as presented in Table 5-2.14 is a professional judgment based on consideration of magnitude in relation to indicator thresholds, geographic extent, duration, frequency, reversibility of effects, and certainty and probability of occurrence.

Table 5-2.13 Residual Effect Rating Criteria used for the Air Quality Assessment

Criteria	Rating Term	Definition
Magnitude	Level I	The expected emission, ambient concentration, or deposition is less than the background value; is less than 10 % of the indicator threshold; or the associated change is less than 5 %
	Level II	The expected emission, ambient concentration, or deposition is more than the background value; is less than the indicator threshold; or the associated change is greater than 10 %
	Level III	The expected emission, ambient concentration or deposition is predicted to exceed the indicator threshold
Geographic Extent	Level I	The expected measurable changes are confined to the LSA
	Level II	The expected measurable changes extend beyond the LSA
Duration	Level I	The predicted effect persists briefly - no longer than several hours or several days per year
	Level II	The predicted effect persists for the duration of the project phase
	Level III	The predicted effect persists beyond the duration of the Project
Frequency	Level I	Predicted effects occur only a few hours a year due to variable exposures from meteorological variability
	Level II	Predicted effects occur during clearly defined seasons
	Level III	The predicted effect occurs continuously and/or is associated with annual averaging periods
Reversibility	Level I	The predicted effect is reversible after the activity ceases
	Level II	The predicted effect is reversible with cost/effort when the activity ceases
	Level III	The effect cannot be reversed
Qualifiers		
Certainty	High	Baseline data is comprehensive; predictions are based on quantitative data; effect relationship is well understood
	Medium	Intermediate degree of confidence between high and low
	Low	Baseline data are limited; predictions are based on qualitative data; effect relationship is not well understood
Probability	Unlikely	Less than 20 % likelihood of occurrence
	Moderate	Between 20 and 60 % likelihood of occurrence
	Likely	Over 60 % likelihood of occurrence

Table 5-2.14 Effects Assessment Summary: Air Quality

Potential Effect			Evaluation Criteria				
Project Activity	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**
Mine site operations	Negative: increased concentrations of CACs	Emission controls on fugitive emission sources	Level III for: TSP, metals, TSP deposition, PM_{10}, $PM_{2.5}$, and NO_2	Level III for TSP Deposition Level II for all other parameters	Level III	Level I for $PM_{2.5}$ and NO_2 and most metals Level II for PM_{10}, TSP, TSP deposition, and Mn	Level III for TSP deposition Level I for all other parameters
			Level II for all other CACs and PAI	Level II	Level III	Level I	Level I
Rail operations	Negative: increased concentrations of CACs	None	Level I or II for all contaminants	Level II	Level III	Level I	Level I
Steensby operations	Negative: increased concentrations of CACs	Emission controls on fugitive emission sources	Level III for: TSP, metals, TSP deposition, PM_{10}, $PM_{2.5}$, and NO_2	Level III for TSP Deposition Level II for all other parameters	Level III	Level I	Level III for TSP deposition Level I for all other parameters
			Level II for all other CACs and PAI	Level II	Level III	Level I	Level I
Construction and closure phases	Negative: increased concentrations of CACs	Best practices to minimize air emissions	Level III for: TSP, metals, TSP deposition, PM_{10}, and $PM_{2.5}$	Level III for TSP Deposition Level II for all other parameters	Level III	Level I	Level III for TSP deposition Level I for all other parameters
			Level II for all other CACs and PAI	Level II	Level III	Level I	Level I

NOTE(S):
1. CACs = CRITERIA AIR CONTAMINANTS [TSP, PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO].

Residual effects to air quality can be summarized as follows:

- The ambient concentrations of the air quality parameters are at a Level I or II for all phases of the Project. Concentrations in excess of the thresholds are predicted to generally be confined to the LSA and the effects are fully reversible.

The residual air quality effects are predicted to be not significant (Table 5-2.15).

Table 5-2.15 Significance of Residual Air Quality Effects

Effect	Significance of Predicted Residual Environmental Effect		Likelihood (1)	
	Significance Rating		Level of Confidence	Certainty
Increase in air emissions	N	3	3	3

KEY:
Significance Rating: S = Significant, N = not Significant, P = Positive
Level of Confidence[1]: 1 = Low; 2 = Medium; 3 = High
Likelihood - only applicable to significant effects
Probability: 1 = Unlikely; 2 = Moderate; 3 = Likely
Certainty[2]: 1 = Low; 2 = Medium; 3 = High

NOTE(S):
1. Level of confidence in the assignment of significance.
2. Certainty around the assignment of likelihood.

While not an ambient air quality parameter, dust deposition was also evaluated in relation to Ontario's dust deposition criterion (Section 2.5), which is based on nuisance considerations. Dust deposition levels are rated at a Level III and are expected to exceed threshold; effects extend beyond the LSA and are irreversible. Dust deposition at the Mine Site in particular will be relatively high. The potential effects on other VECs are evaluated in Volume 6 (vegetation, mammals), Volume 7 (freshwater quality), and Volume 8 (marine water quality, marine mammals).

2.6.6 Prediction Confidence

Air Emissions Estimation Limitations

The largest emissions associated with mining operations tend to be in the form of particulate matter from sources other than exhaust stacks; these so-called fugitive emission sources include open material handling, movement of heavy equipment over unpaved routes, wind erosion, and blow-off from rail cars and truck trailers. Emissions from these sources are highly variable, depending on weather conditions, surface conditions, characteristics of the bulk material being handled, and specifics of equipment operations. Current experimental methods do not allow for accurate quantification, and published emission factors from studies of fugitive emission sources, which are used in the present assessment, have a high degree of uncertainty, tending to err on the high side.

The US EPA has assigned emission factor quality ratings ranging from A (Excellent) to E (Poor) to provide a general indication of the reliability or robustness of the factor. Quality ratings specific to Mine Site Project emissions are as follows:

- Mining Operations (Section 11.9): The factors for TSP, PM_{10} and $PM_{2.5}$ range from B (Above Average) to E (Poor), depending on the activity;
- Blasting (Section 11.9 and Section 13.3): The Section 11.9 factors are rated as C (Average) for TSP and D (Below Average) for $PM_{2.5}$. While Section 11.19.2 (Crushed Stone Processing and Pulverized Mineral Processing) explicitly states that the AP-42 11.9 (Western Surface Coal Mining) particulate matter blasting emission factor should not be used in quarry type operations, this emission factor is in fact often used, and has been used for this assessment for lack of alternatives. The Air Pollution Engineering Manual (Davis, 2000) corroborates these facts, indicating that no particulate emission factor data are available for quarry (open-pit) type operations. It indicates emissions will be low because of the short time for which the plume exists.
- Mine Fleet Exhaust Emissions: These emissions were not determined from AP-42 and were obtained from Tier II/III emission standards proposed by the US EPA for off-road vehicles. The assumption that emission rates equal emission limits is a significant source of uncertainty. Emissions could vary depending on make, age, and state of maintenance of the equipment. Activity data is also a significant source of uncertainty.

The level of confidence in estimating emissions is high for combustion sources such as the power generation units and the mobile fleet. The level of confidence decreases to medium to low, for the estimation of TSP and $PM_{2.5}$ from mining operations. The level of confidence is lowest for blasting operations (low, or “poor” according to the US EPA). Notwithstanding this level of uncertainty, the approach gives a reasonable indication of the emissions that can be expected from a complex operation with many ancillary activities.

An effort was made to bias towards overestimation of the activity and/or the emission factor associated with a specified activity, which helps to offset the average-to-poor variability of the available emission factors for TSP and $PM_{2.5}$. For many sources, the emissions were estimated based on the design capacity of a specific piece of equipment; for others, a more precise approach was followed. Fugitive dust sources such as bulk material handling and wind erosion from stockpiles vary considerably with time, based on wind conditions. This variability was accounted for in the modelling. Fugitive dust emissions were calculated on an hourly basis using site-specific meteorological data applied in the dispersion modelling.

Model Limitations

Uncertainty associated with dispersion model predictions stems from two main areas (US EPA, 2005):

- Uncertainties associated with the input values and the limitations of the model physics and formulations. Reducible uncertainty can be minimized by better, more accurate and representative, measurements and by improved model physics.
- Inherent uncertainty associated with the stochastic nature of the atmosphere and its representation, including the representativeness of the meteorological data. Models predict concentrations that represent an ensemble average of numerous repetitions of the same nominal event. An individual observed value can deviate significantly from the ensemble value. This uncertainty may be responsible for a ± 50 % deviation.

Generally, models are quoted as having a factor-of-two accuracy. Comparison studies have indicated that models can predict the magnitude of highest concentration occurring sometime and somewhere within an area to within ± 10-40 %. Predictions that occur at a specific site and time are often poorly correlated with observed values. This poor correlation can be related to reducible errors in wind direction; for example, an uncertainty of 5º-10º in wind direction can produce a concentration error in the 20-70 % range.

The model should be viewed as an indication of the magnitude of the resulting ambient contaminant concentration and the spatial variation.

2.6.7 Follow Up

The air quality assessment has identified TSP, metals, PM_{10} and $PM_{2.5}$ concentrations at the Mine Site and Steensby Port could be a concern. Visual observations will readily confirm the sources of excessive dust emissions and corrective actions will be taken as required.

Periodic sampling of dust fall will be carried out to confirm FEIS dust fall predictions. Typically, TSP will be measured using hi-vol samplers over a period of several days or weeks. The information collected will be used to confirm modelling predictions.

In terms of gaseous emissions, SO_2, NO_X and greenhouse gases emissions will be calculated on the basis of fuel consumption.

This monitoring is described in the Air Quality and Noise Abatement Management Plan (Appendix 10D-1).

Meaningful dust deposition (measured as TSP) will occur mainly as a result of ore handling and will contain metals as described in this section. The effects of this dust deposition are addressed in Volume 6 (vegetation, wildlife), Volume 7 (freshwater quality), and Volume 8 (marine water quality, marine mammals).

Railway and Tote Road Corridors

Monitoring is not required along the rail corridor. The Tote Road will be watered as required during dry weather to minimize dust emissions.

2.7 IMPACT STATEMENT

Air quality parameter concentrations in excess of their respective thresholds are predicted, though these exceedances are generally confined to the LSAs, and are generally reversible. Effects of the Project on air quality are predicted to be not significant.

2.8 AUTHORS

This air quality effects statement was prepared by Sharon Schajnoha, B.Sc., P.Eng. (Project Manager/Associate) of RWDI AIR Inc., with the support of Ahammad Ali, MA.Sc., B.Sc., EIT (Junior Air Quality Coordinator), Alain Carrière, B.A., Dipl. Ecotox (Senior Project Manager) and Mike Lepage, M.Sc., ACM, CCM (Project Director).

SECTION 3.0 - NOISE AND VIBRATION

3.1 BASELINE SUMMARY

A detailed baseline assessment conducted in 2007 is documented in a baseline noise assessment report (Appendix 5D-1). The basic procedure to establish baseline noise levels consisted of:

- Conducting measurements and recording sound levels at Milne Port, the Mine Site, and Steensby Port;
- Validating the data based on the recordings and weather information; and
- Calculating the resulting validated sound level data.

In the absence of specific requirements for Nunavut, the noise measurement requirements of Alberta Energy and Utilities Board (AEUB) Directive 038: Noise Control (AEUB , 2007), and Ontario Ministry of the Environment Publications NPC-103 were followed (MOE, 1977).

Monitoring Locations

Sound level meters were operated for approximately 10 days in July 2007 near the Mine Site, Steensby Inlet and Milne Inlet. The locations were chosen to ensure minimal effect from exploration activities underway at the time. Effects from frequent low-flying aircraft were unavoidable, but were excluded during analysis. Distances of approximately 2 km from the exploration activities at the Mary River site and approximately 1 km from the exploration activities at the Steensby and Milne sites were found to be sufficient to prevent interference from noise caused by most other human activity. Locations of the sound monitoring stations are shown in Figure 5-3.1.

Baseline Noise Environment

The Local Study Areas, because of their remote locations, are not presently influenced by any existing permanent anthropogenic noise sources. The only anthropogenic noise in the Project area comes from the existing mineral exploration, baseline environmental data collection activities and the occasional traditional use of the area by hunters, trappers and fishermen.

Background atmospheric noise levels in remote areas are typically low, ranging from about 25 to 40 dBA, similar to those measured for the Mine Site, Steensby Inlet and Milne Inlet. Table 5-3.1 shows measured ambient noise values for each site. At these levels, noise would be described as faint.

Table 5-3.1 Baseline Noise Monitoring Results

Site	L_{eq} (24 h) (dBA)	L_{eq} (Day, 15h) (dBA)	L_{eq} (Night, 9h) (dBA)	Minimum L_{eq} (1 h) (dBA)	Maximum L_{eq} (1 h) (dBA)
Mary River	25	25	26	20	34
Steensby Inlet	29	31	26	23	35
Milne Inlet	30	31	29	21	35

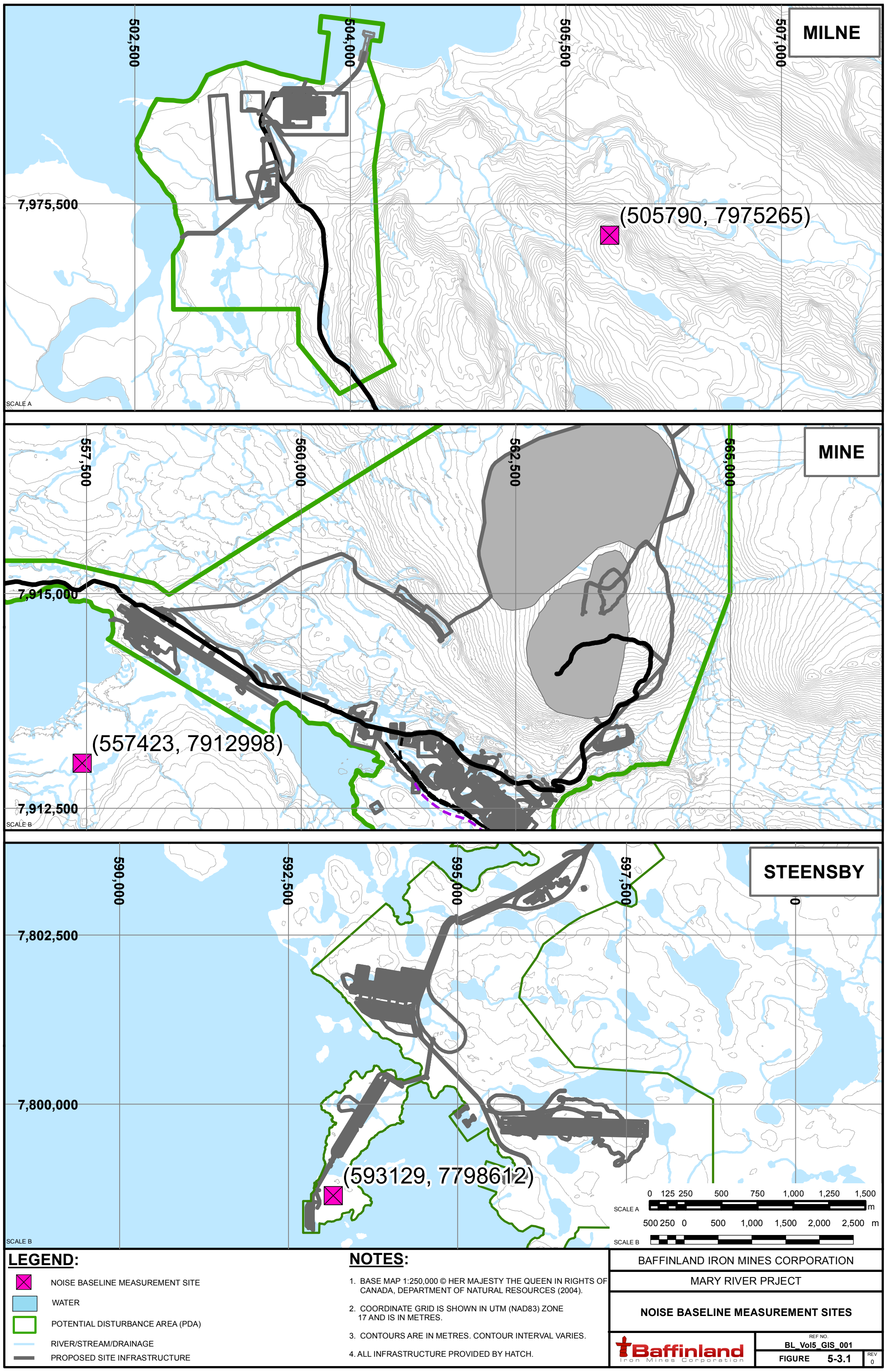


Figure 5-3.1 Noise Baseline Measurement Sites

Noise observed at all three sites consists mainly of wind, insect, and small animal and bird noise. Flowing water and breaking waves contribute to the baseline noise levels the port sites. Differences observed between daytime and night-time sound levels are generally small, and are attributed mainly to very low level noise from human activity that could not be screened out.

Comparison with Other Northern EIAs

The measured ambient sound levels presented in Table 5-3.1 are quieter than those used as the basis of D038, which assumes an average rural ambient sound level of 35 dBA, and are quieter than those measured in ambient surveys conducted for other northern locations (e.g., in the Northwest Territories) and those measured by the Ontario Ministry of the Environment for wind noise in rural locations (MOE, 2004). The main reason for this is likely the relative lack of noise from wind-vegetation interaction for the Baffin Island locations (lichens and low-lying grasses/bushes at the Project sites, versus trees, shrubs and tall grasses at more southern sites).

Baseline Vibration Environment

As there are no anthropogenic sources of vibration in the area other than Baffinland-related activities, no baseline vibration measurements were judged necessary.

Local Study Area

Local Study Areas (LSAs) were selected to represent areas where Project noise and vibration effects are likely to occur, and to illustrate the spatial distribution of these effects. Boundaries of the LSAs were located where Project sound levels were anticipated to be similar to background levels without the project. LSAs are offset from the PDA by 3 km. Figures 5-3.2 and 5-3.3 show the LSAs and PDAs selected for this assessment for the Mine Site and Steensby Port.

Regional Study Area

The project area is in pristine natural condition, remote from any established human settlement, with neither industrial nor resource extraction development nearby. At the time of RWDI's baseline noise monitoring (June 2007), there were no existing anthropogenic noise sources that would influence ambient noise levels except for those associated with exploration activities at the mine site.

No regional study area has been defined where there are other local anthropogenic noise effects. This is consistent with the approaches taken in other environmental assessments in Nunavut and the Northwest Territories.

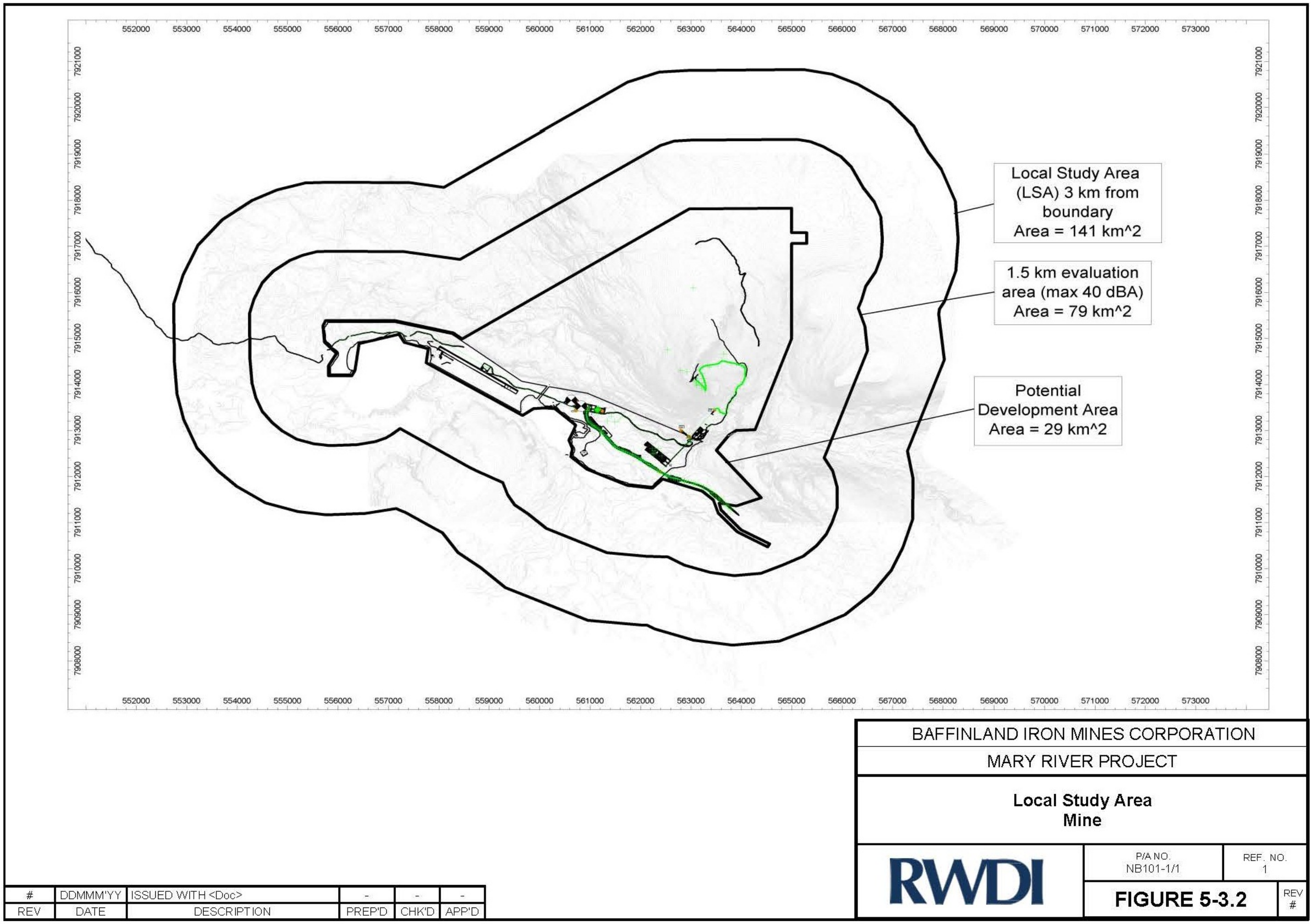


Figure 5-3.2 Noise Local Study Area - Mine Site

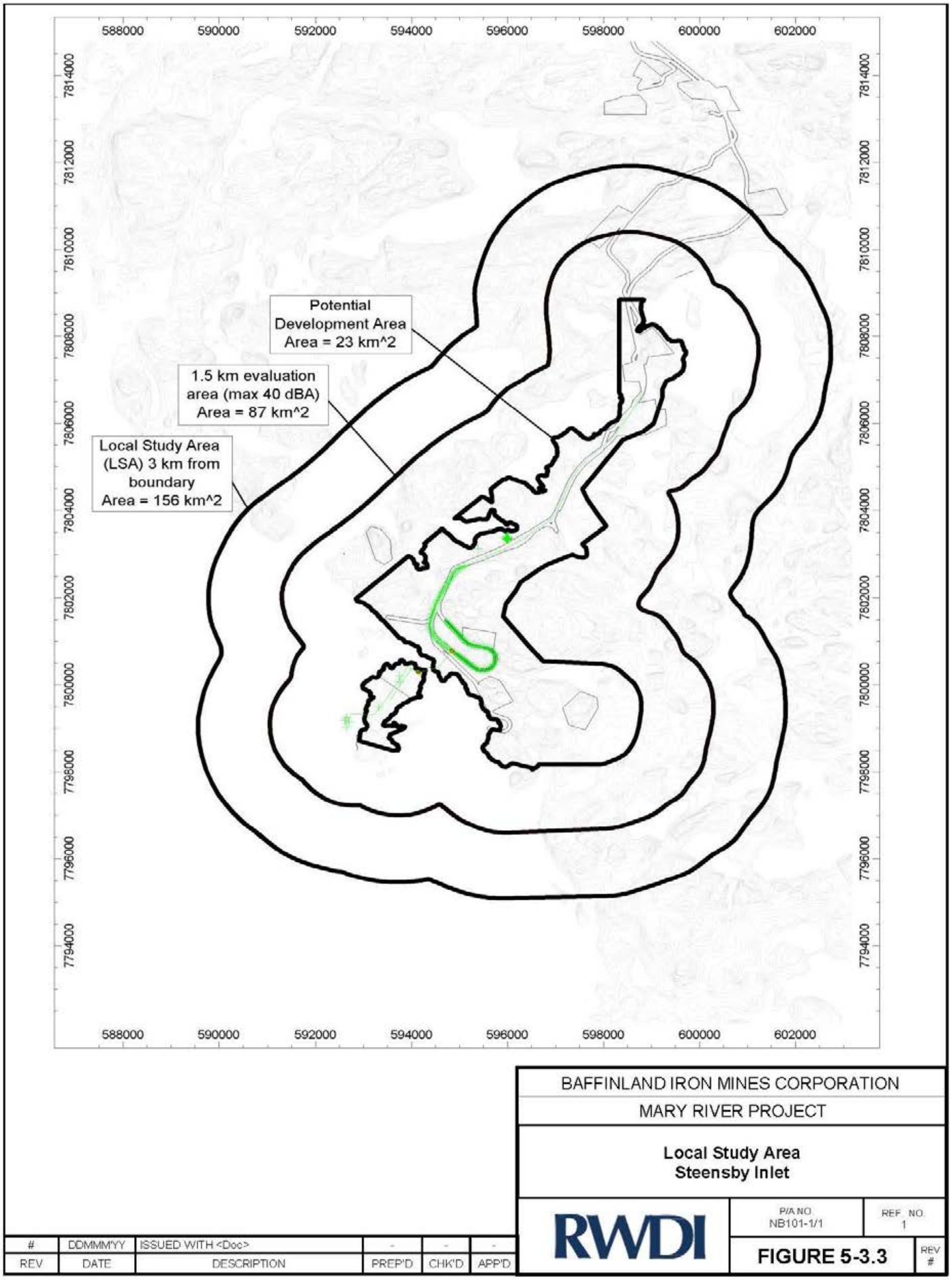


Figure 5-3.3 Noise Local Study Area - Steensby Inlet

3.2 ISSUES SCOPING

Noise and Vibration Issues

The Mary River Project site is in a remote location with no existing local sources of industrial noise or vibration. Construction and operation will introduce new, local sources of noise and vibration that have the potential to affect wildlife and human receptors. Table 5-3.2 summarizes these issues, which have been addressed in either a quantitative or qualitative manner.

This report identifies the existing noise environment in the project area and describes the potential effects of the Mary River Project. The potential effects were evaluated and compared to Alberta Energy and Utilities Board (AEUB) Directive 038 guidelines (AEUB 2007), which were used to assess noise effects for similar projects in Nunavut and the Northwest Territories.

This assessment concentrates on comparisons with guideline limits and effects on human receptors. Effects on other biophysical components, including wildlife, vegetation and human health, are addressed separately by the appropriate disciplines.

Table 5-3.2 Key Issues for Noise and Vibration

Project Phase	Key Issue	Relevance to Project
Construction and closure/post-closure	Noise	Construction and decommissioning of project facilities, including the Mine Site and ports, and transportation links such as roadways and the railway, may generate substantial amounts of noise that can affect human receptors and other VECs such as wildlife.
	Vibration	
Operations	Noise	Operation of project facilities, including the Mine Site and ports, and transportation links such as roadways and the railway, may generate substantial amounts of noise that can affect human receptors and other VECs such as wildlife.
	Vibration	

This assessment focuses on ground-borne vibration that may be perceptible to humans or wildlife. Potential effects of vibration are addressed in Volume 7, Section 4, for freshwater fish, and in Volume 8, Sections 4 and 5, for fish and marine mammals in the marine environment.

Valued Ecosystem Components and Indicator Selection

High levels of environmental noise and vibration can affect people by impairing their enjoyment of using the land, can affect wildlife by causing changes in behaviour or avoidance of affected areas, at least temporarily. Environmental noise and vibration levels are therefore Key Indicators (KIs) selected for study.

Table 5-3.3 Summary of Noise and Vibration Key Indicators

Key Indicator	Issue Identified and Reason for Selection of KI	Measurable Parameter
Environmental Sound Levels	Minimize disturbance of natural terrestrial wildlife use patterns in the region. Minimize effects on seasonal human dwellings in the area of Milne Inlet	A-Weighted Sound Levels (L_{eq} dBA)
Environmental Vibration Levels	Minimize disturbance of natural terrestrial wildlife use patterns in the region	Peak vibration levels (mm/s)

3.3 NOISE

3.3.1 Assessment Methods

The effects assessment identifies potential changes or effects to existing noise conditions that may result from project activities.

Effects during the Construction and Closure and Reclamation phases were assessed qualitatively. The Operations Phase was assessed quantitatively for all three sites. Sound levels from deliveries by sealift at Milne Inlet were assessed as part of a monitoring program conducted in September 2007.

Noise effects for summer and winter conditions for Mary River and Steensby Inlet were assessed separately, to account for potentially significant changes in noise propagation with the weather conditions.

Project Emissions

As the Project has not yet been constructed, there are no direct measures of Project emissions. Noise emissions were therefore estimated based on engineering data for the proposed equipment, obtained from:

- Manufacturer's data for specific equipment, where available;
- Previously measured data of similar equipment from previous studies;
- Published engineering estimates from textbooks; and
- Data from published prediction models.

Activities with corresponding temporal and spatial boundaries were collected from Development Proposal and Project engineering staff. Manufacturer's data on file for similar equipment was used where appropriate. Appendix 5D-2 provides technical details regarding the noise source emission inventory for the Mine Site and Steensby Port.

Noise Modelling

Model Selection

Off-site sound levels were modelled using Cadna/A, a software implementation of the internationally recognized ISO 9613 environmental noise propagation algorithms (ISO, 1993 & 1996). Cadna/A is produced by Datakustik GmbH. The modelling took into account the following factors:

- Source sound power level and directivity;
- Distance attenuation;
- Source-receptor geometry, including heights and elevations;

- Barrier effects of the buildings and surrounding topography;
- Ground and air (atmospheric) attenuation; and
- Meteorological effects on noise propagation.

The ISO 9613 algorithms are the current international standard for airborne noise propagation, and are widely used in noise assessments in Canadian jurisdictions. Modelling parameters have been selected to conform to the ISO standard.

Model Parameters

Several modelling parameters affect the results.

Table 5-3.4 Modelling Parameters Used in the Analysis

Modelling Parameters	Value Used in the Analysis
Ground Absorption	0.8 (summer) / 1.0 (winter)
Temperature	8° C (summer) / -30° C (winter)
Relative Humidity	70 %
Effective Stability Class (per ISO 9613)	E
Barrier Parameters	
Include Ground Absorption over Barrier?	No
Negative Path Length Allowed?	Yes
Barrier Lateral Diffraction Distances	3000 m
Reflection Parameters	
Order of Refection	0
Reflection Loss	n/a
Reflection Search Distances	n/a

Summer and winter conditions were modelled. Temperatures represent the mean maximum temperature for June-July-August, and the mean minimum temperature for November-December-January, respectively, based on climate normals measured at Mary River for 2005 to 2007.

The ground attenuation factor G is one of the most important parameters. In the ISO 9613 algorithms, G is a value ranging from 0 to 1, with 1 being perfectly absorptive, and 0 being perfectly reflective. RWDI's selection of 0.8 for summer conditions takes into account the presence of vegetation and exposed rock. The selection of the value is also based on RWDI's experience and review of the results of previous studies where modelling and measurements were conducted. The ISO 9613 equations are known to under-predict the effects of effects of ground absorption over long distances, resulting in slightly conservative over-predictions.

Overview of Methodology

A standard assessment approach was used to determine the potential effects of the Project. This approach is outlined in Table 5-3.5 and included the following tasks:

- Identify and quantify noise emission sources (for Mary River, and Steensby Inlet);
- Use baseline ambient monitoring results to establish existing background levels;

- Use noise models to predict levels from worst-case operations;
- Compare the predicted noise modelling results to the ambient levels and to the guideline limits; and
- Identify the incremental changes and assess the significance of the Project.

Table 5-3.5 Noise Assessment Approach

Component	Description
Noise Emission Characterization	Facility designs were reviewed to identify equipment and activities that have the potential to generate significant levels of noise and vibration. Predictable worst-case scenarios for noise and vibration effects from Project operations were developed for locations of equipment, timing and intensity of operations, etc. Noise emission data for significant sources were then determined, based on manufacturer's data, measurements of existing/similar equipment, or engineering estimates using published emission factors
Review of Ambient Noise Environment	An ambient monitoring program was undertaken to establish baseline noise conditions in the absence of the Project
Establishment of Noise Guideline Limits	Guideline limits for noise were established based on a review of the relevant guidelines and the ambient noise measurements
Noise Modelling Approach	Noise effects from summer and winter conditions were modelled using a computerized version of the ISO 9613 international standard noise model

Noise Guidelines and Metrics

Environmental sound levels vary continuously over time. To account for both daily and short-term variations in sound levels, several single numerical descriptors have been developed based on large-scale psycho-acoustic studies of annoyance with environmental noise. These allow sound monitoring to be conducted for a constantly varying sound environment over an extended period, with the results described as a single number that accurately describes the environment.

The single number descriptor commonly used in most international standards for environmental sound measurements is the energy equivalent sound level (L_{eq}); expressed in dBA, this is the energy-averaged, A-weighted sound level for the complete measurement interval. It is the steady, continuous sound level over a given period that has the same acoustic energy as the actual varying sound levels occurring over the same period in the measured environment. The L_{eq} is one of the most common and useful predictors of human response to noise, and is the one used in the majority of to environmental noise criteria. The A-weighting accounts for the frequency content of the measured sound based on a frequency response similar to that heard by the human ear.

The descriptors specific to this study are:

- The 24-hour A-weighted energy equivalent sound level, L_{eq} (24), referred to as the daily sound level;
- The 15-hour A-weighted energy equivalent sound level, L_{eq} Day or Leq (15), referred to as the daytime sound level;
- The 9-hour A-weighted energy equivalent sound level, L_{eq} Night or L_{eq} (9), referred to as the night-time sound level; and
- The 1-hour A-weighted energy equivalent sound level, L_{eq} (1), referred to as the hourly sound level.

Ranges of typical sound levels are presented in Table 5-3.6.

Table 5-3.6 Typical Ranges of Commonly Encountered Sound Levels

Modelling Parameters	dBA	Common Noise Sources
Deafening	**120**	Threshold of pain
	115	Maximum noise level at a hard rock concert
	110	Accelerating motorcycle at 1 m
	105	Loud auto horn at 3 m
Very Loud	**100**	Dance club; maximum human vocal output at 1 m
	95	Jackhammer at 15 m
	90	Inside a noisy factory
	85	Heavy truck pass-by at 15 m
Loud	**80**	School cafeteria; noisy bar
	75	Near edge of major highway; inside automobile travelling at 60 km/h
	70	Vacuum cleaner at 1.5 m
	65	Normal human speech, i.e., an un raised voice, at 1 m
Moderate	**60**	Typical background noise levels in a large department store; hair dryer
	55	Running tap water
	50	Clothes dryer; air conditioner
	45	Typical background office noise level caused by HVAC; flowing stream
Faint	**40**	Typical background noise level in a library; EUB guideline for noise at 1.5 km
	35	Average whisper; typical quiet outdoors
	30	Broadcast studio
	25	
Very Faint	**20**	Deep woods on a calm day
	15	
	10	
	5	Human breathing
	0	Threshold of hearing, i.e., quietest sound that can be heard

Noise Guidelines

Nunavut has no regulations or guidelines that address environmental noise levels. However, noise has been addressed in recent environmental assessments of other mining projects in Nunavut, including the Meadowbank Gold Project, the Doris North Gold Project and the High Lake Project.

These projects, and projects in the Northwest Territories, have adopted the Alberta Energy and Utilities Board (AEUB) Directive 038 guidelines (AEUB 2007) as indicative of what is generally considered acceptable with respect to noise levels from industrial activities in remote areas. Directive 038 (D038) guidelines have been adopted for the Mary River Project for comparison purposes.

General Format of D038

D038 sets out Permissible Sound Levels (PSLs) that must be met at all dwellings surrounding a project. These limits apply to operational noise only. The cumulative sound level from all energy-related (in this case Project-related) development in the area is measured or predicted. This is called the Comprehensive Sound Level (CSL), and is compared to the PSL. The CSL includes background ambient sound levels.

The base PSL value is an average 1-hour sound level (L_{eq}(1-hour)) of 40 dBA, which is based on a typical rural or remoter Ambient Sound Level (ASL) of 35 dBA, plus a 5 dB allowance for the industrial activity. Research conducted by Alberta Environment showed that, in general, people tolerate sound from energy facilities of up to 5 dB above the ambient sound environment.

The PSL may be increased to account for the presence of other industrial and transportation noise sources, such as road and rail traffic, and for the population density of developed areas.

In remote pristine areas, an ambient sound level adjustment based on measured existing sound levels, may be applied; this may reduce the PSL at these locations.

Dwellings

A dwelling is defined in D038 as permanently or seasonally-occupied residences, including trailer parks and campgrounds in regular and consistent use. Worker residences, dormitories and construction camps are specifically excluded. An old cabin at the far east portion of the beach at Milne Port is in poor condition but is available for refuge from storms if necessary (Figures 5-3.10 and 5-3.11). The beach area east of the cabin is occasionally used as a campground by residents of Pond Inlet. Neither would meet the D038 definition of a dwelling as a noise-sensitive receptor, since it is not in regular and consistent use. The cabin is nevertheless considered in the noise assessment.

While there are cabins at each of the Mine Site (in usable condition) and Steensby Port (not in usable condition), it is expected that these cabins will be no longer available for use (Volume 4, Section 10). Thus no dwellings are considered within the Mine Site and Steensby Port LSAs.

Noise Limit for Remote Areas

Where no noise sensitive receptors are located within 1.5 km of the facility, the CSL from the facility (facility noise plus ambient) must meet a PSL of 40 dBA Leq (Night) measured at 1.5 km from the facility fence line. This limit applies to Project-related activities at the Mine Site and at Steensby Port.

The “fence line” is not defined for facilities such as those at the Baffinland sites, where there is no fence or other fixed facility boundary. This assessment uses the PDA as a proxy for the fence line. Thus, the PSL for these facilities is 40 dBA at 1.5 km from the PDA.

Worker Residences (Work Camps)

Although work camps are specifically excluded from the requirements of D038, worker health demands an adequate sleep environment. Interior levels can be characterized using Balanced Noise Criterion (NCB) curves. For sleeping areas in larger complexes, NCB ratings of NCB 28 to NCB 33 are generally accepted. Due to the nature of this project, a rating of NCB 33 or less is recommended for the work camps.

If required, mitigation measures may be specified as required, including but not limited to:

- Relocation of the dwellings;
- Reorientation of the dwellings;
- Berms or noise barriers near the dwellings; and
- Upgraded building construction such as upgraded windows and mandatory air conditioning.

Road and Rail Traffic

D038 provides no guidance on noise from road and rail traffic sources outside of the facility boundaries (road and rail noise within the boundary of a facility is generally included in the modeled noise sources).

Noise from these sources will be intermittent in nature, occurring only when a vehicle passes by. They will be remote from any stationary human receptors, although caribou hunters can be expected to be travelling through the area. While specific guideline limits are not established, predictions of noise from these sources are provided for other disciplines to use in their assessments.

Air Traffic

D038 provides no guidance for noise from air traffic. Federal regulations exist for average sound levels at airports, but those are not appropriate to a remote airstrip with limited traffic. Noise from aircraft will be intermittent and will be remote from all human receptors outside of the Mine Site, Milne Port and Steensby Port. Noise from aircraft ground operations has not been assessed. Aircraft flights are anticipated to be infrequent.

Construction

D038 noise guideline limits do not apply to construction activities. Instead, good management practices are required to reduce the potential for effects. These are discussed further in Section 3.3.2.

3.3.2 Potential Effects and Proposed Mitigation - Construction Phase

Details of the construction activities at all three sites are provided in Volume 3.

A detailed noise modelling assessment was not conducted for the Construction Phase because of the intermittent and temporary nature of activities. Potential effects were therefore assessed qualitatively based on:

- Previous experience and some limited noise monitoring conducted in September 2007 at Milne Inlet during the preparation for the bulk sampling phase; and
- Noise monitoring conducted at Mary River during bulk sampling activities in April 2008.

Noise emitted during construction activities is not regulated by D038 guidelines, which do however, require that reasonable measures be undertaken to minimize the effects of construction activities on nearby residences. There may be elevated noise levels at the camping area at the east side of the beach, which is very occasionally used by Pond Inlet hunters.

3.3.2.1 Mine Site

Activities, Equipment and Schedule

Volume 3, Section 2 includes descriptions of the anticipated construction activities, equipment and schedule at the Mine Site. Construction activities with the potential for noise emissions include:

- Upgrade of the airstrip to accommodate Boeing 737s, Bombardier Dash-8s or similar sized aircraft;
- Preparation of lay down areas or work areas;
- Construction of project facilities;
- Construction and operation of a concrete batch plant;
- Construction of access roads;
- Construction of the railway from the Mine Site to Steensby Port; and
- Development of existing aggregate sources for rock, sand and gravel.

Estimate of Noise Effects

The following noise emissions are expected at the Mine Site during construction:

- Noise levels at some locations may be moderate to loud depending on proximity to the sources. There is a potential for construction noise to extend out to 1.5 km from the PDA.

- The duration of effect is short-term. The frequency of effect is occasional and the effect is reversible. The effect is anticipated to be insignificant after implementation of the mitigation measures described below.

Recommended Noise Controls

Construction noise effects are temporary, and therefore higher noise levels are generally acceptable to affected residents; this is why construction noise is exempt from AEUB Directive 038 (AEUB 2007). However D038 recommends that, where feasible, mitigation measures be used to minimize noise effects on nearby residents. Among the various measures recommended in D038, the following are applicable in the present case:

- Ensure that all internal combustion engines are fitted with appropriate muffler systems; and
- Take advantage of acoustical screening from existing on-site buildings to shield dwellings from construction equipment noise.

Where feasible, temporary construction accommodations should be sited to avoid potential construction noise effects.

Conclusions

Elevated noise levels may occur near construction activity at the Mine Site; however, significant effects are not anticipated.

3.3.2.2 Milne Port

Activities, Equipment and Schedule

Activities at Milne Port are limited to receiving material and equipment by sealifts; this will take place during the Construction Phase, and infrequently thereafter, for the routine replacement of equipment. Noise impacts will therefore be temporary and of short duration, and so sound levels have not been modelled.

Volume 3, Section 2, includes descriptions of the anticipated construction activities, equipment and schedule at Milne Port. Activities that have the potential to effect local noise levels include:

- Preparation of any additional lay down areas or work areas;
- Construction and operation of a concrete batch plant;
- Construction of the port and related facilities;
- Operation of quarries and borrow sources for construction of the port, airstrip and railway; and
- Construction activities related to upgrades to the existing road.

Estimate of Noise Effects

Construction activities at Milne Port have the potential to generate audible construction noise that extends out to 1.5 km from the facility. Noise levels at some locations within the construction area may be moderate to loud. The duration is short-term, the frequency of effect is occasional and the effect is reversible. The effect after implementing the mitigation measures is anticipated to be *"not significant"*.

Conclusions

Elevated noise levels may occur near construction activity. However, with the inclusion of the mitigation measures outlined above, significant effects are not anticipated.

3.3.2.3 Steensby Port

Activities, Equipment and Schedule

Volume 3, Section 2, includes descriptions of the anticipated construction activities, equipment and schedule at Steensby Port. Construction activities that have the potential to affect local noise levels include:

- Preparation of additional lay down areas or work areas;
- Development of the airstrip and the access road from the port site to the airstrip;
- Construction of the railway access road;
- Construction and operation of a concrete batch plant;
- Construction of the port and related facilities;
- Operation of quarries and borrow sources for construction of the port, airstrip and railway; and
- Underwater blasting for port construction.

Estimate of Noise Effects

Construction at Steensby Port has the potential to generate construction noise that may extend out to 1.5 km from the PDA. Noise levels at some locations may be moderate to loud. The duration is short-term, the frequency of effect is occasional and the effect is reversible. After implementation of the mitigation measures described below, the effect is anticipated to be *"not significant"*. Underwater noise effects to marine receptors are evaluated in Volume 8.

Recommended Noise Controls

Construction noise effects are temporary, and therefore higher noise levels are generally acceptable to affected residents and are thus exempt from AEUB Directive 038 (AEUB 2007) noise requirements. However D038 recommends that, where feasible, mitigation measures be used to minimize noise. Among the various measures recommended in D038, the following are applicable in the present case:

- Ensure that all internal combustion engines are fitted with appropriate muffler systems; and
- Take advantage of acoustical screening from existing on-site buildings to shield dwellings from noise.

Where feasible, temporary construction accommodations should be sited to avoid construction noise effects.

Conclusions

Elevated noise levels may occur near construction activity. However, with the inclusion of the mitigation measures outlined above, significant effects are not anticipated.

3.3.2.4 Railway

Activities, Equipment and Schedule

Volume 3, Section 2 of the EIS includes descriptions of the anticipated construction activities, equipment and schedule related to the railway.

Estimate of Noise Effects

The following noise effects are expected along the rail corridor during construction:

- Noise levels at some locations within the construction area may be moderate to loud, depending on proximity to the sources. There is a potential for construction noise to extend out to 1.5 km from the construction area.
- The duration is short-term, the frequency of effect is occasional and the effect is reversible. After implementing mitigation measures, the effect is anticipated to be *"not significant"*.

Recommended Noise Controls

Noise controls similar to those used at the Mine Site are recommended (see Section 5.1.3)

Conclusions

Elevated noise levels may occur near construction activity. However, with the inclusion of mitigation measures, significant effects are not anticipated.

3.3.3 Potential Effects and Proposed Mitigation - Operation Phase

3.3.3.1 Mine Site

A detailed description of operations at the Mine Site during the Operations Phase is provided in Volume 3.

Description of Operations

The following activities have the potential for local noise effects and were considered in the assessment:

- Open-pit mine operations including drilling, blasting, grading and dozing;
- Crushing, screening, and conveying operations;
- Mobile engine operations including drills, shovels, loaders, trucks;
- Mine haul trucks;
- Ore stockpiling including stacker/reclaimer and conveyance systems;
- Power generation, including a series of generators, with boilers providing emergency backup heat;
- Railway activities, specifically the loading of railcars and operation of locomotive engines; and
- Waste incineration.

The noise emission level estimates applied in the noise assessment are provided in Appendix 5D-2.

Noise Mitigation Measures

A number of noise mitigation measures have been incorporated into the design. The following features have been included in the assessment:

- Bulk material conveyors and transfer points are enclosed;
- Dust collectors are enclosed or vent into enclosures;
- Secondary crushers and screens are enclosed;
- Rotary rail dumpers are enclosed; and
- Exhaust stacks and air inlets for the power generators will include silencers (mufflers).

Operational Noise Levels

Worst-case noise levels are summarized in Table 5-3.7. Graphical representations of L_{eq}(1-hour) sound levels during summer and winter operations are provided in Figures 5-3.4 and 5-3.5, respectively. Predicted operational noise levels inside the worker accommodation building (with windows closed) are represented by a Balanced Noise Criterion (NCB) level, and are summarized in Table 5-3.8.

Table 5-3.7 Mine Site Modelled Noise Levels - Operation Phase

Modelling Parameters	Seasonal Sound Level at Location (L_{eq}(1-hour), dBA)	
	Summer	Winter
1.5 km from PDA	23 to 45	17 to 43
Worker Accommodation Building	36 to 55	36 to 55

Table 5-3.8 Mine Site Modelled Indoor Noise Levels - Operation Phase

Modelling Parameters	Maximum Seasonal Sound Level at Location (Balanced Noise Criterion)	
	Summer	Winter
Worker Accommodation Building	NCB 29	NCB 29

Conclusions

The results of the noise assessment for the Mine Site can be summarized as follows:

- Mitigation features have been incorporated into the design;
- Predicted worst-case noise levels range from 17 to 45 dBA, 1.5 km from the PDA; and
- Predicted worst-case noise levels range from 36 dBA to 55 dBA at the accommodation building, with an estimated worst-case NCB rating of NCB 29, which is below the recommended level of NCB 33.

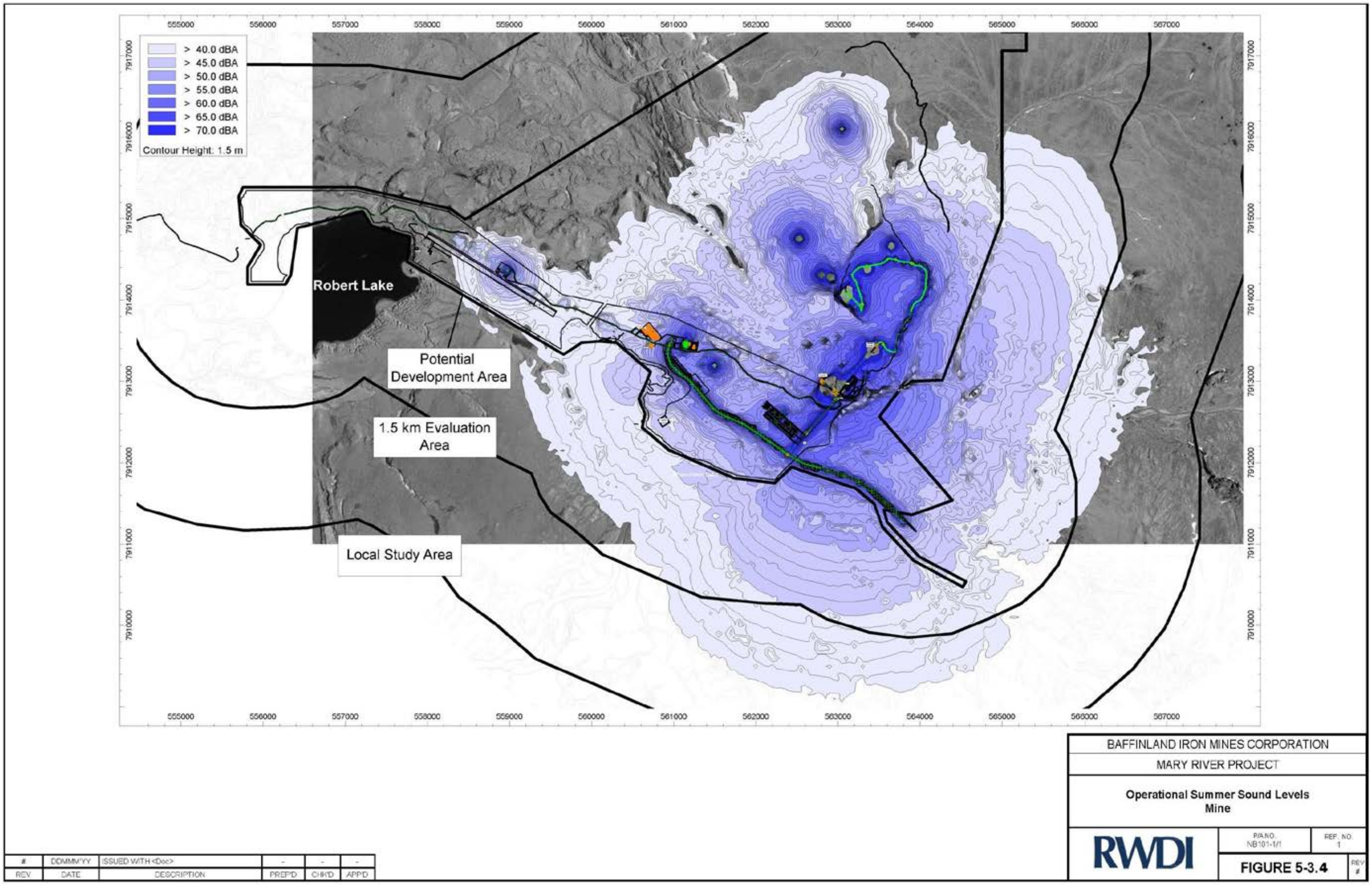


Figure 5-3.4 Mine Site Noise Contour Plot - Operation Phase – Summer

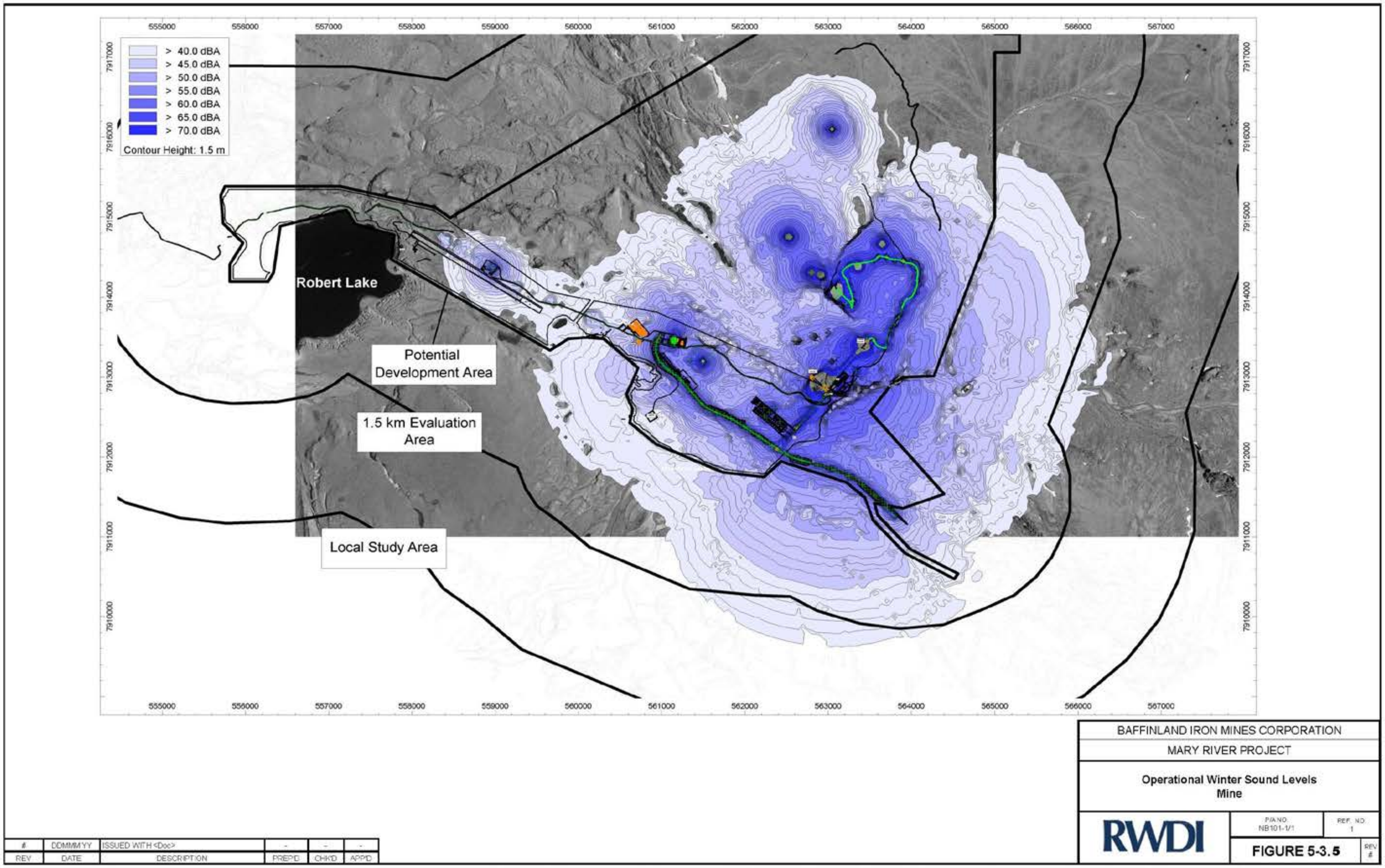


Figure 5-3.5 Mine Site Noise Contour Plot - Operation Phase - Winter

3.3.3.2 Milne Port

There are no major sources of noise at the Milne Port during the Operation Phase of the Project.

3.3.3.3 Steensby Port

A detailed description of operations at Steensby Port is provided in Volume 3.

Description of Operations

The following activities have the potential for local noise effects and were considered in the assessment:

- Screening and conveying operations;
- Ore stockpiling including stacker/reclaimer and conveyance systems;
- Power generation, including a series of generators, with boilers providing emergency backup heat;
- Railway activities, specifically the unloading of railcars and operation of locomotive engines;
- Operation of ice management and tug vessels in the harbour; and
- Waste incineration.

Noise emission level estimates applied in the noise assessment are provided in Appendix 5D-2.

Noise Mitigation Measures

The following features have been included in the assessment:

- Bulk material conveyors and transfer points are enclosed;
- Dust collectors are enclosed or vent into enclosures;
- The secondary crushers and screens are enclosed;
- Rotary rail dumpers are enclosed; and
- Exhaust stacks and air inlets for the power generators will include silencers (mufflers).

Operational Noise Levels

Worst-case predicted operational noise levels are summarized in Table 5-3.9. Graphical representations of summer and winter operations are provided in Figures 5-3.6 and 5-3.7, respectively. Predicted operational noise levels inside the worker accommodation building (with windows closed) are represented by a Balanced Noise Criterion (NCB) level, and are summarized in Table 5-3.10.

Table 5-3.9 Operational Noise Levels - Steensby Port

Location	Seasonal Sound Level at Location (dB)	
	Summer	Winter
1.5 km from PDA	15 to 44	11 to 40
Worker accommodation building	47	47

Table 5-3.10 Steensby Port Modelled Indoor Noise Levels - Operation Phase

Modelling Parameters	Maximum Seasonal Sound Level at Location (Balanced Noise Criterion)	
	Summer	Winter
Worker Accommodation Building, windows closed	Less than NCB 10	Less than NCB 10

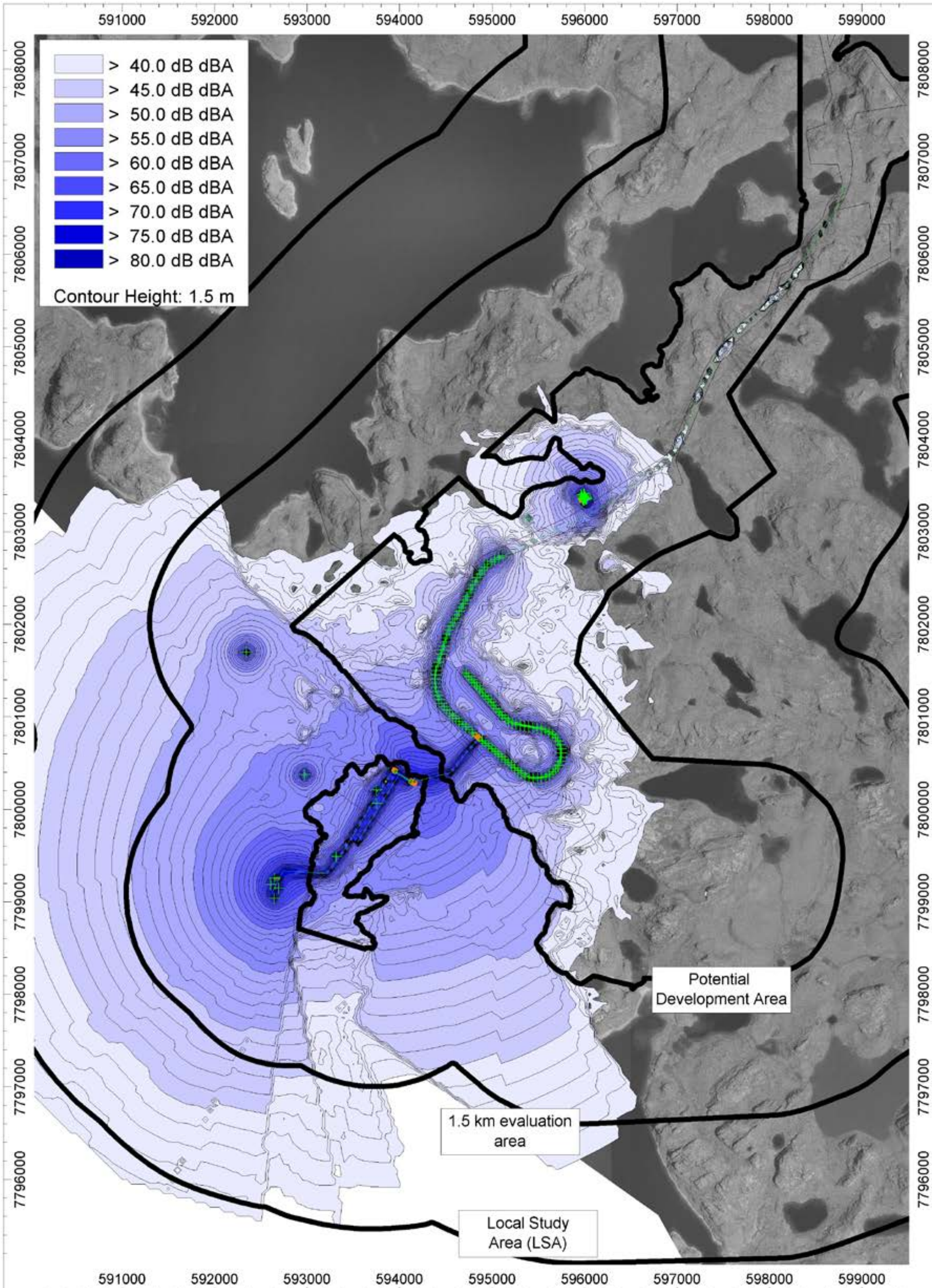


Figure 5-3.6 Steensby Port Noise Contour Plot - Operation Phase - Summer

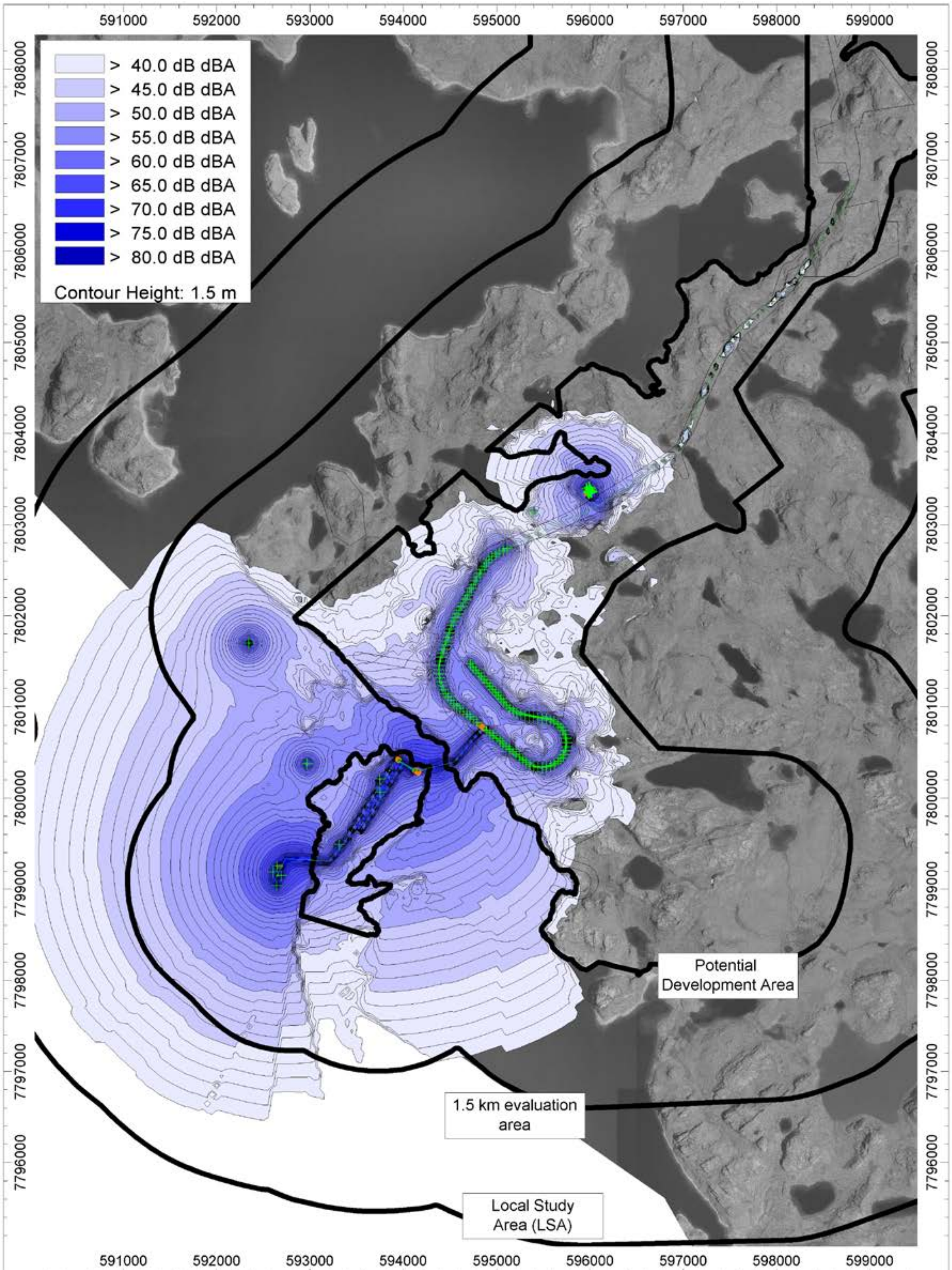


Figure 5-3.7 Steensby Port Noise Contour Plot - Operation Phase - Winter

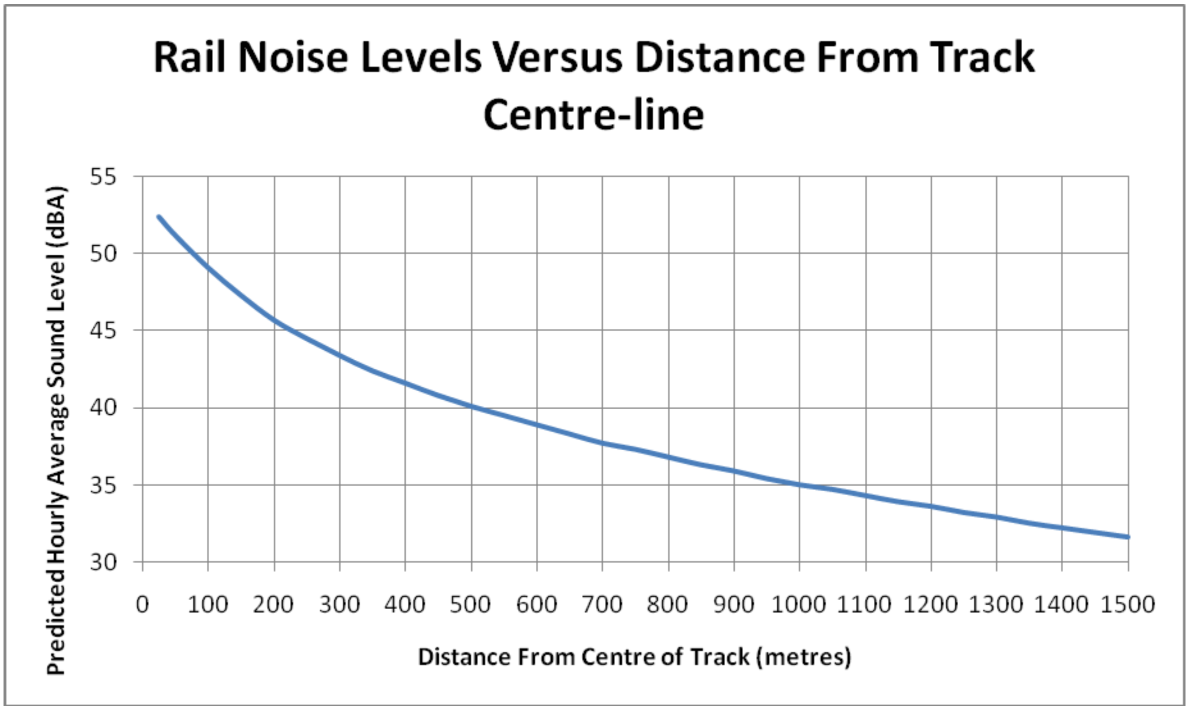


Figure 5-3.8 Rail Noise Levels vs. Distance from Track Centre-line

3.3.3.4 Milne Inlet Tote Road

The existing Milne Inlet Tote Road connects Milne Port to the Mine Site. During the Operation Phase, the road will primarily accommodate infrequent transportation of oversized material to the Mine Site. Sound levels for these activities have not been modelled due to their brief, temporary nature.

3.3.3.5 Aircraft

Description of Operations

Airstrips at the Mine Site and Steensby Port will be designed for year-round access by aircraft. Both will be used regularly during the Construction Phase to land Boeing 737 (Mine Site) or turboprop aircraft such as the Bombardier Dash 8. The existing airstrip at the Milne Port will continue to be maintained, and will be used mainly for emergency purposes. Additionally, smaller aircraft will land at temporary airstrips within the construction access road near railway construction camps, and helicopters will be used as required along the length of (mainly) the railway to support geotechnical drilling that will be undertaken concurrent with construction. Project air traffic is presented on Table 3-1.1 in Volume 3. During the Operation Phase, the Mine Site airstrip will be the primary location of aircraft activities, while the other two airstrips will be used for incidental or emergency flights. There will be an estimated 104 flights per year to the Mine Site during operations.

Noise exposure forecasts (NEFs) for aircraft noise were predicted by Hatch, using NEFCalc, a software package developed by Transport Canada. Forecasts were based on the largest aircraft expected to be used (a Boeing 737) and their possible frequency of operation. According to Transport Canada, land exposed to Noise Exposure Forecast (NEF) contours NEF 30 and greater are typically subject to development restrictions. As a conservatism, contours have therefore been shown for a Zone of Influence starting at NEF 25. Contours are shown for takeoffs for each direction. It is assumed that aircraft will not execute turns below an elevation of 650m. NEF forecasts are shown in Figures 5-3.9 and 5-3.10 for Eastward and Westward aircraft takeoffs respectively, from the mine site. NEF forecasts are shown in Figures 5-3.11 and 5-3.12 for Eastward and Westward aircraft takeoffs respectively, from the Steensby Port site.

The primary mitigation of aircraft noise is adherence to the 600 m minimum flight altitude requirements specified in land use permits (contingent to safety concerns). The Aeronautical Information Manual, RAC section 1.14 and 1.15 provides guidance on flying near wildlife and birds. The intent is to achieve voluntary compliance with the recommended minimums rather than be restrictive and place a pilot in non-compliance with a regulation or legal requirement due to outside influences such as weather. This is mainly applicable to smaller fixed-wing aircraft and helicopters moving between construction sites. Aircraft noise disturbance will be concentrated within a circle around each Project site.

All flights over Auyuittuq National Park will maintain a minimum altitude of 2000 feet when possible. Parks Canada will be provided with regular flight schedules (and updates in the case of a substantial change) that can be used to brief visitors.

It will be ensured that, where applicable, all aircraft serving the project will have current noise certification.

3.3.4 Assessment of Residual Effects

Residual effects are those that remain when all mitigation options have been incorporated into Project design and operation. The overall rating is a professional judgment based on consideration of the magnitude in relation to geographic extent, duration, frequency and reversibility of the effect.

Potential noise effects discussed above are presented in Table 5-3.11. Following applicable mitigation measures, noise effects are anticipated to include small exceedances throughout the lifetime of the project. These effects are confined to the LSA and are fully reversible.

Residual effects from noise are considered minimal. The extent of effects is limited to areas directly surrounding the Mine Site and the two port sites. Effects occurring outside of these sites have short duration, and are infrequent. Noise effects are considered to be reversible. The significance of potential residual effects is summarized in Table 5-3.12.

3.3.5 Prediction Confidence

The modelling used in this assessment has an overall prediction accuracy that depends on three factors: the accuracy of the acoustical source data, the accuracy of the noise propagation model, and the accuracy of locations and quantities of noise sources.

The sound level data used in this assessment are based on manufacturer's data, engineering calculations, or data from existing similar equipment, and are expected to have a high degree of accuracy.

The ISO 9613 propagation algorithms have a published accuracy of + 3 dB over source-receiver distances between 100 and 1000 m. A similar degree of accuracy would be expected over the distances considered in this assessment. This is considered to be an excellent agreement for an environmental noise model over such a large distance. A 3 dB increase or decrease would be considered imperceptible to humans.

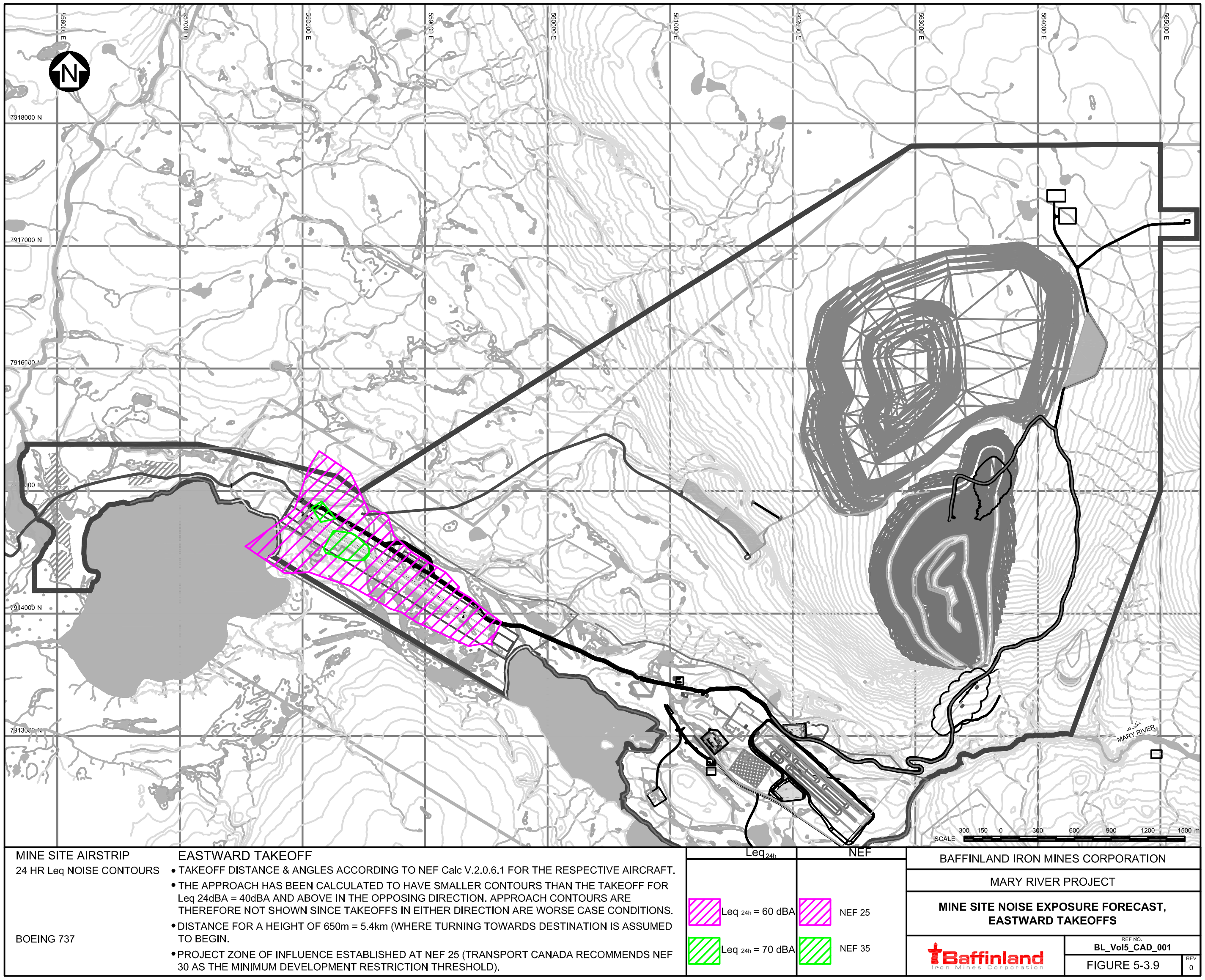


Figure 5-3.9 Mine Site Noise Exposure Forecast, Eastward takeoffs

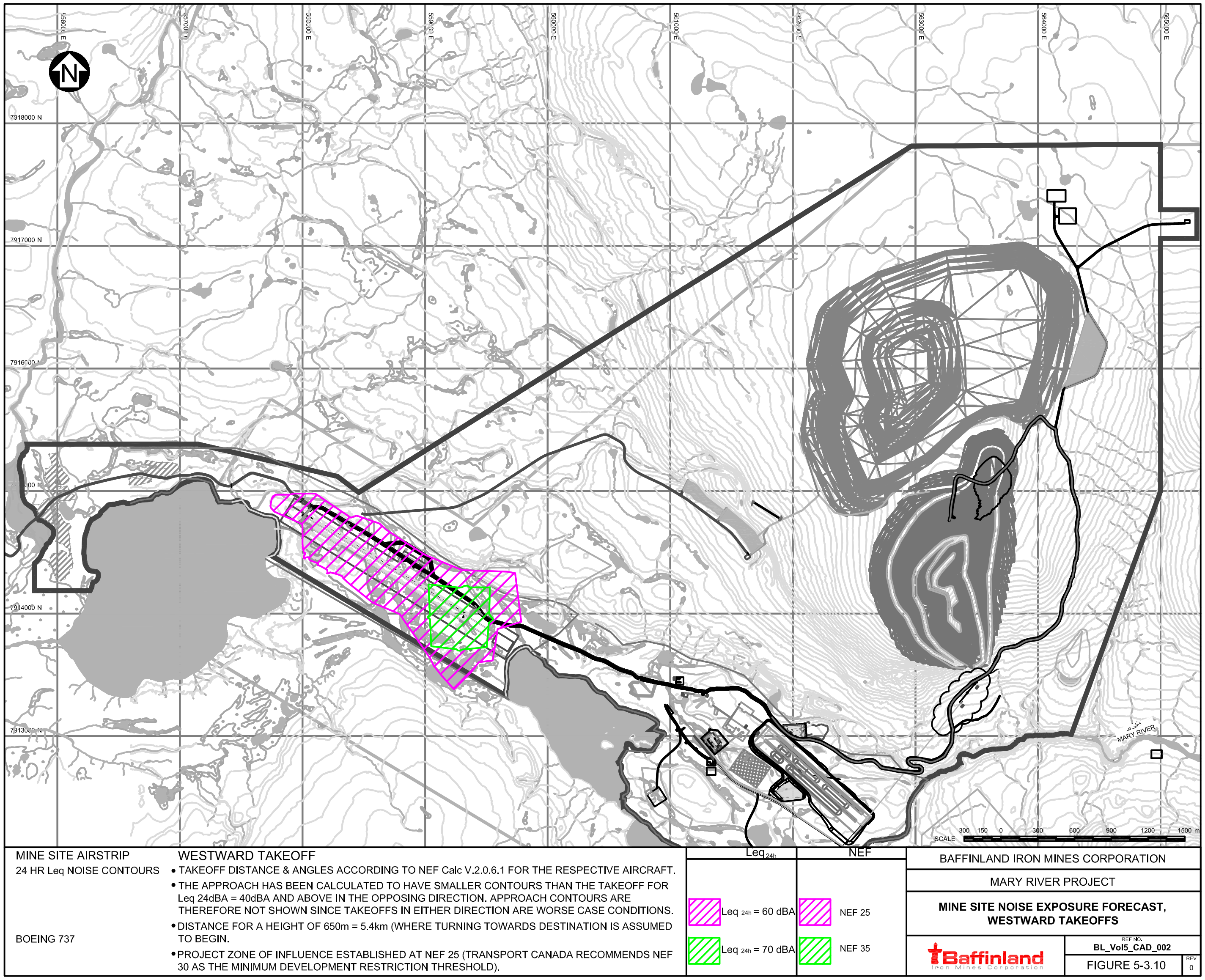


Figure 5-3.10 Mine Site Noise Exposure Forecast, Westward takeoffs

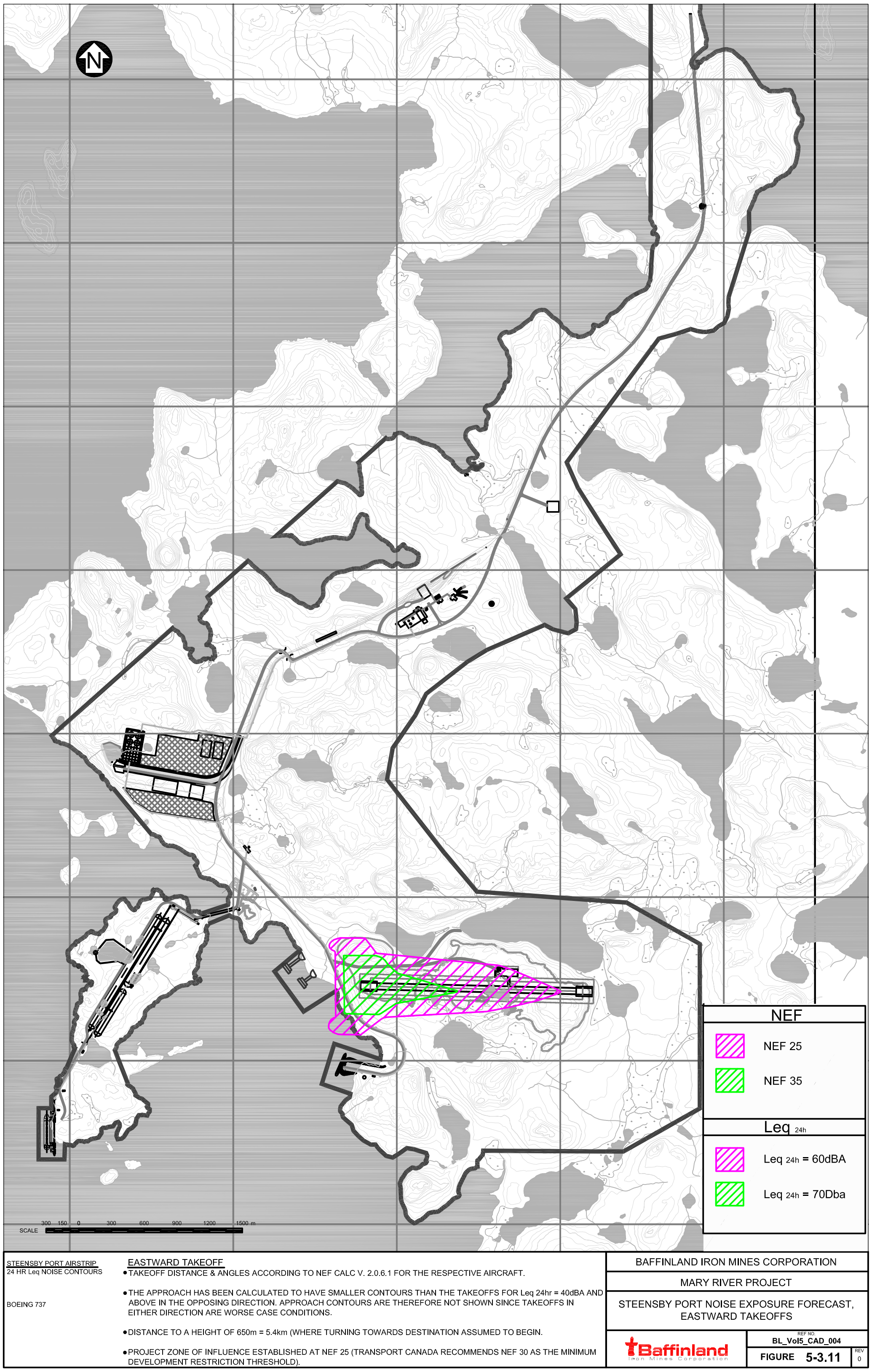


Figure 5-3.11 Steensby Port Noise Exposure Forecast, Eastward takeoffs

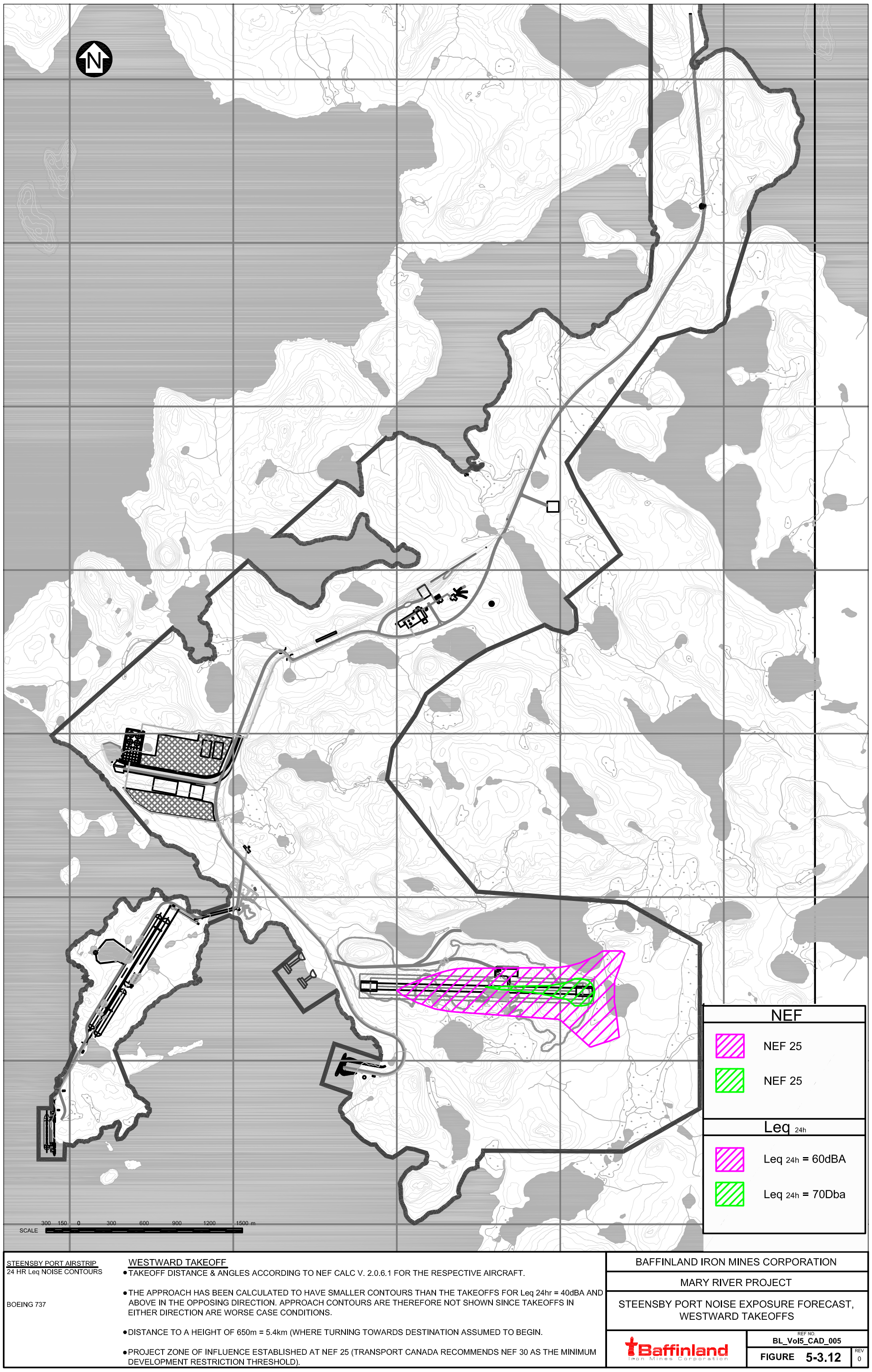


Figure 5-3.12 Steensby Port Noise Exposure Forecast, Westward takeoffs

Table 5-3.11 Effects Assessment Summary: Noise

Potential Effects			Evaluation Criteria				
Project Activity	**Direction and Nature of Interaction**	**Mitigation Measure (s)**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**
Mine site, Steensby, Milne Inlet and Tote Road operations	Negative: increased noise levels	Mufflers on mobile equipment	Level II	Level II: Medium term (life of the project)	Level III: Frequent	Level I: Confined to the LSA	Level 1: fully reversible
Rail operations	Negative: increased noise levels	None	Level II	Level II: Medium term (life of the project)	Level III: Frequent	Level I: Confined to the LSA	Level 1: fully reversible
Construction and closure phases: all	Negative: increased noise levels	Mufflers on mobile equipment	Level II	Level I: Short term (throughout construction and closure operations)	Level III: Frequent	Level I: Confined to the LSA	Level 1: fully reversible

Table 5-3.12 Significance of Residual Noise Effects

Effect	**Significance of Predicted Residual Environmental Effect**		**Likelihood (1)**	
			Probability	**Certainty**
	Significance Rating	**Level of Confidence**		
Increase in noise levels	N	3	3	3

Key
Significance Rating: S = Significant, N = not Significant, P = Positive
Level of Confidence[1]: 1 = Low; 2 = Medium; 3 = High
Likelihood - only applicable to significant effects
Probability: 1 = Unlikely; 2 = Moderate; 3 = Likely
Certainty[2]: 1 = Low; 2 = Medium; 3 = High

NOTE(S):
1. LEVEL OF CONFIDENCE IN THE ASSIGNMENT OF SIGNIFICANCE.
2. CERTAINTY AROUND THE ASSIGNMENT OF LIKELIHOOD.

In addition, the ISO 9613 model produces results that are representative of meteorological conditions favouring sound propagation (e.g., downwind and/or inversion conditions). These conditions do not occur all the time; therefore, model predictions will be conservative, and actual sound levels may be less than indicated for much of the time.

Locations for mobile equipment and mining equipment were estimated when not explicitly given in layout drawings. The positions of equipment around the Mine Site have an effect on the overall shape of the noise contours. Regardless of placement, however, effects from the project remain within the LSA.

Based on the above, the overall model prediction confidence is expected to be high.

3.3.6 Follow-Up

Follow-up monitoring is not required under D038 (unless there are complaints), and is not applicable. A follow-up noise monitoring program is not proposed.

3.4 VIBRATION

3.4.1 Assessment Methods

Overview of Methodology

A standard assessment approach was used to determine the potential effects of the Project. This approach is outlined in Table 5-3.13 and includes the following tasks:

- Identify and quantify vibration emission sources;
- Use vibration models to predict levels from worst-case operations;
- Compare the predicted vibration modelling results to published vibration criteria; and
- Identify the incremental changes and assess the significance of the project.

Table 5-3.13 Vibration Assessment Approach

Component	Description
Vibration Emission Characterization	Facility designs were reviewed to identify equipment and activities that have the potential to generate significant levels of vibration. Predictable worst-case scenarios for vibration effects from Project operations were developed, in terms of locations of equipment, timing and intensity of operations, etc. Vibration emission data for significant sources were then determined, based on engineering estimates and published vibration estimation models.
Establishment of Vibration Criteria	Published perceptibility and damage criteria were reviewed, and chosen to evaluate the effects of modeled vibration levels.
Vibration Modelling Approach	Receptors of concern for vibration were identified for Construction and Operation Phases. Guidance for construction vibration assessment and mitigation is provided. Effects from the Operation Phase were assessed using screening level models.

Vibration Guidelines and Metrics

Ground-borne vibration has different effects, depending on the media surrounding the receiver. Human perception of ground-borne vibration for various peak particle velocities (ppv) can be ranked as follows (Bender, 1996):

- Barely to distinctly perceptible - 0.50 to 2.50 mm/s ppv
- Distinctly to strongly perceptible - 2.50 to 6.25 mm/s ppv
- Strongly perceptible to mildly unpleasant - 6.25 to 25.4 mm/s ppv
- Increased potential for structural damage - 12.5 to 25.4 mm/s ppv

Human perception of ground-borne vibration for various root mean square (RMS) vibration levels can be ranked as follows (ISO, 2007):

- Vibration not felt - 0.10 mm/s rms
- Barely felt - 0.20 mm/s rms
- Felt - 0.41 mm/s rms
- Distinctly felt - 0.81 mm/s rms

The potential for structural damage increases for air-borne vibration overpressures in excess of 120 dB (MOE, 1997).

3.4.2 Potential Effects and Proposed Mitigation - Construction and Closure Phases

Details of the construction and closure activities at all three sites are provided in Volume 3.

A detailed vibration modelling assessment was not conducted for the Construction and Closure phases due to their intermittent and temporary nature. Potential effects were therefore assessed qualitatively based on previous experience. References to vibration effects during construction also apply to the closure phase, as the level and nature of activities are similar.

3.4.2.1 Mine Site

Activities, Equipment and Schedule

Volume 3, Section 2, includes descriptions of the anticipated construction activities, equipment and schedule at Mary River. Construction activities at the Mine Site that have potential for vibration effects include:

- Upgrade of the airstrip to accommodate Boeing 737s, Bombardier Dash-8s or similar sized aircraft;
- Preparation of lay down areas or work areas;
- Construction of project facilities;
- Construction and operation of a concrete batch plant;
- Construction of access roads;
- Construction of railway from Mary River to Steensby Inlet; and
- Development of existing aggregate sources for rock, sand and gravel.

Estimate of Vibration Effects

Construction activities at the Mine Site have the potential to generate perceptible vibration levels that extend outwards from blasting activities; however, since there are no vibration-sensitive environmental receptors, effects are not anticipated. The duration of effect is short-term, the frequency of effect is occasional and the effect is reversible.

Recommended Vibration Controls

No specific vibration controls are required.

Conclusions

Elevated vibration levels may occur near construction activity. Significant effects are not anticipated.

3.4.2.2 Milne Port

Activities, Equipment and Schedule

Volume 3, Section 2, includes descriptions of the anticipated construction activities, equipment and schedule at Milne Port. Activities that have the potential to affect local vibration levels include:

- Preparation of any additional lay down areas or work areas;
- Construction and operation of a concrete batch plant; and
- Operation of quarries and borrow sources for construction of the port, airstrip and railway;

Estimate of Vibration Effects

Vibration from construction activity at Milne Port has the potential for the following effects:

- On land, there is a potential for perceptible vibration levels to extend outwards from blasting activities. There are, however, no vibration sensitive environmental receptors in the Milne Port area. Therefore, vibration effects on land are not anticipated.
- The duration is short-term, the frequency of effect is occasional and the effect is reversible.

Recommended Vibration Controls

No specific vibration controls are required for effects on land.

Conclusions

Although elevated vibration levels may occur near construction activity, significant effects are not anticipated.

3.4.2.3 Steensby Port

Activities, Equipment and Schedule

Volume 3, Section 2, includes descriptions of the anticipated construction activities, equipment and schedule at Steensby Port. Construction activities that have the potential to affect local vibration levels include:

- Preparation of any additional lay down areas or work areas;
- Development of the airstrip and the access road to the port site;
- Construction of the railway access road;
- Construction and operation of a concrete batch plant;
- Construction of the port and related facilities; and
- Operation of quarries and borrow sources for construction of the port, airstrip and railway.

The potential exists for underwater blasting for dock construction to affect marine fish and marine mammals. This is addressed in Section 4 and 5 of Volume 8.

Estimate of Vibration Effects

There is a potential for perceptible vibration levels to extend outwards from blasting activities (cut and fill operations; quarrying). Since there are no vibration sensitive environmental receptors in the Steensby Port area, vibration effects on land are not anticipated. The duration is short-term, the frequency is occasional, and the effect is reversible.

Recommended Vibration Controls

No specific vibration controls are required for effects on land.

Conclusions

Elevated vibration levels may occur near construction activity; however, significant effects are not anticipated.

3.4.2.4 Railway

Activities, Equipment and Schedule

Volume 3, Section 2, of the EIS includes descriptions of the anticipated construction activities, equipment and schedule related to the railway.

Estimate of Vibration Effects

Construction activities along the rail corridor have the potential to generate perceptible vibration levels that extend outwards from blasting activities. The duration is short-term, the frequency is occasional, and the effect is reversible.

Potential vibration effects from blasting on freshwater fish in watercourses along the railway are addressed in Volume 7, Section 4.

Recommended Vibration Controls

No vibration controls will be required.

Conclusions

Elevated vibration levels may occur near construction activity; however, significant effects are not anticipated.

3.4.3 Potential Effects and Proposed Mitigation - Operations

3.4.3.1 Mine Site

A detailed description of operations at the Mine Site during the Operations Phase is provided in Volume 3.

Description of Operation

The following activities have the potential for local vibration effects and were considered in the assessment:

- Open-pit mine operations including blasting; and
- Railway loading/unloading and transit operations.

Operational Vibration Levels

Vibration during the Operations Phase is expected to be minor, with the exception of blasting at the pit working face. Vibration levels from blasting are influenced by factors including blast configuration, charge weight, and the properties of the earth between the blast and receptor locations. Vibration levels have been estimated and a plot showing predicted peak vibration levels (Peak Particle Velocity) versus distance is shown in Figure 5-3.13. PPV estimates are based on an exponential decay function. For most blast configurations and locations at the Mine Site, vibration levels are expected to fall between the minimum and maximum levels show in Figure 5-3.8. Predicted operational vibration levels at key locations are summarized in Table 5-3.14.

Table 5-3.14 Vibration Levels - Mine Site Operation Phase

Location	Peak Vibration Level (mm/s, ppv)
1.5 km from PDA	0.01 to 2.5
Worker Accommodation Building	0.01 to 2.5

<u>Conclusion</u>

Operational vibration levels are expected to be below 2.5 mm/s, and although potentially perceptible are not of concern.

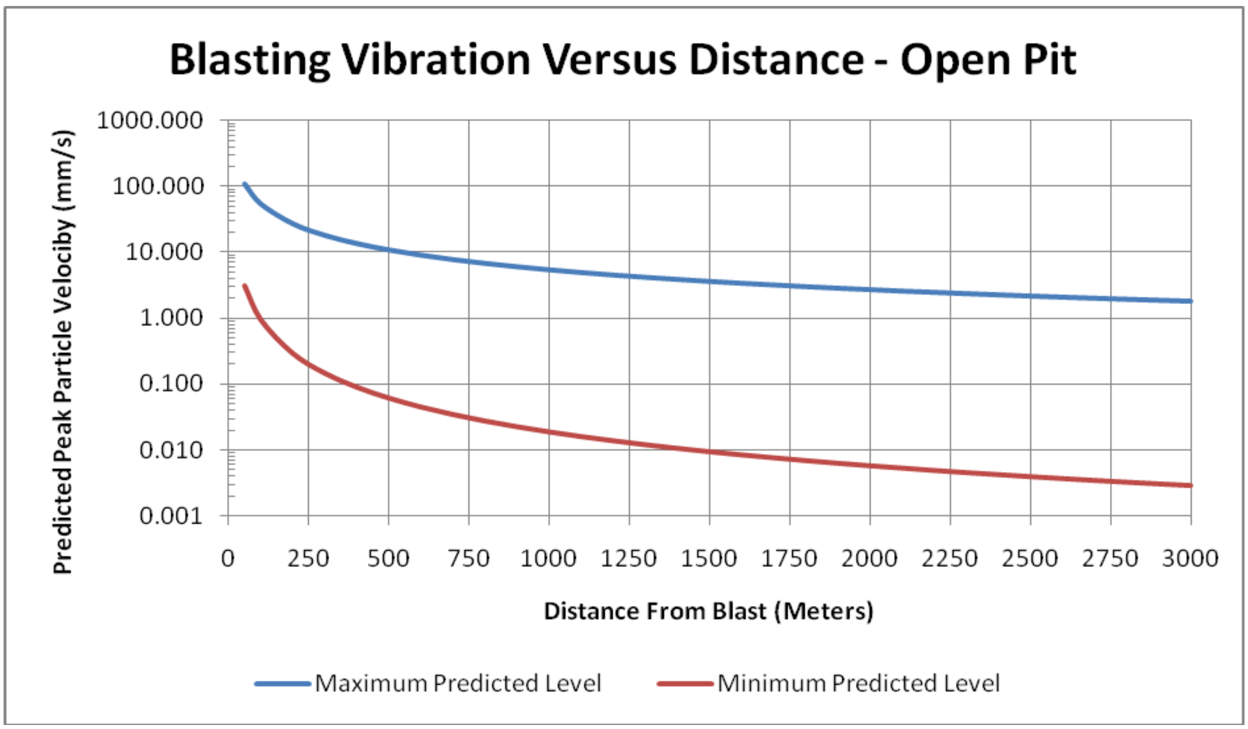


Figure 5-3.13 Vibration Levels Resulting from Blasting in the Open Pit

3.4.3.2 <u>Milne Port</u>

There are no major sources of vibration associated with Milne Port operations, and therefore no notable effects are expected.

3.4.3.3 Milne Inlet Tote Road

The existing Milne Inlet Tote Road connects Milne Port to the Mary River site. During the Operations Phase, the road will carry occasional truck traffic. Due to the temporary and short duration nature of vibration along the Milne Inlet Tote Road, vibration effects from truck traffic along the haul route are not anticipated.

3.4.4 Steensby Port

A detailed description of operations at Steensby Port during the Operations Phase is provided in Volume 3.

There are no major sources of vibration associated with Steensby Port operations, and therefore no notable vibration effects are expected.

3.4.5 Railway

Description of Operations

A 149-km railway will transport iron ore from the mine site at Mary River Steensby Port 4-6 times per day and will also carry some mixed general freight traffic to supply the mining operation. A passenger train (for employees) will operate three times a week. All trains will operate at a speeds ranging between 60 km/h (loaded) and 70 km/h (empty).

Vibration Effects

Trains can produce significant amounts of vibration; however, activity will be intermittent and temporary, so significant effects are not anticipated. Predicted RMS vibration levels versus distance from the track are shown in Figure 5-3.14. Vibration levels were calculated using the United States Federal Transit Administration Vibration Screening Model (FTA, 2006).

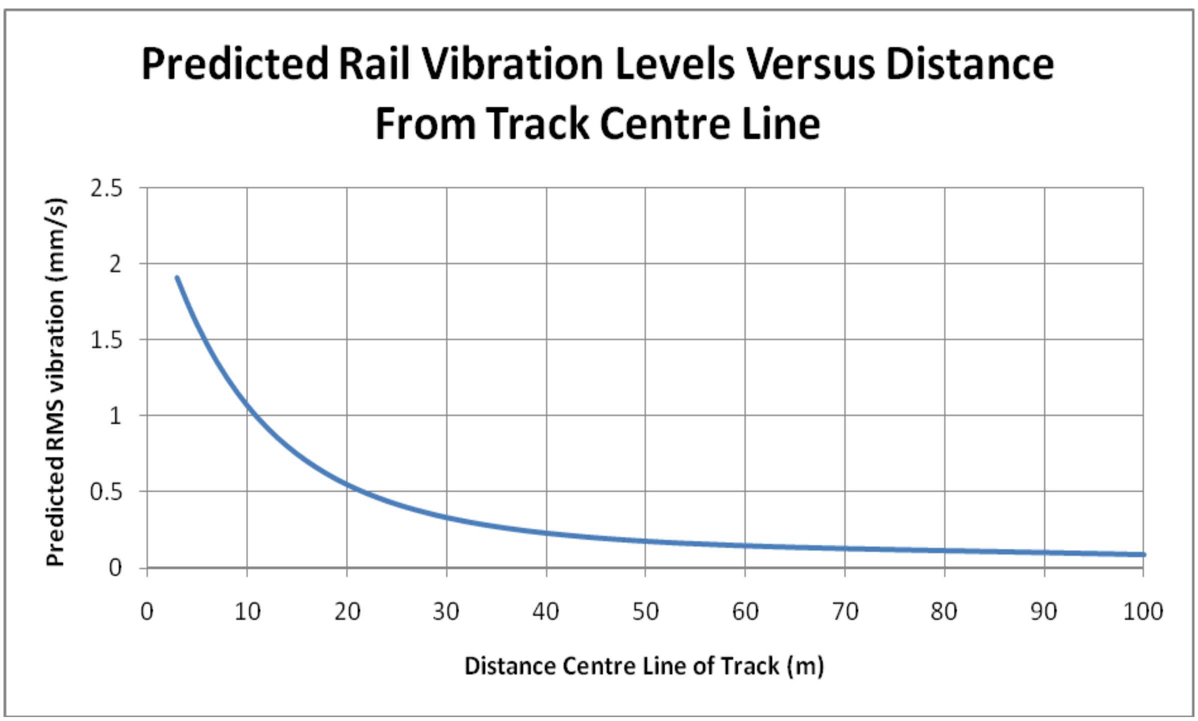


Figure 5-3.14 Predicted Rail Vibration vs. Distance from Track Centre-line

3.4.6 Assessment of Residual Effects

Residual effects are those that remain when all mitigation options have been incorporated into the project design and operation. The overall rating is a professional judgment based on consideration of the magnitude in relation to geographic extent, duration, frequency and reversibility of effects.

Potential vibration effects are discussed above for each site individually. Table 5-3.15 presents a summary of the potential effects. Vibration effects are not predicted to have significant effects during the Operation and Closure Phases. During construction, effects may be mitigated by following applicable DFO guidelines. Vibration effects are considered minor, and will exist throughout the Construction Phase. These effects are confined to the LSA and are fully reversible.

Table 5-3.15 Effects Assessment Summary: Vibration

Potential Effects			Evaluation Criteria				
Project Activity	**Direction and Nature of Interaction**	**Mitigation measures**	**Magnitude**	**Duration**	**Frequency**	**Extent**	**Reversibility**
All operations	Negative: increased vibration levels	None	Level I	Level II: life of the project	Level III: Frequent	Level I: confined to LSA	Level I: reversible
Construction phase: all	Negative: increased vibration levels	None	Level I	Level I: Short term - Construction Phase	Level III: Frequent	Level I: confined to LSA	Level I: reversible
Closure phase: all	Negative: increased vibration levels	None	Level I	Level I: Short term	Level III: Frequent	Level I: confined to LSA	Level I: reversible

Residual effects for vibration are considered to be minimal. The extent of effects is limited to areas directly surrounding the Mine Site, Steensby Port and Milne Port. Vibration effects are considered to be reversible. The significance of potential residual effects is summarized in Table 5-3.16.

Table 5-3.16 Significance of Residual Vibration Effects

Effect	Significance of Predicted Residual Environmental Effect		Likelihood (1)	
	Significance Rating		Level of Confidence	Certainty
Increase in vibration levels	N	3	3	3

KEY:
Significance Rating: S = Significant, N = not Significant, P = Positive
Level of Confidence[1] : 1 = Low; 2 = Medium; 3 = High
Likelihood - only applicable to significant effects
Probability: 1 = Unlikely; 2 = Moderate; 3 = Likely
Certainty[2]: 1 = Low; 2 = Medium; 3 = High

NOTE(S):
1. LEVEL OF CONFIDENCE IN THE ASSIGNMENT OF SIGNIFICANCE.
2. CERTAINTY AROUND THE ASSIGNMENT OF LIKELIHOOD.

3.4.7 Prediction Confidence

The modelling used in this assessment has an overall prediction accuracy that is dependent on two factors: the accuracy of the vibration source data, and the accuracy of the vibration propagation model.

The vibration data used in this assessment are based on typical values for blasting, and on levels built into the models. These data are expected to have a high degree of accuracy.

Modelling of vibration levels through soil was based on exponential decay equations, which generally have good accuracy as they are dependent on a good understanding of the soil characteristics in the blasting area. Outputs from vibration modelling generally agree with published measurement data for areas with similar soil types. Vibration modelling is therefore predicted to have a high degree of accuracy.

Based on the above, the overall prediction confidence is expected to be high.

3.4.8 Follow-Up

A follow-up vibration monitoring program is not planned.

3.5 IMPACT STATEMENT

A systematic approach was adopted to identify potential noise and vibration sources and to quantify Project emissions at the Mine Site, Steensby Port and Milne Port. This assessment concentrates on comparisons with guideline limits and effects on human receptors. The effects of potential noise and vibration effects on other biophysical components, including wildlife, vegetation and human health are addressed separately by the appropriate disciplines. The assessment concludes that potential effects of noise and vibration are "*not significant*".

Noise

D038 noise guideline limits do not apply to construction activities; instead, good management practices are required to reduce the potential for effects. All internal combustion engines used during construction will be fitted with appropriate muffler systems. Screening from on-site building should help to shield dwellings from construction noise.

Modelling predictions for the for the Operations Phase indicate that noise levels at 1.5 km from the PDAs for the Mine Site, Steensby Port and Milne Port will be as high as 45 dBA, 44 dBA, and 42 dBA, respectively. D038 limits the sound level at 1.5 km from the fence line of a facility to 40 dBA. These exceedances are contained entirely within the LSA.

Vibration

Vibration levels from the Construction Phase are not anticipated to be of concern on land. No specific vibration controls are required.

3.6 AUTHORS

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SECTION 5.0 - DEFINITIONS AND ABBREVIATIONS

5.1 DEFINITIONS

Acceleration Acceleration is rate of change of velocity with time (denoted as dv/dt or d2x/dt2), usually along a specified axis, usually expressed in g or gravitational units. It may refer to angular motion.

Accelerometer A sensor or transducer or pickup for converting acceleration to an electrical signal.

Acid Deposition A comprehensive term for the various ways acidic compounds precipitate from the atmosphere and deposit onto surfaces. It can include: 1) wet deposition by means of acid rain, fog, and snow; and 2) dry deposition of acidic particles (aerosols).

Acute Exposure One or a series of short-term exposures generally lasting less than 24 hours.

Aerosol Particles of solid or liquid matter that can remain suspended in air from a few minutes to many months depending on the particle size and weight.

Air Pollutants Amounts of foreign and/or natural substances occurring in the atmosphere that may result in adverse effects to humans, animals, vegetation, and/or materials.

Air Quality Dispersion Model A mathematical relationship between emissions and downwind air quality which simulates on a computer the plume rise, transport, dispersion, and transformation of compounds emitted into the air. Examples include ISC3, AERMOD and CALPUFF.

Air So called "pure" air is a mixture of gases containing about 78 percent nitrogen; 21 percent oxygen; less than 1 percent of carbon dioxide, argon, and other gases; and varying amounts of water vapour.

Airborne Sound Sound that reaches the point of interest by propagation through air.

Airshed A geographical area that shares the same air because of similar topography, meteorology, and climate. Airshed boundaries are often defined along political boundary lines.

Ambient Air Monitoring Sampling for and measuring of pollutants present in the atmosphere.

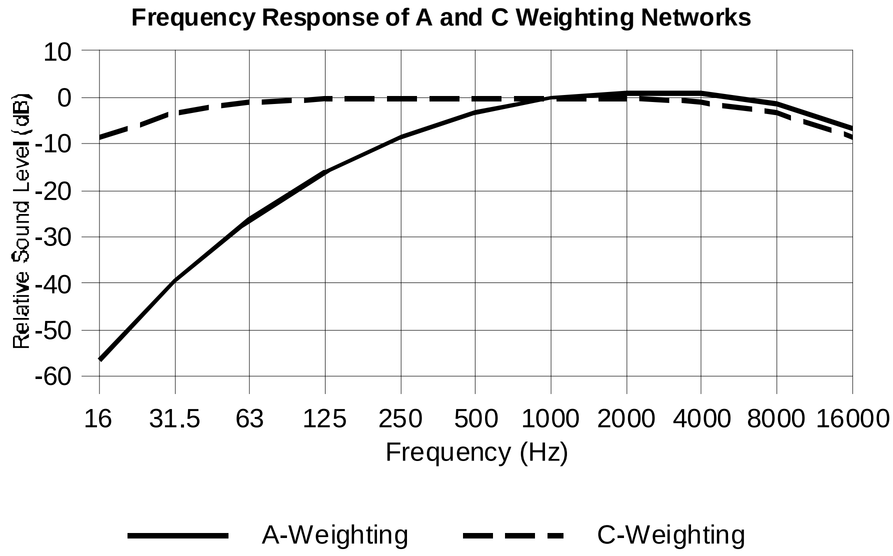
Ambient Air Quality Standard Generally, this is a prescribed level of a pollutant in the outside air that should not be exceeded during a specific time period. They are typically established by federal, provincial or territorial governments. Depending on the jurisdiction the term used (i.e., criteria, threshold, objectives and guidelines) and the exact meaning of the term may vary.

Ambient Air The air occurring at a particular time and place outside of structures. Often used interchangeably with "outdoor air".

Ambient or Background Noise	The ambient noise from all sources other than the sound of interest (i.e. sound other than that being measured). Under most MOE guidelines, aircraft overflights and train noise, due to their transient nature, are normally excluded from measurements of background noise.
Ambient vibration	Ambient vibration is the all-encompassing vibration associated with a given environment, being usually a composite of vibration from many sources, near and far.
Amplitude	The magnitude of variation (in a changing quantity) from its zero value. Always modify it with an adjective such as peak, RMS, average, etc. May refer to displacement, velocity, acceleration, voltage, current force of pressure.
Angular Frequency	(Also known as circular frequency.) w is the torsional vibration frequency in radians per second. Or divide by 2p and express in hertz (Hz) or cycles per second (cps).
Area Sources	An emission source associated with a surface or geographic area. This can include sources such as tailings ponds and storage piles.
Articulation Index (AI)	A numerically calculated measure of the intelligibility of transmitted or processed speech. It takes into account the limitations of the transmission path and the background noise. The articulation index can range in magnitude between 0 and 1.0. If the AI is less than 0.1, speech intelligibility is generally low. If it is above 0.6, speech intelligibility is generally high.
Atmosphere	The gaseous mass or envelope of air surrounding the Earth. From ground-level up, the atmosphere is further subdivided into the troposphere, stratosphere, mesosphere, and the thermosphere.
Atmospheric Stability Class	A classification of turbulence levels in the atmosphere that considers parameters such as wind speed, time of day and solar radiation.
Attenuation	The reduction of sound intensity by various means (e.g., air, humidity, porous materials, etc.).
Average	A number that typifies a set of numbers of which it is a function.
Background Noise	Background noise is the total of all sources of interference in a system used for the production, detection, measurement, or recording of a signal, independent of the presence of the signal.
Baghouse	An air pollution control device that traps particulates by forcing gas streams through large permeable bags usually made of glass fibres.
Calibration	(as applied to vibration sensors) An orderly procedure for determining sensitivity as a function of frequency, temperature, altitude, etc.
Calibrator (Acoustical)	A device which produces a known sound pressure on the microphone of a sound level measurement system, and is used to adjust the system to standard specifications.

Chronic Exposure	Long-term exposure, usually lasting one year to a lifetime.
Circular Frequency	(See Angular Frequency).
Combustion	The act or instance of burning some type of fuel such as gasoline. Combustion is typically the process that powers automobile engines and power plant generators.
Comparison	A term applied to calibration (e.g., of an accelerometer) in which sensitivity is tested against a standard.
Complex Vibration	Complex vibration is vibration whose components are sinusoids not harmonically related to one another. (See harmonic).
Concentration	The amount of a specified material contained in a unit volume or mass of another gaseous, liquid or solid material. Concentration is typically expressed in units of mass per unit volume (i.e., $\mu g/m^3$).
Continuous Emission Monitor (CEM)	A type of air emission monitoring system installed to operate continuously inside of a smokestack or other emission source.
Crest Factor	The crest factor is the ratio of the peak value to the root-mean-squared value.
Critical Frequency	A particular resonant frequency (see resonance) at which damage or degradation in performance is likely.
Cycle	The complete sequence of instantaneous values of a periodic event, during one period.
Damper	A damper is a device used to reduce the magnitude of a shock or vibration by one or more energy dissipation methods.
Damping	Damping is the dissipation of energy with time or distance.
dB - Decibel	The logarithmic units associated with sound pressure level, sound power level, or acceleration level. See sound pressure level, for example.
dBA - Decibel, A-Weighted	The logarithmic units associated with a sound pressure level, where the sound pressure signal has been filtered using a frequency weighting that mimics the response of the human ear to quiet sound levels. The resultant sound pressure level is therefore representative of the subjective response of the human ear. A-weighted sound pressure levels are denoted by the suffix 'A' (i.e., dBA), and the term pressure is normally omitted from the description (i.e., sound level or noise level).

dBC - Decibel, C-Weighted The logarithmic units associated with a sound pressure level, where the sound pressure signal has been filtered using a frequency weighting that mimics the response of the human ear to loud sound levels. C-weighted sound pressure levels are denoted by the suffix 'C' (i.e., dBC). C-weighted levels are often used in low-frequency noise analysis, as the filtering effect is



nearly flat at lower frequencies.

dBL or dBLin - Decibel, Linear The logarithmic units associated with a sound pressure level, where the sound pressure signal is unfiltered, and represents the full spectrum of incoming noise.

Deposition The mechanism by which particles, liquid droplets and gasses are removed from the atmosphere. Dry deposition refers to gravitational settling of material, while wet deposition refers to removal of material through absorption in water (precipitation). Deposition is typically expressed in units of mass per unit area (i.e., g/m^2). For acid deposition the units of keq H^+/ha/yr are used where 1 keq H+ = 1 kg of hydrogen ion equivalents.

Deterministic Vibration A vibration whose instantaneous value at any future time can be predicted by an exact mathematical expression. Sinusoidal vibration is the classic example. Complex vibration is less simple (two or more sinusoids).

Directivity Factor (Q) (also, **Directional** or **Directionality Factor)** A factor mathematically related to Directivity Index, used in calculating propagated sound levels to account for the effect of reflecting surfaces near to the source. For example, for a source in free space where the sound is radiating spherically, Q = 1. For a source located on or very near to a surface (such as the ground, a wall, rooftop, etc.), where the sound is radiating hemispherically, Q = 2. This accounts for the additional sound energy reflecting off the surface, and translates into a +3 dB add.

Directivity Index	In a given direction from a sound source, the difference in decibels between (a) the sound pressure level produced by the source in that direction, and (b) the space-average sound pressure level of that source, measured at the same distance.
Dispersion	The gradual decrease in concentration of a material with increasing distance from a source of emission. Dispersion is enhanced by turbulence in the surrounding environment, and can be limited by deposition.
Displacement Pickup	Displacement pickup is a transducer that converts an input displacement to an output that is proportional to the input displacement.
Displacement	Specified change of position, or distance, usually measured from mean position or position of rest. Usually applies to uniaxial, less often to angular motion.
Dust	Solid particulate matter that can become airborne.
Effective Perceived Noise Level (EPNdB)	A complex measure of perceived noisiness derived by making adjustments to the magnitude of measured sound levels in narrow frequency bands (1/3 octaves) for tonality and rise time of the noise. EPNdB values are the base measure of an individual overflight noise exposure from aircraft under the NEF metric, analogous to the manner in which SEL is used for computing L_{eq}(24).
Emission Factor	The relationship between the amount of an emission produced and the amount of raw material processed, moved, burned, etc. By using the emission factor of a pollutant and specific data regarding quantities of materials used by a given source, it is possible to compute emissions for the source. This approach is used in preparing an emissions inventory.
Emission Inventory	An estimate of the amount of pollutants emitted into the atmosphere from mobile, stationary, area-wide and natural sources over a specific period of time such as a day or a year.
Emission Rate	The weight of a pollutant emitted per unit of time (e.g., tonnes/year).
Emission	The release of a material, normally a contaminant of interest, and including heat, radiation, noise and vibration, into the environment.
Energy Equivalent Sound Level (L_{eq})	An energy-average sound level taken over a specified period of time. It represents the average sound pressure encountered for the period. The time period is often added as a suffix to the label (i.e., L_{eq}(24) for the 24-hour equivalent sound level). L_{eq} is usually A-weighted. An L_{eq} value expressed in dBA is a good, single value descriptor of the annoyance of noise.
Exceedance Noise Level (L_N)	The noise level exceeded N % of the time; a statistical measure of the noise level. For highly varying sounds, the L_{90} represents the background noise level, L_{50} represents the median or typical noise level, and L_{10} represents the short term peak noise levels, such as those due to occasional traffic or a barking dog.

Exceedance	A measured level of an air pollutant higher than the established standards (see Ambient Air Quality Standard).
Far Field	Describes a region in free space where the sound pressure level from a source obeys the inverse-square law (the sound pressure level decreases 6 dB with each doubling of distance from the source). Also, in this region the sound particle velocity is in phase with the sound pressure. Closer to the source where these two conditions do not hold constitutes the "near field" region.
Forced Vibration	The vibratory motion of a system caused by some mechanical excitation. If the excitation is periodic and continuous, the response motion eventually becomes steady-state.
Forcing Frequency	In sinusoidal vibration testing or resonance searching, the frequency at which a shaker vibrates. The frequency or frequencies at which forced vibration occurs.
Fossil Fuels	Fuels such as coal, oil, and natural gas; so-called because they are the remains of ancient plant and animal life.
Free Sound Field (Free Field)	A sound field in which the effects of obstacles or boundaries on sound propagated in that field are negligible.
Free Vibration	Free vibration occurs without forcing, as after a reed is plucked, or after a heel-drop on a floor.
Frequency Spectrum	A description of the resolution of any electrical signal into its frequency components, giving the amplitude (sometimes also phase) of each component.
Frequency (Noise)	The number of times per second that the sine wave of sound or of a vibrating object repeats itself. Now expressed in hertz (Hz), formerly in cycles per second (cps).
Frequency (of an effect)	The number of times during a project or a project phase that an interaction or environmental effect can be expected to occur.
Fugitive Dust	Dust particles that are introduced into the air through certain activities such as soil cultivation, or vehicles operating on open fields or dirt roadways. A subset of fugitive emissions.
Fugitive Emissions	A source associated with an area rather than a distinct point of emission is known as a fugitive source. In addition, a fugitive emission source can be described as a source whose emission stream is not under the control of the facility between the point in which the contaminant is created (source) and the point where it is released into the natural environment (emission point).

Fundamental Mode of Vibration That mode having the lowest natural frequency.

Global Warming An increase in the temperature of the Earth's troposphere. Global warming has occurred in the past as a result of natural influences, but the term is most often used to refer to the warming predicted by computer models to occur as a result of increased emissions of greenhouse gases.

Greenhouse Effect The warming effect of the Earth's atmosphere. Light energy from the sun which passes through the Earth's atmosphere is absorbed by the Earth's surface and re-radiated into the atmosphere as heat energy. The heat energy is then trapped by the atmosphere, creating a situation similar to that which occurs in a car with its windows rolled up. A number of scientists believe that significant emissions of CO_2 and other gases into the atmosphere may increase the greenhouse effect and contribute to global warming.

Greenhouse Gases Atmospheric gases such as carbon dioxide, methane, chlorofluorocarbons, nitrous oxide, ozone, and water vapour that slow the passage of re-radiated heat through the Earth's atmosphere.

Harmonic A sinusoidal quantity having a frequency that is an integral multiple (x2, x3, etc.) of a fundamental (x1) frequency.

Hertz (Hz) Unit of measurement of frequency, numerically equal to cycles per second.

Human Perception of Sound The human perception of noise effects is an important consideration in qualifying the noise effects caused by projects. The following table presents a general guideline.

Increase in Noise Level (dBA)	Perception
1 to 3	Insignificant due to imperceptibility
4 to 5	Just-noticeable difference
6 to 9	Marginally significant
10 or more	Significant, perceived as a doubling of sound exposure

Hydrocarbons Compounds containing various combinations of hydrogen and carbon atoms. They may be emitted into the air by natural sources (e.g., trees) and as a result of fossil and vegetative fuel combustion, fuel volatilization, and solvent use. Hydrocarbons are a major contributor to smog.

Impact Insulation Class (IC) A single-figure rating that compares the impact sound insulating capabilities of floor-ceiling assemblies to a reference contour.

Impact Sound	The sound produced by the collision of two solid objects, e.g., footsteps, dropped objects, etc., on an interior surface (wall, floor, or ceiling) of a building. Typical industrial sources include punch presses, forging hammers, etc.
Impulsive Noise	Single or multiple sound pressure peak(s) (with either a rise time less than 200 milliseconds or total duration less than 200 milliseconds) spaced at least by 500 millisecond pauses. Also, a sharp sound pressure peak occurring in a short interval of time.
Incineration	The act of burning a material to ashes.
Infrasonic	Sounds of a frequency lower than 20 hertz.
Insertion Loss (IL)	The arithmetic difference between the sound level from a source before and after the installation of a noise mitigation measure, at the same location. Insertion loss is typically presented as a positive number, i.e., the post-mitigation sound level is lower than the pre-mitigation level. Insertion loss is expressed in dB and is usually specified per 1/1 octave band, per 1/3 octave band, or overall.
Intensity	The sound energy flow through a unit area in a unit time.
Internal Combustion Engine	An engine in which both the heat energy and the ensuing mechanical energy are produced inside the engine. Includes gas turbines, spark ignition gas, and compression ignition diesel engines.
Isolation	A reduction of motion severity, usually by resilient support. A shock mount or isolator attenuates shock. A vibration mount or isolator attenuates steady-state vibration.
Low Frequency Noise (LFN)	Noise in the low frequency range, from infrasonic sounds (<20 Hz) up to 100 Hz.
Magnetic Recorder	A magnetic recorder is equipment incorporating an electromagnetic transducer and means for moving a ferromagnetic recording medium relative to the transducer for recording electric signals as magnetic variations in the medium.
Masking	The process by which the threshold of audibility for a sound is raised by the presence of another (masking) sound. Also, the amount by which the threshold of audibility of a sound is raised by the presence of another (masking) sound.
Mass	A physical property, dynamically computed as acceleration divided by force. Statistically computes as W (which can be measured on a butcher scale) divided by the acceleration due to gravity. Ordinary structures are not pure masses as they contain reactive elements (i.e., springs and damping).
Maximum Point of Impingement	A location in the environment where the centerline of a contaminant plume first reaches the terrain or a receptor.

Maximum Value	The maximum value is the value of a function when any small change in the independent variable causes a decrease in the value of the function.
Mean	Average.
Median	The middle value in a population distribution, above and below which lie an equal number of individual values; midpoint.
Mixing Height	The height above the surface through which relatively vigorous vertical mixing of the atmosphere occurs. The mixing height depth is least in the evening period and is at a maximum in the daytime.
Mobile Sources	Sources of air pollution such as automobiles, motorcycles, trucks, off-road vehicles, boats, and airplanes.
Mode	A characteristic pattern in a vibrating system. All points reach their maximum displacements at the same instant.
Model	(see Air Quality Simulation Model**)**
Monitoring	The periodic or continuous sampling and analysis of air pollutants in ambient air or from individual pollution sources.
Natural Environments	Conditions occurring in nature, not caused by any equipment; effects are observed whether an equipment or activity is at rest or in operation.
Natural Frequency	The frequency of an undamped system's free vibration; also, the frequency of any of the normal modes of vibration. Natural frequency drops when damping is present.
Natural Mode of Vibration	The natural mode of vibration is a mode of vibration assumed by a system when vibration freely.
Near Field	The sound field very near to a source, where sound pressure does not obey the inverse-square law and the particle velocity is not in phase with the sound pressure.
Nitric Oxide (NO)	Precursor of ozone, NO_2, and nitrate; nitric oxide is usually emitted from combustion processes. Nitric oxide is converted to nitrogen dioxide (NO_2) in the atmosphere, and then becomes involved in the photochemical processes and / or particulate formation.
Nitrogen Oxides (Oxides of Nitrogen, NO_x)	A general term pertaining to compounds of nitric oxide (NO), nitrogen dioxide (NO_2) and other oxides of nitrogen. Nitrogen oxides are typically created during combustion processes, and are major contributors to smog formation and acid deposition. NO_2 may result in numerous adverse health effects.

Noise Criteria (NC) Curves	A single number rating for noise in 1/1-octave frequency bands which is sensitive to the relative loudness and speech interference properties of a given sound spectrum. The method consists of a family of criteria curves extending from 63 Hz to 8000 Hz, and a tangency rating procedure. Originally proposed by Bernanek in 1957. While other more modern criteria curve rating schemes exist (NCB, RC, RC Mark II, RNC, etc.), NC curves are still widely used in determining acceptability of noise levels within spaces. Levels of NC 25 to NC 35 are usually considered acceptable for residences, private offices, and schools.
Noise Exposure Forecast (NEF)	A calculated measure of aircraft noise based on the type of aircraft in use, the take-off and landing patterns of the aircraft, and times of operation. It represents the noise exposure over a typical 24 hour period. A penalty is applied to night-time operation.
Noise Isolation Class (NIC)	A single number rating derived in a prescribed manner from the measured values of noise reduction between two areas or rooms. It provides an evaluation of the sound isolation between two enclosed spaces that are acoustically connected by one or more paths.
Noise Level	Same as Sound Level, except applied to unwanted sounds.
Noise Reduction (NR)	The numerical difference, in decibels, of the average sound pressure levels in two areas or rooms. A measurement of "noise reduction" combines the effect of the sound transmission loss performance of structures separating the two areas or rooms, plus the effect of acoustic absorption present in the receiving room.
Noise Reduction Coefficient (NRC)*	A measure of the acoustical absorption performance of a material, calculated by averaging its sound absorption coefficients at 250, 500, 1000 and 2000 Hz, expressed to the nearest multiple of 0.05.
Noise	Unwanted sound.
Oscillation	Variation with time of a quantity such as force, stress, pressure, displacement, velocity, acceleration or jerk. Usually implies some regularity (as in sinusoidal or complex vibration).
Ozone Layer	A layer of ozone in the lower portion of the stratosphere -- 12 to 15 miles above the Earth's surface -- which helps to filter out harmful ultraviolet rays from the sun. It may be contrasted with the ozone component of photochemical smog near the Earth's surface which is harmful.
Ozone Precursors	Chemicals such as non-methane hydrocarbons and oxides of nitrogen, occurring either naturally or as a result of human activities, which contribute to the formation of ozone, a major component of smog.

Ozone	A strong smelling, pale blue, reactive toxic chemical gas consisting of three oxygen atoms. It is a product of the photochemical process involving the sun's energy and ozone precursors, such as hydrocarbons and oxides of nitrogen. Ozone exists in the upper atmosphere ozone layer (stratospheric ozone) as well as at the Earth's surface in the troposphere (ozone). Ozone in the troposphere causes numerous adverse health effects and is a major component of smog.
Particulate Matter (PM)	Any material, except pure water, that exists in the solid or liquid state in the atmosphere. The size of particulate matter can vary from coarse, wind-blown dust particles to fine particle combustion products.
Peak Sound Pressure Level	Same as Sound Pressure Level except that peak (not peak-to-peak) sound pressure values are used in place of RMS pressures.
Peak	Extreme value of a varying quantity, measured from the zero or mean value. Also, a maximum spectral value.
Peak-to-Peak Value	The algebraic difference between extreme values (as D = 2X).
Period	The interval of time over which a cyclic vibration repeats itself.
Periodic Vibration	(See also Deterministic Vibration.) An oscillation whose waveform regularly repeats. Compare with probabilistic vibration.
Persistent Organic Pollutants	Chemical substances that persist in the environment, bio-accumulate, and can cause adverse effects to human health and the environment.
Pickup	(See transducer).
Plume	A visible or measurable discharge of a contaminant from a given point of origin that can be measured.
PM_{10} (Particulate Matter)	Small particles with an aerodynamic diameter less than or equal to a nominal 10 microns. PM_{10} can result in adverse health effects and visibility reduction.
$PM_{2.5}$ (Particulate Matter)	Includes tiny particles with an aerodynamic diameter less than or equal to a nominal 2.5 microns. This fraction of particulate matter penetrates most deeply into the lungs.
Point of Impingement	A location in the environment where a contaminant plume reaches the terrain or a receptor.
Point Sources	Specific points of origin where pollutants are emitted into the atmosphere such as factory smokestacks.

Polycyclic Aromatic Hydrocarbons (PAHs)	Organic compounds that include only carbon and hydrogen with a fused ring structure containing at least two benzene (six-sided) rings. PAHs may also contain additional fused rings that are not six-sided. The combustion of organic substances is a common source of atmospheric PAHs.
Pseudo-Steady State	A sequence of impulses emitted from the same source with a short time period between impulses.
Quasi-Steady Impulsive Noise	Noise composed of a series of short, discrete events, characterized by rapid rise times, but with less than 0.5 seconds elapsing between events.
Random Vibration	One whose instantaneous magnitudes cannot be predicted. Adjustive "Gaussian" applies if they follow the Gaussian distribution. May be broadband, covering a wide, continuous frequency range, or narrow band, covering a relatively narrow frequency range. No periodic or deterministic components.
Receptor	A theoretical location used for modeling purposes at which the model calculates a given contaminant concentration.
Recording Channel	The term recording channel refers to one of a number of independent recorders in a recording system or to independent recording tracks on a recording medium.
Recording System	A recording system is a combination of transducing devices and associated equipment suitable for storing signals in a form capable of subsequent reproduction.
Resonance Frequency	Resonance frequency is a frequency at which resonance exists.
Resonance	Forced vibration of a true single degree of freedom system causes resonance when the forcing frequency equals the natural frequency, when any forcing frequency change decreases system response.
Response Signal	The signal from a "response sensor" measuring the mechanical response of a mechanical system to an input vibration or shock.
Response	The vibratory motion or force that results from some mechanical input.
Reverberant Field	The region in a room where the reflected sound dominates, as opposed to the region close to the noise source where the direct sound dominates.
Reverberation Time (RT)	The time taken for the sound pressure level to decrease 60 dB from its steady-state value when the source of sound energy is suddenly interrupted. It is a measure of the persistence of an impulsive sound in a room as well as of the amount of acoustical absorption present inside the room. Rooms with long reverberation times are called live rooms.
Reverberation	The persistence of sound in an enclosed space, as a result of multiple reflections, after the sound source has stopped.

RMS or Root-Mean-Square Value	The square root of the time-averaged squares of a series of measurements. Refer to a textbook on electrical engineering. In the exclusive case of sine wave, s, the RMS value is 0.707 x the peak value.
RMS Sound Pressure	The square-root of the mean-squared pressure of a sound (usually the result of an RMS detector on a microphone signal).
Sabin	A measure of the sound absorption of a surface; it is the equivalent of one square metre of a perfectly absorptive surface (or one square foot in imperial units).
Scrubber	An air pollution control device that uses a high energy liquid spray to remove aerosol and gaseous pollutants from an air stream. The gases are removed either by absorption or chemical reaction.
Seismic Pickup; Seismic Transducer	A device consisting of a seismic system in which the differential movement between the mass and the base of the system produces a measurable indication of such movement.
Sensitivity	Of a mechanical-to-electrical sensor or pickup, the ratio between electrical signal (output) and mechanical quantity (input).
Shock Pulse	A transmission of kinetic energy into a system in a relatively short interval compared with the system's natural period. A natural decay of oscillatory motion follows. Usually displayed as time history, as on an oscilloscope.
Signal Conditioner	An amplifier following a sensor, which prepares the signal for succeeding amplifiers, transmitters, readout instruments, etc. May also supply sensor power.
Simple Harmonic Motion	Periodic vibration that is a sinusoidal function of time.
Smog	A combination of smoke and other particulates, ozone, hydrocarbons, nitrogen oxides, and other chemically reactive compounds which, under certain conditions of weather and sunlight, may result in a murky brown haze that causes adverse health effects.
Soot	Very fine carbon particles that have a black appearance when emitted into the air.
Sound Exposure Level (SEL)	L_{eq} referenced to a one second duration. Also known as the Single Event Level. It is a measure of the cumulative noise exposure for a single event. It provides a measure of the accumulation of sound energy over the duration of the event.
Sound Level (SL)	The A-weighted Sound Pressure Level expressed in dBA.

Sound Level Meter	An instrument comprised of a microphone, amplifier, output meter, and frequency-weighting networks which is used for the measurement of noise and sound levels.
Sound Power Level (PWL)	The logarithmic ratio of the instantaneous sound power (energy) of a noise source to that of an international standard reference power. The sound power level is defined by equation (1) where W is the sound power of the source in watts, and W0 is the reference power of 10-12 watts. (1) PWL (dB) = 10 log(W/W0) Interrelationships between sound pressure level (SPL) and sound power level (PWL) depend on the location and type of source.
Sound Pressure Level (SPL)	The logarithmic ratio of the RMS sound pressure to the sound pressure at the threshold of hearing. The sound pressure level is defined by equation (2) where P is the RMS pressure due to a sound and P_0 is the reference pressure. P_0 is usually taken as 2.0×10^{-5} Pascals. (2) SPL (dB) = 20 log(Prms/P0)
Sound Transmission Class (STC)	The preferred single figure rating system designed to give an estimate of the sound insulation properties of a structure or a rank ordering of a series of structures.
Sound Transmission Loss (STL)	A measure of sound insulation provided by a structural configuration. Expressed in decibels, it is 10 times the logarithm to the base 10 of the reciprocal of the sound transmission coefficient of the configuration.
Sound	a dynamic (fluctuating) pressure
Spatial Boundaries	These quantify how far apart events occur are in time. As such, a Temporal Boundary might refer to the bounds of a pattern in time (i.e., a diurnal temporal profile describes how something changes by hour of day).
Speech Interference Level (SIL)	A calculated quantity providing a guide to the interference of a noise with the reception of speech. The speech-interference level is the arithmetic average of the octave band levels of the interfering noise in the most important part of the speech frequency range. The levels in octave bands centered at 500, 1000, and 2000 Hz are commonly averaged to determine the speech-interference level.
Speed (Velocity) of Sound in Air	344 m/s (1128 ft/s) at 70°F (21°C) in air at sea level.
Stakeholders	Citizens, environmentalists, businesses, and government representatives that have a stake or concern about how air quality is managed.

Stationary Sources	Non-mobile sources such as power plants, refineries, and manufacturing facilities which emit air pollutants.
Steady-State Vibration	Periodic vibration for which the statistical measurement properties (such as the peak, average, RMS and mean values) are constant.
Stiffness	Stiffness is the ratio of change of force (or torque) to the corresponding change on translational or rotational) deflection of an elastic element.
Stratosphere	The layer of the Earth's atmosphere above the troposphere and below the mesosphere. It extends between 10 and 60 km above the Earth's surface and contains the ozone layer in its lower portion. The stratospheric layer mixes relatively slowly; pollutants that enter it may remain for long periods of time.
Sulfur Dioxide (SO_2)	A strong smelling, colorless gas that is formed by the combustion of fossil fuels. Power plants, which may use coal or oil high in sulphur content, can be major sources of SO_2. SO_2 and other sulphur oxides contribute to the problem of acid deposition.
Sulfur Oxides	Pungent, colorless gases (sulphates are solids) formed primarily by the combustion of sulphur-containing fossil fuels, especially coal and oil. Considered major air pollutants, sulphur oxides may affect human health and damage vegetation.
Temporal Boundary	These quantify how far apart objects are geographically. A Spatial Boundary might refer to the geographic extent of something being assessed (i.e., extent covered by a model domain, political jurisdiction, etc.).
Threshold of Audibility (Threshold of Detectability)	The minimum sound pressure level at which a person can hear a specified frequency of sound over a specified number of trials.
Topography	The configuration of a surface, especially the Earth's surface, including its relief and the position of its natural and man-made features.
Transducer (Pickup)	A transducer is a device that converts shock or vibratory motion into an optical, a mechanical, or most commonly to an electrical signal that is proportional to a parameter of the experienced motion.
Transient Vibration	Short-term vibration of a mechanical system.
Transmissibility	In steady-state vibration, T is the non-dimensional ratio of response motion/input motion: two displacements, two velocities or two accelerations. The maximum T value is the mechanical “Q” of a system. At resonance, T is maximum.
Transmission Loss	Transmission loss is the reduction in the magnitude of some characteristic of a signal, between two stated points in a transmission system.

Transmission Loss	A measure of the reduction in sound energy resulting from incident sound waves striking a wall, partition or enclosure, and radiating through to the other side. Mathematically, the transmission coefficient t is the ratio of transmitted acoustic power to the incident acoustic power, and in decibels, the Transmission Loss (TL) of the wall is: (3) TL = 10 log (1 / t) The TL of a wall varies by frequency. The associated noise reduction (NR) due to the TL of the wall is a function of the TL and the acoustical parameters of the receiving space. For noise radiating from an enclosure into the outdoors, NR̃(TL + 6).
Troposphere	The layer of the Earth's atmosphere nearest to the surface of the Earth. The troposphere extends outward about five miles at the poles and about 10 miles at the equator.
Vapour Density	The vapour density is expressed in grams per litre (g / L) and is compared to the density of air (air = 1).
Vapour Pressure	The pressure, often expressed in millimetres of mercury (mm Hg) or pounds per square inch (PSI) that is characteristic at any given temperatures of a vapour in equilibrium with its liquid or solid form.
Vapour	The gaseous phase of liquids or solids at atmospheric temperature and pressure.
Velocity Pickup	A velocity pickup is a transducer that converts an input velocity to an output (usually electrical) that is proportional to the input velocity.
Velocity	Rate of change of displacement with time, usually along a specified axis; it may refer to angular motion as well as to uniaxial motion.
Vibration Isolator	A vibration isolator is a resilient support that tends to isolate a system from steady-state excitation.
Vibration Meter	An apparatus (usually an electronic amplifier, detector and readout meter) for measuring electrical signals from vibration sensors. May display displacement, velocity and/or acceleration.
Vibration	Mechanical oscillation or motion about a reference point of equilibrium.
Volatile Organic Compounds (VOCs)	Carbon-containing compounds that evaporate into the air (with a few exceptions). VOCs contribute to the formation of smog and / or may themselves be toxic. VOCs often have an odour, and some examples include gasoline, alcohol, and the solvents used in paints.
Volume Source	An emission source associated with a volume rather than a surface or a point. These can include fugitive emissions from a building.
Weight	That property of an object that can be weighted, as on a scale; the gravitational force on an object.

5.2 ABBREVIATIONS

Baffinland .... Baffinland Iron Mines Corporation
CLARC .... Community Land and Resource Committee
CTA .... Canadian Transportation Agency
DFO .... Fisheries and Oceans Canada
EHS .... Environmental Health and Safety
EIS .... Environmental impact statement
EMMP .... Environmental Mitigation and Monitoring Plans
HTA/HTO .... Hamlets, Hunters, and Trappers Association/Organization
IIBA .... Inuit Impact and Benefits Agreement
IPG .... Institute of Public Government
IQ .... Inuit Qaujimajatuqangit (Inuit knowledge, or traditional knowledge)
KI .... Key indicator
LSA .... Local study area
MAC .... Mining Association of Canada
MDAG .... Mineral Development Advisory Group
MHTO .... Mittimatalik Hunters and Trappers Organization
MOU .... Memorandum of Understanding
Mt/a .... Million tonne-per-annum
NBRLUP .... North Baffin Regional Land Use Plan
NIRB .... Nunavut Impact Review Board
NLCA .... Nunavut Land Claims Agreement
NPC .... Nunavut Planning Commission
NRCan .... Natural Resources Canada
NSA .... Nunavut Settlement Area
NTI .... Nunavut Tunngavik Incorporated
NWB .... Nunavut Water Board
PDA .... Potential development area
QIA .... Qikiqtani Inuit Association
RSA .... Regional study area
TC-NWPP .... Transport Canada Navigable Waters Protection Program
the Project .... Mary River Project
TK .... Traditional Knowledge
VC .... Valued component
VEC .... Valued ecosystem component
VSEC .... Valued socio-economic component