APPENDIX 4
HEALTH CANADA ATTACHMENTS

HC 02 ATTACHMENT 1: FULL RESPONSE

Health Canada HC-02 – Drinking Water

Issue/Concern:

TSD-07 / TSD-11 / TSD-13 did not assess the potential for recreational or drinking water impacts from surface water or melted snow/ice (to be used as drinking water) in the area affected by emissions and dust. However, it was noted in the TSD-13 community consultations that drinking water is obtained from various unidentified areas. “two comments were related to the quality of traditional drinking water locations;” (TSD-13 page 15). Additionally, TSD-05 Mary River Inuit Knowledge Study Mapbook: Figure 3.19, 3.20 makes note of many water bodies that are of importance.

With respect to water quality, an HHRA can be used to assess the risk of potential contamination of drinking or recreational water by taking into consideration the levels of contaminants in the water.

Information Request:

1. Health Canada recommends further evaluation of impacts on human health, including vulnerable persons, with regards to recreational and drinking water quality identified in TSD-05, including those used for hunting.

2. If such impacts are found, and if the same contaminants may have an effect on human health through other exposure routes a quantitative risk assessment, such as an HHRA, is recommended.

Technical Response:

The Project area is remote to any community, and hence, there are no drinking water sources, such as groundwater wells or community water treatment plants that would be affected by the Project. The closest community to the Project is Pond Inlet, which is approximately 160 km from the Project. While Health Canada (2016) recognizes that surface water should not be consumed without treatment, the Inuit way of life involves considerable travel across the land, wherein Inuit routinely drink untreated water from local streams and water courses. As such, direct consumption of surface water sources is assessed in this Technical Response. This Technical Response follows Health Canada guidance on assessment of drinking water quality related to Environmental Impact Assessments (Health Canada, 2016). The components of the assessment are as follows:

1. Identification of sources used for drinking water (locations and proximities to the proposed project);

2. Determination of potential changes to source and well water quality;

3. Determination of impacts of changes in water quality;

4. Mitigation;

5. Assessment of residual risk;

6. Monitoring (if required); and

<u>Identification of Sources Used for Drinking Water</u>:

As described previously, there are no groundwater or community water locations near the Project, but Inuit travel across the land near the Project for many reasons and activities, including hunting, stone collection, and travel and camping (See TSD-05; Inuit Map Book). Specific drinking water locations near the Project area were not identified within the Inuit Map book, or in interviews conducted during the Inuit Knowledge study (Baffinland, 2014). Nevertheless, Inuit put considerable cultural value on water within their lands. Further details on the Inuit knowledge study, the importance Inuit place on water, and the selection of the drinking water prediction area for this response are provided in Attachment A, Knight Piésold (2019). The Traditional knowledge gathered in the development of the Inuit Map book gathered important insight from the Inuit on water sources near the Project site. While out on the land, hunters and travellers consume water from ice, snow, lakes and rivers. In winter, snow is relied upon as a water source. Water from glaciers was identified by many study participants as the best available water.

With respect to the Project areas, no specific drinking water locations were identified near the Milne Port Project site in the TK study. A stream behind the HTO camp located east of Baffinland's Facilities could be occasionally used for consumption, but the stream is fairly distant to the Project, and deposition rates in the area would be very low, relative to Camp Lake, which is near the Mine site. For the Tote Road transportation corridor, while some camp sites have been identified along this route (Inuit Map Book; TSD-05; Figure 1.8), areas in close proximity to the road are restricted, in terms of access. Streams nearby Tote Road would be smaller in size, and hence, unlikely to be prime drinking water locations. No important waters were identified within the Transportation corridor (Inuit Map Book; TSD-05; Figure 3.20).

For the Mine site, no important waters were identified in the Mine Site area during the MRIKS (Baffinland, 2014). The Hunters and Trappers Organization cabin near the Mine site is on Camp Lake, which is an obvious water source for camp occupants, at least during the period of open water. In addition, this is a source for drinking water for the mine camp.

Therefore, for the purposes of this assessment, Camp Lake was selected as a representative water course in close proximity of Project-related activities (mine site) which could be used as a drinking water source by local travellers and hunters. The potential influence of dustfall on this lake and surrounding areas was considered in this assessment.

<u>Determination of Potential Changes to Water</u>

To determine potential change to water within the areas near Camp Lake related to dust deposition, Knight Piésold (2019) conducted an evaluation of potential sources to the Camp Lake area and watershed. As summarized by Knight Piésold (2019), the water quality in Camp Lake is currently influenced by dust deposition from the mine, along with runoff from Quarry QMR2. Later in the mine life, mine effluent from the west pond will be discharged into a tributary of Camp Lake. The focus of the assessment was on changes to metals concentrations in surface water, as a result of dustfall. Dustfall represents the largest potential influencer of surface waters in the Project area. Therefore, the assessment of Chemicals of Potential Concern are focused on inorganics (metals and metalloids), which would be associated with deposited dusts.

As described in Knight Piésold (2019), Figure HC-02-1 presents a conceptual water quality model for Camp Lake, identifying the following sources of metals loading:

1. Direct dust deposition into the lake;
2. CLT-1, which drains Catchment MR-10. branch L1 of CLT-1 will receive effluent discharges from the west pond later in operations, and branch L2 currently receives runoff from Quarry QMR2;
3. Camp Lake Tributary 2 (CLT-2), which drains Catchment MR-08; and
4. Runoff from the MR-09 catchment area.

The current location of the HTO cabin is presented in Figure HC-02-1, as well as the proposed location for the HTO cabin, which will be relocated in the near future. Both of these locations are at the outfall of Camp Lake. Note that Figure HC-02-1 also provides the dust deposition for the catchment areas, as predicted by RWDI (TSD-07; Appendix A) for the mine site.

As discussed in Attachment A (Knight Piésold, 2019), quantifying the loading from these sources is challenging. Predicting what proportion of dust falling directly on the lake will remain in the water column versus collecting as bottom sediment is an involved process and estimating water quality in streams collecting runoff from dust deposited areas is similarly challenging. As an alternative, Knight Piésold (2019) investigated the current impacts to water quality in Camp Lake as a means of predicting future water quality, through an assessment of current and predicted future dustfall. The approach and methods are provided in the Attachment A (Knight Piésold, 2019). Based on the assessment of dust deposition, the predicted average dustfall deposition rate for all catchments of Camp Lake was estimated at 60 g/m^2/year, which is lower but within the same order or magnitude of the dustfall measured at site. As such, the current dustfall contributions to Camp Lake are likely indicative of future dustfall contributions, either through direct deposition on the lake or from runoff within the lake catchment into the lake.

Based on this, water quality monitoring stations were selected to be used as prediction nodes for the current Technical Response, and the selected stations are as follows (see Figure HC-02-1):

- JLO-02 – Near field station in Camp Lake, closest to Mine. This lake station is closest to the two tributaries most likely to be affected by the Project;
- JLO-09 – Far field station in Camp Lake, closest to HTO cabin.

Baffinland established baseline water quality in Camp Lake over the period of 2006 to 2013 (Knight Piésold, 2014). Since that time, Baffinland has implemented its Aquatic Effects Monitoring Program, which has covered construction of the Early Revenue Phase (ERP) in 2014, and mine operation from 2015 through 2018 (Knight Piésold, 2015; Minnow Environmental Inc., 2016, 2017 and 2018).

These data were available for review and trending assessment by Knight Piésold (2019) relative to the federal drinking water quality guidelines (Health Canada, 2017).

<u>Determination of the Impact of Changes in Water Quality</u>

The predicted changes to water quality in the 2 selected prediction nodes are provided in Knight Piésold (2019). These figures present annual average concentrations of dissolved and total concentrations of metals for which a Canadian Drinking Water Quality guideline (CDWQGl; Health Canada, 2017) exists, for the stations referenced above.

The CDWQGl are generally calculated based on an assumed consumption rate of 1.5 L of water per day over a lifetime (70 years) (Health Canada, 2017). As previously discussed, consumption of surface waters at this rate in the Project area are unlikely. Based on the assessment conducted, all metals were found to be less than the CDWQGs at the two lake stations, and current trends for several metals are not expected to approach the CDWQGs over the life of the mine.

Monitoring and Mitigation

The assessment did not predict an impact to drinking water quality in the Camp Lake watershed. Water quality monitoring is conducted annually as part of the Aquatic Effects Monitoring Program (AEMP). Therefore, monitoring is regularly conducted in a number of water courses near the various Project areas, and comparisons to more stringent guidelines (protection of aquatic life guidelines) is conducted. This ensures that data are being collected and evaluated during operations, and any need for mitigation would be identified through these frequent and on going monitoring events.

References:

Baffinland Iron Mines Corporation (Baffinland), 2014. Mary River Inuit Knowledge Study, 2006-2010. Compiled by Knight Piésold Ltd

Baffinland, 2015. Baffinland's Hunter and Visitor Site Access Procedure.

Health Canada. 2016. Guidance for Evaluating Human Health Impacts in Environmental Assessment: Drinking and Recreational Water Quality. Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario.

Health Canada. 2017. Guidelines for Canadian Drinking Water Quality – Summary Table. Prepared by the Federal-Provincial-Territorial Committee on Drinking Water of the Federal-Provincial-Territorial Committee on Health and the Environment. February 2017. https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/water-quality/guidelines-canadian-drinking-water-quality-summary-table.html#t2

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HC 02 ATTACHMENT 2: MEMO - ASSESSMENT OF POTENTIAL IMPACTS OF THE MARY RIVER PROJECT'S PHASE 2 PROPOSAL ON WATERBODIES USED BY INUIT – RESPONSE TO INFORMATION REQUEST HC-02

Knight Piésold CONSULTING

MEMORANDUM

Date:	January 22, 2019	**File No.:**	NB102-00181/45-A.01
		Cont. No.:	NB18-00878
To:	Mr. Lou Kamermans		
Copy To:	Christine Moore		
From:	Simon Foster		
Re:	**Assessment of Potential Impacts of the Mary River Project's Phase 2 Proposal on Waterbodies Used by Inuit – Response to Information Request HC-02**		

1.0 INTRODUCTION

Baffinland Iron Mines Corporation (Baffinland) received various information requests (IRs) from reviewers and interveners in response to its Addendum to the Final Environmental Impact Assessment (FEIS) submitted to the Nunavut Impact Review Board (NIRB) for its Phase 2 Proposal (Baffinland, 2018).

This memorandum is prepared in response to IR HC-02 from Health Canada (Table 1), which requests an evaluation of potential Project impacts to human health through water consumption. Knight Piésold Ltd. (KP) was requested by Baffinland to contribute to a response to IR HC-02 being prepared by Intrinsik Corporation (Intrinsik).

KP selected Camp Lake to assess the Phase 2 Proposal's impacts on drinking water quality, as it is potentially affected by Project activities, and it is the water supply for the mine camp and likely for users of a Hunter and Trapper Organization (HTO) cabin located immediately adjacent the west side of the lake. Other waterbodies potentially used by Inuit land users and the basis for selecting Camp Lake to focus the assessment is presented in Appendix A.

KP has utilized baseline and monitoring water quality data for Camp Lake, along with dustfall monitoring and modelling data, to evaluate the current and projected effects of the Project on water quality within Camp Lake.

2.0 METHODOLOGY

The evaluation of the impacts of the Phase 2 Proposal on the water quality of Camp Lake has been completed by trending and projecting water quality data collected at Camp Lake from baseline through to the operations of the Early Revenue Phase (ERP). The synthesis of existing data is thought to be the preferred method of evaluating future impacts because actual monitoring data are being incorporated into the analysis. A detailed geochemistry model, or a mass balance approach was briefly considered but detailed geochemistry inputs (metal solubilisation, speciation, mixing, precipitation) are not available.

The following section describes the data sets and methods used to trend and project future water quality in Camp Lake. Limitations of this method are described.

Table 1 Information Request HC-02

IR Source:	Health Canada
IR Number:	HC-02
IR Directed to:	The Proponent - Baffinland Iron Mines Corporation
Subject/Topic:	Recreational and Drinking Water Impacts to Human Health
Reference:	TSD-05 Mary River Inuit Knowledge Study Map book: Figures: 3.19; 3.20; TSD-11 Evaluation of Exposure Potential from Ore Dusting Events in Selected VECs; TSD-13 Surface Water Rev 01; Section 1.3; page 15
Issue/Concern:	TSD-07 / TSD-11 / TSD-13 did not assess the potential for recreational or drinking water impacts from surface water or melted snow/ice (to be used as drinking water) in the area affected by emissions and dust. However, it was noted in the TSD-13 community consultations that drinking water is obtained from various unidentified areas. *"two comments were related to the quality of traditional drinking water locations;"* (TSD-13 page 15). Additionally, TSD-05 Mary River Inuit Knowledge Study Mapbook: Figure 3.19, 3.20 makes note of many water bodies that are of importance. With respect to water quality, an HHRA can be used to assess the risk of potential contamination of drinking or recreational water by taking into consideration the levels of contaminants in the water.
Information Request:	1. Health Canada recommends further evaluation of impacts on human health, including vulnerable persons, with regards to recreational and drinking water quality identified in TSD-05, including those used for hunting. 2. If such impacts are found, and if the same contaminants may have an effect on human health through other exposure routes a quantitative risk assessment, such as an HHRA, is recommended.

2.1 CONCEPTUAL MODEL

Three catchments report to Camp Lake: MR-08, MR-09 and MR-10 (Figure 1). Camp Lake water quality is currently influenced by dust generated by the mine that is deposited within these three catchments. In the past several years, Quarry QMR2 has been active, and runoff from this quarry reports to the L2 branch of Camp Lake Tributary 1 (CLT-1). Later in the mine life, mine effluent from the west pond will be discharged into branch L1 of CLT-1. Figure 1 presents a conceptual water quality model for Camp Lake, identifying the following sources of metals loading:

1. Direct dust deposition into the lake;
2. CLT-1, which drains Catchment MR-10. branch L1 of CLT-1 will receive effluent discharges from the west pond later in operations, and branch L2 currently receives runoff from Quarry QMR2;
3. CLT-2, which drains Catchment MR-08; and
4. Runoff from the MR-09 catchment area.

Quantifying the loading from these sources has technical limitations. Predicting what proportion of dust falling directly on the lake will remain in the water column versus collecting as bottom sediment is an involved process. Similarly, estimating water quality in streams collecting runoff from dust deposited areas is challenging. Recent water quality monitoring data are likely to be more representative, recognizing that dust deposition and runoff conditions will change through the life of mine. As such, KP investigated the current impacts to water quality in Camp Lake as a means of predicting future water quality.

Current water quality trends in Camp Lake may be representative of future concentrations, if current loadings are reasonably representative of future loadings. In this regard:

- The current loadings entering CLT-1, L2 branch from QMR2 are likely to decrease following construction of Phase 2
- The current loadings entering CLT-1 do not include discharges from the west pond that will occur later in the mine life
- Predicted dustfall at the Mine Site during the Phase 2 Proposal is compared to recent dustfall monitoring results

The second and the third bullets are discussed further below.

2.2 COMPARISON OF CURRENT AND FUTURE DUSTFALL

Three dustfall gauges have been under operation at the Mine Site since 2014; annual dustfall for 2014-2017 is presented in Table 2 (from EDI, 2015; 2016; 2017 and 2018). The locations of the dustfall monitoring stations are shown on Figure 1. The average annual dustfall at the three stations over the operating period (2015 to 2017) is 93.7 g/m^2. Annual dustfall results for 2018 are not yet available.

Table 2 Measured Dustfall at the Mine Site (2014-2017)

Site	Measured Dustfall (g/m²/yr)			
	2014	2015	2016	2017
DF-01-M	27.73	108.54	77.99	198.37
DF-02-M	12.47	41.05	128.23	82.32
DF-03-M	9.68	58.06	81.9	66.83

The contours of predicted annual dust deposition (total suspended particulate – TSP) from air quality dispersion modelling of the Phase 2 Proposal (RWDI AIR Inc., 2018) is also shown within the contributing catchments of Camp Lake on Figure 1. As noted by KP (2018), dust deposition at the Mine Site is expected to decrease as a result of the Phase 2 Proposal, relative to the Approved Project, mainly due to relocation of secondary ore crushing to Milne Port (Figure 3.1). Current operations, and subsequent measured dustfall), include the current deposited dustfall during the ERP.

The TSP deposition modelling for the Phase 2 Proposal was used to establish an average dustfall deposition rate within the Camp Lake catchments, for comparison to the measured dustfall presented in Table 2. The dust loadings for each of the three contributing catchments to Camp Lake (MR-08, MR-09 and MR-10), along with the average annual TSP deposition rate for each catchment and for the three Camp Lake catchments combined are presented in Table 3. Average annual loadings were calculated within each catchment for each contour interval by using the midpoint value of the indicated range of TSP deposition.

Table 3 Predicted Annual Dust Deposition within Camp Lake Catchments

Annual TSP Deposition (g/m²/year)		**Catchment**					
		MR-08		**MR-09**		**MR-10**	
Range	Midpoint	Area (m²)	Loading (g/year)	Area (m²)	Loading (g/year)	Area (m²)	Loading (g/year)
2 - 8	5	1,397,664	6,988,322	1,267,808	6,339,039		
8 - 15	11.5	3,901,000	44,861,500	4,233,876	48,689,571	672,078	7,728,897
15 - 30	22.5	1,344,200	30,244,500	3,200,460	72,010,350	5,707,848	128,426,573
30 - 55	42.5	279,816	11,892,180	712,231	30,269,818	1,768,770	75,172,725
55 - 120	87.5	58,721	5,138,105			658,171	57,589,963
120 - 240	180	26,779	4,820,274			381,340	68,641,182
240 - 480	360					422,126	151,965,360
480 – 3,400	1,940					434,860	843,628,400
Average TSP Deposition (g/m²/year)		14.83		16.7		132.7	
		60					

The predicted average dustfall deposition rate for all catchments of Camp Lake is 60 g/m²/year (Table 3), which is lower but within the same order or magnitude of the dustfall measured at site (Table 2). As such, the current dustfall contributions to Camp Lake are likely roughly indicative of future dustfall contributions, either through direct deposition on the lake surface or from runoff within the lake catchment into the lake.

Another potential source of metal loading into Camp Lake will be mine effluent discharged from the waste rock facility's west pond. Source terms for runoff from the waste rock facility (WRF) were developed based on waste rock geochemistry to support water quality modelling in the FEIS (Baffinland, 2012). However, runoff from the starter WRF has been mildly acidic and higher in metals than predicted in the FEIS, necessitating the installation and operation of a water treatment system that was commissioned in June 2018. Studies continue on the waste rock runoff that will likely drive modifications to how waste rock is managed over the long-term. For this reason, there are no new source terms that can be applied to consider metal loading contributions from the west pond.

2.3 WATER QUALITY DATA

Having established that current dustfall is similar to future dustfall, we reviewed water quality baseline and monitoring data for two Aquatic Effects Monitoring Program sampling stations in Camp Lake (Figure 1):

- JL0-02 – The lake station closest to the two tributaries most likely to be affected by the Project
- JL0-09 – The lake station furthest from the Project but closest to the off-site receptor (the HTO cabin)

Baffinland established baseline water quality in Camp Lake over the period of 2006 to 2013 (KP, 2014). Since that time, Baffinland has implemented its AEMP, which has covered construction of the Early Revenue Phase (ERP) in 2014, and mine operation from 2015 through 2018 (KP, 2015; Minnow Environmental Inc., 2016, 2017 and 2018).

3.0 RESULTS

Based on a review of the MRIKS database and current information regarding the location of HTO cabins and other land uses relative to the Project, Camp Lake is the most suitable waterbody to assess potential effects of the Project on waters potentially used for personal consumption by Inuit (Section 1 and Appendix A).

To evaluate the effects of the Project on Camp Lake water quality, monitoring data (collected from the AEMP) were compiled and presented as a series of plots (Figures 2 and 3) to evaluate trends of metal concentrations over time. The metal parameters considered within this evaluation are those for which a Canadian Drinking Water Quality (CDWQ; Health Canada, 2017) guideline value exists. Baseline results are presented as the mean values of all sampling between 2006 and 2013. Annual monitoring values are represented by the mean of three sampling events each year, from 2015 to 2018.

To evaluate whether the water quality trends forecasted to the end of the operation phase (2035) have the potential to effect human health, a linear trend line was established for each metal and sampling location. The Canadian Drinking Water Quality standard (Health Canada, 2017) are also shown on Figures 2 and 3.

The following metals show a trend of increasing concentration over the monitoring period:

- Aluminum
- Barium
- Iron
- Selenium
- Uranium

Current metals concentrations are well below the applicable drinking water guidelines, and current trends are unlikely to approach the applicable guideline over the life of the mine.

Concentrations of total aluminum and total iron are higher at JL0-02, closest to the main tributaries that are likely to be affected by the mine, compared to concentrations of the same parameters at the far afield station JL0-09. At JL0-02, total metals are higher than dissolved metals for some parameters, suggesting that the water column contains colloids (or sediment particles) from the nearby tributaries. These colloids are expected to fall out of suspension in Camp Lake.

Provided dustfall levels remain in the same order of magnitude as current levels, it is expected that the current trends are likely to be the best available indicator of future trends in water quality in Camp Lake (Section 2). Loadings would need to increase significantly relative to current trends, for any metals parameters to approach the respective drinking water guideline value.

4.0 ASSUMPTIONS AND LIMITATIONS

The following provides a summary of the assumptions and limitations of this evaluation:

- Water quality data and subsequent trending are determined based on observations of site operations for the past five years. It is possible that there may be a delay in the observation of impacts to Camp Lake due to mixing reactions. Ongoing AEMP monitoring and trending is required to confirm the forecasted results.
- Section 2.2 states that dustfall experienced during the ERP is within the same order of magnitude as to the expected dustfall for the Phase 2 Project. This statement assumes that the modelled Phase 2

Proposal is accurate, and that metal loadings to Camp Lake will be similar. Ongoing monitoring is required to confirm the accuracy of the modelled dustfall.

5.0 REFERENCES

Environmental Dynamic Inc. (EDI), 2015. *2014 Mary River Project, Terrestrial Environment Annual Monitoring Report*. March.

Environmental Dynamic Inc. (EDI), 2016. *2015 Mary River Project, Terrestrial Environment Annual Monitoring Report*. March.

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Intrinsik, 2017. *Evaluation of Exposure from Ore Dusting Events in Selected VECS: Humans, Caribou and Blueberry.* October 25.

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Minnow Environmental Inc. (Minnow), 2017. *Mary River Project - 2016 Core Receiving Environment Monitoring Program Report*. March.

Minnow Environmental Inc. (Minnow), 2018. *Mary River Project - 2017 Core Receiving Environment Monitoring Program Report*. March.

RWDI AIR Inc. (RWDI), 2018. *Air Quality Model - Phase 2 Proposal - Mary River Project, Baffin Island, Nunavut*. March 21. RWDI Ref. No. 1402090.

6.0 CLOSURE

We trust this meets with your present requirements. Please don't hesitate to contact the undersigned with any questions.

Yours truly,
Knight Piésold Ltd.

Prepared:

Simon Foster, M.Sc. P.Geo.
Project Scientist

Reviewed:

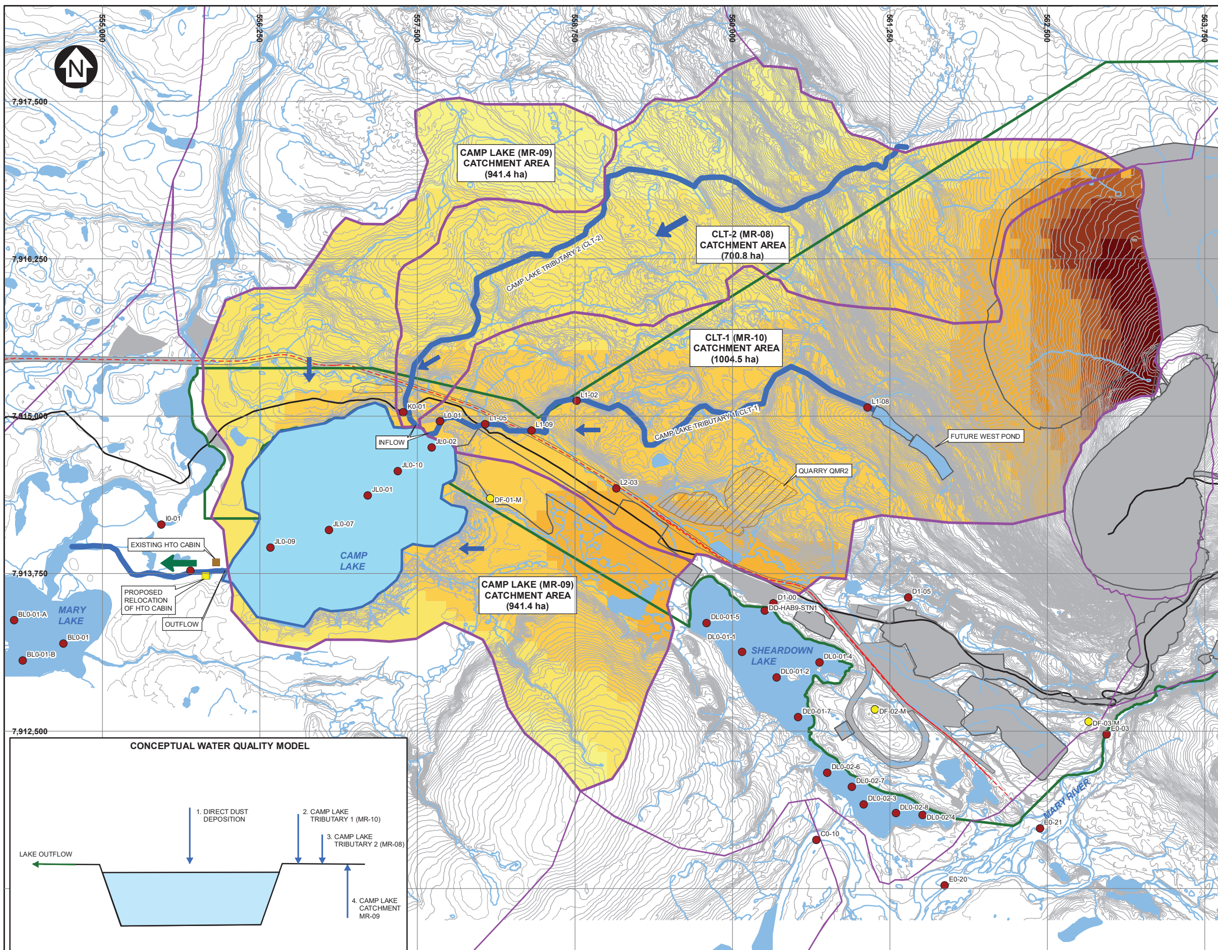
Richard Cook, P.Geo. (Ltd)
Specialist Environmental Scientist | Associate

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

Attachments:

Figure 1 Rev 0	Camp Lake – Conceptual Water Quality Model
Figure 2 Rev 0	Trends in Dissolved and Total Metal Concentrations in Camp Lake - Sheet 1 of 2
Figure 3 Rev 0	Trends in Dissolved Metal Concentrations in Camp Lake - Sheet 2 of 2
Figure 3.1	Air Quality Modelling – Dust Deposition Rates (from TSD-13; KP, 2018)
Appendix A	Freshwater Waterbodies with Unique Value and/or Cultural Significance to Inuit

/rc



REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	18JAN'19	ISSUED WITH MEMO	SBF	AS	RAC

LEGEND:

- AQUATIC EFFECTS MONITORING PROGRAM WATER QUALITY STATION
- DUSTFALL MONITORING STATION
- EXISTING HTO CABIN
- PROPOSED RELOCATION OF HTO CABIN
- MILNE INLET TOTE ROAD
- PROPOSED NORTH RAILWAY
- POTENTIAL DEVELOPMENT AREA
- PROPOSED INFRASTRUCTURE
- PROPOSED INFRASTRUCTURE
- CATCHMENT BOUNDARY
- QUARRY QMR2

ANNUAL DUST DEPOSITION ($g/m^2/year$)

- < 2
- 8
- 9 - 15
- 16 - 30
- 31 - 55
- 56 - 120
- 121 - 240
- 241 - 480
- > 481

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
2. ANNUAL DUST DEPOSITION CONTOURS PROVIDED BY RWDI AIR INC. (APRIL 16, 2013). THRESHOLD = 60 $\mu g/m^3$.
3. CONTOUR ARE IN METRES. CONTOUR INTERVAL VARIES.

SCALE 250 125 0 250 500 750 1,000 1,250 m

BAFFINLAND IRON MINES CORPORATION

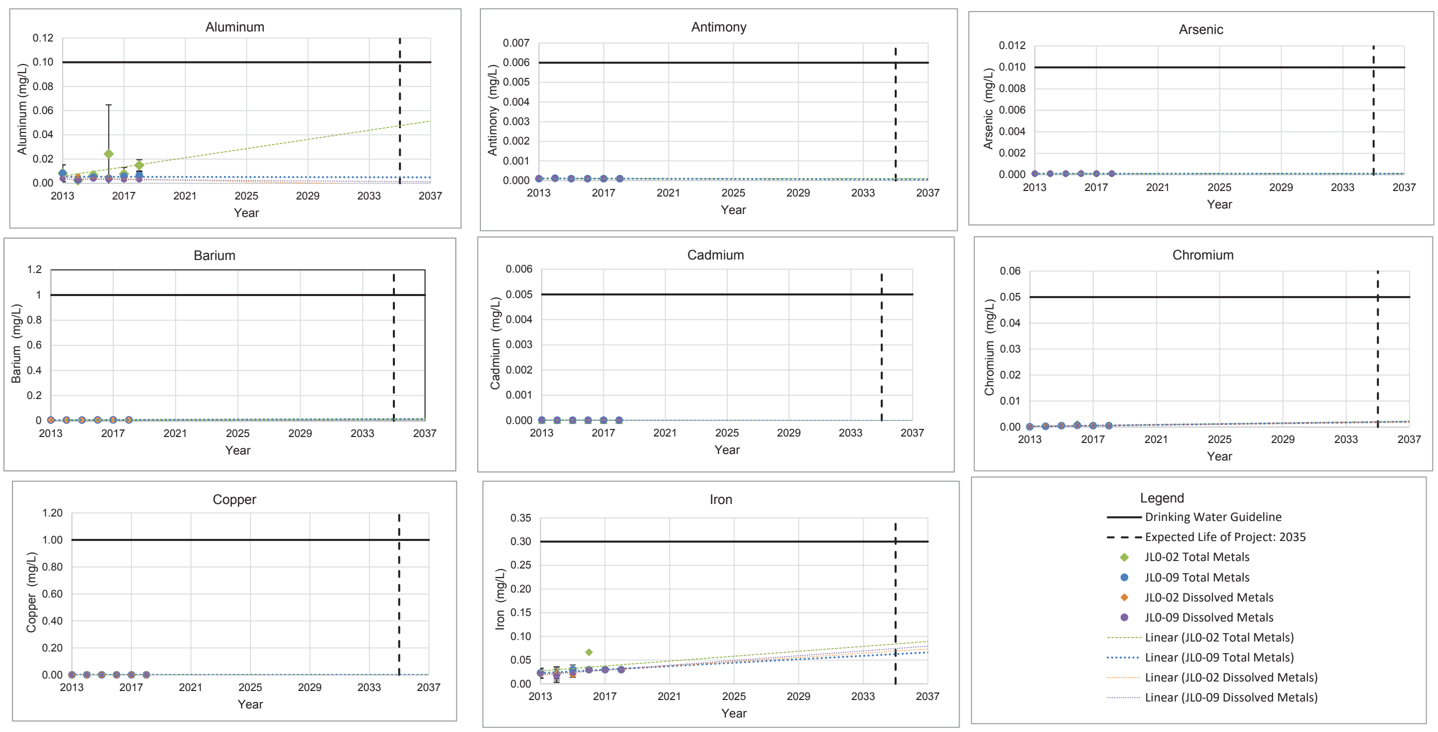
MARY RIVER PROJECT

CAMP LAKE
CONCEPTUAL WATER QUALITY MODEL

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/45	NB18-00878

FIGURE 1 REV 0



NOTES:

1. BASELINE DATA FOR CAMP LAKE SAMPLE LOCATIONS JL0-02 AND JL0-09 (REPRESENTED AS A 2013 DATA POINT) IS BASED ON THE MEAN OF SAMPLING VALUES FROM 2007 TO 2013.
2. MONITORING DATA DURING CONSTRUCTION (2014) AND OPERATIONS (2015-2018) IS BASED ON THE MEAN OF SEASONAL SAMPLING (THREE SEASONS).
3. WATER QUALITY GUIDELINES: *GUIDELINES FOR CANADIAN DRINKING WATER QUALITY* (HEALTH CANADA, 2017).
4. ERROR BARS REPRESENT THE STANDARD DEVIATION OF THE WATER SAMPLE CONCENTRATIONS FOR A GIVEN YEAR.
5. METAL CONCENTRATIONS LESS THAN DETECTION LIMIT ARE REPRESENTED AS THE DETECTION LIMIT.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

TRENDS IN TOTAL AND DISSOLVED METAL CONCENTRATIONS IN CAMP LAKE SHEET 1 OF 2

Knight Piésold CONSULTING

P/A NO.	REF. NO.
NB102-181/45	NB18-00878

FIGURE 2 REV 0

REV	DATE	DESCRIPTION	PREP'D	RVW'D
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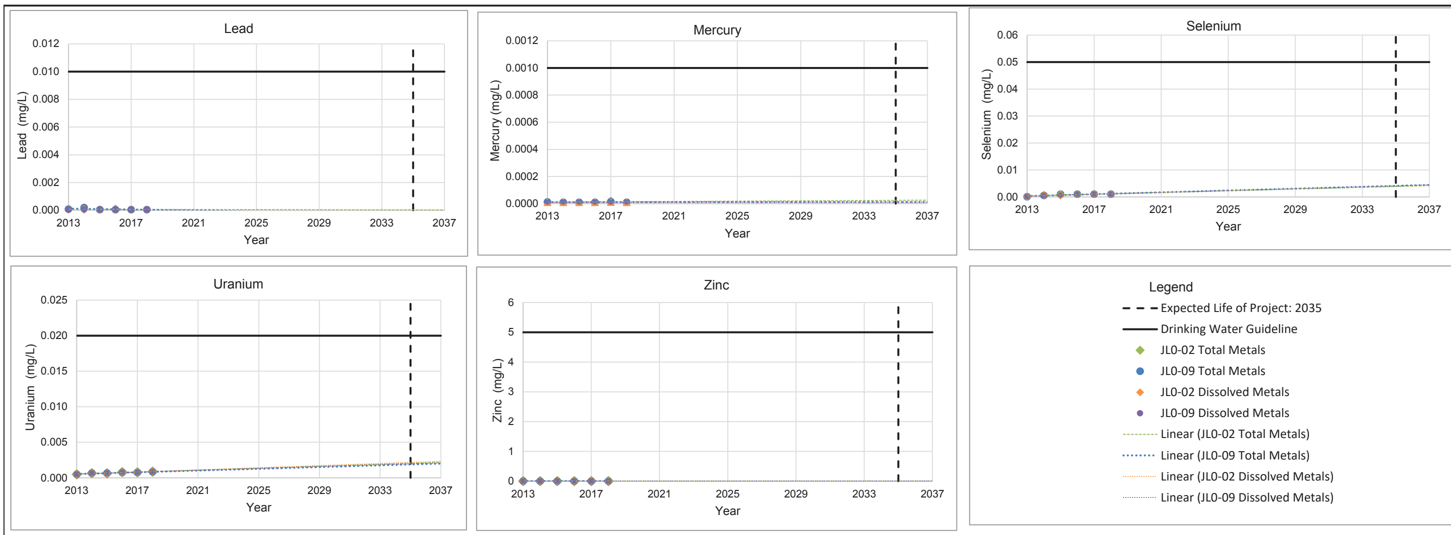


NOTES:

1. BASELINE DATA FOR CAMP LAKE SAMPLE LOCATIONS JL0-02 AND JL0-09 (REPRESENTED AS A 2013 DATA POINT) IS BASED ON THE MEAN OF SAMPLING VALUES FROM 2007 TO 2013.
2. MONITORING DATA DURING CONSTRUCTION (2014) AND OPERATIONS (2015-2018) IS BASED ON THE MEAN OF SEASONAL SAMPLING (THREE SEASONS).
3. WATER QUALITY GUIDELINES: *GUIDELINES FOR CANADIAN DRINKING WATER QUALITY* (HEALTH CANADA, 2017).
4. ERROR BARS REPRESENT THE STANDARD DEVIATION OF THE WATER SAMPLE CONCENTRATIONS FOR A GIVEN YEAR.
5. METAL CONCENTRATIONS LESS THAN DETECTION LIMIT ARE REPRESENTED AS THE DETECTION LIMIT.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	22JAN'19	ISSUED WITH MEMO	BA	RAC

BAFFINLAND IRON MINES CORPORATION

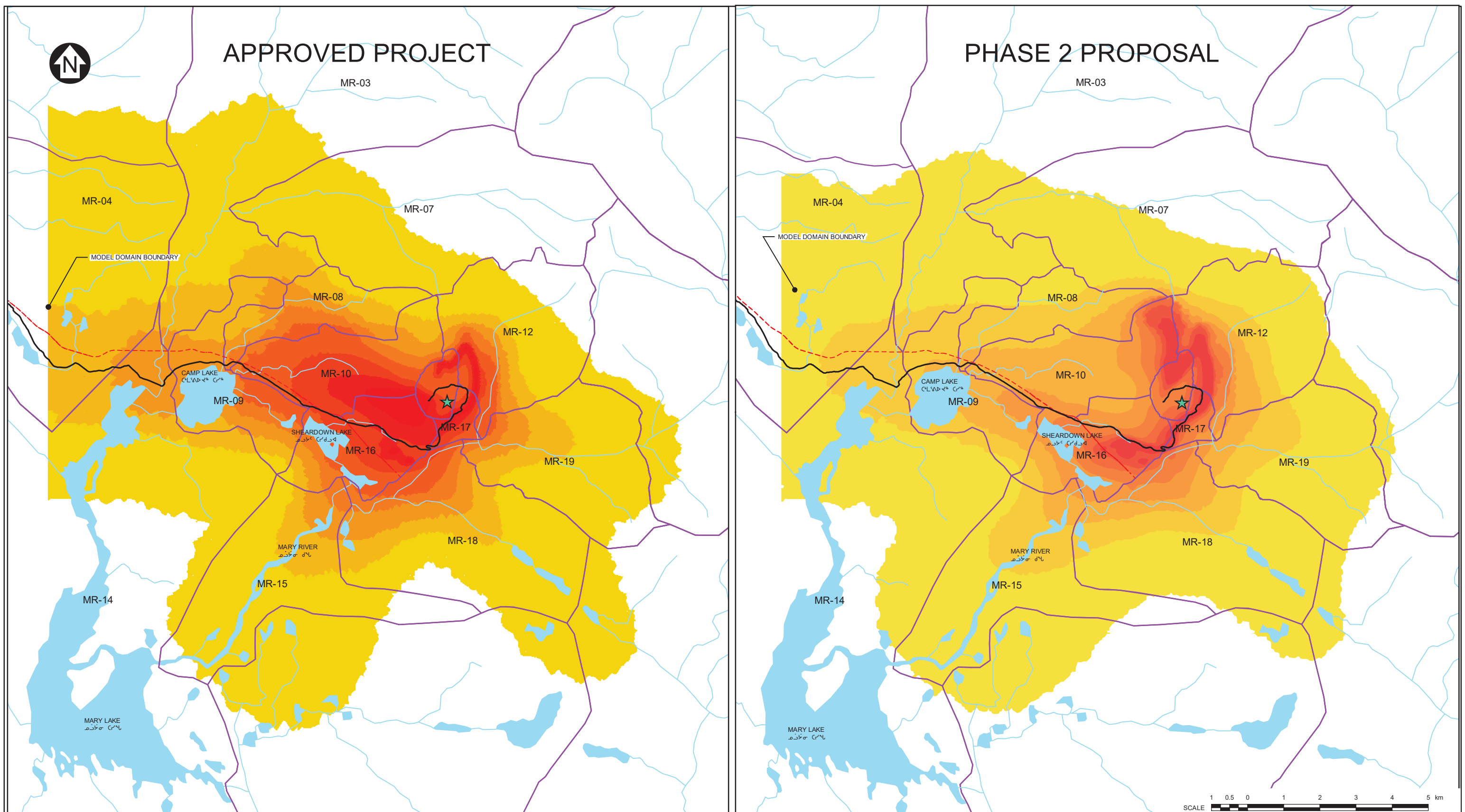
MARY RIVER PROJECT

TRENDS IN TOTAL AND DISSOLVED METAL CONCENTRATIONS IN CAMP LAKE SHEET 2 OF 2

Knight Piésold CONSULTING

P/A NO.	REF. NO.
NB102-181/45	NB18-00878

FIGURE 3 REV 0



LEGEND :

- PROJECT FACILITY LOCATION
- MILNE INLET TOTE ROAD
- PROPOSED NORTH RAILWAY
- CATCHMENT BOUNDARY

ANNUAL DUST DEPOSITION (g/m²/year)

- <2
- 2 - 7.5
- 7.5 - 15
- 15 - 30
- 30 - 55
- 55 - 120
- 120 - 240
- 240 - 480
- > 480

NOTES :

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
2. ANNUAL DUST DEPOSITION CONTOURS PROVIDED BY RWDI AIR INC. (APRIL 16, 2013). THRESHOLD = 60 µg/m³.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
1	10JUL'18	CHANGED HEADING TITLES ON FIGURES	RAC	SBF	RAC
0	20JUN'18	ISSUED WITH REPORT	RAC	RF	RAC

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

AIR QUALITY MODELLING
MINE SITE DUST DEPOSITION RATES

P/A NO.	REF NO.	REV
NB102-181/39	8	1

FIGURE 3.1

SAVED: I:\1102\00181\39\A\GIS\Figs\B49_r1 - air quality modelling.mxd; Jul 13, 2018 11:25 AM; sfeder

November 30, 2018

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Mr. Christopher Murray
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Baffinland Iron Mines Corporation
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Canada, L6H 0C3

Dear Christopher,

RE: Mary River Project - Freshwater Waterbodies with Unique Value and/or Cultural Significance to Inuit

1.0 INTRODUCTION

Baffinland Iron Mines Corporation (Baffinland) requested that Knight Piésold Ltd. (KP) identify freshwater waterbodies with unique value and/or cultural significance to Inuit that occur on Inuit Owned Land (IOL) and have the potential to be affected by the Mary River Project. The Mary River Inuit Knowledge Study (MRIKS); (Baffinland, 2014) was identified as a key information source in this regard. This work will assist Baffinland in its interpretation of the Water Compensation Agreement (WCA) between the company and the Qikiqtani Inuit Association (QIA).

2.0 BACKGROUND

Article 20 of the *Nunavut Agreement* is titled Inuit Water Rights, and Section 20.3.1 states the following:

> *"No project or activity within the Nunavut Settlement Area which may substantially affect the quality of water flowing through Inuit Owned Lands, or the quantity of such water, or its flow, shall be approved by the NWB [Nunavut Water Board] unless the applicant for a licence has entered into a compensation agreement with the DIO [Designated Inuit Organization] for any loss or damage which may be caused by the change in quality, quantity or flow of the water or the NWB has made a determination in accordance with Section 20.3.2."*

Baffinland and the QIA signed a WCA in 2013, in accordance with Section 20.3.2 of the *Nunavut Agreement*, and Section 63 of the *Nunavut Waters and Nunavut Surface Rights Tribunal Act*. Section 20.3.3 of the *Nunavut Agreement* provides guidance in regard to determining compensation for loss or damage caused by the change in quality, compensation, or flow of water through IOL:

> *"In determining the appropriate compensation for loss or damage under Section 20.3.2, the NWB shall take into account the following:*
>
> - *the adverse effects of the change in quality, quantity or flow of water on Inuit Owned Lands, owned or used by the person or group affected*
> - *the nuisance, inconvenience, disturbance or noise caused by the change in quality, quantity or flow of water to the person or group affected*
> - *the adverse effects of the change in quality, quantity or flow of water in combination with existing water uses*

- *the cumulative effect of the change in quality, quantity or flow of water in combination with existing water uses*
- *the cultural attachment of Inuit to Inuit Owned Lands, including water, adversely affected by the change in quality, quantity or flow of water*
- *the peculiar and special value of Inuit Owned Lands, including water, affected by the change in quality, quantity or flow of water, and*
- *interference with Inuit rights, whether derived from this Article or some other source."*

We understand that it is bullets 5 and 6 above (the cultural attachment and peculiar and special value of IOL including water) that Baffinland would like to identify in relation to the Project.

Overlap of the Project footprint with IOL is shown on Figure 1. Milne Port, the Mine Site, most of the Northern Transportation Corridor, and the northern 30 km of the South Railway is situated on IOL. As such, this review will focus on potential interactions of these project components with waters important to Inuit.

3.0 INUIT KNOWLEDGE STUDIES

Community based research programs were undertaken by Baffinland to obtain community input, socio-economic information, and Inuit knowledge. The MRIKS was conducted by Baffinland from 2006 through 2010 (Baffinland, 2014). Objectives of the study included obtaining local knowledge of wildlife, land use, and areas of cultural significance to support Project decision-making and the environmental assessment process. Inuit have a unique knowledge about their local environment, how it functions, and its characteristic ecological relationships. Inuit knowledge is recognized as an important part of project planning, resource management, and environmental assessment.

Workshops and interviews with elders were undertaken in the communities of Arctic Bay, Clyde River, Hall Beach, Igloolik, and Pond Inlet in 2007 and 2008, and workshops were held in the South Baffin communities of Cape Dorset and Kimmirut in 2010. The results of Inuit knowledge studies were incorporated to the Final Environmental Impact Statement (FEIS) report (Baffinland, 2012) and FEIS Addendum report (Baffinland, 2013) for the Early Revenue Phase (ERP). A database was eventually assembled that consists of research agreements, interview questions, audio recordings of interviews, written interview transcripts in Inuktitut and English, and the keyword summaries and maps that were the main products of the study (Baffinland, 2014). The study methodology is summarized in Appendix A.

4.0 METHODOLOGY

KP led the study and developed the study products, and hence has a familiarity with the MRIKS database. KP reviewed the database with the aim of identifying those waters that were identified as important to Inuit that may potentially be affected by the Project. A number of interview questions produced information on areas of importance to Inuit. This included questions regarding travel routes and camps, water, and areas important for fishing. The interview questions assessed as having information on the importance of freshwater bodies in the region are provided in Appendix B.

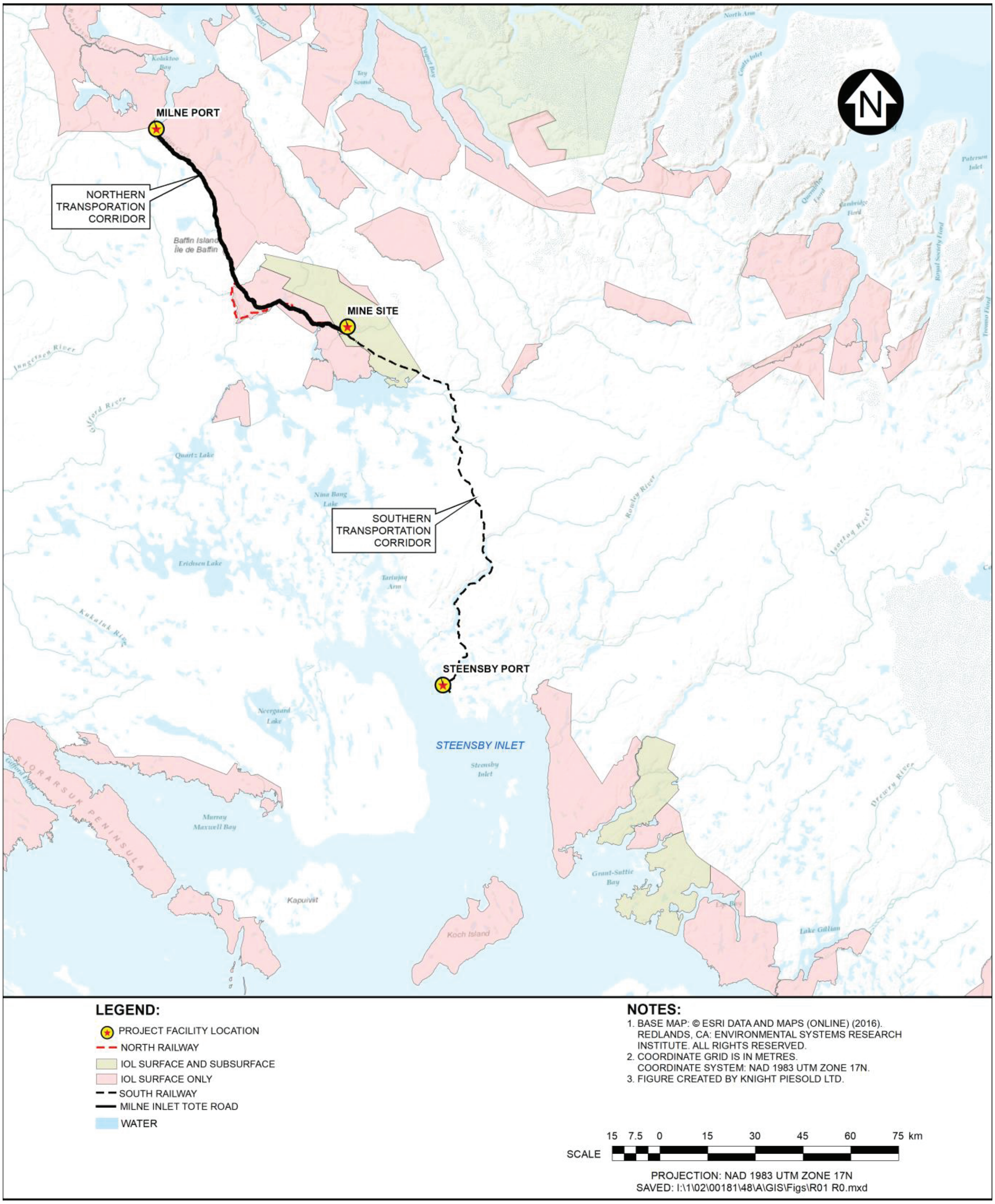

Figure 1 Project Location Relative to Inuit Owned Lands

In completing this review, KP undertook the following:

- Identified and reviewed the applicable maps that show the following information:
  - Camps
  - Travel routes
  - Lakes and rivers of importance
  - Special places and resource collection areas
  - Fishing areas
- Reviewed keyword summaries related to the above topics
- Reviewed individual transcripts corresponding to mapped features discussing lakes and rivers of importance

Relevant figures presenting the above information are included in Appendix C, as follows:

- Figure 1.4 Travel Routes - Project Study Area (Interview Results)
- Figure 1.6 Berry Picking Locations - Project Study Area (Workshop Results)
- Figure 1.8 Camping Locations - Project Study Area (Workshop Results)
- Figure 1.12 Special Places - Project Study Area (Interview Results)
- Figure 1.16 Stone Quarry Locations - Project Study Area (Workshop Results)
- Figure 3.20 Water and Ice Features - Project Study Area (Interview Results)
- Figure 5.2 Fish Locations - Project Study Area (Interview Results)

The results of the review are provided below.

5.0 RESULTS

5.1 THE IMPORTANCE OF WATER

A number of study participants stated that good drinking water was of primary importance for well-being, and water is also an important source of food (fish).

> *It's vitally important you get some water for drinking purposes. But, lakes are also important because when I go fishing to a lake and I stay there for a long time and when I become thirsty I can drink the water from the lake. Yea, there are a whole lot of lakes in this area here. For example, the residents of Pond Inlet we go to this lake to go fishing.* (PI-03, Pond Inlet)

Several elders emphasized the need to have a good water source near to camp sites.

> *We made sure to camp nearby water sources such as lakes, rivers and streams so we had water nearby our camp… This has always been one of the case for all time, when choosing a camp site, we had to be sure to have a water source nearby… Lakes and rivers are all important as we camp or live around those for our water source and we fish off the lakes and rivers during the run… Having water is essential to us and water keeps us alive.* (Elijah Panipakoocho, Pond Inlet)

> *We have always had to live nearby lakes for our water source and we even use it as storage or deep freeze with our meat supplies. This lake is where the river runs from where we fish. … These lakes are very, very important to me. Some campers camp where there are no lakes, and in early fall they have no water source at all, so it is important to live or camp nearby lakes.* (Ikey Kigutikkarrjuk, Arctic Bay)

While out on the land, hunters and travellers consume water from ice, snow, lakes and rivers. In winter, snow is relied upon as a water source. Water from glaciers was identified by many study participants as the best available water.

> *Only when you have good drinking water are you more livelily and when you don't have good drinking water it is unpleasant and you always look for a source of good drinking water… When you're at Qaurnak in the summertime and the icebergs arrive you have an excellent source of drinking water… When we were camping out there we had excellent drinking water. Water is very important to our livelihood.* (Jochabed Katsak, Pond Inlet)
>
> *Our waters are frozen for longer periods of time. There is a lot of snow that we can also use for water. They are clean as they are frozen more than half the time. Outside of the community there are lakes that have clean water. Lakes up here freeze often and there is an abundance of it to be used for drinking. There is a lot of that in our environment. We can get our water anywhere. We can either use ice or snow.* (AB-13, Arctic Bay)

The lakes and rivers are an important source of food, fish are caught from their depths and mammals are hunted from the water. During the open water period, major rivers are generally preferred over smaller watercourses, and in particular, rivers with a gravel bottom, with an awareness that smaller streams or streams with finer substrate (and hence lower flow) are more likely to contain harmful bacteria. Inuit commonly observe the water to see if it is foggy or murky, since it is believed that clear water is the best water to consume.

> *After there's no longer some ice we didn't just fetch water from ordinary streams but major rivers seemed to have better drinking water source and also rivers have little germs… we were discouraged from drinking from small streams or lakes. Only we were told to drink water from major rivers such as if the river had gravel bottom. That's a very good drinking water and everyone has known that for a long time… if it's for making tea then you can easily identify if it's poor source of drinking water and the tea tends to turn black and you can tell that it is not good drinking water by sampling the tea you can notice it right away so tea is an excellent source of identifying the quality of drinking water because they tend to turn black and then you know.* (Jochabed Katsak, Pond Inlet)

Tea is said to be a good indicator of water quality. Also, nowadays people reportedly boil their water before consuming.

5.2 PROJECT AREAS

Table 1 summarizes the Inuit land uses including the identification of important waters within the Project's development areas on IOL, as established by the mapping developed from the MRIKS (Appendix C).

Table 1 Geographic Areas with Cultural or Land Use Importance

Project Areas	Travel Routes	Camps	Water (specific locations)	Harvesting Food (specific locations)	Special Places (includes carving stone deposits)
Milne Port	Yes	Yes	No	No	No
Northern Transportation Corridor	Yes	Yes	No	No	No
Mine Site	Yes	Yes	No	No	Yes

A summary of the land uses and likely presence of waters of importance to Inuit is provided below for each of the Project Areas. Although the first 30 km of the South Railway is located on IOL, this area has been incorporated into the discussion on the Mine Site.

5.3 MILNE PORT

Milne Port is an important entrance into the interior of northern Baffin Island, mainly for the people of Pond Inlet. It is also along the main travel route between Pond Inlet and Igloolik (Figure 1.4). It is an area historically and currently used for camping (Figure 1.8). Important waterbodies were not identified at the port site as part of the MRIKS (Figure 3.20). Important waters nearest to Milne Port include the Robertson River system to the northeast, which drains into Koluktoo Bay, and the Tugaat River system to the east. Both these rivers are important for harvesting anadromous Arctic Char.

An old outpost camp is located on the beach at Milne Port to the east of Baffinland's port facilities. The camp was originally constructed during mineral exploration activities in the early 1960s, and while the building is in poor condition and not habitable, it continues to serve as a refuge for land users, and the area continues to be where hunters will land their boats, sometimes offloading all-terrain vehicles (ATVs) to travel inland. It is reasonable to assume that land users use the stream adjacent to the HTO cabin, though this stream beyond the influence of the Project.

Prior to development of Milne Port, hunters would also land boats at the mouth of Phillips Creek, anchoring them inside the sand spit that crosses part of the mouth of the river. The lowest reach of the river behind the sand spit has been found to be brackish and not suitable for drinking, though further upstream at Baffinland's approved water withdrawal location, the water is fresh with no evidence of salt intrusion. Baffinland's Hunter and Visitor Site Access Procedure (Baffinland, 2015) directs hunters to land on the east end of the beach in the vicinity of the HTO cabin mentioned above, and as such, presumably land users no longer land boats at Phillips Creek and depart inland from this location.

5.4 NORTHERN TRANSPORTATION CORRIDOR

Phillips Creek and the Milne Inlet Tote Road (Tote Road) is part of the corridor into the interior of the island, as referenced above (Figure 1.4), and a number of camp sites have been identified (Figure 1.8). No important waters were identified within the corridor (Figure 3.20). The lakes within this corridor were noted to support land-locked Arctic Char.

Given the amount of travel and camps found along Phillips Creek, as well as archaeological sites that demonstrate its historic use as a travel corridor, it is reasonable to assume that Phillips Creek and the lakes within the river system (i.e., KM26 Lake, KM32 Lake and Katiktok Lake) have been and may continue to be used by Inuit as a water source. As noted in Section 5.1, Inuit strategies to obtain good drinking water includes seeking larger waterbodies with gravel substrate, and hence it is unlikely that land users (at least experienced land users) would seek to obtain drinking water from the many small tributaries of Phillips Creek that are crossed by the Tote Road.

5.5 MINE SITE

Deposit No. 1 (Nuluujaak) is used as a landmark for navigation while traveling on the land, being about 500 m above the surrounding ground to the south, and highly visible from afar. It is removed from the main Pond Inlet to Igloolik travel corridor. Nonetheless, Inuit have traditionally traveled through the Mine Site area to reach lands further east via the Ravn River valley (Figure 1.4), or to hunt caribou or collect carving stone (Figure 1.16).

> *Yes …Hunters would hunt for caribou there as there would be a lot of caribou in early spring. I would be able to see Mary River from there. We knew Mary River all along as we would be able to see it from there. We weren't aware of the fact that it has minerals but the mountains would become visible and we could tell that it was Mary River. We knew where Mary River is but weren't aware that it has minerals in it.* (Sakiasie Qaunaq, Arctic Bay)
>
> *We used to go [to Mary River] to go pick up soapstone. We would take the soapstone to Pond Inlet. The soapstone at Mary River is good quality stone.* (Ipeelie Koonoo, Arctic Bay)
>
> *The only place that I know is at Nulujaak (Mary River) near the camp they had set up, up at the hill, in a gully there is some variety carving stones that some people quarried and stones for making pots can be found at Tuapak, and marble, Nallua has some marble.* (Calab Ootoova, Pond Inlet*)*

No important waters were identified in the Mine Site area, or along the first 30 km of the South Railway (Figure 3.20). Although not identified in the IQ studies (Figure 1.8), there was a cabin at the Mine Site, originally constructed as part of mineral exploration in the early 1960s, which was used by hunters until construction of the mine in 2013. At the start of mine construction, Baffinland replaced this cabin with a new cabin, positioned on the west side of Camp Lake near its outlet at the request of the Mittimatalik Hunters and Trappers Organization. Based on the location of the new cabin, Camp Lake is the obvious water source for camp occupants, at least during the period of open water. The outlet stream of Camp Lake is not expected to be used for water, as it is shallow with sometimes limited flow. Water could be withdrawn from the Tom River, which is similar in size to the Mary River, though it is further removed from the cabin. Snow is likely the source of water during periods of ice cover, which is much of the year.

6.0 CONCLUSIONS

The MRIKS (Baffinland, 2014) is a useful resource for identifying waters that are important to Inuit, i.e., with a cultural attachment and peculiar and special value. Though waters on IOL that are important to Inuit were identified from the study, none of the identified locations are close to the Project.

It is reasonable to assume, however, that watercourses close to areas used by Inuit may be used as sources of drinking water. This includes:

- The stream next to the HTO cabin on the east side of the Milne Inlet beach
- Phillips Creek and the lakes within the Phillips Creek catchment
- Camp Lake
- Possibly the Tom River

These watercourses are not thought to qualify as having a cultural attachment and peculiar and special value, as described in Section 20.3.3 of the *Nunavut Agreement*.

7.0 REFERENCES

Baffinland Iron Mines Corporation (Baffinland), 2012. *Mary River Project - Final Environmental Impact Statement*. February.

Baffinland Iron Mines Corporation (Baffinland), 2013. *Mary River Project - Addendum to the Final Environmental Impact Statement for the Early Revenue Phase*. June.

Baffinland Iron Mines Corporation (Baffinland), 2014. *Mary River Inuit Knowledge Study, 2006-2010*. Compiled by Knight Piésold Ltd.

Baffinland Iron Mines Corporation (Baffinland), 2015. *Hunter and Visitor Site Access Procedure*. February 17. Doc. No. BAF-PH1-830-PRO-0002, Rev. 1.

Knight Piésold Ltd. (KP), 2015. Letter to: Oliver Curran, Baffinland Iron Mines Corporation, Re: *Mary River Project's Inuit Knowledge Study Database*. February 6. Ref. No. NB14-00411.

8.0 CLOSURE

Please contact the undersigned if you have questions or comments about the content of this letter.

Yours truly,
Knight Piésold Ltd.

Prepared:

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

Reviewed:

Oscar Gustafson, R.P. Bio.
Specialist Environmental Scientist | Associate

Approval that this document adheres to the Knight Piésold Quality System:

Attachments:

Appendix A	MRIKS Study Methodology
Appendix B	Select Interview Questions
Appendix C	Select MRIKS Figures

/rc

APPENDIX A

MRIKS Study Methodology

(Pages A-1 to A-4)

APPENDIX A
MRIKS STUDY METHODOLOGY

1.0 INFORMATION SOURCES

Community based research programs were undertaken by Baffinland to obtain community input, socio-economic information, and Inuit knowledge. The Mary River Inuit Knowledge Study (MRIKS) was undertaken by Baffinland from 2006 through 2010. Inuit have a unique knowledge about their local environment, how it functions, and its characteristic ecological relationships. Inuit Qaujimajatuqangit (IQ) is recognized as an important part of project planning, resource management, and environmental assessment. In 2006, the study started in Pond Inlet. Workshops and interviews with elders were undertaken in the communities of Arctic Bay, Clyde River, Hall Beach, Igloolik, and Pond Inlet between 2007 and 2010. Workshops were held in the South Baffin communities of Cape Dorset and Kimmirut during 2010. The objectives of the IQ study were to obtain local knowledge of wildlife, land use, and areas of cultural value to support Project decision-making and the environmental assessment process. The results of IQ studies conducted from 2006 through 2010 were incorporated to the Final Environmental Impact Statement (FEIS) report (Baffinland, 2012) and FEIS Addendum report (Baffinland, 2013) for the Early Revenue Phase (ERP).

Research agreements were negotiated between each of the five North Baffin community working groups and Baffinland as follows:

- Pisiksik Working Group (Pond Inlet) - 2006
- Qaatiliit Working Group (Igloolik) - 2007
- Inuksuligarjuk Working Group (Arctic Bay) - 2007
- Tikkuu Working Group (Hall Beach) - 2008
- Ukkakkut Working Group (Clyde River) - 2008

These agreements outline the following:

- Roles and responsibilities of the parties
- Purpose and methods of the IQ study
- Clarification on matters of privacy, informed consent and ownership of data

IQ workshops were initiated to provide another source of community-based data, to help verify results from other data sources (e.g. IQ interviews, working group meetings), and to engage a broader community audience. Workshops on caribou, marine mammals and Inuit land use were conducted in the North Baffin and South Baffin communities to identify areas of importance and use to Inuit and to identify potential project interactions with these things. In the North Baffin, these workshops were structured to have both ‘public’ and ‘invited persons’ components. Workshop minutes were recorded for all meetings. In some cases, additional public outreach was made, in the form of radio call-in shows and staffed tables set up in public places (e.g., Co-op stores).

Baffinland has continued to consult with Inuit communities for the existing operations and Phase 2 Proposal. These discussions have not provided new information specific to the designation of new and/or culturally important freshwater waterbodies.

2.0 INTERVIEW QUESTIONS AND WORKSHOPS

2.1 METHODOLOGY

IQ interviews with elders were held in Arctic Bay, Igloolik and Pond Inlet over the period of late 2006 into 2008. Working groups identified the key knowledge holders in the community.

Interviews were carried out using a set list of interview questions. The Pisiksik Working Group developed an initial list of 168 interview questions based on an example provided by Knight Piésold from another Project. Questions focused on Inuit use and understanding of the land, caribou, marine mammals, fish, birds, and other land mammals. For Arctic Bay and Igloolik a shorter questionnaire was developed, containing only 83 questions. Questionnaires in Arctic Bay and Igloolik were shortened after it was recognized the Pond Inlet questionnaire was cumbersome and the length of interviews and subsequent transcribing was difficult for the interviewer and elder consultant to complete.

Interviews were recorded on either recordable mini-disc or by digital recorder and relevant information mapped at a 1:1,000,000 scale. The audio recordings of the interviews were transcribed into Inuktitut and then translated into English.

Data verification sessions were held in each of the three communities after all the interviews had been completed. During these visits, the interviewees were invited to review draft GIS IQ maps. Interviewees commented on the accuracy of the data that had been produced. Data features were deleted, added or modified on the maps to reflect interviewee wishes.

The types of data collection during interviews and workshops included marine mammals, caribou, land use, fish, birds, and other land mammals.

Land use data were collected during workshops in Arctic Bay, Clyde River, Hall Beach, Igloolik, Pond Inlet, Kimmirut and Cape Dorset, although only a selection of questions were asked in the South Baffin communities. Land use data were also collected through individual interviews with elders in Arctic Bay, Igloolik and Pond Inlet. Questions asked during the interviews and workshops pertained specifically to:

- Travel routes
- Camps
- Archaeological sites
- Traditional plant use
- Resource collection areas (including carving stone and berry picking areas)
- Ice and water conditions
- Special places on the land

Lines of questioning focussed on:

- Inuit land use (e.g. locations, uses of locations, stories and/or legends)
- Interaction of Project components with land use activities (e.g. location of Project components in regards to land use activities)

Fish data were collected during individual interviews with elders in Arctic Bay, Igloolik and Pond Inlet. Additionally, some fish data were collected during workshops in Kimmirut and Cape Dorset. Questions asked during the interviews pertained specifically to fish interviewees were familiar with. Lines of questioning focussed on:

- Life cycle activities (e.g. migrations, areas of concentration, spawning areas) of fish
- Inuit use of fish (e.g. harvesting locations, harvesting methods)
- Interaction of Project components with fish (e.g. ship traffic)

These questions were asked in an effort to better understand potential impact pathways and opportunities for mitigation.

2.2 MAPS

A number of maps were produced during both the IQ interviews and workshops. Sheets of transparent Mylar were placed over large (1.1m x 1.6m) topographic regional maps, so geographic and other features of interest could be marked directly onto the sheets. The sheets of Mylar were then hand digitized by Knight Piésold staff (i.e., the mapped information was copied into a computer database using a digitizing table) using the AutoCAD software program. Once digitizing was complete, files were transferred over to the Geographic Information System (GIS) software package ArcView for more detailed data analysis and presentation.

A separate series of maps were produced for the workshops and interviews. For example, maps from each of the communities' workshops were digitally combined and then presented according to theme (e.g. Inuit travel routes, ringed seal locations, berry-picking locations). Similarly, maps from each of the individual interviews were digitally combined and also presented according to theme. Presenting data in this fashion allowed for data from all the communities to be displayed at once and facilitated comparison between the two data sources (i.e. workshops and interviews).

These maps have been released in a separate mapbook (KP, 2015). The relevant maps from the mapbook related to freshwater waterbodies are included as Attachment A.

2.3 IQ DATABASE

All interview transcripts, workshop notes and working group meeting minutes were incorporated into a central database and coded to sort by topic. Coding was completed using the NVivo 7 software package, a commonly used application for analyzing qualitative research data. The IQ database contains over 500 topic 'directories', often organized according to major themes. As an example, 'caribou' is one major theme, while 'calving locations', 'migrations' and 'reaction to disturbance' are a few examples of caribou sub-themes. Other major themes include: 'marine mammals', 'birds', 'fish', 'Inuit and the land', 'shipping' and 'terrestrial mammals'. There also exists a directory for all other topics not covered under a major theme. All topic reports were made available on a password-protected FTP site for the various scientists and specialists involved in the Project to use. IQ data from these topic reports is then available to be incorporated into the impact assessment, and for other long-term Project needs.

Keywords were used to code the interview transcripts, workshop notes and working group meeting minutes, as well as the number of references associated with each keyword. The keywords and sub-keywords related to the unique value and/or cultural significance of freshwater waterbodies include:

- Inuit and the Land - camps and living areas, places names, water, water quality, song and stories, and importance of lakes and rivers
- Fish - Arctic char, land-locked (nutilliarjuit), locations and harvesting locations, non-migrating fish, and fish living only in rivers, and stories

The IQ database was compiled and issued to the participating communities and the QIA in 2014. The information can be used by the public, in accordance with the research agreements Baffinland negotiated with the working groups that led the study in each community.

APPENDIX B

Select Interview Questions

(Pages B-1 to B-2)

APPENDIX B
SELECT INTERVIEW QUESTIONS

1. Can you show me [on the map] the major camps you used for the areas you will talk about today? Seasons: spring, summer, fall, and winter. Why are these places important?
2. Can you show me [on the map] special areas on the land? These might include sacred places, mythical events, giant sites and supernatural areas that might cause disorientation or where people would receive visits. Other important places would include archaeological sites and burials places.
3. We are interested in place names. Can you give us the names for the major land and water features [on the map] for the areas you know?
4. Where did you go to collect other significant resources such as water, wood, carving stone, stone for fire starters, etc. Did this differ by season - spring, summer, fall, and winter? [Use map]
5. Can you show me [on the map] the areas you traveled with your family when you were young?
6. Can you show me [on the map] the areas you traveled during your adult life up to now? It would be use full to us if you could talk about the seasons you used the land (spring, summer, fall, and winter).
7. Can you show me [on the (map) the major] Inuit travel routes in Mary River area around it? Did these vary by seasons - spring, summer, fall and winter?
8. Could you show me [on the map] which lakes and rivers are most important in your area? Why are they important?
9. What does good water mean to you?
10. Do the places you set nets change by season? [Use map]
11. Where are the best places to jig for fish? [Use map]
12. Are there Arctic char in the _______________ River (Individuals may want to discuss several rivers in their traditional lands). Are the fish land locked, or sea run? Do the sea run fish move every year? How far up river do the fish run? Do the fish hold over the winter in the river? [Use map]
13. How did people in the past catch fish in rivers? Do people fish in rivers today?
14. Are the mouths of rivers important fishing areas? Please show me on the map which rivers are important for fishing.
15. Are there areas that were important for fishing in the past but are no longer used?
16. Which lakes do people regularly fish in your area? [Use map] What time of year do people fish on the lakes?
17. Which lakes have Arctic char in your area? [Use map]. Are they sea run or land locked fish? If they migrate when do they return to the lake? When do they return to the sea?

18. Please tell me about fish in lakes and rivers.
19. In which lakes are landlocked char found?
20. In which lakes is migrating char found? When do these fish migrate to the sea? When do they return to lakes?

APPENDIX C

Select MRIKS Figures

Figure No.	Revision	Description
Figure 1.4	0	Travel Routes - Project Study Area (Interview Results)
Figure 1.8	0	Camping Locations - Project Study Area (Workshop Results)
Figure 3.20	0	Water and Ice Features - Project Study Area (Interview Results)
Figure 1.6	0	Berry Picking Locations - Project Study Area (Workshop Results)
Figure 5.2	0	Fish Locations - Project Study Area (Interview Results)
Figure 1.12	0	Special Places - Project Study Area (Interview Results)
Figure 1.16	0	Stone Quarry Locations - Project Study Area (Workshop Results)

ᑐᑭᓯᐅᑦ LEGEND:

- ᐃᓄᒻᒥᓂᒃ ᐃᓪᓕᓂᐅᔪᑦ
  TRAVEL ROUTE
- ᐅᐊᑦᑎᐊᕈ ᑐᓪᓕᓈᕆᓂᑦ ᐊᕐᑭᑎᓪᓗᐊᑕᕆᓂᓪᓗ
  TRAVEL ROUTE USED IN THE PAST
- ᓯᑯᒥ ᐃᓪᓕᓂᐅᓚᖓ
  SEA ICE MAIN TRAVEL ROUTE
- ᕿᖓᒃᑯᓂ ᐊᕐᑯᑎ ᐅᓯᑲᑦᑕᕕᒃ
  MILNE INLET TOTE ROAD
- ᓄᓇᓯᐅᑎᑯᑦ ᐊᑯᑎᒋᓂᐊᑦᑕᖓ
  PROPOSED RAILWAY ALIGNMENT
- ᐃᑲᓐᓂᑯᑦ ᐅᒥᐊᕐᔪᐊᓐᓂᑦ ᐊᕐᑯᑕᐅᑲᑦᑕᓂᐊᕐᑐᖅ
  NOMINAL SHIPPING ROUTE

ᖃᐅᔨᒪᔭᒃᓴᐃᑦ NOTES:

1. ᓄᓇᖑᐊᓕᐅᕐᑕᑦ: ᑯᐃᓐ ᑲᓇᑕᒥᑦ
   IMAGERY: © ESRI DATA & MAPS [ONLINE] (2014). REDLANDS, CA: ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE. ALL RIGHTS RESERVED.
2. ᓄᓇᖑᐊᑦ ᑎᑎᕋᒪᓂᖓ ᒪᓕᒡᓗᒍ UTM (NAD83) ZONE 17 AND IS IN METRES.
   COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. THIS MAP WAS PRODUCED FROM INFORMATION COLLECTED DURING INUIT QAUJIMAJATUQANGIT INTERVIEWS WITH LOCAL RESIDENTS. THIS INFORMATION SHOWS PATTERNS OF LAND USE AND LOCAL KNOWLEDGE OF THE LAND. THE MAP IS NOT INTENDED TO BE A COMPLETE REPRESENTATION OF WHAT IS KNOWN.

BAFFINLAND IRON MINES CORPORATION

ᓄᕐᔪᓂ ᐅᔭᖅᓯᐅᕐᑐᑦ MARY RIVER PROJECT

ᓇᒧᓄᐃᑦᑕᐅᓂᑯᑦ ᐃᖏᕋᓗᓐᓂ ᐊᕐᑯᑕᐅᕙᒃᑐᑦ (ᑕᕆᐅᑯᑦ ᐊᒻᒪ ᓄᓇᑯᑦ) ᖃᐅᔨᔭᐅᓂᑯ ᐊᐱᕐᓱᖃᑦᑕᕐᓗᑎᒃ
TRAVEL ROUTES - PROJECT STUDY AREA (INTERVIEW RESULTS)

Knight Piésold CONSULTING

P/A NO.	REF NO.	REV
NB102-181/35	NB14-00411	0

ᑎᑎᖅᐅᔭᖅᓯᒪᔪᖅ FIGURE 1.4

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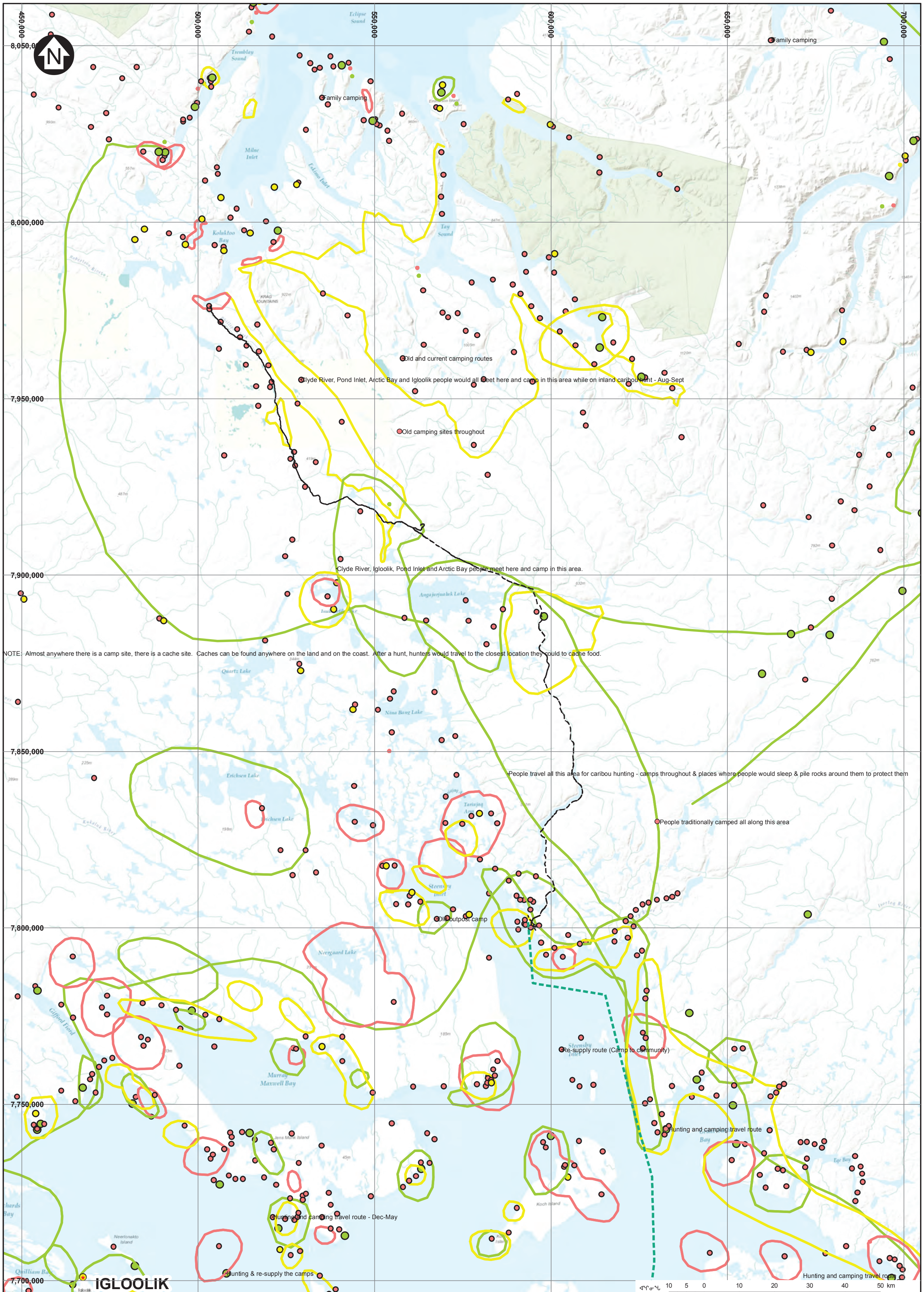

LEGEND:

- PLACES THAT YOU HAVE CAMPED IN YOUR LIFETIME
- PLACES THAT YOU KNOW YOUR FAMILY AND FRIENDS HAVE CAMPED IN THE PAST
- CAMPS THAT WERE OCCUPIED SO LONG AGO THAT YOU DON'T KNOW WHO CAMPED THERE
- MILNE INLET TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT

NOTES:

1. IMAGERY: © ESRI DATA & MAPS [ONLINE] (2014). REDLANDS, CA: ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE. ALL RIGHTS RESERVED.
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. THIS MAP WAS PRODUCED FROM INFORMATION COLLECTED DURING INUIT QAUJIMAJATUQANGIT WORKSHOPS IN THE COMMUNITIES OF ARCTIC BAY (JULY 22-23, 2008), CLYDE RIVER (JULY 18-19, 2008), HALL BEACH (JULY 8-9, 2008), IGLOOLIK (JULY 10-12, 2008) AND POND INLET (JULY 15-17 AND SEPTEMBER 4, 2008). THIS INFORMATION SHOWS PATTERNS OF LAND USE AND LOCAL KNOWLEDGE OF THE LAND. THE MAP IS NOT INTENDED TO BE A COMPLETE REPRESENTATION OF WHAT IS KNOWN.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

CAMPING LOCATIONS - PROJECT STUDY AREA (WORKSHOP RESULTS)

Knight Piésold CONSULTING

P/A NO.	REF NO.	REV
NB102-181/25	NB14-00411	0

FIGURE 1.8

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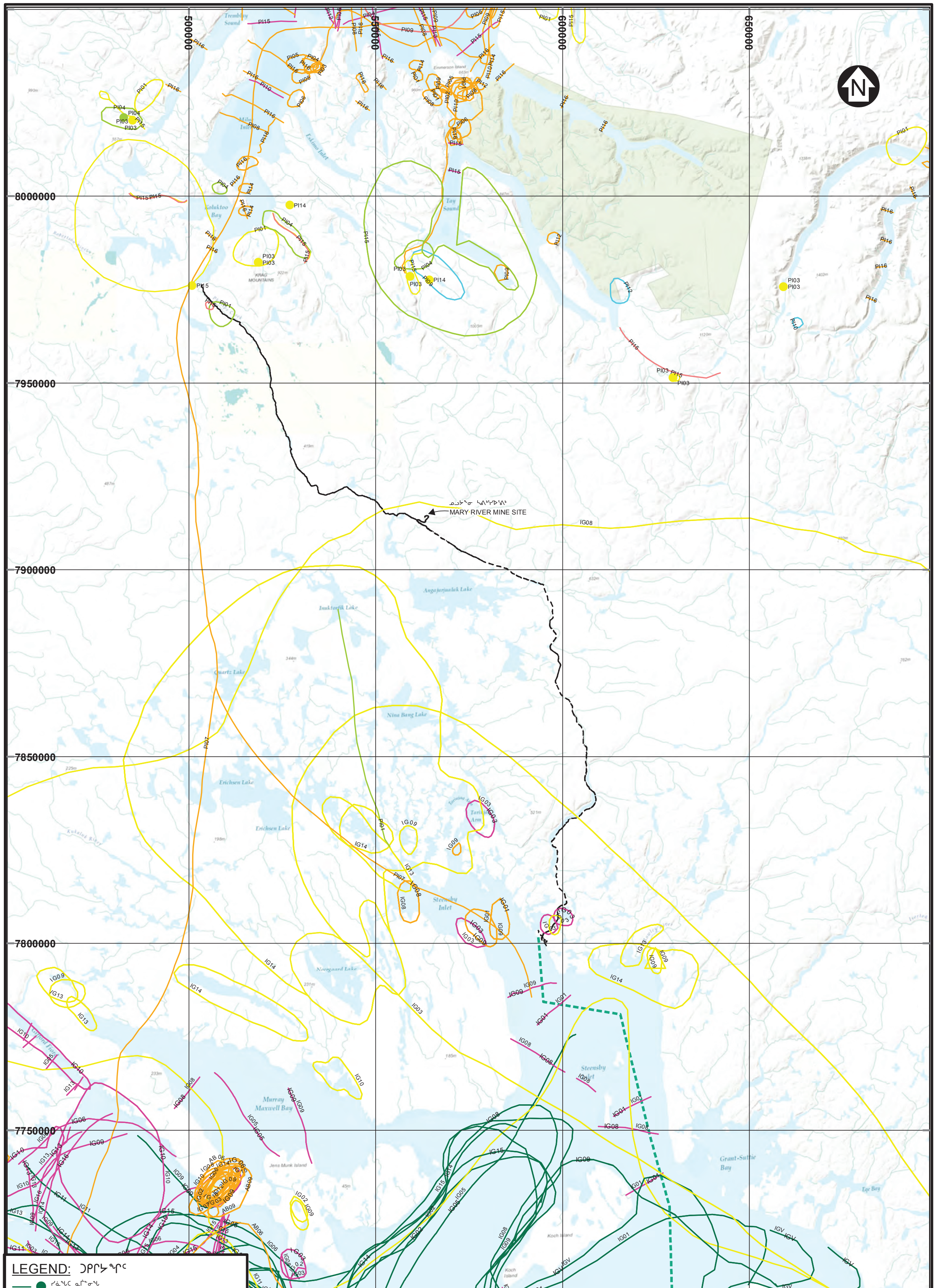

LEGEND: ᑐᑭᖁᓯᖏᑦ

ᓯᕼᓈᖓᑕ ᓇᒥᓐᖓᓂᖓ
FLOE EDGE LOCATION

ᑐᕙᒃᑯᑦ ᐊᐃᔪᕆᐅᕙᒃᑐᑦ ᐃᓂᒋᓱᖏᑦ
SEA-ICE LEADS LOCATION

ᓯᑯᔪᓐᓇᖏᑦᑐᖅ ᐊᕐᕌᒍᓕᒫᖅ
SEA-ICE OPEN YEAR ROUND

ᑕᓯᑦ ᐊᒻᒪ ᑰᒃᑐᑦ ᐱᓗᐊᕈᑎᓂᖏᑦ
LAKES AND RIVERS OF IMPORTANCE

ᖀᒥᑦᑕᕐᑐᖅ ᐅᕙᓗᓐᓂᑦ ᐅᓕᑦᑕᕐᓂᖓ ᑕᑉᐸᐅᖓᓗᒃᑦᑕᕐᑐᖅ
BAD FLOOD OR EXTREMELY HIGH TIDE LOCATION

ᒃᖓᖑᕋᖓᑦ ᐊᕋᒍ ᐃᓗᐊᓂ ᐃᒥᖅ ᐊᓯᔾᔨᕐᓂᕆᒃᑦᑕᕐᑕᖓ
SEASONAL WATER QUALITY CHANGE LOCATION

ᐃᒥᐅᑦ ᐱᐅᓂᖓᑕ ᐊᓯᔾᔨᕐᓂᖓ ᐃᓂᖓ
GENERAL WATER QUALITY CHANGE LOCATION

ᕿᖑᐊᓂ ᐊᕐᑯᑎ ᐅᓯᑲᕐᑕᕐᕕᒃ
MILNE INLET TOTE ROAD

ᓅᓇᓯᐅᑎᑯᑕᒃ ᐊᕐᑯᑎᒋᓂᐊᕐᑕᖓ
PROPOSED RAILWAY ALIGNMENT

ᐃᓚᖕᓂᑯᑦ ᐅᒥᐊᕐᔪᐊᖕᓂᑦ ᐊᕐᑯᑕᐅᒃᑕᕐᓂᐊᕐᑐᖅ
NOMINAL SHIPPING ROUTE

ᖃᐅᔨᒪᔭᒃᓴᐃᑦ NOTES:

1. ᓄᓇᖑᐊᓪᓗᐊᑕᐃᑦ: ᑯᐃᓐ ᑲᓇᑕᒧᑦ

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2. ᓄᓇᖑᐊᕐ ᑎᑎᕐᓯᒪᓂᖓ ᒪᓕᒃᑐᖅ UTM (NAD83) ZONE 17 AND IS IN METRES.

COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.

3. ᐅᓇ ᓄᓇᖕᖑᐊᖅ ᓴᖅᑭᑕᐅᓯᒪᔪᖅ ᑐᑭᓯᔪᓂᒃᓴᐃᑦ ᐅᖃᐅᓯᐅᔪᑦ ᐃᓄᖕᓄᑦ ᐊᕗᖅᐸᓪᓕᐊᑎᓪᓗᒋᑦ ᐃᓄᐃᑦ ᖃᐅᔨᒪᔭᑐᖃᖏᑦ ᓄᓇᓕᒥᐅᑦ ᐊᐱᖅᓱᖅᑕᐅᑎᓪᓗᒋᑦ ᓄᓇᒋᑕ ᒥᒃᓵᓄᑦ. ᑖᒃᑯᐊ ᓇᓗᓇᐃᖅᑕᐅᓯᒪᔪᑦ ᐃᓄᖕᓄᑦ ᓴᖅᑭᑎᕆᓪᒪᑕ ᓄᓇᐅᑉᐊᑐᖅᑕᐅᓂᖓᓂᑦ ᐊᒻᒪ ᓄᓇᒋᑕ ᖃᐅᔨᒪᓂᕆᔭᖏᓐᓄᑦ ᐃᓄᖏᑦ. ᐅᓇ ᓄᓇᖕᖑᐊᖅ ᐃᓗᐃᑦᑑᖕᖏᑦᑐᖅ ᑭᒡᒐᖅᑐᐃᓇᓂᓗ ᐃᓗᐃᑦᑐᒥᒃ ᑕᒪᐃᑕ ᐊᑐᖅᓯᒪᔭᖏᓐᓂᒃ ᓄᓇᐅᔪᓂᒃ.

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ᐊᖏᓂᖓ
SCALE
10 5 0 10 20 30 40 50 Km
ᑭᓚᒥᑕ

BAFFINLAND IRON MINES CORPORATION

ᓄᕐᔫᓂ ᐅᔭᖅᓯᐅᕐᑐᑦ MARY RIVER PROJECT

ᓇᑐᓇᐃᕐᑕᐅᓂᑯᑦ ᐃᒪᖅᑲᕐᐸᓐᓂᖏᑦ ᐊᒪᓗ ᓯᑯᖃᕐᐸᓐᓂᖏᑦ ᑕᒪᓇ ᖃᐅᔨᔭᐅᓂᑯ ᐊᐱᕐᓱᖅᑕᕐᓗᑎᒃ
WATER AND ICE FEATURES - PROJECT STUDY AREA
(INTERVIEW RESULTS)

Knight Piésold
CONSULTING

P/A NO.	REF.	REV.
NB102-181/35	NB14-00411	0

ᑎᑎᕋᐅᔭᕐᓯᒪᔪᖅ FIGURE 3.20

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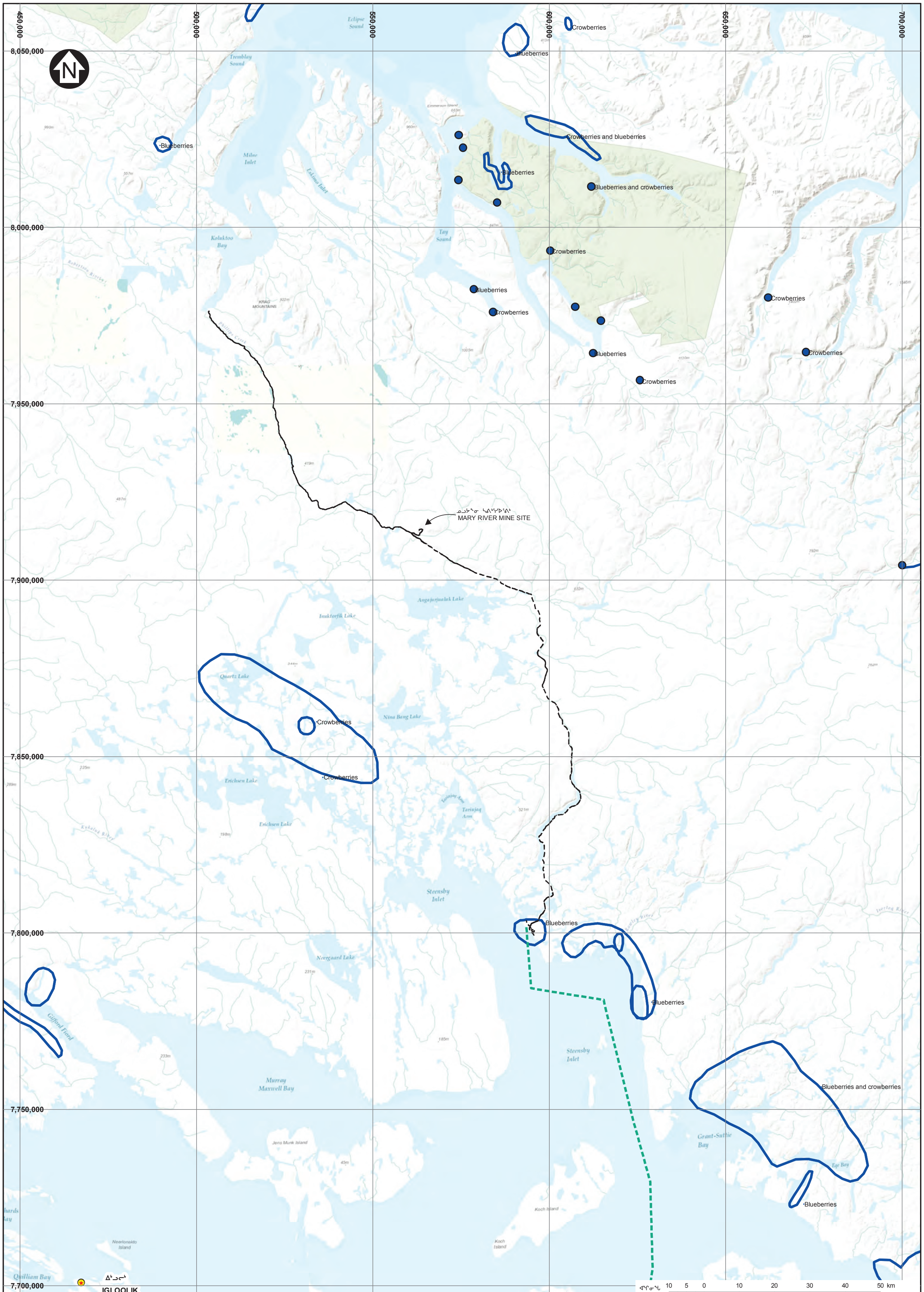

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ᑐᑭᓯᒋᐊᕐᓂᑦ LEGEND:

- ᐊᐅᓚᕐᕕᐅᔪᑦ — BERRY PICKING PLACES
- ᒥᓪᓄ ᐊᖅᑭᑦ ᐅᓯᒃᑕᕐᕕᒃ — MILNE INLET TOTE ROAD
- ᓄᓇᓯᐅᑎᑦ ᐊᖅᑭᑦ — PROPOSED RAILWAY ALIGNMENT
- ᐃᓚᓐᓂᑦ ᐅᒥᐊᖅᓯᐊᕐᓂᑦ ᐊᖅᑐᐅᑕᕐᓂᐊᖅᑐᖅ — NOMINAL SHIPPING ROUTE

ᖃᐅᔨᒪᔭᒃᓴᐃᑦ NOTES:

1. ᓄᓇᖑᐊᓐᓄᐊᑕᐃᑦ: ᑯᐃᓐ ᑲᓇᑕᒧᑦ
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2. ᓄᓇᖑᐊᑦ ᑎᑎᕐᓯᒪᓂᖓ ᒪᓕᒃᑐᖅ UTM (NAD83) ZONE 17 AND IS IN METRES.
COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. ᐅᓇ ᓄᓇᖑᐊᖅ ᐊᑉᐸᖅᑕᐅᓚᐅᕐᓯᒪᔪᖅ ᐃᓄᐃᑦ ᖃᐅᔨᒪᔭᑐᖃᖏᓐᓂᒃ ᑲᑎᒪᐅᑎᖃᕐᓇᒋᑦ ᖃᐅᔨᓴᐅᑎᓂᒃ ᑲᑎᒪᑎᓪᓗᒋᑦ ᐃᒃᐱᐊᕐᔪᖕᒥ (ᔪᓚᐃ 22-23, 2008), ᑲᖏᖅᓱᒡᔪᐊᖅ (ᔪᓚᐃ 18-19,2008), ᓴᓂᕌᔮᕐᒥ (ᔪᓚᐃ 8-9, 2008), ᐃᒡᓗᓕᖕᒥ (ᔪᓚᐃ 10-12, 2008), ᐊᒻᒪᓗ ᒥᑎᒪᑕᓕᖕᒥ (ᔪᓚᐃ 15-17 ᐊᒻᒪᓗ ᓯᑎᐱᕆ 4, 2008). ᒪᓐᓇ ᖃᐅᔨᓴᐅᑎᒃ ᖃᐅᔨᒃᑲᐅᑎᑦᑎᕗᖅ ᓄᓇ ᖃᓄᖅ ᐊᑐᖅᑕᐅᕙᓐᓂᖓᓂᒃ ᐊᒻᒪᓗ ᐃᓄᐃᑦ ᖃᓄᖅ ᖃᐅᔨᒪᓂᖏᓐᓂᒃ ᓇᓗᓇᐃᕐᓯᕙᑦᑕᐅᓗᓂ. ᒪᓐᓇ ᓄᓇᖑᐊᖅ ᑕᒪᐃᓐ ᖃᐅᔨᒃᑲᐅᑎᑦᑎᙱᑦᑐᖅ ᑭᓯᐊᓂᓕ ᖃᐅᔨᒪᔭᕗᑦ ᓇᓗᓇᐃᕐᓯᕙᑦᑕᐅᓗᑎᒃ.
THIS MAP WAS PRODUCED FROM INFORMATION COLLECTED DURING INUIT QAUJIMAJATUQANGIT WORKSHOPS IN THE COMMUNITIES OF ARCTIC BAY (JULY 22-23, 2008), CLYDE RIVER (JULY 18-19, 2008), HALL BEACH (JULY 8-9, 2008), IGLOOLIK (JULY 10-12, 2008) AND POND INLET (JULY 15-17 AND SEPTEMBER 4, 2008). THIS INFORMATION SHOWS PATTERNS OF LAND USE AND LOCAL KNOWLEDGE OF THE LAND. THE MAP IS NOT INTENDED TO BE A COMPLETE REPRESENTATION OF WHAT IS KNOWN.

BAFFINLAND IRON MINES CORPORATION

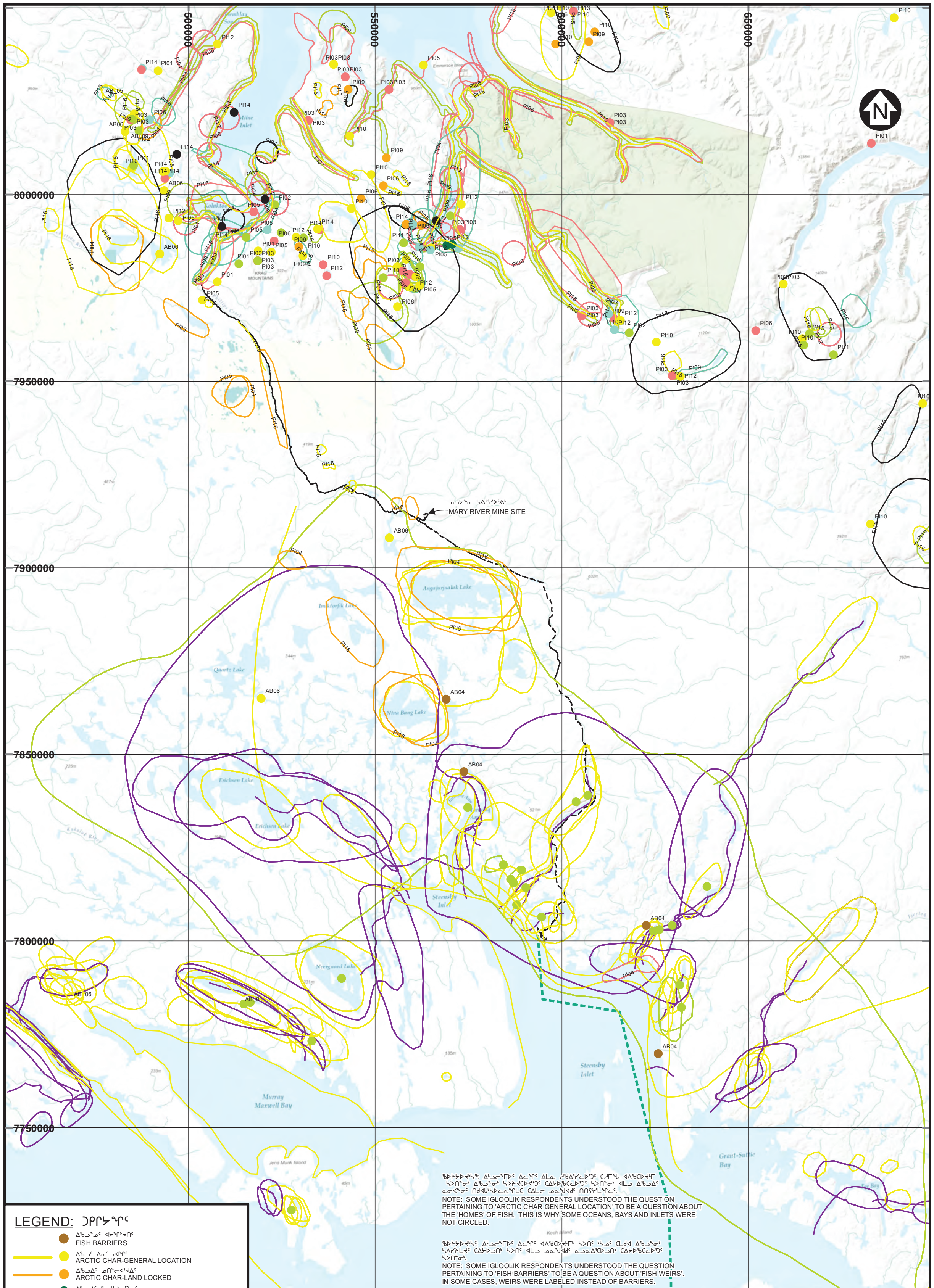
ᓄᓚᔾᔨᓂ ᐅᔭᕐᓯᐅᕐᑐᑦ — MARY RIVER PROJECT

ᐊᐅᓚᕐᕕᒃ ᐊᒻᒪᓗ ᖃᐅᔨᓴᐅᑎᒥᓗᒍ ᓄᓇᒥ ᐊᑐᖅᑕᐅᓗᐊᕐᒥᒃ ᖃᐅᔨᓴᕐᓗᑎᒃ.
BERRY PICKING LOCATIONS - PROJECT STUDY AREA (WORKSHOP RESULTS)

Knight Piésold CONSULTING

P/A NO.	REF NO.	REV
NB102-181/35	NB14-00411	0

ᑎᑎᖅᐅᔭᕐᓯᒪᔪᖅ FIGURE 1.6



LEGEND:

- FISH BARRIERS
- ARCTIC CHAR-GENERAL LOCATION
- ARCTIC CHAR-LAND LOCKED
- ARCTIC CHAR-DISEASED
- ARCTIC CHAR-POPULATION FLUCTUATING
- RIVER OF IMPORTANCE
- FISHING LOCATION YEAR-ROUND
- JIG AND NET FISHING LOCATION
- OCEAN FISHING LOCATION
- MILNE INLET TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- NOMINAL SHIPPING ROUTE

NOTES:

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2. UTM (NAD83) ZONE 17 AND IS IN METRES.
   COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. THIS MAP WAS PRODUCED FROM INFORMATION COLLECTED DURING INUIT QAUJIMAJATUQANGIT INTERVIEWS WITH LOCAL RESIDENTS. THIS INFORMATION SHOWS PATTERNS OF LAND USE AND LOCAL KNOWLEDGE OF THE LAND. THE MAP IS NOT INTENDED TO BE A COMPLETE REPRESENTATION OF WHAT IS KNOWN.

SCALE 10 5 0 10 20 30 40 50 Km

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

FISH LOCATIONS - PROJECT STUDY AREA (INTERVIEW RESULTS)

Knight Piésold CONSULTING

P/A NO.	REF.	REV.
NB102-181/35	NB14-00411	0

FIGURE 5.2

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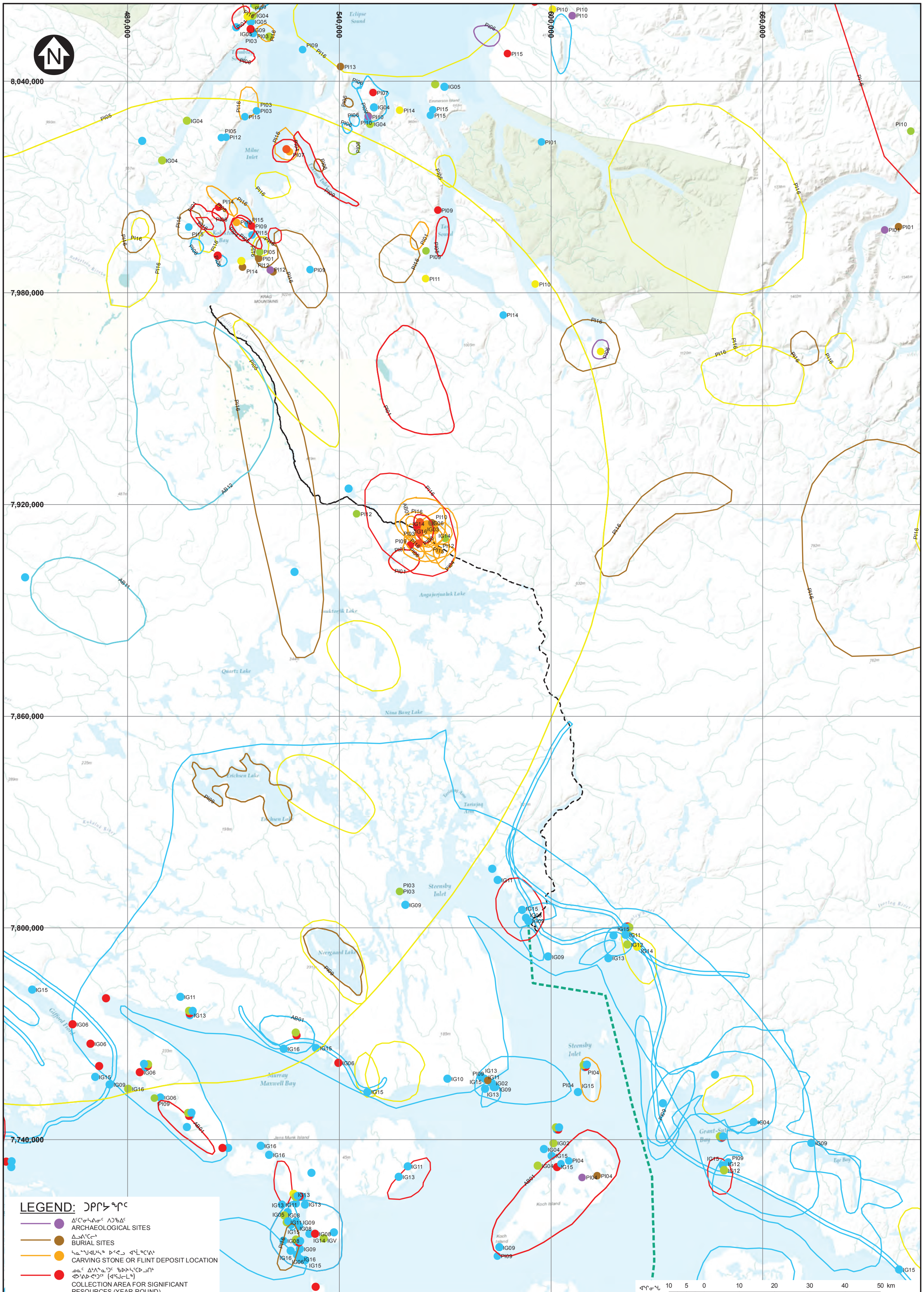

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LEGEND:

- ARCHAEOLOGICAL SITES
- BURIAL SITES
- CARVING STONE OR FLINT DEPOSIT LOCATION
- COLLECTION AREA FOR SIGNIFICANT RESOURCES (YEAR-ROUND)
- CONSULTANT'S BIRTH LOCATION
- CONSULTANT'S CAMP LOCATION AND MAJOR YEAR-ROUND CAMPS
- SPECIAL AREAS
- MILNE INLET TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- NOMINAL SHIPPING ROUTE

NOTES:

1.
2. UTM (NAD83) ZONE 17 AND IS IN METRES.
   COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. THIS MAP WAS PRODUCED FROM INFORMATION COLLECTED DURING INUIT QAUJIMAJATUQANGIT INTERVIEWS WITH LOCAL RESIDENTS. THIS INFORMATION SHOWS PATTERNS OF LAND USE AND LOCAL KNOWLEDGE OF THE LAND. THE MAP IS NOT INTENDED TO BE A COMPLETE REPRESENTATION OF WHAT IS KNOWN.

SCALE 10 5 0 10 20 30 40 50 km

BAFFINLAND IRON MINES CORPORATION

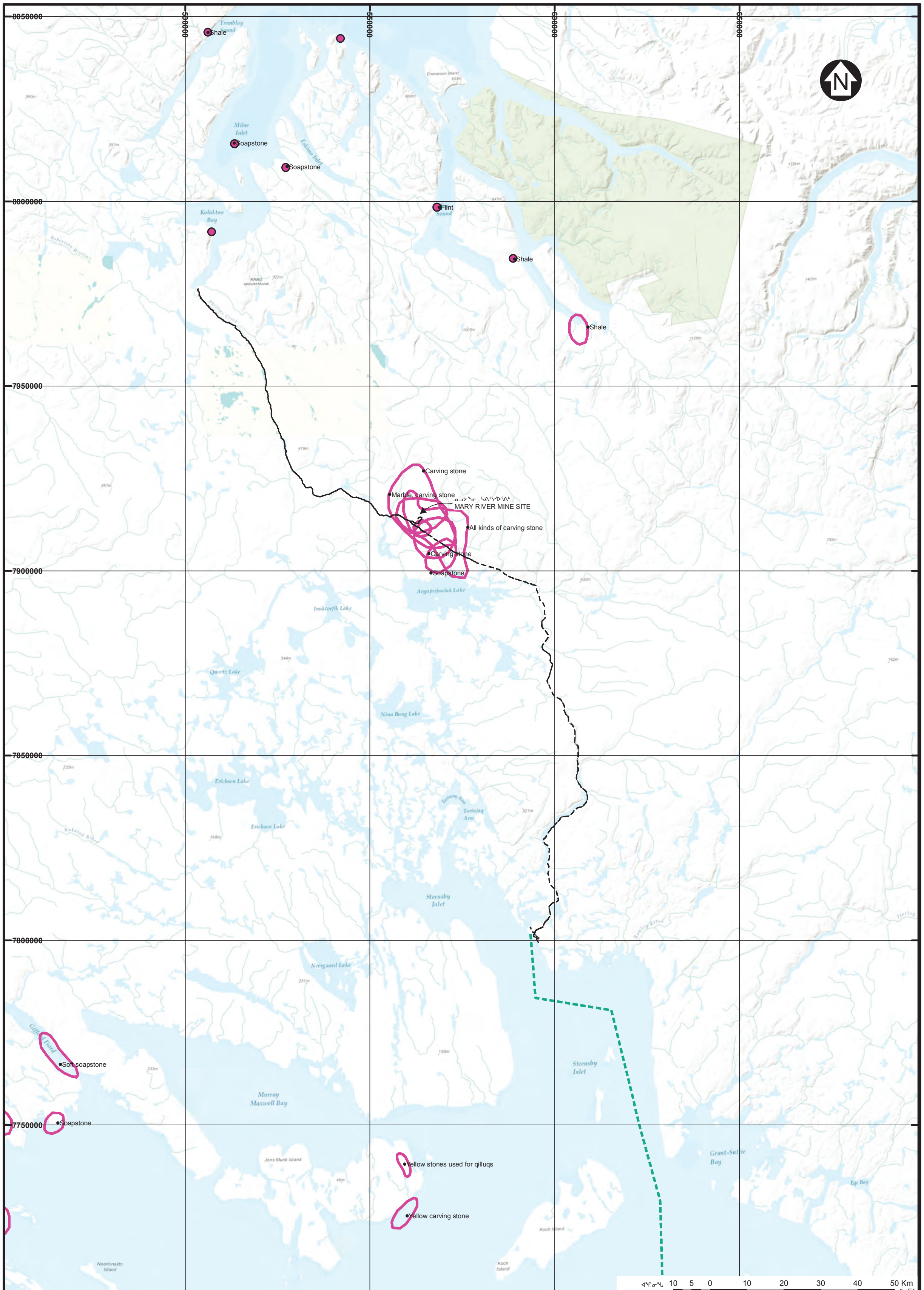
MARY RIVER PROJECT

SPECIAL PLACES - PROJECT STUDY AREA (INTERVIEW RESULTS)

Knight Piésold CONSULTING

P/A NO.	REF NO.	REV
NB102-181/35	NB14-00411	0

FIGURE 1.12



ᑐᑭᓯᒋᐊᕈᑎᑦ LEGEND:

- ᐅᔭᕐᓱᐃᑦ ᐃᓄᖕᓄᑦ ᐊᑐᕐᑕᐅᕙᖕᓂᒃᑯᑦ STONES USED BY PEOPLE
- ᒥᓪᓐ ᐃᓐᓚᑦ ᐊᖅᑯᑎ ᐅᓯᒃᓯᑦᑎᕕᒃ MILNE INLET TOTE ROAD
- ᓄᓇᓯᐅᑎᒃᑕᒃ ᐊᖅᑯᑎᓕᐊᕐᑕᖓ PROPOSED RAILWAY ALIGNMENT
- ᐃᓚᖓᓂᒃ ᐅᒥᐊᕐᔪᐊᖓᓂᑦ ᐊᖅᑯᑖᕐᑕᕐᓂᐊᕐᑐᖅ NOMINAL SHIPPING ROUTE

ᖃᐅᔨᒪᔭᖅᓴᐃᑦ NOTES:

1. ᓄᓇᖑᐊᖑᐊᑕᐃᑦ: ᑯᐃᓐ ᑲᓇᑕᒧᑦ
   IMAGERY: © ESRI DATA & MAPS [ONLINE] (2014). REDLANDS, CA: ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE. ALL RIGHTS RESERVED.
2. ᓄᓇᖑᐊᑦ ᑎᑎᕋᕐᒪᓂᖓ ᒪᓕᒃᑐᖅ UTM (NAD83) ZONE 17 AND IS IN METRES.
   COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. ᐅᓐᓇ ᓄᓇᖑᐊᖅ ᐊᖏᕐᑕᐅᓚᐅᕐᓯᒪᔪᖅ ᐃᓄᐃᑦ ᖃᐅᔨᒪᔭᑐᖃᖏᓐᓂᒃ ᑲᑎᒪᔪᑎᖃᕐᑐᓂᒃ ᖃᐅᔨᓴᐅᓂᒃᑯᓐᓂᒃ ᑲᑎᒪᑎᑐᒥᑦ ᐃᒃᐱᐊᕐᔪᖕᒥ (ᔪᓚᐃ 22-23, 2008), ᑲᖏᖅᖢᒃᐱᒃ (ᔪᓚᐃ 18-19,2008), ᓴᓂᕋᔭᖕᒥ (ᔪᓚᐃ 8-9, 2008), ᐃᒡᓗᓕᖕᒥ (ᔪᓚᐃ 10-12, 2008), ᐊᒻᒪᓗ ᒥᑎᒪᑕᓕᒃ (ᔪᓚᐃ 15-17 ᐊᒻᒪᓗ ᓯᑎᐱᕆ 4, 2008). ᐅᓐᓇ ᖃᐅᔨᔭᐅᓂᖅ ᖃᐅᔨᒃᑲᐅᑕᐅᔪᓐᓇᖅᑐᖅ ᓄᓇ ᖃᓄᐃᓕ ᐊᑐᕐᑕᐅᕙᖕᓂᖓᓂᒃ ᐊᒻᒪᓗ ᐃᓄᐃᑦ ᖃᓄᐃᓕ ᖃᐅᔨᒪᓂᕆᖕᒥᓂᒃ ᓇᓗᓇᐃᕐᓯᔪᑕᐅᓗᓂ. ᐅᓐᓇ ᓄᓇᖑᐊᖅ ᑕᐃᒪᓐᓂᒃ ᖃᐅᔨᒃᑲᐅᑕᐅᔪᓐᓇᖏᑐᖅ ᑭᓯᐊᓂᓕ ᖃᐅᔨᒪᔭᐅᔪᓂᒃ ᓇᓗᓇᐃᕐᓯᔪᑕᐅᔪᖅ.
   THIS MAP WAS PRODUCED FROM INFORMATION COLLECTED DURING INUIT QAUJIMAJATUQANGIT WORKSHOPS IN THE COMMUNITIES OF ARCTIC BAY (JULY 22-23, 2008), CLYDE RIVER (JULY 18-19, 2008), HALL BEACH (JULY 8-9, 2008), IGLOOLIK (JULY 10-12, 2008) AND POND INLET (JULY 15-17 AND SEPTEMBER 4, 2008). THIS INFORMATION SHOWS PATTERNS OF LAND USE AND LOCAL KNOWLEDGE OF THE LAND. THE MAP IS NOT INTENDED TO BE A COMPLETE REPRESENTATION OF WHAT IS KNOWN.

BAFFINLAND IRON MINES CORPORATION

ᓄᓘᔾᔭᓂ ᐅᔭᕐᓯᐅᕐᑐᑦ MARY RIVER PROJECT

ᐅᔭᕐᓱᐃᑦ ᐃᓄᖕᓄᑦ ᐊᑐᕐᑕᐅᕙᖕᓂᒃᑯᑦ ᓇᓂᓯᒪᖔᑕ ᓄᓇᒦᒃ ᖃᐅᔨᓴᕐᑕᐅᓂᒃ ᓇᓂᔭᐅᓂᒃᑯᑦ

STONE QUARRY LOCATIONS - PROJECT STUDY AREA (WORKSHOP RESULTS)

Knight Piésold CONSULTING

P/A NO.	REF.	REV
NB102-181/35	NB14-00411	0

ᑎᑎᕋᐅᓯᐊᕐᒪᔪᖅ **FIGURE** 1.16

HC 03 ATTACHMENT 1: FULL RESPONSE

SCIENCE INTEGRITY KNOWLEDGE

TECHNICAL RESPONSE HEALTH CANADA (HC-03) COUNTRY FOODS

RESPONSE

January 24, 2019

Prepared For: **Baffinland Iron Ore Mines**
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Technical Response- HC-03 Country Foods

Issue/Concern:

Within the risk assessment of a proposed project, ingestion of contaminants via food can be a significant pathway of exposure, particularly when chemicals that may increase as a result of project activities possess the ability to bioaccumulate or biomagnify in the food chain; and/or when the consumption of country food may constitute a significant portion of an exposed person's diet.

TSD-07 - notes that dust and project emissions have the potential to land on blueberries nearby. The vegetation is identified as country foods. The assessment undertaken did not look at the consumption of foods by vulnerable persons such as toddlers.

TSD-14 - notes that Arctic char is a country food of concern for community members and project works have the potential to impact the quality of the food through metal leaching. The assessment undertaken did not look at the consumption of foods such as Arctic char by vulnerable persons such as toddlers.

Information Request:

1. Health Canada recommends further evaluation of human health impacts, including vulnerable persons, with regards to country foods consumption.

2. If such impacts are found, and if the same contaminants may have an effect on human health through other exposure routes a quantitative risk assessment, such as an HHRA, is recommended.

1.0 TECHNICAL RESPONSE INTRODUCTION:

TSD-11 predicted future concentrations in blueberries and lichen, as a result of dust deposition onto area soils, and vegetation, and discussed the potential health implications of consumption of foods in the Project area, using a screening level risk assessment approach, rather than using consumption estimates and a consumption assessment of country foods. Health Canada has requested further evaluation of country foods, using consumption rates in a more quantitative modelling approach. This Technical Response will build on the screening level approach used in TSD-11 and will generally follow the recently released Health Canada Guidance related to country foods consumption (Health Canada, 2018), and professional judgement. The sections provided in this Technical Response will capture the 4 key phases in a human health risk assessment, including a Problem Formulation, Exposure Assessment, Effects Assessment and Risk Characterization. The focus of this response is only on Country Foods consumption as per the IR request for Health Canada. Hence, the problem formulation does not pertain to other potential exposure pathways. Other relevant exposure pathways have been screened in TSD-11 (soil and soil related pathways; note that soil exposures have been re-screened against human health soil quality guidelines in Technical Response to HC-07, question 2, using a shallower soil mixing depth of 10 cm), the technical response to HC-02 (Drinking water exposure), and HC-04 (air inhalation exposure).

2.0 PROBLEM FORMULATION:

The Problem Formulation for country foods exposures focuses on identification of Chemicals of Potential Concern (COPCs), identification of exposure pathways, based on media that could be affected by Project activities, and identification of receptors (local people who could consume food from the area). In addition, components of the country food diet, as well as consumption rates, are also presented in this part of the Technical Response.

2.1 Identification of Chemicals of Potential Concern:

With respect to COPCs, the project has the potential to release COPCs through a variety of activities. As discussed in TSD-11, the primary source of contaminants in the environment is through the deposition of dust from Project activities. Since the vast majority of dust generated from the Project is expected to be related to the mining, transportation, crushing, screening, and stockpiling of ore, the chemical composition of the dust considered in TSD-11 and in this Technical Response is specifically associated with metals in ore and other dust generated by project activities. No other chemical analytes associated with Project emissions are considered in this report such as organic emissions from waste management activities, burning of fuels for power generation, vehicles and equipment, waste rock handling, etc. With respect to incinerator emissions, these could include volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), dioxins and furans (PCDD/F). A Waste Management Plan, which includes Incineration Operations Procedures (see TSD 28, Phase II EIS) is in place during all phases of the Project in order to minimize emissions from incineration activities. This Management Plan states that all incinerators must operate in accordance with Government of Nunavut's Environmental Guideline for the Burning and Incineration of Solid Waste (GN, January, 2012), and will include stack testing for Chlorinated Dioxins and Furans, as well as mercury, every 5 years to ensure operations are within Canada Wide Standards for Dioxins and Furans (CCME, 2000a) Canada-Wide Standards for Mercury emissions (CCME, 2000b). Due to the use of modern incineration equipment, and management protocols, these emission sources were not considered further. With respect to trains travelling between the mine site and port, emissions related to products of combustion will be released and have the potential to produce airborne dust from blow-off from open rail cars. Since the trains will be 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.

To identify the inorganic COPCs requiring further assessment, a detailed evaluation of the existing dustfall monitoring data was undertaken in TSD-11. Section 2.1 of TSD-11 provides a summary of the dustfall data collected at various monitoring stations near the Mine, Milne Port and Tote Road, and explains which stations were selected for detailed evaluation of geochemistry. Appendix A of TSD-11 provides the data evaluation process and data used to determine which inorganic compounds merited further assessment in the TSD-11, and the geochemistry ratios which could be used to represent the geochemical fingerprint of ore dust that could be emitted into the future as a result of mining and transportation activities at each of these three sites.

The COPCs identified in TSD-11 were further evaluated in this Technical Response, relative to country foods consumption.

These include:

- Aluminum
- Antimony
- Arsenic
- Barium
- Cadmium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Manganese
- Mercury
- Molybdenum
- Nickel
- Selenium
- Silver
- Strontium
- Thallium
- Tin
- Uranium
- Vanadium
- Zinc

Several of these inorganic compounds are only present in very small percentages in dustfall (see Table 2-1a, b; TSD-11).

2.2 Identification of Operable Country Foods Exposure Pathway:

With respect to exposure pathways, the country food pathway is an operable pathway in this Project. This pathway was discussed in TSD-11, and a screening approach was taken to identify whether soils and vegetation could potential change as a result of Project releases (relative to baseline and environmental quality guidelines in the case of soils, and relative to baseline in the case of vegetation), such that consumption risks could be present in the future, related to the Project. The significance of other exposure pathways, such as soil ingestion (evaluated in TSD-11), drinking water ingestion (evaluated in Technical Response to HC-02), and air inhalation (evaluated in Technical Response to HC-04) have also been completed. Further discussion of the diet, as well as consumption rates, are provided later in the Problem Formulation.

2.3 Identification of Receptors:

With respect to potential receptors, human receptors of concern will be local hunters and gathers, out on the land that would visit the project area occasionally or intermittently. The Inuit Map Book (TSD-05) has a number of maps which show travel routes (Figure 1.1 – 1.4), berry picking areas (Figures 1.5 and 1.6), camping locations (Figures 1.7 and 1.8), special places (Figures 1.9 – 1.12), historic sites (Figures 1.13 – 1.14) and stone quarry locations (Figures 1.15 and 1.16). These maps show broad usage of the Baffin Island area, with many travel routes crossing near and through the Project area. There are also some camping areas near the

Project area, that have either been used historically, or more recently (in ones' lifetime). Based on the Inuit Map Book, travel and camping routes and locations are found near the Milne Port, Northern Transportation Corridor and Mine Site, but no specific water or food harvesting locations are identified, and with regard to special places, only carving stone locations are located near the Mine Site, with no special places near either the Milne Port Location or the Northern Transportation Corridor. Based on this information, human receptors, including families with toddlers, and the elderly, could be expected to be in the areas of the Project development areas on occasion, for travelling, camping or stone carving collection. It is also assumed that food harvest would occur in the areas near the Project. The Project development areas are remote to any town or village, and therefore any time spent in the immediate vicinity of the PDAs would be expected to be limited in duration, and infrequent. The two most likely locations where individuals could spend time are the HTO cabins (located at Milne Port and the Mine Site), which are distant from the active areas of the facilities but considered a reasonable assumption for a receptor location in the quantitative assessment.

Note that access to the facility areas within the PDA areas is restricted, and any non-employees must adhere to the Hunters and Visitor Site Access Procedures, which limits non-employee access to active industrial areas of the site, including travel along Tote Road (which is prohibited) (Baffinland, 2015). In summer, hunters and visitors must notify Security at Baffinland if they plan to travel between Milne Port and Mary River. Baffinland will provide arrangements for a safe method of travel, which will be determined based on resources available and size of party. Similarly, winter travel between these areas by non-employees requires them to advise the Security Department prior to departure, such that crossing points for Tote Road can be appropriately notified in advance to ensure safe crossings. In addition to the hazards associated with truck traffic on Tote Road, there are hazards at the Mine Site, including a high voltage power lines and a water pipeline, and these areas must be avoided. Hence, any site visitors must follow the established protocols and approvals, which restricts access to any hazardous or active industrial usage areas of the facility. In light of this, spatial boundaries are limited to areas outside of the PDA and as only limited access to areas inside of the PDA are allowed for non-employees.

Detail on receptor characteristics is provided in the Exposure Assessment.

2.4 Dietary Components:

With respect to diet, country foods identified for potential inclusion in the Technical Response are listed in Table HC03-1. The list of species was compiled from a number of sources. The primary source identified was the Nunavut Wildlife Harvest Survey (2014). In this survey, all of the species harvested by hunters from Pond Inlet (which is the closest town to the Project) between the years 1996 and 2001 were identified through interviews with the harvesters. Table 6.1.10 (p.360) in the Harvest Survey provides annual totals by species and presents a mean value calculated for the five-year period. Any species where the mean value was >10 was considered for inclusion in the assessment. There was an 85% response rate for inclusion in the survey from the hunters and harvesters of Pond Inlet. Vegetation and edible plants were not included in the Harvest Survey. Species of vegetation and berries harvested by Elders from Pond inlet were identified in the Vegetation Baseline Study Report (Baffinland Iron Mines Corporation - Mary River Project; Burt 2010).

It is not necessarily feasible to assess all country foods identified in the Harvest Survey due to the large number of species that are harvested and their seasonal availability (due to migration patterns of the harvested populations or accessibility to hunting grounds). Based on mean number of animals the most commonly harvested species included caribou, ringed seal, murre and goose eggs, and Arctic char all with a mean estimate of >1000 animals. Arctic hare, narwhal, snow goose and ptarmigan had a mean harvesting estimate of 100<x<1000 animals.

In order to further refine the species for inclusion in the country foods risk assessment additional sources were considered in order to identify both the most commonly consumed species and species of local relevance for the assessment.

Using harvest data from both the Baffin Regional Inuit Association (BRIA) harvest surveys (1981-1988) and the Nunavut Wildlife Harvest Survey (1996-2001), Wenzel et al. (2016) combined the individual counts of the animals harvested with the edible weight attributable to each animal in order to identify the resource quantity available to consumers. Wenzel et al. (2016) identified the major food species for Pond Inlet as narwhal, ringed seal, Arctic char, caribou.

Black et al. (2008) completed a quantitative ethnobotanical assessment of the medicinal plants used by the Inuit of the Qikiqtaaluk Region. Through interviews with volunteer informants in 2004 and a review of historical interview transcripts (obtained between 1976 and 1999), 13 different medicinal plant species and their uses were identified. Four (4) of the medicinal species identified by Black et al. (2008) were also included in the traditional knowledge component of the Baseline Vegetation Assessment (Burt 2010).

Kuhnlein et al. (1996) completed interviews and food frequency questionnaires (FFQ) with Inuit women from Baffin Island (concentrating in Qikiqtarjuaq) and identified the traditional and market foods making the main contributions to intakes of energy, protein, fat and a number of micronutrients. The primary traditional foods identified as being substantial contributors were caribou, ringed seal, Arctic char and narwhal.

The 2007-08 Inuit Health Survey was completed with adult members of the population in Nunavut (Kivalliq and Baffin Communities) in late summer and fall in 2007 and in the Inuvialuit Settlement Region, Nunavut (Kitikmeot) and Nunatsiavut in 2008. Kenny et al. (2018) presented the consumption data by from the IHS by region (Nunatsiavut, Nunavut and the Inuvialuit Settlement Region (ISR) for the entire population both consumers and non-consumers and Egeland (2010) presented the Nunavut data alone by consumers only. Both of these studies that identify caribou, Arctic char and ringed seal are primary sources of protein for the Inuit of Nunavut and that berries are consumed by a proportion of the population. The Nunavut Child Health Survey identified that the top four country foods consumed by children were caribou, fish, berries and ringed seal meat (Egeland 2009).

Nancarrow (2007) identified consumption rates and portion sizes for key food species for the community of Repulse Bay including ptarmigan. The small mammal, Arctic hare, was not identified as a key consumption species in the top results of any of the dietary surveys, however it was included in the FFQ for the IHS (Chan 2011), and Wenzel et al. (2016) identified that there is an average of 600g of edible weight from a 2kg arctic hare. The Arctic hare is included as a country food species in the assessment as it has a small home range and was assumed to represent local conditions.

Table HC03-1 Country Food Species Consumed by Local Inuit

Terrestrial Wildlife	*Marine Wildlife*	*Fish*	*Birds*	*Vegetation and Berries*
caribou[1,3,5,6,7]	**ringed seal[1,3,5,7]**	**Arctic char[1,3,5,7]**	**ptarmigan[1]**	**blueberries or kigutangirnait (*Vaccinium uliginosum*) [2,6,7]**
polar bear[1]	breaded seal[1,5]	Sculpin[1]	snow goose[1]	crowberries or paungait (*Empetrum nigrum*) called "black berry" [2,6,7]
Wolf[1]	harp seal[1]		eider duck[1]	willow leaves or uqaujat (*Salix arctica*) [2,4]
Arctic fox[1]	**narwhal[1,3,5,6]**		goose eggs[1]	**purple mountain saxifrage or aupilattunnguat (*Saxifraga oppositifolia*) – TEA [2,4]**
Arctic hare[1]			murre eggs[1]	prickly saxifrage or kakillaqnait (*Saxifraga tricuspidata*) – TEA [2,4]
				large-flowered wintergreen (*Pyrola grandiflora*) – TEA [2]
				mountain sorrel or qunguliq (*Oxyria digyna*) [2]
				yellow crazyweed (airaq) root (*Oxytropis maydelliana*) [2,4]
				bistort or taqlak (*Persicaria vivipara*) [2]
				wooly lousewort (*Pedicularis lanata*) [2]

Notes:
1. Priest and Usher (2004)
2. Burt (2010)
3. Wenzel et al. (2016)
4. Black et al. (2008)
5. Kuhnlein et al. (1996)
6. Kenny et al. (2018)
7. Egeland (2011)

Country foods shown in **bold** were selected for inclusion in the assessment

2.5 Consumption Rates:

The primary source for consumption rates was the Nunavut specific data from the IHS (Egeland 2010) and the adult daily consumption rate for consumers only was utilized for caribou muscle, Arctic char, ringed seal muscle and liver and berries. Consumption rates for caribou organs (including both liver and kidney), and ptarmigan were cited from Nancarrow (2007) who completed FFQ with 361 adults from Repulse Bay in 2003 and 2005. Daily consumption quantities were calculated from the FFQ presented in Nancarrow by multiplying the portion size by the days consumed and dividing by 365. Consumption rates for Arctic hare were obtained from Coad 1994 who summarized Estimated Mean Fish and Wildlife Harvests for the Baffin Region, NWT, 1981-83 from a number of sources. The daily consumption quantity was based on the mean number of Arctic hares harvested in the previous three years (n=414) and the population of Pond Inlet in 1982 (n=682). Snow geese were identified as the primary migratory bird species harvested in the Nunavut Wildlife Harvest Survey (2014). As specific consumption quantities were unavailable for snow goose, a proration factor of 0.45 was applied to the daily consumption quantity identified for Canada goose in the IHS. The proration factor applied was based on the ratio of average snow goose mass to the average Canada goose mass (North Dakota 2017). Specific consumption quantities were also unavailable for narwhal for “consumers only” therefore the consumption rate of 84 g/day was derived from the sum of the 12 g/day which was the mean consumption rate for the entire population (which included eaters and non-eaters) and the standard deviation of 74 g/day as presented for respondents to the IHS from Nunavut as reported in Kenny et al. (2018). The adoption of a consumption rate based on the mean plus one standard deviation was undertaken to ensure that an appropriate narwhal consumption rate was used in the assessment. Using the mean plus one standard deviation means that 84.1% of the population consume less than 84 g/day of narwhal. This value of 84 g/person/d for all narwhal was then adjusted to reflect muscle meat consumption through the subtraction of 10 g/day attributed to Narwhal skin and fat consumption as cited in the IHS (2010), to estimate a consumption rate of 74 g/person/day for Narwhal meat. Specific daily consumption quantities were not available for toddlers therefore a factor of 0.43 was applied to the adult diet for protein, and a factor of 0.38 was applied to the adult diet for berries based on data presented in Richardson (1997) and Health Canada (1994) for strawberries and blueberries combined, respectively. Wein (1989) identified the usage rates of vegetation for teas and McAuley et al. (2016) present data on both the lack of consumption of tea by toddlers and the very low transfer rates of metals from vegetation into tea decocts. The consumption rates for adults and toddlers used in the assessment are included in Table HC03-2.

Consumption of blubber, while identified as being consumed (Nancarrow 2007, Egeland 2010), was not considered in the assessment. Blubber is fat and this tissue tends to accumulate lipophilic organic contaminants rather than metals; therefore, metals in blubber were assumed to be a minor contributor to exposure in comparison to other sources like muscle or organ meats. Wagemann et al. (1983) identified that all of the metals analysed with the exception of arsenic were lowest in concentration in the blubber or narwhals and highest in the organs.

The sum of the consumption rates use in the assessment is equivalent to 519g of traditional food/day. This is within the same order of magnitude as the data presented in Chan 2011 and Egeland 2010 (639 g/day) but does not include the contribution of blubber and maktaaq which are assumed not to accumulate metal constituents.

Table HC03-2 Consumption Rates used in the assessment

Food type	***Adult kg/day***	***Toddler kg/day***	***Adult quantity/year (kg)***	***Reference***
Caribou muscle	0.2080	0.0894	75.9	IHS Egeland (2010)
Caribou organs (liver+kidney)	0.0140	0.0060	5.1	Nancarrow (2007)
Arctic hare	0.0038	0.0016	1.4	Coad 1994 (Table A-7.13 pgA88 citing Wong 1985)
Snow goose (based on Canada Goose)	0.0104	0.0045	3.8	IHS Egeland (2010) (applied factor of 0.45 to Canada goose consumption quantity of 23g/day)
Arctic char	0.1127	0.0485	41.1	IHS Egeland (2010)
Ptarmigan	0.0026	0.0011	1.0	Nancarrow (2007) (presented as a 192g portion 5 times per year)
Ringed seal muscle	0.0591	0.0254	21.6	IHS Egeland (2010)
Ringed seal liver	0.0181	0.0078[a]	6.6	IHS Egeland (2010)

Food type	Adult kg/day	Toddler kg/day	Adult quantity/year (kg)	Reference
Narwhal	0.074	0.032	27.01	Kenny et al. (2018) mean+SD of entire population (eaters and non-eaters) less skin and fat consumption
Berries	0.0130	0.0049	4.7	Egeland (2010)
Medicinal plants	0.0030	0.0000	1.1	(Wein 1989, McAuley et al. 2016)
			189.3	kg/year
			0.519	kg/day

Notes:
[a] The toddler was assumed not to be consuming seal liver due to current consumption advisories; this value is presented, but the model assumed zero consumption of this tissue.

There is currently a consumption advisory in place on ringed seal liver for pregnant women, and women of child-bearing age and Inuit women of child-bearing age in Nunavut who may become pregnant, are planning to get pregnant, or are pregnant are advised to eat ringed seal meat instead of ringed seal liver (Nunavut 2013). Ringed seal muscle tissue is considered a nutritious and safe choice for consumption, for pregnant woman and women of childbearing age (Egeland, 2010; Chan 2011). There are currently no fish consumption advisories in place in Nunavut associated with mercury concentrations in fish (Environment Canada 2015).

There are also no consumption advisories in place in Nunavut associated with the consumption of caribou (either muscle or organ meat). Specific advice from the Nunavut Department of Health identifies that with respect to mercury that the levels in the kidneys of NWT caribou is very low and does not pose a health risk to either caribou or people who eat caribou and that both the meat and organs of (NWT) caribou are safe to eat (Nunavut 2015). The Nunavut Department of Health also identifies that the levels of cadmium in (NWT) caribou are not of concern for caribou health, and caribou remain a safe and healthy food choice for northern people. Specifically, cadmium levels vary considerably with age (increasing levels in older animals), season (higher in spring than in fall), and sex (higher in female vs. male caribou) but the levels of cadmium in (NWT) caribou kidneys are generally low (Nunavut 2015). Gamberg (2008) identifies that Qamanirjuaq caribou herds have low levels of contaminants and there is no immediate cause for concern.

2.6 Conceptual Model:

A conceptual model of exposure pathways and receptors, as well as contaminant sources (dust deposition) is presented in Figure 2-1.

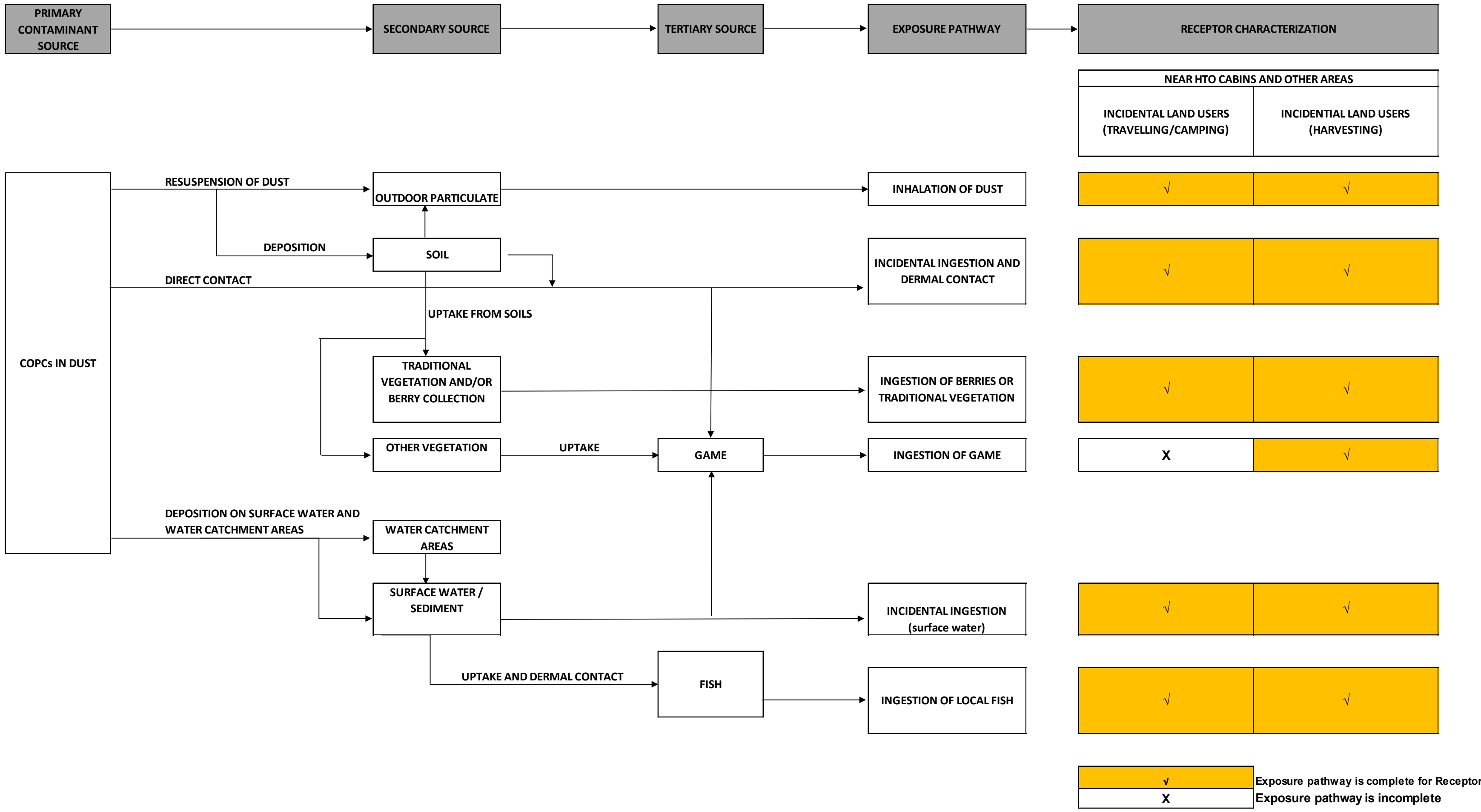

Figure 2-1 Conceptual Site Model for the Quantitative Human Health Risk Assessment

3.0 EXPOSURE ASSESSMENT:

The primary objective of the Exposure Assessment is to estimate, based on reasonable and conservative assumptions, potential chemical exposures received by human receptors while harvesting traditional foods in the project area. The Exposure Assessment predicts the rate of exposure (*i.e.*, the quantity and rate at which a COPC is received) of humans to COPC via the ingestion pathway, as identified in the problem formulation step. The rate of exposure to the COPC is usually expressed as the amount of COPC taken in per unit body weight per unit time (*e.g.*, mg chemical/kg body weight/day). Daily intakes are calculated in the form of chronic estimated daily intakes (EDIs). The following sections detail the approach used to predict human exposure from consumption of country foods, including the scenarios considered in the assessment, receptor characteristics, exposure point concentrations, and exposure calculation methods.

3.1 Scenarios Considered:

The focus of this assessment is on the operations phase of the Project, as this has been identified as the stage in the Project phases with the greatest emissions. When examining potential emissions from the 3 phases of a mine lifecycle (construction, operations, decommissioning), typically, the operations phase represents the highest predicted emissions scenarios, and hence, all predictions presented in this report are related to this phase.

The following scenarios are being assessed for the Project operations phase:

<u>Baseline Scenario:</u>

- This scenario predicts potential exposures, and risks, associated with the baseline dietary components identified in the Problem Formulation (Table HC-03-1), at the consumption rates presented in Table HC-03-2. In the Baseline scenario, a full human health risk assessment for oral pathways was conducted, which included exposures related to soils and dust ingestion in the area (using baseline soils) and drinking water (which was assumed to equal that in baseline from Camp Lake, based on baseline monitoring data). This approach allows for a more comprehensive evaluation of the predominant oral pathways, and baseline risks associated with those pathways.

<u>Project Increment Scenario:</u>

- The potential increment provided by the Phase II operations was assessed separately. This increment evaluated only those components of the diet that could be influenced by Project releases (discussed further below), as well as potential incremental contributions related to soil exposures. Soil exposure contributions were predicted based on a 10 cm mixing depth, as discussed in Technical Response to HC-07, question 7.2.

- The Project Increment was predicted over a number of time periods (*i.e.*, 2016, 2017-2018, 2019-2020, 2021, 2022-2023, 2024, 2025-2035) based on the deposition rates over time as the operation of the mine increases to full operations in 2025 through 2035. The incremental exposures for these time frames were summed for non-carcinogens, to create an overall Project related exposure for assessment purposes.

- For the Project scenario, the Mine site and Milne Port were selected as modelling locations, as both of these areas have HTO cabins, and hence, there is a higher likelihood of people harvesting in these areas more frequently than areas along the Northern Transportation Corridor.

Baseline + Project Scenario:

- The two scenario results were summed to examine the potential incremental risks associated with the Project, when added to Baseline risks.

With respect to the potential for the Project releases to influence only some of the dietary components, the following rationale is presented:

- The main source of emissions from the Project is dust deposition onto area soils in the various Project areas. This is evident in the dustfall deposition figures provided in TSD-11, Section 3.1 (Figures 3-1 to 3-4). As a result, dust deposition has the potential to influence soils, and vegetation. Therefore, berries and medicinal plants could be influenced by Project releases, and therefore merit inclusion in the Project scenario of the assessment;

- Similarly, since soils and vegetation near the Project facility areas could be influenced by Project dust deposition, Arctic hare and Ptarmigan could be influenced by dust deposition onto food sources. Arctic hare is a resident species and present all year round, and some ptarmigan species are present throughout Baffin Island, and consumed by Inuit (Kuhnlein and Humphries, CINE, http://traditionalanimalfoods.org/birds/upland-fowl/page.aspx?id=6461). Therefore, these two species could be influenced by Project releases, and therefore merit inclusion in the Project scenario of the assessment;

- Snow goose is a migratory species, and hence, only spends part of its lifecycle in the Project area. In light of this, this species was only modelled in the Baseline scenario, as influence from the Project due to dust deposition would be limited and seasonal. Only areas in close proximity to the facility PDAs are anticipated to receive dust deposition, and the number geese which might nest in areas close to the facility, and subsequently be hunted, are assumed to be limited.

- Caribou is a common food item for the Inuit in this region, as evident in Table HC-03-2. This species spends limited time in areas influenced by dust deposition. EDI (M. Setterington, personal communication) has examined collar data for caribou which illustrates very low interaction with the PDA (including a 100 m buffer beyond the PDA, which is maximum extent of measurable dust fall). Based on the collar data collected, only 3 collared caribou were found within the PDA, or 100 m of the PDA between 2008 – 2010. The data are presented below, as absolute time, and proportion of year. The number of hours in a given year within 100 m of the PDA ranged from 0:51 hours to 4:05 hours, with a total percentage of time in the PDA/Year ranging from 0.009% to 0.0047% of time (based on 8760 hours in a year). Based on this, and the large home range of this species, the potential for the project to influence either caribou meat or organ meats is extremely low. Hence, caribou was included in the baseline Country foods assessment, and assumed that influence from the Project scenario on meat concentrations was limited.

- Arctic char is consumed by Inuit in the region (see Table HC-03-2). Inuit prefer anadromous (searun) Arctic char, to landlocked char in terms of consumption preferences. Based on the Inuit Map book (TSD-05), important waters nearest to Milne Port include the Robertson River system to the northeast, which drains into Koluktoo

Bay, and the Tugaat River system to the east. Both these rivers are important for harvesting anadromous Arctic Char, but they are outside the influence of dust deposition from the Project. Near the Tote Road and Mine Project areas, no important waters were identified (Figure 3.20; TSD-05). The lakes within this corridor were noted to support land-locked Arctic Char, and include Camp Lake, Angajurjualuk Lake, Mary Lake and Mary River. Char from these lakes are included in the baseline sampling program, and hence, were included in the Baseline Country foods assessment (even though consumption is not expected at any significant rate). Based on the drinking water quality Technical Response (HC-02), there is limited predicted influence of Project dusting activities to lake surface waters (Camp Lake), and hence, fish tissues in these areas are not considered likely to change over time. Therefore, prediction of future concentrations was not considered relevant, particularly in light of the lack of consumption related to land locked char. With respect to Arctic char in the marine area of Milne Port, incidental Arctic char tissue samples have been analyzed for metals during monitoring events and were mostly below detection limits. Exceptions were concentrations of arsenic, chromium, copper, iron, mercury and zinc. Concentrations of these metals in fish tissue were, in general, consistent from 2010 to 2016 (see TSD-17; section 3.3). None of the samples exceeded Health Canada's guidance values for mercury in fish tissue of 0.5 mg/kg for occasional consumers and 0.2 mg/kg for subsistence consumers (Health Canada 1979). Since Arctic char would be expected to be transient in the Port area near facility operations, no significant change in fish tissue concentrations were anticipated for this area as well. Therefore, Arctic char were included in the Baseline country food assessment, and it was assumed that no incremental change in tissue concentrations was expected to occur in the Project scenario.

- Narwhal and Ringed seal are both common food items for Inuit in Pond Inlet. Narwhal are transient and only reside in the Milne Port area for a limited period of time, and hence, would experience limited exposure to Project releases related to dust deposition. For ringed seal, this species is resident in Milne Port, but has a reasonably large home range. An assessment of the impacts of dust deposition on marine sediments and surface waters in Milne Port area was conducted (See TSD-17), and the conclusions of this assessment were that dust deposition is not expected to result in detectable changes in concentrations of metals in sediment in Milne Inlet (see Section 2.6.5, TSD-17). The monitoring studies conducted to date in the marine environment from 2015 to 2017 showed no statistically significant long term trend in changes in sediment quality and no significant differences in iron concentrations in sediments (iron being the most predominant metal) in 2017 from 2014 except for a limited area in the eastern proximity of the dock. In addition, only a few low-level exceedances of CCME ISQGs were found in sediments. As discussed in TSD-17, Early Revenue Phase (ERP) operations have not resulted in significant effects on sediment quality including from ore dust deposition, to date. Collectively, the effects of dust accumulation on marine sediment quality were predicted to be not detectable and therefore negligible in the context of the assessment (TSD-17). TSD-17 concluded that concentrations of metals, particularly iron, in water may measurably increase in the same areas due to introduction of dust, even though marine water quality guidelines for these metals do not exist. The magnitude of effects were classified to range from negligible (i.e., not detectable) to moderate (low-level exceedances) in the LSA. Based on this assessment, and the length of time that either Narwhal or ringed seal may spend in the area adjacent to Milne Port facilities (which was considered to be reasonably limited), these species were considered only in the baseline country foods assessment, and not in the Project scenario, as no change in tissue concentrations associated with the Project is anticipated.

3.2 Receptor Characteristics:

A human receptor is a hypothetical person (e.g., toddler or adult) who may reside, spend leisure time and/or work in the area being investigated and is, or could potentially be, exposed to the chemicals identified as being of potential concern. General physical and behavioural characteristics specific to the receptor type (e.g., body weight, exposed surface areas, incidental soil ingestion rate, etc.) are used to approximate the amount of chemical exposure received by each receptor. The HHRA must be sufficiently comprehensive to ensure that those receptors with the greatest potential for exposure to COPCs, and those that have the greatest sensitivity, or potential for developing adverse effects from these exposures, are included. With this in mind, the selection of hypothetical receptors, with somewhat exaggerated life style habits (to ensure a conservative assessment), should be developed for consideration in the HHRA. Due to differences in physiological characteristics and activity patterns between toddlers and adults, the exposures received by a toddler and an adult will be different. Consequently, the potential risks estimated for the same COPC will differ depending on the receptor chosen for evaluation.

In order to evaluate potential exposures, it is necessary to characterize the physiological and behavioural characteristics of each receptor group. Several published resources were considered in the selection of these parameters, including but not limited to:

- Federal Contaminated Sites Risk Assessment in Canada. PART I: Guidance on Complex Human Health Detailed Quantitative Risk Assessment for Chemicals (DQRA). (Health Canada, 2012a);

- Compendium of Canadian Human Exposure Factors for Risk Assessment. O'Connor Associates Environmental Inc. (Richardson and O'Connor, 1997);

These sources have been used in numerous HHRAs that have been critically reviewed and accepted by regulatory agencies across Canada and the United States. Both the Compendium of Canadian Human Exposure Factors for Risk Assessment (Richardson and O'Connor, 1997) and Health Canada (2012a) rely on data from published and reliable Canadian sources, such as Health Canada, Statistics Canada, and the Canadian Fitness and Lifestyles Research Institute.

Table HC03-3 presents the physical characteristics from Health Canada (2012) that were used to assess exposure to receptors in the assessment.

Table HC-03-3 Assumed Receptor Characteristics

Characteristic	***Toddler***	***Adult***	***Reference***
Age	7 months -4 years	≥ 20 years	Health Canada (2012)
Age group duration	4.5 years	60 years	Health Canada (2012)
Body weight (kg)	16.5	70.7	Health Canada (2012)
Inhalation rate (m^3/d)	8.3	16.6	Health Canada (2012)
Soil ingestion rate (kg/d)	0.00008	0.00002	Health Canada (2012)
Water ingestion rate (L/d)	0.6	1.5	Health Canada (2012)

3.3 Baseline Exposure Point Concentrations

Baseline exposure point concentrations (EPCs) were obtained from available scientific literature characterizing metal concentrations in various plants, terrestrial wildlife (*i.e.*, arctic hare, caribou, ptarmigan, and geese) and aquatic life (*i.e.*, arctic char, narwhal, and ringed seal). Much of the literature focused on lead, cadmium and mercury in tissues; however, select data were available for other COPC. These concentrations, where available, were used to characterize baseline conditions for the Project area. Where data from the Project area were available, it was used preferentially over literature values. Table HC03-4 presents the EPCs of plant species; Table HC03-5 presents the EPCs of terrestrial wildlife species; and, Table HC03-6 presents the EPCs of aquatic life species used in the baseline assessment. For Arctic Char, baseline fish tissue data from Mary River were used to represent local fish concentrations (FEIS, Volume 7; Appendix C). This river is near the Mine site, and hence, relevant to the assessment. As indicated previously, Inuit prefer sea run Arctic Char, but since the Mary River char data are available to characterize metals levels in char, they were used for the assessment. Table HC03-7 presents the mean surface water concentrations measured at Camp Lake from April to August 2018. These concentrations were used to characterize baseline surface water concentrations in the assessment, as Camp Lake is located near the Mine site (see Technical Response to HC-02). Baseline soils and blueberries in the model were assumed to equal those presented in TSD-11, pre-operational soils and berry data (90^{th} percentile of baseline soils was used). Baseline soil and berry data are presented in TSD-11, Section 2.

Table HC-03-4 Measured Exposure Point Concentrations of Plant Species Used in the Baseline Assessment [mg/kg-DW]

COPC	Medicinal Plants	
	EPC	Reference
Aluminum	NV	--
Antimony	NV	--
Arsenic	NV	--
Barium	NV	--
Cadmium	0.1	mid-point value - yellow crazy weed; Baffinland Mary River Project EIS Dec 2010 Appendix C6 Vegetation Baseline Report
Chromium	13.9	mid-point value - yellow crazy weed; Baffinland Mary River Project EIS Dec 2010 Appendix C6 Vegetation Baseline Report
Cobalt	0.75	mid-point value- yellow crazy weed; Baffinland Mary River Project EIS Dec 2010 Appendix C6 Vegetation Baseline Report
Copper	3.75	mid-point value- yellow crazy weed; Baffinland Mary River Project EIS Dec 2010 Appendix C6 Vegetation Baseline Report
Iron	1696.5	mid-point value- yellow crazy weed; Baffinland Mary River Project EIS Dec 2010 Appendix C6 Vegetation Baseline Report
Lead	1.69	mid-point value- yellow crazy weed; Baffinland Mary River Project EIS Dec 2010 Appendix C6 Vegetation Baseline Report
Manganese	NV	--
Mercury	NV	--
Molybdenum	NV	--
Nickel	8.5	mid-point value- yellow crazy weed; Baffinland Mary River Project EIS Dec 2010 Appendix C6 Vegetation Baseline Report
Selenium	NV	--
Silver	NV	--
Strontium	NV	--
Thallium	NV	--
Tin	NV	--
Uranium	NV	--
Vanadium	NV	--
Zinc	19.1	mid-point value - yellow crazy weed; Baffinland Mary River Project EIS Dec 2010 Appendix C6 Vegetation Baseline Report

Notes:
NV indicates no values were available; N = 6

Table HC-03-5 Measured Exposure Point Concentrations of Terrestrial Species Used in the Baseline Assessment [mg/kg-DW]

COPC	Arctic Hare			Caribou Muscle			Caribou Organ (kidney)			Ptarmigan			Snow Goose		
	EPC	n	Reference	EPC	n	Reference	EPC	n	Reference	EPC	n	Reference	EPC	n	Reference
Aluminum	64	2	geomean; Mallory et al 2004 Baffin NU	1.35	88	mean; Gamberg et al 2016	1.39	78	value as presented; Gamburg 2016	NV	--	--	NV	--	--
Antimony	NV	--	--	NV	--	--	NV	--	--	NV	--	--	NV	--	--
Arsenic	0.85	2	1/2 DL; Mallory et al 2004 Baffin NU	0.0395	88	mean; Gamberg et al 2016	0.05	78	value as presented; Gamburg 2016	0.0678	46	median; Braune and Malone 2006	0.05	194	mean; Horak et al 2014
Barium	NV	--	--	NV	--	--	NV	--	--	NV	--	--	NV	--	--
Cadmium	0.082	2	geomean; Pedersen and Lierhagen 2006	0.0217	220	mean; Gamberg et al 2016	27.2	78	value as presented; Gamburg 2016	0.203	46	median; Braune and Malone 2006	0.016	194	mean; Horak et al 2014
Chromium	NV	--	--	NV	--	--	NV	--	--	NV	--	--	NV	--	--
Cobalt	0.1	2	1/2 DL; Mallory et al 2004 Baffin NU	NV	--	--	NV	--	--	NV	--	--	0.028	194	mean; Horak et al 2014
Copper	10	2	geomean; Pedersen and Lierhagen 2006	12.38	88	mean; Gamberg et al 2016	22.2	78	value as presented; Gamburg 2016	NV	--	--	8.22	194	mean; Horak et al 2014
Iron	240	2	geomean; Mallory et al 2004 Baffin NU	NV	--	--	NV	--	--	NV	--	--	79.6	194	mean; Horak et al 2014
Lead	0.001	2	geomean; Pedersen and Lierhagen 2006	0.034	220	mean; Gamberg et al 2016	0.4	78	value as presented; Gamburg 2016	NV	--	--	0.191	194	mean; Horak et al 2014
Manganese	3.2	2	geomean; Mallory et al 2004 Baffin NU	NV	--	--	NV	--	--	NV	--	--	0.3	194	mean; Horak et al 2014
Mercury	0.002	2	1/2 DL; Mallory et al 2004 Baffin NU	0.065	220	mean; Gamberg et al 2016	5.67	78	value as presented; Gamburg 2016	0.169	46	1/2 DL; Braune and Malone 2006	0.154	194	mean; Horak et al 2014
Molybdenum	NV	--	--	NV	--	--	NV	--	--	NV	--	--	0.02		mean; Horak et al 2014
Nickel	NV	--	--	NV	--	--	NV	--	--	NV	--	--	NV		--
Selenium	0.5	2	1/2 DL; Mallory et al 2004 Baffin NU	0.46	88	mean; Gamberg et al 2016	4.26	78	value as presented;	0.610	46	median; Braune and	0.347		mean; Horak et al 2014

COPC	Arctic Hare			Caribou Muscle			Caribou Organ (kidney)			Ptarmigan			Snow Goose		
	EPC	n	Reference	EPC	n	Reference	EPC	n	Reference	EPC	n	Reference	EPC	n	Reference
									Gamburg 2016			Malone 2006			
Silver	NV	--	--	NV	--	--	NV	--	--	NV	--	--	NV		--
Strontium	NV	--	--	NV	--	--	NV	--	--	NV	--	--	NV		--
Thallium	NV	--	--	NV	--	--	NV	--	--	NV	--	--	0.1		mean; Horak et al 2014
Tin	NV	--	--	NV	--	--	NV	--	--	NV	--	--	NV		--
Uranium	NV	--	--	NV	--	--	NV	--	--	NV	--	--	NV		--
Vanadium	NV	--	--	NV	--	--	NV	--	--	NV	--	--	NV		--
Zinc	67.2	2	geomean; Mallory et al 2004 Baffin NU	83.48	88	mean; Gamberg et al 2016	107.4	78	value as presented; Gamburg 2016	NV	--	--	13.6		mean; Horak et al 2014

Notes:
NV indicates no values were available
n indicates number of samples

Table HC-03-6 Measured Exposure Point Concentrations of Aquatic Species Used in the Baseline Assessment [mg/kg-DW]

COPC	Arctic Char			Narwhal			Ringed Seal Liver			Ringed Seal Muscle		
	EPC	n	Reference	EPC	n	Reference	EPC	n	Reference	EPC	n	Reference
Aluminum	13.4	30	mean	0.648	58	mean; Wagemann 1983	16.5	2	1/2 DL; Mallory et al 2004 Baffin NU	16.5	2	1/2 DL; Mallory et al 2004 Baffin NU
Antimony	0.02	30	1/2 DL	NV	--	--	NV	2	--	NV	2	--
Arsenic	0.0215	30	mean	NV	--	--	0.71	13	mean; Wagemann et al 1989	0.13	13	mean; Wagemann et al 1989
Barium	0.133	30	mean	NV	--	--	NV	2	--	NV	2	--
Cadmium	0.01	30	1/2 DL	0.76	58	mean; Wagemann 1983	11.93	13	mean; Wagemann et al 1989	0.189	13	mean; Wagemann et al 1989
Chromium	0.345	30	mean	NV	--	--	NV	2	--	NV	2	--
Cobalt	0.04	30	1/2 DL	NV	--	--	0.1	2	1/2 DL; Mallory et al 2004 Baffin NU	0.1	2	1/2 DL; Mallory et al 2004 Baffin NU
Copper	1.74	30	mean	2.64	58	mean; Wagemann 1983	35.4	13	mean; Wagemann et al 1989	8.56	13	mean; Wagemann et al 1989
Iron	18.9	30	mean	NV	--	--	731.8	2	geomean; Mallory et al 2004 Baffin NU	827.7	2	geomean; Mallory et al 2004 Baffin NU
Lead	0.04	30	1/2 DL	0.036	58	mean; Wagemann 1983	0.11	13	mean; Wagemann et al 1989	0.052	13	mean; Wagemann et al 1989
Manganese	0.696	30	mean	NV	--	--	13	2	geomean; Mallory et al 2004 Baffin NU	0.4	2	geomean; Mallory et al 2004 Baffin NU
Mercury	0.128	30	mean	3.24	20	mean; Wagemann 2005	23.6	13	mean; Wagemann et al 1989	0.49	13	mean; Wagemann et al 1989
Molybdenum	0.0208	30	mean	NV	--	--	NV	--	--	NV	--	--
Nickel	0.216	30	mean	NV	--	--	NV	--	--	NV	--	--
Selenium	1.752	30	mean	1.76	58	mean; Wagemann 1983	13.9	13	mean; Wagemann et al 1989	1.64	13	mean; Wagemann et al 1989
Silver	NV	--	--	NV	--	--	NV	--	--	NV	--	--
Strontium	0.37	30	mean	NV	--	--	NV	--	--	NV	--	--
Thallium	0.0215	30	mean	NV	--	--	NV	--	--	NV	--	--
Tin	0.1	30	1/2 DL	NV	--	--	NV	--	--	NV	--	--
Uranium	0.004	30	1/2 DL	NV	--	--	NV	--	--	NV	--	--
Vanadium	0.2	30	1/2 DL	NV	--	--	NV	--	--	NV	--	--
Zinc	37.76	30	mean	71.2	58	mean; Wagemann 1983	171	13	mean; Wagemann et al 1989	82.9	13	mean; Wagemann et al 1989

Notes:
NV indicates no values were available
n indicates number of samples

Table HC-03-7 Surface Water Quality Exposure Point Concentrations [mg/L] (Minnow, 2018)

COPC	EPC	n	Statistic/Reference
Aluminum	0.00564	4	Mean JLO-09 from 2018; Project-specific
Antimony	0.0001	4	Mean JLO-09 from 2018; Project-specific
Arsenic	0.0001	4	Mean JLO-09 from 2018; Project-specific
Barium	0.006974	4	Mean JLO-09 from 2018; Project-specific
Cadmium	0.00001	4	Mean JLO-09 from 2018; Project-specific
Chromium	0.0005	4	Mean JLO-09 from 2018; Project-specific
Cobalt	0.0001	4	Mean JLO-09 from 2018; Project-specific
Copper	0.000934	4	Mean JLO-09 from 2018; Project-specific
Iron	0.03	4	Mean JLO-09 from 2018; Project-specific
Lead	0.00005	4	Mean JLO-09 from 2018; Project-specific
Manganese	0.00173	4	Mean JLO-09 from 2018; Project-specific
Mercury	0.00001	4	Mean JLO-09 from 2018; Project-specific
Molybdenum	0.000313	4	Mean JLO-09 from 2018; Project-specific
Nickel	0.000603	4	Mean JLO-09 from 2018; Project-specific
Selenium	0.001	4	Mean JLO-09 from 2018; Project-specific
Silver	0.00001	4	Mean JLO-09 from 2018; Project-specific
Strontium	0.010488	4	Mean JLO-09 from 2018; Project-specific
Thallium	0.0001	4	Mean JLO-09 from 2018; Project-specific
Tin	0.0001	4	Mean JLO-09 from 2018; Project-specific
Uranium	0.000811	4	Mean JLO-09 from 2018; Project-specific
Vanadium	0.001	4	Mean JLO-09 from 2018; Project-specific
Zinc	0.003	4	Mean JLO-09 from 2018; Project-specific

Notes:
n indicates number of samples

3.4 Prediction of Future Concentrations

To predict future concentrations of the media in the Project scenario, a dust deposition rate was first selected from isopleth diagrams presented in TSD-11. For the mine site area, a dust deposition rate of 10 g/m^2/year was selected, as this deposition rate is a conservative estimate of deposition in areas near the HTO cabin. For Milne Port, a dust deposition rate of 5 g/m^2/year was selected, based on depositional rates near the HTO (see Figures 3-1 and 3-4 in TSD-11). While higher depositional rates occur in areas closer to the facility, the Project country foods scenario assumed that all of a persons diet could come from this area (as opposed to an amortized amount from the Project area). Hence, these depositional rates were considered more appropriate, but would considerably overestimate what would be expected to come from the Project area.

Methods for predicting future soil and berry concentrations are provided in TSD-11, Section 4. Soil mixing depth was adjusted to 10 cm, in response to HC-07 question 2 for the purposes of this country food technical response. Project related contributions to medicinal plant concentrations were estimated using the same approach as that taken for berries (see TSD-11; Section 4).

Table HC-03-8 presents the exposure variables that were assumed for the arctic hare and ptarmigan in the human health risk assessment. Game meat concentrations for arctic hare and ptarmigan were based on measured baseline conditions and predicted changes in soil and vegetation concentrations associated with the Project. Predicted game meat concentrations were used for estimating exposure to COPC in the human health risk assessment. Chemical concentrations in game meat were predicted based on the following equation (US EPA Office of Solid Waste [OSW] 2005):

$$C_{animal} = BTF_{ss} \times EDI_{total}$$

$$BTF_{ss} = \frac{EPC}{EDI_{total}}$$

Where:

C_{animal} = chemical concentration in game meat (mg/kg ww)

BTF_{ss} = Site-specific biotransfer factor for metabolism ([mg/kg tissue] / [mg/day])

EDI_{total} = total estimated daily intake of chemical via all routes of exposure (mg/day)

EPC = Exposure point concentration [mg/kg-tissue]

Measured baseline exposure point concentrations (e.g., soil, surface water and berries) were used to predict estimated daily intake of COPC for wild game and the baseline game meat exposure point concentrations were used to calculate site-specific biotransfer factors. Predicted changes in game meat concentrations (i.e., arctic hare and ptarmigan) were based on changes in soil and vegetation (i.e., berries) from dust deposition.

Table HC-03-8 Exposure Variables Assumed for Selected Wildlife Receptors

Receptor	*Parameter*	*Value*	*Units*	*Reference / Comment*
Arctic hare	Body Weight	1.30E+00	kg-WW	GOC 2012
Arctic hare	Food Ingestion Rate	7.80E-02	kg-DW/day	GOC 2012
Arctic hare	Soil Ingestion Rate	4.91E-03	kg-DW/day	GOC 2012; 6.3% of food ingestion rate
Arctic hare	Water Ingestion Rate	1.30E-01	L/day	GOC 2012
Ptarmigan	Body Weight	5.21E-01	kg-WW	Dunning 2007; Rock ptarmigan (NWT) mean
Ptarmigan	Food Ingestion Rate	3.81E-02	kg-DW/day	GOC 2012; Allometric equation for "All Birds"
Ptarmigan	Soil Ingestion Rate	2.40E-03	kg-DW/day	None identified; Assumed 2%
Ptarmigan	Water Ingestion Rate	3.81E-02	L/day	GOC 2012; Allometric equation for "All Birds"

Human exposure to arsenic and mercury was modified based on the portion of organic verses inorganic levels in various foods. Table HC-03-9 presents the inorganic and organic content values that were applied to total metal concentrations that was measured in various foods.

Table HC-03-9 Inorganic Content of Arsenic and Organic Content of Mercury in Foods Assumed for the HHRA

Food	*Inorganic Arsenic Value*	*Reference / Comment*	*Organic Mercury Value (MeHg)*	*Reference / Comment*
Arctic char	2%	Schoof et al 1999	90%	Assumed conservative value; Range 60-100%
Arctic hare	5%	Schoof et al 1999	57%	US EPA 2001; Based on wild deer
Berries	78%	Schoof et al 1999	23%	US EPA 2001; Based on leafy vegetables
Caribou MUSCLE	5%	Schoof et al 1999	57%	US EPA 2001; Based on wild deer
Caribou ORGAN	5%	Schoof et al 1999	18%	US EPA 2001; Based on control group beef liver
Medicinal plants	78%	Schoof et al 1999	23%	US EPA 2001; Based on leafy vegetables
Narwhal	5%	Schoof et al 1999	65%	Lemire 2015; Used beluga as surrogate
Ptarmigan	5%	Schoof et al 1999	20%	US EPA 2001; Based on turkey
Ringed seal liver	5%	Schoof et al 1999	11%	Lemire 2015
Ringed seal muscle	5%	Schoof et al 1999	86%	Lemire 2015
Snow goose	5%	Schoof et al 1999	20%	US EPA 2001; Based on turkey

3.4 Exposure Calculations

The approach to predicting human exposure to COPC via ingestion of plants, fish and game meat, incidental ingestion of soil, ingestion of water, and inhalation of dust was based on Health Canada (2012) guidance as detailed in the sections below.

Ingestion of Soil (Incidental)

The following equation was used to estimate human exposure via incidental ingestion of soil. Soil ingestion rates and equations used to predict exposures were based on recommendations from Health Canada (2012).

$$EDI_{soil} = C_s \times SIR \times CF1 \times CF2$$

Where:

EDI_{soil} = estimated daily intake of chemical via ingestion of soil (µg/d)

C_s = chemical concentration in surface soil (mg/kg)

SIR = incidental soil ingestion rate (g/d)

$CF1$ = conversion factor from µg to mg (1,000 µg/mg)

$CF2$ = conversion factor from g to kg (0.001 kg/g)

Ingestion of Drinking Water

Water ingestion rates and equations used to predict exposures were based on recommendations from Health Canada (2012) and exposures were based on the following equation:

$$EDI_{water} = C_{dw} \times WIR \times CF$$

Where:

EDI_{water} = estimated daily intake of chemical via ingestion of water (µg/d)

C_{dw} = chemical concentration in drinking water (mg/L)

WIR = water ingestion rate (L/d)

CF = conversion factor from mg to µg (1,000 µg/mg)

Inhalation of Dust

The following equation was used to estimate human exposure via inhalation of dust. Air inhalation rates and equations used to predict exposures were based on recommendations from Health Canada (2012).

$$EDI_{dust} = C_{dust} \times AIR$$

Where:

EDI_{dust} = estimated daily intake of chemical via inhalation of dust (µg/d)

C_{dust} = chemical concentration in dust (µg/m^3)

AIR = air inhalation rate (m^3/d)

Ingestion of Berries

The following equation was used to estimate human exposure via consumption of wild berries (Health Canada, 2012).

$$EDI_{berry} = P_b \times IR_{berry}$$

Where:

EDI_{berry} = estimated daily intake of chemical via consumption of berries (µg/d)

Pb = chemical concentration in berries from root uptake (mg/kg WW)

IR_{berry} = berry ingestion rate (g/d)

Note: bio-accessibility of chemical in plant was assumed to be 100%.

Ingestion of Medicinal Plants

The following equation was used to estimate human exposure via consumption of medicinal plants. Consumption rates and equations used to predict exposures were obtained from Health Canada (2012).

$$EDI_{plant} = C_{plant} \times IR_{plant}$$

Where:

EDI_{plant} = (μg/d) estimated daily intake of chemical via consumption of medicinal plants

C_{plant} = total chemical concentration in medicinal plant (mm/kg ww)

IR_{plant} = medicinal plant ingestion rate (g/d)

Ingestion of Wild Game and Fish

The following equation was used to estimate human exposure via consumption of wild game and fish (Health Canada 2012).

$$EDI_{animal} = C_{animal} \times IR_{animal}$$

Where:

EDI_{animal} = estimated daily intake of chemical via consumption of wild game or fish (μg/d)

C_{animal} = chemical concentration in animal tissue (mg/kg WW)

IR_{animal} = fish or wild game ingestion rate (g/d)

Total Human Exposure

Total exposure was calculated by summing the individual exposures from each medium (i.e., soil, water, berries, medicinal plants, wild game and fish) for all relevant exposure pathways on a per chemical and per life stage basis (Health Canada, 2012):

$$EDI_{total} = EDI_{soil} + EDI_{water} + EDI_{dust} + EDI_{berry} + EDI_{plants} + EDI_{animal}$$

Where:

EDItotal = total estimated daily intake of chemical via all media (μg/d)

EDIsoil = estimated daily intake of chemical from soil ingestion (μg/d)

EDIwater = estimated daily intake of chemical from ingestion of water (μg/d)

EDIdust = estimated daily intake of chemical from dust inhalation (µg/d)

EDIberries = estimated daily intake of chemical from consumption of berries (µg/d)

EDIplants = estimated daily intake of chemical from consumption of medicinal plants (µg/d)

EDIanimal = estimated daily intake of chemical from consumption of wild game and fish (µg/d)

The total estimated daily intake was normalized to body weight as follows:

$$EDI_{total\_BW} = \frac{EDI_{total}}{BW}$$

Where:

EDI_{total_BW} = total estimated daily intake of chemical via all routes adjusted to body weight (µg/kg bw/d)

EDI_{total} = total estimated daily intake of chemical via all routes (µg/d)

BW = body weight (kg)

4.0 TOXICITY OR EFFECTS ASSESSMENT

Toxicity is the potential for a chemical or agent to produce temporary or permanent damage to the structure or functioning of any part of the body. The toxicity of a chemical depends on the amount of chemical taken into the body (referred to as the “dose”) and the duration of exposure (*i.e.*, the length of time the person is exposed to the chemical). For every chemical, there is a specific dose and duration of exposure necessary to produce a toxic effect in humans (this is referred to as the “dose-response relationship” of a chemical). In the toxicity assessment, information related to the dose-response relationships of each chemical is evaluated (usually from laboratory animal studies and studies of human exposure in the workplace) in order to determine the maximum dose of chemicals to which humans can be exposed that would be associated with a very low probability of experiencing adverse health effects. These toxicity estimates are typically called exposure limits or toxicity reference values (TRVs) and indicate an exposure that will not likely result in harmful effects.

For this project, as per Health Canada guidance (Health Canada 2018; 2012a), preference was given to TRVs developed by Health Canada. Where exposure limits were not available from Health Canada, they were obtained from a number of other leading scientific and regulatory authorities, including the following:

- United States Environmental Protection Agency (US EPA);
- World Health Organization (WHO);
- Health Institute of the Netherlands (RIVM); and
- JECFA (Joint FAO/WHO Expert Committee on Food Additives).

To ensure that the most defensible and appropriate exposure limit was selected for each chemical, consideration was given only to exposure limits meeting the following criteria:

- Established or recommended by leading scientific and regulatory authorities.
- Protective of the health of the general public based on the current scientific understanding of the health effects known to be associated with exposures to the COPC.
- Protective of sensitive individuals, typically through the use of appropriate uncertainty factors.
- Supported by adequate and available documentation.

All supporting documents were critically evaluated to identify the most appropriate and defensible limits for use in the assessment. In the case that the above criteria were supported by more than one standard, guideline or objective, the most scientifically defensible limit was selected. Table HC-03-8 presents the toxicity reference values (TRVs) selected for use in the assessment of risks from exposure to the COPC.

Table HC-03-8 Toxicity Reference Values used in the Assessment

Chemical of Potential Concern	Chronic Oral Exposure Limits				
	Averaging Time	Type	Value (µg/kg bw/day)	Critical Effect	Agency
Aluminum (Al)	Annual	RfD	143	Developmental, kidney, liver, nervous system and reproductive effects	WHO 2010a,b
Antimony (Sb)	Annual	RfD	0.2	Liver effects	Health Canada 2010
Arsenic (As)[a]	Annual	RsD	0.006	Bladder, liver and lung cancer	Health Canada 2010
Barium (Ba)	Annual	RfD	200	Renal effects	Health Canada 2010
Cadmium (Cd)	Annual	RfD	1	Renal effects	Health Canada 2010
Chromium (Cr)	Annual	RfD	1	Hepatotoxicity	Health Canada 2010
Cobalt (Co)	Annual	RfD	1.4	Cardiovascular effects	RIVM 2001
Copper (Cu) (Adult)	Annual	RfD	141	Hepatotoxicity and gastrointestinal effects	Health Canada 2010
Copper (Cu) (Toddler)	Annual	RfD	91	Hepatotoxicity and gastrointestinal effects	Health Canada 2010
Iron (Fe)	Annual	RfD	700	Gastrointestinal effects	US EPA 2006
Lead (Pb) (Adult)	Annual	RfD	1.3	Increased blood pressure	JECFA 2011
Lead (Pb) (Toddler)	Annual	RfD	0.6	Neurodevelopmental effects	JECFA 2011
Manganese (Mn) (Adult)	Annual	RfD	156	Neurotoxicity	Health Canada 2010
Manganese (Mn) (Toddler)	Annual	RfD	136	Neurotoxicity	Health Canada 2010
Mercury (Hg)	Annual	RfD	0.57	Renal effects	WHO 2010c
MethylMercury (MeHg)	Annual	RfD	0.1	Developmental effects	US EPA 2001
Molybdenum (Mo) (Adult)	Annual	RfD	28	Reproductive effects	Health Canada 2010
Molybdenum (Mo) (Toddler)	Annual	RfD	23	Reproductive effects	Health Canada 2010
Nickel (Ni)	Annual	RfD	11	Perinatal lethality	Health Canada 2010
Selenium (Se) (Adult)	Annual	RfD	5.7	Selenosis	Health Canada 2010
Selenium (Se) (Toddler)	Annual	RfD	6.2	Selenosis	Health Canada 2010
Silver (Ag)	Annual	RfD	5	Argyria	US EPA 1996a
Strontium (Sr)	Annual	RfD	600	Developmental effects, skeletal changes	US EPA 1996b
Tin (Sn)	Annual	RfD	200	Liver effects	RIVM 2009
Uranium (U)	Annual	RfD	0.6	Nephrotoxicity and hepatotoxicity	Health Canada 2010
Vanadium (V)	Annual	RfD	2.1	Developmental effects	RIVM 2009
Zinc (Zn) (Adult)	Annual	RfD	570	Reduced iron and copper status	Health Canada 2010
Zinc (Zn) (Toddler)	Annual	RfD	480	Developmental effects	Health Canada 2010

[a] Arsenic was only considered as a carcinogen in this Technical Response. Non cancer risks are typically lower than those associated with cancer and hence, only the cancer endpoint was assessed in this evaluation.

5.0 RISK CHARACTERIZATION:

Risk characterization for chemicals with a threshold-type dose-response consists of a comparison between the TRV (*i.e.*, the rate of exposure that would not produce adverse effects) against the total estimated exposure.

For COPCs assessed in the Country Foods model, a Hazard Quotient (HQ) was calculated. These ratios are calculated by dividing the predicted exposure (from the exposure model) by the TRV (or Exposure Limit), as indicated in the following equations:

$$Hazard\ Quotient = \frac{Estimated\ \ Exposure\ \ (ug\ /kg\ /day)}{Exposure\ \ Limit\ \ (ug\ /kg\ /day)}$$

If the calculated HQ in Baseline or for Baseline + Project is greater than the benchmark of 1.0, then there may be potential for adverse health effects and further assessment may be required. An HQ less than 1.0 indicates that the intake of the COPC through the consumption of traditional foods (and other pathways) does not exceed the TRV and no adverse health effects are expected. Since the Project Case only considered the consumption of country foods, the ingestion of soil (incidental), and inhalation of dust, an HQ of 0.2 was used as a benchmark to assess the risk level for non-carcinogenic exposures to allow for contribution from exposure via other routes (*e.g.*, water).

Carcinogenic chemicals are assumed to act via a non-threshold mechanism and exposures are assessed over a lifetime. Health Canada recommends that a full lifetime of exposure be adopted as the most sensitive approach, based on combining exposures from five individual life stages (*i.e.*, infant, toddler, child, teen and adult). As the Project area is in a remote site, it is considered to be unreasonably conservative to assume that receptors would harvest all country foods over their entire lifetimes (assumed as 80 years) from this area. Therefore, for the purposes of this assessment, only exposures from the toddler and adult life stages were combined. This is considered to be conservative as the toddler and adult are assumed to be exposed to country foods harvested from this area over their entire life stages, 4.5 years and 60 years duration, respectively, combined. Furthermore, the federal human health soil quality guidelines for carcinogens, including arsenic, only consider adults and ignores other life stages in their derivation.

For carcinogenic chemicals, potential risks are expressed as incremental lifetime cancer risks (ILCRs). The ILCR estimates the incremental probability that an individual will develop cancer as a result of lifetime exposure to a substance in the pathway examined. The ILCR is in addition to the probability of developing cancer due to ambient exposures, which are not quantified or calculated. Health Canada (2010) recommends a benchmark cancer risk level of 1 in 100,000 (*i.e.*, 1×10^{-5}) for the purposes of assessing carcinogenic substances; thus, cancer risks are deemed negligible when the estimated ILCR is ≤1 in 100,000. An ILCR greater than 1 in 100,000 does not necessarily imply that action is required to mitigate risks; rather, an exceedance is an indication that the data and assumptions used to estimate the risks should be more closely examined before concluding that an actual risk might exist.

The highest of the ILCR value for the Project scenario timeframe of the adult and toddler life stages was presented in the report for carcinogens and is calculated as follows:

$$ILCR = \frac{EDI_{total\_BW-tod}}{RsD} \times LAF_{-tod} + \frac{EDI_{total\_BW-adult}}{RsD} \times LAF_{-adult}$$

Where:

ILCR = ILCR of chemical for the life stages of the Indigenous peoples (unitless)

EDItotal_BW-I = total estimated daily intake of chemical via all routes adjusted to body weight for the 'i' life stage (µg/kg bw/d)

RsD = chemical-specific risk-specific dose (µg/kg bw/d)

LAF-i = Lifetime adjustment factor for the 'i' life stage for general population (yr-life stage/yr-total)

5.1 Uncertainties in the Assessment:

As in any risk assessment, there are a number of uncertainties in the assessment. Some of the primary uncertainties are as follows:

- There are limited data available to characterize baseline concentrations of a number of metals in game meat tissues. Data are most commonly available for inorganic contaminants such as cadmium, mercury, lead, methyl mercury, with other inorganics having either no or limited data sets. The focus of much of the dietary research is on lead, cadmium and mercury, inthat these substances have found to be of greatest concern, due to their propensity to accumulate in selected tissues. Other metals may be lacking data in the baseline assessment, due to the paucity of literature. In addition, some of the data are older, and hence, may not reflect current concentrations.

- The assessment assumed that 100% of metal concentrations in media and game meat were 100% bio-accessible via consumption in the HHRA. This assumption will likely bias exposures, and risks, high, rather than low, as there is ample literature supporting the reasonably low bioavailability of metals in soils.

- Consumption estimates are based on available surveys and information, and in some cases, are regionalized estimates, which may or may not reflect local consumption patterns. Although many of the consumption estimates are for "eaters-only" the narwhal daily consumption estimate specifically was based both eaters and non-eaters and therefore was calculated based on the sum of the mean plus one standard deviation. This calculation may introduce uncertainty into the estimated value. Additionally, consumption rates obtained from the IHS results (Chan 2011) are based on the actual number of participants in Nunavut and the data presented were not specific to any single community, but to all of Nunavut.

- Metal losses from soil due to erosion, run-off and leaching was assumed to be very limited; therefore, deposition was assumed to accumulate through-out the life of the Project.

- Toxicity reference values assumed in the assessment were derived to be conservative (i.e., protection of sensitive of individuals with compromised health), based on no-observable-adverse-effect-levels (NOAEL) and applied uncertainty factors ranging in value from 10 to 1000 to account for lack of toxicological information. Combined these assumptions ensure toxicity reference values are conservative to minimize the likelihood of underpredicting risks to human receptors.

- Air dispersion modelling incorporated assumptions and meteorological data that represented conditions contributing to maximum predicted ground level air concentrations of the COPC.
- Indigenous peoples were assumed to obtain 100% of their food from local sources (e.g., berries and plants, wild game and fish) and drinking water from local waterbodies.

5.2 Results of the Baseline and Project Related Country Food Modelling:

The predicted RQ values for the non-carcinogenic COPC are presented in Table HC03-9. The table presents the higher RQ value of either the toddler or the adult. With the exceptions of cadmium, mercury, and methylmercury, all COPC were below the benchmark RQ value of 1.0 in the Baseline Case and the Baseline + Project Case. For the Project Case, all COPC are predicted to be below the RQ benchmark of 0.2.

The majority of the exceedances in the Baseline + Project Case for cadmium, mercury, and methylmercury are due to the contribution from the Baseline Case.

For all three COPC, the Project contributed minimal amounts to the risk.

Table HC03-9 Chronic Non-Carcinogenic Risk Quotients for Inuit

	Mine			*Milne Port*		
COPC	*Baseline*	*Project*	*Baseline + Project*	*Baseline*	*Project*	*Baseline + Project*
Aluminum	4.9E-01	4.7E-02	5.4E-01	4.9E-01	2.2E-02	5.1E-01
Antimony	1.0E-01	1.7E-02	1.2E-01	1.0E-01	5.5E-03	1.1E-01
Barium	2.7E-02	2.4E-04	2.8E-02	2.7E-02	1.8E-04	2.7E-02
Cadmium	**2.8E+00**	6.8E-03	**2.8E+00**	**2.8E+00**	3.7E-03	**2.8E+00**
Chromium	4.9E-01	4.6E-02	5.3E-01	4.9E-01	1.3E-02	5.0E-01
Cobalt	1.1E-01	4.6E-03	1.2E-01	1.1E-01	1.9E-03	1.2E-01
Copper	3.1E-01	6.0E-04	3.1E-01	3.1E-01	6.5E-04	3.1E-01
Iron	8.0E-01	1.5E-02	8.1E-01	8.0E-01	8.7E-03	8.1E-01
Lead	3.8E-01	1.1E-02	3.9E-01	3.8E-01	5.6E-03	3.8E-01
Manganese	6.8E-01	4.7E-03	6.9E-01	6.8E-01	2.0E-03	6.9E-01
Mercury	**3.7E+00**	6.3E-03	**3.7E+00**	**3.7E+00**	1.0E-02	**3.7E+00**
Methylmercury	**1.4E+01**	1.1E-02	**1.5E+01**	**1.4E+01**	1.7E-02	**1.5E+01**
Molybdenum	1.9E-03	2.9E-04	2.2E-03	1.9E-03	4.3E-05	2.0E-03
Nickel	8.2E-02	3.9E-03	8.6E-02	8.2E-02	1.2E-03	8.3E-02
Selenium	6.5E-01	2.7E-03	6.5E-01	6.5E-01	2.2E-03	6.5E-01
Silver	4.2E-04	4.9E-05	4.7E-04	4.2E-04	1.9E-05	4.4E-04
Strontium	2.2E-03	2.7E-05	2.3E-03	2.2E-03	5.2E-05	2.3E-03
Tin	4.4E-04	7.2E-06	4.5E-04	4.4E-04	7.2E-06	4.5E-04
Uranium	7.8E-02	2.7E-03	8.0E-02	7.8E-02	2.3E-03	8.0E-02

COPC	Mine			Milne Port		
	Baseline	Project	Baseline + Project	Baseline	Project	Baseline + Project
Vanadium	1.8E-01	6.4E-03	1.8E-01	1.8E-01	3.9E-03	1.8E-01
Zinc	5.4E-01	4.8E-04	5.4E-01	5.4E-01	7.0E-04	5.4E-01

Based on the exposure model, the most predominant exposure pathways for the baseline HQ values above 1 are dietary exposure to cadmium, inorganic mercury and methyl mercury through consumption of locally harvested narwhal, ringed seal and caribou. Predicted baseline HQ values are the same for the Milne Port or Mine. Over 90% of the baseline cadmium adult and toddler exposure is derived from caribou organ, narwhal and seal liver, which are not predicted be influence by the project (see Table HC03-10). Similarly, over 90% of the baseline inorganic mercury adult and toddler exposure is derived from caribou organ, narwhal and seal liver, which are not predicted be influence by the project (see HC-03-11). Finally, Table HC-04-12 presents the baseline pathway contribution to methyl mercury HQ values for the adult and toddler. Over 84% of baseline methyl mercury exposure is predicted to be derived from consumption of narwhal, seal liver and seal muscle, which are not predicted to be influence by the project. Human health risks for cadmium and mercury are not influenced from the project and adverse effects from the project are not expected.

Table HC-03-10 Predicted Pathway Contribution for Cadmium

Lifestage	Caribou Organ	Narwhal	Seal Liver	Sum
Adult	49%	8%	37%	94%
Toddler	79%	13%	0%	92%

Table HC-03-11 Predicted Pathway Contribution for Inorganic Mercury

Lifestage	Caribou Organ	Narwhal	Seal Liver	Sum
Adult	9%	14%	74%	97%
Toddler	37%	54%	0%	91%

Table HC-03-12 Predicted Pathway Contribution for Organic Mercury

Lifestage	Narwhal	Seal Liver	Seal Muscle	Sum
Adult	56%	20%	11%	87%
Toddler	70%	0%	14%	84%

As discussed previously, there is a food advisory on consumption of seal liver for children and women of child bearing age, but no food advisory on caribou organ meats. As discussed in Section 2 of this response, The Nunavut Department of Health also identifies that the levels of cadmium in (NWT) caribou are not of concern for caribou health, and caribou remain a safe and healthy food choice for northern people. Specifically, cadmium levels vary considerably with age (increasing levels in older animals), season (higher in spring than in fall), and sex (higher in female vs. male caribou) but the levels of cadmium in (NWT) caribou kidneys are generally low (Nunavut 2015). Gamberg (2008) identifies that Qamanirjuaq caribou herds have low levels of contaminants and there is no immediate cause for concern.

The Inuit Health Study (2010) states that:

- Country foods provide many essential nutrients like *selenium* and *omega-3 fatty acids* that can lower the risk of *chronic diseases*.
- Most Inuit adults in Nunavut should have minimal concern of contaminant-related effects from country food consumption.
- Generally, the benefits and nutritional value of eating country foods outweigh the risks from contaminant exposure.

Note that there is uncertainty in the consumption quantities used in the assessment which are calculated based on regional consumption estimates specifically consumption rates obtained from the IHS results (Chan 2011) are based on the actual number of participants in Nunavut and are not specific to any single community, but rather to all of Nunavut. In cases where specific species (snow goose, ptarmigan, Arctic hare) were not identified in regional datasets assumptions were made based on surrogate species (Canada goose), mass of edible portion (Arctic hare) or consumption rates from other communities (ptarmigan). The narwhal daily consumption rate estimate (based on the sum of the mean plus one standard deviation of the consumption rate for all consumers) specifically may introduce uncertainty into the estimated value. The assumptions used in the determination of the consumption rates could contribute to higher calculated risks than those actually occurring. In order to assess community level exposures, community specific consumption data could be used to recalculate exposures.

The predicted ILCRs for the carcinogenic COPC (*i.e.*, arsenic) are presented in Table HC03-13. The predicted ILCRs at the Mine and at Milne Port are all below the benchmark value of 1 in 100,000. Therefore, the incremental cancer risk from the consumption of country foods collected from the Project area accounting for Project emissions (dust) are considered to be negligible and adverse health effects are not expected.

Table HC03-13 Chronic Incremental Lifetime Cancer Risks for the Indigenous Group

	Incremental Lifetime Cancer Risks (per 100,000)	
	Mine	***Milne Port***
	Project	***Project***
Arsenic	1.6E-01	4.4E-01

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HC 04 ATTACHMENT 1: FULL RESPONSE

Health Canada HC-04 – Air Quality Assessment

Issue/Concern

Air pollution has significant human health impacts. Causal associations have linked poor air quality to respiratory and cardiovascular illnesses, hospitalizations and mortality. Harmful health outcomes attributable to air pollution can range from respiratory symptoms to premature death encompassing acute irritation and respiratory problems, the development or worsening of existing respiratory and/or cardiovascular diseases, and cancer. TSD 07 - Atmospheric Assessment in several areas briefly describes the HTO cabin as not being adversely affected. However, several exceedances are noted to occur in the cabin area, and other sites identified as travel routes, camp sites, and areas visited for cultural significance throughout TSD 05 Mary River Inuit Knowledge Study Map book.

Information Request

1. Health Canada recommends further evaluation of human health impacts, including vulnerable persons, with regards to air quality.

2. If such impacts are found, and if the same contaminants may have an effect on human health through other exposure routes a quantitative risk assessment, such as an HHRA, is recommended.

3. Health Canada suggests that the evaluation is not limited to the HTO Cabin but also including identified areas in TSD 05 for hunting, travelling, camping, recreational water use, and areas cultural importance.

Technical Response

TSD 07 – Atmospheric Assessment provides an air quality assessment of Criteria Air Contaminants (CACs) such as fine particulate matter (PM2.5), particulate matter of 10 microns or less in diameter (PM_{10}), Total Suspended Particulate matter (TSP), nitrogen oxides (NOx), sulphur dioxide (SO_2) and Carbon Monoxide (CO). The TSD 07 assessment focused on areas near the active operational areas (Mine Site, Milne Port, and Tote Road), and areas extending outside of the Project Development Area (PDA) into the Air Quality Local Study Area (AQ LSA). The HTO cabins at the Mine Site and Milne Port were identified as potential locations where local land users could spend time, and both of these cabins are located in the LSA of the Mine Site and Milne Port site.

This technical response will follow Health Canada (2016a) guidance, and will present the following:

- Spatial and temporal boundaries for the assessment
- Identification and characterization of Human Receptors
- A description of exposure pathways
- Identification of Contaminants of Potential Concern
- Assessment of baseline, project alone and “baseline + project” scenarios

Spatial and Temporal Boundaries

Within TSD 07, the LSAs were identified as spatial areas for assessment of air quality (See Section 2.1 of TSD 07). The LSAs allow for an assessment of Project-related effects to air quality at a local, operational scale. LSAs were established at a distance of 3 km around the edge of each established PDA. The HTO cabins at the Mine Site and at Milne Port are located outside of the PDA, but well inside the LSA of each site. The air quality temporal boundary for each of the two project sites were selected to capture the maximum operational impacts. Air dispersion analysis was conducted at full operations for the Mine Site (30 MTpa) and Milne Port area (12 MTpa). Similarly, Tote Road was modelled assuming maximal hauling at 6 MTpa and also assessed assuming a 12 MTpa scenario, wherein the ore is assumed to be hauled up to km 56 on Tote Road, and then transferred to the newly constructed northern rail line at that transfer point. The mine is currently operating and will continue to operate until 2035, under the current proposed plan. Hauling of ore along Tote Road will cease in 2022, once the rail line comes on line. Emissions associated with rail line transport of materials from the Mine to the Port are considerably lower than those associated with the haul road usage. Full details of these spatial and temporal boundaries are presented in TSD 07.

Note that access to the facility areas within the PDAs is restricted, and all non-employees must adhere to the Hunters and Visitor Site Access Procedures, which prohibits non-employee access to active industrial areas of the site, including travel along Tote Road (Baffinland 2015). In summer, hunters and visitors must notify Baffinland's Security personnel if they plan to travel between Milne Port and Mary River. Baffinland will provide arrangements for a safe method of travel, which will be determined based on resources available and size of party. Similarly, winter travel between these areas by non-employees requires them to advise the Security Department prior to departure, such that crossing points for Tote Road can be appropriately notified in advance to ensure safe crossings. In addition to the hazards associated with truck traffic on Tote Road, there are hazards at the Mine Site, including high voltage power lines and a water pipeline. As such, these areas must be avoided. Site visitors must follow the established protocols and approvals, which restricts access to any hazardous or active industrial usage areas of the facility. In light of this, the spatial boundaries of any health risk analysis are limited to areas outside of the PDA.

Identification and Characterization of Human Receptors

Health Canada's IR indicates additional assessment is of merit for air quality in the HTO cabin areas, and other sites identified as travel routes, camp sites, and areas visited for cultural significance throughout TSD 05 Mary River Inuit Knowledge Study Map book. Therefore, the human receptors of concern will be local hunters and gatherers out on the land. The Inuit Map Book (TSD 05) has a number of maps which show travel routes (Figure 1.1 – 1.4), berry picking areas (Figures 1.5 and 1.6), camping locations (Figures 1.7 and 1.8), special places (Figures 1.9 – 1.12), historic sites (Figures 1.13 – 1.14) and stone quarry locations (Figures 1.15 and 1.16). These maps show broad usage of the Baffin Island area, with many travel routes crossing near and through the LSA. There are also some camping areas near the Project area that have either been used historically, or more recently (in one's lifetime). Travel and camping routes are found near the Milne Port, Northern Transportation Corridor and Mine Site. With respect to special places, only carving stone locations are located near the Mine Site, with no special places near either the Milne Port Location or the Northern Transportation Corridor. Based on this information, human receptors, including families with toddlers, and the elderly, could be expected to be in the areas of the PDAs on occasion, for travelling, camping or stone carving collection. The PDA areas are remote to any town or village, and therefore any time spent in the immediate vicinity of the PDAs would be expected to be limited in duration, and infrequent. The two most likely locations where individuals could spend time are the HTO cabins (located at Milne Port and the Mine Site), which are distant from the active areas of the facilities or transportation corridor between Milne Port and the Mine. As indicated previously, access to the active facility areas is restricted, and a strict visitor protocol must be followed. As well, no travel on the Northern Transportation Corridor is allowed, due to the hazards related to haul truck usage of this road.

Exposure Pathways

Exposure to air contaminants within the LSA could occur via air inhalation and dust inhalation. Other potential exposure pathways are being considered under other technical responses, including HC-02 (Drinking water), and HC-03 (Country foods).

Contaminants of Potential Concern (COPCs)

The main COPCs already considered in the TSD 07 are the criteria air contaminants ($PM_{2.5}$; PM_{10}; TSP; NOx; SO_2 and CO). As described in TSD 07, the Project has the potential to generate dust related to the open pit mining operation at the Mine Site, as well as the operations related to ore transport via truck (on Tote Road), and stockpiling, crushing and shipping of materials at Milne Port. The vast majority of the dust is expected to be generated from the mining, transportation, crushing, screening, and stockpiling of ore. Emission sources for each of the three project areas are discussed in TSD 07 (Appendix A Tables 3, 4 and 5).

Inorganics on airborne dust are considered as COPCs. Inorganic fractions of both PM_{10} and $PM_{2.5}$ will be considered in this response. Metals on $PM_{2.5}$ have the potential to travel deeper into the lungs, due to the smaller size of these particles, and hence are considered to be of greater concern from a health perspective. Metals on TSP are not considered, as TSP represents a larger particle size which is generally not carried deep into the respiratory tract, and hence, is not associated with inhalation concerns. The specific inorganic compounds on $PM_{2.5}$ and PM_{10} considered in this Technical Response (HC-04) Air Quality assessment are based on the derivation of geochemistry composition of dusts (which was based on site specific dustfall data collected at dustfall monitoring stations near the Mine Site, Milne Port and Tote Road), which is described in TSD 11 (Section 2.1). Metal composition can vary depending upon particle size, and hence, the application of these metal fractions to finer particulate matter is associated with some degree of uncertainty. Nonetheless, the data are specific to the study area and were therefore considered more appropriate than generic assumptions.

With respect to the CACs, HC-05 requested an evaluation of NO_x, SO_2 and $PM_{2.5}$ relative to the Canadian Ambient Air Quality Standards (CAAQs). The CAAQs are meant to be applied to assist in maintaining and improving air quality in larger communities (communities of 100,000 people or more) which can be impacted by a variety of sources, including vehicular exhaust, industrial emissions, wood smoke, and other sources (CCME 2012a/b; 2018). The CAAQs are instrumental in the Air Quality Management

System (AQMS) established for Canada in 2012, as they assist in protecting human health and the environment through continuous improvements of air quality. They are meant to be applied to measured data, as opposed to predicted data, as they are used to assess existing air quality and ultimately inform the management of air quality-related issues. The CAAQS were developed as part of Canada's Air Quality Management System (AQMS). Under the AQMS, achievement of the CAAQS is determined for air zones across the country. Air management in each air zone is managed by the Air Zone Management Framework. The Canadian Council of Ministers of the Environment (CCME) describes the process for selecting monitoring stations, measuring pollutant concentrations and determining achievement of the CAAQS (CCME 2012a/b). According to CCME, monitoring stations that are used for reporting air data should be located in areas that reflect air quality in communities (CCME 2012b). CCME states that the monitoring stations should not be located near or unduly influenced by nearby emission sources (CCME 2012c). Therefore, the CAAQS are not appropriate to evaluate the acceptability of maximum predicted pollutant concentrations along or near the development boundaries of a project like the Baffinland Iron Ore Mine.

Comparisons of predicted CACs to the CAAQs are undertaken in the Technical Response to HC-05, but the focus of that IR is on mitigation strategies, as opposed to health. Therefore, the health implications of exposure to $PM_{2.5}$, SO_2 and NOx, relative to the CAAQs, are discussed in this Technical Response.

No other chemical analytes associated with Project emissions are considered in this Technical Response such as organic emissions from waste management activities, burning of fuels for power generation, vehicles and equipment, and waste rock handling. With respect to incinerator emissions, these could include volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), dioxins and furans (PCDD/F). A Waste Management Plan, which includes Incineration Operations Procedures (see TSD 28, Phase II EIS) is in place during all phases of the Project in order to minimize emissions from incineration activities. This Management Plan states that all incinerators must operate in accordance with Government of Nunavut's Environmental Guideline for the Burning and Incineration of Solid Waste (GN 2012), and will include stack testing for Chlorinated Dioxins and Furans, as well as mercury, every five (5) years to ensure operations are within Canada Wide Standards for Dioxins and Furans (CCME 2000a) Canada-Wide Standards for Mercury emissions (CCME 2000b). Due to the use modern incineration equipment, and management protocols, these emission sources were not considered further. Truck transport is only occurring for a limited time frame, relative to life of mine, along the Northern Transportation Corridor, as hauling of ore buy truck is anticipated to cease in 2022/2023. With respect to trains travelling between the mine site and port, emissions related to products of combustion will be released and have the potential to produce airborne dust from blow-off from open rail cars. Since the trains will be 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.

Assessment of Baseline, Project Alone and "Baseline + Project" Scenarios

The Baseline scenario is meant to capture the existing conditions, whereas Project Alone will capture the project emissions in the absence of baseline. The Baseline + Project scenario provides the summed concentrations of these two scenarios.

Methods – Metals in Air Exposures

The assessment of potential exposures to metals on particulate matter involves calculation of baseline metals concentrations in ambient air (as measured metals on PM_{10} and $PM_{2.5}$ are not available), as well as prediction of the incremental project concentration (Project Alone), and the Baseline + Project scenario. Each of these scenarios is discussed as follows:

- **Baseline**: Measured baseline concentrations of 24-hour PM_{10} are available from the study area (3.8 µg/m^3; TSD 07; Appendix A; RWDI 2017; Table 6 Measured Baseline Concentrations from the FEIS). No measured baseline was available for $PM_{2.5}$, and hence, $PM_{2.5}$ was assumed to equal 50% of measured PM_{10} (1.9 µg/m^3), which is similar to the value of 1.8 µg/m^3 cited in Health Canada (2016a) as average background level of $PM_{2.5}$ in Canada. To predict baseline metals concentrations on the PM, the geochemistry of dustfall from the Mine, Milne Port and Tote Road areas were used. The specific geochemistry fractions were developed and are presented in Table 2-1a and b of TSD 11, with details being provided in Appendix A of that TSD. These fractions were applied to the baseline PM_{10} and $PM_{2.5}$ data, to estimate metals-specific baseline air concentrations. It is recognized that the baseline metals composition on $PM_{2.5}$ and PM_{10} may be different than that estimated in this project, but since the area is naturally enriched in metals, it is anticipated that this approach is a reasonable surrogate in the absence of site-specific data. Note there are no other projects in the vicinity of this Project that would be anticipated to influence baseline concentrations.
- **Project Alone**: To calculate potential exposures to metals in areas near the PDA where local land users could spend time, predicted PM_{10} and $PM_{2.5}$ isopleth figures (predicted maximum 24 hour concentrations) were reviewed and a representative concentration of each size fraction was selected from the isopleths of the Mine Site (TSD 07 Appendix A; Figure E-11 and E-12; RWDI 2017) and Milne Port (TSD 07; Appendix A; Figure D-11 and D-12, RWDI 2017). Calculations are not provided for Tote Road as Tote Road was assumed to be represented by either the Mine site or Milne Port, based on the similar geochemistry and isopleth figures for the three sites. The site-specific geochemistry fractions for the Mine Site and Milne Port were applied to these selected concentrations, to estimate possible Project Alone exposure concentrations to metals in ambient air. For $PM_{2.5}$, a concentration of 30 µg/m^3 was selected at the Mine Site and Milne Port. This value largely falls near the border of the PDA, and in many cases, inside the PDA (See Figures E-12 and D-12; RWDI 2017; TSD 07, Appendix A). For PM_{10}, a concentration of 100 µg/m^3 was selected. This concentration occurs inside the PDA at the Mine and Milne Port, but also stretches to areas approximately 1 km or 1.5 km from the PDA at the Mine Site (see Figure E-11 and D-11; RWDI 2017; TSD 07, Appendix A). In addition, concentrations of $PM_{2.5}$ and PM_{10} at the two HTO cabins were also estimated from the isopleth figures and were included in the assessment. For PM_{10}, the estimated PM_{10} 24-hour air concentration at the HTO cabins was 30 µg/m^3, and for $PM_{2.5}$, the estimated 24-hour air concentration was 10 µg/m^3.
- **Project + Baseline**: the estimated baseline metals air concentrations were added to the estimated Project alone increment, to calculate an estimated total concentration for each metal in air.

- **Ambient Air Quality Guidelines**: To assess the predicted concentrations, 24 hour ambient air quality criteria were selected from Ontario.

Assessment Results – Metals in Air

Table HC-04-1 presents the estimated metals concentrations on PM_{10}, near the Mine Site and Milne Port as well as the HTO cabins. None of the estimated concentrations exceed ambient air quality criteria, with the exception of iron. The iron ambient air quality benchmark is based on soiling, and hence, is not associated with health effects (MOE 2005).

Table HC-04-2 presents the estimated metals concentrations on $PM_{2.5}$, near the Mine Site and Milne Port, as well as the HTO cabins. None of the estimated concentrations exceed ambient air quality guidelines.

Based on this assessment, possible exposures to metals in air are not considered to present a risk to local land users. This assessment is considered conservative, in that it used the maximum daily predicted concentrations for either PM_{10} or $PM_{2.5}$ and site-specific geochemistry developed from dustfall samples at the locations. Metals partitioning on particulate can vary depending upon particle size, and hence, there is some uncertainty in these estimates. In addition, local land users would be expected to be in the area infrequently, due to the remote nature of the surrounding environment. Based on the low estimated exposure levels, the risk from exposure to particulate-bound metals in air is considered to be low. Concentrations for areas further from the PDA would be expected to be lower, and therefore, those using the land in areas more distant to the PDAs would experience lower exposure levels than those estimated in this evaluation.

Table HC-04-1 Estimated Exposures to Ambient Metals on Particulate (PM_{10}) in Areas Outside the PDA near the Mine Site and Milne Port, and at the HTO Cabins

Metals	Ontario 24 Hour Benchmark (ug/m^3)	Baseline PM_{10}[1] (ug/m^3)	Mine outside PDA (PM_{10})			Milne Port outside PDA (PM_{10})			HTO Cabin - Milne Port		HTO Cabin - Mine site	
			% Metals on dust - Mine	Project Increment PM_{10} (100 ug/m^3)[2,3]	Baseline+Project (Column C+E) (ug/m^3)	%Metals on Dust - Milne Port	Project Increment PM_{10} (>100 ug/m^3)[2,3]	Baseline+Project (Column C+H) (ug/m^3)	Project Increment PM_{10} (30 ug/m^3)[2,3]	Baseline+Project (Column C+I) (ug/m3)	Project Increment PM_{10} (assumed 30 ug/m^3)[2,3]	Baseline+Project (Column D+L) (ug/m^3)
Aluminum	12	0.108	2.83	2.83	2.94	1.58	1.58	1.69	0.474	0.582	0.849	0.957
Antimony	25	0.0000532	0.0014	0.0014	0.0015	0.00054	0.00054	0.00059	0.00016	0.00022	0.00042	0.00047
Arsenic	0.3	0.000125	0.0033	0.0033	0.0034	0.018	0.018	0.018	0.0054	0.0055	0.0010	0.0011
Barium	10	0.000494	0.013	0.013	0.013	0.013	0.013	0.013	0.0039	0.0044	0.0039	0.0044
Cadmium	0.025	0.0000456	0.0012	0.0012	0.0012	0.00091	0.00091	0.0010	0.00027	0.00032	0.00036	0.00041
Chromium (III)	0.5	0.00076	0.020	0.020	0.021	0.0066	0.0066	0.0074	0.0020	0.0027	0.0060	0.0068
Cobalt	0.1	0.000103	0.0027	0.0027	0.0028	0.0013	0.0013	0.0014	0.00039	0.00049	0.00081	0.00091
Copper	50	0.000608	0.016	0.016	0.017	0.022	0.022	0.023	0.0066	0.0072	0.0048	0.0054
Iron	4	0.168	4.43	**4.43**	**4.60**	3.06	3.06	3.23	0.918	1.09	1.33	1.50
Lead	0.5	0.000103	0.0027	0.0027	0.0028	0.0017	0.0017	0.0018	0.00051	0.00061	0.00081	0.00091
Manganese	0.2	0.00418	0.11	0.11	0.11	0.064	0.064	0.068	0.019	0.023	0.033	0.037
Mercury	2	0.0000418	0.0011	0.0011	0.0011	0.0021	0.0021	0.0021	0.00063	0.00067	0.00033	0.00037
Molybdenum	120	0.000095	0.0025	0.0025	0.0026	0.00045	0.00045	0.00055	0.00014	0.00023	0.00075	0.00085
Nickel	0.1	0.000646	0.017	0.017	0.018	0.0062	0.0062	0.0068	0.0019	0.0025	0.0051	0.0057
Selenium	10	0.000125	0.0033	0.0033	0.0034	0.0032	0.0032	0.0033	0.0010	0.0011	0.0010	0.0011
Silver	1	0.00000365	0.000096	0.00010	0.0001	0.000044	0.000044	0.000048	0.000013	0.000017	0.000029	0.000032
Strontium	120	0.000243	0.0064	0.0064	0.0066	0.015	0.015	0.015	0.0045	0.0047	0.0019	0.0022
Thallium	0.5	0.00000171	0.000045	0.000045	0.000047	0.00032	0.00032	0.00032	0.00010	0.00010	0.000014	0.000015
Tin	10	0.0000224	0.00059	0.00059	0.00061	0.00071	0.00071	0.00073	0.00021	0.00024	0.00018	0.00020
Uranium	0.15	0.0000266	0.00070	0.00070	0.00073	0.00071	0.00071	0.00074	0.00021	0.00024	0.00021	0.00024
Vanadium	2	0.000220	0.0058	0.0058	0.0060	0.0042	0.0042	0.0044	0.0012	0.0015	0.0017	0.0020
Zinc	120	0.00095	0.025	0.025	0.026	0.053	0.053	0.054	0.016	0.017	0.0075	0.0085

Notes:

* Baseline PM_{10} values RWDI 2017 3.8 ug/m^3 - no baseline $PM_{2.5}$ data are available. Metals on $PM_{2.5}$ are not available; therefore, metals from the project (%) were assumed to be similar to metals in baseline

** All Ontario guidelines were from 'Ontario's Ambient Air Quality Criteria' April 2012. The limiting effect for all metals were "Health", except for Aluminum and Zinc, which were "Particulate". For chemicals where multiple ambient air quality criteria (AAQC) are available from the MOE (2012), the following AAQC were selected for use: the AAQC for manganese (Mn) is the AAQC for Mn in PM_{10}; the AAQC for nickel (Ni) is the AAQC for Ni in PM_{10}; and, the AAQC for uranium (U) is the AAQC for U in PM_{10}.

[1] Baseline Values predicted from measured baseline PM_{10} value of 3.8 ug/m^3, with assumed same geochemistry as mine site

[2] Percent composition of particulates from Table 2-1a, TDS 11; based on site geochemistry data

[3] Project values selected from RWDI 2017 air dispersion figure E-12 (mine) and D-12 (Milne Port) ($PM_{2.5}$) Figure E-11 (mine) and D-11 (Milne Port) (PM_{10})

Bolded and shaded values indicate an exceedance of the MOE (2012) air quality guidelines

Table HC-04-2 Estimated Exposures to Ambient Metals on Particulate ($PM_{2.5}$) in Areas Outside the PDA near the Mine Site and Milne Port, and at the HTO Cabins

Metals	Ontario 24 Hour Benchmark (ug/m^3)	Baseline $PM_{2.5}$[1] (ug/m^3)	Mine outside PDA ($PM_{2.5}$)			Milne Port outside PDA ($PM_{2.5}$)			HTO Cabin - Milne Port		HTO Cabin - Mine site	
			% Metals on dust - Mine[2]	Project Increment $PM_{2.5}$ (30 ug/m^3)[2, 3]	Baseline+Project (Column C+E) (ug/m^3)	%Metals on Dust[2] - Milne Port	Project Increment $PM_{2.5}$ (30 ug/m^3)[2,3]	Baseline+Project (Column C+H) (ug/m^3)	Project Increment $PM_{2.5}$ (<10 ug/m^3)[2,3]	Baseline+Project (Column C+I) (ug/m^3)	Project Increment $PM_{2.5}$ (assumed <10 ug/m^3)[2,3]	Baseline+Project (Column D+L) (ug/m^3)
Aluminum	12	0.05377	2.83	0.849	0.903	1.58	0.474	0.528	0.158	0.212	0.283	0.337
Antimony	25	0.0000266	0.0014	0.00042	0.00045	0.00054	0.00016	0.00019	0.000054	0.000081	0.00014	0.00017
Arsenic	0.3	0.0000627	0.0033	0.00099	0.0011	0.018	0.0054	0.0055	0.0018	0.0019	0.00033	0.00039
Barium	10	0.000247	0.013	0.0039	0.0041	0.013	0.0039	0.0041	0.0013	0.0015	0.0013	0.0015
Cadmium	0.025	0.0000228	0.0012	0.00036	0.00038	0.00091	0.00027	0.00030	0.000091	0.00011	0.00012	0.00014
Chromium (III)	0.5	0.00038	0.02	0.0060	0.0064	0.0066	0.0020	0.0024	0.00066	0.0010	0.0020	0.0024
Cobalt	0.1	0.0000513	0.0027	0.00081	0.00086	0.0013	0.00039	0.00044	0.00013	0.00018	0.00027	0.00032
Copper	50	0.000304	0.016	0.0048	0.0051	0.022	0.0066	0.0069	0.0022	0.0025	0.0016	0.0019
Iron	4	0.08417	4.43	1.33	1.41	3.06	0.918	1.00	0.306	0.390	0.443	0.527
Lead	0.5	0.0000513	0.0027	0.00081	0.00086	0.0017	0.00051	0.00056	0.00017	0.00022	0.00027	0.00032
Manganese	0.1	0.00209	0.11	0.033	0.035	0.064	0.019	0.021	0.0064	0.0085	0.011	0.013
Mercury	2	0.0000209	0.0011	0.00033	0.00035	0.0021	0.00063	0.00065	0.00021	0.00023	0.00011	0.00013
Molybdenum	120	0.0000475	0.0025	0.00075	0.00080	0.00045	0.00014	0.00018	0.000045	0.000093	0.00025	0.00030
Nickel	0.1	0.000323	0.017	0.0051	0.0054	0.0062	0.0019	0.0022	0.00062	0.00094	0.0017	0.0020
Selenium	10	0.0000627	0.0033	0.0010	0.0011	0.0032	0.0010	0.0010	0.00032	0.00038	0.00033	0.00039
Silver	1	0.000001824	0.000096	0.000029	0.000031	0.000044	0.000013	0.000015	0.0000044	0.0000062	0.000010	0.000011
Strontium	120	0.0001216	0.0064	0.0019	0.0020	0.015	0.0045	0.0046	0.0015	0.0016	0.00064	0.00076
Thallium	0.5	0.000000855	0.000045	0.000014	0.000014	0.00032	0.00010	0.00010	0.000032	0.000033	0.0000045	0.0000054
Tin	10	0.00001121	0.00059	0.00018	0.00019	0.00071	0.00021	0.00022	0.000071	0.000082	0.000059	0.000070
Uranium	0.15	0.0000133	0.00070	0.00021	0.00022	0.00071	0.00021	0.00023	0.000071	0.000084	0.000070	0.000083
Vanadium	2	0.0001102	0.0058	0.0017	0.0019	0.0042	0.0012	0.0014	0.00042	0.00053	0.00058	0.00069
Zinc	120	0.000475	0.025	0.0075	0.0080	0.053	0.016	0.016	0.0053	0.0058	0.0025	0.0030

Notes:

** All Ontario guidelines were from 'Ontario's Ambient Air Quality Criteria' April 2012. The limiting effect for all metals was "Health", except for Aluminum and Zinc, which were "Particulate", and Iron, which was "soiling" For chemicals where multiple ambient air quality criteria (AAQC) are available from the MOE (2012), the following AAQC were selected for use: the AAQC for manganese (Mn) is the AAQC for Mn in $PM_{2.5}$; the AAQC for nickel (Ni) is the AAQC for Ni in PM_{10}; and, the AAQC for uranium (U) is the AAQC for U in PM_{10}.

[1] Baseline $PM_{2.5}$ values were estimated at 1.9 ug/m^3, based on measured PM_{10} values of 3.8 ug/m^3, divided by 2. Baseline metal concentrations on $PM_{2.5}$ are not available; therefore, the metal concentrations in baseline air were assumed to be similar to the geochemistry data on particulate matter from the project (%), applied to the estimated $PM_{2.5}$ value of 1.9 ug/m3

[2] Percent composition of particulates from Table 2-1a, TDS 11; based on site geochemistry data

[3] Project values selected from RWDI 2017 air dispersion figure E-12 (mine) and D-12 (Milne Port) ($PM_{2.5}$); Figure E-11 (mine) and D-11 (Milne Port) (PM_{10})

Bolded and shaded values indicate an exceedance of the MOE (2012) air quality guidelines

Methods – CAAQS

The assessment of potential exposures to CAAQs involves estimation of baseline concentrations in ambient air, as well as prediction of the incremental project concentration (Project Alone), and the Baseline + Project scenario. For $PM_{2.5}$, the CAAQS-relevant exposure level is calculated using the 3-year average of the annual 98th percentile of the daily 24-hour average concentrations. For SO_2, the CAAQS-relevant exposure is calculated using the 3-year average of the annual 99th percentile of the SO_2 daily maximum 1-hour average concentrations, and for NO_2, the CAAQS-relevant exposure is calculated using the 3-year average of the annual 98th percentile of the NO_2 daily maximum 1-hour average concentrations (CCME 2018). As such, the calculation is meant to be conducted with measured data, as opposed to predicted data. In addition, in the current circumstance related to Baffinland Iron Ore Mines, land use in the areas near the mine is sporadic, rather than involving a typical residential/community land use scenario. As such, local land users would be unlikely to be exposed over protracted periods of time.

The methods used to predict possible exposure levels, based on the CAAQs averaging periods are described below, for Baseline, Project Alone and Project + Baseline. All calculations relative to the CAAQs and air dispersion modelling were conducted by RWDI.

- **Baseline**: There are no baseline $PM_{2.5}$ data for the site. In the metals air quality assessment, $PM_{2.5}$ was assumed to equal 50% of measured baseline 24-h PM_{10} value (1.9 µg/m^3), which is similar to the value of 1.8 µg/m^3 cited in Health Canada (2016a; averaging metric not stated) as typical background levels of $PM_{2.5}$ in Canada. The site-specific value is a 24 hour average value, as opposed to a value calculated following the CAAQs protocol (for $PM_{2.5}$, a 3-year average of the 98th percentiles of the 24 hour $PM_{2.5}$ concentrations). Similar challenges occur with NO_2 and SO_2, as only a 30-day average values are available for both of these contaminants for baseline (0.188 µg/m^3 for NO_2, and 0.262 µg/m^3 for SO_2; see TSD 07; RWDI 2017 Appendix A; Table 6). Despite these limitations, these data were used to represent baseline concentrations. No annual average baseline concentrations are available, and hence, no value was selected in these instances. Note there are no other Projects in the vicinity of this Project that would be anticipated to influence baseline concentrations.

- **Project Alone**: To calculate potential exposures to $PM_{2.5}$, NO_2 and SO_2 associated with the Project, using the CAAQs metrics, RWDI conducted supplementary calculations and modelling to predict exposure levels. Note that these calculations are based on 1 year of meteorological data, as opposed to 3 years. A sequence of figures provide the isopleths indicating possible exposure levels, relative to the CAAQs management thresholds (see Appendix A of this Technical Response; Mine Site: Figure E-1b SO_2 hourly; Figure E3 SO_2 Annual; Figure E4b NOx 1 hour; Figure E6 NOx annual; Figure E12b $PM_{2.5}$ 24 hour; and Figure E15 $PM_{2.5}$ annual; Milne Port: Figure D1b SO_2 1hr; Figure D3 SO_2 Annual; Figure D4b NOx 1 hour; Figure D6 NOx annual; Figure D12b $PM_{2.5}$ 24 hour; Figure D15 $PM_{2.5}$ annual; Tote Road: Figure F16b $PM_{2.5}$ 24 hour; Figure F19 $PM_{2.5}$ annual). To select a concentration for assessment purposes, a range of concentrations are provided in Table HC-04-3 for areas outside the PDA, based on visual inspection of the isopleth diagrams. There are cases wherein a very small area outside the PDA is predicted to have higher concentrations than the upper value selected, but these areas are limited in size, and the CAAQs are not meant to be applied at the fenceline.

- **Project + Baseline**: the estimated baseline air concentrations were added to the estimated Project alone increment to calculate estimated total concentrations for the criteria air contaminants. It is recognized that since the metrics of the baseline data are not the same averaging periods as those in the Project predicted data, there is some uncertainty in this addition. Where no baseline data are available, this calculation was not completed.

Ambient Air Quality Guidelines: The CAAQs were used to assess the predicted future air concentrations.

Assessment Results – $PM_{2.5}$, SO_2 and NO_2

The baseline and predicted future Project concentrations are provided in Table HC-04 -3, relative to the CAAQs. Where the concentration range predicted for an area is exceeded, the cell is shaded, and further discussion is provided. The possible exposure levels at the HTO cabins are discussed as well.

$PM_{2.5}$

Predicted concentrations of $PM_{2.5}$ based on the 24 hr and annual calculations are less than the CAAQs outside the PDA at both the Mine site and Milne Port, as well as both HTO cabins. However, the predicted concentrations in close proximity to certain areas along Tote Road exceed both the 24 hr CAAQs and the annual average CAAQS (Table HC-04-3). With respect to Tote Road, the 24 hr CAAQs of 27 $\mu g/m^3$ is only exceeded in a small area near the construction railbed (see Figure F-16b; Appendix A). Hunters or travellers could pass through this area, but areas in proximity to the Tote Road are managed by Baffinland, and any non-employees in the area must report to and follow Baffinland's protocols related to site visitation. As a result, any exposures to elevated $PM_{2.5}$ would be limited, infrequent, and transient.

In light of the fact that no clear threshold of effect has been identified for $PM_{2.5}$, there is increased risk associated with any increase in exposure. Therefore, since the model predicts increased exposure levels in the Tote Road area, as well as areas in close proximity to the Mine and Milne Port (relative to baseline), there is an increase in risk present in all three areas (relative to baseline). The extent of this risk will depend on a number of factors, including the magnitude of the increase in air concentrations, the likelihood of a person being present at the location where the $PM_{2.5}$ concentrations are expected to occur, and the potential susceptibility of that person to $PM_{2.5}$ exposure.

There are several factors that merit further discussion to contextualize the risk, as follows:

- There is an inherent level of conservatism in the air dispersion model which may bias the predicted future air concentrations high, relative to that which may occur in the future. The air dispersion modelling was conducted to maximize emissions over a peak year of operations, and hence, emissions, and exposure levels will be lower than those projected during non-peak years of operations. For the Mine site, the majority of $PM_{2.5}$ is related to road dust on the road, material handling and grading of the Tote Road. For the Milne Port area, two ships were assumed to be continuously idling at the port, and three other ships were assumed to be idling at anchor from July to October. In addition, three tugboats were assumed to be continuously operating from July to October. These assumptions likely bias the emissions of $PM_{2.5}$ high in both areas.

- Because of its small size, $PM_{2.5}$ can reach deep into the lungs, and there is a vast literature on the associations between $PM_{2.5}$ and cardiovascular and respiratory mortality and morbidity (sickness) which are well documented (WHO 2013). The specific toxicity data considered in the development of the $PM_{2.5}$ is not cited on the CCME website (CCME 2018), but would be based on the significant research related to large epidemiology studies from cities in North America, Europe, and other parts of the globe, as per the US EPA science assessment of $PM_{2.5}$ (US EPA 2009). Much of the literature is focused on large cities, with complex mixtures of air pollutants. As such, it is difficult to determine the magnitude of change in the frequency of mortality or morbidity (sickness) because of small changes in $PM_{2.5}$, as is the case for the much of the areas inside the LSA. Concentrations of $PM_{2.5}$ predicted for the HTO cabins at Milne Port and the Mine Site are very low (3 $\mu g/m^3$ for the 24 hour average metric at the Mine site, and 7 $\mu g/m^3$ for the 24 hour average at Milne Port; see Table HC-04-3). Baseline concentrations are somewhat uncertain but are estimated at 1.9 $\mu g/m^3$. The minor increase in exposure levels predicted for the Project relative to baseline at the HTO cabins (which are locations that hunters and travellers would have the highest likelihood of spending time at) are not considered to represent a situation of concern with respect to adverse health outcomes.

- Comparison of the Tote Road predicted 24-hour ground-level air concentrations for $PM_{2.5}$ where exceedances of the CAAQs of 27 $\mu g/m^3$ are predicted to occur (Figure F-16b). Since travellers and hunters are infrequently in the area, exposures could be lower than those predicted on the actual days people are there. Overall, the likelihood that a hunter or traveller (including vulnerable members of the population, such as elderly or young) would be present in areas in close proximity to Tote Road for extended periods of time, and experience elevated exposures is considered to be low.

- As previously described, concentration-response functions and the associated concept of no-threshold of effect are based on large urban centres with typical populations well in excess of one million people (i.e., significantly larger than the population within the LSA, wherein there is no village or town). To reliably measure a small relative risk, large study populations are required to confirm adequate statistical strength. However, analysis of short-term exposure-response relationships for $PM_{2.5}$ do not always demonstrate evidence for increased mortality, indicating other factors may be responsible. Baxter et al. (2012) documented significant heterogeneity among community-specific $PM_{2.5}$ estimates of mortality effects between 27 communities in the United States. The magnitude of the effect varies dependent on the nature of the particulate matter (e.g., types of emission sources, composition of particulate matter), the characteristics of the exposed population (e.g., presence of vulnerable or susceptible groups, such as individuals with pre-existing health conditions), and the extent of the exposure itself (e.g., concentrations of $PM_{2.5}$ and length of exposure). Hoek et al. (2013) identified significant heterogeneity in $PM_{2.5}$ effect estimates, likely related to differences in particle composition, infiltration of particles indoors, population characteristics and methodological differences in exposure assessment and other risk factors that can confound the results. Therefore, a certain degree of caution should be exercised when applying the findings of large urban studies to exposures within the existing LSA.

- Similar statements can be made with respect to annual $PM_{2.5}$ exposure levels. Figure F-19 (Appendix A) illustrates that small areas near Tote Road exceed the annual CAAQs of 8.8 µg/m^3. This area is remote, and no hunter or traveller would be present in these areas over a year time frame. Therefore, the predicted annual concentrations are not considered to represent a situation denoting a health concern for local travellers or hunters, albeit, risks associated with annualized exposure will be higher than those associated with baseline, if people were to spend significant timeframes in the areas in close proximity to the road. The vast majority of the lands where hunters and travellers will spend time (including vulnerable members of the populations, such as the elderly or very young) are predicted to have lower concentrations. Areas which could see visitors on a more frequent basis, such as the HTO cabins near the Mine site and Milne Port, indicate exposure levels at these areas are predicted to be at 1 µg/m^3 (see Table HC-04-3).

- Based on this evaluation and the predicted air concentrations, the potential risk of adverse health effects associated with the predicted $PM_{2.5}$ concentrations is considered to be low.

Table HC-04 – 3 Estimated Exposure Levels to $PM_{2.5}$, SO_2 and NO_2 Relative to the Canadian Ambient Air Quality Standards (CAAQs) Near the Mine Site, Milne Port, and Tote Road, and HTO Cabins

Pollutant	CAAQs (µg/m³)[a]		Baseline[b]	Mine Outside PDA				Milne Port Outside PDA				Tote Road	
				Project Alone	Baseline + Project	HTO Cabin	HTO Cabin + Baseline	Project Alone	Baseline + Project	HTO Cabin	HTO Cabin + Baseline	Project Alone	Baseline + Project
$PM_{2.5}$	24 hr	28/27	1.9	< 15 - 20	21.9	3	4.9	<15	15.19	7	8.9	< 15 - > 30	< 16.9 – > 31.9
	Annual	10.0/8.8	NV	5	5	1	1	< 1 - < 5	< 1 - < 5	1	8.9	< 1 - > 8.8	< 1 - > 8.8
SO_2	1 hr	183/170	0.262	< 15	15.262	0.3	0.652	<15	15.262	10.6	10.86	NM	NM
	Annual	13/10.5	NV	<0.3	NS	0.02	NS	< 0.3 - <1.5	NS	0.2	NS	NM	NM
NO_2	1 hr	113/79	0.262	<79 - 200	79-200	109	109.26	79 - 200	200	133	133.26	NM	NM
	Annual	32/23	NV	< 15-32	NS	11	NS	<23	NS	15	NS	NM	NM

NV = no value available; NS = in the absence of a baseline value, Project + Baseline was not calculated. NM = not modelled; no significant sources of these pollutants are present in this area (see Table 5, TSD 07; Appendix A). Shaded cells in table exceed the CAAQs

A CAAQ values are the 2020 or 2025 limits, as per CCME. All values are expressed in µg/m³, with conversions of ppb to µg/m³ for NOx using a factor of 1.88, and 2.62 for SO_2

B Baseline data are limited and are either a 30-d average (SO_2 and NO_2) or a 24 hour average, as opposed to being calculated following the CAAQs statistical approach. Hence there are uncertainty in these values.

SO_2

None of the SO_2 CAAQs are predicted to be exceeded outside the PDA at the Mine, or Milne Port, as well as the HTO cabins at both the Mine and the Milne Port site (Table HC-04-3). Exposure levels are predicted to be low, relative to the CAAQs. Therefore, risks to hunters and travellers, including vulnerable members of the population, are expected to be low if they happen to be in the vicinity of the facilities.

NO_2

NO_2 is predicted to exceed the CAAQs at the Mine and Milne Port sites in areas outside the PDA, for the 1 hr averaging period at both sites and the annual average metric at the Mine site (see Figure E-4b; 24 Hr; and Figure E-6; Mine Site; and Figure D-4b and D-6, Milne Port; Appendix A). Predicted NO_2 concentrations do not exceed the 1 hour or annual guideline at the Mine HTO cabin, but predicted levels do exceed the 1 hour guideline at the Milne Port HTO cabin. As discussed for $PM_{2.5}$, since land use by local hunters and travellers is more infrequent and transient, there is a low likelihood of people experiencing an annual average level of exposure in the remote areas of the Mine or Milne Port. With regard to the 1 hour averaging period, exceedances extend well beyond the PDA boundary at the Mine site into the LSA (see Figure E-4b; Appendix A). At Milne Port, the situation is similar, with a wide area being affected (Figure D-4b; Appendix A). The calculation for NO_2 involves the identification of the daily maximum 1- hour average concentrations, and the calculation of a 3 year average of the annual 98th percentile of those values. The CAAQs of 113 µg/m^3 (2020) and 79 µg/m^3 (2025) are conservative, relative to the Nunavut 1-hour ambient air quality standard NO_2 of 400 µg/m^3 (which was not exceeded in areas outside the PDA at Milne Port (Figure D-4; TSD 07); or Mine site (Figure E-4; TSD 07).

The predicted short-term NO_2 concentrations merit further discussion.

- From information provided by RWDI, the primary sources of nitrogen oxides at the facilities at Milne Port are the tugboats, ships in transit, ships idling at the port, and generators. For the Mine, NO_2 is largely related to generators and diesel equipment on the haul roads (see Table 3 and 4; TSD 07; Appendix A). Several conservative assumptions were implemented at both locations. For Milne Port, two ships were assumed to be continuously idling at the port and three others were idling at the anchor locations from July to October; three tugboats were assumed to be continuously operating from July to October. In addition, 10 generators were assumed to be continuously operating and 100 frost fighters were assumed to be continuously operating from November to April. The Frost Fighters are low release sources of NO_2 that may have a significant contribution to predicted NO_2 concentrations. For the Mine, seven generators were assumed to be continuously operating in addition to 100 frost fighters were assumed to be continuously operating from November to April. The air dispersion modelling was conducted to maximize emissions over a peak year of operations, and hence, emissions, and exposure levels will be lower than those projected during non-peak years of operations.

- The epidemiology literature on NO_2 is likely conservative relative to the air quality in Baffin Island near the Project area, in that the evaluation of the potential for adverse health effects relies on many studies conducted in large urban areas with complex emission sources and pollutants (Health Canada 2016b). The air quality mixture in the remote areas of Baffin Island, near the Project facilities could differ from the complex mixtures in many of these studies. Many of these studies considered in Health Canada (2016b) link exposures (and associated health outcomes) to a single central air quality monitoring site, which does not account for exposures occurring at the homes of people reporting health outcomes. There could be additional specific exposures occurring with regard to the individuals reporting health effects, which are not accounted for in these studies. Health Canada (2016b) also indicates that co-pollutant exposures could also be playing a role in some cases. Therefore, as per $PM_{2.5}$, care must be taken when assessing the potential for adverse health effects associated with NO_2, based on the application of the CAAQs standards which are based on complex urban air quality environments to the areas near the proposed project.

- The locations with the highest likelihood of exposure are the HTO cabins near the Milne Port facility and the Mine site. The 1-hour average exposure metric meets the 2020 CAAQs limit at the Mine Site cabin but is projected to exceed the 2025 limit (See Table HC-04-3). The Milne Port HTO cabin exceeds both the 2020 and the 2025 1-hour CAAQs limit (Table HC-04-3). Risks associated with an exceedance of the annual average are not considered relevant, as the HTO cabins are not full-time residential locations, and hence exposures occurring at these locations will be more short-term in nature. For the Mine site and Milne Port HTO cabins, as well as areas near the Mine and Port facilities, the predicted 1-hour values suggest there is a potential for increased exposures relative to the guidelines. For hunters and travelers to actually experience elevated exposures, they would have to be in the area on days and time frames when the NO_2 values are elevated. As discussed previously, the CAAQS for NO_2 is based on the 3-year annual average of the annual 98th percentile of the daily maximum 1-hour average concentrations. This is in essence the average of the 3 years' 8th highest predicted concentration.

- A substantial amount of toxicity literature is available that describes the short-term (acute) health effects of NO_2 (see Table HC-04-4). While some studies have reported mild respiratory effects in asthmatics at levels of NO_2 in the range of 190 to 560 µg/m³, because of the absence of a clear dose–response relationship and statistical uncertainty in these studies, the findings are not considered to reflect the acute effects associated with NO_2 exposure (Forastiere et al. 1996; WHO 2000; Cal EPA 2007). At the upper end of that concentration range (490 µg/m³), possible allergen induced decrements in lung function and increased allergen induced airways inflammatory responses were reported among asthmatics (Strand et al. 1997; Cal EPA 2007; US EPA 2008). However, a more recent meta-analysis of NO_2 exposure and airway hyper-responsiveness in asthmatics indicates that there is no clear evidence that NO_2 causes clinically relevant effects in asthmatics at concentrations up to 1,100 µg/m³ (Goodman et al. 2009).

Table HC-04-4: Summary of Potential Acute Health Effects of Nitrogen Dioxide

Air Concentration		Description of the Potential Acute Health Effects[a]
(µg/m³)	(ppb)	
<190	<100	No documented reproducible evidence (consistent and significant) of adverse health effects among healthy individuals or susceptible individuals following short-term exposure. Study results are variable and are indiscernible from background or control groups.
190 to 560	100 to 300	Increased airways responsiveness, detectable via meta-analysis, among asthmatics; however, large variability in protocols and responses. At the higher end of the range, possible allergen induced decrements in lung function and increased allergen induced airways inflammatory response among asthmatics. Most studies used non-specific airways challenges.
560 to 750	300 to 400	Potential effects on lung function indices, including inconsistent changes FEV_1 and forced vital capacity among patients with COPD during mild exercise.
1,900 to 3,700	1,000 to 2,000	Asthmatics might experience small decrements in FEV_1. Increased likelihood of inflammatory response and airway responsiveness among healthy individuals during intermittent exercise. Symptoms have not been detected by most investigators among healthy individuals.
≥3,700	≥2,000	Changes in lung function, such as increased airway resistance, in healthy individuals.

NOTE:
Sources: Beil and Ulmer (1976); von Nieding and Wagner (1977); von Nieding et al. (1979, 1980); Hazucha et al. (1983); Koenig et al. (1985); Morrow et al. (1992); Jorres et al. (1995); Vagaggini et al. (1996); Blomberg et al. (1997); Strand et al. (1997); Azadniv et al. (1998); Blomberg et al. (1999); Devlin et al. (1999); Gong et al. (2005); Cal EPA (2007); US EPA (2008); Hesterberg et al. (2009); Goodman et al. (2009).
FEV_1 = forced expiratory volume in 1 second; COPD = chronic obstructive pulmonary disease; µg/m³ = microgram per cubic metre; < = less than; ≥ = less than or equal to.

The predicted 1-hour NO_2 concentrations for the two HTO cabins at the Mine and at Milne Port are below levels at which short-term, clinically significant adverse health effects have been identified in toxicity studies. Frequency analysis at the HTO cabins at Milne Port and the Mine site, in areas outside the PDA at each of these locations indicates the following:

- The peak (or maximum) 1-hour NO_2 concentration (159 µg/m³ at Milne Port; 117 µg/m³ at Mine site) are not predicted to exceed the Nunavut hourly ambient air quality standard of 400 µg/m³ at locations where members of the public (i.e., non-employees) are most likely to be.
- The peak 1-hour NO_2 concentration at these two locations are not predicted to exceed 190 µg/m³, the concentration at which no short-term effects have been identified in toxicity studies.

All 1-hour air concentrations outside the PDA at the Mine and Milne Port meet the 1-hr NO_2 Nunavut air quality standard of 400 µg/m³ (see TSD 07). Although there are some areas outside the PDA of both areas where air concentrations are predicted to range from 200 to 300 µg/m^3 (See TSD 07; Figure D-4 for Milne Port, and Figure E-4 for Mine Site), these areas are: (a) small in size; and, (b) associated with hourly concentrations that are lower than concentrations at which possible allergen induced respiratory effects have been reported in some exercising individuals with pre-existing breathing disorders (490 µg/m^3). Based on the above information, the overall weight of evidence indicates that, despite the predicted exceedances of the 1-hour CAAQS for NO_2, the potential risk of adverse health effects as a result of short-term exposure to NO_2 in the LSA is low.

Mitigation

Emissions reductions are an ongoing and iterative process for Baffinland that involves the consideration of best practices, new technologies, and updated guidelines and regulations. As part of the Phase 2 Proposal, Baffinland has included installation of wind turbines, which would reduce overall emissions, including NOx.

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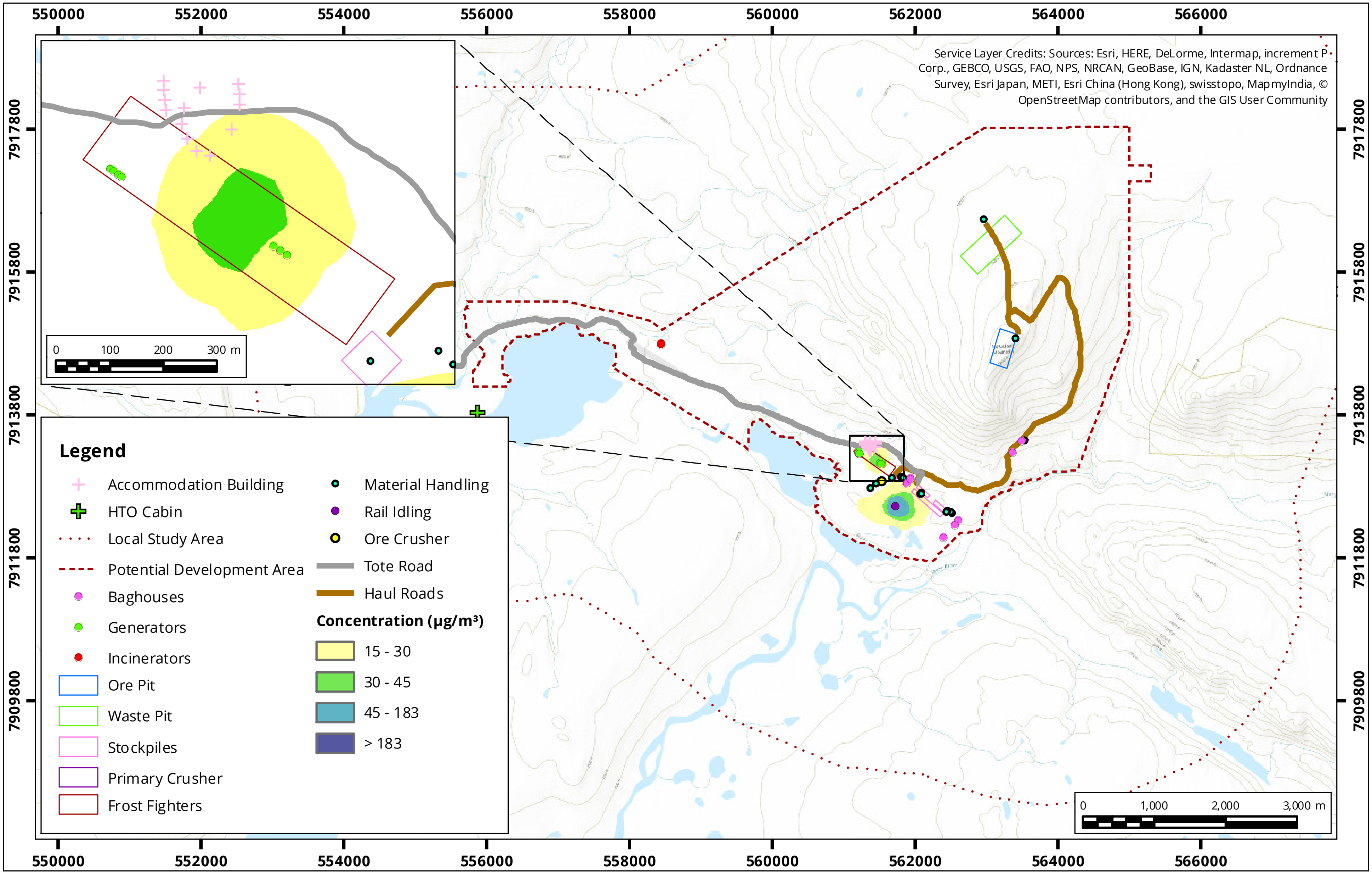
Predicted Concentrations of SO_2, NO_2 and $PM_{2.5}$ Related to CAAQs at the Mine Site, Milne Port and Northern Transportation Corridor. RWDI, 2018

Mine Site Isopleth Figures; CAAQs; RWDI, 2018



Predicted 1-Hour SO_2 Concentrations

Mine Site

True North

Drawn by: DJH | Figure: E-1b

Approx. Scale: 1:75,000

Date Revised: Dec 13, 2018

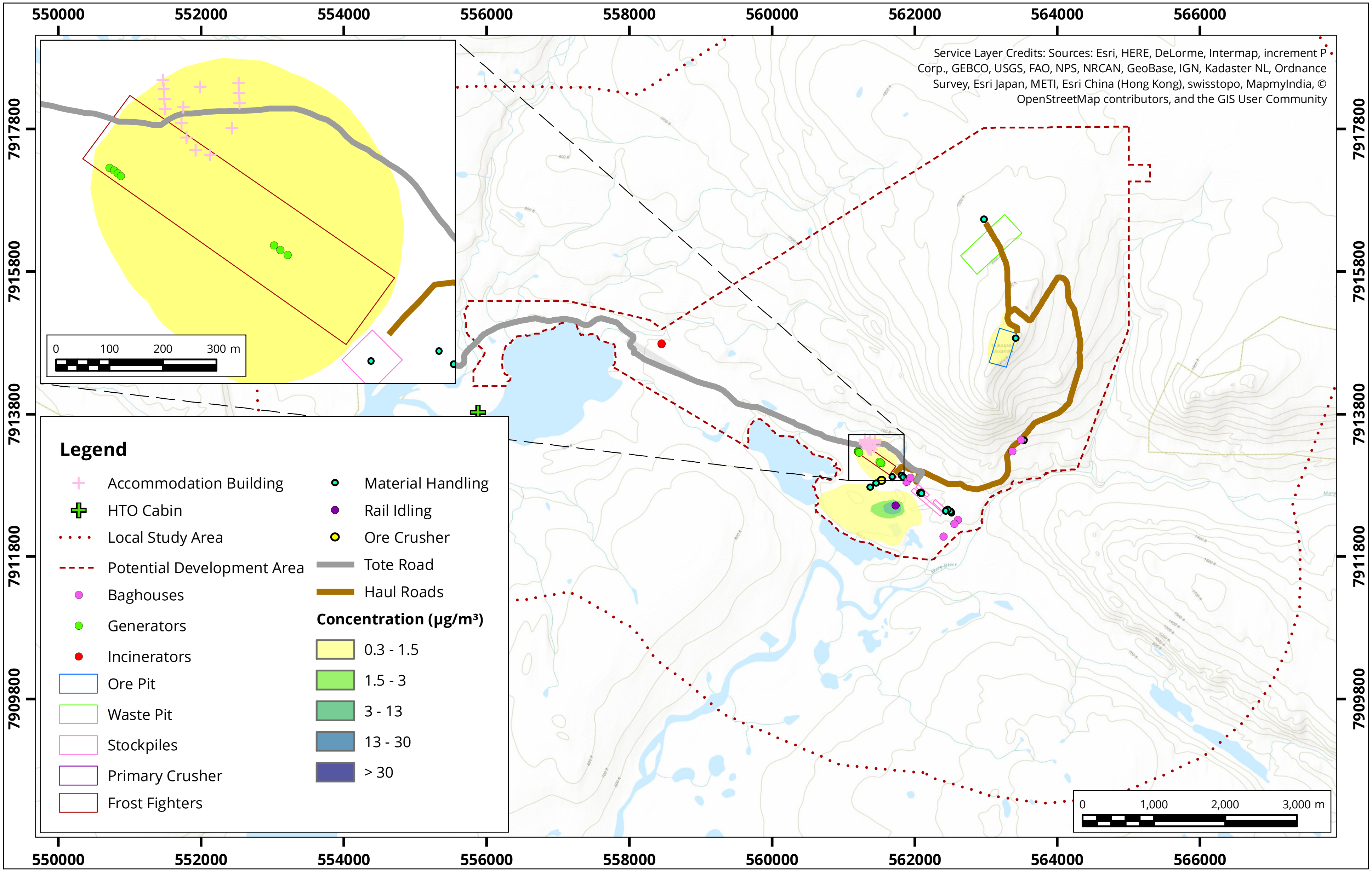
Map Projection: NAD 1983 UTM Zone 17N

1-Hour SO_2 CAAQS: 183 µg/m³

Baffinland Iron Mines Corporation - Nunavut, Canada

Project #: 1402090

Map Document: C:\Users\djh\OneDrive - ROWAN WILLIAMS DAVIES & IRWIN INC\GIS Temp\1402090\BK Mine\1402090 - Baffinland - AQ Mine Contour Plots_upd_181213.mxd



Predicted Annual SO_2 Concentrations
Mine Site

Map Projection: NAD 1983 UTM Zone 17N

Baffinland Iron Mines Corporation - Nunavut, Canada

Annual SO_2 Indicator Threshold: 30 µg/m³

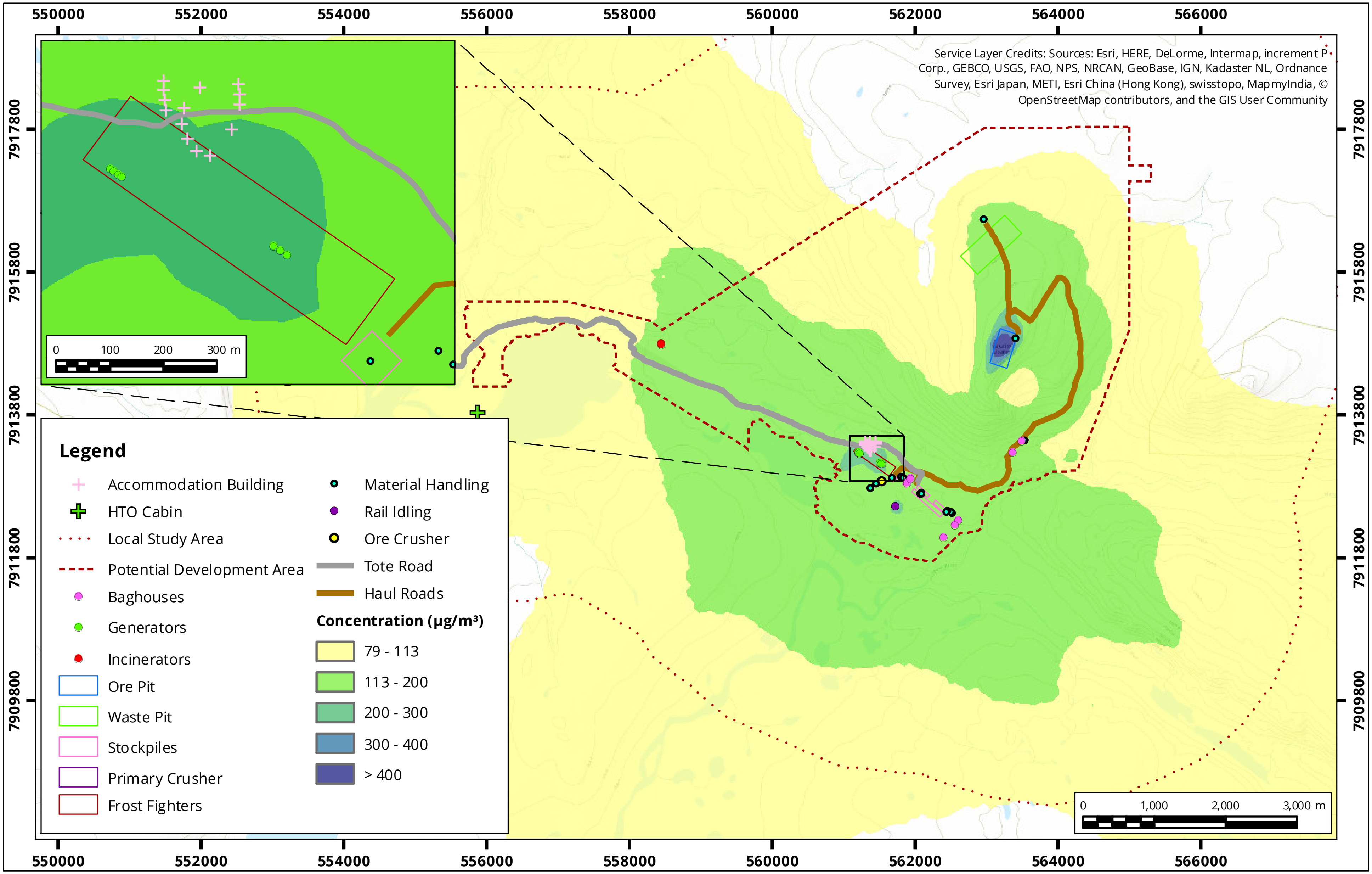
Annual SO_2 CAAQS: 13 µg/m³

True North

Project #: 1402090

Drawn by: DJH	Figure: E-3
Approx. Scale:	1:75,000
Date Revised:	Jan 3, 2019

Map Document: C:\Users\djh\OneDrive - ROWAN WILLIAMS DAVIES & IRWIN INC\GIS Temp\1402090\BIM\Mine\1402090 - Baffinland - AQ Mine Contour Plots_upd_181213.mxd



Predicted 1-Hour NO_2 Concentrations
Mine Site

True North

Drawn by: DJH	Figure: E-4b
Approx. Scale:	1:75,000
Date Revised:	Dec 13, 2018

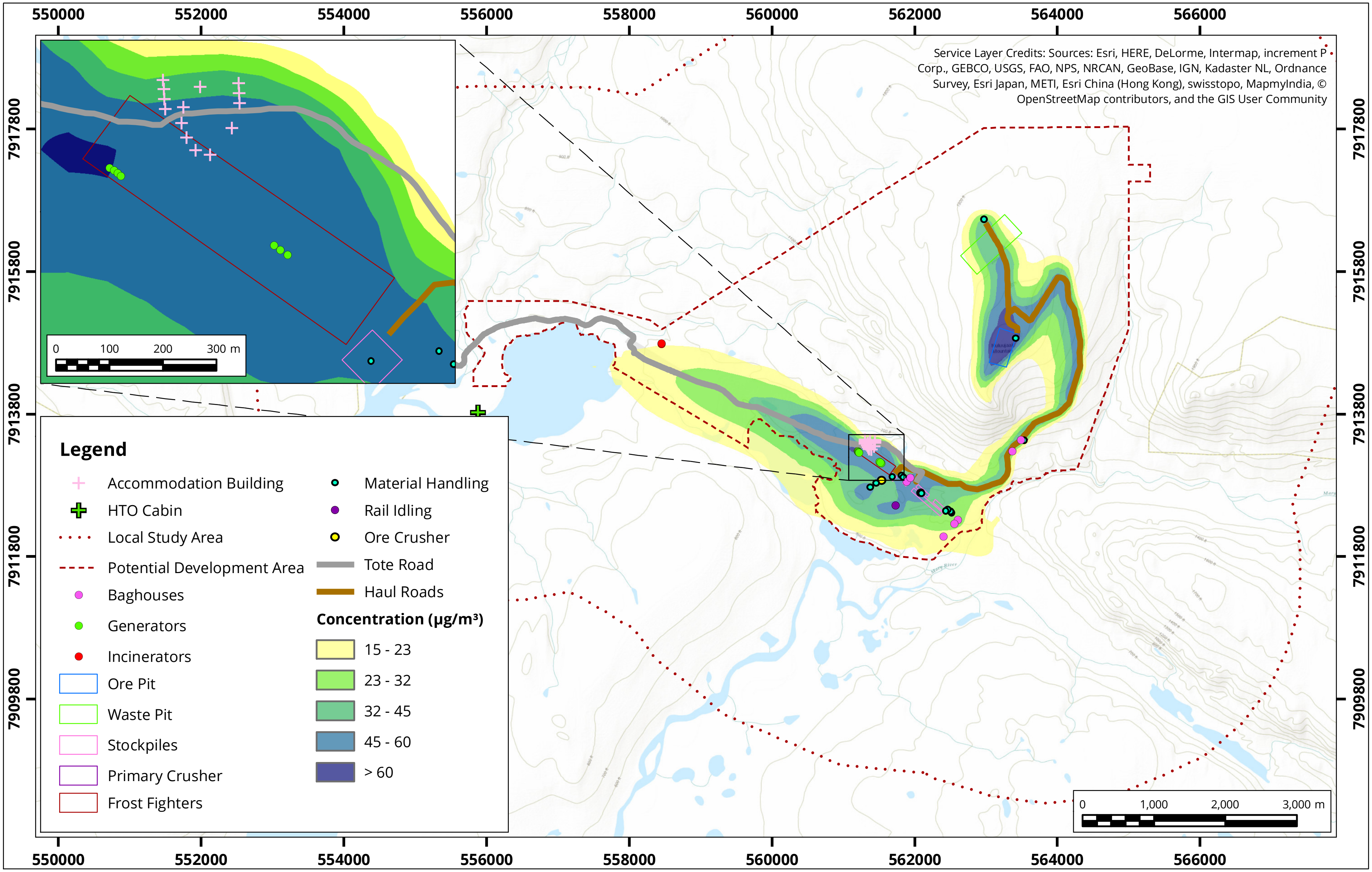
Map Projection: NAD 1983 UTM Zone 17N

Baffinland Iron Mines Corporation - Nunavut, Canada

1-Hour NO_2 2020 CAAQS: 113 µg/m³

1-Hour NO_2 2025 CAAQS: 79 µg/m³

Project #: 1402090



Predicted Annual NO_2 Concentrations
Mine Site

Map Projection: NAD 1983 UTM Zone 17N

Baffinland Iron Mines Corporation - Nunavut, Canada

Annual NO_2 2020 CAAQS: 32 µg/m³
Annual NO_2 2025 CAAQS: 23 µg/m³

True North

Project #: 1402090

Drawn by: DJH	Figure: E-6
Approx. Scale:	1:75,000
Date Revised:	Jan 3, 2019

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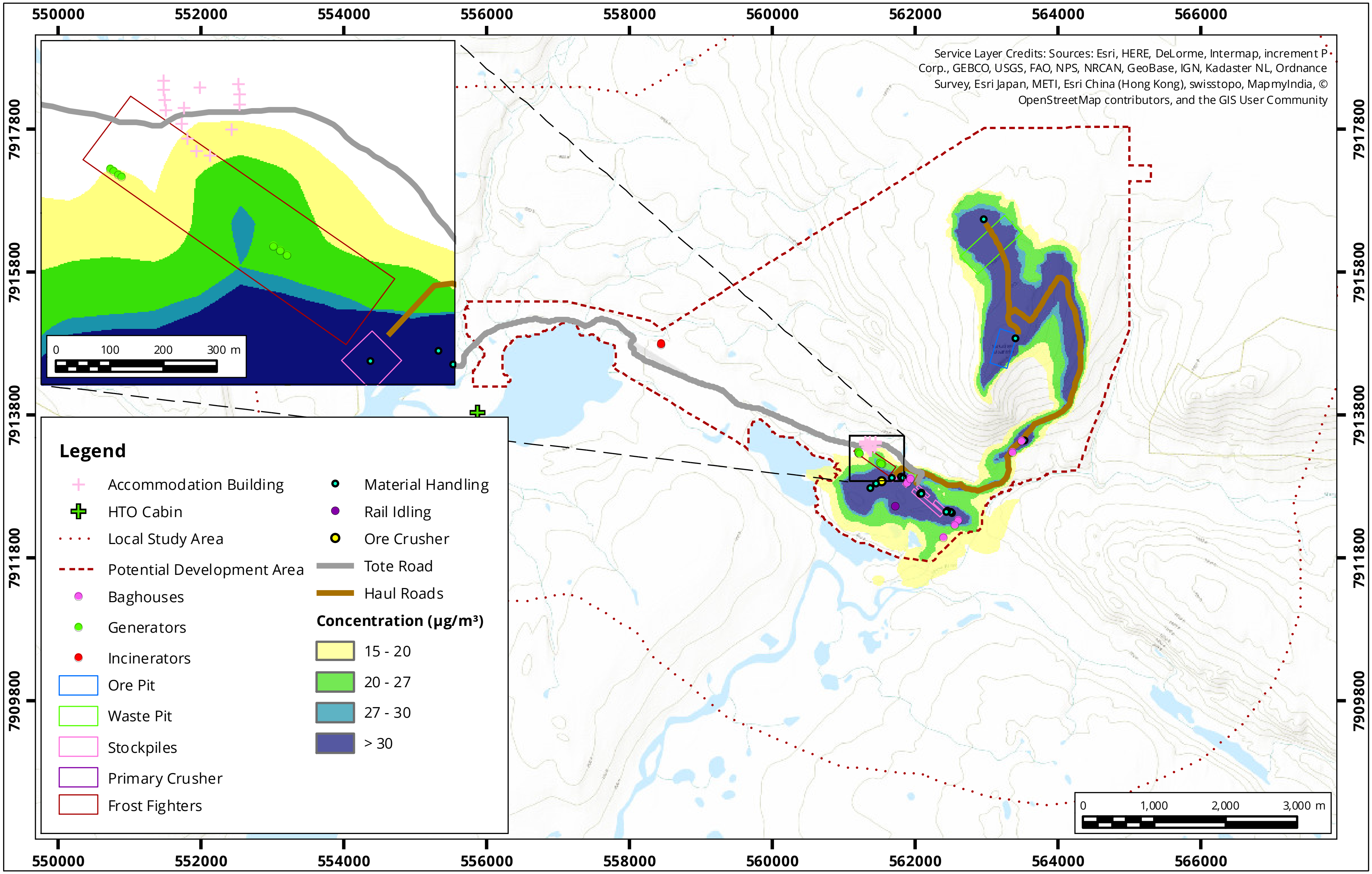


Predicted 24-Hour $PM_{2.5}$ Concentrations

Mine Site

True North

Drawn by: DJH	Figure: E-12b
Approx. Scale:	1:75,000
Date Revised:	Dec 13, 2018

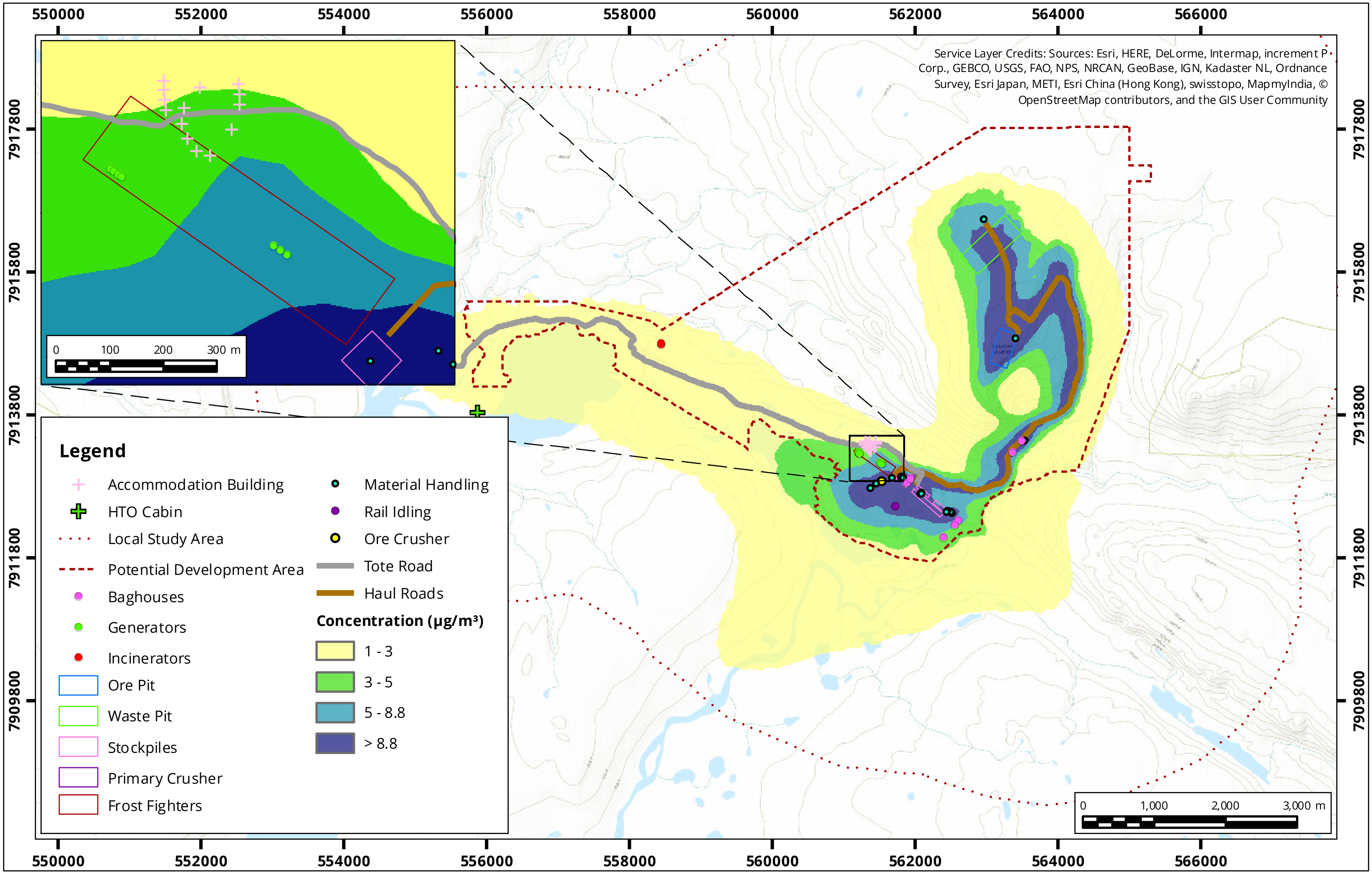
Map Projection: NAD 1983 UTM Zone 17N

24-Hour $PM_{2.5}$ CAAQS: 27 µg/m³

Baffinland Iron Mines Corporation - Nunavut, Canada

Project #: 1402090

Map Document: C:\Users\djh\OneDrive - ROWAN WILLIAMS DAVIES & IRWIN INC\GIS Temp\1402090\BK Mine\1402090 - Baffinland - AQ Mine Contour Plots_upd_181213.mxd



Predicted Annual $PM_{2.5}$ Concentrations
Mine Site

True North

Drawn by: DJH	Figure: E-15
Approx. Scale:	1:75,000
Date Revised:	Dec 13, 2018

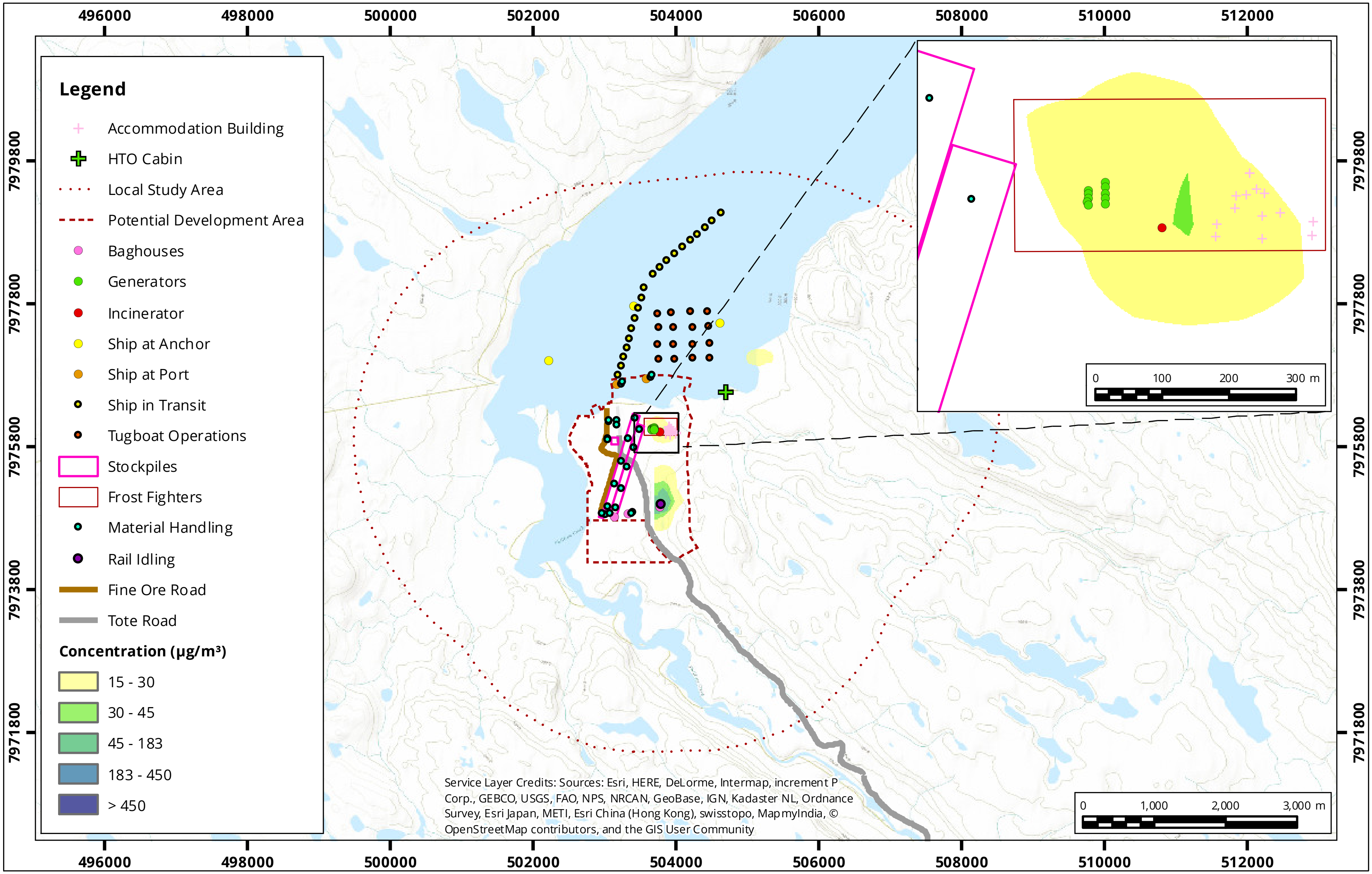
Map Projection: NAD 1983 UTM Zone 17N

Annual PM_{25} CAAQS: 8.8 µg/m³

Baffinland Iron Mines Corporation - Nunavut, Canada

Project #: 1402090

Milne Port Isopleth Figures; CAAQs; RWDI, 2018



Predicted Maximum 1-Hour SO_2 Concentrations

Milne Port

True North

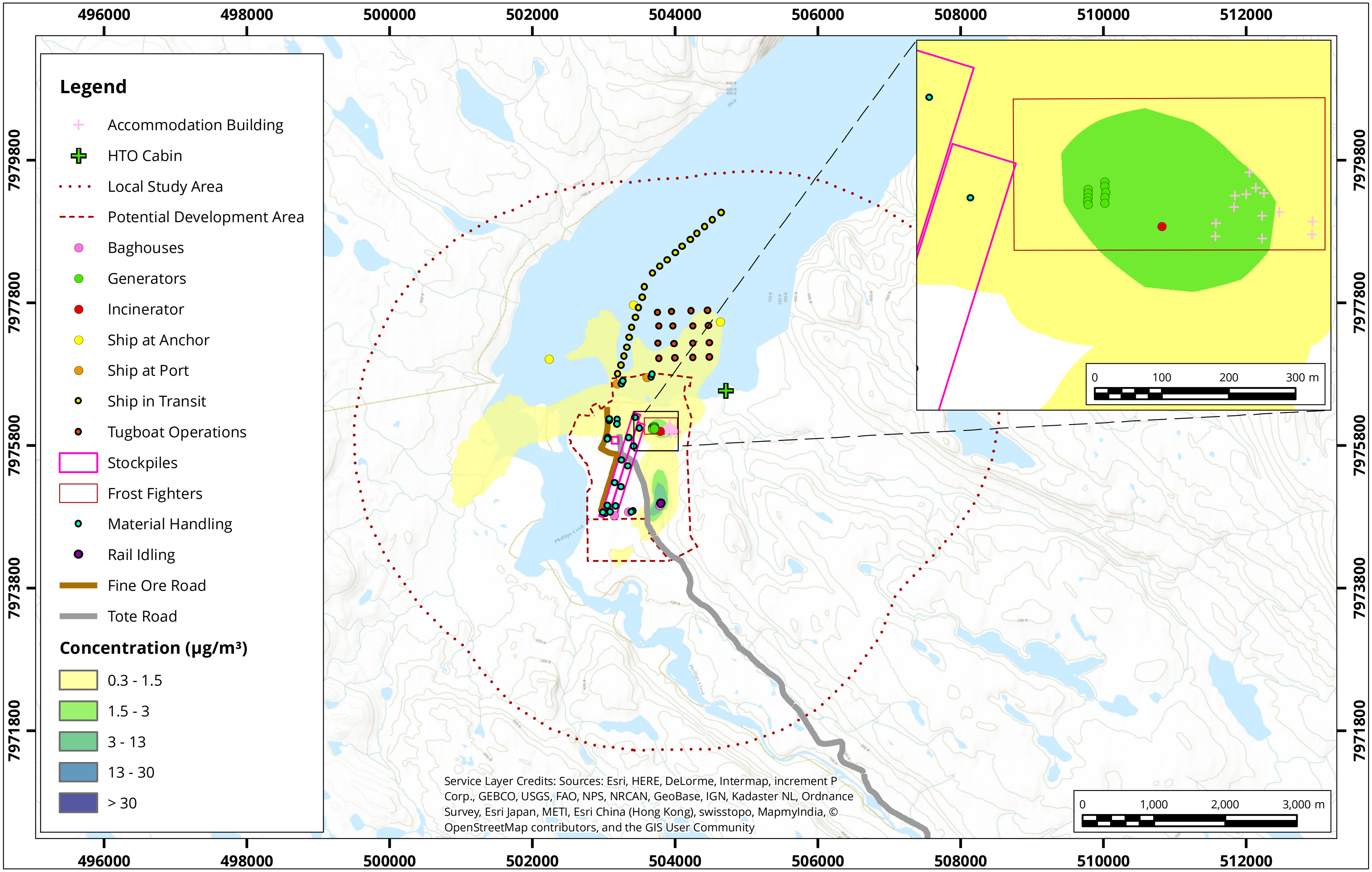
Drawn by: DJH	Figure: D-1b
Approx. Scale:	1:75,000
Date Revised:	Dec 13, 2018

Map Projection: NAD 1983 UTM Zone 17N

1-Hour SO_2 CAAQS: 183 µg/m³

Baffinland Iron Mines Corporation - Nunavut, Canada

Project #: 1402090



Predicted Annual SO_2 Concentrations
Milne Port

True North

Map Projection: NAD 1983 UTM Zone 17N

Baffinland Iron Mines Corporation - Nunavut, Canada

Annual SO_2 Indicator Threshold: 30 μg/m³

Annual SO_2 CAAQS: 13 μg/m³

Project #: 1402090

Drawn by: DJH	Figure: D-3
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Date Revised:	Jan 3, 2019

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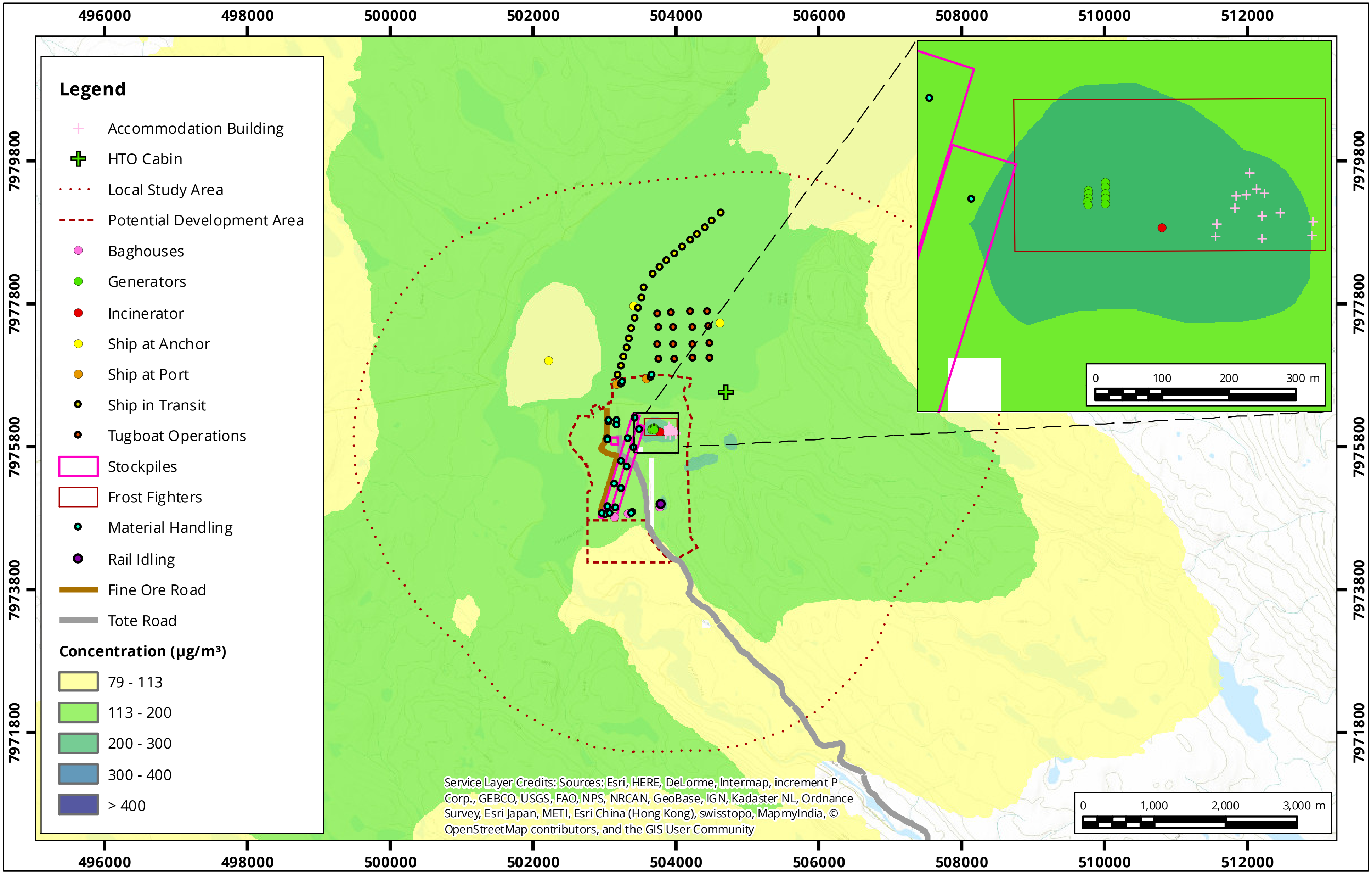

Predicted Maximum 1-Hour NO_2 Concentrations

Milne Port

Map Projection: NAD 1983 UTM Zone 17N

Baffinland Iron Mines Corporation - Nunavut, Canada

1-Hour NO_2 2020 CAAQS: 113 µg/m³

1-Hour NO_2 2025 CAAQS: 79 µg/m³

True North

Project #: 1402090

Drawn by: DJH	Figure: D-4b
Approx. Scale:	1:75,000
Date Revised:	Dec 13, 2018

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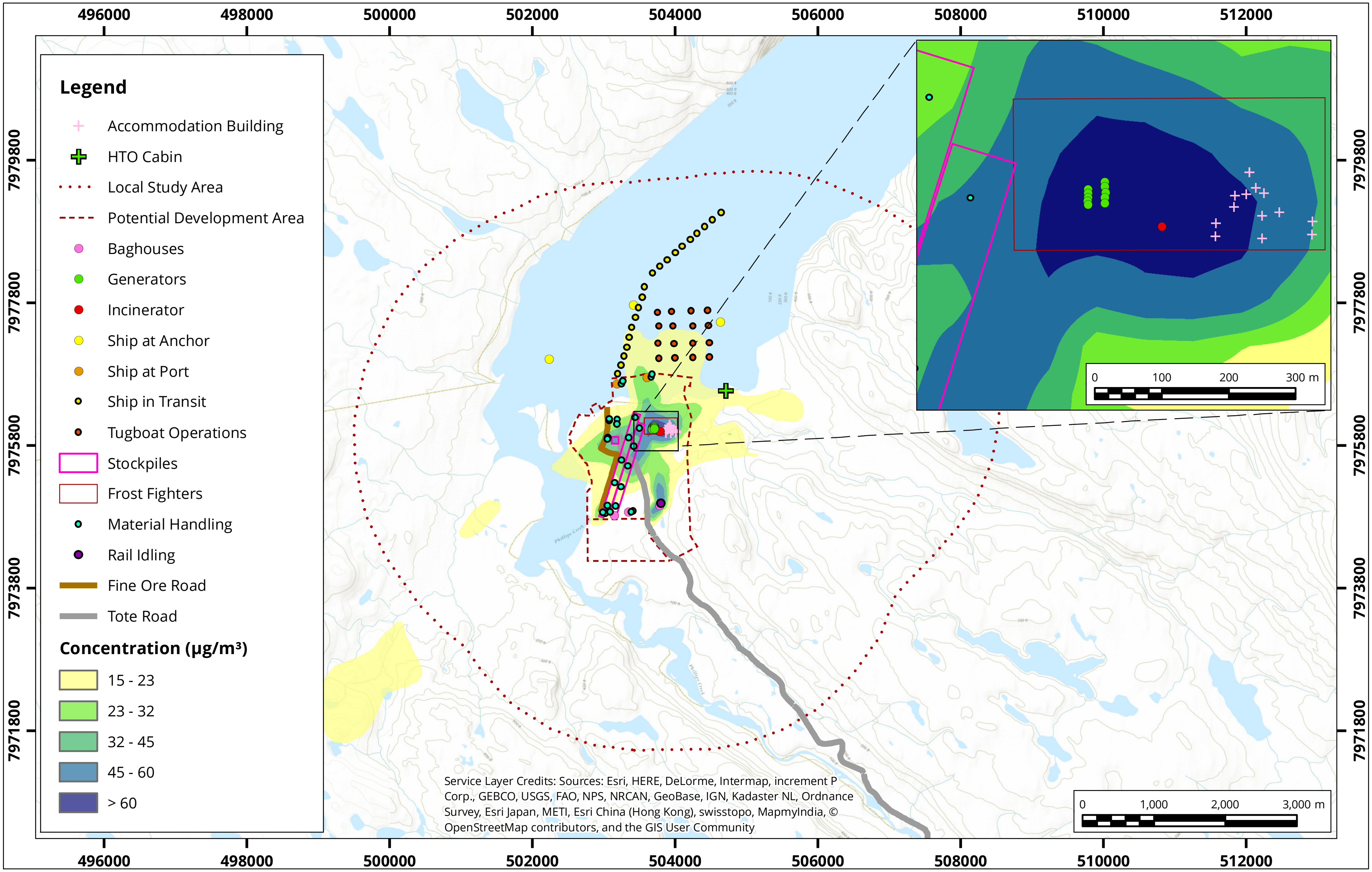

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Predicted Annual NO_2 Concentrations

Milne Port

Map Projection: NAD 1983 UTM Zone 17N

Baffinland Iron Mines Corporation - Nunavut, Canada

Annual NO_2 2020 CAAQS: 32 μg/m³

Annual NO_2 2025 CAAQS: 23 μg/m³

True North

Project #: 1402090

Drawn by: DJH	Figure: D-6
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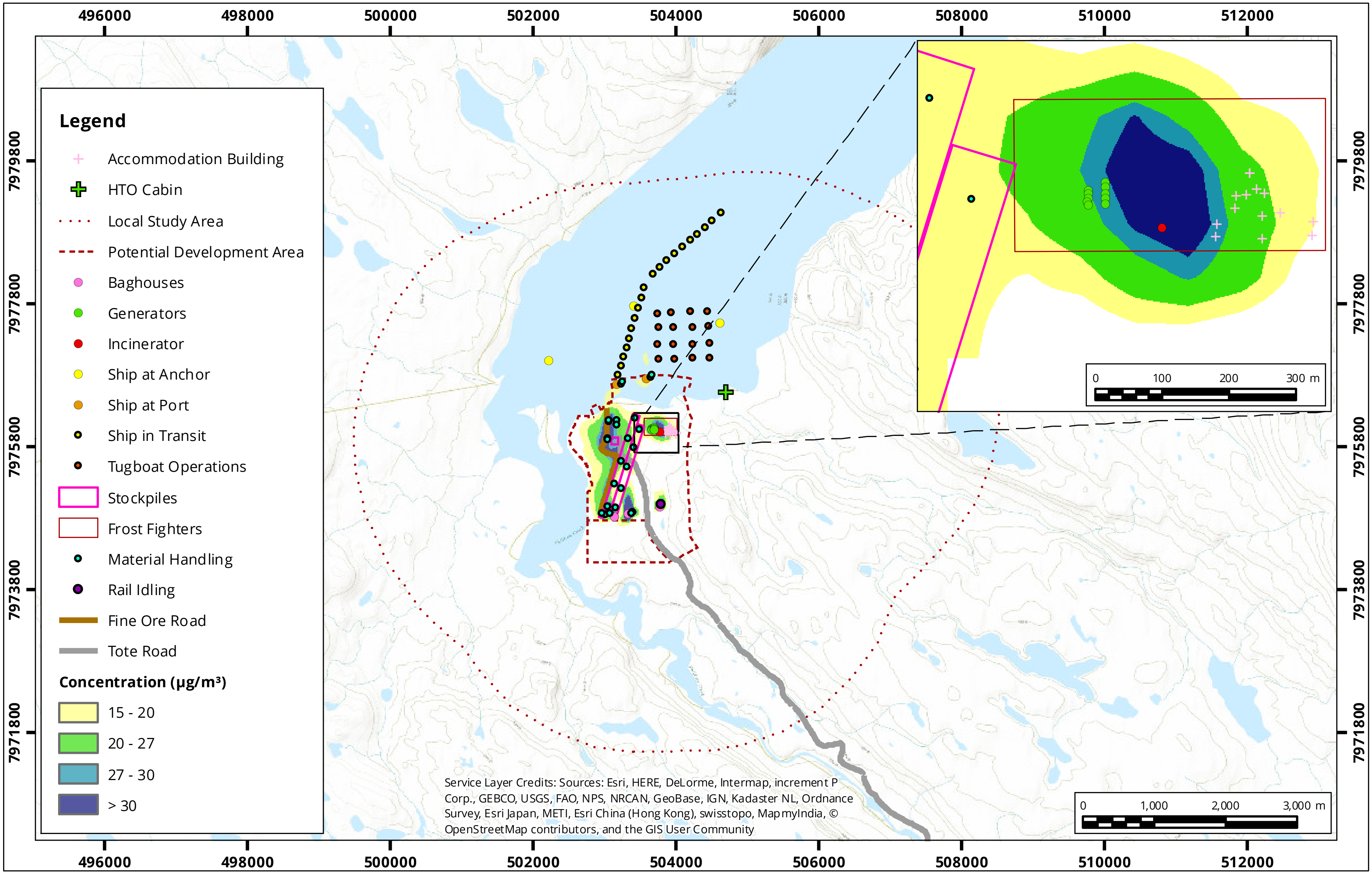

Predicted Maximum 24-Hour $PM_{2.5}$ Concentrations
Milne Port

Map Projection: NAD 1983 UTM Zone 17N

24-Hour $PM_{2.5}$ CAAQS: 27 µg/m³

Baffinland Iron Mines Corporation - Nunavut, Canada

True North

Project #: 1402090

Drawn by: DJH	Figure: D-12b
Approx. Scale:	1:75,000
Date Revised:	Dec 13, 2018

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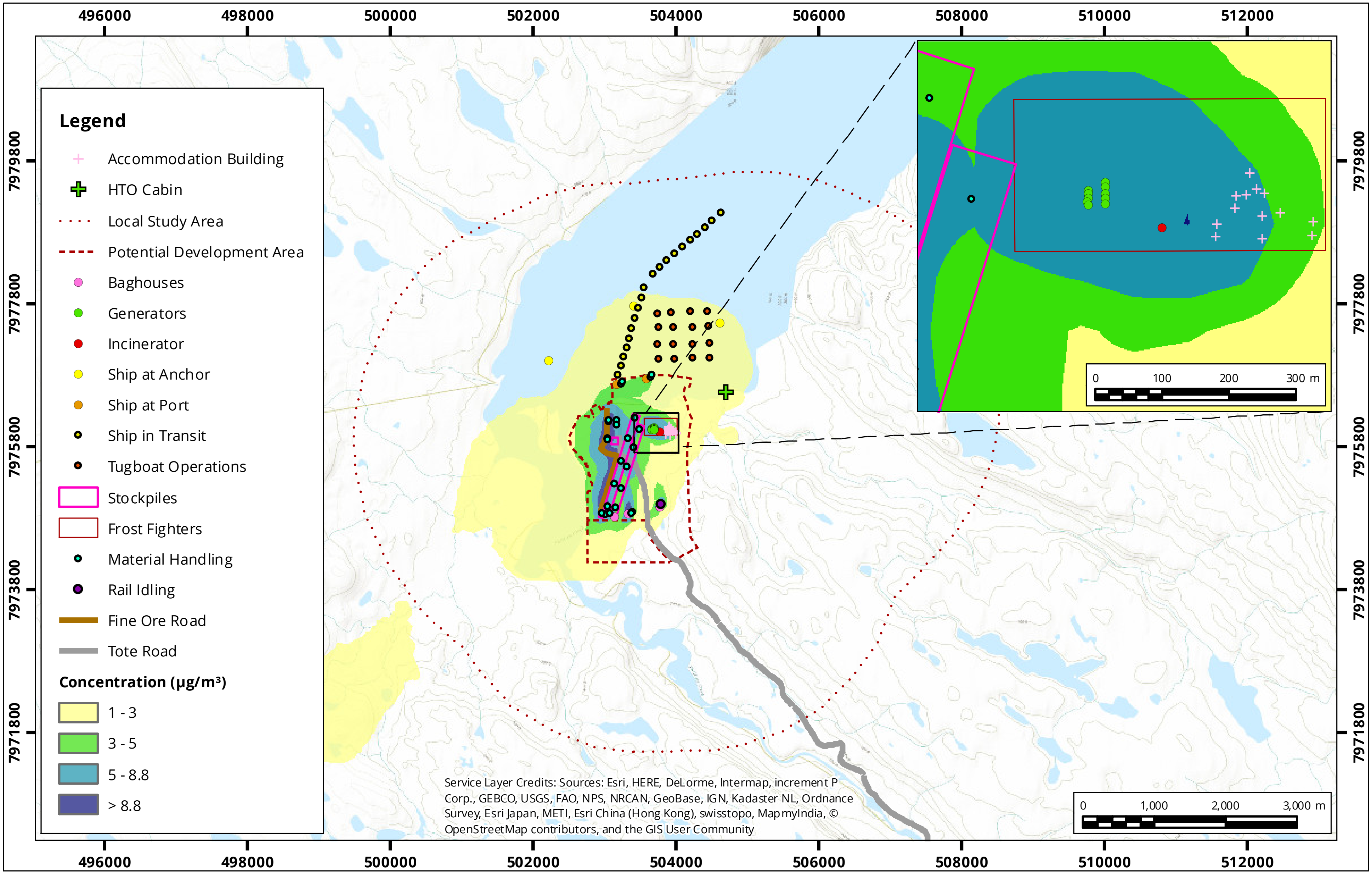


Predicted Maximum Annual $PM_{2.5}$ Concentrations
Milne Port

Map Projection: NAD 1983 UTM Zone 17N

Annual $PM_{2.5}$ CAAQS: 8.8 µg/m³

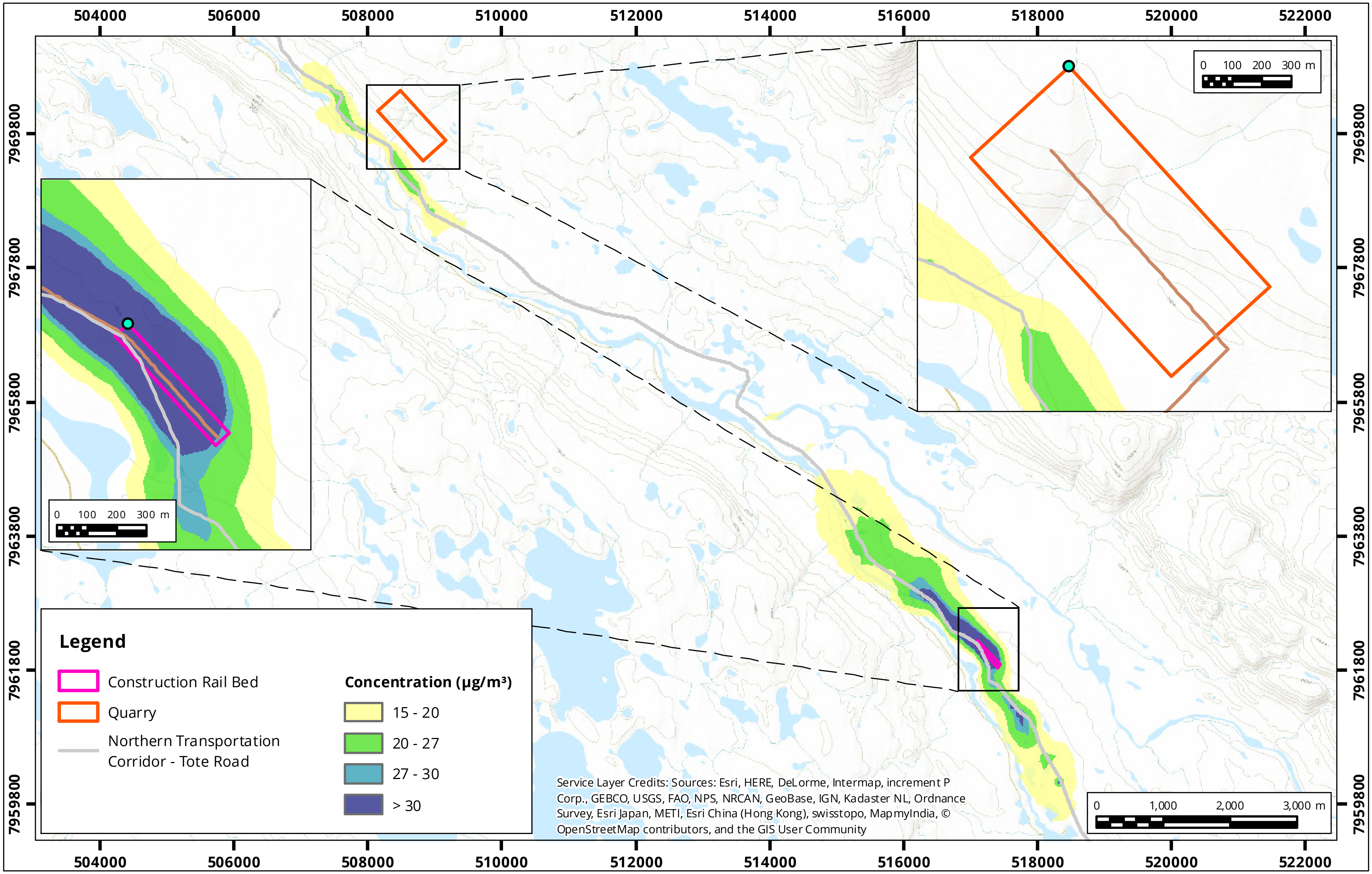
Baffinland Iron Mines Corporation - Nunavut, Canada

True North

Project #: 1402090

Drawn by: DJH	Figure:D-15
Approx. Scale:	1:75,000
Date Revised:	Dec 13, 2018

Tote Road Isopleth Figures; CAAQs; RWDI 2018



Predicted Maximum 24-Hour $PM_{2.5}$ Concentrations

Northern Transportation Corridor - Tote Road and Construction Sources

True North

Map Projection: NAD 1983 UTM Zone 17N

24-Hour $PM_{2.5}$ CAAQS: 27 µg/m³

Baffinland Iron Mines Corporation - Nunavut, Canada

Project #: 1402090

Drawn by: DJH	Figure: F-16b
Approx. Scale:	1:80,000
Date Revised:	Dec 13, 2018

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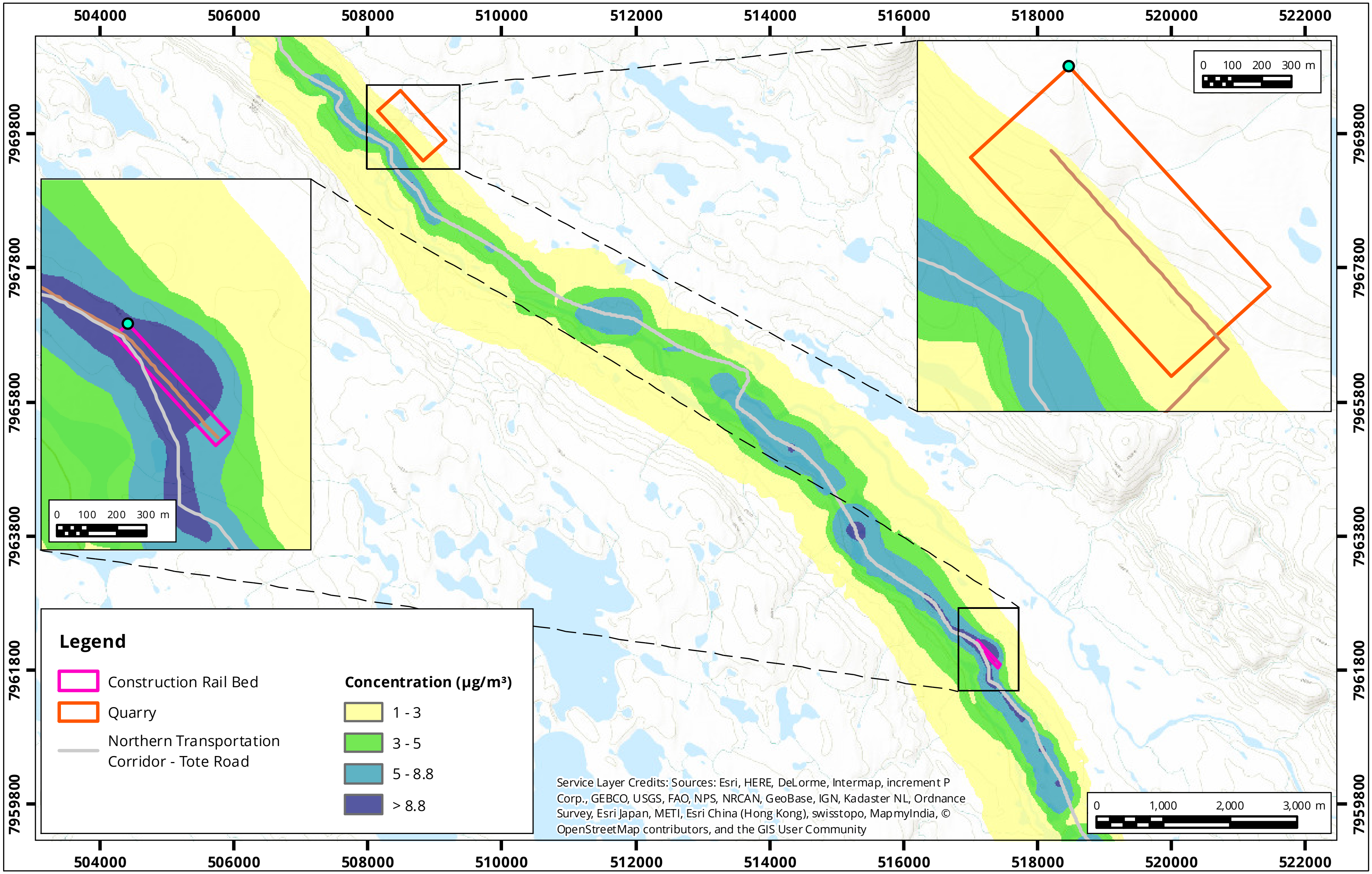


Predicted Annual $PM_{2.5}$ Concentrations

Northern Transportation Corridor - Tote Road and Construction Sources

True North

Drawn by: DJH	Figure: F-19
Approx. Scale:	1:80,000
Date Revised:	Dec 13, 2018

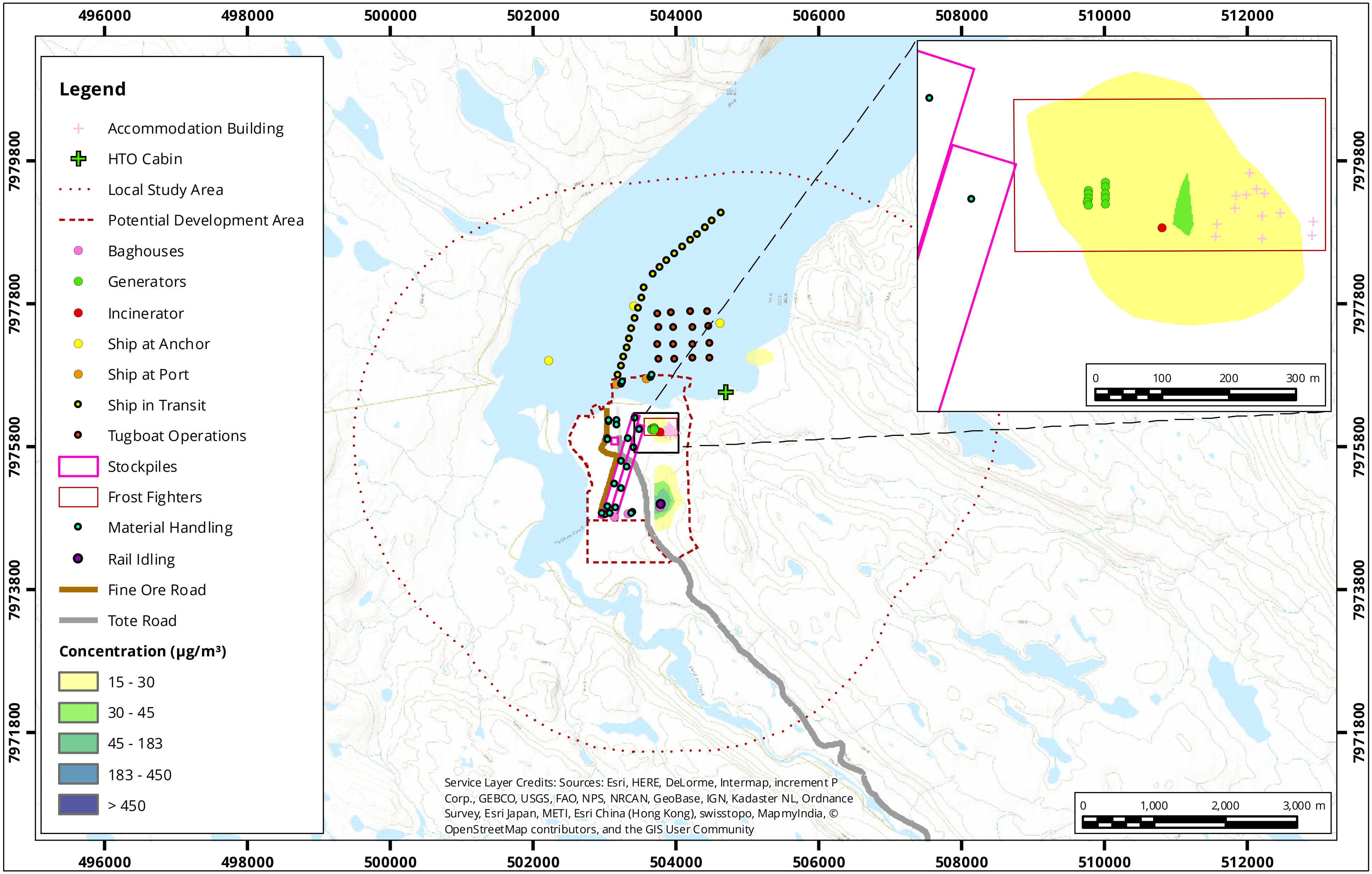
Map Projection: NAD 1983 UTM Zone 17N

Annual PM_{25} CAAQS: 8.8 μg/m³

Baffinland Iron Mines Corporation - Nunavut, Canada

Project #: 1402090

HC 05 ATTACHMENT 1: FIGURE D1B; FIGURE D3; FIGURE D4B; FIGURE D6; FIGURE D12B; FIGURE D15; FIGURE E1B; FIGURE E3 ; FIGURE E4B; FIGURE E6; FIGURE E12; FIGURE E15; FIGURE F16B; FIGURE F19



Predicted Maximum 1-Hour SO_2 Concentrations

Milne Port

Map Projection: NAD 1983 UTM Zone 17N

1-Hour SO_2 CAAQS: 183 µg/m³

Baffinland Iron Mines Corporation - Nunavut, Canada

Project #: 1402090

Drawn by: DJH	Figure: D-1b
Approx. Scale:	1:75,000
Date Revised:	Dec 13, 2018

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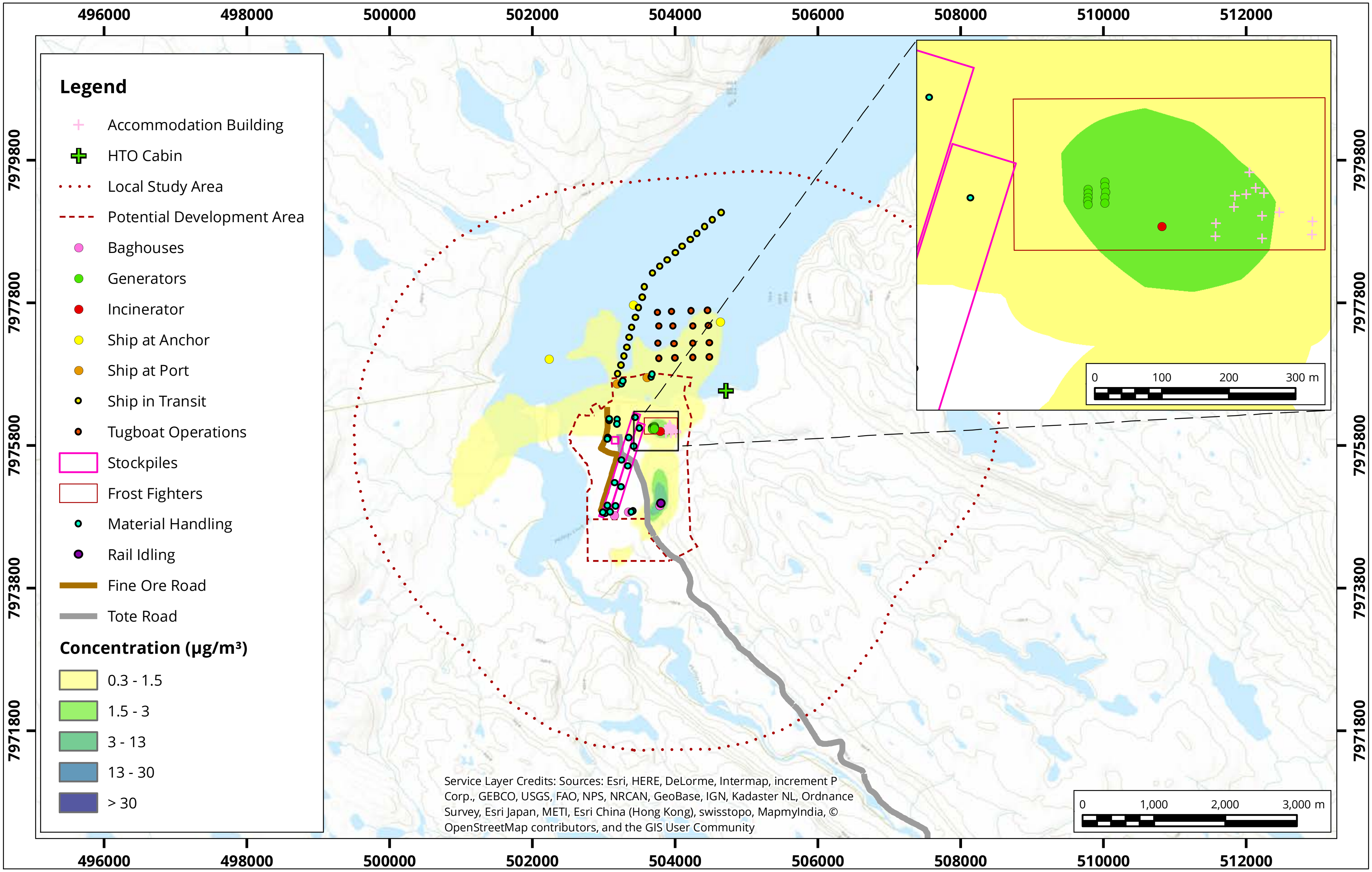

Predicted Annual SO_2 Concentrations

Milne Port

Map Projection: NAD 1983 UTM Zone 17N

Baffinland Iron Mines Corporation - Nunavut, Canada

Annual SO_2 Indicator Threshold: 30 µg/m³

Annual SO_2 CAAQS: 13 µg/m³

True North

Project #: 1402090

Drawn by: DJH	Figure: D-3
Approx. Scale:	1:75,000
Date Revised:	Jan 3, 2019

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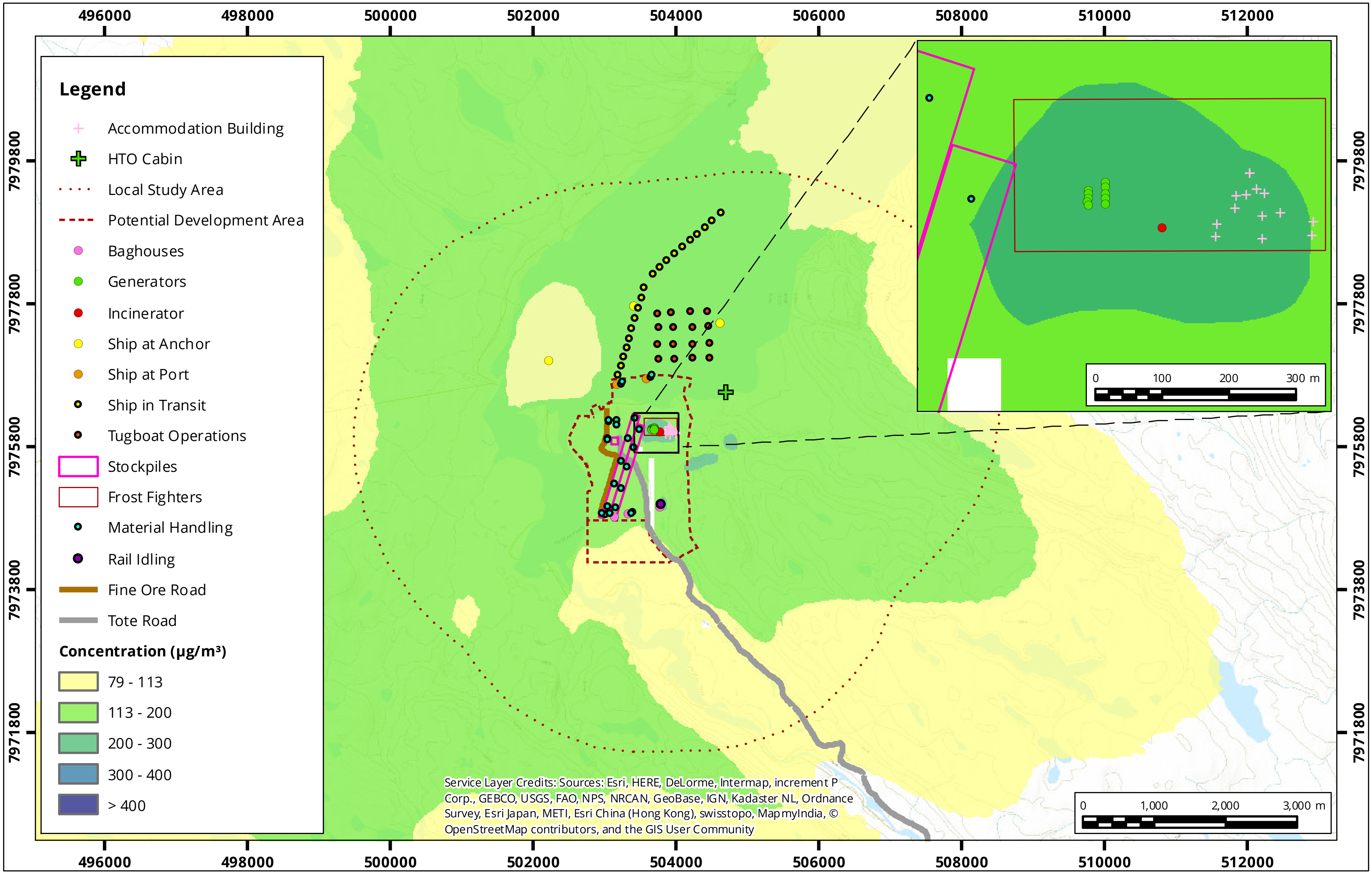

Predicted Maximum 1-Hour NO_2 Concentrations
Milne Port

Map Projection: NAD 1983 UTM Zone 17N

Baffinland Iron Mines Corporation - Nunavut, Canada

1-Hour NO_2 2020 CAAQS: 113 µg/m³

1-Hour NO_2 2025 CAAQS: 79 µg/m³

True North

Project #: 1402090

Drawn by: DJH	Figure:D-4b
Approx. Scale:	1:75,000
Date Revised:	Dec 13, 2018

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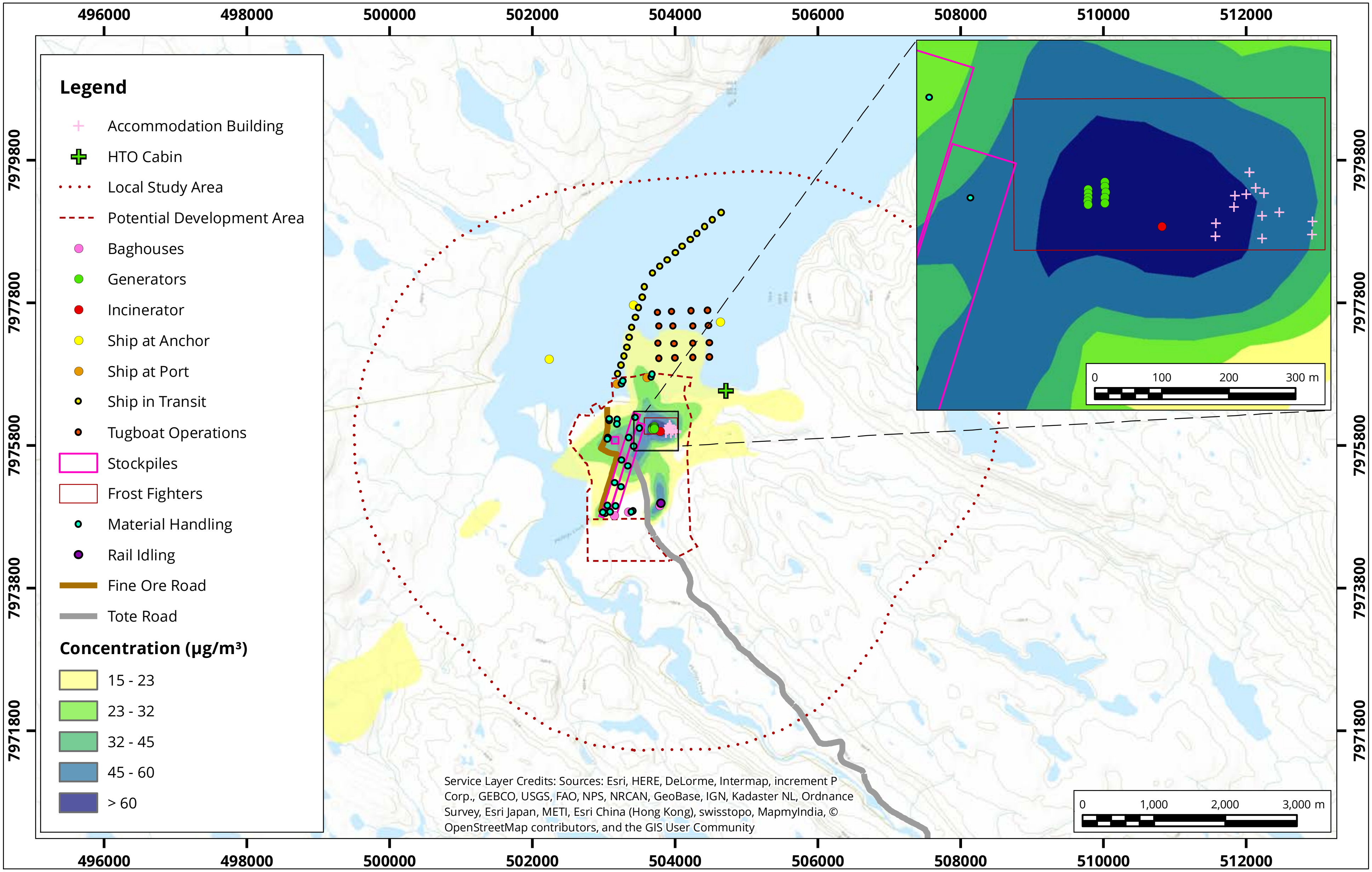


Predicted Annual NO_2 Concentrations
Milne Port

Map Projection: NAD 1983 UTM Zone 17N

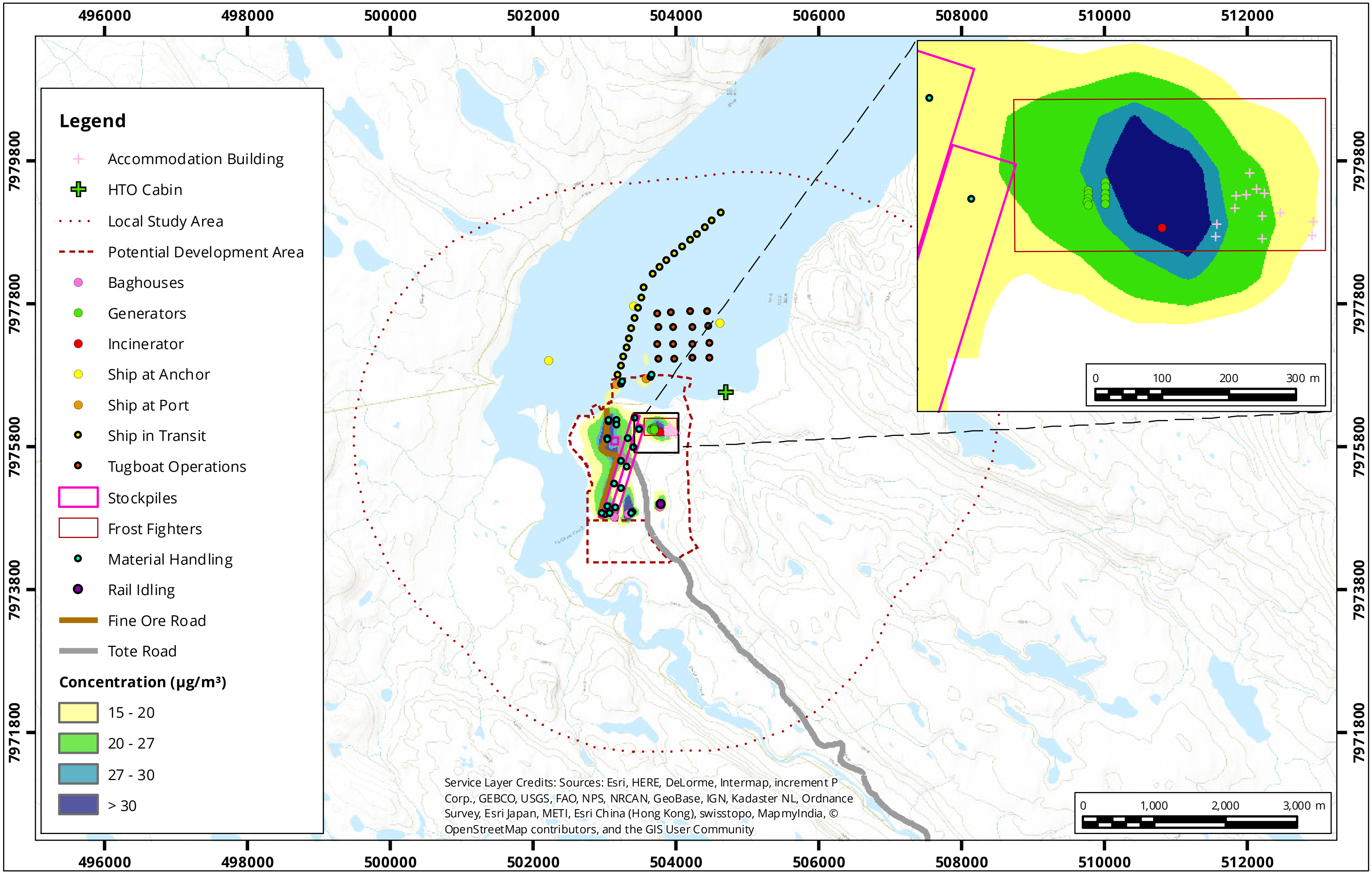
Baffinland Iron Mines Corporation - Nunavut, Canada

Annual NO_2 2020 CAAQS: 32 µg/m³
Annual NO_2 2025 CAAQS: 23 µg/m³

True North

Project #: 1402090

Drawn by: DJH	Figure: D-6
Approx. Scale:	1:75,000
Date Revised:	Jan 3, 2019



Predicted Maximum 24-Hour $PM_{2.5}$ Concentrations
Milne Port

Map Projection: NAD 1983 UTM Zone 17N

24-Hour $PM_{2.5}$ CAAQS: 27 µg/m³

Baffinland Iron Mines Corporation - Nunavut, Canada

True North

Project #: 1402090

Drawn by: DJH	Figure: D-12b
Approx. Scale:	1:75,000
Date Revised:	Dec 13, 2018

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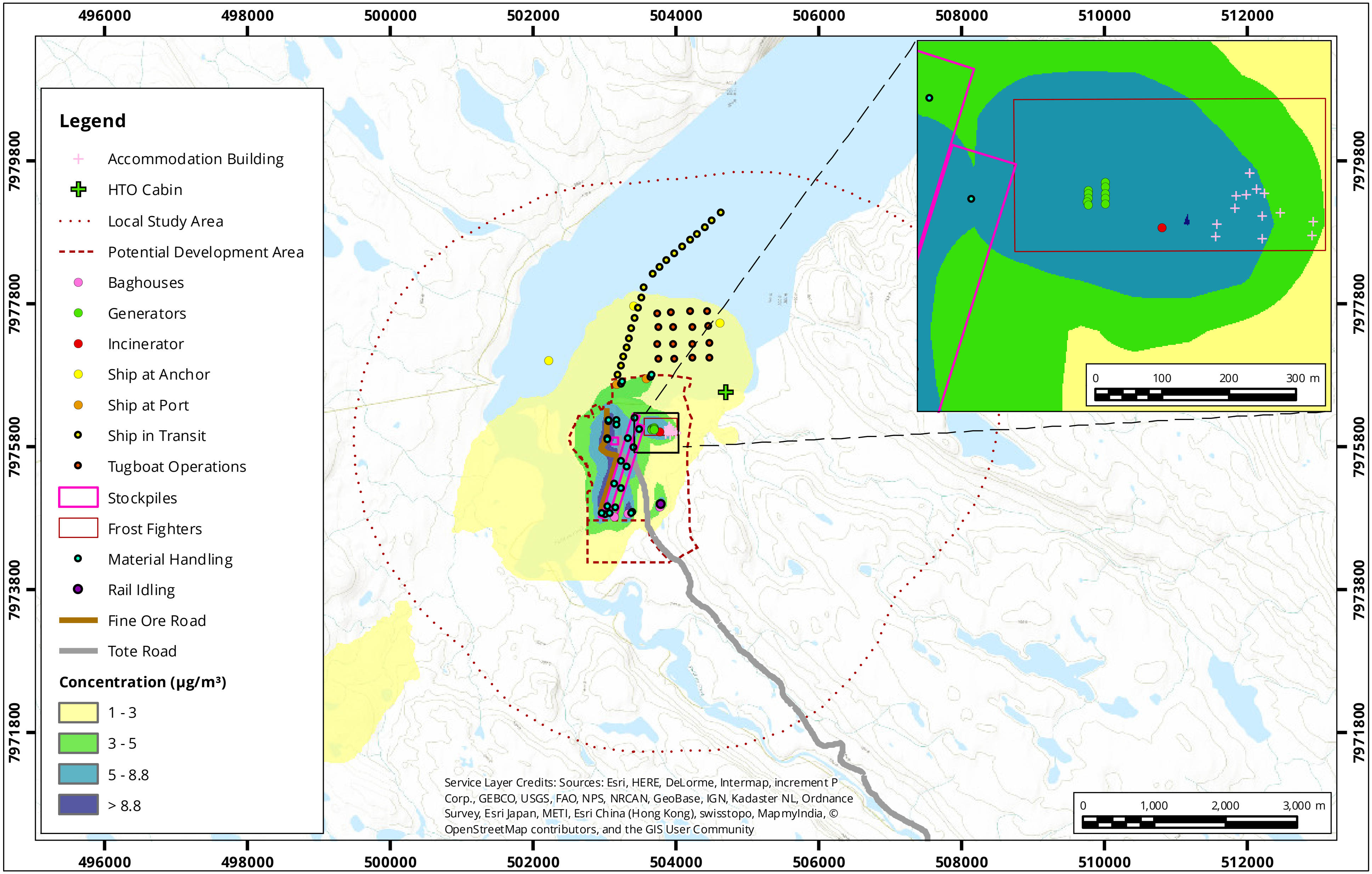

Predicted Maximum Annual $PM_{2.5}$ Concentrations
Milne Port

Map Projection: NAD 1983 UTM Zone 17N

Annual $PM_{2.5}$ CAAQS: 8.8 µg/m³

Baffinland Iron Mines Corporation - Nunavut, Canada

True North

Project #: 1402090

Drawn by: DJH	Figure: D-15
Approx. Scale:	1:75,000
Date Revised:	Dec 13, 2018

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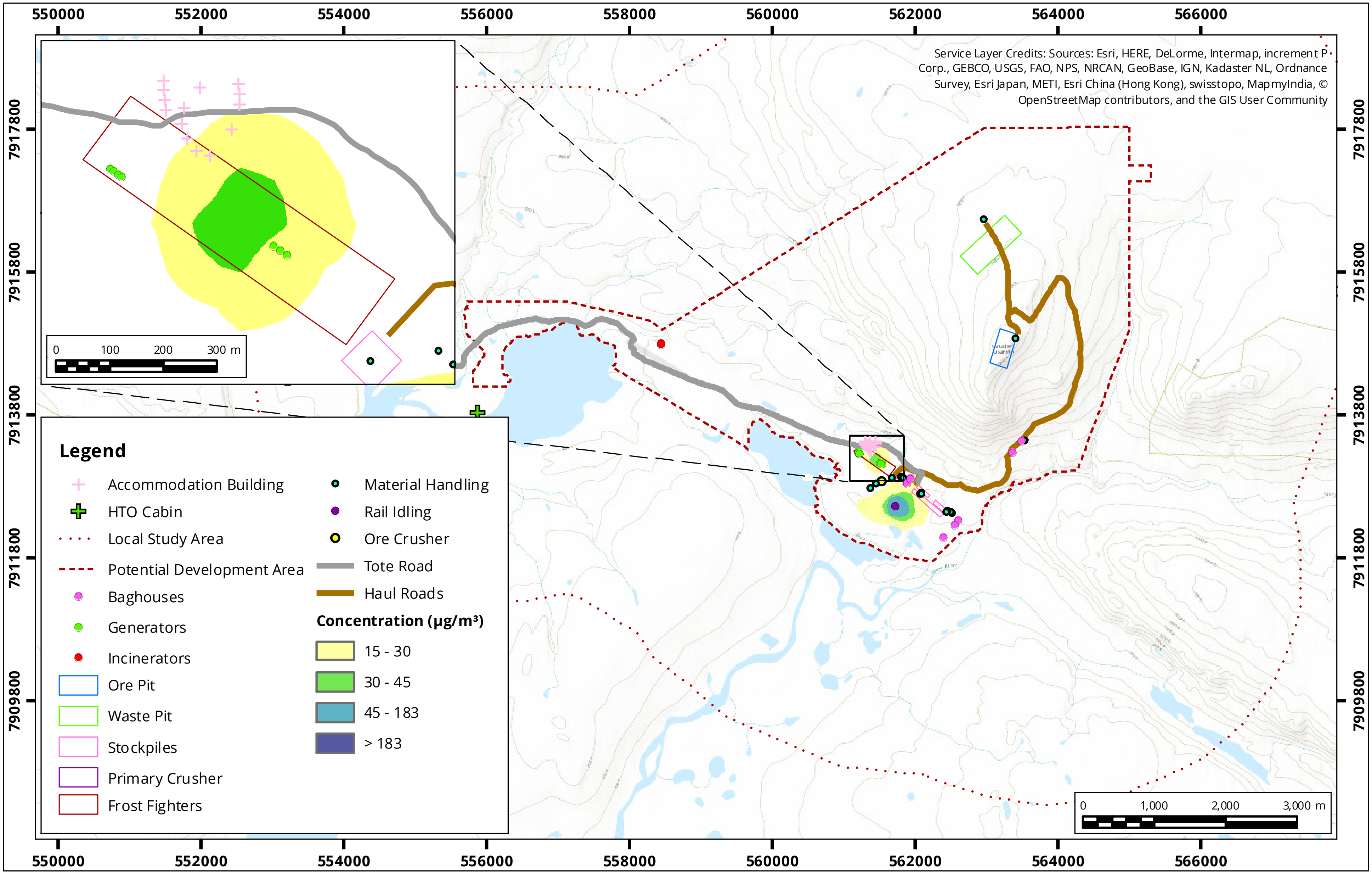

Predicted 1-Hour SO_2 Concentrations
Mine Site

Map Projection: NAD 1983 UTM Zone 17N

1-Hour SO_2 CAAQS: 183 µg/m³

Baffinland Iron Mines Corporation - Nunavut, Canada

True North

Project #: 1402090

Drawn by: DJH	Figure: E-1b
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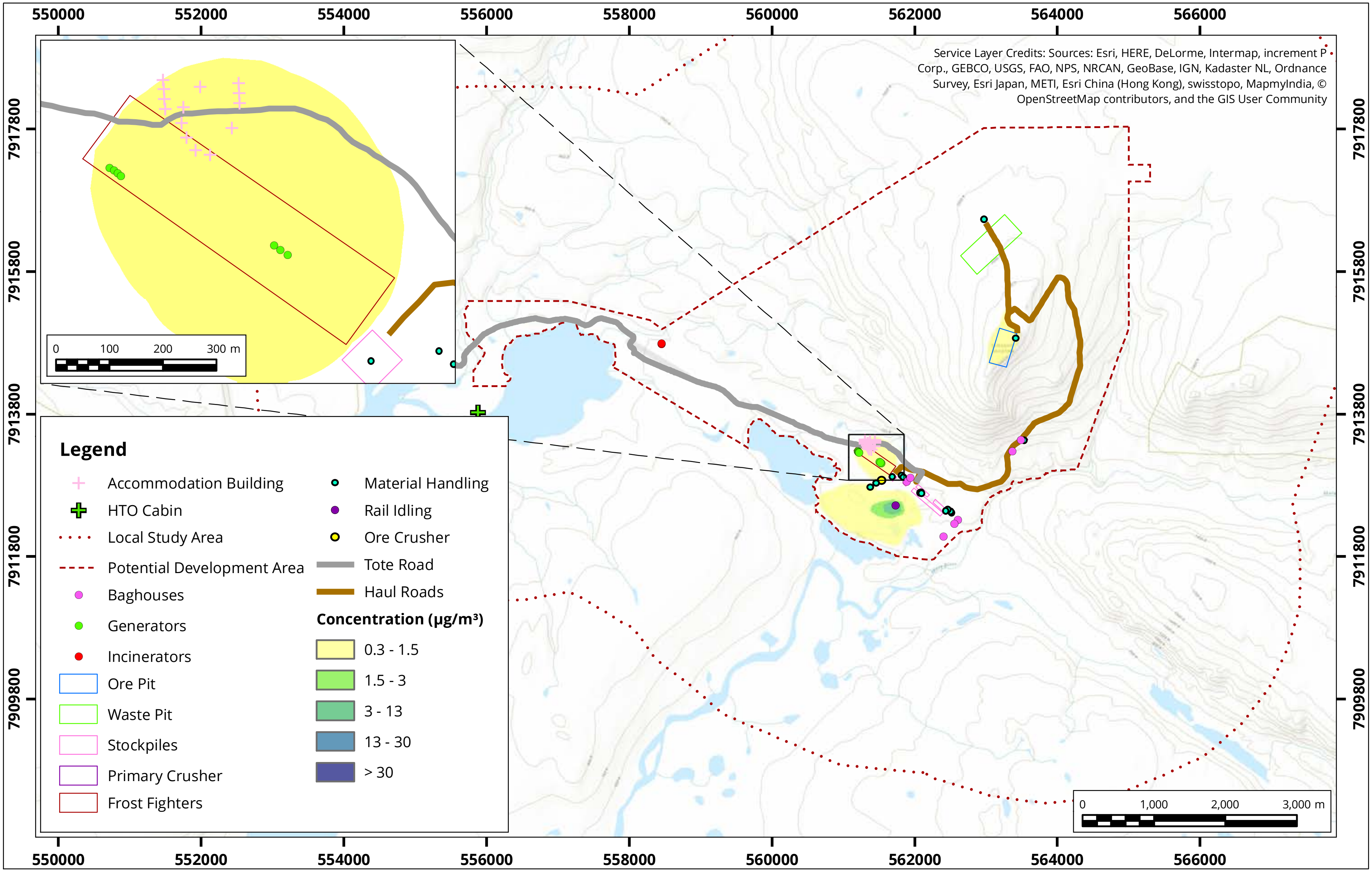
Date Revised:	Dec 13, 2018



Predicted Annual SO_2 Concentrations
Mine Site

Map Projection: NAD 1983 UTM Zone 17N

Baffinland Iron Mines Corporation - Nunavut, Canada

Annual SO_2 Indicator Threshold: 30 µg/m³

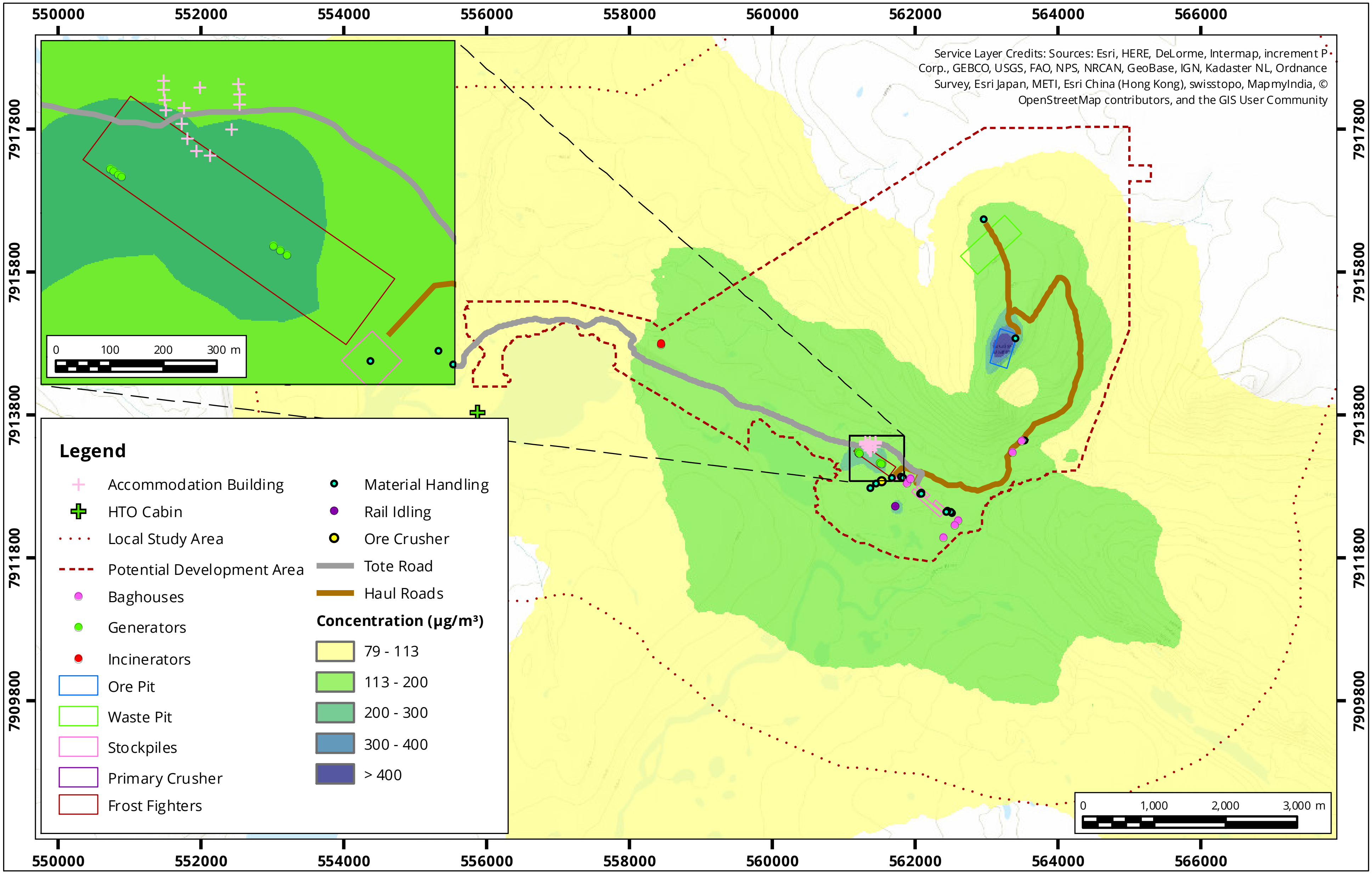
Annual SO_2 CAAQS: 13 µg/m³

True North

Project #: 1402090

Drawn by: DJH	Figure: E-3
Approx. Scale:	1:75,000
Date Revised:	Jan 3, 2019

Map Document: C:\Users\djh\OneDrive - ROWAN WILLIAMS DAVIES & IRWIN INC\GIS Temp\1402090\BKMine\1402090 - Baffinland - AQ Mine Contour Plots_upd_181213.mxd



Predicted 1-Hour NO_2 Concentrations
Mine Site

True North

Drawn by: DJH | Figure: E-4b

Approx. Scale: 1:75,000

Date Revised: Dec 13, 2018

Map Projection: NAD 1983 UTM Zone 17N

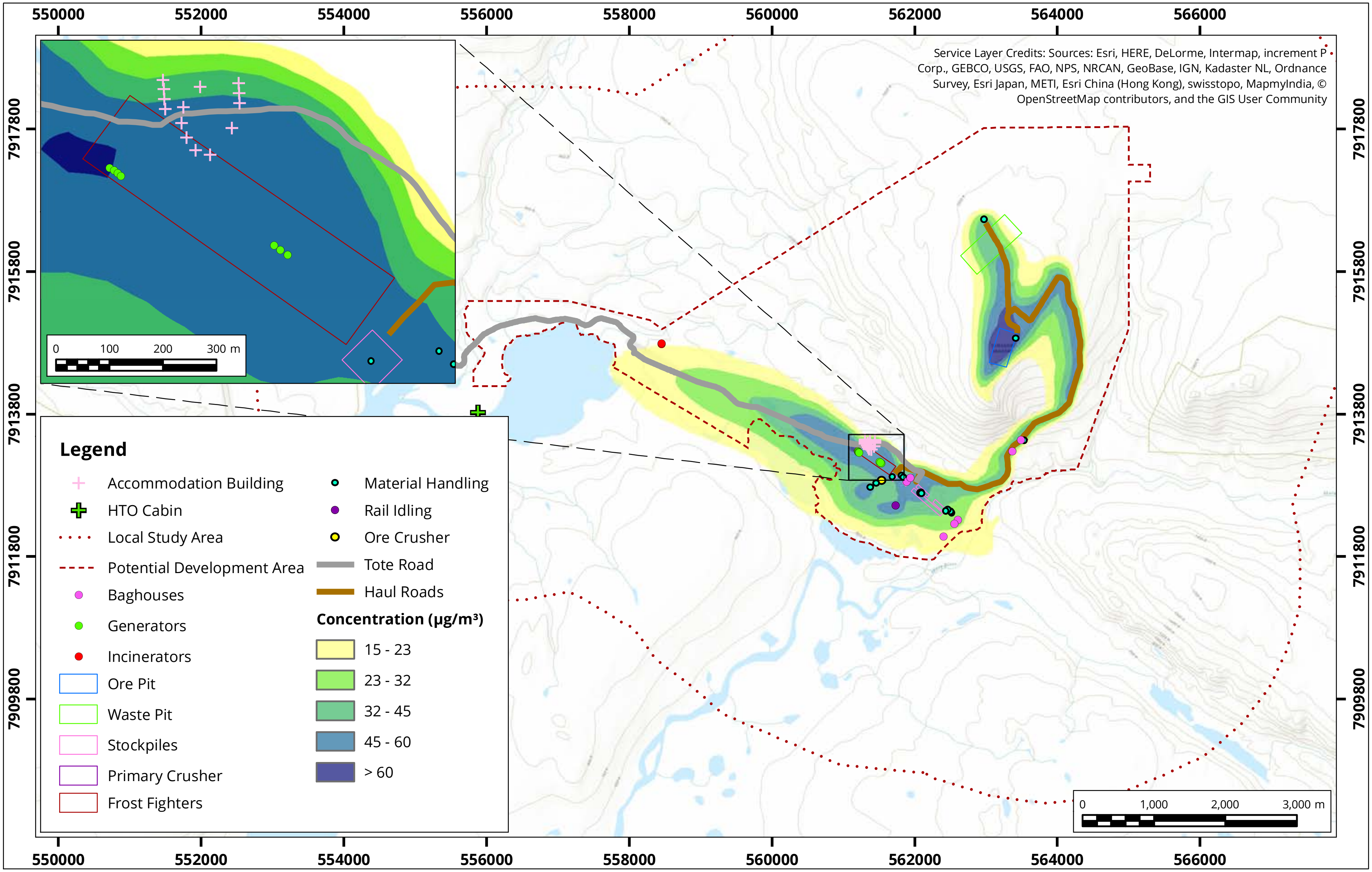
Baffinland Iron Mines Corporation - Nunavut, Canada

1-Hour NO_2 2020 CAAQS: 113 µg/m³

1-Hour NO_2 2025 CAAQS: 79 µg/m³

Project #: 1402090

Map Document: C:\Users\djh\OneDrive - ROWAN WILLIAMS DAVIES & IRWIN INC\GIS Temp\1402090\BK\Mine\1402090 - Baffinland - AQ Mine Contour Plots_upd_181213.mxd



Predicted Annual NO_2 Concentrations
Mine Site

Map Projection: NAD 1983 UTM Zone 17N

Baffinland Iron Mines Corporation - Nunavut, Canada

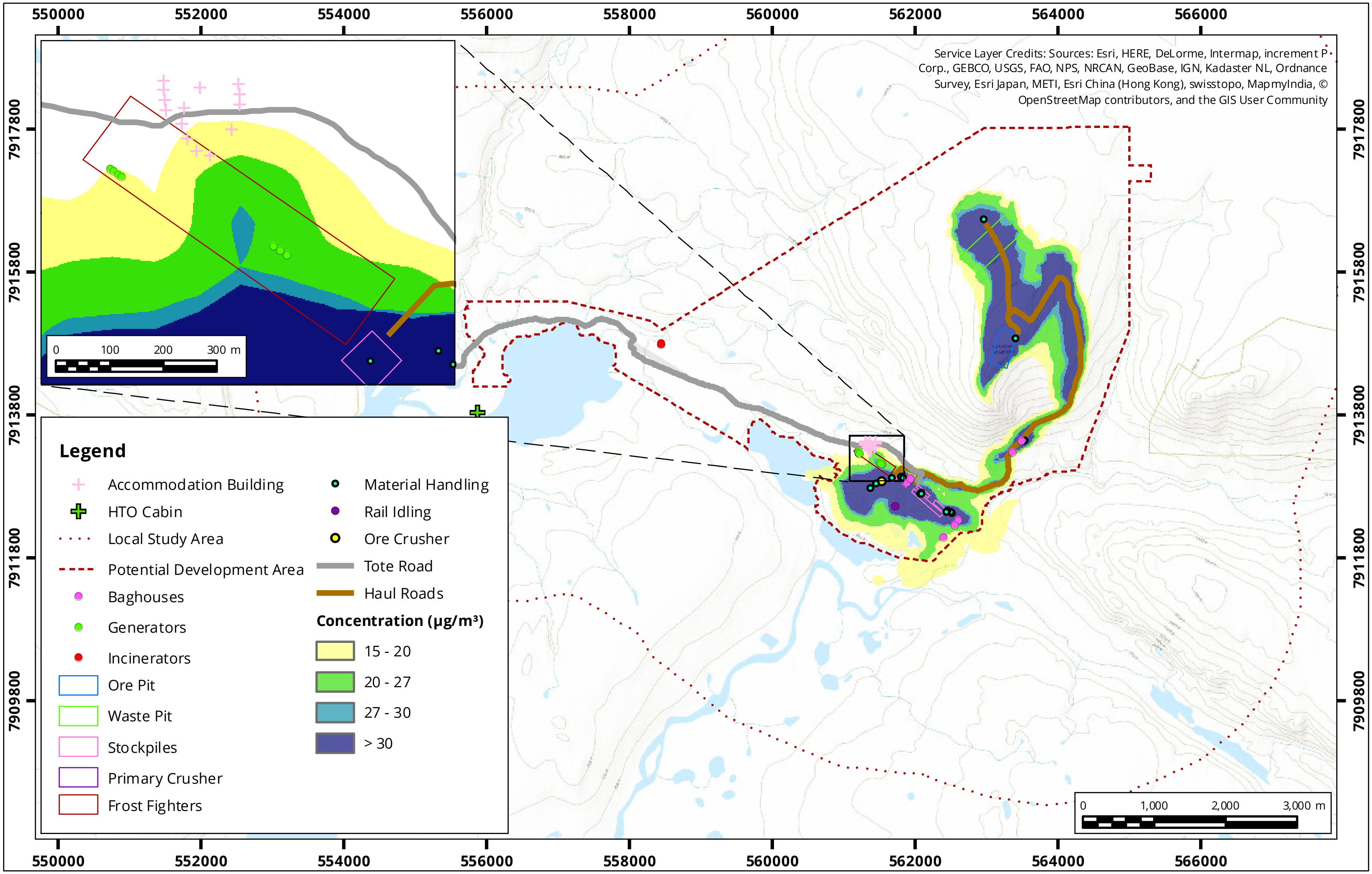
Annual NO_2 2020 CAAQS: 32 µg/m³
Annual NO_2 2025 CAAQS: 23 µg/m³

True North

Project #: 1402090

Drawn by: DJH	Figure: E-6
Approx. Scale:	1:75,000
Date Revised:	Jan 3, 2019

Map Document: C:\Users\djh\OneDrive - ROWAN WILLIAMS DAVIES & IRWIN INC-\GIS Temp\1402090\BK\Mine\1402090 - Baffinland - AQ Mine Contour Plots_upd_181213.mxd



Predicted 24-Hour PM$_{2.5}$ Concentrations
Mine Site

True North

Drawn by: DJH	Figure: E-12b
Approx. Scale:	1:75,000
Date Revised:	Dec 13, 2018

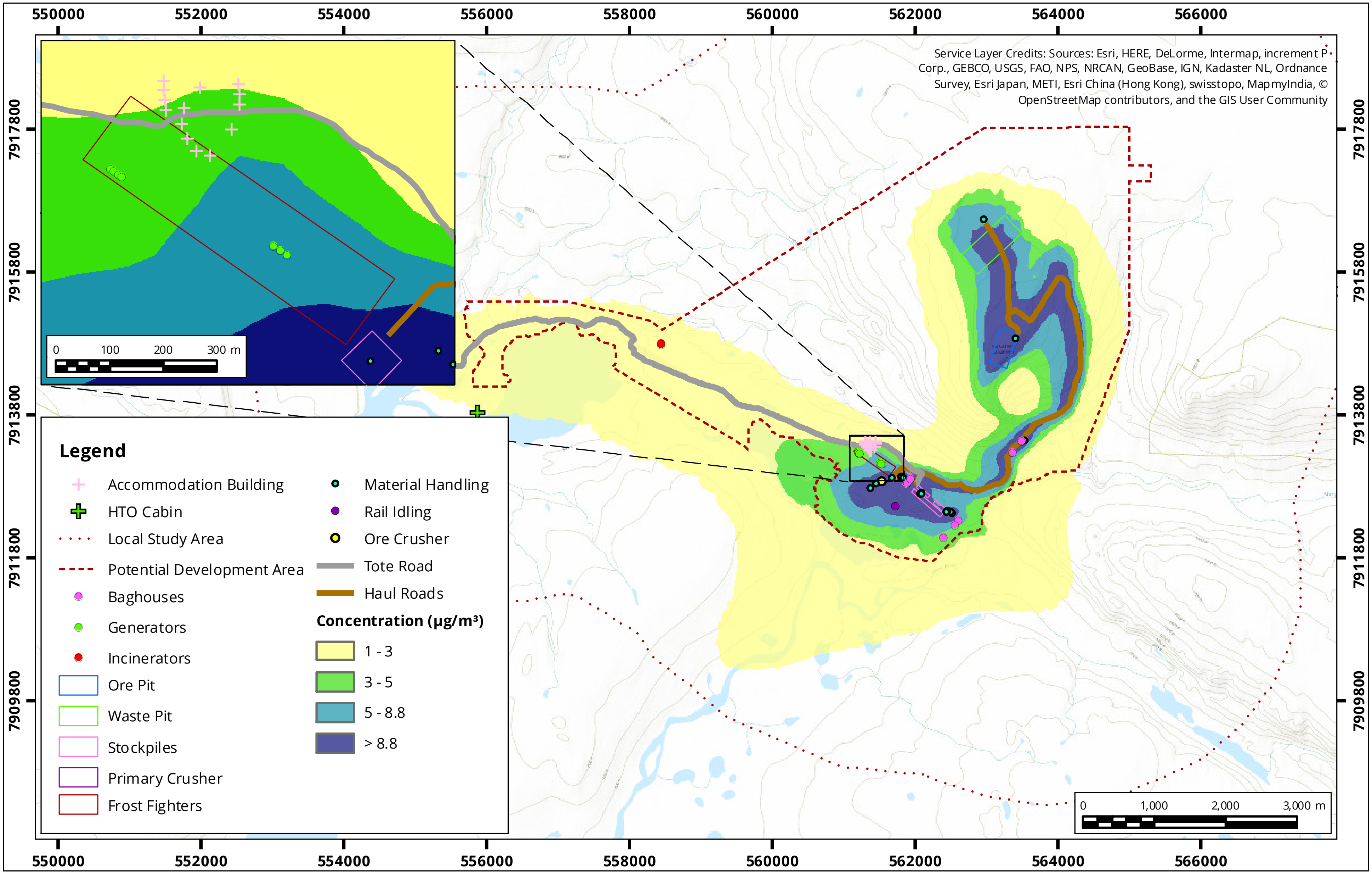
Map Projection: NAD 1983 UTM Zone 17N

24-Hour PM$_{2.5}$ CAAQS: 27 μg/m³

Baffinland Iron Mines Corporation - Nunavut, Canada

Project #: 1402090

Map Document: C:\Users\djh\OneDrive - ROWAN WILLIAMS DAVIES & IRWIN INC-\GIS Temp\1402090\BK\Mine\1402090 - Baffinland - AQ Mine Contour Plots_upd_181213.mxd



Predicted Annual $PM_{2.5}$ Concentrations

Mine Site

Map Projection: NAD 1983 UTM Zone 17N

Annual PM_{25} CAAQS: 8.8 µg/m³

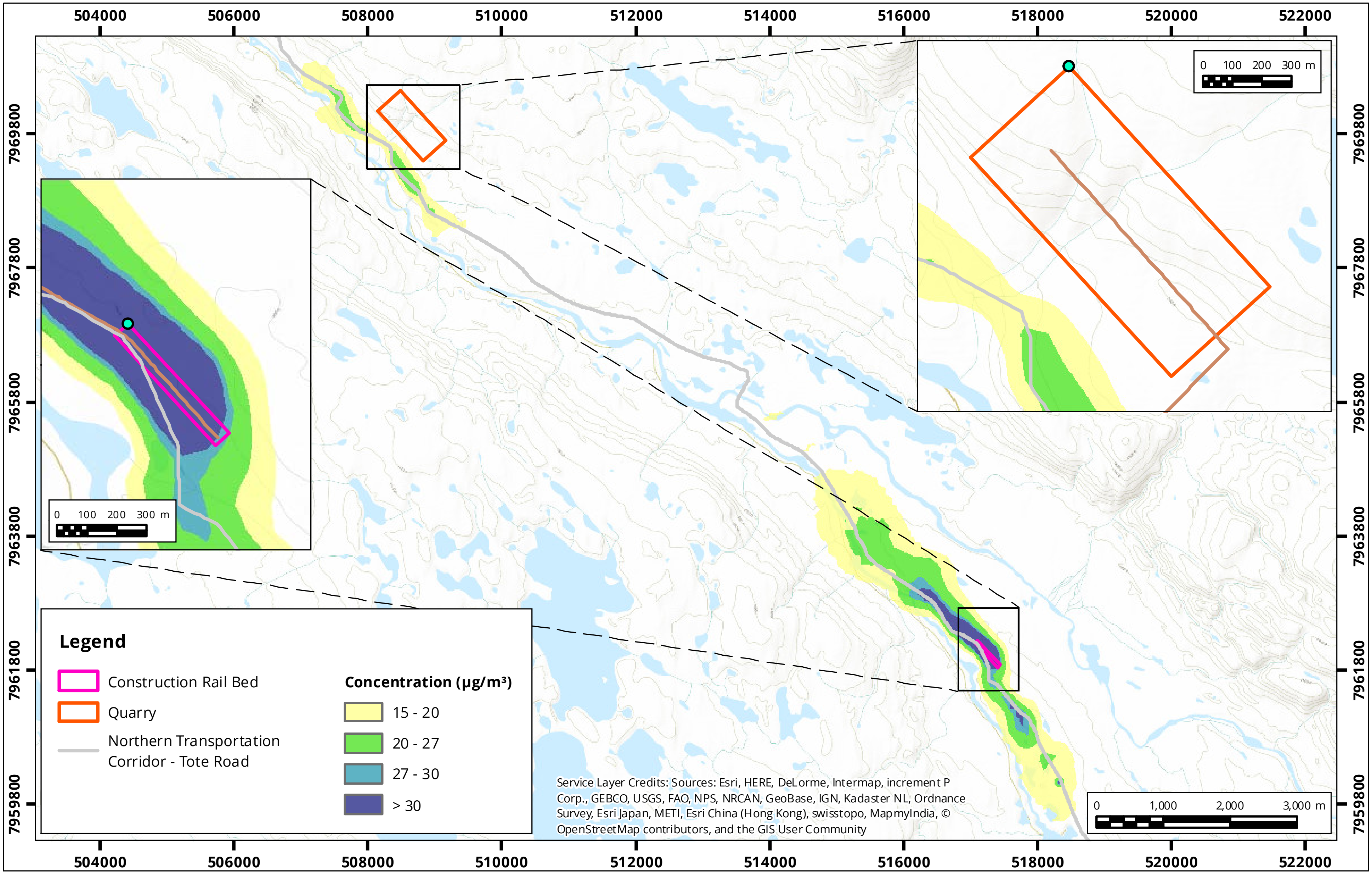
Baffinland Iron Mines Corporation - Nunavut, Canada

True North

Project #: 1402090

Drawn by: DJH	Figure: E-15
Approx. Scale:	1:75,000
Date Revised:	Dec 13, 2018

Map Document: C:\Users\djh\OneDrive - ROWAN WILLIAMS DAVIES & IRWIN INC-\GIS Temp\1402090\JBK\Mine\1402090 - Baffinland - AQ Mine Contour Plots_upd_181213.mxd



Predicted Maximum 24-Hour $PM_{2.5}$ Concentrations

Northern Transportation Corridor - Tote Road and Construction Sources

True North

Map Projection: NAD 1983 UTM Zone 17N

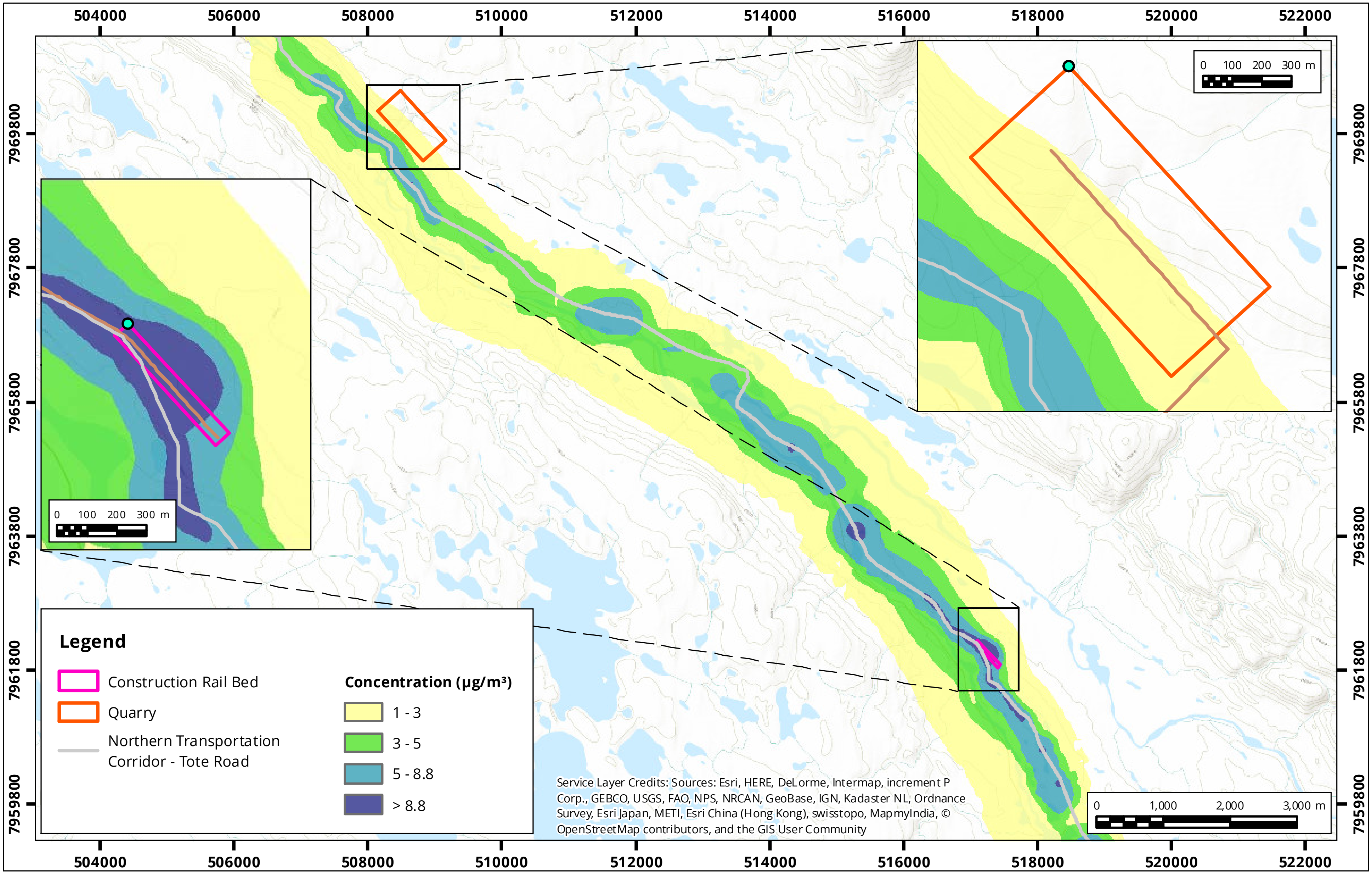
24-Hour $PM_{2.5}$ CAAQS: 27 µg/m³

Baffinland Iron Mines Corporation - Nunavut, Canada

Project #: 1402090

Drawn by: DJH	Figure: F-16b
Approx. Scale:	1:80,000
Date Revised:	Dec 13, 2018

Map Document: C:\Users\djh\OneDrive - ROWAN WILLIAMS DAVIES & IRWIN INC-\GIS Temp\1402090\BK\Cons\1402090 - Baffinland - AQ Construction Contour Plots_170529.mxd



Predicted Annual $PM_{2.5}$ Concentrations

Northern Transportation Corridor - Tote Road and Construction Sources

Map Projection: NAD 1983 UTM Zone 17N

Annual $PM_{2.5}$ CAAQS: 8.8 µg/m³

Baffinland Iron Mines Corporation - Nunavut, Canada

True North

Project #: 1402090

Drawn by: DJH	Figure: F-19
Approx. Scale:	1:80,000
Date Revised:	Dec 13, 2018

Map Document: C:\Users\djh\OneDrive - ROWAN WILLIAMS DAVIES & IRWIN INC\GIS Temp\1402090\JBK\Cons\1402090 - Baffinland - AQ Construction Contour Plots_170529.mxd

HC 07 ATTACHMENT 1: TABLES

Table HC-07-1 Predicted Future Soil Concentrations for Time Frame of Operations at the Mine Site Based on a Dust Deposition Rate of 144 g/m2/year, Compared to Ecological-Health Based Soil Quality Guidelines and Maximum Baseline Soil Concentrations

Metal/ COPC	Baseline Surface Soil Concentration (90th %ile) (mg/kg)	2016		2017-2018		2019-2020		2021		2022-2023		2024		2025-2035		Soil Quality Guideline[a]	Maximum Baseline
		Project	Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline		
Aluminum	6515	14.7	6529.7	27.6	6557.3	27.6	6584.9	26.8	6611.7	53.0	6664.7	26.8	6691.548	260.9	6952.4	pH < 5.5[b]	39300
Antimony	<0.1	0.00728	0.107	0.0137	0.121	0.01365	0.135	0.0133	0.148	0.0262	0.174	0.0133	0.187	0.129	0.316	20[c]	0.85
Arsenic	1.24	0.0173	1.26	0.0325	1.29	0.0325	1.32	0.0316	1.35	0.0623	1.42	0.0316	1.448	0.307	1.75	17	4.14
Barium	31.3	0.0697	31.3	0.131	31.5	0.1307	31.6	0.127	31.7	0.251	32.0	0.127	32.086	1.24	33.3	390[c]	132
Cadmium	0.172	0.00634	0.178	0.0119	0.190	0.01190	0.202	0.0116	0.214	0.0228	0.237	0.0116	0.248	0.112	0.361	3.8/10	0.275
Chromium	26.4	0.101	26.5	0.190	26.7	0.190	26.9	0.185	27.1	0.365	27.4	0.185	27.616	1.80	29.4	64	55.7
Cobalt	4.72	0.0138	4.73	0.0258	4.76	0.0258	4.79	0.0251	4.81	0.0496	4.86	0.0251	4.885	0.244	5.13	40[c]	17.5
Copper	9.65	0.0837	9.73	0.157	9.89	0.1570	10.0	0.153	10.2	0.301	10.5	0.153	10.6	1.48	12.1	63	48.4
Iron	20500	23.0	20523.0	43.2	20566.2	43.2	20609.4	42.0	20651.4	82.9	20734.4	42.0	20776.4	408.4	21184.7	pH 5-8[d]	90500
Lead	6.67	0.0141	6.68	0.0264	6.71	0.0264	6.74	0.0257	6.76	0.0507	6.81	0.0257	6.84	0.250	7.09	70/300	31.7
Manganese	203.5	0.556	204	1.04	205.1	1.043	206.1	1.014	207.2	2.00	209.2	1.01	210.2	9.86	220.0	220/4000[f]	416
Mercury	<0.05	0.00582	0.0558	0.0109	0.0667	0.01092	0.0777	0.0106	0.0883	0.0210	0.109	0.0106	0.120	0.103	0.223	12	0.152
Molybdenum	0.35	0.0131	0.363	0.0246	0.388	0.0246	0.412	0.0239	0.436	0.0472	0.483	0.0239	0.507	0.232	0.740	6.9[c]	2.53
Nickel	19.3	0.0863	19.4	0.162	19.5	0.1619	19.7	0.157	19.9	0.311	20.2	0.157	20.3	1.53	21.9	50	39.4
Selenium	<0.5	0.0174	0.517	0.0326	0.550	0.0326	0.583	0.0317	0.614	0.0625	0.677	0.0317	0.708	0.308	1.02	1	0.51
Silver	<0.05	0.000498	0.0505	0.00093	0.0514	0.000934	0.0524	0.000908	0.0533	0.00179	0.0551	0.000908	0.0560	0.00883	0.0648	20[c]	0.198
Strontium	21.4	0.0334	21.4	0.063	21.5	0.0627	21.6	0.0610	21.6	0.120	21.7	0.0610	21.8	0.593	22.4	NGA	83.3
Thallium	0.128	0.000232	0.128	0.000435	0.129	0.000435	0.129	0.000423	0.130	0.00084	0.130	0.000423	0.131	0.00411	0.135	1/1.4	0.435
Tin	0.585	0.00306	0.588	0.0057	0.594	0.00574	0.600	0.00558	0.605	0.0110	0.616	0.00558	0.622	0.0543	0.676	5[g]	2.66
Uranium	1.90	0.00365	1.90	0.0068	1.91	0.00684	1.91	0.00665	1.92	0.0131	1.93	0.00665	1.94	0.0646	2.00	33/500	6.13
Vanadium	28.8	0.0303	28.8	0.057	28.8	0.0568	28.9	0.0552	28.9	0.109	29.1	0.0552	29.1	0.536	29.6	86[c]	83.9
Zinc	25.6	0.127	25.7	0.239	26.0	0.239	26.2	0.232	26.4	0.459	26.9	0.232	27.1	2.26	29.4	200	118

Notes:

a) Unless otherwise noted, all soil quality guidelines are from CCME 2017 (on-line; http://ceqg-rcqe.ccme.ca/). Guidelines are ecological health-based soil quality guidelines for residential/parkland and agricultural land use (agricultural guidelines are applicable to wildlands). Where agricultural and residential / parkland are different, the agricultural guideline is presented first followed by the residential / parkland guideline.

b) U.S. EPA (2003a); for soils with pH <5.5 Al should be retained as a COC. The pH of 68 soil samples analyzed ranged 4.58 to 8.81 with an average pH of 6.57.

c) OMOE (Ontario Ministry of the Environment; 2016) soil component value. Value presented is lower of the mammal / bird and plant / soil organism soil component value.

d) U.S. EPA (2003b); for soils with pH between 5 and 8, iron is considered non-toxic. The pH of 68 soil samples analyzed ranged 4.58 to 8.81 with an average pH of 6.57.

e) OMOE Soil Component Value, based on background

f) U.S. EPA EcoSSL (https://rais.ornl.gov/documents/eco-ssl_manganese.pdf); vegetation / mammalian soil quality guidelines

g) Alberta Environment, 2016; http://aep.alberta.ca/land/land-industrial/inspections-and-compliance/documents/AlbertaTier1Guidelines-Feb02-2016A.pdf

Shaded values are > Soil Quality Guidelines; Underlined values are > Maximum soil baseline concentrations

Table HC-07-2 Predicted Future Soil Concentrations for Time Frame of Operations at the Mine Site Based on a Dust Deposition Rate of 55 g/m2/year, Compared to Ecological-Health Based Soil Quality Guidelines and Maximum Baseline Soil Concentrations

Metal/ COPC	Baseline Surface Soil Concentration (90^{th} %ile) (mg/kg)	2016		2017-2018		2019-2020		2021		2022-2023		2024		2025-2035		Soil Quality Guideline[a]	Maximum Baseline
		Project	Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline		
Aluminum	6515	0.948	6515.9	3.68	6519.6	4.05	6523.7	4.28	6528.0	8.46	6536.4	7.32	6543.7	99.6	6643.4	pH < 5.5[b]	39300
Antimony	<0.1	0.000469	0.100	0.00182	0.102	0.00200	0.104	0.00212	0.106	0.00419	0.111	0.00362	0.114	0.0493	0.164	20[c]	0.85
Arsenic	1.24	0.00112	1.24	0.00433	1.25	0.00476	1.25	0.00504	1.26	0.0100	1.27	0.00862	1.27	0.117	1.39	17	4.14
Barium	31.3	0.00449	31.3	0.0174	31.3	0.0192	31.3	0.0203	31.3	0.040	31.4	0.0347	31.4	0.472	31.9	390[c]	132
Cadmium	0.172	0.000409	0.172	0.00159	0.174	0.00174	0.176	0.00185	0.178	0.0036	0.181	0.00316	0.184	0.0430	0.227	3.8/10	0.275
Chromium	26.4	0.00653	26.4	0.0254	26.4	0.0279	26.5	0.0295	26.5	0.0583	26.5	0.0504	26.6	0.687	27.3	64	55.7
Cobalt	4.72	0.000888	4.72	0.00345	4.72	0.00379	4.73	0.00401	4.73	0.00792	4.74	0.00686	4.75	0.0933	4.84	40[c]	17.5
Copper	9.65	0.00539	9.65	0.0209	9.67	0.0230	9.69	0.0244	9.72	0.0481	9.77	0.0417	9.81	0.567	10.4	63	48.4
Iron	20500	1.48	20501.5	5.76	20507.2	6.34	20513.6	6.71	20520.3	13.2	20533.5	11.5	20545.0	156.0	20701.0	pH 5-8[d]	90500
Lead	6.67	0.000908	6.67	0.00352	6.67	0.00388	6.68	0.00410	6.68	0.00810	6.69	0.00701	6.70	0.0954	6.79	70/300	31.7
Manganese	203.5	0.0359	203.5	0.139	203.7	0.153	203.8	0.162	204.0	0.320	204.3	0.277	204.6	3.77	208.4	220/4000[f]	416
Mercury	<0.05	0.000375	0.0504	0.00146	0.0518	0.00160	0.0534	0.00170	0.0551	0.00335	0.0585	0.00290	0.0614	0.0394	0.101	12	0.152
Molybdenum	0.35	0.000844	0.351	0.00328	0.354	0.00360	0.358	0.00382	0.362	0.00754	0.369	0.00652	0.376	0.0887	0.464	6.9[e]	2.53
Nickel	19.3	0.00556	19.3	0.0216	19.3	0.0237	19.4	0.0251	19.4	0.0496	19.4	0.0429	19.5	0.584	20.1	50	39.4
Selenium	<0.5	0.00112	0.501	0.00434	0.505	0.00478	0.510	0.00506	0.515	0.00999	<u>0.525</u>	0.00864	<u>0.534</u>	0.118	<u>0.652</u>	1	0.51
Silver	<0.05	0.0000321	0.0500	0.000125	0.0502	0.000137	0.0503	0.000145	0.0504	0.000286	0.0507	0.000248	0.0510	0.00337	0.0543	20[c]	0.198
Strontium	21.4	0.00215	21.4	0.00836	21.4	0.00920	21.4	0.00974	21.4	0.0192	21.4	0.0166	21.5	0.226	21.7	NGA	83.3
Thallium	0.128	0.0000149	0.128	0.0000580	0.128	0.0000638	0.128	0.0000675	0.128	0.000133	0.128	0.000115	0.128	0.00157	0.130	1/1.4	0.435
Tin	0.585	0.000197	0.585	0.000766	0.586	0.000842	0.587	0.000892	0.588	0.00176	0.589	0.00152	0.591	0.0207	0.612	5[g]	2.66
Uranium	1.90	0.000235	1.90	0.000911	1.90	0.00100	1.90	0.00106	1.90	0.00210	1.90	0.00181	1.90	0.0247	1.93	33/500	6.13
Vanadium	28.8	0.00195	28.8	0.00757	28.8	0.00832	28.8	0.00881	28.8	0.0174	28.8	0.0151	28.8	0.205	29.0	86[e]	83.9
Zinc	25.6	0.00821	25.6	0.0319	25.6	0.0350	25.7	0.0371	25.7	0.0733	25.8	0.0634	25.8	0.863	26.7	200	118

Notes:

a) Unless otherwise noted, all soil quality guidelines are from CCME 2017 (on-line; http://ceqg-rcqe.ccme.ca/). Guidelines are ecological health-based soil quality guidelines for residential/parkland and agricultural land use (agricultural guidelines are applicable to wildlands). Where agricultural and residential / parkland are different, the agricultural guideline is presented first followed by the residential / parkland guideline.

b) U.S. EPA (2003a); for soils with pH <5.5 Al should be retained as a COC. The pH of 68 soil samples analyzed ranged 4.58 to 8.81 with an average pH of 6.57.

c) OMOE (Ontario Ministry of the Environment; 2016) soil component value. Value presented is lower of the mammal / bird and plant / soil organism soil component value.

d) U.S. EPA (2003b); for soils with pH between 5 and 8, iron is considered non-toxic. The pH of 68 soil samples analyzed ranged 4.58 to 8.81 with an average pH of 6.57.

e) OMOE Soil Component Value, based on background

f) U.S. EPA EcoSSL (https://rais.ornl.gov/documents/eco-ssl_manganese.pdf); vegetation / mammalian soil quality guidelines

g) Alberta Environment, 2016; http://aep.alberta.ca/land/land-industrial/inspections-and-compliance/documents/AlbertaTier1Guidelines-Feb02-2016A.pdf

Shaded values are > Soil Quality Guidelines; Underlined values are > Maximum soil baseline concentrations

Table HC-07-3 Predicted Future Soil Concentrations for Time Frame of Operations at Tote Road Based on a Dust Deposition Rate of 55 g/m2/year, Compared to Ecological-Health Based Soil Quality Guidelines and Maximum Baseline Soil Concentrations

Metal/ COPC	Baseline Surface Soil Concentration (90th %ile) (mg/kg)	2016		2017-2018		2019-2020		2021		2022-2023		2024		2025-2035		Soil Quality Guideline[a]	Maximum Baseline
		Project	Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline		
Aluminum	6515	8.43	6523.4	13.9	6537.4	15.3	6552.7	15.5	6568.2	0	6568.2	0	6568.2	0	6568.2	pH < 5.5[b]	39300
Antimony	<0.1	0.000692	0.101	0.00114	0.102	0.00126	0.103	0.00127	0.104	0	0.104	0	0.104	0	0.104	20[c]	0.85
Arsenic	1.24	0.0351	1.28	0.0579	1.33	0.0637	1.40	0.0645	1.46	0	1.46	0	1.46	0	1.5	17	4.14
Barium	31.3	0.0684	31.3	0.113	31.4	0.124	31.6	0.126	31.7	0	31.7	0	31.7	0	31.7	390[c]	132
Cadmium	0.172	0.00237	0.174	0.00392	0.178	0.00431	0.183	0.00436	0.187	0	0.187	0	0.187	0	0.187	3.8/10	0.275
Chromium	26.4	0.0217	26.4	0.0359	26.5	0.0395	26.5	0.0400	26.5	0	26.5	0	26.5	0	26.5	64	55.7
Cobalt	4.72	0.00465	4.72	0.00768	4.73	0.00844	4.74	0.00855	4.75	0	4.75	0	4.75	0	4.75	40[c]	17.5
Copper	9.65	0.0460	9.69	0.0760	9.77	0.0836	9.85	0.0846	9.94	0	9.94	0	9.94	0	9.94	63	48.4
Iron	20500	12.1	20512.1	20.0	20532.1	22.0	20554.1	22.3	20576.4	0	20576.4	0	20576.4	0	20576.4	pH 5-8[d]	90500
Lead	6.67	0.00951	6.68	0.0157	6.70	0.0173	6.71	0.0175	6.73	0	6.73	0	6.73	0	6.73	70/300	31.7
Manganese	203.5	0.194	203.7	0.321	204.0	0.353	204.4	0.357	204.7	0	204.7	0	204.7	0	204.7	220/4000[f]	416
Mercury	<0.05	0.00558	0.0556	0.00921	0.0648	0.0101	0.0749	0.0103	0.0852	0	0.0852	0	0.0852	0	0.0852	12	0.152
Molybdenum	0.35	0.00146	0.351	0.00241	0.354	0.00266	0.357	0.00269	0.359	0	0.359	0	0.359	0	0.359	6.9[c]	2.53
Nickel	19.3	0.0176	19.3	0.0291	19.3	0.0320	19.4	0.0324	19.4	0	19.4	0	19.4	0	19.4	50	39.4
Selenium	<0.5	0.00639	0.506	0.0105	0.517	0.0116	0.529	0.0118	0.540	0	0.540	0	0.540	0	0.540	1	0.51
Silver	<0.05	0.000116	0.0501	0.000192	0.0503	0.000211	0.0505	0.000214	0.0507	0	0.0507	0	0.0507	0	0.0507	20[c]	0.198
Strontium	21.4	0.0262	21.4	0.0432	21.5	0.0475	21.5	0.0482	21.6	0	21.6	0	21.6	0	21.6	NGA	83.3
Thallium	0.128	0.000663	0.129	0.00109	0.130	0.00120	0.131	0.00122	0.132	0	0.132	0	0.132	0	0.132	1/1.4	0.435
Tin	0.585	0.00197	0.587	0.00326	0.590	0.00358	0.594	0.00363	0.597	0	0.597	0	0.597	0	0.597	5[g]	2.66
Uranium	1.90	0.00134	1.90	0.00221	1.90	0.00243	1.90	0.00246	1.90	0	1.90	0	1.90	0	1.90	33/500	6.13
Vanadium	28.8	0.0142	28.8	0.0235	28.8	0.0258	28.8	0.0262	28.8	0	28.8	0	28.8	0	28.8	86[e]	83.9
Zinc	25.6	0.0626	25.7	0.103	25.8	0.114	25.9	0.115	26.0	0	26.0	0	26.0	0	26.0	200	118

Notes:

a) Unless otherwise noted, all soil quality guidelines are from CCME 2017 (on-line; http://ceqg-rcqe.ccme.ca/). Guidelines are ecological health-based soil quality guidelines for residential/parkland and agricultural land use (agricultural guidelines are applicable to wildlands). Where agricultural and residential / parkland are different, the agricultural guideline is presented first followed by the residential / parkland guideline.
b) U.S. EPA (2003a); for soils with pH <5.5 Al should be retained as a COC. The pH of 68 soil samples analyzed ranged 4.58 to 8.81 with an average pH of 6.57.
c) OMOE (Ontario Ministry of the Environment; 2016) soil component value. Value presented is lower of the mammal / bird and plant / soil organism soil component value.
d) U.S. EPA (2003b); for soils with pH between 5 and 8, iron is considered non-toxic. The pH of 68 soil samples analyzed ranged 4.58 to 8.81 with an average pH of 6.57.
e) OMOE Soil Component Value, based on background
f) U.S. EPA EcoSSL (https://rais.ornl.gov/documents/eco-ssl_manganese.pdf); vegetation / mammalian soil quality guidelines
g) Alberta Environment, 2016; http://aep.alberta.ca/land/land-industrial/inspections-and-compliance/documents/AlbertaTier1Guidelines-Feb02-2016A.pdf

Shaded values are > Soil Quality Guidelines; Underlined values are > Maximum soil baseline concentrations

Table HC-07-4 Predicted Future Soil Concentrations for Time Frame of Operations at Milne Port Based on a Dust Deposition Rate of 55 g/m2/year, Compared to Ecological-Health Based Soil Quality Guidelines and Maximum Baseline Soil Concentrations

Metal/ COPC	Baseline Surface Soil Concentration (90^{th} %ile) (mg/kg)	2016		2017-2018		2019-2020		2021		2022-2023		2024		2025-2035		Soil Quality Guideline[a]	Maximum Baseline
		Project	Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline		
Aluminum	6515	0.814	6515.81	5.17	6521.0	5.64	6526.6	5.7	6532.3	11.3	6543.6	5.71	6549.3	55.6	6604.9	pH < 5.5[b]	39300
Antimony	<0.1	0.000276	0.100	0.00175	0.102	0.00191	0.104	0.00194	0.106	0.00383	0.110	0.00194	0.112	0.0189	0.131	20[c]	0.85
Arsenic	1.24	0.00917	1.25	0.0582	1.31	0.0636	1.37	0.0644	1.44	0.127	1.56	0.0644	1.63	0.626	2.25	17	4.14
Barium	31.3	0.00662	31.3	0.0420	31.3	0.0459	31.3	0.0465	31.4	0.0917	31.5	0.0465	31.5	0.452	32.0	390[c]	132
Cadmium	0.172	0.000471	0.172	0.00299	0.175	0.00326	0.18	0.00331	0.182	0.00653	0.189	0.00331	0.192	0.0321	0.224	3.8/10	0.275
Chromium	26.4	0.00341	26.4	0.0217	26.4	0.0236	26.4	0.0239	26.5	0.0473	26.5	0.0239	26.5	0.233	26.8	64	55.7
Cobalt	4.72	0.000668	4.72	0.00424	4.72	0.00462	4.73	0.00468	4.73	0.00925	4.74	0.00468	4.75	0.0455	4.79	40[c]	17.5
Copper	9.65	0.0115	9.66	0.0730	9.73	0.0797	9.81	0.0807	9.89	0.159	10.0	0.0807	10.1	0.785	10.9	63	48.4
Iron	20500	1.58	20501.6	10.0	20511.6	10.9	20522.6	11.1	20533.6	21.9	20556	11.1	20566.6	107.8	20674.4	pH 5-8[d]	90500
Lead	6.67	0.000874	6.67	0.00555	6.68	0.00606	6.68	0.00613	6.69	0.0121	6.70	0.00613	6.71	0.0596	6.77	70/300	31.7
Manganese	203.5	0.0332	203.5	0.211	203.7	0.230	204.0	0.233	204.2	0.460	204.7	0.233	204.9	2.26	207.2	220/4000[f]	416
Mercury	<0.05	0.00110	0.0511	0.00700	0.0581	0.00764	0.0657	0.00773	0.0735	0.0153	0.089	0.00773	0.0965	0.0752	0.172	12	0.152
Molybdenum	0.35	0.000233	0.350	0.00148	0.352	0.00161	0.353	0.00163	0.355	0.00323	0.358	0.00163	0.360	0.0159	0.376	6.9[c]	2.53
Nickel	19.3	0.00318	19.3	0.0202	19.3	0.0220	19.3	0.0223	19.4	0.0440	19.4	0.0223	19.4	0.217	19.7	50	39.4
Selenium	<0.5	0.00163	0.502	0.0103	0.512	0.0113	0.523	0.0114	0.535	0.0226	0.557	0.0114	0.569	0.111	0.680	1	0.51
Silver	<0.05	0.0000226	0.0500	0.000144	0.0502	0.000157	0.0503	0.000159	0.0505	0.000314	0.0508	0.000159	0.0510	0.00154	0.0525	20[c]	0.198
Strontium	21.4	0.00771	21.4	0.0489	21.5	0.0534	21.5	0.0541	21.6	0.107	21.7	0.0541	21.7	0.526	22.3	NGA	83.3
Thallium	0.128	0.000163	0.128	0.00104	0.129	0.00113	0.130	0.00115	0.131	0.00226	0.134	0.00115	0.135	0.0112	0.146	1/1.4	0.435
Tin	0.585	0.000367	0.585	0.00233	0.588	0.00254	0.590	0.00258	0.593	0.00509	0.598	0.00258	0.600	0.025	0.626	5[g]	2.66
Uranium	1.90	0.000368	1.90	0.00234	1.90	0.00255	1.90	0.00258	1.90	0.00510	1.91	0.00258	1.91	0.025	1.94	33/500	6.13
Vanadium	28.8	0.00215	28.8	0.0136	28.8	0.0149	28.8	0.0150	28.8	0.0297	28.8	0.0150	28.8	0.146	29.0	86[c]	83.9
Zinc	25.6	0.0273	25.6	0.173	25.8	0.189	26.0	0.191	26.2	0.378	26.6	0.191	26.7	1.86	28.6	200	118

Notes:

a) Unless otherwise noted, all soil quality guidelines are from CCME 2017 (on-line; http://ceqg-rcqe.ccme.ca/). Guidelines are ecological health-based soil quality guidelines for residential/parkland and agricultural land use (agricultural guidelines are applicable to wildlands). Where agricultural and residential / parkland are different, the agricultural guideline is presented first followed by the residential / parkland guideline.

b) U.S. EPA (2003a); for soils with pH <5.5 Al should be retained as a COC. The pH of 68 soil samples analyzed ranged 4.58 to 8.81 with an average pH of 6.57.

c) OMOE (Ontario Ministry of the Environment; 2016) soil component value. Value presented is lower of the mammal / bird and plant / soil organism soil component value.

d) U.S. EPA (2003b); for soils with pH between 5 and 8, iron is considered non-toxic. The pH of 68 soil samples analyzed ranged 4.58 to 8.81 with an average pH of 6.57.

e) OMOE Soil Component Value, based on background

f) U.S. EPA EcoSSL (https://rais.ornl.gov/documents/eco-ssl_manganese.pdf); vegetation / mammalian soil quality guidelines

g) Alberta Environment, 2016; http://aep.alberta.ca/land/land-industrial/inspections-and-compliance/documents/AlbertaTier1Guidelines-Feb02-2016A.pdf

Shaded values are > Soil Quality Guidelines; Underlined values are > Maximum soil baseline concentrations

Table HC-07-5 Predicted Future Lichen Concentrations (mg/kg-DW) for Time Frame of Operations at the Mine Site Based on a Dust Deposition Rate of 55 g/m2/year, Compared to Maximum Baseline Lichen Concentrations

Metal/COPC	Baseline Lichen Concentration (90th %ile)	2016	2017-2018	2019-2020	2021	2022-2023	2024	2025-2035	Maximum Baseline
		Project + Baseline	Accumulated Project + Baseline	Accumulated Project + Baseline	Accumulated Project + Baseline	Accumulated Project + Baseline	Accumulated Project + Baseline	Accumulated Project + Baseline	
Aluminum	577.1	600.8	623.8	628.5	684.1	684.5	760.0	840.9	1240
Antimony	0.0147	0.0264	0.0379	0.0402	<u>0.0678</u>	<u>0.068</u>	<u>0.105</u>	<u>0.148</u>	0.064
Arsenic	0.194	0.222	0.250	0.255	0.321	0.321	0.410	0.513	1.1
Barium	18.5	18.6	18.8	18.8	19.0	19.1	19.4	20.0	43.3
Cadmium	0.193	0.204	0.215	0.217	0.241	0.243	0.275	<u>0.351</u>	0.297
Chromium	3.10	3.26	3.42	3.45	3.84	3.84	4.36	4.94	6.03
Cobalt	0.554	0.577	0.598	0.603	0.655	0.655	0.726	0.804	1.39
Copper	2.34	2.47	2.60	2.63	2.95	2.95	3.38	<u>3.92</u>	3.82
Iron	1103.0	1140.0	1175.9	1183.2	1270.3	1270.6	1388.8	1510.6	8830
Lead	2.63	2.66	2.68	2.68	2.74	2.74	2.81	2.91	6.71
Manganese	70.5	71.4	72.3	72.5	74.6	74.6	77.5	81.4	97.8
Mercury	0.0942	0.104	0.115	0.117	0.140	0.143	0.172	<u>0.269</u>	0.236
Molybdenum	0.134	0.156	0.177	0.181	0.231	0.232	0.299	<u>0.396</u>	0.364
Nickel	2.92	3.06	3.20	3.22	3.55	3.55	4.00	4.50	12.2
Selenium	0.105	0.133	0.161	0.166	<u>0.232</u>	<u>0.233</u>	<u>0.322</u>	<u>0.431</u>	0.197
Silver	<0.02	0.0208	0.0216	0.0218	0.0237	0.0237	0.0263	0.0300	0.045
Strontium	33.9	33.9	34.0	34.0	34.1	34.1	34.3	34.8	75.9
Thallium	0.0155	0.0159	0.0163	0.0164	0.0172	0.0172	0.0184	0.0197	0.0249
Tin	0.11	0.115	0.120	0.121	0.132	0.133	0.148	0.167	0.5
Uranium	0.23	0.236	0.242	0.243	0.257	0.257	0.275	0.296	0.847
Vanadium	1.6	1.61	1.65	1.66	1.78	1.78	1.93	2.09	3.43
Zinc	24.14	24.4	24.6	24.6	25.1	25.1	25.8	27.2	33.2

Notes:
Underlined values are > Maximum Baseline lichen concentration

Table HC-07-6 Predicted Future Lichen Concentrations (mg/kg-DW) for Time Frame of Operations at Tote Road Based on a Dust Deposition Rate of 55 g/m2/year, Compared to Maximum Baseline Lichen Concentrations

Metal/COPC	Baseline Lichen Concentration (90th %ile)	2016	2017-2018	2019-2020	2021	2022-2023	2024	2025-2035	Maximum Baseline
		Project + Baseline	Accumulated Project + Baseline	Accumulated Project + Baseline	Accumulated Project + Baseline	Accumulated Project + Baseline	Accumulated Project + Baseline	Accumulated Project + Baseline	
Aluminum	577.1	787.7	753.8	771.5	964.5	577.1	577.1	577.1	1240
Antimony	0.0147	0.0320	0.0293	0.0307	0.0466	0.0147	0.0147	0.0147	0.064
Arsenic	0.194	1.072	0.933	1.007	1.809	0.194	0.194	0.194	1.1
Barium	18.5	20.3	20.0	20.2	21.7	18.5	18.5	18.5	43.3
Cadmium	0.193	0.255	0.247	0.252	0.307	0.193	0.193	0.193	0.297
Chromium	3.10	3.64	3.55	3.60	4.10	3.10	3.10	3.10	6.03
Cobalt	0.554	0.671	0.652	0.662	0.768	0.554	0.554	0.554	1.39
Copper	2.34	3.49	3.31	3.41	4.46	2.34	2.34	2.34	3.82
Iron	1103.0	1405.0	1356.1	1381.4	1658.6	1103.0	1103.0	1103.0	8830
Lead	2.63	2.87	2.84	2.86	3.08	2.63	2.63	2.63	6.71
Manganese	70.5	75.4	74.6	75.1	79.5	70.5	70.5	70.5	97.8
Mercury	0.0942	0.244	0.228	0.2410	0.3689	0.0942	0.0942	0.0942	0.236
Molybdenum	0.134	0.171	0.166	0.169	0.202	0.134	0.134	0.134	0.364
Nickel	2.92	3.36	3.29	3.33	3.73	2.92	2.92	2.92	12.2
Selenium	0.105	0.265	0.240	0.254	0.400	0.105	0.105	0.105	0.197
Silver	<0.02	0.0229	0.0225	0.0227	0.0254	0.0200	0.0200	0.0200	0.045
Strontium	33.9	34.5	34.5	34.5	35.1	33.9	33.9	33.9	75.9
Thallium	0.0155	0.0321	0.0295	0.0309	0.0460	0.0155	0.0155	0.0155	0.0249
Tin	0.110	0.159	0.152	0.156	0.201	0.110	0.110	0.110	0.500
Uranium	0.23	0.264	0.258	0.261	0.292	0.230	0.230	0.230	0.847
Vanadium	1.6	1.91	1.86	1.89	2.21	1.56	1.56	1.56	3.43
Zinc	24.1	25.8	25.5	25.7	27.1	24.1	24.1	24.1	33.2

Notes:
Underlined values are > Maximum Baseline lichen concentration

Table HC-07-7 Predicted Future Lichen Concentrations (mg/kg-DW) for Time Frame of Operations at Milne Port Based on a Dust Deposition Rate of 55 g/m2/year, Compared to Maximum Baseline Lichen Concentrations

Metal/COPC	Baseline Lichen Concentration (90th %ile)	2016	2017-2018	2019-2020	2021	2022-2023	2024	2025-2035	Maximum Baseline
		Project + Baseline	Accumulated Project + Baseline	Accumulated Project + Baseline	Accumulated Project + Baseline	Accumulated Project + Baseline	Accumulated Project + Baseline	Accumulated Project + Baseline	
Aluminum	577.1	597.4	642.7	648.7	719.8	720.3	719.8	724.2	1240
Antimony	0.0147	0.0216	0.0371	0.0391	0.0632	0.0635	0.0632	0.0657	0.064
Arsenic	0.194	0.424	0.937	1.01	1.81	1.82	1.81	1.89	1.1
Barium	18.5	18.7	19.1	19.1	19.7	19.7	19.7	20.0	43.3
Cadmium	0.193	0.205	0.234	0.238	0.279	0.283	0.279	0.311	0.297
Chromium	3.10	3.18	3.37	3.40	3.70	3.70	3.70	3.72	6.03
Cobalt	0.554	0.571	0.608	0.613	0.671	0.672	0.671	0.676	1.39
Copper	2.34	2.62	3.27	3.36	4.36	4.38	4.36	4.53	3.82
Iron	1103	1142.4	1229.9	1241.5	1379.4	1380.0	1379.4	1384.6	8830
Lead	2.63	2.66	2.71	2.71	2.79	2.79	2.79	2.81	6.71
Manganese	70.5	71.3	73.2	73.5	76.4	76.4	76.4	77.1	97.8
Mercury	0.0942	0.124	0.196	0.205	0.301	0.315	0.301	0.428	0.236
Molybdenum	0.134	0.140	0.154	0.155	0.176	0.176	0.176	0.181	0.364
Nickel	2.92	3.00	3.18	3.20	3.48	3.48	3.48	3.51	12.2
Selenium	0.105	0.146	0.238	0.250	0.392	0.394	0.392	0.413	0.197
Silver	<0.02	0.0206	0.0219	0.0220	0.0240	0.0241	0.0240	0.0246	0.045
Strontium	33.9	34.1	34.5	34.6	35.3	35.4	35.3	36.0	75.9
Thallium	0.0155	0.0196	0.0287	0.0299	0.0442	0.0444	0.0442	0.0454	0.0249
Tin	0.110	0.119	0.140	0.143	0.175	0.175	0.175	0.179	0.5
Uranium	0.230	0.239	0.260	0.263	0.295	0.295	0.295	0.297	0.847
Vanadium	1.56	1.61	1.73	1.75	1.93	1.94	1.93	1.94	3.43
Zinc	24.1	24.8	26.5	26.7	29.1	29.3	29.1	30.7	33.2

Notes:
Underlined values are > Maximum Baseline lichen concentration

Table HC-07-8 Predicted Future Soil Concentrations for Time Frame of Operations at the Mine Site Based on a Dust Deposition Rate of 144 g/m2/year, Compared to Human-Health Based Soil Quality Guidelines and Maximum Baseline Soil Concentrations

Metal/ COPC	Baseline Surface Soil Concentration (90th %ile) (mg/kg)	2016		2017-2018		2019-2020		2021		2022-2023		2024		2025-2035		Soil Quality Guideline[a]	Maximum Baseline
		Project	Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline		
Aluminum	6515	14.7	6529.7	27.6	6557.3	27.6	6584.9	26.8	6611.7	53.0	6664.7	26.8	6691.548	260.9	6952.4	15,400[b]	39300
Antimony	<0.1	0.00728	0.107	0.0137	0.121	0.01365	0.135	0.0133	0.148	0.0262	0.174	0.0133	0.187	0.129	0.316	7.5[d]	0.85
Arsenic	1.24	0.0173	1.26	0.0325	1.29	0.0325	1.32	0.0316	1.35	0.0623	1.42	0.0316	1.448	0.307	1.75	12	4.14
Barium	31.3	0.0697	31.3	0.131	31.5	0.1307	31.6	0.127	31.7	0.251	32.0	0.127	32.086	1.24	33.3	750/500 (direct contact: 6800)	132
Cadmium	0.172	0.00634	0.178	0.0119	0.190	0.01190	0.202	0.0116	0.214	0.0228	0.237	0.0116	0.248	0.112	0.361	1.4/14	0.275
Chromium	26.4	0.101	26.5	0.190	26.7	0.190	26.9	0.185	27.1	0.365	27.4	0.185	27.616	1.80	29.4	220[c]	55.7
Cobalt	4.72	0.0138	4.73	0.0258	4.76	0.0258	4.79	0.0251	4.81	0.0496	4.86	0.0251	4.885	0.244	5.13	22[d]	17.5
Copper	9.65	0.0837	9.73	0.157	9.89	0.1570	10.0	0.153	10.2	0.301	10.5	0.153	10.6	1.48	12.1	1100	48.4
Iron	20500	23.0	20523.0	43.2	20566.2	43.2	20609.4	42.0	20651.4	82.9	20734.4	42.0	20776.4	408.4	21184.7	11000[b]	90500
Lead	6.67	0.0141	6.68	0.0264	6.71	0.0264	6.74	0.0257	6.76	0.0507	6.81	0.0257	6.84	0.250	7.09	140	31.7
Manganese	203.5	0.556	204	1.04	205.1	1.043	206.1	1.014	207.2	2.00	209.2	1.01	210.2	9.86	220.0	360[b]	416
Mercury	<0.05	0.00582	0.0558	0.0109	0.0667	0.01092	0.0777	0.0106	0.0883	0.0210	0.109	0.0106	0.120	0.103	0.223	6.6	0.152
Molybdenum	0.35	0.0131	0.363	0.0246	0.388	0.0246	0.412	0.0239	0.436	0.0472	0.483	0.0239	0.507	0.232	0.740	110[d]	2.53
Nickel	19.3	0.0863	19.4	0.162	19.5	0.1619	19.7	0.157	19.9	0.311	20.2	0.157	20.3	1.53	21.9	330[d]	39.4
Selenium	<0.5	0.0174	0.517	0.0326	0.550	0.0326	0.583	0.0317	0.614	0.0625	0.677	0.0317	0.708	0.308	1.02	80	0.51
Silver	<0.05	0.000498	0.0505	0.00093	0.0514	0.000934	0.0524	0.000908	0.0533	0.00179	0.0551	0.000908	0.0560	0.00883	0.0648	77[d]	0.198
Strontium	21.4	0.0334	21.4	0.063	21.5	0.0627	21.6	0.0610	21.6	0.120	21.7	0.0610	21.8	0.593	22.4	9,400[b]	83.3
Thallium	0.128	0.000232	0.128	0.000435	0.129	0.000435	0.129	0.000423	0.130	0.00084	0.130	0.000423	0.131	0.00411	0.135	1	0.435
Tin	0.585	0.00306	0.588	0.0057	0.594	0.00574	0.600	0.00558	0.605	0.0110	0.616	0.00558	0.622	0.0543	0.676	9,400[b]	2.66
Uranium	1.90	0.00365	1.90	0.0068	1.91	0.00684	1.91	0.00665	1.92	0.0131	1.93	0.00665	1.94	0.0646	2.00	23	6.13
Vanadium	28.8	0.0303	28.8	0.057	28.8	0.0568	28.9	0.0552	28.9	0.109	29.1	0.0552	29.1	0.536	29.6	86[e]	83.9
Zinc	25.6	0.127	25.7	0.239	26.0	0.239	26.2	0.232	26.4	0.459	26.9	0.232	27.1	2.26	29.4	5600[d]	118

Notes:

a) Unless otherwise noted, all soil quality guidelines are from CCME 2017 (on-line; http://ceqg-rcqe.ccme.ca/). Guidelines are human health-based soil quality guidelines for residential / parkland and agricultural land use. Where agricultural and residential / parkland are different, the agricultural guideline is presented first followed by the residential / parkland guideline.

b) US EPA, 2016 Regional Screening Values: Residential Land use. Values divided by 5 to create a value based on a Hazard Quotient of 0.2, rather than 1.0 (https://www.epa.gov/sites/production/files/2016-06/documents/master_sl_table_run_may2016.pdf)

c) CCME guideline for total chromium (derived in 1997).

d) OMOE (Ontario Ministry of the Environment, 2016) soil screening standards from their generic site condition standards (SCS) document (OMOE, 2011). Standard provided is the S1 (soil contact) guideline

e) OMOE Soil Component Value, based on background

Shaded values are > Soil Quality Guidelines; Underlined values are > Maximum soil baseline concentrations

Table HC-07-9 Predicted Future Soil Concentrations for Time Frame of Operations at the Mine Site Based on a Dust Deposition Rate of 55 g/m2/year, Compared to Human-Health Based Soil Quality Guidelines and Maximum Baseline Soil Concentrations

Metal/ COPC	Baseline Surface Soil Concentration (90[th] %ile) (mg/kg)	2016		2017-2018		2019-2020		2021		2022-2023		2024		2025-2035		Soil Quality Guideline[a]	Maximum Baseline
		Project	Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline		
Aluminum	6515	0.948	6515.9	3.68	6519.6	4.05	6523.7	4.28	6528.0	8.46	6536.4	7.32	6543.7	99.6	6643.4	15,400[b]	39300
Antimony	<0.1	0.000469	0.100	0.00182	0.102	0.00200	0.104	0.00212	0.106	0.00419	0.111	0.00362	0.114	0.0493	0.164	7.5[d]	0.85
Arsenic	1.24	0.00112	1.24	0.00433	1.25	0.00476	1.25	0.00504	1.26	0.0100	1.27	0.00862	1.27	0.117	1.39	12	4.14
Barium	31.3	0.00449	31.3	0.0174	31.3	0.0192	31.3	0.0203	31.3	0.040	31.4	0.0347	31.4	0.472	31.9	750/500 (direct contact: 6800)	132
Cadmium	0.172	0.000409	0.172	0.00159	0.174	0.00174	0.176	0.00185	0.178	0.0036	0.181	0.00316	0.184	0.0430	0.227	1.4/14	0.275
Chromium	26.4	0.00653	26.4	0.0254	26.4	0.0279	26.5	0.0295	26.5	0.0583	26.5	0.0504	26.6	0.687	27.3	220[c]	55.7
Cobalt	4.72	0.000888	4.72	0.00345	4.72	0.00379	4.73	0.00401	4.73	0.00792	4.74	0.00686	4.75	0.0933	4.84	22[d]	17.5
Copper	9.65	0.00539	9.65	0.0209	9.67	0.0230	9.69	0.0244	9.72	0.0481	9.77	0.0417	9.81	0.567	10.4	1100	48.4
Iron	20500	1.48	20501.5	5.76	20507.2	6.34	20513.6	6.71	20520.3	13.2	20533.5	11.5	20545.0	156.0	20701.0	11000[b]	90500
Lead	6.67	0.000908	6.67	0.00352	6.67	0.00388	6.68	0.00410	6.68	0.00810	6.69	0.00701	6.70	0.0954	6.79	140	31.7
Manganese	203.5	0.0359	203.5	0.139	203.7	0.153	203.8	0.162	204.0	0.320	204.3	0.277	204.6	3.77	208.4	360[b]	416
Mercury	<0.05	0.000375	0.0504	0.00146	0.0518	0.00160	0.0534	0.00170	0.0551	0.00335	0.0585	0.00290	0.0614	0.0394	0.101	6.6	0.152
Molybdenum	0.35	0.000844	0.351	0.00328	0.354	0.00360	0.358	0.00382	0.362	0.00754	0.369	0.00652	0.376	0.0887	0.464	110[d]	2.53
Nickel	19.3	0.00556	19.3	0.0216	19.3	0.0237	19.4	0.0251	19.4	0.0496	19.4	0.0429	19.5	0.584	20.1	330[d]	39.4
Selenium	<0.5	0.00112	0.501	0.00434	0.505	0.00478	0.510	0.00506	0.515	0.00999	0.525	0.00864	0.534	0.118	0.652	80	0.51
Silver	<0.05	0.0000321	0.0500	0.000125	0.0502	0.000137	0.0503	0.000145	0.0504	0.000286	0.0507	0.000248	0.0510	0.00337	0.0543	77[d]	0.198
Strontium	21.4	0.00215	21.4	0.00836	21.4	0.00920	21.4	0.00974	21.4	0.0192	21.4	0.0166	21.5	0.226	21.7	9,400[b]	83.3
Thallium	0.128	0.0000149	0.128	0.0000580	0.128	0.0000638	0.128	0.0000675	0.128	0.000133	0.128	0.000115	0.128	0.00157	0.130	1	0.435
Tin	0.585	0.000197	0.585	0.000766	0.586	0.000842	0.587	0.000892	0.588	0.00176	0.589	0.00152	0.591	0.0207	0.612	9,400[b]	2.66
Uranium	1.90	0.000235	1.90	0.000911	1.90	0.00100	1.90	0.00106	1.90	0.00210	1.90	0.00181	1.90	0.0247	1.93	23	6.13
Vanadium	28.8	0.00195	28.8	0.00757	28.8	0.00832	28.8	0.00881	28.8	0.0174	28.8	0.0151	28.8	0.205	29.0	86[e]	83.9
Zinc	25.6	0.00821	25.6	0.0319	25.6	0.0350	25.7	0.0371	25.7	0.0733	25.8	0.0634	25.8	0.863	26.7	5600[d]	118

Notes:

a) Unless otherwise noted, all soil quality guidelines are from CCME 2017 (on-line; http://ceqg-rcqe.ccme.ca/). Guidelines are human health-based soil quality guidelines for residential / parkland and agricultural land use. Where agricultural and residential / parkland are different, the agricultural guideline is presented first followed by the residential / parkland guideline.

b) US EPA, 2016 Regional Screening Values: Residential Land use. Values divided by 5 to create a value based on a Hazard Quotient of 0.2, rather than 1.0 (https://www.epa.gov/sites/production/files/2016-06/documents/master_sl_table_run_may2016.pdf)

c) CCME guideline for total chromium (derived in 1997).

d) OMOE (Ontario Ministry of the Environment, 2016) soil screening standards from their generic site condition standards (SCS) document (OMOE, 2011). Standard provided is the S1 (soil contact) guideline

e) OMOE Soil Component Value, based on background

Shaded values are > Soil Quality Guidelines; Underlined values are > Maximum soil baseline concentrations

Table HC-07-10 Predicted Future Soil Concentrations for Time Frame of Operations at Tote Road Based on a Dust Deposition Rate of 55 g/m2/year, Compared to Human-Health Based Soil Quality Guidelines and Maximum Baseline Soil Concentrations

Metal/ COPC	Baseline Surface Soil Concentration (90^{th} %ile) (mg/kg)	2016		2017-2018		2019-2020		2021		2022-2023		2024		2025-2035		Soil Quality Guideline[a]	Maximum Baseline
		Project	Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline		
Aluminum	6515	8.43	6523.4	13.9	6537.4	15.3	6552.7	15.5	6568.2	0	6568.2	0	6568.2	0	6568.2	15,400[b]	39300
Antimony	<0.1	0.000692	0.101	0.00114	0.102	0.00126	0.103	0.00127	0.104	0	0.104	0	0.104	0	0.104	7.5[d]	0.85
Arsenic	1.24	0.0351	1.28	0.0579	1.33	0.0637	1.40	0.0645	1.46	0	1.46	0	1.46	0	1.5	12	4.14
Barium	31.3	0.0684	31.3	0.113	31.4	0.124	31.6	0.126	31.7	0	31.7	0	31.7	0	31.7	750/500 (direct contact: 6800)	132
Cadmium	0.172	0.00237	0.174	0.00392	0.178	0.00431	0.183	0.00436	0.187	0	0.187	0	0.187	0	0.187	1.4/14	0.275
Chromium	26.4	0.0217	26.4	0.0359	26.5	0.0395	26.5	0.0400	26.5	0	26.5	0	26.5	0	26.5	220[c]	55.7
Cobalt	4.72	0.00465	4.72	0.00768	4.73	0.00844	4.74	0.00855	4.75	0	4.75	0	4.75	0	4.75	22[d]	17.5
Copper	9.65	0.0460	9.69	0.0760	9.77	0.0836	9.85	0.0846	9.94	0	9.94	0	9.94	0	9.94	1100	48.4
Iron	20500	12.1	20512.1	20.0	20532.1	22.0	20554.1	22.3	20576.4	0	20576.4	0	20576.4	0	20576.4	11000[b]	90500
Lead	6.67	0.00951	6.68	0.0157	6.70	0.0173	6.71	0.0175	6.73	0	6.73	0	6.73	0	6.73	140	31.7
Manganese	203.5	0.194	203.7	0.321	204.0	0.353	204.4	0.357	204.7	0	204.7	0	204.7	0	204.7	360[b]	416
Mercury	<0.05	0.00558	0.0556	0.00921	0.0648	0.0101	0.0749	0.0103	0.0852	0	0.0852	0	0.0852	0	0.0852	6.6	0.152
Molybdenum	0.35	0.00146	0.351	0.00241	0.354	0.00266	0.357	0.00269	0.359	0	0.359	0	0.359	0	0.359	110[d]	2.53
Nickel	19.3	0.0176	19.3	0.0291	19.3	0.0320	19.4	0.0324	19.4	0	19.4	0	19.4	0	19.4	330[d]	39.4
Selenium	<0.5	0.00639	0.506	0.0105	0.517	0.0116	0.529	0.0118	0.540	0	0.540	0	0.540	0	0.540	80	0.51
Silver	<0.05	0.000116	0.0501	0.000192	0.0503	0.000211	0.0505	0.000214	0.0507	0	0.0507	0	0.0507	0	0.0507	77[d]	0.198
Strontium	21.4	0.0262	21.4	0.0432	21.5	0.0475	21.5	0.0482	21.6	0	21.6	0	21.6	0	21.6	9,400[b]	83.3
Thallium	0.128	0.000663	0.129	0.00109	0.130	0.00120	0.131	0.00122	0.132	0	0.132	0	0.132	0	0.132	1	0.435
Tin	0.585	0.00197	0.587	0.00326	0.590	0.00358	0.594	0.00363	0.597	0	0.597	0	0.597	0	0.597	9,400[b]	2.66
Uranium	1.90	0.00134	1.90	0.00221	1.90	0.00243	1.90	0.00246	1.90	0	1.90	0	1.90	0	1.90	23	6.13
Vanadium	28.8	0.0142	28.8	0.0235	28.8	0.0258	28.8	0.0262	28.8	0	28.8	0	28.8	0	28.8	86[e]	83.9
Zinc	25.6	0.0626	25.7	0.103	25.8	0.114	25.9	0.115	26.0	0	26.0	0	26.0	0	26.0	5600[d]	118

Notes:

a) Unless otherwise noted, all soil quality guidelines are from CCME 2017 (on-line; http://ceqg-rcqe.ccme.ca/). Guidelines are human health-based soil quality guidelines for residential / parkland and agricultural land use. Where agricultural and residential / parkland are different, the agricultural guideline is presented first followed by the residential / parkland guideline.
b) US EPA, 2016 Regional Screening Values: Residential Land use. Values divided by 5 to create a value based on a Hazard Quotient of 0.2, rather than 1.0 (https://www.epa.gov/sites/production/files/2016-06/documents/master_sl_table_run_may2016.pdf)
c) CCME guideline for total chromium (derived in 1997).
d) OMOE (Ontario Ministry of the Environment, 2016) soil screening standards from their generic site condition standards (SCS) document (OMOE, 2011). Standard provided is the S1 (soil contact) guideline
e) OMOE Soil Component Value, based on background

Shaded values are > Soil Quality Guidelines; Underlined values are > Maximum soil baseline concentrations

Table HC-07-11 Predicted Future Soil Concentrations for Time Frame of Operations at Milne Port Based on a Dust Deposition Rate of 55 g/m2/year, Compared to Human-Health Based Soil Quality Guidelines and Maximum Baseline Soil Concentrations

Metal/ COPC	Baseline Surface Soil Concentration (90th %ile) (mg/kg)	2016		2017-2018		2019-2020		2021		2022-2023		2024		2025-2035		Soil Quality Guideline[a]	Maximum Baseline
		Project	Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline	Project	Accumulated Project + Baseline		
Aluminum	6515	0.814	6515.81	5.17	6521.0	5.64	6526.6	5.7	6532.3	11.3	6543.6	5.71	6549.3	55.6	6604.9	15,400[b]	39300
Antimony	<0.1	0.000276	0.100	0.00175	0.102	0.00191	0.104	0.00194	0.106	0.00383	0.110	0.00194	0.112	0.0189	0.131	7.5[d]	0.85
Arsenic	1.24	0.00917	1.25	0.0582	1.31	0.0636	1.37	0.0644	1.44	0.127	1.56	0.0644	1.63	0.626	2.25	12	4.14
Barium	31.3	0.00662	31.3	0.0420	31.3	0.0459	31.3	0.0465	31.4	0.0917	31.5	0.0465	31.5	0.452	32.0	750/500 (direct contact: 6800)	132
Cadmium	0.172	0.000471	0.172	0.00299	0.175	0.00326	0.18	0.00331	0.182	0.00653	0.189	0.00331	0.192	0.0321	0.224	1.4/14	0.275
Chromium	26.4	0.00341	26.4	0.0217	26.4	0.0236	26.4	0.0239	26.5	0.0473	26.5	0.0239	26.5	0.233	26.8	220[c]	55.7
Cobalt	4.72	0.000668	4.72	0.00424	4.72	0.00462	4.73	0.00468	4.73	0.00925	4.74	0.00468	4.75	0.0455	4.79	22[d]	17.5
Copper	9.65	0.0115	9.66	0.0730	9.73	0.0797	9.81	0.0807	9.89	0.159	10.0	0.0807	10.1	0.785	10.9	1100	48.4
Iron	20500	1.58	20501.6	10.0	20511.6	10.9	20522.6	11.1	20533.6	21.9	20556	11.1	20566.6	107.8	20674.4	11000[b]	90500
Lead	6.67	0.000874	6.67	0.00555	6.68	0.00606	6.68	0.00613	6.69	0.0121	6.70	0.00613	6.71	0.0596	6.77	140	31.7
Manganese	203.5	0.0332	203.5	0.211	203.7	0.230	204.0	0.233	204.2	0.460	204.7	0.233	204.9	2.26	207.2	360[b]	416
Mercury	<0.05	0.00110	0.0511	0.00700	0.0581	0.00764	0.0657	0.00773	0.0735	0.0153	0.089	0.00773	0.0965	0.0752	0.172	6.6	0.152
Molybdenum	0.35	0.000233	0.350	0.00148	0.352	0.00161	0.353	0.00163	0.355	0.00323	0.358	0.00163	0.360	0.0159	0.376	110[d]	2.53
Nickel	19.3	0.00318	19.3	0.0202	19.3	0.0220	19.3	0.0223	19.4	0.0440	19.4	0.0223	19.4	0.217	19.7	330[d]	39.4
Selenium	<0.5	0.00163	0.502	0.0103	0.512	0.0113	0.523	0.0114	0.535	0.0226	0.557	0.0114	0.569	0.111	0.680	80	0.51
Silver	<0.05	0.0000226	0.0500	0.000144	0.0502	0.000157	0.0503	0.000159	0.0505	0.000314	0.0508	0.000159	0.0510	0.00154	0.0525	77[d]	0.198
Strontium	21.4	0.00771	21.4	0.0489	21.5	0.0534	21.5	0.0541	21.6	0.107	21.7	0.0541	21.7	0.526	22.3	9,400[b]	83.3
Thallium	0.128	0.000163	0.128	0.00104	0.129	0.00113	0.130	0.00115	0.131	0.00226	0.134	0.00115	0.135	0.0112	0.146	1	0.435
Tin	0.585	0.000367	0.585	0.00233	0.588	0.00254	0.590	0.00258	0.593	0.00509	0.598	0.00258	0.600	0.025	0.626	9,400[b]	2.66
Uranium	1.90	0.000368	1.90	0.00234	1.90	0.00255	1.90	0.00258	1.90	0.00510	1.91	0.00258	1.91	0.025	1.94	23	6.13
Vanadium	28.8	0.00215	28.8	0.0136	28.8	0.0149	28.8	0.0150	28.8	0.0297	28.8	0.0150	28.8	0.146	29.0	86[e]	83.9
Zinc	25.6	0.0273	25.6	0.173	25.8	0.189	26.0	0.191	26.2	0.378	26.6	0.191	26.7	1.86	28.6	5600[d]	118

Notes:

a) Unless otherwise noted, all soil quality guidelines are from CCME 2017 (on-line; http://ceqg-rcqe.ccme.ca/). Guidelines are human health-based soil quality guidelines for residential / parkland and agricultural land use. Where agricultural and residential / parkland are different, the agricultural guideline is presented first followed by the residential / parkland guideline.

b) US EPA, 2016 Regional Screening Values: Residential Land use. Values divided by 5 to create a value based on a Hazard Quotient of 0.2, rather than 1.0 (https://www.epa.gov/sites/production/files/2016-06/documents/master_sl_table_run_may2016.pdf)

c) CCME guideline for total chromium (derived in 1997).

d) OMOE (Ontario Ministry of the Environment, 2016) soil screening standards from their generic site condition standards (SCS) document (OMOE, 2011). Standard provided is the S1 (soil contact) guideline

e) OMOE Soil Component Value, based on background

Shaded values are > Soil Quality Guidelines; Underlined values are > Maximum soil baseline concentrations