

GAHCHO KUÉ PROJECT
ENVIRONMENTAL IMPACT STATEMENT

SECTION 11.4
SUBJECT OF NOTE: AIR QUALITY

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11.4 BIOPHYSICAL SUBJECTS OF NOTE: AIR QUALITY

11.4.1 Introduction

11.4.1.1 Context

Section 11.4 of the Environmental Impact Statement (EIS) for the Gahcho Kué Project (Project) consists solely of the Subject of Note: Air Quality. In the *Terms of Reference for the Gahcho Kué Environmental Impact Statement* (Terms of Reference) issued on October 5, 2007, the Gahcho Kué Panel (2007) provided the following rationale for defining this subject of note:

“During the environmental assessment, concerns over air quality were based, in part, on Gahcho Kué being the fifth diamond mine in the general area contributing to air pollution.”

This subject of note includes the specific effects of changes to air quality within the airshed potentially affected by the Project. This subject of note also includes an assessment of cumulative effects resulting from the Project in combination with the Snap Lake Mine. No other past, present, and reasonably foreseeable future developments affecting air quality were identified for inclusion in the cumulative effects assessment. Detailed information pertaining to air quality effects is also provided as input to assessments in the following key lines of inquiry and subjects of note:

- Caribou (Section 7);
- Water Quality and Fish in Kennady Lake (Section 8);
- Downstream Water Effects (Section 9);
- Vegetation (Section 11.7);
- Carnivore Mortality (Section 11.10);
- Other Ungulates (Section 11.11);
- Species at Risk and Birds (Section 11.12); and
- Proposed National Park (Section 12.7.4).

The air quality assessment includes an examination of potential changes in air quality at hunting and fishing lodges as well as the permanent worker camp. A broader impact assessment of effects on the well-being of residents, particularly Aboriginal communities within the proposed Project area, is provided in the Key Line of Inquiry: Long-term Social, Cultural, and Economic Effects (Section 12.6.1).

11.4.1.2 Purpose and Scope

The purpose of the Subject of Note: Air Quality is to meet the Terms of Reference for the EIS issued by the Gahcho Kué Panel. The Terms of Reference for this subject of note are shown in Table 11.4-1. The entire Terms of Reference document is included in Appendix 1.I and the complete table of concordance for the EIS is in Appendix 1.II of Section 1, Introduction of the EIS.

11.4.1.3 Study Areas

11.4.1.3.1 General Location

The Project is situated north of the East Arm of Great Slave Lake in the Northwest Territories (NWT) at Longitude 63° 26' North and Latitude 109° 12' West. The Project site is about 140 kilometres (km) northeast of the nearest community, Łutselk'e, and 280 km northeast of Yellowknife (Figure 11.1-1).

11.4.1.3.2 Study Area Selection

Appropriate spatial boundaries require definition to assess the potential effects of the Project on air quality. The study area for this subject of note was identified in the final Terms of Reference (Gahcho Kué Panel 2007) as follows:

"The geographical scope for this Subject of Note must include the area of any potentially affected airsheds."

The boundaries for the baseline air quality study were selected based on the consideration of the following factors:

- location and strength of emission sources;
- potentially sensitive receptor locations;
- potential use of meteorological data from the Snap Lake Mine in dispersion modelling; and
- terrain and distance scales associated with plume dispersion processes.

Table 11.4-1 Terms of Reference Pertaining to Air Quality

Final Terms of Reference Requirements		Applicable EIS Sub-section
Section	Description	
3.1.3 Existing Environment: Air Quality	describe airshed(s) within which the Project is located and a rationale for the delineation	11.4.1.3.2
	describe any current sources of emissions to the airshed(s), including current seasonal variations, climatic conditions that affect air quality	11.4.2.2, Appendix 11.4.II and Annex B
	describe visibility	11.4.2.2.3, Annex B
	describe sources of data, including locations of any recording stations and length of record available	11.4.2.2 and Annex B
5.2.2 Biophysical Subjects of Note: Air Quality	general requirements pertaining to air quality include:	
	- the EIS must provide air quality modelling for construction and operational phases, including worst case scenarios	11.4.5.1, 11.4.5.11, and Appendix 11.4.II
	- the air quality assessment must include an assessment of risk to human health, including worker camps	11.4.5.8
	- the EIS must further identify best available technologies and best management practices to be used	11.4.3.2 and 11.4.8
	- in addition to providing predictions and a significance evaluation for impacts on air quality, the EIS must provide an analysis of how air quality changes, particularly pollutants with bioaccumulation potential, will affect vegetation, wildlife, and fish; this analysis must be factored into the impact analysis for fish and wildlife issues	7, 8, 9
	specific requirements pertaining to air quality include:	
	- evaluate diesel powered equipment and power generation, and the related transportation of fuel	11.4.5 and Appendix 11.4.II
	- evaluate dust generated by traffic, use of explosives, the exposed lake bottom, and other exposed surfaces including the processed kimberlite	11.4.5.5 and Appendix 11.4.II
	- evaluate the release of persistent organic pollutants and metals from waste incineration, including a description of how compliance with Canada-wide standards for dioxins, furans, and mercury will be achieved	11.4.3. 2, 11.4.5.8, 11.4.5.9, 11.4.5.10, Appendix 11.4.II and Appendix 11.4.III

Table 11.4-1 Terms of Reference Pertaining to Air Quality (continued)

Final Terms of Reference Requirements		Applicable EIS Sub-section
Section	Description	
5.2.2 Biophysical Subjects of Note: Air Quality (cont)	- evaluate the release of various pollutants including NO _x , SO ₂ , CO, with air quality predictions based on an air quality model comparing predicted ambient pollutant concentrations with applicable ambient air quality and deposition standards	11.4.3. 2, 11.4.5.1, 11.4.5.2, 11.4.5.3, 11.4.5.4, 11.4.5.5, 11.4.5.6, and Appendix 11.4.II
7 (Table 7-4) Other Issues	remaining issues pertaining to air quality include:	
	- increased dust from exposed lake bed	11.4.5.5 and Appendix 11.4.II
	- waste incineration impacts	11.4.5.10
	- impacts from emissions	11.4.6, 11.4.7
3.2.7 Follow-up Programs	The EIS must include a description of any follow up programs, contingency plans, or adaptive management programs the developer proposes to employ before, during, and after the proposed development, for the purpose of recognizing and managing unpredicted problems. The EIS must explain how the developer proposes to verify impact predictions. The impact statement must also describe what alternative measures will be used in cases where a proposed mitigation measure does not produce the anticipated result.	11.4.8,
	The EIS must provide a review of relevant research, monitoring and follow up activities since the first diamond mine was permitted in the Slave Geological Province to the extent that the relevant information is publicly available. This review must focus on the verification of impact predictions and the effectiveness of mitigation measures proposed in previous diamond mine environmental impact assessments. In particular the developer must make every reasonable effort to verify and evaluate the effectiveness of any proposed mitigation measures that have been used, or are similar to those used at other diamond mining projects in the Mackenzie Valley.	11.4.2.2, Appendix 4.II, Annex B

Source: Terms of Reference for the Gahcho Kué Environmental Impact Statement (Gahcho Kué Panel 2007).

EIS = environmental impact statement; NO_x = nitrogen oxide; SO₂ = sulphur dioxide; CO = carbon monoxide.

Based on the final Terms of Reference and the factors listed above, a baseline study area with an east-west extent of 160 km and a north-south extent of 80 km was selected. This area captures the following:

- the Project, as a source of emissions;
- the Snap Lake Mine, as a source of emissions;
- traffic emissions on various legs of the Winter Access Road that connects the Project with Snap Lake and Yellowknife via the Tibbitt-to-Contwoyto Winter Road (typically between January and April);
- the permanent worker camp; and
- areas of a proposed National Park on the East Arm of Great Slave Lake.

Air Quality Study Areas

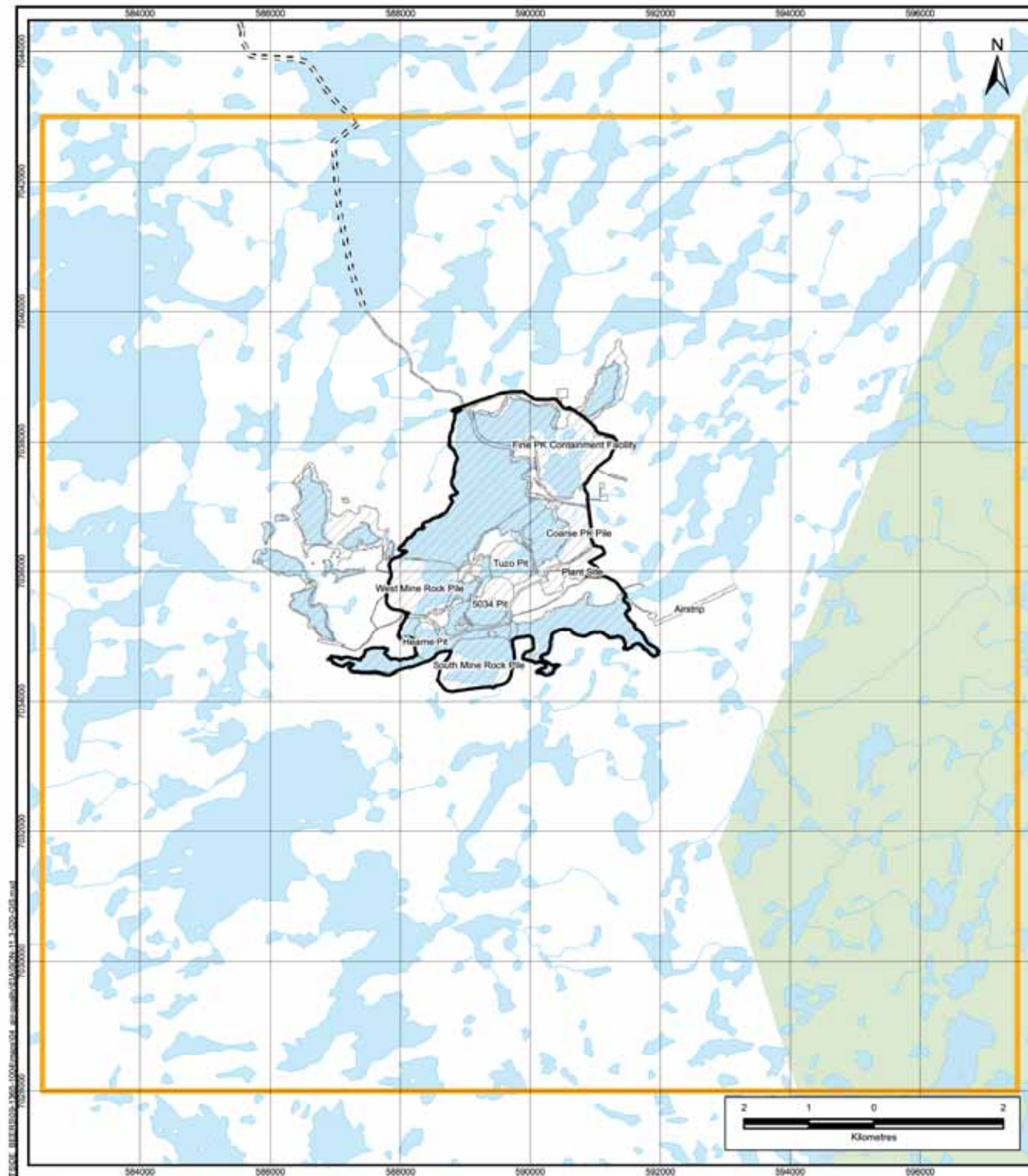
The Subject of Note: Air Quality has two study areas which are shown in Figure 11.4-1:

- Regional Study Area (RSA); and
- Local Study Area (LSA).

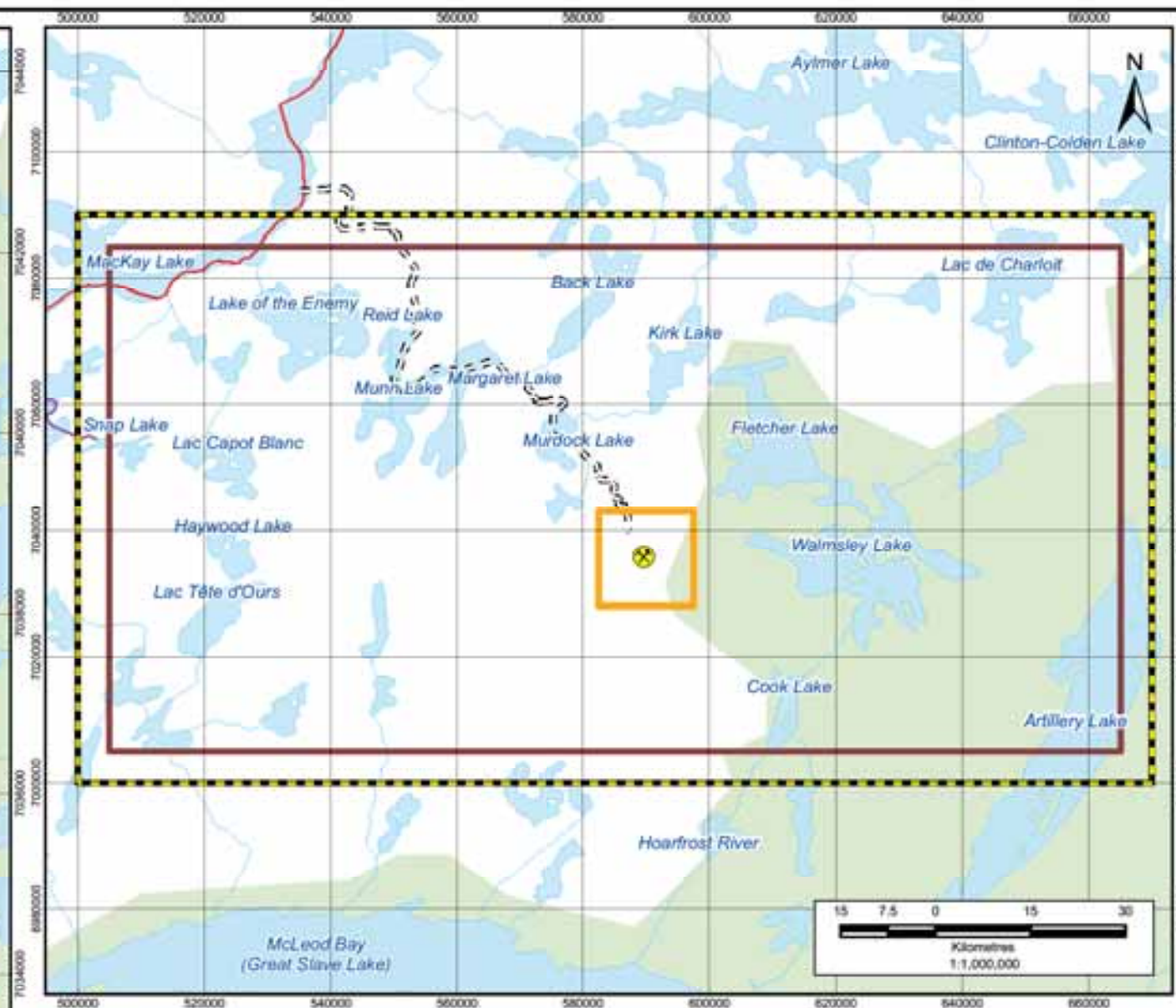
The RSA defines the region over which modelling results are presented. The RSA for the Project is defined by an 80 km by 160 km area. The RSA was selected to capture air quality cumulative effects associated with emissions from existing and approved industrial sources within the region in combination with the proposed Project

The LSA defines an area in the immediate vicinity of the Project where the majority of air quality effects caused by the Project are expected to occur. The LSA represents a subset of the RSA and allows a more focused assessment of the effects associated with the Project. The LSA is defined by an area of 15 km by 15 km, which includes the Project footprint. The area of interest for a proposed national park is located within the RSA and LSA boundaries.

Two other areas that were also considered in the assessment are the Project footprint and development area. The Project footprint represents the areas that will be physically disturbed due to the construction, operation and reclamation of the Project. The development area is an area approximately outlined by the Project footprint that is only used in the air quality assessment to determine compliance with applicable ambient air quality standards. The NWT Standards (GNWT 2010, internet site) are applicable outside this boundary. The developed area enveloped all major emission sources associated with the activities at the Project.



NOTES
Base data source: National Topographic Base Data (NTDB) 1:50,000.




LEGEND

- Gahcho Kué Project
- Existing Winter Road
- Tibbitt to Contwoyto Winter Road
- Proposed Winter Access Road
- Watercourse
- Waterbody
- Development Area Boundary
- Local Study Area
- Modelling Domain
- Project Footprint
- Regional Study Area
- The Study Area for a National Park on the East Arm of Great Slave Lake

GAHCHO KUÉ PROJECT

Air Quality Local and Regional Study Areas

PROJECTION UTM Zone 12	DATUM NAD83	 De BEERS CANADA
Scale: 1:70,000 (LSA)		
FILE NO. SON-11.3-020-GIS		DATE December 13, 2010
JOB NO. 09-1365-1004	REVISION NO. 2	Figure 11.4-1
OFFICE GOLD-CAL	DRAWN SK CHECK GU	

11.4.1.4 Content

Section 11.4 provides details of the effects analysis and assessment related to impacts of the Project on air quality. The headings in this section are arranged according to the sequence of steps in the assessment. The following briefly describes the content under each heading of this subject of note:

- **Existing Environment** summarizes baseline information relevant to air quality, including a description of the general environmental setting in which the Project occurs, and the baseline methods and results for regional air quality and plume dispersion meteorology (Section 11.4.2).
- **Pathway Analysis** identifies all the potential pathways by which the Project could affect air quality and provides a screening level assessment of each identified pathway after applying environmental design features and mitigation that should reduce or eliminate these effects (Section 11.4.3).
- **Effects Analysis Methods** explains the methods (i.e. the dispersion model, the modelling approaches and the main and subsidiary emission scenarios) that were used to predict changes to air quality as a result of the Project (Section 11.4.4).
- **Effects on Air Quality** identifies effects of the Project on air quality during the construction and operations phases, including effects on sulphur dioxide, oxides of nitrogen, carbon monoxide and particulate matter (Section 11.4.5).
- **Residual Effects Summary** summarizes the effects on air quality that are predicted to remain after accounting for the environmental design features and mitigation that have been incorporated into the Project design to eliminate or reduce negative effects (Section 11.4.6).
- **Residual Impact Classification** describes methods used to classify residual effects and summarizes the classification results (Section 11.4.7).
- **Uncertainty** discusses sources of uncertainty surrounding the predictions of effects on air quality (Section 11.4.8).
- **Monitoring, Adaptive Management, and Mitigation** describes monitoring programs, contingency plans, and adaptive management strategies related to air quality (Section 11.4.9).
- **References** lists all documents and other material used in the preparation of this section (Section 11.4.10).
- **Glossary, Acronyms, and Units** explains the meaning of scientific, technical, or other uncommon terms used in this section. In addition, acronyms and abbreviated units are defined (Section 11.4.11).

11.4.2 Existing Environment

This sub-section documents the current air quality in the area surrounding the Project as well as meteorological data relevant to atmospheric dispersion. The information presented in this section was gathered from various sources, including meteorological and ambient air quality measurements collected by De Beers Canada Inc. (De Beers) at the Snap Lake Mine and the proposed site of the Project, ambient air quality measurements collected by the Government of the Northwest Territories (GNWT) from several locations in the territory, as well as Environment Canada meteorological data collected from Yellowknife.

This section also summarizes meteorological data. Key meteorological variables such as wind direction, wind speed, atmospheric stability, and mixing heights are analyzed and summarized in this section because they influence the dispersion of potentially harmful substances emitted by the Project and, consequently, the air quality within the region.

Baseline air quality data are analyzed to establish background air concentrations that are added to modelled concentrations of various substances. These background concentrations result from emissions from natural sources (e.g., wind-blown dust) and/or long-range transport from sources outside the RSA. Regional air quality information was collected at the Project site as well as from the following stations: Snap Lake, Daring Lake, Yellowknife, and Inuvik (Annex B, Air Quality Baseline).

11.4.2.1 General Setting

The Project is located at Kennady Lake (63° 26' North; 109° 12' West), a headwater lake of the Lockhart River watershed in the NWT (Figure 11.1-1). Kennady Lake is about 280 km northeast of Yellowknife, and 140 km northeast of the Dene Community of Łutselk'e on the eastern arm of Great Slave Lake. The Project is 84 km east of the Snap Lake Mine, the only other active mine in the Lockhart River watershed. The Diavik Diamond Mine and Ekati Diamond Mine are located about 127 and 158 km northeast of Kennady Lake, respectively, in the Coppermine River watershed.

The climate is Arctic tundra with typical minimum and maximum temperatures of –45 degrees Celsius (°C) and +25°C, respectively, and maximum winds of 110 kilometres per hour (km/h) prevailing from the northeast.

11.4.2.2 Regional Meteorology and Air Quality

11.4.2.2.1 *Methods*

De Beers conducted a baseline meteorological monitoring program at the Project site from August 1998 through September 2005. Data from the monitoring station consist of hourly observations of meteorological parameters. This information was quality checked and is summarized in Annex B, Section B4.1. In addition, De Beers monitored ambient air quality during the summers of 2004 and 2005 at the Project site.

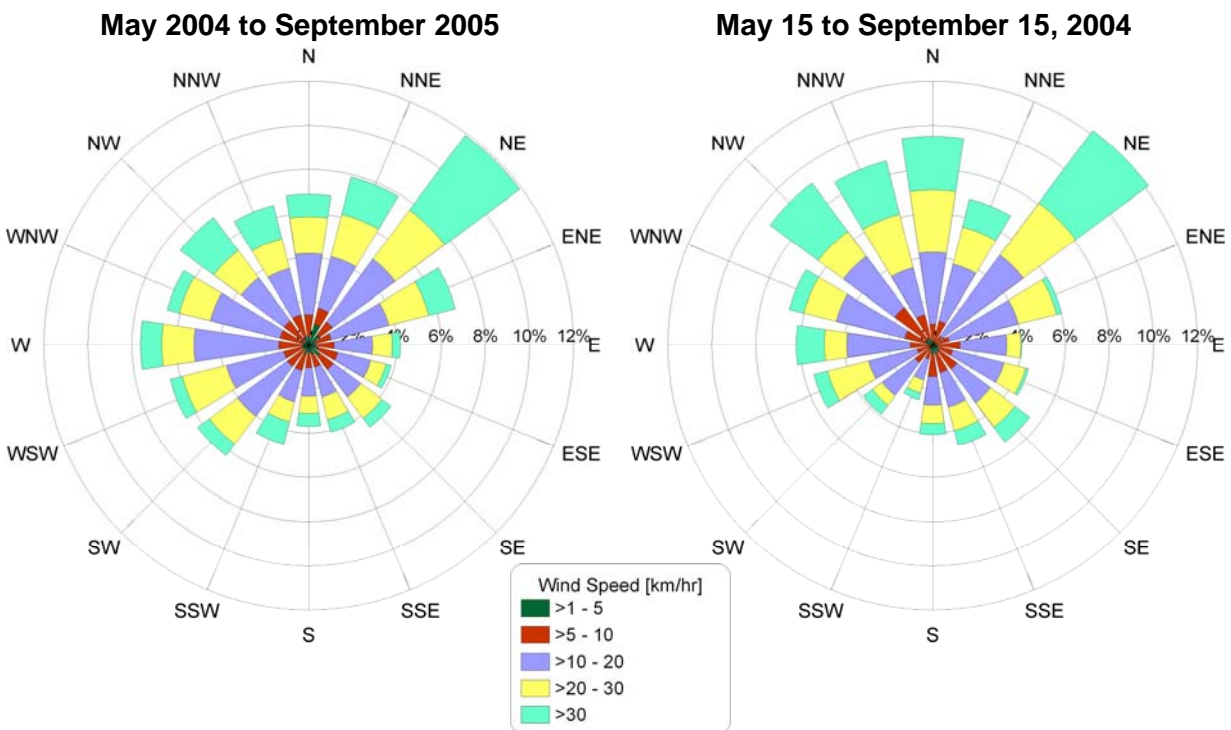
Jacques Whitford Environmental Ltd. (Jacques Whitford 2002, 2003) previously quality-checked a portion of the meteorological data from 1998 to 2003. De Beers also checked the quality of subsequently collected data as part of the work leading to the baseline air quality (Annex B). The quality assurance included identifying and matching periods of missing data due to recurring operational problems with the data logger. The monitoring program yielded about 6.5 years of hourly average data values. The data were then used to develop an understanding of the overall meteorological profile for the Project site. Annex B, Section B3.2 describes the methods of meteorological data monitoring at the Project site. The results are reviewed in Annex B, Section B4.1.

11.4.2.2.2 *Results of the Baseline Meteorology Analysis*

The key meteorological variables for modelling ground-level concentrations and deposition are winds, atmospheric stability, and mixing heights. An automated meteorological station installed at the Project site in the summer of 1998 provided data for De Beers design work associated with the Project. Data were summarized and reported for the period from start-up through September 2005.

The analysis of data for the RSA showed some variation in wind roses between the Snap Lake Mine and the Project and from year-to-year within the Project data set (winds for 2004 to 2005 are shown in Figure 11.4-2). Both stations showed a high frequency of winds from the northeast quadrant but secondary directions varied with station and the time period.

Figure 11.4-2 Gahcho Kué Project Site Wind Rose (May 2004 to September 2005)



Note: Left: full period (May 2004 to September 2005).

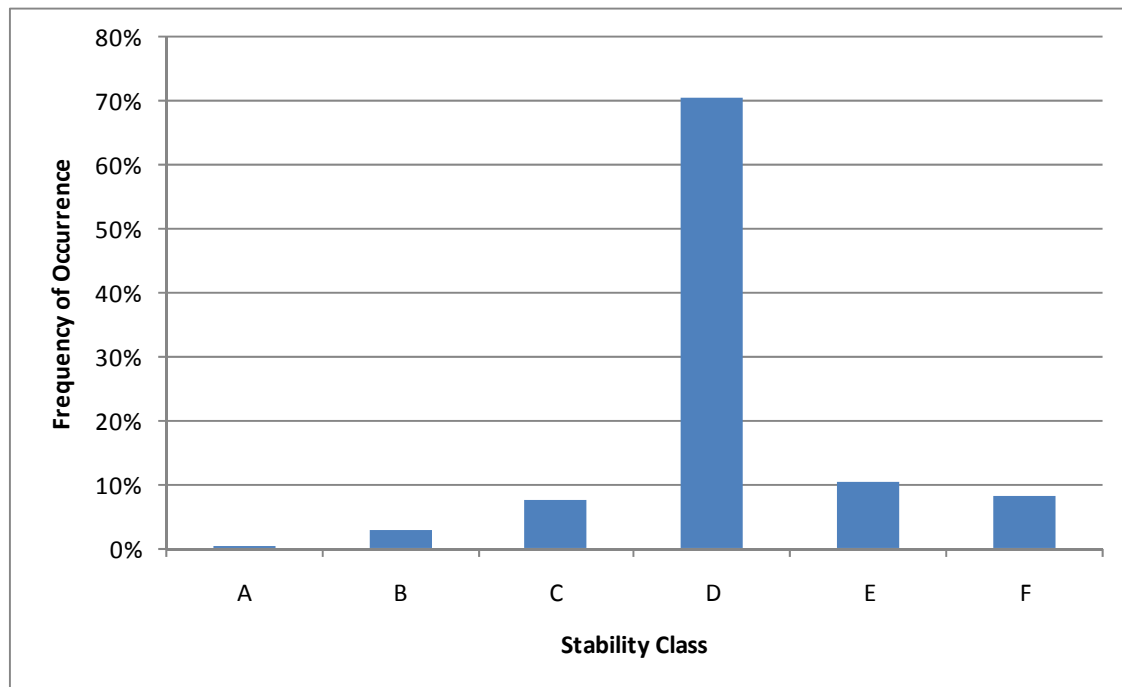
Right: foliage season (May 15 to September 15, 2004).

km/hr = kilometres per hour; % = percent; > = greater than; N = north; E = east; S = south; W = west.

The CALMET meteorological model (detailed in Appendix 11.4.I) was used to model temporally and spatially dependent wind, temperature, and turbulence fields. The diagnostic 3D meteorological “first guess” field for input to CALMET was provided specifically for this Project by the National Centre for Atmospheric Research based on the North American Regional Reanalysis (NARR) model. CALMET data were used in the CALPUFF model due to the large size of the RSA and the need to have spatially and temporally varying meteorology throughout the modelling domain.

Atmospheric stability is a primary influence on plume dispersion. Stable atmospheres, most common at night and in winter, limit dispersion and enhance the channelling effects of terrain. Unstable conditions result in greater mixing and can result in elevated plumes impinging the surface. Figure 11.4-3, based on the output from the CALMET meteorological model, shows the frequency of occurrence of Pasquill stability classes (Pasquill 1961) ranging from A (very unstable) to F (very stable). Neutral stability (D) is most common. Unstable conditions occur most often in spring and summer, and during midday. Stable conditions occur most often in winter.

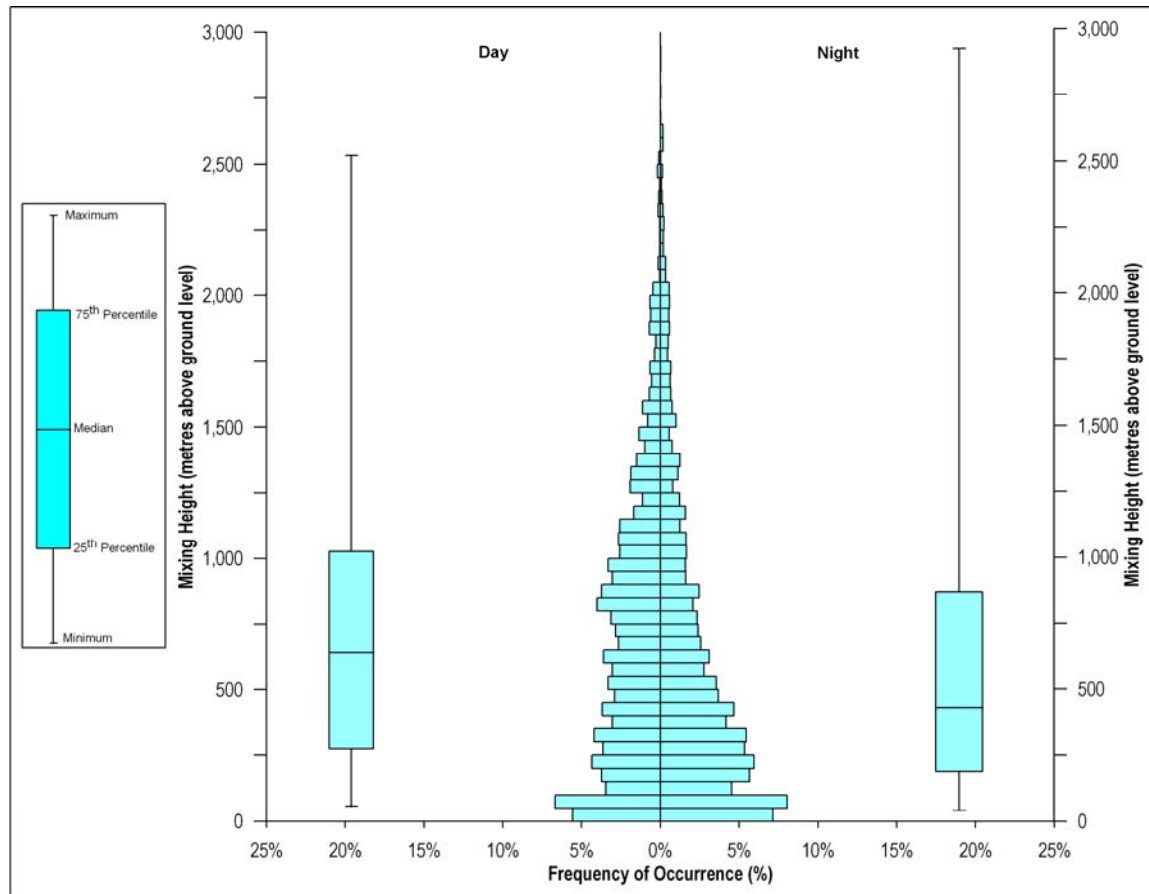
Figure 11.4-3 Pasquill Stability Classes Based on CALMET Model Results for the Project Site, September 2004 to September 2005



% = percent.

Mixing heights (Figure 11.4-4) determine the extent to which emitted plumes can be vertically mixed and can, on a seasonal basis, be derived from CALMET model output data at the grid-point nearest the Project site. Mixing heights are typically lower at night than during the day. The average nighttime mixing height is 615 metres (m) and the average daytime mixing height is 702 m. The minimum and maximum mixing heights were set to 50 m and 3,000 m, respectively.

Figure 11.4-4 CALMET-Derived Mixing Heights for the Project Site, September 2004 to September 2005



% = percent.

11.4.2.2.3 Results of the Baseline Air Quality Monitoring and Analysis

A variety of emission sources produce suspended particles less than 2.5 microns (μm) in diameter ($\text{PM}_{2.5}$). Among the sources are forest fires, wind-blown dust from Project activity, vehicle exhaust and stationary combustion processes.

De Beers measured concentrations of particulates in the air during the summers of 2004 and 2005 at the Project site. In 2004, forest fires were identified as a major contributor to particulate concentrations in the vicinity of the Project, at Snap Lake Mine, and in Yellowknife. The detection limit of the monitor at the Project was insufficient to resolve concentrations of $\text{PM}_{2.5}$ less than 6 microgram per cubic metre ($\mu\text{g}/\text{m}^3$) during 2004. The detection limit was 3.5 $\mu\text{g}/\text{m}^3$ for particulates smaller than 10 μm (PM_{10}) and total suspended particulates (TSP). These detection limits were sufficiently low to allow detection of the high concentrations associated with the forest fires in 2004. In 2005, the field

sampling duration was increased to 144 hours and the laboratory instrumentation was upgraded to lower the detection level to $0.2 \mu\text{g}/\text{m}^3$. Later data analysis of the measured 2005 data showed inconsistent relationships between $\text{PM}_{2.5}$, PM_{10} , and TSP data and hence, the 2004 and 2005 data were determined to be invalid and replaced by estimates derived from measured data for regional monitoring stations (Annex B).

Longer (2001 to 2004) records of TSP were analyzed from the Snap Lake Mine site. GNWT data were available for 2003 from several sites, including Daring Lake, NWT which is nearest GNWT monitoring station to the Project site. Measured particulate concentrations, and the background estimates for the Project site, are summarized in Table 11.4-2.

Table 11.4-2 Average Concentrations of the $\text{PM}_{2.5}$, PM_{10} , and Total Suspended Particulate at Selected Stations

Particulate	Snap Lake	Daring Lake	Yellowknife	Inuvik	Gahcho Kué ^(a) Project
$\text{PM}_{2.5}$ ($\mu\text{g}/\text{m}^3$)	6.9 ^(b)	1.9 ^(c)	1.7 ^(d)	2.5 ^(e)	2
PM_{10} ($\mu\text{g}/\text{m}^3$)	N/A	1.7 ^(f)	no data	no data	3
TSP ($\mu\text{g}/\text{m}^3$)	7.1 ^(g)	no data	no data	no data	7

^(a) Background estimates as per Annex B, Section B5.2.

^(b) Partisol measurements in 2004 – Median value from two sites.

^(c) Median value for 2003 to 2006.

^(d) Based on monthly median values for 2003 (12 months).

^(e) Based on monthly median values for 2004 (10 months).

^(f) Median value for 2002.

^(g) Median of measurements recorded at three stations from 2001 to 2004 and at 2006.

$\mu\text{g}/\text{m}^3$ = micrograms per cubic metre; $\text{PM}_{2.5}$ = particulate matter of particle diameter less than $2.5 \mu\text{m}$; PM_{10} = particulate matter of particle diameter less than $10 \mu\text{m}$.

The statistics above are not summarized over a common period. All monitoring data in Table 11.4-2 are influenced by anthropogenic emission sources near the monitoring sties with the exception of the Daring Lake data. For this reason, it was determined that the monitoring data at Daring Lake provide most representative background particulate concentrations at the Project. A representative value for background $\text{PM}_{2.5}$ concentrations at the Project is $1.9 \mu\text{g}/\text{m}^3$ based on Daring Lake monitoring data.

A PM_{10} concentration that best represents conditions at the Project is also derived from the Daring Lake monitoring data. The Daring Lake PM_{10} value is based on one-year of measurement in 2002. In comparison, the Daring Lake $\text{PM}_{2.5}$ value is based on four years of measurement between 2003 and 2006. Due to the short monitoring period for the PM_{10} concentrations measured at

Daring Lake, the PM_{10} value is lower than the $PM_{2.5}$ value. A pre-development ambient PM_{10} concentration of $3 \mu\text{g}/\text{m}^3$ representative of the Project area was derived by multiplying the Daring Lake median $PM_{2.5}$ value of $1.9 \mu\text{g}/\text{m}^3$ by the $PM_{10}/PM_{2.5}$ rural concentration ratio of 1.5 reported by Brook et al. (1997).

TSP is not monitored at Daring Lake. Therefore, the Snap Lake TSP monitoring data are the next most representative background concentrations at the Project. The median TSP concentrations measured at the Snap Lake was $7.1 \mu\text{g}/\text{m}^3$.

Estimated background concentrations in the study area for gaseous substances, based on measurements in four NWT communities, are as follows (Annex B):

- sulphur dioxide (SO_2) – $2.6 \mu\text{g}/\text{m}^3$ based on the highest observed monthly median concentration in NWT communities;
- nitrogen dioxide (NO_x) – $5.7 \mu\text{g}/\text{m}^3$, which is the median value based on measurements in the Yellowknife Airport during 2006; and
- ozone (O_3) – $53 \mu\text{g}/\text{m}^3$, which is the median value based on measurements in the Yellowknife Airport during 2006.

There are no regional monitoring data for carbon monoxide (CO), volatile organic compound (VOC), polycyclic aromatic hydrocarbon (PAH) and metals. These substances are typically by-products of anthropogenic emissions. With no anthropogenic emission sources near the Project site, the background concentrations of these compounds were assumed to be negligible.

11.4.3 Pathway Analysis

11.4.3.1 Methods

Pathway analysis identifies and assesses the issues and linkages between the Project components or activities, and the corresponding potential residual effects on air quality. Pathway analysis is a three-step process for identifying and validating linkages between Project activities and environmental effects that are assessed in Section 11.4.7. Potential pathways through which the Project could influence air quality were identified from a number of sources including:

- potential pathways identified in the Terms of Reference for the Gahcho Kué Environmental Impact Statement (Gahcho Kué Panel 2007) and the Report of Environmental Assessment (MVEIRB 2006);
- a review of the Project Description and scoping of potential effects by the environmental assessment and Project engineering teams for the Project; and

- consideration of potential effects identified for the other diamond mines in the NWT and Nunavut.

The first part of the analysis is to produce a list of all potential effects pathways for the Project. Each pathway is initially considered to have a linkage to potential effects on air quality. This step is followed by the development of environmental design features and mitigation that can be incorporated into the Project to remove the pathway or limit (mitigate) the effects to air quality. Environmental design features include Project designs, environmental best practices, management policies and procedures. Environmental design features were developed through an iterative process between the Project's engineering and environmental teams to avoid or mitigate effects.

Knowledge of the ecological system and environmental design and mitigation features is then applied to each of the pathways to determine the expected amount of project-related changes to the environment and the associated residual effects (i.e., after mitigation) on air quality. For an effect to occur there has to be a source (Project component or activity) and a correspondent effect on air quality.

Pathway analysis is a screening step that is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is largely a qualitative assessment, and is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on air quality. Pathways are determined to be primary, secondary (minor), or as having no linkage using scientific and traditional knowledge, logic, and experience with similar developments and environmental design features. Each potential pathway is assessed and described as follows:

- no linkage – pathway is removed by environmental design features and mitigation so that the Project results in no detectable environmental change and, therefore, no residual effects to a value component (VC) relative to baseline or guideline values;
- secondary - pathway could result in a measurable and minor environmental change, but would have a negligible residual effect on a VC relative to baseline or guideline values; or
- primary - pathway is likely to result in a measurable environmental change that could contribute to residual effects on a VC relative to baseline or guideline values.

Primary pathways require further effects analysis and impact classification to determine the environmental significance from the Project on the persistence of

air quality changes and maintaining compliance with NWT air quality standards. Pathways with no linkage to air quality or that are considered minor (secondary) are not analyzed further or classified in Section 11.4.7 because environmental design features and mitigation will remove the pathway (no linkage) or residual effects can be determined to be negligible through a simple qualitative evaluation of the pathway. Pathways determined to have no linkage to air quality or those that are considered secondary are not predicted to result in environmentally significant effects on maintaining compliance with NWT air quality guidelines. Primary pathways are assessed in more detail in Section 11.4.7.

11.4.3.2 Results

This section identifies and validates the potential pathways through which the Project can affect air quality and impact VCs (Table 11.4-3). Valued components for air quality effects include water quality, wildlife, fish and human health. Environmental design features and management processes incorporated into the Project to remove a pathway or limit (mitigate) the effects to VCs are described in detail below, along with relevant regulatory requirements.

Table 11.4-3 Validation of Pathways Leading to Potential Effects on Air Quality

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Assessment
Construction and Mining Activity, Winter Access Road and Tibbitt-to-Contwoyto Winter Road	Air emissions (sulphur dioxide [SO ₂], nitrogen oxides [NO _x], carbon monoxide [CO], particulate matter [PM], and total suspended particulates [TSP]) can affect air quality.	compliance with regulatory emission requirements good design and operational practices to mitigate and reduce emissions and to improve energy efficiencies	primary
	Dust emissions can affect air quality.		primary
Dewatering of Kennady Lake	Dust emissions from dewatered lake-bed of basins K1, K2, K3 and K4 of Kennady Lake	compliance with regulatory emission requirements good design and operational practices to mitigate and reduce emissions	primary

11.4.3.2.1 Good Practices to Mitigate and Reduce Emissions

In keeping with its focus on responsible and sustainable development, De Beers has identified a series of good practices to minimize air quality changes that it will employ.

Continuous improvement and emission reduction are key management approaches that support the principle of keeping clean areas clean and encompass the De Beers goal of using best available technology economically achievable (BATEA). For example, Project facilities and activities will incorporate BATEA technologies and any upgrades made during capital stock turnover of engines and equipment will consider and incorporate BATEA.

De Beers is committed to the following general management approaches for air emissions from the Project:

- Project mine equipment and haul vehicles will be regularly maintained to reduce emissions and maximize fuel efficiency;
- Low sulphur (15 parts per million by weight [ppmw]) diesel will be used in fleet vehicles;
- Site road topping surfaces will be regularly maintained for operational efficiencies and to minimize fuel consumption; and
- Project waste will be screened. Material containing metal and chlorinated organic waste will be segregated and set aside. The remainder will be combusted in an approved incinerator. The waste incinerator will be engineered and operated to meet the CCME emission standards for dioxins and furans (CCME 2001).

De Beers will minimize NO_x emissions through the following specific measures:

- Committing to use corporate project fleet vehicles that meet applicable emission standards at the time of purchase and to encouraging contractors to do the same with their vehicles;
- Considering NO_x emissions as a criterion in future engine and boiler upgrades;
- Energy conservation initiatives such as maintaining site road topping surfaces for energy efficiency; and
- Considering the use of diesel engine exhaust catalytic converters to reduce NO_x emissions from the mobile fleet.

Specifically with respect to dust control, the largest emissions are transport related. De Beers will manage dust and particulate emissions by adopting the following management practices:

- water spray application to control dust emissions on haul roads during summer;

- considering limiting the height from which material is dropped onto conveyors; and
- managing vehicle speed to limit wind-blown dust from vehicle wheel entrainment.

No mitigation has been planned currently for the drained Kennady Lake. Anecdotal information (Rescan 2004) for the Ekati Diamond Mine suggests the combination of moisture remaining in the ground and the formation of a hardpan surface will minimize the potential for dust emissions. De Beers plans to include consideration of the potential for dust from the drained lake-bed in its air quality monitoring program, and to develop contingency plans should monitoring data indicate that excessive dust concentrations are occurring.

De Beers plans to incorporate the results of its ambient air quality monitoring program into its emission management plans as part of its response to the principle of continuous improvement.

11.4.3.2.2 *Regulatory Emission Requirements*

De Beers will design the Project facilities to meet Canadian Council of Ministers of the Environment (CCME) emission requirements for boilers, fuel storage tanks, and waste incinerators. These requirements are summarized below.

The CCME has published National Emission Guidelines for Commercial/Industrial Boilers and Heaters (CCME 1998). The values set out in this document are frequently referenced by regulatory agencies as targets that need to be achieved for approval and permit compliance. A summary of these guidelines is presented in Table 11.4-4.

Table 11.4-4 Canadian Council of Ministers of the Environment Emission Guidelines for Industrial Boilers and Heaters

Parameter	Fuel Type	Emission Limits per Energy Input (g/GJ)	
		10.5 to 105 GJ/h	> 105 GJ/h
NO _x (as mass NO ₂ equivalent)	gaseous fuel	26	40
	distillate oil	40	50
	residual oil (<0.35% N)	90	90
	residual oil (>0.35% N)	110	125
CO	all fuels	125	125

NO_x = nitrogen oxides; NO₂ = nitrogen dioxide; CO = carbon monoxide; N = nitrogen; % = percent; GJ/h = gigajoule per hour; g/GJ = gram per gigajoule; < = less than; > = more than.

The CCME issued the document *Environmental Guidelines for Controlling Emissions of Volatile Organic Compounds from Aboveground Storage Tanks* (CCME 1995), which is intended to provide consistency in controlling VOC emissions from fuel storage tanks.

National standards for dioxin and furan emissions from waste incinerators were established by CCME (2001). Emission limits are expressed as a concentration in the exhaust gas exiting the stack of the facility. The limits will be met using generally available incineration and emission control technology and waste diversion. Application of best available pollution prevention and control techniques, such as a waste diversion program, is encouraged by regulators to minimize dioxin and furan emissions. The following emission concentration limits are specified (in pico-grams of International Toxic Equivalency Quotients per cubic metre [pg I-TEQ/m³]):

- municipal waste incineration: 80 pg I-TEQ/m³;
- hazardous waste incineration: 80 pg I-TEQ/m³; and
- sewage sludge incineration: 80 pg I-TEQ/m³.

The Project incinerator will be receiving a combination of the above listed common waste material categories.

11.4.4 Effects Analysis Methods

A dispersion model was used to provide a spatial understanding of ambient ground-level concentrations and deposition distribution patterns (i.e., air quality modelling results). The model provided a scientific link between emissions and ambient air quality by accounting for local topographical and meteorological considerations. The Project was assessed using several environmental impact assessment cases and emission scenarios with a focus on the maximum substance concentrations predicted to occur overall and outside the Project development area boundary. As shown in Figure 11.4-1, the Project development area is located entirely within the LSA. Figure 11.4-1 also shows the locations of other points of interest where predicted changes to air quality were characterized.

There is no air modelling guideline for NWT. Therefore, the dispersion modelling approach for this assessment is based on the Air Quality Model Guideline developed by Alberta Environment (AENV 2009). The AENV guideline has been used as the basis for air quality assessments of many developments in the NWT.

11.4.4.1 Assessment Approach

Air quality was assessed considering the following assessment cases and emission scenarios:

- The Baseline Case, which includes an assessment of air quality from the approved Snap Lake Mine emission sources. The predicted concentrations and deposition were added to the estimated background levels described in Section 11.4.2.2.3.
- The Application Case, which considers a combination of selected emission source configurations from the Project in combination with the Baseline Case sources (i.e., Application = Baseline Case + Project). The two key Project emission source configurations are: Mining Year 1 (South Mine Rock Pile used) and Year 5 (West Mine Rock Pile used). Winter Access Road emissions associated with the Project are also considered in the Application Case.
- The Construction Case, which considers the emissions associated with initial facility construction activities, site clearing, selected overburden removal and other miscellaneous activities in the preliminary stages of mine development.

The rationale for considering the two Application Case source configurations described above is due to the potential for widely different locations of selected emission sources within the project footprint from year to year. In Year 1 of production, the mine rock disposal and transportation activities will be taking place primarily in and around only the South Mine Rock Pile; in Year 5, the same activities will be taking place primarily in and around the West Mine Rock Pile. Due to these spatial differences, the maximum predicted air concentrations may occur at different locations (i.e., to the south or west of the Project). Rather than modelling only one of the two potential source configurations, each configuration was modelled separately and the highest predicted values of the two runs were used as the Application Case predictions.

11.4.4.2 Selected Air Compounds

A thorough review was conducted of emissions associated with mines in the NWT, including the Snap Lake Mine (Golder 2004 and 2007), Ekati Diamond Mine (BHP 1995), and Diavik Diamond Mine (Diavik 1998). Relevant air quality guidelines were also reviewed, including the Northwest Territories Air Quality Standards (GNWT 2010), the Canada-Wide Standards (CCME 2000) and the National Ambient Air Quality Objectives (Environment Canada 1981) (which are described below). A list of substances was developed from these reviews. They included SO₂, NO₂, CO, particulate matters, VOCs, PAHs, trace metals, dioxins

and furans, as well as deposited potential acid input (PAI) and nitrogen. Table 11.4-5 summarizes the annual emission rates of some of these substances from the proposed Project, the Snap Lake Mine, as well as a section of the Winter Access Road connecting the Project to the Tibbitt-to-Contwoyto Winter Road.

Table 11.4-5 Summary of Project and Regional Annual Emission Rates

Source	Emission Rate [t/d]					
	SO ₂	NO _x	CO	TSP	PM ₁₀	PM _{2.5}
Baseline Case						
Snap Lake Mine	0.304	8.673	3.014	0.502	0.251	0.166
Application Case						
Gahcho Kué Project ^(a)	0.041	4.600	2.488	8.625	2.163	0.407
Snap Lake Mine	0.304	8.673	3.014	0.502	0.251	0.166
Total	0.345	13.273	5.502	9.127	2.414	0.573
Construction Scenario						
Gahcho Kué Project ^(a)	0.025	1.909	1.267	2.810	0.806	0.169
Snap Lake Mine	0.304	8.673	3.014	0.502	0.251	0.166
Total	0.330	10.582	4.281	3.311	1.057	0.336

^(a) Winter Access Road emissions associated with the Project are included in the project emissions.

Note: The emission rates presented in the above table have been rounded to three decimal places. Therefore, the totals may not appear to be sum of individual values.

t/d = tonnes per day; SO₂ = sulphur dioxide; NO₂ = nitrogen dioxide; CO = carbon monoxide; PM = particulate matter; TSP = total suspended particulate.

The air quality assessment encompassed modelling of the following types of Project and regional emission sources:

- exhaust from stationary combustion sources (electrical generators, boilers, heaters and waste incinerators);
- diesel engine exhaust from mine mobile equipment (excavators, loaders, graders, haul trucks, and dozers);
- fugitive dust from mine pit activities (i.e., blasting, drilling, loading/unloading and dozing), haul road grading and transport activities and ore processing;
- wind-blown lake-bed dust from drained Kennady Lake areas;
- diesel engine exhaust from vehicle traffic on and the Winter Access Road connecting the Project to the Tibbitt-to-Contwoyto Winter Road; and
- aircraft emissions that may affect ground-level air quality occur for a short period of time during take-off and landing. They occur infrequently

or intermittently and were not used in the assessment of routine or upset operations.

Stationary and mobile combustion exhausts are the primary sources of SO₂ and NO_x emissions from the Project. Particulate matter emissions are associated with mining activities which generate fugitive dust emissions. PAH and VOC emissions are predominantly from combustion exhausts, and metal emissions are associated with all sources but in varying degrees. Details of these emission sources and substance emission rates are included in Appendix 11.4.II.

Northwest Territories Air Quality Standards

The NWT Air Quality Standards (GNWT 2010) are applied to air quality assessments of proposed and existing developments, and reporting on the state of air quality in the NWT. Any actions to maintain or improve air quality will include consideration of factors such as the frequency and magnitude of exceeding standards, the size of the affected area, availability of control options, and environmental, human health, and socio-economic impacts.

Canada-Wide Standards

The CCME reached an agreement in 1998 (CCME 1998, internet site) on the harmonization of environmental regulations across Canada. As part of the process, the CCME has established a sub-agreement for the creation of Canada-Wide Standards with respect to the environment (including air quality guidelines).

The Canada-Wide Standards are intended to be achievable standards that are based on sound science, and which take into consideration social implications and technical feasibility. The Canada-Wide Standards do not have legal force under federal legislation; however, each provincial jurisdiction participating in the Harmonization Accord has committed to implementing the standards under existing provincial legislation, or through the drafting of new legislation.

The Canada-Wide Standards process has been progressing for a limited set of compounds, namely ozone and fine particulate matter (PM_{2.5}). The first set of Canada-Wide Standards for air pollutants was ratified by the CCME in June 2000. The compounds for which Canada-Wide Standards have been adopted include fine particulate matter (PM_{2.5}), ground-level ozone (O₃), benzene, and mercury. The CCME has not yet established an acceptable ambient air quality criterion for benzene, but has set targets for reducing the emissions of benzene by approximately 40 percent (%) from the 1995 levels by the end of 2010 (CCME 2001). Canada-Wide Standards for mercury emissions have been developed for the waste incineration sector in Canada.

National Ambient Air Quality Objectives

The Canadian Federal Government has established three levels of National Ambient Air Quality Objectives (Environment Canada 1981). The levels are described as follows:

- The maximum desirable level defines the long-term goal for air quality and provides a basis for an anti-degradation policy for the unpolluted parts of the country and for the continuing development of control technology.
- The maximum acceptable level is intended to provide adequate protection against adverse effects on soil, water, vegetation, materials, animals, visibility, personal comfort, and well-being.
- The maximum tolerable level denotes an air contaminant concentration that requires abatement (mitigation) to avoid further deterioration to an air quality that endangers the prevailing Canadian lifestyle or ultimately, that poses a substantial risk to public health.

The tolerable levels were not used in the assessment of effects on air quality for the Project, because they represent the highest allowable concentrations, which are higher than corresponding NWT guidelines and inconsistent with De Beers approach to use of good practice.

11.4.4.3 Use of Measured Background as Baseline Concentration

Background concentrations should be considered when conducting a cumulative air quality analysis. The widespread, low-intensity human activities in the region, as well as contributions from forest fires and communities several hundred kilometres away were assumed to contribute as additive background sources. Measurements of SO₂, NO₂ and other substances made in the region and other NWT locations were used to estimate background concentrations (Annex B and Appendix 11.4.I). The background concentrations were added to the modelled results in both the Baseline Case and Application Case.

11.4.4.4 Choice of Dispersion Model – CALPUFF

The California puff (CALPUFF) dispersion model was used to model changes in air quality due to the Project. The California meteorological (CALMET) model was used in combination with CALPUFF to develop a three-dimensional meteorological parameters field to emulate the spatial transport, dispersion, and chemical transformation of emitted substances. A detailed review of these models, as applied in this air quality assessment, is provided in Appendix 11.4.I.

The CALPUFF model is one of the refined dispersion models recommended by Alberta Environment (AENV 2009). Key advantages of the modelling system over others are:

- It is applicable to spatial scales ranging from a few kilometres to more than 100 km.
- It simulates wet and dry atmospheric substance removal processes (i.e., substance deposition).
- It simulates both SO₂ and NO_x chemistry that is required to model PAI.
- It simulates wind speed and wind direction in three spatial dimensions and time providing for a realistic representation of plume movement. To emulate the plume movement, the initial source substance emissions are represented by a series of puffs.
- It is a model that has been accepted by the GNWT for environmental assessments.
- It is based on sound, openly documented physical principles that have undergone independent review.
- It incorporates the Plume Rise Model Enhancement (PRIME) downwash algorithms to determine the aerodynamic effects of buildings on the plume rise from stacks.

11.4.4.5 Modelling Approach

The modelling approach used for the Project is consistent with the approaches used for the Snap Lake Mine in the NWT and the Jericho Diamond Mine in Nunavut. It should be noted however that the Snap Lake Mine assessment used a simplified version of the CALPUFF model with simplified ISC3 meteorology. Moreover, the original Jericho Diamond Mine Environmental Impact Assessment (EIA) used the ISC3 model whereas a recent update used CALPUFF.

Some of the key aspects of the Project modelling approach include the following:

- A nested receptor grid per the AENV model guideline (AENV 2009) was placed over the project emission sources. The receptor spacing ranged from 50 m to 1000 m. In addition, a series of 20-m spaced receptors were placed along the development area boundary.
- For the purpose of evaluating dry deposition, non-uniform land use types were assumed in the study area. Model results were obtained for foliage (June 1 to September 25, 2005) and non-foliage (September 26, 2004 to May 31, 2005) periods. Primary cover types included tundra, water, and wetlands. Other surface parameters were

made functions of the ground cover. Details are provided in Appendix 11.4.I.

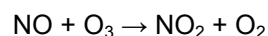
- The National Centre for Atmospheric Research (NCAR), Colorado provided project-area-specific meteorological (upper air) data using the CALNARR (modified CALETA) pre-processor program for CALMET. The results of the NARR model were used as the first guess wind field in CALMET (for September 26, 2004 to September 25, 2005). The upper air data were interpolated to a 2 by 2 km grid in the horizontal. Vertical grid points were located at the ground surface and at eight other levels above ground level up to and including 2,200 m.
- Surface meteorological data from the Project station (operated by De Beers and using data from August 2004 to September 2005) was also used for modelling, including winds measured at the 10 m level. The data were supplemented by data from the Yellowknife Airport.
- The background PAI was based on wet deposition data collect by Environment Canada at Snare Rapids, NWT and dry deposition data derived from Regional Lagrangian Acid Deposition Model (RELAD) modelling runs conducted by AENV (NAtChem 2003 to 2007, Cheng 2006a, 2006b). A single PAI value of 0.064 kiloequivalent per hectare per year (keq/ha/y) was applied throughout the RSA.

Model results are presented inside and outside the Project development area boundary which is designed to encircle the Project activities associated with key air emissions, including the primary sources such as the plant, haul roads, mine, and various storage piles. It is meant to provide a boundary beyond which receptors may be exposed to the largest air quality changes due to the Project. The boundary is similar to the “fenceline” around a development in a less isolated area and as such, it does not encompass the dewatered lake bed, the airstrip, or the planned Winter Access Road, which are considered to be small and/or intermittent sources.

Further details of the modelling approach are presented in Appendix 11.4.I.

11.4.4.5.1 Approach for Nitrogen Dioxide

Nitrogen oxides (NO_x) are comprised of nitric oxide (NO) and nitrogen dioxide (NO₂). High temperature combustion processes primarily produce NO that in turn can be converted to NO₂ in the atmosphere through reactions with tropospheric ozone:



The CALPUFF dispersion model uses a modified version of the RIVAD/ARM3 SO_x and NO_x chemistry scheme that was adopted to allow NO₂ concentrations to be calculated from NO emissions within the model. However, the CALPUFF model chemistry scheme has been shown to overestimate ambient NO₂ concentrations, especially close to large area emission sources such as mine pits (Staniaszek and Davies 2006).

For that reason, the NO_x ground-level concentrations obtained from the modelling were converted to NO₂ ground-level concentrations using the Ozone Limited Method (OLM) according to AENV (2009). The OLM assumes that the conversion of NO to NO₂ in the atmosphere is limited by the ambient O₃ concentration in the atmosphere. If the ozone concentration is greater than 90% of the modelled NO_x ground-level concentration, the method assumes all NO_x is converted to NO₂. Otherwise, the NO₂ concentration is equal to the sum of the ozone available to oxidize NO_x and 10% of the modelled NO_x ground-level concentration:

$$\text{NO}_2 = \text{O}_3 + 0.1 \times \text{NO}_x$$

The OLM is recommended by the United States Environmental Protection Agency (U.S. EPA) and by other jurisdictions for locations with well-defined, isolated sources (Wilson 1997).

The hourly, daily and annual O₃ concentrations used in the OLM calculations in assessment are 41.7, 38.6 and 25.6 parts per billion (ppb), respectively. These values were determined based ozone monitoring data for Yellowknife from 2005 through 2009 (GNWT 2006, 2008, 2009).

11.4.4.5.2 Approach for Acid Deposition

Acidifying emissions include oxides of sulphur and nitrogen, and ammonia and are modelled with the CALPUFF model. Deposition of acidifying emissions can occur via wet and dry processes. Wet deposition results remove these atmospheric emissions by precipitation. Dry processes remove emissions by direct contact with surface features (e.g., vegetation, soils, and surface water).

Both wet and dry depositions are expressed as a flux in units of kilograms per hectare per year (kg/ha/y). Where more than one chemical species is considered, the flux is often expressed in terms of kiloequivalents per hectare per year (keq/ha/y) where 'keq' refers to hydrogen ion equivalents (1 keq = 1 kmol H⁺), the common acidic ion associated with various negatively charged ions.

Potential acid input (PAI) is used as a deposition measure of acidification and is defined as follows:

$$PAI = PAI_{sulphur} + PAI_{nitrogen} + PAI_{background}$$

Where:

$PAI_{sulphur}$ is the model predicted PAI contributed by sulphur compounds;

$PAI_{nitrogen}$ is the model predicted PAI contributed by nitrogen compounds;
and

$PAI_{background}$ is the background PAI.

Further details on the PAI calculations are provided in Appendix 11.4.I, Sections 11.4.I.5.7 and 11.4.I.5.8.

11.4.4.5.3 Approach for Nitrogen Deposition

Deposition of nitrogen includes both wet (removal in precipitation) and dry (direct contact with surface features) processes. In the current approach, nitrate particulate is determined to be deposited by both wet and dry processes and is directly calculated by the dispersion model based on modelled annual average concentrations and an assumed deposition velocity.

The deposited nitrogen (expressed as a mass flux of nitrogen mass equivalent species) is scaled by the molecular weights of the deposited species as follows:

Nitrogen Deposition

$$\begin{aligned} &= \frac{NO_{dry} \times 14}{30} + \frac{NO_{2,dry} \times 14}{46} + \frac{(NO_{3,dry}^- + NO_{3,wet}^-) \times 14}{62} \\ &+ \frac{(HNO_{3,dry} + HNO_{3,wet}) \times 14}{63} \end{aligned}$$

Using this approach, nitrate deposition is accounted for in both acidification and eutrophication calculations, which is conservative.

11.4.4.6 Guideline Comparison

Predicted changes to air quality were evaluated with respect to air quality guidelines, including the Northwest Territories Air Quality Standards (GNWT 2010), the Canada-Wide Standards (CCME 2000) and the National Ambient Air Quality Objectives (Environment Canada 1981). These guideline comparisons focused on the compounds for which standards and objectives have been

established, which include (as summarized in Table 11.4-6) SO₂, nitrogen dioxide (NO₂), CO, TSP and PM_{2.5}. Predicted results for other compounds considered in the air quality assessment, including VOCs, PAHs, metals, dioxins and furans, are summarized in Appendix III. The potential for the predicted changes in the concentrations of these compounds to affect the health of aquatic life is outlined in EIA Section 8 and 9. A summary of how the predicted changes in air quality could affect human health is presented in this subject of note (Section 11.4.5.8) in accordance with the TOR.

Table 11.4-6 Canadian Air Quality Guidelines

Substance	GNWT Air Quality Standards ^(a)	Canada-Wide Standards ^(b)	National Ambient Air Quality Objectives ^(c)		
			Desirable	Acceptable	Tolerable
SO ₂ (µg/m ³)					
1-Hour	450	–	450	900	–
24-Hour	150	–	150	300	800
Annual	30	–	30	60	–
NO ₂ (µg/m ³)					
1-Hour	–	–	–	400	1,000
24-Hour	–	–	–	200	300
Annual	–	–	60	100	–
CO (µg/m ³)					
1-Hour	–	–	15,000	35,000	–
8-Hour	–	–	6,000	15,000	20,000
TSP (µg/m ³)					
24-Hour	120	–	–	120	400
Annual	60	–	60	70	–
PM ₁₀ (µg/m ³)					
24-Hour	–	–	–	–	–
Annual	–	–	–	–	–
PM _{2.5} (µg/m ³)					
24-Hour	30 ^(d)	30 ^(d)	–	–	–
Annual	–	–	–	–	–

(a) Source: GNWT (2010).

(b) Source: CCME (2000).

(c) Source: Environment Canada (1981).

(d) Compliance with the GNWT standard is based on measured maximum value (Veale 2008) whereas compliance with the Canada Wide Standard is based on the 98th percentile of the annual monitored data averaged over three years of measurements.

Note: – = No guideline available; µg/m³ = micrograms per cubic metre; SO₂ = sulphur dioxide gas; NO₂ = nitrogen dioxide; TSP = total suspended particulates; PM = particulate matter; CO = carbon monoxide; GNWT = Government of the Northwest Territories.

11.4.5 Effects on Air Quality

The following subsections summarize the results of the air quality modelling for the baseline and application (and cumulative effects) assessment cases with reference to the predicted concentrations of SO₂, NO₂, CO, particulate matter

and the deposition of potential acid inputs. The following comments apply to the model results:

- All Baseline Case results are presented in tabular form only. The predicted maximum values are located near the Snap Lake Mine, which is approximately 85 km west of the Project.
- All Application Case results are presented in tabular form for the predicted maximum values overall and outside the Project development area. Changes in predicted values from the Baseline Case due to the Project are also presented in the tables.
- The Application Case results are also shown graphically in contour (i.e., isopleths) figures. The isopleths are shown at 100, 50 and 25% of the applicable air quality guideline. Isopleth figures are not presented if the maximum predicted concentrations are below 25% of the applicable air quality guideline.
- All isopleth figures show the locations and values of predicted maxima overall and outside the Project development area. Predicted concentrations are discussed in the context of exceeding regulatory air quality guidelines, with emphasis on concentrations outside the development area boundary that indicate potentially significant air quality impacts.
- All tables show the frequency of predictions outside the Project development area boundary exceeding a regulated air quality guideline. Areas exceeding the guideline are also presented in the tables.

11.4.5.1 Application Case Project Emissions

An understanding of the Project emissions is important when analyzing the model predicted concentrations and deposition rates. Table 11.4-7 provides a summary of the Project emissions. Detailed information on the basis and the method used in the project emission estimation is provided in Appendix 11.4.II.

Table 11.4-7 Gahcho Kué Project Application Case Emissions

Source	Emission Rate [t/d]					
	SO ₂	NO _x	CO	TSP	PM ₁₀	PM _{2.5}
Generators	0.001	2.692	0.715	0.059	0.048	0.047
Auxiliary boiler	0.000	0.007	0.002	0.001	0.001	0.000
Waste incinerator	0.004	0.004	0.012	0.008	0.008	0.008
Mine fleet	0.003	1.638	0.532	0.080	0.080	0.078
Drilling and Blasting	0.032	0.256	1.226	0.064	0.032	0.003
Loading/unloading	—	—	—	0.224	0.106	0.016
Bulldozing	—	—	—	0.023	0.003	0.002
Crushers	—	—	—	0.030	0.013	0.011
Conveyors	—	—	—	0.077	0.028	0.028
Aggregate plant	—	—	—	0.062	0.024	0.018
Wind erosion	—	—	—	0.216	0.108	0.016
Grading	—	—	—	0.312	0.091	0.010
Road dust	—	—	—	7.155	1.464	0.146
Winter Access Road	0.000	0.003	0.001	0.000	0.000	0.000
Drained lakebed	—	—	—	0.312	0.156	0.023
Total	0.041	4.600	2.488	8.625	2.163	0.407

Note: The emission rates presented in the above table have been rounded to three decimal places. Therefore, the totals may not appear to be sum of individual values.

t/d = tonnes per day; SO₂ = sulphur dioxide; NO₂ = nitrogen dioxide; CO = carbon monoxide; PM = particulate matter; TSP = total suspended particulate.

11.4.5.2 Sulphur Dioxide

The maximum 1-hour, 24-hour and annual average SO₂ predictions in the Baseline Case and Application Case are summarized in Tables 11.4-8, 11.4-9 and 11.4-10, respectively. The predicted concentrations are all below the GNWT air quality standards. The 24-hour and annual SO₂ predictions are shown graphically in Figures 11.4-5 and 11.4-6, respectively.

Table 11.4-8 Comparison of Predicted Baseline Case and Application Case 1-Hour Sulphur Dioxide Concentrations

Parameters	Baseline Case	Application Case	Change Due to Project
Local Study Area (LSA)			
maximum 1-hour SO ₂ [µg/m ³]	3.4	67.5	64.1
maximum 1-hour SO ₂ (excluding development area) [µg/m ³]	3.4	42.9	39.5
occurrences above 1-hour NWT AQS ^(a)	0	0	0
area above 1-hour NWT AQS ^(a) (excluding development area) [ha]	0	0	0
Regional Study Area (RSA)			
maximum 1-hour SO ₂ [µg/m ³]	24.0	67.5	44
maximum 1-hour SO ₂ (excluding development area) [µg/m ³]	24.0	42.9	19
occurrences above 1-hour NWT AQS ^(a)	0	0	0
area above 1-hour NWT AQS ^(a) (excluding development area) [ha]	0	0	0

^(a) NWT Air Quality Standard (AQS) for 1-hour SO₂ = 450 µg/m³.

µg/m³ = microgram per cubic metre; SO₂ = sulphur dioxide; ha = hectare.

Table 11.4-9 Comparison of Predicted Baseline Case and Application Case 24-Hour Sulphur Dioxide Concentrations

Parameters	Baseline Case	Application Case	Change Due to Project
Local Study Area (LSA)			
maximum 24-hour SO ₂ [µg/m ³]	2.8	49.5	46.8
maximum 24-hour SO ₂ (excluding development area) [µg/m ³]	2.8	32.9	30.1
occurrences above 24-hour NWT AQS ^(a)	0	0	0
area above 24-hour NWT AQS ^(a) (excluding development area) [ha]	0	0	0
Regional Study Area (RSA)			
maximum 24-hour SO ₂ [µg/m ³]	8.5	49.5	41
maximum 24-hour SO ₂ (excluding development area) [µg/m ³]	8.5	32.9	24
occurrences above 24-hour NWT AQS ^(a)	0	0	0
area above 24-hour NWT AQS ^(a) (excluding development area) [ha]	0	0	0

^(a) NWT Air Quality Standard (AQS) for 24-hour SO₂ = 150 µg/m³.

µg/m³ = microgram per cubic metre; SO₂ = sulphur dioxide; ha = hectare.

Table 11.4-10 Comparison of Predicted Baseline Case and Application Case Annual Sulphur Dioxide Concentrations

Parameters	Baseline Case	Application Case	Change Due to Project
Local Study Area (LSA)			
maximum annual SO ₂ [µg/m ³]	2.6	7.3	4.7
maximum annual SO ₂ (excluding development area) [µg/m ³]	2.6	4.8	2.2
area above annual NWT AQS ^(a) (excluding development area) [ha]	0	0	0
Regional Study Area (RSA)			
maximum annual SO ₂ [µg/m ³]	3.0	7.3	4.3
maximum annual SO ₂ (excluding development area) [µg/m ³]	3.0	4.8	1.8
area above annual NWT AQS ^(a) (excluding development area) [ha]	0	0	0

^(a) NWT Air Quality Standard (AQS) for annual SO₂ = 30 µg/m³.

µg/m³ = microgram per cubic metre; SO₂ = sulphur dioxide; ha = hectare.

11.4.5.3 Nitrogen Oxides

Tables 11.4-11, 11.4-12 and 11.4-13 present the comparisons of predicted 1-hour, 24-hour and annual average NO₂ concentrations in the Baseline Case and Application Case. The Application Case 1-hour, 24-hour and annual average predictions are shown graphically in Figures 11.4-6, 11.4-7 and 11.4-8. The Application Case predicted 1-hour NO₂ concentrations outside the development area are below the national air quality objective. The Application Case predicted 24-hour and annual concentrations are above the respective air quality objectives. The 24-hour objective is exceeded outside the development area for 2 days per year. Approximately 9 hectares (ha) and 1 ha outside of the development area are exceeding the 24-hour and annual objectives, respectively. These areas are located near the South Mine Rock Pile and the haul roads along the south side of the development area. The high predicted concentrations are a result of the close proximity of haul truck exhaust emission sources to the development area boundary. The predictions at the western edge of the proposed national park are all below the national air quality objectives.

Table 11.4-11 Comparison of Predicted Baseline Case and Application Case 1-Hour Nitrogen Dioxide Concentrations

Parameters	Baseline Case	Application Case	Change Due to Project
Local Study Area (LSA)			
maximum 1-hour NO ₂ [µg/m ³]	17.9	325.7	307.7
maximum 1-hour NO ₂ (excluding development area) [µg/m ³]	17.9	314.3	296.4
occurrences above 1-hour NAQO ^(a)	0	0	0
area above 1-hour NAQO ^(a) (excluding development area) [ha]	0	0	0
Regional Study Area (RSA)			
maximum 1-hour NO ₂ [µg/m ³]	109.8	325.7	215.8
maximum 1-hour NO ₂ (excluding development area) [µg/m ³]	109.8	314.3	204.5
occurrences above 1-hour NAQO ^(a)	0	0	0
area above 1-hour NAQO ^(a) (excluding development area) [ha]	0	0	0

^(a) National Air Quality Objective (NAQO) for 1-hour NO₂ = 400 µg/m³.
µg/m³ = microgram per cubic metre; NO₂ = nitrogen dioxide; ha = hectare.

Table 11.4-12 Comparison of Predicted Baseline Case and Application Case 24-Hour Nitrogen Dioxide Concentrations

Parameters	Baseline Case	Application Case	Change Due to Project
Local Study Area (LSA)			
maximum 24-hour NO ₂ [µg/m ³]	8.6	258.8	250.2
maximum 24-hour NO ₂ (excluding development area) [µg/m ³]	8.6	224.8	216.2
occurrences above 24-hour NAQO ^(a)	0	2	2
area above 24-hour NAQO ^(a) (excluding development area) [ha]	0	9	9
Regional Study Area (RSA)			
maximum 24-hour NO ₂ [µg/m ³]	81.2	258.8	177.6
maximum 24-hour NO ₂ (excluding development area) [µg/m ³]	81.2	224.8	143.6
occurrences above 24-hour NAQO ^(a)	0	2	2
area above 24-hour NAQO ^(a) (excluding development area) [ha]	0	9	9

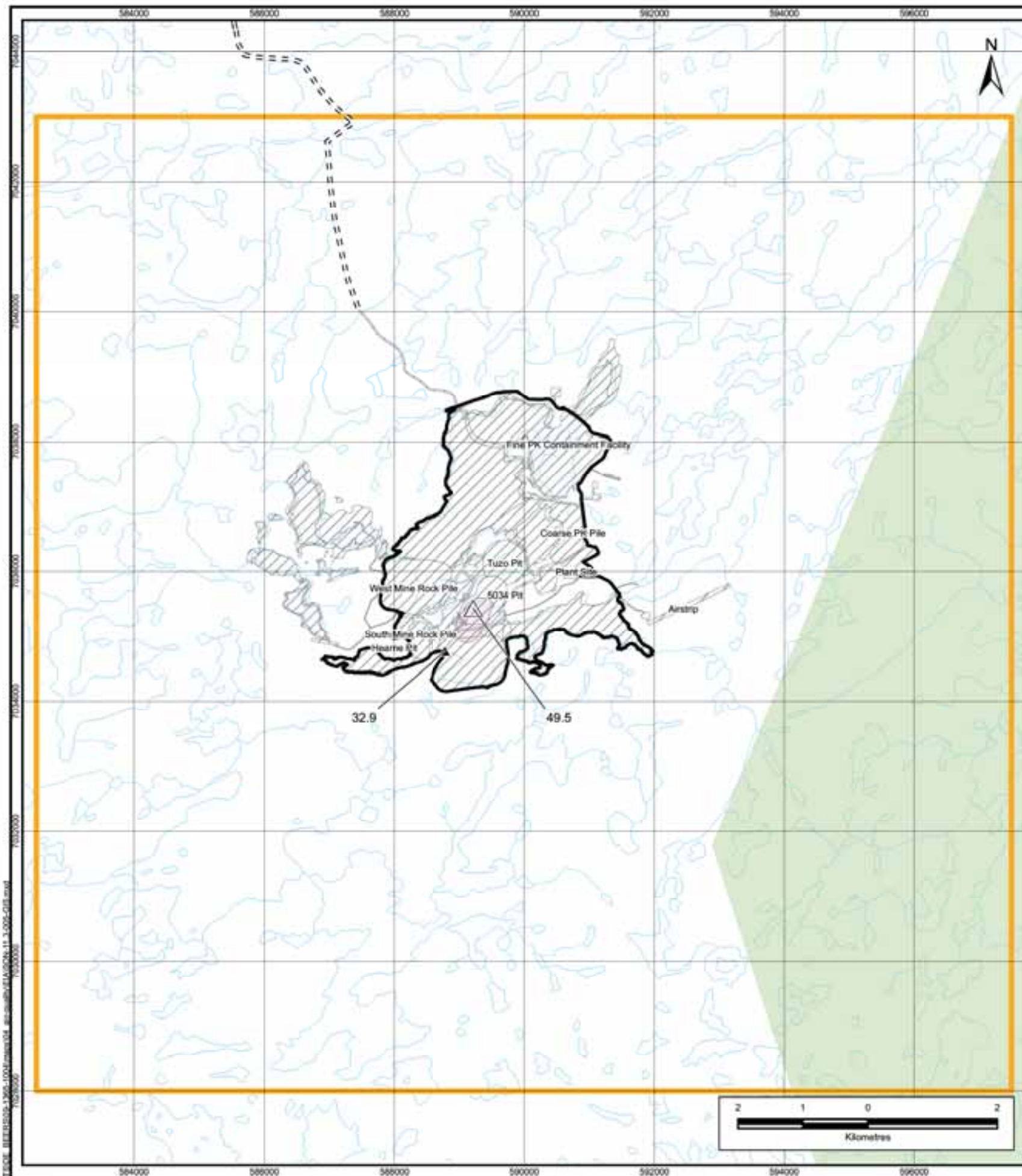
^(a) National Air Quality Objective (NAQO) for 24-hour NO₂ = 200 µg/m³.
µg/m³ = microgram per cubic metre; NO₂ = nitrogen dioxide; ha = hectare.

Table 11.4-13 Comparison of Predicted Baseline Case and Application Case Annual Nitrogen Dioxide Concentrations

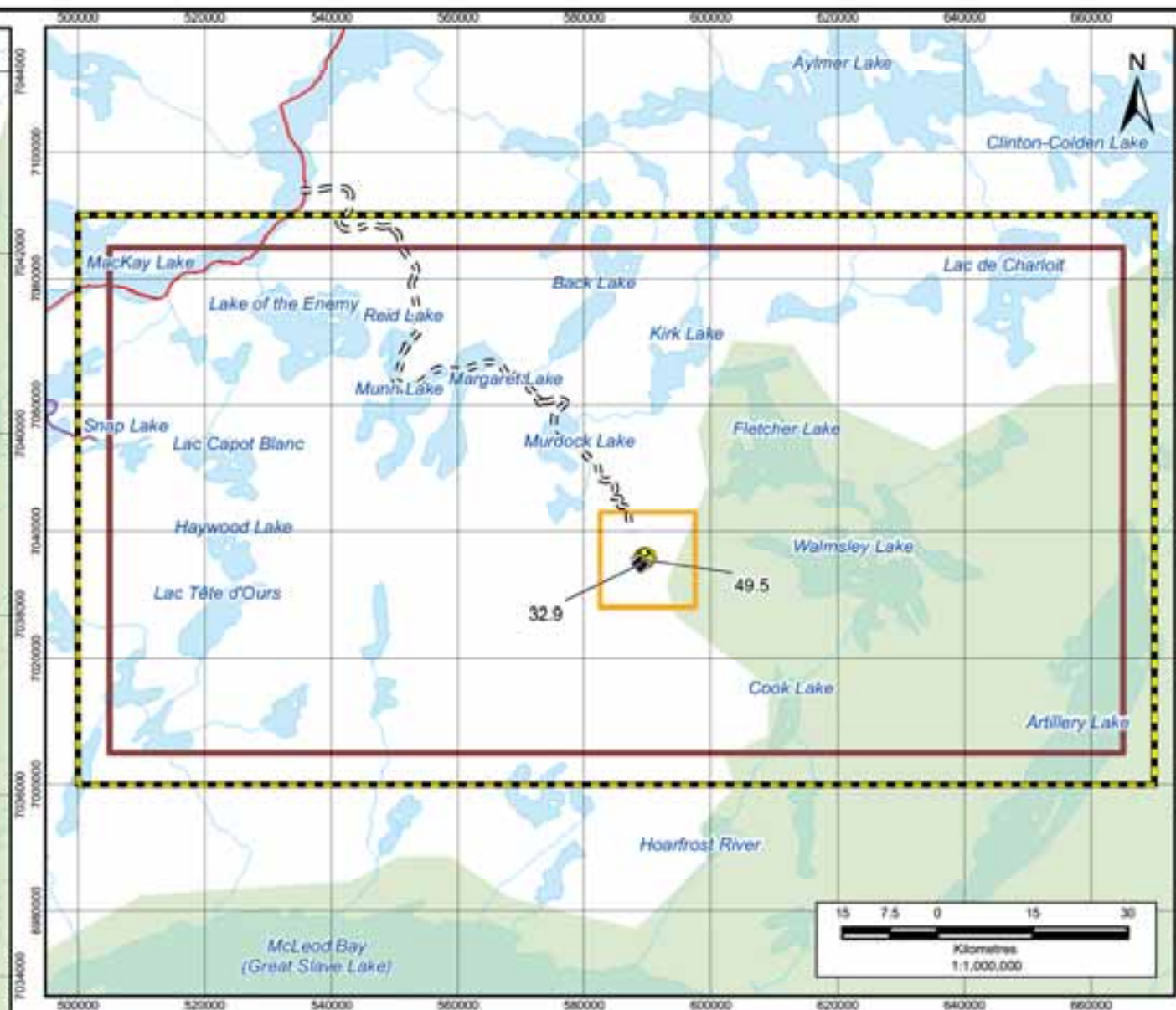
Parameters	Baseline Case	Application Case	Change Due to Project
Local Study Area (LSA)			
maximum annual NO ₂ [µg/m ³]	5.8	67.7	61.9
maximum annual NO ₂ (excluding development area) [µg/m ³]	5.8	64.3	58.5
area above annual NAQO ^(a) (excluding development area) [ha]	0	1	1
Regional Study Area (RSA)			
maximum annual NO ₂ [µg/m ³]	11.9	67.7	55.8
maximum annual NO ₂ (excluding development area) [µg/m ³]	11.9	64.3	52.4
area above annual NAQO ^(a) (excluding development area) [ha]	0	1	1

^(a) National Air Quality Objective (NAQO) for annual NO₂ = 60 µg/m³.

µg/m³ = microgram per cubic metre; NO₂ = nitrogen dioxide; ha = hectare.



NOTES
Base data source: National Topographic Base Data (NTDB) 1:50,000.




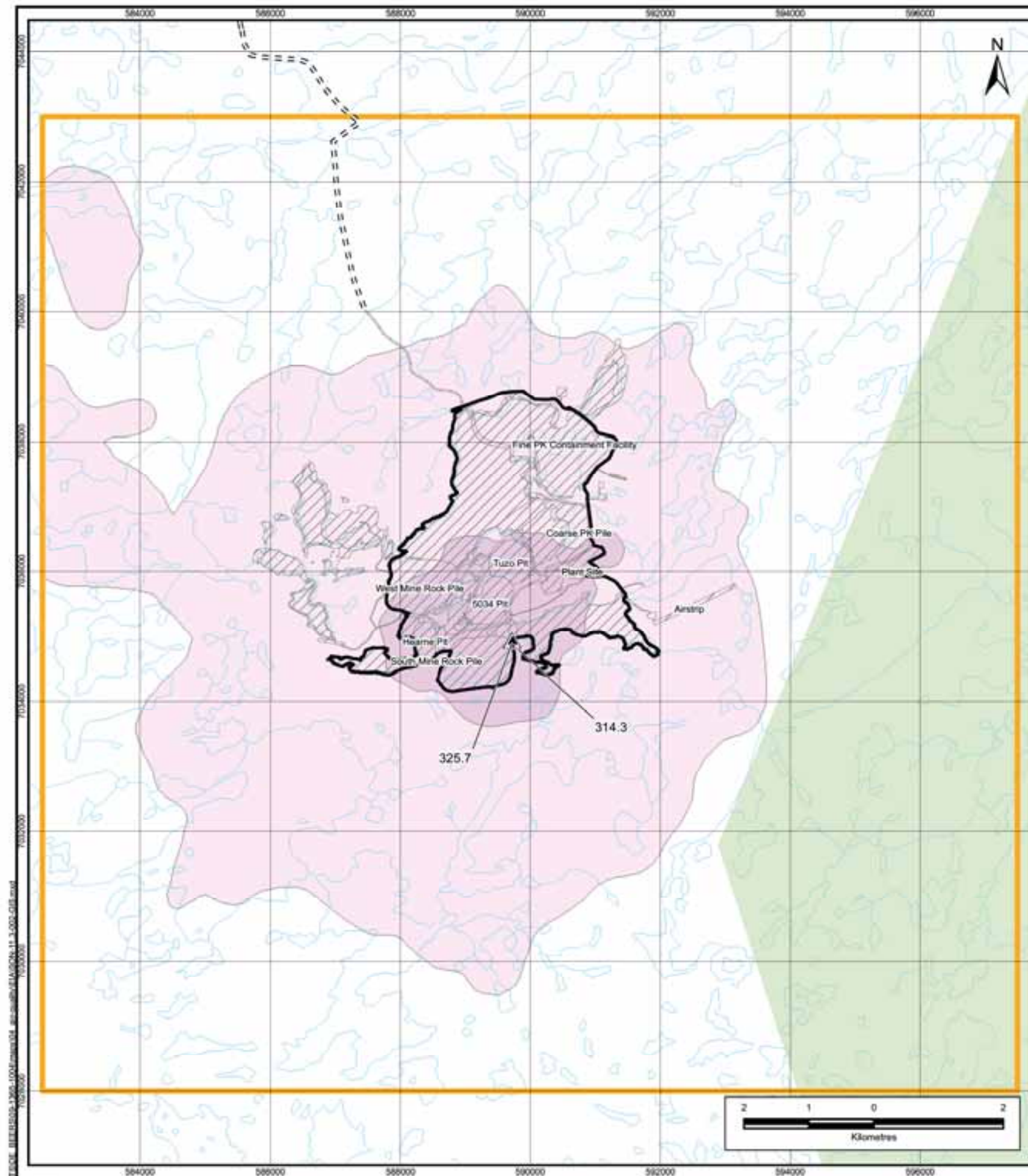
LEGEND

- Gahcho Kué Project
 - Existing Winter Road
 - Tibbitt to Contwoyto Winter Road
 - Proposed Winter Access Road
 - Watercourse
 - Waterbody
 - Maximum Prediction Within LSA Excluding Development Area
 - Maximum Prediction Within LSA
 - Maximum Prediction Within RSA
 - Maximum Prediction Within RSA Excluding Development Area
 - Development Area Boundary
 - Local Study Area
 - Modelling Domain
 - Project Footprint
 - Regional Study Area
 - The Study Area for a National Park on the East Arm of Great Slave Lake
- Concentration ($\mu\text{g}/\text{m}^3$)**
- ≥ 150
 - 75 to < 150
 - 37.5 to < 75
 - 0 to < 37.5
- NWT Standard = $150 \mu\text{g}/\text{m}^3$ GNWT (2010)

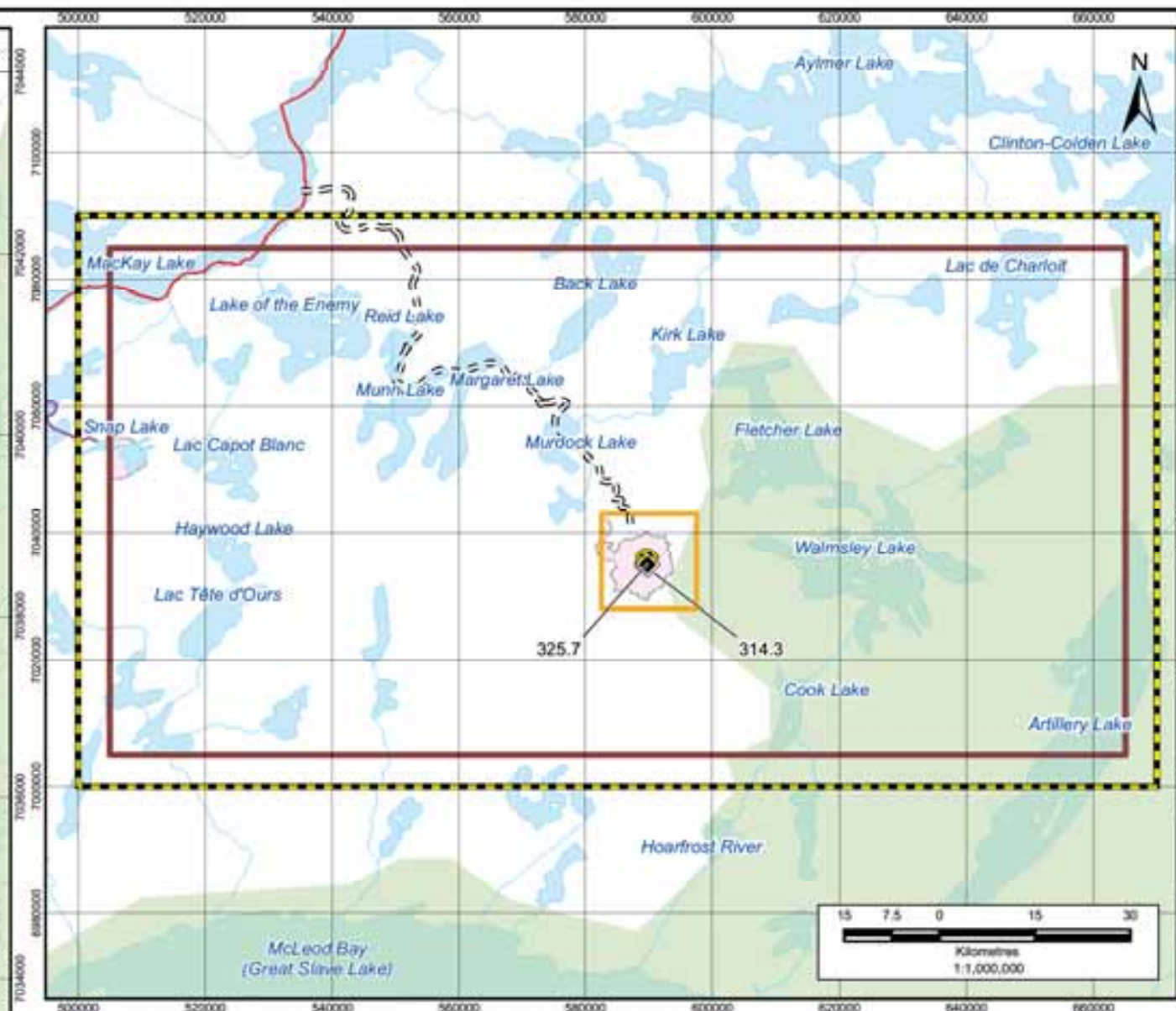
GAHCHO KUÉ PROJECT

Application Case Maximum
24-hour SO_2 Concentrations

PROJECTION UTM Zone 12	DATE NAD83	 DE BEERS CANADA
Scale: 1:70,000 (LSA)		
FILE NO. SON-11.3-005-GIS		DATE December 13, 2010
JOB NO. 09-1365-1004	REVISION NO. 1	Figure 11.4-5
OFFICE GOLD-CAL	DRAWN SK CHECK GU	



NOTES
Base data source: National Topographic Base Data (NTDB) 1:50,000.



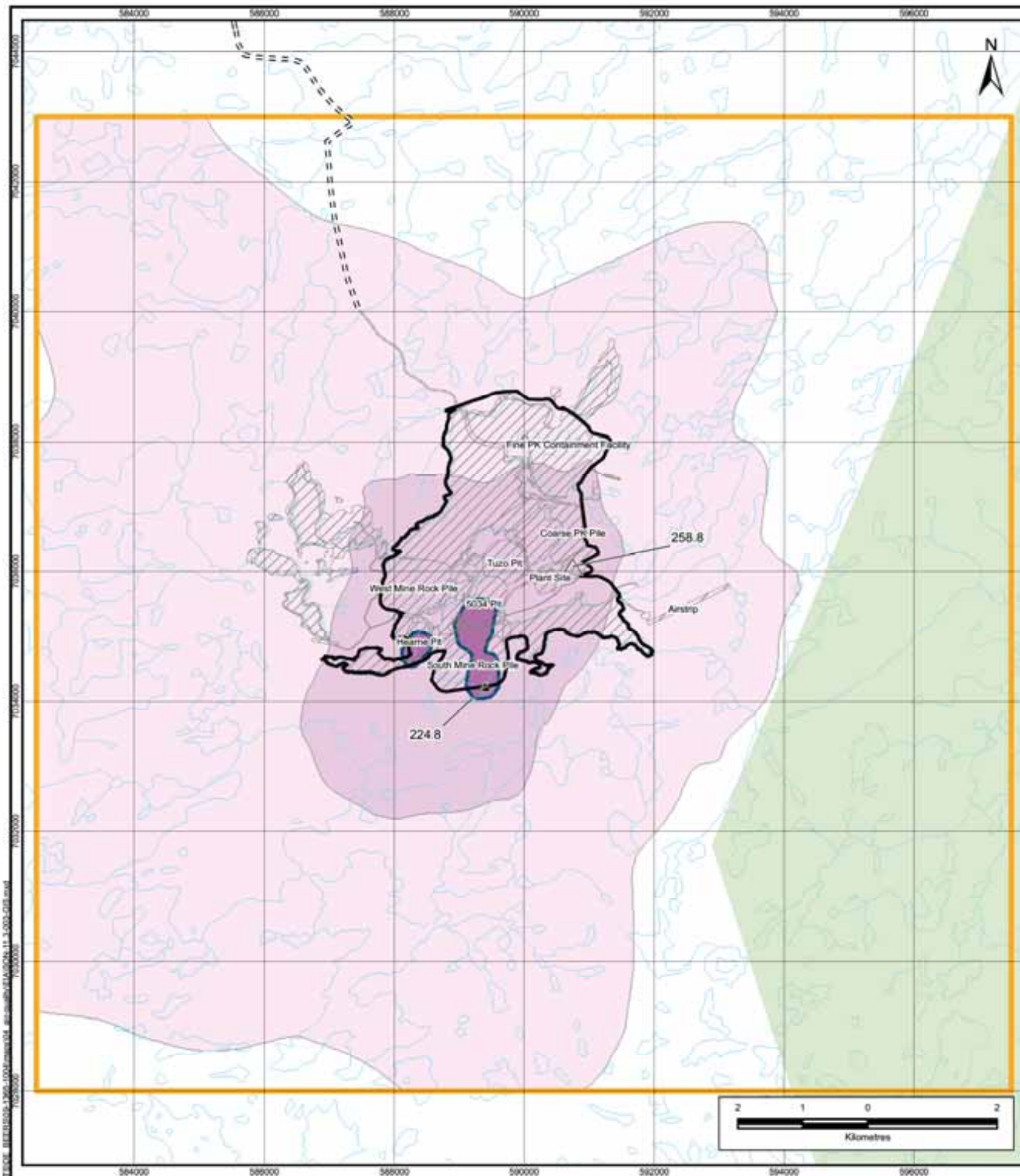
LEGEND

- Gahcho Kué Project
 - Existing Winter Road
 - Tibbitt to Contwoyto Winter Road
 - Proposed Winter Access Road
 - Watercourse
 - Waterbody
 - Maximum Prediction Within LSA Excluding Development Area
 - Maximum Prediction Within LSA
 - Maximum Prediction Within RSA
 - Maximum Prediction Within RSA Excluding Development Area
 - Development Area Boundary
 - Local Study Area
 - Modelling Domain
 - Project Footprint
 - Regional Study Area
 - The Study Area for a National Park on the East Arm of Great Slave Lake
- Concentration ($\mu\text{g}/\text{m}^3$)**
- ≥ 400
 - 200 to < 400
 - 100 to < 200
 - 0 to < 100
- National AQO = $400 \mu\text{g}/\text{m}^3$
Environment Canada (1981)

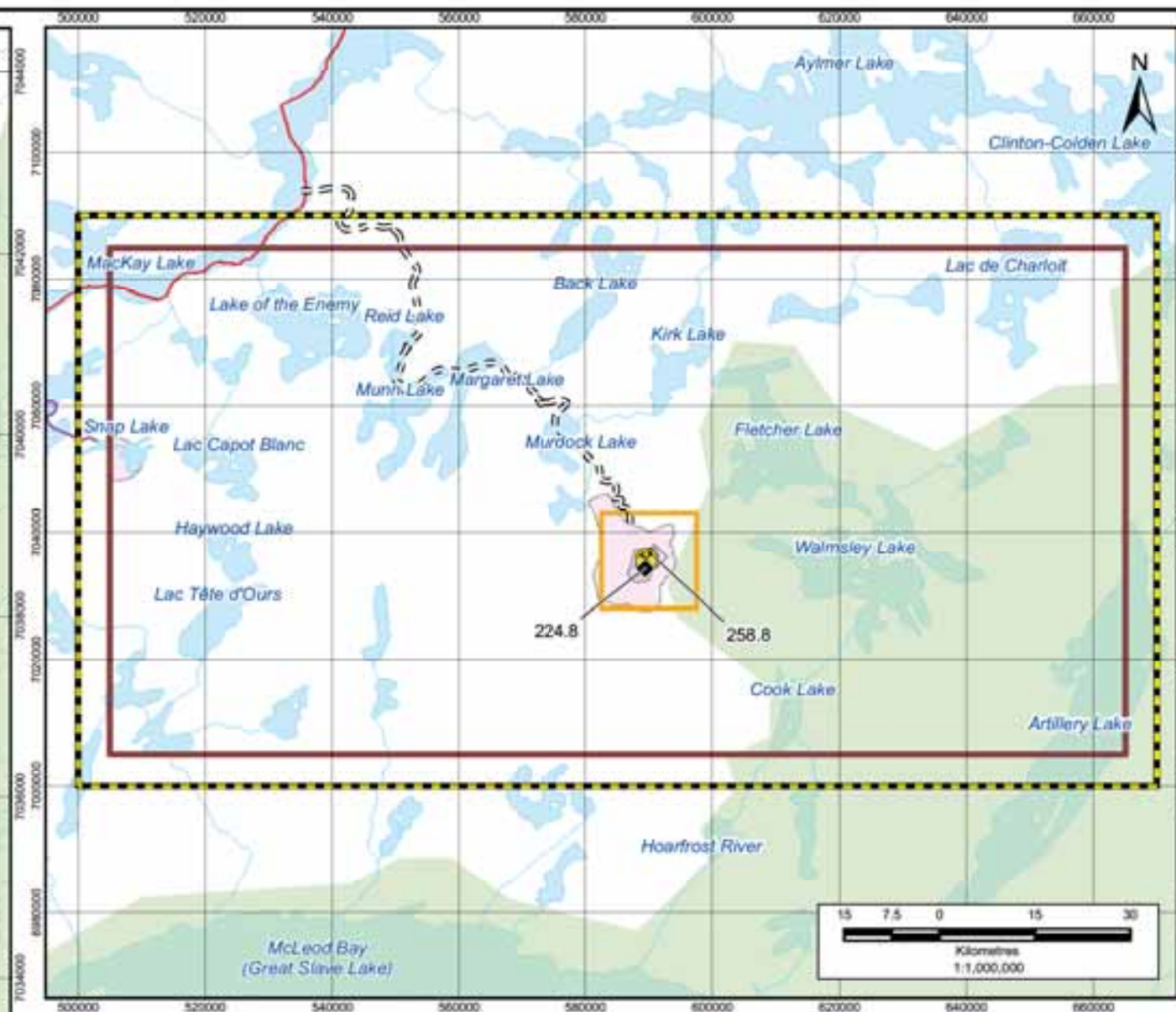
GAHCHO KUÉ PROJECT

Application Case Maximum 1-hour NO_2 Concentrations

PROJECTION UTM Zone 12	DATUM NAD83	
Scale: 1:70,000 (LSA)		
FILE NO. SON-11.3-002-GIS		DATE December 13, 2010
JOB NO. 09-1365-1004	REVISION NO. 1	Figure 11.4-6
OFFICE GOLD-CAL	DRAWN BY SK CHECKED BY GU	



NOTES
Base data source: National Topographic Base Data (NTDB) 1:50,000.




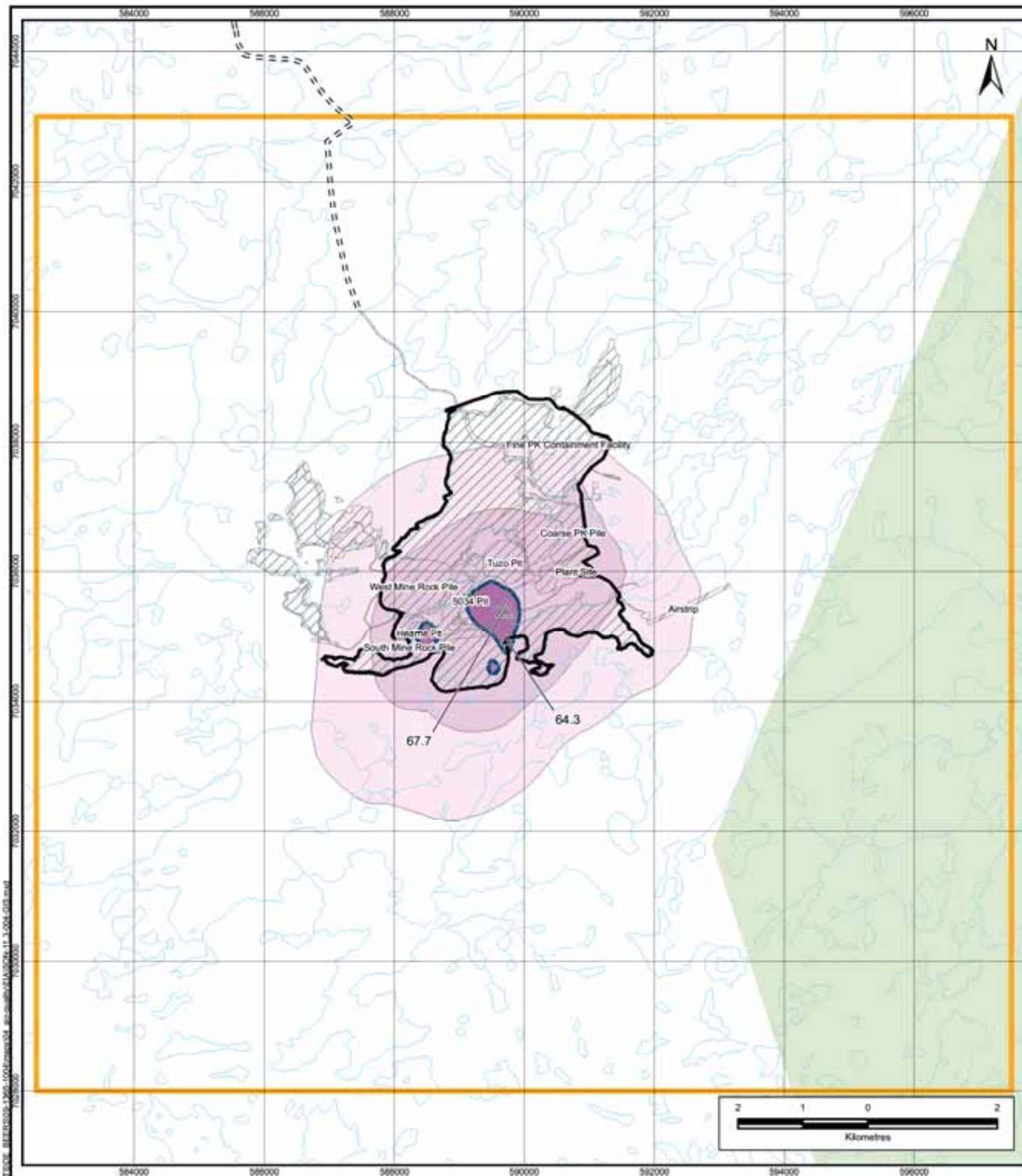
LEGEND

- Gahcho Kué Project
 - Existing Winter Road
 - Tibbitt to Contwoyto Winter Road
 - Proposed Winter Access Road
 - Watercourse
 - Waterbody
 - Maximum Prediction Within LSA Excluding Development Area
 - Maximum Prediction Within LSA
 - Maximum Prediction Within RSA
 - Maximum Prediction Within RSA Excluding Development Area
 - Development Area Boundary
 - Local Study Area
 - Modelling Domain
 - Project Footprint
 - Regional Study Area
 - The Study Area for a National Park on the East Arm of Great Slave Lake
- Concentration ($\mu\text{g}/\text{m}^3$)**
- ≥ 200
 - 100 to < 200
 - 50 to < 100
 - 0 to < 50
- National AQO = $200 \mu\text{g}/\text{m}^3$
Environment Canada (1981)

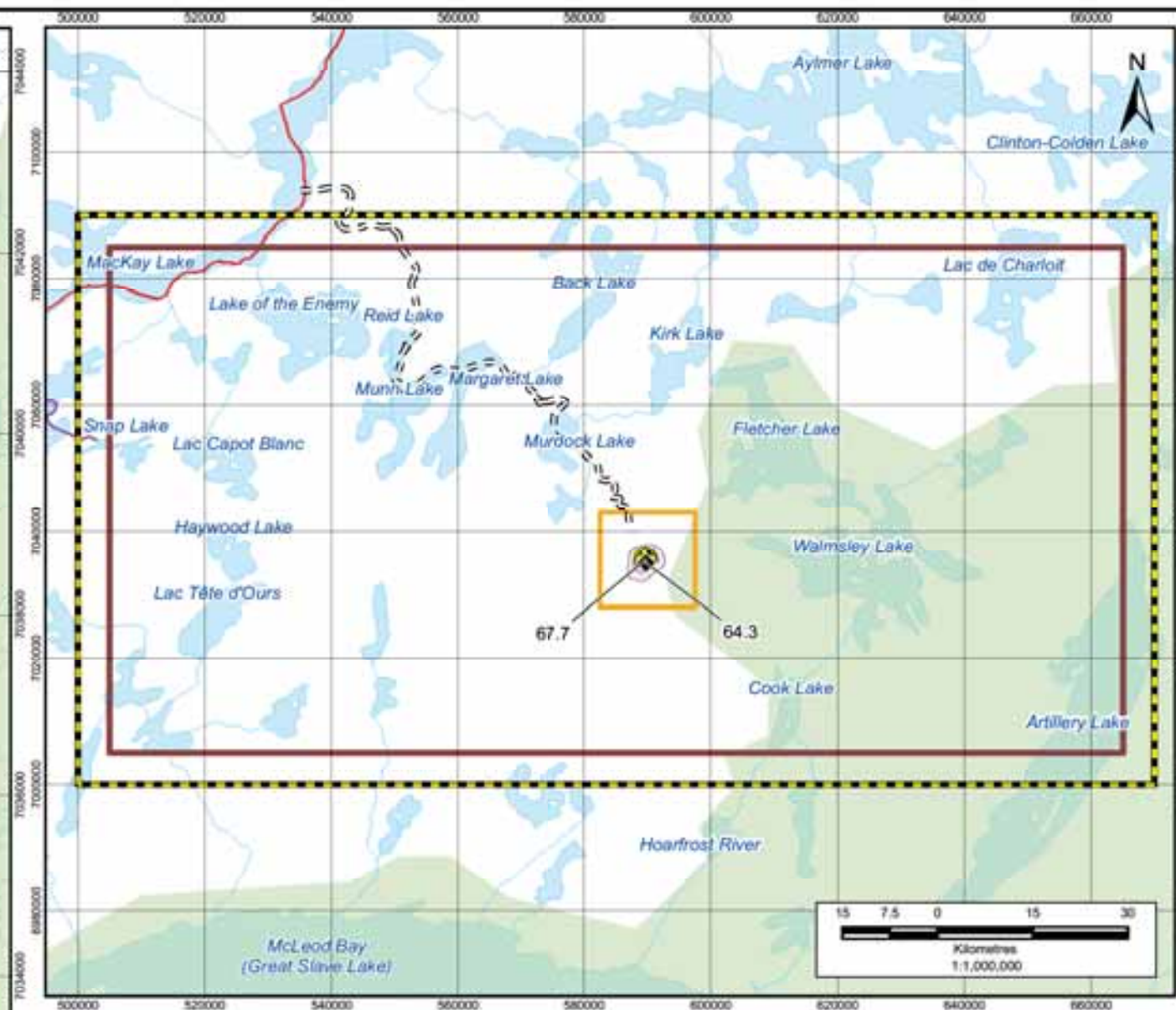
GAHCHO KUÉ PROJECT

Application Case Maximum
24-hour NO_2 Concentrations

PROJECTION UTM Zone 12	DATUM NAD83	
Scale: 1:70,000 (LSA)		
FILE NO. SON-11.3-003-GIS		DATE December 13, 2010
JOB NO. 09-1365-1004	REVISION NO. 1	Figure 11.4-7
OFFICE GOLD-CAL	DRAWN SK CHECK GU	



NOTES
Base data source: National Topographic Base Data (NTDB) 1:50,000.




LEGEND

- Gahcho Kué Project
 - Existing Winter Road
 - Tibbitt to Contwoyto Winter Road
 - Proposed Winter Access Road
 - Watercourse
 - Waterbody
 - Maximum Prediction Within LSA Excluding Development Area
 - Maximum Prediction Within LSA
 - Maximum Prediction Within RSA
 - Maximum Prediction Within RSA Excluding Development Area
 - Development Area Boundary
 - Local Study Area
 - Modelling Domain
 - Project Footprint
 - Regional Study Area
 - The Study Area for a National Park on the East Arm of Great Slave Lake
- Concentration ($\mu\text{g}/\text{m}^3$)**
- ≥ 60
 - 30 to < 60
 - 15 to < 30
 - 0 to < 15
- National AQO = $60 \mu\text{g}/\text{m}^3$
Environment Canada (1981)

GAHCHO KUÉ PROJECT

Application Case Annual Average NO_2 Concentrations

PROJECTION UTM Zone 12	DATE NAD83	
Scale: 1:70,000 (LSA)		
FILE NO. SON-11.3-004-GIS		DATE December 13, 2010
JOB NO. 09-1365-1004	REVISION NO. 1	Figure 11.4-8
OFFICE GOLD-CAL	DRAWN BY SK CHECKED BY GU	

11.4.5.4 Carbon Monoxide

Tables 11.4-14 and 11.4-15 compare the Baseline Case and Application Case predicted 1-hour and 8-hour CO concentrations. The predicted concentrations in both assessment cases are below the national air quality objectives. Figures 11.4-9 shows the maximum 8-hour Application Case CO concentrations.

Table 11.4-14 Comparison of Predicted Baseline Case and Application Case 1-Hour Carbon Monoxide Concentrations

Parameters	Baseline Case	Application Case	Change Due to Project
Local Study Area (LSA)			
maximum 1-hour CO [$\mu\text{g}/\text{m}^3$]	3.5	2,884.4	2,880.9
maximum 1-hour CO (excluding development area) [$\mu\text{g}/\text{m}^3$]	3.5	1,978.6	1,975.1
occurrences above 1-hour NAQO ^(a)	0	0	0
area above 1-hour NAQO ^(a) (excluding development area) [ha]	0	0	0
Regional Study Area (RSA)			
maximum 1-hour CO [$\mu\text{g}/\text{m}^3$]	159.2	2,884.4	2,725.2
maximum 1-hour CO (excluding development area) [$\mu\text{g}/\text{m}^3$]	159.2	1,978.6	1,819.4
occurrences above 1-hour NAQO ^(a)	0	0	0
area above 1-hour NAQO ^(a) (excluding development area) [ha]	0	0	0

^(a) National Air Quality Objective (NAQO) for 1-hour CO = 15,000 $\mu\text{g}/\text{m}^3$.

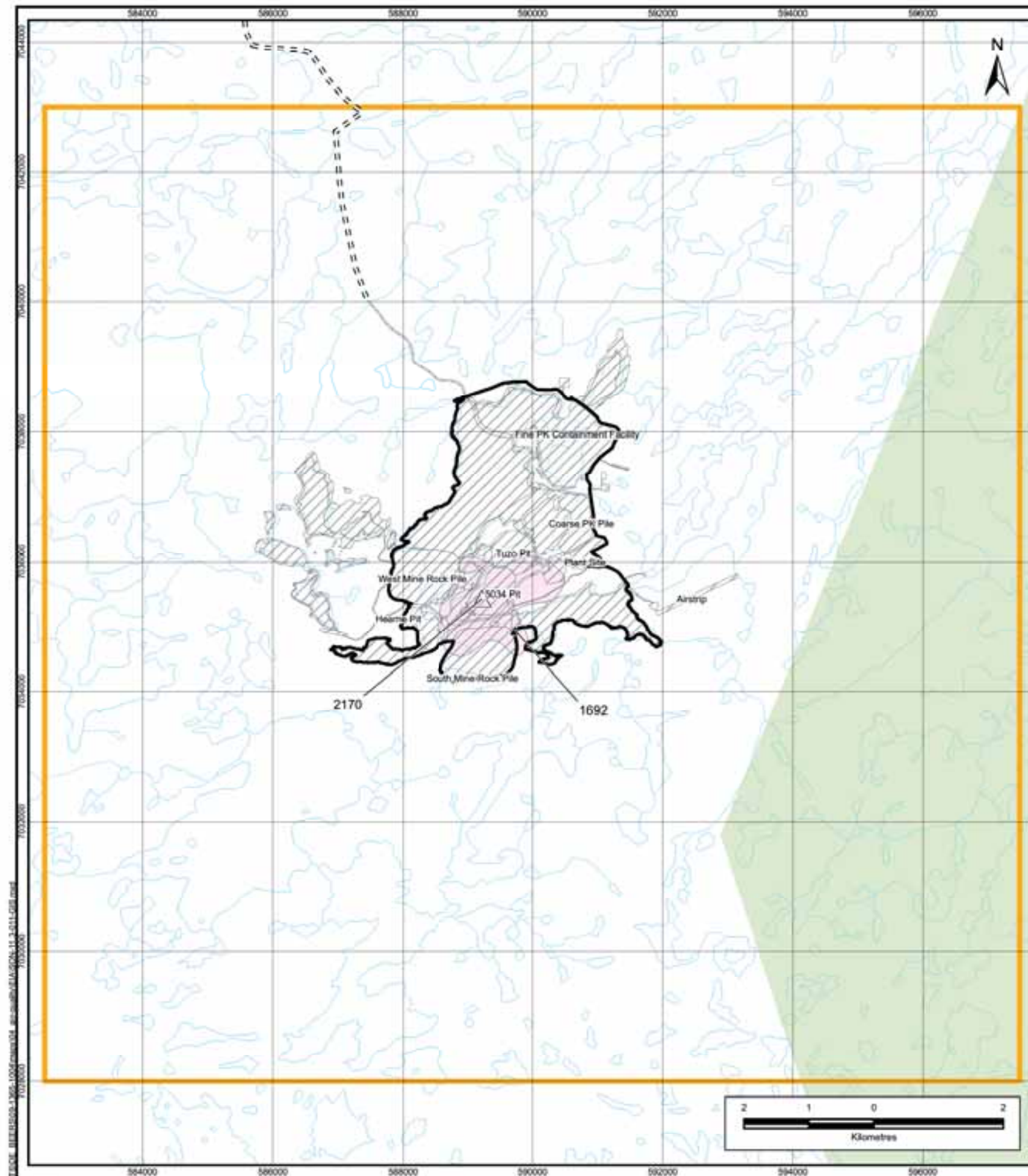
$\mu\text{g}/\text{m}^3$ = microgram per cubic metre; CO = carbon monoxide; ha = hectare.

Table 11.4-15 Comparison of Predicted Baseline Case and Application Case 8-Hour Carbon Monoxide Concentrations

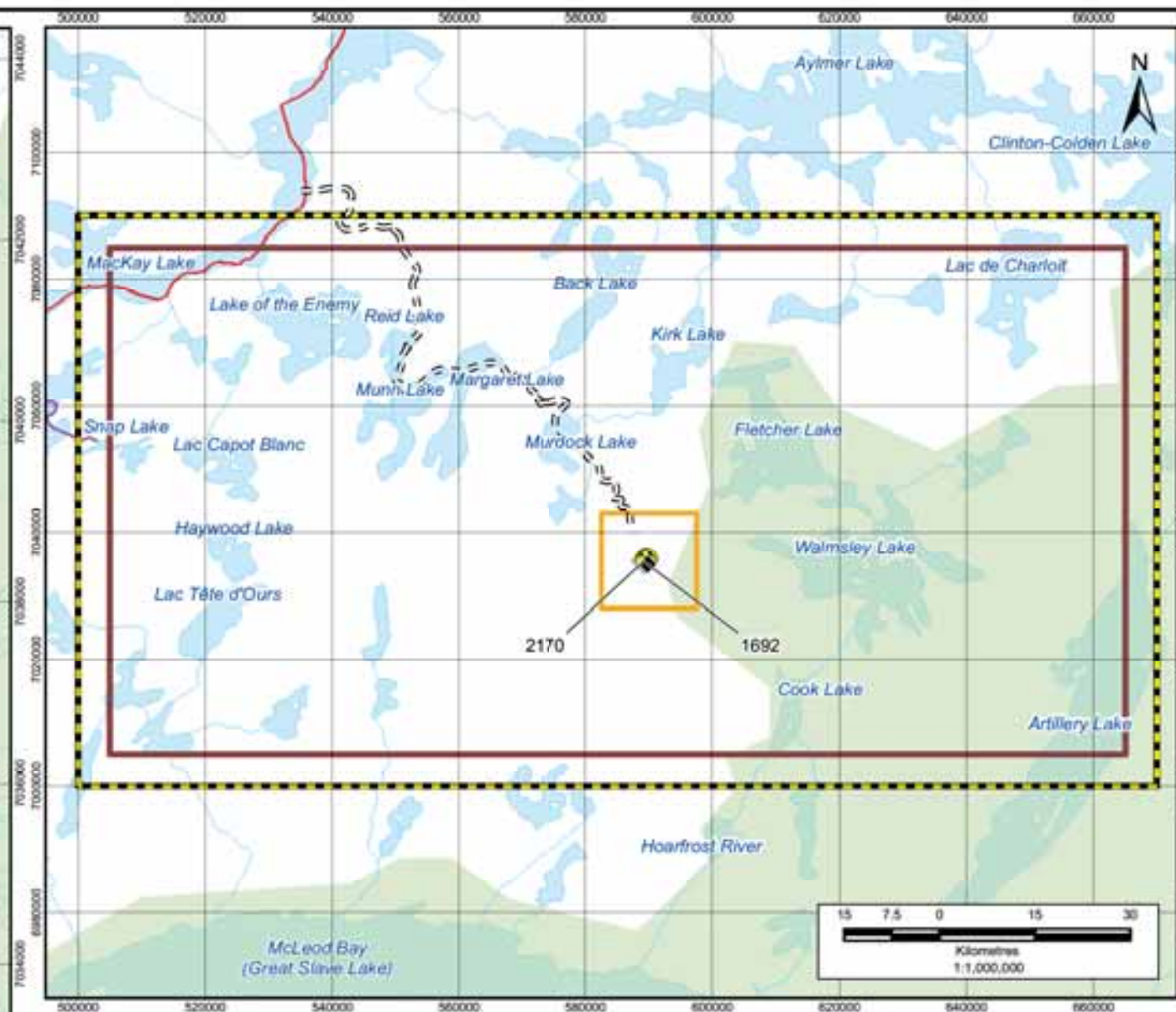
Parameters	Baseline Case	Application Case	Change Due to Project
Local Study Area (LSA)			
maximum 8-hour CO [$\mu\text{g}/\text{m}^3$]	1.8	2,170.2	2,168.4
maximum 8-hour CO (excluding development area) [$\mu\text{g}/\text{m}^3$]	1.8	1,692.1	1,690.3
occurrences above 8-hour NAQO ^(a)	0	0	0
area above 8-hour NAQO ^(a) (excluding development area) [ha]	0	0	0
Regional Study Area (RSA)			
maximum 8-hour CO [$\mu\text{g}/\text{m}^3$]	83.7	2,170.2	2,086.5
maximum 8-hour CO (excluding development area) [$\mu\text{g}/\text{m}^3$]	83.7	1,692.1	1,608.4
occurrences above 8-hour NAQO ^(a)	0	0	0
area above 8-hour NAQO ^(a) (excluding development area) [ha]	0	0	0

^(a) National Air Quality Objective (NAQO) for 24-hour CO = 6,000 $\mu\text{g}/\text{m}^3$.

$\mu\text{g}/\text{m}^3$ = microgram per cubic metre; CO = carbon monoxide; ha = hectare.



NOTES
Base data source: National Topographic Base Data (NTDB) 1:50,000.




LEGEND

- Gahcho Kué Project
 - Existing Winter Road
 - Tibbitt to Contwoyto Winter Road
 - Proposed Winter Access Road
 - Watercourse
 - Waterbody
 - Maximum Prediction Within LSA Excluding Development Area
 - Maximum Prediction Within LSA
 - Maximum Prediction Within RSA
 - Maximum Prediction Within RSA Excluding Development Area
 - Development Area Boundary
 - Local Study Area
 - Modelling Domain
 - Project Footprint
 - Regional Study Area
 - The Study Area for a National Park on the East Arm of Great Slave Lake
- Concentration ($\mu\text{g}/\text{m}^3$)**
- ≥ 6000
 - 3000 to < 6000
 - 1500 to < 3000
 - 0 to < 1500
- National AQO = $6000 \mu\text{g}/\text{m}^3$
Environment Canada (1981)

GAHCHO KUÉ PROJECT

Application Case Maximum 8-hour CO Concentrations

PROJECTION UTM Zone 12	DATE NAD83	
Scale: 1:70,000 (LSA)		
FILE NO. SON-11.3-011-GIS	DATE December 13, 2010	Figure 11.4-9
JOB NO. 09-1365-1004	REVISION NO. 1	
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11.4.5.5 Particulate Matter

11.4.5.5.1 $PM_{2.5}$ Air Concentrations

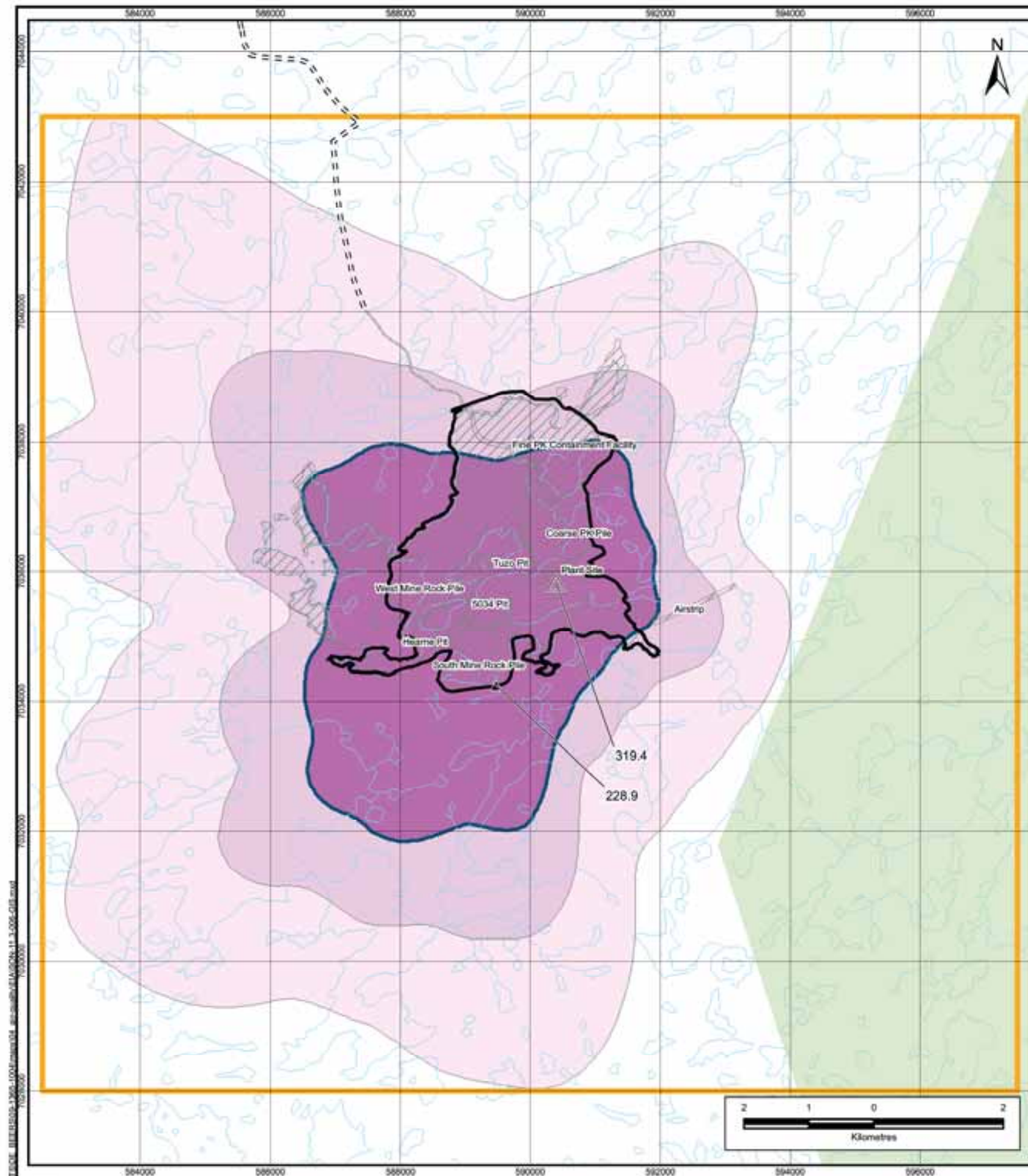
Table 11.4-16 provides a comparison of the Baseline Case and Application Case predicted maximum 24-hour $PM_{2.5}$ concentrations. Figure 11.4-10 shows the Application Case predicted 24-hour $PM_{2.5}$ concentrations. The Application Case predicted maximum 24-hour concentrations outside the development area exceed the NWT air quality standard of $30 \mu\text{g}/\text{m}^3$ for a maximum of 69 days per year or 19% of the time. Predicted maximum $PM_{2.5}$ concentrations are located near the haul roads which run along the southern, western and eastern boundaries of the development area. More specifically, they are largely a result of fugitive road dust emissions during the winter when there will be no road watering. Although precipitation and snow accumulation on the haul road surface will provide some degree of natural mitigation of the road dust emissions during the winter, the winter road dust emissions modelled in the Application Case were based on a conservative assumption of no natural mitigation. The predicted concentrations should therefore be considered highly conservative. A detailed description of the assumptions and the methodology for estimating road dust emissions is provided in Appendix 11.4.II, Section 11.4.II.3.2.4.9.

Table 11.4-16 Comparison of Predicted Baseline Case and Application Case 24-Hour $PM_{2.5}$ Concentrations

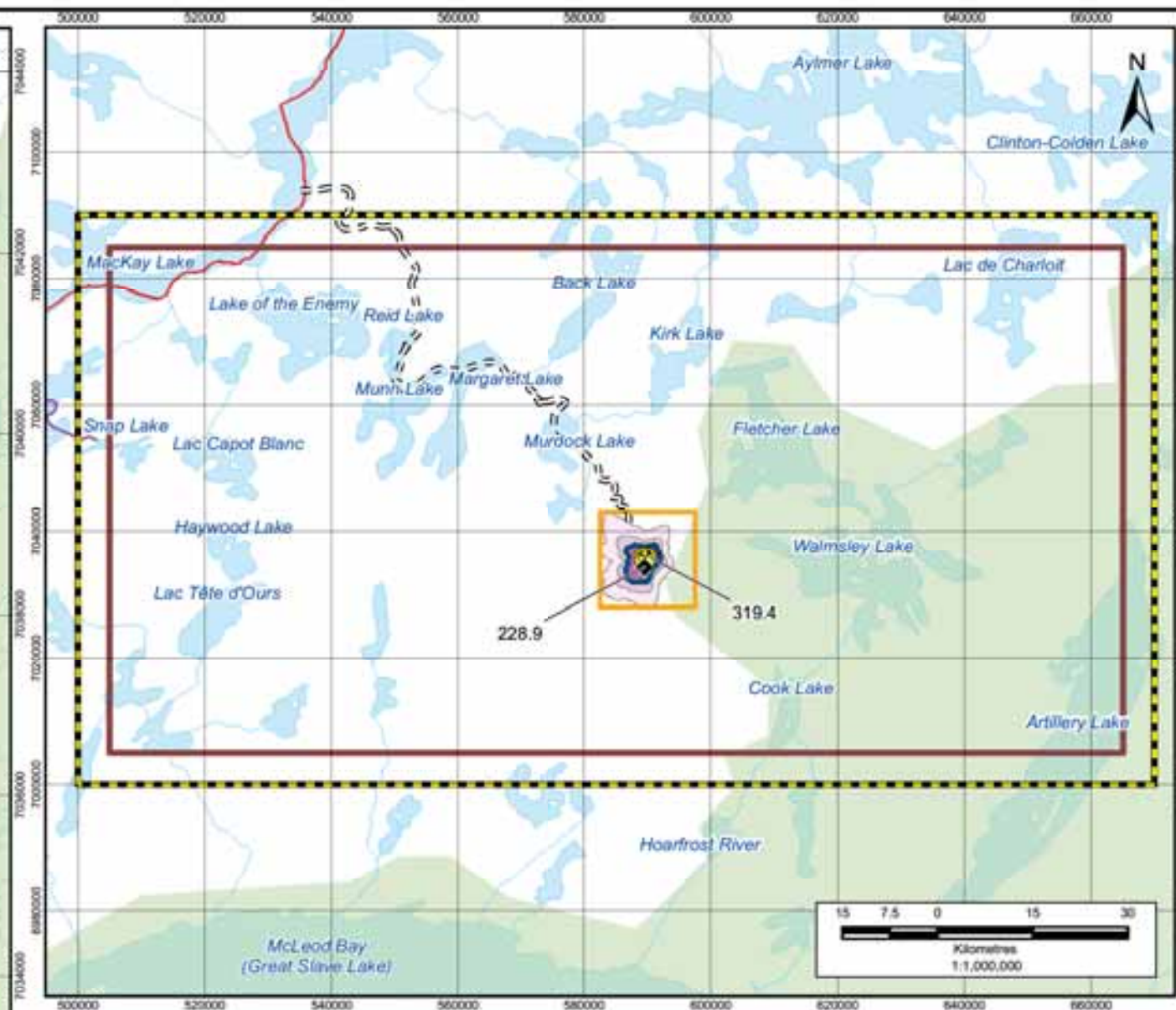
Parameters	Baseline Case	Application Case	Change Due to Project
Local Study Area (LSA)			
maximum 24-hour $PM_{2.5}$ [$\mu\text{g}/\text{m}^3$]	2.2	319.4	317.1
maximum 24-hour $PM_{2.5}$ (excluding development area) [$\mu\text{g}/\text{m}^3$]	2.2	228.9	226.6
occurrences above 24-hour NWT AQS ^(a)	0	69	69
area above 24-hour NWT AQS ^(a) (excluding development area) [ha]	0	1,620	1,620
Regional Study Area (RSA)			
maximum 24-hour $PM_{2.5}$ [$\mu\text{g}/\text{m}^3$]	5.5	319.4	313.9
maximum 24-hour $PM_{2.5}$ (excluding development area) [$\mu\text{g}/\text{m}^3$]	5.5	228.9	223.4
occurrences above 24-hour NWT AQS ^(a)	0	69	69
area above 24-hour NWT AQS ^(a) (excluding development area) [ha]	0	1,620	1,620

^(a) NWT Air Quality Standard (AQS) for 24-hour $PM_{2.5}$ = $30 \mu\text{g}/\text{m}^3$.

$\mu\text{g}/\text{m}^3$ = microgram per cubic metre; PM = particulate matter; ha = hectare.



NOTES
Base data source: National Topographic Base Data (NTDB) 1:50,000.



LEGEND

- Gahcho Kué Project
 - Existing Winter Road
 - Tibbitt to Contwoyto Winter Road
 - Proposed Winter Access Road
 - Watercourse
 - Waterbody
 - Maximum Prediction Within LSA Excluding Development Area
 - Maximum Prediction Within LSA
 - Maximum Prediction Within RSA
 - Maximum Prediction Within RSA Excluding Development Area
 - Development Area Boundary
 - Local Study Area
 - Modelling Domain
 - Project Footprint
 - Regional Study Area
 - The Study Area for a National Park on the East Arm of Great Slave Lake
- Concentration ($\mu\text{g}/\text{m}^3$)**
- ≥ 30
 - 15 to < 30
 - 7.5 to < 15
 - 0 to < 7.5
- NWT Standard = $30 \mu\text{g}/\text{m}^3$ GNWT (2010)

GAHCHO KUÉ PROJECT

Application Case Maximum
24-hour $\text{PM}_{2.5}$ Concentrations


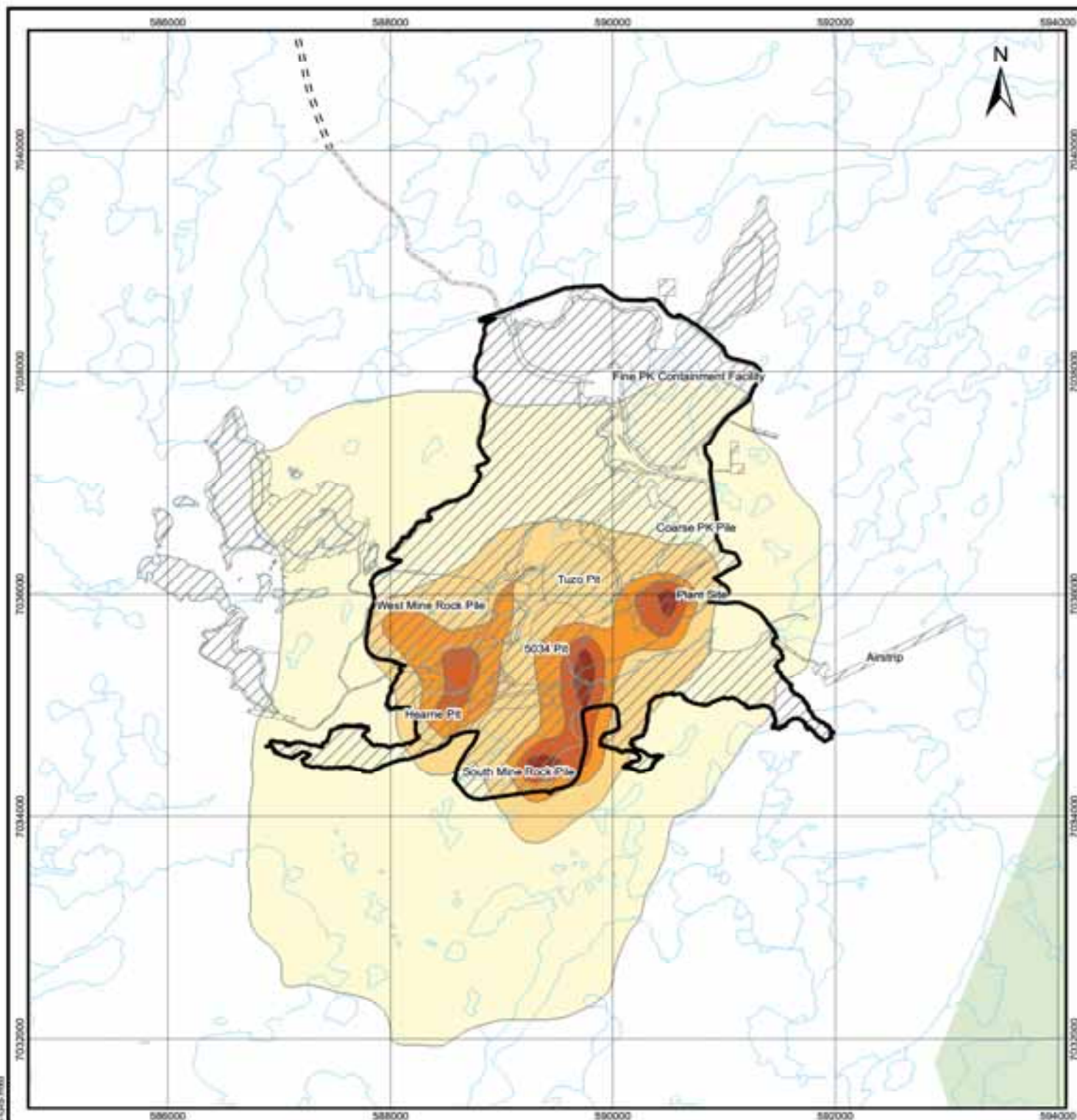
PROJECTION UTM Zone 12	DATUM NAD83	 DE BEERS CANADA
Scale: 1:70,000 (LSA)		
FILE NO. SON-11.3-006-GIS		DATE December 13, 2010
JOB NO. 09-1365-1004	REVISION NO. 1	Figure 11.4-10
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Figure 11.4-11 illustrates the number of days the area surrounding the Project will experience $PM_{2.5}$ concentrations above the NWT air quality standard. The figure shows that the majority of the area with predicted concentrations above the standard will experience 1 to 14 days of values over the standard. Only the area adjacent to the emission sources will experience more than 14 days of concentrations above the standard. No concentration above the NWT air quality standard is predicted beyond 3 km from the development area boundary or inside the proposed East Arm National Park.

Recent $PM_{2.5}$ concentrations measured at the De Beers Snap Lake Mine and BHP Billiton's Ekati Diamond Mine (Golder 2008, 2009 and IEMA 2009, 2010) are generally below the NWT standard with approximately one measurement exceeding the NWT standard per year. Due to the conservative nature of the emission estimation for the Project as discussed in the Appendix 11.4.II, Section 11.4.II.5, it is expected that the actual $PM_{2.5}$ concentrations at the Project will be lower than predicted, closer to the concentrations measured at these other diamond mines. De Beers is committed to further evaluating the assumptions used to complete the modelling outlined herein and to developing an ambient air quality monitoring program that will be used to guide adaptive management strategies and the implementation of mitigation, if and as required, to maintain exposure to $PM_{2.5}$ levels below those that would be of concern.

11.4.5.5.2 *Total Suspended Particulate Air Concentrations*

Table 11.4-17 provides a comparison of Baseline Case and Application Case predicted 24-hour TSP concentrations. The Application Case predicted maximum concentrations exceed the NWT air quality standard of $120 \mu g/m^3$ for a maximum of 325 days per year or 89% of the time. Figure 11.4-12 shows that the area above the standard extends no further than approximately 2 km beyond the development area boundary. Predicted maximum concentrations are located near the haul roads along the southern, western and eastern boundary of the development area; and are primarily results of winter fugitive road dust emissions. The conservative nature of the winter road dust emissions are explained in Section 11.4.5.5.1 and in detail in Appendix 11.4.II, Sections 11.4.II.3.2.4.9 and 11.4.II.5.



LEGEND

- Proposed Winter Access Road
- Watercourse
- Waterbody
- ▭ Development Area Boundary
- ▨ Project Footprint
- ▭ The Study Area for a National Park on the East Arm of Great Slave Lake

Numbers of Days Exceeding Air Quality Standard

- > 60
- 45 to 59
- 30 to 44
- 15 to 29
- 1 to 14

NWT Standard $30 \mu\text{g}/\text{m}^3$
GNWT (2010)

NOTES

Base data source: National Topographic Base Data (NTDB) 1:50,000

GAHCHO KUÉ PROJECT

Number of Days Exceeding 24-hour $\text{PM}_{2.5}$ Air Quality Standard

PROJECTION: UTM Zone 12
DATUM: NAD83

Scale: 1:50,000
500 250 0 500
Metres



FILE NO:
SON-11.3-014-GIS

DATE:
December 13, 2010

JOB NO:
09-1365-1004

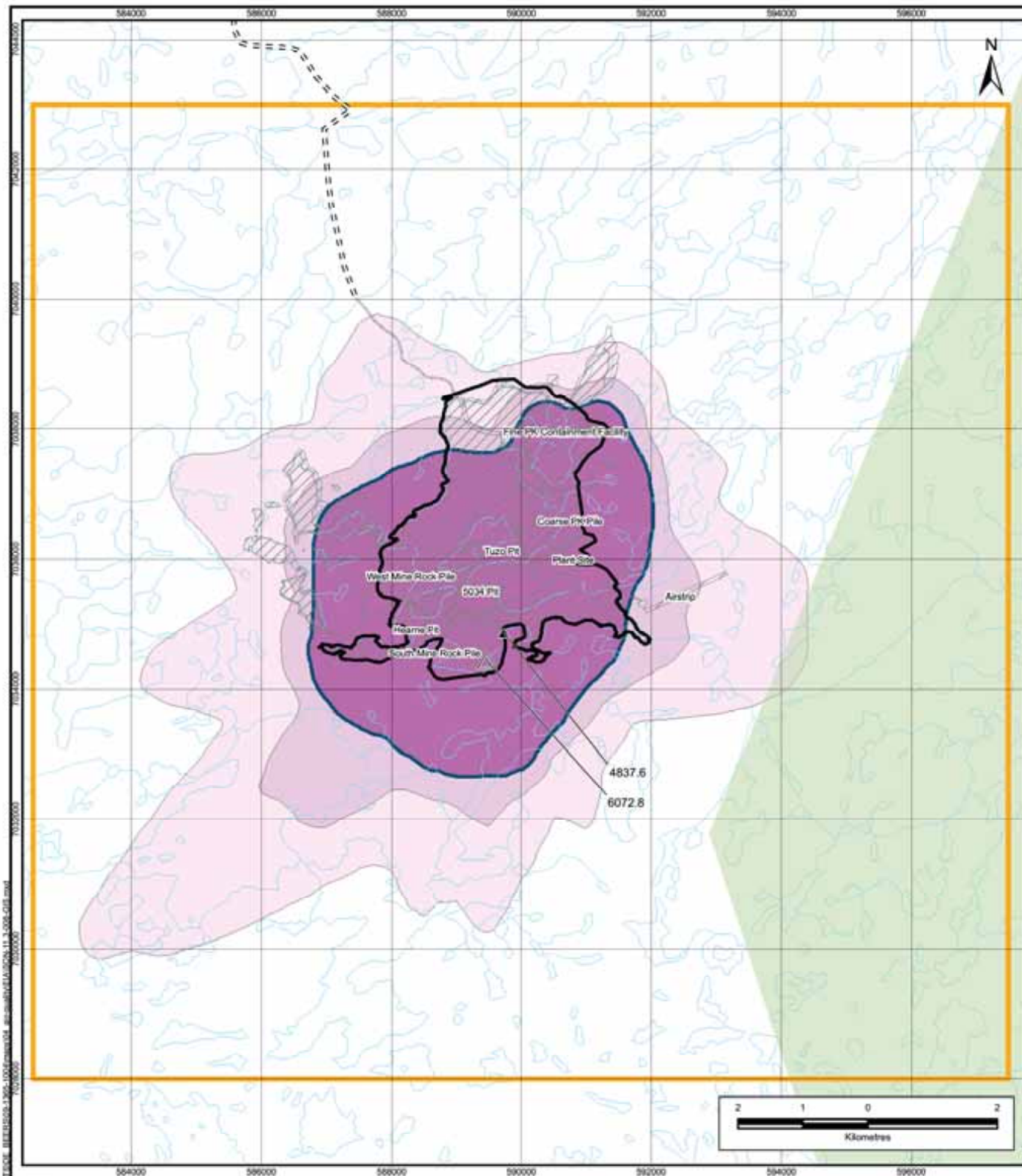
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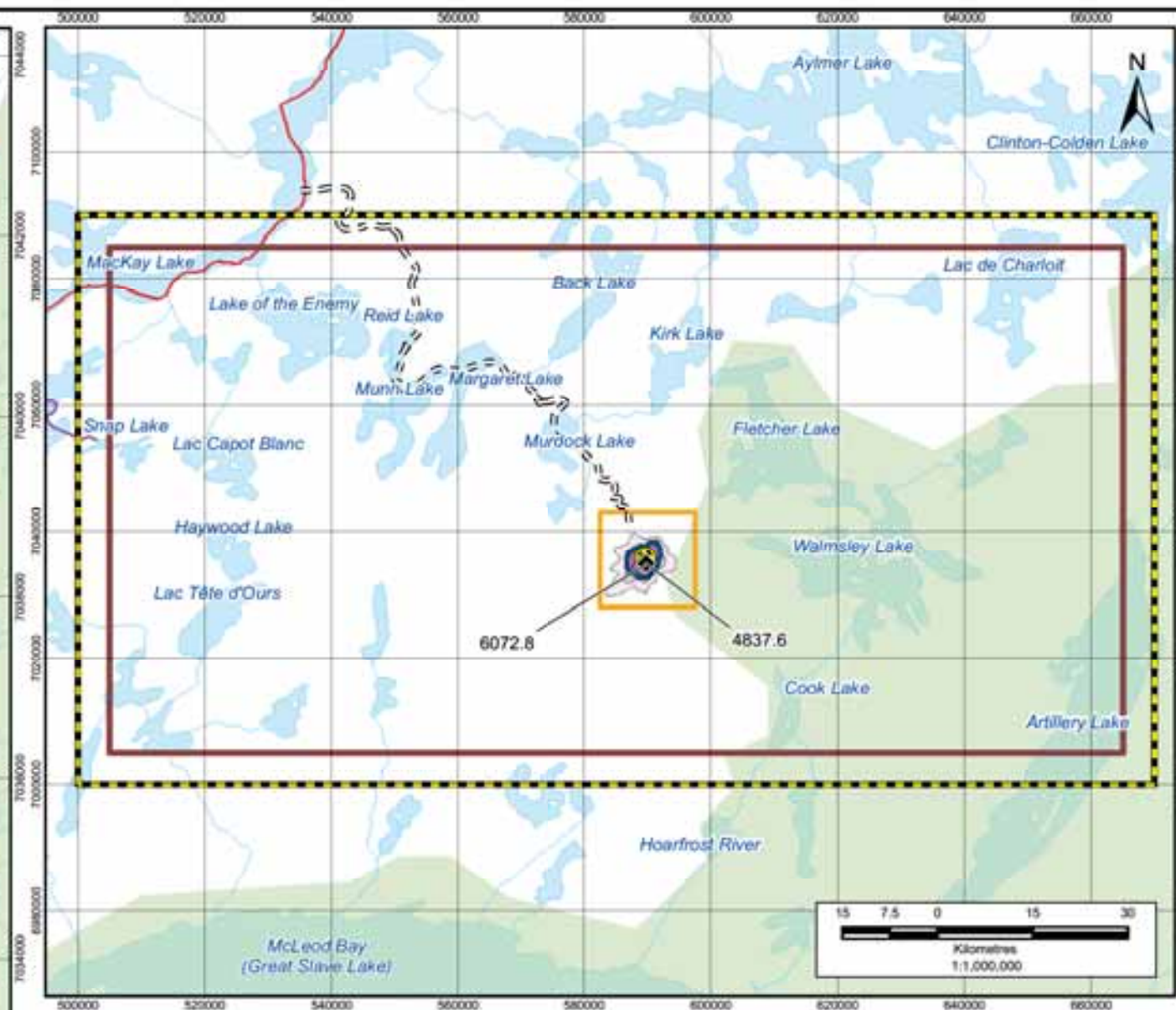
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Figure 11.4-11



NOTES
Base data source: National Topographic Base Data (NTDB) 1:50,000.



LEGEND

- Gahcho Kué Project
 - Existing Winter Road
 - Tibbitt to Contwoyto Winter Road
 - Proposed Winter Access Road
 - Watercourse
 - Waterbody
 - Maximum Prediction Within LSA Excluding Development Area
 - Maximum Prediction Within LSA
 - Maximum Prediction Within RSA
 - Maximum Prediction Within RSA Excluding Development Area
 - Development Area Boundary
 - Local Study Area
 - Modelling Domain
 - Project Footprint
 - Regional Study Area
 - The Study Area for a National Park on the East Arm of Great Slave Lake
- Concentration ($\mu\text{g}/\text{m}^3$)**
- ≥ 120
 - 60 to < 120
 - 30 to < 60
 - 0 to < 30
- NWT Standard = $120 \mu\text{g}/\text{m}^3$ GNWT (2010)

GAHCHO KUÉ PROJECT

Application Case Maximum
24-hour TSP Concentrations


PROJECTION UTM Zone 12	DATUM NAD83	 DE BEERS CANADA
Scale: 1:70,000 (LSA)		
FILE NO. SON-11.3-008-GIS		DATE December 13, 2010
JOB NO. 09-1365-1004	REVISION NO. 1	Figure 11.4-12
OFFICE GOLD-CAL	DRAWN BY SK CHECKED BY GU	

Table 11.4-17 Comparison of Predicted Baseline Case and Application Case 24-Hour TSP Concentrations

Parameters	Baseline Case	Application Case	Change Due to Project
Local Study Area (LSA)			
maximum 24-hour TSP [$\mu\text{g}/\text{m}^3$]	7.1	6,072.8	6,065.7
maximum 24-hour TSP (excluding development area) [$\mu\text{g}/\text{m}^3$]	7.1	4,837.6	4,830.5
occurrences above 24-hour NWT AQS ^(a)	0	325	325
area above 24-hour NWT AQS ^(a) (excluding development area) [ha]	0	1,217	1,217
Regional Study Area (RSA)			
maximum 24-hour TSP [$\mu\text{g}/\text{m}^3$]	7.1	6,072.8	6,065.7
maximum 24-hour TSP (excluding development area) [$\mu\text{g}/\text{m}^3$]	7.1	4,837.6	4,830.5
occurrences above 24-hour NWT AQS ^(a)	0	325	325
area above 24-hour NWT AQS ^(a) (excluding development area) [ha]	0	1,217	1,217

^(a) NWT Air Quality Standard (AQS) for 24-hour TSP = 120 $\mu\text{g}/\text{m}^3$.

$\mu\text{g}/\text{m}^3$ = microgram per cubic metre; TSP = total suspended particulate; ha = hectare.

Figure 11.4-13 shows the number of days the area surrounding the Project will experience TSP concentrations above the NWT air quality standard. The majority of the area with predicted concentrations above the standard will experience 1 to 59 days of concentrations above the standards. Only the area adjacent to the emission sources will experience more than 59 days of concentrations above the standard. No concentration above the NWT air quality standard is predicted beyond approximately 2 km from the development area boundary or inside the proposed national park.

Table 11.4-18 provides a comparison of the Baseline Case and Application Case predicted maximum annual TSP concentrations. The predicted maximum concentrations outside the development area exceed the NWT air quality standard of 60 $\mu\text{g}/\text{m}^3$. Figure 11.4-14 shows that the area above the standard extends no further than approximately 1 km beyond the development area boundary or inside the proposed national park. The maximum concentrations are located near the haul roads along the southern, western and eastern boundary of the development area; and are primarily results of winter fugitive road dust emissions.

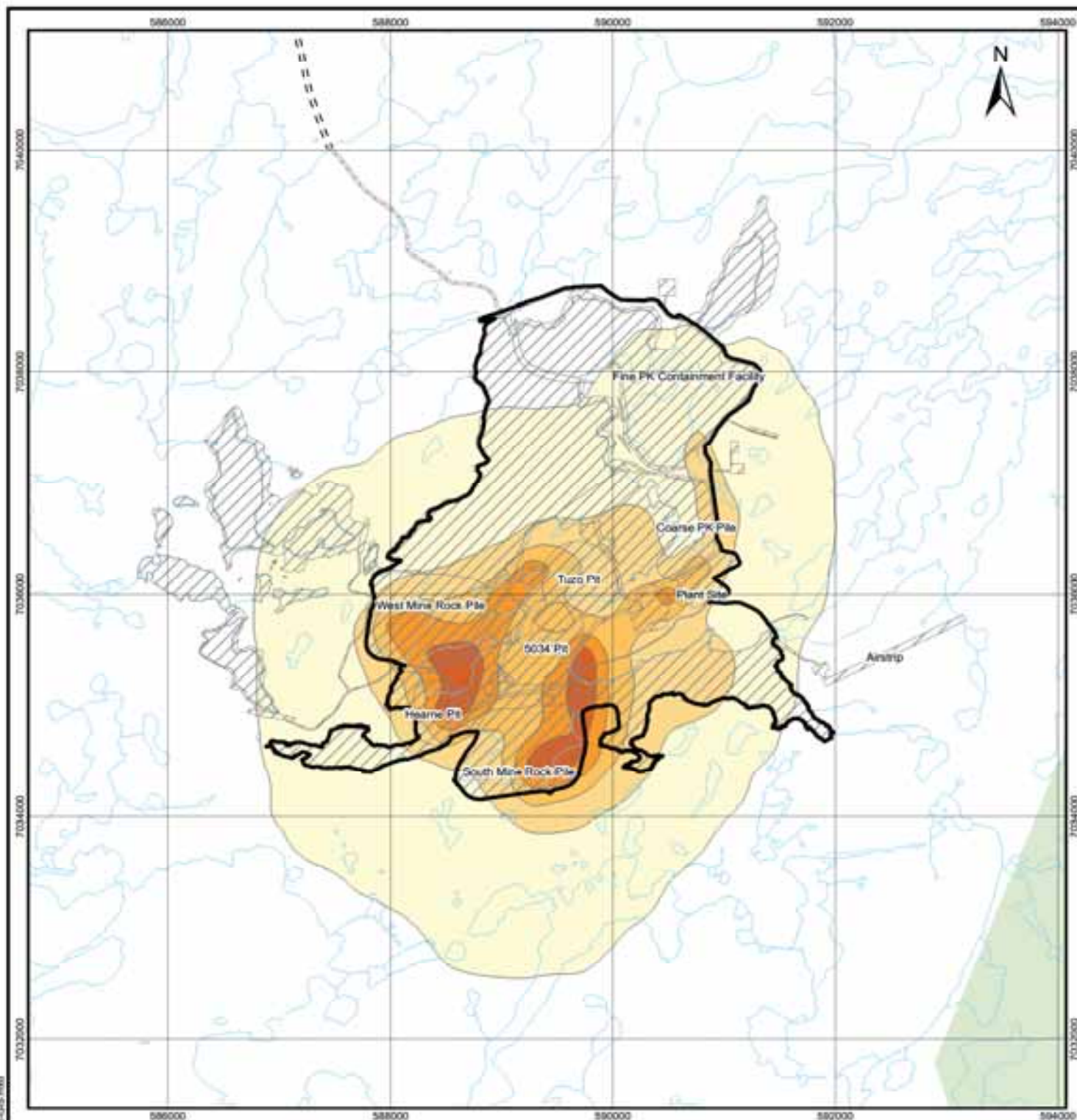
Table 11.4-18 Comparison of Predicted Baseline Case and Application Case Annual TSP Concentrations

Parameters	Baseline Case	Application Case	Change Due to Project
Local Study Area (LSA)			
maximum annual TSP [$\mu\text{g}/\text{m}^3$]	7.1	688.7	681.6
maximum annual TSP (excluding development area) [$\mu\text{g}/\text{m}^3$]	7.1	604.8	597.7
area above annual NWT AQS ^(a) (excluding development area) [ha]	0	202	202
Regional Study Area (RSA)			
maximum annual TSP [$\mu\text{g}/\text{m}^3$]	7.1	688.7	681.6
maximum annual TSP (excluding development area) [$\mu\text{g}/\text{m}^3$]	7.1	604.8	597.7
area above annual NWT AQS ^(a) (excluding development area) [ha]	0	202	202

^(a) NWT Air Quality Standard (AQS) for annual TSP = $60 \mu\text{g}/\text{m}^3$.

$\mu\text{g}/\text{m}^3$ = microgram per cubic metre; TSP = total suspended particulate; ha = hectare.

Recent TSP concentrations measured at the De Beers Snap Lake Mine and BHP Billiton's Ekati Diamond mine (Golder 2008, 2009 and IEMA 2009, 2010) are generally below the NWT standard with approximately one or two daily measurements exceeding the NWT standard per year. It is expected that actual TSP concentrations at the Project will be lower than predicted, closer to the concentrations measured at these other diamond mines. As previously noted, De Beers is committed to further evaluating the assumptions used to complete the modelling outlined herein and to developing an ambient air quality monitoring program that will be used to guide adaptive management strategies and the implementation of mitigation, if and as required, to maintain exposure to TSP levels below those that would be of concern.



LEGEND

- == Proposed Winter Access Road
- Watercourse
- Waterbody
- Development Area Boundary
- Project Footprint
- The Study Area for a National Park on the East Arm of Great Slave Lake

Numbers of Days Exceeding Air Quality Standard

- > 300
- 240 to 299
- 180 to 239
- 120 to 179
- 60 to 119
- 1 to 59

NWT Standard $120 \mu\text{g}/\text{m}^3$
GNWT (2010)

NOTES

Base data source: National Topographic Base Data (NTDB) 1:50,000

GAHCHO KUÉ PROJECT

Number of Days Exceeding 24-hour TSP Air Quality Standard

PROJECTION: UTM Zone 12
DATUM: NAD83

Scale: 1:50,000
500 250 0 500
Metres



FILE NO: SON-11.3-015-GIS

DATE: December 13, 2010

JOB NO: 09-1365-1004

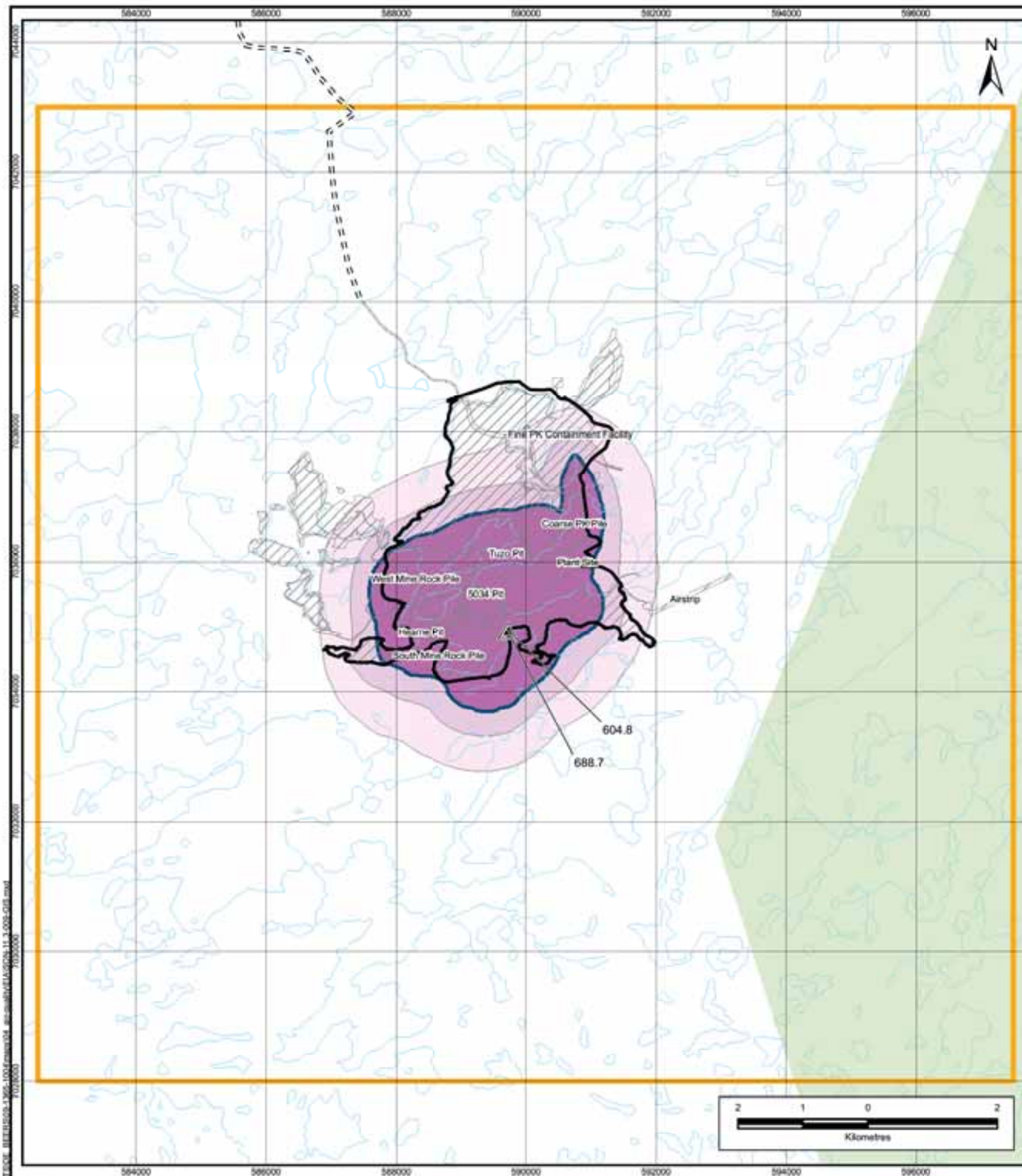
REVISION NO: 1

OFFICE: GOLD-CAL

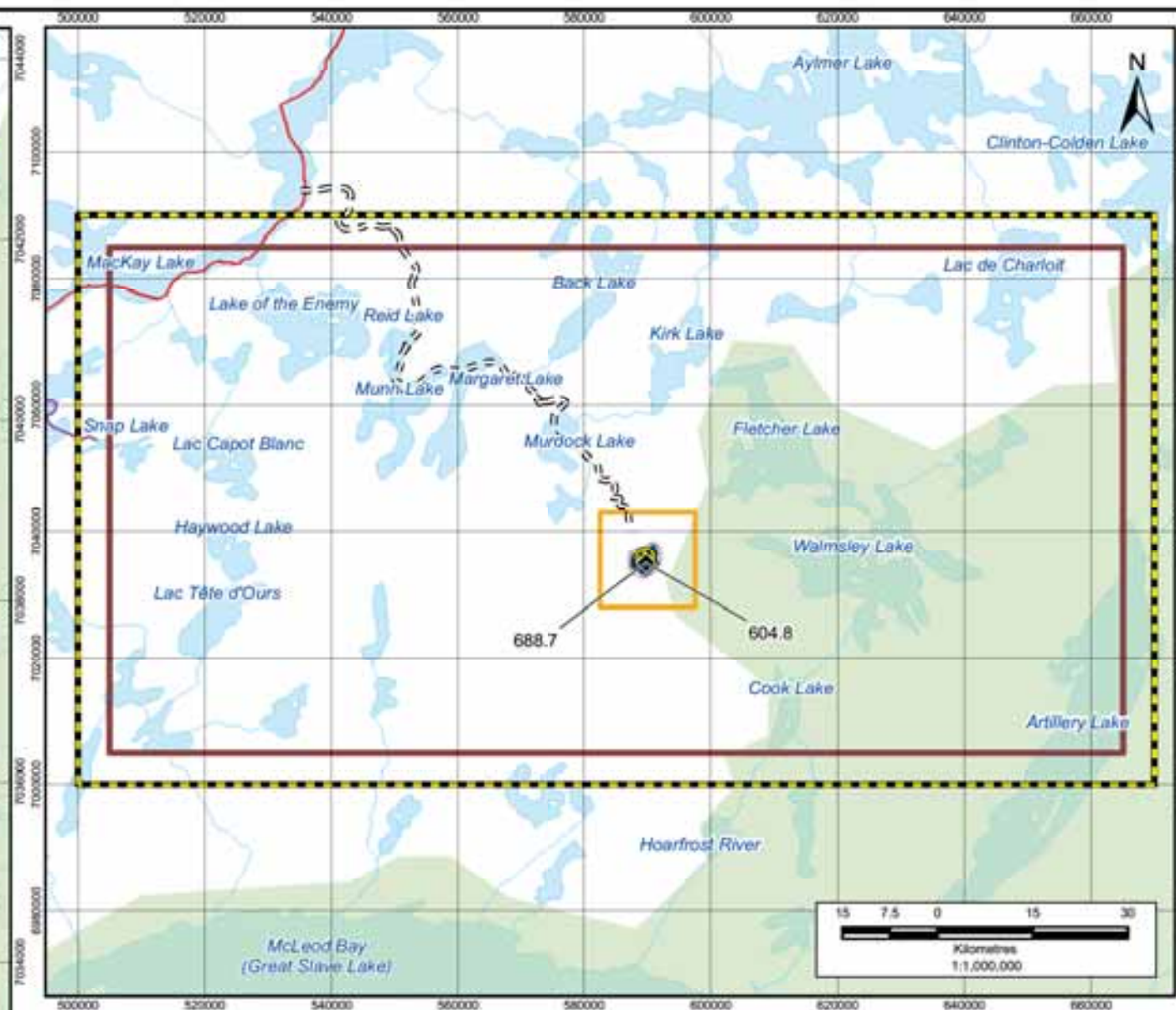
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Figure 11.4-13



NOTES
Base data source: National Topographic Base Data (NTDB) 1:50,000.




LEGEND

- Gahcho Kué Project
 - Existing Winter Road
 - Tibbitt to Contwoyto Winter Road
 - Proposed Winter Access Road
 - Watercourse
 - Waterbody
 - Maximum Prediction Within LSA Excluding Development Area
 - Maximum Prediction Within LSA
 - Maximum Prediction Within RSA
 - Maximum Prediction Within RSA Excluding Development Area
 - Development Area Boundary
 - Local Study Area
 - Modelling Domain
 - Project Footprint
 - Regional Study Area
 - The Study Area for a National Park on the East Arm of Great Slave Lake
- Concentration ($\mu\text{g}/\text{m}^3$)**
- ≥ 60
 - 30 to < 60
 - 15 to < 30
 - 0 to < 15
- NWT Standard = $60 \mu\text{g}/\text{m}^3$ GNWT (2010)

GAHCHO KUÉ PROJECT

Application Case Annual Average TSP Concentrations

PROJECTION UTM Zone 12	DATUM NAD83	 DE BEERS CANADA
Scale: 1:70,000 (LSA)		
FILE NO. SON-11.3-009-GIS		DATE December 13, 2010
JOB NO. 09-1365-1004	REVISION NO. 1	Figure 11.4-14
OFFICE GOLD-CAL	DRAWN BY SK CHECKED BY GU	

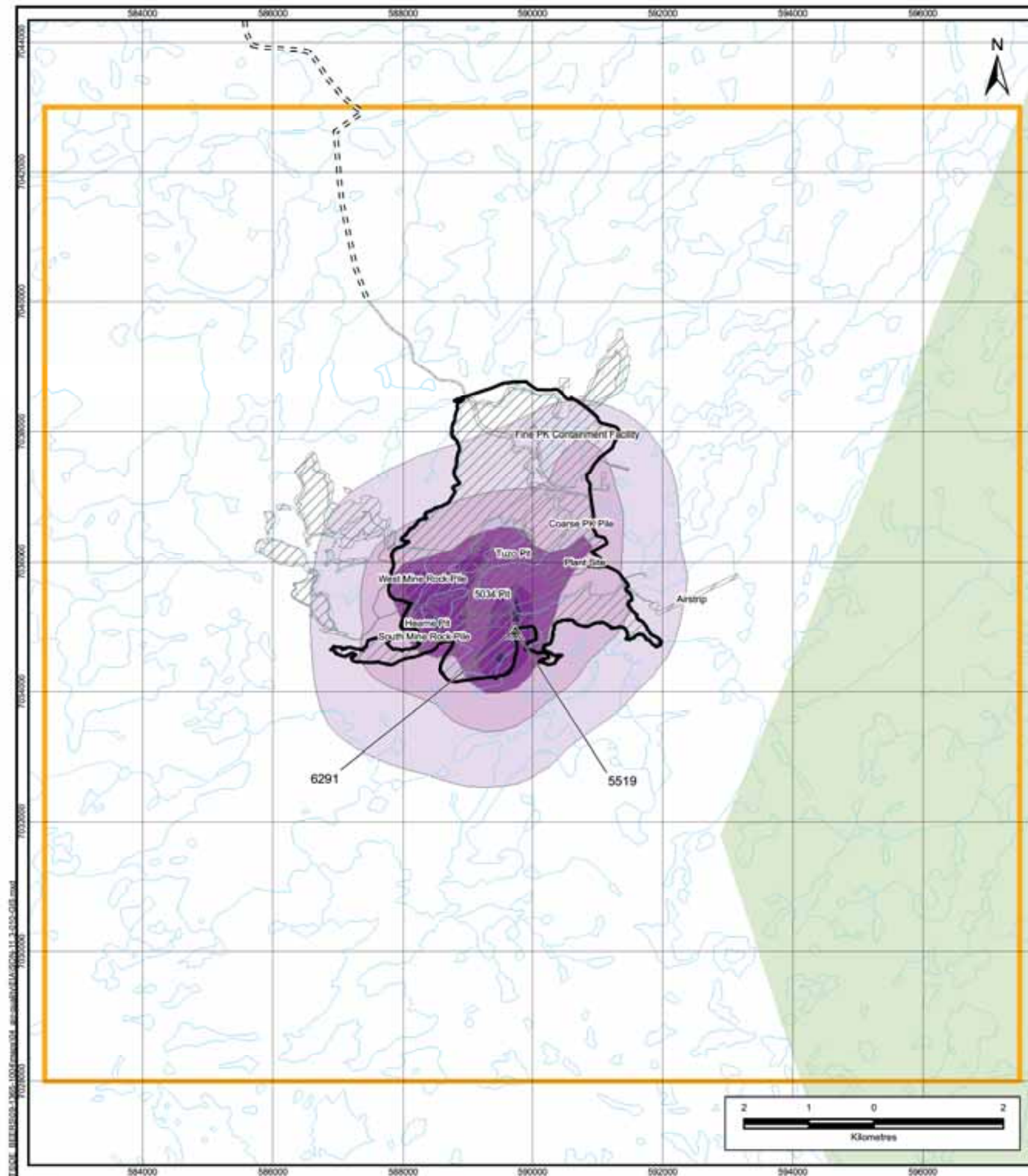
11.4.5.5.3 *Total Suspended Particulate Deposition*

Table 11.4-19 presents the Baseline Case and Application Case predicted TSP deposition rates overall and outside the development area. The predicted maximum TSP deposition rate outside the development area is 5,529 kg/ha/y. Figure 11.4-15 shows the pattern of annual TSP deposition for the Application Case. The areas with the highest deposition are the mine pits and the mine rock piles.

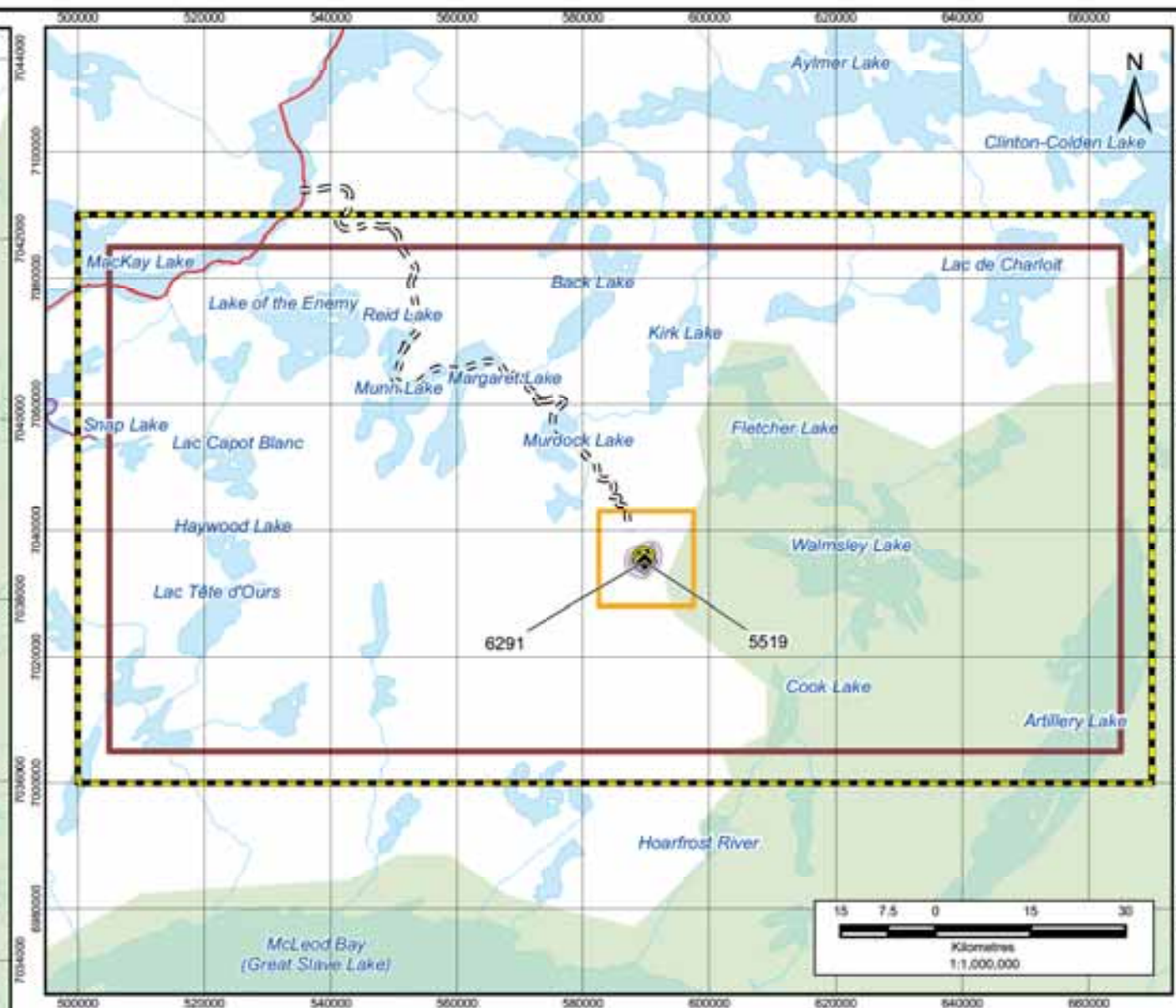
Table 11.4-19 Comparison of Predicted Baseline Case and Application Case Total Suspended Particulate Deposition

Parameters	Baseline Case	Application Case	Change Due to Project
Local Study Area (LSA)			
TSP deposition [kg/ha/y]	0.0	6,292	6,291.8
TSP deposition [kg/ha/y] (excluding development area)	0.0	5,520	5,519.5
Regional Study Area (RSA)			
TSP deposition [kg/ha/y]	4.7	6,292	6,287.1
TSP deposition [kg/ha/y] (excluding development area)	4.7	5,520	5,514.8

kg/ha/y = kilogram per hectare per year; TSP = total suspended particulate.



NOTES
Base data source: National Topographic Base Data (NTDB) 1:50,000.




LEGEND

- Gahcho Kué Project
 - Existing Winter Road
 - Tibbitt to Contwoyto Winter Road
 - Proposed Winter Access Road
 - Watercourse
 - Waterbody
 - Maximum Prediction Within LSA Excluding Development Area
 - Maximum Prediction Within LSA
 - Maximum Prediction Within RSA
 - Maximum Prediction Within RSA Excluding Development Area
 - Development Area Boundary
 - Local Study Area
 - Modelling Domain
 - Project Footprint
 - Regional Study Area
 - The Study Area for a National Park on the East Arm of Great Slave Lake
- Deposition (kg/ha/y)**
- ≥ 4000
 - 2000 to < 4000
 - 1000 to < 2000
 - 250 to < 1000
 - 50 to < 250
 - 0 to < 50

GAHCHO KUÉ PROJECT

Application Case TSP Deposition Predictions

PROJECTION UTM Zone 12	DATUM NAD83	 DE BEERS CANADA
Scale: 1:70,000 (LSA)		
FILE NO. SON-11.3-010-GIS		DATE December 13, 2010
JOB NO. 09-1365-1004	REVISION NO. 1	Figure 11.4-15
OFFICE GOLD-CAL	DRAWN BY SK CHECKED BY GU	

11.4.5.6 Potential Acid Input Deposition

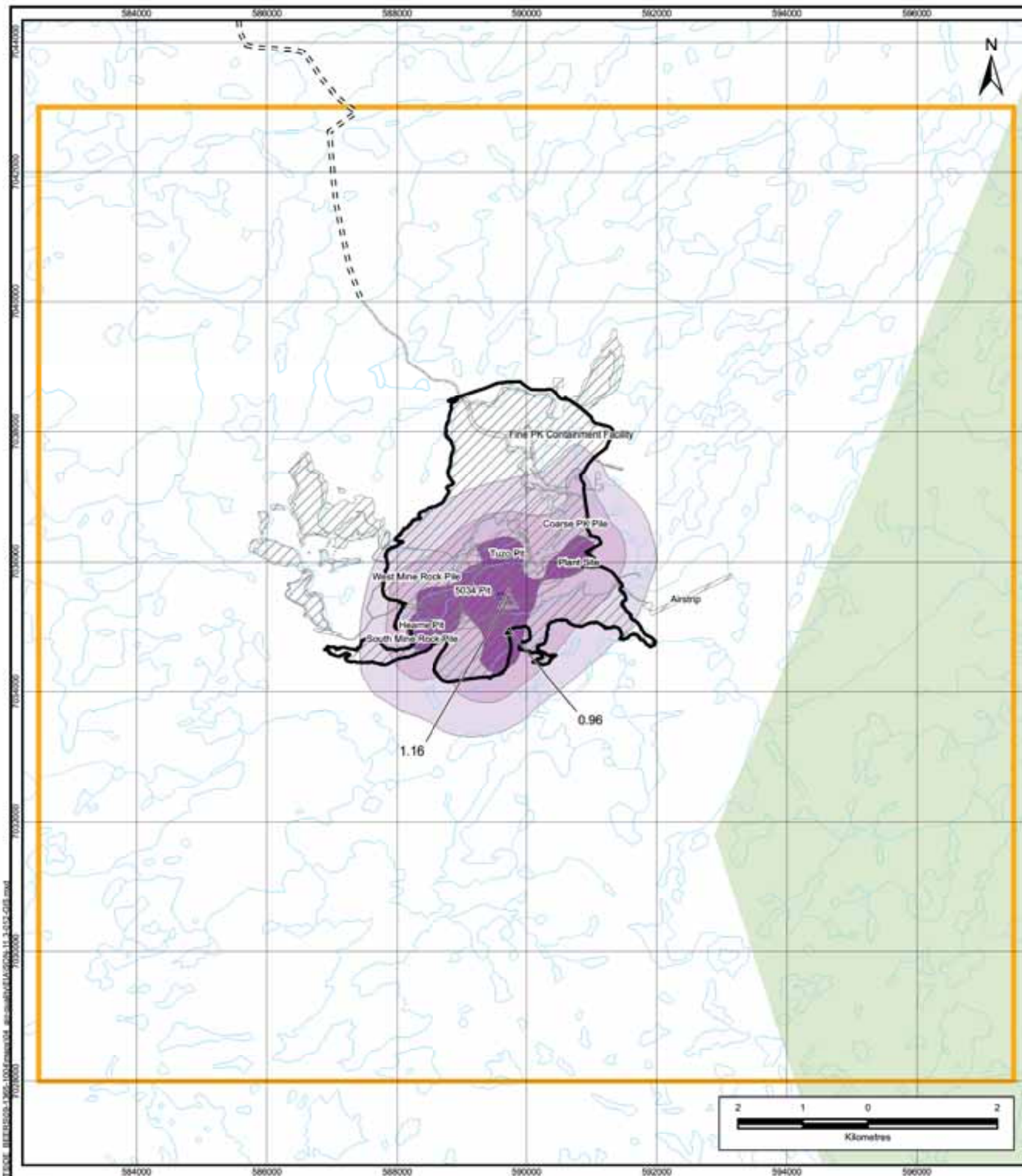
Table 11.4-20 presents a comparison of the PAI, sulphate and nitrate deposition rates between the Baseline Case and Application Case. The Application Case PAI deposition rates are presented graphically in Figure 11.4-16. In the Application Case, the maximum PAI deposition within the development area boundary is 1.16 keq/ha/y. It occurs near the 5034 Pit where the majority of the mine exhaust emissions are released from. The maximum PAI deposition outside the development boundary is 0.96 keq/ha/y. It occurs on the southern boundary of the development area, near a haul road that connects the mine pits to the South Mine Rock Pile.

Table 11.4-20 Comparison of Predicted Baseline Case and Application Case Acid Deposition Results

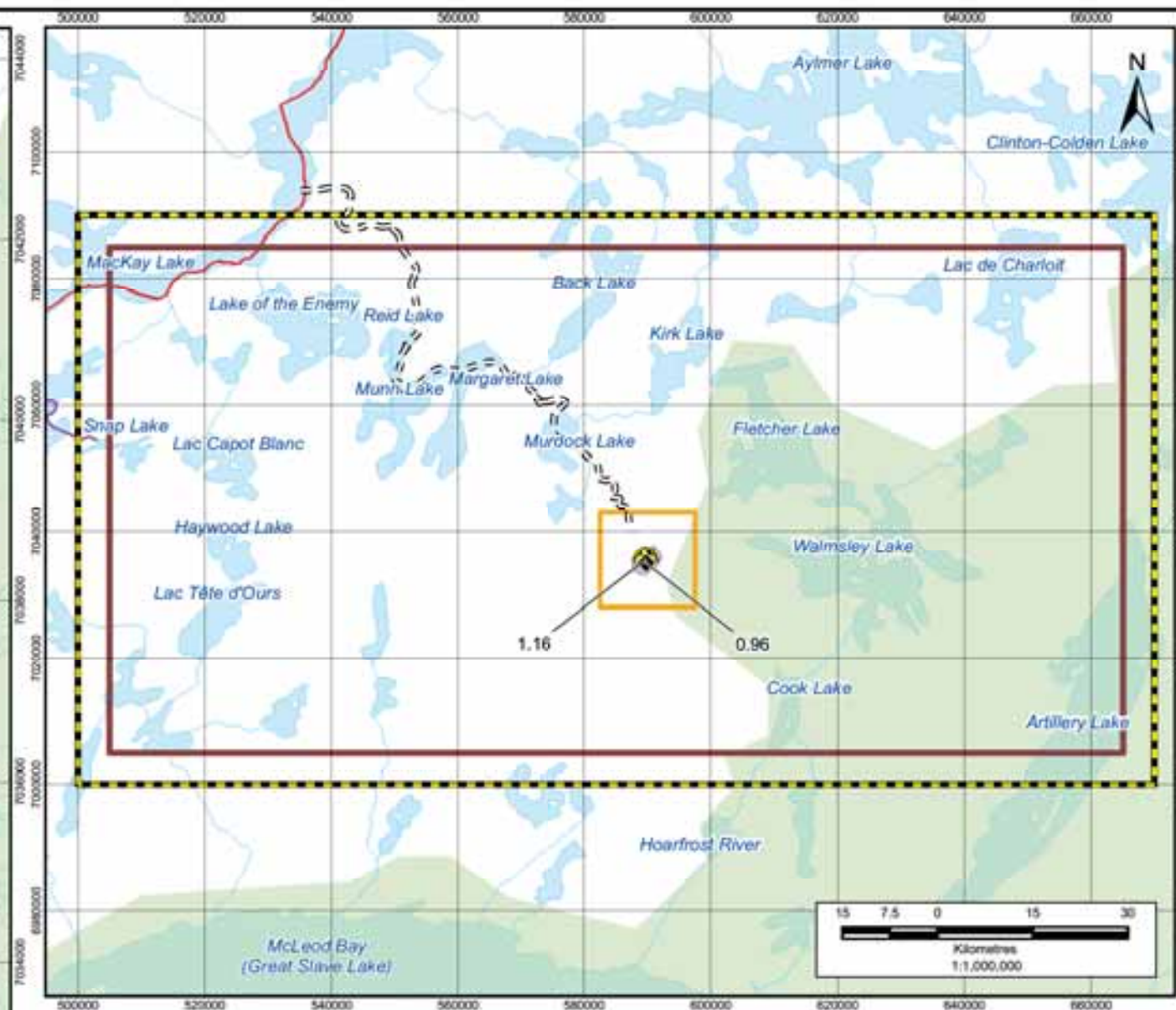
Parameter	Baseline Case	Application Case	Change Due to Project
Local Study Area (LSA)			
PAI [keq/ha/y]	0.06	1.16	1.09
PAI (excluding development area) [keq/ha/y]	0.06	0.96	0.89
nitrate (excluding development area) [keq/ha/y]	0.03	0.91	0.88
sulphate (excluding development area) [keq/ha/y]	0.04	0.06	0.02
Regional Study Area (RSA)			
PAI [keq/ha/y]	0.10	1.16	1.06
PAI (excluding development area) [keq/ha/y]	0.10	0.96	0.86
nitrate (excluding development area) [keq/ha/y]	0.06	0.91	0.85
sulphate (excluding development area) [keq/ha/y]	0.04	0.06	0.02

keq/ha/y = kiloequivalent per hectare per year; PAI = potential acid input.

The predicted PAI, sulphate and nitrate deposition on the regional waterbodies were provided as inputs to the Key Line of Inquiry: Water Quality and Fish in Kennady Lake (Section 8). These deposition results are presented in Appendix 11.4.III.



NOTES
Base data source: National Topographic Base Data (NTDB) 1:50,000.




LEGEND

- Gahcho Kué Project
 - Existing Winter Road
 - Tibbitt to Contwoyto Winter Road
 - Proposed Winter Access Road
 - Watercourse
 - Waterbody
 - Maximum Prediction Within LSA Excluding Development Area
 - Maximum Prediction Within LSA
 - Maximum Prediction Within RSA
 - Maximum Prediction Within RSA Excluding Development Area
 - Development Area Boundary
 - Local Study Area
 - Modelling Domain
 - Project Footprint
 - Regional Study Area
 - The Study Area for a National Park on the East Arm of Great Slave Lake
- Deposition (keq/ha/y)**
- ≥ 1
 - 0.5 to < 1
 - 0.25 to < 0.5
 - 0.17 to < 0.25
 - 0 to < 0.17

GAHCHO KUÉ PROJECT

Application Case Potential Acid Input Predictions

PROJECTION UTM Zone 12	DATUM NAD83	 DE BEERS CANADA
Scale: 1:70,000 (LSA)		
FILE NO. SON-11.3-012-GIS		DATE December 13, 2010
JOB NO. 09-1365-1004	REVISION NO. 1	Figure 11.4-16
OFFICE GOLD-CAL	DRAWN SK CHECK GU	

11.4.5.7 Construction Case

The construction of the Project will occur over a period of two years, in 2013 and 2014. The construction period will include installation of the Project infrastructure and dewatering part of Kennady Lake before production mining can begin. After the water above the ore bodies has been drained, pre-stripping of the open pits and initial mining will begin.

Sources of emissions during the construction phase of the Project will be similar to emission sources during the operations phase of the Project with the exception of kimberlite ore processing and coarse processed kimberlite (PK) disposal activities. These activities will not commence until the operations phase. The construction phase emissions are summarized in Table 11.4-21. Details on the construction emissions are provided in Appendix 11.4.II, Section 11.4.II.3.3.

Table 11.4-21 Gahcho Kué Project Construction Case Emissions

Source	Emission Rate (t/d)					
	SO ₂	NO _x	CO	TSP	PM ₁₀	PM _{2.5}
Generators	0.000	0.897	0.238	0.020	0.016	0.016
Waste incinerator	0.004	0.004	0.012	0.008	0.008	0.008
Mine fleet	0.002	0.847	0.279	0.043	0.043	0.042
Drilling and blasting	0.019	0.156	0.735	0.041	0.020	0.002
Loading/unloading	—	—	—	0.093	0.044	0.007
Bulldozing	—	—	—	0.018	0.002	0.002
Aggregate plant	—	—	—	0.062	0.024	0.018
Wind erosion	—	—	—	0.185	0.092	0.014
Grading	—	—	—	0.156	0.046	0.005
Road dust	—	—	—	1.967	0.402	0.040
Winter Access Road	0.000	0.005	0.002	0.000	0.000	0.000
Drained lakebed	—	—	—	0.216	0.108	0.016
Total	0.025	1.909	1.267	2.810	0.806	0.169

Note: The emission rates presented in the above table have been rounded to three decimal places. Therefore, the totals may not appear to be sum of individual values.

t/d = tonnes per day; SO₂ = sulphur dioxide; NO₂ = nitrogen dioxide; CO = carbon monoxide; PM = particulate matter; TSP = total suspended particulate.

The predicted maximum SO₂, NO₂, CO, PM_{2.5} and TSP concentrations during the construction phase are presented in the following sections.

11.4.5.7.1 Sulphur Dioxide

Table 11.4-22 presents predicted SO₂ concentrations for the construction phase. The Construction Case predictions are lower than the Application Case predictions. The predicted maximum concentrations outside of the development

area are all below the applicable NWT air quality standards for all averaging periods.

Table 11.4-22 Construction Case Predicted SO₂ Concentrations

Parameters	Averaging Periods		
	1-Hour	24-Hour	Annual
Local Study Area (LSA)			
maximum SO ₂ [µg/m ³]	42.3	31.2	5.5
maximum SO ₂ (excluding development area) [µg/m ³]	27.0	21.0	3.2
occurrences above NWT AQS	0	0	—
area above NWT AQS (excluding development area) [ha]	0	0	0
Regional Study Area (RSA)			
maximum SO ₂ [µg/m ³]	42.3	31.2	5.5
maximum SO ₂ (excluding development area) [µg/m ³]	27.0	21.0	3.2
occurrences above NWT AQS	0	0	—
area above NWT AQS (excluding development area) [ha]	0	0	0
NWT AQS [µg/m³]	450	150	30

AQS = Air Quality Standard; µg/m³ = microgram per cubic metre; SO₂ = sulphur dioxide; ha = hectare.

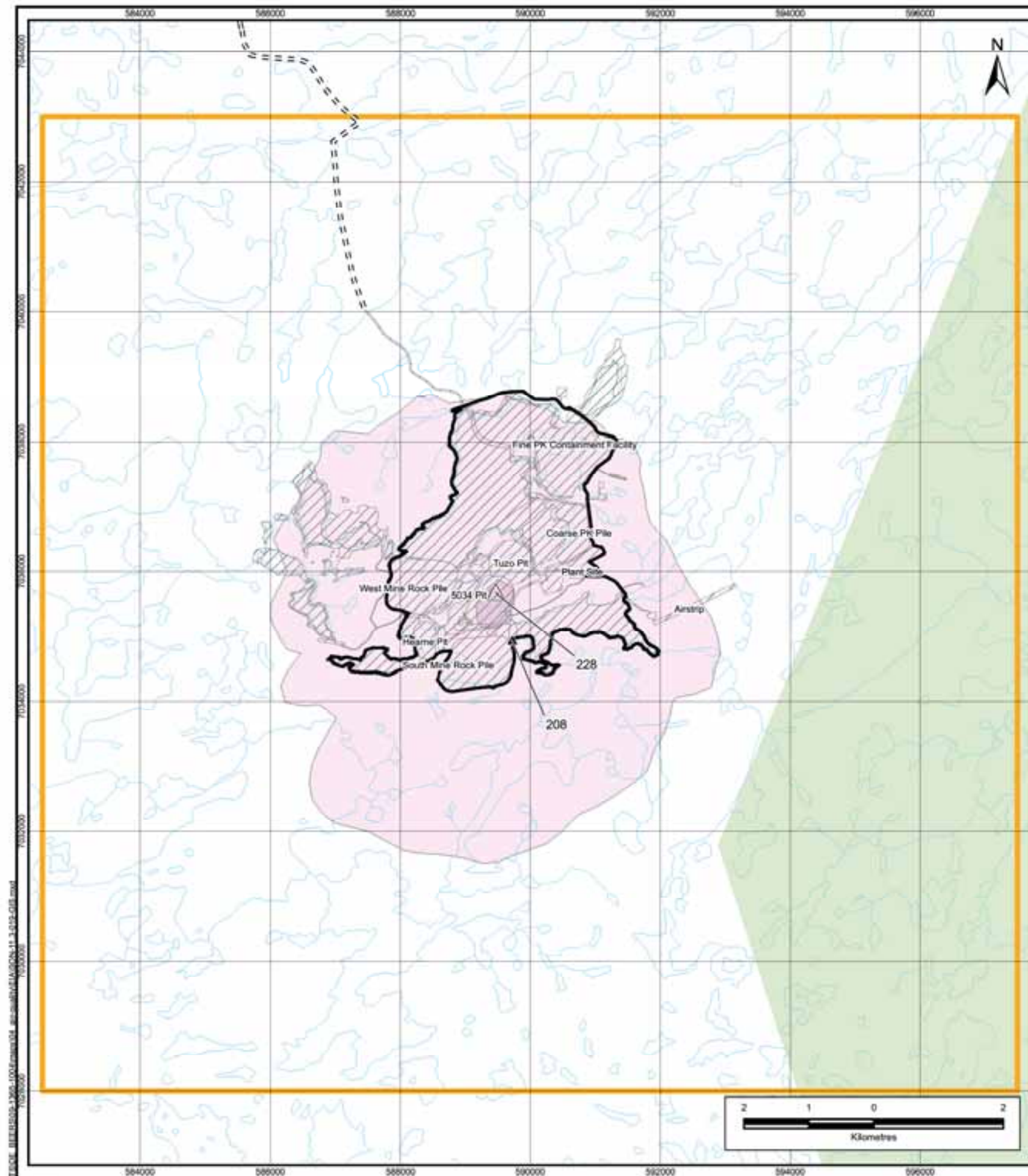
11.4.5.7.2 Nitrogen Dioxide

Table 11.4-23 summarizes the Construction Case predicted NO₂ concentrations. Overall, the Construction Case predictions are lower than the Application Case predictions. The predicted maximum concentrations outside of the development area are all below the applicable national air quality objectives for all averaging periods. The predicted 1-hour, 24-hour and annual concentrations are shown graphically in Figures 11.4-17, 11.4-18 and 11.4-19, respectively.

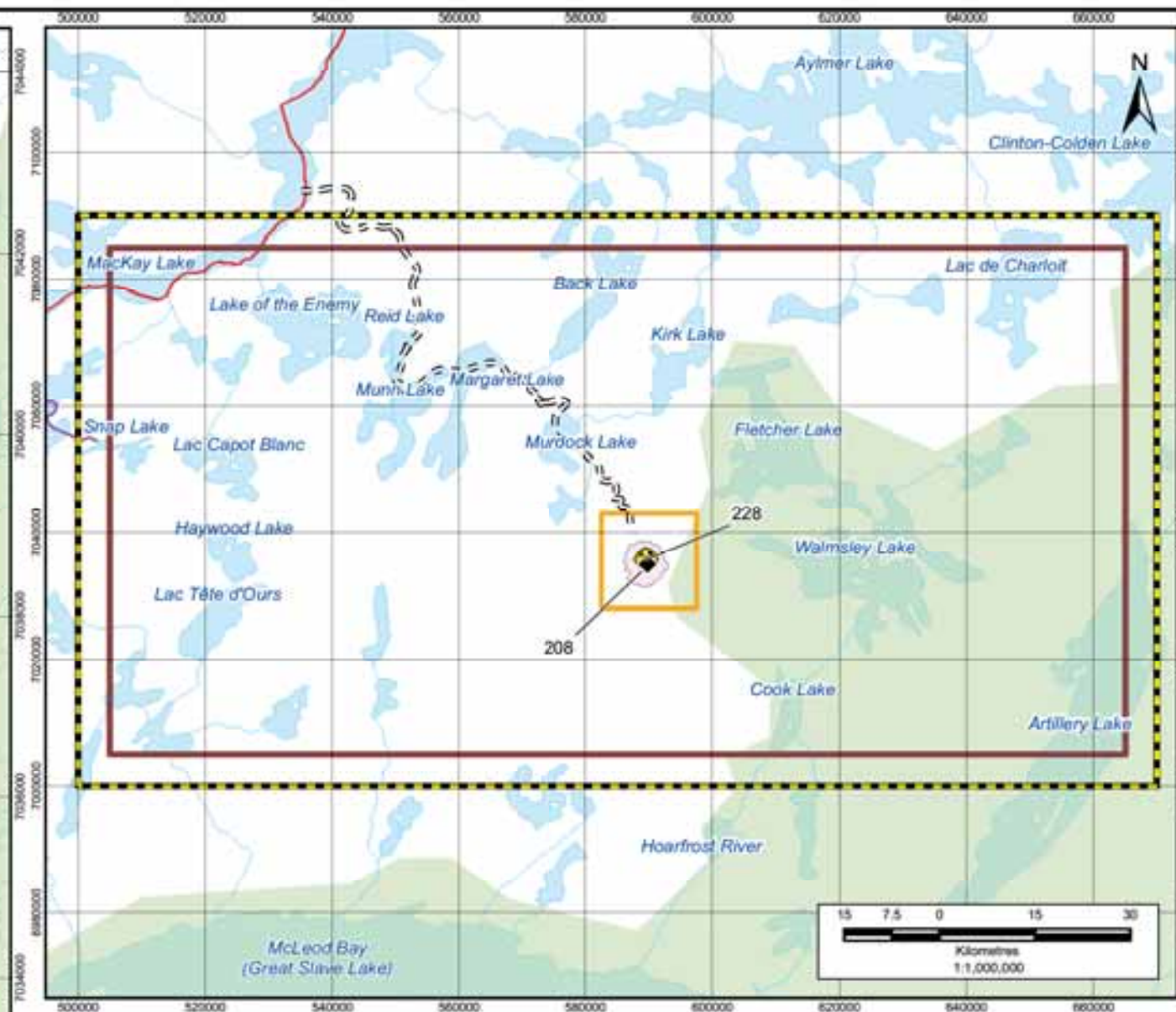
Table 11.4-23 Construction Case Predicted NO₂ Concentrations

Parameters	Averaging Periods		
	1-Hour	24-Hour	Annual
Local Study Area (LSA)			
maximum NO ₂ [µg/m ³]	227.9	175.8	60.3
maximum NO ₂ (excluding development area) [µg/m ³]	207.7	146.3	55.9
occurrences above NAQO	0	0	—
area above NAQO (excluding development area) [ha]	0	0	0
Regional Study Area (RSA)			
maximum NO ₂ [µg/m ³]	227.9	175.8	60.3
maximum NO ₂ (excluding development area) [µg/m ³]	207.7	146.3	55.9
occurrences above NAQO	0	0	—
area above NAQO (excluding development area) [ha]	0	0	0
NAQO [µg/m³]	400	200	60

NAQO = National Air Quality Objective; µg/m³ = microgram per cubic metre; NO₂ = nitrogen dioxide; ha = hectare.



NOTES
Base data source: National Topographic Base Data (NTDB) 1:50,000.




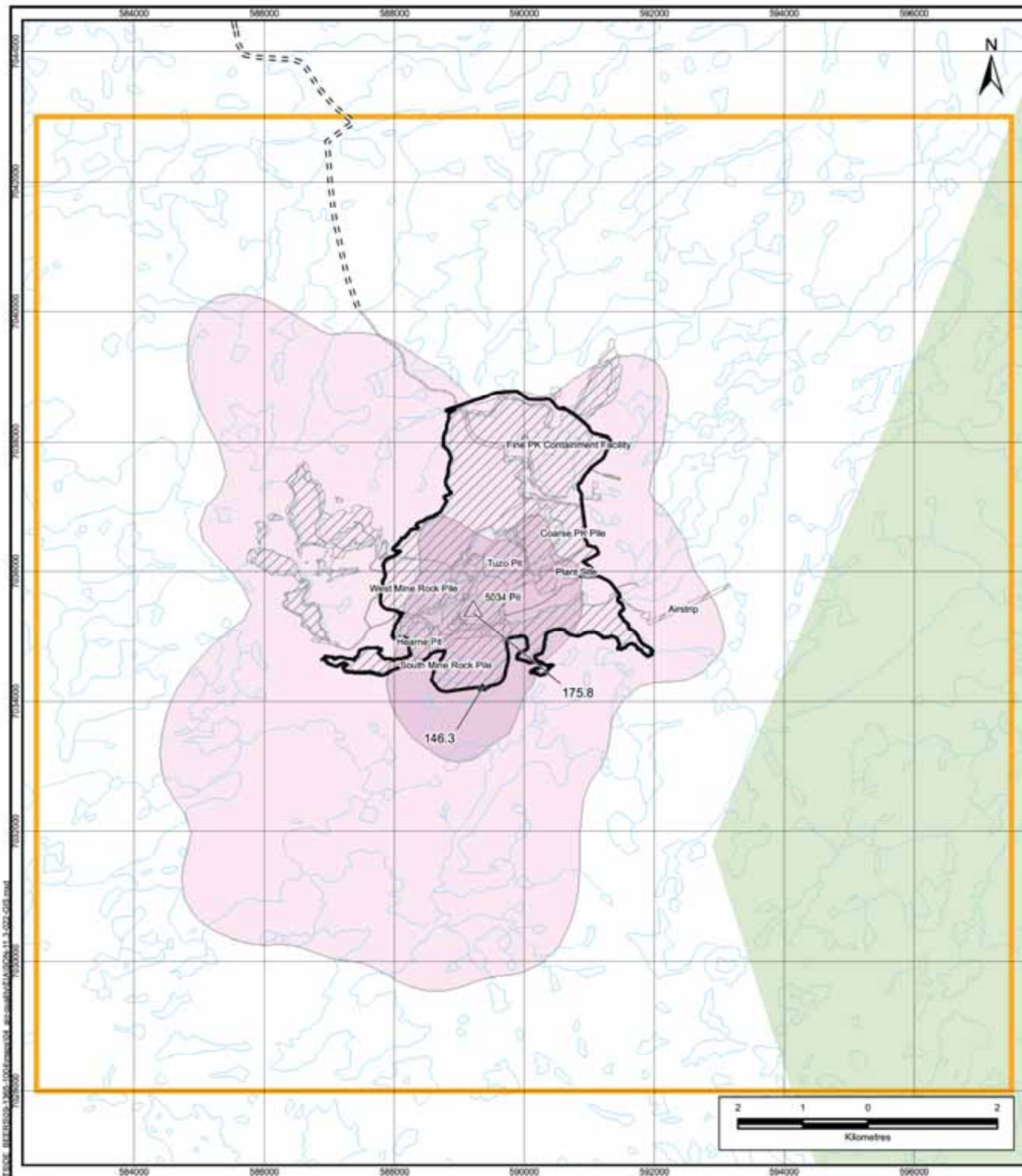
LEGEND

- Gahcho Kué Project
 - Existing Winter Road
 - Tibbitt to Contwoyto Winter Road
 - Proposed Winter Access Road
 - Watercourse
 - Waterbody
 - Maximum Prediction Within LSA Excluding Development Area
 - Maximum Prediction Within LSA
 - Maximum Prediction Within RSA
 - Maximum Prediction Within RSA Excluding Development Area
 - Development Area Boundary
 - Local Study Area
 - Modelling Domain
 - Project Footprint
 - Regional Study Area
 - The Study Area for a National Park on the East Arm of Great Slave Lake
- Concentration ($\mu\text{g}/\text{m}^3$)**
- ≥ 400
 - 200 to < 400
 - 100 to < 200
 - 0 to < 100
- National AQO = $400 \mu\text{g}/\text{m}^3$
Environment Canada (1981)

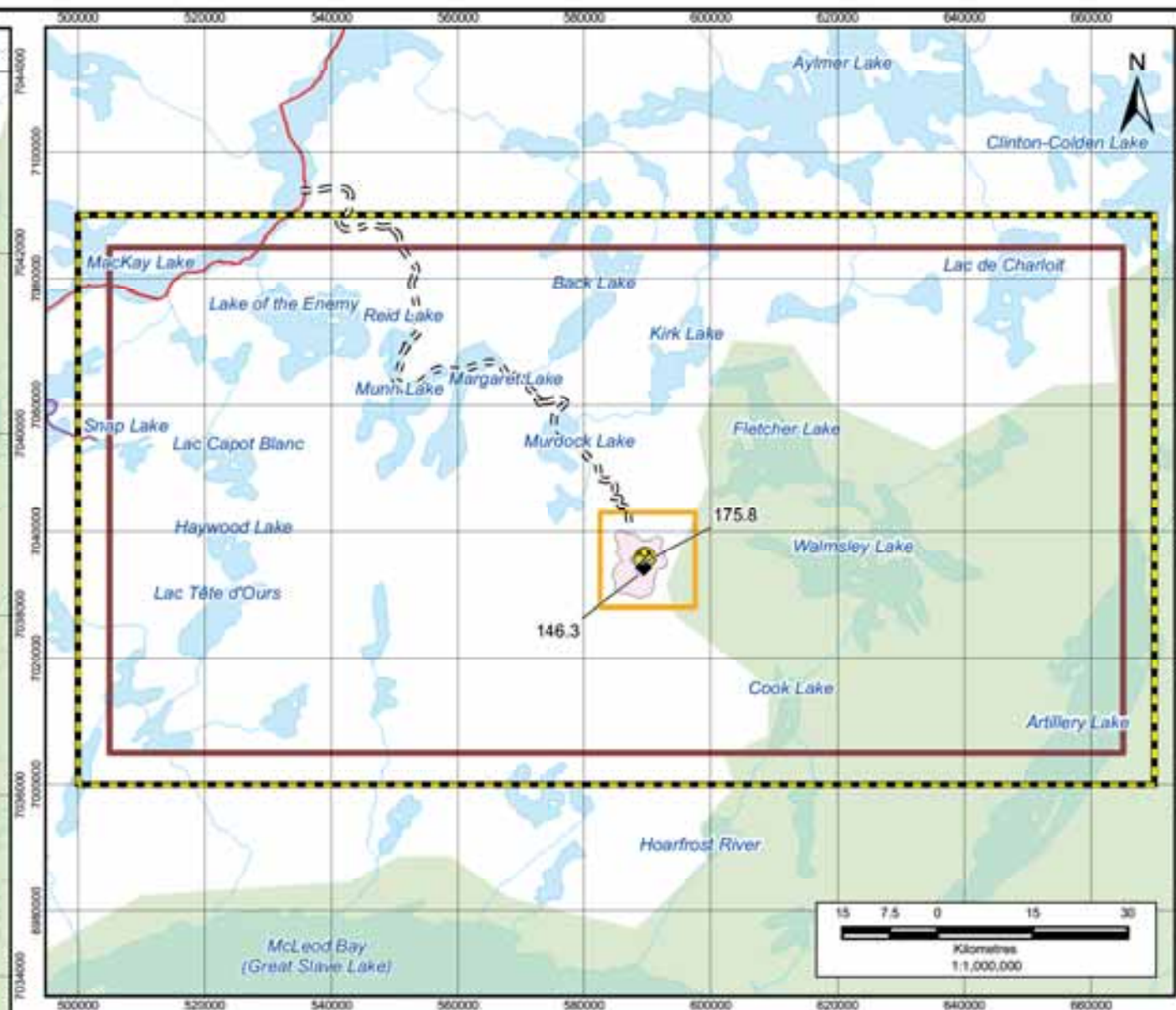
GAHCHO KUÉ PROJECT

Construction Case Maximum 1-hour NO_2 Concentrations

PROJECTION UTM Zone 12	DATE NAD83	
Scale: 1:70,000 (LSA)		
FILE NO. SON-11.3-019-GIS		DATE December 13, 2010
JOB NO. 09-1365-1004	REVISION NO. 1	Figure 11.4-17
OFFICE GOLD-CAL	DRAWN SK CHECK GU	



NOTES
Base data source: National Topographic Base Data (NTDB) 1:50,000.




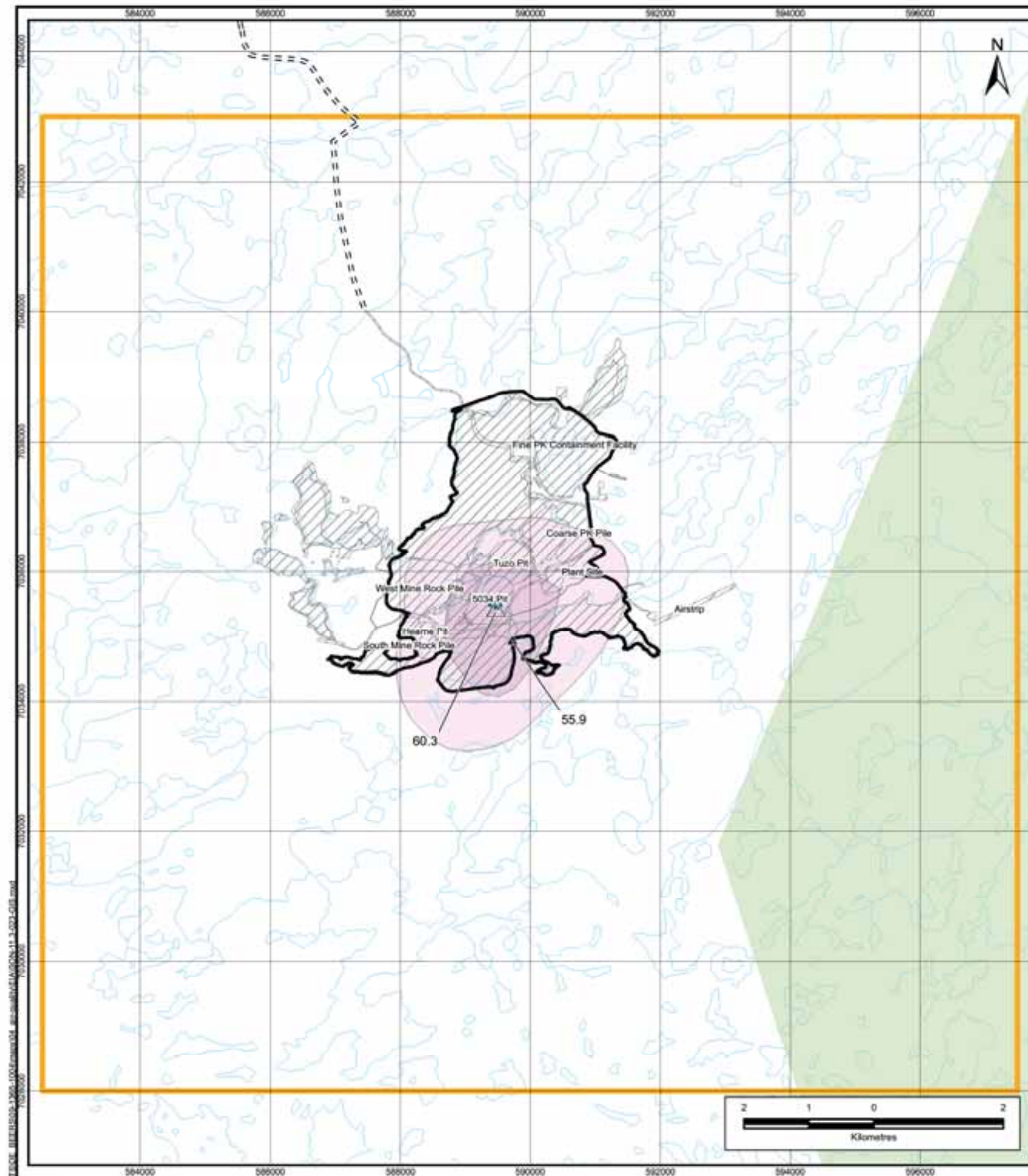
LEGEND

- Gahcho Kué Project
 - Existing Winter Road
 - Tibbitt to Contwoyto Winter Road
 - Proposed Winter Access Road
 - Watercourse
 - Waterbody
 - Maximum Prediction Within LSA Excluding Development Area
 - Maximum Prediction Within LSA
 - Maximum Prediction Within RSA
 - Maximum Prediction Within RSA Excluding Development Area
 - Development Area Boundary
 - Local Study Area
 - Modelling Domain
 - Project Footprint
 - Regional Study Area
 - The Study Area for a National Park on the East Arm of Great Slave Lake
- Concentration ($\mu\text{g}/\text{m}^3$)**
- ≥ 200
 - 100 to < 200
 - 50 to < 100
 - 0 to < 50
- National AQO = $200 \mu\text{g}/\text{m}^3$
Environment Canada (1981)

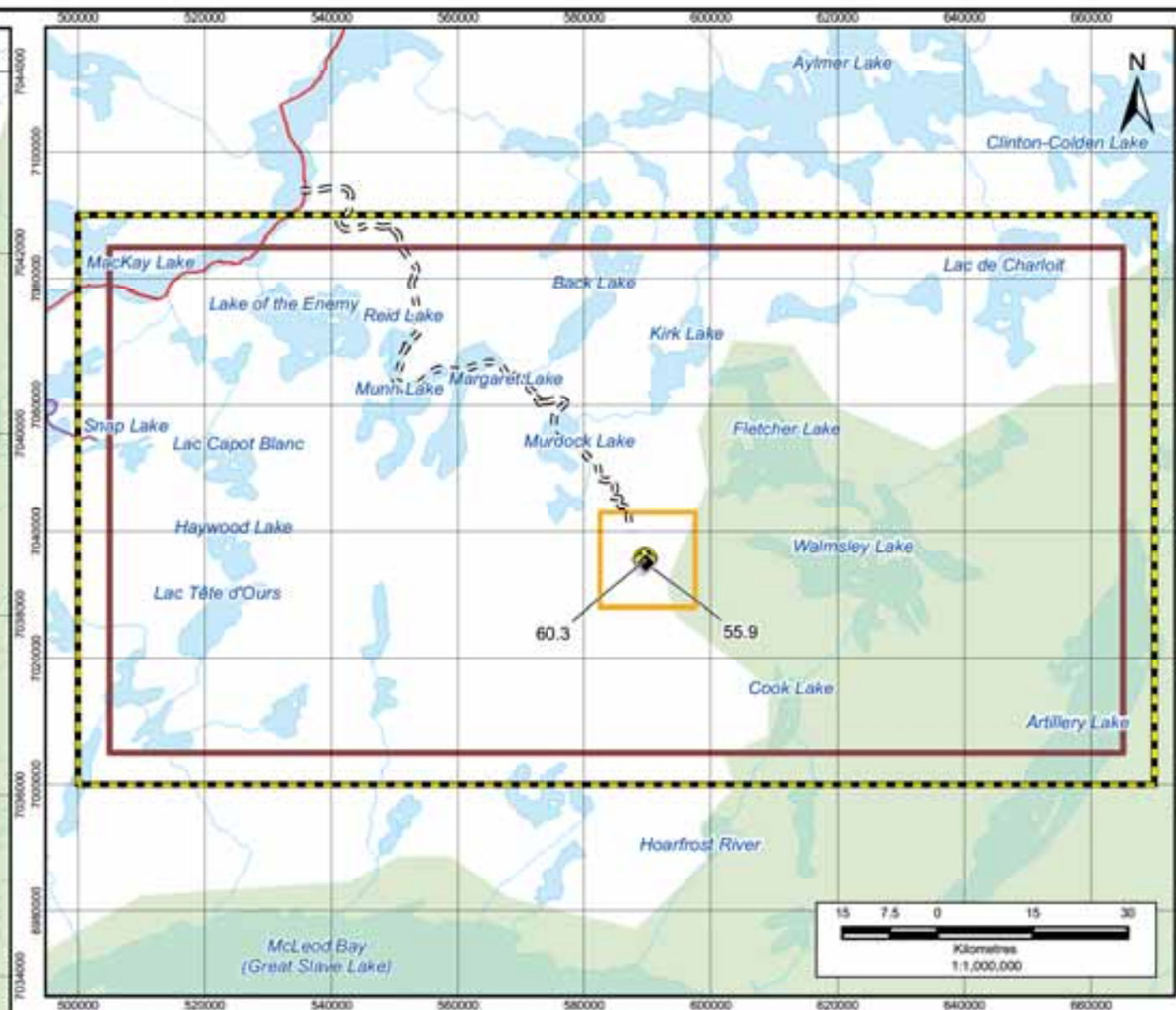
GAHCHO KUÉ PROJECT

Construction Case Maximum 24-hour NO_2 Concentrations

PROJECTION UTM Zone 12	DATUM NAD83	 DE BEERS CANADA
Scale: 1:70,000 (LSA)		
FILE NO. SON-11.3-022-GIS		DATE December 13, 2010
JOB NO. 09-1365-1004	REVISION NO. 1	Figure 11.4-18
OFFICE GOLD-CAL	DRAWN BY SK CHECKED BY GU	



NOTES
Base data source: National Topographic Base Data (NTDB) 1:50,000.




LEGEND

- Gahcho Kué Project
 - Existing Winter Road
 - Tibbitt to Contwoyto Winter Road
 - Proposed Winter Access Road
 - Watercourse
 - Waterbody
 - Maximum Prediction Within LSA Excluding Development Area
 - Maximum Prediction Within LSA
 - Maximum Prediction Within RSA
 - Maximum Prediction Within RSA Excluding Development Area
 - Development Area Boundary
 - Local Study Area
 - Modelling Domain
 - Project Footprint
 - Regional Study Area
 - The Study Area for a National Park on the East Arm of Great Slave Lake
- Concentration ($\mu\text{g}/\text{m}^3$)**
- ≥ 60
 - 30 to < 60
 - 15 to < 30
 - 0 to < 15
- National AQO = $60 \mu\text{g}/\text{m}^3$
Environment Canada (1981)

GAHCHO KUÉ PROJECT

Construction Case Annual Average NO_2 Concentrations

PROJECTION UTM Zone 12	DATUM NAD83	 DE BEERS CANADA
Scale: 1:70,000 (LSA)		
FILE NO. SON-11.3-023-GIS		DATE December 13, 2010
JOB NO. 09-1365-1004	REVISION NO. 1	Figure 11.4-19
OFFICE GOLD-CAL	DRAWN BY SK CHECKED BY GU	

11.4.5.7.3 Carbon Monoxide

Table 11.4-24 summarizes the Construction Case predicted CO concentrations. The predicted maximum concentrations outside of the development area are all below the applicable national air quality objectives for both 1-hour and 8-hour averaging periods.

Table 11.4-24 Construction Case Predicted CO Concentrations

Parameters	Averaging Periods	
	1-Hour	8-Hour
Local Study Area (LSA)		
maximum CO [$\mu\text{g}/\text{m}^3$]	1,814.3	1,356.4
maximum CO (excluding development area) [$\mu\text{g}/\text{m}^3$]	1,181.9	1,013.8
occurrences above NAQO	0	0
area above NAQO (excluding development area) [ha]	0	0
Regional Study Area (RSA)		
maximum CO [$\mu\text{g}/\text{m}^3$]	1,814.3	1,356.4
maximum CO (excluding development area) [$\mu\text{g}/\text{m}^3$]	1,181.9	1,013.8
occurrences above NAQO	0	0
area above NAQO (excluding development area) [ha]	0	0
NAQO [$\mu\text{g}/\text{m}^3$]	15,000	6,000

NAQO = National Air Quality Objective; $\mu\text{g}/\text{m}^3$ = microgram per cubic metre; CO = carbon monoxide; ha = hectare.

11.4.5.7.4 Particulate Matter

Table 11.4-25 summarizes the Construction Case predicted 24-hour $\text{PM}_{2.5}$ concentrations. The predicted maximum 24-hour concentration outside the development area is $113.1 \mu\text{g}/\text{m}^3$, above the NWT air quality standard of $30 \mu\text{g}/\text{m}^3$. The NWT air quality standard will be exceeded for 31 days per year or 8.5% of the time. The predicted 24-hour concentrations are shown graphically in Figure 11.4-20. The predicted maximum concentrations outside the development area are associated with fugitive dust emissions from the activities at the South Mine Rock Pile and haul roads along the southern boundary of the development area.

Table 11.4-25 Construction Case Predicted PM_{2.5} Concentrations

Parameters	Averaging Period
	24-Hour
Local Study Area (LSA)	
maximum PM _{2.5} [µg/m³]	118.7
maximum PM _{2.5} (excluding development area) [µg/m³]	113.1
occurrences above NWT AQS	31
area above NWT AQS (excluding development area) [ha]	293
Regional Study Area (RSA)	
maximum PM _{2.5} [µg/m³]	118.7
maximum PM _{2.5} (excluding development area) [µg/m³]	113.1
occurrences above NWT AQS	31
area above NWT AQS (excluding development area) [ha]	293
NWT AQS [µg/m³]	30

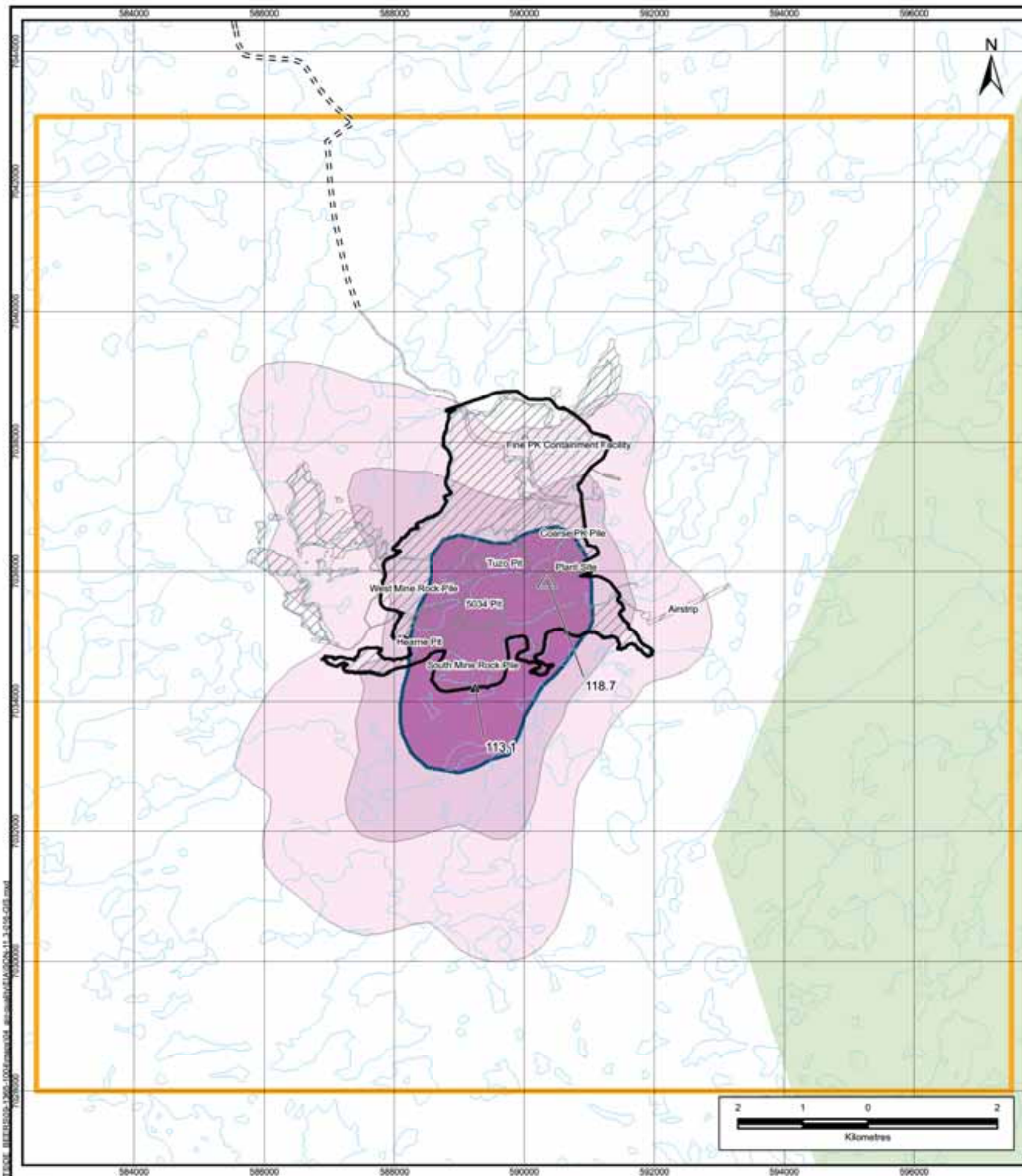
AQS = Air Quality Standard; µg/m³ = microgram per cubic metre; PM = particulate matter; ha = hectare.

Table 11.4-26 summarizes the construction phase predicted 24-hour and annual TSP concentrations. The predicted maximum 24-hour concentrations outside the development area exceed the NWT air quality standard for 252 days per year or 69% of the time. The predicted 24-hour and annual concentrations are shown graphically in Figures 11.4-21 and 11.4-22, respectively. The predicted maximum concentrations outside the development area are associated with fugitive dust emissions from the activities at the South Mine Rock Pile and haul roads along the southern boundary of the development area.

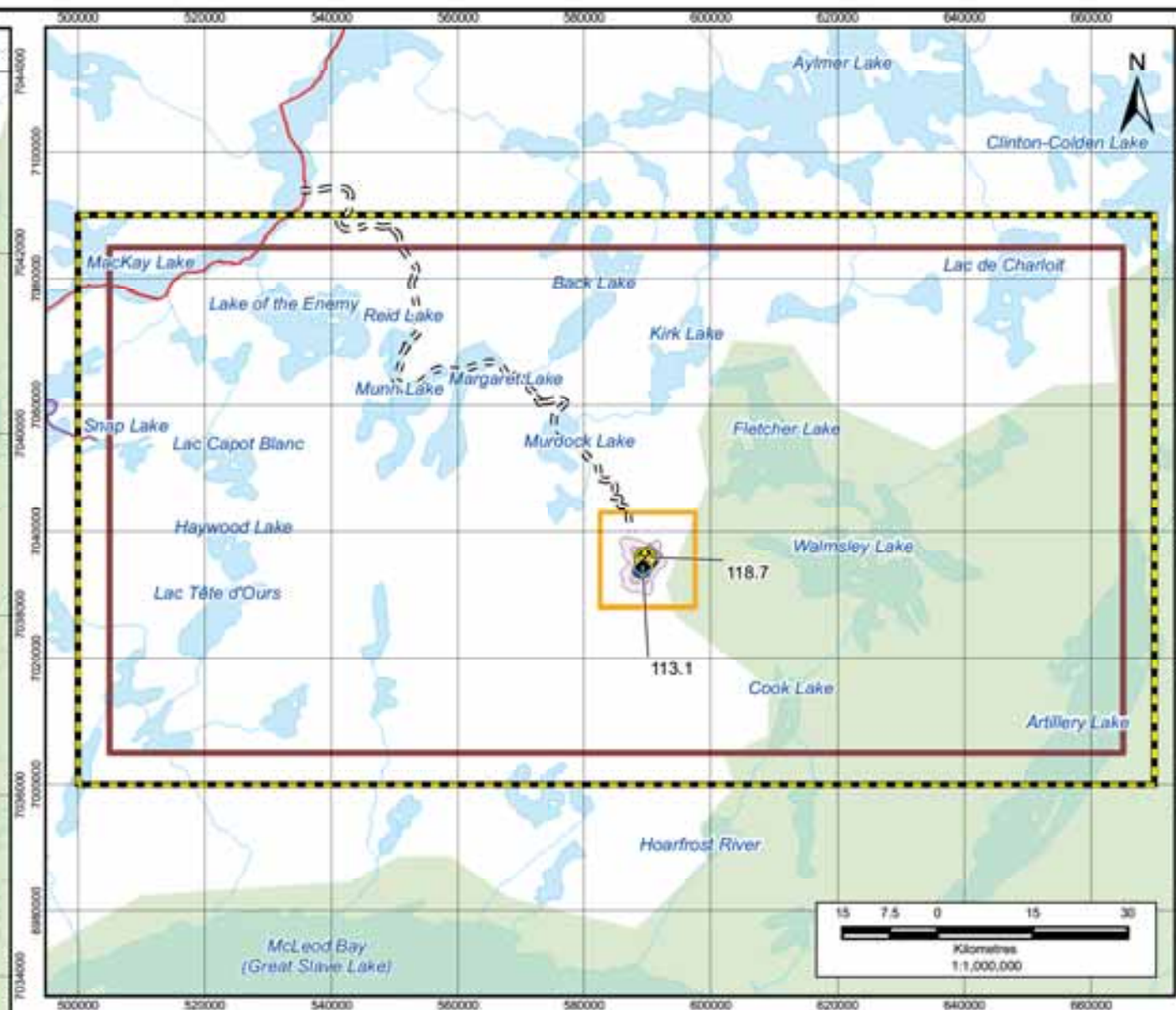
Table 11.4-26 Construction Case Predicted TSP Concentrations

Parameters	Averaging Periods	
	24-Hour	Annual
Local Study Area (LSA)		
maximum TSP [µg/m³]	2,938.7	337.6
maximum TSP (excluding development area) [µg/m³]	2,381.5	295.9
occurrences above NWT AQS	252	—
area above NWT AQS (excluding development area) [ha]	392	40
Regional Study Area (RSA)		
maximum TSP [µg/m³]	2,938.7	337.6
maximum TSP (excluding development area) [µg/m³]	2,381.5	295.9
occurrences above NWT AQS	252	—
area above NWT AQS (excluding development area) [ha]	392	40
NWT AQS [µg/m³]	120	60

AQS = Air Quality Standard; µg/m³ = microgram per cubic metre; TSP = total suspended particulate; ha = hectare.



NOTES
Base data source: National Topographic Base Data (NTDB) 1:50,000.




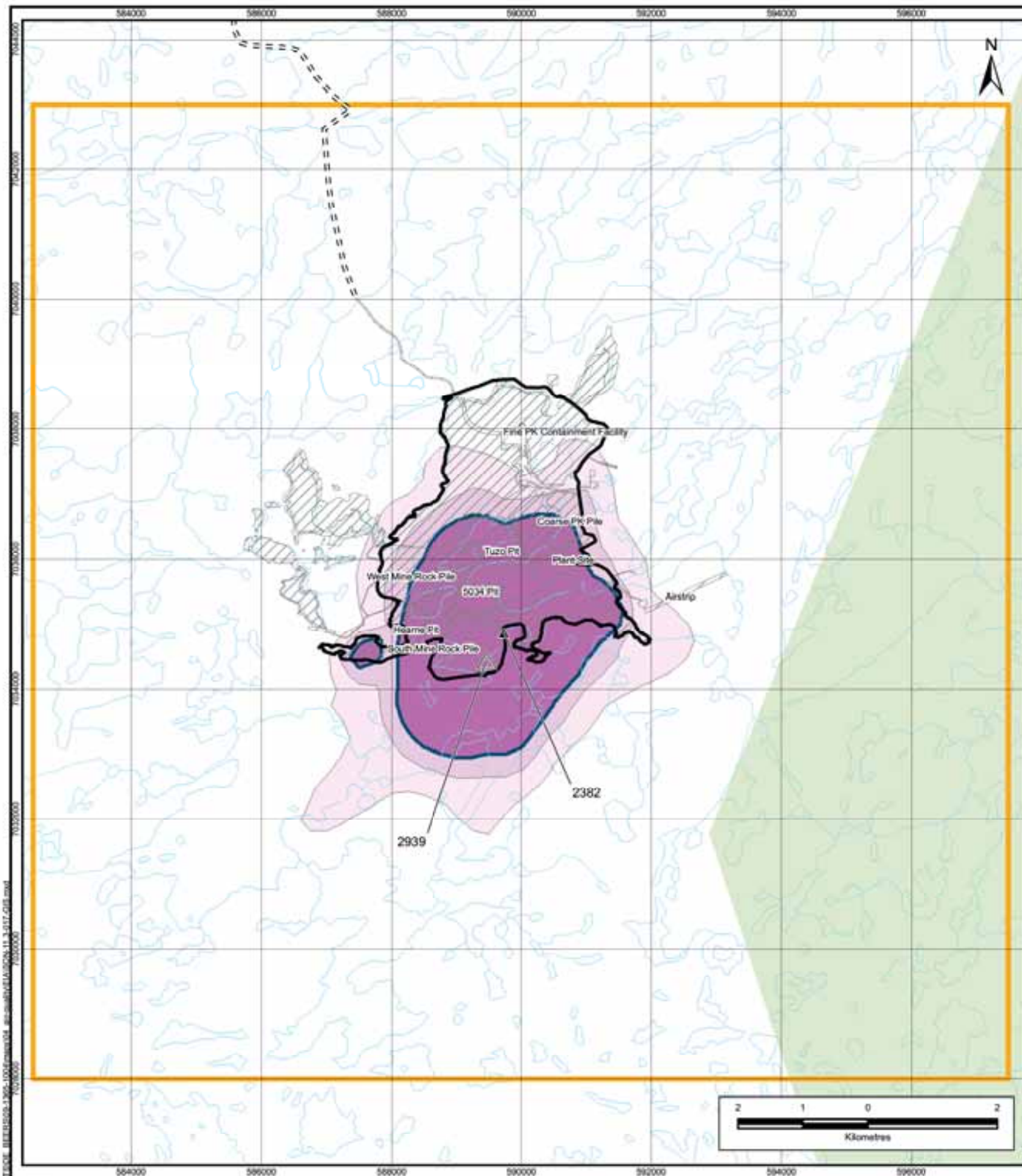
LEGEND

- Gahcho Kué Project
 - Existing Winter Road
 - Tibbitt to Contwoyto Winter Road
 - Proposed Winter Access Road
 - Watercourse
 - Waterbody
 - Maximum Prediction Within LSA Excluding Development Area
 - Maximum Prediction Within LSA
 - Maximum Prediction Within RSA
 - Maximum Prediction Within RSA Excluding Development Area
 - Development Area Boundary
 - Local Study Area
 - Modelling Domain
 - Project Footprint
 - Regional Study Area
 - The Study Area for a National Park on the East Arm of Great Slave Lake
- Concentration ($\mu\text{g}/\text{m}^3$)**
- ≥ 30
 - 15 to < 30
 - 7.5 to < 15
 - 0 to < 7.5
- NWT Standard = $30 \mu\text{g}/\text{m}^3$ GNWT (2010)

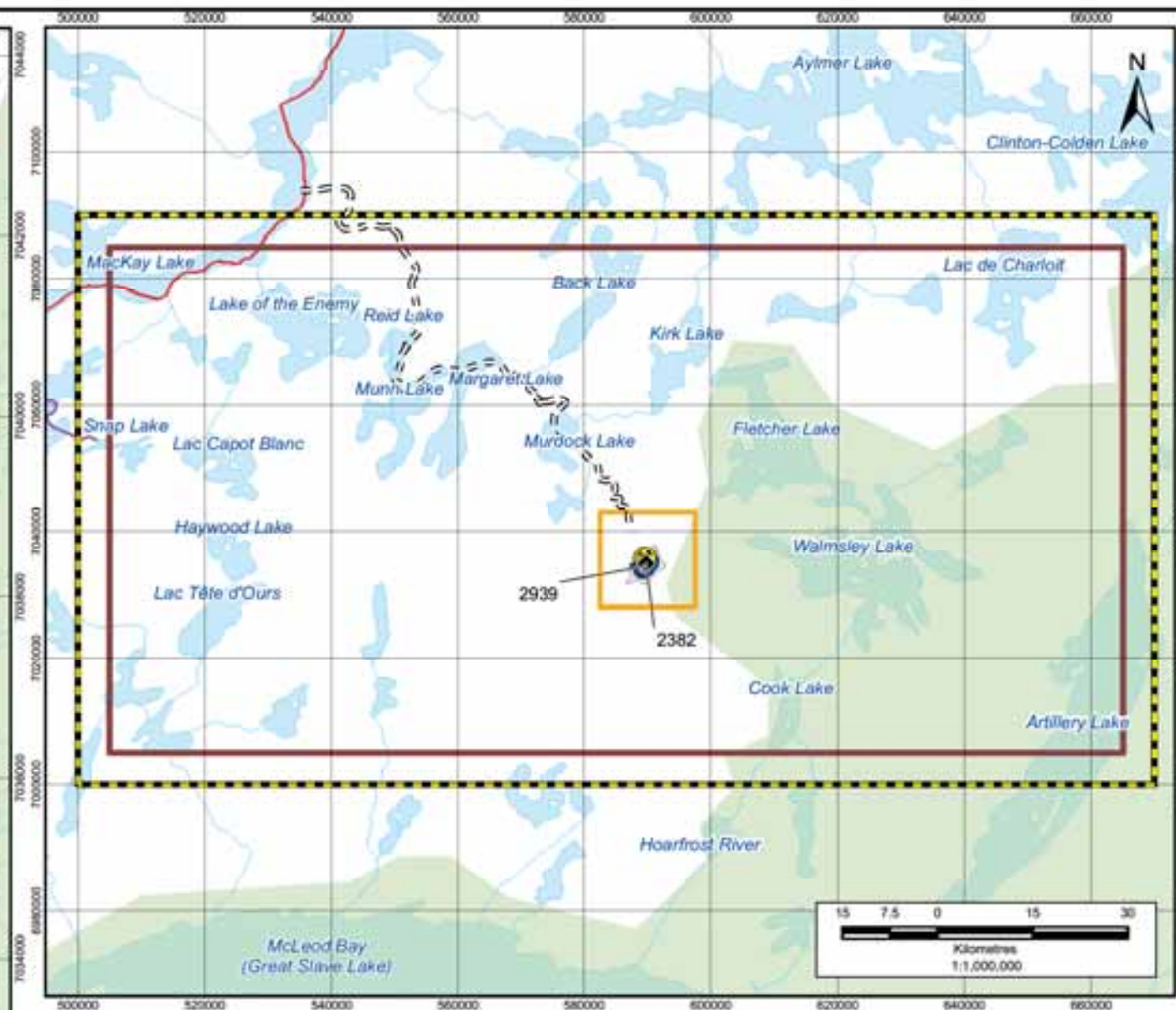
GAHCHO KUÉ PROJECT

Construction Case Maximum
24-hour $\text{PM}_{2.5}$ Concentrations

PROJECTION UTM Zone 12	DATUM NAD83	 DE BEERS CANADA
Scale: 1:70,000 (LSA)		
FILE NO. SON-11.3-016-GIS		DATE December 13, 2010
JOB NO. 09-1365-1004	REVISION NO. 1	Figure 11.4-20
OFFICE GOLD-CAL	DRAWN SK CHECK GU	



NOTES
Base data source: National Topographic Base Data (NTDB) 1:50,000.




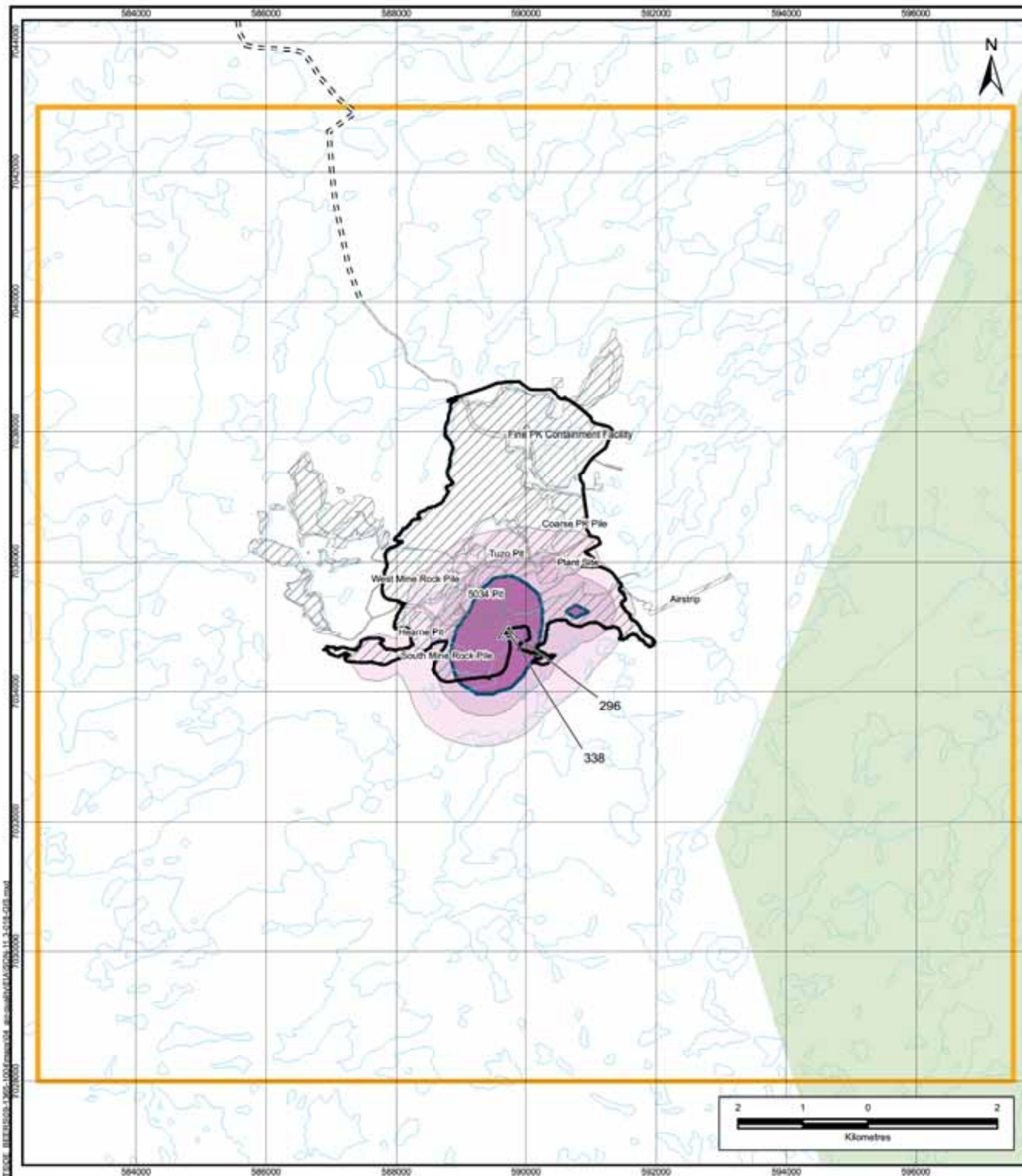
LEGEND

- Gahcho Kué Project
 - Existing Winter Road
 - Tibbitt to Contwoyto Winter Road
 - Proposed Winter Access Road
 - Watercourse
 - Waterbody
 - Maximum Prediction Within LSA Excluding Development Area
 - Maximum Prediction Within LSA
 - Maximum Prediction Within RSA
 - Maximum Prediction Within RSA Excluding Development Area
 - Development Area Boundary
 - Local Study Area
 - Modelling Domain
 - Project Footprint
 - Regional Study Area
 - The Study Area for a National Park on the East Arm of Great Slave Lake
- Concentration ($\mu\text{g}/\text{m}^3$)**
- ≥ 120
 - 60 to < 120
 - 30 to < 60
 - 0 to < 30
- NWT Standard = $120 \mu\text{g}/\text{m}^3$ GNWT (2010)

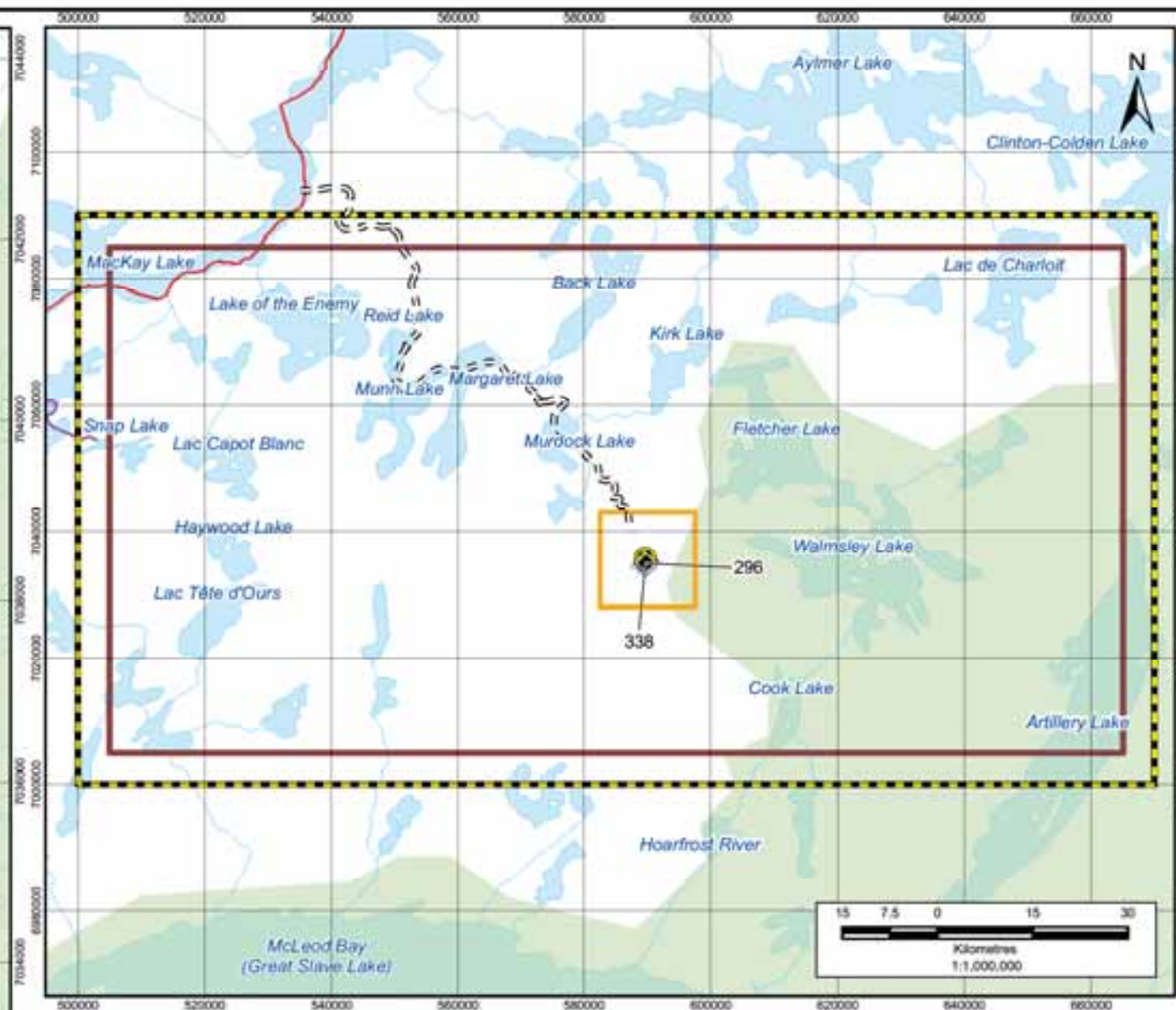
GAHCHO KUÉ PROJECT

Construction Case Maximum 24-hour TSP Concentrations

PROJECTION UTM Zone 12	DATE NAD83	 DE BEERS CANADA
Scale: 1:70,000 (LSA)		
FILE NO. SON-11.3-017-GIS		DATE December 13, 2010
JOB NO. 09-1365-1004	REVISION NO. 1	Figure 11.4-21
OFFICE GOLD-CAL	DRAWN SK CHECK GU	



NOTES
Base data source: National Topographic Base Data (NTDB) 1:50,000.




LEGEND

- Gahcho Kué Project
 - Existing Winter Road
 - Tibbitt to Contwoyto Winter Road
 - Proposed Winter Access Road
 - Watercourse
 - Waterbody
 - Maximum Prediction Within LSA Excluding Development Area
 - Maximum Prediction Within LSA
 - Maximum Prediction Within RSA
 - Maximum Prediction Within RSA Excluding Development Area
 - Development Area Boundary
 - Local Study Area
 - Modelling Domain
 - Project Footprint
 - Regional Study Area
 - The Study Area for a National Park on the East Arm of Great Slave Lake
- Concentration ($\mu\text{g}/\text{m}^3$)**
- ≥ 60
 - 30 to < 60
 - 15 to < 30
 - 0 to < 15
- NWT Standard = $60 \mu\text{g}/\text{m}^3$ GNWT (2002)

GAHCHO KUÉ PROJECT

Construction Case Annual Average TSP Concentrations

PROJECTION UTM Zone 12	DATUM NAD83	 DE BEERS CANADA
Scale: 1:70,000 (LSA)		
FILE NO. SON-11.3-018-GIS		DATE December 13, 2010
JOB NO. 09-1365-1004	REVISION NO. 1	Figure 11.4-22
OFFICE GOLD-CAL	DRAWN BY SK CHECKED BY GU	

11.4.5.8 Summary of Human Health Assessment

A human health risk assessment was completed to evaluate how the predicted changes to air quality outlined herein could potentially affect human health. The result of the assessment indicated that individuals living immediately adjacent to the Project site (i.e., at the Project development area boundary) could experience health issues related to the elevated levels of particulate matter and associated metals that are predicted to occur in this area. However, individuals do not currently live at the Project development area boundary, and it is unlikely that non-workers would do so during the construction and operation phases of the Project when particulate levels are predicted to be elevated. This exposure scenario was used to provide a conservative evaluation of potential effects to individuals using the area for traditional purposes, because traditional purposes typically involve a temporary presence on the land near the Project site. No impacts were predicted for individuals residing farther away from the Project area, in established communities or within the boundaries of the proposed national park.

For individuals at the Project site, the human health assessment was completed using the conservative air quality predictions described herein and conservatively assuming complete, continuous exposure to maximum air concentrations at the worker camp. It did not account for the filtration or other similar systems that are to be incorporated into on-site buildings where workers spend appreciable amounts of time, including the processing plant, the on-site workers camp and other non-storage facilities. It also did not account for the issuance and use of personal protective equipment and De Beers commitment to maintaining a healthy and safe work environment that meets or exceeds all applicable operational health and safety standards. Consequently, the results of the human health risk assessment correspond to an extreme condition that has a low likelihood of occurring.

De Beers is committed to:

- further evaluating the assumptions used to develop the predicted particulate and associated metal levels outlined herein;
- updating the human health assessment based on any changes to these assumptions; and
- developing an ambient air quality monitoring program that will be used to guide adaptive management strategies and the implementation of mitigation, if and as required, to maintain exposure to particulate materials below those that would be of concern.

As a result, the health of on-site workers and off-site traditional or recreational land users is not expected to be detrimentally affected by the changes to air quality that may occur as a result of Project activities. However, this statement is contingent on the results of further study and the implementation of mitigative strategies to the extent required to maintain exposure levels below those that would be of concern.

11.4.6 Residual Effects Summary

Residual effects on air quality for the Application Case were evaluated by comparison to ambient air quality guidelines that include NWT Air Quality Standards and National Ambient Air Quality Objectives. A summary of the predicted maximum concentrations outside of the development area within the RSA is presented in Table 11.4-27 for all substances with regulatory ambient air quality guidelines. No predicted concentrations were above ambient air quality guidelines outside of the LSA or inside of the proposed national park.

Table 11.4-27 Summary of Key Modelled Air Quality Concentrations in the Regional Study Area

Substance and Averaging Period	Regulatory Air Quality Guidelines ($\mu\text{g}/\text{m}^3$)	Maximum Concentrations Excluding Development Area	
		Baseline Case	Application Case
1-hour SO_2	450 ^(a)	24.0	42.9
24-hour SO_2	150 ^(a)	8.5	32.9
Annual SO_2	30 ^(a)	3.0	4.8
1-hour NO_2	400 ^(b)	109.8	314.3
24-hour NO_2	200 ^(b)	81.2	224.8
Annual NO_2	60 ^(c)	11.9	64.3
1-hour CO	15,000 ^(c)	159.2	1,978.6
8-hour CO	6,000 ^(c)	83.7	1,692.1
24-hour $\text{PM}_{2.5}$	30 ^(d)	5.5	228.9
24-hour TSP	120 ^(d)	7.1	4,837.6
Annual TSP	60 ^(a)	7.1	604.8

Note: A predicted concentration that exceeds a criterion is accentuated in bold.

^(a) GNWT (2010) air quality standard and Environment Canada (1981) national desirable ambient air quality objective.

^(b) Environment Canada (1981) acceptable ambient air quality objective.

^(c) Environment Canada (1981) desirable ambient air quality objective.

^(d) GNWT (2010) air quality standard and Environment Canada (1981) national acceptable ambient air quality objective.

$\mu\text{g}/\text{m}^3$ = microgram per cubic metre; SO_2 = sulphur dioxide; NO_2 = nitrogen dioxide; CO = carbon monoxide; PM = particulate matter; TSP = total suspended particulates.

Predicted maximum concentrations of SO_2 and CO outside the development area are in compliance with the applicable ambient air quality guidelines. Predicted

maximum concentrations outside the Project development area are higher than ambient air quality guidelines for NO₂ (24-hour and annual), PM_{2.5} (24-hour), and TSP (24-hour and annual).

The maximum Application Case 24-hour NO₂ concentration exceeds the most stringent National Ambient Air Quality Objective outside the Project development area for no more than two days per year. Maximum 24-hour and annual NO₂ results occur along the edge of the Project development area boundary, near the South Mine Rock Pile and haul road. Predicted exceedences of guidelines are localized. Predicted NO₂ concentrations may be over-estimated by the use of the OLM method for conversion of NO_x to NO₂, rather than the ambient ratio method, which is based on regionally measured values.

The maximum 24-hour PM_{2.5} concentration exceeds the NWT Air Quality Standard outside the Project development area for as much as 69 days in a year. The exceedences are located in areas to the south, west and east of the Project. They are primarily a result of fugitive road dust emissions from haul roads along the development area boundary. Particulate fugitive emissions are also based on conservative estimates. Areas of exceedence are confined to a 3-km radius around the Project, with predictions decreasing rapidly with increasing distance from the development area boundary.

Maximum predicted 24-hour and annual TSP concentrations outside the development area are above guidelines. The 24-hour concentration is predicted to exceed the guideline for up to 325 days in a year. The exceedences are located in areas to the south, west and east of the Project and they are due primarily fugitive road dust emissions from haul roads along the development area boundary. The areas of exceedence are confined to a 2-km radius of the Project, with predicted concentrations decreasing rapidly as distance from the development area boundary increases. As with the other particulates, the TSP fugitive emission estimates are expected to be a conservative representation of predicted air quality changes.

11.4.7 Residual Impact Classification

11.4.7.1 Methods

11.4.7.1.1 *Impact Classification Criteria*

The purpose of the residual impact classification is to describe the residual air quality effects associated with the Project in terms of compliance with applicable ambient air quality guidelines. The ambient air quality guidelines that were used for this exercise are the NWT Air Quality Standards (GNWT 2010) and the National Ambient Air Quality Objectives (Environment Canada 1981). Residual impact criteria use a scale of common words (rather than numbers or units), which is stipulated in the Terms of Reference for the Project (Gahcho Kué Panel 2007).

As specified in the Terms of Reference (Gahcho Kué Panel 2007), the classification system uses the following criteria to describe impacts of the Project on the valued components:

- direction;
- magnitude;
- geographic extent;
- duration;
- reversibility;
- frequency;
- likelihood; and
- ecological context.

The impact classification for air quality followed the general approach outlined in Section 6. Definitions for each criterion are provided below; and details of the selected impact classification criteria for air quality are presented in Table 11.4-28.

Table 11.4-28 Definition of Terms Used in the Residual Impact Classification

Direction	Magnitude	Geographic Extent ^(a)	Duration	Frequency	Reversibility	Likelihood
Negative: An increase relative to baseline values Positive: A decrease relative to baseline values Neutral: No change from the baseline values	Negligible: modelled increase less than 1% of the relevant regulatory ambient air quality guideline Low: maximum value remains below the most conservative (stringent) regulatory ambient air quality guideline – federal “desirable” level Moderate: maximum concentration falls between the most conservative and least conservative regulatory ambient air quality guideline (although not the “tolerable” federal level) High: maximum is greater than the least conservative regulatory ambient air quality guideline (although not the “tolerable” federal level)	Local: restricted to the local study area Regional: geographic extent is greater than local, but occurs within the regional study area Beyond Regional: occurs outside of the regional study area	Short-term: impact lasts for less than or equal to two years Medium-term: impact lasts for more than two years, but does not extend beyond closure Long-term: impact extends beyond mine closure	Isolated: confined to a specific discrete period Periodic: occurs intermittently but repeatedly over the assessment period Continuous: will occur continually over the assessment period	Reversible: impact will not result in a permanent change in concentrations or deposition Irreversible: impact is not reversible (i.e., duration of impact is unknown or permanent)	Unlikely: the impact is likely to occur less than one in 100 years Possible: the impact will have at least one chance of occurring in the next 100 years Likely: the impact will have at least one chance of occurring in the next 10 years Highly Likely: the impact is very probable (100% chance) within a year

^(a) “The only air quality receptor endpoint within the LSA that is relevant to the regulatory ambient air quality guidelines is the boundary of the area of interest for the proposed East Arm National Park, which is located approximately 3 km southeast of the Project development area boundary. For the purposes of impact classification, impacts within the area of interest for the proposed national park would be considered regional.

% = percent.

Direction: Direction indicates whether the projected impact is negative (i.e., less favourable), positive (i.e., beneficial), or neutral (i.e., no change). The direction of all air quality effects is considered to be negative.

Magnitude: Magnitude is a measure of the intensity of the projected impact. The four scales of intensity are negligible, low, moderate, or high (i.e., a measure of the degree of modelled change in an air quality constituent, and is classified as negligible, low, moderate, or high). Magnitude was assessed using the NWT Air Quality Standards and National Ambient Air Quality Objectives, which are collectively referred to herein as regulatory ambient air quality guidelines:

- The magnitude was classified as “negligible” if there was no predicted increase, or the predicted increase due to the Project emissions was less than 1% of the relevant regulatory ambient air quality guideline. Predicted increases of this magnitude should not be measurable.
- A “low” magnitude was assigned when an increase was predicted; however, the maximum value remains below the most stringent regulatory ambient air quality guideline.
- A “moderate” magnitude was assigned when the predicted maximum concentration falls between the most stringent and least stringent regulatory ambient air quality guideline (excluding federal “tolerable” level).
- A “high” magnitude would be assigned when the predicted maximum concentration is greater than the least stringent regulatory ambient air quality guideline.

For substances with only one regulatory criterion, there would be no moderate magnitude, only negligible, low, or high.

Geographic Extent: Geographic extent refers to area impacted. For most air quality key impact parameters, effects are largest nearest the source (local effects) and decrease rapidly with distance away.

Duration:	Duration refers to the overall time frame during which the impact may occur.
Frequency:	Frequency refers to how often the projected impact will occur. The scales of frequency are isolated, periodic, and continuous. Project air emissions are generally continuous and, therefore, the potential frequency of impact is continuous, even though the frequency at which predicted concentrations exceed guideline values may vary.
Reversibility:	Impacts are reversible if the impact will last for only a finite and reasonable period of time. Impacts are irreversible if impacts will last indefinitely. Reversibility must be evaluated separately for any air quality impacts that are long-term in duration.
Likelihood:	Likelihood is the probability of an impact occurring and is described in parallel with uncertainty. In the case of air quality, likelihood depends on the several factors, including the certainty in the emission estimates, the representativeness of meteorology and surface features, and confidence in model results.
Ecological Context:	Ecological context refers to the nature of the projected impact and takes into account the assessment endpoint that is being classified. Ecological context is not used for classifying air quality impacts.

11.4.7.1.2 *Environmental Consequence*

The classification of projected impacts was completed using the residual impact classification criteria presented in Table 11.4-28, and was based on a two-step process. Initially, direction, magnitude, geographic extent, duration, and reversibility were used to determine environmental consequence. Environmental consequence represents, in a single term, the overall impact of the Project on the assessment endpoint in question, and it was scored as negligible, low, moderate, or high.

Direction, magnitude, duration, geographic extent, and reversibility were used to determine environmental consequence, because they describe key aspects of the projected impact, in terms of the nature of the impact (direction), the intensity of the impact (magnitude), how long it will last (duration), how spatially extensive it will be (geographic extent), and whether the system will recover after the stressor is removed or the activity stopped (reversibility).

When evaluating environmental consequence, the classification of projected impacts proceeded in a stepwise manner, beginning with direction followed by magnitude. If the magnitude of projected impacts to a given assessment endpoint was determined to be negligible, then the classification process stopped at that point. For example, the duration, geographic extent, and reversibility of an impact of negligible magnitude become meaningless, because, by definition, an impact of negligible magnitude equates to no measurable change from existing conditions.

11.4.7.1.3 Significance

For air quality, environmental significance was classified as follows:

- Impacts with an environmental consequence of negligible or low will not be considered environmentally significant.
- Impacts with a moderate environmental consequence will not be considered environmentally significant if impact magnitudes of moderate or high occur in the immediate vicinity of the Project but not within the area of interest for the proposed national park.
- Impacts with a moderate environmental consequence will be considered to be environmentally significant if impact magnitudes of moderate or high occur within the area of interest for the proposed national park.
- Impacts with a high environmental consequence will be considered environmentally significant.

The area of interest for the proposed national park was used as a key assessment location within the LSA for determination of environmental significance because it is the closest location to the Project with the potential to be used regularly by people in the future.

11.4.7.2 Results

A summary of the proposed air quality impact ratings is provided in Table 11.4-29. All air quality impacts were classified as local in geographic extent and of medium-term duration since emissions cease when Project activities stop. Maximum impact magnitudes ranged from low to high within the LSA; however, impact magnitudes were low within the area of interest of the proposed national park. Consequently, impacts to air quality were classified as not environmentally significant.

The impact ratings are discussed in more detail below for the air quality assessment endpoint (i.e., substances with applicable ambient air quality guidelines):

- The impact of potential SO₂ emissions is considered low magnitude, with predicted concentrations at all locations substantially less than NWT Air Quality Standards. Confidence in Project assessment results is considered high assuming that diesel fuel with 15 ppmw sulphur content will be available for use in the area.
- The impact magnitudes due to Project NO_x emissions vary from low (1-hour NO₂) to moderate (annual NO₂) to high (24-hour NO₂). Depending on the NO_x to NO₂ conversion approach used in the modelling, predicted concentrations could be lower than the most stringent ambient guideline. Based on a conservative NO_x to NO₂ conversion technique (OLM), predicted concentrations are near guideline levels immediately outside the Project development area. The Project effects are limited to the immediate vicinity of emission sources.
- Predicted PM_{2.5} concentrations are considered high magnitude as predicted concentrations outside the development area are above the NWT air quality standard. Uncertainty in modelled results is high given the uncertainty in the estimated fugitive dust emissions. Due to the generally conservative nature of fugitive and wind-blown emission estimates, there is a high degree of confidence that actual concentrations will be less than modelled results.

Table 11.4-29 Summary of Environmental Consequence and Impact Significance for Air Quality

Assessment Endpoint	Ecological Context	Direction	Geographical Extent	Duration	Frequency	Reversibility	Magnitude	Level of Confidence	Likelihood	Environmental Consequences	Environmental Significance
SO ₂ Concentration	potential animal and human health impacts	negative	local	medium-term	continuous	reversible	low	high ^(a)	likely	low	not significant
NO ₂ Concentration	potential for odour perception, human and animal health impacts at high concentrations and vegetation impacts	negative	local	medium-term	continuous	reversible	high	moderate	likely	low	not significant
CO Concentration	potential animal and human health impacts	negative	local	medium-term	continuous	reversible	low	high	likely	low	not significant
PM _{2.5} Concentration	potential animal and human health impacts and visibility impairment health and vegetation impacts	negative	local	medium-term	continuous	reversible	high	low ^(b)	likely	moderate	not significant
TSP Concentration	potential nuisance impacts and visibility impairment	negative	local	medium-term	continuous	reversible	high	low ^(b)	likely	moderate	not significant

^(a) Assuming availability of low sulphur (15 parts per million by weight) in diesel.

^(b) Degree of natural mitigation on road dust emissions during winter is uncertain. Assumption of no natural mitigation on the road dust emissions during winter may be overly conservative. As a result, there is a low level of confidence that observed concentrations will be as high as outlined herein. There is a high level of confidence that actual concentrations will be lower than predicted.

SO₂ = sulphur dioxide; NO₂ = nitrogen dioxide; PM = particulate matter; TSP = total suspended particulates.

- Predicted 24-hour and annual TSP concentrations are above NWT air quality standards outside the development area; therefore the magnitude of the impact is high. Uncertainty in modelled results is considered high given the uncertainty in estimating fugitive dust emissions. Due to the conservative nature of the road dust emission estimates, there is a high degree of confidence that actual concentrations will be less than the modelled results. Similarly, estimates of TSP deposition and associated metal deposition rates are conservative due to the conservative nature of the emission estimation methods.

In summary, none of the impacts on specific air quality indicators have been rated as above moderate. Modelled parameters including particulate and NO₂ exceed guideline levels but in areas immediately adjacent to the Project activities. Monitoring programs, discussed in Section 11.4.9, will be developed within the context of an emissions management plan. This is considered an appropriate response to the predicted results and will also act to increase the certainty that impacts will not be greater than expected.

11.4.8 Uncertainty

Dispersion models simplify the atmospheric processes associated with air mass movement and turbulence. This simplification limits the capability of a model to replicate discrete events and therefore introduces uncertainty. As a result of the uncertainty, dispersion models, coupled with their model inputs, are generally designed to conservatively model concentration and deposition values so that practitioners can apply model results with the understanding that effects are likely to be over-estimated.

The following general comments are made with respect to representative modelling results for this Project:

- Modelling maximum emission rates from the Project will provide conservative results due to the fact that most equipment does not operate at its maximum capacity on a continuous basis. This assumption can lead to overestimation of the potential Project impacts for the longer averaging periods (24-hour and annual).
- Parameterization of emissions from diffuse area sources is difficult to simulate in dispersion models. The Project area emission sources include mine pits, roads, and mine rock piles.
- The Project fugitive particulate matter emissions are difficult to quantify accurately. The estimated fugitive particulate matter emissions, particularly the annual particulate matter emissions, assessed in the EIS

are decidedly conservative. Detail discussions on the conservatism in the emission estimation are provided in Appendix 11.4.II, Section 11.4.II.5. Based on a review of the PM monitoring data at the Snap Lake Mine and the Ekati mine, the high particulate matter impacts identified in this assessment are due in part to the conservative emission estimates. De Beers is committed to conducting further analysis of the particulate matter issue by providing additional refinement of the emission characterizations and investigating the potential to take additional mitigation measures to reduce the fugitive particulate matter emissions.

The CALPUFF model as applied to the Project and described in detail in Appendix 11.4.I has a number of limitations that result in model uncertainty. For this Project:

- Modelled results near mine pits and other sources of mechanically generated particulate are most uncertain. Most estimates of particulate emissions for mining activities are based on U.S. EPA emission factors. Many of these factors have limited applicability outside of the area in which they were developed (typically south-western United States coal mines). Based on experience, it is expected that emissions estimated using this approach would be conservative.
- In cold weather conditions, such as those experienced at the Project site, the conversion of NO emissions to NO₂ concentrations will occur at a slower rate than in warmer conditions because the transformation is temperature dependent. Models assume the conversion is instantaneous, introducing uncertainty into the location and magnitude of predicted NO₂ concentrations.

11.4.9 Monitoring and Follow-up

11.4.9.1 Emissions Monitoring

De Beers will conduct an emissions test for one of the power generators after Project start-up to confirm the estimated emission rates documented in Appendix 11.4.II. After start-up, annual emission testing of one stack will be conducted, decreasing in frequency after two years of consistently compliant results. The tests will include SO₂, NO₂, CO, and PM_{2.5}.

11.4.9.2 Ambient Air Quality Monitoring

A small network of monitoring stations, e.g., SO₂, NO₂, particulates and dustfall will be established around the Project site, targeting locations where vegetation and soils are considered most sensitive and where predicted concentrations and

dust deposition rates are elevated. Appropriate care would be taken to ensure that the monitoring can occur year-round.

An air quality and emissions management plan (also including dust deposition) will be developed which will include a detailed assessment of the timing, specific technology and monitoring locations for each of the air quality parameters being considered for monitoring. The plan will be developed so that monitoring can adapt to changing conditions and influence the pertinent management decisions relating to ongoing Project operations. The plan will also include a mechanism that will identify conditions that should lead to a reduced monitoring program, e.g., measured ambient concentrations that are actually substantially lower than the modelled results presented in this EIS.

11.4.10 References

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11.4.11 Acronyms and Glossary

11.4.11.1 Acronyms and Abbreviations

AENV	Alberta Environment
AMEC	AMEC Earth & Environmental
BATEA	best available technology economically achievable
C	carbon
CALMET	California meteorological model
CALPUFF	California puff plume dispersion model
CASA	Clean Air Strategic Alliance
CCME	Canadian Council of Ministers for the Environment
CO	carbon monoxide
CO₂	carbon dioxide
De Beers	De Beers Canada Inc.
EIA	environmental impact assessment
EIS	environmental impact statement
GHG	greenhouse gas

GNWT	Government of the Northwest Territories
ISC3	industrial source complex – version 3
ISO	International Organization for Standardization
LSA	local study area
MVEIRB	MacKenzie Valley Environmental Impact Review Board
N	nitrogen
NARR	North American Regional Reanalysis
NCAR	National Centre for Atmospheric Research.
NO	nitric oxide
NO₂	nitrogen dioxide gas
NO₃⁻	nitrate ion
NO_x	nitrogen oxides
NWT	Northwest Territories
OLM	ozone limited method
PAH	polycyclic aromatic hydrocarbon
PAI	potential acid input
PM	particulate matter, generally
PM₁₀	particulate matter of particle diameter less than 10 µm
PM_{2.5}	particulate matter of particle diameter less than 2.5 µm
PRIME	plume rise model enhancement
Project	Gahcho Kué Project
RELAD	Regional Lagrangian Acid Deposition Model
RSA	regional study area
S	sulphur
SO₂	sulphur dioxide gas
SO_x	sulphur oxides
SP	suspended particulate
TSP	total suspended particulates
U.S. EPA	United States Environmental Protection Agency
UTM	universal transverse mercator
VC	valued component
VOC	volatile organic compound
W	watt
WHO	world health organization

11.4.11.2 Units of Measure

%	percent
μ	micro - 10^{-6}
μg/m³	micrograms per cubic metre
°	degree
°C	degrees Celsius
μm	micron or micrometre = 10^{-6} m
5.21E-02	Scientific notation: 0.0521 = 5.21E-02 = 5.21×10^{-2}
d	day = calendar day
g	gram
g/GJ	gram per gigajoule
GJ/h	gigajoule per hour
h	hour
ha	hectare (0.01 km ²)
I-TEQ	International Toxic Equivalency Quotient, relative to the toxic equivalent of 2,3,7,8-tetrachlorodibenzo-para-dioxin
J	Joule
k	kilo – a thousand - 10^3
keq/ha/y	Kilo-equivalent (hydrogen ion equivalent – 1 keq = 1 kmol H ⁺) per hectare per year. Measure of PAI deposition.
kg	kilogram
kgN/ha/y	kilogram nitrogen per hectare per year
km	kilometre
km/h	kilometres per hour
km²	square kilometres
kmol	10^3 mol
L	litre
M	mega – million - 10^6
m	metre
m/s	metres per second
Mt	mega-tonne, one million (10^6) tonnes
p	Pico - 10^{-12}
Pa	Pascal
pg I-TEQ/m³	picograms of international toxic equivalency quotients per cubic metre
ppb	parts per billion
ppbv	parts per billion by volume
ppm	parts per million
ppmv	parts per million by volume

ppmw	parts per million by weight
t	tonne = 1,000 kg
t/d	tonnes per day
t/y	tonne per year
y	year

11.4.11.3 Glossary

Ambient air quality guideline	An ambient outdoor air concentration or deposition value for a specific substance, or groups of substances that has been established to safeguard the health of ecosystem components (most often sensitive humans or vegetation).
Ambient air quality objectives	Levels of concentration or deposition of specific chemicals or materials that are established to safeguard the health of ecosystem components (most often sensitive humans or vegetation).
Acrolein	Simplest unsaturated aldehyde (molecular formula C ₃ H ₄ O).
Adverse effect	An undesirable or harmful effect to an organism (human or animal) indicated by some result such as mortality, altered food consumption, altered body and organ weights, altered enzyme concentrations or visible pathological changes.
Air quality	A measure of contaminant concentrations in ambient air. Lower concentrations lead to better air quality.
Airshed	A geographical region with similar dispersion characteristics or common emissions.
Al₂O₃	The native oxide growth that occurs on freshly deposited aluminum used as an abrasive used in grinding operations.
Aldehyde	Organic compound containing carbonyl group (COH). The word aldehyde originates from alcohol dehydrogenated.
Aluminum	Silvery white and ductile member of the poor metal group of chemical elements, the most abundant metal in the Earth's crust, and the third most abundant element overall.
Ambient	The conditions surrounding a person, sampling location, etc.
Anthropogenic	Anthropogenic effects or processes are those that are derived from human activities, as opposed to effects or processes that occur in the natural environment without human influences.
Area source	Source of pollution which emits a substance or radiation from a specified area.
Arsenic	As: chemical element.
Atmospheric stability	Tendency of parcels of air to move in the vertical relative to the atmosphere surrounding them. Three conditions are generally described: stable, unstable, and neutral. The oldest and the most popular stability classification is the Pasquill Stability Classification.
Average	A single statistical value used to characterize a series of data values. The average value is calculated as the sum of the data values divided by the number of data values. It represents the data centre value of a series of values, and does not differ substantially from the statistical median value when the data values are evenly and symmetrically distributed.

Background	An area (or state of the atmosphere) not influenced by chemicals released from the site under evaluation.
BATEA	Best Available Technology Economically Achievable (BATEA) refers to technology that can achieve superior emissions performance and that has been demonstrated to be economically feasible through successful commercial application across a range of regions and fuel types.
Base Cation	An alkali or alkaline earth metal cation (Ca^{2+} , Mg^{2+} , K^{+} , Na^{+}).
Baseline	A condition which serves as a reference point to which later observations or model results can be correlated.
Benzene	Aromatic hydrocarbon ring or cyclic compound (C_6H_6) where each carbon in the ring only leaves one free bond for hydrogen.
Benzo(a)Pyrene	A polycyclic aromatic hydrocarbon with a high level of toxicity.
Biogenic	Produced by living organisms or biological processes.
Cadmium	A relatively rare, soft, bluish-white, transition metal.
CALETA	CALMET pre-processor converting NCEP Eta Model output to the format that may be used by CALMET model.
CALMET	California Meteorological Model is a model that numerically simulates a three dimensional field of meteorological parameters for use by CALPUFF.
CALNARR	CALMET preprocessor converting NCEP NARR model output to a format used by the CALMET model. This program was developed by NCAR specifically for the current Project.
CALPUFF	California Puff Model is a plume dispersion model that utilizes a three-dimensional field of meteorological parameters to simulate substance transport through atmosphere resulting in the numerical simulation of deposition rates and concentrations of substances.
Catalytic converters	A reaction chamber typically containing a finely divided platinum-iridium catalyst into which exhaust gases from an automotive engine are passed together with excess air so that carbon monoxide and hydrocarbon substances are oxidized to carbon dioxide and water.
Cation	A positively charged ion such as calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), and hydrogen (H).
Climate	Weather averaged over a long period of time.
Carbon monoxide	An odourless, colourless, non-irritating, toxic gas and a product of incomplete combustion of fuel (gas, diesel, etc.).
Carbon dioxide	A greenhouse gas emitted from combustion or respiration.
Cobalt	A hard, lustrous, silver-grey meta, often occurring as a metal oxide or sulphide together with other trace metals in wind-blown dust associated with mineral deposits rich in trace metal minerals.
Combustion	The burning of substances in a closed chamber under pressure.
Canada-Wide Standards	Government of Canada guidance for air quality standards prepared by Canadian Council of Ministers of Environment.
Data logger	A stand-alone device that can read various types of electrical signals and store the data in internal memory for later download to a computer.

Dioxins	A variety of chemical compounds that can be described by the chemical formula: $C_4H_4O_2$.
Dispersion modelling	Computer, mathematical simulation of contaminants transport through atmosphere. Dispersion modelling may also account for chemical transformations in atmosphere. The results of dispersion modelling are simulated values of deposition to ground or air concentration of chemicals.
Dry deposition	The removal of gaseous or particulate material from the pollution plume by contact with the ground surface or vegetation (or even water surfaces) through transfer processes such as absorption and gravitational sedimentation.
Ecological risk	Process for analyzing and evaluating the possibility of adverse ecological effects caused by environmental pollutants.
Ecosystem	An integrated and stable association of living and non-living resources functioning within a defined physical location.
Emission	Release of substances to atmosphere (can be fugitive emission, stack emission, diesel exhaust, mechanical ground disturbance, etc.).
Eutrophication	Increases in chemical nutrients, typically compounds containing nitrogen or phosphorus, in an ecosystem. The term is often used to describe the resultant increase in the ecosystem's primary productivity, including excessive plant growth and decay resulting in a lack of oxygen and reductions in water quality and in fish and other animal populations.
Exposure	Estimated dose of a substance that is received by a particular receptor via various specific exposure pathways (e.g., ingestion, inhalation, and skin contact).
Foliage	Plant leaves, especially tree leaves.
Formaldehyde	A colourless gaseous compound (HCHO) and the simplest aldehyde.
Fugitive emissions	Contaminants emitted from any source except those from stacks and vents. Typical particulate sources include wind blown dust, bulk storage areas, open conveyors, construction areas or plant roads.
Furans	One of a group of colorless, volatile, heterocyclic organic compounds containing a ring of four carbon atoms and one oxygen atom.
Greenhouse gas	Greenhouse gas which when emitted to the atmosphere causes heat emitted from the earth to be partially trapped within the atmosphere.
Ground-level concentration	Modelled concentration of a substance in the air near ground level.
Granite	A coarsely crystalline igneous intrusive rock composed of quartz, potassium and sodium feldspar, mica or hornblende.
Health risk	The likelihood or probability that the toxic effects associated with a chemical will be produced in populations of individuals under their actual conditions of exposure. Risk is usually expressed as the probability of occurrence of an adverse effect, i.e., the expected ratio between the number of individuals that would experience an adverse effect at a given time and the total number of individuals exposed to the chemical.
Hydrology	Study of the movement, distribution, and quality of water.
Indicator	A measurable parameter used as a surrogate. For example, SO_2 and NO_2 concentrations are used as surrogates for air quality.

ISC3	U.S. Environmental Protection Agency Gaussian steady-state dispersion model - Industrial Source Complex, Version 3.
ISO 14001	Environmental management standards (drafted by International Standard Organization), which help organizations minimize how their operations negatively affect the environment, comply with applicable laws, regulations, and other environmentally oriented requirements, and continually improve on the above.
Isopleth	A line on a map connecting places sharing the same feature (e.g., ground-level concentrations).
I-TEQ	International Toxic Equivalency Quotients (relative to 2,3,7,8-tetrachlorodibenzo-para-dioxin) are internationally established (through NATO) multiplication factors that are used to collectively express the toxicity of various dioxins, furans and co-planar PCBs (polychlorinated biphenyls) to humans, mammals, fish and birds relative to most toxic of these substances: 2,3,7,8-tetrachlorodibenzo-para-dioxin. The multiplication factors range from 0.000001 to 1.000000.
Kimberlite	Igneous rocks that originate deep in the mantle, intrude into the earth's crust and typically form narrow pipe-like deposits that may contain diamonds.
Lead	A soft, heavy, toxic, and malleable poor metal that is bluish white when freshly cut but tarnishes to dull gray when exposed to air.
Manganese	Free metal element in nature (often in combination with iron) and in many minerals.
Mechanical turbulence	Flow characterized by chaotic property changes (e.g., rapid variation of pressure and velocity in space and time) caused by wind going over obstacles.
Median	A single statistical value used to characterize a series of data values. Half of the data values are larger than the median value, and half of the data values are less than the median value.
Metal	A particular metal concentration (in ambient air) or deposition value (as herein documented) refers to the total metal portion of various metal oxides, sulphides, salts, and organic versions associated with the minerals in wind-blown dust and the partially reacted metals (from lube oil additives and engine wear) in diesel engine exhaust.
Mercury	A heavy, silvery potentially toxic transition metal.
Mitigation	Actions taken to reduce negative or harmful effects.
Mixing height	The height to which the lower atmosphere will undergo mechanical or thermal mixing and produce a nearly homogeneous air mass. Lower mixing heights may result in elevated ground-level concentrations for sources releasing emissions close to the ground (e.g., mines).
MnO	Manganese oxide found in granites and kimberlite.
Mol	The amount of a substance that contains as many atoms, molecules, ions, or other elementary units as the number of atoms in 0.012 kilogram of carbon 12. The number is 6.0225×10^{23} , or Avogadro's number.
Maximum point of impingement	The point where an elevated plume first touches the ground.
Naphthalene	A white crystalline aromatic hydrocarbon (C ₁₀ H ₇ OH).

NARR	North American Regional Reanalysis weather forecast model created by NCEP which is part of NOAA http://www.emc.ncep.noaa.gov/mmb/rreanl .
Nickel	Silvery white metal that takes on a high polish.
Nitrogen dioxide	One of the component gases of oxides of nitrogen which also includes nitric oxide. In burning natural gas, coal, oil and gasoline, atmospheric nitrogen may combine with molecular oxygen to form nitric oxide, an ingredient in the brown haze observed near large cities. Nitric oxide is converted to nitrogen dioxide in the atmosphere.
Nitric oxide	Nitric oxide gas (NO) is the principal nitrogen oxide (NO _x) constituent in the exhaust from combustion sources (due to the oxidation of fuel nitrogen constituents and the nitrogen in the combustion air). Nitrogen dioxide gas (NO ₂) is also produced during combustion; however, in much smaller amounts relative to NO (due to the slow rate of NO to NO ₂ oxidation in the presence of oxygen only and without catalysts present). Exhaust containing NO will however completely transform into NO ₂ when entering the atmosphere for two reasons: (i) the presence of atmospheric ozone (which is a much stronger NO to NO ₂ oxidation driver than oxygen, although the ambient air initially entrained into the exhaust plume may contain insufficient ozone to fully oxidize all NO present), and (ii) the long chemical transformation and reaction time, for NO to NO ₂ oxidation, afforded by hours of plume transport time (with ongoing entrainment of ozone-containing ambient air during dispersion).
Nitrogen deposition	The deposition of ammonia (NH ₄ ⁺), nitrogen dioxide (NO ₂), and nitrate (NO ₃ ⁻) substances, expressed as mass equivalent nitrogen per unit area per unit time.
Non-foliage period	Period of the year when there are no leaves on trees.
Nutrient	Water dissolved ammonia and phosphorous based substances that act as fertilizers in aquatic ecosystems.
Overburden	Material overlying a useful mineral deposit.
Ozone	A molecule, consisting three oxygen atoms, formed from precursor emissions of NO _x and volatile organic compounds with potentially harmful effects on respiratory system of animals and humans.
Ozone limited method	A means to estimate the creation rate of NO ₂ from NO based on the amount of ozone in the air.
Polycyclic aromatic hydrocarbons	A group of products of incomplete combustion or evaporation of hydrocarbons.
Potential acid input	A measure of acidification resulting from sulphur and nitrogen deposition to water and soil.
Parameter	A particular physical, chemical property that is being measured in air (e.g., wind speed, wind direction, temperature benzene content, etc.).
Peak operation	Associated with operations at maximum plant and mine design levels for all equipment, resulting in the maximum daily and hourly emissions of contaminants.
Percentile (e.g., 98%)	The 98 th percentile is the specific value (e.g., air quality ground-level concentration) below which 98% of the observed or modelled values occur (and only 2% of the values exceed the 98 th percentile).
Photochemical	Chemical reactions brought about by the light energy of the sun.

Plume	A space in the air, water, or soil containing pollutants released from a source.
Plume rise	The final vertical plume position which depends on the temperature difference between stack and atmosphere and on the exit velocity.
PM₁₀	Airborne particulate matter with a mean diameter less than 10 µm (microns) in diameter. This represents the fraction of airborne particles that can be inhaled into the upper respiratory tract.
PM_{2.5}	Airborne particulate matter with a mean diameter less than 2.5 µm (microns) in diameter. This represents the fraction of airborne particles that can be inhaled deeply into the pulmonary tissue.
Precursors	Something that comes before. In air quality, usually a substance from which the ozone is formed due to photosynthetic reactions.
Processed Kimberlite Containment	Man-made impoundment structure required to contain processed kimberlite slurry. Processed Kimberlite Containment (PKC) are enclosed dykes made with granite rock and overburden materials, constructed to stringent geotechnical standards.
Pollutant	A substance or condition that contaminates air, water, or soil (e.g., SO ₂ , CO ₂ , heat, light).
PRIME	The Plume Rise Model Enhancements model, designed to incorporate the two fundamental features associated with building downwash: enhanced plume dispersion coefficients due to turbulent wake, and reduced plume rise caused by a combination of the descending streamlines in the lee of the building and the increased entrainment in the wake.
Pristine	Original state of an ecosystem before human alterations were imposed
Radiation	Energy that comes from a source and travels through some material or through space. Light, heat and sound are types of radiation.
Receptor	The person or organism subjected to substance exposure.
RIVAD/ARM3	Chemical transformation module within CALPUFF dispersion model calculating NO _x and SO _x conversions, and sulphate and nitrate production.
Scale	Level of spatial resolution.
Silicon oxide	Quartz (silica, sand): the oxide of silicon commonly found in granite and kimberlite minerals.
Sulphur dioxide gas	Bluish in colour and is a product of combustion of sulphur compounds in fuels.
Sulphate ion	A product of sulphur dioxide oxidation in water, can be assimilated by roots of plants.
Suspended particulate	Often referred to as Total Suspended Particulate (TSP), consisting of all particles less than about 30-40 µm in diameter.
Spatial	Related to space.
Stable atmosphere	Atmospheric conditions in which colder air underlies warmer air. In this situation, mechanical turbulence is damped by the thermal stratification of the atmosphere. Resulting in limited vertical air motion and poor dispersion conditions.
Temporal	Related to time.
Thermal effects	Thermal convection caused by solar heating.
Threshold	Specified level.

Toxic	May, potentially, have adverse health effects.
Tundra	Any of the vast relatively treeless zones that lie to the south of the polar ice cap in North America and Eurasia, where the subsoil is permanently frozen.
Turbulence	Airflow characterized by chaotic property changes (e.g., rapid variation of pressure and velocity in space and time).
Typical operations	Associated with operations at average plant and mine design levels for all equipment. Operations result in the average annual emissions of substances.
UTM	Universal Transverse Mercator coordinate system: a grid based method of specifying locations, employing a series of sixty zones each based on a specifically defined secant Transverse Mercator projection.
VOC	Volatile Organic Compound that boils below a temperature of about 100°C, including all non-methane hydrocarbons (NMHC).
Volume source	a three-dimensional source of pollutant emissions (e.g., wind erosion from stockpiles).
Waste incinerator	A combustion chamber that incinerates biological, medical, hazardous chemicals, household waste, etc. and converts them to ashes.
Water quality	A measure of concentrations of contaminants, or naturally occurring minerals, in water. Lower the concentrations of a particular contaminant lead to better water quality.
Wet deposition	The removal of plume components by the action of rain or snow.
Wetlands	A low-lying area of soft, waterlogged ground and standing water. A lowland area, such as a marsh or swamp that is saturated with moisture.
Wind rose	A diagram showing the frequency and strength of the wind from different directions.

APPENDIX 11.4.I

DISPERSION MODELLING APPROACH

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11.4.I.1 INTRODUCTION

The purpose of this appendix is to present the technical information associated with air dispersion modelling that was completed for the Gahcho Kué Project (the Project). The following sections provide a synopsis of the appendix:

- description of the models considered for the assessment and rationale for model selection;
- overview of the meteorology data used in the modelling;
- description of modelling domain and associated receptor locations where ground-level concentrations and deposition values were calculated; and
- description of dispersion modelling approaches, including assumptions and model options.

Emission information used in the dispersion modelling is presented in Appendix 11.4.II.

11.4.I.2 REGULATORY MODEL GUIDANCE

11.4.I.2.1 NORTHWEST TERRITORIES AIR DISPERSION MODELLING GUIDELINES

Dispersion modelling guidelines have been established by several jurisdictions in Canada including Alberta and British Columbia. In the absence of a dispersion modelling guideline for the Northwest Territories (NWT), the dispersion modelling approach for this assessment is based on Air Quality Model Guideline developed by Alberta Environment (AENV 2009). The purpose of the guideline is to provide uniform benchmarks and a structured approach to the selection and application of dispersion models, and to ensure a sound scientific basis for the selection of alternatives. Issues considered by the guideline include:

- determination of model performance by comparing model predictions to air quality observations;
- meteorological data requirements;
- receptor placement;
- consideration of permanent structure (e.g., building) downwash effects;
- incorporation of complex terrain; and
- assumptions for consideration when preparing source information.

11.4.I.2.2 UNITED STATES ENVIRONMENTAL PROTECTION AGENCY GUIDANCE

All dispersion models considered for this Project were either developed or recommended by the United States (US) Environmental Protection Agency (US EPA 1992; 1999) to address regulatory modelling requirements. National (i.e., US) dispersion modelling guidelines used for regulatory application have a long development history and provide consistency between air quality assessments conducted in the US. These guidelines are found in Appendix W of Section 40 of the Code of Federal Regulations (US Government 2005), which describes each model accepted for regulatory use and provides guidance on the suitability of each model, which is dependent on the application.

11.4.I.2.3 MODELS EVALUATED

The models that were evaluated for use in the Project air quality assessment include:

- CALPUFF 3D – Lagrangian puff model in dynamic three-dimensional (3D) mode (CALPUFF using CALMET three-dimensional meteorology);
- CALPUFF 2D - Lagrangian model in steady-state two-dimensional (2D) mode (CALPUFF using Industrial Source Complex Model Version 3 [ISC3] single station meteorology); and
- AERMOD - a steady-state Gaussian dispersion model designed for short-range (up to 50 kilometres [km]) dispersion of air pollutant emissions from stationary industrial sources.

A brief description of each model follows.

11.4.I.2.3.1 CALPUFF 3D

The CALPUFF modelling system is a non-steady state meteorological and air quality modelling system that has been recommended for use by the US EPA (US EPA 1999), specifically for long-range transport (i.e., greater than 50 km) of air pollutants and associated effects.

The CALPUFF model was developed with the following objectives:

- to consider time varying point, line, area and volume sources;
- be suitable for modelling domains ranging from tens of metres to hundreds of kilometres from a source;
- predict averages ranging from one hour to one year;
- incorporate building downwash effects;
- be capable of incorporating horizontal and vertical wind shear effects;
- be applicable to inert pollutants and those subject to linear removal and chemical conversion mechanisms; and
- applicable for complex terrain scenarios.

Suitable application of the CALPUFF modelling system may include near field impacts associated with complex flow or drop areas (e.g., complex terrain, stagnation, calm wind conditions), long range transport of air pollutants, visibility assessment, criteria air pollutant (e.g., nitrogen oxide [NO_x], sulphur oxide [SO_x],

volatile organic compounds [VOCs]) modelling, buoyant area and line sources, and others.

In 3D mode, wind fields determined by the CALMET meteorological model can vary across the modelling domain on both horizontal and vertical scales. This variation often results in improved estimates of plume dispersion compared to non-varying wind fields. Additionally, terrain effects are incorporated into the wind field derivations to enable plumes to travel around or over terrain features, as appropriate, rather than impacting the features directly.

11.4.I.2.3.2 CALPUFF 2D

The CALPUFF model can be run in a steady-state or two-dimensional mode, which is more indicative of historical dispersion models including ISC3. Many of the CALPUFF dynamic model features are also available in two-dimensional mode. Features available include puff splitting, long-range transport estimates and chemical transformations; however, wind field variation is not a component of the 2D model. These features are considered to be a significant advantage over other models such as ISC3, but less of an advantage over AERMOD (Hanna et al. 2001).

11.4.I.2.3.3 AERMOD

The improvements of AERMOD over ISC3 include introduction of a non-Gaussian probability density function in the vertical dimension for unstable conditions. The dispersion is Gaussian in the horizontal for unstable conditions and in the horizontal and vertical for stable conditions. AERMOD produces profiles of wind, temperature and turbulence, using upper air measurements (Paine 2006).

The AERMOD model uses data from only one meteorological station. Additional land use parameters like Bowen Ratio, albedo, and roughness height (Z_o) are calculated or estimated for the area surrounding the station. These parameters may be different in the area of emission sources or sensitive receptors. The model is sensitive to the choice of those parameters (especially to the roughness height).

In the US, AERMOD is considered as the model of the choice for plume travel distances less than 50 kilometres (km). Since the Regional Study Area (RSA) chosen for the Project is larger enough (80 by 160 km) to capture the cumulative air quality effects contributed by the nearest diamond mine, which is located 85 km from the Project, the AERMOD model was not considered further.

11.4.I.3 SELECTED MODEL: CALPUFF 3D

For the purposes of assessing air quality effects from the Project, CALPUFF-3D (hereafter CALPUFF) was determined to be the most appropriate model. Key features of the CALPUFF model are presented in Table 11.4.I-1. The primary rationale for use of the CALPUFF model includes the following:

- the applicability at a range of spatial scales from a few kilometres to more than 100 km (e.g., evaluating regional and local air emission effects);
- it incorporates wet and dry removal processes (deposition);
- it includes both SO₂ and NO_x chemistry which is required for predicting potential acid input (PAI);
- it applies three-dimensional wind speed and wind direction and time allowing for more realistic plume movement simulations;
- it is based on principles that have been explicitly documented and undergone independent peer review; and
- the most recent version incorporates PRIME downwash algorithms.

The CALPUFF model has recently undergone improvements, to make it more suitable for application at the regional level (Scire 2007). Modifications to the CALPUFF system include:

- new modules to treat buoyant rise and dispersion from area sources;
- buoyant line sources;
- volume sources;
- improved treatment of complex terrain;
- additional model switches to facilitate its use in regulatory applications;
- enhanced treatment of wind shear through puff splitting;
- capability to model time periods shorter than 1 hour, e.g., 0.5 hour, 15 minutes, etc. (Version 6 – CALPUFF-Professional Beta 2.3.1005); and
- capability to model plume length and frequency of fog occurrences (CALPUFF-VISTA).

Table 11.4.I-1 Major Features of the CALPUFF Model

Source Types
Point sources (constant or variable emissions)
Line sources (constant emissions)
Volume sources (constant or variable emissions)
Area sources (constant or variable emissions)
Cooling Towers (variable emissions)
Non-steady State Emissions and Meteorological Conditions (if CALMET is used)
Gridded 3D fields of meteorological variables (winds, temperature)
Spatially variable fields of mixing height, friction velocity, convective velocity scale, Monin-Obukhov length, precipitation rate
Vertically and horizontally varying turbulence and dispersion rates
Time-independent source and emissions data
Dispersion Coefficient (σ_y, σ_z) Options
Direct measurements of σ_y and σ_w
Estimated values of σ_y and σ_w based on similarity theory
Pasquill-Gifford (PG) dispersion coefficients (rural areas)
McElroy-Pooler (MP) dispersion coefficients (urban areas)
Vertical Wind Shear
Puff splitting
Differential advection and dispersion
Plume Rise
Partial penetration
Buoyant and momentum rise
Stack tip effects
Vertical wind shear
Dry Deposition
Gases and particulate matter
Three options: - Full treatment of space and time variations of deposition with a resistance model - User-specified diurnal cycles for each pollutant - No dry deposition
Chemical Transformation Options
Pseudo first order chemical mechanism for SO ₂ , SO ₄ , NO _x , HNO ₃ , and NO ₃ (MESOPUFF II method)
User-specified diurnal cycles of transformation rates
Wet Removal
Scavenging coefficient approach
Removal rate a function of precipitation intensity and precipitation type
Graphical User Interface
Click and point model set-up and data input
Enhanced error checking of model inputs

σ_z = initial vertical dimension for volume source; SO₂ = sulphur dioxide, SO₄ = sulphate, NO_x = nitrogen oxides, HNO₃ = nitric acid; NO₃ = nitrate ion.

The CALPUFF model was run in 3D mode for the purposes of assessing the Project using a wind field developed specifically for the Project from regional surface meteorological data and mesoscale data for northern Canada. The RIVAD/ARM3 chemistry was used for calculations of wet and dry deposition of sulphate and nitrate compounds.

Despite many advancements of the CALPUFF modelling system over other available models, CALPUFF has some limitations. For example, predicted concentrations and deposition of airborne contaminants are known to be higher than observed near major area sources of SO₂ and NO_x, such as mine pits. This is likely due to the RIVAD/ARM3 chemical transformation algorithms used by the model (Staniaszek et al. 2006; Staniaszek and Davies 2006).

The CALPUFF model in dynamic mode was selected to meet the assessment Terms of Reference for the Gahcho Kué Environmental Impact Statement, particularly with respect to deposition. Its use in environmental impact assessments (EIAs) in the NWT is generally supported by regulators and regional stakeholders. CALPUFF Version 6.267 was used for this assessment.

11.4.I.4 DISPERSION METEOROLOGY

11.4.I.4.1 CALMET DESCRIPTION

The three-dimensional wind fields used in the CALPUFF dispersion modelling assessment were created using the CALMET model pre-processor developed specifically for use with the CALPUFF model. The CALMET wind fields were simulated over an area larger than the modelling domain to ensure the CALPUFF model uses the most representative wind fields across the entire region. One year of meteorological data covering September 26, 2004 to September 25, 2005 was generated using output from a mesoscale meteorological model in combination with local meteorological observations.

The CALMET model is composed of two main components: a wind field module and a boundary layer meteorological module. In Step 1 of the wind field development, an initial guess wind field is adjusted for the kinematic effects of terrain, slope flows and blocking effects as appropriate. Observational data are introduced in Step 2 through an objective analysis procedure. An inverse-distance squared interpolation scheme is used where observational data are weighted most heavily around the observation station.

The overland boundary layer model computes gridded fields of surface friction velocity, convective velocity scale, Monin-Obukhov length, mixing height, Pasquill-Gifford stability class, air temperature and precipitation rate using the energy balance method of Holtslag and van Ulden (1983).

The CALMET modelling domain size is 170 km in the east-west direction and 90 km in the north-south direction. The domain lies between 63.13°N and 63.90°N latitude and 107.54°W to 111.00°W longitude. The horizontal grid spacing is 2 km x 2 km. This combination of grid size and number of cells was chosen to minimize run time while capturing large-scale terrain feature influences on wind flow patterns.

The height of vertical layers is defined as the midpoint between two adjacent layers or interfaces (i.e., eleven interfaces for 10 layers, with the lowest layer always at ground level). The vertical interfaces used for this project were 0, 20, 50, 100, 200, 400, 800, 1,200, 1,600, 2,200 and 3,000 metres (m) above ground level.

Surface observations from three meteorological stations were used in CALMET. The initial guess wind field was determined from the US National Weather Service North American Regional Reanalysis (NARR).

11.4.I.4.1.1 North American Regional Reanalysis

Predictions from the US National Weather Service NARR were used as the initial guess field in CALMET due to the lack of upper air observations and the large size of the modelling domain.

The North American Regional Reanalysis products are produced at the National Centre for Environmental Protection (NCEP) based on observations and a version of the Eta 32-km mesoscale model which is run with three-hour time steps. The Eta model remained the same from 1979 to 2003 when it was renamed the Regional Climate Data Assimilation System (R-CDAS). Since the NARR is a reanalysis, there are no data gaps in the archive.

The NARR data were used to create an MM5-format meteorological dataset by the National Centre for Atmospheric Research (NCAR) specifically for this project, with the CALNARR (modified CALETA) pre-processor program for CALMET.

11.4.I.4.1.2 Geophysical Parameters

The CALMET model requires a physical description of the ground surface to determine meteorological parameters near the surface. The geophysical parameters are land use category, terrain elevation, roughness length, albedo, Bowen ratio, soil heat flux parameter, anthropogenic heat flux and Leaf Area Index (LAI). Values for all land use parameters except land use category and elevation were determined for the following periods:

- foliage period – summer (June 1, 2005 to September 25, 2005); and
- non-foliage period – winter (September 26, 2004 to May 31, 2005).

The CALMET modelling domain was described using five land use categories. A category was assigned to each 2 km x 2 km grid cell using the CALMET pre-processor TERREL and MAKEGEO and a global land use categories file for North America. The output from MAKEGEO was used as the geophysical (GEO.DAT) file for the summer (foliage) period.

For the winter (non-foliage) period, each land use category was assigned winter values of roughness length, albedo, Bowen Ratio, soil and anthropogenic flux parameters and LAI. Unless otherwise noted, geophysical parameters were

selected using the default values recommended in the CALMET manual (Scire et al. 2000) or from PCRAMMET (US EPA 1995). The geophysical parameters for the non-foliage season are summarized in Table 11.4.I-2.

Table 11.4.I-2 Geophysical Parameters for the Non-Foliage Season

Land Use Category	Description	Z ₀ (m)	Albedo	Bowen Ratio	Soil Heat Flux	Anthropogenic Heat Flux	Leaf Area Index
30	rangeland	0.2	0.6	1.0	0.15	0.0	0.5
40	forest land	0.7	0.3	1.5	0.15	0.0	2.0
51	streams and canals	0.1	0.7	0.5	0.15	0.0	0.0
61	forested wetlands	0.7	0.2	1.0	0.15	0.0	1.0
80	tundra	0.2	0.7	0.5	0.15	0.0	0.0

m = metres.

Land Use

As mentioned in the previous section, the CALMET modelling domain was described using five land use categories using the TERREL and MAKEGEO pre-processors and the global land use categories file for North America.

Tundra covers approximately 70 percent (%) of the modelling domain, water covers approximately 7%, forested wetlands cover 20%, rangeland covers 3%, and forest land covers less than 1% of the modelling domain.

Terrain

The terrain elevations for the modelling domain were obtained from the US Geological Survey (USGS) DEM5 (GeoTopo 30 arc second data). These data have 900 m (30 arc second) resolution which is adequate for relatively flat terrain around the proposed Project. The data can be downloaded from TRC (2007).

The CALMET pre-processor program, TERREL, was used to extract terrain data for the geophysical files (for input to CALMET) and for source and receptor elevations (for input to CALPUFF).

Roughness Length

Roughness length (Z₀) is the height at which the vertical wind profile is extrapolated to zero wind speed. It is a measure of the aerodynamic roughness of a surface and is related to the height, shape and density of the surface, as well as wind speed.

The CALMET model default values were used for most of the land use categories for the Project (Table 11.4.I-3) except in the following cases:

- Rangeland Z_0 was increased to 0.2 m in winter considering local vegetation cover. It was assumed that ground cover and roughness is similar to tundra, which has also Z_0 equal to 0.2 m.
- The forest land and wetlands forest categories had slightly lower Z_0 values during winter due to lower tree heights, snow effects and absence of leaves. These values are between recommended values from the US EPA PCRAMMET meteorological preprocessor for the winter season and CALMET default values, which are seasonally independent.
- The Z_0 values for waterbodies were slightly higher in winter due to ice and snow accumulation on the lakes and rivers which increases the roughness of the surface.

Table 11.4.I-3 Comparison of Winter Roughness Length Estimates

LUC	Description	CALMET Default (m)	PCRAMMET (m)	Project (m)
30	rangeland	0.05	0.001	0.2
40	forest land	1.0	0.5	0.7
51	streams and canals	0.001	0.001	0.1
61	forested wetlands	1.0	0.5	0.7
80	tundra	0.20	0.15	0.2

LUC = land use category; m = metres.

Albedo

Albedo is defined as the ratio of the reflected solar radiation to the total incoming solar radiation received at the surface. The lowest albedo values are recorded for oceans (0.035) and the highest for snow (0.90). Table 11.4.I-4 summarizes albedo values recommended by CALMET, PCRAMMET, and Brown and Williams (1998).

Table 11.4.I-4 Comparison of Winter Albedo Estimates

LUC	Description	CALMET Default	PCRAMMET/ Iqbal (1983)	Project
30	rangeland	0.25	0.6	0.6
40	forest land	0.1	0.5	0.3
51	streams and canals	0.1	0.2	0.7
61	forested wetlands	0.1	0.5	0.2
80	tundra	0.3	–	0.71

– = not applicable.

Default values for albedo, recommended by CALMET (Scire et al. 2000) were used for the summer season but were increased significantly for winter to reflect the presence of snow. The albedo value 0.7 is recommended by CALMET for perennial snow. The albedo of snow covered vegetation can range from 0.2 to 0.8 (Henderson-Sellers and Robinson 1986). For that reason, an albedo value of 0.2 was used in winter for forested wetlands, the value of 0.3 was used for forests, an albedo of 0.6 was used for rangelands and an albedo of 0.7 was used for tundra and waterbodies. Studies have also shown that winter albedos of treeless areas are 10% to 50% higher than nearby forested areas because snow does not cover the trees as readily (Betts and Ball 1997). Finally, albedo values in summer and winter obtained for white pine and hardwood forest in southeastern USA ranged from 0.10 to 0.22 (Vose and Swank 1992). For that reason, winter albedo values for northern forests were estimated to be 0.3, which is lower than recommended PCRAMMET value of 0.45.

Bowen Ratio

The Bowen Ratio is defined as the ratio of sensible heat flux to latent heat flux. Bowen Ratio values range from below 0.1 (tropical ocean) to above 10 (deserts).

The Bowen Ratio values used in the assessment (Table 11.4.I-5) were taken from CALMET defaults (Scire et al. 2000) and PCRAMMET (US EPA 1995).

Table 11.4.I-5 Comparison of Winter Bowen Ratio Estimates

LUC	Description	CALMET	PCRAMMET	Other	Project
30	rangeland	1.0	1.5	0.5–1.51	1.0
40	forest land	1.0	1.5	>1, 0.72–1.51	1.5
51	streams and canals	0.0	1.5	0.3–1.51	0.5
61	forested wetlands	0.5	1.5	–	1.0
80	tundra	0.5	–	0.53	0.5

LUC = land use category; > = less than; – = not applicable.

Soil Heat Flux Parameter

The soil heat flux parameter is a function of the surface properties and is used to compute the rate of energy transfer from the soil into the atmosphere. Since soil, water, and vegetation are covered by snow in winter, soil heat flux in winter was set to 0.15 Watts per square metre (W/m^2) (Table 11.4.I-6). The values recommended by CALMET were used for the summer season.

Table 11.4.I-6 Comparison of Winter Soil Heat Flux (W/m^2) Estimates

LUC	Description	CALMET	Project
30	rangeland	0.15	0.15
40	forest land	0.15	0.15
51	streams and canals	1.0	0.15
61	forested wetlands	0.25	0.15
80	tundra	0.15	0.15

W/m^2 = Watts per square metre.

For modelling purposes, the anthropogenic heat flux is usually considered to be zero due to lack of local measurements. For the Project, the anthropogenic heat is considered zero due to lack of human settlements.

Small industrial facilities, like the Snap Lake Mine and Gahcho Kué projects, do not generate enough heat to be considered “urban heat islands”. The urban heat island effect is a result of the interaction of several factors, including the absorption of heat during the day by surfaces such as asphalt roads, concrete pavements, and roofs, which is then radiated out into the atmosphere at night. There is also the release of heat from the tailpipes of vehicles, and ventilation stacks from buildings to be considered.

Leaf Area Index

The LAI is defined as the ratio of leaf area to soil surface area. A non-uniform forest canopy was assumed for the modelling domain for the purpose of evaluating dry deposition. Since in winter, vegetation is covered by snow, LAI was reduced for Forested Wetlands (1.0 instead of the recommended value of 2.0), and Forest Land (2.0 instead of 7.0) (Table 11.4.I-7).

Table 11.4.I-7 Comparison of Winter Leaf Area Index Estimates

LUC	Description	CALMET	Project
30	rangeland	0.5	0.5
40	forest land	7.0	2.0
51	streams and canals	0.0	0.0
61	forested wetlands	2.0	1.0
80	tundra	0.0	0.0

11.4.I.4.1.3 Surface and Precipitation Data

The CALMET model requires hourly values of the following observed parameters for at least one surface station in the domain:

- wind speed and direction;
- temperature;
- relative humidity;
- cloud (ceiling height and cloud opacity);
- station pressure; and
- precipitation rate and code.

Meteorological data from the Snap Lake Mine and Gahcho Kué Project meteorological stations, operated by De Beers, and the Environment Canada Yellowknife Airport station were included in CALMET.

Since hourly precipitation was not available for any of the stations, daily total precipitation from the Yellowknife Airport was used and divided evenly over the 24 hours in the day. Precipitation code was based on the hourly temperature observed during precipitation events. If the temperature was lower than 0 degrees Celsius (°C), the precipitation was classified as snow. If the temperature was higher than 0°C, the precipitation was classified as rain.

11.4.I.4.1.4 CALMET Model Options

Table 11.4.I-8 and Table 11.4.I-9 provide the model input options used for the CALMET model. The CALMET model contains several options for calculating the domain wind field. Surface winds are extrapolated to upper layers using the similarity theory.

Table 11.4.I-8 CALMET Model Input Options

Input Group	Parameter	Default	Project	Description
	IBYR	-	2004	starting year
	IBMO	-	9	starting month
	IBDY	-	26	starting day
	IBHR	-	0	starting hour
	IBSEC	-	0	starting second
	IEYR	-	2005	ending year
	IEMO	-	1	ending month
	IEDY	-	31	ending day
	IEHR	-	23	ending hour
	IESEC	-	3600	ending second
	ABTZ	-	UTC-0700	UTC time zone (Mountain Standard Time)
Input Group 1 – General Run Control Parameters	NSECDT	3600	3600	length of modelling timestep (seconds)
	IRTYPE	1	1	run type – computes wind fields and micrometeorological variables
	LCALGRD	T	T	do not compute special data fields required by CALGRID
	ITEST	2	2	continues with execution of computational phase after setup
	MREG	-	0	no checks for conformance with US EPA guidance
	PMAP	UTM	UTM	map projection = Universal Transverse Mercator
Input Group 2 – Map Projection and Grid Control Parameters	FEAST	0	-	false easting at the projection origin - not used when PMAP = UTM
	FNORTH	0	-	false northing at the projection origin - not used when PMAP = UTM
	IUTMZN	-	12	UTM zone
	UTMHEM	N	N	northern hemisphere projection
	RLAT0	-	-	latitude of projection origin – not used when PMAP = UTM
	RLON0	-	-	longitude of projection origin – not used when PMAP = UTM
	XLAT1	-	-	matching parallel(s) of latitude for projection – not used when PMAP = UTM
	XLAT2	-	-	matching parallel(s) of latitude for projection – not used when PMAP = UTM
	DATUM	WGS-84	NAR-C	datum region for output coordinates = NAR-C North American 1983 GRS 80 Spheroid
	NX	-	85	number of X grid cells
	NY	-	45	number of Y grid cells
	DGRIDKM	-	2	grid spacing (km)
	XORIGKM	-	500.000	X coordinate of southwest corner of domain (km)
	YORIGKM	-	7000.000	Y coordinate of southwest corner of domain (km)
	NZ	-	10	number of vertical layers

Table 11.4.I-8 CALMET Model Input Options (continued)

Input Group	Parameter	Default	Project	Description
Input Group 2 continued	ZFACE	-	0, 20, 50, 100, 200, 400, 800, 1200, 1600, 2200, 3000	cell face heights in vertical grid (m)
	LSAVE	T	T	save meteorological fields in an unformatted output file
	IFORMO	1	1	CALPUFF/CALGRID type of unformatted output file
	LPRINT	F	F	do not print meteorological fields
	IPRINF	1	1	print interval (hours)
	IUVOUT	NZ*0	NZ*0	layers of U, V wind component to print (0=no, 1=yes)
	IWOUT	NZ*0	NZ*0	levels of W wind component to print (0=no, 1=yes)
	ITOUT	NZ*0	NZ*0	I (0=no, 1=yes)
	STABILITY	0	0	print PGT stability class
	USTAR	0	0	print friction velocity
	MONIN	0	0	print Monin-Obukhov length
	MIXHT	0	0	print mixing height
Input Group 3 – Output Options	WSTAR	0	0	print convective velocity scale
	PRECIP	0	0	print precipitation rate
	SENSHEAT	0	0	do not print sensible heat flux
	CONVZI	0	0	do not print convective mixing height
	LDB	F	F	do not print input meteorological data and internal variables
	NN1	1	1	first time step for which debug data are printed
	NN2	1	1	last time step for which debug data are printed
	LDBCST	F	F	do not print distance to land internal variables
	IOUTD	0	0	control variable for writing the test/debug wind fields to disk files
	NZPRN2	1	1	number of levels to print
	IPR0 to IPR8	0	0	do not print wind field components after each adjustment
	NOOBS	0	1	use surface, overwater or upper air observations.
Input Group 4 – Meteorological Data Options	NSSTA	-	3	number of surface stations
	NPSTA	-	1	number of precipitation stations
	ICLOUD	0	0	gridded cloud cover not used
	IFORMS	2	2	free-formatted user input for surface meteorological data file format
	IFORMP	2	2	free-formatted user input for precipitation data file format
	IFORMC	2	2	cloud data format
	IWFOD	1	1	diagnostic wind module
	IFRADJ	1	1	compute Froude number adjustment effects
	IKINE	0	0	do not compute kinematic effects

Table 11.4.I-8 CALMET Model Input Options (continued)

Input Group	Parameter	Default	Project	Description
Input Group 4 continued	IOBR	0	0	do not use O'Brien procedure for adjustment of the vertical velocity
	ISLOPE	1	1	compute slope flows
	IEXTRP	-4	-4	similarity theory used, surface wind observations not extrapolated to upper layers
	ICALM	0	0	do not extrapolate surface winds if calm
	BIAS	NZ*0	NZ*0	layer-dependant biases for modifying the weights of surface and upper air stations
Input Group 5 – Wind Field Options and Parameters	RMIN2	4	-1	minimum distance from nearest upper air station to surface station for which extrapolation of surface winds at surface station will be allowed. Set to -1 when all surface stations should be extrapolated
	I PROG	0	14	winds from MM5/M3D.dat used as initial guess field
	ISTEPPG	3600	10,800	timestep of the prognostic model input data (seconds)
	IGFMET	0	0	do not use CALMET fields as initial guess fields
	L VARY	F	T	use varying radius of influence
	RMAX1	-	50	maximum radius of influence over land in the surface layer (km)
	RMAX2	-	100	maximum radius of influence over land aloft (km)
	RMAX3	-	300	maximum radius of influence over water
	RMIN	0.1	0.1	minimum radius of influence used in the wind field interpolation (km)
	TERRAD	-	20	radius of influence of terrain features
	R1	-	25	relative weighting of the first guess field and observations in the surface layer (km)
	R2	-	50	relative weighting of the first guess field observations in the layers aloft (km)
	R PROG	-	-	relative weighting parameter of the prognostic wind field data (km). Used only if I PROG=1.
	DIVLIM	0.000005	0.000005	maximum acceptable divergence in the divergence minimization procedure
	NITER	50	50	maximum number of iterations in the divergence minimization procedure
	NSMTH	2, (mxnz-1)*4	2,4,4,4,4,4,4,4	number of passes in the smoothing procedure
	NINTR2	99	99, 99, 99, 99, 99, 99, 99, 99, 99, 99	maximum number of stations used in each layer for the interpolation of data to a grid point
	CRITFN	1	1	critical Froude number

Table 11.4.I-8 CALMET Model Input Options (continued)

Input Group	Parameter	Default	Project	Description
Input Group 5 continued	ALPHA	0.1	0.1	empirical factor controlling the influence of kinematic effects
	FEXTR2	NZ*0	NZ*0	multiplicative scaling factor for extrapolation of surface observations to upper layers. Used only if IEXTRP = 3 or -3.
	NBAR	0	0	number of barriers to interpolation of the wind fields
	IDIOPT1	0	0	compute surface temperature internally from hourly surface observations
	ISURFT	-	1	surface meteorological station to use for the surface temperature (Gahcho Kué)
	IDIOPT2	0	0	compute domain-averaged temperature lapse rate internally from twice-daily upper air observations
	IUPT	-1	-2	use a domain-average prognostic lapse rate
	ZUPT	200	200	depth through which the domain-scale lapse rate is computed
	IDIOPT3	0	0	compute domain-averaged wind components internally from twice-daily upper air observations
	IUPWIND	-1	-1	upper air station to use for the domain-scale winds
	ZUPWND	1, 1000	1, 3000	bottom and top of layer through which the domain-scale winds are computed
	IDIOPT4	0	0	read wind speed and wind direction from a surface data file for observed surface wind components for wind field module
	IDIOPT5	0	0	read WS and WD from an upper air data file for observed upper air wind components for wind field module
	LLBREZE	F	F	do not use lake breeze module
	CONSTB	1.41	1.41	constant for neutral mechanical equation
	CONSTE	0.15	0.15	constant for convective mixing height equation
	CONSTN	2400	2,400	constant for stable mixing height equation
	CONSTW	0.16	0.16	constant for overwater mixing height equation
	FCORIOI	0.0001	0.00012	absolute value of Coriolis parameter
	IAVEZI	1	1	conduct spatial averaging of mixing heights
Input Group 6 – Mixing Height, Temperature and Precipitation Parameters	MNMDAV	1	1	maximum search radius in averaging process (grid cells)
	HAFANG	30	30	half-angle of upwind looking cone for averaging

Table 11.4.I-8 CALMET Model Input Options (continued)

Input Group	Parameter	Default	Project	Description
Input Group 6 continued	ILEVZI	1	1	layer of winds used in upwind averaging
	IMIXH	1	1	convective mixing height option = Maul-Carson for land and water cells
	THRESHL	0	0	threshold buoyancy flux required to sustain convective mixing height growth overland (expressed as a heat flux per metre of boundary layer W/m^3)
	THRESHW	0.05	0.05	threshold buoyancy flux required to sustain convective mixing height growth overwater (expressed as a heat flux per metre of boundary layer W/m^3)
	ITWPROG	0	0	use SEA.DAT lapse rates and deltaT or assume neutral conditions if missing
	ILUOC3D	16	16	land use category ocean in 3D.dat datasets
	DPTMIN	0.001	0.001	minimum potential temperature lapse rate in the stable layer above the current convective mixing height (K/m)
	DZZI	200	200	depth of layer above current convective mixing height through which lapse rate is computed
	ZIMIN	50	50	minimum overland mixing height (m)
	ZIMAX	3,000	3,000	maximum overland mixing height (m)
	ZIMINW	50	50	minimum overwater mixing height (m)
	ZIMAXW	3,000	3,000	maximum overwater mixing height (m)
	ICOARE	10	10	use COARE with no wave parameterization for overwater surface fluxes
	DSHELF	0	0	coastal/shallow water length scale (km) (COARE fluxes only)
	IWARM	0	0	COARE warm layer computation off
	ICOOL	0	0	COARE cool skin layer computation off
	ITPROG	0	0	use surface and upper air stations for 3D temperature.
	IRAD	1	1	use 1/R for temperature interpolation
	TRADKM	500	500	radius of influence for temperature interpolation (km)
	NUMTS	5	5	maximum number of stations to include in temperature interpolation
	IAVET	1	1	conduct spatial averaging of temperatures
	TGDEFB	-0.0098	-0.0098	default temperature gradient below the mixing height over water (K/m)

Table 11.4.I-8 CALMET Model Input Options (continued)

Input Group	Parameter	Default	Project	Description
Input Group 6 continued	TGDEFA	-0.0045	-0.0045	default temperature gradient above the mixing height over water (K/m)
	JWAT1, JWAT2	-	99,99	beginning and ending land use categories for temperature interpolation over water
	NFLAGP	2	2	use 1/R2 for precipitation interpolation
	SIGMAP	100	100	radius of influence (km)
	CUTP	0.01	0.01	minimum precipitation rate cut-off (mm/hr)
Input Group 7 – Surface Meteorological Station Parameters	-	-	Table 11.4.I.9	surface meteorological station parameters
Input Group 8 – Upper Air Meteorological Station Parameters	-	-	-	upper air meteorological station parameters
Input Group 9 – Precipitation Station Parameters	-	-	Table 11.4.I-9	precipitation station parameters

- = Not applicable; W/m² = Watts per square metres; km = kilometres; m = metres; K/m = Kelvin per metre; mm/hr = millimetre per hour.

Table 11.4.I-9 Surface and Precipitation Station Parameters

Station Name	Station Type	Station ID	X Coordinate (km)	Y Coordinate (km)	Time Zone	Anemometer Height (m)
Gahcho Kué	surface	99991	591.000	7036.000	7	10
Snap Lake	surface	99992	513.550	7051.400	7	10
Yellowknife	surface/ precip	71936	322.606	6930.151	7	10

Note: Coordinates are in NAD83, UTM Zone 12.

ID = identification; km = kilometres; m = metres.

Since upper air observations were not available in the region of the modelling domain, NARR data were used for upper air (NOOBS = 1).

The maximum radius of influence over land in the surface layer is 50 km. At upper levels the radius of influence is 100 km. The minimum radius of influence in the wind field interpolation is 0.1 km. The radius of influence of terrain features is set to 20 km.

Mixing heights are computed using the hourly surface heat fluxes and observed morning and afternoon temperature soundings. The minimum and maximum allowed mixing heights for both land and water are 50 m and 3,000 m, respectively.

The inverse distance-squared method was used for precipitation interpolation, which was recommended by Dean and Snyder (1977) and Wei and McGuinness (1973). The radius of influence was set to 100 km.

11.4.I.4.2 CALMET EVALUATION

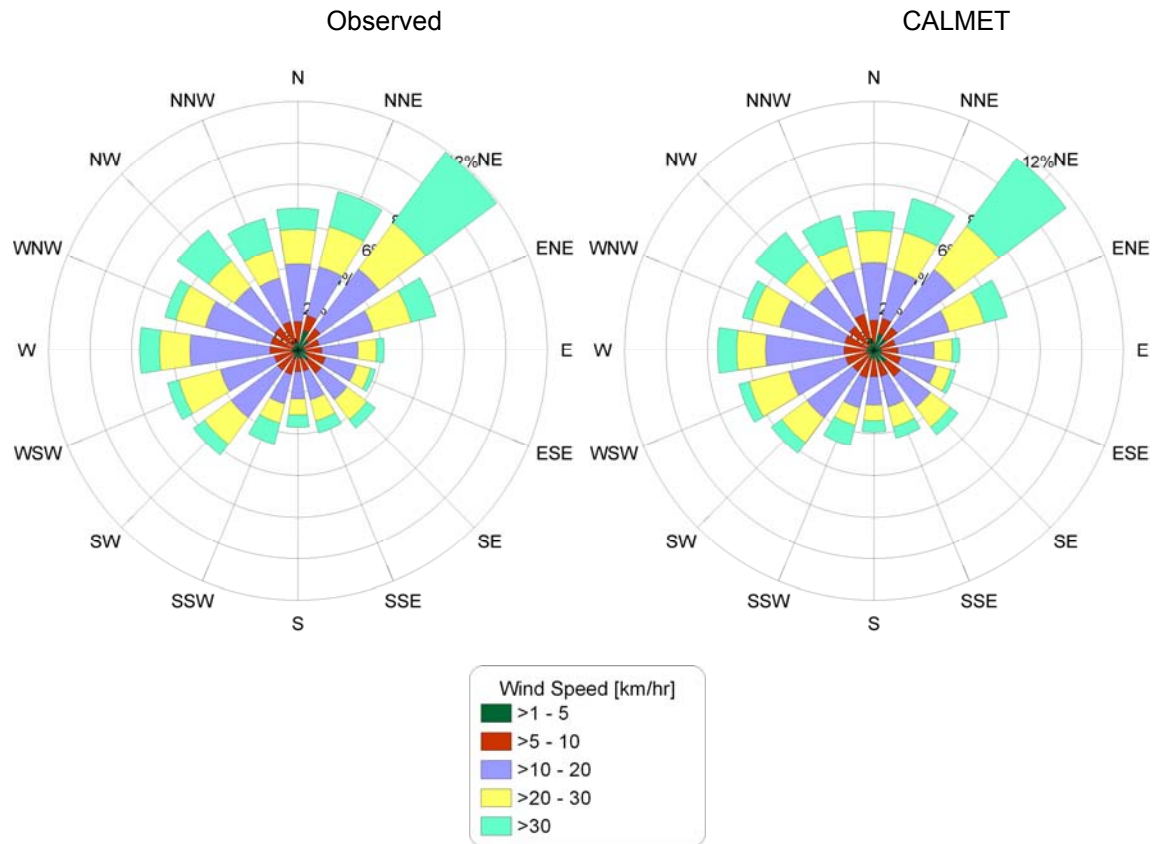
A summary of the meteorological parameters generated by CALMET, including wind, temperature, mixing height and stability class, are provided in the following sections.

11.4.I.4.2.1 Wind

The dispersion and transport of atmospheric emissions are driven primarily by the wind. A windrose is often used to illustrate the frequency of wind direction and the magnitude of wind velocity. The lengths of the bars on the windrose indicate the frequency and speed of wind, and the direction from which the wind blows is illustrated by the orientation of the bar in one of 16 directions.

Figure 11.4.I-1 presents a comparison of the observed and CALMET-derived winds for the Project site. The predominant winds at the Project site are from the northeast. The CALMET winds for the 2 by 2 km grid cell containing the Project also indicate that winds from the northeast dominate.

Figure 11.4.I-1 Observed and CALMET-Derived Windroses for the Project Site

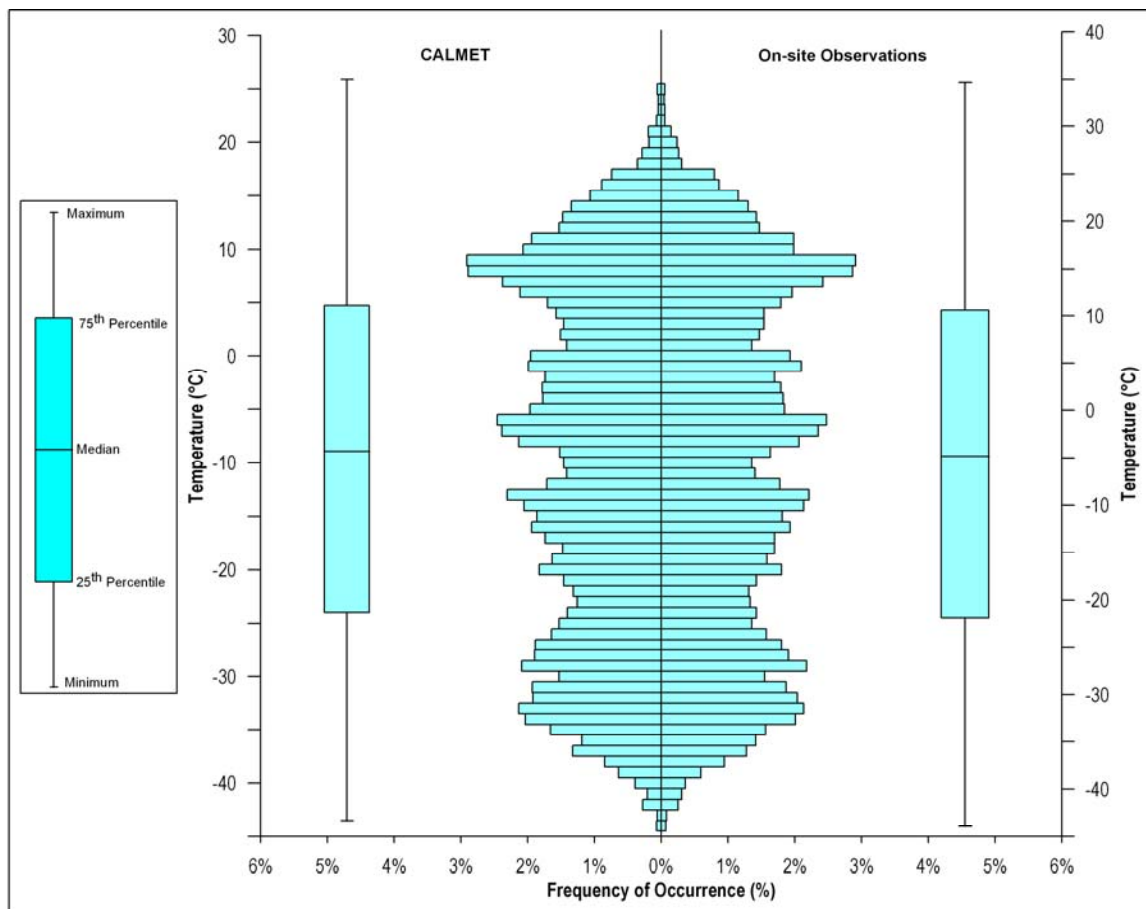


N = North; E = East; S = South; W = West; km/hr = kilometre per hour; > = greater than.

11.4.I.4.2.2 Temperature

Figure 11.4.I-2 shows the comparison of observed and CALMET-derived temperatures for the Project site. The figure includes a box-whisker plot which shows the minimum and maximum temperatures, the 25th and 75th percentiles and the median temperature. The frequency distribution of temperatures is also shown. This comparison indicates that the CALMET-derived temperatures are similar to the observed temperatures.

Figure 11.4.I-2 Comparison of Observed and CALMET-Derived Temperatures for the Project Site



°C = degrees Celsius; % = percent.

11.4.I.4.2.3 Mixing Height

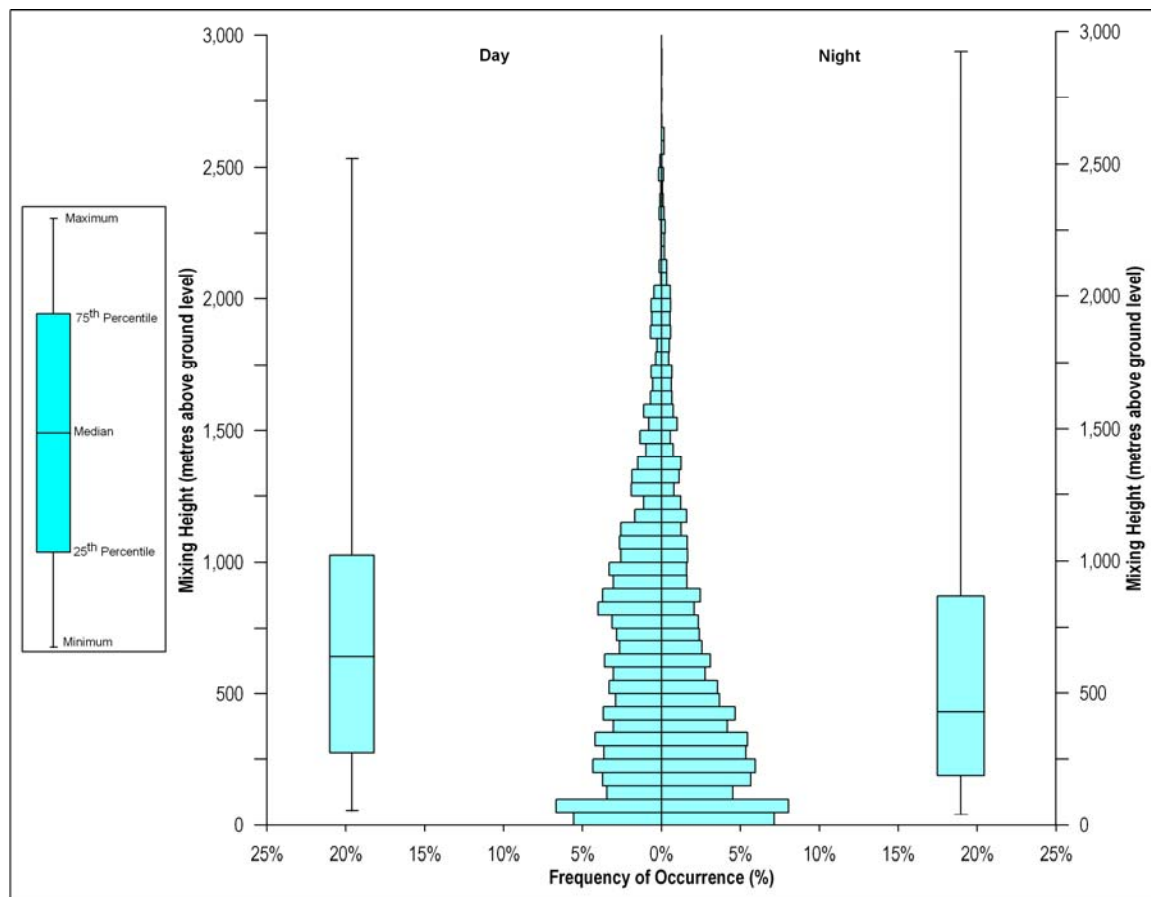
Mixing height is a measure of the depth of the atmosphere through which mixing of emissions can occur. Mixing heights often exhibit a strong diurnal and seasonal variation: they are lower during the night and higher during the day. Seasonally, mixing heights are typically lower in the winter and higher in the late spring and early summer.

CALMET calculates an hourly convective mixing height for each grid cell from hourly surface heat fluxes and vertical temperature profiles from twice-daily soundings. Mechanical mixing heights are calculated using an empirical relationship that is a function of friction velocity. To incorporate advective effects, mixing height fields are smoothed by incorporating values from upwind grid cells. The higher of the two mixing heights (convective or mechanical) in a given hour

is used. A more detailed description of this method is given in the CALMET User's Manual Version 5.0 (Earth Tech 2000).

Figure 11.4.I-3 shows the frequency of diurnal mixing heights derived by CALMET for the Project site for the assessment period. Mixing heights are typically lower at night than during the day. The average nighttime mixing height is 615 m and the average daytime mixing height is 702 m. The minimum and maximum mixing heights were set to 50 and 3,000 m, respectively.

Figure 11.4.I-3 CALMET-Derived Mixing Heights for the Project Site



% = percent.

11.4.I.4.2.4 Stability Class

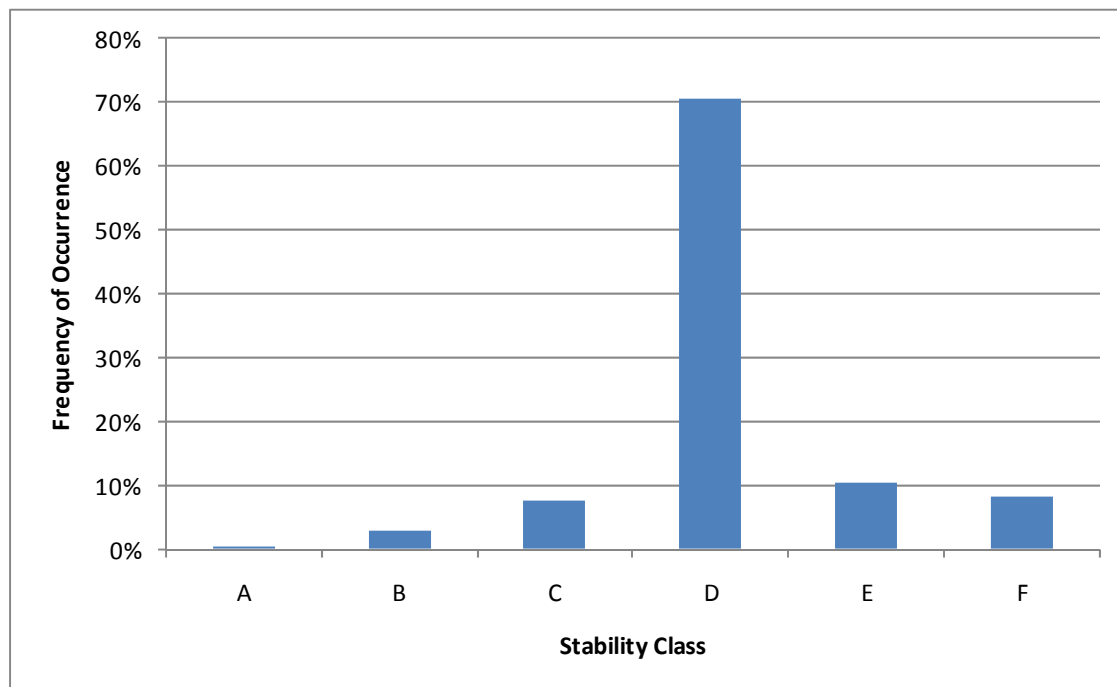
Atmospheric stability can be viewed as a measure of the atmosphere's capability to disperse emissions. The amount of turbulence plays an important role in the dilution of a plume as it is transported by the wind. Turbulence can be generated by either thermal or mechanical mechanisms. Surface heating or cooling by radiation contributes to the generation or suppression of thermal turbulence, while high wind speeds contribute to the generation of mechanical turbulence.

The Pasquill-Gifford (PG) stability classification scheme is one classification of the atmosphere. The classification ranges from Unstable (Stability Classes A, B and C), Neutral (Stability Class D) to Stable (Stability Classes E and F). Unstable conditions are primarily associated with daytime heating conditions which result in enhanced turbulence levels (enhanced dispersion). Stable conditions are associated primarily with nighttime cooling conditions, which result in suppressed turbulence levels (poorer dispersion). Neutral conditions are primarily associated with higher wind speeds or overcast conditions.

Figure 11.4.I-4 provides a comparison between the stability conditions derived by CALMET for the Project site for the assessment period. The following can be observed from the comparison:

- The CALMET model estimated that unstable (A, B and C) conditions would occur 11% of the time.
- Neutral conditions were estimated to occur 70% of the time.
- Stable (E and F) conditions were estimated to occur 19% of the time.

Figure 11.4.I-4 CALMET-Derived Pasquill-Gifford Stability Classes for the Project Site



% = percent.

11.4.I.5 DISPERSION MODELLING APPROACH

11.4.I.5.1 DISPERSION MODELLING ASSUMPTIONS

The Air Quality Assessment (Section 11.4) for the Project included several assumptions regarding assessment scenarios, emission rates and dispersion modelling approaches. Whenever possible, assumptions were made to ensure model predictions were not underestimated. The main assumptions included in the Air Quality Assessment are as follows:

- The dispersion modelling was performed per the Alberta Air Quality Model Guideline (AENV 2009). There is no air quality modelling guideline for NWT.
- For each modelling scenario, it was assumed that all developments were operating at their maximum capacity at the same time. In reality, the operational life of each development will be staggered over time.
- The 2004 to 2005 meteorological data were deemed to be appropriate for use in preparing the 3D meteorological data set.
- It was assumed that 100% of the airborne sulphates and nitrates form secondary aerosols, resulting in conservative estimations of fine particulate (PM_{2.5}) concentrations.

11.4.I.5.2 MODELLING DOMAIN

The Air Quality Assessment of the Project was based on the following regions:

- The Air Quality **modelling domain** defines the region over which air quality predictions were performed. Emission sources located within the modelling domain were quantified and used in the air quality predictions. The modelling domain chosen for the Air Quality Assessment of the Project is presented in Figure 11.4.I-5. It is large enough to encompass the effects related to air emissions from developments in the region.
- The Air Quality **Regional Study Area** (RSA) defines the region over which modelling results are presented and is typically smaller than the modelling domain. The RSA for the Project is defined by a 80 km by 160 km area (Figure 11.4.I-5). The RSA is also large enough to capture the air quality cumulative effects associated with emissions from existing and approved industrial sources within the region in combination with the proposed Project.
- The Air Quality **Local Study Area** (LSA) defines the area in the immediate vicinity of the Project where the majority of air quality effects are expected to occur. The LSA represents a subset of the RSA and

allows a more focused assessment of the effects associated with the Project. The LSA (Figure 11.4.I-5) is defined by an area of about 15 km by 15 km, encompassing the Project Footprint.

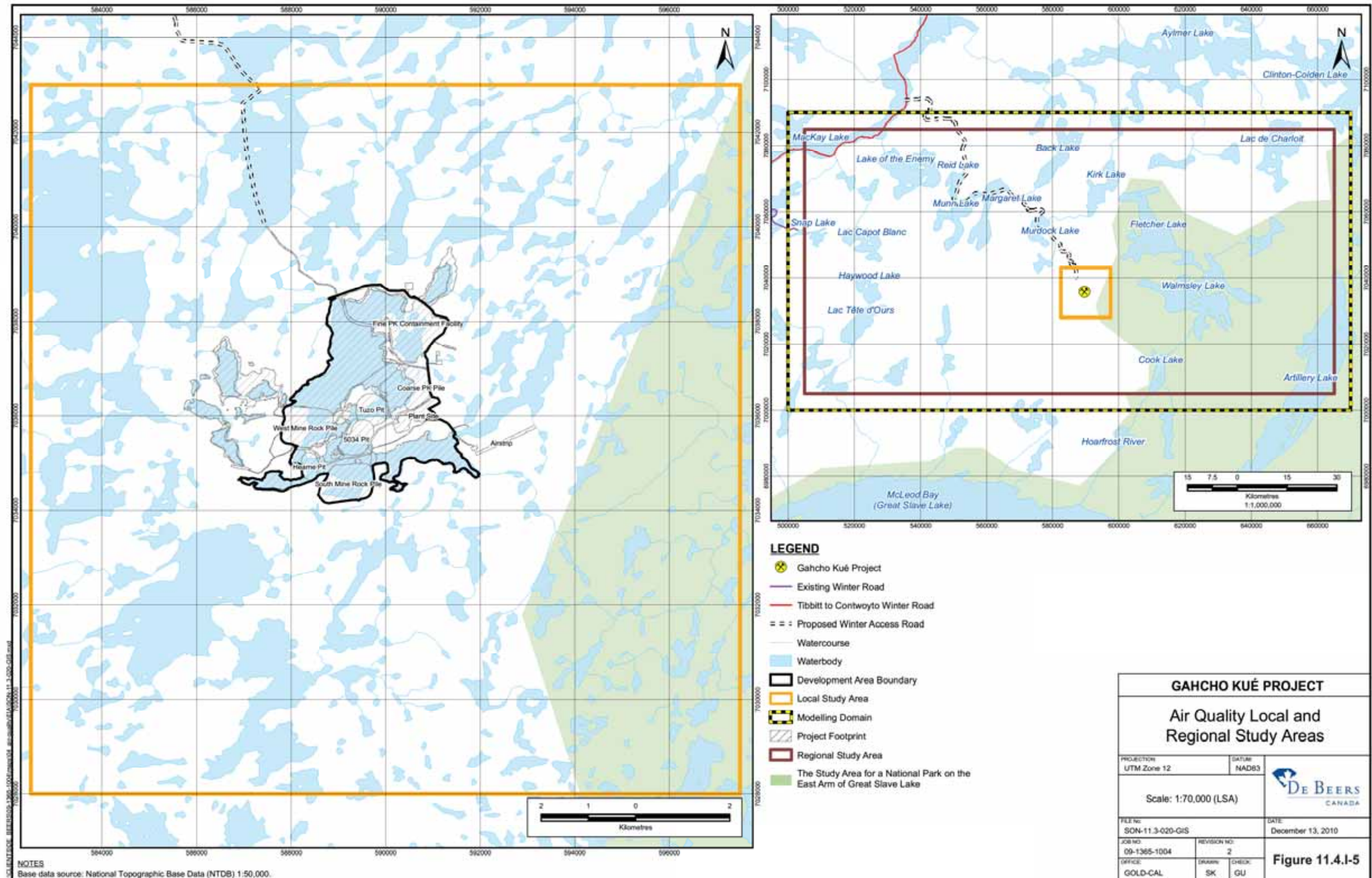
- The **project footprint** represents the areas that will be physically disturbed due to the construction, operation and reclamation of the Project (Figure 11.4.I-5).
- The **development area** is an area approximately outlined by the project footprint that is only used in the air quality assessment to determine compliance with applicable ambient air quality standards (Figure 11.4.I-5). The NWT Standards (GNWT 2010, internet site) are applicable outside this boundary. The developed area enveloped all major emission sources associated with the activities at the Project.

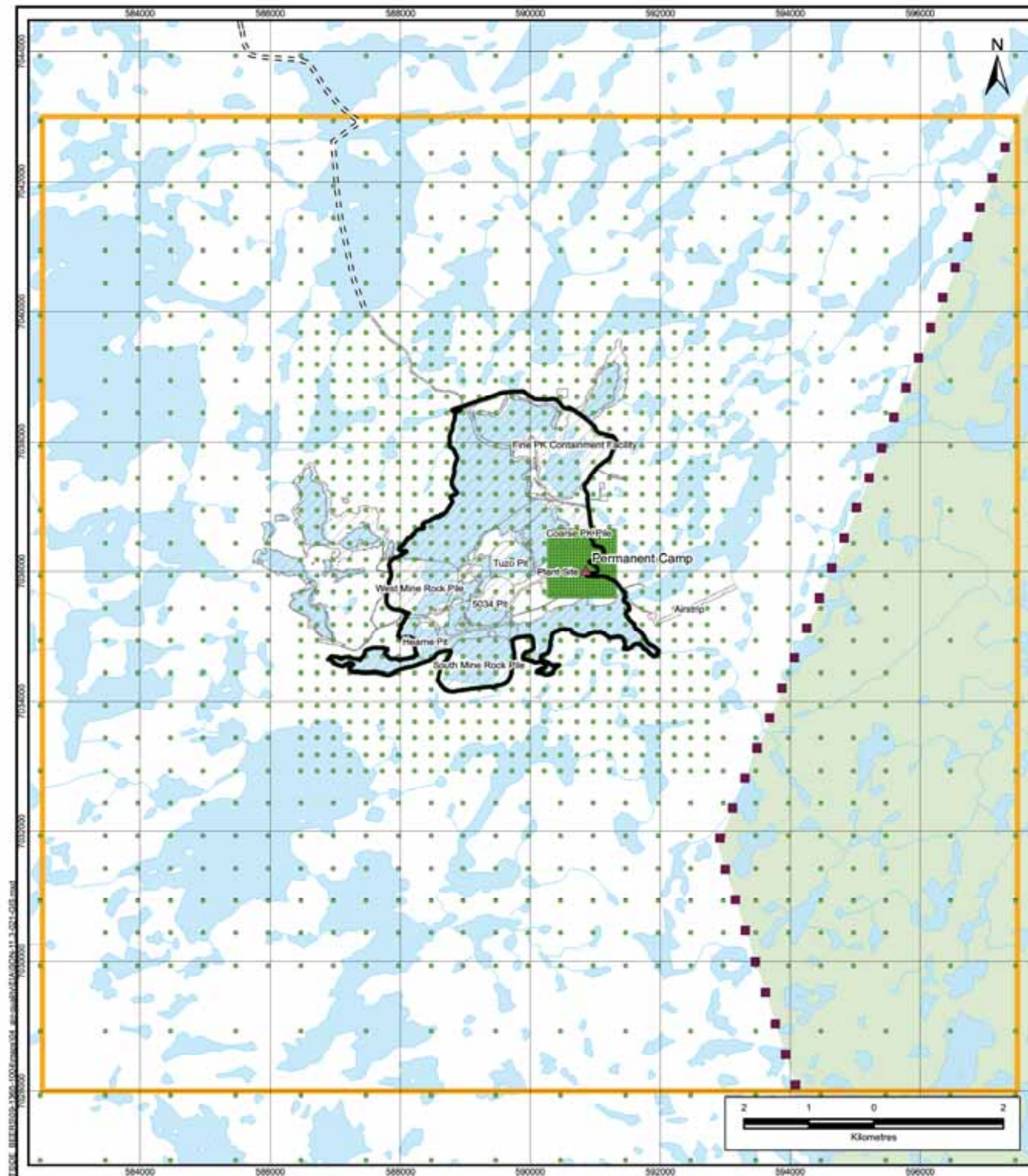
11.4.I.5.3 REGIONAL RECEPTORS

Ground-level concentrations and deposition rates were modelled at selected locations (referred to as receptors) within the modelling domain. In the absence of NWT specific air quality modelling guidelines, the receptor locations are based primarily on AENV modelling guidance (AENV 2009) which recommends the following receptor placement:

- spacing of 20 m in the general area of maximum impact and the property boundary;
- spacing of 50 m within 1 km of the sources of interest;
- spacing of 250 m within 2 km of the sources of interest;
- spacing of 500 m within 5 km of the sources of interest; and
- spacing of 1,000 m between 5 and 10 km from the Project.

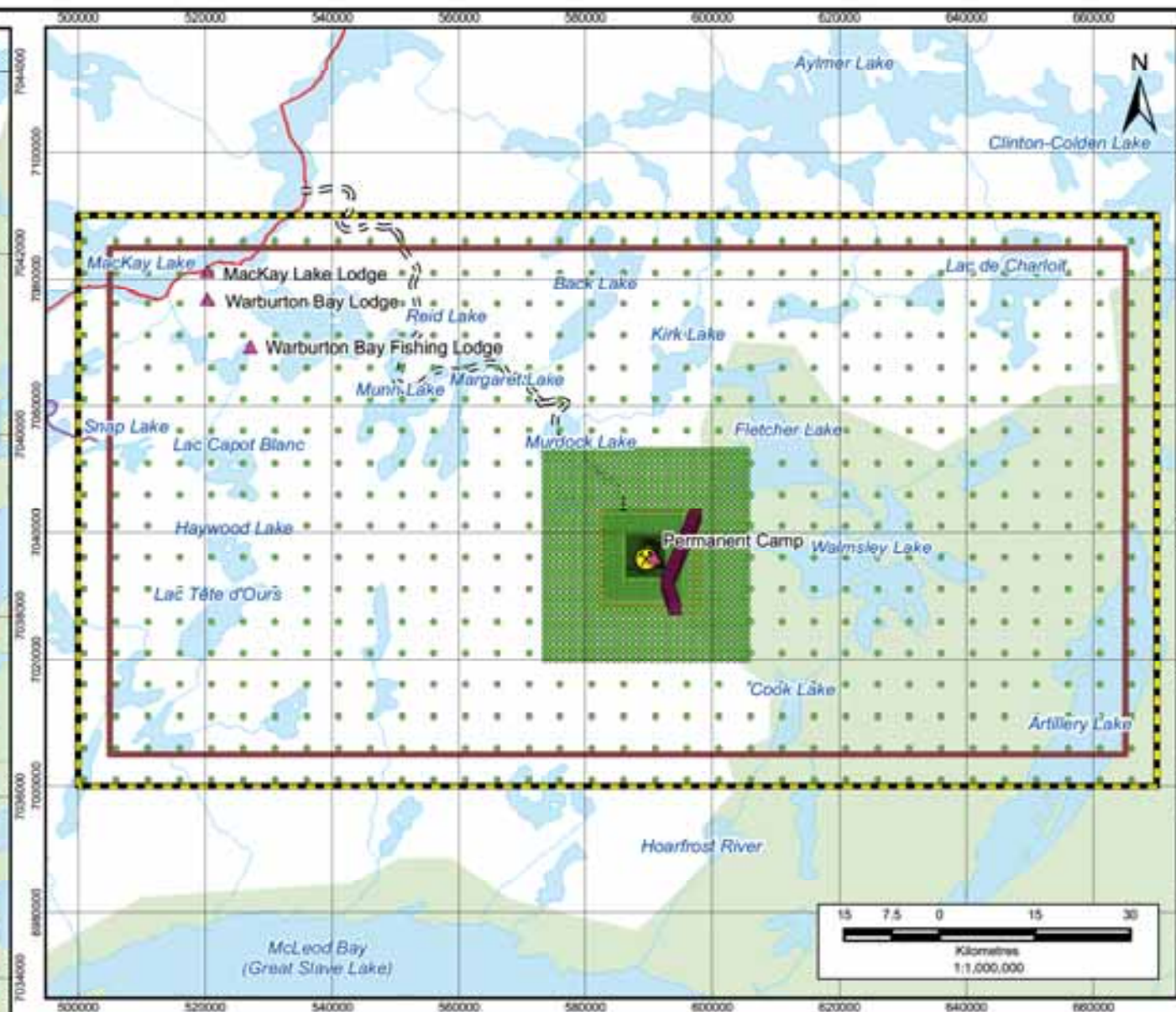
In addition to the receptors placed near the Project operations, the air quality assessment included additional receptors distributed across the modelling domain. These receptors were spaced at 5-km intervals. This receptor scheme is shown in Figure 11.4.I-6.





NOTES

Base data source: National Topographic Base Data (NTDB) 1:50,000. Footprint based on preliminary mine plan.




LEGEND

- Gahcho Kué Project
- Existing Winter Road
- Tibbitt to Contwoyto Winter Road
- Proposed Winter Access Road
- Watercourse
- Waterbody
- Air Quality Receptor
- Human Health Assessment Receptor
- Proposed National Park Boundary Receptor
- Development Area Boundary
- Local Study Area
- Modelling Domain
- Project Footprint
- Regional Study Area
- The Study Area for a National Park on the East Arm of Great Slave Lake

GAHCHO KUÉ PROJECT

Air Quality Receptors

PROJECTION UTM Zone 12	DATUM NAD83	
Scale: 1:70,000 (LSA)		
FILE NO. SON-11.3-021-GIS		DATE December 13, 2010
JOB NO. 09-1365-1004	REVISION NO. 1	Figure 11.4.I-6
OFFICE GOLD-CAL	DRAWN BY SK CHECKED BY GU	

11.4.I.5.4 COMMUNITY RECEPTORS

One of the objectives of this air quality assessment is to put the potential air concentrations into perspective for regional stakeholders and regulatory authorities. To facilitate this, maximum air quality concentrations were also predicted at sensitive receptor locations presented in Table 11.4.I-10 and is graphically shown in Figure 11.4.I-6. The list includes three recreational areas, the on-site camp, receptors along the boundary of a proposed National Park on the East Arm of Great Slave Lake and along the development area boundary where persons could experience prolonged exposure to emissions.

Table 11.4.I-10 Sensitive Receptor Included in the Air Assessment

Receptors	Location ^(a)	
	Distance (km)	Distance
Warburton Bay Lodge	81.3	WNW
Warburton Bay Fishing Lodge	71.8	WNW
MacKay Lake Lodge	83.7	WNW
Permanent Camp	0.1	SSE
Development Area Boundary ^(b)	—	—

^(a) Distance and direction are relative to the power plant.

^(b) Maximum property boundary receptors are spaces 20 m apart around the development area.

km = kilometres; m = metres; WNW = west by northwest; SSE = south by southeast.

11.4.I.5.5 MODEL OPTIONS

The CALPUFF dispersion model is a sophisticated tool that uses numerous user-specified options. The selection of options used in the analysis requires great care and understanding of the underlying model algorithms. Most of the modelling options used in the model are US EPA default CALPUFF model options as recommended by Air Quality Model Guideline (AENV 2009). However, a few of the model options are not the default options and each is discussed in detail here.

11.4.I.5.5.1 MBDW – (Building Downwash)

Buildings or other solid structures may affect the flow of air in the vicinity of a source and cause eddies to form on the downwind side of a building. Building downwash algorithms only apply to point sources. The point sources and the main buildings at the Project are located towards the center of the development area, far from the development area boundary. Therefore, the effects of building downwash on the ground-level concentrations or deposition rates outside the

development area would be minimal. Therefore, building downwash was not included in this assessment.

11.4.I.5.5.2 MCHM – (Chemistry Scheme)

The RIVAD/ARM3 scheme (MCHM=3) is used for chemical transformation as opposed to the default MESOPUFF II method. The RIVAD/ARM3 method models nitric oxide (NO) and nitrogen dioxide (NO₂) separately, whereas MESOPUFF II models only total NO_x.

11.4.I.5.5.3 MDISP – (Dispersion Coefficients)

Dispersion coefficients are calculated internally using similarity theory and micrometeorological variables instead of the default ISC3 multi-segment approximation method. The similarity theory is a more sophisticated and precise method of determining dispersion coefficients.

11.4.I.5.5.4 MPDF – (Convective Turbulence)

The Probability Distribution Function (PDF) (MPDF=1) approach accounts for downdrafts that occur under convective conditions. The PDF approach may increase the predicted concentrations resulting from stacks under convective conditions. Although the US EPA default option does not use PDF, using PDF in CALPUFF will provide more accurate predictions and at the same time, be consistent with the regulatory dispersion model AERMOD as well.

In this assessment, the importance of near field prediction (i.e., local effects due to the Project) accuracy was ranked higher than the long range transport prediction (i.e., regional cumulative effects) accuracy. The US EPA does not approve the use of CALPUFF for near field applications (i.e., distances less than 50 km) at this time; therefore, the U.S. EPA default options are selected according to the requirements of long range CALPUFF modelling.

A review of Alberta (Alberta Environment, 2009), British Columbia (BC Ministry of Environment 2008) and Ontario (OMOE 2009) modelling guidelines permit the use of CALPUFF for near field applications. However, the BC and Ontario guidelines recommend non-EPA default MPDF (and MDISP) settings.

The final decision to use the non-default US EPA option for MDISP and MPDF was made based on professional judgement and consultation with the CALPUFF model developer Joseph Scire (2010, pers. comm.).

11.4.I.5.5.5 MREG – (Regulatory Check)

Test options specified to see if they conform to regulatory values. MREG is an optional check and it was turned off (MREG=0).

11.4.I.5.5.6 DATUM – (Geographic Coordinate System)

The DATUM option was set to NAR-C (DATUM=NAR-C) since the coordinates used in the assessment are in NAD83 (North American 1983 GRS 80 Spheroid) datum. NAD83 uses the same GRS 80 spheroid as WGS 84.

11.4.I.5.5.7 IVEG – (Vegetation State in Unirrigated Areas)

The IVEG option was set to 2 (IVEG=2) to represent the unirrigated land as stressed.

Table 11.4.I-11 provides a detailed summary of the model input options that were used in the modelling completed for the Project.

Table 11.4.I-11 CALPUFF Model Input Options

Input Group	Parameter	Project	Description
Group 1 - General Run Control Parameters	METRUN	0	run period explicitly defined below
	IBYR	2004	starting year for run if METRUN = 0
	IBMO	9	starting month for run if METRUN = 0
	IBDY	26	starting day for run if METRUN = 0
	IBHR	0	starting hour for run if METRUN = 0
	IBSEC	0	starting hour for run if METRUN = 0
	IEYR	2005	ending year for run if METRUN = 0
	IEMO	9	ending month for run if METRUN = 0
	IEDY	25	ending day for run if METRUN = 0
	IEHR	23	ending hour for run if METRUN = 0
	IEMIN	0	ending minute for run if METRUN = 0
	IESEC	3,600	ending hour for run if METRUN = 0
	XBTZ	7	base time zone (PST = 8, MST = 7, CST = 6, EST = 5)
	NSPEC	6	number of chemical species
	NSE	3	number of chemical species to be emitted
	ITEST	2	program is executed after SETUP phase
	MRESTART	0	does not read or write a restart file
	NRESPD	0	restart file written only at last period
	METFM	1	CALMET binary file (CALMET.MET)
	MPRFFM	1	meteorological profile data format
	AVET	60	Averaging time (minutes)
	PGTIME	60	PG Averaging Time (minutes)
Group 2 - Technical Options	MGAUSS	1	Gaussian distribution used in near field
	MCTADJ	3	partial plume path terrain adjustment
	MCTSG	0	subgrid-scale complex terrain not modelled
	MSLUG	0	near-field puffs not modelled as elongated
	MTRANS	1	transitional plume rise modelled
	MTIP	1	stack tip downwash used
	MBDW	2	method to simulate building downwash (PRIME method)
	MRISE	1	Briggs plume rise used
	MSHEAR	0	vertical wind shear not modelled
	MSPLIT	0	puffs are not split
	MCHEM	3	transformation rates computed internally using RIVAD/ARM3 scheme
	MAQCHEM	0	aqueous phase transformation rates not modelled
	MWET	1	wet removal modelled
	MDRY	1	dry deposition modelled
	MTILT	0	Gravitational settling not modelled
	MDISP	2	dispersion coefficients from internally calculated sigma v, sigma w using micrometeorological variables (u*, w*, L, etc.)

Table 11.4.I-11 CALPUFF Model Input Options (continued)

Input Group	Parameter	Project	Description
Group 2 - Technical Options (continued)	MTURBVW	3	use both sigma-(v/theta) and sigma-w from PROFILE.DAT to compute sigma-y and sigma-z (valid for METFM = 1,2,3,4)
	MDISP2	3	PG dispersion coefficients for RURAL areas (computed using the ISCST multi-segment approximation) and MP coefficients in urban areas
	MTAULY	0	Method used for Lagrangian timescale for Sigma-y (used only if MDISP=1,2 or MDISP2=1,2) Draxler default 617.284 (s)
	MTAUADV	0	Method used for Advective-Decay timescale for Turbulence (used only if MDISP=2 or MDISP2=2) 0 = No turbulence advection
	MCTURB	1	Method used to compute turbulence sigma-v & sigma-w using micrometeorological variables (Used only if MDISP = 2 or MDISP2 = 2) Standard CALPUFF subroutines
	MROUGH	0	PG sigma-y and sigma-z not adjusted for roughness
	MPARTL	1	partial plume penetration of elevated inversion
	MPARTLBA	1	Partial plume penetration of Default: 1 ! MPARTLBA = 1 ! elevated inversion modeled for buoyant area sources
	MTINV	0	strength of temperature inversion not computed from measured/default gradients
	MPDF	1	PDF used for dispersion under convective conditions
	MSGTIBL	0	sub-grid TIBL module not used for shoreline
	MBCON	0	boundary conditions not modelled
	MSOURCE	0	Individual source contributions are not saved
	MFOG	0	do not configure for FOG Model output
	MREG	0	do not test options specified to see if they conform to regulatory values
Group 3 - Species List	CSPEC	SO ₂ , SO ₄ , NO, NO ₂ , HNO ₃ , NO ₃	list of chemical species
		1,1,1,1,1,1	is SO ₂ , SO ₄ , NO, NO ₂ , HNO ₃ , NO ₃ modelled? (0=no, 1=yes)
		1,0,1,1,0,0	is SO ₂ , SO ₄ , NO, NO ₂ , HNO ₃ , NO ₃ emitted? (0=no, 1=yes)
		1,2,1,1,1,2	SO ₂ , SO ₄ , NO, NO ₂ , HNO ₃ , NO ₃ dry deposition method (1=computed-gas, 2=computed-particle)
		0,0,0,0,0,0	SO ₂ , SO ₄ , NO, NO ₂ , HNO ₃ , NO ₃ output group number
Group 4 - Map Projection and Grid Control Parameters	PMAP	UTM	map projection
	FEAST	0	false Easting (km) at the projection origin
	FNORTH	0	false Northing (km) at the projection origin
	IUTMZN	12	UTM zone
	UTMHEM	N	hemisphere for UTM projection (N = north, S = south)
	RLAT0	40N	latitude of projection origin (not used if PMAP = UTM)
	RLON0	90W	longitude of projection origin (not used if PMAP = UTM)
	XLAT1	30N	matching parallel(s) of latitude (decimal degrees) for projection (used only if PMAP = LCC or PS)

Table 11.4.I-11 CALPUFF Model Input Options (continued)

Input Group	Parameter	Project	Description
Group 4 (continued)	XLAT2	60N	matching parallel(s) of latitude (decimal degrees) for projection (used only if PMAP = LCC or PS)
	DATUM	NAR-C	datum-region for output coordinates
	NX	85	number of X grid cells in meteorological grid
	NY	45	number of Y grid cells in meteorological grid
	NZ	10	number of vertical layers in meteorological grid
	DGRIDKM	2	grid spacing in kilometres
	ZFACE	0, 20, 50, 100, 200, 400, 800, 1200, 1600, 2200, 3000	cell face heights in meteorological grid (m)
	XORIGKM	500	reference X coordinate for south-west corner of grid cell (1,1) of meteorological grid (km)
	YORIGKM	7,000.00	reference Y coordinate for south-west corner of grid cell (1,1) of meteorological grid (kilometres)
	IBCOMP	1	X index of lower left corner of the computational grid
	JBCOMP	1	Y index of lower left corner of the computational grid
	IECOMP	85	X index of upper right corner of the computational grid
	JECOMP	45	Y index of upper right corner of the computational grid
	LSAMP	F	sampling grid is not used
	IBSAMP	-	X index of lower left corner of the sampling grid
	JBSAMP	-	Y index of lower left corner of the sampling grid
	IESAMP	-	X index of upper right corner of the sampling grid
	JESAMP	-	Y index of upper right corner of the sampling grid
	MESHDN	1	nesting factor of the sampling grid
Group 5 – Output Options	ICON	1	output file CONC.DAT containing concentration fields is created
	IDRY	1	output file DFLX.DAT containing dry flux fields is created
	IWET	1	output file WFLX.DAT containing wet flux fields is created
	IVIS	0	output file containing relative humidity data is not created
	LCOMPRS	F	do not perform data compression in output files
	IMFLX	0	mass flux across specified boundaries for selected species not reported hourly
	IMBAL	0	mass balance for each species not reported hourly
	ICPRT	0	do not print concentration fields to the output list file
	IDPRT	0	do not print dry flux fields to the output list file
	IWPRT	0	do not print wet flux fields to the output list file
	ICFRQ	1	concentration fields are printed to output list file every 1 hour
	IDFRQ	1	dry flux fields are printed to output list file every 1 hour
	IWFRQ	1	wet flux fields are printed to output list file every 1 hour
	IPRTU	3	units for line printer output are in $\mu\text{g}/\text{m}^3$ for concentration and $\mu\text{g}/\text{m}^2/\text{s}$ for deposition
	IMESG	2	messages tracking the progress of run are written on screen
		0,0,0,0,0,0	concentrations printed to output list file (0 = no, 1 = yes)

Table 11.4.I-11 CALPUFF Model Input Options (continued)

Input Group	Parameter	Project	Description
Group 5 (continued)		1,1,1,1,1,1	concentrations saved to disk (0=no, 1=yes)
		0,0,0,0,0,0	dry fluxes printed to output list file (0=no, 1=yes)
		1,1,1,1,1,1	dry fluxes saved to disk (0=no, 1=yes)
		0,0,0,0,0,0	wet fluxes printed to output list file (0=no, 1=yes)
		1,1,1,1,1,1	wet fluxes saved to disk (0=no, 1=yes)
		0,0,0,0,0,0	mass fluxes saved to disk (0=no, 1=yes)
	LDEBUG	F	logical value for debug output
	IPFDEB	1	first puff to track
	NPFDEB	1	number of puffs to track
	NN1	1	meteorological period to start output
	NN2	10	meteorological period to end output
Group 6 - Subgrid Scale Complex Terrain Inputs	NHILL	0	number of terrain features
	NCTREC	0	number of special complex terrain receptors
	MHILL	-	input terrain and receptor data for CTSG hills input in CTDM format not used
	XHILL2M	1	conversion factor for changing horizontal dimensions to metres
	ZHILL2M	1	conversion factor for changing vertical dimensions to metres
	XCTDMKM	-	X origin of CTDM system relative to CALPUFF coordinate system in kilometres
	YCTDMKM	-	Y origin of CTDM system relative to CALPUFF coordinate system in kilometres
Group 7 - Chemical Parameters for Dry Deposition of Gases	YCTDMKM	0.1509	diffusivity for SO ₂ (cm ² /s)
		1,000.00	alpha star for SO ₂
		8	reactivity for SO ₂
		0	mesophyll resistance for SO ₂ (s/cm)
		0.04	Henry's Law coefficient for SO ₂
		0.1345	diffusivity for NO (cm ² /s)
		1	alpha star for NO
		2	reactivity for NO
		25	mesophyll resistance for NO (s/cm)
		18	Henry's Law coefficient for NO
		0.1656	diffusivity for NO ₂ (cm ² /s)
		1	alpha star for NO ₂
		8	reactivity for NO ₂
		5	mesophyll resistance for NO ₂ (s/cm)
		3.5	Henry's Law coefficient for NO ₂
		0.1628	diffusivity for HNO ₃ (cm ² /s)
		1	alpha star for HNO ₃
		18	reactivity for HNO ₃
Group 8 - Size Parameters for Dry Deposition of Particles	YCTDMKM	0.00000008	Henry's Law coefficient for HNO ₃
		0.48	geometric mass mean diameter of SO ₄ (µm)
		2	geometric standard deviation of SO ₄ (µm)
		0.48	geometric mass mean diameter of NO ₃ (µm)
		2	geometric standard deviation of NO ₃ (µm)
	RCUTR	30	reference cuticle resistance in seconds/centimetre (s/cm)
Group 9 - Miscellaneous Dry Deposition Parameters	RGR	10	reference ground resistance in s/cm
	REACTR	8	reference pollutant reactivity
	NINT	9	number of particle size intervals used to evaluate effective particle deposition velocity
	IVEG	2	vegetation in un-irrigated areas is active and stressed

Table 11.4.I-11 CALPUFF Model Input Options (continued)

Input Group	Parameter	Project	Description
Group 10 – Wet Deposition Parameters	IVEG	0.00003	the SO ₂ scavenging coefficient for liquid precipitation (1/second [1/s])
		0	the SO ₂ scavenging coefficient for frozen precipitation (1/s)
		0.0001	the SO ₄ ²⁻ scavenging coefficient for liquid precipitation (1/s)
		0.00003	the SO ₄ ²⁻ scavenging coefficient for frozen precipitation (1/s)
		0.00006	the HNO ₃ scavenging coefficient for liquid precipitation (1/s)
		0	the HNO ₃ scavenging coefficient for frozen precipitation (1/s)
		0.0001	the NO ₃ ⁻ scavenging coefficient for liquid precipitation (1/s)
		0.00003	the NO ₃ ⁻ scavenging coefficient for frozen precipitation (1/s)
Group 11 – Chemistry Parameters	MOZ	0	a monthly background ozone value is used in chemistry calculation
	BCKO3	25,26,28,35,33,28,23,20,19,20,25,25	average monthly maximum ozone concentrations from Yellowknife from 2005 to 2009
	BCKNH3	12*0.22	monthly ammonia concentration
	RNITE1	0.2	nighttime SO ₂ loss rate in percent/hour
	RNITE2	2	nighttime NO _x loss rate in percent/hour
	RNITE3	2	nighttime HNO ₃ formation rate in percent/hour
	MH2O2	1	H ₂ O ₂ data input option not used since MAQCHEM = 0
	BCKH2O2	12*1	monthly H ₂ O ₂ concentrations in ppb
Group 12 – Miscellaneous Dispersion and Computational Parameters	SYTDEP	550	horizontal size of a puff in metres beyond which the time dependant Heffter dispersion equation is used
	MHFTSZ	0	do not use Heffter formulas for sigma z
	JSUP	5	stability class used to determine dispersion rates for puffs above boundary layer
	CONK1	0.01	vertical dispersion constant for stable conditions
	CONK2	0.1	vertical dispersion constant for neutral/unstable conditions
	TBD	0.5	use ISC transition point for determining the transition point between the Schulman-Scire to Huber-Snyder Building Downwash scheme
	IURB1	10	lower range of land use categories for which urban dispersion is assumed
	IURB2	19	upper range of land use categories for which urban dispersion is assumed
	ILANDUIN	20	land use category for modelling domain
	Z0IN	0.25	roughness length in metres for modelling domain
	XLAIXN	3	leaf area index for modelling domain
	ELEVIN	0	elevation above sea level in (m)
	XLATIN	-999	latitude of station in degrees (°)
	XLONIN	-999	longitude of station in degrees (°)
	ANEMHT	10	anemometer height in (m)
	ISIGMAV	1	sigma-v is read for lateral turbulence data
	IMIXCTDM	0	predicted mixing heights are used
	XXMLEN	1	maximum length of emitted slug in meteorological grid units
	XSAMLEN	1	maximum travel distance of slug or puff in meteorological grid units during one sampling unit
Group 12 (Continued)	MXNEW	50	maximum number of puffs or slugs released from one source during one time step

Table 11.4.I-11 CALPUFF Model Input Options (continued)

Input Group	Parameter	Project	Description
	MXSAM	99	maximum number of sampling steps during one time step for a puff or slug
	NCOUNT	2	number of iterations used when computing the transport wind for a sampling step that includes gradual rise
	SYMIN	1	minimum sigma y in metres for a new puff or slug
	SZMIN	1	minimum sigma z in metres for a new puff or slug
	SVMIN	0.5	minimum turbulence (σ_v) for A stability (m/s)
		0.5	minimum turbulence (σ_v) for B stability (m/s)
		0.5	minimum turbulence (σ_v) for C stability (m/s)
		0.5	minimum turbulence (σ_v) for D stability (m/s)
		0.5	minimum turbulence (σ_v) for E stability (m/s)
		0.5	minimum turbulence (σ_v) for F stability (m/s)
	SWMIN	0.2	minimum turbulence (σ_w) for A stability (m/s)
		0.12	minimum turbulence (σ_w) for B stability (m/s)
		0.08	minimum turbulence (σ_w) for C stability (m/s)
		0.06	minimum turbulence (σ_w) for D stability (m/s)
		0.03	minimum turbulence (σ_w) for E stability (m/s)
		0.016	minimum turbulence (σ_w) for F stability (m/s)
	CDIV	0.0, 0.0	divergence criteria for dw/dz in met cells
	WSCALM	0.5	minimum wind speed allowed for non-calm conditions (m/s)
	XMAXZI	3,000	maximum mixing height (m)
	XMINZI	50	minimum mixing height (m)
	WSCAT	1.54	wind speed category 1 (m/s)
		3.09	wind speed category 2 (m/s)
		5.14	wind speed category 3 (m/s)
		8.23	wind speed category 4 (m/s)
		10.8	wind speed category 5 (m/s)
	PLX0	0.07	wind speed profile exponent for A stability
		0.07	wind speed profile exponent for B stability
		0.1	wind speed profile exponent for C stability
		0.15	wind speed profile exponent for D stability
		0.35	wind speed profile exponent for E stability
PTG0	0.55	wind speed profile exponent for F stability	
	0.02	potential temperature gradient for E stability (K/m)	
	0.035	potential temperature gradient for F stability (K/m)	
	PPC	0.5	plume path coefficient for A stability
		0.5	plume path coefficient for B stability
0.5		plume path coefficient for C stability	
0.5		plume path coefficient for D stability	
0.35		plume path coefficient for E stability	
	0.35	plume path coefficient for F stability	
	SL2PF	10	slug-to-puff transition criterion factor equal to sigma y/length of slug
	NSPLIT	2	number of puffs that result every time a puff is split (not used since NSPLIT=0)
	IRESPLIT	0,0	

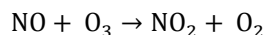
Table 11.4.I-11 CALPUFF Model Input Options (continued)

Input Group	Parameter	Project	Description
	SYSPLITH	1	minimum sigma-y (grid cells units) of puff before it may be split
	SHSPLITH	2	minimum puff elongation rate (SYSPLITH/hr) due to wind shear before it may be split
	CNSPLITH	1.0E-07	minimum concentration (g/m ³) of each species in puff before it may be split
	EPSSLUG	1.00E-04	fractional convergence criterion for numerical SLUG sampling integration
	EPSAREA	1.00E-06	fractional convergence criterion for numerical AREA source integration
	DSRISE	1	trajectory step-length (m) used for numerical rise integration
Group 13 -Point Source Parameters	NPT1	24	number of point sources
	IPTU	1	units for point source emission rates is grams per second (g/s)
	NSPT1	0	number of source-species combinations with variable emissions scaling factors
	NPT2	0	number of point sources with variable emission parameters provided in external file
Group 14 - Area Source Parameters	NAR1	132	number of polygon area sources
	IARU	1	area source emission rates (g/m ² /s)
	NSAR1	0	number of source-species combinations with variable emissions scaling factors
	NAR2	0	number of buoyant polygon area sources with variable location and emission parameters
Group 15 - Line Source Parameters	NLN2	0	number of buoyant line sources with variable location and emission parameters
	NLINES	0	number of buoyant line sources
	ILNU	1	line source emission rates (g/s)
	NSLN1	0	number of source-species combinations with variable emissions scaling factors
	MXNSEG	0	maximum number of segments used to model each line
	NLRISE	0	number of distances at which transitional rise is computed
	XL	0	average line source length (m)
	HL	0	average height of line source height (m)
	WBL	0	average building width (m)
	WML	0	average line source width (m)
	DXL	0	average separation between buildings (m)
	FPRIMEL	0	average buoyancy parameter
Group 16 - Volume Source Parameters	NVL1	0	number of volume sources
	IVLU	1	volume source emission rates (g/s)
	NSVL1	0	number of source-species combinations with variable emissions scaling factors
	NSVL2	0	number of volume sources with variable location and emission parameters
Group 17 - Non-Gridded Receptor Information	NREC	4,531	number of non-gridded receptors

° = degrees; m/s = metres per second; ppb = parts per billion; 1/s = 1 per second; cm²/s = square centimetres per second; µm = micrometre; /hr = per hour; g/s = grams per second; m = metre, g/m²/s = grams per square metre per second; g/m³ = grams per cubic metres.

11.4.I.5.6 NO_x TO NO₂ CONVERSION

Oxides of nitrogen (NO_x) are comprised of nitric oxide (NO) and nitrogen dioxide (NO₂). High temperature combustion processes primarily produce NO that in turn can be converted to NO₂ in the atmosphere through reactions with tropospheric ozone (O₃):



For the purposes of estimating potential acid input (PAI), CALPUFF uses a modified version of the RIVAD/ARM3 SO_x and NO_x chemistry scheme that was adopted to allow NO and NO₂ chemistry to be addressed explicitly. However, the CALPUFF model chemistry scheme has been shown to overestimate ambient NO₂ concentrations, especially close to emission sources (Staniaszek and Davies 2006). For that reason the NO_x obtained from the modelling was converted to NO₂ using the Ozone Limited Method (OLM). The OLM assumes that the conversion of NO to NO₂ in the atmosphere is limited by the ambient O₃ concentration in the atmosphere. If the ozone concentration is greater than 90% of the predicted NO_x, the method assumes all NO_x is converted to NO₂. Otherwise, the NO₂ concentration in parts per million (ppm) is equal to the sum of the ozone and 10% of the predicted NO_x concentration:

$$\text{NO}_2 = \text{O}_3 + 0.1 \times \text{NO}_x$$

The hourly, daily and annual O₃ concentrations used in the OLM calculations in assessment are 41.7, 38.6 and 25.6 parts per billion (ppb), respectively. These values were determined based ozone monitoring data for Yellowknife from 2005 through 2009 (GNWT 2006, 2008, 2009).

The OLM is recommended by the US EPA (and other jurisdictions) for locations with well defined, isolated sources. Hour-by-hour ozone values were not used in the OLM calculations as they were not available for the region for the time period of interest.

11.4.I.5.7 POTENTIAL ACID INPUT

Deposition includes both wet and dry processes and can result in the long-term accumulation of compounds in aquatic and terrestrial ecosystems. Wet processes involve the removal of emissions vented into the atmosphere by precipitation. Dry processes involve the removal by direct contact with surface features (e.g., vegetation). Both wet and dry deposition values are expressed as a flux in units of mass per area per time (e.g., kg/ha/yr).

Because several chemical species of nitrogen, sulphur and base cations are considered in the estimate of deposition, the flux is expressed in “keq/ha/yr” where “keq” refers to the number of equivalent hydrogen ions (1 keq = 1 kmol H⁺). For sulphur species, each molecule is equivalent to two hydrogen ions. Each molecule of nitrogen species is equivalent to one hydrogen ion. The deposition of sulphur and nitrogen compounds to these systems has been associated with changes in water and soil chemistry, and with the acidification of water and soil.

The calculation of PAI is based on the wet and dry deposition of sulphur compounds (e.g., SO₂ gas, SO₄²⁻ particle), nitrogen compounds (e.g., NO gas, NO₂ gas, HNO₃ gas, NO₃⁻ particle), chlorine ions (Cl⁻ gas), ammonium ions (NH₄⁺ particle) and base cations (e.g., Ca²⁺ particle, Mg⁺ particle, K⁺ particle and Na⁺ particle). Since PAI combines both sulphur and nitrogen, the individual deposition rates need to be converted to a common measure, namely “keq/ha/yr” (kilomoles of equivalent hydrogen ions [H⁺] per hectare per year), given these molecules have different equivalences to hydrogen ions as discussed above. The steps for completing the calculations are as follows:

- The PAI resulting from sulphur species is calculated from the annual sulphur deposition rates (expressed as kg/ha/yr). These are converted to keq/ha/yr by dividing the predicted deposition by the molecular weight and multiplying by the hydrogen ion equivalents, according to the following equation:

$$PAI_{sulphur} = \frac{([SO_2]_{dep,wet} + [SO_2]_{dep,dry}) \times 2}{64} + \frac{([SO_4^{2-}]_{dep,wet} + [SO_4^{2-}]_{dep,dry}) \times 2}{96}$$

- The PAI resulting from nitrogen species is calculated from the annual nitrogen deposition rates (expressed as kg/ha/yr). These are converted to keq/ha/yr by dividing the predicted deposition by the molecular weight and multiplying by the hydrogen ion equivalents, as follows:

$$PAI_{\text{nitrogen}} = \frac{([NO]_{dep,wet} + [NO]_{dep,dry})}{30} + \frac{([NO_2]_{dep,wet} + [NO_2]_{dep,dry})}{46} \\ + \frac{([HNO_3]_{dep,wet} + [HNO_3]_{dep,dry})}{63} + \frac{([NO_3^-]_{dep,wet} + [NO_3^-]_{dep,dry})}{62}$$

The total PAI is calculated as the sum of the sulphur and nitrogen deposition rates from sources within the study area together with the background PAI for the region.

$$PAI = PAI_{\text{sulphur}} + PAI_{\text{nitrogen}} + PAI_{\text{background}}$$

In this equation, the $PAI_{\text{background}}$ accounts for the background sulphur, nitrogen, Cl^- , NH_4^+ and base cations. Background PAI levels for the modelling domain were determined using the National Atmospheric Chemistry Precipitation Database (NAtChem) for Snare Rapids, NWT (NAtChem 2003, 2004, 2005, 2006 and 2007) and through the Regional Acid Deposition (RELAD) modelling completed by AENV (Cheng 2009, pers. comm.). A detailed discussion of background PAI is provided in Section 11.4.I.5.8.

11.4.I.5.8 BACKGROUND LEVELS OF ACID-FORMING COMPOUNDS

Selecting the background PAI that best represents the background conditions is important. Ideally this background value should not include the influence of industrial activities within the region of the proposed project.

The background PAI for the region was determined using a combination of two data sources:

- the NAtChem precipitation data for wet deposition; and
- the RELAD data for dry deposition.

NAtChem/Precipitation Chemistry Database system is a Canadian central database and analysis facility set up to accommodate and maintain diverse and variable network data and combine them together into one database. The purpose of the system is to determine the chemistry of regional scale precipitation in Canada and the US. Snare Rapids is the only location in the NWT for which NAtChem precipitation data are available and therefore was used to determine the background PAI for the assessment. NAtChem data provides wet deposition values for sulphur, nitrogen, Cl^- , NH_4^+ and base cations.

RELAD model data was used to determine the dry deposition values of sulphur and nitrogen. AENV has used the RELAD model (Cheng et al. 1997, 1995; Cheng and Angle 1996, 1993; McDonald et al. 1996) to determine background sulphur, nitrogen, PAI and base cation values for the Alberta Oil Sands Region. To find the background values that would occur in the absence of oil sands activities, all of the Oil Sands Region emission sources were excluded from the modeling. The resulting data considered in this assessment was provided by AENV (Cheng 2009, personal communication). This data was considered suitable for determining background for the Project modeling domain as the contribution of Oil Sands sources in the Project modeling domain can be expected to be minimal.

The following equations demonstrate the background PAI calculation:

$$PAI_{background} = PAI_{acidifying\ substances} + PAI_{base\ cations}$$

The PAI from acidifying substances can be expressed as:

$$PAI_{acidifying\ substances} = \frac{([SO_4^{2-}]_{dep,wet} + [SO_4^{2-}]_{dep,dry}) \times 2}{96} + \frac{[NO_3^-]_{dep,wet} + [NO_3^-]_{dep,dry}}{62} + \frac{[NH_4^+]_{dep,wet}}{18} + \frac{[Cl^-]_{dep,wet}}{35.5}$$

The buffering capacity of base cations would be calculated according to the following equation:

$$PAI_{base\ cation} = - \left(\frac{[Ca^{2+}]_{dep,back} \times 2}{40} + \frac{[Mg^{2+}]_{dep,back} \times 2}{24} + \frac{[K^+]_{dep,back}}{39} + \frac{[Na^+]_{dep,back}}{23} \right)$$

The RELAD model is an appropriate tool for assessing acid deposition on a provincial or continental scale. The data generated by the model is at a resolution of 1° of latitude by 1° of longitude, and covered between 53° and 60° in latitude and 109° and 114° in longitude. Cells 60° x 109° to 60° x 114° compass the border between Alberta and NWT. It is reasonable to assume that the contribution of industrial emissions to background PAI in these cells will be negligible and similar to background PAI within the modeling domain. Since RELAD data are not available for the NWT, the average background deposition values in these cells were used as surrogates for the dry and wet deposition rations in the modeling domain.

NAtChem data only provides wet deposition values. In order to determine dry deposition values for the modeling domain, it was assumed that on average the ratio of dry deposition to wet deposition for nitrogen and sulphur in the cells 60° x 109° through 60° x 114° will be applicable for the region of the proposed project. This dry to wet deposition ratio for nitrogen and sulphur was then applied to NAtChem wet nitrogen and sulphur deposition values to determine the dry nitrogen and sulphur deposition values for the modeling domain.

A background PAI value of 0.064 keq/ha/yr was used in the assessment.

11.4.I.5.9 BACKGROUND CONCENTRATIONS

As part of the cumulative air quality assessment, background concentrations were added to predicted ground level concentrations due to the Project and existing and approved industrial sources in the Project region. Background concentrations include the contributions of natural sources, nearby sources and unidentified distant sources.

A summary of background SO₂, NO_x, TSP, PM₁₀ and PM_{2.5} concentrations used in the air quality assessment for is presented in Table 11.4.I-13. The methodology used to determine the background concentrations is presented in Appendix B.

Table 11.4.I-12 Background Concentrations Used in Air Quality Assessment

Parameter	Concentration [µg/m ³]
Sulphur dioxide gas (SO ₂)	2.6
Nitrogen oxides (NO _x)	5.7
Total suspended particulates (TSP)	7.1
PM ₁₀	3.0
PM _{2.5}	1.9

PM₁₀ = particulate matter of particle diameter less than 10 µm; PM_{2.5} = particulate matter of particle diameter less than 2.5 µm; µg/m³ = micrograms per cubic metres; µm = microns.

The concentrations of metals, VOCs and PAHs were assumed to be primarily from industrial sources and their background concentrations were assumed to be negligible.

Table 11.4.I-13 summarizes the background monthly ozone values used in the model. These values are average monthly ozone concentrations collected in Yellowknife between 2005 and 2009 and published in Northwest Territories Air Quality Reports (GNWT 2006, 2008 and 2009).

Table 11.4.I-13 Background Monthly Ozone Concentrations

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
O ₃ [µg/m ³]	25	26	28	35	33	28	23	20	19	20	25	25

µg/m³ = micrograms per cubic metres.

As shown in Table 11.4.I-13, the typical monthly ozone concentrations recorded at Yellowknife are between 40 and 80 µg/m³, this indicates that most of the O₃ detected is likely naturally occurring or background (GNWT 2006, 2008, and 2009).

11.4.I.6 SCIENTIFIC UNCERTAINTY

11.4.I.6.1 PREDICTED CONCENTRATIONS

The evaluation of changes in air quality depends primarily on the use of air dispersion models to estimate future ambient levels. As with any form of prediction, there are uncertainties associated with the model's capability to predict concentrations accurately. An accepted dispersion model (i.e., CALPUFF) was selected for the analysis to minimize some of these uncertainties.

Another uncertainty associated with air quality predictions is tied to the predicted emissions within the region. Emissions associated with industrial activities are reasonably well defined and were largely taken from recent applications. However, the emissions from non-industrial activities within regional communities are more difficult to predict. Appropriate background concentrations were incorporated into the assessment using the following three approaches:

- The contribution of certain compounds (e.g., metals, VOCs and PAHs) was considered negligible when compared to industrial sources.
- When reliable emission estimation methods were not available for a particular compound, representative monitoring data was added to model predictions. This approach was adopted for NO_x, SO₂, PM_{2.5}, PM₁₀ and TSP.

11.4.I.6.2 PREDICTED DEPOSITION LEVELS

The evaluation of changes in the deposition of acid-forming compounds depends on the use of air dispersion models to estimate future ambient levels. As with any form of prediction, there are uncertainties associated with the model's capability to predict concentrations accurately. To minimize some of these uncertainties, an accepted dispersion model (i.e., CALPUFF) was selected for the analysis.

The Canadian National Atmospheric Chemistry Precipitation Database and RELAD data were used to determine the background PAI values for the region of the proposed project. The background PAI value used in the Project Air Quality Assessment is presented in Section 11.4.I.1.5.8.

Another area of uncertainty associated with PAI levels is related to effects of acidifying emissions on the receiving environment. Acid deposition will affect different elements of the ecosystem in different ways. A complete evaluation of the effects of acidifying emissions on the local and regional ecosystems is presented in Section 8.8 and Section 9.8.

11.4.I.7 MODELLING APPROACH FOR NON-STACK SOURCES

11.4.I.7.1 CONFIGURATION OF SOURCES

The purpose of this section is to provide additional information related to the parameterization of mines, facilities, and roads as emissions sources used in the CALPUFF model.

Emissions from stacks were treated as point sources and the required parameters for these sources include location, base elevation, stack height, diameter, exit velocity, exit temperature and mass emission rate. Emissions that do not pass through a stack, such as fugitive and tailpipe emissions were treated as area sources (haul roads, vehicle tailpipes, plant and mine operations). For modelling area sources, the required parameters include elevation, effective release height and vertical initial dispersion parameters, and mass emission rate.

Details of emission configures and rates are provided in Appendix 11.4.II.

11.4.I.7.1.1 Mine Pits, Mine Rock Piles and Fine Processed Kimberlite Containment Facility

Emissions from each of the three mine pits were modelled in separate area sources. Mine rock pile emissions were modelled as two area sources: one for the South Mine Rock Pile and the other West Rock Mine Pile. Those sources have an effective release height of 6.0 m based on the tailpipe height of large haul trucks, the average height of the centre-line of the plume from drilling, blasting, bulldozing, loading and unloading activities. The initial vertical dimension of the area sources, σ_z , was set at 16 m based on recommended value for modelling mine pit emissions (RWDI 2008).

11.4.I.7.1.2 Plant Emission Area Sources

Plant emission area sources at the Project include:

- run-of-mine (ROM) stockpile;
- primary crusher;
- conveyors;
- coarse ore stockpile;

- coarse processed kimberlite loadout area; and
- aggregate plant.

The ROM, coarse ore stockpile and coarse processed kimberlite loadout area were assumed to be released at 7.5 m above the ground, half of the 15-m stockpile height. The σ_z was calculated to be 7.0 m.

The crusher and conveyor emissions were assumed to be released at 5 m above ground, half of the 10 m conveyor drop height. The σ_z was calculated to be 4.7 m.

11.4.I.7.1.3 Haul Roads

Haul trucks transporting overburden and mine rock from mine pits to the mine rock piles, kimberlite from the mine pits to the process plant, and coarse processed kimberlite from the plant to the fine processed kimberlite containment facility were modelled as an array of area sources with an effective emission height of 6 m. That height was considered to be the average height of the centre-line of plumes from tailpipes height of haul trucks. The initial σ_z was calculated also to be 5.6 m, which corresponds to a 12 m vertical plume dimension.

The efficiency of watering on road dust reduction was assumed to be 80% in summer (Appendix 11.4.II). Dust reduction in winter was conservatively assumed to be zero.

11.4.I.7.1.4 Winter Access Road

Winter access road emissions were modelled as an array of area sources with an effective release height of 6 m, which was considered to be the average height of the centre-line of the plume from buoyant vehicle exhaust. The initial σ_z was 5.6 m based on a plume of 12 m vertical dimension. Appendix 11.4.II includes a detailed description of the winter access road emissions.

11.4.I.7.1.5 Drained Kennady Lakebed

The wind-blown dust emissions from drained Kennady lakebed were modelled as three area sources. The effective height of these area sources was set to 0 m and the initial σ_z was set to 1 m.

11.4.I.8 REFERENCES

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11.4.I.9 ACRONYMS AND GLOSSARY

11.4.I.9.1 ABBREVIATIONS AND ACRONYMS

2D	two dimensional
3D	three dimensional
AAAQO	Alberta Ambient Air Quality Objectives
AAQG	Ambient Air Quality Guidelines
AAQO	Ambient Air Quality Objectives
AENV	Alberta Environment
Al₂O₃	aluminum oxide
AMEC	AMEC Earth & Environmental
ANFO	ammonium nitrate fuel oil
BATEA	best available technology economically achievable
BC	British Columbia
BC MOE	British Columbia Ministry of Environment.
C	carbon
Ca²⁺	calcium ion
CALMET	California meteorological model
CALPUFF	California puff plume dispersion model
CASA	Clean Air Strategic Alliance
CCME	Canadian Council of Ministers for the Environment
CEA	cumulative effects assessment
CH₄	methane
CO	carbon monoxide
CO₂	carbon dioxide
CWS	Canada-wide standards
De Beers	De Beers Canada Inc.
DEM	Digital Elevation Model.
Eh	effective height
EIA	environmental impact assessment
EIS	environmental impact statement
GHG	greenhouse gas
GNWT	Government of the Northwest Territories
H⁺	hydrogen ion
HHRA	human health risk assessment
HNO₃	nitric acid, gas
ISC3	industrial source complex – version 3

ISO	International Organization for Standardization
LAI	Leaf Area Index
LAI	Leaf Area Index
LSA	local study area
LUC	Land Use Categories
Mg²⁺	magnesium ion
MM5	Penn State Mesoscale Model
MnO	manganese oxide
MVEIRB	MacKenzie Valley Environmental Impact Review Board
N	nitrogen
N₂O	nitrous oxide
NAD	North American Datum
NARR	North American Regional Reanalysis
NCAR	National Centre for Atmospheric Research.
NCEP	National Center for Environmental Protection
NH₃	ammonia
NH₄	ammonia(particle)
NO	nitric oxide
NO₂	nitrogen dioxide gas
NO₃⁻	nitrate ion
NOAA	National Oceanographic and Atmospheric Administration
NO_x	nitrogen oxides
NO_x	nitrogen oxides, a mixture of nitric oxide (NO) and nitrogen dioxide (NO ₂)
NWT	Northwest Territories
O₂	oxygen molecule (two oxygen atoms)
O₃	ozone molecule (three oxygen atoms)
OLM	ozone limited method
PAH	polycyclic aromatic hydrocarbon
PAI	potential acid input
pers. Comm.	Personal Communication
PG	Pasquill-Gifford stability class
PK	processed Kimberlite
PKC	processed kimberlite containment
PM	particulate matter, generally
PM₁₀	particulate matter of particle diameter less than 10 µm
PM_{2.5}	particulate matter of particle diameter less than 2.5 µm
PPE	personal protective equipment
PRIME	plume rise model enhancement
Project	Gahcho Kué Project

R-CDAS	Regional Climate Data Assimilation System
RELAD	Regional Lagrangian Acid Deposition Model
RIVAD/ARM3	Regional Impact in Visibility and Acid Deposition/Acid Rain Mountain Mesoscale Model
ROM	Run-of-mine
RSA	Regional Study Area
RWED	Department of Resources, Wildlife, and Economic Development of the Environmental Protection Division of Government of Northwest Territories
S	south
S	sulphur
SiO₂	silicon oxide
SO₂	sulphur dioxide gas
SO₄²⁻	sulphate ion
SOA	Secondary Organic Aerosol
SO_x	sulphur oxides
SP	suspended particulate
SRTM3	Shuttle Radar Topography Mission 3
TSP	total suspended particulates
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UTM	universal transverse mercator
VC	valued component
VOC	volatile organic compound
W	watt
WHO	World Health Organization
Z₀	roughness height

11.4.I.9.2 UNITS OF MEASURE

%	percent
μ	micro - 10 ⁻⁶
°C	degrees Celsius
μg/m²/s	micrograms per square metres per second
μg/m³	micrograms per cubic metre
<	less than
>	more than
°	degree
μm	micron or micrometre = 10 ⁻⁶ m

5.21E-02	Scientific notation: $0.0521 = 5.21\text{E-}02 = 5.21 \times 10^{-2}$
cm/s	centimetres per second
CO₂e/yr	Equivalent Carbon Dioxide
d	day = calendar day
g	gram
g/GJ	gram per gigajoule
GJ/h	gigajoule per hour
h	hour
ha	hectare (0.01 km ²)
ha	Hectare
I-TEQ	International Toxic Equivalency Quotient, relative to the toxic equivalent of 2,3,7,8-tetrachlorodibenzo-para-dioxin
J	joule
K	degree Kelvin
keq	kiloequivalent – equal to 1 kmol of hydrogen ion (H ⁺)
keq/ha/y	kilo-equivalent (hydrogen ion equivalent – 1 keq = 1 kmol H ⁺) per hectare per year. Measure of PAI deposition.
kg	kilogram
kg/VKT	kilogram per vehicle kilometre
kgN/ha/y	kilogram nitrogen per hectare per year
km	kilometre
km/h	kilometres per hour
km²	square kilometres
kmol	10 ³ mol
Kt CO₂e/yr	Kilotonnes of Equivalent Carbon Dioxide per year
L	litre
lb/VMT	pounds per vehicle kilometer
M	mega – million - 10 ⁶
m	metre
m/s	metres per second
m³	cubic meter
m³/d	cubic metres per day
m³/s	cubic metres per second
mm	millimetre
mol	mole
Mt	million -tonne, one million (10 ⁶) tonnes
Mt/y	mega-tonne per year
p	Pico - 10 ⁻¹²
Pa	Pascal

pgl-TEQ/m³	picograms of international toxic equivalency quotients per cubic metre
ppb	Parts per billion - measure of concentration 1 part to 10 ⁹ parts
ppbv	parts per billion by volume
ppm	parts per million – measure of concentration 1 part to 10 ⁶ parts
ppmv	parts per million by volume
ppmw	parts per million by weight
t	tonne = 1,000 kg
t/d	tonnes per day
t/h	Tonnes per hour
t/yr	Tonnes per year
W/m²	unit of the energy (heat) flux – Watt per unit of the area in meter square
y	year
yr	Year
σ_z	Initial vertical dimension for volume source

11.4.I.9.3 GLOSSARY

Absorption	In Physics: the taking up and storing of energy, such as radiation, light, or sound, without it being reflected or transmitted.
AERMOD	A steady-state dispersion model designed for short-range (up to 50 km) dispersion of air pollutant emissions from stationary industrial sources.
Albedo	Albedo is fraction of solar energy reflected back from the Earth into space.
Alpha Star	Aqueous phase dissociation constant, α^* . A value which quantitatively expresses the extent to which a substance dissociates in solution (water). The smaller the value of α^* , the less dissociation of the species in solution.
Anthropogenic Heat Flux	is the surface heating caused by human activity, including automobiles and heating systems.
Averaging Times	Period of time over which predicted concentrations are averaged, for example, over one hour, one day or a year.
Boundary Layer	Lower part of the Troposphere that is directly influenced by the presence of the Earth's surface.
Bowen Ratio	For any moist surface, the ratio of heat energy used for sensible heating (conduction and convection) to the heat energy used for latent heating (evaporation of water or sublimation of snow).
Building Downwash	Building downwash occurs when a particular stack is short enough that the plume is entrained into turbulence caused by nearby structures. As wind flows across a building (or structure) eddies are formed in the downwind side of the building, and some air upstream of the building is "downwashed" in the lee side. This results in higher ground level concentrations.
Calm Winds	No apparent air motion (usually winds below the stall speed of the anemometer, e.g., below 1 knot or 0.5 m/s).

CALPUFF-2D	CALPUFF plume dispersion model in steady-state (two-dimensional) mode which utilizes one meteorological station and meteorological data are in ISC3 format (no upper air data).
CALPUFF-3D	CALPUFF model in dynamic (three-dimensional) mode using meteorological data from CALMET model output (three dimensional meteorological data field).
CO	Carbon Monoxide. Odourless, colourless non-irritating but toxic gas. It is a product of incomplete combustion of fuel (e.g., gas, diesel, etc.).
Complex Terrain	Terrain within several kilometres of a facility whose height is above stack top height.
Contaminants	A general term referring to any chemical compound added to a receiving environment in excess of natural concentrations. The term includes chemicals or effects not generally regarded as "toxic", such as nutrients, colour and salts.
CTDMPLUS	The Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations is a refined air quality dispersion model for use in all stability conditions for complex terrain applications.
DEM	Digital Elevation Model. DEM data are produced by interpolating elevations at certain intervals from contours, ridgelines, and drains digitized from 1:250,000-scale topographic maps.
Diffusion	The movement of atoms or molecules from an area of higher concentration to an area of lower concentration.
Diffusivity	Diffusion Coefficient: temperature dependent material parameter described by amount of material, diffusing across an area of 1 cm ² in 1 second in a unit of concentration gradient (unit cm ² /s).
Eh	Effective height of emissions for volume and area sources.
Emission	Release of substances to atmosphere (e.g., fugitive emission, stack emission, diesel exhaust, wind blow dust, etc.).
Eta	National Weather Service forecast model (45 vertical layers, 32 km horizontal space grid). Model predictions are made every three hours.
Exposure	Estimated dose of substance that is received by a particular receptor via various exposure pathway, (e.g., ingestion, inhalation).
Foliage Period	Period of year when there are leaves on trees.
Forest Canopy	The uppermost layer of a forest, formed by the crowns of the trees.
Friction Velocity	A characteristic velocity based on surface stress. This velocity is also representative of turbulent fluctuations in the lowest layer of the atmospheric boundary layer.
Geophysics	The physics of the earth and its environment, including the physics of fields such as meteorology, oceanography, and seismology.
Heat Flux	Amount of heat, transferred in a liquid, or in the atmosphere, per unit of time through a unit area.
Henry's Law	At a constant temperature, the amount of a given gas dissolved in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid.
Hydrology	Hydrology is the study of the movement, distribution, and quality of water..
Inert Pollutant	Pollutants which are resistant to chemical transformation.
Interpolation	Interpolation is a method of constructing new data points from a discrete set of known data points.

Lagrangian Model	Lagrangian dispersion models mathematically follow pollution plume parcels (also called particles) as the parcels move in the atmosphere. They model the motion of the parcels as a random walk process. Lagrangian models calculate dispersion by computing the statistics of the trajectories of a large number of plume parcels.
LAI	Leaf Area Index, the ratio of total upper leaf surface of vegetation divided by the surface area of the land on which the vegetation grows.
Line Source	A source of air, noise, water contamination or electromagnetic radiation that emanates from a linear (one-dimensional) geometry (e.g., hauling road).
Linear Removal	Wet deposition of pollutants from Gaussian plumes described by linear equations.
Long Range Transport	The transport extending beyond local and regional scale (hemispheric, global, intercontinental).
Mesophyll Resistance	Foliage resistance to absorb gases from the atmosphere (parameter used in deposition calculations by CALPUFF – units – s/cm)
MAKEGEO	CALMET model pre-processor combining terrain and land characteristic data into geophysical file (geo.dat).
MM5	Penn State / NCAR Mesoscale Model (version 5) is a regional, high-resolution forecast model. It is a meso-scale model, meaning one that provides more detail for a specific region rather than large, continental/oceanic sections.
Monin-Obukhov Length	A measure of atmospheric stability. It is negative during the day when surface heating results in an unstable atmosphere and positive at night when the surface cools (stable atmosphere).
NARR	North American Regional Reanalysis weather forecast model created by NCEP which is part of NOAA. http://www.emc.ncep.noaa.gov/mmb/rreanl
Non-Foliage Period	Period of the year when there are no leaves on trees.
Ozone	Ozone (O ₃) is a triatomic molecule, consisting three oxygen atoms. Ground-level ozone is an air pollutant with harmful effects on respiratory system of animals and humans.
PAI	Potential Acid Input. A Measure of acidification resulting from sulphur and nitrogen deposition to water and soil.
Parameter	A particular physical, chemical property that is being measured in air (e.g., wind speed, wind direction, temperature benzene content, etc.).
PCRAMMET	A utility program to convert meteorological data from the U.S. National Weather Service to a data format which can be used by the U.S. EPA short term air quality dispersion models like ISC3 and AERMOD.
Peak Operation	Associated with operations at maximum Plant and Mine design levels for all equipment. Operations that result in the maximum daily and hourly emissions of contaminants.
Plume	A space in the air, water, or soil containing pollutants released from a source.
Plume Rise	The final vertical plume position which depends on the temperature difference between stack and atmosphere and on the exit velocity.
Point Source	is a single identifiable localized source of air, water, thermal, noise or light pollution (e.g., stack).
Pollutant	A substance or condition that contaminates air, water, or soil (e.g., SO ₂ , CO ₂ , heat, light).

PRIME	The Plume Rise Model Enhancements model, designed to incorporate the two fundamental features associated with building downwash: enhanced plume dispersion coefficients due to turbulent wake, and reduced plume rise caused by a combination of the descending streamlines in the lee of the building and the increased entrainment in the wake.
Quarry	An open excavation pit from which stone is obtained by digging, cutting or blasting.
Radiation	Energy that comes from a source and travels through some material or through space. Light, heat and sound are types of radiation.
Radius of Influence	The radius within which the meteorological data from surface station are used and upper air meteorological data are not considered.
Rangeland	An expanse of land suitable for livestock pasture.
R-CDAS	Regional Climate Data Assimilation System is the real time continuation of the NCEP's NARR.
Receptor	The person or organism or location subjected to chemical exposure.
ROM	Run-of-mine. Raw material transported directly from the mine.
Roughness Height (Z_o)	is the height at which the vertical wind profile is extrapolated to zero wind speed. It is a measure of the aerodynamic roughness of a surface and is related to the height, shape and density of the surface, as well as wind speed.
Scavenging Coefficient	depends on the characteristics of the pollutant (e.g., solubility and reactivity for gases, size distribution for particles) as well as the nature of the precipitation (e.g., liquid or frozen).
SLUG	CALPUFF model run option where the puffs are treated as elongated "slugs". Usually, this option is used for accidental releases scenario and/or where transport from the source to receptors of interest is very short (possibly sub-hour transport). These cases generally involve the demonstration of causality effects due to specific events in the near- to intermediate-field.
SOA	Secondary Organic Aerosol option in CALPUFF model. The SOA module uses monthly values of: fine particulate concentration in $\mu\text{g}/\text{m}^3$, organic fraction of fine particulate, and VOC / NO_x ratio (after reaction) to characterize the air mass when computing the formation of SOA from VOC emissions.
Solar Radiation	Radiant energy emitted by the sun.
SRTM3	Shuttle Radar Topography Mission 3 arc seconds (90 m) spaced terrain elevation data.
Standard Deviation	of a set of variables is a measure of the spread of its values.
Temperature Gradient	The rate of change of temperature with displacement in a given direction from a given reference point.
TERREL	A CALMET pre-processing program that extracts and reformats Digital Elevation Model (DEM) terrain data according to the options selected by the user (domain, resolution, etc.). TERREL output can be used to obtain a geophysical parameter file that is input to the CALMET model.
Toxic	Relating to a harmful effect by a poisonous substance on the human body by physical contact, ingestion or inhalation.
Troposphere	The lowest region of the atmosphere between the earth's surface and the tropopause, characterized by decreasing temperature with increasing altitude.

Unstable Atmosphere	A turbulent state of atmosphere with vertical air motion (e.g., due to sun heating the Earth surface).
UTM	Universal Transverse Mercator coordinate system is a grid based method of specifying locations on the Earth. It employs a series of sixty zones each is based on specifically defined secant Transverse Mercator projection.
VOC	Volatile Organic Compound (that boils below a temperature of about 100°C), including all non-methane hydrocarbons (NMHC).
Volume Source	A three-dimensional source of pollutant emissions (e.g., wind erosion from stockpiles).
Water Quality	A measure of concentrations of contaminants, or naturally occurring minerals, in water. The lower the concentration of a particular contaminant, the better water quality is.
Wet Deposition	The removal of plume components by the action of rain or snow.
Wetlands	A low-lying area of soft, waterlogged ground and standing water. A lowland area, such as a marsh or swamp, that is saturated with moisture.
Wind Shear	A change in wind direction and speed between different altitudes.

APPENDIX 11.4.II

EMISSIONS ASSOCIATED WITH DIAMOND MINE AND PROCESSING PLANT OPERATIONS

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11.4.II.1 INTRODUCTION

This appendix provides information on both the Gahcho Kué Project (Project) emissions and regional emissions considered in the air quality assessment. The objective of this appendix is to identify and document the bases for the emission information used in the assessment.

11.4.II.2 SUMMARY OF PROJECT AND REGIONAL EMISSIONS

The proposed De Beers Canada Inc. (De Beers) Project is located approximately 280 kilometres (km) northeast of Yellowknife, Northwest Territories (NWT). The only other development in the Regional Study Area is the De Beers Snap Lake Mine, which is located approximately 85 km west of the Project. Snap Lake Mine received regulatory approval in May 2004 and began commercial production in January 2008.

Three emission scenarios were included in the air quality modelling assessment as follows:

- Baseline Case, which includes emissions from the existing and approved Snap Lake Mine.
- Application Case, which includes the emissions from the existing and approved Snap Lake Mine in combination with the maximum Project emissions during the operations phase of the Project.
- Construction Case, which includes the emissions from the existing and approved Snap Lake Mine in combination with the maximum Project emissions during the construction phase of the Project.

Table 11.4.II-1 summarizes sulphur dioxide gas (SO₂), nitrogen oxides (NO_x), carbon dioxide (CO) and particulate (total suspended particles [TSP], particulate matter with particle diameter less than 10 microns [µm; PM₁₀] and particulate matter with particle diameter less than 2.5 µm [PM_{2.5}]) emissions from the Project and Snap Lake Mine in all emission scenarios.

Table 11.4.II-1 Summary of Project and Regional Emissions

Source	Emission Rate [t/d]					
	SO ₂	NO _x	CO	TSP	PM ₁₀	PM _{2.5}
Baseline Case						
Snap Lake Mine	0.304	8.673	3.014	0.502	0.251	0.166
Application Case						
Gahcho Kué Project	0.041	4.600	2.488	8.625	2.163	0.407
Snap Lake Mine	0.304	8.673	3.014	0.502	0.251	0.166
Total	0.345	13.273	5.502	9.127	2.414	0.573
Construction Case						
Gahcho Kué Project	0.025	1.909	1.267	2.810	0.806	0.169
Snap Lake Mine	0.304	8.673	3.014	0.502	0.251	0.166
Total	0.330	10.582	4.281	3.311	1.057	0.336

SO₂ = sulphur dioxide; NO_x = nitrogen oxides; CO = carbon dioxide; TSP = total suspended particulates; PM₁₀ = particulate matter with particle diameter less than 10 microns; PM_{2.5} = particulate matter with particle diameter less than 2.5 microns; t/d = tonnes per day.

The information in the following sections describes the detailed emission estimation approaches used for the Project and the Snap Lake Mine.

11.4.II.3 PROJECT EMISSIONS

The Golder Associates Ltd. (Golder) air quality team worked closely with the teams at De Beers and the engineering consulting firm designing the Project namely, JDS Engineering and Mining Inc. (JDS), to define the air emission parameters for the Project. For the purpose of this assessment, the Project emission sources were grouped into the following categories:

- Stack sources: these include power generator, auxiliary boiler, waste incinerator and scrubber stacks.
- Mobile diesel combustion equipment: this includes all of the mobile and portable diesel combustion equipment at the Project.
- Mining and material handling activities: these are activities at the Project that will result in fugitive dust emissions.
- Winter Access Roads.
- Drained Kennady lakebed.

The following sections describe the supporting data used in the Project emission calculations as well as the methodologies for calculating emissions for each emission source during both the operations phase and construction phase.

11.4.II.3.1 SUPPORTING DATA USED IN PROJECT EMISSION CALCULATIONS

11.4.II.3.1.1 Material Balance

Prior to calculating the project emissions, the quantity and distribution of the overburden, mine rock, kimberlite and coarse processed kimberlite (PK) were reviewed to determine the most appropriate basis for each emission calculation. Tables 11.4.II-2, 11.4.II-3 and 11.4.II-4 outline the quantity and distribution of the overburden, mine rock and coarse PK during the construction phase and operations phase of the Project. Kimberlite annual production rate will reach a maximum rate of 3.0 million tonnes per year (Mt/y) after lower production rate in the first two years of production.

Table 11.4.II-2 Overburden Removal from Year -2 to Year 7

Year	Calendar Year	Overburden Removal (m ³)			
		5034	Hearne	Tuzo	Total
-2 ^(a)	2013	204,000	—	—	204,000
-1 ^(a)	2014	117,000	—	—	117,000
1	2015	984,000	—	—	984,000
2	2016	—	—	—	0
3	2017	—	—	—	0
4	2018	—	552,000	—	552,000
5	2019	—	328,000	827,000	1,155,000
6	2020	—	—	159,000	159,000
7	2021	—	—	92,000	92,000
Total		1,305,000	880,000	1,078,000	3,263,000

^(a) Construction years.

m³ = cubic metres.

Table 11.4.II-3 Mine Rock Removal from Year -2 to Year 7

Operation Year	Calendar Year	5034 Mine Rock (Mt)			Hearne Mine Rock (Mt)	Tuzo Mine Rock (Mt)			Total
		To South Mine Rock Pile	To West Mine Rock Pile	Total		To 5034 Pit	To West Mine Rock Pile	Total	
-2	2013	1.6	—	1.8	—	—	—	—	1.8
-1	2014	16.0	—	16.0	—	—	—	—	16.0
1	2015	27.2	—	27.2	—	—	—	—	27.2
2	2016	24.7	—	24.7	—	—	—	—	24.7
3	2017	2.2	15.5	17.7	—	—	—	—	17.7

Table 11.4.II-3 Mine Rock Removal from Year -2 to Year 7 (continued)

Operation Year	Calendar Year	5034 Mine Rock (Mt)			Hearne Mine Rock (Mt)	Tuzo Mine Rock (Mt)			Total
		To South Mine Rock Pile	To West Mine Rock Pile	Total	To West Mine Rock Pile	To 5034 Pit	To West Mine Rock Pile	Total	
4	2018	—	10.5	10.5	1.9	—	—	—	12.4
5	2019	—	2.9	2.9	10.0	11.6	—	11.6	24.5
6	2020	—	—	—	11.8	13.3	—	13.3	25.1
7	2021	—	—	—	3.6	27.2	—	27.2	30.8
8	2022	—	—	—	—	31.5	—	31.5	31.5
9	2023	—	—	—	—	—	9.9	9.9	9.9
10	2024	—	—	—	—	—	4.0	4.0	4.0
11	2025	—	—	—	—	—	1.0	1.0	1.0
Total		71.7	28.9	100.6	27.3	83.6	14.9	98.5	226.4

Mt = million tonnes.

Table 11.4.II-4 Coarse Processed Kimberlite Deposition

Operation Year	Calendar Year	Coarse and Grits (Mt)			
		Coarse PK Pile	Reclaim/ Dyke	In-Pit (5034 Pit)	Total
1	2015	1.89	—	—	1.89
2	2016	2.25	—	—	2.25
3	2017	2.25	—	—	2.25
4	2018	2.15	0.10	—	2.25
5	2019	1.70	0.55	—	2.25
6	2020	0.20	0.49	1.56	2.25
7	2021	—	0.49	1.76	2.25
8	2022	—	0.49	1.76	2.25
9	2023	—	0.49	1.76	2.25
10	2024	—	0.49	1.76	2.25
11	2025	—	0.49	0.86	1.35
Total		10.44	3.59	9.46	23.49

PK = processed kimberlite; Mt = million tonnes.

The overburden, mine rock, kimberlite and coarse PK production rates used in the calculations are presented in Table 11.4.II-5. These production rates were based on the highest annual production rates for each type of material regardless whether they are from the same year. This assumption results in the consideration of the worst case emissions from the Project which is more conservative than the expected emissions during any given year of the Project.

Table 11.4.II-5 Maximum Material Production Rates for the Project Emission Calculations

Parameters	Values
Annual overburden production rate [Mt/y]	2.6
Annual mine rock production rate [Mt/y]	30.567
Annual kimberlite production rate [Mt/y]	3.576
Annual coarse PK production rate [Mt/y]	2.25

PK = processed kimberlite; Mt/y = million tonnes per year.

11.4.II.3.1.2 Moisture Content

Table 11.4.II-6 summarizes moisture data supplied by JDS (Prince-Wright 2010, pers. comm.). The mine rock and kimberlite moisture content values used in the emission calculations were 7.5 percent (%) and 6.0%, respectively. The Previous assessment of both Snap Lake Mine and Diavik Diamond Mine assumed mine rock moisture contents of 5% or higher (Diavik 1998; Golder Associates 2004). The coarse PK moisture content used in the emission calculations was 12.0%, possibly a result of the wet ore processing.

Table 11.4.II-6 Moisture Content of Material

Material	Moisture Content (%)
Overburden	24.0
Mine rock	7.5
Kimberlite	6.0
Coarse Processed Kimberlite	12.0

% = percent.

11.4.II.3.1.3 Silt Content

Silt content is the fraction of silt, particles smaller than 75 µm in diameter, in a specific type of material. The silt content of the overburden was obtained from Table 13.2.4-1 in the United States Environmental Protection Agency (U.S. EPA) Compilation of Air Pollutant Emission Factors: AP-42 (U.S. EPA 2006a) due to a lack of site-specific silt data. Table 13.2.4-1 contains a list of various types of material (e.g., coal, sand, clay and etc.) and their respective silt contents. The silt content for the mine rock, kimberlite and coarse PK were assumed to be similar to the silt content of crushed limestone. The haul roads will be paved with crushed mine rock; therefore, the silt content of the haul roads would be the same as the value selected for the mine rock. Table 11.4.II-7 summarizes the silt content for each type of material.

Table 11.4.II-7 Silt Content of Material

Material	Silt Content (%)
Overburden	7.5
Mine rock	1.6
Kimberlite	1.6
Coarse Processed Kimberlite	1.6

% = percent.

11.4.II.3.1.4 Metal Composition of Mine Rock, Kimberlite and Coarse Processed Kimberlite

The majority of the metal emissions from the Project originate from mine rock, kimberlite and coarse processed kimberlite dust released during mining and transport operations. Metal emissions from the combustion sources are negligible in comparison to metal fractions in the fugitive particulate emissions. The mine rock, kimberlite and coarse PK metal compositions used in the emission calculations were based on geochemistry data provided in Appendix 8-II, Section 8-II.4. Table 11.4.II-8 details the average metal composition for mine rock, kimberlite and coarse PK used in the air quality assessment.

Table 11.4.II-8 Metal Composition of Mine Rock, Kimberlite and Coarse Processed Kimberlite

Metals	Weight Fraction		
	Mine Rock	Kimberlite	Coarse PK
Aluminum	0.00923	0.01945	0.01847
Antimony	0.00000	0.00000	0.00000
Arsenic	0.00000	0.00000	0.00000
Barium	0.00019	0.00059	0.00061
Bismuth	0.00000	0.00000	0.00000
Boron	0.00001	0.00009	—
Cadmium	0.00000	0.00000	0.00000
Calcium	0.00360	0.01458	0.01243
Chromium	0.00008	0.00030	0.00029
Cobalt	0.00001	0.00006	0.00004
Copper	0.00001	0.00004	0.00004
Gallium	0.00001	0.00001	0.00001
Gold	0.00000	0.00000	0.00000
Iron	0.01733	0.03817	0.03696
Lanthanum	0.00004	0.00005	0.00005
Lead	0.00001	0.00001	0.00000
Magnesium	0.01867	0.12150	0.10804
Manganese	0.00025	0.00060	0.00052

Table 11.4.II-8 Metal Composition of Mine Rock, Kimberlite and Coarse Processed Kimberlite (continued)

Metals	Weight Fraction		
	Mine Rock	Kimberlite	Coarse PK
Mercury	0.00000	0.00000	0.00000
Molybdenum	0.00000	0.00000	0.00000
Nickel	0.00012	0.00089	0.00074
Phosphorus	0.00068	0.00116	0.00092
Potassium	0.00475	0.00796	0.00767
Scandium	0.00000	0.00001	0.00001
Selenium	0.00000	0.00000	0.00000
Silver	0.00000	0.00000	0.00000
Sodium	0.00031	0.00136	0.00109
Strontium	0.00004	0.00034	0.00027
Thorium	0.00001	0.00001	0.00001
Titanium	0.00090	0.00066	0.00090
Tungsten	0.00000	0.00000	0.00000
Uranium	0.00000	0.00000	0.00000
Vanadium	0.00003	0.00005	0.00005
Yttrium	0.00000	0.00000	0.00001
Zinc	0.00001	0.00004	0.00004

PK = processed kimberlite.

11.4.II.3.2 OPERATIONS PHASE EMISSIONS

Table 11.4.II-9 summarizes the maximum criteria air contaminant (CAC) emissions from the Project. Table 11.4.II-10 provides a summary of the maximum volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), trace metal, dioxin and furan emissions from the Project during the operations phase.

Table 11.4.II-9 Gahcho Kué Project Maximum Operations Phase CAC Emissions

Source	Emission Rate (t/d)					
	SO ₂	NO _x	CO	TSP	PM ₁₀	PM _{2.5}
Generators	0.001	2.692	0.715	0.059	0.048	0.047
Auxiliary boiler	0.000	0.007	0.002	0.001	0.001	0.000
Waste incinerator	0.004	0.004	0.012	0.008	0.008	0.008
Mine fleet	0.003	1.638	0.532	0.080	0.080	0.078
Drilling and blasting	0.032	0.256	1.226	0.064	0.032	0.003
Loading & unloading	—	—	—	0.224	0.106	0.016
Bulldozing	—	—	—	0.023	0.003	0.002
Crushers	—	—	—	0.030	0.013	0.011
Conveyors	—	—	—	0.077	0.028	0.028
Aggregate plant	—	—	—	0.062	0.024	0.018
Wind erosion	—	—	—	0.216	0.108	0.016

Table 11.4.II-9 Gahcho Kué Project Maximum Operations Phase CAC Emissions (continued)

Source	Emission Rate (t/d)					
	SO ₂	NO _x	CO	TSP	PM ₁₀	PM _{2.5}
Grading	—	—	—	0.312	0.091	0.010
Road dust	—	—	—	7.155	1.464	0.146
Winter access road	0.000	0.003	0.001	0.000	0.000	0.000
Drained lakebed	—	—	—	0.312	0.156	0.023
Total	0.041	4.600	2.488	8.625	2.163	0.407

SO₂ = sulphur dioxide; NO_x = nitrogen oxides; CO = carbon dioxide; TSP = total suspended particulates; PM₁₀ = particulate matter with particle diameter less than 10 microns; PM_{2.5} = particulate matter with particle diameter less than 2.5 microns; t/d = tonnes per day.

Table 11.4.II-10 Gahcho Kué Project Maximum Operations Phase VOC, PAH, Trace Metals and Dioxin/Furan Emissions

Source	Emission Rate [t/d]			
	VOC	PAH	Trace Metals	Dioxins and Furans
Generators	0.069	1.78×10 ⁻⁴	5.01×10 ⁻⁴	—
Auxiliary boiler	0.000	4.28×10 ⁻⁷	2.97×10 ⁻⁶	1.11×10 ⁻¹²
Waste incinerator	0.004	2.07×10 ⁻⁷	2.10×10 ⁻⁵	3.53×10 ⁻⁹
Mine fleet	0.082	6.07×10 ⁻⁴	8.31×10 ⁻⁴	—
Drilling and blasting	—	—	3.63×10 ⁻³	—
Loading and unloading	—	—	1.19×10 ⁻³	—
Bulldozing	—	—	1.28×10 ⁻³	—
Crushers	—	—	6.24×10 ⁻³	—
Conveyors	—	—	1.57×10 ⁻²	—
Aggregate plant	—	—	3.51×10 ⁻³	—
Wind erosion	—	—	4.50×10 ⁻²	—
Grading	—	—	3.25×10 ⁻³	—
Road dust	—	—	4.03×10 ⁻¹	—
Winter access road	0.000	—	6.67×10 ⁻⁷	—
Drained Lakebed	—	—	—	—
Total	0.154	7.86×10⁻⁴	0.484	3.53×10⁻⁹

t/d = tonnes per day; VOC = volatile organic compounds; PAH = polycyclic aromatic hydrocarbons.

11.4.II.3.2.1 Emission Source Configurations

Two main factors that influence the predicted ground-level concentrations at a receptor from the dispersion model are the numerical emission rates and the locations of the emission sources relative to the receptor. The emission rates in the Application Case represent the worst-case emission scenario for the operations phase of the Project. The locations for some of the emission sources

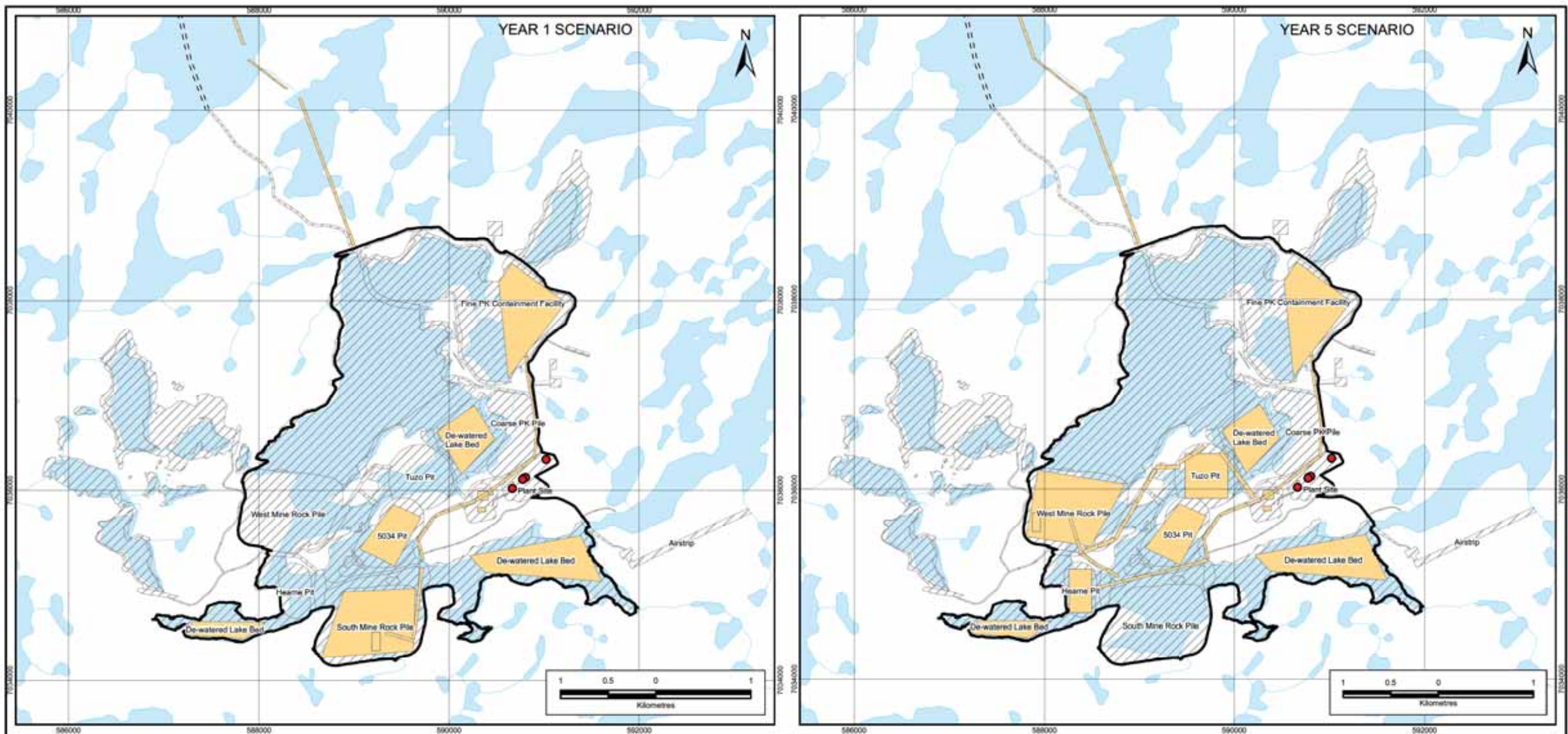
will vary year to year depending on the pit(s) mined and the areas used for mine rock and coarse PK disposal in these years. This factor was considered when determining the configuration of the Project emission sources in the dispersion modelling.

In Year 1 and Year 2, overburden and mine rock will be disposed solely at the South Mine Rock Pile. During these two years, emissions associated with the transportation and disposal of these materials will concentrate in the southern part of the Project footprint. After Year 2, the overburden and mine rock will primarily be disposed at the West Mine Rock Pile. During these years, the emissions associated with the transportation and disposal of these materials will be concentrated near the western part of the Project footprint. In order to capture the maximum predicted concentrations or depositions to south and west of the Project, the maximum project emissions were modelled based on mine configuration for Year 1 and Year 5. These two years were chosen because Year 1 has the largest amount of material transported when only the South Mine Rock Pile is in operation; and Year 5 has the largest amount of material transported when only the West Mine Rock pile is in operation. The main differences between the Project emission source configurations in Year 1 and Year 5 are summarized in Table 11.4.II-11.

Table 11.4.II-11 Emission Source Configuration Differences Between Year 1 and Year 5 Operations

Emission Sources	Year 1	Year 5
Mining activities	5034 Pit	5034 Pit, Hearne Pit, Tuzo Pit
Overburden transport	haul roads between 5034 Pit and South Mine Rock Pile	haul roads between 5034 Pit, Hearne Pit, Tuzo Pit and West Mine Rock Pile
Mine rock transport	haul roads between 5034 Pit and South Mine Rock Pile	haul roads between 5034 Pit, Hearne Pit, Tuzo Pit and West Mine Rock Pile
Kimberlite transport	haul roads between 5034 Pit and ROM	haul roads between 5034 Pit, Hearne Pit, Tuzo Pit and ROM
Overburden unloading	South Mine Rock Pile	West Mine Rock Pile
Mine rock unloading	South Mine Rock Pile	West Mine Rock Pile

Figure 11.4.II-1 shows the locations of the project emission sources modelled in Year 1 and Year 5.



LEGEND

- == Proposed Winter Access Road
- Watercourse
- Waterbody
- Point Source
- Area Source
- Development Area Boundary
- Project Footprint

NOTES

Base data source: National Topographic Base Data (NTDB) 1:50,000.

GAHCHO KUÉ PROJECT

Comparison of Emission Sources
in Application Case
Year 1 and Year 5 Operations

PROJECTION UTM Zone 12	DATUM NAD83	
Scale: 1:40,000		
FILE NO. SON-11.3-013-GIS		DATE December 13, 2010
JOB NO. 09-1365-1004	REVISION NO. 1	Figure 11.4.II-1
OFFICE GOLD-CAL	DRAWN SK CHECK GU	

11.4.II.3.2.2 Stack Emissions

11.4.II.3.2.2.1 Generators

A total of five 2,825 kilowatts electrical (kW[e]) prime-rated diesel-fired power generators will be installed to meet the Project's electricity requirements. Three of the five generators will be running during the operations phase of the Project. The generator emissions were estimated based on the following assumptions and methods:

- SO₂ emission rates were calculated based on a maximum fuel input rate and a sulphur content of 15 parts per million by weight (ppmw) in diesel.
- NO_x, CO, PM, VOC, PAH and trace metal emission rates were calculated based on the maximum fuel input rates and emission factors from U.S. EPA Compilation of Air Pollutant Emission Factors, or commonly referred as AP-42, Section 3.4 (U.S. EPA 1996a).
- Greenhouse Gas (GHG) emission rates were estimated based on the maximum fuel input rates and emission factors from the Environment Canada National Inventory Report: 1990-2008, Greenhouse Gas Sources and Sinks in Canada (Environment Canada 2010).

Table 11.4.II-12 summarizes the CAC emissions from the power generators. Table 11.4.II-13 presents the VOC, PAH and trace metal emissions from the generators. Table 11.4.II-14 summarizes the stack parameters for the power generators. The GHG emissions associated with generators are presented in Section 11.4.II.3.2.7.

Table 11.4.II-12 Power Generator CAC Emissions

Source	Emission Rate [t/d]					
	SO ₂	NO _x	CO	TSP	PM ₁₀	PM _{2.5}
Generator 1	0.000	0.897	0.238	0.016	0.016	0.020
Generator 2	0.000	0.897	0.238	0.016	0.016	0.020
Generator 3	0.000	0.897	0.238	0.016	0.016	0.020
Total	0.001	2.692	0.715	0.047	0.048	0.059

t/d = tonnes per day; SO₂ = sulphur dioxide; NO_x = nitrogen oxides; CO = carbon dioxide; TSP = total suspended particulates; PM₁₀ = particulate matter with particle diameter less than 10 microns; PM_{2.5} = particulate matter with particle diameter less than 2.5 microns.

Table 11.4.II-13 Generator VOC, PAH and Trace Metal Emissions

Source	Emission Rate (t/d)		
	VOC	PAH	Metals
Generator 1	2.30×10^{-2}	5.95×10^{-5}	1.67×10^{-4}
Generator 2	2.30×10^{-2}	5.95×10^{-5}	1.67×10^{-4}
Generator 3	2.30×10^{-2}	5.95×10^{-5}	1.67×10^{-4}
Total	6.89×10^{-2}	1.78×10^{-4}	5.01×10^{-4}

t/d = tonnes per day; VOC = volatile organic compound; PAH = polycyclic aromatic hydrocarbon.

Table 11.4.II-14 Power Generator Stack Parameters

Source	Stack Height (m)	Stack Inside Diameter (m)	Exhaust Exit Velocity (m/s)	Exhaust Exit Temperature (K)
Generator 1	9.0	0.406	49.4	450.2
Generator 2	9.0	0.406	49.4	450.2
Generator 3	9.0	0.406	49.4	450.2

m = metres; m/s = metres per second; K = Kelvin.

11.4.II.3.2.2.2 Auxiliary Boiler

Heating required by the Project's accommodations complex as well as the central process and maintenance facilities will be provided primarily by the heat recovered from the generator engine jacket water coolers and exhaust gas. A diesel-fired auxiliary boiler will be installed to supplement the heat from the generators during extreme weather and to provide supplementary heating during lower power demand periods when limited heat recovery is available from the power plant. The emissions from the auxiliary boiler were estimated based on the following assumptions and methods:

- SO₂ emissions were calculated based on the maximum fuel input rate and a diesel sulphur content of 15 ppmw.
- NO_x, CO, PM, VOC, PAH and trace metal emission rates were calculated based on the maximum fuel input rate and emission factors from U.S. EPA AP-42, Section 1.3 (U.S. EPA 2010).
- Greenhouse gas emission rates were estimated based on the maximum fuel input rate and emission factors from the Environment Canada National Inventory Report: 1990-2008, Greenhouse Gas Sources and Sinks in Canada (Environment Canada 2010).

Table 11.4.II-15 provides a summary of the CAC emissions from the auxiliary boiler. Table 11.4.II-16 presents the VOC, PAH and trace metal emissions

associated with the boiler. Table 11.4.II-17 summarizes the boiler stack parameters.

Table 11.4.II-15 Auxiliary Boiler CAC Emissions

Source	Emission Rate (t/d)					
	SO ₂	NO _x	CO	TSP	PM ₁₀	PM _{2.5}
Auxiliary boiler	0.000	0.007	0.002	0.000	0.001	0.001

t/d = tonnes per day; SO₂ = sulphur dioxide; NO_x = nitrogen oxides; CO = carbon dioxide; TSP = total suspended particulates; PM₁₀ = particulate matter with particle diameter less than 10 microns; PM_{2.5} = particulate matter with particle diameter less than 2.5 microns; t/d = tonnes per day.

Table 11.4.II-16 Auxiliary Boiler VOC, PAH and Trace Metal Emissions

Source	Emission Rate (t/d)			
	VOC	PAH	Metal	Dioxins/Furans
Auxiliary boiler	7.18×10 ⁻⁵	4.28×10 ⁻⁷	2.97×10 ⁻⁶	1.11×10 ⁻¹²

t/d = tonnes per day; VOC = volatile organic compound; PAH = polycyclic aromatic hydrocarbon.

Table 11.4.II-17 Auxiliary Boiler Stack Parameters

Source	Stack Height (m)	Stack Inside Diameter (m)	Exhaust Exit Velocity (m/s)	Exhaust Exit Temperature (K)
Auxiliary boiler	10.0	0.406	10.0	408.2

m = metres; m/s = metres per second; K = Kelvin.

11.4.II.3.2.2.3 Waste Incinerator

Solid waste other than mine waste that is collected at the Project site will be segregated based on its suitability to be burned in an on-site waste incinerator. Certain types of waste, such as sewage sludge, will not be incinerated. The dual-chamber, diesel-fired incinerator will be sized to meet the demand of the construction workforce housed in the permanent camp. The incinerator emissions were calculated based on the following assumptions and methods:

- A waste production rate for a maximum employee camp capacity of 400 workers during the construction phase of the Project. In reality, the camp capacity during the operation phase will be approximately 200 workers.
- SO₂, NO_x, CO, PM, VOCs, trace metals, dioxin and furan emission rates were calculated based on the maximum waste incineration rate and emission factors from U.S. EPA AP-42, Tables 2.1-9 and 2.1-12 (U.S. EPA 1996b).

- PAH emission rate was calculated based on the maximum fuel consumption rate and emission factor from the U.S. EPA AP-42, Table 1.3-9. (U.S. EPA 2010).
- Greenhouse gas emissions were estimated based on the maximum fuel input rate and emission factors from Environment Canada National Inventory Report: 1990-2008, Greenhouse Gas Sources and Sinks in Canada (Environment Canada 2010).

Table 11.4.II-18 summarizes the incinerator CAC emissions. Table 11.4.II-19 presents the VOC, PAH, trace metal, dioxin and furan emissions. Table 11.4.II-20 provides a summary of the waste incinerator stack parameters.

Table 11.4.II-18 Waste Incinerator CAC Emissions

Source	Emission Rate (t/d)					
	SO ₂	NO _x	CO	TSP	PM ₁₀	PM _{2.5}
Incinerator	0.004	0.004	0.012	0.008	0.008	0.008

t/d = tonnes per day; SO₂ = sulphur dioxide; NO_x = nitrogen oxides; CO = carbon dioxide; TSP = total suspended particulates; PM₁₀ = particulate matter with particle diameter less than 10 microns; PM_{2.5} = particulate matter with particle diameter less than 2.5 microns; t/d = tonnes per day.

Table 11.4.II-19 Waste Incinerator VOC, PAH, Trace Metal and Dioxin/Furan Emissions

Source	Emission Rate (t/d)			
	VOC	PAH	Metal	Dioxins/Furans
Incinerator	3.60×10 ⁻³	2.07×10 ⁻⁷	2.10×10 ⁻⁵	3.53×10 ⁻⁹

t/d = tonnes per day; VOC = volatile organic compound; PAH = polycyclic aromatic hydrocarbon.

Table 11.4.II-20 Waste Incinerator Stack Parameters

Source	Stack Height (m)	Stack Inside Diameter (m)	Exhaust Exit Velocity (m/s)	Exhaust Exit Temperature (K)
Incinerator	8.0	0.460	10.0	1,123.2

m = metres; m/s = metres per second; K = Kelvin.

11.4.II.3.2.2.4 High Pressure Roller Crusher Scrubber Stack

Kimberlite processing will consist of ore crushing in three stages including: a primary crusher, a secondary crusher and a high pressure roller crusher. The primary crusher will be located outside the process plant. The emissions associated with the primary crusher are described in Section 11.4.II.3.2.4.4. The secondary crusher and the high pressure roller crusher will be located inside the process plant. The secondary crusher is a wet process; therefore, no particulate emissions are expected from this stage. The fugitive particulate emissions from the high roller crusher will be captured and controlled by a wet venturi scrubber.

Any remaining exhaust will be released through the scrubber stack. The PM_{2.5}, PM₁₀ and TSP emission rates from the scrubber stack were calculated based on the maximum crusher throughput rate and emission factors for controlled tertiary crushers from AP-42, Section 11.19 (U.S. EPA 1998a).

Table 11.4.II-21 summarizes the emissions from the high pressure roller crusher scrubber stack. Table 11.4.II-22 presents the scrubber stack parameters.

Table 11.4.II-21 High Pressure Roller Crusher Scrubber Stack Emissions

Source	Emission Rate (t/d)		
	TSP	PM ₁₀	PM _{2.5}
Scrubber stack	7.84×10^{-3}	3.53×10^{-3}	6.53×10^{-4}

t/d = tonnes per day; VOC = volatile organic compound; PAH = polycyclic aromatic hydrocarbon.

Table 11.4.II-22 High Pressure Roller Crusher Scrubber Stack Parameters

Source	Stack Height (m)	Stack Inside Diameter (m)	Exhaust Exit Velocity (m/s)	Exhaust Exit Temperature (K)
Scrubber	26.0	0.794	10.0	298.2

11.4.II.3.2.3 Exhaust Emissions from Mining Equipment

Emissions from the mine vehicle exhaust were calculated using the methodology from the NONROAD emission model. The NONROAD emission model was created by the U.S. EPA to assist state and local regulatory agencies in the development of accurate emission inventories for off-road diesel engines. The NONROAD model estimates emission rates for single off-road diesel engines based on the following equation:

$$\text{Vehicle Emissions} = \text{Engine Horsepower} \times \text{Zero-Hour, Steady-State Emission Factor} \times \text{Gross Operating Hours} \times \text{Load Factor} \times \text{Transient Adjustment Factor} \times \text{Deterioration Factor}$$

The NONROAD model includes several key elements. First, an inventory of steady-state emission factors is developed for off-road diesel engines with various horsepower ranges. The emission factors represent the emissions from brand new engines under steady-state operation. These emission factors are also called zero-hour, steady-state emission factors. Second, the NONROAD model includes load factors accounting for the fact that the engines do not operate constantly at their maximum rated horsepower in real world applications. Lastly, the NONROAD model incorporates the emission profile for engines during

transient operating conditions and takes into consideration the deterioration of engine performance over time.

A list of the major Project diesel-combustion mining equipment is provided in Table 11.4.II-23. The zero-hour, steady-state emission factors from the NONROAD model are summarized in Table 11.4.II-24. The transient adjustment factors and deterioration factors from the NONROAD model are presented in Table 11.4.II-25. The load factors from the NONROAD methods are listed in Table 11.4.II-26.

Table 11.4.II-23 Major Mining Equipment

Equipment Type	Engine Size (bhp)	Maximum Annual Gross Operating Hours	Maximum Annual Diesel Consumption (10 ³ L)
CAT 793D haul trucks	2,415	56,415	4,381
CAT 777F haul trucks	1,015	18,943	815
Bucyrus RH340B excavators	3,000	10,089	3,874
RH90C excavators	1,150	5,151	639
CAT 992K front-end loaders	800	4,500	410
CAT 994F front-end loaders	1,465	3,691	532
CAT D10 track dozers	580	17,870	1,421
CAT 834 RTD wheel dozer	500	6,701	350
CAT D16M grader	300	6,701	254

bhp = brake horse power; L = litres.

Table 11.4.II-24 Zero-Hour, Steady-State Emission Factors for NONROAD Diesel Engines

Category of Vehicles	Model Year	Zero-Hour, Steady-State Emission Factors (g/bhp-h)		
		NO _x	CO	PM ₁₀
Vehicles 300 to 600 bhp				
Tier 1	1996	6.015	1.306	0.201
Tier 2	2001	4.335	0.843	0.132
Tier 3	2006	2.500	0.843	0.150
Tier 4 final	2011	0.276	0.084	0.009
Vehicles 600 to 750 bhp				
Tier 1	1996	5.822	1.327	0.220
Tier 2	2002	4.100	1.327	0.132
Tier 3	2006	2.500	1.327	0.150
Tier 4 final	2011	0.276	0.133	0.009
Vehicles >750 bhp				
Tier 1	2000	6.153	0.764	0.193
Tier 2	2006	4.100	0.764	0.132
Tier 3	—	—	—	—
Tier 4 final	2011	2.392	0.076	0.069 ^(a)

Source: U.S. EPA NONROAD Methods (U.S. EPA 2004a and 2005).

^(a) Tier 4 transitional emission factors that are more conservative than tier 4 final emission factors are used for both particulate matter (PM) and hydrocarbon (HC) emissions.

— = No criteria available; NO_x = nitrogen oxides; CO = carbon dioxide; PM₁₀ = particulate matter with particle diameter less than 10 µm; g/bhp-h = grams per brake horse power per hour.

Table 11.4.II-25 Transient Adjustment and Deterioration Factors for NONROAD Diesel Engines

Category of Vehicle	NO _x	CO	PM
Transient Adjustment Factors			
Tier 1	0.95	1.53	1.23
Tier 2	0.95	1.53	1.23
Tier 3	1.04	1.53	1.47
Tier 4 ^(a)	—	—	—
Deterioration Factors^(b)			
Tier 1	1.024	1.101	1.473
Tier 2	1.009	1.101	1.473
Tier 3	1.008	1.151	1.473
Tier 4	1.008	1.151	1.473

Source: U.S. EPA NONROAD Methods (U.S. EPA 2004a and 2005).

^(a) There is no transient adjustment factor for tier 4 engines since transient emission control is expected to be an integral part of all tier 4 engines.

^(b) Engines are assumed to be at the end of their median life to have conservative deterioration factors in calculations.

NO_x = nitrogen oxide; CO = carbon monoxide; PM = particulate matter; — = not applicable.

Table 11.4.II-26 Load Factors for NONROAD Diesel Engines

Category of Vehicle	Load Factor
Agricultural Tractor	0.78
Crawler Dozer	0.58
Rubber-tired Loader	0.48
Excavator	0.53
Backhoe Loader	0.21
Skid-steer Loader	0.23
Arc Welder	0.19
None	0.43

Source: U.S. EPA NONROAD Methods (U.S. EPA 2004a and 2005).

In addition to the NONROAD model methodology, the following assumptions were made in the emission calculations:

- The mining equipment was assumed to meet U.S. EPA Tier 2 emission standards for nonroad diesel engines (U.S. EPA 1998b). These emission standards have been adopted by Canada.
- Sulphur content in diesel was assumed to be 15 ppmw.
- PAH emissions were calculated based on diesel consumption rates and emission factors from the technical Reference for the Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region (Golder and Conor Pacific 1998).
- GHG emissions were estimated based on maximum fuel input rates and emission factors from the Environment Canada National Inventory Report: 1990-2008, Greenhouse Gas Sources and Sinks in Canada (Environment Canada 2010).

Table 11.4.II-27 summarizes maximum CAC emissions associated with the mine vehicle exhaust. Table 11.4.II-28 presents the VOC, PAH and trace metal emission rates from the mine vehicle exhaust.

Table 11.4.II-27 Mine Equipment Exhaust CAC Emissions

Source	Emission Rates (t/d)					
	SO ₂	NO _x	CO	TSP ^(a)	PM ₁₀	PM _{2.5}
Mine equipment	0.003	1.638	0.532	0.080	0.080	0.078

^(a) The NONROAD model does not provide TSP emission factors. TSP emissions were assumed to be equal to PM₁₀ emissions.

t/d = tonnes per day; SO₂ = sulphur dioxide; NO_x = nitrogen oxides; CO = carbon dioxide; TSP = total suspended particulates; PM₁₀ = particulate matter with particle diameter less than 10 microns; PM_{2.5} = particulate matter with particle diameter less than 2.5 microns; t/d = tonnes per day.

Table 11.4.II-28 Mine Equipment Exhaust VOC, PAH and Trace Metal Emissions

Source	Emission Rates (t/d)		
	VOC	PAH	Metal
Mine equipment	0.082	0.001	3.57×10 ⁻⁴

t/d = tonnes per day; VOC = volatile organic compound; PAH = polycyclic aromatic hydrocarbon.

11.4.II.3.2.4 Fugitive Particulate Emissions from Mine and Plant Operations

11.4.II.3.2.4.1 Drilling and Blasting Operations

Emissions from drilling were calculated using a TSP emission factor of 0.59 kg/hole from AP-42, Table 11.9-4 (U.S. EPA 1998a). Approximately 50 holes will be drilled per blast based on information provided by JDS (Prince-Wright 2010, pers. comm.).

Two types of emissions are typically generated from blasting. The detonation of the explosives and the associated chemical reactions will result in emissions of compounds such as SO₂, NO_x and CO. The explosion will also generate fugitive particulate emissions.

The emission volumes generated by the detonation of the explosives were estimated based on the amount and the type of the explosives that will be used. Ammonia nitrate mixed with fuel oil, also known as ammonium nitrate fuel oil (ANFO), will be the primary explosive material being used at the Project. Other types of explosives such as trinitrotoluene (TNT) or pentaerythritol tetranitrate (PETN) may also be used to supplement the primary explosives.

The maximum amount of ANFO that will be consumed per year is 11,694 tonnes; while the average amount of ANFO that will be consumed over the 11 years of production will be approximately 7,100 tonnes per year. The maximum quantity of other explosives that will be consumed in a year is 125 tonnes; with a 13-year average of 67.9 t/y. The emission factors for the detonation of ANFO and TNT from AP-42, Table 13.3 (U.S. EPA 1980) were used in the emission calculations. It was assumed that all supplemental explosives would be TNT because the emission factors for TNT are more conservative than the emission factors for PETN.

The fugitive particulate emissions resulting from blasting were calculated using the equations taken from AP-42, Table 11.9-2 (U.S. EPA 1998b):

$$TSP\ EF = 0.00022(A)^{1.5}$$

$$PM_{10}\ EF = 0.52 \times TSP\ EF$$

$$PM_{2.5}\ EF = 0.03 \times TSP\ EF$$

Where:

EF = emission factor (kg/blast)

A = blasted mine area [m²]

The blasted mine area was calculated using the maximum total annual volume of kimberlite and granite mined (12,834,609 m³) divided by the depth of the blasted material (12 m), and the number of blasts per year. Based on information provided by JDS (Prince-Wright 2010, pers. comm.), there will be approximately one blast per day during the operating years. Table 11.4.II-29 presents a summary of the emissions associated with the drilling and blasting operations.

Table 11.4.II-29 Drilling and Blasting Emissions

Source	Emission Rates (t/d)					
	SO ₂	NO _x	CO	TSP	PM ₁₀	PM _{2.5}
Drilling	—	—	—	0.035	0.018	0.001
Explosive detonation	0.032	0.256	1.226	—	—	—
Fugitive dust	—	—	—	0.030	0.014	0.002
Total	0.032	0.256	1.226	0.064	0.032	0.003

t/d = tonnes per day; SO₂ = sulphur dioxide; NO_x = nitrogen oxides; CO = carbon dioxide; TSP = total suspended particulates; PM₁₀ = particulate matter with particle diameter less than 10 microns; PM_{2.5} = particulate matter with particle diameter less than 2.5 microns.

11.4.II.3.2.4.2 Loading and Unloading Operations

Particulate emissions associated with loading and unloading the overburden, mine rock, kimberlite and coarse PK were calculated based on the maximum annual production rates and emission estimation methodology described in AP-42, Section 13.2-4 (U.S. EPA 2006b). The quantity of the particulate emissions per tonne of material being loaded or unloaded can be expressed by the following formula:

$$EF = k(0.0016) \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where:

EF = emission factor (kg/tonne)

k = particle size-specific multiplier from AP-42, Section 13.2.4 (U.S. EPA 2006b);

M = moisture content in percentage (%);

U = mean wind speed (m/s).

The mean wind speed used in the calculations was 5.14 m/s, which was calculated based on data collected at Gahcho Kué climate station during 2004 to 2005. The moisture content used in the calculations are outlined in Table 11.4.II-6. Table 11.4.II-30 summarizes the loading and unloading emissions.

Table 11.4.II-30 Loading and Unloading Emissions

Material	Emission Rates (t/d)		
	TSP	PM ₁₀	PM _{2.5}
Overburden	1.49×10 ⁻²	7.06×10 ⁻³	7.07×10 ⁻³
Mine rock	1.75×10 ⁻¹	8.30×10 ⁻²	1.26×10 ⁻²
Kimberlite	2.05×10 ⁻²	9.70×10 ⁻³	1.47×10 ⁻³
Coarse processed kimberlite	1.49×10 ⁻²	7.06×10 ⁻³	1.07×10 ⁻³
Total	2.26×10⁻¹	1.07×10⁻¹	1.62×10⁻²

t/d = tonnes per day; TSP = total suspended particulates; PM₁₀ = particulate matter with particle diameter less than 10 microns; PM_{2.5} = particulate matter with particle diameter less than 2.5 microns.

11.4.II.3.2.4.3 Bulldozing Operations

The particulate emissions associated with bulldozing of overburden, mine rock, kimberlite and coarse PK were estimated based on methodology described in AP-42, Section 11.9 (U.S. EPA 1998a). The bulldozing emission factors are expressed as kilograms of particulate emissions per hour of dozer in operation based on the following formulas:

$$TSP\ EF = 0.0034(S)^{2.5}$$

$$PM_{15}\ EF = 0.0056(S)^{2.0}$$

$$PM_{10}\ EF = 0.60 \times PM_{15}\ EF$$

$$PM_{2.5}\ EF = 0.031 \times TSP\ EF$$

Where:

EF = emission factor (kg/hr)

s = material silt content (%)

M = material moisture content (%)

The maximum annual operating hours for bulldozers is 24,944 hours. Material silt content and moisture content were taken from Tables 11.4.II-5 and 11.4.II-6. Table 11.4.II-31 presents a summary of the bulldozing emission factors and emissions.

Table 11.4.II-31 Bulldozing Emissions

Material	Emission Factor (kg/h)			Emission Rates (t/d)		
	TSP	PM ₁₀	PM _{2.5}	TSP	PM ₁₀	PM _{2.5}
Overburden	0.47	0.08	0.05	1.84×10^{-4}	3.17×10^{-5}	1.93×10^{-5}
Mine rock	0.33	0.04	0.03	1.93×10^{-2}	2.36×10^{-3}	2.03×10^{-3}
Kimberlite	0.44	0.06	0.05	2.51×10^{-3}	3.14×10^{-4}	2.64×10^{-4}
Coarse PK	0.18	0.02	0.02	7.66×10^{-4}	8.93×10^{-5}	8.04×10^{-5}
Total				2.28×10^{-2}	2.80×10^{-3}	2.39×10^{-3}

kg/h = kilograms per hour; t/d = tonnes per day; TSP = total suspended particulates; PM₁₀ = particulate matter with particle diameter less than 10 microns; PM_{2.5} = particulate matter with particle diameter less than 2.5 microns.

11.4.II.3.2.4.4 Crushing Operations

The kimberlite ore from the run-of-mine (ROM) stockpile will be fed to a primary crusher. The primary crusher will be located approximately 200 m from the process plant and will be connected to the rest of the process plant by conveyors. The PM_{2.5}, PM₁₀ and TSP emission rates associated with the primary crusher were calculated based on the maximum crusher throughput rate and emission factors for uncontrolled primary crushers in Section 11.19 of AP-42 (U.S. EPA 1998a). Table 11.4.II-32 presents the primary crusher emissions.

Table 11.4.II-32 Primary Crusher Emissions

Emission Rates (t/d)		
TSP	PM ₁₀	PM _{2.5}
2.22×10^{-2}	9.86×10^{-3}	9.86×10^{-3}

t/d = tonnes per day; TSP = total suspended particulates; PM₁₀ = particulate matter with particle diameter less than 10 microns; PM_{2.5} = particulate matter with particle diameter less than 2.5 microns.

11.4.II.3.2.4.5 Conveyor Operation

There will be four conveyors used to transfer crushed kimberlite ore from the primary crusher to the main process plant. Two conveyors will be used to discharge the coarse PK from the process plant to an adjacent temporary outdoor storage pile. Particulate emissions associated with the conveyor transfer points were calculated based on the maximum conveyance rates and emission factors for uncontrolled conveyor transfer points from AP-42, Section 11.19 (U.S. EPA 2004b). Table 11.4.II-33 presents the conveyor emissions.

Table 11.4.II-33 Conveyor Emissions

Emission Rates (t/d)		
TSP	PM ₁₀	PM _{2.5}
7.73×10^{-2}	2.83×10^{-2}	2.83×10^{-2}

t/d = tonnes per day; TSP = total suspended particulates; PM₁₀ = particulate matter with particle diameter less than 10 microns; PM_{2.5} = particulate matter with particle diameter less than 2.5 microns.

11.4.II.3.2.4.6 Aggregate Plant Operations

An aggregate plant will be built to provide aggregates required for Project construction. After the construction of the Project is completed, the aggregate plant will operate intermittently for approximately one month each year to provide the granular material for haul road maintenance. The preliminary design of the aggregate plant indicated that the plant will consist of:

- one screen;
- three crushers; and
- five conveyors.

The particulate emissions associated with the operation of the aggregate plant were estimated based on the crusher and conveyor emission estimation methodologies described in Sections 11.4.II.3.2.4.4 and 11.4.II.3.2.4.3. Table 11.4.II-34 provides a summary of the aggregate plant emissions. Although the aggregate plant will be operating for approximately one month per year during the operating phase of the Project, it was conservatively assumed that the plant will be in continuous operation.

Table 11.4.II-34 Aggregate Plant Emissions

Material	Emission Rates (t/d)		
	TSP	PM ₁₀	PM _{2.5}
Screen	6.60×10^{-3}	2.22×10^{-3}	1.50×10^{-4}
Crushers	1.08×10^{-2}	4.86×10^{-3}	9.00×10^{-4}
Conveyors	4.50×10^{-2}	1.65×10^{-2}	1.65×10^{-2}
Total	6.24×10^{-2}	2.36×10^{-2}	1.76×10^{-2}

t/d = tonnes per day; TSP = total suspended particulates; PM₁₀ = particulate matter with particle diameter less than 10 microns; PM_{2.5} = particulate matter with particle diameter less than 2.5 microns.

11.4.II.3.2.4.7 Wind Erosion

Fugitive dust emissions may be generated by wind erosion of outdoor stockpiles or exposed surfaces of loose materials at the South Mine Rock Pile, West Mine Rock Pile and ROM stockpile. The fugitive dust emissions from these sources were estimated based on a methodology described in Section 13.2.5 of AP-42 (U.S. EPA 2006b). The amount of fugitive dust emissions from these sources depends primarily on the following parameters:

- Magnitude of local wind gusts.
- Disturbance frequency of the erodible surface. A disturbance is when new material is added to or remove from a stockpile or an exposed surface.
- Erosion potential which describes the finite availability of erodible material between disturbances.
- Threshold friction velocity which is the minimum wind friction velocity to initiate wind erosion of a specific type of material.

The wind speed profile in the surface boundary can be expressed by the following equation:

$$u(z) = \frac{u^*}{0.4} \times \ln \frac{z}{z_0} \quad (1)$$

Where:

u = wind speed (centimetres per second [cm/s])

u* = friction velocity (cm/s)

z = height above test surface (centimetres [cm])

z₀ = roughness height (cm)

The above equation can be rearranged and expressed in terms of friction velocity (u^*), which is a measure of wind shear stress on the erodible surface as:

$$u^* = \frac{u(z) \times 0.4}{\ln \frac{z}{z_0}} \quad (2)$$

The erosion potential can be determined by the following equation:

$$p = 58(u^* - u_t^*)^2 + 25(u^* - u_t^*) \quad (3)$$

$$P = 0 \text{ for } u^* \leq u_t^*$$

Where:

P = erosion potential (grams per square metre [g/m²])

u^* = friction velocity (metres per second [m/s])

u_t = threshold friction velocity (m/s)

The erosion potential for a disturbance event would be zero if the friction velocity is lower than or equal to the threshold friction velocity. The wind erosion emission factors can finally be estimated based on the following equation:

$$EF = k \sum_{i=1}^N P_i \quad (4)$$

Where:

EF = emission factor (grams per square metres per year [g/m²/y])

k = particle size multiplier from AP-42, Section 13.2.4

N = number of disturbance per year

P_i = erosion potential corresponding to the fastest mile of wind for the i th period between disturbances (g/m²)

Overall, the wind erosion emission factors are determined based on the following steps:

1. Determine the threshold friction velocity for erodible material of interest.
2. Tabulate the fastest wind velocity values for each frequency of disturbance and correct them to 10 m.
3. Convert the fastest wind velocity values to equivalent friction velocities using Equation 2.

4. Calculate the erosion potential for each period between disturbances using Equation 3.
5. Calculate the emission factors by using Equation 4.
6. Multiply the emission factors by the area of the stockpile or exposed surface.

In Step 1, the threshold friction velocity for overburden, mine rock and kimberlite were taken from Table 13.2.5-2 of AP-42 (U.S. EPA 2006b). A threshold friction velocity of 1.02 m/s was assumed for overburden. The threshold friction velocity for scoria (1.33 m/s) was assumed for mine rock and kimberlite.

In Steps 2 and 3, the maximum hourly wind speed recorded by the on-site monitoring program was used and the equivalent friction velocities were determined.

At both the mine rock piles and the ROM stockpile, only a portion of the total surface of the piles will be constantly disturbed by trucks unloading material onto the piles. Because the wind erosion emissions are dependent on the frequency of disturbances, the surface of the stockpiles can be separated into two categories: active area and inactive area. The emissions for the active area of a surface were calculated assuming the area will be disturbed on an hourly basis. An erosion potential for every hour of the year was calculated and summed to provide an annual emission factor. Conversely, the emissions for the inactive area of a surface were estimated assuming the area will be disturbed once a year. In this case, erosion potentials were calculated based on the maximum hourly wind speed in a year. Table 11.4.II-35 presents the active, inactive and total area for the surfaces with wind erosion emissions.

Table 11.4.II-35 Active and Inactive Areas for Wind Erosion Emission Sources

Material	Area (m ²)		
	Active	Inactive	Total
South Mine Rock Pile	18,000	760,453	778,453
West Mine Rock Pile	18,000	770,719	788,719
ROM	3,000	11,000	14,000
Total	39,000	1,542,172	1,581,172

ROM = run of mine; m² = square metres.

In the air quality assessment, it was conservatively assumed that the conditions favourable for wind-blown emissions from the inactive areas of the exposed surfaces can only occur between May and September. Because these areas will be disturbed infrequently, the areas will be covered by snow during the rest of the year. Therefore, no wind-blown emissions from the inactive areas of the

exposed surfaces are expected. Table 11.4.II-36 summarizes the wind-erosion emission rates.

Table 11.4.II-36 Wind Erosion Emission Factors and Emissions

Material	Summer Emission Rates (t/d)			Non-Summer Emission Rates (t/d)		
	TSP	PM ₁₀	PM _{2.5}	TSP	PM ₁₀	PM _{2.5}
Active Areas						
ROM	0.013	0.007	0.001	0.013	0.007	0.001
South Mine Rock Pile	0.111	0.056	0.008	0.111	0.056	0.008
West Mine Rock Pile	0.111	0.056	0.008	0.111	0.056	0.008
Inactive Areas						
ROM	0.001	0.001	0.000	—	—	—
South Mine Rock Pile	0.090	0.045	0.007	—	—	—
West Mine Rock Pile	0.091	0.046	0.007	—	—	—
Total^(a)	0.215	0.108	0.016	0.124	0.063	0.009

t/d = tonnes per day; TSP = total suspended particulates; PM₁₀ = particulate matter with particle diameter less than 10 microns; PM_{2.5} = particulate matter with particle diameter less than 2.5 microns.

11.4.II.3.2.4.8 Grading Operations

Graders will be used keep on-site haul roads in working condition. Particulate emissions from the haul road grading operations were estimated based on emission factors from Section 11.9 of AP-42 (U.S. EPA 1998a). The emission factors are expressed by the following formulas:

$$TSP\ EF = 0.0034(S)^{2.5}$$

$$PM_{15}\ EF = 0.0056(S)^{2.0}$$

$$PM_{10}\ EF = 0.60 \times PM_{15}\ EF$$

$$PM_{2.5}\ EF = 0.031 \times TSP\ EF$$

Where:

EF = emission factor kilogram per vehicle kilometre travelled (kg/VKT)

S = mean vehicle speed (kilometres per hour [km/hr])

The total distance the graders will travel was calculated based on annual grader operation hours of 6,701 and an assumed grader mean speed of 11.4 km/hr from AP-42, Table 11.9-3 (U.S. EPA 1998a). Table 11.4.II-37 presents the grading emission factors and the grading emissions.

Table 11.4.II-37 Grading Emissions

Emission Factor (kg/VKT)			Emission Rates (t/d)		
TSP	PM ₁₀	PM _{2.5}	TSP	PM ₁₀	PM _{2.5}
1.49	0.60	0.03	3.12×10^{-1}	9.14×10^{-2}	9.68×10^{-3}

kg/VKT = kilogram per vehicle kilometre; t/d = tonnes per day; TSP = total suspended particulates; PM₁₀ = particulate matter with particle diameter less than 10 microns; PM_{2.5} = particulate matter with particle diameter less than 2.5 microns.

11.4.II.3.2.4.9 Road Dust Emissions

Particulate emissions are expected to be generated when mining vehicles travel on the unpaved Project haul roads. The road dust emissions were estimated based on Section 13.2.2 of AP-42 (U.S. EPA 2006c). The emission factor from AP-42 can be expressed by the following formula:

$$EF = k \left(\frac{s}{12} \right)^a \left(\frac{W}{3} \right)^b$$

where:

EF = emission factor in pounds (lb) per vehicle miles travelled (lb/VMT)

s = silt content of the unpaved road surface (percent [%])

k, a, b = particulate matter size-specific constants from Section 13.2.2 of AP-42 (U.S. EPA 2006c)

W = mean vehicle weight (ton)

The silt content of the haul road was assumed to be 1.6% in the calculations. The mean vehicle weight of the haul trucks were assumed to be 276 tons and 117 tons for CAT 793D and CAT 777F, respectively. The material transportation activities considered in the Year 1 scenario include:

- overburden transport from 5034 Pit to South Mine Rock Pile;
- mine rock transport from 5034 Pit to South Mine Rock Pile;
- kimberlite transport from 5034 Pit to ROM at the plant site; and
- coarse PK transport from coarse PK temporary stockpile to Area 1.

The material transportation activities considered in the Year 5 scenario include:

- overburden transport from 5034 Pit, Hearne Pit and Tuzo Pit to West Mine Rock Pile;

- mine rock transport from 5034 Pit, Hearne Pit and Tuzo Pit to South Mine Rock Pile;
- kimberlite transport from 5034 Pit, Hearne Pit and Tuzo Pit to ROM at the plant site; and
- coarse PK transport from coarse PK temporary stockpile to Area 1.

During the summer months of May to September, road dust emissions can be mitigated by frequent watering of the haul roads. The quantity of road dust emitted into the atmosphere depends primarily on the amount of water applied to the roads, the frequency of application and the water evaporation rate from the road surface. Data from field tests conducted in North Dakota, New Mexico, Ohio and Missouri (U.S. EPA 1987) indicated that frequent water applications every 1.8 to 4.5 hours can achieve dust control efficiencies between 59% and 88%. The Environment Canada guidance document for National Pollution Release Inventory (Environment Canada 2010a) reporting recommends a 55% control efficiency when roads are watered twice. For modelling purposes, it was assumed that the road dust emissions will be reduced by 55% from watering during summer.

Watering of the haul roads will not be possible in the winter due to freezing conditions. However, a certain level of natural mitigation of the road dust emissions can be expected from precipitation and snow accumulation on the road surface. In AP-42 (U.S. EPA 2006c), annual road dust emission factors are derived by assuming no emissions for days where precipitation was at least 0.254 millimetres (mm). The duration formula for mitigation effects due to precipitation is as follows:

$$E_{ext} = EF \times \frac{(365 - P)}{365}$$

where:

E_{ext} = annual size-specific emission factor extrapolated for natural mitigation (lb/VMT)

EF = emission factor

P = number of days in a year with at least 0.254 mm of precipitation

Environment Canada guidance on estimating road dust emissions from industrial unpaved surfaces (Environment Canada 2010b) also recommends applying a similar adjustment factor to annual emission factors to account for natural mitigation, which further considers the number of days when the road surface is covered with snow or frozen without high traffic volume. The Environment

Canada formula for adjusting road dust emissions due to precipitation and snow cover is:

$$ADJ = \frac{[365 - (p + snow)]}{365}$$

Where:

ADJ = annual adjustment factor for precipitation, snow cover and frozen days;

p = number of days in a year with at least 0.254 mm of precipitation

snow = number of days in a year when the roads are frozen or snow covered

The estimated road dust emissions in this assessment are based on maximum daily emission rates; and therefore, didn't take into consideration the above annual adjustment factors recommended by AP-42 and Environment Canada. An assessment based on maximum daily emissions provides conservative 1-hour and 24-hour predictions; however, it can lead to overestimated annual predictions. Table 11.4.II-38 summarizes the Year 1 and Year 5 road dust emissions during the summer and non-summer seasons.

Table 11.4.II-38 Operating Year 1 and Year 5 Road Dust Emissions

Material	Summer Emission Rates (t/d)			Non-Summer Emission Rates (t/d)		
	TSP	PM ₁₀	PM _{2.5}	TSP	PM ₁₀	PM _{2.5}
Year 1	2.404	0.492	0.049	5.343	1.093	0.109
Year 5	3.220	0.659	0.066	7.155	14.46	0.146

t/d = tonnes per day; TSP = total suspended particulates; PM₁₀ = particulate matter with particle diameter less than 10 microns; PM_{2.5} = particulate matter with particle diameter less than 2.5 microns.

11.4.II.3.2.5 Winter Access Road Emissions

The Tibbitt-to-Contwoyto Winter Road is the main artery used for transporting construction equipment, building materials, fuel and food to the Lupin, Ekati, Diavik, Snap Lake and Jericho mines. A 34-km stretch of the 568-km long Tibbitt-to-Contwoyto Winter Road passes through the Regional Study Area (RSA). This stretch of road is located near the north-western corner of the RSA and approximately 85 km from the Project (Figure 11.4.I-5).

The Project will be connected to the Tibbitt-to-Contwoyto Winter Road via a 120-km long Winter Access Road. During the operations phase of the Project, the maximum traffic volume on the Winter Access Road is expected to be 1,200 loads per year. From 2000 to 2010, the average operating period of the Tibbitt-to-Contwoyto Winter Road is 63 days (Joint Venture 2010). Based on the

most recent 10-year data, the winter road operating period can begin as early as January and end as late as April.

In the Application Case, the vehicle exhaust emissions from a 15-km stretch of the Winter Access Road closest to the Project were modelled. Road sources are typically modelled as either area or volume sources with a length to width ratio of less than 5. The Winter Access Road was modelled by a series of 150 m by 50 m area sources. Modelling the entire 120-km stretch of the road would require 800 area sources. To avoid modelling unreasonably large numbers of sources but still be able to capture the contributions of the Winter Access Road to traffic emissions, it was decided that only the emissions associated with a 15-km stretch of the road closest to the Project would be modelled in the assessment.

The exhaust emissions associated with the selected 15-km stretch of Winter Access Road were estimated based on emission factors derived from MOBILE6.2C. MOBILE6.2C is the Canadian version of the MOBILE6.2 software program that was developed by the U.S. EPA to estimate on-road traffic emissions. Emission factors for Class 8b heavy-duty diesel vehicles with gross vehicle weight rating above 60,000 pounds (lb) were chosen to estimate truck exhaust emissions. Table 11.4.II-39 summarizes the truck emission factors and the truck exhaust emissions on the 15-km stretch road. The Winter Access Road was only modelled as active emission sources from January to April to reflect the seasonal nature of winter road traffic.

Table 11.4.II-39 Emissions from 15-km Stretch of the Winter Access Road

	Emission Factors (g/VMT)	Emission Rates (t/d)
SO ₂	0.0151	5.32×10^{-6}
NO _x	8.270	2.92×10^{-3}
CO	3.796	1.34×10^{-3}
TSP	—	$6.41 \times 10^{-5(a)}$
PM ₁₀	0.182	6.41×10^{-5}
PM _{2.5}	0.167	5.90×10^{-5}
VOC	3.796	2.73×10^{-4}

^(a) MOBILE does not provide an emission factor for TSP. PM₁₀ is a subset of TSP. Therefore, it was assumed that TSP emission rate equals the PM₁₀ emission rate.

g/VMT = grams per vehicle kilometre; t/d = tonnes per day.

11.4.II.3.2.6 Wind Blown Dust Emissions from Drained Kennady Lakebed

The development of the Gahcho Kué mine will require the partial draining of Kennady Lake and the exposure of a substantial portion of the lakebed to the atmosphere. Concern has been expressed that the sediment at the bottom of the lake would dry and contribute to windblown dust. Anecdotal evidence from Ekati Diamond Mine (Jarratt 2004) and the experience of hydrology and water quality experts on the De Beers team indicate this is unlikely to be the case. Instead, it is expected that the sediment would solidify and that the lake bottom would form a hardpan crust.

In the air quality assessment, it was conservatively assumed that the conditions favourable for wind-blown emissions from the dried lake bed can occur from May to September. It was assumed that the lake bed will be covered by snow during the rest of the year; and no wind-blown emissions can be expected during that time. The dust emissions from were estimated based on the same methodology used for estimating the wind erosion emissions described in Section 11.4.II.3.2.4.7.

Table 11.4.II-40 presents the estimated wind-blown dust emissions from the exposed lakebed.

Table 11.4.II-40 Wind-blown Dust Emissions from Drained Kennady Lakebed

Month	Emission Rates (t/d)		
	TSP	PM ₁₀	PM _{2.5}
January to April	—	—	—
May to September	0.312	0.156	0.023
October to December	—	—	—

t/d = tonnes per day; TSP = total suspended particulates; PM₁₀ = particulate matter with particle diameter less than 10 microns; PM_{2.5} = particulate matter with particle diameter less than 2.5

11.4.II.3.2.7 Greenhouse Gas Emissions

Greenhouse gases that will be emitted by the Project include carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). These gases are byproducts of combustion sources. Greenhouse gas emissions were calculated based on either equipment rated capacity or fuel consumption rate, and emission factors from the Environment Canada National Inventory 1990-2008 (Environment Canada 2010). Estimates of maximum annual GHG emissions are expressed as kilotonnes of CO₂ equivalent (CO₂ eq), which were calculated based on the global warming potential for each greenhouse gas relative to the global warming potential of CO₂. The formula for expressing GHG emissions in CO₂ eq is as follows:

$$\text{CO}_2 \text{ equivalent} = \text{CO}_2 + (21 \times \text{CH}_4) + (310 \times \text{N}_2\text{O})$$

Table 11.4.II-41 presents a summary of the maximum annual estimated GHG emissions during the operations phase of the Project.

Table 11.4.II-41 Maximum Annual Greenhouse Gas Emissions

Source	Emission Rates (kt CO ₂ eq/y)			
	CO ₂	CH ₄	N ₂ O	Total
Generators	49.80	0.05	2.32	52.2
Auxiliary boiler	2.91	0.00	0.14	3.1
Waste incinerator	1.41	0.00	0.07	1.5
Mine fleet	42.20	0.05	5.40	47.7
Total	96.33	0.11	7.92	104.4

kt CO₂ eq/y = kilotons of carbon dioxide equivalent per year; CO₂ = carbon dioxide; CH₄ = methane; N₂O = nitrous oxide.

11.4.II.3.3 CONSTRUCTION PHASE EMISSIONS

The construction of the Project will occur over a period of two years, between 2013 and 2014. The construction period will include Project construction and dewatering part of Kennady Lake before mining can begin. After the water above the ore bodies has been drained, pre-stripping of the open pits and initial mining will begin.

Sources of emissions during the construction phase of the Project will be similar to emission sources during the operations phase of the Project with the exception of the sources associated with the kimberlite ore processing and coarse PK disposal activities. The construction emissions were estimated based on the maximum material production rates in Years -2 and -1. These rates are summarized in Table 11.4.II-42.

Table 11.4.II-42 Maximum Material Production Rates for the Construction Emission Calculations

Parameters	Values
Annual overburden production rate [Mt/y]	0.300
Annual mine rock production rate [Mt/y]	15.950
Annual kimberlite production rate [Mt/y]	0.002
Annual coarse PK production rate [Mt/y]	—

Mt/y = million tonnes per year.

Methods and assumptions used in the construction emission calculations are as follows:

- Only one of the five generators will be running at the Project during the construction phase of the Project. The generator emissions were estimated based on the method described in Section 11.4.II.3.2.2.1.
- The waste incinerator emissions will be identical to the waste incinerator emissions during the operations phase of the Project. Although a larger workforce will be required during the construction phase and resulting in more waste being generated, the incinerator emissions for both phases were calculated based on the maximum employee camp capacity. The method for estimating the incinerator emissions is described in Section 11.4.II.3.2.2.3.
- Construction mine fleet emissions were estimated based on the maximum annual operating hours and diesel consumption rate during the construction phase. The calculation method used is described in Section 11.4.II.3.2.3.

- Drilling, blasting, loading and unloading as well as bulldozing emissions were estimated based on the maximum material production rates for the construction phase presented in Table 11.4.II-37. The emission calculation methods are described in Sections 11.4.II.3.2.4.1 to 11.4.II.3.2.4.3.
- Construction phase aggregate plant emissions will be identical to the operations phase aggregate plant emissions. The methodology and basis of the emission calculations are described in Section 11.4.II.3.2.4.6.
- Construction phase wind erosion emissions were estimated based on the maximum material production rates presented in Table 11.4.II-37 and the method described in Section 11.4.II.3.2.4.7.
- Grading emissions during the construction phase were estimated based on the method described in Section 11.4.II.3.2.4.8. The maximum grader operating hours during the construction phase is 3,351 hours per year.
- Construction road dust emissions were calculated based on the maximum material production rates presented in Table 11.4.II-37 and the method described in Section 11.4.II.3.2.4.9.
- The traffic loads on the Winter Access Road during the construction phase will be higher than during the operations phase. The maximum traffic volume on the Winter Access Road during the construction is expected to be 2,000 loads per winter road season. The calculation method for the Winter Access Road emissions is described in Section 11.4.II.3.2.5.
- Maximum wind-blown dust emissions from the drained Kennady Lake were assumed to be the same during both the construction phase and operations phase of the Project. A description of the emission estimation method is provided in Section 11.4.II.3.2.6.

Table 11.4.II-43 summarizes the maximum CAC emissions associated with the construction activities at the Project. Table 11.4.II-44 presents the construction phase maximum VOC, PAH, trace metal, dioxin and furan emissions.

Table 11.4.II-43 Gahcho Kué Project Maximum Construction Phase CAC Emissions

Source	Emission Rate (t/d)					
	SO ₂	NO _x	CO	TSP	PM ₁₀	PM _{2.5}
Generators	0.000	0.897	0.238	0.020	0.016	0.016
Waste incinerator	0.004	0.004	0.012	0.008	0.008	0.008
Mine fleet	0.002	0.847	0.279	0.043	0.043	0.042
Drilling and blasting	0.019	0.156	0.735	0.041	0.020	0.002
Loading/unloading	—	—	—	0.093	0.044	0.007
Bulldozing	—	—	—	0.018	0.002	0.002
Aggregate plant	—	—	—	0.062	0.024	0.018
Wind erosion	—	—	—	0.185	0.092	0.014
Grading	—	—	—	0.156	0.046	0.005
Road dust	—	—	—	1.967	0.402	0.040
Winter access road	0.000	0.005	0.002	0.000	0.000	0.000
Drained lakebed	—	—	—	0.216	0.108	0.016
Total	0.025	1.909	1.267	2.810	0.806	0.169

t/d = tonnes per day; SO₂ = sulphur dioxide; NO_x = nitrogen oxides; CO = carbon monoxide; TSP = total suspended particulates; PM₁₀ = particulate matter with particle diameter less than 10 microns; PM_{2.5} = particulate matter with particle diameter less than 2.5 microns.

Table 11.4.II-44 Gahcho Kué Project Maximum Construction Phase VOC, PAH, Trace Metal and Dioxin/Furan Emissions

Source	Emission Rate (t/d)			
	VOC	PAH	Metals	Dioxins/Furans
Generators	0.023	5.95×10 ⁻⁵	1.67×10 ⁻⁴	—
Waste incinerator	0.004	2.07×10 ⁻⁷	2.10×10 ⁻⁵	3.53×10 ⁻⁹
Mine fleet	0.042	2.96×10 ⁻⁴	4.46×10 ⁻⁴	—
Drilling and blasting	—	—	2.28×10 ⁻³	—
Loading/unloading	—	—	3.69×10 ⁻⁴	—
Bulldozing	—	—	1.02×10 ⁻³	—
Aggregate plant	—	—	3.51×10 ⁻³	—
Wind erosion	—	—	3.84×10 ⁻²	—
Grading	—	—	1.62×10 ⁻³	—
Road dust	—	—	1.11×10 ⁻¹	—
Winter access road	0.000	—	4.46×10 ⁻⁶	—
Drained lakebed	—	—	—	—
Total	0.069	3.55×10⁻⁴	0.484	3.53×10⁻⁹

t/d = tonnes per day; VOC = volatile organic compound; PAH = polycyclic aromatic hydrocarbons.

11.4.II.4 DETAILS OF REGIONAL EMISSION ESTIMATES

11.4.II.4.1 SNAP LAKE EMISSIONS

De Beers Snap Lake Mine is an underground diamond mining operation located approximately 280 km northeast of Yellowknife, NWT and 85 km west of the Project. Snap Lake Mine received regulatory approval in May 2004. Commercial production commenced in January 2008.

The emission information for the Snap Lake Mine was based on an air dispersion modelling study of the Snap Lake Mine conducted by Golder on behalf of De Beers in 2007. The Snap Lake Mine CO, VOC, PAH and trace metal emissions were not provided in the study; therefore, they have to be calculated. These emissions were calculated based on equipment specifications provided by De Beers using the following emission estimation methods:

- Primary and auxiliary power generator emissions were calculated based on the generator fuel consumption rates and emission factors from AP-42, Section 3.4 (U.S. EPA 2006a).
- Glycol boiler emissions were calculated based on fuel consumption rate and emission factors from AP-42, Section 1.3 (U.S. EPA 2010).
- Waste incinerator CO, VOC and metal emissions were estimated based on the amount of waste burned and emission factors from AP-42, Tables 2.1-9 and 2.1-12 (U.S. EPA 2006b). The PAH emissions were calculated based on the supplemental fuel consumption rate and emission factors from AP-42, Table 1.3-9 (U.S. EPA 2010).
- Mine air heater emissions were estimated based on fuel consumption rate and emission factors from AP-42, Section 1.3 (U.S. EPA 2010).
- Mining equipment CO and VOC emissions were calculated based on engine ratings and U.S. EPA pre-tier emission standards for non-road diesel engines. The PAH emissions were estimated based on fuel consumption rates and emission factors from the Technical Reference for the Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region (Golder and Conor Pacific 1998).

Table 11.4.II-45 summarizes the Snap Lake Mine CAC emissions. Table 11.4.II-46 summarizes the Snap Lake Mine's VOC, PAH, trace metal and dioxin/furan emissions. Tables 11.4.II-47 and 11.4.II-48 provide a summary of the parameters for the point sources and area sources, respectively, at the Snap Lake Mine.

Table 11.4.II-45 CAC Emissions from the Snap Lake Mine

Sources	Emission Rates (t/d)					
	SO ₂	NO _x	CO	TSP	PM ₁₀	PM _{2.5}
Prime power generators	0.063	5.221	0.346	0.046	0.038	0.037
Auxiliary power generators	0.022	0.994	0.126	0.018	0.015	0.014
Glycol boilers	0.016	0.078	0.005	0.007	0.005	0.004
Incinerator	0.127	0.182	0.004	0.016	0.016	0.016
Mine air heaters	0.028	0.398	0.014	0.009	0.006	0.004
Underground mine vents	0.037	1.560	2.284	0.132	0.081	0.056
Aggregate plant	—	—	—	0.020	0.006	0.002
Process and paste plant	—	—	—	0.053	0.019	0.006
Surface fleet	0.010	0.202	0.197	0.015	0.015	0.015
Road dust	—	—	—	0.168	0.041	0.007
Quarry vehicles	0.001	0.038	0.038	0.001	0.001	0.001
Quarry activities	—	—	—	0.005	0.002	0.001
North pile	—	—	—	0.011	0.006	0.003
Total	0.304	8.673	3.014	0.502	0.251	0.166

t/d = tonnes per day; SO₂ = sulphur dioxide; NO_x = nitrogen oxides; CO = carbon monoxide; TSP = total suspended particulates; PM₁₀ = particulate matter with particle diameter less than 10 microns; PM_{2.5} = particulate matter with particle diameter less than 2.5 microns.

Table 11.4.II-46 VOC, PAH, Trace Metal and Dioxin/Furan Emissions from the Snap Lake Mine

Sources	Emission Rates (t/d)			
	VOC	PAH	Metal	Dioxins/Furans
Prime power generators	0.033	8.64×10 ⁻⁵	3.93×10 ⁻⁴	—
Auxiliary power generators	0.012	3.15×10 ⁻⁵	1.52×10 ⁻⁴	—
Glycol boilers	0.000	1.17×10 ⁻⁶	1.87×10 ⁻⁵	3.04×10 ⁻¹²
Incinerator	0.001	7.60×10 ⁻⁸	4.02×10 ⁻⁵	1.29×10 ⁻⁹
Mine air heaters	0.001	3.26×10 ⁻⁶	2.26×10 ⁻⁵	8.48×10 ⁻¹²
Underground mine vents	0.229	1.76×10 ⁻⁴	5.35×10 ⁻³	—
Aggregate plant	—	—	1.13×10 ⁻³	—
Process and paste plant	—	—	1.10×10 ⁻²	—
Surface fleet	0.037	2.97×10 ⁻⁵	1.55×10 ⁻⁴	—
Road dust	—	—	9.48×10 ⁻³	—
Quarry vehicles	0.007	5.86×10 ⁻⁶	1.46×10 ⁻⁵	—
Quarry activities	—	—	2.99×10 ⁻⁴	—
North pile	—	—	6.20×10 ⁻⁴	—
Total	0.321	3.34×10⁻⁴	0.029	1.31×10⁻⁹

t/d = tonnes per day; VOC = volatile organic compound; PAH = polycyclic aromatic hydrocarbons.

Table 11.4.II-47 Snap Lake Mine Point Source Stack Parameters

Emission Source	Stacks Height (m)	Stacks Diameter (m)	Stack Gas Velocity (m/s)	Stack Gas Temperature (K)
Prime generator 1	36.2	0.61	51.8	706.2
Prime generator 2	36.2	0.61	51.8	706.2
Prime generator 3	36.2	0.61	51.8	706.2
Auxiliary generator 1	33.0	0.36	52.7	692.1
Auxiliary generator 2	33.0	0.36	52.7	692.1
Auxiliary generator 3	33.0	0.36	52.7	692.1
Glycol boiler 1	16.6	0.51	10.0	430.4
Glycol boiler 2	16.6	0.51	10.0	430.4
Incinerator	11.2	0.70	4.6	1,273.2
Mine air heater 1	10.0	0.31	9.0	673.2
Mine air heater 2	10.0	0.31	9.0	673.2
Mine air heater 3	10.0	0.31	9.0	673.2
Mine air heater 4	10.0	0.31	9.0	673.2
Mine air heater 5	10.0	0.31	9.0	673.2
Mine air heater 6	10.0	0.31	9.0	673.2
Mine air heater 7	10.0	0.31	9.0	673.2
Mine air heater 8	10.0	0.31	9.0	673.2
Underground mine vent stack 1	0.0	3.70	35.3	273.0
Underground mine vent stack 2	0.0	3.70	35.3	273.0
Aggregate crushing plant	12.0	0.30	15.0	273.0
Process and paste plant	25.0	0.30	15.0	273.0

m = metres; m/s = metres per second; K = Kelvin.

Table 11.4.II-48 Snap Lake Mine Area Sources Parameters

Parameters	Truck Area 1	Truck Area 2	North Pile
Area (km ²)	0.2	0.02	0.7
Effective height (m)	3.0	1.5	2.5
Initial vertical plume dimension - σ_z (m)	4.1	4.1	4.1

km² = square kilometres; m = metres; σ_z = Initial vertical dimension for volume source.

11.4.II.5 SCIENTIFIC UNCERTAINTY

This section discusses the uncertainties associated with the emission estimations in the assessment. Uncertainty in emission estimates generally depends on the assumptions and the quality of the project related data used. Each source of uncertainty is discussed in turn below.

The Project emission profile modelled in this assessment was developed based on the assumption that maximum volumes of material (e.g., overburden, mine rock, kimberlite and coarse PK) will be mined at the same time. In reality, the maximum production of these materials will occur in different years.

All stationary combustion equipment was assumed to be operating at the maximum ratings. It is more likely that the power generators, boiler and waste incinerator will be operating below the maximum capacities on a continuous basis.

The Year 1 and Year 5 source configurations for the Application Case are based on maximum emissions released from locations (e.g., mine pits, mine rock disposal area, haul roads and etc.) that will result in the highest predicted concentrations outside the development area. In reality, the Project will never emit at the combined modelled rates simultaneously..

No vendor specific data for the waste incinerator were available at the time of the assessment was completed. Vendor emission data is more accurate and indicative of the emissions from incinerators that have been designed specifically for waste disposal in northern region. Based on previous experience, the AP-42 emission factors are more conservative vendor data.

The 1-hour, 24-hour and annual particulate matter and metal predictions in the assessment were based on maximum daily road dust emission rates. This approach would result in relatively accurate predictions of 1-hour and 24-hour results; however, it led to overestimation of the annual predictions. As discussed in Section 11.4.II.3.2.4.9, the maximum annual road dust emissions are generally lower than the maximum daily road dust emission rates because the road dust emissions are negligible on days with at least 0.254 mm of precipitation. Based on Environment Canada climate normals data for Yellowknife airport (Environment Canada 2010c), there are on average 118.9 days with precipitation above or equal to 0.2 mm in a year. If the annual adjustment factor recommended by AP-42 is applied to the maximum daily road dust emissions, the resulting annual road dust emission rates would be approximately 30% lower than those used in the assessment.

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11.4.II.6.4 ACRONYMS

11.4.II.6.4.1 Acronyms

ANFO	ammonium nitrate fuel oil
CAC	criteria air contaminant
CH₄	methane
CO	carbon monoxide
CO₂	carbon dioxide
CO₂ eq	CO ₂ equivalent
De Beers	De Beers Canada Inc.
GHG	greenhouse gas
Golder	Golder Associates Ltd.
JDS	JDS Engineering and Mining Inc.
N	nitrogen
N₂O	nitrous oxide
NO	nitric oxide
NO₂	nitrogen dioxide gas

NO_x	nitrogen oxides
NWT	Northwest Territories
PAH	polycyclic aromatic hydrocarbon
PAI	potential acid input
PETN	pentaerythritol tetranitrate
PM	particulate matter, generally
PK	processed kimberlite
PM₁₀	particulate matter with particle diameter less than 10 µm
PM_{2.5}	particulate matter with particle diameter less than 2.5 µm
Project	Gahcho Kué Project
ROM	run-of-mine
RSA	regional study area
SO₂	sulphur dioxide gas
TNT	trinitrotoluene
TSP	total suspended particulates
U.S. EPA	United States Environmental Protection Agency
VOC	volatile organic compound

11.4.II.6.4.2 Units of Measure

%	percent
µ	micro - 10 ⁻⁶
°C	temperature in degrees Celsius
µm	micron or micrometre = 10 ⁻⁶ m
5.21E⁻⁰²	Scientific notation: 0.0521 = 5.21E-02 = 5.21×10 ⁻²
bhp	break horse power
cm	centimetre
cm/s	centimetres per second
d	day = calendar day
g	gram
g/bhp-h	grams per brake horse power per hour
g/m²	grams per square metre
g/m²/y	grams per square metre per year
h	hour
K	Kelvin
kg	kilogram
kg/h	kilograms per hour
kg/KVT	kilograms per vehicle kilometre
km	kilometre

km/h	kilometres per hour
km²	square kilometres
kt CO₂eq/y	kilotons of Carbon dioxide equivalent per year
kW(e)	kilowatt (electric)
L	litre
lb	pound
lb/VMT	pound per vehicle miles travelled
m	metre
m/s	metres per second
m³	cubic metres
mm	millimetres
Mt	million tonne
Mt/y	million tonnes per year
ppmw	parts per million by weight
t	tonne = 1,000 kg
t/d	tonnes per day
t/y	tonne per year

APPENDIX 11.4.III

SUMMARY RESULTS OF AIR QUALITY MODELLING

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11.4.III.1 INTRODUCTION

This appendix summarizes all air quality dispersion modelling results.

11.4.III.2 PREDICTED AIR QUALITY AT SELECTED LOCATIONS

Table 11.4.III-1 SO₂ Predictions at Selected Locations

Location	Maximum 1-Hour ^(a) (µg/m ³)		Maximum 24-Hour ^(b) (µg/m ³)		Annual ^(c) (µg/m ³)	
	Baseline	Application	Baseline	Application	Baseline	Application
Warburton Bay Lodge	3.7	3.7	2.9	2.9	2.6	2.6
Warburton Bay Fishing Lodge	4.1	4.1	2.9	2.9	2.6	2.6
MacKay Lake Lodge	3.5	3.5	2.9	2.9	2.6	2.6
Employee Camp	3.1	31.6	2.7	11.6	2.6	3.0
Proposed National Park Boundary	3.1	7.2	2.7	3.4	2.6	2.7
Development Area Boundary	3.1	42.9	2.7	32.9	2.6	4.8

(a) The 1-hour Northwest Territories (NWT) Standard for SO₂ is 450 µg/m³ (GNWT 2010, internet site).

(b) The 24-hour NWT Standard for SO₂ is 150 µg/m³ (GNWT 2010, internet site).

(c) The annual NWT Standard for SO₂ is 30 µg/m³ (GNWT 2010, internet site).

SO₂ = sulphur dioxide gas; µg/m³ = micrograms per cubic metres.

Table 11.4.III-2 NO₂ Predictions at Selected Locations

Location	Maximum 1-Hour ^(a) (µg/m ³)		Maximum 24-Hour ^(b) (µg/m ³)		Annual ^(c) (µg/m ³)	
	Baseline	Application	Baseline	Application	Baseline	Application
Warburton Bay Lodge	43.1	43.1	9.7	9.7	5.9	5.9
Warburton Bay Fishing Lodge	38.1	38.1	11.2	11.2	5.9	6.0
MacKay Lake Lodge	23.2	23.2	10.2	10.2	5.9	5.9
Employee Camp	11.5	226.1	7.2	170.3	5.8	55.7
Proposed National Park Boundary	12.1	98.3	7.7	47.4	5.8	9.6
Development Area Boundary	13.1	314.3	7.6	224.8	5.8	64.3

(a) The 1-hour National Ambient Air Quality Objective (NAAQO) for NO₂ is 400 µg/m³ (Environment Canada 1981).

(b) The 24-hour NAAQO for NO₂ is 200 µg/m³ (Environment Canada 1981).

(c) The annual NAAQO for NO₂ is 60 µg/m³ (Environment Canada 1981).

NO₂ = nitrogen dioxide gas; µg/m³ = micrograms per cubic metres.

Table 11.4.III-3 CO Predictions at Selected Locations

Location	Maximum 1-Hour ^(a) (µg/m ³)		Maximum 8-Hour ^(b) (µg/m ³)	
	Baseline	Application	Baseline	Application
Warburton Bay Lodge	13.8	13.8	4.0	4.0
Warburton Bay Fishing Lodge	12.7	12.7	5.1	5.1
MacKay Lake Lodge	7.5	7.5	2.7	2.7
Employee Camp	2.4	1,377.2	1.4	846.1
Proposed National Park Boundary	2.4	218.4	1.5	95.6
Development Area Boundary	2.4	1,978.6	1.5	1,692.1

(a) The 1-hour National Ambient Air Quality Objective (NAAQO) for CO is 15,000 µg/m³ (Environment Canada 1981).

(b) The 8-hour NAAQO for CO is 6,000 µg/m³ (Environment Canada 1981).

CO = carbon monoxide; µg/m³ = micrograms per cubic metres.

Table 11.4.III-4 TSP Predictions at Selected Locations

Location	Maximum 24-Hour ^(a) (µg/m ³)		Annual Average ^(b) (µg/m ³)	
	Baseline	Application	Baseline	Application
Warburton Bay Lodge	7.2	7.3	7.1	7.1
Warburton Bay Fishing Lodge	7.2	7.4	7.1	7.1
MacKay Lake Lodge	7.2	7.3	7.1	7.1
Employee Camp	7.1	826.4	7.1	84.1
Proposed National Park Boundary	7.1	33.5	7.1	8.8
Development Area Boundary	7.1	4,837.6	7.1	604.8

^(a) The 24-hour NWT Standard for TSP is 120 µg/m³ (GNWT 2010, internet site).

^(b) The annual NWT Standard for TSP is 60 µg/m³ (GNWT 2010, internet site).

TSP = total suspended particulates; µg/m³ = micrograms per cubic metres.

Table 11.4.III-5 PM_{2.5} Predictions at Selected Locations

Location	Maximum 24-Hour ^(a) (µg/m ³)	
	Baseline	Application
Warburton Bay Lodge	2.1	2.1
Warburton Bay Fishing Lodge	2.1	2.1
MacKay Lake Lodge	2.1	2.1
Employee Camp	2.1	108.5
Proposed National Park Boundary	2.1	6.7
Development Area Boundary	2.2	228.9

^(a) The 24-hour NWT Standard for PM_{2.5} is 30 µg/m³ (GNWT 2010, internet site).

PM_{2.5} = particulate matter of particle diameter less than 2.5 µm; µg/m³ = micrograms per cubic metres.

Table 11.4.III-6 PM₁₀ Predictions at Selected Locations

Location	Maximum 24-Hour (µg/m ³)	
	Baseline	Application
Warburton Bay Lodge	3.1	3.2
Warburton Bay Fishing Lodge	3.1	3.2
MacKay Lake Lodge	3.1	3.2
Employee Camp	3.0	227.9
Proposed National Park Boundary	3.0	20.5
Development Area Boundary	3.0	1,222.6

PM₁₀ = particulate matter of particle diameter less than 10 µm; µg/m³ = micrograms per cubic metres.

Table 11.4.III-7 Maximum 1-Hour VOC Predictions at Selected Locations

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Maximum 1-Hour ($\mu\text{g}/\text{m}^3$)						
1,1,1-Trichloroethane	0.000005	0.000005	0.000008	0.000008	0.000004	0.000004
1,3-Butadiene	0.001981	0.001981	0.001820	0.001820	0.001075	0.001075
Acetaldehyde	0.267140	0.267140	0.245410	0.245410	0.144970	0.144970
Acetone	0.140600	0.140600	0.129160	0.129160	0.076302	0.076302
Acrolein	0.021729	0.021729	0.019961	0.019961	0.011792	0.011792
Aldehydes	0.370670	0.370670	0.340520	0.340520	0.201160	0.201160
Benzene	0.017544	0.017544	0.016119	0.016119	0.009534	0.009534
C16+ aliphatics	0.022380	0.022380	0.020560	0.020560	0.012146	0.012146
C2 to C8 aliphatics	0.218050	0.218050	0.200320	0.200320	0.118340	0.118340
C6 to C8 aromatics	0.032593	0.032593	0.029942	0.029942	0.017688	0.017688
C9 to C16 aliphatics	0.028483	0.028483	0.026166	0.026166	0.015458	0.015458
C9 to C16 aromatics	0.032172	0.032172	0.029555	0.029555	0.017460	0.017460
Ethylbenzene	0.003010	0.003010	0.002765	0.002765	0.001636	0.001636
Formaldehyde	0.142760	0.142760	0.131100	0.131100	0.077541	0.077541
Methyl Ethyl Ketone	0.047931	0.047931	0.044032	0.044032	0.026012	0.026012
Toluene	0.025553	0.025553	0.023471	0.023471	0.013908	0.013908
Trimethylbenzenes	0.007286	0.007286	0.006693	0.006693	0.003954	0.003954
Xylenes	0.020216	0.020216	0.018573	0.018573	0.010979	0.010979

Table 11.4.III-7 Maximum 1-Hour VOC Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Maximum 1-Hour ($\mu\text{g}/\text{m}^3$)						
1,1,1-Trichloroethane	0.000002	0.000169	0.000002	0.000007	0.000003	0.000130
1,3-Butadiene	0.000360	0.080544	0.000356	0.012718	0.000373	0.155870
Acetaldehyde	0.048556	10.860000	0.048017	1.714900	0.050350	21.018000
Acetone	0.025556	5.716000	0.025272	0.902560	0.026500	11.062000
Acrolein	0.003950	0.883390	0.003906	0.139490	0.004096	1.709600
Aldehydes	0.067375	15.070000	0.066627	2.379500	0.069864	29.164000
Benzene	0.003198	0.711900	0.003174	0.112410	0.003322	1.377700
C16+ aliphatics	0.004068	0.909860	0.004023	0.143670	0.004218	1.760800
C2 to C8 aliphatics	0.039635	8.865000	0.039195	1.399800	0.041099	17.156000
C6 to C8 aromatics	0.005924	1.325100	0.005859	0.209230	0.006143	2.564400
C9 to C16 aliphatics	0.005177	1.158000	0.005120	0.182850	0.005369	2.241000
C9 to C16 aromatics	0.005848	1.308000	0.005783	0.206530	0.006064	2.531200
Ethylbenzene	0.000549	0.122120	0.000545	0.019282	0.000570	0.236320
Formaldehyde	0.026011	5.794000	0.025822	0.914870	0.027033	11.213000
Methyl Ethyl Ketone	0.008712	1.948600	0.008616	0.307690	0.009034	3.771100
Toluene	0.004676	1.034100	0.004667	0.163280	0.004872	2.001200
Trimethylbenzenes	0.001324	0.296190	0.001310	0.046769	0.001373	0.573210
Xylenes	0.003680	0.821030	0.003647	0.129640	0.003820	1.588900

C = carbon; $\mu\text{g}/\text{m}^3$ = micrograms per cubic metres.

Table 11.4.III-8 Maximum 24-Hour VOC Predictions at Selected Locations

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Maximum 24-Hour ($\mu\text{g}/\text{m}^3$)						
1,1,1-Trichloroethane	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
1,3-Butadiene	0.000199	0.000199	0.000401	0.000402	0.000200	0.000200
Acetaldehyde	0.026897	0.026897	0.054061	0.054161	0.026993	0.026994
Acetone	0.014157	0.014157	0.028453	0.028506	0.014207	0.014207
Acrolein	0.002188	0.002188	0.004397	0.004405	0.002196	0.002196
Aldehydes	0.037322	0.037322	0.075012	0.075151	0.037455	0.037455
Benzene	0.001775	0.001775	0.003544	0.003551	0.001781	0.001781
C16+ aliphatics	0.002253	0.002253	0.004529	0.004537	0.002261	0.002262
C2 to C8 aliphatics	0.021955	0.021955	0.044128	0.044210	0.022034	0.022034
C6 to C8 aromatics	0.003282	0.003282	0.006596	0.006608	0.003294	0.003294
C9 to C16 aliphatics	0.002868	0.002868	0.005764	0.005775	0.002878	0.002878
C9 to C16 aromatics	0.003239	0.003239	0.006511	0.006523	0.003251	0.003251
Ethylbenzene	0.000304	0.000304	0.000608	0.000609	0.000306	0.000306
Formaldehyde	0.014435	0.014435	0.028872	0.028926	0.014496	0.014496
Methyl Ethyl Ketone	0.004826	0.004826	0.009700	0.009718	0.004843	0.004843
Toluene	0.002602	0.002602	0.005154	0.005164	0.002612	0.002612
Trimethylbenzenes	0.000734	0.000734	0.001474	0.001477	0.000736	0.000736
Xylenes	0.002041	0.002041	0.004087	0.004095	0.002048	0.002048

Table 11.4.III-8 Maximum 24-Hour VOC Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Maximum 24-Hour ($\mu\text{g}/\text{m}^3$)						
1,1,1-Trichloroethane	0.000000	0.000074	0.000000	0.000001	0.000000	0.000047
1,3-Butadiene	0.000106	0.035231	0.000142	0.002747	0.000131	0.107920
Acetaldehyde	0.014344	4.750500	0.019111	0.370380	0.017620	14.552000
Acetone	0.007550	2.500300	0.010059	0.194940	0.009274	7.658700
Acrolein	0.001167	0.386400	0.001555	0.030127	0.001433	1.183600
Aldehydes	0.019903	6.591600	0.026518	0.513920	0.024449	20.191000
Benzene	0.000946	0.311420	0.001260	0.024290	0.001162	0.953890
C16+ aliphatics	0.001202	0.397980	0.001601	0.031029	0.001476	1.219100
C2 to C8 aliphatics	0.011709	3.877700	0.015600	0.302330	0.014383	11.878000
C6 to C8 aromatics	0.001750	0.579610	0.002332	0.045190	0.002150	1.775400
C9 to C16 aliphatics	0.001529	0.506520	0.002038	0.039491	0.001879	1.551500
C9 to C16 aromatics	0.001728	0.572120	0.002302	0.044606	0.002122	1.752500
Ethylbenzene	0.000162	0.053423	0.000216	0.004167	0.000199	0.163620
Formaldehyde	0.007697	2.538500	0.010252	0.197640	0.009452	7.763200
Methyl Ethyl Ketone	0.002574	0.852360	0.003429	0.066456	0.003162	2.610900
Toluene	0.001386	0.453090	0.001847	0.035300	0.001702	1.385600
Trimethylbenzenes	0.000391	0.129560	0.000521	0.010101	0.000481	0.396860
Xylenes	0.001088	0.359140	0.001450	0.028007	0.001336	1.100100

C = carbon; $\mu\text{g}/\text{m}^3$ = micrograms per cubic metres.

Table 11.4.III-9 Annual Average VOC Predictions at Selected Locations

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Annual Average (µg/m³)						
1,1,1-Trichloroethane	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1,3-Butadiene	0.000014	0.000016	0.000015	0.000018	0.000011	0.000013
Acetaldehyde	0.001841	0.002184	0.001966	0.002424	0.001474	0.001764
Acetone	0.000969	0.001150	0.001035	0.001276	0.000776	0.000929
Acrolein	0.000150	0.000178	0.000160	0.000197	0.000120	0.000144
Aldehydes	0.002554	0.003031	0.002728	0.003364	0.002045	0.002448
Benzene	0.000121	0.000144	0.000130	0.000160	0.000097	0.000117
C16+ aliphatics	0.000154	0.000183	0.000165	0.000203	0.000123	0.000148
C2 to C8 aliphatics	0.001502	0.001783	0.001605	0.001979	0.001203	0.001440
C6 to C8 aromatics	0.000225	0.000267	0.000240	0.000296	0.000180	0.000215
C9 to C16 aliphatics	0.000196	0.000233	0.000210	0.000258	0.000157	0.000188
C9 to C16 aromatics	0.000222	0.000263	0.000237	0.000292	0.000177	0.000212
Ethylbenzene	0.000021	0.000025	0.000022	0.000028	0.000017	0.000020
Formaldehyde	0.000989	0.001172	0.001057	0.001301	0.000791	0.000946
Methyl Ethyl Ketone	0.000330	0.000392	0.000353	0.000435	0.000264	0.000317
Toluene	0.000178	0.000212	0.000190	0.000236	0.000142	0.000171
Trimethylbenzenes	0.000050	0.000060	0.000054	0.000066	0.000040	0.000048
Xylenes	0.000140	0.000166	0.000149	0.000184	0.000112	0.000134

Table 11.4.III-9 Annual Average VOC Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Annual Average ($\mu\text{g}/\text{m}^3$)						
1,1,1-Trichloroethane	0.000000	0.000006	0.000000	0.000000	0.000000	0.000005
1,3-Butadiene	0.000006	0.003445	0.000005	0.000230	0.000006	0.010499
Acetaldehyde	0.000767	0.464580	0.000735	0.030955	0.000836	1.415700
Acetone	0.000403	0.244510	0.000387	0.016292	0.000440	0.745080
Acrolein	0.000062	0.037789	0.000060	0.002518	0.000068	0.115150
Aldehydes	0.001064	0.644630	0.001020	0.042952	0.001159	1.964300
Benzene	0.000051	0.031178	0.000049	0.002052	0.000055	0.092900
C16+ aliphatics	0.000064	0.038921	0.000062	0.002593	0.000070	0.118600
C2 to C8 aliphatics	0.000626	0.379220	0.000600	0.025268	0.000682	1.155600
C6 to C8 aromatics	0.000094	0.056683	0.000090	0.003777	0.000102	0.172720
C9 to C16 aliphatics	0.000082	0.049535	0.000078	0.003301	0.000089	0.150940
C9 to C16 aromatics	0.000092	0.055951	0.000089	0.003728	0.000101	0.170490
Ethylbenzene	0.000009	0.005348	0.000008	0.000352	0.000009	0.015935
Formaldehyde	0.000412	0.248640	0.000395	0.016524	0.000449	0.755290
Methyl Ethyl Ketone	0.000138	0.083357	0.000132	0.005554	0.000150	0.254010
Toluene	0.000074	0.046015	0.000071	0.003001	0.000081	0.135040
Trimethylbenzenes	0.000021	0.012670	0.000020	0.000844	0.000023	0.038609
Xylenes	0.000058	0.035582	0.000056	0.002355	0.000063	0.107090

C = carbon; $\mu\text{g}/\text{m}^3$ = micrograms per cubic metres.

Table 11.4.III-10 Dioxin/Furan Predictions at Selected Locations

Receptors	1-Hour Concentrations ($\mu\text{g}/\text{m}^3$)		24-Hour Concentrations ($\mu\text{g}/\text{m}^3$)		Annual Concentrations ($\mu\text{g}/\text{m}^3$)	
	Baseline	Application	Baseline	Application	Baseline	Application
Warburton Bay Lodge	7.28×10^{-09}	7.28×10^{-09}	2.02×10^{-09}	2.03×10^{-09}	5.49×10^{-11}	9.82×10^{-11}
Waburton Bay Fishing Lodge	1.02×10^{-08}	1.02×10^{-08}	1.76×10^{-09}	1.76×10^{-09}	6.26×10^{-11}	1.21×10^{-10}
MacKay Lake Lodge	5.15×10^{-09}	5.15×10^{-09}	1.77×10^{-09}	1.77×10^{-09}	4.17×10^{-11}	7.73×10^{-11}
Employee Camp	3.48×10^{-09}	2.14×10^{-06}	4.42×10^{-10}	7.73×10^{-07}	2.68×10^{-11}	5.86×10^{-08}
Proposed National Park Boundary	2.93×10^{-09}	2.18×10^{-07}	5.98×10^{-10}	4.30×10^{-08}	2.54×10^{-11}	2.19×10^{-09}
Development Area Boundary	3.65×10^{-09}	5.02×10^{-06}	5.33×10^{-10}	3.87×10^{-06}	2.95×10^{-11}	1.95×10^{-07}

$\mu\text{g}/\text{m}^3$ = micrograms per cubic metres.

Table 11.4.III-11 Maximum 1-Hour PAH Predictions at Selected Locations

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Maximum 1-Hour (µg/m³)						
1-Methylnaphthalene	0.000179	0.000179	0.000160	0.000160	0.000093	0.000093
1-Methylphenanthrene	0.000008	0.000008	0.000007	0.000007	0.000004	0.000004
2-Methylantracene	0.000005	0.000005	0.000004	0.000004	0.000003	0.000003
2-Methylfluorene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2-Methylnaphthalene	0.000289	0.000289	0.000259	0.000259	0.000151	0.000151
2-Methylphenanthrene	0.000020	0.000020	0.000018	0.000018	0.000010	0.000010
2-Methylpyrene	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
3-Methyldibenzothiophene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3-Methylphenanthrene	0.000014	0.000014	0.000013	0.000013	0.000007	0.000007
4-+9-Methylphenanthrene	0.000011	0.000011	0.000010	0.000010	0.000006	0.000006
4-Methyldibenzothiophene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Acenaphthene	0.000009	0.000009	0.000008	0.000008	0.000005	0.000005
Acenaphthylene	0.000033	0.000033	0.000030	0.000030	0.000017	0.000017
Acephenanthrylene	0.000006	0.000006	0.000005	0.000005	0.000003	0.000003
Anthracene	0.000006	0.000006	0.000005	0.000005	0.000003	0.000003
Benz(a)anthracene	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
Benzo(a)fluorene	0.000002	0.000002	0.000002	0.000002	0.000001	0.000001
Benzo(a)pyrene	0.000001	0.000001	0.000001	0.000001	0.000000	0.000000
Benzo(b)fluoranthene	0.000007	0.000007	0.000006	0.000006	0.000003	0.000003
Benzo(e)pyrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Benzo(g,h,i)fluoranthene	0.000003	0.000003	0.000002	0.000002	0.000001	0.000001
Benzo(g,h,i)perylene	0.000002	0.000002	0.000002	0.000002	0.000001	0.000001
Benzo(k)fluoranthene	0.000001	0.000001	0.000001	0.000001	0.000000	0.000000
Chrysene	0.000002	0.000002	0.000001	0.000001	0.000001	0.000001
Coronene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Cyclopenta(c,d)pyrene	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001

Table 11.4.III-11 Maximum 1-Hour PAH Predictions at Selected Locations (continued)

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Dibenzo(a,h)anthracene	0.000002	0.000002	0.000002	0.000002	0.000001	0.000001
Dibenzothiophene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fluoranthene	0.000025	0.000025	0.000023	0.000023	0.000013	0.000013
Fluorene	0.000047	0.000047	0.000042	0.000042	0.000025	0.000025
Indeno(1,2,3-cd)fluoranthene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Indeno(1,2,3-cd)pyrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Indeno(1,2,3-W)pyrene	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
Naphthalene	0.000717	0.000717	0.000641	0.000641	0.000376	0.000376
Nitro-pyrene	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
Perylene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Phenanthrene	0.000044	0.000044	0.000040	0.000040	0.000023	0.000023
Picene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Pyrene	0.000034	0.000034	0.000031	0.000031	0.000018	0.000018

PAH = polycyclic aromatic hydrocarbon; $\mu\text{g}/\text{m}^3$ = micrograms per cubic metre.

Table 11.4.III-11 Maximum 1-Hour PAH Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Maximum 1-Hour ($\mu\text{g}/\text{m}^3$)						
1-Methylnaphthalene	0.000029	0.052095	0.000032	0.008121	0.000035	0.102140
1-Methylphenanthrene	0.000001	0.002343	0.000001	0.000365	0.000002	0.004594
2-Methylantracene	0.000001	0.001433	0.000001	0.000223	0.000001	0.002810
2-Methylfluorene	0.000000	0.000048	0.000000	0.000008	0.000000	0.000095
2-Methylnaphthalene	0.000048	0.084207	0.000053	0.013127	0.000056	0.165100
2-Methylphenanthrene	0.000003	0.005788	0.000004	0.000902	0.000004	0.011349
2-Methylpyrene	0.000000	0.000429	0.000000	0.000067	0.000000	0.000841
3-Methyldibenzothiophene	0.000000	0.000089	0.000000	0.000014	0.000000	0.000174
3-Methylphenanthrene	0.000002	0.004176	0.000003	0.000651	0.000003	0.008187
4+9-Methylphenanthrene	0.000002	0.003156	0.000002	0.000492	0.000002	0.006188
4-Methyldibenzothiophene	0.000000	0.000056	0.000000	0.000009	0.000000	0.000111
Acenaphthene	0.000002	0.002660	0.000002	0.000415	0.000002	0.005215
Acenaphthylene	0.000005	0.009661	0.000006	0.001506	0.000006	0.018942
Acephenanthrylene	0.000001	0.001654	0.000001	0.000258	0.000001	0.003243
Anthracene	0.000001	0.001723	0.000001	0.000269	0.000001	0.003378
Benz(a)anthracene	0.000000	0.000411	0.000000	0.000064	0.000000	0.000805
Benzo(a)fluorene	0.000000	0.000520	0.000000	0.000081	0.000000	0.001020
Benzo(a)pyrene	0.000000	0.000228	0.000000	0.000035	0.000000	0.000446
Benzo(b)fluoranthene	0.000001	0.001909	0.000001	0.000298	0.000001	0.003742
Benzo(e)pyrene	0.000000	0.000032	0.000000	0.000005	0.000000	0.000063
Benzo(g,h,i)fluoranthene	0.000000	0.000802	0.000001	0.000125	0.000001	0.001573
Benzo(g,h,i)perylene	0.000000	0.000521	0.000000	0.000081	0.000000	0.001022
Benzo(k)fluoranthene	0.000000	0.000217	0.000000	0.000034	0.000000	0.000426
Chrysene	0.000000	0.000462	0.000000	0.000072	0.000000	0.000905
Coronene	0.000000	0.000004	0.000000	0.000001	0.000000	0.000008

Table 11.4.III-11 Maximum 1-Hour PAH Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Cyclopenta(c,d)pyrene	0.000000	0.000284	0.000000	0.000044	0.000000	0.000557
Dibenzo(a,h)anthracene	0.000000	0.000597	0.000000	0.000093	0.000000	0.001170
Dibenzothiophene	0.000000	0.000034	0.000000	0.000005	0.000000	0.000067
Fluoranthene	0.000004	0.007304	0.000005	0.001139	0.000005	0.014321
Fluorene	0.000008	0.013754	0.000009	0.002144	0.000009	0.026967
Indeno(1,2,3-cd)fluoranthene	0.000000	0.000020	0.000000	0.000003	0.000000	0.000039
Indeno(1,2,3-cd)pyrene	0.000000	0.000002	0.000000	0.000000	0.000000	0.000001
Indeno(1,2,3-W)pyrene	0.000000	0.000362	0.000000	0.000056	0.000000	0.000709
Naphthalene	0.000120	0.206220	0.000136	0.032147	0.000148	0.404320
Nitro-pyrene	0.000000	0.000322	0.000000	0.000050	0.000000	0.000631
Perylene	0.000000	0.000004	0.000000	0.000001	0.000000	0.000008
Phenanthrene	0.000007	0.012831	0.000008	0.002000	0.000009	0.025157
Picene	0.000000	0.000004	0.000000	0.000001	0.000000	0.000008
Pyrene	0.000006	0.009909	0.000006	0.001545	0.000007	0.019428

PAH = polycyclic aromatic hydrocarbon; $\mu\text{g}/\text{m}^3$ = microgram per cubic metre.

Table 11.4.III-12 Maximum 24-Hour PAH Predictions at Selected Locations

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Maximum 24-Hour (µg/m³)						
1-Methylnaphthalene	0.000018	0.000026	0.000028	0.000028	0.000018	0.000028
1-Methylphenanthrene	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
2-Methylantracene	0.000000	0.000001	0.000001	0.000001	0.000000	0.000001
2-Methylfluorene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2-Methylnaphthalene	0.000029	0.000042	0.000045	0.000046	0.000029	0.000045
2-Methylphenanthrene	0.000002	0.000003	0.000003	0.000003	0.000002	0.000003
2-Methylpyrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3-Methyldibenzothiophene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3-Methylphenanthrene	0.000001	0.000002	0.000002	0.000002	0.000001	0.000002
4-+9-Methylphenanthrene	0.000001	0.000002	0.000002	0.000002	0.000001	0.000002
4-Methyldibenzothiophene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Acenaphthene	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
Acenaphthylene	0.000003	0.000005	0.000005	0.000005	0.000003	0.000005
Acephenanthrylene	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
Anthracene	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
Benz(a)anthracene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Benzo(a)fluorene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Benzo(a)pyrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Benzo(b)fluoranthene	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
Benzo(e)pyrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Benzo(g,h,i)fluoranthene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Benzo(g,h,i)perylene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Benzo(k)fluoranthene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Chrysene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Coronene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Table 11.4.III-12 Maximum 24-Hour PAH Predictions at Selected Locations (continued)

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Cyclopenta(c,d)pyrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Dibenzo(a,h)anthracene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Dibenzothiophene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fluoranthene	0.000003	0.000004	0.000004	0.000004	0.000003	0.000004
Fluorene	0.000005	0.000007	0.000007	0.000007	0.000005	0.000007
Indeno(1,2,3-cd)fluoranthene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Indeno(1,2,3-cd)pyrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Indeno(1,2,3-W)pyrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Naphthalene	0.000076	0.000104	0.000114	0.000114	0.000075	0.000113
Nitro-pyrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Perylene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Phenanthrene	0.000005	0.000006	0.000007	0.000007	0.000004	0.000007
Picene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Pyrene	0.000003	0.000005	0.000005	0.000005	0.000003	0.000005

PAH = polycyclic aromatic hydrocarbon; $\mu\text{g}/\text{m}^3$ = microgram per cubic metre.

Table 11.4.III-12 Maximum 24-Hour PAH Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Maximum 24-Hour ($\mu\text{g}/\text{m}^3$)						
1-Methylnaphthalene	0.000008	0.021190	0.000012	0.001711	0.000011	0.071116
1-Methylphenanthrene	0.000000	0.000953	0.000001	0.000077	0.000000	0.003198
2-Methylantracene	0.000000	0.000583	0.000000	0.000047	0.000000	0.001957
2-Methylfluorene	0.000000	0.000020	0.000000	0.000002	0.000000	0.000066
2-Methylnaphthalene	0.000013	0.034252	0.000019	0.002765	0.000018	0.114950
2-Methylphenanthrene	0.000001	0.002355	0.000001	0.000190	0.000001	0.007902
2-Methylpyrene	0.000000	0.000174	0.000000	0.000014	0.000000	0.000586
3-Methyldibenzothiophene	0.000000	0.000036	0.000000	0.000003	0.000000	0.000121
3-Methylphenanthrene	0.000001	0.001699	0.000001	0.000137	0.000001	0.005701
4-+9-Methylphenanthrene	0.000000	0.001284	0.000001	0.000104	0.000001	0.004308
4-Methyldibenzothiophene	0.000000	0.000023	0.000000	0.000002	0.000000	0.000077
Acenaphthene	0.000000	0.001082	0.000001	0.000087	0.000001	0.003631
Acenaphthylene	0.000002	0.003930	0.000002	0.000317	0.000002	0.013188
Acephenanthrylene	0.000000	0.000673	0.000000	0.000054	0.000000	0.002258
Anthracene	0.000000	0.000701	0.000000	0.000057	0.000000	0.002352
Benz(a)anthracene	0.000000	0.000167	0.000000	0.000013	0.000000	0.000561
Benzo(a)fluorene	0.000000	0.000212	0.000000	0.000017	0.000000	0.000710
Benzo(a)pyrene	0.000000	0.000093	0.000000	0.000007	0.000000	0.000311
Benzo(b)fluoranthene	0.000000	0.000776	0.000000	0.000063	0.000000	0.002605
Benzo(e)pyrene	0.000000	0.000013	0.000000	0.000001	0.000000	0.000044
Benzo(g,h,i)fluoranthene	0.000000	0.000326	0.000000	0.000026	0.000000	0.001095
Benzo(g,h,i)perylene	0.000000	0.000212	0.000000	0.000017	0.000000	0.000711
Benzo(k)fluoranthene	0.000000	0.000088	0.000000	0.000007	0.000000	0.000296
Chrysene	0.000000	0.000188	0.000000	0.000015	0.000000	0.000630
Coronene	0.000000	0.000002	0.000000	0.000000	0.000000	0.000005

Table 11.4.III-12 Maximum 24-Hour PAH Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Cyclopenta(c,d)pyrene	0.000000	0.000115	0.000000	0.000009	0.000000	0.000388
Dibenzo(a,h)anthracene	0.000000	0.000243	0.000000	0.000020	0.000000	0.000815
Dibenzothiophene	0.000000	0.000014	0.000000	0.000001	0.000000	0.000047
Fluoranthene	0.000001	0.002971	0.000002	0.000240	0.000002	0.009971
Fluorene	0.000002	0.005595	0.000003	0.000452	0.000003	0.018776
Indeno(1,2,3-cd)fluoranthene	0.000000	0.000008	0.000000	0.000001	0.000000	0.000027
Indeno(1,2,3-cd)pyrene	0.000000	0.000001	0.000000	0.000000	0.000000	0.000000
Indeno(1,2,3-W)pyrene	0.000000	0.000147	0.000000	0.000012	0.000000	0.000494
Naphthalene	0.000034	0.083890	0.000048	0.006773	0.000045	0.281510
Nitro-pyrene	0.000000	0.000131	0.000000	0.000011	0.000000	0.000439
Perylene	0.000000	0.000002	0.000000	0.000000	0.000000	0.000005
Phenanthrene	0.000002	0.005220	0.000003	0.000421	0.000003	0.017516
Picene	0.000000	0.000002	0.000000	0.000000	0.000000	0.000005
Pyrene	0.000002	0.004031	0.000002	0.000325	0.000002	0.013527

PAH = polycyclic aromatic hydrocarbon; $\mu\text{g}/\text{m}^3$ = microgram per cubic metre.

Table 11.4.III-13 Annual Average PAH Predictions at Selected Locations

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Annual Average (µg/m³)						
1-Methylnaphthalene	0.000001	0.000002	0.000001	0.000003	0.000001	0.000002
1-Methylphenanthrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2-Methylantracene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2-Methylfluorene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2-Methylnaphthalene	0.000002	0.000004	0.000002	0.000004	0.000001	0.000003
2-Methylphenanthrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2-Methylpyrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3-Methyldibenzothiophene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3-Methylphenanthrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4-+9-Methylphenanthrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4-Methyldibenzothiophene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Acenaphthene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Acenaphthylene	0.000000	0.000000	0.000000	0.000001	0.000000	0.000000
Acephenanthrylene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Anthracene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Benz(a)anthracene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Benzo(a)fluorene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Benzo(a)pyrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Benzo(b)fluoranthene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Benzo(e)pyrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Benzo(g,h,i)fluoranthene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Benzo(g,h,i)perylene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Benzo(k)fluoranthene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Chrysene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Coronene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Table 11.4.III-13 Annual Average PAH Predictions at Selected Locations (continued)

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Cyclopenta(c,d)pyrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Dibenzo(a,h)anthracene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Dibenzothiophene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fluoranthene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fluorene	0.000000	0.000001	0.000000	0.000001	0.000000	0.000001
Indeno(1,2,3-cd)fluoranthene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Indeno(1,2,3-cd)pyrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Indeno(1,2,3-W)pyrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Naphthalene	0.000005	0.000009	0.000005	0.000011	0.000004	0.000008
Nitro-pyrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Perylene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Phenanthrene	0.000000	0.000001	0.000000	0.000001	0.000000	0.000000
Picene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Pyrene	0.000000	0.000000	0.000000	0.000001	0.000000	0.000000

Table 11.4.III-13 Annual Average PAH Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Annual Average (µg/m³)						
1-Methylnaphthalene	0.000001	0.001612	0.000000	0.000126	0.000001	0.006833
1-Methylphenanthrene	0.000000	0.000073	0.000000	0.000006	0.000000	0.000307
2-Methylantracene	0.000000	0.000044	0.000000	0.000003	0.000000	0.000188
2-Methylfluorene	0.000000	0.000001	0.000000	0.000000	0.000000	0.000006
2-Methylnaphthalene	0.000001	0.002606	0.000001	0.000203	0.000001	0.011045
2-Methylphenanthrene	0.000000	0.000179	0.000000	0.000014	0.000000	0.000759
2-Methylpyrene	0.000000	0.000013	0.000000	0.000001	0.000000	0.000056
3-Methyldibenzothiophene	0.000000	0.000003	0.000000	0.000000	0.000000	0.000012
3-Methylphenanthrene	0.000000	0.000129	0.000000	0.000010	0.000000	0.000548
4-+9-Methylphenanthrene	0.000000	0.000098	0.000000	0.000008	0.000000	0.000414
4-Methyldibenzothiophene	0.000000	0.000002	0.000000	0.000000	0.000000	0.000007
Acenaphthene	0.000000	0.000083	0.000000	0.000006	0.000000	0.000349
Acenaphthylene	0.000000	0.000299	0.000000	0.000023	0.000000	0.001267
Acephenanthrylene	0.000000	0.000051	0.000000	0.000004	0.000000	0.000217
Anthracene	0.000000	0.000053	0.000000	0.000004	0.000000	0.000226
Benz(a)anthracene	0.000000	0.000013	0.000000	0.000001	0.000000	0.000054
Benzo(a)fluorene	0.000000	0.000016	0.000000	0.000001	0.000000	0.000068
Benzo(a)pyrene	0.000000	0.000007	0.000000	0.000001	0.000000	0.000030
Benzo(b)fluoranthene	0.000000	0.000059	0.000000	0.000005	0.000000	0.000250
Benzo(e)pyrene	0.000000	0.000001	0.000000	0.000000	0.000000	0.000004
Benzo(g,h,i)fluoranthene	0.000000	0.000025	0.000000	0.000002	0.000000	0.000105
Benzo(g,h,i)perylene	0.000000	0.000016	0.000000	0.000001	0.000000	0.000068
Benzo(k)fluoranthene	0.000000	0.000007	0.000000	0.000001	0.000000	0.000028
Chrysene	0.000000	0.000014	0.000000	0.000001	0.000000	0.000061
Coronene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001

Table 11.4.III-13 Annual Average PAH Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Cyclopenta(c,d)pyrene	0.000000	0.000009	0.000000	0.000001	0.000000	0.000037
Dibenzo(a,h)anthracene	0.000000	0.000019	0.000000	0.000001	0.000000	0.000078
Dibenzothiophene	0.000000	0.000001	0.000000	0.000000	0.000000	0.000005
Fluoranthene	0.000000	0.000226	0.000000	0.000018	0.000000	0.000958
Fluorene	0.000000	0.000426	0.000000	0.000033	0.000000	0.001804
Indeno(1,2,3-cd)fluoranthene	0.000000	0.000001	0.000000	0.000000	0.000000	0.000003
Indeno(1,2,3-cd)pyrene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Indeno(1,2,3-W)pyrene	0.000000	0.000011	0.000000	0.000001	0.000000	0.000047
Naphthalene	0.000002	0.006410	0.000002	0.000499	0.000002	0.027051
Nitro-pyrene	0.000000	0.000010	0.000000	0.000001	0.000000	0.000042
Perylene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001
Phenanthrene	0.000000	0.000398	0.000000	0.000031	0.000000	0.001683
Picene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001
Pyrene	0.000000	0.000307	0.000000	0.000024	0.000000	0.001300

PAH = polycyclic aromatic hydrocarbon; $\mu\text{g}/\text{m}^3$ = microgram per cubic metre.

Table 11.4.III-14 Maximum 1-Hour Metals Predictions at Selected Locations

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Maximum 1-Hour ($\mu\text{g}/\text{m}^3$)						
Aluminum	0.009842	0.022525	0.009670	0.024493	0.005741	0.019822
Antimony	0.000000	0.000001	0.000000	0.000001	0.000000	0.000001
Arsenic	0.000017	0.000017	0.000016	0.000016	0.000012	0.000012
Barium	0.000237	0.000468	0.000237	0.000509	0.000138	0.000412
Beryllium	0.000008	0.000008	0.000007	0.000007	0.000005	0.000005
Bismuth	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Boron	0.000023	0.000023	0.000024	0.000024	0.000014	0.000018
Bromine	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Cadmium	0.000261	0.000261	0.000233	0.000233	0.000138	0.000138
Calcium	0.005154	0.009056	0.005274	0.009851	0.003070	0.007972
Chromium	0.000151	0.000201	0.000156	0.000218	0.000094	0.000176
Cobalt	0.000054	0.000054	0.000048	0.000048	0.000027	0.000036
Copper	0.000057	0.000057	0.000050	0.000050	0.000031	0.000031
Gallium	0.000045	0.000045	0.000040	0.000040	0.000023	0.000023
Gold	0.000001	0.000002	0.000001	0.000002	0.000000	0.000001
Indium	0.000250	0.000250	0.000222	0.000222	0.000128	0.000128
Iron	0.018720	0.042293	0.018286	0.045990	0.010815	0.037220
Lanthanum	0.000037	0.000097	0.000036	0.000106	0.000022	0.000086
Lead	0.000055	0.000055	0.000048	0.000048	0.000030	0.000030
Magnesium	0.035506	0.048965	0.037794	0.053300	0.021837	0.043125
Manganese	0.000301	0.000614	0.000304	0.000667	0.000179	0.000540
Mercury	0.000055	0.000055	0.000051	0.000051	0.000038	0.000038
Molybdenum	0.000002	0.000008	0.000002	0.000008	0.000001	0.000007
Nickel	0.000300	0.000312	0.000300	0.000339	0.000191	0.000274
Palladium	0.000042	0.000042	0.000037	0.000037	0.000021	0.000021

Table 11.4.III-14 Maximum 1-Hour Metals Predictions at Selected Locations (continued)

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Phosphorus	0.000675	0.001648	0.000667	0.001792	0.000401	0.001450
Potassium	0.004645	0.011478	0.004518	0.012479	0.002711	0.010100
Rubidium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Scandium	0.000003	0.000006	0.000003	0.000006	0.000002	0.000005
Selenium	0.000039	0.000039	0.000037	0.000037	0.000027	0.000027
Silicon	0.002622	0.002622	0.002335	0.002335	0.001346	0.001346
Silver	0.000042	0.000042	0.000037	0.000037	0.000021	0.000021
Sodium	0.000463	0.000784	0.000478	0.000853	0.000278	0.000690
Strontium	0.000095	0.000119	0.000102	0.000130	0.000059	0.000105
Thallium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Thorium	0.000009	0.000028	0.000009	0.000031	0.000006	0.000025
Tin	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Titanium	0.000715	0.002130	0.000694	0.002316	0.000431	0.001874
Tungsten	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Uranium	0.000001	0.000002	0.000001	0.000002	0.000000	0.000002
Vanadium	0.000028	0.000071	0.000027	0.000077	0.000016	0.000062
Yttrium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Zinc	0.000305	0.000305	0.000271	0.000271	0.000157	0.000157
Zirconium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Table 11.4.III-14 Maximum 1-Hour Metals Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Maximum 1-Hour ($\mu\text{g}/\text{m}^3$)						
Aluminum	0.001240	22.774000	0.001238	1.902300	0.001401	85.862000
Antimony	0.000000	0.000664	0.000000	0.000067	0.000000	0.003189
Arsenic	0.000002	0.002128	0.000002	0.000190	0.000002	0.008669
Barium	0.000029	0.526050	0.000028	0.040351	0.000032	1.752500
Beryllium	0.000001	0.000300	0.000001	0.000011	0.000001	0.000231
Bismuth	0.000000	0.000223	0.000000	0.000020	0.000000	0.000929
Boron	0.000002	0.035689	0.000002	0.001963	0.000003	0.067809
Bromine	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Cadmium	0.000026	0.033752	0.000026	0.003351	0.000028	0.089023
Calcium	0.000610	10.917000	0.000601	0.792640	0.000677	33.440000
Chromium	0.000020	0.237440	0.000020	0.017313	0.000022	0.720940
Cobalt	0.000006	0.046994	0.000006	0.003502	0.000006	0.138530
Copper	0.000007	0.038061	0.000007	0.002932	0.000007	0.116110
Gallium	0.000004	0.017097	0.000004	0.001539	0.000005	0.060499
Gold	0.000000	0.001435	0.000000	0.000129	0.000000	0.005976
Indium	0.000024	0.033539	0.000024	0.003342	0.000027	0.088197
Iron	0.002322	43.246000	0.002319	3.579900	0.002628	161.070000
Lanthanum	0.000005	0.089852	0.000005	0.008100	0.000005	0.377750
Lead	0.000007	0.017558	0.000007	0.001625	0.000007	0.064989
Magnesium	0.004068	70.638000	0.003970	4.467300	0.004436	173.390000
Manganese	0.000039	0.637370	0.000039	0.052037	0.000044	2.315500
Mercury	0.000006	0.004047	0.000007	0.000394	0.000008	0.009566
Molybdenum	0.000000	0.006094	0.000000	0.000630	0.000000	0.029817
Nickel	0.000033	0.476140	0.000032	0.028686	0.000036	1.075300
Palladium	0.000004	0.005590	0.000004	0.000557	0.000004	0.014700

Table 11.4.III-14 Maximum 1-Hour Metals Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Phosphorus	0.000087	1.584300	0.000088	0.137900	0.000099	6.328300
Potassium	0.000582	11.081000	0.000585	0.961430	0.000665	44.153000
Rubidium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Scandium	0.000000	0.005964	0.000000	0.000476	0.000000	0.021055
Selenium	0.000004	0.001518	0.000004	0.000112	0.000004	0.004645
Silicon	0.000255	0.352160	0.000256	0.035087	0.000282	0.926070
Silver	0.000004	0.005810	0.000004	0.000567	0.000004	0.015525
Sodium	0.000055	0.966790	0.000054	0.068945	0.000060	2.879500
Strontium	0.000011	0.182330	0.000010	0.011038	0.000012	0.415210
Thallium	0.000000	0.000318	0.000000	0.000031	0.000000	0.001456
Thorium	0.000001	0.024461	0.000001	0.002356	0.000001	0.111470
Tin	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Titanium	0.000093	1.848600	0.000095	0.176050	0.000108	8.329000
Tungsten	0.000000	0.000213	0.000000	0.000020	0.000000	0.000929
Uranium	0.000000	0.001955	0.000000	0.000175	0.000000	0.008144
Vanadium	0.000004	0.067677	0.000004	0.005914	0.000004	0.272470
Yttrium	0.000000	0.000570	0.000000	0.000012	0.000000	0.000450
Zinc	0.000029	0.071864	0.000029	0.005925	0.000032	0.195750
Zirconium	0.000000	0.002451	0.000000	0.000050	0.000000	0.001936

µg/m³ = micrograms per cubic metres.

Table 11.4.III-15 Maximum 24-Hour Metals Predictions at Selected Locations

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Maximum 24-Hour ($\mu\text{g}/\text{m}^3$)						
Aluminum	0.001853	0.006203	0.002168	0.007651	0.001586	0.005753
Antimony	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Arsenic	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003
Barium	0.000044	0.000129	0.000049	0.000159	0.000037	0.000120
Beryllium	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
Bismuth	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Boron	0.000004	0.000006	0.000004	0.000007	0.000003	0.000005
Bromine	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Cadmium	0.000030	0.000030	0.000044	0.000044	0.000028	0.000028
Calcium	0.000969	0.002496	0.001050	0.003079	0.000794	0.002315
Chromium	0.000031	0.000055	0.000035	0.000068	0.000026	0.000051
Cobalt	0.000007	0.000011	0.000010	0.000014	0.000007	0.000011
Copper	0.000009	0.000010	0.000012	0.000014	0.000009	0.000011
Gallium	0.000005	0.000006	0.000008	0.000008	0.000005	0.000006
Gold	0.000000	0.000000	0.000000	0.000001	0.000000	0.000000
Indium	0.000026	0.000026	0.000039	0.000039	0.000024	0.000025
Iron	0.003503	0.011648	0.004058	0.014367	0.002982	0.010802
Lanthanum	0.000007	0.000027	0.000008	0.000033	0.000006	0.000025
Lead	0.000009	0.000009	0.000012	0.000012	0.000008	0.000008
Magnesium	0.006721	0.013514	0.006915	0.016662	0.005354	0.012533
Manganese	0.000059	0.000169	0.000069	0.000208	0.000050	0.000157
Mercury	0.000010	0.000010	0.000009	0.000009	0.000010	0.000010
Molybdenum	0.000000	0.000002	0.000001	0.000003	0.000000	0.000002
Nickel	0.000057	0.000086	0.000057	0.000106	0.000045	0.000080
Palladium	0.000004	0.000004	0.000006	0.000006	0.000004	0.000004

Table 11.4.III-15 Maximum 24-Hour Metals Predictions at Selected Locations (continued)

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Phosphorus	0.000128	0.000454	0.000153	0.000560	0.000111	0.000421
Potassium	0.000863	0.003160	0.001024	0.003898	0.000745	0.002931
Rubidium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Scandium	0.000000	0.000002	0.000001	0.000002	0.000000	0.000001
Selenium	0.000007	0.000007	0.000007	0.000007	0.000006	0.000006
Silicon	0.000271	0.000271	0.000409	0.000409	0.000252	0.000259
Silver	0.000004	0.000004	0.000007	0.000007	0.000004	0.000004
Sodium	0.000087	0.000216	0.000094	0.000266	0.000071	0.000200
Strontium	0.000018	0.000033	0.000018	0.000041	0.000014	0.000031
Thallium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Thorium	0.000002	0.000008	0.000002	0.000010	0.000002	0.000007
Tin	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Titanium	0.000132	0.000586	0.000166	0.000723	0.000118	0.000544
Tungsten	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Uranium	0.000000	0.000001	0.000000	0.000001	0.000000	0.000001
Vanadium	0.000005	0.000019	0.000006	0.000024	0.000005	0.000018
Yttrium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Zinc	0.000034	0.000034	0.000050	0.000050	0.000032	0.000035
Zirconium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Table 11.4.III-15 Maximum 24-Hour Metals Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Maximum 24-Hour ($\mu\text{g}/\text{m}^3$)						
Aluminum	0.000363	8.615100	0.000542	0.668680	0.000524	50.494000
Antimony	0.000000	0.000308	0.000000	0.000024	0.000000	0.001865
Arsenic	0.000001	0.000854	0.000001	0.000070	0.000001	0.005091
Barium	0.000008	0.195720	0.000012	0.013990	0.000012	1.033400
Beryllium	0.000000	0.000132	0.000000	0.000002	0.000000	0.000083
Bismuth	0.000000	0.000092	0.000000	0.000007	0.000000	0.000545
Boron	0.000001	0.012822	0.000001	0.000629	0.000001	0.040876
Bromine	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Cadmium	0.000008	0.015596	0.000010	0.001074	0.000010	0.049962
Calcium	0.000176	4.028700	0.000265	0.272010	0.000256	19.767000
Chromium	0.000006	0.087894	0.000009	0.005956	0.000008	0.427330
Cobalt	0.000002	0.017692	0.000003	0.001201	0.000002	0.083084
Copper	0.000002	0.014452	0.000003	0.001010	0.000003	0.069745
Gallium	0.000001	0.006825	0.000002	0.000541	0.000002	0.036730
Gold	0.000000	0.000586	0.000000	0.000046	0.000000	0.003507
Indium	0.000007	0.015532	0.000009	0.001056	0.000009	0.049417
Iron	0.000680	16.327000	0.001015	1.256700	0.000982	94.734000
Lanthanum	0.000001	0.037105	0.000002	0.002880	0.000002	0.221590
Lead	0.000002	0.007051	0.000003	0.000573	0.000003	0.039339
Magnesium	0.001164	25.489000	0.001755	1.491200	0.001692	103.200000
Manganese	0.000011	0.240410	0.000017	0.018218	0.000017	1.363800
Mercury	0.000002	0.001469	0.000002	0.000081	0.000002	0.007376
Molybdenum	0.000000	0.002872	0.000000	0.000221	0.000000	0.017435
Nickel	0.000010	0.170760	0.000014	0.009493	0.000014	0.642040
Palladium	0.000001	0.002589	0.000002	0.000176	0.000001	0.008236

Table 11.4.III-15 Maximum 24-Hour Metals Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Phosphorus	0.000026	0.625850	0.000038	0.048767	0.000037	3.717500
Potassium	0.000172	4.366900	0.000255	0.339960	0.000247	25.929000
Rubidium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Scandium	0.000000	0.002234	0.000000	0.000166	0.000000	0.012398
Selenium	0.000001	0.000675	0.000002	0.000037	0.000002	0.002725
Silicon	0.000071	0.163080	0.000097	0.011092	0.000094	0.518870
Silver	0.000001	0.002652	0.000002	0.000182	0.000001	0.008779
Sodium	0.000016	0.355870	0.000024	0.023576	0.000023	1.703600
Strontium	0.000003	0.065443	0.000005	0.003647	0.000004	0.247840
Thallium	0.000000	0.000142	0.000000	0.000011	0.000000	0.000852
Thorium	0.000000	0.010850	0.000001	0.000838	0.000001	0.065278
Tin	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Titanium	0.000028	0.811940	0.000041	0.062739	0.000040	4.878700
Tungsten	0.000000	0.000091	0.000000	0.000007	0.000000	0.000544
Uranium	0.000000	0.000801	0.000000	0.000062	0.000000	0.004778
Vanadium	0.000001	0.026925	0.000002	0.002094	0.000001	0.159970
Yttrium	0.000000	0.000234	0.000000	0.000002	0.000000	0.000155
Zinc	0.000009	0.028969	0.000012	0.002037	0.000012	0.119070
Zirconium	0.000000	0.001004	0.000000	0.000009	0.000000	0.000667

µg/m³ = micrograms per cubic metres.

Table 11.4.III-16 Annual Average Metals Predictions at Selected Locations

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Annual Average (µg/m³)						
Aluminum	0.000077	0.000308	0.000080	0.000371	0.000060	0.000257
Antimony	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Arsenic	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Barium	0.000002	0.000007	0.000002	0.000008	0.000001	0.000006
Beryllium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Bismuth	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Boron	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Bromine	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Cadmium	0.000001	0.000002	0.000001	0.000002	0.000001	0.000002
Calcium	0.000040	0.000133	0.000042	0.000160	0.000030	0.000110
Chromium	0.000001	0.000003	0.000001	0.000004	0.000001	0.000003
Cobalt	0.000000	0.000001	0.000000	0.000001	0.000000	0.000001
Copper	0.000000	0.000001	0.000000	0.000001	0.000000	0.000001
Gallium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Gold	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Indium	0.000001	0.000002	0.000001	0.000002	0.000001	0.000001
Iron	0.000144	0.000578	0.000151	0.000697	0.000113	0.000483
Lanthanum	0.000000	0.000001	0.000000	0.000002	0.000000	0.000001
Lead	0.000000	0.000001	0.000000	0.000001	0.000000	0.000001
Magnesium	0.000278	0.000787	0.000290	0.000933	0.000207	0.000641
Manganese	0.000002	0.000009	0.000003	0.000011	0.000002	0.000007
Mercury	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Molybdenum	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Nickel	0.000002	0.000006	0.000002	0.000007	0.000002	0.000004
Palladium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Table 11.4.III-16 Annual Average Metals Predictions at Selected Locations (continued)

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Phosphorus	0.000005	0.000022	0.000006	0.000027	0.000004	0.000019
Potassium	0.000036	0.000153	0.000037	0.000185	0.000028	0.000128
Rubidium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Scandium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Selenium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Silicon	0.000011	0.000017	0.000012	0.000019	0.000010	0.000014
Silver	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Sodium	0.000004	0.000012	0.000004	0.000014	0.000003	0.000010
Strontium	0.000001	0.000002	0.000001	0.000002	0.000001	0.000002
Thallium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Thorium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Tin	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Titanium	0.000005	0.000027	0.000006	0.000033	0.000004	0.000023
Tungsten	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Uranium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Vanadium	0.000000	0.000001	0.000000	0.000001	0.000000	0.000001
Yttrium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Zinc	0.000001	0.000002	0.000001	0.000003	0.000001	0.000002
Zirconium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Table 11.4.III-16 Annual Average Metals Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Annual Average (µg/m³)						
Aluminum	0.000019	0.892340	0.000018	0.038468	0.000022	5.623200
Antimony	0.000000	0.000028	0.000000	0.000001	0.000000	0.000207
Arsenic	0.000000	0.000111	0.000000	0.000004	0.000000	0.000569
Barium	0.000000	0.019980	0.000000	0.000809	0.000001	0.115110
Beryllium	0.000000	0.000010	0.000000	0.000000	0.000000	0.000009
Bismuth	0.000000	0.000009	0.000000	0.000000	0.000000	0.000061
Boron	0.000000	0.001029	0.000000	0.000038	0.000000	0.004568
Bromine	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Cadmium	0.000000	0.002135	0.000000	0.000090	0.000001	0.006871
Calcium	0.000009	0.401200	0.000009	0.015789	0.000011	2.202600
Chromium	0.000000	0.008947	0.000000	0.000351	0.000000	0.047845
Cobalt	0.000000	0.001808	0.000000	0.000074	0.000000	0.009476
Copper	0.000000	0.001526	0.000000	0.000063	0.000000	0.007989
Gallium	0.000000	0.000763	0.000000	0.000036	0.000000	0.004307
Gold	0.000000	0.000056	0.000000	0.000003	0.000000	0.000390
Indium	0.000000	0.002070	0.000000	0.000088	0.000000	0.006803
Iron	0.000036	1.688800	0.000034	0.072301	0.000042	10.548000
Lanthanum	0.000000	0.003635	0.000000	0.000165	0.000000	0.024659
Lead	0.000000	0.000813	0.000000	0.000038	0.000000	0.004598
Magnesium	0.000063	2.469100	0.000060	0.087541	0.000072	11.514000
Manganese	0.000001	0.024703	0.000001	0.001053	0.000001	0.152070
Mercury	0.000000	0.000122	0.000000	0.000004	0.000000	0.000373
Molybdenum	0.000000	0.000256	0.000000	0.000013	0.000000	0.001939
Nickel	0.000001	0.016361	0.000000	0.000562	0.000001	0.071681
Palladium	0.000000	0.000345	0.000000	0.000015	0.000000	0.001134

Table 11.4.III-16 Annual Average Metals Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Phosphorus	0.000001	0.062862	0.000001	0.002800	0.000002	0.413990
Potassium	0.000009	0.441200	0.000009	0.019498	0.000010	2.886000
Rubidium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Scandium	0.000000	0.000230	0.000000	0.000010	0.000000	0.001381
Selenium	0.000000	0.000094	0.000000	0.000003	0.000000	0.000306
Silicon	0.000004	0.021734	0.000004	0.000926	0.000005	0.071433
Silver	0.000000	0.000353	0.000000	0.000015	0.000000	0.001195
Sodium	0.000001	0.035137	0.000001	0.001371	0.000001	0.189860
Strontium	0.000000	0.006212	0.000000	0.000215	0.000000	0.027663
Thallium	0.000000	0.000013	0.000000	0.000001	0.000000	0.000095
Thorium	0.000000	0.001022	0.000000	0.000048	0.000000	0.007262
Tin	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Titanium	0.000001	0.077021	0.000001	0.003580	0.000002	0.542790
Tungsten	0.000000	0.000009	0.000000	0.000000	0.000000	0.000061
Uranium	0.000000	0.000079	0.000000	0.000004	0.000000	0.000532
Vanadium	0.000000	0.002715	0.000000	0.000120	0.000000	0.017804
Yttrium	0.000000	0.000021	0.000000	0.000000	0.000000	0.000020
Zinc	0.000001	0.003549	0.000001	0.000152	0.000001	0.014793
Zirconium	0.000000	0.000089	0.000000	0.000001	0.000000	0.000085

µg/m³ = micrograms per cubic metres.

Table 11.4.III-17 Annual PAH Wet Deposition at Selected Locations

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Annual Wet Deposition (kg/ha/yr)						
1-Methylnaphthalene	2.87×10^{-07}	4.63×10^{-07}	2.48×10^{-07}	4.92×10^{-07}	2.36×10^{-07}	4.14×10^{-07}
1-Methylphenanthrene	1.29×10^{-08}	2.08×10^{-08}	1.11×10^{-08}	2.21×10^{-08}	1.06×10^{-08}	1.86×10^{-08}
2-Methylantracene	7.90×10^{-09}	1.27×10^{-08}	6.81×10^{-09}	1.35×10^{-08}	6.49×10^{-09}	1.14×10^{-08}
2-Methylfluorene	2.66×10^{-10}	4.30×10^{-10}	2.30×10^{-10}	4.57×10^{-10}	2.19×10^{-10}	3.84×10^{-10}
2-Methylnaphthalene	4.64×10^{-07}	7.49×10^{-07}	4.00×10^{-07}	7.96×10^{-07}	3.81×10^{-07}	6.69×10^{-07}
2-Methylphenanthrene	3.19×10^{-08}	5.15×10^{-08}	2.75×10^{-08}	5.47×10^{-08}	2.62×10^{-08}	4.60×10^{-08}
2-Methylpyrene	2.36×10^{-09}	3.82×10^{-09}	2.04×10^{-09}	4.05×10^{-09}	1.94×10^{-09}	3.40×10^{-09}
3-Methyldibenzothiophene	4.88×10^{-10}	7.88×10^{-10}	4.21×10^{-10}	8.37×10^{-10}	4.01×10^{-10}	7.03×10^{-10}
3-Methylphenanthrene	2.30×10^{-08}	3.71×10^{-08}	1.98×10^{-08}	3.95×10^{-08}	1.89×10^{-08}	3.32×10^{-08}
4-+9-Methylphenanthrene	1.74×10^{-08}	2.81×10^{-08}	1.50×10^{-08}	2.98×10^{-08}	1.43×10^{-08}	2.51×10^{-08}
4-Methyldibenzothiophene	3.11×10^{-10}	5.02×10^{-10}	2.68×10^{-10}	5.33×10^{-10}	2.55×10^{-10}	4.48×10^{-10}
Acenaphthene	1.51×10^{-08}	2.41×10^{-08}	1.30×10^{-08}	2.55×10^{-08}	1.24×10^{-08}	2.14×10^{-08}
Acenaphthylene	5.33×10^{-08}	8.59×10^{-08}	4.59×10^{-08}	9.13×10^{-08}	4.38×10^{-08}	7.67×10^{-08}
Acephenanthrylene	9.12×10^{-09}	1.47×10^{-08}	7.86×10^{-09}	1.56×10^{-08}	7.49×10^{-09}	1.31×10^{-08}
Anthracene	9.52×10^{-09}	1.53×10^{-08}	8.21×10^{-09}	1.63×10^{-08}	7.82×10^{-09}	1.37×10^{-08}
Benz(a)anthracene	2.34×10^{-09}	3.74×10^{-09}	2.02×10^{-09}	3.95×10^{-09}	1.92×10^{-09}	3.32×10^{-09}
Benzo(a)fluorene	2.87×10^{-09}	4.63×10^{-09}	2.47×10^{-09}	4.91×10^{-09}	2.36×10^{-09}	4.13×10^{-09}
Benzo(a)pyrene	1.25×10^{-09}	2.02×10^{-09}	1.08×10^{-09}	2.15×10^{-09}	1.03×10^{-09}	1.81×10^{-09}
Benzo(b)fluoranthene	1.06×10^{-08}	1.70×10^{-08}	9.09×10^{-09}	1.81×10^{-08}	8.66×10^{-09}	1.52×10^{-08}
Benzo(e)pyrene	1.77×10^{-10}	2.86×10^{-10}	1.53×10^{-10}	3.04×10^{-10}	1.46×10^{-10}	2.56×10^{-10}
Benzo(g,h,i)fluoranthene	4.42×10^{-09}	7.13×10^{-09}	3.81×10^{-09}	7.58×10^{-09}	3.63×10^{-09}	6.37×10^{-09}
Benzo(g,h,i)perylene	2.92×10^{-09}	4.68×10^{-09}	2.51×10^{-09}	4.96×10^{-09}	2.39×10^{-09}	4.17×10^{-09}
Benzo(k)fluoranthene	1.20×10^{-09}	1.93×10^{-09}	1.03×10^{-09}	2.05×10^{-09}	9.83×10^{-10}	1.72×10^{-09}
Chrysene	2.59×10^{-09}	4.16×10^{-09}	2.23×10^{-09}	4.41×10^{-09}	2.13×10^{-09}	3.70×10^{-09}
Coronene	2.22×10^{-11}	3.58×10^{-11}	1.91×10^{-11}	3.81×10^{-11}	1.82×10^{-11}	3.20×10^{-11}

Table 11.4.III-17 Annual PAH Wet Deposition at Selected Locations (continued)

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Cyclopenta(c,d)pyrene	1.57×10^{-09}	2.53×10^{-09}	1.35×10^{-09}	2.68×10^{-09}	1.29×10^{-09}	2.25×10^{-09}
Dibenzo(a,h)anthracene	3.32×10^{-09}	5.34×10^{-09}	2.86×10^{-09}	5.67×10^{-09}	2.73×10^{-09}	4.76×10^{-09}
Dibenzothiophene	2.14×10^{-10}	3.52×10^{-10}	1.83×10^{-10}	3.76×10^{-10}	1.74×10^{-10}	3.14×10^{-10}
Fluoranthene	4.04×10^{-08}	6.51×10^{-08}	3.48×10^{-08}	6.92×10^{-08}	3.32×10^{-08}	5.81×10^{-08}
Fluorene	7.59×10^{-08}	1.22×10^{-07}	6.54×10^{-08}	1.30×10^{-07}	6.23×10^{-08}	1.09×10^{-07}
Indeno(1,2,3-cd)fluoranthene	1.11×10^{-10}	1.79×10^{-10}	9.57×10^{-11}	1.90×10^{-10}	9.12×10^{-11}	1.60×10^{-10}
Indeno(1,2,3-cd)pyrene	4.23×10^{-11}	4.38×10^{-11}	3.64×10^{-11}	3.84×10^{-11}	3.10×10^{-11}	3.25×10^{-11}
Indeno(1,2,3-W)pyrene	1.99×10^{-09}	3.22×10^{-09}	1.72×10^{-09}	3.42×10^{-09}	1.64×10^{-09}	2.87×10^{-09}
Naphthalene	1.16×10^{-06}	1.86×10^{-06}	9.99×10^{-07}	1.97×10^{-06}	9.50×10^{-07}	1.65×10^{-06}
Nitro-pyrene	1.77×10^{-09}	2.86×10^{-09}	1.53×10^{-09}	3.04×10^{-09}	1.46×10^{-09}	2.56×10^{-09}
Perylene	2.22×10^{-11}	3.58×10^{-11}	1.91×10^{-11}	3.81×10^{-11}	1.82×10^{-11}	3.20×10^{-11}
Phenanthrene	7.11×10^{-08}	1.15×10^{-07}	6.13×10^{-08}	1.22×10^{-07}	5.84×10^{-08}	1.02×10^{-07}
Picene	2.22×10^{-11}	3.58×10^{-11}	1.91×10^{-11}	3.81×10^{-11}	1.82×10^{-11}	3.20×10^{-11}
Pyrene	5.47×10^{-08}	8.83×10^{-08}	4.72×10^{-08}	9.38×10^{-08}	4.50×10^{-08}	7.88×10^{-08}

kg/ha/yr = kilogram per hectare per year.

Table 11.4.III-17 Annual PAH Wet Deposition at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Annual Wet Deposition (kg/ha/yr)						
1-Methylnaphthalene	4.55×10^{-08}	2.53×10^{-04}	4.66×10^{-08}	1.47×10^{-05}	5.29×10^{-08}	3.54×10^{-04}
1-Methylphenanthrene	2.05×10^{-09}	1.14×10^{-05}	2.10×10^{-09}	6.63×10^{-07}	2.38×10^{-09}	1.59×10^{-05}
2-Methylantracene	1.25×10^{-09}	6.96×10^{-06}	1.28×10^{-09}	4.05×10^{-07}	1.46×10^{-09}	9.74×10^{-06}
2-Methylfluorene	4.23×10^{-11}	2.35×10^{-07}	4.32×10^{-11}	1.37×10^{-08}	4.91×10^{-11}	3.28×10^{-07}
2-Methylnaphthalene	7.36×10^{-08}	4.09×10^{-04}	7.53×10^{-08}	2.38×10^{-05}	8.55×10^{-08}	5.72×10^{-04}
2-Methylphenanthrene	5.06×10^{-09}	2.81×10^{-05}	5.18×10^{-09}	1.64×10^{-06}	5.88×10^{-09}	3.93×10^{-05}
2-Methylpyrene	3.75×10^{-10}	2.08×10^{-06}	3.84×10^{-10}	1.21×10^{-07}	4.36×10^{-10}	2.91×10^{-06}
3-Methyldibenzothiophene	7.75×10^{-11}	4.30×10^{-07}	7.92×10^{-11}	2.51×10^{-08}	9.00×10^{-11}	6.02×10^{-07}
3-Methylphenanthrene	3.65×10^{-09}	2.03×10^{-05}	3.73×10^{-09}	1.18×10^{-06}	4.24×10^{-09}	2.84×10^{-05}
4+9-Methylphenanthrene	2.76×10^{-09}	1.53×10^{-05}	2.82×10^{-09}	8.93×10^{-07}	3.21×10^{-09}	2.14×10^{-05}
4-Methyldibenzothiophene	4.93×10^{-11}	2.74×10^{-07}	5.05×10^{-11}	1.60×10^{-08}	5.73×10^{-11}	3.83×10^{-07}
Acenaphthene	2.38×10^{-09}	1.30×10^{-05}	2.44×10^{-09}	7.54×10^{-07}	2.76×10^{-09}	1.81×10^{-05}
Acenaphthylene	8.45×10^{-09}	4.69×10^{-05}	8.64×10^{-09}	2.73×10^{-06}	9.81×10^{-09}	6.56×10^{-05}
Acephenanthrylene	1.45×10^{-09}	8.03×10^{-06}	1.48×10^{-09}	4.68×10^{-07}	1.68×10^{-09}	1.12×10^{-05}
Anthracene	1.51×10^{-09}	8.37×10^{-06}	1.54×10^{-09}	4.87×10^{-07}	1.75×10^{-09}	1.17×10^{-05}
Benz(a)anthracene	3.69×10^{-10}	2.00×10^{-06}	3.78×10^{-10}	1.16×10^{-07}	4.29×10^{-10}	2.79×10^{-06}
Benzo(a)fluorene	4.55×10^{-10}	2.53×10^{-06}	4.65×10^{-10}	1.47×10^{-07}	5.28×10^{-10}	3.53×10^{-06}
Benzo(a)pyrene	1.99×10^{-10}	1.11×10^{-06}	2.03×10^{-10}	6.44×10^{-08}	2.31×10^{-10}	1.55×10^{-06}
Benzo(b)fluoranthene	1.67×10^{-09}	9.27×10^{-06}	1.71×10^{-09}	5.40×10^{-07}	1.94×10^{-09}	1.30×10^{-05}
Benzo(e)pyrene	2.81×10^{-11}	1.56×10^{-07}	2.88×10^{-11}	9.11×10^{-09}	3.27×10^{-11}	2.19×10^{-07}
Benzo(g,h,i)fluoranthene	7.01×10^{-10}	3.90×10^{-06}	7.17×10^{-10}	2.27×10^{-07}	8.15×10^{-10}	5.45×10^{-06}
Benzo(g,h,i)perylene	4.61×10^{-10}	2.54×10^{-06}	4.72×10^{-10}	1.48×10^{-07}	5.36×10^{-10}	3.54×10^{-06}
Benzo(k)fluoranthene	1.90×10^{-10}	1.05×10^{-06}	1.94×10^{-10}	6.14×10^{-08}	2.20×10^{-10}	1.47×10^{-06}
Chrysene	4.09×10^{-10}	2.25×10^{-06}	4.19×10^{-10}	1.31×10^{-07}	4.76×10^{-10}	3.14×10^{-06}
Coronene	3.52×10^{-12}	1.96×10^{-08}	3.60×10^{-12}	1.14×10^{-09}	4.09×10^{-12}	2.74×10^{-08}

Table 11.4.III-17 Annual PAH Wet Deposition at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Cyclopenta(c,d)pyrene	2.48×10^{-10}	1.38×10^{-06}	2.54×10^{-10}	8.03×10^{-08}	2.88×10^{-10}	1.93×10^{-06}
Dibenzo(a,h)anthracene	5.26×10^{-10}	2.90×10^{-06}	5.38×10^{-10}	1.69×10^{-07}	6.11×10^{-10}	4.06×10^{-06}
Dibenzothiophene	3.30×10^{-11}	2.60×10^{-07}	3.41×10^{-11}	1.20×10^{-08}	3.85×10^{-11}	3.14×10^{-07}
Fluoranthene	6.40×10^{-09}	3.56×10^{-05}	6.55×10^{-09}	2.07×10^{-06}	7.44×10^{-09}	4.97×10^{-05}
Fluorene	1.20×10^{-08}	6.68×10^{-05}	1.23×10^{-08}	3.89×10^{-06}	1.40×10^{-08}	9.34×10^{-05}
Indeno(1,2,3-cd)fluoranthene	1.76×10^{-11}	9.78×10^{-08}	1.80×10^{-11}	5.70×10^{-09}	2.05×10^{-11}	1.37×10^{-07}
Indeno(1,2,3-cd)pyrene	5.04×10^{-12}	4.42×10^{-09}	5.77×10^{-12}	2.14×10^{-10}	6.19×10^{-12}	5.84×10^{-09}
Indeno(1,2,3-W)pyrene	3.16×10^{-10}	1.76×10^{-06}	3.24×10^{-10}	1.02×10^{-07}	3.67×10^{-10}	2.46×10^{-06}
Naphthalene	1.83×10^{-07}	1.00×10^{-03}	1.87×10^{-07}	5.84×10^{-05}	2.13×10^{-07}	1.40×10^{-03}
Nitro-pyrene	2.81×10^{-10}	1.56×10^{-06}	2.88×10^{-10}	9.11×10^{-08}	3.27×10^{-10}	2.19×10^{-06}
Perylene	3.52×10^{-12}	1.96×10^{-08}	3.60×10^{-12}	1.14×10^{-09}	4.09×10^{-12}	2.74×10^{-08}
Phenanthrene	1.13×10^{-08}	6.29×10^{-05}	1.15×10^{-08}	3.64×10^{-06}	1.31×10^{-08}	8.73×10^{-05}
Picene	3.52×10^{-12}	1.96×10^{-08}	3.60×10^{-12}	1.14×10^{-09}	4.09×10^{-12}	2.74×10^{-08}
Pyrene	8.68×10^{-09}	4.83×10^{-05}	8.88×10^{-09}	2.81×10^{-06}	1.01×10^{-08}	6.74×10^{-05}

kg/ha/yr = kilogram per hectare per year.

Table 11.4.III-18 Annual PAH Dry Deposition Predictions at Selected Locations

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Annual Dry Deposition (kg/ha/yr)						
1-Methylnaphthalene	1.40×10^{-06}	2.30×10^{-06}	1.45×10^{-06}	2.60×10^{-06}	1.21×10^{-06}	1.96×10^{-06}
1-Methylphenanthrene	6.31×10^{-08}	1.03×10^{-07}	6.53×10^{-08}	1.17×10^{-07}	5.42×10^{-08}	8.83×10^{-08}
2-Methylanthracene	3.86×10^{-08}	6.32×10^{-08}	4.00×10^{-08}	7.16×10^{-08}	3.32×10^{-08}	5.40×10^{-08}
2-Methylfluorene	1.30×10^{-09}	2.13×10^{-09}	1.35×10^{-09}	2.41×10^{-09}	1.12×10^{-09}	1.82×10^{-09}
2-Methylnaphthalene	2.27×10^{-06}	3.71×10^{-06}	2.35×10^{-06}	4.20×10^{-06}	1.95×10^{-06}	3.17×10^{-06}
2-Methylphenanthrene	1.56×10^{-07}	2.55×10^{-07}	1.61×10^{-07}	2.89×10^{-07}	1.34×10^{-07}	2.18×10^{-07}
2-Methylpyrene	1.16×10^{-08}	1.89×10^{-08}	1.20×10^{-08}	2.14×10^{-08}	9.93×10^{-09}	1.62×10^{-08}
3-Methyldibenzothiophene	2.39×10^{-09}	3.91×10^{-09}	2.47×10^{-09}	4.42×10^{-09}	2.05×10^{-09}	3.34×10^{-09}
3-Methylphenanthrene	1.13×10^{-07}	1.84×10^{-07}	1.16×10^{-07}	2.08×10^{-07}	9.67×10^{-08}	1.57×10^{-07}
4+9-Methylphenanthrene	8.50×10^{-08}	1.39×10^{-07}	8.80×10^{-08}	1.58×10^{-07}	7.31×10^{-08}	1.19×10^{-07}
4-Methyldibenzothiophene	1.52×10^{-09}	2.49×10^{-09}	1.57×10^{-09}	2.82×10^{-09}	1.31×10^{-09}	2.13×10^{-09}
Acenaphthene	7.66×10^{-08}	1.22×10^{-07}	7.95×10^{-08}	1.38×10^{-07}	6.52×10^{-08}	1.04×10^{-07}
Acenaphthylene	2.60×10^{-07}	4.26×10^{-07}	2.69×10^{-07}	4.82×10^{-07}	2.24×10^{-07}	3.64×10^{-07}
Acephenanthrylene	4.46×10^{-08}	7.29×10^{-08}	4.61×10^{-08}	8.26×10^{-08}	3.83×10^{-08}	6.23×10^{-08}
Anthracene	4.67×10^{-08}	7.63×10^{-08}	4.83×10^{-08}	8.63×10^{-08}	4.01×10^{-08}	6.51×10^{-08}
Benz(a)anthracene	1.20×10^{-08}	1.91×10^{-08}	1.25×10^{-08}	2.15×10^{-08}	1.02×10^{-08}	1.62×10^{-08}
Benzo(a)fluorene	1.40×10^{-08}	2.29×10^{-08}	1.45×10^{-08}	2.60×10^{-08}	1.20×10^{-08}	1.96×10^{-08}
Benzo(a)pyrene	6.13×10^{-09}	1.00×10^{-08}	6.35×10^{-09}	1.14×10^{-08}	5.27×10^{-09}	8.58×10^{-09}
Benzo(b)fluoranthene	5.18×10^{-08}	8.45×10^{-08}	5.36×10^{-08}	9.57×10^{-08}	4.44×10^{-08}	7.22×10^{-08}
Benzo(e)pyrene	8.67×10^{-10}	1.42×10^{-09}	8.98×10^{-10}	1.61×10^{-09}	7.45×10^{-10}	1.21×10^{-09}
Benzo(g,h,i)fluoranthene	2.16×10^{-08}	3.54×10^{-08}	2.24×10^{-08}	4.00×10^{-08}	1.86×10^{-08}	3.02×10^{-08}
Benzo(g,h,i)perylene	1.46×10^{-08}	2.35×10^{-08}	1.51×10^{-08}	2.66×10^{-08}	1.24×10^{-08}	2.00×10^{-08}
Benzo(k)fluoranthene	5.85×10^{-09}	9.57×10^{-09}	6.05×10^{-09}	1.08×10^{-08}	5.02×10^{-09}	8.18×10^{-09}
Chrysene	1.30×10^{-08}	2.09×10^{-08}	1.35×10^{-08}	2.37×10^{-08}	1.11×10^{-08}	1.78×10^{-08}
Coronene	1.09×10^{-10}	1.78×10^{-10}	1.12×10^{-10}	2.01×10^{-10}	9.32×10^{-11}	1.52×10^{-10}

Table 11.4.III-18 Annual PAH Dry Deposition at Selected Locations (continued)

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Cyclopenta(c,d)pyrene	7.65×10^{-09}	1.25×10^{-08}	7.92×10^{-09}	1.42×10^{-08}	6.57×10^{-09}	1.07×10^{-08}
Dibenzo(a,h)anthracene	1.65×10^{-08}	2.67×10^{-08}	1.71×10^{-08}	3.02×10^{-08}	1.41×10^{-08}	2.28×10^{-08}
Dibenzothiophene	1.18×10^{-09}	1.90×10^{-09}	1.23×10^{-09}	2.16×10^{-09}	9.83×10^{-10}	1.59×10^{-09}
Fluoranthene	1.98×10^{-07}	3.24×10^{-07}	2.05×10^{-07}	3.66×10^{-07}	1.70×10^{-07}	2.76×10^{-07}
Fluorene	3.72×10^{-07}	6.08×10^{-07}	3.85×10^{-07}	6.88×10^{-07}	3.19×10^{-07}	5.19×10^{-07}
Indeno(1,2,3-cd)fluoranthene	5.43×10^{-10}	8.88×10^{-10}	5.61×10^{-10}	1.01×10^{-09}	4.66×10^{-10}	7.59×10^{-10}
Indeno(1,2,3-cd)pyrene	5.01×10^{-10}	5.09×10^{-10}	5.37×10^{-10}	5.46×10^{-10}	3.65×10^{-10}	3.71×10^{-10}
Indeno(1,2,3-W)pyrene	9.75×10^{-09}	1.60×10^{-08}	1.01×10^{-08}	1.81×10^{-08}	8.38×10^{-09}	1.36×10^{-08}
Naphthalene	5.82×10^{-06}	9.37×10^{-06}	6.04×10^{-06}	1.06×10^{-05}	4.97×10^{-06}	7.97×10^{-06}
Nitro-pyrene	8.67×10^{-09}	1.42×10^{-08}	8.98×10^{-09}	1.61×10^{-08}	7.45×10^{-09}	1.21×10^{-08}
Perylene	1.09×10^{-10}	1.78×10^{-10}	1.12×10^{-10}	2.01×10^{-10}	9.32×10^{-11}	1.52×10^{-10}
Phenanthrene	3.50×10^{-07}	5.71×10^{-07}	3.62×10^{-07}	6.46×10^{-07}	3.00×10^{-07}	4.87×10^{-07}
Picene	1.09×10^{-10}	1.78×10^{-10}	1.12×10^{-10}	2.01×10^{-10}	9.32×10^{-11}	1.52×10^{-10}
Pyrene	2.68×10^{-07}	4.39×10^{-07}	2.78×10^{-07}	4.96×10^{-07}	2.30×10^{-07}	3.75×10^{-07}

Table 11.4.III-18 Annual PAH Dry Deposition at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Annual Dry Deposition (kg/ha/yr)						
1-Methylnaphthalene	5.52×10^{-07}	2.85×10^{-03}	5.24×10^{-07}	1.53×10^{-04}	6.07×10^{-07}	1.41×10^{-02}
1-Methylphenanthrene	2.48×10^{-08}	1.28×10^{-04}	2.36×10^{-08}	6.86×10^{-06}	2.73×10^{-08}	6.34×10^{-04}
2-Methylantracene	1.52×10^{-08}	7.84×10^{-05}	1.44×10^{-08}	4.20×10^{-06}	1.67×10^{-08}	3.88×10^{-04}
2-Methylfluorene	5.12×10^{-10}	2.64×10^{-06}	4.87×10^{-10}	1.42×10^{-07}	5.64×10^{-10}	1.31×10^{-05}
2-Methylnaphthalene	8.92×10^{-07}	4.60×10^{-03}	8.48×10^{-07}	2.47×10^{-04}	9.82×10^{-07}	2.28×10^{-02}
2-Methylphenanthrene	6.13×10^{-08}	3.16×10^{-04}	5.83×10^{-08}	1.69×10^{-05}	6.75×10^{-08}	1.57×10^{-03}
2-Methylpyrene	4.54×10^{-09}	2.35×10^{-05}	4.32×10^{-09}	1.26×10^{-06}	5.00×10^{-09}	1.16×10^{-04}
3-Methyldibenzothiophene	9.38×10^{-10}	4.85×10^{-06}	8.92×10^{-10}	2.59×10^{-07}	1.03×10^{-09}	2.40×10^{-05}
3-Methylphenanthrene	4.42×10^{-08}	2.28×10^{-04}	4.20×10^{-08}	1.22×10^{-05}	4.87×10^{-08}	1.13×10^{-03}
4-+9-Methylphenanthrene	3.34×10^{-08}	1.73×10^{-04}	3.18×10^{-08}	9.24×10^{-06}	3.68×10^{-08}	8.55×10^{-04}
4-Methyldibenzothiophene	5.98×10^{-10}	3.08×10^{-06}	5.68×10^{-10}	1.65×10^{-07}	6.58×10^{-10}	1.53×10^{-05}
Acenaphthene	2.92×10^{-08}	1.47×10^{-04}	2.78×10^{-08}	7.80×10^{-06}	3.22×10^{-08}	7.20×10^{-04}
Acenaphthylene	1.02×10^{-07}	5.28×10^{-04}	9.73×10^{-08}	2.83×10^{-05}	1.13×10^{-07}	2.62×10^{-03}
Acephenanthrylene	1.75×10^{-08}	9.04×10^{-05}	1.66×10^{-08}	4.84×10^{-06}	1.93×10^{-08}	4.48×10^{-04}
Anthracene	1.83×10^{-08}	9.43×10^{-05}	1.74×10^{-08}	5.05×10^{-06}	2.02×10^{-08}	4.66×10^{-04}
Benz(a)anthracene	4.55×10^{-09}	2.27×10^{-05}	4.32×10^{-09}	1.20×10^{-06}	5.02×10^{-09}	1.11×10^{-04}
Benzo(a)fluorene	5.51×10^{-09}	2.84×10^{-05}	5.24×10^{-09}	1.52×10^{-06}	6.06×10^{-09}	1.41×10^{-04}
Benzo(a)pyrene	2.41×10^{-09}	1.24×10^{-05}	2.29×10^{-09}	6.66×10^{-07}	2.65×10^{-09}	6.16×10^{-05}
Benzo(b)fluoranthene	2.03×10^{-08}	1.04×10^{-04}	1.93×10^{-08}	5.59×10^{-06}	2.23×10^{-08}	5.17×10^{-04}
Benzo(e)pyrene	3.41×10^{-10}	1.76×10^{-06}	3.24×10^{-10}	9.43×10^{-08}	3.75×10^{-10}	8.72×10^{-06}
Benzo(g,h,i)fluoranthene	8.49×10^{-09}	4.39×10^{-05}	8.07×10^{-09}	2.35×10^{-06}	9.35×10^{-09}	2.17×10^{-04}
Benzo(g,h,i)perylene	5.63×10^{-09}	2.86×10^{-05}	5.35×10^{-09}	1.53×10^{-06}	6.21×10^{-09}	1.41×10^{-04}
Benzo(k)fluoranthene	2.30×10^{-09}	1.19×10^{-05}	2.19×10^{-09}	6.36×10^{-07}	2.53×10^{-09}	5.88×10^{-05}
Chrysene	5.01×10^{-09}	2.54×10^{-05}	4.76×10^{-09}	1.35×10^{-06}	5.52×10^{-09}	1.25×10^{-04}
Coronene	4.26×10^{-11}	2.20×10^{-07}	4.05×10^{-11}	1.18×10^{-08}	4.70×10^{-11}	1.09×10^{-06}
Cyclopenta(c,d)pyrene	3.01×10^{-09}	1.55×10^{-05}	2.86×10^{-09}	8.31×10^{-07}	3.31×10^{-09}	7.69×10^{-05}

Table 11.4.III-18 Annual PAH Dry Deposition at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Dibenzo(a,h)anthracene	6.40×10^{-9}	3.27×10^{-5}	6.09×10^{-9}	1.75×10^{-6}	7.05×10^{-9}	1.62×10^{-4}
Dibenzothiophene	4.26×10^{-10}	2.32×10^{-6}	4.05×10^{-10}	1.15×10^{-7}	4.72×10^{-10}	9.35×10^{-6}
Fluoranthene	7.77×10^{-8}	4.00×10^{-4}	7.38×10^{-8}	2.14×10^{-5}	8.55×10^{-8}	1.98×10^{-3}
Fluorene	1.46×10^{-7}	7.52×10^{-4}	1.39×10^{-7}	4.03×10^{-5}	1.61×10^{-7}	3.72×10^{-3}
Indeno(1,2,3-cd)fluoranthene	2.13×10^{-10}	1.10×10^{-6}	2.03×10^{-10}	5.90×10^{-8}	2.35×10^{-10}	5.45×10^{-6}
Indeno(1,2,3-cd)pyrene	1.07×10^{-10}	1.16×10^{-7}	1.02×10^{-10}	1.28×10^{-9}	1.23×10^{-10}	1.05×10^{-7}
Indeno(1,2,3-W)pyrene	3.83×10^{-9}	1.98×10^{-5}	3.64×10^{-9}	1.06×10^{-6}	4.22×10^{-9}	9.80×10^{-5}
Naphthalene	2.24×10^{-6}	1.13×10^{-2}	2.13×10^{-6}	6.05×10^{-4}	2.47×10^{-6}	5.58×10^{-2}
Nitro-pyrene	3.41×10^{-9}	1.76×10^{-5}	3.24×10^{-9}	9.43×10^{-7}	3.75×10^{-9}	8.72×10^{-5}
Perylene	4.26×10^{-11}	2.20×10^{-7}	4.05×10^{-11}	1.18×10^{-8}	4.70×10^{-11}	1.09×10^{-6}
Phenanthrene	1.37×10^{-7}	7.05×10^{-4}	1.30×10^{-7}	3.77×10^{-5}	1.51×10^{-7}	3.47×10^{-3}
Picene	4.26×10^{-11}	2.20×10^{-7}	4.05×10^{-11}	1.18×10^{-8}	4.70×10^{-11}	1.09×10^{-6}
Pyrene	1.05×10^{-7}	5.43×10^{-4}	1.00×10^{-7}	2.90×10^{-5}	1.16×10^{-7}	2.68×10^{-3}

PAH = polycyclic aromatic hydrocarbon; kg/ha/yr = kilogram per hectare per year.

Table 11.4.III-19 Annual PAH Total Deposition Predictions at Selected Locations

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Annual Total Deposition (kg/ha/yr)						
1-Methylnaphthalene	1.69×10^{-06}	2.76×10^{-06}	1.70×10^{-06}	3.09×10^{-06}	1.44×10^{-06}	2.38×10^{-06}
1-Methylphenanthrene	7.60×10^{-08}	1.24×10^{-07}	7.65×10^{-08}	1.39×10^{-07}	6.48×10^{-08}	1.07×10^{-07}
2-Methylanthracene	4.65×10^{-08}	7.60×10^{-08}	4.68×10^{-08}	8.51×10^{-08}	3.97×10^{-08}	6.54×10^{-08}
2-Methylfluorene	1.57×10^{-09}	2.56×10^{-09}	1.58×10^{-09}	2.87×10^{-09}	1.34×10^{-09}	2.21×10^{-09}
2-Methylnaphthalene	2.73×10^{-06}	4.46×10^{-06}	2.75×10^{-06}	5.00×10^{-06}	2.33×10^{-06}	3.84×10^{-06}
2-Methylphenanthrene	1.88×10^{-07}	3.07×10^{-07}	1.89×10^{-07}	3.44×10^{-07}	1.60×10^{-07}	2.64×10^{-07}
2-Methylpyrene	1.39×10^{-08}	2.27×10^{-08}	1.40×10^{-08}	2.55×10^{-08}	1.19×10^{-08}	1.96×10^{-08}
3-Methyldibenzothiophene	2.88×10^{-09}	4.70×10^{-09}	2.89×10^{-09}	5.26×10^{-09}	2.45×10^{-09}	4.04×10^{-09}
3-Methylphenanthrene	1.36×10^{-07}	2.21×10^{-07}	1.36×10^{-07}	2.48×10^{-07}	1.16×10^{-07}	1.91×10^{-07}
4-+9-Methylphenanthrene	1.02×10^{-07}	1.67×10^{-07}	1.03×10^{-07}	1.87×10^{-07}	8.73×10^{-08}	1.44×10^{-07}
4-Methyldibenzothiophene	1.83×10^{-09}	2.99×10^{-09}	1.84×10^{-09}	3.35×10^{-09}	1.56×10^{-09}	2.57×10^{-09}
Acenaphthene	9.17×10^{-08}	1.46×10^{-07}	9.25×10^{-08}	1.64×10^{-07}	7.75×10^{-08}	1.25×10^{-07}
Acenaphthylene	3.14×10^{-07}	5.12×10^{-07}	3.15×10^{-07}	5.74×10^{-07}	2.67×10^{-07}	4.41×10^{-07}
Acephenanthrylene	5.37×10^{-08}	8.76×10^{-08}	5.40×10^{-08}	9.82×10^{-08}	4.58×10^{-08}	7.55×10^{-08}
Anthracene	5.62×10^{-08}	9.16×10^{-08}	5.65×10^{-08}	1.03×10^{-07}	4.79×10^{-08}	7.88×10^{-08}
Benz(a)anthracene	1.43×10^{-08}	2.28×10^{-08}	1.45×10^{-08}	2.55×10^{-08}	1.21×10^{-08}	1.95×10^{-08}
Benzo(a)fluorene	1.69×10^{-08}	2.76×10^{-08}	1.70×10^{-08}	3.09×10^{-08}	1.44×10^{-08}	2.37×10^{-08}
Benzo(a)pyrene	7.39×10^{-09}	1.21×10^{-08}	7.43×10^{-09}	1.35×10^{-08}	6.30×10^{-09}	1.04×10^{-08}
Benzo(b)fluoranthene	6.23×10^{-08}	1.02×10^{-07}	6.27×10^{-08}	1.14×10^{-07}	5.31×10^{-08}	8.74×10^{-08}
Benzo(e)pyrene	1.04×10^{-09}	1.71×10^{-09}	1.05×10^{-09}	1.91×10^{-09}	8.91×10^{-10}	1.47×10^{-09}
Benzo(g,h,i)fluoranthene	2.60×10^{-08}	4.25×10^{-08}	2.62×10^{-08}	4.76×10^{-08}	2.22×10^{-08}	3.66×10^{-08}
Benzo(g,h,i)perylene	1.75×10^{-08}	2.82×10^{-08}	1.76×10^{-08}	3.16×10^{-08}	1.48×10^{-08}	2.42×10^{-08}
Benzo(k)fluoranthene	7.05×10^{-09}	1.15×10^{-08}	7.08×10^{-09}	1.29×10^{-08}	6.01×10^{-09}	9.90×10^{-09}
Chrysene	1.56×10^{-08}	2.51×10^{-08}	1.57×10^{-08}	2.81×10^{-08}	1.32×10^{-08}	2.15×10^{-08}
Coronene	1.31×10^{-10}	2.13×10^{-10}	1.31×10^{-10}	2.39×10^{-10}	1.11×10^{-10}	1.84×10^{-10}

Table 11.4.III-19 Annual PAH Total Deposition at Selected Locations (continued)

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Cyclopenta(c,d)pyrene	9.21×10^{-09}	1.50×10^{-08}	9.27×10^{-09}	1.69×10^{-08}	7.86×10^{-09}	1.30×10^{-08}
Dibenzo(a,h)anthracene	1.98×10^{-08}	3.21×10^{-08}	1.99×10^{-08}	3.59×10^{-08}	1.68×10^{-08}	2.75×10^{-08}
Dibenzothiophene	1.39×10^{-09}	2.25×10^{-09}	1.41×10^{-09}	2.54×10^{-09}	1.16×10^{-09}	1.90×10^{-09}
Fluoranthene	2.39×10^{-07}	3.89×10^{-07}	2.40×10^{-07}	4.36×10^{-07}	2.03×10^{-07}	3.35×10^{-07}
Fluorene	4.48×10^{-07}	7.30×10^{-07}	4.50×10^{-07}	8.18×10^{-07}	3.81×10^{-07}	6.28×10^{-07}
Indeno(1,2,3-cd)fluoranthene	6.54×10^{-10}	1.07×10^{-09}	6.57×10^{-10}	1.20×10^{-09}	5.57×10^{-10}	9.19×10^{-10}
Indeno(1,2,3-cd)pyrene	5.44×10^{-10}	5.53×10^{-10}	5.73×10^{-10}	5.85×10^{-10}	3.96×10^{-10}	4.03×10^{-10}
Indeno(1,2,3-W)pyrene	1.17×10^{-08}	1.92×10^{-08}	1.18×10^{-08}	2.15×10^{-08}	1.00×10^{-08}	1.65×10^{-08}
Naphthalene	6.98×10^{-06}	1.12×10^{-05}	7.03×10^{-06}	1.26×10^{-05}	5.92×10^{-06}	9.62×10^{-06}
Nitro-pyrene	1.04×10^{-08}	1.71×10^{-08}	1.05×10^{-08}	1.91×10^{-08}	8.91×10^{-09}	1.47×10^{-08}
Perylene	1.31×10^{-10}	2.13×10^{-10}	1.31×10^{-10}	2.39×10^{-10}	1.11×10^{-10}	1.84×10^{-10}
Phenanthrene	4.21×10^{-07}	6.85×10^{-07}	4.23×10^{-07}	7.68×10^{-07}	3.58×10^{-07}	5.89×10^{-07}
Picene	1.31×10^{-10}	2.13×10^{-10}	1.31×10^{-10}	2.39×10^{-10}	1.11×10^{-10}	1.84×10^{-10}
Pyrene	3.23×10^{-07}	5.27×10^{-07}	3.25×10^{-07}	5.90×10^{-07}	2.75×10^{-07}	4.53×10^{-07}

Table 11.4.III-19 Annual PAH Total Deposition at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Annual Total Deposition (kg/ha/yr)						
1-Methylnaphthalene	5.97×10^{-07}	3.10×10^{-03}	5.62×10^{-07}	1.66×10^{-04}	6.56×10^{-07}	1.45×10^{-02}
1-Methylphenanthrene	2.69×10^{-08}	1.39×10^{-04}	2.53×10^{-08}	7.47×10^{-06}	2.95×10^{-08}	6.50×10^{-04}
2-Methylantracene	1.64×10^{-08}	8.53×10^{-05}	1.55×10^{-08}	4.57×10^{-06}	1.81×10^{-08}	3.98×10^{-04}
2-Methylfluorene	5.54×10^{-10}	2.88×10^{-06}	5.22×10^{-10}	1.54×10^{-07}	6.09×10^{-10}	1.34×10^{-05}
2-Methylnaphthalene	9.65×10^{-07}	5.01×10^{-03}	9.09×10^{-07}	2.68×10^{-04}	1.06×10^{-06}	2.34×10^{-02}
2-Methylphenanthrene	6.64×10^{-08}	3.45×10^{-04}	6.25×10^{-08}	1.84×10^{-05}	7.29×10^{-08}	1.61×10^{-03}
2-Methylpyrene	4.92×10^{-09}	2.55×10^{-05}	4.63×10^{-09}	1.37×10^{-06}	5.40×10^{-09}	1.19×10^{-04}
3-Methyldibenzothiophene	1.02×10^{-09}	5.28×10^{-06}	9.56×10^{-10}	2.82×10^{-07}	1.12×10^{-09}	2.46×10^{-05}
3-Methylphenanthrene	4.79×10^{-08}	2.49×10^{-04}	4.51×10^{-08}	1.33×10^{-05}	5.26×10^{-08}	1.16×10^{-03}
4+9-Methylphenanthrene	3.62×10^{-08}	1.88×10^{-04}	3.41×10^{-08}	1.01×10^{-05}	3.97×10^{-08}	8.76×10^{-04}
4-Methyldibenzothiophene	6.47×10^{-10}	3.36×10^{-06}	6.09×10^{-10}	1.80×10^{-07}	7.11×10^{-10}	1.57×10^{-05}
Acenaphthene	3.16×10^{-08}	1.60×10^{-04}	2.97×10^{-08}	8.49×10^{-06}	3.48×10^{-08}	7.38×10^{-04}
Acenaphthylene	1.11×10^{-07}	5.75×10^{-04}	1.04×10^{-07}	3.08×10^{-05}	1.22×10^{-07}	2.68×10^{-03}
Acephenanthrylene	1.90×10^{-08}	9.85×10^{-05}	1.78×10^{-08}	5.27×10^{-06}	2.08×10^{-08}	4.59×10^{-04}
Anthracene	1.98×10^{-08}	1.03×10^{-04}	1.87×10^{-08}	5.49×10^{-06}	2.18×10^{-08}	4.78×10^{-04}
Benz(a)anthracene	4.92×10^{-09}	2.47×10^{-05}	4.63×10^{-09}	1.31×10^{-06}	5.41×10^{-09}	1.14×10^{-04}
Benzo(a)fluorene	5.96×10^{-09}	3.10×10^{-05}	5.61×10^{-09}	1.66×10^{-06}	6.55×10^{-09}	1.44×10^{-04}
Benzo(a)pyrene	2.61×10^{-09}	1.35×10^{-05}	2.46×10^{-09}	7.25×10^{-07}	2.87×10^{-09}	6.32×10^{-05}
Benzo(b)fluoranthene	2.20×10^{-08}	1.14×10^{-04}	2.07×10^{-08}	6.08×10^{-06}	2.41×10^{-08}	5.30×10^{-04}
Benzo(e)pyrene	3.69×10^{-10}	1.92×10^{-06}	3.47×10^{-10}	1.03×10^{-07}	4.05×10^{-10}	8.94×10^{-06}
Benzo(g,h,i)fluoranthene	9.20×10^{-09}	4.78×10^{-05}	8.66×10^{-09}	2.56×10^{-06}	1.01×10^{-08}	2.23×10^{-04}
Benzo(g,h,i)perylene	6.09×10^{-09}	3.11×10^{-05}	5.74×10^{-09}	1.66×10^{-06}	6.70×10^{-09}	1.45×10^{-04}
Benzo(k)fluoranthene	2.49×10^{-09}	1.29×10^{-05}	2.34×10^{-09}	6.92×10^{-07}	2.73×10^{-09}	6.03×10^{-05}
Chrysene	5.42×10^{-09}	2.76×10^{-05}	5.10×10^{-09}	1.47×10^{-06}	5.96×10^{-09}	1.28×10^{-04}
Coronene	4.62×10^{-11}	2.40×10^{-07}	4.35×10^{-11}	1.28×10^{-08}	5.07×10^{-11}	1.12×10^{-06}

Table 11.4.III-19 Annual PAH Total Deposition at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Cyclopenta(c,d)pyrene	3.25×10^{-09}	1.69×10^{-05}	3.06×10^{-09}	9.05×10^{-07}	3.58×10^{-09}	7.88×10^{-05}
Dibenzo(a,h)anthracene	6.93×10^{-09}	3.56×10^{-05}	6.52×10^{-09}	1.90×10^{-06}	7.62×10^{-09}	1.66×10^{-04}
Dibenzothiophene	4.59×10^{-10}	2.58×10^{-06}	4.32×10^{-10}	1.27×10^{-07}	5.07×10^{-10}	9.61×10^{-06}
Fluoranthene	8.41×10^{-08}	4.36×10^{-04}	7.91×10^{-08}	2.33×10^{-05}	9.24×10^{-08}	2.03×10^{-03}
Fluorene	1.58×10^{-07}	8.19×10^{-04}	1.49×10^{-07}	4.38×10^{-05}	1.73×10^{-07}	3.82×10^{-03}
Indeno(1,2,3-cd)fluoranthene	2.31×10^{-10}	1.20×10^{-06}	2.17×10^{-10}	6.42×10^{-08}	2.54×10^{-10}	5.59×10^{-06}
Indeno(1,2,3-cd)pyrene	1.12×10^{-10}	1.21×10^{-07}	1.06×10^{-10}	1.49×10^{-09}	1.29×10^{-10}	1.10×10^{-07}
Indeno(1,2,3-W)pyrene	4.15×10^{-09}	2.15×10^{-05}	3.90×10^{-09}	1.15×10^{-06}	4.56×10^{-09}	1.00×10^{-04}
Naphthalene	2.42×10^{-06}	1.23×10^{-02}	2.28×10^{-06}	6.58×10^{-04}	2.67×10^{-06}	5.72×10^{-02}
Nitro-pyrene	3.69×10^{-09}	1.92×10^{-05}	3.47×10^{-09}	1.03×10^{-06}	4.05×10^{-09}	8.94×10^{-05}
Perylene	4.62×10^{-11}	2.40×10^{-07}	4.35×10^{-11}	1.28×10^{-08}	5.07×10^{-11}	1.12×10^{-06}
Phenanthrene	1.48×10^{-07}	7.68×10^{-04}	1.39×10^{-07}	4.10×10^{-05}	1.63×10^{-07}	3.56×10^{-03}
Picene	4.62×10^{-11}	2.40×10^{-07}	4.35×10^{-11}	1.28×10^{-08}	5.07×10^{-11}	1.12×10^{-06}
Pyrene	1.14×10^{-07}	5.91×10^{-04}	1.07×10^{-07}	3.16×10^{-05}	1.25×10^{-07}	2.75×10^{-03}

PAH = polycyclic aromatic hydrocarbon; kg/ha/yr = kilogram per hectare per year.

Table 11.4.III-20 Annual Metals Wet Deposition Predictions at Selected Locations

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Annual Wet Deposition (kg/ha/yr)						
Aluminum	6.11×10^{-08}	4.23×10^{-07}	5.27×10^{-08}	5.30×10^{-07}	4.75×10^{-08}	4.15×10^{-07}
Antimony	1.69×10^{-12}	1.46×10^{-11}	1.46×10^{-12}	1.85×10^{-11}	1.34×10^{-12}	1.45×10^{-11}
Arsenic	8.08×10^{-11}	1.23×10^{-10}	6.86×10^{-11}	1.24×10^{-10}	5.99×10^{-11}	1.03×10^{-10}
Barium	1.36×10^{-09}	8.90×10^{-09}	1.18×10^{-09}	1.11×10^{-08}	1.05×10^{-09}	8.70×10^{-09}
Beryllium	3.59×10^{-11}	3.68×10^{-11}	3.08×10^{-11}	3.20×10^{-11}	2.64×10^{-11}	2.73×10^{-11}
Bismuth	5.49×10^{-13}	4.39×10^{-12}	4.75×10^{-13}	5.54×10^{-12}	4.31×10^{-13}	4.34×10^{-12}
Boron	1.08×10^{-10}	4.40×10^{-10}	9.23×10^{-11}	5.34×10^{-10}	8.09×10^{-11}	4.18×10^{-10}
Bromine	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$
Cadmium	1.64×10^{-09}	2.42×10^{-09}	1.39×10^{-09}	2.47×10^{-09}	1.32×10^{-09}	2.11×10^{-09}
Calcium	2.87×10^{-08}	1.75×10^{-07}	2.47×10^{-08}	2.18×10^{-07}	2.21×10^{-08}	1.70×10^{-07}
Chromium	1.03×10^{-09}	4.28×10^{-09}	8.77×10^{-10}	5.18×10^{-09}	7.96×10^{-10}	4.09×10^{-09}
Cobalt	3.61×10^{-10}	1.04×10^{-09}	3.07×10^{-10}	1.21×10^{-09}	2.88×10^{-10}	9.77×10^{-10}
Copper	4.08×10^{-10}	9.87×10^{-10}	3.48×10^{-10}	1.12×10^{-09}	3.22×10^{-10}	9.10×10^{-10}
Gallium	2.81×10^{-10}	6.08×10^{-10}	2.38×10^{-10}	6.78×10^{-10}	2.27×10^{-10}	5.59×10^{-10}
Gold	3.87×10^{-12}	2.86×10^{-11}	3.34×10^{-12}	3.59×10^{-11}	3.02×10^{-12}	2.82×10^{-11}
Indium	1.51×10^{-09}	2.27×10^{-09}	1.28×10^{-09}	2.33×10^{-09}	1.22×10^{-09}	1.99×10^{-09}
Iron	1.13×10^{-07}	7.93×10^{-07}	9.79×10^{-08}	9.94×10^{-07}	8.82×10^{-08}	7.78×10^{-07}
Lanthanum	2.33×10^{-10}	1.79×10^{-09}	2.01×10^{-10}	2.26×10^{-09}	1.82×10^{-10}	1.77×10^{-09}
Lead	3.90×10^{-10}	7.37×10^{-10}	3.32×10^{-10}	7.98×10^{-10}	3.08×10^{-10}	6.59×10^{-10}
Magnesium	1.87×10^{-07}	9.81×10^{-07}	1.60×10^{-07}	1.21×10^{-06}	1.42×10^{-07}	9.48×10^{-07}
Manganese	1.98×10^{-09}	1.18×10^{-08}	1.70×10^{-09}	1.47×10^{-08}	1.54×10^{-09}	1.16×10^{-08}
Mercury	2.65×10^{-10}	3.06×10^{-10}	2.21×10^{-10}	2.79×10^{-10}	1.97×10^{-10}	2.39×10^{-10}
Molybdenum	1.54×10^{-11}	1.36×10^{-10}	1.33×10^{-11}	1.72×10^{-10}	1.22×10^{-11}	1.35×10^{-10}
Nickel	1.53×10^{-09}	6.60×10^{-09}	1.31×10^{-09}	8.03×10^{-09}	1.16×10^{-09}	6.30×10^{-09}
Palladium	2.51×10^{-10}	3.78×10^{-10}	2.13×10^{-10}	3.88×10^{-10}	2.04×10^{-10}	3.31×10^{-10}

Table 11.4.III-20 Annual Metals Wet Deposition Predictions at Selected Locations (continued)

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Phosphorus	4.37×10^{-09}	3.08×10^{-08}	3.77×10^{-09}	3.86×10^{-08}	3.42×10^{-09}	3.03×10^{-08}
Potassium	2.87×10^{-08}	2.13×10^{-07}	2.48×10^{-08}	2.67×10^{-07}	2.24×10^{-08}	2.09×10^{-07}
Rubidium	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$
Scandium	1.54×10^{-11}	1.05×10^{-10}	1.33×10^{-11}	1.31×10^{-10}	1.19×10^{-11}	1.03×10^{-10}
Selenium	1.82×10^{-10}	2.06×10^{-10}	1.56×10^{-10}	1.88×10^{-10}	1.34×10^{-10}	1.58×10^{-10}
Silicon	1.58×10^{-08}	2.38×10^{-08}	1.34×10^{-08}	2.45×10^{-08}	1.29×10^{-08}	2.09×10^{-08}
Silver	2.52×10^{-10}	3.82×10^{-10}	2.13×10^{-10}	3.94×10^{-10}	2.05×10^{-10}	3.36×10^{-10}
Sodium	2.56×10^{-09}	1.52×10^{-08}	2.20×10^{-09}	1.89×10^{-08}	1.96×10^{-09}	1.48×10^{-08}
Strontium	4.87×10^{-10}	2.42×10^{-09}	4.18×10^{-10}	2.99×10^{-09}	3.69×10^{-10}	2.34×10^{-09}
Thallium	8.18×10^{-13}	5.26×10^{-12}	7.09×10^{-13}	6.54×10^{-12}	6.45×10^{-13}	5.15×10^{-12}
Thorium	6.27×10^{-11}	5.18×10^{-10}	5.43×10^{-11}	6.54×10^{-10}	4.94×10^{-11}	5.12×10^{-10}
Tin	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$
Titanium	4.73×10^{-09}	3.88×10^{-08}	4.10×10^{-09}	4.90×10^{-08}	3.73×10^{-09}	3.84×10^{-08}
Tungsten	5.49×10^{-13}	4.37×10^{-12}	4.75×10^{-13}	5.51×10^{-12}	4.31×10^{-13}	4.31×10^{-12}
Uranium	5.07×10^{-12}	3.88×10^{-11}	4.38×10^{-12}	4.88×10^{-11}	3.97×10^{-12}	3.82×10^{-11}
Vanadium	1.74×10^{-10}	1.31×10^{-09}	1.51×10^{-10}	1.65×10^{-09}	1.36×10^{-10}	1.29×10^{-09}
Yttrium	$0.00 \times 10^{+00}$	8.76×10^{-13}	$0.00 \times 10^{+00}$	1.22×10^{-12}	$0.00 \times 10^{+00}$	8.83×10^{-13}
Zinc	1.89×10^{-09}	3.23×10^{-09}	1.60×10^{-09}	3.43×10^{-09}	1.53×10^{-09}	2.88×10^{-09}
Zirconium	$0.00 \times 10^{+00}$	3.77×10^{-12}	$0.00 \times 10^{+00}$	5.24×10^{-12}	$0.00 \times 10^{+00}$	3.80×10^{-12}

Table 11.4.III-20 Annual Metals Wet Deposition Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Annual Wet Deposition (kg/ha/yr)						
Aluminum	8.38×10^{-09}	1.34×10^{-04}	9.22×10^{-09}	1.45×10^{-05}	1.02×10^{-08}	5.87×10^{-04}
Antimony	2.37×10^{-13}	4.01×10^{-09}	2.60×10^{-13}	4.97×10^{-10}	2.88×10^{-13}	2.13×10^{-08}
Arsenic	9.92×10^{-12}	3.59×10^{-08}	1.13×10^{-11}	2.15×10^{-09}	1.21×10^{-11}	6.45×10^{-08}
Barium	1.84×10^{-10}	3.04×10^{-06}	2.04×10^{-10}	3.09×10^{-07}	2.24×10^{-10}	1.21×10^{-05}
Beryllium	4.32×10^{-12}	2.75×10^{-09}	4.95×10^{-12}	1.34×10^{-10}	5.28×10^{-12}	3.64×10^{-09}
Bismuth	7.61×10^{-14}	1.40×10^{-09}	8.38×10^{-14}	1.51×10^{-10}	9.25×10^{-14}	6.28×10^{-09}
Boron	1.39×10^{-11}	1.54×10^{-07}	1.55×10^{-11}	1.65×10^{-08}	1.70×10^{-11}	5.70×10^{-07}
Bromine	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$
Cadmium	2.54×10^{-10}	1.20×10^{-06}	2.61×10^{-10}	6.15×10^{-08}	2.96×10^{-10}	1.40×10^{-06}
Calcium	3.85×10^{-09}	6.13×10^{-05}	4.26×10^{-09}	6.08×10^{-06}	4.70×10^{-09}	2.36×10^{-04}
Chromium	1.42×10^{-10}	1.61×10^{-06}	1.54×10^{-10}	1.41×10^{-07}	1.70×10^{-10}	5.27×10^{-06}
Cobalt	5.42×10^{-11}	4.18×10^{-07}	5.66×10^{-11}	3.28×10^{-08}	6.39×10^{-11}	1.12×10^{-06}
Copper	5.96×10^{-11}	3.77×10^{-07}	6.29×10^{-11}	2.85×10^{-08}	7.05×10^{-11}	9.58×10^{-07}
Gallium	4.37×10^{-11}	2.56×10^{-07}	4.49×10^{-11}	1.74×10^{-08}	5.10×10^{-11}	5.45×10^{-07}
Gold	5.31×10^{-13}	8.10×10^{-09}	5.86×10^{-13}	9.78×10^{-10}	6.46×10^{-13}	4.05×10^{-08}
Indium	2.37×10^{-10}	1.12×10^{-06}	2.42×10^{-10}	5.94×10^{-08}	2.76×10^{-10}	1.37×10^{-06}
Iron	1.55×10^{-08}	2.54×10^{-04}	1.71×10^{-08}	2.73×10^{-05}	1.89×10^{-08}	1.10×10^{-03}
Lanthanum	3.21×10^{-11}	5.35×10^{-07}	3.54×10^{-11}	6.15×10^{-08}	3.91×10^{-11}	2.55×10^{-06}
Lead	5.68×10^{-11}	2.67×10^{-07}	6.00×10^{-11}	1.82×10^{-08}	6.71×10^{-11}	5.76×10^{-07}
Magnesium	2.46×10^{-08}	3.87×10^{-04}	2.73×10^{-08}	3.55×10^{-05}	3.01×10^{-08}	1.31×10^{-03}
Manganese	2.73×10^{-10}	3.84×10^{-06}	2.98×10^{-10}	4.02×10^{-07}	3.30×10^{-10}	1.60×10^{-05}
Mercury	3.27×10^{-11}	1.70×10^{-07}	3.73×10^{-11}	6.41×10^{-09}	3.96×10^{-11}	3.74×10^{-07}
Molybdenum	2.17×10^{-12}	3.68×10^{-08}	2.38×10^{-12}	4.61×10^{-09}	2.63×10^{-12}	1.99×10^{-07}
Nickel	1.99×10^{-10}	2.73×10^{-06}	2.22×10^{-10}	2.36×10^{-07}	2.43×10^{-10}	8.42×10^{-06}
Palladium	3.96×10^{-11}	1.87×10^{-07}	4.04×10^{-11}	9.90×10^{-09}	4.60×10^{-11}	2.29×10^{-07}
Phosphorus	6.05×10^{-10}	9.43×10^{-06}	6.64×10^{-10}	1.05×10^{-06}	7.34×10^{-10}	4.31×10^{-05}

Table 11.4.III-20 Annual Metals Wet Deposition Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Potassium	3.94×10^{-09}	6.54×10^{-05}	4.35×10^{-09}	7.31×10^{-06}	4.80×10^{-09}	3.00×10^{-04}
Rubidium	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$
Scandium	2.09×10^{-12}	3.48×10^{-08}	2.31×10^{-12}	3.63×10^{-09}	2.55×10^{-12}	1.45×10^{-07}
Selenium	2.20×10^{-11}	2.01×10^{-08}	2.52×10^{-11}	1.31×10^{-09}	2.69×10^{-11}	3.77×10^{-08}
Silicon	2.49×10^{-09}	1.18×10^{-05}	2.54×10^{-09}	6.24×10^{-07}	2.90×10^{-09}	1.44×10^{-05}
Silver	3.96×10^{-11}	1.89×10^{-07}	4.05×10^{-11}	1.00×10^{-08}	4.61×10^{-11}	2.35×10^{-07}
Sodium	3.42×10^{-10}	5.38×10^{-06}	3.79×10^{-10}	5.30×10^{-07}	4.17×10^{-10}	2.05×10^{-05}
Strontium	6.40×10^{-11}	9.77×10^{-07}	7.10×10^{-11}	8.91×10^{-08}	7.82×10^{-11}	3.22×10^{-06}
Thallium	1.14×10^{-13}	1.56×10^{-09}	1.25×10^{-13}	2.20×10^{-10}	1.39×10^{-13}	9.77×10^{-09}
Thorium	8.74×10^{-12}	1.49×10^{-07}	9.61×10^{-12}	1.77×10^{-08}	1.06×10^{-11}	7.48×10^{-07}
Tin	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$
Titanium	6.59×10^{-10}	1.13×10^{-05}	7.24×10^{-10}	1.33×10^{-06}	8.00×10^{-10}	5.60×10^{-05}
Tungsten	7.61×10^{-14}	1.28×10^{-09}	8.38×10^{-14}	1.50×10^{-10}	9.25×10^{-14}	6.26×10^{-09}
Uranium	6.99×10^{-13}	1.16×10^{-08}	7.70×10^{-13}	1.33×10^{-09}	8.50×10^{-13}	5.51×10^{-08}
Vanadium	2.40×10^{-11}	4.03×10^{-07}	2.64×10^{-11}	4.50×10^{-08}	2.92×10^{-11}	1.85×10^{-06}
Yttrium	$0.00 \times 10^{+00}$	4.30×10^{-09}	$0.00 \times 10^{+00}$	1.00×10^{-10}	$0.00 \times 10^{+00}$	2.58×10^{-09}
Zinc	2.94×10^{-10}	1.50×10^{-06}	3.02×10^{-10}	8.79×10^{-08}	3.43×10^{-10}	2.33×10^{-06}
Zirconium	$0.00 \times 10^{+00}$	1.85×10^{-08}	$0.00 \times 10^{+00}$	4.32×10^{-10}	$0.00 \times 10^{+00}$	1.11×10^{-08}

kg/ha/yr = kilogram per hectare per year.

Table 11.4.III-21 Annual Metals Dry Deposition Predictions at Selected Locations

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Annual Dry Deposition (kg/ha/yr)						
Aluminum	5.52×10^{-07}	2.22×10^{-06}	5.75×10^{-07}	2.67×10^{-06}	4.32×10^{-07}	1.85×10^{-06}
Antimony	1.33×10^{-11}	7.25×10^{-11}	1.38×10^{-11}	8.85×10^{-11}	1.10×10^{-11}	6.16×10^{-11}
Arsenic	8.76×10^{-10}	1.08×10^{-09}	9.47×10^{-10}	1.20×10^{-09}	6.50×10^{-10}	8.20×10^{-10}
Barium	1.32×10^{-08}	4.79×10^{-08}	1.38×10^{-08}	5.75×10^{-08}	1.01×10^{-08}	3.98×10^{-08}
Beryllium	4.10×10^{-10}	4.15×10^{-10}	4.43×10^{-10}	4.49×10^{-10}	3.01×10^{-10}	3.05×10^{-10}
Bismuth	4.64×10^{-12}	2.23×10^{-11}	4.84×10^{-12}	2.71×10^{-11}	3.73×10^{-12}	1.88×10^{-11}
Boron	1.26×10^{-09}	2.80×10^{-09}	1.31×10^{-09}	3.26×10^{-09}	9.10×10^{-10}	2.22×10^{-09}
Bromine	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$
Cadmium	9.21×10^{-09}	1.32×10^{-08}	9.47×10^{-09}	1.46×10^{-08}	7.69×10^{-09}	1.10×10^{-08}
Calcium	2.89×10^{-07}	9.61×10^{-07}	3.01×10^{-07}	1.15×10^{-06}	2.19×10^{-07}	7.94×10^{-07}
Chromium	9.15×10^{-09}	2.42×10^{-08}	9.59×10^{-09}	2.86×10^{-08}	7.05×10^{-09}	1.99×10^{-08}
Cobalt	2.40×10^{-09}	5.59×10^{-09}	2.47×10^{-09}	6.51×10^{-09}	1.94×10^{-09}	4.66×10^{-09}
Copper	2.96×10^{-09}	5.68×10^{-09}	3.08×10^{-09}	6.53×10^{-09}	2.35×10^{-09}	4.67×10^{-09}
Gallium	1.55×10^{-09}	3.11×10^{-09}	1.59×10^{-09}	3.57×10^{-09}	1.31×10^{-09}	2.64×10^{-09}
Gold	3.44×10^{-11}	1.48×10^{-10}	3.59×10^{-11}	1.79×10^{-10}	2.72×10^{-11}	1.24×10^{-10}
Indium	7.79×10^{-09}	1.16×10^{-08}	7.93×10^{-09}	1.28×10^{-08}	6.63×10^{-09}	9.87×10^{-09}
Iron	1.04×10^{-06}	4.17×10^{-06}	1.09×10^{-06}	5.02×10^{-06}	8.13×10^{-07}	3.48×10^{-06}
Lanthanum	2.01×10^{-09}	9.19×10^{-09}	2.10×10^{-09}	1.11×10^{-08}	1.61×10^{-09}	7.74×10^{-09}
Lead	2.79×10^{-09}	4.44×10^{-09}	2.92×10^{-09}	5.02×10^{-09}	2.22×10^{-09}	3.63×10^{-09}
Magnesium	2.00×10^{-06}	5.67×10^{-06}	2.09×10^{-06}	6.72×10^{-06}	1.49×10^{-06}	4.62×10^{-06}
Manganese	1.75×10^{-08}	6.30×10^{-08}	1.83×10^{-08}	7.57×10^{-08}	1.37×10^{-08}	5.25×10^{-08}
Mercury	2.76×10^{-09}	3.00×10^{-09}	3.00×10^{-09}	3.32×10^{-09}	2.06×10^{-09}	2.26×10^{-09}
Molybdenum	1.18×10^{-10}	6.71×10^{-10}	1.24×10^{-10}	8.19×10^{-10}	9.86×10^{-11}	5.71×10^{-10}
Nickel	1.67×10^{-08}	4.01×10^{-08}	1.75×10^{-08}	4.72×10^{-08}	1.23×10^{-08}	3.24×10^{-08}
Palladium	1.30×10^{-09}	1.94×10^{-09}	1.32×10^{-09}	2.14×10^{-09}	1.10×10^{-09}	1.65×10^{-09}

Table 11.4.III-21 Annual Metals Dry Deposition Predictions at Selected Locations (continued)

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Phosphorus	3.81×10^{-08}	1.60×10^{-07}	3.97×10^{-08}	1.93×10^{-07}	3.01×10^{-08}	1.34×10^{-07}
Potassium	2.56×10^{-07}	1.10×10^{-06}	2.67×10^{-07}	1.33×10^{-06}	2.02×10^{-07}	9.25×10^{-07}
Rubidium	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$
Scandium	1.45×10^{-10}	5.57×10^{-10}	1.52×10^{-10}	6.71×10^{-10}	1.13×10^{-10}	4.65×10^{-10}
Selenium	2.07×10^{-09}	2.18×10^{-09}	2.24×10^{-09}	2.38×10^{-09}	1.52×10^{-09}	1.62×10^{-09}
Silicon	8.18×10^{-08}	1.22×10^{-07}	8.33×10^{-08}	1.35×10^{-07}	6.96×10^{-08}	1.04×10^{-07}
Silver	1.30×10^{-09}	1.96×10^{-09}	1.33×10^{-09}	2.17×10^{-09}	1.11×10^{-09}	1.66×10^{-09}
Sodium	2.60×10^{-08}	8.43×10^{-08}	2.71×10^{-08}	1.01×10^{-07}	1.96×10^{-08}	6.94×10^{-08}
Strontium	5.35×10^{-09}	1.43×10^{-08}	5.58×10^{-09}	1.69×10^{-08}	3.95×10^{-09}	1.16×10^{-08}
Thallium	6.70×10^{-12}	2.65×10^{-11}	6.98×10^{-12}	3.19×10^{-11}	5.45×10^{-12}	2.24×10^{-11}
Thorium	5.13×10^{-10}	2.60×10^{-09}	5.35×10^{-10}	3.17×10^{-09}	4.18×10^{-10}	2.20×10^{-09}
Tin	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$
Titanium	3.90×10^{-08}	1.96×10^{-07}	4.06×10^{-08}	2.38×10^{-07}	3.17×10^{-08}	1.65×10^{-07}
Tungsten	4.64×10^{-12}	2.22×10^{-11}	4.84×10^{-12}	2.70×10^{-11}	3.73×10^{-12}	1.87×10^{-11}
Uranium	4.41×10^{-11}	1.99×10^{-10}	4.60×10^{-11}	2.41×10^{-10}	3.51×10^{-11}	1.68×10^{-10}
Vanadium	1.54×10^{-09}	6.75×10^{-09}	1.61×10^{-09}	8.18×10^{-09}	1.22×10^{-09}	5.67×10^{-09}
Yttrium	$0.00 \times 10^{+00}$	4.14×10^{-12}	$0.00 \times 10^{+00}$	5.31×10^{-12}	$0.00 \times 10^{+00}$	3.54×10^{-12}
Zinc	1.05×10^{-08}	1.70×10^{-08}	1.07×10^{-08}	1.91×10^{-08}	8.77×10^{-09}	1.43×10^{-08}
Zirconium	$0.00 \times 10^{+00}$	1.78×10^{-11}	$0.00 \times 10^{+00}$	2.28×10^{-11}	$0.00 \times 10^{+00}$	1.52×10^{-11}

Table 11.4.III-21 Annual Metals Dry Deposition Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Annual Dry Deposition (kg/ha/yr)						
Aluminum	1.40×10^{-07}	6.41×10^{-03}	1.33×10^{-07}	2.77×10^{-04}	1.60×10^{-07}	4.04×10^{-02}
Antimony	3.73×10^{-12}	2.00×10^{-07}	3.53×10^{-12}	9.72×10^{-09}	4.24×10^{-12}	1.49×10^{-06}
Arsenic	2.04×10^{-10}	7.95×10^{-07}	1.94×10^{-10}	3.16×10^{-08}	2.34×10^{-10}	4.09×10^{-06}
Barium	3.20×10^{-09}	1.44×10^{-04}	3.04×10^{-09}	5.83×10^{-06}	3.67×10^{-09}	8.27×10^{-04}
Beryllium	9.10×10^{-11}	7.25×10^{-08}	8.67×10^{-11}	8.15×10^{-10}	1.05×10^{-10}	6.56×10^{-08}
Bismuth	1.24×10^{-12}	6.70×10^{-08}	1.17×10^{-12}	2.92×10^{-09}	1.41×10^{-12}	4.35×10^{-07}
Boron	2.69×10^{-10}	7.39×10^{-06}	2.56×10^{-10}	2.71×10^{-07}	3.10×10^{-10}	3.28×10^{-05}
Bromine	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$
Cadmium	3.33×10^{-09}	1.31×10^{-05}	3.16×10^{-09}	5.91×10^{-07}	3.69×10^{-09}	4.93×10^{-05}
Calcium	6.83×10^{-08}	2.88×10^{-03}	6.48×10^{-08}	1.14×10^{-04}	7.83×10^{-08}	1.58×10^{-02}
Chromium	2.37×10^{-09}	6.43×10^{-05}	2.25×10^{-09}	2.53×10^{-06}	2.69×10^{-09}	3.44×10^{-04}
Cobalt	7.58×10^{-10}	1.30×10^{-05}	7.20×10^{-10}	5.27×10^{-07}	8.47×10^{-10}	6.80×10^{-05}
Copper	8.80×10^{-10}	1.10×10^{-05}	8.37×10^{-10}	4.47×10^{-07}	9.88×10^{-10}	5.74×10^{-05}
Gallium	5.65×10^{-10}	5.47×10^{-06}	5.37×10^{-10}	2.49×10^{-07}	6.25×10^{-10}	3.09×10^{-05}
Gold	8.85×10^{-12}	4.03×10^{-07}	8.39×10^{-12}	1.88×10^{-08}	1.01×10^{-11}	2.80×10^{-06}
Indium	2.99×10^{-09}	1.26×10^{-05}	2.84×10^{-09}	5.76×10^{-07}	3.29×10^{-09}	4.88×10^{-05}
Iron	2.62×10^{-07}	1.21×10^{-02}	2.49×10^{-07}	5.21×10^{-04}	2.99×10^{-07}	7.58×10^{-02}
Lanthanum	5.28×10^{-10}	2.61×10^{-05}	5.01×10^{-10}	1.19×10^{-06}	6.03×10^{-10}	1.77×10^{-04}
Lead	8.41×10^{-10}	5.84×10^{-06}	8.00×10^{-10}	2.63×10^{-07}	9.44×10^{-10}	3.30×10^{-05}
Magnesium	4.53×10^{-07}	1.77×10^{-02}	4.31×10^{-07}	6.31×10^{-04}	5.21×10^{-07}	8.27×10^{-02}
Manganese	4.51×10^{-09}	1.77×10^{-04}	4.29×10^{-09}	7.58×10^{-06}	5.15×10^{-09}	1.09×10^{-03}
Mercury	6.75×10^{-10}	8.73×10^{-07}	6.39×10^{-10}	2.95×10^{-08}	7.73×10^{-10}	2.69×10^{-06}
Molybdenum	3.38×10^{-11}	1.84×10^{-06}	3.20×10^{-11}	9.05×10^{-08}	3.84×10^{-11}	1.39×10^{-05}
Nickel	3.77×10^{-09}	1.18×10^{-04}	3.58×10^{-09}	4.05×10^{-06}	4.34×10^{-09}	5.15×10^{-04}
Palladium	4.98×10^{-10}	2.10×10^{-06}	4.73×10^{-10}	9.60×10^{-08}	5.49×10^{-10}	8.14×10^{-06}

Table 11.4.III-21 Annual Metals Dry Deposition Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Phosphorus	9.94×10^{-09}	4.52×10^{-04}	9.43×10^{-09}	2.02×10^{-05}	1.13×10^{-08}	2.97×10^{-03}
Potassium	6.57×10^{-08}	3.17×10^{-03}	6.24×10^{-08}	1.40×10^{-04}	7.51×10^{-08}	2.07×10^{-02}
Rubidium	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$
Scandium	3.59×10^{-11}	1.65×10^{-06}	3.41×10^{-11}	6.90×10^{-08}	4.11×10^{-11}	9.92×10^{-06}
Selenium	4.61×10^{-10}	6.76×10^{-07}	4.39×10^{-10}	1.81×10^{-08}	5.32×10^{-10}	2.20×10^{-06}
Silicon	3.14×10^{-08}	1.33×10^{-04}	2.98×10^{-08}	6.05×10^{-06}	3.46×10^{-08}	5.13×10^{-04}
Silver	4.99×10^{-10}	2.17×10^{-06}	4.74×10^{-10}	9.89×10^{-08}	5.50×10^{-10}	8.57×10^{-06}
Sodium	6.10×10^{-09}	2.52×10^{-04}	5.79×10^{-09}	9.87×10^{-06}	7.00×10^{-09}	1.36×10^{-03}
Strontium	1.19×10^{-09}	4.46×10^{-05}	1.13×10^{-09}	1.55×10^{-06}	1.37×10^{-09}	1.99×10^{-04}
Thallium	1.83×10^{-12}	8.45×10^{-08}	1.73×10^{-12}	4.48×10^{-09}	2.08×10^{-12}	6.81×10^{-07}
Thorium	1.40×10^{-10}	7.34×10^{-06}	1.33×10^{-10}	3.44×10^{-07}	1.59×10^{-10}	5.22×10^{-05}
Tin	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$
Titanium	1.06×10^{-08}	5.53×10^{-04}	1.00×10^{-08}	2.58×10^{-05}	1.21×10^{-08}	3.90×10^{-03}
Tungsten	1.24×10^{-12}	6.29×10^{-08}	1.17×10^{-12}	2.90×10^{-09}	1.41×10^{-12}	4.35×10^{-07}
Uranium	1.15×10^{-11}	5.66×10^{-07}	1.09×10^{-11}	2.57×10^{-08}	1.31×10^{-11}	3.82×10^{-06}
Vanadium	3.98×10^{-10}	1.95×10^{-05}	3.78×10^{-10}	8.65×10^{-07}	4.55×10^{-10}	1.28×10^{-04}
Yttrium	$0.00 \times 10^{+00}$	1.49×10^{-07}	$0.00 \times 10^{+00}$	1.03×10^{-09}	$0.00 \times 10^{+00}$	1.41×10^{-07}
Zinc	3.81×10^{-09}	2.37×10^{-05}	3.62×10^{-09}	1.02×10^{-06}	4.21×10^{-09}	1.06×10^{-04}
Zirconium	$0.00 \times 10^{+00}$	6.39×10^{-07}	$0.00 \times 10^{+00}$	4.44×10^{-09}	$0.00 \times 10^{+00}$	6.08×10^{-07}

kg/ha/yr = kilogram per hectare per year.

Table 11.4.III-22 Annual Metals Total Deposition Predictions at Selected Locations

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Annual Total Deposition (kg/ha/yr)						
Aluminum	6.13×10^{-07}	2.64×10^{-06}	6.28×10^{-07}	3.20×10^{-06}	4.80×10^{-07}	2.27×10^{-06}
Antimony	1.50×10^{-11}	8.71×10^{-11}	1.53×10^{-11}	1.07×10^{-10}	1.23×10^{-11}	7.61×10^{-11}
Arsenic	9.57×10^{-10}	1.20×10^{-09}	1.02×10^{-09}	1.33×10^{-09}	7.10×10^{-10}	9.23×10^{-10}
Barium	1.46×10^{-08}	5.68×10^{-08}	1.49×10^{-08}	6.86×10^{-08}	1.12×10^{-08}	4.85×10^{-08}
Beryllium	4.46×10^{-10}	4.52×10^{-10}	4.74×10^{-10}	4.81×10^{-10}	3.27×10^{-10}	3.32×10^{-10}
Bismuth	5.19×10^{-12}	2.67×10^{-11}	5.31×10^{-12}	3.26×10^{-11}	4.16×10^{-12}	2.32×10^{-11}
Boron	1.36×10^{-09}	3.24×10^{-09}	1.40×10^{-09}	3.79×10^{-09}	9.91×10^{-10}	2.64×10^{-09}
Bromine	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$
Cadmium	1.09×10^{-08}	1.56×10^{-08}	1.09×10^{-08}	1.70×10^{-08}	9.01×10^{-09}	1.31×10^{-08}
Calcium	3.17×10^{-07}	1.14×10^{-06}	3.26×10^{-07}	1.37×10^{-06}	2.41×10^{-07}	9.64×10^{-07}
Chromium	1.02×10^{-08}	2.85×10^{-08}	1.05×10^{-08}	3.38×10^{-08}	7.84×10^{-09}	2.40×10^{-08}
Cobalt	2.76×10^{-09}	6.63×10^{-09}	2.78×10^{-09}	7.72×10^{-09}	2.23×10^{-09}	5.64×10^{-09}
Copper	3.36×10^{-09}	6.67×10^{-09}	3.43×10^{-09}	7.65×10^{-09}	2.67×10^{-09}	5.58×10^{-09}
Gallium	1.83×10^{-09}	3.72×10^{-09}	1.83×10^{-09}	4.25×10^{-09}	1.54×10^{-09}	3.20×10^{-09}
Gold	3.83×10^{-11}	1.77×10^{-10}	3.92×10^{-11}	2.15×10^{-10}	3.02×10^{-11}	1.53×10^{-10}
Indium	9.30×10^{-09}	1.39×10^{-08}	9.21×10^{-09}	1.52×10^{-08}	7.85×10^{-09}	1.19×10^{-08}
Iron	1.15×10^{-06}	4.96×10^{-06}	1.18×10^{-06}	6.02×10^{-06}	9.01×10^{-07}	4.26×10^{-06}
Lanthanum	2.25×10^{-09}	1.10×10^{-08}	2.30×10^{-09}	1.34×10^{-08}	1.79×10^{-09}	9.51×10^{-09}
Lead	3.18×10^{-09}	5.18×10^{-09}	3.26×10^{-09}	5.82×10^{-09}	2.53×10^{-09}	4.28×10^{-09}
Magnesium	2.19×10^{-06}	6.65×10^{-06}	2.25×10^{-06}	7.93×10^{-06}	1.63×10^{-06}	5.57×10^{-06}
Manganese	1.95×10^{-08}	7.49×10^{-08}	2.00×10^{-08}	9.04×10^{-08}	1.52×10^{-08}	6.41×10^{-08}
Mercury	3.02×10^{-09}	3.31×10^{-09}	3.22×10^{-09}	3.60×10^{-09}	2.26×10^{-09}	2.50×10^{-09}
Molybdenum	1.34×10^{-10}	8.07×10^{-10}	1.37×10^{-10}	9.91×10^{-10}	1.11×10^{-10}	7.05×10^{-10}
Nickel	1.82×10^{-08}	4.67×10^{-08}	1.88×10^{-08}	5.52×10^{-08}	1.35×10^{-08}	3.87×10^{-08}
Palladium	1.55×10^{-09}	2.31×10^{-09}	1.53×10^{-09}	2.53×10^{-09}	1.31×10^{-09}	1.98×10^{-09}

Table 11.4.III-22 Annual Metals Total Deposition Predictions at Selected Locations (continued)

Compounds	Warburton Bay Lodge		Warburton Bay Fishing Lodge		MacKay Lake Lodge	
	Baseline	Application	Baseline	Application	Baseline	Application
Phosphorus	4.25×10^{-08}	1.91×10^{-07}	4.35×10^{-08}	2.32×10^{-07}	3.36×10^{-08}	1.64×10^{-07}
Potassium	2.85×10^{-07}	1.31×10^{-06}	2.92×10^{-07}	1.60×10^{-06}	2.25×10^{-07}	1.13×10^{-06}
Rubidium	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$
Scandium	1.61×10^{-10}	6.62×10^{-10}	1.65×10^{-10}	8.03×10^{-10}	1.25×10^{-10}	5.68×10^{-10}
Selenium	2.26×10^{-09}	2.39×10^{-09}	2.39×10^{-09}	2.57×10^{-09}	1.66×10^{-09}	1.77×10^{-09}
Silicon	9.77×10^{-08}	1.46×10^{-07}	9.67×10^{-08}	1.59×10^{-07}	8.25×10^{-08}	1.25×10^{-07}
Silver	1.56×10^{-09}	2.34×10^{-09}	1.54×10^{-09}	2.56×10^{-09}	1.31×10^{-09}	2.00×10^{-09}
Sodium	2.85×10^{-08}	9.95×10^{-08}	2.93×10^{-08}	1.20×10^{-07}	2.16×10^{-08}	8.42×10^{-08}
Strontium	5.84×10^{-09}	1.67×10^{-08}	6.00×10^{-09}	1.99×10^{-08}	4.32×10^{-09}	1.39×10^{-08}
Thallium	7.51×10^{-12}	3.17×10^{-11}	7.69×10^{-12}	3.84×10^{-11}	6.09×10^{-12}	2.75×10^{-11}
Thorium	5.76×10^{-10}	3.12×10^{-09}	5.89×10^{-10}	3.82×10^{-09}	4.67×10^{-10}	2.72×10^{-09}
Tin	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$
Titanium	4.37×10^{-08}	2.34×10^{-07}	4.47×10^{-08}	2.87×10^{-07}	3.54×10^{-08}	2.04×10^{-07}
Tungsten	5.19×10^{-12}	2.66×10^{-11}	5.31×10^{-12}	3.25×10^{-11}	4.16×10^{-12}	2.30×10^{-11}
Uranium	4.92×10^{-11}	2.38×10^{-10}	5.04×10^{-11}	2.90×10^{-10}	3.91×10^{-11}	2.06×10^{-10}
Vanadium	1.72×10^{-09}	8.06×10^{-09}	1.76×10^{-09}	9.82×10^{-09}	1.36×10^{-09}	6.96×10^{-09}
Yttrium	$0.00 \times 10^{+00}$	5.01×10^{-12}	$0.00 \times 10^{+00}$	6.52×10^{-12}	$0.00 \times 10^{+00}$	4.42×10^{-12}
Zinc	1.24×10^{-08}	2.03×10^{-08}	1.23×10^{-08}	2.25×10^{-08}	1.03×10^{-08}	1.72×10^{-08}
Zirconium	$0.00 \times 10^{+00}$	2.16×10^{-11}	$0.00 \times 10^{+00}$	2.81×10^{-11}	$0.00 \times 10^{+00}$	1.90×10^{-11}

Table 11.4.III-22 Annual Metals Total Deposition Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Annual Total Deposition (kg/ha/yr)						
Aluminum	1.49×10^{-07}	6.54×10^{-03}	1.40×10^{-07}	2.92×10^{-04}	1.69×10^{-07}	4.10×10^{-02}
Antimony	3.97×10^{-12}	2.04×10^{-07}	3.73×10^{-12}	1.02×10^{-08}	4.50×10^{-12}	1.51×10^{-06}
Arsenic	2.14×10^{-10}	8.31×10^{-07}	2.02×10^{-10}	3.37×10^{-08}	2.45×10^{-10}	4.15×10^{-06}
Barium	3.39×10^{-09}	1.47×10^{-04}	3.19×10^{-09}	6.13×10^{-06}	3.87×10^{-09}	8.39×10^{-04}
Beryllium	9.54×10^{-11}	7.52×10^{-08}	9.04×10^{-11}	9.49×10^{-10}	1.10×10^{-10}	6.83×10^{-08}
Bismuth	1.31×10^{-12}	6.84×10^{-08}	1.24×10^{-12}	3.07×10^{-09}	1.49×10^{-12}	4.41×10^{-07}
Boron	2.83×10^{-10}	7.54×10^{-06}	2.68×10^{-10}	2.87×10^{-07}	3.26×10^{-10}	3.34×10^{-05}
Bromine	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$
Cadmium	3.58×10^{-09}	1.43×10^{-05}	3.37×10^{-09}	6.44×10^{-07}	3.96×10^{-09}	5.07×10^{-05}
Calcium	7.21×10^{-08}	2.94×10^{-03}	6.80×10^{-08}	1.20×10^{-04}	8.25×10^{-08}	1.61×10^{-02}
Chromium	2.51×10^{-09}	6.59×10^{-05}	2.37×10^{-09}	2.67×10^{-06}	2.85×10^{-09}	3.49×10^{-04}
Cobalt	8.12×10^{-10}	1.34×10^{-05}	7.65×10^{-10}	5.59×10^{-07}	9.06×10^{-10}	6.92×10^{-05}
Copper	9.40×10^{-10}	1.13×10^{-05}	8.87×10^{-10}	4.75×10^{-07}	1.05×10^{-09}	5.83×10^{-05}
Gallium	6.08×10^{-10}	5.73×10^{-06}	5.73×10^{-10}	2.65×10^{-07}	6.72×10^{-10}	3.15×10^{-05}
Gold	9.38×10^{-12}	4.11×10^{-07}	8.83×10^{-12}	1.98×10^{-08}	1.07×10^{-11}	2.84×10^{-06}
Indium	3.22×10^{-09}	1.38×10^{-05}	3.04×10^{-09}	6.27×10^{-07}	3.55×10^{-09}	5.02×10^{-05}
Iron	2.77×10^{-07}	1.24×10^{-02}	2.61×10^{-07}	5.48×10^{-04}	3.16×10^{-07}	7.68×10^{-02}
Lanthanum	5.60×10^{-10}	2.67×10^{-05}	5.27×10^{-10}	1.25×10^{-06}	6.37×10^{-10}	1.80×10^{-04}
Lead	8.98×10^{-10}	6.11×10^{-06}	8.47×10^{-10}	2.80×10^{-07}	1.00×10^{-09}	3.36×10^{-05}
Magnesium	4.78×10^{-07}	1.81×10^{-02}	4.51×10^{-07}	6.65×10^{-04}	5.48×10^{-07}	8.40×10^{-02}
Manganese	4.79×10^{-09}	1.81×10^{-04}	4.51×10^{-09}	7.99×10^{-06}	5.44×10^{-09}	1.11×10^{-03}
Mercury	7.07×10^{-10}	1.04×10^{-06}	6.67×10^{-10}	3.59×10^{-08}	8.09×10^{-10}	2.81×10^{-06}
Molybdenum	3.59×10^{-11}	1.88×10^{-06}	3.38×10^{-11}	9.51×10^{-08}	4.08×10^{-11}	1.41×10^{-05}
Nickel	3.97×10^{-09}	1.20×10^{-04}	3.75×10^{-09}	4.28×10^{-06}	4.55×10^{-09}	5.23×10^{-04}
Palladium	5.37×10^{-10}	2.29×10^{-06}	5.06×10^{-10}	1.04×10^{-07}	5.91×10^{-10}	8.37×10^{-06}

Table 11.4.III-22 Annual Metals Total Deposition Predictions at Selected Locations (continued)

Compounds	Employee Camp		Proposed National Park Boundary		Development Area Boundary	
	Baseline	Application	Baseline	Application	Baseline	Application
Phosphorus	1.05×10^{-08}	4.61×10^{-04}	9.93×10^{-09}	2.12×10^{-05}	1.20×10^{-08}	3.01×10^{-03}
Potassium	6.97×10^{-08}	3.24×10^{-03}	6.56×10^{-08}	1.48×10^{-04}	7.94×10^{-08}	2.10×10^{-02}
Rubidium	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$
Scandium	3.80×10^{-11}	1.69×10^{-06}	3.58×10^{-11}	7.26×10^{-08}	4.34×10^{-11}	1.01×10^{-05}
Selenium	4.83×10^{-10}	6.96×10^{-07}	4.58×10^{-10}	1.93×10^{-08}	5.56×10^{-10}	2.23×10^{-06}
Silicon	3.38×10^{-08}	1.44×10^{-04}	3.19×10^{-08}	6.58×10^{-06}	3.72×10^{-08}	5.27×10^{-04}
Silver	5.39×10^{-10}	2.36×10^{-06}	5.07×10^{-10}	1.08×10^{-07}	5.93×10^{-10}	8.81×10^{-06}
Sodium	6.44×10^{-09}	2.58×10^{-04}	6.08×10^{-09}	1.04×10^{-05}	7.37×10^{-09}	1.38×10^{-03}
Strontium	1.26×10^{-09}	4.56×10^{-05}	1.19×10^{-09}	1.63×10^{-06}	1.44×10^{-09}	2.02×10^{-04}
Thallium	1.94×10^{-12}	8.60×10^{-08}	1.83×10^{-12}	4.68×10^{-09}	2.20×10^{-12}	6.90×10^{-07}
Thorium	1.49×10^{-10}	7.49×10^{-06}	1.40×10^{-10}	3.62×10^{-07}	1.69×10^{-10}	5.29×10^{-05}
Tin	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$	$0.00 \times 10^{+00}$
Titanium	1.12×10^{-08}	5.65×10^{-04}	1.06×10^{-08}	2.71×10^{-05}	1.28×10^{-08}	3.95×10^{-03}
Tungsten	1.31×10^{-12}	6.42×10^{-08}	1.24×10^{-12}	3.05×10^{-09}	1.49×10^{-12}	4.41×10^{-07}
Uranium	1.22×10^{-11}	5.78×10^{-07}	1.15×10^{-11}	2.70×10^{-08}	1.39×10^{-11}	3.87×10^{-06}
Vanadium	4.22×10^{-10}	1.99×10^{-05}	3.98×10^{-10}	9.10×10^{-07}	4.81×10^{-10}	1.30×10^{-04}
Yttrium	$0.00 \times 10^{+00}$	1.53×10^{-07}	$0.00 \times 10^{+00}$	1.13×10^{-09}	$0.00 \times 10^{+00}$	1.42×10^{-07}
Zinc	4.10×10^{-09}	2.52×10^{-05}	3.86×10^{-09}	1.10×10^{-06}	4.53×10^{-09}	1.09×10^{-04}
Zirconium	$0.00 \times 10^{+00}$	6.58×10^{-07}	$0.00 \times 10^{+00}$	4.87×10^{-09}	$0.00 \times 10^{+00}$	6.10×10^{-07}

kg/ha/yr = kilogram per hectare per year.

11.4.III.3 PREDICTED AIR QUALITY AT SELECTED LAKES

Table 11.4.III-23 Predicted Deposition Rates of Metals at Selected Lakes

Lake ID on Figure	Lake Name	Calcium ($\mu\text{g}/\text{m}^2/\text{s}$)	Magnesium ($\mu\text{g}/\text{m}^2/\text{s}$)	Potassium ($\mu\text{g}/\text{m}^2/\text{s}$)	Sodium ($\mu\text{g}/\text{m}^2/\text{s}$)	Aluminum ($\mu\text{g}/\text{m}^2/\text{s}$)	Antimony ($\mu\text{g}/\text{m}^2/\text{s}$)	Arsenic ($\mu\text{g}/\text{m}^2/\text{s}$)	Barium ($\mu\text{g}/\text{m}^2/\text{s}$)	Beryllium ($\mu\text{g}/\text{m}^2/\text{s}$)
3	A3	1.91×10^{-04}	1.05×10^{-03}	2.40×10^{-04}	1.66×10^{-05}	4.73×10^{-04}	1.61×10^{-08}	5.15×10^{-08}	9.89×10^{-06}	$0.00 \times 10^{+00}$
4	A9	8.50×10^{-04}	4.62×10^{-03}	1.07×10^{-03}	7.36×10^{-05}	2.11×10^{-03}	7.54×10^{-08}	2.28×10^{-07}	4.39×10^{-05}	2.56×10^{-09}
5	B1	2.38×10^{-04}	1.29×10^{-03}	3.01×10^{-04}	2.06×10^{-05}	5.91×10^{-04}	2.02×10^{-08}	6.33×10^{-08}	1.23×10^{-05}	9.77×10^{-10}
6	B2	3.00×10^{-04}	1.62×10^{-03}	3.81×10^{-04}	2.59×10^{-05}	7.47×10^{-04}	2.71×10^{-08}	7.86×10^{-08}	1.55×10^{-05}	2.04×10^{-09}
7	C1	6.07×10^{-04}	3.25×10^{-03}	7.77×10^{-04}	5.25×10^{-05}	1.52×10^{-03}	5.54×10^{-08}	1.58×10^{-07}	3.15×10^{-05}	1.68×10^{-09}
8	CL	4.40×10^{-05}	2.38×10^{-04}	5.58×10^{-05}	3.81×10^{-06}	1.10×10^{-04}	3.78×10^{-09}	1.37×10^{-08}	2.28×10^{-06}	7.77×10^{-10}
10	D10	7.40×10^{-04}	3.89×10^{-03}	9.65×10^{-04}	6.39×10^{-05}	1.88×10^{-03}	6.90×10^{-08}	1.92×10^{-07}	3.86×10^{-05}	2.12×10^{-10}
11	D2	6.93×10^{-04}	3.66×10^{-03}	8.99×10^{-04}	5.98×10^{-05}	1.75×10^{-03}	6.39×10^{-08}	1.79×10^{-07}	3.61×10^{-05}	4.73×10^{-10}
12	D3	3.25×10^{-04}	1.73×10^{-03}	4.18×10^{-04}	2.81×10^{-05}	8.18×10^{-04}	2.90×10^{-08}	8.58×10^{-08}	1.69×10^{-05}	1.93×10^{-09}
13	D7	1.24×10^{-04}	6.64×10^{-04}	1.58×10^{-04}	1.07×10^{-05}	3.10×10^{-04}	1.12×10^{-08}	3.31×10^{-08}	6.41×10^{-06}	5.50×10^{-10}
14	E1	2.86×10^{-04}	1.51×10^{-03}	3.70×10^{-04}	2.47×10^{-05}	7.24×10^{-04}	2.68×10^{-08}	7.56×10^{-08}	1.49×10^{-05}	$0.00 \times 10^{+00}$
15	E2	7.75×10^{-04}	4.07×10^{-03}	1.01×10^{-03}	6.68×10^{-05}	1.97×10^{-03}	7.26×10^{-08}	2.02×10^{-07}	4.04×10^{-05}	2.48×10^{-10}
16	E3	1.69×10^{-03}	8.84×10^{-03}	2.22×10^{-03}	1.46×10^{-04}	4.32×10^{-03}	1.59×10^{-07}	4.38×10^{-07}	8.84×10^{-05}	1.28×10^{-09}
17	F1	8.09×10^{-04}	4.38×10^{-03}	1.02×10^{-03}	7.00×10^{-05}	2.01×10^{-03}	7.13×10^{-08}	2.08×10^{-07}	4.18×10^{-05}	6.24×10^{-10}
18	G1	2.74×10^{-04}	1.53×10^{-03}	3.35×10^{-04}	2.38×10^{-05}	6.63×10^{-04}	2.37×10^{-08}	7.54×10^{-08}	1.40×10^{-05}	2.14×10^{-09}
19	G2	2.32×10^{-04}	1.29×10^{-03}	2.86×10^{-04}	2.02×10^{-05}	5.65×10^{-04}	1.95×10^{-08}	6.41×10^{-08}	1.19×10^{-05}	2.34×10^{-09}
20	H1	1.96×10^{-04}	1.11×10^{-03}	2.36×10^{-04}	1.70×10^{-05}	4.68×10^{-04}	1.53×10^{-08}	5.61×10^{-08}	9.95×10^{-06}	1.85×10^{-09}
21	I1	6.13×10^{-04}	3.59×10^{-03}	7.13×10^{-04}	5.36×10^{-05}	1.42×10^{-03}	4.73×10^{-08}	1.81×10^{-07}	3.08×10^{-05}	8.04×10^{-09}
22	I2	8.28×10^{-04}	4.73×10^{-03}	9.91×10^{-04}	7.21×10^{-05}	1.97×10^{-03}	6.70×10^{-08}	2.64×10^{-07}	4.21×10^{-05}	7.37×10^{-09}
23	J1a	2.49×10^{-04}	1.38×10^{-03}	3.07×10^{-04}	2.16×10^{-05}	6.06×10^{-04}	2.07×10^{-08}	7.45×10^{-08}	1.28×10^{-05}	2.78×10^{-09}
24	J1b	2.62×10^{-04}	1.45×10^{-03}	3.24×10^{-04}	2.27×10^{-05}	6.39×10^{-04}	2.19×10^{-08}	7.61×10^{-08}	1.34×10^{-05}	1.97×10^{-09}
25	J2	3.11×10^{-04}	1.74×10^{-03}	3.81×10^{-04}	2.70×10^{-05}	7.53×10^{-04}	2.65×10^{-08}	9.48×10^{-08}	1.59×10^{-05}	3.31×10^{-09}
33	Kb2	2.48×10^{-03}	1.33×10^{-02}	3.18×10^{-03}	2.14×10^{-04}	6.22×10^{-03}	2.26×10^{-07}	6.57×10^{-07}	1.29×10^{-04}	5.09×10^{-09}
34	Kb3	1.07×10^{-03}	5.89×10^{-03}	1.33×10^{-03}	9.25×10^{-05}	2.61×10^{-03}	9.11×10^{-08}	2.97×10^{-07}	5.49×10^{-05}	3.82×10^{-09}

$\mu\text{g}/\text{m}^2/\text{s}$ = micrograms per square metres per second.

Table 11.4.III-24 Predicted Deposition Rates of Metals at Selected Lakes

Lake ID on Figure	Lake Name	Boron ($\mu\text{g}/\text{m}^2/\text{s}$)	Cadmium ($\mu\text{g}/\text{m}^2/\text{s}$)	Chromium ($\mu\text{g}/\text{m}^2/\text{s}$)	Cobalt ($\mu\text{g}/\text{m}^2/\text{s}$)	Copper ($\mu\text{g}/\text{m}^2/\text{s}$)	Iron ($\mu\text{g}/\text{m}^2/\text{s}$)	Lead ($\mu\text{g}/\text{m}^2/\text{s}$)	Manganese ($\mu\text{g}/\text{m}^2/\text{s}$)	Mercury ($\mu\text{g}/\text{m}^2/\text{s}$)
3	A3	4.16×10^{-07}	8.78×10^{-07}	4.23×10^{-06}	8.67×10^{-07}	7.36×10^{-07}	8.88×10^{-04}	4.28×10^{-07}	1.29×10^{-05}	3.15×10^{-08}
4	A9	1.88×10^{-06}	4.46×10^{-06}	1.87×10^{-05}	3.83×10^{-06}	3.24×10^{-06}	3.96×10^{-03}	1.89×10^{-06}	5.74×10^{-05}	1.27×10^{-07}
5	B1	5.40×10^{-07}	1.06×10^{-06}	5.24×10^{-06}	1.08×10^{-06}	9.12×10^{-07}	1.11×10^{-03}	5.32×10^{-07}	1.61×10^{-05}	2.42×10^{-08}
6	B2	6.70×10^{-07}	1.28×10^{-06}	6.58×10^{-06}	1.34×10^{-06}	1.14×10^{-06}	1.40×10^{-03}	6.64×10^{-07}	2.03×10^{-05}	2.52×10^{-08}
7	C1	1.34×10^{-06}	2.48×10^{-06}	1.33×10^{-05}	2.71×10^{-06}	2.29×10^{-06}	2.86×10^{-03}	1.34×10^{-06}	4.14×10^{-05}	3.48×10^{-08}
8	CL	9.85×10^{-08}	2.47×10^{-07}	9.83×10^{-07}	2.07×10^{-07}	1.77×10^{-07}	2.06×10^{-04}	1.08×10^{-07}	2.99×10^{-06}	1.45×10^{-08}
10	D10	1.56×10^{-06}	2.35×10^{-06}	1.61×10^{-05}	3.19×10^{-06}	2.69×10^{-06}	3.53×10^{-03}	1.54×10^{-06}	5.09×10^{-05}	2.15×10^{-08}
11	D2	1.47×10^{-06}	2.32×10^{-06}	1.51×10^{-05}	3.01×10^{-06}	2.53×10^{-06}	3.29×10^{-03}	1.46×10^{-06}	4.75×10^{-05}	2.37×10^{-08}
12	D3	7.06×10^{-07}	1.26×10^{-06}	7.11×10^{-06}	1.44×10^{-06}	1.22×10^{-06}	1.54×10^{-03}	7.09×10^{-07}	2.22×10^{-05}	1.96×10^{-08}
13	D7	2.73×10^{-07}	5.50×10^{-07}	2.72×10^{-06}	5.60×10^{-07}	4.74×10^{-07}	5.81×10^{-04}	2.80×10^{-07}	8.42×10^{-06}	1.60×10^{-08}
14	E1	6.11×10^{-07}	1.14×10^{-06}	6.26×10^{-06}	1.27×10^{-06}	1.08×10^{-06}	1.36×10^{-03}	6.32×10^{-07}	1.96×10^{-05}	1.78×10^{-08}
15	E2	1.62×10^{-06}	2.52×10^{-06}	1.69×10^{-05}	3.35×10^{-06}	2.82×10^{-06}	3.70×10^{-03}	1.63×10^{-06}	5.34×10^{-05}	2.32×10^{-08}
16	E3	3.50×10^{-06}	4.32×10^{-06}	3.66×10^{-05}	7.12×10^{-06}	5.98×10^{-06}	8.10×10^{-03}	3.37×10^{-06}	1.17×10^{-04}	2.76×10^{-08}
17	F1	1.82×10^{-06}	3.50×10^{-06}	1.78×10^{-05}	3.64×10^{-06}	3.08×10^{-06}	3.77×10^{-03}	1.79×10^{-06}	5.47×10^{-05}	5.16×10^{-08}
18	G1	6.65×10^{-07}	1.56×10^{-06}	6.10×10^{-06}	1.29×10^{-06}	1.10×10^{-06}	1.25×10^{-03}	6.53×10^{-07}	1.82×10^{-05}	6.09×10^{-08}
19	G2	5.58×10^{-07}	1.33×10^{-06}	5.18×10^{-06}	1.10×10^{-06}	9.35×10^{-07}	1.06×10^{-03}	5.57×10^{-07}	1.55×10^{-05}	4.96×10^{-08}
20	H1	4.87×10^{-07}	1.16×10^{-06}	4.36×10^{-06}	9.14×10^{-07}	7.76×10^{-07}	8.81×10^{-04}	4.54×10^{-07}	1.29×10^{-05}	6.30×10^{-08}
21	I1	1.61×10^{-06}	3.68×10^{-06}	1.37×10^{-05}	2.84×10^{-06}	2.40×10^{-06}	2.68×10^{-03}	1.37×10^{-06}	3.93×10^{-05}	2.86×10^{-07}
22	I2	2.04×10^{-06}	5.06×10^{-06}	1.86×10^{-05}	3.82×10^{-06}	3.24×10^{-06}	3.71×10^{-03}	1.86×10^{-06}	5.41×10^{-05}	5.26×10^{-07}
23	J1a	5.85×10^{-07}	1.54×10^{-06}	5.56×10^{-06}	1.16×10^{-06}	9.86×10^{-07}	1.14×10^{-03}	5.83×10^{-07}	1.66×10^{-05}	1.01×10^{-07}
24	J1b	6.11×10^{-07}	1.56×10^{-06}	5.84×10^{-06}	1.21×10^{-06}	1.03×10^{-06}	1.20×10^{-03}	6.05×10^{-07}	1.75×10^{-05}	9.38×10^{-08}
25	J2	7.38×10^{-07}	1.93×10^{-06}	6.96×10^{-06}	1.45×10^{-06}	1.23×10^{-06}	1.42×10^{-03}	7.24×10^{-07}	2.06×10^{-05}	1.39×10^{-07}
33	Kb2	5.34×10^{-06}	1.39×10^{-05}	5.45×10^{-05}	1.12×10^{-05}	9.47×10^{-06}	1.17×10^{-02}	5.57×10^{-06}	1.69×10^{-04}	2.60×10^{-07}
34	Kb3	2.45×10^{-06}	5.86×10^{-06}	2.36×10^{-05}	4.83×10^{-06}	4.09×10^{-06}	4.91×10^{-03}	2.36×10^{-06}	7.13×10^{-05}	2.86×10^{-07}

$\mu\text{g}/\text{m}^2/\text{s}$ = micrograms per square metres per second.

Table 11.4.III-25 Predicted Deposition Rates of Metals at Selected Lakes

Lake ID on Figure	Lake Name	Molybdenum ($\mu\text{g}/\text{m}^2/\text{s}$)	Nickel ($\mu\text{g}/\text{m}^2/\text{s}$)	Selenium ($\mu\text{g}/\text{m}^2/\text{s}$)	Silver ($\mu\text{g}/\text{m}^2/\text{s}$)	Strontium ($\mu\text{g}/\text{m}^2/\text{s}$)	Uranium ($\mu\text{g}/\text{m}^2/\text{s}$)	Vanadium ($\mu\text{g}/\text{m}^2/\text{s}$)	Zinc ($\mu\text{g}/\text{m}^2/\text{s}$)
3	A3	1.55×10^{-07}	6.66×10^{-06}	2.89×10^{-08}	1.48×10^{-07}	2.55×10^{-06}	4.43×10^{-08}	1.48×10^{-06}	1.59×10^{-06}
4	A9	7.01×10^{-07}	2.93×10^{-05}	1.24×10^{-07}	7.48×10^{-07}	1.12×10^{-05}	1.97×10^{-07}	6.62×10^{-06}	7.07×10^{-06}
5	B1	1.97×10^{-07}	8.20×10^{-06}	3.47×10^{-08}	1.80×10^{-07}	3.15×10^{-06}	5.54×10^{-08}	1.85×10^{-06}	1.96×10^{-06}
6	B2	2.50×10^{-07}	1.02×10^{-05}	4.37×10^{-08}	2.17×10^{-07}	3.93×10^{-06}	6.95×10^{-08}	2.35×10^{-06}	2.40×10^{-06}
7	C1	5.13×10^{-07}	2.05×10^{-05}	8.65×10^{-08}	4.25×10^{-07}	7.89×10^{-06}	1.43×10^{-07}	4.79×10^{-06}	4.75×10^{-06}
8	CL	3.70×10^{-08}	1.52×10^{-06}	8.40×10^{-09}	4.01×10^{-08}	5.79×10^{-07}	1.07×10^{-08}	3.45×10^{-07}	4.20×10^{-07}
10	D10	6.45×10^{-07}	2.43×10^{-05}	1.05×10^{-07}	4.07×10^{-07}	9.38×10^{-06}	1.78×10^{-07}	5.95×10^{-06}	5.01×10^{-06}
11	D2	5.99×10^{-07}	2.29×10^{-05}	9.84×10^{-08}	4.00×10^{-07}	8.82×10^{-06}	1.65×10^{-07}	5.54×10^{-06}	4.83×10^{-06}
12	D3	2.79×10^{-07}	1.09×10^{-05}	4.69×10^{-08}	2.17×10^{-07}	4.19×10^{-06}	7.73×10^{-08}	2.58×10^{-06}	2.46×10^{-06}
13	D7	1.04×10^{-07}	4.19×10^{-06}	1.98×10^{-08}	9.28×10^{-08}	1.61×10^{-06}	2.97×10^{-08}	9.74×10^{-07}	1.01×10^{-06}
14	E1	2.47×10^{-07}	9.49×10^{-06}	4.14×10^{-08}	1.96×10^{-07}	3.66×10^{-06}	6.85×10^{-08}	2.28×10^{-06}	2.21×10^{-06}
15	E2	6.77×10^{-07}	2.54×10^{-05}	1.10×10^{-07}	4.36×10^{-07}	9.79×10^{-06}	1.86×10^{-07}	6.24×10^{-06}	5.32×10^{-06}
16	E3	1.49×10^{-06}	5.50×10^{-05}	2.36×10^{-07}	7.58×10^{-07}	2.12×10^{-05}	4.08×10^{-07}	1.37×10^{-05}	1.02×10^{-05}
17	F1	6.71×10^{-07}	2.77×10^{-05}	1.14×10^{-07}	5.98×10^{-07}	1.07×10^{-05}	1.88×10^{-07}	6.31×10^{-06}	6.54×10^{-06}
18	G1	2.14×10^{-07}	9.86×10^{-06}	4.36×10^{-08}	2.60×10^{-07}	3.77×10^{-06}	6.10×10^{-08}	2.06×10^{-06}	2.63×10^{-06}
19	G2	1.83×10^{-07}	8.30×10^{-06}	3.62×10^{-08}	2.23×10^{-07}	3.18×10^{-06}	5.32×10^{-08}	1.76×10^{-06}	2.24×10^{-06}
20	H1	1.50×10^{-07}	7.19×10^{-06}	3.32×10^{-08}	1.93×10^{-07}	2.74×10^{-06}	4.34×10^{-08}	1.45×10^{-06}	1.89×10^{-06}
21	I1	4.38×10^{-07}	2.36×10^{-05}	1.05×10^{-07}	6.05×10^{-07}	8.97×10^{-06}	1.30×10^{-07}	4.38×10^{-06}	5.90×10^{-06}
22	I2	6.23×10^{-07}	3.10×10^{-05}	1.38×10^{-07}	8.20×10^{-07}	1.17×10^{-05}	1.81×10^{-07}	6.10×10^{-06}	7.87×10^{-06}
23	J1a	1.97×10^{-07}	8.93×10^{-06}	4.22×10^{-08}	2.55×10^{-07}	3.40×10^{-06}	5.58×10^{-08}	1.89×10^{-06}	2.45×10^{-06}
24	J1b	2.08×10^{-07}	9.33×10^{-06}	4.23×10^{-08}	2.56×10^{-07}	3.56×10^{-06}	5.91×10^{-08}	2.00×10^{-06}	2.46×10^{-06}
25	J2	2.44×10^{-07}	1.13×10^{-05}	5.27×10^{-08}	3.18×10^{-07}	4.28×10^{-06}	6.99×10^{-08}	2.35×10^{-06}	3.05×10^{-06}
33	Kb2	2.10×10^{-06}	8.35×10^{-05}	3.53×10^{-07}	2.34×10^{-06}	3.21×10^{-05}	5.83×10^{-07}	1.96×10^{-05}	2.16×10^{-05}
34	Kb3	8.59×10^{-07}	3.77×10^{-05}	1.60×10^{-07}	9.75×10^{-07}	1.44×10^{-05}	2.42×10^{-07}	8.17×10^{-06}	9.23×10^{-06}

$\mu\text{g}/\text{m}^2/\text{s}$ = micrograms per square metres per second.

Table 11.4.III-26 Predicted Application Case TSP Deposition Rates at Selected Lakes

Lake ID on Figure	Lake Name	TSP Deposition Rates (kg/ha/yr)
3	A3	25
4	A9	214
5	B1	23
6	B2	29
7	C1	88
8	CL	4
10	D10	142
11	D2	112
12	D3	35
13	D7	11
14	E1	40
15	E2	162
16	E3	441
17	F1	143
18	G1	36
19	G2	30
20	H1	26
21	I1	109
22	I2	184
23	J1a	39
24	J1b	43
25	J2	52
33	Kb2	783
34	Kb3	275

TSP = total suspended particles; kg/ha/yr = kilogram per hectare per year.

Table 11.4.III-27 Predicted Application Case Sulphate and Nitrate Deposition Rates at Selected Lakes

Lake ID on Figure	Lake Name	Sulphates Deposition Rates ^(a) (keq/ha/yr)	Nitrates Deposition Rates ^(a) (keq/ha/yr)
3	A3	7.401×10^{-04}	3.741×10^{-02}
4	A9	1.427×10^{-03}	1.063×10^{-01}
5	B1	8.643×10^{-04}	3.801×10^{-02}
6	B2	9.891×10^{-04}	4.287×10^{-02}
7	C1	1.581×10^{-03}	6.737×10^{-02}
8	CL	3.961×10^{-04}	1.046×10^{-02}
10	D10	1.517×10^{-03}	6.758×10^{-02}
11	D2	1.357×10^{-03}	6.528×10^{-02}
12	D3	9.452×10^{-04}	4.241×10^{-02}
13	D7	5.752×10^{-04}	2.434×10^{-02}
14	E1	1.055×10^{-03}	4.500×10^{-02}
15	E2	1.724×10^{-03}	7.393×10^{-02}
16	E3	2.160×10^{-03}	1.045×10^{-01}
17	F1	2.029×10^{-03}	8.857×10^{-02}
18	G1	9.722×10^{-04}	5.110×10^{-02}
19	G2	8.510×10^{-04}	4.392×10^{-02}
20	H1	7.441×10^{-04}	4.140×10^{-02}
21	I1	1.663×10^{-03}	1.318×10^{-01}
22	I2	2.129×10^{-03}	1.765×10^{-01}
23	J1a	9.463×10^{-04}	6.329×10^{-02}
24	J1b	9.453×10^{-04}	6.248×10^{-02}
25	J2	1.094×10^{-03}	7.642×10^{-02}
33	Kb2	2.258×10^{-03}	2.357×10^{-01}
34	Kb3	1.828×10^{-03}	1.491×10^{-01}

^(a) Deposition rates from CALPUFF model. These rates do not include background sulphate and nitrate deposition values.

keq/ha/yr = kilo-equivalent (hydrogen ion equivalent – 1 keq = 1 kmol H+) per hectare per year. Measure of PAI deposition.

11.4.III.4 SUMMARY OF PREDICTED AIR QUALITY IN LOCAL AND REGIONAL STUDY AREAS

Table 11.4.III-28 Comparison of Regional Baseline Case and Application Case for SO₂

Parameter	Baseline Case	Application Case
Local Study Area (LSA)		
maximum 1-hour SO ₂ (excluding development area) [µg/m ³]	3.4	42.9
occurrences above 1-hour NWT Ambient Air Quality Standard (AAQS) ^(a)	0	0
area above 1-hour NWT AAQS (excluding development area) [ha]	0	0
maximum 24-hour SO ₂ (excluding development area) [µg/m ³]	2.8	32.9
occurrences above 24-hour NWT AAQS ^(b)	0	0
area above 24-hour NWT AAQS (excluding development area) [ha]	0	0
annual average SO ₂ (excluding development area) [µg/m ³]	2.6	4.8
occurrences above annual NWT AAQS ^(c)	—	—
area above annual NWT AAQS (excluding development area) [ha]	0	0
Regional Study Area (RSA)		
maximum 1-hour SO ₂ (excluding development area) [µg/m ³]	24.0	42.9
occurrences above 1-hour NWT AAQS ^(a)	0	0
area above 1-hour NWT AAQS (excluding development area) [ha]	0	0
maximum 24-hour SO ₂ (excluding development area) [µg/m ³]	8.5	32.9
occurrences above 24-hour NWT AAQS ^(b)	0	0
area above 24-hour NWT AAQS (excluding development area) [ha]	0	0
annual average SO ₂ (excluding development area) [µg/m ³]	3.0	4.8
occurrences above annual NWT AAQS ^(c)	—	—
area above annual NWT AAQS (excluding development area) [ha]	0	0

^(a) The 1-hour NWT Standard for SO₂ is 450 µg/m³ (GNWT 2010, internet site).

^(b) The 24-hour NWT Standard for SO₂ is 150 µg/m³ (GNWT 2010, internet site).

^(c) The annual NWT Standard for SO₂ is 30 µg/m³ (GNWT 2010, internet site).

AAQS = Ambient Air Quality Standard; NWT = Northwest Territories; SO₂ = sulphur dioxide gas; µg/m³ = micrograms per cubic metres; ha = hectares.

Table 11.4.III-29 Comparison of Regional Baseline Case and Application Case for NO₂

Parameter	Baseline Case	Application Case
Local Study Area (LSA)		
maximum 1-hour NO ₂ (excluding development area) [µg/m ³]	17.9	314.3
occurrences above 1-hour NAAQO ^(a)	0	0
area above 1-hour NWT AAQS (excluding development area) [ha]	0	0
maximum 24-hour NO ₂ (excluding development area) [µg/m ³]	8.6	224.8
occurrences above 24-hour NAAQO ^(b)	0	2
area above 24-hour NWT AAQS (excluding development area) [ha]	0	9
annual average NO ₂ (excluding development area) [µg/m ³]	5.8	64.3
occurrences above annual NAAQO ^(c)	—	—
area above annual NWT AAQS (excluding development area) [ha]	0	1
Regional Study Area (RSA)		
maximum 1-hour NO ₂ (excluding development area) [µg/m ³]	109.8	314.3
occurrences above 1-hour NAAQO ^(a)	0	0
area above 1-hour NWT AAQS (excluding development area) [ha]	0	0
maximum 24-hour NO ₂ (excluding development area) [µg/m ³]	81.2	224.8
occurrences above 24-hour NAAQO ^(b)	0	2
area above 24-hour NWT AAQS (excluding development area) [ha]	0	9
annual average NO ₂ (excluding development area) [µg/m ³]	11.9	64.3
occurrences above annual NAAQO ^(c)	—	—
area above annual NWT AAQS (excluding development area) [ha]	0	1

^(a) The 1-hour NAAQO for NO₂ is 400 µg/m³ (Environment Canada 1981).

^(b) The 24-hour NAAQO for NO₂ is 200 µg/m³ (Environment Canada 1981).

^(c) The annual NAAQO for NO₂ is 60 µg/m³ (Environment Canada 1981).

AAQS = Ambient Air Quality Standard; NAAQO = National Ambient Air Quality Objectives; NWT = Northwest Territories
NO₂ = Nitrogen Dioxide Gas; µg/m³ = micrograms per cubic metres; ha = hectares.

Table 11.4.III-30 Comparison of Regional Baseline Case and Application Case for CO

Parameter	Baseline Case	Application Case
Local Study Area (LSA)		
maximum 1-hour CO (excluding development area) [$\mu\text{g}/\text{m}^3$]	3.5	1,978.6
occurrences above 1-hour NAAQO ^(a)	0	0
area above 1-hour Canadian Objectives (excluding development area) [ha]	0	0
maximum 8-hour CO (excluding development area) [$\mu\text{g}/\text{m}^3$]	1.8	1,692.1
occurrences above 8-hour NAAQO ^(b)	0	0
area above 8-hour Canadian Objectives (excluding development area) [ha]	0	0
annual average CO (excluding development area) [$\mu\text{g}/\text{m}^3$]	0.0	105.4
occurrences above annual NAAQO ^(c)	—	—
area above annual Canadian Objectives (excluding development area) [ha]	—	—
Regional Study Area (RSA)		
maximum 1-hour CO (excluding development area) [$\mu\text{g}/\text{m}^3$]	159.2	1,978.6
occurrences above 1-hour NAAQO ^(a)	0	0
area above 1-hour Canadian Objectives (excluding development area) [ha]	0	0
maximum 8-hour CO (excluding development area) [$\mu\text{g}/\text{m}^3$]	83.7	1,692.1
occurrences above 8-hour NAAQO ^(b)	0	0
area above 8-hour Canadian Objectives (excluding development area) [ha]	0	0
annual average CO (excluding development area) [$\mu\text{g}/\text{m}^3$]	3.3	105.4
occurrences above annual NAAQO ^(c)	—	—
area above annual Canadian Objectives (excluding development area) [ha]	—	—

^(a) The 1-hour NAAQO for CO is 15,000 $\mu\text{g}/\text{m}^3$ (Environment Canada 1981).

^(b) The 8-hour NAAQO for CO is 6,000 $\mu\text{g}/\text{m}^3$ (Environment Canada 1981).

^(c) There is no annual NAAQO for CO (Environment Canada 1981).

AAQS = Ambient Air Quality Standard; NAAQO = National Ambient Air Quality Objectives; NWT = Northwest Territories
CO = Carbon monoxide; $\mu\text{g}/\text{m}^3$ = micrograms per cubic metres; ha = hectares.

Table 11.4.III-31 Comparison of Regional Baseline Case and Application Case for TSP

Parameter	Baseline Case	Application Case
Local Study Area (LSA)		
maximum 1-hour TSP (excluding development area) [$\mu\text{g}/\text{m}^3$]	7.2	9,302.2
occurrences above 1-hour NAAQO ^(a)	—	—
maximum 24-hour TSP (excluding development area) [$\mu\text{g}/\text{m}^3$]	7.1	4,837.6
occurrences above 24-hour NWT AAQS ^(b)	0	325
area above 24-hour NWT AAQS (excluding development area) [ha]	0	1,217
annual average TSP (excluding development area) [$\mu\text{g}/\text{m}^3$]	7.1	604.8
occurrences above annual NWT AAQS ^(c)	—	—
area above annual NWT AAQS (excluding development area) [ha]	0	202
Regional Study Area (RSA)		
maximum 1-hour TSP (excluding development area) [$\mu\text{g}/\text{m}^3$]	7.2	9,302.2
occurrences above 1-hour NAAQO ^(a)	—	—
maximum 24-hour TSP (excluding development area) [$\mu\text{g}/\text{m}^3$]	7.1	4,837.6
occurrences above 24-hour NWT AAQS ^(b)	0	325
area above 24-hour NWT AAQS (excluding development area) [ha]	0	1,217
annual average TSP (excluding development area) [$\mu\text{g}/\text{m}^3$]	7.1	604.8
occurrences above annual NWT AAQS ^(c)	—	—
area above annual NWT AAQS (excluding development area) [ha]	0	202

^(a) There is no 1-hour NWT Standard for TSP (GNWT 2010, internet site).

^(b) The 24-hour NWT Standard for TSP is $120 \mu\text{g}/\text{m}^3$ (GNWT 2010, internet site).

^(c) The annual NWT Standard for TSP is $60 \mu\text{g}/\text{m}^3$ (GNWT 2010, internet site).

AAQS = Ambient Air Quality Standard; NAAQO = National Ambient Air Quality Objectives; NWT = Northwest Territories
TSP = Total suspended particulates; $\mu\text{g}/\text{m}^3$ = micrograms per cubic metres; ha = hectares.

Table 11.4.III-32 Comparison of Regional Baseline Case and Application Case for PM_{2.5}

Parameter	Baseline Case	Application Case
Local Study Area (LSA)		
maximum 1-hour PM _{2.5} (excluding development area) [µg/m³]	3.2	321.4
occurrences above 1-hour NWT AAQS ^(a)	—	—
maximum 24-hour PM _{2.5} (excluding development area) [µg/m³]	2.2	228.9
occurrences above 24-hour NWT AAQS ^(b)	0	69
area above 24-hour NWT AAQS (excluding development area) [ha]	0	1,620
annual average PM _{2.5} (excluding development area) [µg/m³]	1.9	24.1
occurrences above annual NWT AAQS ^(c)	—	—
Regional Study Area (RSA)		
maximum 1-hour PM _{2.5} (excluding development area) [µg/m³]	13.7	321.4
occurrences above 1-hour NWT AAQS ^(a)	—	—
maximum 24-hour PM _{2.5} (excluding development area) [µg/m³]	5.5	228.9
occurrences above 24-hour NWT AAQS	0	69
area above 24-hour NWT AAQS (excluding development area) [ha]	0	1,620
annual average PM _{2.5} (excluding development area) [µg/m³]	2.2	24.1
occurrences above annual NWT AAQS ^(c)	—	—

(a) There is no 1-hour NWT Standard for PM_{2.5} (GNWT 2010, internet site).

(b) The 24-hour NWT Standard for PM_{2.5} is 30 µg/m³ (GNWT 2010, internet site).

(c) There is no annual NWT Standard for PM_{2.5} (GNWT 2010, internet site).

AAQS = Ambient Air Quality Standard; NAAQO = National Ambient Air Quality Objectives; NWT = Northwest Territories
PM_{2.5} = particulate matter of particle diameter less than 2.5 µm (micrometres); µg/m³ = micrograms per cubic metres; ha = hectares.

Table 11.4.III-33 Comparison of Regional Baseline Case and Application Case for PM₁₀

Parameter	Baseline Case	Application Case
Local Study Area (LSA)		
maximum 1-hour PM ₁₀ (excluding development area) [µg/m³]	3.1	2,087.7
maximum 24-hour PM ₁₀ (excluding development area) [µg/m³]	3.1	1,222.6
annual average PM ₁₀ (excluding development area) [µg/m³]	3.0	142.1
Regional Study Area (RSA)		
maximum 1-hour PM ₁₀ (excluding development area) [µg/m³]	14.0	2,087.7
maximum 24-hour PM ₁₀ (excluding development area) [µg/m³]	7.2	1,222.6
annual average PM ₁₀ (excluding development area) [µg/m³]	3.4	142.1

PM₁₀ = particulate matter of particle diameter less than 10 µm (micrometres); µg/m³ = micrograms per cubic metres; ha = hectares.

Table 11.4.III-34 Comparison of Regional Baseline Case and Application Case for Annual PAI, Sulphate, Nitrate and Nitrogen Deposition

Annual Deposition	Baseline Case	Application Case
Local Study Area (LSA)		
PAI [keq/ha/yr]	0.06	1.16
PAI (excluding development area) [keq/ha/yr]	0.06	0.96
Nitrate (excluding development area) [keq/ha/yr]	0.03	0.91
Sulphate (excluding development area) [keq/ha/yr]	0.04	0.06
Nitrogen [kg/ha/yr] (excluding development area)	0.40	12.77
Regional Study Area (RSA)		
PAI [keq/ha/yr]	0.10	1.16
PAI (excluding development area) [keq/ha/yr]	0.10	0.96
Nitrate (excluding development area) [keq/ha/yr]	0.06	0.91
Sulphate (excluding development area) [keq/ha/yr]	0.04	0.06
Nitrogen [kg/ha/yr] (excluding development area)	0.86	12.77

PAI = potential acid input; kg/ha/yr = kilogram per hectare per year; keq/ha/yr = kilo-equivalent (hydrogen ion equivalent – 1 keq = 1 kmol H⁺) per hectare per year. Measure of PAI deposition.

Table 11.4.III-35 Comparison of Regional Baseline Case and Application Case for Annual TSP Deposition

Annual Deposition	Baseline Case	Application Case
Local Study Area (LSA)		
TSP deposition [kg/ha/yr]	0.0	6,291.8
TSP deposition [kg/ha/yr] (excluding development area)	0.0	5,519.5
Regional Study Area (RSA)		
TSP deposition [kg/ha/yr]	4.7	6,291.8
TSP deposition [kg/ha/yr] (excluding development area)	4.7	5,519.5

TSP = total suspended solids; kg/ha/yr = kilogram per hectare per year.

Table 11.4.III-36 Comparison of Regional Baseline Case and Application Case for 1-hour Metal Predictions

Parameter	Including Development Area		Excluding Development Area	
	Baseline Case Maximum 1-Hour Concentration (µg/m³)	Application Case Maximum 1-Hour Concentration (µg/m³)	Baseline Case Maximum 1-Hour Concentration (µg/m³)	Application Case Maximum 1-Hour Concentration (µg/m³)
Aluminum	0.301250	94.970000	0.301250	85.862000
Antimony	0.000011	0.003527	0.000011	0.003189
Arsenic	0.000410	0.009589	0.000410	0.008669
Barium	0.006884	1.938300	0.006884	1.752500
Beryllium	0.000195	0.000510	0.000195	0.000231
Bismuth	0.000003	0.001027	0.000003	0.000929
Boron	0.000756	0.143850	0.000756	0.067809
Bromine	0.000000	0.000000	0.000000	0.000000
Cadmium	0.002524	0.093885	0.002524	0.089023
Calcium	0.153300	36.986000	0.153300	33.440000
Chromium	0.003753	0.797760	0.003753	0.720940
Cobalt	0.000726	0.153590	0.000726	0.138530
Copper	0.000715	0.128800	0.000715	0.116110
Gallium	0.000453	0.067291	0.000453	0.060499
Gold	0.000021	0.006609	0.000021	0.005976
Indium	0.002261	0.092951	0.002261	0.088197
Iron	0.562730	178.150000	0.562730	161.070000
Lanthanum	0.001316	0.417800	0.001316	0.377750
Lead	0.000707	0.072257	0.000707	0.064989
Magnesium	1.118200	208.570000	1.118200	173.390000
Manganese	0.008318	2.561400	0.008318	2.315500
Mercury	0.001935	0.013554	0.001935	0.009566
Molybdenum	0.000104	0.032979	0.000104	0.029817
Nickel	0.008357	1.510700	0.008357	1.075300
Palladium	0.000377	0.015492	0.000377	0.014700
Phosphorus	0.022293	6.999700	0.022293	6.328300
Potassium	0.153840	48.835000	0.153840	44.153000
Rubidium	0.000000	0.000000	0.000000	0.000000
Scandium	0.000076	0.023288	0.000076	0.021055
Selenium	0.000980	0.005137	0.000980	0.004645
Silicon	0.023740	0.975990	0.023740	0.926070
Silver	0.000378	0.016426	0.000378	0.015525
Sodium	0.013879	3.184900	0.013879	2.879500
Strontium	0.003051	0.577410	0.003051	0.415210
Thorium	0.000388	0.123290	0.000388	0.111470
Tin	0.000000	0.000000	0.000000	0.000000

Table 11.4.III-36 Comparison of Regional Baseline Case and Application Case for 1-hour Metal Predictions (continued)

Parameter	Including Development Area		Excluding Development Area	
	Baseline Case Maximum 1-Hour Concentration ($\mu\text{g}/\text{m}^3$)	Application Case Maximum 1-Hour Concentration ($\mu\text{g}/\text{m}^3$)	Baseline Case Maximum 1-Hour Concentration ($\mu\text{g}/\text{m}^3$)	Application Case Maximum 1-Hour Concentration ($\mu\text{g}/\text{m}^3$)
Titanium	0.028993	9.212200	0.028993	8.329000
Tungsten	0.000003	0.001027	0.000003	0.000929
Uranium	0.000028	0.009007	0.000028	0.008144
Vanadium	0.000949	0.301370	0.000949	0.272470
Yttrium	0.000000	0.002971	0.000000	0.000450
Zinc	0.002880	0.216150	0.002880	0.195750
Zirconium	0.000000	0.012777	0.000000	0.001936

$\mu\text{g}/\text{m}^3$ = micrograms per cubic metres.

Table 11.4.III-37 Comparison of Regional Baseline Case and Application Case for 24-hour Metal Predictions

Parameter	Including Development Area		Excluding Development Area	
	Baseline Case Maximum 24-Hour Concentration (µg/m³)	Application Case Maximum 24-Hour Concentration (µg/m³)	Baseline Case Maximum 24-Hour Concentration (µg/m³)	Application Case Maximum 24-Hour Concentration (µg/m³)
Aluminum	0.105550	60.695000	0.105550	50.494000
Antimony	0.000004	0.002240	0.000004	0.001865
Arsenic	0.000123	0.006117	0.000123	0.005091
Barium	0.002140	1.243100	0.002140	1.033400
Beryllium	0.000048	0.000166	0.000048	0.000083
Bismuth	0.000001	0.000654	0.000001	0.000545
Boron	0.000160	0.071810	0.000160	0.040876
Bromine	0.000000	0.000000	0.000000	0.000000
Cadmium	0.000676	0.057696	0.000676	0.049962
Calcium	0.042043	23.790000	0.042043	19.767000
Chromium	0.001243	0.513830	0.001243	0.427330
Cobalt	0.000261	0.099532	0.000261	0.083084
Copper	0.000276	0.083453	0.000276	0.069745
Gallium	0.000166	0.043681	0.000166	0.036730
Gold	0.000007	0.004214	0.000007	0.003507
Indium	0.000638	0.057089	0.000638	0.049417
Iron	0.197090	113.880000	0.197090	94.734000
Lanthanum	0.000461	0.266230	0.000461	0.221590
Lead	0.000245	0.046807	0.000245	0.039339
Magnesium	0.274490	124.400000	0.274490	103.200000
Manganese	0.002919	1.639300	0.002919	1.363800
Mercury	0.000477	0.010566	0.000477	0.007376
Molybdenum	0.000036	0.020932	0.000036	0.017435
Nickel	0.002342	0.784180	0.002342	0.642040
Palladium	0.000106	0.009515	0.000106	0.008236
Phosphorus	0.007816	4.467100	0.007816	3.717500
Potassium	0.053889	31.161000	0.053889	25.929000
Rubidium	0.000000	0.000000	0.000000	0.000000
Scandium	0.000026	0.014909	0.000026	0.012398
Selenium	0.000243	0.003273	0.000243	0.002725
Silicon	0.006696	0.599430	0.006696	0.518870
Silver	0.000107	0.010120	0.000107	0.008779
Sodium	0.003747	2.050700	0.003747	1.703600
Strontium	0.000719	0.300200	0.000719	0.247840
Thorium	0.000136	0.078401	0.000136	0.065278
Tin	0.000000	0.000000	0.000000	0.000000
Titanium	0.010161	5.859700	0.010161	4.878700

Table 11.4.III-37 Comparison of Regional Baseline Case and Application Case for 24-hour Metal Predictions (continued)

Parameter	Including Development Area		Excluding Development Area	
	Baseline Case Maximum 24-Hour Concentration ($\mu\text{g}/\text{m}^3$)	Application Case Maximum 24-Hour Concentration ($\mu\text{g}/\text{m}^3$)	Baseline Case Maximum 24-Hour Concentration ($\mu\text{g}/\text{m}^3$)	Application Case Maximum 24-Hour Concentration ($\mu\text{g}/\text{m}^3$)
Tungsten	0.000001	0.000654	0.000001	0.000544
Uranium	0.000010	0.005741	0.000010	0.004778
Vanadium	0.000333	0.192230	0.000333	0.159970
Yttrium	0.000000	0.001501	0.000000	0.000155
Zinc	0.000872	0.140030	0.000872	0.119070
Zirconium	0.000000	0.006454	0.000000	0.000667

$\mu\text{g}/\text{m}^3$ = micrograms per cubic metres.

Table 11.4.III-38 Comparison of Regional Baseline Case and Application Case for Annual Metal Predictions

Parameter	Including Development Area		Excluding Development Area	
	Baseline Case Annual Average Concentration (µg/m³)	Application Case Annual Average Concentration (µg/m³)	Baseline Case Annual Average Concentration (µg/m³)	Application Case Annual Average Concentration (µg/m³)
Aluminum	0.008773	6.381600	0.008773	5.623200
Antimony	0.000000	0.000236	0.000000	0.000207
Arsenic	0.000006	0.000646	0.000006	0.000569
Barium	0.000192	0.130580	0.000192	0.115110
Beryllium	0.000002	0.000014	0.000002	0.000009
Bismuth	0.000000	0.000069	0.000000	0.000061
Boron	0.000012	0.008531	0.000012	0.004568
Bromine	0.000000	0.000000	0.000000	0.000000
Cadmium	0.000071	0.007744	0.000071	0.006871
Calcium	0.003898	2.497700	0.003898	2.202600
Chromium	0.000105	0.054230	0.000105	0.047845
Cobalt	0.000025	0.010721	0.000025	0.009476
Copper	0.000026	0.009037	0.000026	0.007989
Gallium	0.000015	0.004863	0.000015	0.004307
Gold	0.000001	0.000443	0.000001	0.000390
Indium	0.000061	0.007676	0.000061	0.006803
Iron	0.016488	11.971000	0.016488	10.548000
Lanthanum	0.000036	0.027996	0.000036	0.024659
Lead	0.000022	0.005194	0.000022	0.004598
Magnesium	0.023551	13.050000	0.023551	11.514000
Manganese	0.000254	0.172540	0.000254	0.152070
Mercury	0.000020	0.000519	0.000020	0.000373
Molybdenum	0.000003	0.002203	0.000003	0.001939
Nickel	0.000176	0.092878	0.000176	0.071681
Palladium	0.000010	0.001279	0.000010	0.001134
Phosphorus	0.000630	0.469910	0.000630	0.413990
Potassium	0.004325	3.276000	0.004325	2.886000
Rubidium	0.000000	0.000000	0.000000	0.000000
Scandium	0.000002	0.001567	0.000002	0.001381
Selenium	0.000012	0.000347	0.000012	0.000306
Silicon	0.000643	0.080599	0.000643	0.071433
Silver	0.000010	0.001338	0.000010	0.001195
Sodium	0.000343	0.215270	0.000343	0.189860
Strontium	0.000060	0.035513	0.000060	0.027663
Thorium	0.000010	0.008247	0.000010	0.007262
Tin	0.000000	0.000000	0.000000	0.000000
Titanium	0.000755	0.616390	0.000755	0.542790

Table 11.4.III-38 Comparison of Regional Baseline Case and Application Case for Annual Metal Predictions (continued)

Parameter	Including Development Area		Excluding Development Area	
	Baseline Case Annual Average Concentration ($\mu\text{g}/\text{m}^3$)	Application Case Annual Average Concentration ($\mu\text{g}/\text{m}^3$)	Baseline Case Annual Average Concentration ($\mu\text{g}/\text{m}^3$)	Application Case Annual Average Concentration ($\mu\text{g}/\text{m}^3$)
Tungsten	0.000000	0.000069	0.000000	0.000061
Uranium	0.000001	0.000604	0.000001	0.000532
Vanadium	0.000026	0.020211	0.000026	0.017804
Yttrium	0.000000	0.000217	0.000000	0.000020
Zinc	0.000086	0.016605	0.000086	0.014793
Zirconium	0.000000	0.000931	0.000000	0.000085

$\mu\text{g}/\text{m}^3$ = micrograms per cubic metres.

11.4.III.5 REFERENCES

11.4.III.5.1 LITERATURE SITED

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11.4.III.5.2 INTERNET SITES

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