7   AIR QUALITY

7.1   SCOPE OF ASSESSMENT

7.1.1   Terms of Reference

This is the air quality component of the environmental assessment

The De Beers Canada Mining Inc. (De Beers) Snap Lake Diamond Project environmental assessment (EA) has been prepared for the Mackenzie Valley Environmental Impact Review Board (MVEIRB).   This air quality assessment section constitutes the air component of the EA.

Terms of Reference are summarized in Table 7.1-1

The air quality assessment provides the information required by the Snap Lake Diamond Project EA Terms of Reference. Table 7.1-1 summarizes the MVEIRB requirements listed in the Terms of Reference regarding the air quality components. The information included in this air quality assessment is also based on the input and feedback provided by the MVEIRB and Environment Canada. Section 2.6.1 of the Terms of Reference also includes climate which is addressed in Hydrology (Section 9.3); terms related to climate are not included in Table 7.1-1.

Table 7.1-1   Terms of Reference for Air Quality

TOR Section	Environmental Assessment or Topic
2.5.2	**Description of the Existing Environment…**
	All existing reports and documents shall be appropriately referenced. De Beers will be expected to clearly and succinctly describe the following environmental components, as they relate to the proposed development: I. air and climate; …
2.6.1	**Air Quality and Climate**
	Report the impacts of the proposed development on air quality. The analysis should include a discussion of measures considered to minimize the release of air contaminants (dust, particulate exhaust fumes, and other air contaminants)…. The analysis should also include: I. atmospheric dispersion of emissions on a local and regional scale; II. greenhouse gas emissions including, but not limited to, CO_2 and CH_4, and All green house gas accounting should be done in CO2 equivalent values; III. acid deposition and impact of the acidic precipitation resulting from release of gasses such as NO_X and So_X; and IV. impact on biological receptors such as vegetation and wildlife;

Source: Terms of Reference and Work Plan for the Environmental Assessment of the De Beers Canada Mining Inc. Snap Lake Diamond Project, September 20, 2001 Issued by: Mackenzie Valley Environmental Impact Review Board (MVEIRB).

The effect of air quality changes on land and water are included in other sections

The air quality impact analysis focuses on determining changes to the chemical composition of the air and not on the effect that these changes may have on the receiving environment such as water. Thus, the air component provides the initial results for the evaluation of effects of project emissions on biological

receptors (Item IV in Table 7.1-1). The effects of changes in air quality and deposition to the receiving environment have been completed in the sections dealing with the individual components. Specifically, effects are evaluated in Water Quality (Section 9.4), Aquatic Organisms and Habitat (Section 9.5), Terrestrial Resources (Section 10), and Environmental Health (Section 11).

7.1.2   Component Description and Organization

The air component consists of seven sections

The air component of the EA includes the scope of assessment (Section 7.1), baseline (Section 7.2), impact assessment (Section 7.3), mitigation and monitoring (Section 7.4), conclusions (Section 7.5), references (Section 7.6), units, acronyms, and glossary (Section 7.7). The cumulative effects assessment is provided in Section 12. Further detail on Sections 7.1 to 7.4 is provided below.

The approach and methods are provided in Section 7.1

Section 7.1 of the EA provides the introductory information needed to understand the scope and methods of the assessment, and includes the following:

- the Terms of Reference;
- the assessment approach including the derivation of key questions, the assessment cases, and the project phases;
- the rationale for the selection of the study area;
- a summary of the regulatory criteria for air quality compounds;
- modelling and other methods used in the analysis of impacts; and,
- the method used to classify residual impacts.

Baseline conditions are provided in Section 7.2

Section 7.2 summarizes the baseline conditions providing an environmental setting, and includes the following:

- a summary of the local meteorology and air quality monitoring in the vicinity of Snap Lake; and,
- a summary of the available emissions data for the region. The regional climate is described in Hydrology (Section 9.3).

Air quality impacts due to the Snap Lake Diamond Project are evaluated in Section 7.3

Section 7.3 of the EA defines air quality impacts associated with the Snap Lake Diamond Project, and includes the following:

- a detailed summary of the atmospheric emissions associated with the Snap Lake Diamond Project including both construction and operation;

- dispersion model predictions of ambient (*i.e.*, present in the surrounding environment) concentrations and deposition patterns associated with Snap Lake Diamond Project operations; and,

- an evaluation of the air quality impacts associated with emissions from the Snap Lake Diamond Project.

Mitigation and monitoring is outlined in Section 7.4

Section 7.4 of the EA summarizes the mitigation measures incorporated into the design and planned operations of the Snap Lake Diamond Project. The section also includes a summary of the planned air monitoring.

7.1.3   Assessment Approach

7.1.3.1   Key Issues and Key Questions

Total suspended particulates (TSP) and fine particulate matter (PM$_{10}$ and PM$_{2.5}$) are important air issues

Several key air quality parameters have been assessed as part of the EA. An important air quality parameter associated with the Snap Lake Diamond Project is the total suspended particulate (TSP) matter and two subsets of TSP, the fine particles, commonly referred to as PM$_{10}$ and PM$_{2.5}$. The term TSP refers to small airborne particles that are smaller than 30 micrometres (microns) in diameter. Fine particulate matter PM$_{10}$ refers to particles that are 10 microns or smaller in diameter (about one-eighth the width of a human hair). PM$_{10}$ particles can reach lungs and are considered as inhalable particles. The smaller the particle, as a rule, the deeper into the lungs it can be inhaled. Fine particles less than 2.5 micron (PM$_{2.5}$), known as respirable particles, are able to reach deeper into the respiratory tract and may have greater deleterious health impacts than the coarser PM$_{10}$ particles. The Northwest Territories (NWT) currently has a standard for TSP.

SO$_2$, NO$_X$, and PAI are included

Other parameters that have been assessed in the air quality assessment include sulphur dioxide (SO$_2$), oxides of nitrogen (NO$_X$), and the deposition of acid-forming compounds, expressed as potential acid input (PAI). The deposition of acid-forming compounds on soils or lakes can have a direct effect on their chemistry (assessed in Sections 9.4, 9.5, and 10.3).

Polycyclic aromatic hydrocarbons (PAHs) and metals are also included

In addition, trace air compounds including polycyclic aromatic hydrocarbon (PAH) compounds and trace metals have been evaluated and modelled for use by other disciplines. The potential impacts of these compounds on environmental health, vegetation, and fisheries will be assessed in other sections of the EA.

The greenhouse gas potential of the project will be assessed

While there are no criteria for emissions of greenhouse gases (GHG), this issue is important to the regulators, stakeholders, and De Beers. GHG emissions have been linked with global warming. Therefore, the air quality evaluation of the Snap Lake Diamond Project includes an evaluation of the

emissions from combustion sources at the Snap Lake Diamond Project. The emissions of GHG from the combustion sources include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). These three compounds are the only GHG associated with the project.

Key questions are derived

The air quality issues associated with the Snap Lake Diamond Project have been summarized in a series of key questions, as detailed in Table 7.1-2.

Table 7.1-2   Key Questions for Air Quality

Number	Key Question
AQ-1	What impacts will air emissions from the Snap Lake Diamond Project have on air quality?
AQ-2	What impacts will air emissions from the Snap Lake Diamond Project have on the deposition of acid forming compounds?
AQ-3	What air quality impacts will result from construction activities at the Snap Lake Diamond Project?
AQ-4	What impacts will the Snap Lake Diamond Project have on visibility near Snap Lake?
AQ-5	What impacts will the Snap Lake Diamond Project have on the production and management of greenhouse gas emissions?

7.1.3.2   Assessment Cases

The three assessment cases include baseline, application (Snap Lake Diamond Project), and cumulative effects assessment (CEA)

In order to evaluate the potential air quality impacts associated with the Snap Lake Diamond Project, the following three sets of information have been provided:

- The **baseline** case describes the current environmental setting, against which changes in the environment from the Snap Lake Diamond Project could be assessed. As there are no approved developments within the regional study area (RSA), the baseline case focusses on summarizing the available monitoring data gathered at the Snap Lake Diamond Project.

- The **application** case represents the air quality impact predicted to occur from the emissions associated with the Snap Lake Diamond Project. This case is based on the level of emissions when the project is fully developed and the activities at the mine site will be at a maximum.

- The **cumulative effect assessment** (CEA) case presents the predicted ambient air quality in the region at some future date. It includes an assessment of the cumulative air quality impacts from the Snap Lake Diamond Project in combination with other existing, approved, or reasonably foreseeable developments in the region. The CEA assessment case is presented in Section 12.

7.1.3.3   Temporal Considerations

The three cases represent the maximum emission levels

Although the baseline case represents the current conditions at Snap Lake, neither the application nor CEA cases represent fixed points in time. Both cases represent the ultimate emission levels that could occur when the following occur:

- the application case represents the conditions when the Snap Lake Diamond Project is fully operational; and,

- the CEA case represents the conditions when the approved, reasonably foreseeable, and Snap Lake Diamond Project all reach their full operating capacities.

7.1.4   Study Area

The air component will have one study area, the regional study area (RSA)

For environmental studies, it is often desirable to establish both a local study area (LSA) and a regional study area (RSA). The air quality impact assessment for the Snap Lake Diamond Project will use one study area, the RSA, due to the mobility of air. Although there are no physical barriers to the movement of atmospheric pollutants, there are numerous practical limitations that require us to delineate an RSA that can be evaluated as part of the EA process.

A regional study area is typically defined by a geometric form (e.g., circle or rectangle)

Two of the typical approaches used to define the air quality RSA include:

- a circular area surrounding the mine site which would cover areas where concentrations from the project emissions are expected to exceed some threshold; and,

- a rectangular area large enough to enclose areas where concentrations from the project emissions are expected to exceed some threshold.

These definitions do not incorporate the complexity of air dispersion

These approaches, however, do not recognize the complex processes involved in the transport or dispersion of air compounds in the atmosphere. To incorporate these aspects into the selection of the RSA, it is necessary to combine local meteorological data with an understanding of the way in which atmospheric dispersion models work.

The size of the regional study area is based on the distance pollutants can travel in one hour

The majority of dispersion models used for the evaluation of emissions in the NWT are based on the solution of the Gaussian dispersion formula. These models predict the hourly downwind concentrations for each hour of available meteorological data. These models rarely track the dispersion of compounds during the subsequent hours. Therefore, it is logical to define

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the size of the RSA for air quality study on the basis of the distance these compounds can travel in a single hour.

The regional study area is defined by 99% of observed wind speeds in 16 cardinal (22.5º) downwind directions

For the Snap Lake Diamond Project, wind speed and direction data collected at the mine site since March 1998 were used to define the RSA for the air quality impact study. These data were sorted into 16 cardinal downwind directions (these are the same 22½° sectors of a windrose described in Section 7.2.2.1 and shown in Figure 7.2-2). The dimension of the RSA in each of these directions was based on the 99th percentile of the observed wind speeds. This method covers virtually all of the conditions observed at the site while avoiding the effect of unusual and extreme events.

Regional study area dimensions summarized

Table 7.1-3 summarizes the resulting RSA dimensions for each of the 16 cardinal directions considered in defining the RSA.

Table 7.1-3   Resulting Air Quality Regional Study Area Dimensions for the 16 Cardinal Downwind Directions

Direction	Distance [km]
N	30.85
NNE	33.83
NE	36.31
ENE	38.91
E	33.29
ESE	40.43
SE	37.68
SSE	38.28
S	37.66
SSW	37.09
SW	45.67
WSW	48.71
W	45.54
WNW	40.30
NW	33.82
NNW	28.96

The regional study area extends 29 to 49 km from the site

The resulting area extends between 29 and 49 km from the site, depending on the direction. The RSA is presented graphically in Figure 7.1-1 to demonstrate areas included in the air quality impact assessment. The figure shows that the air quality RSA is of sufficient size to include maximum predicted contaminant concentrations for combined emissions from the project, and existing and publicly disclosed developments in the area. Further, the air quality RSA covers all of the wildlife RSA, portions of McKay Lake and the most likely migration corridors for caribou and other wildlife (see also Sections 10.4 and 11).

Figure 7.1-1   Regional Study Area for Air Quality Assessment

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7.1.5   Assessment Methods

7.1.5.1   Criteria Compounds

Criteria have been established for five air compounds included in the environmental assessment

The impact of air emissions introduced into the atmosphere by industrial activities can be broad. The emissions can have direct and indirect effects on humans, animals, vegetation, soil, and water. For these reasons, environmental regulatory agencies have established ambient air concentration limits for a range of air quality compounds. These compounds are typically referred to as "criteria compounds". The air quality impact assessment of the Snap Lake Diamond Project will assess the following five criteria compounds (Table 7.1-4).

Table 7.1-4   Criteria Compounds Assessed for the Snap Lake Diamond Project

Compound	Description
Sulphur dioxide (SO_2)	Fuels contain amounts of sulphur. During combustion, sulphur is transformed into SO_2, which plays an important role in acid deposition.
Nitrogen oxides (NO_X)	The combustion of fuel results in the emissions of oxides of nitrogen (NO_X). These emissions are a mixture of nitric oxide (NO) and nitrogen dioxide (NO_2). Nitric oxide (NO) is an unstable component which rapidly reacts with oxygen to form nitrogen dioxide (NO_2). Nitrogen oxides play an important role in acid rain and ground-level ozone level.
Total suspended particulate (TSP) matter	Total suspended particulates (TSP) is the fraction of airborne particulates that will remain airborne after their release in the atmosphere. The average diameter is nominally of 30 μm (micrometres) and below.
Inhalable particulate matter (PM_{10})	The emphasis in evaluating airborne particulate matter has shifted in the last ten years from assessing the total airborne particles to the smaller particles that have been linked to human health effects. These fine particles, which are 10 micrometre (micron) or smaller in diameter (about one-eighth the width of a human hair) are referred to as inhalable particles. The PM_{10} portion of the emissions from the Snap Lake Diamond Project represents a subset of the TSP emissions and not a separate compound. All of the PM_{10} emitted from the facility is included in the TSP emissions.
Respirable particulate matter ($PM_{2.5}$)	Recent studies have indicated that the fine particles less than 2.5 microns in diameter ($PM_{2.5}$), known as respirable particles, which are able to reach deeper into the respiratory tract may have greater health impacts than the coarser particles. This has resulted in the category of particulate matter called $PM_{2.5}$ (particles that are nominally smaller than 2.5 μm in diameter). $PM_{2.5}$ is often referred to as respirable particulate matter since it is of a size that can readily enter the lower respiratory tract. Like PM_{10}, $PM_{2.5}$ represents a subset of the TSP and PM_{10} emissions and not a separate compound. All of the $PM_{2.5}$ emitted from the facility is included in the TSP emissions.

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7.1.5.1.1   NWT Air Quality Standards

Maximum ambient concentrations of TSP and SO$_2$ have been established for the NWT

The Department of Resources, Wildlife and Economic Development (RWED) of the Northwest Territories (NWT) administers two environmental protection statutes: the Environmental Protection Act and the Pesticide Act. The guideline entitled "Guideline Respecting Ambient Air Quality Standards for Sulphur Dioxide and Total Suspended Particulate in the Northwest Territories" (GNWT 1994) has been established under the Environmental Protection Act. This document establishes the maximum ambient levels of TSP and SO$_2$ considered to be acceptable in the NWT.

Road dust can be mitigated, but dust suppressants must be approved

In addition to the point sources of particulate emissions to the atmosphere, there are several non-point sources of TSP including road dust. The amount of dust generated from roads around the mine site can be mitigated or minimized by using dust suppressants. The Environmental Protection Division, RWED regulates the application of dust suppressants in the NWT. Only approved products are permitted to be used as dust suppressants.

Wastes suitable for open burning are regulated

The Environmental Protection Division of the NWT also regulates open burning of municipal solid wastes. Under the regulation, solid wastes suitable for open burning are paper products, paperboard packaging, and untreated wood wastes. This regulation also applies to camp wastes.

7.1.5.1.2   Federal Objectives and Standards

Federal ambient air quality objectives stipulate maximum desirable, acceptable, and tolerable levels

The Federal Government has also established three levels of ambient air quality objectives (Environment Canada 1981) for a range of criteria compounds. 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 a concentration of an air contaminant that requires abatement (mitigation) without delay to avoid further deterioration to an air quality that endangers the prevailing Canadian lifestyle or ultimately, to an air quality that poses a substantial risk to public health.

NO$_2$ and SO$_2$ objectives have been reviewed recently

These air quality objectives have been regularly reviewed by the joint federal provincial groups to determine if they are still meeting the original purpose. Recent review of the NO$_2$ and SO$_2$ objectives confirmed that the objectives are still appropriate (FPACAQ 1987a,b).

7.1.5.1.3   Canada-Wide Standards

The Canada-Wide Standards include a standard for PM$_{2.5}$

The Canadian Council of Ministers of the Environment (CCME), under an agreement on the harmonization of environmental regulations across Canada, has established a sub-agreement for the creation of Canada-Wide Standards with respect to the environment (including air quality). 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 compounds for which Canada-Wide Standards have been adopted include PM$_{2.5}$ on a 24-hour average period.

The Canada-Wide Standards do not have any legal standing in the NWT

The Canada-Wide Standards do not have any legal standing. Each jurisdiction participating in the *Harmonization Accord* will implement the standards under existing provincial legislation, or by drafting new legislation. Under the Canada-Wide Standards process, each jurisdiction is committed to the following:

- stating their course of action regarding each of the Canada-Wide Standards;

- developing an implementation plan for achieving the standard; and,

- publicly reporting their progress.

However, this standard will be used in the environmental assessment

Since the NWT has yet to adopt its own PM$_{2.5}$ guidelines or standards, the Canada-Wide Standards criteria will be used for assessing the predicted PM$_{2.5}$ levels from the Snap Lake Diamond Project.

7.1.5.1.4   Summary of Regulatory Criteria for Ambient Air Quality

Relevant air quality criteria are summarized in Table 7.1-5

Table 7.1-5 presents a summary of the applicable ambient air quality criteria for the six criteria air compounds evaluated as part of the air quality assessment for the Snap Lake Diamond Project. The values presented in the table include standards for the NWT, Canada-Wide Standards, federal ambient air quality objectives, and other relevant guidelines. For some compounds (*i.e.*, PM$_{10}$ and PM$_{2.5}$), United States Environmental Protection Agency (U.S. EPA) standards have been included as these were the only North American Standards available and are widely used. The criteria

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compounds listed in the table include SO_2, NO_2, TSP, PM_{10}, and $PM_{2.5}$. The listed criteria refer to averaging periods ranging from one hour to one year.

Table 7.1-5   Relevant Ambient Air Quality Criteria

Parameter	NWT Standards[a]	Canada-Wide Standards[b]	Federal Air Quality Objectives[c]			Other Criteria
			Desirable	Acceptable	Tolerable	
SO_2 [µg/m³]						
1-Hour	450	—[d]	450	900	—	—
24-Hour	150	—	150	300	800	—
Annual	30	—	30	60	—	—
NO_2 [µg/m³]						
1-Hour	—	—	—	400	1,000	—
24-Hour	—	—	—	200	300	—
Annual	—	—	60	100	—	—
TSP [µg/m³]						
24-Hour	100	—	—	120	400	—
Annual[e]	60	—	60	70	—	—
PM_{10} [µg/m³]						
24-Hour	—	—	—	—	—	50[f][g]
Annual	—	—	—	—	—	60[g]
$PM_{2.5}$ [µg/m³]						
24-Hour[h]	—	30	—	—	—	65[h]
Annual[h]	—	—	—	—	—	15[h]

[a] Source: GNWT 1994.

[b] Source: CCME 2000.

[c] Source: Environment Canada 1981.

[d] "—" = not applicable.

[e] As a geometric mean.

[f] Newfoundland, Ontario and BC have established a 24-hour PM_{10} guideline of 50 µg/m³.

[g] U.S. EPA primary PM_{10} standards are 150 µg/m³ for 24 hours and 60 µg/m³ annually (U.S. Government 1998).

[h] U.S. EPA primary $PM_{2.5}$ standards are 65 µg/m³ for 24 hours and 15 µg/m³ annually (U.S. Government 1998).

7.1.5.2   Deposition Criteria

Acid deposition of sulphur and nitrogen can affect soils and water

The deposition of acid forming compounds has been a concern in Europe and North America for a number of years. Initially, the focus was placed on limiting the emissions of sulphur dioxide from large industrial sources. However, the current understanding of acid deposition has expanded the evaluation to include the deposition of sulphur and nitrogen compounds that can result in long-term accumulations that have been associated with the acidification of soil and water. Evaluation of acid deposition has shifted from a purely source-based approach to one that considers the sensitivity of the affected ecosystem in combination with the emissions.

The Europeans have developed a loading approach which includes acid deposition and ecological sensitivity

The system developed in Europe used a loading approach, which combines acid deposition expressed as potential acid input (PAI) and ecosystem sensitivities. The concepts of critical loads, target loads, and monitoring loads have been defined as follows:

- The **critical load** is defined as being the highest load that will not cause chemical changes leading to long-term harmful effects on the most sensitive ecological systems.

- The **target load** is defined as the maximum level of atmospheric deposition that provides long-term protection from adverse ecological consequences, and is practically and politically achievable.

- The **monitoring load** is the level of deposition predicted or estimated by a dispersion model that will trigger monitoring and/or research action.

Alberta is the first Canadian jurisdiction to adopt critical loads

Alberta is the first jurisdiction in Canada to adopt the critical loading system based on PAI. The basis for the recommendation was the belief that sensitive soils in Alberta would be no more sensitive to acid deposition than are the soils in Europe. The Target Loading subgroup of the Clean Air Strategic Alliance in Alberta (CASA) has set out critical loads of 0.25 keq/ha/yr for highly sensitive soils, 0.5 keq/ha/yr for moderately sensitive soils, and 1.0 keq/ha/yr for soils with low sensitivity (CASA 1999). The system used in Alberta includes consideration of the wet (*i.e.*, by precipitation) and dry (*i.e.*, directly falling on a surface) deposition of sulphur and nitrogen.

Critical loads for potential acid input will be used for the Snap Lake Diamond Project

Table 7.1-6 summarizes the various deposition criteria established over the last 18 years. For the purposes of evaluating acid deposition associated with the Snap Lake Diamond Project, PAI and the critical loads adopted in Europe and Alberta will be used. PAI is the most comprehensive measure of acid deposition since it includes wet and dry deposition of both nitrogen and sulphur. Other measures of acid deposition focus on only some of these.

7.1.5.3   Air Modelling Approach

The selection of a numerical air dispersion model was based on five criteria

In order to predict concentration and deposition patterns from the Snap Lake Diamond Project, a numerical air dispersion model was required. A suitable dispersion model must be able to do the following:

- evaluate the various emission source types present in the region, such as point, area, and volume sources;

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- predict the necessary pollutant concentrations;

- employ the latest principles regarding atmospheric dispersion of contaminants;

- incorporate assumptions and formulations that have undergone rigorous and independent scrutiny; and,

- generate model predictions consistent with local observations.

Table 7.1-6   Deposition Criteria for Acid Forming Emissions

Parameter	Criteria[a]	Reference
Wet sulphate deposition	20 kg/ha/yr	United States-Canada Memorandum of Intent (1983)
Acidifying potential (AP)	0.12 to 0.31 keq/ha/yr	Interim Acid Deposition Critical Loadings Task Group (1990)
Effective acidity (EA)	0.1 to 0.7 keq/ha/yr depending on soil sensitivity	Peake and Fong (1992)
Acid neutralizing capacity (ANC)	0.25 to 1.5 keq/ha/yr depending on ecosystem	World Health Organization (1994)
Potential acid input (PAI)	0.25 keq/ha/yr highly sensitive ecosystems	CASA (1999)
	0.50 keq/ha/yr moderately sensitive ecosystems	
	1.00 keq/ha/yr ecosystems with low sensitivity	

[a] Does not include dry deposition or NO_X precursors.

[b] Does not include dry deposition or NO_X precursors. $AP = [SO_4^{2-}] - ([Ca^{2+}] + [Mg^{2+}])$.

[c] Various forms account for wet and dry deposition and NO_X precursors. Accounts for soil response to deposition. $EA = [H^+] + 1.15 [NH_4^+] - 0.7 [NO_3^-] + [SO_2] + [SO_4^{2-}]$.

[d] Includes wet and dry deposition of all components. $ANC = ([Ca^{2+}] + [Mg^{2+}] + [K^+] + [Na^+]) - ([SO_4^{2-}] + [NO_3^-] + [NH_4^+] + [Cl^-])$.

Both the ISC3 and CALPUFF dispersion models meet the criteria

A review of available atmospheric dispersion models identified two models suitable for assessing the air quality impacts associated with the Snap Lake Diamond Project. Both the Industrial Source Complex (ISC3) and CALPUFF dispersion models were developed by the United States Environmental Protection Agency (U.S. EPA), and have had a long history of usage and have undergone rigorous testing. In addition, both models have been widely accepted by regulators in Canada. Both the ISC3 and CALPUFF models incorporate useful features, such as the following:

- simulation of dispersion from multiple sources;

- simulation of the effects of buildings and structures;

- assimilation of meteorological data from the closest suitable station;

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- ability to predict 1-hour, 24-hour, and annual concentrations; and,

- ability to incorporate topographic effects.

However, the CALPUFF model is capable of meeting additional requirements of this environmental assessment

However, the modelling completed for the Snap Lake Diamond Project require capabilities that were only available in the CALPUFF model. These included the following capabilities:

- to simulate the chemical transformation of sulphur and nitrogen compounds required for predicting acid deposition;

- to predict both wet and dry deposition of acid forming compounds; and,

- to predict ambient concentrations and deposition patterns close to the facility as well as at distances in excess of 50 km from the site.

The CALPUFF model was used for all simulations

Rather than model some of the compounds using the ISC3 model and the remaining compounds using CALPUFF, the CALPUFF model was used to simulate all of the concentration and deposition values presented in the air quality assessment.

7.1.5.3.1 CALPUFF Dispersion Model

CALPUFF has been reviewed extensively and found suitable by U.S. agencies

The steady-state (2-D) version of the CALPUFF dispersion model was determined to be the best model for assessing the air emissions from the Snap Lake Diamond Project. This modelling system has been reviewed extensively by the Interagency Workgroup on Air Quality Modelling (IWAQM 1998) which consists of representatives from the U.S. EPA, U.S. Forest Service, U.S. National Park Service, and the U.S. Fish and Wildlife Service. This working group is responsible for making recommendations on modelling approaches suitable for estimating concentrations of compounds in air at Class I areas in the United States.

The CALPUFF system consists of a meteorological model, a transport and dispersion model, and an output program

The CALPUFF system consists of three major components:

- CALMET is a meteorological model that develops hourly wind and temperature fields on a three-dimensional gridded modelling domain.

- CALPUFF is a transport and dispersion model that advects "puffs" of material emitted from modelled sources, simulating dispersion and transformation processes.

- CALPOST is a program that takes the output of CALPUFF and provides usable concentrations and deposition rates.

7.1.5.3.2   Model Limitations

Dispersion models have limited capability to replicate individual events and hourly variations

Numerical dispersion models simplify small-scale atmospheric motions and turbulence, which limits their capability to replicate individual events. Therefore, these models must predict concentration and deposition patterns for a given set of meteorological parameters. Furthermore, the modelling cannot deal with hour-to-hour variations in the emission rates that may occur during the life of the project.

7.1.5.3.3 NO_X to NO_2 Conversion Methods

NO_X includes nitric oxide (NO) and nitrogen dioxide (NO_2)

The oxides of nitrogen (NO_X) that are emitted from industrial facilities, automobiles, and other combustion sources are a mixture of nitric oxide (NO) and nitrogen dioxide (NO_2). Nitric oxide (NO) is an unstable component which rapidly reacts with oxygen to form nitrogen dioxide (NO_2).

The fraction of NO that is converted to NO_2 is estimated in two steps

Currently the NWT does not have an established protocol for determining the fraction of the NO that is converted to NO_2. On recent applications in the NWT (*e.g.*, Paramount Cameron Hills Project), Environment Canada has identified that the most reasonable approach is to follow the guidance provided by Alberta Environment (AENV 2000). This approach, which was confirmed as being appropriate for this EA (Dave Fox, Environment Canada, pers. comm.), involves two steps. The initial, conservative step assumes that all of the emitted NO_X is converted to NO_2. Should this approach yield numbers that are above the relevant criteria, then the NO_X predictions should be converted to NO_2 using the ozone limiting method (OLM). The OLM assumes that approximately 10% of the NO_X emissions are in the form of NO_2, with the balance being in the form of NO. The NO is assumed to rapidly react with ambient levels of ozone (O_3) to form additional NO_2. The following OLM formulation is based on the work of Cole and Summerhays (1979):

$$[NO_2] = [O_3] + 0.1 \times [NO_X]$$

Where:

[*NO_2*]   is the nitrogen dioxide concentration [ppm];

[*O_3*]   is the ambient ozone concentration [ppm]; and,

[*NO_X*]   is the concentration of oxides of nitrogen [ppm].

Assumed values for ambient ozone concentrations may be used in the ozone limiting method

Since no site-specific ozone data are available, Environment Canada have indicated that the following ozone values should be used:

- for converting hourly NO_X concentrations   50 ppb;

- for converting daily NO_X concentrations   40 ppb; and,

- for converting annual NO_X concentrations   35 ppb.

7.1.5.3.4 *Background Levels of Acid-Forming Compounds*

Wet and dry deposition, expressed as keq/ha/yr, is associated with acidification

Deposition, including both wet and dry processes, can result in the long-term accumulation of compounds in aquatic and terrestrial ecosystems. Wet processes involve the removal of emissions by precipitation. Dry processes are emission removal by direct contact with surface features (*e.g.*, vegetation). Both wet and dry deposition values, expressed as a flux, are in units of "kg/ha/yr." Because estimates of deposition include several chemical forms of nitrogen, sulphur, and base cations (*i.e.*, positively charged alkaline earth metals), the flux is expressed as "keq/ha/yr", where "keq" refers to the number of equivalent hydrogen ions (1 keq = 1 kmol H^+). For sulphur compounds, each molecule is equivalent to two hydrogen ions. Each molecule of a nitrogen compound is equivalent to one hydrogen ion. The deposition of sulphur and nitrogen compounds has been associated with changes in water and soil chemistry, and with the acidification of water and soil.

Acidic input is measured as potential acid input (PAI)

Potential acid input (PAI) has become the preferred measure of acidic input for Alberta Environment since it incorporates the following:

- the effects of both nitrogen and sulphur compounds;

- the impacts of both dry and wet deposition mechanisms; and,

- the effect of base cations in mitigating acidity.

PAI will be dominated by wet deposition

In areas with numerous sources of SO_2 and NO_X emissions, the wet and dry deposition will contribute equally to PAI. In remote areas like Snap Lake, however, the acid deposition will be dominated by wet deposition.

PAI includes deposition of sulphur compounds, nitrogen compounds, and base cations according to the calculations shown

Calculation of the PAI involves the wet and dry deposition of sulphur compounds (*e.g.*, SO_2 gas, SO_4^{2-} particle), nitrogen compounds (*e.g.*, NO gas, NO_2 gas, HNO_3 gas, NO_3^- particle), and base cations (*e.g.*, Ca^{2+} particle, Mg^+ particle and K^+ particle). The steps for completing the calculations are as follows:

- The potential acid input, resulting from sulphur compounds, derives from the annual rates of sulphur deposition (expressed as kg/ha/yr). This is 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:

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

- The potential acid input, resulting from nitrogen compounds, derives from the annual rates of nitrogen deposition (expressed as kg/ha/yr). This is converted to keq/ha/yr by dividing the predicted deposition by the molecular weight, and multiplying by the hydrogen ion equivalents, as follows:

$$PAI_{nitrogen} = \frac{\left([NO]_{dep,wet} + [NO]_{dep,dry}\right)}{30} + \frac{\left([NO_2]_{dep,wet} + [NO_2]_{dep,dry}\right)}{46} \ldots$$
$$\ldots + \frac{\left([HNO_3]_{dep,wet} + [HNO_3]_{dep,dry}\right)}{47} + \frac{\left([NO_3^-]_{dep,wet} + [NO_3^-]_{dep,dry}\right)}{52}$$

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

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

In this equation, the PAI$_{back}$ accounts for the background sulphur, nitrogen, and base cations. The calculation used to establish the background PAI in the region is:

$$PAI_{back} = PAI_{wet,back} + \frac{[SO_2]_{back,dry} \times 2}{64} + \frac{[SO_4^{2-}]_{back,dry} \times 2}{96} \ldots$$
$$\ldots + \frac{[NO]_{dep,dry}}{30} + \frac{[NO_2]_{dep,dry}}{46} + \frac{[HNO_3]_{dep,dry}}{47} + \frac{[NO_3^-]_{dep,dry}}{52} \ldots$$
$$\ldots - \left(\frac{[Ca^{2+}]_{dep,back} \times 2}{40} + \frac{[Mg^{2+}]_{dep,back} \times 2}{24} + \frac{[K^+]_{dep,back}}{39}\right)$$

Background PAI is calculated from data from representative monitoring stations

The ideal situation would be to determine the background PAI from long term monitoring at the Snap Lake site; however, such data are not available. Background PAI data are available from the monitoring station at Snare Rapids, Northwest Territories. Snare Rapids is the closest station where wet

deposition was available, and provides the most representative information for the conditions at Snap Lake.

Wet background PAI values are presented

The wet background PAI value obtained from the precipitation monitoring completed at Snare Rapids is presented in Table 7.1-7. Since Snap Lake is a remote site, PAI will be dominated by wet deposition. The background PAI value at Snare Rapids of 0.04 keq/ha/yr will be used for assessing acid deposition from the Snap Lake Diamond Project. This value will be added to the PAI values predicted across the study area.

Table 7.1-7 Background PAI Values at Snare Rapids

Parameter	PAI Value[a] [keq/ha/yr]
Wet PAI	0.04

[a] The Snare Rapids, NWT data include monitoring results from 1989 through 1996.

7.1.5.4   Assessment Method

Residual impacts were classified according to direction, magnitude, geographic extent, duration, reversibility, and frequency

The assessment method used for the Snap Lake Diamond Project involves the evaluation of residual impacts. Each impact is first described in terms of the following criteria: direction, magnitude, geographic extent, duration, reversibility, and frequency (including seasonal effects). The direction of impacts may be either positive or negative. Table 7.1-8 details the impact criteria definitions for the air quality component of the Snap Lake Diamond Project EA.

The magnitude or intensity of an impact is classified as negligible, low, moderate, or high based on a comparison with standards or criteria

Magnitude is related to the intensity of the impact rather than the area impacted. (Area is described as geographic extent.) Since magnitude is a measure of the degree of change in a measurement or analysis endpoint, it is specific to air quality predictions and standards. It is classified as negligible, low, moderate, or high. The categorization of the impact magnitude is based on available criteria and professional judgement. The air quality resources evaluated and the magnitude criteria used to evaluate the residual effects are outlined in Table 7.1-9. Generally, the magnitude would be classified as "negligible" when there was no measurable increase predicted as a result of emissions from the Snap Lake Diamond Project. A "low" magnitude would be assigned when an increase was predicted; however, the maximum value remains below the relevant NWT standard or, in the absence of any NWT standard, the lowest available criteria. A "moderate" magnitude would be assigned to parameters that were above the NWT standards (or lowest available criteria), but less than the federal acceptable objectives (in some cases, the U.S. EPA standards were substituted if federal objectives were unavailable). A "high" magnitude would be assigned to all parameters that exceeded the federal acceptable objectives.

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Table 7.1-8   Impact Classification Criteria for the Snap Lake Diamond Project

Direction[a]	Magnitude[b]	Geographic Extent[c]	Duration[d]	Reversibility[e]	Frequency[f]
Positive: a decrease in emissions and/or ambient concentrations **Negative**: an increase in emissions and/or ambient concentrations	**Magnitude**: varies with the air emission compound being evaluated; specifics provided in Table 7.1-10	**Local**: effect restricted to the active mine area and areas within 500 m of the active mine area **Regional**: effect restricted to the RSA **Beyond Regional**: effect extends beyond the RSA	**Short-term**: <3 years **Medium-term**: 3 to 26 years **Long-term**: >26 years	**Reversible (short-term)**: effects can be reversed at closure of the project; **Reversible (long-term)**: effects can be reversed in +100 years; **Irreversible**: effects cannot be reversed.	**Low**: occurs once **Moderate**: occurs intermittently **High**: occurs continuously

Note: The ecological resilience has not been assessed for air quality since air is a pathway or route of exposure. The ecological resilience is more applicable when assessing the receiving environment as discussed in Sections 9.1, 10.1 and 11.1.

[a]   Direction: positive or negative effect for measurement endpoints, as defined for the specific component.

[b]   Magnitude: degree of change to analysis endpoint.

[c]   Geographic Extent: area affected by the impact.

[d]   Duration: length of time over which the environmental effect occurs which is related to the project phase.

[e]   Reversibility: effect on the resource (or resource capability) can be reversed (in the short- or long-term) or cannot be reversed.

[f]   Frequency: how often the environmental effect occurs.

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Table 7.1-9   Magnitude Characterization of Criteria Air Compounds for the Snap Lake Diamond Project

	Magnitude if Maximum is:			
	Negligible	**Low**	**Moderate**	**High**
1-hour SO_2 concentration [µg/m³]	no increase	< 450	< 900	> 900
24-hour SO_2 concentration [µg/m³]	no increase	< 150	< 300	> 300
Annual SO_2 concentration [µg/m³]	no increase	< 30	< 60	> 60
1-hour NO_2 concentration [µg/m³]	no increase	< 400	—	> 400
24-hour NO_2 concentration [µg/m³]	no increase	< 200	—	> 200
Annual NO_2 concentration [µg/m³]	no increase	< 60	< 100	> 100
1-hour CO concentration [µg/m³]	no increase	< 15,000	< 35,000	> 35,000
8-hour CO concentration [µg/m³]	no increase	< 6,000	< 15,000	> 15,000
24-Hour TSP concentration [µg/m³]	no increase	< 100	< 120	> 120
Annual TSP concentration [µg/m³]	no increase	< 60	< 70	> 70
24-Hour PM_{10} concentration [µg/m³]	no increase	< 50	< 150	> 150
Annual PM_{10} concentration [µg/m³]	no increase	< 60	—	> 60
24-hour $PM_{2.5}$ concentration [µg/m³]	no increase	< 30	< 65	> 65
Annual $PM_{2.5}$ concentration [µg/m³]	no increase	< 15	—	> 15

Note: CO = carbon monoxide.

The geographic extent is defined as local, regional, and beyond regional

The geographic extent is defined as local, regional, and beyond regional. The local study area usually includes the area expected to receive direct impact of project activities. Since the air quality section does not have a local study area, the local extent is restricted to the active mine area plus a 500 m buffer. The buffer accommodates the direct effects of activities such as quarrying that occur at the edge of the active mine area. The RSA has been defined earlier (Section 7.1.4) and is shown in Figure 7.1-1.

Duration is classified; timing is incorporated into the duration definition

There are three criteria related to time: duration, timing, and frequency. Duration is based on the project schedule; changes that occur only during construction and closure are considered short-term, changes during operation are medium-term, and changes that continue beyond project closure are considered long-term. The duration of short-term, medium-term and long-term has been defined as 3, 26, and >26 years, respectively. Since the duration is tied to project phases, it incorporates the concept of timing (*e.g.*, mid-term impact occurs during the operation phase). The schedule for each phase is provided in the Project Description (Section 3.2). Because timing is incorporated in the duration definitions, it is not shown separately.

Frequency of project impacts is classified	Frequency includes events that occur once, intermittently, or continuously. Frequency refers to the project rather than the modelling results. For example, SO_2 emissions from the power plant will be continuous and they are classified as continuous. However, the model predicts the maximum concentration at a given location under all climate conditions. The maximum concentration used to determine magnitude may only occur once at that location during the operation of the plant.
Reversibility refers to changes after the impact ceases	Reversibility refers to changes that occur after the impact ceases allowing the environment to return to a capability or condition equivalent to the baseline. Concepts related to the reversibility of impacts to the terrestrial and aquatic environments are discussed further in Sections 10.1 and 9.1. Many impacts to the air cease immediately when the activity ceases. The reversibility of the effects of air emissions on specific receiving environments (*e.g.*, vegetation, water quality) will be addressed in those sections.
Ecological resilience does not apply to air	Ecological resilience refers to the environment rather than the project. Ecological resilience was not evaluated for air quality impacts since the air is a pathway or route of exposure for the receiving environment. The current state of scientific knowledge pertaining to ecological resilience is discussed in more detail in Sections 9.1.5 and 10.1.5.
Probability of occurrence and level of confidence relate to the methods used	The probability of occurrence and confidence level relate to assumptions made in assessing the possible impacts of the Snap Lake Diamond Project. For example, a series of conservative assumptions can lead to impacts that have a low probability of occurring. However, there will be a high level of confidence that the actual impacts will be lower than presented in the assessment. The level of confidence is also inversely related to the degree of uncertainty in the assessment components.
Environmental consequence provides an overall assessment by combining criteria representing the most important aspects of the impact	Environmental consequence provides an overall assessment of the residual effects based on a ranking system that incorporates four criteria (magnitude, geographic extent, duration, and reversibility) that represent the most important aspects of the impact. Combining the criteria shown in the residual impact classification into a single answer to the key question involves choices. The choices that have been made in this EA include the following:

- the method is transparent;
- the results will be shown as a bar graph (Figure 7.1-2) and as words in the residual impact classification table;

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Figure 7.1-2   Generic Environmental Consequence

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- the criteria will be added to form the bars of the graph;
- the criteria will be given equal weight except for the following:
  - only one criterion related to time will be used to prevent time from being over-weighted;
  - irreversible and magnitude will be slightly over-weighted due to the greater severity of the consequence of an irreversible impact of high magnitude.

Numbers have been used only to determine relative positions in the bar graph

The words (*e.g.*, negligible, low, moderate, high) used to rank the criteria (*e.g.,* magnitude) have been assigned numbers to create the bar graph, but the numbers have no meaning other than to ensure that ranks are shown in the correct relative position to each other. The numbers used are shown in Table 7.1-10. Environmental consequence is only determined for residual impacts that are negative in direction.

Table 7.1-10 Generic Residual Impact Classification

Magnitude	Geographic Extent	Duration	Reversibility
Negligible (0)	local (0)	short-term (0)	reversible (short-term) (0)
Low (5)	regional (5)	medium-term (5)	reversible (long-term) (5)
Moderate (10)	beyond regional (10)	long-term (10)	irreversible (15)
High (15)			

Environmental consequence is ranked as negligible, low, moderate, or high

The environmental consequence will be determined by adding the numbers and comparing the sum to the scale determined on the following basis:

- negligible = ≤ 5;
- low = > 5 to ≤ 20;
- moderate = > 20 to ≤ 30; and,
- high = > 30.

The ranking of environmental consequence was based on professional judgement

The relative positions of negligible, low, moderate, and high, are illustrated on a generic graph (Figure 7.1-2). The position of the lines determining the consequence scale is based on professional judgement. For example, an impact that was of moderate magnitude, regional extent, medium-term duration, and irreversible was deemed to be a high environmental consequence. If the same impact was reversible in the long-term, it was deemed to be a moderate environmental consequence. If it was reversible in

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the short-term, it was deemed to be a low environmental consequence. Professional judgement was used *a priori* to determine the method for ranking consequences. The determination of environmental consequence for each residual noise impact followed this method and was not modified within individual key questions.

Methods provide a standardized comparison of environmental consequences throughout the EA

The true environmental consequence would occur over a continuum rather than four categories. Because other professionals may have other opinions on the dividing line between low and moderate, or moderate and high, the method used here has been kept as simple and transparent as possible, while still providing a standardized comparison of the consequence of the project across all parts of the EA. This method of determining environmental consequence will be used to summarize noise and all other residual impacts in the EA.

7.2 BASELINE

7.2.1 Introduction

Local meteorology and existing air quality are described in this section

The atmospheric environment describes those components of the environment that deal with the weather, the movement of air, and the contaminants transported in the air. The baseline explores the present state of the atmospheric environment. The components of the atmospheric environment evaluated for this section are the local meteorology and existing air quality.

7.2.2 Local Meteorology and Background Air Quality

7.2.2.1 Local Meteorology

Meteorological data were collected by on-site monitoring from February 1998 to January 2001

The local meteorology at the Snap Lake Diamond Project site dictates the transport and dispersion of airborne contaminants. In February 1998, an on-site monitoring program to study the local climate and meteorology was commissioned. The meteorological data for this report cover the period from February 1998 through to January 2001.

Meteorological data serves several purposes

Although originally designed to provide climate information for local water balances, the meteorological parameters collected at Snap Lake were also sufficient to describe the transport and dispersion of airborne contaminants. For the hydrologic components of the EA, a further study of long-term trends in precipitation and climate patterns was completed. A detailed analysis of climatic extremes and how the observed data from Snap Lake are related to these extremes is discussed in Section 9.3.

Station locations, monitoring equipment, and parameters measured are described

Figure 7.2-1 shows the location of the on-site meteorological and ambient air quality monitoring stations at Snap Lake. Table 7.2-1 lists the parameters monitored, along with associated monitoring equipment. Observations collected at the station were stored in a data logger at the site, and downloaded on a monthly basis for processing. To ensure the equipment was operating correctly, semi-annual on-site audits and calibration were performed.

Table 7.2-1 Description of the On-Site Meteorological Monitoring Station

Parameter	Instrumentation
Temperature	
Average air temperature [°C]	Campbell Scientific YSI 44002A thermistor
Winds	
Wind speed [km/hr]	R.M. Young 05103 Wind Monitor
Wind direction [°]	R.M. Young 05103 Wind Monitor
Standard deviation of wind direction [°]	R.M. Young 05103 Wind Monitor, (calculated internally in the datalogger using the Yarmartino algorithm)
Solar Radiation	
Incoming solar radiation [W/m^2]	Licor: LI200S pyranometer
Precipitation	
Total rainfall [mm/hr]	Texas Instruments: TE525 Tipping Bucket Rain Gage
Relative Humidity	
Relative humidity [%]	Vaisala capacity relative humidity sensor
Data Storage and Retrieval	
Datalogger	Campbell Scientific CR10X
Power supply	Solar panel and battery back-up
Instrument mounting	3 m self supporting tripod

7.2.2.1.1 Wind Speed and Direction

The windrose presents wind speed and direction

Figure 7.2-2 depicts a "windrose" of the winds that were observed at the Snap Lake monitoring station between February 1998 and January 2001. Windroses are useful for presenting both wind speed and direction information in a single figure, using a 16-point compass. The windrose consists of bars whose length indicates the frequency of winds blowing from a given direction. The bars are also broken into sections, each of which defines a speed range. A longer section indicates that winds blow more frequently at a given speed for that compass direction.

Figure 7.2-1   Snap Lake Diamond Project Monitoring Stations

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Figure 7.2-2   Windrose of Observed Wind Speeds and Directions at Snap Lake
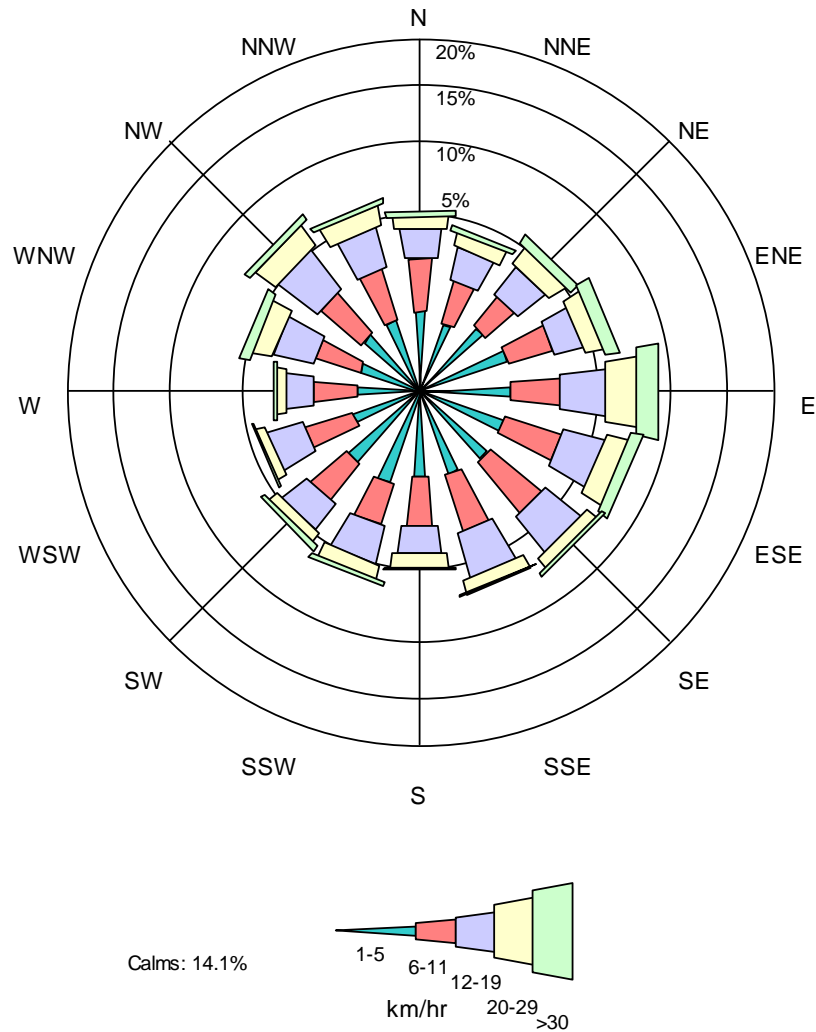
Wind speed and direction also provided in tables

Tables 7.2-2 and 7.2-3 summarize the observed winds at Snap Lake, complimenting the windrose provided in Figure 7.2-2. Separating the frequency of wind in this way helps to evaluate the potential transport and diffusion of airborne emissions. Table 7.2-4 summarizes the monthly wind speed information at Snap Lake.

The gentle topography has a negligible effect on wind direction, but Snap Lake may have an effect

The study area for the De Beers Snap Lake Diamond Project is in the barren lands of the Northwest Territories, characterized by numerous lakes and rocky hills of limited relief. Elevations near the weather station rise from 450 metres above sea level (masl), along the shoreline of Snap Lake, to 480 masl near the station. The gentle topography has a negligible effect on the wind directions. The windrose in Figure 7.2-2 shows a slightly higher frequency of winds from the east to east-southeast. This may be the result of onshore breezes from Snap Lake during the warmer, ice-free months.

The yearly average wind speed is 13.6 km/h

The most frequent wind speeds are in the 6 to 19 km/h range, with a yearly average of 13.6 km/h (Table 7.2-2, Figure 7.2-3). The highest average winds occur in the late summer and early fall, while the lowest are in January (Table 7.2-4).

Table 7.2-2   Observed Wind Speeds and Directions at Snap Lake

Direction	Frequency [%]	Average [km/h]	Maximum [km/h]
Calm[a]	14.1	1.8	—
N	4.7	14.3	54.9
NNE	3.9	15.3	49.3
NE	4.9	17.4	55.2
ENE	5.6	17.1	52.9
E	8.2	19.2	51.1
ESE	7.3	16.5	47.3
SE	6.9	13.6	40.3
SSE	6.1	13.5	36.3
S	4.5	13.4	36.2
SSW	5.3	14.5	44.9
SW	4.9	13.5	51.1
WSW	4.0	13.7	47.5
W	3.1	13.7	59.2
WNW	4.7	17.3	58.0
NW	6.4	16.6	59.1
NNW	5.4	15.6	61.6
Overall	**100.0**	**13.6**	**61.6**

[a]   Calm conditions include hours when the average wind speeds are less than the instrument threshold of 1 m/s (3.6 km/h).

Table 7.2-3   Frequency of Wind Speeds and Directions at Snap Lake

| Direction	Frequency of Observed Wind Speeds [%]					
	Calm	3 - 5 km/h	6 - 11 km/h	12 - 19 km/h	20 - 29 km/h	>30 km/h
N	4.4	0.5	1.7	1.4	0.8	0.3
NNE	0.6	0.3	1.3	1.3	0.8	0.2
NE	0.7	0.4	1.2	1.5	1.2	0.5
ENE	0.8	0.6	1.7	1.4	1.2	0.8
E	0.9	0.6	1.8	2.3	2.2	1.4
ESE	0.6	0.6	2.2	2.2	1.6	0.8
SE	0.6	0.7	2.6	2.6	0.9	0.2
SSE	0.7	0.6	2.1	2.5	0.9	0.1
S	0.6	0.5	1.8	1.3	0.8	0.1
SSW	0.8	0.7	1.6	1.8	1.0	0.2
SW	0.7	0.7	1.7	1.6	0.7	0.2
WSW	0.4	0.4	1.4	1.6	0.5	0.1
W	0.4	0.3	1.2	1.0	0.5	0.1
WNW	0.6	0.3	1.2	1.6	1.2	0.5
NW	0.8	0.5	1.6	2.4	1.5	0.4
NNW	0.5	0.4	1.7	1.8	1.3	0.3
Overall	**14.1**	**8.2**	**26.5**	**28.2**	**17.0**	**6.0**

Figure 7.2-3   Frequency of Wind Speeds at Snap Lake
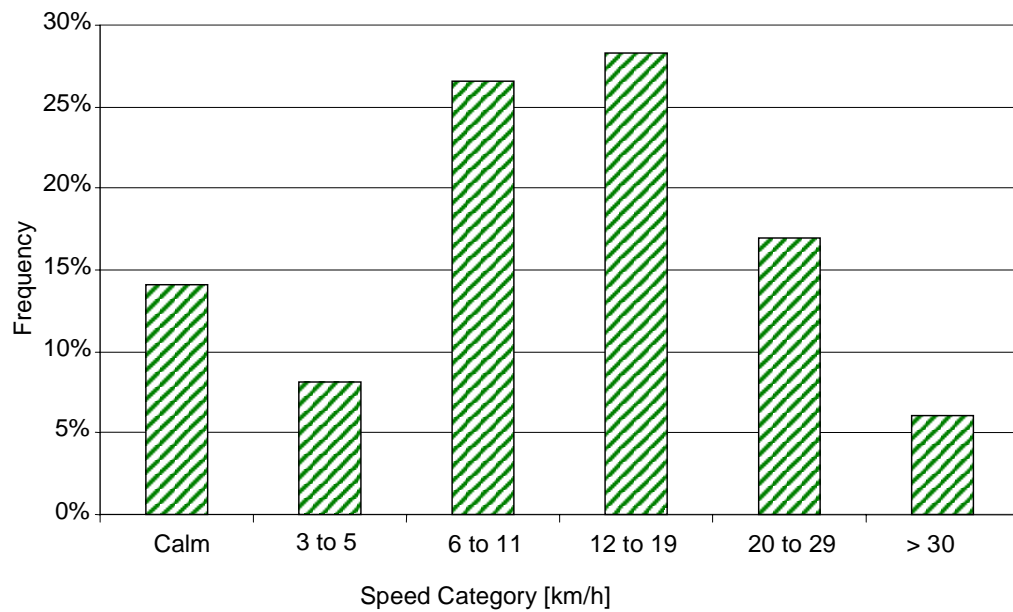
Table 7.2-4   Observed Monthly Wind Speeds at Snap Lake

Month	Average [km/h]	Maximum [km/h]
January	7.6	59.2
February	14.0	50.3
March	11.6	40.7
April	14.6	45.9
May	15.6	46.7
June	14.8	51.1
July	14.4	59.1
August	16.0	52.9
September	15.3	40.9
October	16.8	46.8
November	11.8	47.0
December	11.2	61.6
Year	**13.6**	**61.6**

7.2.2.1.2   Atmospheric Stability

Turbulence can be generated by wind and radiant heating or cooling

Generally, atmospheric stability is an indirect measure of atmospheric turbulence. The amount of atmospheric turbulence determines to a large extent how quickly a plume is dispersed and mixed as it is transported by the wind. Turbulence can be generated by either mechanical or thermal 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. Two methods for classifying atmospheric stability are discussed below.

There are six Pasquill-Gifford stability classes ranging from unstable to stable

One generalized scheme to classify atmospheric stability was developed by Pasquill and Gifford (referred to as Pasquill-Gifford or PG stability classes). The classification scheme is comprised of the following six categories: Classes A, B, and C (Unstable); Class D (Neutral); and Classes E and F (Stable). A description of these categories is provided below.

- Unstable conditions often result from daytime heating, which enhances turbulence and dispersion.

- Neutral conditions are associated with moderate to high wind speeds or overcast conditions, which temper the amount of radiational cooling and heating.

- Stable conditions often occur as a result of night time cooling. This results in suppressed turbulence levels and weaker dispersion of airborne emissions.

The relationship between the PG stability classes and commonly measured meteorological parameters is given in Table 7.2-5.

Table 7.2-5   Description of Pasquill-Gifford Stability Categories

Surface Wind Speed (at 10 m) [m/s]	Day			Night	
	Incoming Solar Radiation			Thinly Overcast or ≥ 4/8 Low Cloud	≤ 3/8 Low Cloud
	Strong	Moderate	Slight		
< 2	A	A-B	B	—	—
2 to 3	A-B	B	C	E	F
3 to 5	B	B-C	C	D	E
5 to 6	C	C-D	D	D	D
> 6	C	D	D	D	D

Note: The neutral class, D, should be assumed for heavily overcast conditions during day or night.

The standard deviation of the wind direction was used to determine stability

The stability classes in this assessment were determined using the standard deviation of the wind direction (σ_θ or sigma-theta) method recommended by the U.S. EPA (2000) when limited surface observations are available. Figure 7.2-4 provides a summary of the observed fluctuations of wind direction at Snap Lake.

Figure 7.2-4   Observed Fluctuations of Wind Directions at Snap Lake
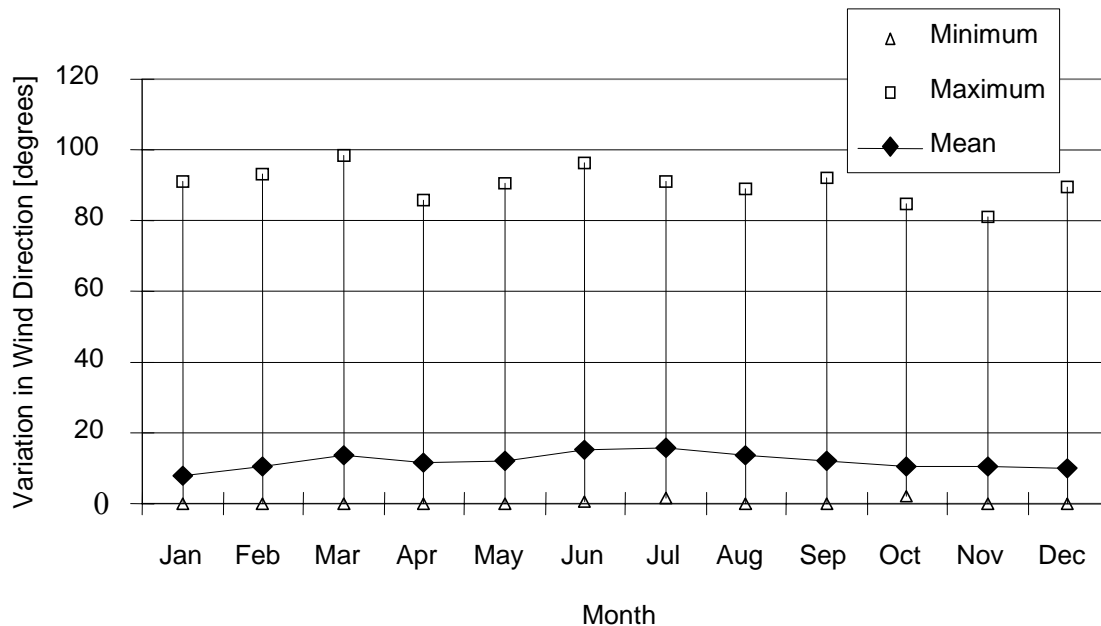
Neutral and stable conditions predominate

Figure 7.2-5 provides a histogram showing the frequency of the derived PG stability classes at Snap Lake. Unstable conditions occurred about 15% of the time, neutral conditions occurred 55% of the time, and stable conditions accounted for the remaining 30% of the observations.

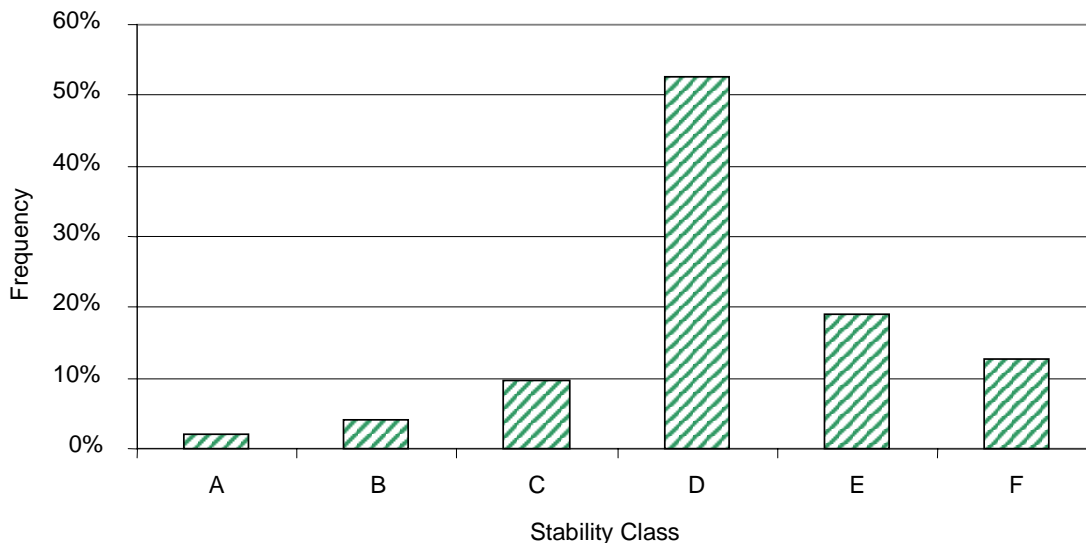**Figure 7.2-5   Frequency of Pasquill-Gifford Stability Conditions at Snap Lake**

7.2.2.1.3   *Atmospheric Mixing Heights*

Mixing heights, which indicate the space available for plume dispersion were calculated

The atmospheric mixing height is the depth of the surface layer in which the majority of dispersion will occur. The depth of this well-mixed layer is a function of surface heating and wind turbulence. Low mixing heights provide little vertical room for dispersion and can result in elevated concentrations at ground level. When an inversion, characterized by a stable atmospheric layer in which temperatures increase with height, sits above the mixed layer it will effectively act as a cap for plumes. Mixing heights were calculated from the observed surface wind speed following the Benkley and Schulman (1979), and Randerson (1984) formulations.

Mixing height varies from 400 m to 550 m

Figure 7.2-6 gives a monthly summary of calculated mixing heights at Snap Lake. The average mixing height varies relatively little throughout the year. The lowest average mixing height of about 400 m occurs during the winter, while the highest average of about 550 m occurs during the summer.

Figure 7.2-6　Summary of Monthly Mixing Heights at Snap Lake
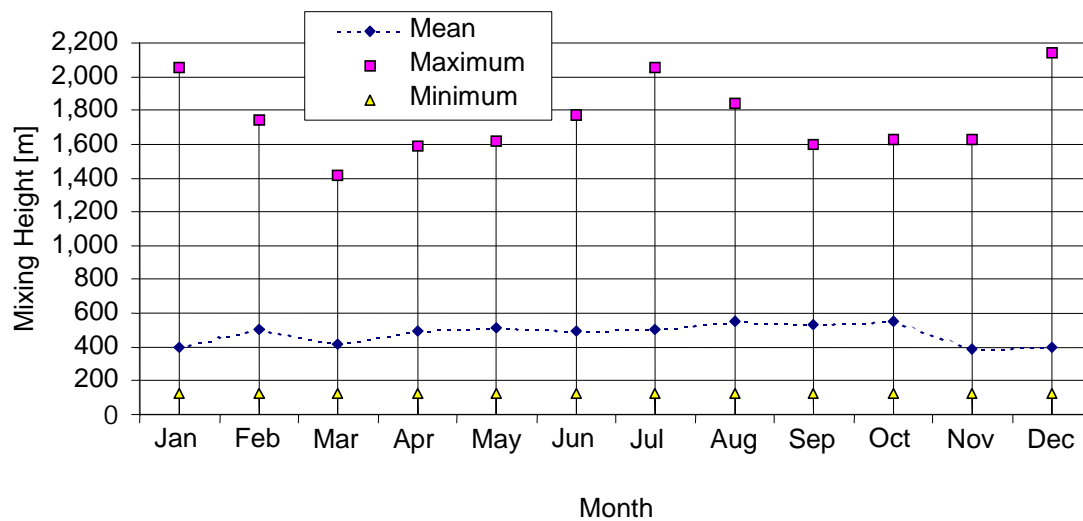
7.2.2.1.4　Temperature

A summary of monthly surface temperatures is provided

Summaries of the monthly surface temperatures observed at the Snap Lake monitoring station are in Table 7.2-6 and Figure 7.2-7. Average monthly temperatures at Snap Lake are below freezing from October through April. Minimum temperatures dropped below 0°C for every month except July and August, while maximum temperatures were above freezing from March through October. The average temperatures observed at Snap Lake were consistent with the 30-year climate normals data for Yellowknife Airport.

Table 7.2-6　Observed Monthly Surface Temperatures at Snap Lake

Month	Observed Temperature [°C]		
	Minimum	**Average**	**Maximum**
January	-39.5	-27.3	-1.3
February	-36.2	-20.9	-5.7
March	-36.3	-19.1	1.1
April	-30.9	-9.3	8.7
May	-13.2	1.1	20.0
June	-7.2	10.6	28.9
July	4.0	15.1	28.8
August	0.9	11.8	26.6
September	-6.0	5.6	19.1
October	-17.1	-3.1	7.2
November	-30.1	-12.3	-0.9
December	-39.0	-22.7	-4.5
Year	**-39.5**	**-5.9**	**28.9**

Figure 7.2-7   Observed Monthly Surface Temperatures at Snap Lake
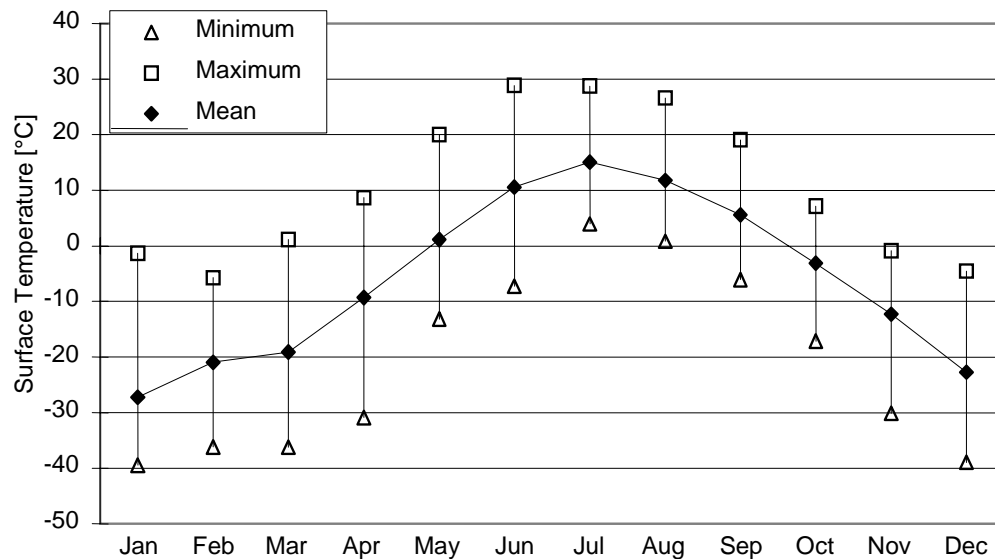
7.2.2.1.5   *Solar Radiation*

A summary of monthly solar radiation is provided

Solar radiation has an effect on local evaporation, water balances, chemical transformations, and atmospheric stability. Table 7.2-7 and Figure 7.2-8 present summaries of the monthly variations in solar radiation observed at Snap Lake. Solar radiation is measured as watts per square metre (W/m^2).

Table 7.2-7   Monthly Solar Radiation at Snap Lake

Month	Average [W/m^2]	Maximum [W/m^2]
January	6.5	205.0
February	56.7	525.0
March	166.3	920.0
April	285.6	1,192.0
May	389.0	1,417.0
June	432.2	1,390.0
July	413.6	1,363.0
August	267.0	1,257.0
September	149.0	1,037.0
October	58.3	620.2
November	18.1	389.5
December	3.1	99.3
Year	**187.1**	**1,417.0**

Figure 7.2-8   Monthly Solar Radiation at Snap Lake
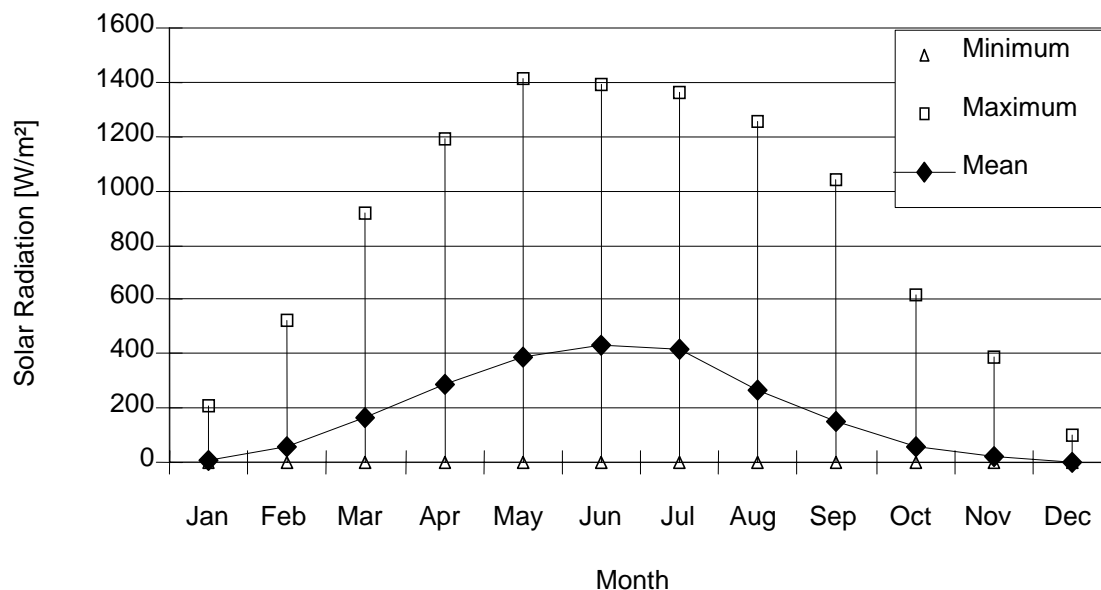
Radiation varies during the day

In addition to varying from month to month, solar radiation will vary with the time of day. As the sun rises above the horizon, the potential solar radiation increases (Figure 7.2-9).

Figure 7.2-9   Hourly Solar Radiation at Snap Lake
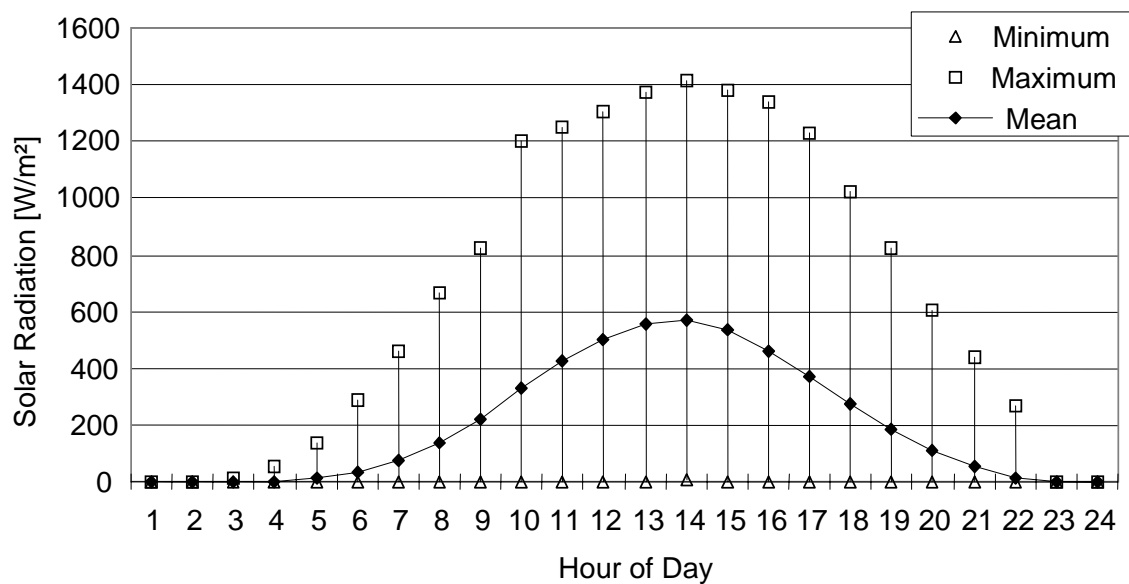
7.2.2.2   Air Quality Monitoring

A monitoring program focussing on total suspended particulate (TSP) concentrations started in April 2000

To determine the current air quality at Snap Lake, De Beers initiated a monitoring program in April of 2000. Based on discussions with regulators and stakeholders, a primary concern was the release of airborne particles from the Snap Lake Diamond Project. Therefore, the initial monitoring program focused on establishing the total suspended particulate (TSP) matter concentrations near the advanced exploration program activities, and at a remote area close to the Snap Lake exploration camp.

Dustfall monitoring and a snow survey began in 2001

To gather information regarding the deposition of airborne particles, metals, and polycyclic aromatic hydrocarbon (PAH) compounds, a program to monitor dustfall began in July 2001. The dustfall monitoring was conducted to compliment a snow survey completed in the spring of 2001. Snow samples were analyzed for trace metals (*i.e.*, metals present in extremely small quantities) and PAH compounds.

7.2.2.2.1   Total Suspended Particulates

Three high-volume samplers were used to measure total suspended particulate at the site

To sample TSP, three high-volume (Hi-Vol) samplers were located strategically about the Snap Lake Diamond Project site. Hi-Vol sampling is an approved method for collecting TSP data in the NWT and other jurisdictions. In fact, NWT regulators specifically requested that TSP monitoring be performed at Snap Lake in preference to PM_{10} or $PM_{2.5}$ monitoring. The following placement of Hi-Vol samplers was such that TSP levels could be determined for various activities during the advanced exploration program operations at Snap Lake:

- The first Hi-Vol sampler ("Hi-Vol Station A" in Figure 7.2-1) was located to the west of the aggregate crushing and batch plant. This location was in the predominant downwind direction from both the crushers and the mine portal.

- The second Hi-Vol sampler (location "Hi-Vol Station B" in Figure 7.2-1) was located slightly to the east of the mine portal. This site is downwind of the crushers and mine portal when winds are blowing from a northwesterly direction (the second most prevalent wind direction observed in the area).

- The third Hi-Vol sampler ("Hi-Vol Station C" in Figure 7.2-1) was sited near the Snap Lake exploration camp. This sampler was relocated to the west of the existing camp when the exploration camp was decommissioned.

*The total
suspended
particulate matter
is collected on
pre-weighed filters
for 24 hours every
six days*

The three Hi-Vol samplers were identical Anderson Instruments Inc. Model GSP2310, mass-flow controlled, high-volume samplers. Audits and calibrations of the Hi-Vols were completed on a semi-annual basis to ensure that they operated within proper specifications. The monitoring program was designed to collect concurrent 24-hour samples, every six days, in accordance with the National Air Pollution Surveillance network schedule. After each 24-hour sampling period, the pre-weighed filters were retrieved and sent to a laboratory for determination of the total weight gain.

*Atmospheric
pressure readings
are needed to
determine total
suspended
particulate*

The concentration of TSP, for each sampling period, was then determined by dividing weight gained on the filter by volume of air sampled. To do this accurately, local atmospheric pressure readings were required. For the majority of valid samples, these data were available on-site. For the readings when on-site pressure data were unavailable, atmospheric pressure readings from the weather station at the Yellowknife Airport were used.

*A total of 47 valid
samples were
collected*

Tables 7.2-8, 7.2-9, and 7.2-10, provide the valid TSP monitoring data for Hi-Vol stations A, B, and C, respectively. Overall, there were 21 valid samples collected at Hi-Vol Station A, 16 at Station B, and 10 at Station C. The reasons identified as the cause of the invalid data ranged from frozen equipment to missing site observations. TSP readings in Tables 7.2-8 to 7.2-10 are valid even though they were not collected under ideal conditions. Concerns with these data are footnoted in each table.

*The average 24-hr
total suspended
particulate
concentration
downwind from
the crusher was
39 µg/m³; other
averages were
lower*

Table 7.2-11 provides a comparison of the valid TSP monitoring results collected at all three monitoring stations. The valid 24-hour TSP concentrations observed at Snap Lake ranged from 1 to 148 µg/m³. The average 24-hour TSP concentrations at monitoring stations A, B, and C were 39 µg/m³, 16 µg/m³, and 7 µg/m³, respectively. These readings are consistent with the location of the monitoring stations relative to site activities and predominant winds.

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Table 7.2-8   Monitoring Results for Total Suspended Particulates at Hi-Vol Station A

Date of Sample	Weight of Particulate [mg]	Flow Rate [m³/min]	TSP Concentration [µg/m³]
06 May 2000	120.0	1.472	58
12 May 2000[a]	89.1	1.472	42
18 May 2000[b]	88.7	1.472	43
24 May 2000	84.4	1.446	40
30 May 2000	26.9	1.463	13
05 June 2000	64.5	1.418	32
11 June 2000	12.1	1.418	6
17 June 2000	63.6	1.434	31
23 June 2000	71.3	1.434	36
29 June 2000	209.0	1.434	105
05 July 2000	377.2	1.411	148
11 July 2000[c]	113.6	1.419	56
17 July 2000[c]	105.0	1.444	52
23 July 2000[d]	64.3	1.427	31
29 July 2000[c]	16.4	1.444	8
14 April 2001	24.6	1.068	11
28 April 2001[e]	50.3	1.408	26
01 May 2001[e]	88.7	1.481	43
07 May 2001[e]	38.3	1.465	19
13 May 2001[e]	63.5	1.397	24
19 May 2001[e]	8.8	1.417	4

[a] High winds (30+ knots), temperature –25° C.
[b] Filter had a torn edge.
[c] Filter received open
[d] Filter torn in centre, received open.
[e] Calculations used mean monthly pressure from Yellowknife Airport weather station.

Table 7.2-9   Monitoring Results for Total Suspended Particulates at Hi-Vol Station B

Date of Sample	Weight of Particulate [mg]	Flow Rate [m³/min]	TSP Concentration [µg/m³]
12 May 2000[a]	14.7	1.093	11
18 May 2000	48.9	1.082	33
24 May 2000	8.0	1.049	6
30 May 2000	16.5	1.038	11
05 June 2000	22.9	1.036	18
17 June 2000	82.4	1.025	56
23 June 2000	9.1	1.025	6
29 June 2000[b]	22.5	1.036	15
17 July 2000[c]	34.8	1.052	23
23 July 2000[c]	41.4	1.063	27
29 July 2000[d]	17.2	1.063	12
14 April 2001	3.7	1.741	1
28 April 2001[e]	5.3	1.677	2
01 May 2001[e]	6.7	1.712	3
07 May 2001[e]	4.1	1.692	2
19 May 2001[e]	61.0	1.699	28

[a] Sample broke when collected.
[b] No weight record.
[c] Filter received open.
[d] Filter torn in centre, received open.
[e] Calculations used mean monthly pressure from Yellowknife Airport weather station.

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Table 7.2-10 Monitoring Results for Total Suspended Particulates at Hi-Vol Station C

Date of Sample	Weight of Particulate [mg]	Flow Rate [m³/min]	TSP Concentration [µg/m³]
06 May 2000[a]	8.1	1.668	3
12 May 2000[b]	12.9	1.650	5
19 May 2000[c]	7.8	1.676	3
24 May 2000	2.4	1.693	1
05 June 2000[d]	1.7	0.462	3
05 July 2000[e]	42.3	1.402	20
11 July 2000	31.4	1.561	14
17 July 2000	19.2	1.577	9
23 July 2000	21.5	1.561	9
29 July 2000[f]	11.2	1.586	5

[a]   Helicopter in use, timer set prematurely (extra time).

[b]   Snow storm, high wind, monitor blown over with filter inside.

[c]   First sample after re-installing the monitor.

[d]   Helicopter activity nearby (as per last 2 weeks).

[e]   Forest fire, filter torn in centre.

[f]   Hi-Vol Station C was decommissioned in the summer of 2000 with the closure of the exploration camp. The sampler was relocated to the west of the existing camp, and recommissioned in July of 2001. No data are available from the new location.

Table 7.2-11 Monitoring Results for Total Suspended Particulates at Snap Lake

Date of Sample	24-Hour TSP Concentration [µg/m³]		
	Hi-Vol Station A	Hi-Vol Station B	Hi-Vol Station C
06 May 2000	58	—[a]	3
12 May 2000	42	11	5
18 May 2000	43	33	—
19 May 2000	—	—	3
24 May 2000	40	6	1
30 May 2000	13	11	—
05 June 2000	32	18	3
11 June 2000	6	—	—
17 June 2000	31	56	—
23 June 2000	36	6	—
29 June 2000	105	15	—
05 July 2000	148	—	20
11 July 2000	56	—	14
17 July 2000	52	23	9
23 July 2000	31	27	9
29 July 2000	8	12	5
14 April 2001	11	1	—
28 April 2001	26	2	—
01 May 2001	43	3	—
07 May 2001	19	2	—
13 May 2001	24	—	—
19 May 2001	4	28	—
Average	**39**	**16**	**7**

[a]   "—" Insufficient data to calculate concentration.

7.2.2.2.2   Snow

Snow was sampled at five locations

The results from a snow survey at Snap Lake, conducted in the spring of 2001, were used to determine the amount of trace metals and PAH compounds in the accumulated snow profile. As shown in Figure 7.2-10, the survey examined four sampling locations. A reference site (area R) was located approximately 10 km to the northwest of the Snap Lake Diamond Project, on the shore of Camsell Lake. Area "A" was located between the reference site and Snap Lake. Area "B" was located on the northeast shore of Snap Lake, approximately 5 km to the northeast of the project site. Area "C" was situated at the southern limit of the project site, while Area "D" was sited at the northern limit of the project site.

The hydrology field program included collection of snowcourse, stream flow, and water level data

Except for the reference site, the selection of snow sampling site locations followed the requirements of the surface hydrology monitoring program (Section 9.3). The location of the reference snow sampling site, selected relatively far from any possible contamination from mine site activities, followed the requirements of Environmental Health (Section 11).

Snow accumulation depends on topography (open, upland, and lowland areas) and vegetation

The surface hydrology monitoring program collects snow accumulation data in the Snap Lake watershed as part of the aquatic baseline data collection program. Snow accumulation depends on terrain type, which is a function of both topography and vegetation. In the Snap Lake watershed, topography is the dominant feature dictating the terrain classification. The main terrain types identified were:

- open areas, including lake and land;

- upland areas - elevated areas generally exposed to wind; and,

- lowland areas - low areas generally sheltered from wind, including wetlands.

Snow depth and density were sampled for three terrain types

At each location, the survey sampled snow from three distinct terrain types: open terrain, upland terrain, and lowland terrain (indicated in Figure 7.2-10 by the letters O, U, and L, respectively). Snow sampling entailed the collection of the entire snow layer, down to ground level. Snow depths and snow densities were determined and recorded for each sample.

No polycyclic aromatic hydrocarbon compounds were present; trace metals results are provided

The samples were then analyzed to determine the amount of trace metal and PAH compounds present. Table 7.2-12 presents the results of the trace metals analysis. None of the PAH compounds included in the testing were present in detectable amounts. The PAH testing included the following:

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Figure 7.2-10 Snap Lake Diamond Project Snow Sampling Locations

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Table 7.2-12   Trace Metals Concentrations from Snow Survey

Compound	Reference Area [kg/ha/year]			Area A [kg/ha/year]			Area B [kg/ha/year]			Area C [kg/ha/year]			Area D [kg/ha/year]		
	Open	Upland	Lowland	Open	Upland	Lowland	Open	Upland	Lowland	Open	Upland	Lowland	Open	Upland	Lowland
Aluminum	0.01123	0.00173	0.04199	0.01785	0.00639	0.03478	0.01486	0.01229	0.03226	0.04411	0.06668	0.14092	0.09528	0.05744	0.43778
Antimony	—	—	—	—	—	0.00012	—	—	—	0.00009	—	0.00030	—	0.00010	0.00019
Arsenic	—	—	—	—	0.00002	—	—	0.00002	—	0.00016	0.00003	0.00015	0.00008	0.00006	0.00010
Barium	0.00081	0.00016	0.00251	0.00112	0.00057	0.00172	0.00081	0.00045	0.00269	0.00301	0.00407	0.01449	0.00397	0.00336	0.02738
Boron	0.00528	0.00057	—	0.00003	0.00002	0.00006	—	—	—	0.00005	0.00009	0.00031	0.00012	0.00007	0.00139
Calcium	0.21808	—	—	0.79045	—	0.00001	0.22229	—	—	0.50823	—	0.00030	0.44506	0.00010	0.00001
Chromium	0.00005	0.06684	0.64896	0.00016	0.06795	0.66868	0.00016	0.10174	0.69137	0.00057	0.15166	1.49587	0.00120	0.64154	1.37449
Cobalt	—	—	0.00040	0.00002	0.00057	0.00023	0.00001	0.00009	—	0.00007	0.00130	0.00319	0.00014	0.00058	0.01136
Copper	0.00013	—	—	0.00016	—	0.00003	0.00007	0.00002	—	0.00021	0.00012	0.00030	0.00050	0.00006	0.00167
Iron	0.01288	0.00002	0.00157	0.02131	0.00002	0.00026	0.02417	0.00013	0.01075	0.08947	0.00030	0.00051	0.18683	0.00019	0.00196
Lead	0.00050	0.00195	0.05546	0.00036	0.00560	0.04414	0.00033	0.01842	0.04100	0.00051	0.13911	0.32559	0.00045	0.10320	1.11629
Magnesium	0.04265	0.00006	0.00089	0.09347	0.00022	0.00047	0.06920	0.00016	0.00115	0.22428	0.00008	0.00163	0.34579	0.00052	0.00058
Manganese	0.00090	0.00739	0.19153	0.00080	0.03212	0.17797	0.00095	0.02559	0.08852	0.00354	0.31905	0.97678	0.00453	0.20931	3.34888
Molybdenum	0.00018	0.00002	0.00393	—	0.00044	0.01329	—	0.00046	0.00384	—	0.00851	0.01335	—	0.00695	0.03048
Nickel	0.00032	0.00003	0.00099	0.00016	0.00014	0.00031	0.00031	0.00011	0.00451	0.00221	0.00169	0.00710	0.00196	0.00119	0.02291
Potassium	0.03076	—	0.08814	0.04439	0.01011	0.36783	0.01577	0.02045	0.03840	0.03212	0.03478	0.16317	0.03981	0.09087	0.25335
Sodium	0.09670	0.01433	0.29710	0.09719	0.07078	0.13536	0.07378	0.04494	0.27843	0.11184	0.03780	0.29370	0.08458	0.08957	0.32033
Strontium	0.00074	0.00018	0.00188	0.00142	0.00026	0.00159	0.00064	0.00022	0.00182	0.00172	0.00068	0.00556	0.00125	0.00166	0.00776
Uranium	—	0.00003	—	—	—	—	—	—	—	0.00000	0.00001	0.00002	0.00001	0.00001	0.00007
Vanadium	0.00009	0.00003	—	—	0.00016	0.00006	0.00002	0.00002	—	0.00012	0.00021	0.00037	0.00028	0.00016	0.00145
Zinc	0.01970	0.00633	0.05501	0.08925	0.00623	0.06577	0.01672	0.01858	0.05674	0.02904	0.00426	0.09125	0.01283	0.05955	0.03378

[a] "—" Indicates that the compound was not detectable.

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- acenaphthene;
- acridine;
- anthracene;
- benzo(a)anthracene;
- benzo(a)pyrene;
- benzo(b)fluoranthene;
- benzo(k)fluoranthene;
- chrysene;

- dibenzo(a,h)anthracene;
- fluoranthene;
- fluorene;
- indeno(1,2,3-cd)pyrene;
- naphthalene;
- phenanthrene;
- pyrene; and,
- quinoline.

7.2.2.2.3   Dustfall

Dustfall particles are usually >30 µm; larger particles fall out closer to the source

Dustfall represents the fraction of airborne particles that either wash out of the air with precipitation, or settle out due to gravity. Typically, the bulk of the particles collected in dustfall sampling jars are larger than 30 µm in diameter. Dustfall sampling conducted at greater distances from the sources (*e.g.*, more than a kilometre) will also include a large fraction of smaller particles since nearly all of the larger particles will have settled out.

The metals and polycyclic aromatic hydrocarbon in the particles and the total weight of the particles will be reported

The dustfall-monitoring program at the Snap Lake Diamond Project consists of a series of open-topped containers exposed to the atmosphere for a nominal period of 30 days. Figure 7.2-1 shows the location of the dustfall samplers. The collected samples are analyzed to determine the mass deposited over the area of the sample jar mouth during the monitoring period. In addition to determining the mass of accumulated particulates, laboratory testing also ascertains the amount of metals and PAH compounds collected.

Dustfall sampling is part of the proposed monitoring

The collection of dustfall samples will be an ongoing program during the ice-free months of the year. This program began in the fall of 2001 and the results will be reported as part of the proposed monitoring (see also Section 7.4).

7.2.3   Baseline Regional Emissions

There are no other existing or approved projects in the regional study area

There are currently no approved developments in the immediate vicinity of the Snap Lake Diamond Project, or within the air quality RSA. However, atmospheric emissions released in the flat to rolling terrain of the NWT have the potential to travel long distances. The potential cumulative effect of the BHP EKATI™ Diamond Mine (located 119 km to the north) and the Diavik Diamond Mine (located 102 km to the north-northeast) in combination with the emissions from the Snap Lake Diamond Project have been evaluated in Section 12.4. Any influence of these projects at Snap Lake that occurred up to January 2001 will have been captured in the results presented in Section 7.2.2.

7.3   IMPACT ASSESSMENT

7.3.1   Introduction

This section predicts the impacts of the fully developed project on air

This section of the air quality assessment describes and quantifies the expected changes in air emissions, ground level concentrations, and deposition patterns encompassed by the application case. This includes a detailed summary of the atmospheric emissions from the Snap Lake Diamond Project, when the project is fully developed and activities at the mine site are at a maximum. The assessment of air quality impacts associated with the Snap Lake Diamond Project is presented at the end of this section as answers to the key questions introduced in Section 7.1.3.1.

7.3.2   Project Emissions

Sources at the site will emit sulphur dioxide, oxides of nitrogen and particulate matter

There will be a release of gaseous and particulate atmospheric emissions from operations of the Snap Lake Diamond Project. Emissions will emanate from fuel combustion, vehicle exhausts, and other sources associated with the operation of the project. The primary emissions addressed in this section are sulphur dioxide (SO_2); oxides of nitrogen (NO_X); total suspended particulate matter (TSP); PM_{10} (particles with a nominal diameter less than 10 μm); and $PM_{2.5}$ (particles with a nominal diameter less than 2.5 μm).

Emissions were estimated from manufacturers' specifications and published factors

For the most part, the emission estimates presented in this section have been based on the widely accepted factors published in the AP-42 document (U.S. EPA 1995). In some cases, emission estimates were available from manufacturers' specifications. When available, manufacturer data were used in preference to emission factors. Emissions calculations for some of the equipment also included a contingency factor (*i.e.*, an increase to allow for possible increases in equipment) to ensure the modelled emissions were conservative.

7.3.2.1   Power Plant

Combustion sources are diesel-fired generators

One of the primary combustion sources at the Snap Lake Diamond Project is the main diesel-fired power plant. There will also be a small diesel-fired generator located at the airfield. The main power plant will generate all of the electrical power required at the site. Table 7.3-1 provides a listing of emissions for the power generators. The overall emissions of SO_2, NO_X, TSP, PM_{10}, and $PM_{2.5}$ are expected to be 0.059, 3.715, 0.115, 0.065, and 0.054 tonnes per day (t/d), respectively.

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Table 7.3-1　Power Plant Emissions

Source	Emission Rates [t/d]				
	SO_2	NO_X	TSP	PM_{10}	$PM_{2.5}$
Main power plant	0.057	3.578	0.111	0.063	0.052
Airstrip generator	0.002	0.137	0.004	0.002	0.002
Total	**0.059**	**3.715**	**0.115**	**0.065**	**0.054**

7.3.2.2　Mine Air Heaters and Water Heaters

Heaters contribute to emissions

The water heaters and mine air heaters also contribute to the atmospheric emissions from the Snap Lake Diamond Project. Overall, the emissions of SO_2, NO_X, TSP, PM_{10}, and $PM_{2.5}$ from the heaters are expected to be 0.068, 0.195, 0.030, 0.017, and 0.015 t/d, respectively. These emissions are presented in Table 7.3-2.

Table 7.3-2　Emissions from Mine Air Heaters and Water Heaters

Source	Emission Rates [t/d]				
	SO_2	NO_X	TSP	PM_{10}	$PM_{2.5}$
Water heater	0.014	0.039	0.006	0.003	0.003
Air heater group 1	0.027	0.078	0.012	0.007	0.006
Air heater group 2	0.027	0.078	0.012	0.007	0.006
Total	**0.068**	**0.195**	**0.030**	**0.017**	**0.015**

7.3.2.3　Underground Activities

Underground mining emissions are mitigated due to wet conditions

Underground mining activities comprise the majority of the emission producing activities at the Snap Lake Diamond Project. These underground activities include a combination of combustion sources and material handling operations. However, the emissions from the materials handling operations at the mine are predicted to be relatively low due to the high moisture levels underground. These wet conditions will be effective in mitigating the particulate emissions from the underground material handling activities. Wet dust suppression has been shown to control between 40 and 80% of the particulate emissions (U.S. EPA 1988). Table 7.3-3 presents a summary of the emissions from the underground mining activities. The overall emissions of SO_2, NO_X, TSP, PM_{10}, and $PM_{2.5}$ are expected to be 0.037, 1.560, 0.129, 0.040, and 0.012 t/d, respectively.

Table 7.3-3   Emissions from Underground Mining Activities

Source	Emission Rates [t/d]				
	SO_2	NO_X	TSP	PM_{10}	$PM_{2.5}$
Mine fleet	0.037	1.560	0.045	–	–
Material handling	–	–	0.084	0.040	0.012
Total	**0.037**	**1.560**	**0.129**	**0.040**	**0.012**

7.3.2.4   Quarry and Mobile Surface Emissions

Quarrying and surface transportation contribute to emissions

Although the quarry is relatively small (averaging less than 200 tonnes per day of material handled), activities such as blasting, excavating, conveyance, and crushing will contribute to the overall atmospheric emissions from the Snap Lake Diamond Project. In addition, there are 22 pieces of surface mobile equipment used for the transport of personnel and goods, surface construction, and snow removal. This includes four haul trucks, two loaders and three bulldozers. Table 7.3-4 summarizes the emissions from the quarry and surface mobile equipment. The emissions of SO_2, NO_X, TSP, PM_{10}, and $PM_{2.5}$ from these activities are expected to be 0.011, 0.213, 0.212, 0.070, and 0.021 t/d, respectively.

Table 7.3-4   Emissions from the Quarry and Mobile Surface Equipment

Source	Emission Rates [t/d]				
	SO_2	NO_X	TSP	PM_{10}	$PM_{2.5}$
Quarry activity	0.001	0.011	0.029	0.021	0.007
Surface mobile equipment	0.010	0.202	0.183	0.049	0.014
Total	**0.011**	**0.213**	**0.212**	**0.070**	**0.021**

7.3.2.5   Process Plant

Plant emissions are reduced by wet processing and no combustion

The processing plant at the Snap Lake Diamond Project includes activities such as secondary crushing, screening, dense media separation, and materials conveyance that are potential sources of particulate (TSP, PM_{10}, and $PM_{2.5}$) emissions. These emissions are minimal, however, as the Snap Lake Diamond Project will use a primarily wet process. Any of the dry operations, such as the addition of cement powder to the spent kimberlite, have effective dust control systems in place to capture and mitigate the particulate emissions. The processing plant emissions of TSP, PM_{10}, and $PM_{2.5}$ are 0.045, 0.010, and 0.007 t/d, respectively. As there is no combustion in the process plant, there are no direct emissions of SO_2 or NO_X. A summary of the emissions from the process plant and associated activities is given in Table 7.3-5. The emissions of TSP, PM_{10}, and $PM_{2.5}$

from the process plant are expected to be 0.045, 0.010, and 0.007 t/d, respectively.

Table 7.3-5   Process Plant Emissions

	Emission Rates [t/d]				
Source	SO_2	NO_X	TSP	PM_{10}	$PM_{2.5}$
Aggregate crushing plant	0.000	0.000	0.006	0.003	0.001
Process and paste plant	0.000	0.000	0.039	0.007	0.006
Total	**0.000**	**0.000**	**0.045**	**0.010**	**0.007**

7.3.2.6   Other Project Emissions

Other activities that generate emissions include the waste incinerator and the north pile

In addition to the emissions associated with the power generation, mining and processing activities, the Snap Lake Diamond Project includes two other emission sources. The waste incinerator is a necessary operation at the site to minimize the waste volumes generated and to dispose of any materials that might encourage scavenger animals. Although the incinerator is a relatively small source, it is expected to result in NO_X, TSP, PM_{10}, and $PM_{2.5}$ emissions of 0.001, 0.012, 0.006, and 0.004 t/d, respectively. The north pile is the primary means of storing and containing the processed kimberlite and is a potential source of wind-generated particulate emissions. The processed kimberlite sent to the north pile contains as much as 50% moisture (for the finest particles that are the most susceptible to wind erosion), which effectively mitigates the volumes of wind blown dust that will be generated. As these fine materials start to dry out, they will form a crust that will be resistant to wind erosion (U.S. EPA 1988). The north pile is expected to result in TSP, PM_{10}, and $PM_{2.5}$ emissions of 0.011, 0.005, and 0.002 t/d, respectively. Table 7.3-6 provides a summary of the emissions from the incinerator and north pile.

Table 7.3-6   Emissions from Other Activities at the Snap Lake Diamond Project

	Emission Rates [t/d]				
Source	SO_2	NO_X	TSP	PM_{10}	$PM_{2.5}$
Incinerators	0.000	0.001	0.012	0.006	0.004
North pile	0.000	0.000	0.011	0.005	0.002
Total	**0.000**	**0.001**	**0.023**	**0.011**	**0.006**

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7.3.2.7 Summary of Project Emissions

Emissions from all sources are summarized

Table 7.3-7 provides a summary of the emissions of SO_2, NO_X, TSP, PM_{10}, and $PM_{2.5}$ from all sources at the Snap Lake Diamond Project. The overall emissions of these respective compounds are expected to be 0.175, 5.684, 0.554, 0.213, and 0.115 t/d.

Table 7.3-7   Summary of Project Emissions

Source	Emission Rates [t/d]				
	SO_2	NO_X	TSP	PM_{10}	$PM_{2.5}$
Power plant	0.059	3.715	0.115	0.065	0.054
Mine heaters	0.068	0.195	0.030	0.017	0.015
Underground activities	0.037	1.560	0.129	0.040	0.012
Quarry activities	0.011	0.213	0.212	0.070	0.021
Process plant	0.000	0.000	0.045	0.010	0.007
Incinerators	0.000	0.001	0.012	0.006	0.004
North pile	0.000	0.000	0.011	0.005	0.002
Total	**0.175**	**5.684**	**0.554**	**0.213**	**0.115**

7.3.2.8 Emissions of Trace Air Compounds

Airborne metals and polycyclic aromatic hydrocarbons are also considered

The emissions of SO_2, NO_X, TSP, PM_{10}, and $PM_{2.5}$ are the primary focus of the air quality assessment of the Snap Lake Diamond Project. However, consideration has also been given to the emissions of trace air compounds, including airborne metals and polycyclic aromatic hydrocarbons (PAHs). The emissions of airborne metals are associated with diesel combustion and the releases of processed kimberlite ore. The emissions of PAH compounds are associated with the diesel combustion in the power plant, the mining equipment, mine air and water heaters, and the incinerator.

Quantities were determined from literature and ore geochemistry

Definitive emissions of metals and PAH compounds from diesel combustion are not available. However, the amount of metals and PAH compounds in diesel particulate emissions are available from literature. The fraction of metals present in the processed kimberlite was based on the ore itself. Table 7.3-8 provides a listing of the metal and PAH values used in this assessment.

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Table 7.3-8   Metals and Polycyclic Aromatic Hydrocarbons Present in Diesel and Processed Kimberlite

Trace Metals			PAH Compounds	
Species	Fraction of Processed Kimberlite[a] [%]	Fraction of Diesel PM[b] [%]	Species	Fraction of Diesel PM[c] [%]
Aluminum	1.7894	0.080	1,2-benzathracene	0.000091
Antimony	0.0002	—	1,6-dinitropyrene	0.000068
Arsenic	0.0008	—	1,8-dinitropyrene	0.000068
Barium	0.1556	—	1-chloronaphthalene	0.000070
Bismuth	0.0003	—	1-methylnaphthalene	0.002604
Boron	0.0064	—	2-chloronaphthalene	0.000103
Cadmium	0.0003	0.060	2-methylnaphthalene	0.002527
Calcium	6.3928	0.030	7,12-dimethylbenz(a)anthracene	0.000068
Chromium	0.0705	0.010	Acenaphthene	0.016467
Cobalt	0.0081	0.010	Acenaphylene	0.034465
Copper	0.0075	0.010	Anthracene	0.005086
Gold	0.0007	—	Benzo(a)fluorene	0.001141
Iron	5.5422	0.050	Benzo(a)pyrene	0.000538
Lanthanum	0.0184	—	Benzo(b & j)fluoranthene	0.000556
Lead	0.0016	0.010	Benzo(b)fluorene	0.000049
Magnesium	15.4287	—	Benzo(e)pyrene	0.000115
Manganese	0.1813	0.010	Benzo(g, h, i)perylene	0.001111
Mercury	0.0001	—	Benzo(k)fluoranthene	0.000532
Molybdenum	0.0017	—	Camphene	0.000136
Nickel	0.1155	—	Carbazole	0.000077
Phosphorus	0.2603	0.010	Chrysene	0.003424
Potassium	0.7560	—	Dibenz(a, h)anthracene	0.001287
Silver	0.0001	0.010	Dibenz(a, h)acridine	0.000068
Sodium	0.0410	—	Dibenz(a, j)acridine	0.000082
Strontium	0.0291	—	Dibenzothiophene	0.008425
Thallium	0.0003	—	Fluoranthene	0.012254
Thorium	0.0019	—	Fluorene	0.045188
Titanium	0.1108	—	Ideno(l, 2, 3-cd)pyrene	0.000097
Tungsten	0.0002	—	Indole	0.000141
Uranium	0.0004	—	Naphthalene	0.489406
Vanadium	0.0056	—	Nitrobenzanthrene	0.000002
Zinc	0.0165	0.070	Nitro-pyrene	0.000095
			Perylene	0.000057
			Phenanthrene	0.136329
			Pyrene	0.009803
			Retene	0.000804

[a] These values represent the average analytical result for each metal compound plus one standard deviation.
[b] Source: Schauer *et al.* (1999); PM = particulate matter.
[c] Source: Suncor 1998.

7.3.3   Air Quality Predictions

Concentrations and deposition patterns predicted

The CALPUFF dispersion model, described in Section 7.1.5.4, was used to predict concentrations and deposition patterns for the application case. The modelling results are presented in a combination of tables and figures.

Results for both active mine area and area beyond the mine are shown

The series of tables used in this section include two separate sets of results. The first results represent the predictions over the entire regional study area (RSA) including the active mine area. The second results represent the predictions excluding the active mine area. This allows the reviewers to separate regional air quality impacts from those that occur in the active mine area.

Figures represent the maximum concentration or deposition value

The figures show the distribution of maximum concentration or deposition, as represented by isopleths (*i.e.*, curves joining points of equal concentration or deposition values). To illustrate concentration or deposition isopleths, consider any point (or receptor) in the RSA. For every hour modelled, the dispersion model will calculate a concentration or deposition value at this point. This value changes from hour to hour eventually reaching an absolute maximum concentration or deposition value for the particular point. Each such point modelled in the RSA reaches its maximum value at different times. An isopleth is then simply a curve joining points in the RSA of equal maximum concentrations or deposition values.

The isopleths represent relevant criteria or selected values

The concentration isopleths, in units of $\mu g/m^3$, represent 100%, 50%, and 25% of the relevant criteria. The deposition isopleths represent predicted potential acid input (PAI) values of 1.00, 0.50, 0.25, and 0.17 keq/ha/yr. The isopleths overlay the local topography. In each figure, the larger plot to the left encompasses the entire RSA (dashed line). The smaller plot in the upper right presents the same results as the larger plot, but focuses on the immediate vicinity of the Snap Lake Diamond Project.

7.3.3.1   Particulate Matter

PM_{10} and $PM_{2.5}$ are fractions of the total suspended particulates

For this assessment, three ranges of particulate matter are evaluated. The total suspended particulate (TSP) matter represents the fraction of emitted particles that are small enough to remain airborne for more than a few metres. The PM_{10} fraction of the airborne particles represents the fraction of the TSP that is nominally smaller than 10 µm in diameter. The $PM_{2.5}$ fraction of the airborne particles represents the fraction of the TSP that is nominally smaller than 2.5 µm in diameter. Both PM_{10} and $PM_{2.5}$ are subsets of TSP, therefore the emissions and predictions of TSP include the PM_{10} and $PM_{2.5}$ fractions. As particulate matter emissions were estimated to

be at a maximum during operations, only predictions during the operations phase of the development have been presented.

7.3.3.1.1   Total Suspended Particulates

Total suspended particulate concentrations exceeding the NWT standard are confined to the active mine area and the quarry

Table 7.3-9 presents the TSP predictions resulting from activities at the Snap Lake Diamond Project. Over the entire RSA, the maximum 24-hour and annual TSP concentrations exceed the NWT standards of 100 and 60 µg/m³, respectively. However, the ground-level TSP concentrations decrease rapidly outside the confines of the active mine area. Beyond the active mine area, the 24-hour TSP predictions exceeded the NWT standard of 100 µg/m³ only once, in a small area adjacent to the quarry. None of the annual TSP predictions outside of the active mine area plus a 500 m buffer exceeded the NWT standard of 60 µg/m³.

Table 7.3-9   Maximum Application TSP Predictions

Parameter	Averaging Period	
	24-Hour	Annual
RSA Including Active Mine Area		
Maximum TSP concentration [µg/m³]	270.5	101.8
Occurrences above NWT standard	190	1
Areal extent above NWT standard [ha]	56	8
RSA Excluding Active Mine Area		
Maximum TSP concentration [µg/m³]	116.5 [b]	18.0
Occurrences above NWT standard	1	0
Areal extent above NWT standard [ha]	1	0
NWT TSP Standard[a] [µg/m³]	**100**	**60**

[a]   Guideline respecting ambient air quality standards for sulphur dioxide and total suspended particulate in the Northwest Territories (GNWT 1994).

[b]   This concentration, which exceeds the NWT TSP Standard, occurred adjacent to the active mine area within the 500 m buffer identified in Table 7.1-8.

The maximum 24-hour and annual total suspended particulates are less than the NWT standards outside of the active mine area and the quarry

Plots of the maximum 24-hour and annual TSP predictions for the application case emissions are provided in Figures 7.3-1 and 7.3-2, respectively. The concentration isopleths represent 100%, 50%, and 25% of the NWT standards for TSP. The figures indicate the following:

- The maximum 24-hour predictions (Figure 7.3-1) are generally less than the NWT standard outside the active mine area. The exception is an isolated area near the quarry.

- The plot of annual TSP prediction (Figure 7.3-2) illustrates that the only areas where the concentrations exceed the NWT standards of 60 µg/m³ are contained within the active mine area. Annual TSP concentration outside the active mine area are less than 25% of the NWT standard.

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Figure 7.3-1　Maximum 24-Hour Application TSP Predictions

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Figure 7.3-2   Annual Application TSP Predictions

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7.3.3.1.2　　PM$_{10}$

PM$_{10}$ guidelines are not exceeded except the 24-hour PM$_{10}$ guideline which is exceeded adjacent to the active mine area

Table 7.3-10 presents the PM$_{10}$ predictions resulting from activities at the Snap Lake Diamond Project. As the NWT has yet to establish criteria for PM$_{10}$, the interim 24-hour guidelines adopted in British Columbia, Ontario, and Newfoundland were used. The maximum 24-hour PM$_{10}$ concentrations for the RSA are predicted to exceed the 50 µg/m³ criteria adjacent to the active mine area. The maximum 24-hour PM$_{10}$ concentrations also exceed the criteria at two locations within the active mining area. None of the annual PM$_{10}$ predictions exceed the U.S. EPA primary of 50 µg/m³. This is the only annual PM$_{10}$ criterion available in North America.

Table 7.3-10　Maximum Application PM$_{10}$ Predictions

Parameter	Averaging Period	
	24-Hour	**Annual**
RSA Including Active Mine Area		
Maximum PM$_{10}$ concentration [µg/m³]	120.7	27.5
Occurrences above the criteria	40	0
Areal extent above the criteria [ha]	18	0
RSA Excluding Active Mining Area		
Maximum PM$_{10}$ concentration [µg/m³]	45.2	5.1
Occurrences above the criteria	0	0
Areal extent above the criteria [ha]	0	0
PM$_{10}$ Criteria [µg/m³]	**50[(a)]**	**50[(b)]**

[(a)]　Newfoundland, Ontario and BC have established a 24-hour PM$_{10}$ guideline of 50 µg/m³.

[(b)]　The annual U.S. EPA primary PM$_{10}$ standard is 50 µg/m³.

The maximum 24-hour PM$_{10}$ are below criteria outside the active mine area and the quarry; annual PM$_{10}$ are below criteria

Plots of the maximum 24-hour and annual PM$_{10}$ predictions for the application case emissions are provided in Figures 7.3-3 and 7.3-4, respectively. The concentration isopleths of 50, 25, and 12.5 µg/m³ represent 100%, 50%, and 25% of the available PM$_{10}$ criteria for both the 24-hour and annual averaging periods. The figures indicate the following:

- The maximum 24-hour PM$_{10}$ predictions (Figure 7.3-3) are generally below the 50 µg/m³ interim criteria established in British Columbia, Ontario, and Newfoundland outside the active mine area. The exception is a small area in the vicinity of the quarry.

- Figure 7.3-4 illustrates the annual PM$_{10}$ predictions. None of the annual PM$_{10}$ exceed the U.S. EPA primary standard.

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7.3.3.1.3   PM$_{2.5}$

Predicted 98th percentile PM$_{2.5}$ values are in compliance

Table 7.3-11 presents the PM$_{2.5}$ predictions resulting from activities at the Snap Lake Diamond Project. The maximum 24-hour PM$_{2.5}$ concentrations are predicted to exceed the 30 μg/m³ Canada-Wide Standard (CWS) within the active mine area. However, the 98th percentile of the observed/predicted values is to be used when determining compliance with the CWS for PM$_{2.5}$. The PM$_{2.5}$ CWS would be satisfied on this basis, even in the active mining area. None of the annual PM$_{2.5}$ predictions exceed the U.S. EPA primary standard of 15 μg/m³. There are no annual PM$_{2.5}$ criteria available in Canada.

Table 7.3-11   Maximum Application PM$_{2.5}$ Predictions

Parameter	Averaging Period	
	24-Hour	Annual
RSA Including Active Mine Area		
Maximum PM$_{2.5}$ concentration [μg/m³]	42.1	8.1
Occurrences above criteria	2	0
Areal extent above criteria [ha]	<1	0
RSA Excluding Active Mine Area		
Maximum PM$_{2.5}$ concentration [μg/m³]	16.1	1.6
Occurrences above criteria	0	0
Areal extent above criteria [ha]	0	0
Areal extent above criteria [ha]	0	0
PM$_{2.5}$ Criteria [μg/m³]	**30$^{(a)}$**	**15$^{(b)}$**

(a)   The 24-hour Canada-Wide Standard (CCME 2000) for PM$_{2.5}$ is 30 μg/m³.

(b)   The annual U.S. EPA primary PM$_{2.5}$ standard is 15 μg/m³.

The maximum 24-hour PM$_{2.5}$ is below the standard outside the active mine area and the maximum annual PM$_{2.5}$ is below the standard at all locations

Figures 7.3-5 and 7.3-6 present the maximum 24-hour and annual PM$_{2.5}$ predictions, respectively. The concentration isopleths represent 100%, 50%, and 25% of the available PM$_{2.5}$ criteria. The figures indicate the following:

- The maximum 24-hour PM$_{2.5}$ predictions in the RSA exceed the 30 μg/m³ level adopted as the Canada-Wide Standard over a small area within the active mine area. The area is so small (<1 ha) that it is not visible in Figure 7.3-5. All of the 24-hour PM$_{2.5}$ outside the active mine area are below 30 μg/m³.

- Figure 7.3-6 presents a plot of the annual PM$_{2.5}$ predictions. None of the annual PM$_{2.5}$ predictions in the RSA exceed the U.S. EPA primary standard.

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Figure 7.3-3   Maximum 24-Hour Application PM$_{10}$ Predictions

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Figure 7.3-4   Annual Application PM$_{10}$ Predictions

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Figure 7.3-5   Maximum 24-Hour Application PM$_{2.5}$ Predictions

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Figure 7.3-6   Annual Application PM$_{2.5}$ Predictions

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7.3.3.2   Sulphur Dioxide (SO_2)

Maximum 1-hour, 24-hour, and annual SO_2 concentrations are below the standards

Table 7.3-12 presents the maximum SO_2 predictions resulting from activities at the Snap Lake Diamond Project. The maximum 1-hour, 24-hour, and annual concentrations for the RSA (including the active mine area) are predicted to be below the respective NWT standards of 450, 150, and 30 µg/m³.

Table 7.3-12   Maximum Application SO_2 Predictions

Parameter	Averaging Period		
	1-Hour	24-Hour	Annual
RSA Including Active Mine Area			
Maximum SO_2 concentration [µg/m³]	245.0	129.5	11.6
Occurrences above the NWT standard	0	0	0
Areal extent above the NWT standard [ha]	0	0	0
RSA Excluding Active Mine Area			
Maximum SO_2 concentration [µg/m³]	35.9	12.2	1.6
Occurrences above the NWT standard	0	0	0
Areal extent above the NWT standard [ha]	0	0	0
NWT SO_2 Standard[a] [µg/m³]	**450**	**150**	**30**

[a]   Guideline respecting ambient air quality standards for sulphur dioxide and total suspended particulate in the Northwest Territories (GNWT 1994).

The maximum 1-hour, 24-hour, and annual SO_2 predictions do not exceed the NWT standard

Figures 7.3-7, 7.3-8, and 7.3-9 present the maximum 1-hour, 24-hour, and annual SO_2 predictions, respectively. The concentration isopleths represent 100%, 50%, and 10% of the NWT SO_2 standards. The lowest isopleth line has been set at 10% of the NWT standards in an effort to show some of the predictions on the figures. The figures indicate the following:

- The maximum 1-hour SO_2 predictions (Figure 7.3-7) are below the NWT standard of 450 µg/m³. In fact, there is only a small area near the power plant where the maximum 1-hour SO_2 concentrations were predicted to exceed 10% of the NWT standards.

- The maximum 24-hour SO_2 predictions (Figure 7.3-8) are all well below NWT standard of 150 µg/m³.

- The plot of annual SO_2 predictions (Figure 7.3-9) illustrates patterns similar to the 1-hour and 24-hour predictions. None of the annual SO_2 predictions in the RSA exceed the NWT standard of 30 µg/m³.

7.3.3.3   Oxides of Nitrogen

The maximum 1-hour, 24-hour, and annual NO$_2$ concentrations are below the criteria

Table 7.3-13 summarizes the maximum NO_2 and NO_X predictions resulting from the Snap Lake Diamond Project. As indicated in the table, the maximum 1-hour, 24-hour, and annual NO_2 concentrations over the entire RSA are below the respective federal ambient air quality objectives (FAAQO) of 400, 200, and 100 μg/m³.

Table 7.3-13   Maximum Application NO$_X$ and NO$_2$ Predictions

Parameter	Averaging Period		
	1-Hour	24-Hour	Annual
RSA Including Active Mine Area			
Maximum NO$_X$ concentration [μg/m³]	1,408.5	632.0	219.1
Maximum NO$_2$ concentration[(a)] [μg/m³]	236.5	139.7	88.8
Areal extent above the criteria [ha]	0	0	0
RSA Excluding Active Mine Area			
Maximum NO$_X$ concentration [μg/m³]	1,080.3	216.0	27.3
Maximum NO$_2$ concentration[(a)] [μg/m³]	203.6	98.1	27.3
Areal extent above the criteria [ha]	0	0	0
NO$_2$ Criteria[(b)] [μg/m³]	**400**	**200**	**100**

[(a)]   NO$_2$ concentrations calculated by the ozone limiting method (AENV 2000).

[(b)]   Acceptable federal ambient air quality objective.

All NO$_2$ criteria are met

Figures 7.3-10, 7.3-11 and 7.3-12 present the maximum 1-hour, 24-hour and annual NO_2 predictions, respectively. The concentration isopleths represent 100%, 50%, and 25% of the acceptable FAAQOs. The figures indicate the following:

- The maximum 1-hour NO_2 predictions in the RSA (Figure 7.3-10) are all below FAAQO of 400 μg/m³. The 1-hour NO_2 concentrations were calculated using the ozone limiting method and a background ozone (O_3) concentration of 50 ppb, as requested by Environment Canada personnel (Dave Fox, pers. comm.).

- The maximum 24-hour NO_2 predictions (Figure 7.3-11) are all below the acceptable FAAQO of 200 μg/m³. The 24-hour NO_2 concentrations were calculated using the ozone limiting method and a background O_3 concentration of 40 ppb, in accordance with the Alberta Guideline and the request from Environment Canada personnel.

- The plot of annual NO_2 prediction (Figure 7.3-12) illustrates that none of the annual predictions exceed the acceptable FAAQO of 100 μg/m³. Annual NO_2 concentrations were calculated using the ozone limiting method and a background O_3 concentration of 35 ppb, in accordance with the Alberta Guideline and the requests of Environment Canada personnel.

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Figure 7.3-7   Maximum 1-Hour Application SO$_2$ Predictions

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Figure 7.3-8   Maximum 24-Hour Application SO$_2$ Predictions

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Figure 7.3-9   Annual Application SO$_2$ Predictions

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Figure 7.3-10 Maximum 1-Hour Application NO$_2$ Predictions

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Figure 7.3-11 Maximum 24-Hour Application NO$_2$ Predictions

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Figure 7.3-12 Annual Application NO$_2$ Predictions

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7.3.3.4 Other Air Compounds

7.3.3.4.1 *Polycyclic Aromatic Hydrocarbons (PAH)*

Ground level concentrations and atmospheric deposition of polycyclic aromatic hydrocarbons were predicted

Modern combustion systems are generally highly efficient, and will result in nearly complete combustion of the fuel. However, it is feasible that the diesel fuel burned at the Snap Lake Diamond Project could result in limited emissions of polycyclic aromatic hydrocarbons (PAHs). The PAH emissions were modelled using the CALPUFF dispersion model to determine the ground level concentrations and atmospheric deposition (both wet scavenging and dry deposition) of these compounds throughout the air quality RSA. The maximum ground level concentrations of the PAH compounds emitted from the Snap Lake Diamond Project are listed in Table 7.3-14. The table includes the maximum predictions across the RSA as well as the maximum predictions for only those receptors that fall outside of the active mining area.

Wet and dry deposition was predicted

In addition to the predictions of ground level concentrations, the CALPUFF dispersion model predicted the wet and dry deposition of PAH compounds in the RSA. Maximum predicted PAH deposition rates are provided in Table 7.3-15.

Polycyclic aromatic hydrocarbons were also predicted for use in the wildlife and human health assessment

One of the important uses of the PAH predictions is in the Environmental Health (Section 11) assessment. For the purposes of this assessment, average annual concentration and deposition rates were calculated for the entire wildlife RSA, which encloses a circle, 31 km in radius, centred on the mine site. Annual concentration and deposition rates were also determined over a wildlife local study area (LSA). The wildlife LSA encloses an area that extends 500 m beyond the perimeter of the project footprint. The concentration and deposition values presented in Table 7.3-16 correspond to the average annual concentrations and deposition rates over these areas.

7.3.3.4.2 Trace Metals

Concentrations and deposition of trace metals were predicted for the regional study area

The combustion of diesel fuel, as well as the processing of kimberlite, could result in the emissions of small volumes of trace metal compounds from the Snap Lake Diamond Project. Ground-level concentrations and atmospheric deposition (both wet scavenging and dry deposition) of these compounds throughout the air quality RSA were determined using the CALPUFF model. The maximum ground level concentrations of the trace metals are presented in Table 7.3-17. The table includes the maximum predictions for the entire RSA including the active mine area, as well as the maximum predictions for the portion of the RSA that falls outside of the active mine area.

Table 7.3-14   Predicted PAH Concentrations for the Application Case

Species	Maximum PAH Concentration [µg/m³]					
	RSA[a] Including Active Mine Area			RSA Excluding Active Mine Area		
	1-Hour	24-Hour	Annual	1-Hour	24-Hour	Annual
1,2-benzathracene	0.000062	0.000032	0.000006	0.000057	0.000013	0.000002
1,6-dinitropyrene	0.000046	0.000024	0.000005	0.000042	0.000010	0.000001
1,8-dinitropyrene	0.000046	0.000024	0.000005	0.000042	0.000010	0.000001
1-chloronaphthalene	0.000047	0.000024	0.000005	0.000043	0.000010	0.000001
1-methylnaphthalene	0.001764	0.000915	0.000177	0.001615	0.000377	0.000046
2-chloronaphthalene	0.000070	0.000036	0.000007	0.000064	0.000015	0.000002
2-methylnaphthalene	0.001712	0.000888	0.000172	0.001568	0.000366	0.000044
7,12-dimethylbenz(a)anthracene	0.000046	0.000024	0.000005	0.000042	0.000010	0.000001
Acenaphthene	0.011156	0.005784	0.001120	0.010213	0.002387	0.000289
Acenaphylene	0.023350	0.012107	0.002345	0.021375	0.004995	0.000605
Anthracene	0.003445	0.001786	0.000346	0.003154	0.000737	0.000089
Benzo(a)fluorene	0.000773	0.000401	0.000078	0.000708	0.000165	0.000020
Benzo(a)pyrene	0.000365	0.000189	0.000037	0.000334	0.000078	0.000009
Benzo(b & j)fluoranthene	0.000377	0.000195	0.000038	0.000345	0.000081	0.000010
Benzo(b)fluorene	0.000033	0.000017	0.000003	0.000031	0.000007	0.000001
Benzo(e)pyrene	0.000078	0.000040	0.000008	0.000071	0.000017	0.000002
Benzo(g, h, i)perylene	0.000752	0.000390	0.000076	0.000689	0.000161	0.000019
Benzo(k)fluoranthene	0.000360	0.000187	0.000036	0.000330	0.000077	0.000009
Camphene	0.000092	0.000048	0.000009	0.000085	0.000020	0.000002
Carbazole	0.000052	0.000027	0.000005	0.000048	0.000011	0.000001
Chrysene	0.002319	0.001203	0.000233	0.002123	0.000496	0.000060
Dibenz(a,h)anthracene	0.000872	0.000452	0.000088	0.000798	0.000186	0.000023
Dibenz(a,h)acridine	0.000046	0.000024	0.000005	0.000042	0.000010	0.000001
Dibenz(a,j)acridine	0.000056	0.000029	0.000006	0.000051	0.000012	0.000001
Dibenzothiophene	0.005708	0.002959	0.000573	0.005225	0.001221	0.000148
Fluoranthene	0.008302	0.004305	0.000834	0.007600	0.001776	0.000215
Fluorene	0.030614	0.015874	0.003074	0.028025	0.006550	0.000793
Ideno(l,2,3-cd)pyrene	0.000066	0.000034	0.000007	0.000060	0.000014	0.000002
Indole	0.000095	0.000050	0.000010	0.000087	0.000020	0.000002
Naphthalene	0.331568	0.171919	0.033296	0.303530	0.070935	0.008593
Nitrobenzanthrene	0.000002	0.000001	0.000000	0.000001	0.000000	0.000000
Nitro-pyrene	0.000064	0.000033	0.000006	0.000059	0.000014	0.000002
Perylene	0.000039	0.000020	0.000004	0.000036	0.000008	0.000001
Phenanthrene	0.092362	0.047890	0.009275	0.084551	0.019760	0.002394
Pyrene	0.006642	0.003444	0.000667	0.006080	0.001421	0.000172
Retene	0.000545	0.000282	0.000055	0.000499	0.000117	0.000014

[a]   RSA = regional study area for air quality.

Table 7.3-15 Predicted PAH Deposition for the Application Case

Species	Maximum Annual PAH Deposition [kg/ha/yr]	
	RSA[a] Including Active Mine Area	RSA Excluding Active Mine Area
1,2-benzathracene	0.000015	0.000004
1,6-dinitropyrene	0.000011	0.000003
1,8-dinitropyrene	0.000011	0.000003
1-chloronaphthalene	0.000011	0.000003
1-methylnaphthalene	0.000417	0.000114
2-chloronaphthalene	0.000017	0.000005
2-methylnaphthalene	0.000405	0.000111
7,12-dimethylbenz(a)anthracene	0.000011	0.000003
Acenaphthene	0.002638	0.000723
Acenaphylene	0.005522	0.001513
Anthracene	0.000815	0.000223
Benzo(a)fluorene	0.000183	0.000050
Benzo(a)pyrene	0.000086	0.000024
Benzo(b & j)fluoranthene	0.000089	0.000024
Benzo(b)fluorene	0.000008	0.000002
Benzo(e)pyrene	0.000018	0.000005
Benzo(g, h, i)perylene	0.000178	0.000049
Benzo(k)fluoranthene	0.000085	0.000023
Camphene	0.000022	0.000006
Carbazole	0.000012	0.000003
Chrysene	0.000548	0.000150
Dibenz(a,h)anthracene	0.000206	0.000056
Dibenz(a,h)acridine	0.000011	0.000003
Dibenz(a,j)acridine	0.000013	0.000004
Dibenzothiophene	0.001350	0.000370
Fluoranthene	0.001963	0.000538
Fluorene	0.007240	0.001984
Ideno(l,2,3-cd)pyrene	0.000016	0.000004
Indole	0.000023	0.000006
Naphthalene	0.078409	0.021483
Nitrobenzanthrene	0.000000	0.000000
Nitro-pyrene	0.000015	0.000004
Perylene	0.000009	0.000003
Phenanthrene	0.021842	0.005984
Pyrene	0.001571	0.000430
Retene	0.000129	0.000035

[a]   RSA = regional study area for air quality.

Table 7.3-16   PAH Predictions for Use in the Environmental Health Assessment

Species	Annual Average Concentrations [µg/m³]		Average Annual Deposition [kg/ha/yr]	
	Wildlife RSA[a]	Wildlife LSA[b]	Wildlife RSA	Wildlife LSA
1,2-benzathracene	0.00000003	0.00000057	0.00000007	0.00000148
1,6-dinitropyrene	0.00000002	0.00000042	0.00000005	0.00000110
1,8-dinitropyrene	0.00000002	0.00000042	0.00000005	0.00000110
1-chloronaphthalene	0.00000002	0.00000044	0.00000006	0.00000113
1-methylnaphthalene	0.00000081	0.00001632	0.00000210	0.00004226
2-chloronaphthalene	0.00000003	0.00000065	0.00000008	0.00000168
2-methylnaphthalene	0.00000079	0.00001584	0.00000204	0.00004102
7,12-dimethylbenz(a)anthracene	0.00000002	0.00000042	0.00000005	0.00000110
Acenaphthene	0.00000513	0.00010319	0.00001327	0.00026724
Acenaphylene	0.00001073	0.00021599	0.00002777	0.00055933
Anthracene	0.00000158	0.00003187	0.00000410	0.00008253
Benzo(a)fluorene	0.00000036	0.00000715	0.00000092	0.00001852
Benzo(a)pyrene	0.00000017	0.00000337	0.00000043	0.00000874
Benzo(b & j)fluoranthene	0.00000002	0.00000031	0.00000004	0.00000080
Benzo(b)fluorene	0.00000017	0.00000348	0.00000045	0.00000902
Benzo(e)pyrene	0.00000004	0.00000072	0.00000009	0.00000186
Benzo(g,h,i)perylene	0.00000035	0.00000696	0.00000089	0.00001802
Benzo(k)fluoranthene	0.00000017	0.00000333	0.00000043	0.00000863
Camphene	0.00000004	0.00000085	0.00000011	0.00000221
Carbazole	0.00000002	0.00000048	0.00000006	0.00000124
Chrysene	0.00000107	0.00002145	0.00000276	0.00005556
Dibenz(a,h anthracene	0.00000002	0.00000042	0.00000005	0.00000110
Dibenz(a,h)acridine	0.00000040	0.00000806	0.00000104	0.00002088
Dibenz(a,j)acridine	0.00000003	0.00000051	0.00000007	0.00000133
Dibenzothiophene	0.00000262	0.00005280	0.00000679	0.00013673
Fluoranthene	0.00000381	0.00007679	0.00000988	0.00019887
Fluorene	0.00001407	0.00028318	0.00003642	0.00073334
Ideno(l,2,3-cd)pyrene	0.00000003	0.00000061	0.00000008	0.00000158
Indole	0.00000004	0.00000088	0.00000011	0.00000229
Naphthalene	0.00015233	0.00306700	0.00039440	0.00794249
Nitrobenzanthrene	0.00000000	0.00000001	0.00000000	0.00000004
Nitro-pyrene	0.00000003	0.00000060	0.00000008	0.00000154
Perylene	0.00000002	0.00000036	0.00000005	0.00000093
Phenanthrene	0.00004243	0.00085434	0.00010987	0.00221246
Pyrene	0.00000305	0.00006144	0.00000790	0.00015910
Retene	0.00000025	0.00000504	0.00000065	0.00001305

[a]   RSA = wildlife regional study area = the area within a 31 km radius centred on the mine site.

[b]   LSA = wildlife local study area = project footprint plus a 500 m buffer.

Table 7.3-17   Predicted Trace Metal Concentrations for the Application Case

Species	Maximum Trace Metal Predictions [µg/m³]					
	RSA[a] Including Active Mine Area			RSA Excluding Active Mine Area		
	1-Hour	24-Hour	Annual	1-Hour	24-Hour	Annual
Aluminum	1.24176	0.37097	0.04344	0.68270	0.15611	0.01167
Antimony	0.00010	0.00003	0.00000	0.00005	0.00001	0.00000
Arsenic	0.00050	0.00015	0.00002	0.00027	0.00006	0.00000
Barium	0.10327	0.02981	0.00330	0.05505	0.01257	0.00089
Bismuth	0.00017	0.00005	0.00001	0.00009	0.00002	0.00000
Boron	0.00426	0.00123	0.00014	0.00227	0.00052	0.00004
Cadmium	0.04085	0.02114	0.00409	0.03732	0.00872	0.00106
Calcium	4.26302	1.23546	0.13778	2.28037	0.52063	0.03720
Chromium	0.05358	0.01703	0.00218	0.03115	0.00715	0.00058
Cobalt	0.01217	0.00507	0.00085	0.00908	0.00211	0.00022
Copper	0.01174	0.00495	0.00084	0.00885	0.00205	0.00022
Gold	0.00047	0.00014	0.00002	0.00025	0.00006	0.00000
Iron	3.71208	1.07951	0.12108	1.99185	0.45484	0.03268
Lanthanum	0.01222	0.00353	0.00039	0.00652	0.00149	0.00011
Lead	0.00784	0.00382	0.00071	0.00677	0.00158	0.00018
Magnesium	10.23958	2.95630	0.32760	5.45868	1.24604	0.08852
Manganese	0.12712	0.03826	0.00453	0.07036	0.01609	0.00122
Mercury	0.00003	0.00001	0.00000	0.00002	0.00000	0.00000
Molybdenum	0.00112	0.00032	0.00004	0.00060	0.00014	0.00001
Nickel	0.07666	0.02213	0.00245	0.04087	0.00933	0.00066
Phosphorus	0.17951	0.05338	0.00621	0.09828	0.02247	0.00167
Potassium	0.50176	0.14486	0.01605	0.26749	0.06106	0.00434
Silver	0.00685	0.00353	0.00068	0.00624	0.00146	0.00018
Sodium	0.02722	0.00786	0.00087	0.01451	0.00331	0.00024
Strontium	0.01931	0.00558	0.00062	0.01030	0.00235	0.00017
Thallium	0.00017	0.00005	0.00001	0.00009	0.00002	0.00000
Thorium	0.00127	0.00037	0.00004	0.00068	0.00015	0.00001
Titanium	0.07356	0.02124	0.00235	0.03922	0.00895	0.00064
Tungsten	0.00010	0.00003	0.00000	0.00006	0.00001	0.00000
Uranium	0.00027	0.00008	0.00001	0.00014	0.00003	0.00000
Vanadium	0.00371	0.00107	0.00012	0.00198	0.00045	0.00003
Zinc	0.05840	0.02776	0.00511	0.04926	0.01148	0.00132

[a]   RSA = regional study area for air quality.

Wet and dry deposition was predicted

In addition to the predictions of ground level concentrations, predictions were made of the wet and dry deposition of trace metals in the RSA. The maximum predicted metal deposition rates are shown in Table 7.3-18.

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Table 7.3-18   Predicted Trace Metal Deposition for the Application Case

Species	Maximum Annual Trace Metal Deposition [kg/ha/yr]	
	RSA[a] Including Active Mine Area	RSA Excluding Active Mine Area
Aluminum	0.35709	0.09886
Antimony	0.00003	0.00001
Arsenic	0.00015	0.00004
Barium	0.02994	0.00829
Bismuth	0.00005	0.00001
Boron	0.00124	0.00034
Cadmium	0.00967	0.00265
Calcium	1.23476	0.34197
Chromium	0.01517	0.00420
Cobalt	0.00317	0.00087
Copper	0.00304	0.00084
Gold	0.00014	0.00004
Iron	1.07432	0.29753
Lanthanum	0.00354	0.00098
Lead	0.00191	0.00052
Magnesium	2.96844	0.82216
Manganese	0.03649	0.01010
Mercury	0.00001	0.00000
Molybdenum	0.00032	0.00009
Nickel	0.02222	0.00616
Phosphorus	0.05168	0.01431
Potassium	0.14546	0.04029
Silver	0.00162	0.00044
Sodium	0.00789	0.00219
Strontium	0.00560	0.00155
Thallium	0.00005	0.00001
Thorium	0.00037	0.00010
Titanium	0.02133	0.00591
Tungsten	0.00003	0.00001
Uranium	0.00008	0.00002
Vanadium	0.00108	0.00030
Zinc	0.01440	0.00395

[a]   LSA = wildlife local study area = project footprint plus a 500 m buffer.

Trace metals were also predicted for use in the wildlife and human health assessments

Trace metal predictions are used in Environmental Health (Section 11). For the purposes of the health assessment, average annual concentration and deposition rates were calculated for the entire wildlife RSA, which encloses a circle, 31 km in radius, centred on the mine site. Annual concentration and deposition rates were also determined over the wildlife LSA. The

wildlife LSA encloses an area that extends 500 m beyond the perimeter of the project footprint. The concentration and deposition values presented in Table 7.3-19 correspond to the average annual concentrations and deposition rates over these areas.

Table 7.3-19 Trace Metal Predictions for Use in the Environmental Health Assessment

Species	Average Annual Concentrations [µg/m³]		Average Annual Deposition [kg/ha/yr]	
	Wildlife RSA[a]	Wildlife LSA[b]	Wildlife RSA	Wildlife LSA
Aluminum	0.000120475	0.005332294	0.000971969	0.046073321
Antimony	0.000000008	0.000000405	0.000000076	0.000003753
Arsenic	0.000000041	0.000002052	0.000000385	0.000019016
Barium	0.000008311	0.000420093	0.000078915	0.003893571
Bismuth	0.000000013	0.000000676	0.000000127	0.000006263
Boron	0.000000343	0.000017343	0.000003258	0.000160739
Cadmium	0.000018692	0.000376833	0.000048508	0.000981395
Calcium	0.000350787	0.017447139	0.003266321	0.160450782
Chromium	0.000006879	0.000253071	0.000043826	0.001927017
Cobalt	0.000003547	0.000084603	0.000012179	0.000365597
Copper	0.000003512	0.000082851	0.000011850	0.000349354
Gold	0.000000038	0.000001919	0.000000360	0.000017785
Iron	0.000311582	0.015276152	0.002851072	0.139492211
Lanthanum	0.000000984	0.000049717	0.000009339	0.000460796
Lead	0.000003198	0.000067000	0.000008873	0.000202439
Magnesium	0.000824075	0.041654309	0.007824800	0.386067208
Manganese	0.000012798	0.000552236	0.000100025	0.004699784
Mercury	0.000000003	0.000000135	0.000000025	0.000001251
Molybdenum	0.000000090	0.000004549	0.000000855	0.000042162
Nickel	0.000006170	0.000311852	0.000058582	0.002890357
Phosphorus	0.000017014	0.000765329	0.000140054	0.006674803
Potassium	0.000040381	0.002041136	0.000383429	0.018917990
Silver	0.000003118	0.000062962	0.000008114	0.000165018
Sodium	0.000002190	0.000110718	0.000020799	0.001026176
Strontium	0.000001554	0.000078567	0.000014759	0.000728189
Thallium	0.000000013	0.000000675	0.000000127	0.000006256
Thorium	0.000000102	0.000005176	0.000000972	0.000047977
Titanium	0.000005920	0.000299247	0.000056214	0.002773530
Tungsten	0.000000008	0.000000422	0.000000079	0.000003914
Uranium	0.000000021	0.000001080	0.000000203	0.000010009
Vanadium	0.000000299	0.000015097	0.000002836	0.000139921
Zinc	0.000022671	0.000483312	0.000064797	0.001549737

[a] RSA = wildlife regional study area = the area within a 31 km radius centred on the mine site.

[b] LSA = wildlife local study area = project footprint plus a 500 m buffer.

7.3.3.5   Potential Acid Input

Potential acid input (PAI) due to SO_2 and NO_X was calculated

The air quality assessment of the Snap Lake Diamond Project includes an evaluation of the deposition of acid forming compounds. The air quality assessment will focus on determining the potential acid input (PAI) resulting from the project emissions of SO_2 and NO_X. The PAI is a widely accepted method of assessing acidification, since it incorporates the effect of sulphur and nitrogen compounds as well as the neutralizing effect of available base cations. As discussed in Section 7.1.5.4, PAI was determined using the CALPUFF dispersion model. The PAI predictions include a uniform background PAI value of 0.040 keq/ha/yr.

Potential acid input decreases rapidly within the active mine area

Table 7.3-20 summarizes the maximum PAI, nitrogen, and sulphur deposition levels predicted for the application case emissions. The table shows that the maximum predictions fall off rapidly within the limits of the active mine area.

Table 7.3-20   Maximum Application PAI Predictions

Parameter	Annual Deposition [keq/ha/yr]
RSA Including Active Mine Area	
Overall PAI[a]	1.106
Background PAI	0.040
Nitrogen deposition	0.984
Sulphur deposition	0.083
RSA Excluding Active Mine Area	
Overall PAI[a]	0.175
Background PAI	0.040
Nitrogen deposition	0.123
Sulphur deposition	0.013

[a]   The overall PAI predictions include a uniform background value of 0.040 keq/ha/yr.

All of the potential acid input values beyond the active mine area are below protective levels

In addition to the maximum PAI predictions, CALPUFF was used to determine the areas with predicted PAI above 1.00, 0.50, 0.25, and 0.17 keq/ha/yr. These results are presented in Table 7.3-21. The table demonstrates that none of the predicted PAI values beyond the active mine area exceed 0.25 keq/ha/yr, which has been identified as providing long-term protection to the most sensitive ecosystems (CASA 1999). In fact, less than 1 ha outside the active mining area was predicted to receive PAI levels in excess of 0.17 keq/ha/yr.

Table 7.3-21   Spatial Extent for Predicted Application PAI Values

Parameter	Spatial Extent[a]	
	Area [ha]	Fraction of RSA [%]
RSA Including Active Mine Area		
Area with PAI greater than 0.17 keq/ha/yr	47	0.004
Area with PAI greater than 0.25 keq/ha/yr	35	0.003
Area with PAI greater than 0.50 keq/ha/yr	12	0.001
Area with PAI greater than 1.00 keq/ha/yr	0	0.000
RSA Excluding Active Mine Area		
Area with PAI greater than 0.17 keq/ha/yr	< 1	0.000
Area with PAI greater than 0.25 keq/ha/yr	0	0.000
Area with PAI greater than 0.50 keq/ha/yr	0	0.000
Area with PAI greater than 1.00 keq/ha/yr	0	0.000

[a] Calculations of the spatial extent incorporated a uniform background PAI of 0.040 keq/ha/yr.

Potential acid input deposition occurs within the active mine area

Figure 7.3-13 presents a plot of the PAI predictions resulting from the Snap Lake Diamond Project. The figure indicates that the deposition of acid forming compounds is contained almost entirely within the active mine area.

7.3.4   Key Question AQ-1: What Impacts will Air Emissions from the Snap Lake Diamond Project Have on Air Quality?

7.3.4.1   Linkage Analysis

Linkage is valid and impact assessment was done

The potential for emissions from the Snap Lake Diamond Project to affect the quality of the air in the region is an essential issue with regulators and regional stakeholders. The linkage pathways for this key question are shown in Figure 7.3-14. The linkage diagram illustrates that various components of the Snap Lake Diamond Project can contribute to increased air emissions in the region, which will result in changes in air quality. These changes can, in turn, affect other components of the environment such as vegetation or human and wildlife health. The linkages in Figure 7.3-14 were considered valid, and an impact assessment has been completed.

7.3.4.2   Impact Analysis

Emissions are not large when compared to other projects in the NWT

The first stage of the evaluation of impacts looked at the increase in atmospheric emissions resulting from the Snap Lake Diamond Project. Overall, the development will result in 0.175 and 5.684 t/d of SO_2 and NO_X emissions, respectively. The project will also result in TSP, PM_{10}, and $PM_{2.5}$

emissions of 0.554, 0.213, and 0.115 t/d, respectively. However, these emissions are not large when compared to some of the bigger open-pit mining operations in the region.

Because mining occurs underground under wet conditions, particulate emissions will be low

Table 7.3-22 compares the overall emissions from the Snap Lake Diamond Project to the emissions reported in the recent BHP and Diavik environmental impact assessments (EIAs). The relatively small volume of particulate emissions is the most notable difference between the Snap Lake Diamond Project and the other approved diamond mines in the region. The bulk of the mining activity at Snap Lake will occur below ground in a wet environment. This helps to mitigate the particulate emissions from the development.

Table 7.3-22   Summary of Project Emissions

Description	BHP EKATI™ Project	Diavik Diamond Mine	Snap Lake Diamond Project
SO_2 emissions [t/d]	0.469	0.200	0.173
NO_X emissions [t/d]	5.923	16.500	5.684
TSP emissions [t/d]	21.388	8.900	0.555
PM_{10} emissions [t/d]	—[a]	2.800	0.209
$PM_{2.5}$ emissions [t/d]	—	0.600	0.113

[a]   Data obtained from the BHP EKATI™ Project EIA (BHP 1995).

[b]   Data obtained from the Diavik Diamond Mine EIA (Diavik 1998).

[c]   Neither PM_{10} nor $PM_{2.5}$ emissions data were available for the BHP EKATI™ Project.

Sulphur dioxide, nitrogen dioxide, particulate matter, PAH, and trace metal concentrations were predicted

Although the relative magnitude of the emissions from the Snap Lake Diamond Project gives some indication of the impacts associated with the development, the effects that these emissions will have on ground level concentrations are a more direct indicator. To address this issue, regional concentrations of SO_2, NO_2, TSP, PM_{10}, and $PM_{2.5}$ were predicted using the CALPUFF dispersion model. Where applicable, the modelling results were compared to NWT air quality standards or criteria available from other North American jurisdictions. Some parameters (*e.g.*, PAH and trace metals) also have an important role to play in the impact assessment completed for other disciplines (*e.g.*, wildlife health). In these cases, the predicted concentrations were provided to the other discipline teams to facilitate their impact assessments.

Figure 7.3-13 Application Potential Acid Input (PAI) Predictions

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Figure 7.3-14 Linkage Diagram for Ambient Air Quality
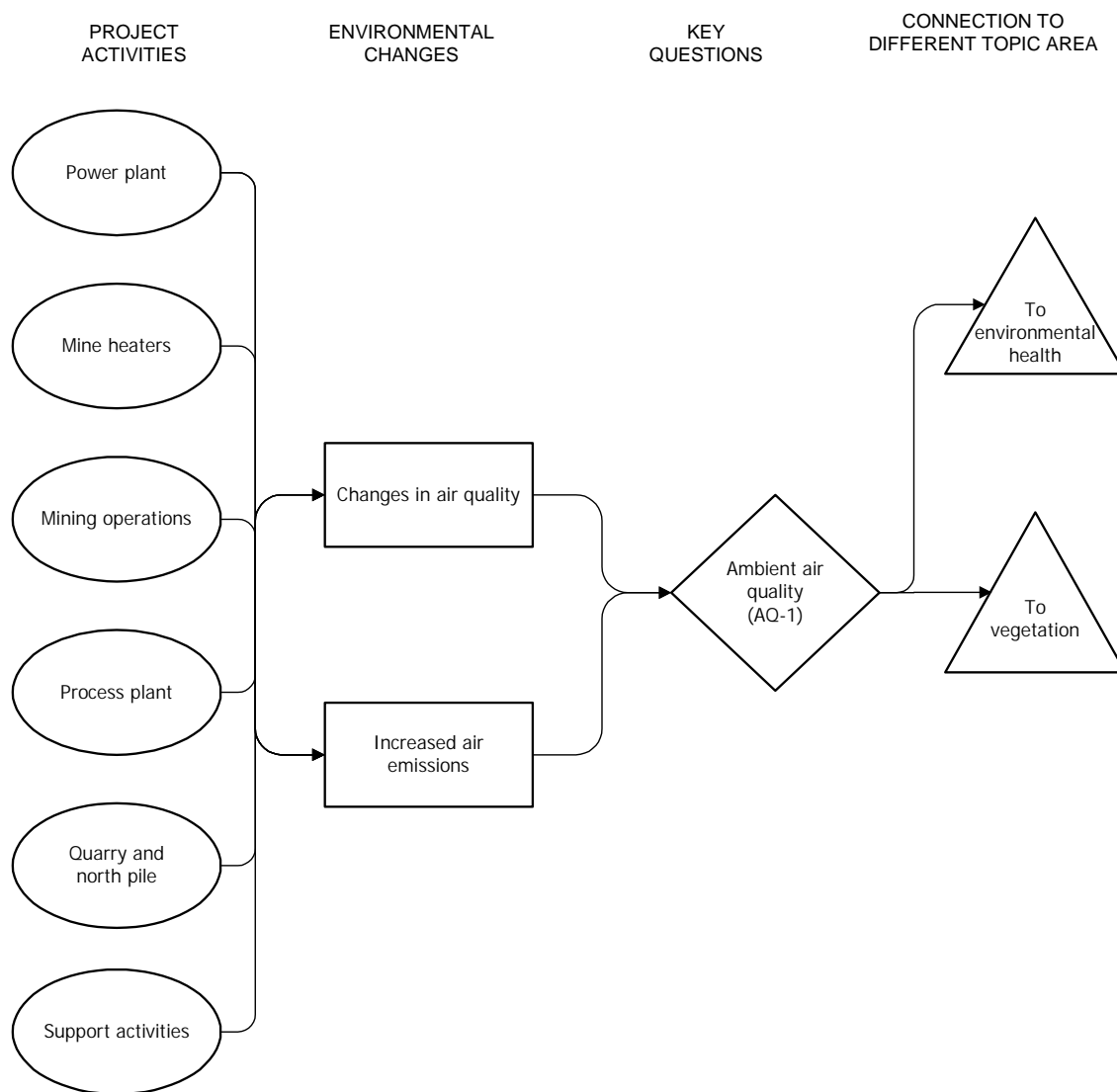
Maximum ground-level concentrations are compared to criteria

Table 7.3-23 summarizes the maximum ground-level concentrations for the air compounds emitted from the Snap Lake Diamond Project for which criteria are available. The predictions indicated the following:

- The maximum predicted 1-hour, 24-hour and annual ground-level SO_2 concentrations were well below the applicable NWT standards both outside and within the active mine area.

- The maximum predicted 1-hour, 24-hour, and annual NO_2 concentrations were below the applicable acceptable federal objectives both outside and within the active mine area.

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- The maximum 24-hour TSP concentrations were predicted to exceed the applicable NWT standards within the active mine area. The standard was also exceeded over a small area just outside the mining perimeter and adjacent to the quarry area. The maximum annual TSP predictions in the RSA were below the applicable NWT standards outside the active mine area.

- The maximum predicted 24-hour concentrations of PM_{10} in the active mine area were predicted to exceed the interim guidelines adopted in British Columbia, Ontario, and Newfoundland (the NWT has yet to adopt a PM_{10} standard). The criteria were also predicted to exceed $50\ \mu g/m^3$ in a small area near the quarry. All of the annual PM_{10} predictions were below the U.S. EPA primary standard.

- The maximum predicted 24-hour $PM_{2.5}$ concentrations in the RSA exceed $30\ \mu g/m^3$ within the active mine area. The $30\ \mu g/m^3$ concentration is the level adopted by the Canadian Council of Ministers of the Environment (CCME) for the Canada-Wide Standard (CWS). However, compliance with the CWS for $PM_{2.5}$ is based on the 98th percentile of the observed/predicted values. On this basis, none of the predicted 24-hour $PM_{2.5}$ concentrations in the RSA would exceed the CWS. The maximum annual $PM_{2.5}$ concentration was below the applicable U.S. EPA primary standard of $15\ \mu g/m^3$.

Table 7.3-23   Summary of Predictions for Criteria Air Compounds

Parameter	Maximum Predictions		Criteria
	RSA Including Active Mine Area	RSA Excluding Active Mine Area	
1-hour SO_2 [μg/m³]	245.0	35.9	450
24-hour SO_2 [μg/m³]	129.5	12.2	150
annual SO_2 [μg/m³]	11.6	1.2	30
1-hour NO_2 [μg/m³]	236.5	203.6	400
24-hour NO_2 [μg/m³]	139.7	98.1	200
Annual NO_2 [μg/m³]	88.8	27.3	100
24-hour TSP [μg/m³]	270.5	116.5	100
Annual TSP [μg/m³]	101.8	18.0	60
24-hour PM_{10} [μg/m³]	120.7	45.2	50
Annual PM_{10} [μg/m³]	27.5	5.1	50
24-hour $PM_{2.5}$ [μg/m³]	42.1	16.1	30
Annual $PM_{2.5}$ [μg/m³]	8.1	1.6	15

7.3.4.3   Residual Impact Classification

Impacts are classified according to the direction, magnitude, geographic extent, duration, frequency, and reversibility of the impact

Despite measures incorporated into the Snap Lake Diamond Project, the project emissions after mitigation will result in changes to the ambient air quality. Evaluating the residual impacts from these changes incorporated the method described in Section 7.1.5. In general, the impacts are classified using the following criteria: direction, magnitude, geographic extent, duration, frequency, and reversibility. The methods outlined in Table 7.1-8 describe the definitions used to classify direction, geographic extent, duration, frequency, and reversibility. Table 7.1-9 defines the magnitude of air quality impacts from the Snap Lake Diamond Project. The impact assessments of changes in the air quality of criteria compounds is presented in Table 7.3-24. The overall environmental consequences of the residual impacts, calculated according to the method described in 7.1.5, are also shown in Table 7.3-24.

The confidence level is related to the measures taken to reduce uncertainty

The confidence level of the impact prediction is directly related to the measures used to reduce uncertainty. Uncertainty is related to natural variability (both spatial and temporal), model uncertainty, uncertainty of future emissions, measurement errors and data errors. Uncertainty due to natural variability has been reduced by using continuous data for more than one year from the meteorological station at Snap Lake. Uncertainty due to measurement and data errors was controlled by the use of appropriate equipment, calibration procedures, sampling protocols and quality assurance (QA) procedures. The QA of model inputs and outputs was undertaken to minimize errors that could lead to uncertainty in the model predictions.

Model uncertainties were reduced by using a proven model

Mathematical assumptions inherent in the models generate uncertainties in the concentration predictions. These uncertainties were minimized by selecting a dispersion model (*i.e.*, CALPUFF) which has been reviewed extensively in the United States to ensure that it provides realistic, but conservative, predictions.

There is high confidence that actual emissions will be less than predicted

The efforts to reduce uncertainty result in a high confidence in the impact assessment. The conservative emission estimates and other assumptions intended to produce conservative predictions result in a high confidence that actual changes in air quality will be less than defined by the dispersion modelling predictions.

There is a high probability that all substantial sources of emissions have been identified

There is a high probability that the types of emissions described in this section will occur if the project goes ahead. There is also a high probability that all substantial sources of air emissions have been identified, based on De Beers' extensive diamond mining experience and the experience of the EA team.

Table 7.3-24   Residual Impact Classification of Changes to the Ambient Air Quality for Criteria Air Compounds

Parameter	Direction[a]	Magnitude[b]	Geographic Extent[a]	Duration[a]	Frequency	Reversibility[a]	Environmental Consequence
1-hour SO_2	negative	low	local	medium-term	moderate	reversible (short-term)	low
24-hour SO_2	negative	low	local	medium-term	moderate	reversible (short-term)	low
Annual SO_2	negative	low	local	medium-term	high	reversible (short-term)	low
1-hour NO_2	negative	low	local	medium-term	moderate	reversible (short-term)	low
24-hour NO_2	negative	low	local	medium-term	moderate	reversible (short-term)	low
Annual NO_2	negative	high	local	medium-term	high	reversible (short-term)	low
24-hour TSP	negative	high	local	medium-term	moderate	reversible (short-term)	low
Annual TSP	negative	high	local	medium-term	high	reversible (short-term)	low
24-hour PM_{10}	negative	moderate	local	medium-term	moderate	reversible (short-term)	low
Annual PM_{10}	negative	low	local	medium-term	high	reversible (short-term)	low
24-hour $PM_{2.5}$	negative	moderate	local	medium-term	moderate	reversible (short-term)	low
Annual $PM_{2.5}$	negative	low	local	medium-term	high	reversible (short-term)	low

[a]   The methods used to classify direction, geographic extent, duration, and reversibility are described in Table 7.1-8. The duration definition includes timing.
[b]   The methods used to classify magnitude are described in Table 7.1-9.

Note: The ecological resilience was not classified or used in determining the environmental consequence for air quality. Air is a pathway or route of exposure.
        The ecological resilience will be discussed when assessing the receiving environment.

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Emissions are unlikely to exceed predictions

There is a low probability that emissions will exceed the predicted concentrations due to the conservative assumptions used and the dispersion modelling method.

Because maximum concentrations are used, most impacts will be lower than predicted

The dispersion modelling predicts the full range of concentrations at each point, most of which are less than the maximum concentration at that point. Since the assessment focusses on the highest values predicted, there is a high probability that most impacts occurring at that point will be lower than predicted because the concentrations will be lower.

7.3.5   Key Question AQ-2: What Impacts Will Air Emissions from the Snap Lake Diamond Project Have on the Deposition of Acid Forming Compounds?

7.3.5.1   Linkage Analysis

Linkage is valid and impact assessment was done

The deposition of sulphur and nitrogen compounds can result in long-term accumulations that have been associated with the acidification of terrestrial and aquatic ecosystems. For this reason, the emissions of oxides of nitrogen (NO_X) and sulphur dioxide (SO_2) from the Snap Lake Diamond Project have raised the issue of increased acid deposition in the region. Figure 7.3-15 depicts the linkage for this key question. The linkages in this figure are valid and an impact assessment was completed.

Deposition of acid forming compounds is determined by potential acid input

The method used for evaluating the deposition of acid forming compounds is to determine the potential acid input (PAI). The PAI takes into account the acidification effect of sulphur and nitrogen compounds as well as the neutralizing effect of available base cations. For the Snap Lake Diamond Project, the CALPUFF dispersion model generated the required predictions of regional PAI. A uniform background PAI value of 0.040 keq/ha/yr (determined from available monitoring in the region) was added to the CALPUFF predictions.
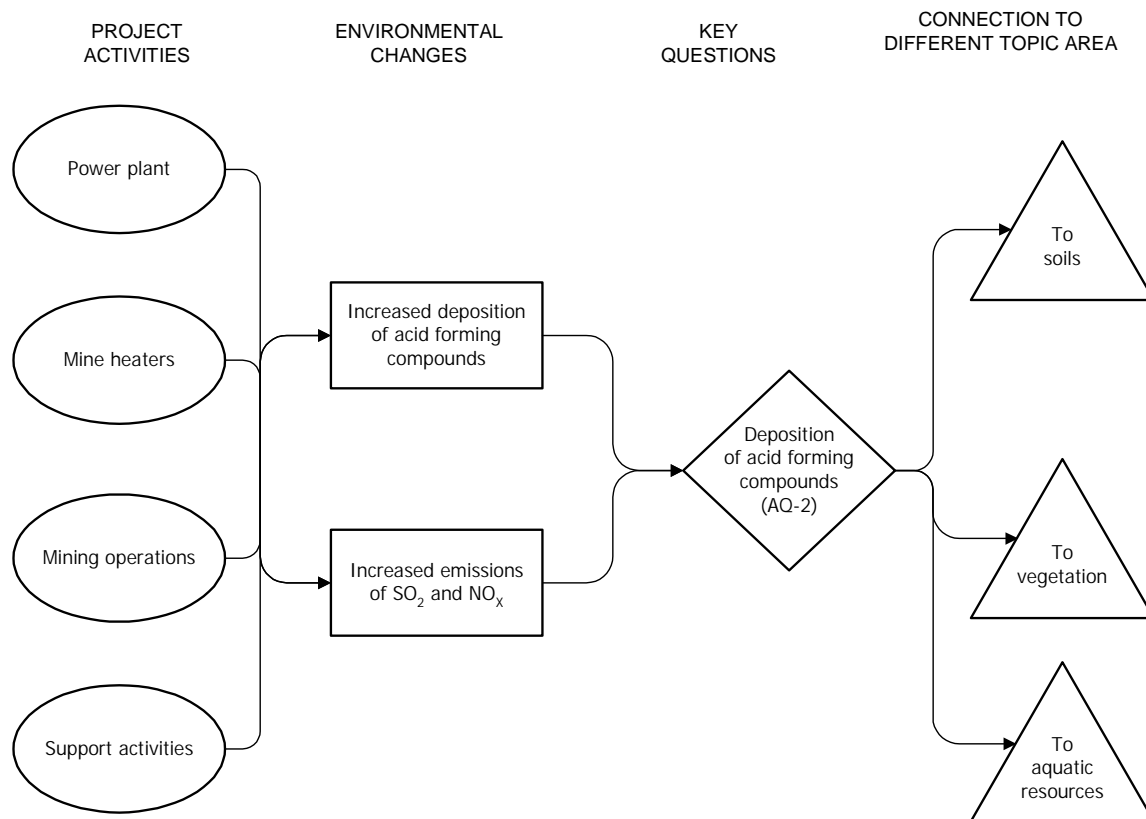
7.3.5.2   Impact Analysis

The overall acid forming emissions from the project are 4.152 t/d

The first stage of the evaluation of impacts looked at the increase in emissions of acid forming compounds that will result from the Snap Lake Diamond Project. Overall, the development will result in 0.173 and 5.684 t/d of SO_2 and NO_X emissions, respectively. The overall acid forming emissions from the project are 4.152 t/d. These emissions are the sum of the SO_2 emissions and 70% of the NO_X emissions. The NO_X emissions are

multiplied by 70% to account for their slightly lower acid forming potential than SO_2 emissions.

Figure 7.3-15 Linkage Diagram for Deposition of Acid Forming Compounds

PROJECT
ACTIVITIES

ENVIRONMENTAL
CHANGES

KEY
QUESTIONS

CONNECTION TO
DIFFERENT TOPIC AREA

Power plant

Mine heaters

Mining operations

Support activities

Increased deposition of acid forming compounds

Increased emissions of SO_2 and NO_X

Deposition of acid forming compounds (AQ-2)

To soils

To vegetation

To aquatic resources

Snap Lake Diamond Project is compared to other projects

Table 7.3-25 compares the overall emissions of acid forming compounds to the similar emissions reported in the recent BHP and Diavik EIAs. The Snap Lake Diamond Project is predicted to have emissions of acid forming compounds that are similar to those reported in the original BHP EKATI™ project application (BHP 1995), although SO_2 emissions predicted at Snap Lake were approximately one-third the BHP emissions (BHP 1995). The NO_X emissions predicted at Snap Lake were approximately one-third of those reported in the Diavik Diamond Mines Inc. application (Diavik 1998). Overall the Snap Lake Diamond Project is predicted to have emissions that are less than 35% of the acid forming emissions of the Diavik Diamonds Project.

Table 7.3-25 Summary of Acid Forming Emissions

Descriptions	BHP EKATI™ Project [a]	Diavik Diamond Mine [b]	Snap Lake Diamond Project
SO_2 emissions [t/d]	0.469	0.200	0.173
NO_X emissions [t/d]	5.923	16.500	5.684
Acid forming compounds [t/d][c]	4.615	11.750	4.152

[a] Source: BHP 1995.

[b] Source: Diavik 1998.

[c] Acid forming compounds are the sum of the SO_2 and 70% of the NO_X emissions. This accounts for the slightly lower acid forming potential of NO_X emissions.

The effect of emissions on potential acid input is an indicator of potential effects

Although the relative magnitude of acid forming emissions from the Snap Lake Diamond Project gives some indication of the acidifying impacts, the effect that these emissions will have on PAI provide a more direct indicator. PAI is a good measure of acidifying emissions since it takes into account the acidification effect of sulphur and nitrogen compounds, as well as the neutralizing effect of available base cations.

Potential acid input was determined using the CALPUFF dispersion model

The PAI associated with the Snap Lake Diamond Project was determined using the CALPUFF dispersion model. CALPUFF is the preferred model for estimating PAI, since it accounts for the chemical transformations of SO_2 and NO_X. This model also predicts both wet (*i.e.*, rain and snow scavenged) and dry (*i.e.*, via an effective dry deposition velocity) deposition of SO_2, SO_4^{2-}, NO, NO_2, NO_3^-, and HNO_3.

Potential acid input was predicted within and beyond the active mine area

Table 7.3-26 summarizes the PAI predictions associated with emissions from the Snap Lake Diamond Project. The table shows the maximum PAI levels predicted across the entire RSA, as well as the predictions that occurred outside the active mine area. The table illustrates that elevated PAI is mainly restricted to the active mine area.

Table 7.3-26 Summary of PAI Predictions

Parameters	Maximum Predictions	
	RSA Including the Active Mine Area	RSA Excluding Active Mine Area
Maximum PAI[a] [keq/ha/yr]	1.106	0.175
Area with PAI greater than 0.17 keq/ha/yr [ha]	47	< 1
Area with PAI greater than 0.25 keq/ha/yr [ha]	35	0
Area with PAI greater than 0.50 keq/ha/yr [ha]	12	0
Area with PAI greater than 1.00 keq/ha/yr [ha]	0	0

[a] The PAI predictions include a uniform background value of 0.040 keq/ha/yr.

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Potential acid input will be low beyond the active mine area

The above table also lists areas where the PAI is predicted to exceed 0.17, 0.25, 0.50, and 1.00 keq/ha/yr. Within the confines of the active mine area, limited areas are predicted to exceed 0.17, 0.25, and 0.50 keq/ha/yr. However, outside the confines of the active mine area, less than one hectare was predicted to have PAI in excess of 0.17 keq/ha/yr. This is 70% of the levels considered in Europe and Alberta to be protective of the most sensitive ecosystems (CASA 1999).

7.3.5.3   Impact Classification

Impacts are classified according to the direction, magnitude, geographic extent, duration, and frequency

Despite the mitigation measures incorporated in the Snap Lake Diamond Project, the air emissions will result in changes in the deposition of acid forming compounds in the region. The impacts from these changes were evaluated using the assessment method described in Section 7.1.5. The methods outlined in Table 7.1-8 describe the definitions used to classify direction, geographic extent, duration, frequency, and reversibility. The results of the impact classification for the deposition of acid forming compounds are presented in Table 7.3-27. Acid deposition is reversible in the short-term from an air perspective; the reversibility of the effects on soil and water may be different. Reversibility of effects is addressed in the sections of the EA that deal with the following:

- Water Quality (Section 9.4.2);

- Fish and Fish Habitat (Section 9.5.2); and,

- Ecological Land Classification (Section 10.4.2).

Table 7.3-27   Residual Impact Classification for Changes to Acid Deposition

Direction [a]	Magnitude [b]	Geographic Extent	Duration	Frequency	Reversibility	Environmental Consequence
negative	moderate	local	medium-term	high	reversible [c] (short-term)	low

[a]   The methods used to classify direction, geographic extent, duration, reversibility and frequency are described in Table 7.1-8. Timing is included in the definition of duration.

[b]   The methods used to classify magnitude are described in Table 7.1-9.

[c]   The evaluation of reversibility associated with acid deposition in the region is also discussed in the water quality (Section 9.4.2), fish and fish habitat (Section 9.5.2), and ecological land classification (Section 10.4.2).

Note: The ecological resilience was not classified or used in determining the environmental consequence for air quality. Air is a pathway or route of exposure. The ecological resilience will be discussed when assessing the receiving environment.

The model was selected to minimize uncertainties

The evaluation of changes in acid deposition patterns depends on the use of air dispersion models to predict the deposition rates and patterns in the region. As with any form of prediction, there are uncertainties regarding the ability of models to predict the deposition values accurately. To minimize

these uncertainties, an accepted dispersion model (*i.e.*, CALPUFF) was selected for the analysis. This model has been reviewed extensively in the United States to ensure that it provides realistic, but conservative, predictions. In addition, the CALPUFF model has been used extensively in northeastern Alberta (an area where the evaluation of the deposition of acid forming compounds has been a key issue for several years).

Background values, a source of uncertainty, were reduced by using long-term monitoring

One of the primary uncertainties with the evaluation of PAI relates to the background values used in the assessment. This assessment used a uniform background PAI of 0.040 keq/ha/yr. This value was determined from long-term precipitation monitoring at Snare Rapids, NWT. The ideal situation would be to calculate the background PAI from long-term monitoring at the Snap Lake site; however, such data are not available.

It is unlikely that deposition values will be as high as predicted

Given the contingencies built into the emissions estimates and the efforts to reduce model uncertainty, there is a high level of confidence that the predictions of PAI presented in the assessment represent the worst case deposition expected to result from the emissions from the Snap Lake Diamond Project. Therefore, it is unlikely that acid deposition values as high as those presented will occur.

7.3.6   Key Question AQ-3: What Air Quality Impacts Will Result from Construction Activities at Snap Lake Diamond Project?
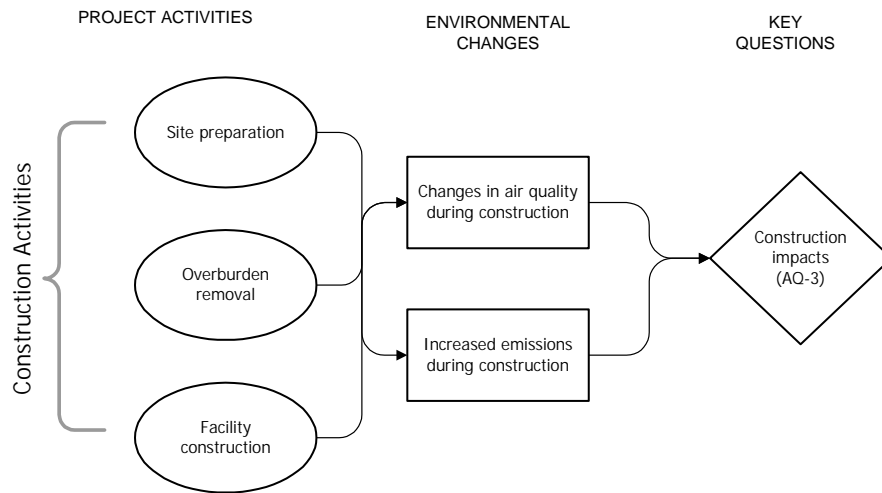
7.3.6.1   Linkage Analysis

The linkage is analyzed

In the case of large open pit mining operations, there is often an extensive construction period when the site is prepared for mining operations and non-commercial overburden materials are moved to expose the target ore bodies. Although the Snap Lake Diamond Project is a relatively small-scale underground mine, atmospheric emissions and air quality impacts during construction remain a concern to regulators and stakeholders. Figure 7.3-16 depicts the linkage pathway for this key question.

Linkage is not valid

A review of the linkages depicted in Figure 7.3-16 suggests that they are not valid for the Snap Lake Diamond Project. Activities often considered construction operations are to be phased over the entire life of the project (*e.g.*, quarrying operations), and have been included in the emissions for the operation activities. Therefore, there is not a distinct construction phase to the Snap Lake Diamond Project that will result in emissions that require a separate air quality assessment.

Figure 7.3-16 Air Linkage Diagram for Construction Impacts

PROJECT ACTIVITIES   ENVIRONMENTAL CHANGES   KEY QUESTIONS

Construction Activities

- Site preparation
- Overburden removal
- Facility construction

Changes in air quality during construction

Increased emissions during construction

Construction impacts (AQ-3)

7.3.7 Key Question AQ-4: What Impacts Will the Snap Lake Diamond Project Have on Visibility near Snap Lake?

7.3.7.1 Linkage Analysis

Linkage is valid and impact assessment was done

Activities and operations at the Snap Lake Diamond Project can result in air emissions that may be visible at great distances or adversely affect the visibility in the region. Given the isolated and undisturbed nature of the region, visibility impacts are a concern with regulators and stakeholders. A linkage diagram for Key Question AQ-4 is presented in Figure 7.3-17. The linkages depicted in the diagram are considered valid and an assessment has been completed.

7.3.7.2 Impact Analysis

Visibility impacts include steam plumes during the winter and haze

Two visibility impacts have been assessed for the Snap Lake Diamond Project. The first deals with the visible plumes from large emission sources at Snap Lake. During the coldest periods of the year, moisture in these plumes can condense and become visible. The dimension of these visible "steam plumes" will vary depending on the atmospheric conditions and the time of year. The other type of visibility impact is the haze associated with secondary aerosols (nitrates and sulphates), oxides of nitrogen, soot and airborne particles. These compounds could appear as either a light or dark haze, depending on the distance and relative position of the viewer to the Snap Lake Diamond Project.

Figure 7.3-17 Linkage Diagram for Project Visibility
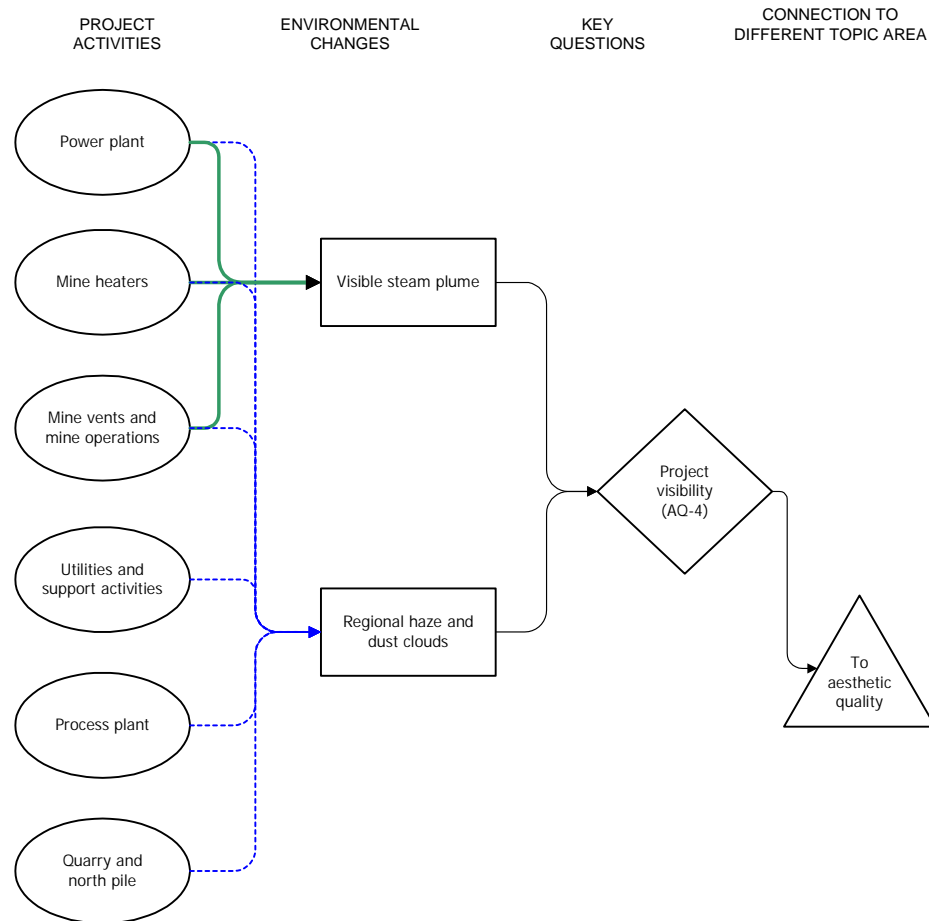
***The height of the
steam plume will
be greatest during
calm conditions***

The height of the visible "steam plumes" can be calculated using
methodologies recommended for the evaluation of plumes from cooling towers
(Hanna *et al*. 1982; Wrigley and Slawson 1975). The following expressions
give the height of the steam plume (Z_p) above the top of the stack. The first
expression is for calm conditions (wind speeds less than 1 m/s), while the
second is for windy conditions. The plume heights should be lower during
windy conditions than during calm conditions. Therefore, only the "steam
plume" formula for calm conditions was used to determine the visible plume
height. The terms used in this formula are described in Table 7.3-28.

$$ Z_p = 9 \times R_0 \times \left[\left(\frac{q_{p_0} + q_{L_0}}{q_s - q_e} \right)^{\frac{1}{2}} - 1 \right] \qquad \text{calm conditions} $$

In the above formula, q_e and q_s derive from the following relationships:

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$$q_s = \frac{\varepsilon \times e_s}{P}$$

$$q_e = RH \times q_s$$

$$\varepsilon = \frac{R_d}{R_v}$$

$$e_s = e_0 \times \exp\left[\frac{L}{R_v} \times \left(\frac{1}{T_d} - \frac{1}{T}\right)\right]$$

Table 7.3-28 lists details of the parameters used to calculate visible plume heights at the Snap Lake Diamond Project.

Table 7.3-28   Parameters Used to Calculate Visible Plume Heights

Parameter	Value	Units	Description	Reference
R_0	—	m	initial plume radius	—
W_0	—	m/s	stack exit velocity	—
q_{p_0}	—	g/g [a]	plume specific humidity	—
q_{L_0}	0.001	g/g	initial specific humidity of liquid water in the plume	Stull 1989
q_s	0.000692	g/g	saturation specific humidity of the environment	calculated
q_e	0.000520	g/g	specific humidity of the environment	calculated
ε	0.622	—	ratio of the gas constants for dry air and water vapour	Stull 1989
e_s	0.1057	kPa [b]	saturation vapour pressure	calculated
e_0	0.611	kPa	vapour pressure at reference temperature	Stull 1989
L	2.50×10^6	J/kg [c]	latent heat of vaporization at 0°C	Stull 1989
R_v	461.5	J/(K×kg) [d]	gas constant for water vapour	Stull 1989
R_d	287.1	J/(K×kg)	gas constant for dry air	Stull 1989
T_d	273.15	K [e]	reference temperature	—
P	see Table 7.3-29	kPa	mean monthly barometric pressure for Yellowknife, NT	Environment Canada 1993
RH	see Table 7.3-29	—	mean monthly relative humidity for Snap Lake	Snap Lake Meteorological Station
U	see Table 7.3-29	m/s	mean monthly wind speed for Snap Lake	Snap Lake Meteorological Station
T	see Table 7.3-29	K	mean monthly daily minimum temperature for Snap Lake	Snap Lake Meteorological Station

a   g/g = grams per gram.

b   kPa = kilo pascals.

c   J/kg = joules per kilogram.

d   J/(K×kg) = joules per Kelvin per kilogram.

e   K = degrees Kelvin.

Most parameters needed to calculate steam plume height were measured at Snap Lake, except barometric pressure

Although the meteorological station at Snap Lake recorded most of the climate parameters required for calculating steam plume height (temperature, wind speed, and relatively humidity), barometric pressure was unavailable. The climatic record from the Environment Canada weather station at the Yellowknife Airport offered a good substitute for barometric pressure at Snap Lake. This was a reasonable selection as there is a relatively small difference in mean monthly barometric pressure over the distance between the two locations. Table 7.3-29 summarizes the atmospheric parameters used to calculate the "steam plume" height at the Snap Lake Diamond Project. The calm conditions most conducive to tall visible plumes are most prevalent during the winter months.

Table 7.3-29   Mean Monthly Atmospheric Parameters at Snap Lake

Month	(U) Wind Speed [km/h]	(T) Minimum Temperature [K]	(RH) Relative Humidity [%]	(P) Barometric Pressure[a] [kPa]	Frequency of Calm Winds[b] [%]
January	7.6	233.5	77.4	99.3	56
February	14.0	236.8	74.7	99.3	14
March	11.6	236.7	69.4	99.3	20
April	14.6	242.1	63.9	99.0	7
May	15.6	259.8	58.9	99.0	5
June	14.8	265.8	58.2	98.6	6
July	14.4	277.0	59.9	98.7	5
August	16.0	273.9	69.8	98.7	3
September	15.3	267.0	78.0	98.8	4
October	16.8	255.9	87.5	98.5	4
November	11.8	242.9	88.6	98.8	13
December	11.2	234.0	77.2	99.1	23

[a]   From monthly normals at the Yellowknife airport (Environment Canada 1993).
[b]   Calms are considered to include all wind speeds less than 1 m/s.

Mine exhausts will generate steam plumes up to 269 m high

Table 7.3-30 summarizes the respective steam plume heights for a diesel generator, mine air heaters, and mine exhausts, for each month at the Snap Lake Diamond Project under calm conditions. Since plumes will generally be higher under calm conditions, the results in Table 7.3-30 represent maximum expected plume heights. The table indicates that the mine exhausts will generate the tallest, and hence most visible, "steam plumes" in the winter months. The plume heights will be greatest in December and January.

Haze is measured by CALPUFF as an extinction coefficient

The second type of visible impact is related to the regional haze resulting from the airborne concentrations of secondary aerosols (sulphates and nitrates), oxides of nitrogen, soot, and airborne particles. The haze is measured as an extinction coefficient, and is calculated directly by the

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CALPUFF dispersion modelling system. The extinction coefficient is an optical measure of the reduction in light resulting from the combination of compounds that take up water (hygroscopic) and those that cannot (non-hygroscopic). The formula can be written as follows:

$$b_{ext} = b_{S,N} \times f(RH) + b_{dry}$$

Table 7.3-30   Maximum "Steam Plume" Height Under Calm[a] Conditions

Month	Maximum Height to the Top of Plume [m]		
	Diesel Generators	**Mine Air Heaters**	**Mine Exhausts**
January	193	145	269
February	154	116	212
March	141	106	193
April	99	75	132
May	42	31	49
June	32	24	34
July	20	15	18
August	27	20	28
September	43	32	51
October	92	69	122
November	173	130	239
December	187	141	260

[2]   Calms are considered to include all wind speeds less than 1 m/s.

The extinction coefficient is the product of the concentration of compounds and the extinction efficiency

In the above formula, $b_{S,N}$ is the extinction coefficient for sulphates and nitrates at 0% relative humidity, $f(RH)$ is the relative humidity adjustment factor and b_{dry} is the extinction coefficient for non-hygroscopic compounds. The b_{dry} term is a combination of light scattering due to fine and coarse particulate matter, organic carbon, soil, and Rayleigh scattering as well as the light absorption due to elemental carbon. The extinction coefficient for each compound is computed as the product of its concentration (in μg/m³) and extinction efficiency (in m²/g). The extinction coefficients were calculated by CALPUFF from the hourly concentrations and relative humidity. These data were used to determine the maximum 24-hour extinction coefficients presented in Figure 7.3-18.

Figure 7.3-18 Maximum 24-hour Extinction Coefficients

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Visible range was also calculated

Table 7.3-31 presents the maximum 24-hour extinction coefficient at selected distances from the Snap Lake Diamond Project. The table also includes a calculation of visible range (VR). The effect of haze on the visibility of an object is related to the average extinction coefficient between a person and the object being viewed, and is expressed as the visible range. If the visible range is much greater than the distance between a person and the object being viewed, then the object will be clearly visible. The visible range can be determined at a distance (x) from the Snap Lake Diamond Project using the following formula:

$$VR_x \text{ (in km)} = \frac{3912}{b_{ext(0-x)}}$$

Table 7.3-31   Maximum 24-hour Extinction Coefficient and Visible Range

Distance from the Snap Lake Diamond Project [km]	Maximum 24-hour Extinction Coefficient (b_{ext}) [1/Mm] [b]	Background Extinction Coefficient [1/Mm]	Visual Range[a] (including background) [km]
< 0.5	170.1	24.3	54
1	188.8	24.3	60
2	52.9	24.3	69
3	45.1	24.3	76
4	31.8	24.3	81
5	29.9	24.3	86
7.	16.9	24.3	95
10	15.0	24.3	102
15	7.0	24.3	110
20	5.3	24.3	116
30	5.9	24.3	123

[a]   The visible range was determined along a line of sight running south from the Snap Lake Diamond Project.

[b]   Mm = mega metre or 1000 km.

7.3.7.3   Impact Classification

Impact is classified in the aesthetics section

It is not practical to classify visible impacts associated with the Snap Lake Diamond Project from an air quality perspective. Since the classification of visibility impacts will need to incorporate a number of aesthetic parameters, a separate assessment of perceived visibility impairment has been completed (Section 6.5.2). The results of the above visibility data were incorporated and used in that section.

7.3.8 Key Question AQ-5: What Impacts Will the Snap Lake Diamond Project Have on the Production and Management of Greenhouse Gas Emissions?

7.3.8.1 Linkage Analysis

Linkages are valid and the impact assessment was done

Activities and operations at the Snap Lake Diamond Project will result in the emission of carbon dioxide and other greenhouse gases (GHG). The release of GHG have been linked to global warming and are a concern with regulators and stakeholders. A linkage diagram for Key Question AQ-5 is shown in Figure 7.3-19. The linkages depicted in the diagram are considered valid and an assessment has been completed.

Figure 7.3-19 Linkage Diagram for Key Question AQ-5
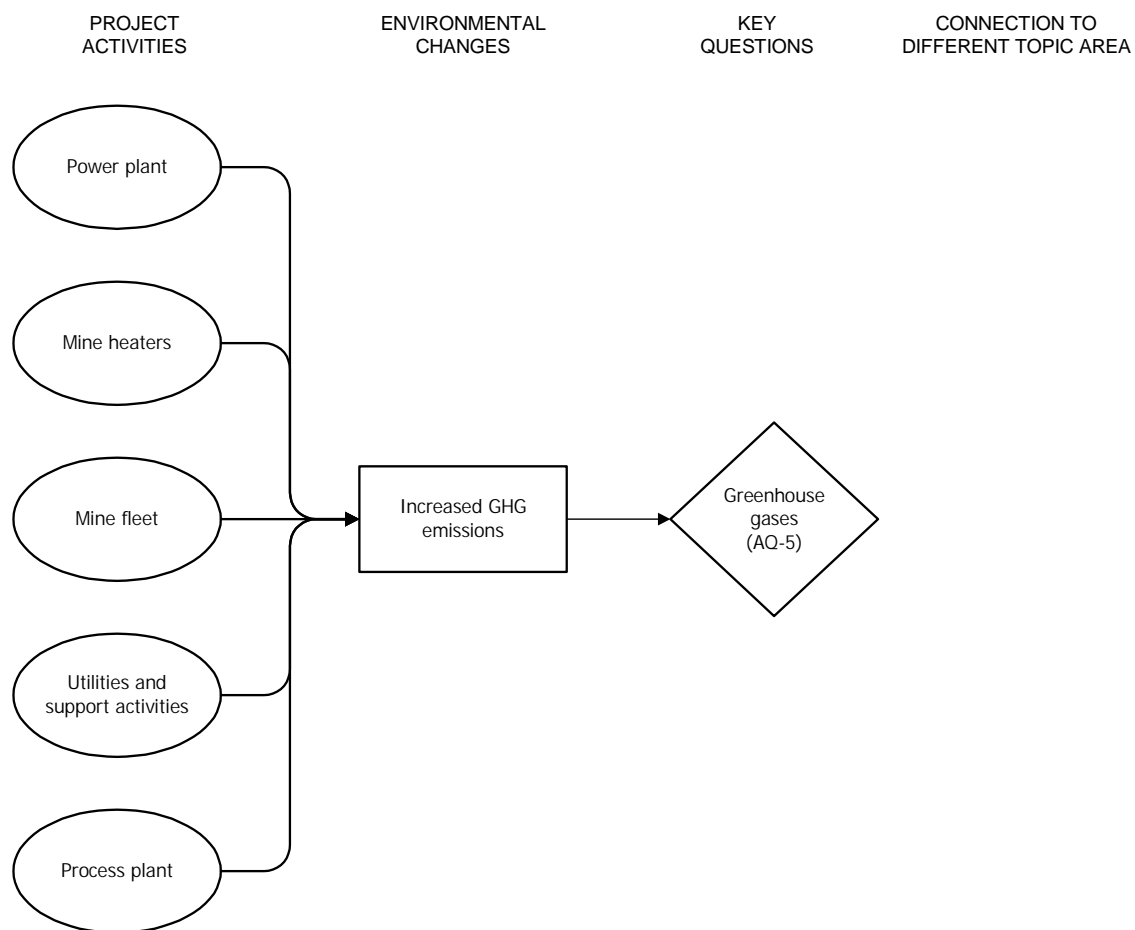
7.3.8.2 Impact Analysis

Overall greenhouse gas emissions are 120 kilotonnes per year, due mainly to power generation

The first stage of the evaluation of impacts looked at the overall change in GHG emissions expressed as equivalent CO_2 (ECO$_2$). Calculating equivalent CO_2 allows the combination of the CO_2, methane (CH_4), nitrous oxide (N_2O) and other GHG emissions into a single measure of greenhouse gas potential. As shown in Table 7.3-32, N_2O and CH_4 have higher GHG potentials than CO_2. The overall GHG emissions from the Snap Lake Diamond Project are projected to be 102 kilotonnes per year (kt/yr). Of this total, 70% is attributed to the emissions from the power generators.

Table 7.3-32 Summary of Project Emissions

Source	CO_2 Emissions [kt/yr]	N_2O Emissions		CH_4 Emissions		ECO$_2$ Emissions [kt/yr]
		[t/yr]	GHG Potential	[t/yr]	GHG Potential	
Power plant	68.0	9.97	310	6.48	21	71.26
Mine heaters	22.4	0.10	310	0.05	21	22.39
Winter haul activities	1.8	0.07	310	0.09	21	1.85
Mine fleet	6.4	0.23	310	0.30	21	6.47
Total	**98.60**	**10.37**	—	**6.92**	—	**101.96**

[a] Expressed as tonnes of equivalent CO_2 (includes methane and nitrous oxide).

Snap Lake Diamond Project will represent 2.3% to 4.7% of the 2005 greenhouse gas emissions in the NWT

To help put the GHG emissions from the Snap Lake Diamond Project into perspective, Table 7.3-33 provides a summary of the overall GHG emissions in Canada and Northwest Territories (including Nunavut). These data are derived from the emission summaries produced by the federal government (Nietzert *et al*. 1999; NRC 1999) as well as for the government of NWT (Ferguson Simek Clarke 1998). The Snap Lake Diamond Project represents an increase in GHG emissions of 102 kt ECO$_2$/yr. This would represent a 5% and 4.7% increase in the respective 2000 and 2005 "business as usual" GHG emissions for the NWT. The Snap Lake Diamond Project would represent a 3.6% and 2.3% increase in the respective 2000 and 2005 "accelerated growth" GHG emissions.

Greenhouse gas emissions will be reduced by minimizing fuel use

Although the Snap Lake Diamond Project is predicted to result in an increase in the GHG emissions, De Beers have been active throughout the design phases of the project to identify means to maximize energy efficiency and minimize fuel use. In addition to being sound business practice, this approach is one of the most effective means of reducing GHG emissions from the development.

Table 7.3-33   National and Provincial GHG Emissions

Reporting Year		Canadian GHG[a] Emissions [kt ECO$_2$/yr][a]		NWT GHG[a] Emissions [kt ECO$_2$/yr]	
		Overall	Mining Sector	Overall	Mining Sector
1996	Actual	671,000	13,000	1,657	19
2000	Business as usual	694,000	—	2,028[b]	—
	Accelerated growth	—	—	2,851[b]	—
2005	Business as usual	728,000	—	2,152[b]	—
	Accelerated growth	—	—	4,433[b]	—

[a]   GHG emissions are expressed in tonnes of equivalent CO_2 per year (includes CH_4 and N_2O).

[b]   The projected GHG emissions for the NWT were taken from Ferguson Simek Clark (1998).

7.3.8.3   Impact Classification

Release of greenhouse gases is a negative impact

Despite the mitigation measures incorporated in the design, the Snap Lake Diamond Project will increase the release of GHG to the atmosphere. These gases have been linked to global warming and are, therefore, considered a negative impact.

The impact is rated as low in magnitude, beyond regional in geographic extent, medium-term in duration, and high in frequency

The release of GHG and the issue of climate change is beyond regional in geographic extent since it is a national and global concern. The magnitude is rated as low since the Snap Lake Diamond Project will release 0.02% of the actual (1996) Canadian emissions.   There is high uncertainty in predicting impacts caused by project-specific GHG emissions. The duration is medium-term since the emissions will occur for the life of the project and the frequency is high since the emissions are continuous.   There is substantial uncertainty and controversy pertaining to the reversibility of GHG emissions and global warming.   There is also a high degree of uncertainty related to predicting the impact of GHG, particularly impacts at specific locations. In view of the uncertainty pertaining to reversibility, no environmental consequence has been assigned to the production and management of greenhouse gases.

7.4   MITIGATION AND MONITORING

7.4.1   Project Mitigation

Underground mining under wet conditions minimizes dust

There are numerous factors incorporated in the planned design and operations of the Snap Lake Diamond Project that will mitigate air emissions. First among these is the use of underground mining to recover the ore. The fact that the bulk of the operations occur underground in wet conditions will ensure that dust from the drilling, blasting, ore handling, and primary crushing activities will also be minimal. Conveyor belts will be used to transport ore from the primary underground crushers to the processing plant during full operations. However, trucks will be used to transport the ore to the surface during the pre-production phase.

Wet processing reduces dust

The De Beers engineering team has selected wet processing for the Snap Lake Diamond Project. This process will result in minimal dust emissions from the ore processing located above ground.

Other dust suppression will be used

The surface operations will incorporate a number of mitigation steps that will minimize dust emissions from the Snap Lake Diamond Project. These include plans that minimize the exposed areas on the north pile, and actions to suppress dust from surface roadways and the airstrip (see also Section 3).

Reducing fuel use reduces emissions

De Beers conducted special studies to look at ways to maximize energy efficiency and minimize fuel use. These are described in Section 2. In addition to reducing fuel costs, these measures will reduce greenhouse gas emissions and potential deposition of acid forming compounds (*i.e.*, oxides of nitrogen and sulphur dioxide). Efforts to minimize fuel use will be on-going.

7.4.2   Air Quality and Meteorological Monitoring

Air quality monitoring activities will continue

A series of air quality monitoring activities were initiated at Snap Lake as part of the baseline work completed at the site. These activities included the operation of a weather station, the collection of TSP matter at three Hi-Vol locations, snow sampling to determine atmospheric deposition during the winter months, and dustfall monitoring to determine deposition during the ice free months. The activities are part of a limited program to finalize the collection of baseline data and confirm the predictions of the EA. The ongoing plans for the air monitoring at Snap Lake are as follows:

- The operation of the meteorological monitoring station will continue at the site. Data from the station is being downloaded on a regular basis.

- The Hi-Vol monitoring program to determine TSP concentrations will be continued. In light of the difficulties encountered during the past winter, the Hi-Vol monitoring will be suspended from the middle of October until the spring.

- The collection of dustfall samples will be continued. Sampling will cease about the middle of October and resume once the warmer weather arrives in the spring.

- Additional snow samples will be collected during the upcoming winter months. These data will be combined with the previous sampling results and the dustfall monitoring data to characterize atmospheric deposition in the region.

7.5   CONCLUSIONS

The air quality assessment included SO₂, NO₂, TSP, PM₁₀ and PM₂.₅

The potential for emissions from the Snap Lake Diamond Project to affect the quality of air in the region is an essential issue with regulators and regional stakeholders. Since the bulk of the mining activity at Snap Lake will occur below ground in a wet environment, the particulate emissions are low relative to open pit mining operations in the region. Although the Snap Lake Diamond Project has relatively low emissions compared to other regional developments, the air quality assessment included the predictions of SO_2, NO_2, TSP, PM_{10}, and $PM_{2.5}$. The environmental consequence of these emissions is shown in Figure 7.5-1.

Maximum concentrations of SO₂ and NO₂ were below the standard or objectives

The CALPUFF dispersion model predicted that the maximum 1-hour, 24-hour, and annual ground-level concentrations of SO_2 and NO_2 were below the applicable NWT standards and acceptable federal objectives, respectively.

Criteria related to dust were exceeded in and near the active mine area

The maximum 24-hour TSP, PM_{10}, and $PM_{2.5}$ concentrations were above the applicable criteria within the active mine area. Maximum 24-hour TSP and PM_{10} predictions were also above the criteria in small areas near the quarry. However, the maximum concentrations in the RSA beyond these locations were below the applicable criteria. The annual concentrations of TSP, PM_{10}, and $PM_{2.5}$ were below the respective criteria. Impacts during construction activities are expected to be much lower than impacts when the Snap Lake Diamond Project is working at its full, proposed capacity.

Deposition of PAHs and trace metals were predicted for the health assessment

Although the combustion equipment proposed for use at the Snap Lake Diamond Project will be highly efficient, emissions of small quantities of PAHs and airborne metals are also possible. The air quality assessment determined the concentrations and deposition rates of these compounds in the RSA.   These results were then provided to Environmental Health (Section 11) and the risks to human and wildlife health are assessed in Section 11.

The maximum potential acid input predicted outside the active mine area was below levels of concern

To assess the deposition of acid forming compounds that could result from the NO_X and SO_2 emissions from Snap Lake Diamond Project, the potential acid input (PAI) was predicted using the CALPUFF dispersion model. The PAI is a widely accepted method of assessing acidification, since it incorporates the effect of sulphur and nitrogen compounds, as well as the neutralizing effect of available base cations. The maximum predicted PAI outside the active mine area was 0.175 keq/ha/yr, which is lower than the levels considered to be protective of the most sensitive ecosystems in

De Beers Canada Mining Inc.

Europe and Alberta (CASA 1999). The environmental consequence of PAI is shown in Figure 7.5-1. The possible impacts of the predicted increase in acidic deposition on the terrestrial and aquatic environments has been assessed separately in other sections.

Plumes of water vapour will reach heights of 269 m

Activities and operations at the Snap Lake Diamond Project can affect regional visibility in two ways. The first visibility impact occurs when the moisture in the plumes condenses and become visible during the coldest months of the year. On calm days in January, these visible plumes of condensed water vapours were predicted to reach heights of 269 m.

Regional visibility will not be reduced substantially

The other potential visibility impact associated with the Snap Lake Diamond Project is haze. The quantity of haze can be assessed using extinction coefficients, which are calculated directly by the CALPUFF dispersion model. The effect of haze on the visibility of an object is related to the average extinction coefficient between a person and the object being viewed, and is expressed as the visible range. If the visible range is much greater than the distance between a person and the object being viewed, then the object will be clearly visible. The CALPUFF modelling results confirm that emissions from the Snap Lake Diamond Project will not substantially degrade the regional visibility.

The Snap Lake Diamond Project will cause a 5% increase in NWT greenhouse gas emissions

Activities and operations at the Snap Lake Diamond Project will result in the emission of carbon dioxide and other greenhouse gases (GHG). The release of GHG has been linked to global warming. The overall GHG emissions (expressed as equivalent CO_2 [ECO_2]) from the Snap Lake Diamond Project were projected to be 102 kilotonnes per year (kt/yr). This represents a 5% and 4.7% increase in the respective 2000 and 2005 "business as usual" GHG emissions for the NWT. However, the GHG emissions from the Snap Lake Diamond Project only represent a 0.01% increase in the 2000 Canadian GHG emissions.

Figure 7.5-1　Classification of Residual Impacts to the Ambient Air Quality and PAI

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7.7   UNITS, ACRONYMS, AND GLOSSARY

UNITS

$\mu g/m^3$	micrograms per cubic metre
μm	micrometre (micron)
g/g	grams per gram
ha	hectare
J/(K×kg)	joules per degree Kelvin per kilogram
J/kg	joules per kilogram
K	Kelvin
keq/ha/yr	kiloequivalents per hectare per year; keq refers to the number of equivalent hydrogen ions (1 keq = 1 kmol H^+)
kg/ha/yr	kilogram per hectare per year
km	kilometre
km/hr	kilometres per hour
kPa	kilopascals
$kt/ECO_2/yr$	kilotonnes per equivalent carbon dioxide per year
kt/yr	kilotonnes per year
m	metre
m/s	metres per second
m^2/g	square metres per gram
m^3/min	cubic metres per minute
masl	metres above sea level
mg	milligram
Mm	mega metre = 1000 kilometres
mm/hr	millimetres per hour

^{o}C	degrees Celsius
ppb	parts per billion
t/d	tonnes per day
t/yr	tonnes per year
W/m^2	watts per square metre

ACRONYMS

ε	ratio of the gas constants for dry air and water vapour
2-D	two dimensional
3-D	three dimensional
AENV	Alberta Environment
ANC	acid neutralizing capacity
AP	acidifying potential
Ca^{2+}	calcium
CASA	Clean Air Strategic Alliance
CCME	Canadian Council of Ministers of the Environment
CEA	cumulative effect assessment
CFR	Code of Federal Regulations
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CWS	Canada-Wide Standard
De Beers	De Beers Canada Mining Inc.
Diavik	Diavik Diamond Mines Inc.

E	east
EA	environmental assessment
EA	effective acidity
ECO_2	equivalent carbon dioxide
EIA	environmental impact assessment
e_o	vapour pressure at reference temperature
e_s	saturation vapour pressure
FAAQO	Federal Ambient Air Quality Objectives
GHG	greenhouse gases
GNWT	Government of Northwest Territories
Hi-Vol	high-volume
HNO_3	nitric acid
ISC3	Industrial Source Complex
IWAQM	Interagency Workgroup on Air Quality Modelling
K^+	potassium
L	latent heat of vaporization at 0^oC
LSA	local study area
Mg^{2+}	magnesium
micron	micrometre
MVEIRB	Mackenzie Valley Environmental Impact Review Board
N	north
N_2O	nitrous oxide
NO	nitric oxide
NO_2	nitrogen dioxide
NO_3^-	nitric acid

NO_X	oxides of nitrogen
NRC	Natural Resources Canada
NWT	Northwest Territories
O	open terrain
O_3	ozone
OLM	ozone limiting method
P	barometric pressure
PAH	polycyclic aromatic hydrocarbon
PAI	potential acid input
PG stability classes	Pasquill-Gifford stability classes
PM	particulate matter
PM_{10}	inhalable particulate matter; fine particles that are 10 microns or smaller in diameter
$PM_{2.5}$	respirable particulate matter; fine particles less than 2.5 microns in diameter
QA	quality assurance
q_e	specific humidity of the environment
q_{Lo}	initial specific humidity of liquid water in the plume
q_{po}	plume specific humidity
q_s	saturation specific humidity of the environment
R_d	gas constant for dry air
RH	relative humidity
R_o	initial plume radius
RSA	regional study area
R_v	gas constant for water vapour
RWED	Resources, Wildlife and Economic Development

S	south
SO_2	sulphur dioxide
SO_4^{2-}	sulphuric acid
Suncor	Suncor Energy Inc.
T	minimum temperature
T_d	reference temperature
TSP	total suspended particulate
U	wind speed
U.S. EPA	United States Environmental Protection Agency
VR	visible range
W	west
W_o	stack exit velocity
x	distance
Z_p	the height of the steam plume above the stack
σ_θ	standard deviation of the wind direction

GLOSSARY

acid forming compounds	compounds that will tend to form acids when deposited in the environment (*e.g.*, sulphur dioxide and sulphuric acid)
acidifying potential (AP)	a measure of acid deposition
ambient	existing or present in the surrounding air
application case	the air quality impact predicted to occur from the emissions associated with the Snap Lake Diamond Project; this case is based on the level of emissions when the project is fully developed and the activities at the mine site will be at a maximum
atmospheric environment	those components of the environment that deal with the weather, the movement of air, and the contaminants transported in the air

atmospheric mixing height	the depth of the surface layer in which the majority of dispersion will occur
atmospheric stability	an indirect measure of atmospheric turbulence
barometric pressure	the pressure of the atmosphere usually expressed in terms of the height of a column of mercury
base cations	an alkali or alkaline earth metal ion that is positively charged (Ca^{2+}, Mg^{2+}, K^+, Na^+)
baseline case	the current environmental setting, against which changes in the environment from the Snap Lake Diamond Project could be assessed
beyond regional	geographic area extends beyond the regional study area (RSA)
biological receptors	ecological components that can be affected by project emissions, *e.g.*, vegetation and wildlife
CALMET	a meteorological model that develops hourly wind and temperature fields on a three-dimensional gridded modelling domain
CALPOST	a post-processing program to output meteorological data, concentrations, and deposition fluxes in various user-defined formats
CALPUFF	a transport and dispersion model that advects "puffs" of material emitted from modelled sources, simulating dispersion and transformation processes
cardinal directions	the 16 cardinal wind directions spaced every 22½ ° (*e.g.,* N, NNE)
contingency factor	a term included in emissions calculations for some of the equipment to account for possible increases in the equipment required
criteria compounds	compounds for which the environmental regulatory agencies have established ambient air concentration limits
critical load	the highest load that will not cause chemical changes leading to long-term harmful effects on the most sensitive ecological systems
cumulative effect assessment (CEA) case	the predicted ambient air quality in the region at some future date; it includes an assessment of the cumulative air quality impacts from the Snap Lake Diamond Project in combination with other existing, approved, or reasonably foreseeable developments in the region
direction	describes an impact or effect as being neutral or negative; the direction reflects the change, if any, from baseline

dispersion model	a computer model that calculates a concentration or deposition value at a particular point; this value changes from hour to hour eventually reaching an absolute maximum concentration or deposition value for the particular point
dry deposition	the removal of airborne compounds by direct contact with surface features (*e.g.*, vegetation)
duration	the length of time that an impact will occur; duration is defined by the timing of the phases of the project
ecological resilience	the rate of ecosystem recovery following a disturbance or the capacity of an ecosystem to absorb disturbances
effective acidity (EA)	a measure of acid deposition
environmental consequence	the overall effect on the environment when the magnitude, geographic extent, duration, and irreversibility of the project's impact are considered together
environmental settings	the present state of the atmospheric environment; the environmental circumstances or events antecedent to development
equivalent CO_2 (ECO_2)	the combination of the CO_2, methane, nitrous oxide and other GHG emissions into a single measure of greenhouse gas potential
extinction coefficient	a term computed for sulphates and nitrates as the product of the concentration (in $\mu g/m^3$) and extinction efficiency (in m^2/g)
flux	both wet and dry deposition values, in units of kg/ha/yr or keq/ha/yr
frequency	how often an effect will occur
geographic extent	the geographic location where the impact is predicted to occur; a local geographic extent is assigned if the effect is restricted to the LSA; a regional geographical extent is assigned if the effect extends beyond the LSA into some part of the RSA
Hi-Vol sampling	an approved method for collecting total suspended particulate data in the NWT and other jurisdictions
hygroscopic	compounds that take up water
inhalable particles (PM_{10})	fine particulate matter that can reach the lungs
isopleths	a curve joining points of equal maximum concentrations or deposition values

latent heat	heat, other than a change of temperature, which is given off or absorbed in a process, such as fusion or vaporization
level of confidence	an opinion directly related to the degree of certainty in the impact prediction
linkage pathway	illustrates how various project activities of the Snap Lake Diamond Project can contribute to environmental changes; also demonstrates linkages among different topic areas in the EA
loading approach	a system developed in Europe to evaluate acid deposition; considers the sensitivity of the affected ecosystem in combination with the emissions
local extent	a geographic area that is restricted to the active mining area plus a 500 metre buffer
lowland areas	terrain classification determined mainly by topography in the Snap Lake Watershed; this terrain classification includes low areas generally sheltered from wind, such as wetlands
magnitude	a measure of the intensity or severity of an impact; it is a measure of the degree of change in a measurement or analysis endpoint
maximum acceptable level of air quality compounds	a concentration of chemicals in the air intended to provide adequate protection against adverse effects on soil, water, vegetation, materials, animals, visibility, personal comfort, and well-being
maximum desirable level of air quality compounds	a concentration of chemicals in the air that 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
maximum tolerable level of air quality compounds	a concentration of chemicals that, if met or exceeded in the air, denotes a concentration of an air contaminant that requires abatement (mitigation) without delay to avoid further deterioration to an air quality that endangers the prevailing Canadian lifestyle or ultimately, to an air quality that poses a substantial risk to public health
mechanical turbulence	air turbulence caused mostly by high wind speeds
molecular weight	the average mass of a molecule of a compound compared to 1/12 the mass of carbon 12 and calculated as the sum of the atomic weights of the constituent atoms
monitoring load	the level of deposition predicted or estimated by a dispersion model that will trigger monitoring and/or research action

neutral conditions	a class of atmospheric stability; associated with moderate to high wind speeds or overcast conditions, which temper the amount of radiational cooling and heating
non-hygroscopic	compounds that cannot take up water
non-point source	a source of impact that is not concentrated at a point (*e.g.*, road dust)
north pile	an area for storing and containing the processed kimberlite material and potentially acid generating rock
open areas	terrain classification determined mainly by topography in the Snap Lake Watershed; this terrain classification includes lakes and land
ozone limiting method (OLM)	method of converting the NO_x predictions to NO_2; the OLM assumes that approximately 10% of the NO_x emissions are in the form of NO_2, with the balance being in the form of NO
Pasquill-Gifford stability classes	a generalized scheme to classify atmospheric stability
point source	a source of impact that is concentrated at a point
potential acid input (PAI)	a composite measure of acidification determined from the relative quantities of deposition from background and industrial emissions of sulphur, nitrogen, and base cations
probability of occurrence	the likelihood that the environmental consequence indicated in the impact prediction will occur if the project goes ahead
regional extent	the geographic area is restricted to the regional study area (RSA)
relative humidity	the ratio of the amount of water vapor actually present in the air to the greatest amount possible at the same temperature
respirable particles ($PM_{2.5}$)	fine particulate matter that is able to reach the lungs, and go deeper into the respiratory tract and may have greater deleterious health impacts than the coarser inhalable particles (PM_{10})
reversibility	changes that occur after the impact ceases allowing the environment to return to a capability or condition equivalent to the baseline
secondary aerosols	fine droplets composed of nitrates and sulphates that are airborne, and sometimes are associated with haze
stable conditions	a class of atmospheric stability; often occurs as a result of night time cooling; this results in suppressed turbulence levels and weaker dispersion of airborne emissions

steam plumes	the visible plumes from large emission sources at Snap Lake, which are formed during the coldest periods of the year; at these times, moisture in the plumes condenses and becomes visible
target load	the maximum level of atmospheric deposition that provides long-term protection from adverse ecological consequences, and is practically and politically achievable
thermal turbulence	air turbulence caused mostly by surface heating or cooling
topography	the configuration of a surface including its relief and the position of its natural and man-made features
total suspended particulate matter (TSP)	the fraction of airborne particulates that will remain airborne after their release in the atmosphere; the average diameter is nominally of 30 μm (micrometres) and below
trace air compounds	compounds present in extremely small quantities; includes potentially hazardous air pollutants (HAP) and metals (concentrations and deposition)
trace metal	an amount of a chemical metal constituent not always quantitatively determinable because of minuteness
uncertainty	inability to definitely know, which is related to natural variability (both spatial and temporal), model uncertainty, uncertainty of future emissions, measurement errors and data errors
unstable conditions	a class of atmospheric stability; result from daytime heating, which enhances turbulence and dispersion
upland areas	terrain classification determined mainly by topography in the Snap Lake Watershed; this terrain classification includes elevated areas generally exposed to wind
visible range	the effect of haze on the visibility of an object; related to the average extinction coefficient between a person and the object being viewed
wet deposition	the removal of airborne compounds by precipitation
windrose	a single figure that presents both wind speed and direction information