

DE BEERS
CANADA

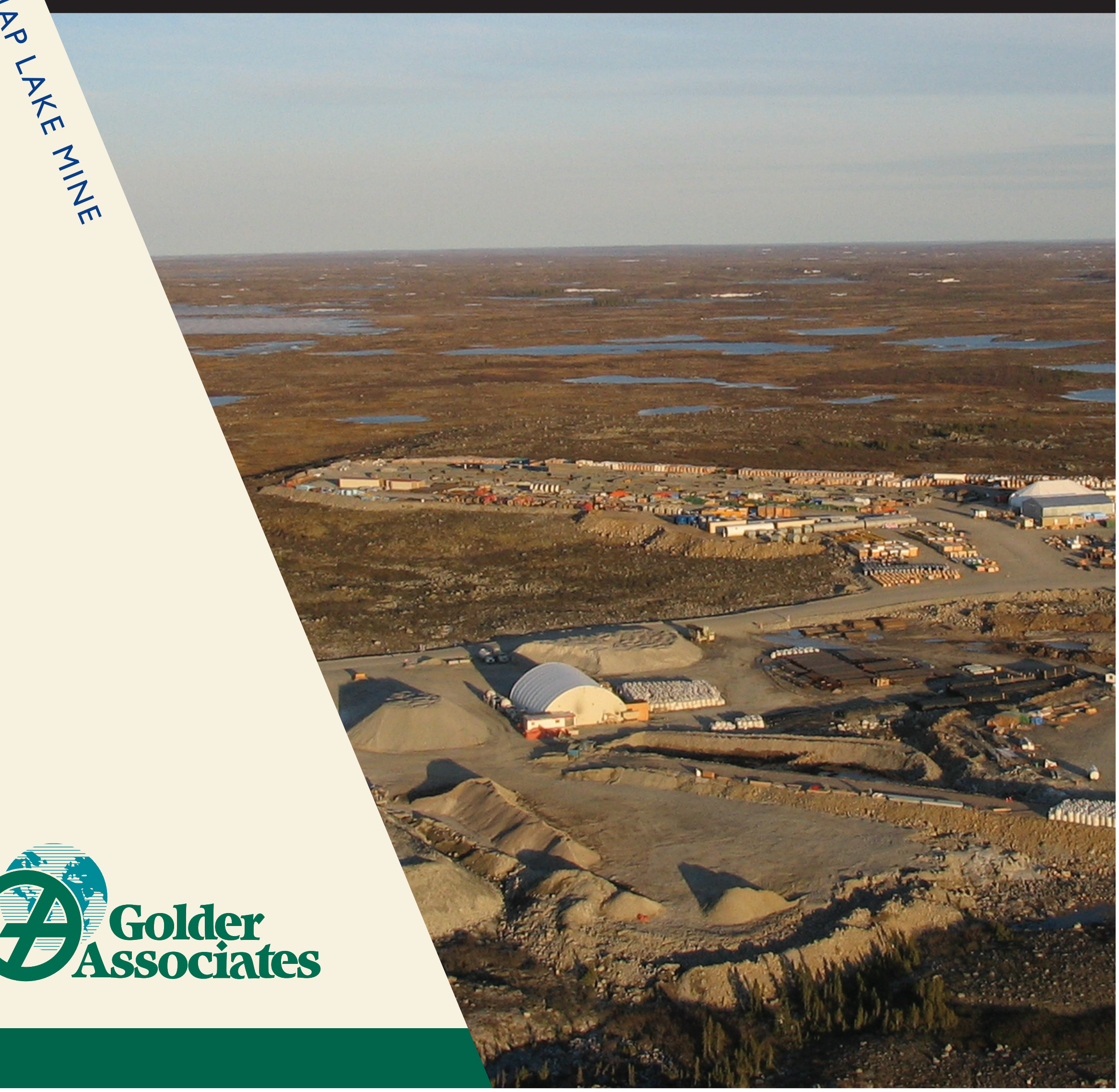
SNAP LAKE MINE

OCTOBER 2007

Air Quality and Emissions Monitoring and Management Plan

October 2007

SNAP LAKE MINE



Golder Associates

EXECUTIVE SUMMARY

The Snap Lake Diamond Project (the Project) Environmental Agreement contained a requirement to develop an Air Quality Monitoring Program (AQMP) and an Emissions Management Plan (EMP). Both the AQMP and EMP have undergone a number of revisions to incorporate feedback from the Government of the Northwest Territories (GNWT) and Environment Canada (EC). This document contains the most recent revision to the AQMP and EMP and harmonizes them into one document, the Air Quality and Emissions Monitoring and Management Plan (AQEMP). This integrated approach demonstrates the linkages between the two programs and shows how the data from each program will be presented together each year in the annual report.

The AQMP component will be used to coordinate off-site monitoring of ambient air quality at the Project during the construction, operations, and closure phases. This ambient air quality monitoring will be compared to applicable air quality criteria and analyzed for trends each year in the annual report. In this fashion, the AQMP will be able to provide an indication of the Project's performance with respect to air quality.

The EMP component presents the approaches that will be used in the annual report to provide a summary of Project emissions. The emission calculation methodology for each of the main Project sources is discussed in detail in this document. The calculated emissions will be compared to those in the Air Modelling Update Report (De Beers 2006a) to evaluate Project emissions performance.

An important outcome of evaluating project emissions performance is to identify potential areas for emissions mitigation. Recommendations for emissions mitigation will be made each year, if necessary, using a pro-active approach that considers the annual emissions and monitoring data against pre-determined action levels. The action levels for each compound are based on the Air Modelling Update (De Beers 2006a) predictions, the applicable ambient air quality criteria and a percent change (year to year) in measured concentrations. In this manner, the potential issues can be resolved before the ambient air quality standards are reached, which is the primary benefit of this type of proactive management system.

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ACRONYMS & DEFINITIONS

Ambient	Existing or present in the surrounding air
AQEMP	Air Quality and Emissions Monitoring and Management Plan
AQMP	Air Quality Monitoring Program
CH_4	methane
CO_2	carbon dioxide
CO_2E	carbon dioxide equivalent
De Beers	De Beers Canada Inc.
EAR	Environmental Assessment Report
EC	Environment Canada
EMP	Emissions Monitoring Program
EMS	Environmental Management System
ENR	Environment and Natural Resources
GHG	greenhouse gas
GNWT	Government of the Northwest Territories
Hi-Vol	high volume sampler
INAC	Indian and Northern Affairs Canada
MVEIRB	Mackenzie Valley Environmental Impact Review Board
N_2O	nitrous oxide
NAAQO	National Ambient Air Quality Objectives
NAPS	National Air Pollution Surveillance
NO_2	nitrogen dioxide
NO_X	oxides of nitrogen
NPRI	National Pollutant Release Inventory
NWT	Northwest Territories

Partisol	dichotomous partisol sampler
PM_{10}	particulate matter concentrations less than 10 micrometres
$PM_{2.5}$	particulate matter concentrations less than 2.5 micrometres
Project	Snap Lake Project
QA	quality assurance
QA/QC	quality assurance/quality control
QC	quality control
SLEMA	Snap Lake Environmental Monitoring Agency
SNP	surveillance network program
SO_2	sulphur dioxide
TSP	total suspended particulate
U.S. EPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator

UNITS

%	Percent
°C	degrees Celsius
cm	Centimetres
g/GJ	grams per gigajoule
g/year	grams per year
GJ/kg	gigajoules per kilogram
kg	Kilogram
kg/kmol	kilograms per kilomol
$kg/m^2/day$	kilograms per squared metre per day
kg/m^3	kilograms per cubic metre
kg/year	kilograms per year
km	kilometres
kph	kilometres per hour
m/s	metres per second
m^3	cubic metres
Mg	megagram
$mg/100cm^2/30$ days	milligrams per 100 square centimetres per 30 days
ppmw	parts per million weight
VKT	vehicle kilometres travelled
VMT	vehicle miles travelled
$\mu g/m^3$	micrograms per cubic metres
µm	micrometers

1 INTRODUCTION

De Beers Canada Inc. (De Beers) owns and operates the Snap Lake Diamond Project (the Project). The Project is located in the Northwest Territories (NWT) approximately 220 kilometres (km) northeast of Yellowknife and 30 km south of MacKay Lake (Figure 1-1). Final regulatory approvals for construction and operation of the mine were granted in May 2004, and construction began in April 2005. Mining processing began in August, 2007 and is expected to continue for 22 years.

This Air Quality and Emissions Monitoring and Management Plan (AQEMP) is a requirement of the Project's Environmental Agreement (Section Article VI, Section 6.3 items d) and e) and Article VII, Section 7.2 item a i) and also fulfills the air quality and meteorological monitoring requirements in the Project's Water License.

1.1 LEGISLATION, REGULATORY AND POLICY REQUIREMENTS

An Environmental Assessment Report (EAR) for the proposed mine (De Beers 2002a) was completed and submitted to the Mackenzie Valley Environmental Impact Review Board (MVEIRB) in February 2002. The Board in turn completed a review, and recommended that the Project proceed subject to the implementation of measures to mitigate environmental impacts (MVEIRB 2003). The MVEIRB's report and recommendation was submitted to the Minister of Indian and Northern Affairs (INAC) in July 2003 and received ministerial approval in October 2003. De Beers received the necessary Water License, Land Use Permit, Land Leases, and Environmental Agreement in May 2004 to begin construction and operation of the mine.

De Beers must meet the following requirements regarding air quality, meteorological monitoring, and emissions monitoring:

1) the development of an Air Quality Monitoring Program (AQMP), as outlined in Article VI, Section 7.2 of the Environmental Agreement. The AQMP is also necessary to meet the meteorological monitoring requirements specified in the General Conditions (Part B) and the Surveillance Network Program (SNP) section of the Project's Water License (MV2001L2-0002); and,
2) the development of an Emissions Management Plan (EMP), as outlined in Article VI, Section 6.3 items d) and e) and Article VII, Section 7.2 item a i) of the Environment Agreement.

1.2 SCOPE

An initial draft of the AQMP was prepared in September 2003 and updated in September 2005 based on feedback from the Government of the Northwest Territories (GNWT) and Environment Canada (EC). A draft of the EMP was submitted to the Snap Lake Environmental Monitoring Agency (SLEMA), GNWT and EC in February 2006. Upon receipt of feedback on this draft (GNWT and EC 2006), the AQMP and EMP have been harmonized into one document (AQEMP) to demonstrate the linkages between the two monitoring programs and because the data from the two programs will be presented together each year in the annual report.

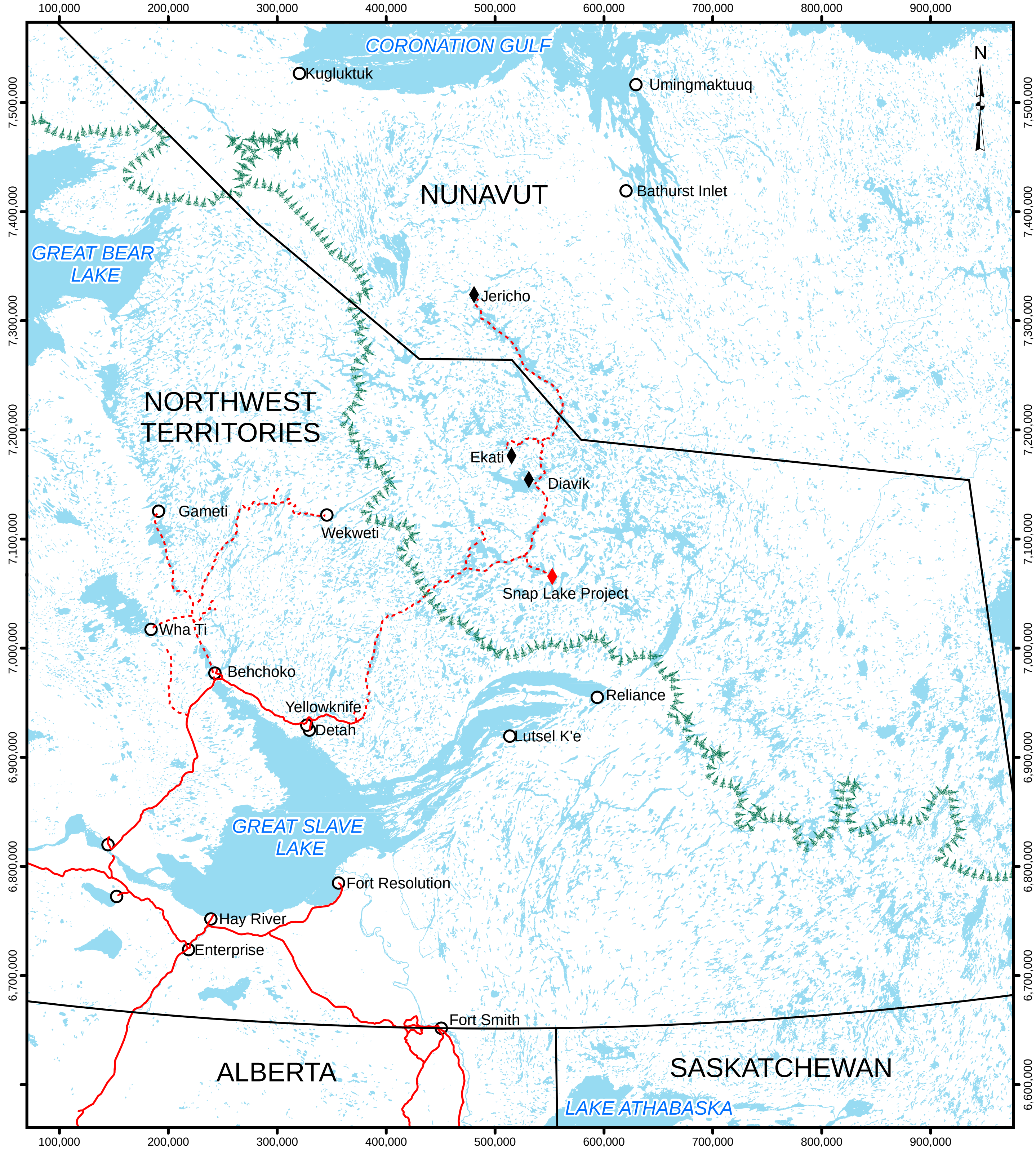
The overall purpose of this integrated document is to provide an overview of the activities involved in the AQMP and EMP and a template for the annual monitoring reports. This report is a "living" document that may need to be adapted as the Project itself evolves, consistent with the Project's Adaptive Management Plan (De Beers 2004).

This AQEMP document has been prepared to address the two monitoring requirements in the Environmental Agreement. The AQMP is presented in Section 2 of this document and the EMP is presented in Section 3.

An important component of the AQEMP is the comparison of annual monitoring data to emission estimates and dispersion modelling predictions presented in the Project EAR (De Beers 2002a). However, an updated air quality assessment has been completed, based upon more recent design information (De Beers 2006a). Therefore, in this document the Air Modelling Update (De Beers 2006a) is referred to as the basis for comparing with monitoring data.

1.3 GOAL

The goal of both the Project's AQMP and EMP is to comply with relevant Articles in the Environmental Agreement (e.g., Articles VI and VII), the Water License, legislation and related corporate environmental policies. Accordingly, De Beers has designed these plans in consultation with the GNWT, EC and the Snap Lake Environmental Monitoring Agency (SLEMA).



LEGEND

- COMMUNITY
- DIAMOND MINE
- ALL WEATHER HIGHWAY
- TREELINE
- WINTER ROAD
- WATER

100 0 100

SCALE 1:5,000,000 KILOMETRES

REFERENCE

Landsat TM landcover classification conducted by Golder Associates Ltd.
Datum: NAD 83 Projection: Transverse Mercator Coordinate System: UTM 12

PROJECT

DE BEERS CANADA SNAP LAKE PROJECT

TITLE

LOCATION OF THE SNAP LAKE PROJECT

Golder Associates
Yellowknife, Northwest Territories

PROJECT No. 06-1328-005. 5300			SCALE AS SHOWN	REV. 0
DESIGN	DP	Feb. 2007	FIGURE: 1-1	
GIS	KB	Feb. 2007		
CHECK	DP	May 2007		
REVIEW	JV	May 2007		

Project: N:\Active\GIS\06-1328-005 De Beers\Final Figures\Figure 1-1

1.4 OBJECTIVES

This document has been developed to address the following objectives:

- demonstrate compliance with applicable Federal and Territorial ambient air quality standards;
- track trends in ambient air quality and Project emissions;
- provide information required for the Project's Environmental Management System (EMS) (De Beers 2002b) to protect air quality;
- verify the accuracy of impact predictions made in the Air Modelling Update (De Beers 2006a);
- outline response plans to respond to increasing trends, exceedences of air quality criteria or occurrences above emission estimates and dispersion modelling predictions presented in the Air Modelling Update;
- provide data that can make a meaningful contribution to a regional cumulative effects monitoring data bank;
- identify strategies for emissions tracking and monitoring;
- document fuel use as it relates to air quality management; and,
- under the EC regulations, facilitate data gathering necessary to develop an approach for emissions mitigation, which includes the fugitive dust abatement program.

To achieve these objectives the AQMP concentrates on the following five main components:

1. on-site meteorological monitoring;
2. on-site hydro-meteorological monitoring;
3. ambient monitoring of Total Suspended Particulate (TSP) and fine particulate matter concentrations less than 10 micrometres (μm) (PM_{10}) and less than 2.5 μm ($PM_{2.5}$);
4. ambient monitoring of dustfall; and,
5. passive monitoring of sulphur dioxide (SO_2) and nitrogen dioxide (NO_2).

While the EMP focuses on the following three main components:

1. emissions estimates;
2. fuel use summary; and,

3. emissions mitigation strategies, which includes the fugitive dust abatement program.

1.5 METHODOLOGY AND APPROACH

De Beers has conducted ambient air quality and meteorological monitoring at the Project site since 1998 when the Advanced Exploration Program began. The various components of the AQMP and EMP have already begun to be implemented at the Project.

De Beers understands the need for adaptive management of the monitoring programs and acknowledges that the monitoring sites may change as the Project evolves. However, an effort will be made to maintain consistency in the monitoring locations, as this is an important consideration in conducting trend analysis.

Monitoring activities at the Project consist of a combination of “on-site” and “off-site” monitoring. In this regard, “on-site” monitoring is defined as monitoring that occurs within the active mine area, whereas “off-site” monitoring occurs outside of the active mine area. A map of the Project site indicating the active mine area and current air monitoring locations is provided in Figure 2-1.

The focus of the AQMP is off-site monitoring to more clearly demonstrate consistency with the applicable ambient air quality standards, which are based on off-site concentrations measured at the facility boundary. This off-site monitoring is important because it provides an indication of the ambient concentrations of air emissions to which the public, or other components of the receiving environment, may be exposed. Ideally, all ambient air quality monitoring for the Project would occur off-site, just outside the active mine area. However, this is not possible in all cases because some of the monitoring equipment requires electrical power, which is only available at select locations off-site.

The effectiveness of the AQMP and the EMP is dependent, in part, on selecting appropriate criteria against which Project emissions and the resulting ambient air concentrations should be compared. Since there is currently no provision for air quality to be included in permits for mines in the NWT, there is no requirement to monitor for compliance with permit limits. In lieu of air quality permit requirements, the Project will be required to comply with the relevant NWT ambient air quality standards for TSP, $PM_{2.5}$ and SO_2 (GNWT 2002) as well as the National Ambient Air Quality Objectives (NAAQO) for NO_2 (Environment Canada 1981). Since there are currently no NWT standards for dustfall, the

Alberta guideline will be used as a means of aiding interpretation of dustfall data (AENV 2005).

In addition to demonstrating that Project emissions and ground-level concentrations are consistent with the applicable regulatory criteria, it is De Beers' intent to manage emissions and ground-level concentrations in keeping with the principles of "Continuous Improvement" (CI) and "Keeping Clean Areas Clean", as described in the Canada-Wide Standards for Particulate Matter (PM) and Ozone (Environment Canada 2000). Therefore, the monitoring of trends in Project emissions and ambient air quality is an important component of the AQEMP, as discussed in Sections 2 and 3.

The AQEMP covers the three main phases of the Project, which are construction, operations, and closure. As the construction phase of the Project, and the associated monitoring, is now approaching completion, this report has evolved to focus on the operations phase. Results of the operations phase monitoring will be presented and discussed in the annual Air Quality and Emissions Monitoring Report (herein referred to as the 'annual report' and discussed in Section 5 of this document). The closure phase monitoring will occur many years into the future and the annual report will continue to evolve as management and monitoring needs change.

2 AIR QUALITY MONITORING PROGRAM

2.1 INTRODUCTION

The AQMP will be used to coordinate off-site monitoring of ambient air quality at the Project during the construction, operations, and closure phases. This ambient air quality monitoring will be compared to applicable air quality criteria and analyzed for trends each year in the annual report. In this fashion, the AQMP will be able to provide an indication of the Project's performance with respect to air quality.

The main components of the AQMP and the sections in which they are discussed are as follows:

- meteorological monitoring (Section 2.2);
- hydro-meteorological monitoring (Section 2.3);
- TSP, PM_{10} and $PM_{2.5}$ monitoring (Section 2.4);
- dustfall monitoring (Section 2.5);
- passive SO_2 and NO_2 monitoring (Section 2.6); and,
- quality assurance/quality control (QA/QC) (Section 2.7).

For each of the AQMP components, the details of the monitoring station locations, methods, parameters, frequency and data analysis are presented in the following sections.

2.2 METEOROLOGICAL MONITORING

Meteorological monitoring serves as part of the basis for interpretation of air quality data. Meteorological parameters are also used by other disciplines (e.g., hydrology) to aid in project design and the analysis of monitoring data. Meteorological monitoring is a vital input for any subsequent emissions dispersion modelling assessments that may be required during the Project lifetime. The data plays a crucial role in the characterization of general air quality trends and specific meteorological conditions at the Project site.

2.2.1 Monitoring Station Locations

A single meteorological station is installed at the Project site (Figure 2-1). It is located approximately 100 metres (m) south of the access road from the air strip to the camp, near the height of land and west of the water management pond (Universal Transverse Mercator [UTM] Zone 12 NAD83 - 506 052E, 7 052 492N). There is a secondary weather station located at the communications building that can provide back-up data if the meteorological station fails.

2.2.2 Monitoring Methods

Meteorological monitoring is being conducted at the site using Campbell Scientific meteorological monitoring equipment. Sensors are mounted on a 10 metre tower, consistent with current accepted practice in Canada. The station operates independently using a battery/solar panel power supply. A radio link permits communications between the station and the on-site De Beers' Environmental technicians' office.

2.2.3 Monitoring Frequency

Meteorological monitoring will be conducted year-round throughout the construction, operations, and closure phases of the Project. Meteorological data are measured continuously and are recorded hourly. The data are downloaded bi-weekly by De Beers' site staff.

2.2.4 Monitoring Parameters

The tower system continuously measures the following meteorological parameters:

- wind speed at 10 m above the ground;
- wind direction at 10 m above the ground;
- temperature at 2 m above the ground;
- relative humidity at 2 m above the ground;
- solar radiation at 2 m above the ground; and,
- rainfall at 2 m above the ground.

2.2.5 Data Analysis

Data will be analyzed regularly by a professional air quality scientist or engineer. A summary of the meteorological monitoring will be presented each year in the annual report. Discussion of extreme meteorological events and trends will be included as part of the annual report.

LEGEND

- DUST FALL SAMPLING LOCATION
- HI-VOL MONITORING STATION
- PARTISOL MONITORING STATION
- NEW LOCATION OF METEOROLOGICAL MONITORING STATION (BEGINNING JUNE 2004)
- SNAP LAKE PROJECT FOOTPRINT

REFERENCE

DIGITAL MAP FROM MACKAY LAKE, NORTHWEST TERRITORIES, PRODUCED BY DEPARTMENT OF ENERGY, MINES AND RESOURCES. MAP 75M, ORIGINAL SCALE 1:250,000, NAD 83 UTM ZONE 12.
ORIGINAL DATA WAS CORRECTED TO LANDSAT7 SATELLITE IMAGE 45/15 FROM SEPT 2, 2000 PROVIDED BY GEOBASE.

1 0 1
SCALE KILOMETRES

PROJECT
DE BEERS CANADA
SNAP LAKE PROJECT

TITLE

2006 CURRENT AIR MONITORING STATION LOCATIONS

Golder Associates
Calgary, Alberta

PROJECT 06-1328-005.5150			FILE No. 2006 Air Monitoring	
DESIGN	MC	16/02/07	SCALE AS SHOWN	REV. 0
CADD	JEF	22/08/07		
CHECK	GH	22/08/07		
REVIEW	CM	22/08/07		

FIGURE: 2-1

L:\2006\1328-YKnife\06-1328-005\5100\5150\ Drawing file: Fig 2-1 2006 Current Air Monitoring Station Loc.dwg Aug 22, 2007 - 5:34pm

2.3 HYDRO-METEOROLOGICAL MONITORING

Hydro-meteorological monitoring is designed to measure parameters that allow for the calculation and recording of lake evaporation rates at the site and aid with the ongoing management of the site water balance. This monitoring component was introduced in the spring of 2005 to fulfill the SNP requirements outlined in the Project Water License (Sections D.1.item a through D.1.item c).

The hydro-meteorological monitoring is linked to the meteorological component of the AQMP and ties in with the Hydrology Monitoring Program. The station management will be administered under the AQMP; however, the processed data will be provided to the hydrology team for processing, storage, analysis, and reporting.

2.3.1 Monitoring Station Locations

The station is installed on the south shore of the west arm of Snap Lake near the Project fresh water intake, as shown in Figure 2-1.

2.3.2 Monitoring Methods

Hydro-meteorological monitoring is being conducted using Campbell Scientific-supplied monitoring equipment. The measured parameters will be used to calculate evaporation. Sensors are mounted on a three metre tripod consistent with current industry practice. The station operates independently using a battery/solar panel power supply but requires a technician to manually download the data.

2.3.3 Monitoring Frequency

Hydro-meteorological monitoring will be conducted during the open water season (June–September, depending upon weather conditions), throughout the construction, operations, and closure phases of the Project. Meteorological and hydrological data will be measured continuously and will be recorded hourly. The recorded hourly data will be downloaded by a site technician bi-weekly.

2.3.4 Monitoring Parameters

The tripod will be fitted with a solar/battery power supply for the continuous monitoring of the following parameters:

- precipitation;
- wind speed and wind direction at approximately 3 m above the water surface;
- air temperature at approximately 0.75 and 2 m above the water surface;
- relative humidity at approximately 0.75 and 2 m above the water surface;
- water temperature at approximately 1 and 2 m below the surface;
- net radiation over the water surface; and,
- water level.

2.3.5 Data Analysis

The data will be given to the Hydrology Monitoring team to calculate lake evaporation. Lake evaporation data will be summarized and compared to estimated values used in the EAR (De Beers 2002a). The lake evaporation data will be combined with other sources of water loss from the lake such as seepage estimates, outflow and Project water withdrawals to determine total losses. Losses will be balanced against water contributions such as precipitation, treated water releases and runoff from the local watershed to determine the water balance for the lake. Lake elevation will be used to verify the water balance calculations.

2.4 TOTAL SUSPENDED PARTICULATE, PM_{10} AND $PM_{2.5}$ MONITORING

Suspended particulate matter (dust) emissions will be generated by wind erosion of local landscapes, movement of vehicles/equipment, airstrip activities, construction activities, the combustion of diesel fuel, and solid waste incineration.

Suspended particulate matter emissions are generally grouped into three size fractions. The particulate matter size fractions are as follows:

- TSP – which includes particulate matter nominally less than 100 µm;
- PM_{10} – which includes particulate matter nominally less than 10 µm; and,
- $PM_{2.5}$ – which includes particulate matter nominally less than 2.5 µm

Current understanding is that those particles small enough to readily enter the lower respiratory tract (i.e., lungs and bronchi) are of the most concern. These particles are typically $PM_{2.5}$. However, there is also evidence linking inhalable particles, or PM_{10}, to health concerns.

The TSP, PM_{10}, and $PM_{2.5}$ monitoring is being carried out to address the AQMP requirements outlined in Section 7.2 item a) of the Environmental Agreement for the Project:

7.2 (a) The Air Quality Monitoring Program shall include but not be limited to:

- *(i) Monitoring total suspended particulate (TSP), PM_{10} and $PM_{2.5}$;*
- *(ii) Monitoring of fugitive dust to determine the effects of dust deposition on the surrounding environment;*
- *(iii) Documentation of quality assurance and quality control (QA/QC) procedures used to ensure valid data collection; and*
- *(iv) Contingency plans to respond to increasing trends or exceedences of air quality criteria/dispersion modelling predictions*

2.4.1 Monitoring Station Locations

The previous on-site monitoring locations were selected during construction to provide a conservative management approach to ambient particulate concentrations. These locations were selected based on areas of maximum particulate predictions from the dispersion modelling assessment, and demonstrating compliance with ambient air quality standards at these locations should extrapolate to compliance at off-site locales.

In response to EC and GNWT's advice, the ambient particulate matter monitoring was relocated in 2007 to three locations (Hi-Vol stations 002, 004, and 005), as indicated in Figure 2-1. These locations were selected because they are a representative estimate of particulate concentrations off-site. The availability of electrical power was also a key consideration for these locations.

Two of the three particulate monitoring sites are located off-site, directly adjacent to the facility boundary. These locations were identified as areas of potentially higher off-site particulate concentrations based on dispersion modelling predictions.

The two off-site particulate monitoring locations are bordering the explosives emulsion plant and airstrip, situated just outside the active mine area. Both of these locations have a TSP high volume (Hi-Vol) sampler, co-located with a PM_{10} and $PM_{2.5}$ dichotomous partisol sampler (Partisol). The one on-site monitoring station is located in the active mine area adjacent to the mine portal. The on-site station is equipped with a Hi-Vol sampler. The locations of these stations may need to be adapted in future revisions of the AQMP based on changes in operations or monitoring methods.

2.4.2 Monitoring Methods

The current suspended particulate matter monitoring network consists of a variety of sampling instruments including Hi-Vol samplers for TSP, and Partisols for PM_{10} and $PM_{2.5}$. The Partisols were added to the program in the spring of 2004 and their use will continue through the life of the Project. In contrast, the Hi-vols for TSP will be replaced with the Partisols in 2007.

Hi-Vol samplers operate on the principle that a stream of ambient air at a controlled flow rate is drawn through a size-selective inlet and then through a pre-weighed filter for a pre-determined time period. The exposed filter is shipped to a laboratory where it is re-weighed. The TSP concentrations can be determined using the measured volume of air and the weight difference between the pre-weighed and exposed filter.

The Hi-Vol samplers at Snap Lake collect particulate with a nominal aerodynamic diameter of 100 µm or smaller. The collection of TSP provides a good measure of airborne particulate and the 24-hour and annual average concentrations are subject to NWT ambient air quality standards of 120 and 60 micrograms per cubic metre ($\mu g/m^3$), respectively (GNWT 2002).

Though the principle of operation is the same for the Partisol as it is for the Hi-Vol, the Partisol sampling system has a number of operational advantages when compared to other particulate samplers. The Partisols require considerably less manual handling in the field than Hi-Vol samplers as the Partisols use an enclosed sample cartridge. The combination of enclosed sampling cartridges and the lower air volumes used in the Partisol system should enhance sample collection in the winter months. This type of monitoring is a United States Environmental Protection Agency (U.S. EPA) reference method for quantifying ambient PM_{10} and $PM_{2.5}$ concentrations. The collection of $PM_{2.5}$ is also subject to a standard in the NWT (GNWT 2002).

2.4.3 Monitoring Frequency

The monitoring of TSP, PM_{10}, and $PM_{2.5}$ concentrations is carried out according to the National Air Pollution Surveillance (NAPS) schedule. This schedule follows a monitoring cycle where a single 24-hour sample is collected every six days. This monitoring schedule has been followed at the Project since April 2000 when the Hi-Vol monitoring program was initiated.

Particulate sampling is being conducted year-round. However, sampling during extreme winter conditions (-20 degrees Celsius [°C] and colder with winds >15 kilometres per hour), which typically occurs between the months of October to April, allows the possibility for snow to be drawn through the inlet resulting in a void sample and possible damage to the electronic components of the sampler. A small amount of data loss is expected during the winter as ambient conditions exceed the normal operating range expected for the equipment being used. However, De Beers has constructed heated shacks to contain the equipment to minimize this problem.

Sampling in accordance with the NAPS schedule provides consistency between the Snap Lake particulate monitoring stations and stations at other facilities across the country. In addition, by operating on a six-day cycle, different days are sampled each week, which allows for the monitoring of differing production intensities or other variations. Monitoring of TSP and fine particulate matter will continue beyond construction, into the operations and closure phases of the Project.

2.4.4 Data Analysis

The TSP, PM_{10} and $PM_{2.5}$ data from the three monitoring locations will be analyzed for indications of air quality concerns (e.g., increasing trends or measured concentrations above the Air Modelling Update predictions or applicable ambient air standards). The results of this analysis will be presented in the annual report and will be used to update and modify the dust management procedures incorporated in the EMS, if necessary.

To analyze for indications of air quality concerns, the TSP and $PM_{2.5}$ data from the two off-site stations will be compared to the EAR (De Beers 2002a) and the Air Modelling Update predictions, NWT standards (GNWT 2002) and Canada-Wide standards (CCME 2000, 2001).

The analysis of spatial particulate trends will compare measured particulate concentrations at the explosives manufacturing site to those at the airstrip and mine portal locations. The readings at the explosives manufacturing site should be consistently lower than those at the airstrip and mine portal sites due the greater distance approximately 1 km from the explosives manufacturing site to the principal particulate emission sources associated with the Project. There is the possibility that unusual events in the region (e.g., a dust storm transporting airborne particulate) could result in higher measured particulate concentrations at the explosives manufacturing site. Any such unusual event will be analyzed in conjunction with the on-site meteorological data to investigate the cause of the event.

The analysis of temporal trends will look for consistent trends in the measured particulate concentrations on an annual basis. The response planning and action levels to deal with increasing trends are described in Section 4. Managing trends in ambient particulate concentrations on an annual basis is appropriate given the scale of the Project and the long-term nature of the monitoring program.

In addition to the annual trend analysis, ongoing visual observation at the site is one mechanism for identifying high dust events and triggering remedial actions The potential cause(s) of the condition and the mitigation action available will be evaluated and implemented as appropriate.

2.5 DUSTFALL MONITORING

The main dust generation processes at the Project will be wind erosion of fugitive sources, rock crushing, deposited kimberlite and movement of vehicles/equipment on site. When the particles are large enough they can settle from the air onto vegetation or water bodies. The dustfall monitoring program required under Section 7.2 a) of the Environmental Agreement measures the quantities of dust deposited near the Project.

2.5.1 Monitoring Station Locations

The 2007 locations of the dustfall monitoring stations are shown in Figure 2-1. A total of five dustfall stations are currently in operation to address concerns raised regarding dust emissions from the North Pile (rock crushing and construction).

2.5.2 Monitoring Methods

Dustfall data are collected using open vessels containing a purified liquid matrix. Particles are deposited and retained in the vessel, which are then sent to a laboratory where total and fixed dustfall are quantified. Total dustfall is everything that falls into the collection vessel, while fixed dustfall is the combustible subset. The dustfall program is a complement to the TSP, PM_{10} and $PM_{2.5}$ monitoring program.

Dustfall canisters will be used to collect ambient dustfall for analysis of deposition rates of dust. Unlike the Hi-Vol and Partisol samples, dustfall collection is a passive program that provides a measure of particulates that would be directly deposited onto vegetation, soil and water in the vicinity of the Project.

2.5.3 Monitoring Frequency

Dustfall canisters are exposed in the field for a nominal period of 30 days. Dustfall sampling is done over this longer period to allow for a sufficient sample size for analysis. In this regard, it provides an indication of longer-term air quality trends.

Dustfall monitoring is proposed for the construction and operations phase of the Project. If dustfall levels are consistently less than or greater than predicted in the Air Modelling Update, or are static, the frequency of monitoring may be adjusted, depending on the acceptability to the regulatory agencies.

2.5.4 Monitoring Parameters

The dustfall samples will be analyzed for the total and fixed dustfall collected over the sampling period. Ambient dustfall nominally includes particles large enough to settle out of the air column.

2.5.5 Data Analysis

The dustfall rates measured at the five dustfall stations will be analyzed for indications of air quality concerns (e.g., increasing trends or measured concentrations above the applicable ambient air standards) as well as spatial and temporal trends. The conclusions of this analysis will be presented each year in the annual report and will be used to update and modify the dust management procedures incorporated in the EMS as required.

The analysis of the fixed dustfall sampling results will include the comparison of the results with Alberta guidelines since the NWT do not have dustfall standards. Specifically, the on-site dustfall readings will be compared to the Alberta industrial guideline of 158 milligrams over a 10 centimetre (cm) by 10 cm area in a 30 day period (mg/100 cm^2/30 days) (AENV 2005). The off-site data will be compared to the more restrictive Alberta recreational guideline of 53 mg/100

cm^2/30 days (AENV 2005). The industrial guideline applies to on-site areas, such as the active mine site, and the recreational guideline applies to off-site areas.

Analysis of spatial dustfall trends will include comparisons among the various dustfall stations. Unusual differences may trigger investigation and examination of mitigation measures via the EMS.

The analysis will also check for consistently increasing trends in the measured dustfall rates on an annual basis. The response planning and action levels for increasing trends are described in Section 4. Managing ambient dustfall rates on an annual basis is appropriate given that the Project is a relatively small-scale underground mine (3000 tonnes per day).

In addition to the annual trend analysis, ongoing visual observation at the site will be performed by personnel to provide real-time monitoring of dust levels.

2.6 PASSIVE MONITORING OF SO_2 AND NO_2

The main sources of SO_2 and NO_2 emissions from the Project will be the power plant, mine heaters, mine and quarry activities, and the incinerators. De Beers intends to incorporate the passive monitoring of SO_2 and NO_2 compounds into the AQMP, in order to demonstrate compliance with the NWT standards (GNWT 2002) and NAAQOs (Environment Canada 1981).

2.6.1 Monitoring Station Locations

The proposed passive SO_2 and NO_2 monitoring stations are co-located with the dustfall stations. Co-locating these stations serves two purposes. First, it will allow for the efficient collection of samples. Second, it will allow for the calculation of ambient secondary particulate (sulphates and nitrate) concentrations if this information is required at a later date.

2.6.2 Monitoring Methods

Passive SO_2 and NO_2 samplers are proposed for this monitoring program. The monitors are suitable for this type of program as they require no electricity, and can be left unattended for extended periods. The sample media are taken to the field and exposed in protective shelters that are mounted to a support pole or small tripod. The passive samplers will be exposed for a nominal period of 30 days before they are retrieved, replaced and sent to the laboratory for analysis.

2.6.3 Monitoring Frequency

Passive samplers are exposed in the field for a nominal period of 30 days. As passive sampling is done over a longer period to allow for a sufficient sample size for analysis, it provides an indication of longer-term air quality trends.

Passive SO_2 and NO_2 monitoring is proposed for the operations phase of the Project. Should it be discovered that SO_2 and NO_2 are consistently less than predicted in the Air Modelling Update, or are static for the first few years of operation, the frequency of monitoring may be adjusted depending on the acceptability of this to the regulatory agencies.

2.6.4 Monitoring Parameters

The passive samples will be analyzed for SO_2 and NO_2.

2.6.5 Data Analysis

The ambient SO_2 and NO_2 concentrations measured at the five passive stations will be analyzed for indications of air quality concerns (e.g., increasing trends or measured concentrations above the Air Modelling Update predictions or applicable ambient air standards) as well as spatial and temporal trends.

The analysis of the SO_2 and NO_2 sampling results will include the comparison of results with the NWT standards (GNWT 2002) and NAAQO (Environment Canada 1981). However, since the passive sampling will be on a monthly basis and neither the NWT standards nor NAAQO have monthly criteria, the annual average of the monthly data will be compared to the annual NWT standard for SO_2 and the annual NAAQO for NO_2.

Analysis of spatial trends would include comparisons between the various passive stations. Consistent differences between stations may trigger investigation and examination of mitigation measures via the EMS.

The analysis of temporal trends will look for consistent, increasing trends in the measured SO_2 and NO_2 concentrations on an annual basis. The response planning and action levels for increasing trends are described in Section 4.

2.7 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

Quality Assurance (QA) refers to plans or programs that encompass a wide range of internal and external management and technical practices designed to ensure the collection of data of known quality that matches the intended use of the data. Quality Control (QC) is a specific aspect of QA that refers to the internal techniques used to measure and assess data quality (American Public Health Association et al. 1989). As QC procedures implemented as part of the AQMP are variable and program-specific, the procedures have been summarized in this section on a program component basis. De Beers has a Quality Assurance and Quality Control (QA/QC) Plan (De Beers 2006b) and applicable procedures will be followed for the AQMP.

2.7.1 Meteorological and Hydro-Meteorological Monitoring

QA/QC procedures for the meteorological and hydro-meteorological monitoring program include the following:

- Data are to be downloaded from the station bi-weekly and manually surveyed by qualified personnel (i.e., a professional air quality scientist or engineer) for anomalous data that may indicate problems with the system.
- Sensors will be calibrated on a schedule consistent with each sensor's requirements (generally every 24 months).
- The station will be attended weekly (as weather conditions permit) to ensure that sensors within reach are free of debris, frost or damage that may prevent accurate measurement of meteorological data. A checklist has been developed that allows an organized approach to determining the fitness of the station.
- Data will be downloaded consistent with detailed written operating instructions from qualified personnel (i.e., a professional air quality scientist or engineer).

2.7.2 Total Suspended Particulate, PM_{10} and $PM_{2.5}$ Monitoring

QA/QC procedures for the particulate monitoring program include the following:

- Travel blanks (laboratory prepared samples that travel with the samples but are not exposed to the atmosphere) will be used.

- Hi-Vol samplers and Partisol samplers will be calibrated and maintained annually.
- An accredited laboratory will be used for pre-sample preparation and determining sample weights.
- Samples will be collected consistent with detailed written operating instructions from qualified personnel (i.e., a professional air quality scientist or engineer).
- Qualified personnel (i.e., a professional air quality scientist or engineer) will interpret the flow charts and calculate ambient particulate concentrations based on laboratory results.
- Data will be downloaded consistent with detailed written operating instructions from qualified personnel (i.e., a professional air quality scientist or engineer).

2.7.3 Dustfall Monitoring

QA/QC procedures for the dustfall monitoring program include the following:

- Travel blanks (laboratory prepared samples that travel with the samples but are not exposed to the atmosphere) will be used.
- An accredited laboratory will be used for pre-sample preparation and analysis.
- Samples will be collected consistent with detailed written operating instructions from qualified personnel (i.e., a professional air quality scientist or engineer).
- Qualified personnel (i.e., a professional air quality scientist or engineer) will calculate ambient dustfall deposition rates based on laboratory results.

3 EMISSIONS MONITORING PROGRAM

3.1 INTRODUCTION

The EMP will be used to coordinate the monitoring of Project emissions during the construction, operations and closure phases. Emissions calculated for these phases will be compared to the Air Modelling Update (De Beers 2006a) emission estimates to evaluate the Project emissions performance. This process will be done on an annual basis and will be summarized in the annual report. If the results of the EMP and AQMP suggest that further mitigation is necessary, then this will be incorporated into the emissions mitigation strategies, which includes the fugitive dust abatement program.

The three main components of the EMP, and the sections in which they are discussed, are as follows:

- emissions estimates (Section 3.2);
- fuel use summary (Section 3.3); and,
- emissions mitigation strategies, which include the dust abatement program (Section 3.4).

3.2 EMISSION ESTIMATES

This section presents the approaches that will be used in the annual report to provide a summary of Project emissions. This section identifies the various types of emissions from the Project, as described in Section 3.2.1.1, and provides examples of approaches for calculating these emissions, as described in Section 3.3.2. The calculated emissions will be compared to those in the Air Modelling Update (De Beers 2006a), to evaluate Project emissions performance.

The emissions estimate component of the EMP has the following objectives:

1) to demonstrate De Beers' commitment to ongoing monitoring of emissions at the Project site;
2) to provide an overview of the appropriate methodology for calculating emissions from the Project;
3) to show that Project emissions do not exceed those modelled in the Air Modelling Update (De Beers 2006a); and,
4) to demonstrate De Beers' commitment to ongoing minimization of emissions.

3.2.1 Types of Emissions

3.2.1.1 Combustion Emissions

Combustion is the process of burning fuels of various types and using the energy released to produce electricity, space or process heating or to facilitate on-site transportation and incineration. There are five primary combustion sources at the Project:

- power generators;
- mine air heaters;
- underground fleet;
- surface fleet; and,
- incinerators.

Compounds such as SO_2, oxides of nitrogen (NO_X), particulates and greenhouse gases (GHGs) are common combustion by-products from the Project sources. These by-products are the subject of regulatory guidance which limits the release amounts of the compounds to protect the receiving environment. De Beers has committed to meet the relevant NWT standards, NAAQO and Canada-Wide standards that apply to these compounds. The applicable criteria are provided in Table 3-1.

Table 3-1 Air Quality Criteria

Air Quality Parameter	Hourly [µg/m³][a]	24-Hour [µg/m³]	Annual [µg/m³]
SO_2 (Government of the Northwest Territories [GNWT])[b]	450	150	30
NO_2 (National Ambient Air Quality Objectives)[c]	400	200	100
TSP (GNWT)[b]	120	—	60
PM_{10} (Newfoundland and British Columbia)[d]	—	50	—
$PM_{2.5}$ (Canada-Wide Standard)[e]	—	30	—

(a) µg/m³=micrograms per cubic metre.

(b) GNWT 2002.

(c) Environment Canada 1981.

(d) British Columbia and Newfoundland have a 24-hour objective of 50 µg/m³ (Government of British Columbia 1995, Government of Newfoundland and Labrador 2004).

(e) The Canada-Wide Standard is based on the 98th percentile of the annual monitored data, averaged over three years of measurements (Canadian Council of Ministers of the Environment 2000).

In addition to the ambient air quality criteria for common combustion compounds (i.e., SO_2, NO_X, and suspended particulates), there also exist Canada-Wide Standards for other combustion by-products, such as dioxins, furans, and mercury that may be released during on-site waste incineration (CCME 2001). A summary of the Canada-Wide Standards for dioxins, furans and mercury is presented in Table 3-2 and these apply to municipal waste incineration at new facilities such as the Project. The achievement of these Canada-Wide Standards requires that the best available control techniques, such as a waste diversion program, be used.

Table 3-2 Canada-Wide Standards for Municipal Waste Incineration Emissions

Municipal Waste Incineration Compound	Emission Limit
Dioxins and Furans[a]	80 picograms of International Toxic Equivalents per cubic metre
Mercury[b]	20 micrograms per cubic metre ($\mu g/m^3$)

(a) Canadian Council of Ministers of the Environment (CCME) 2001.
(b) CCME 2000.

By calculating and reporting annual combustion emissions, De Beers can determine whether operational emissions are at or below these standards and emission estimates provided in the Air Modelling Update (De Beers 2006a).

3.2.1.2 Fugitive Emissions

Fugitive emissions are substances that are released to the atmosphere from various locations and represent unintentional losses of compounds to the atmosphere without passing through a stack, vent or functionally equivalent opening. Fugitive emissions are expected as a result of the Project construction and operation activities and are expected to consist primarily of fugitive dust.

Fugitive dust emissions can result from Project sources through either mechanical or natural processes. Examples of mechanical processes that can generate fugitive dust include crushing, materials handling, vehicle fleet operation, heavy equipment operation, vegetation removal, and the take-off and landing of aircraft from the airstrip. The main natural process that generates fugitive dust is wind erosion. There are three main potential fugitive emission sources at the Project:

- the roads and airstrip;
- the quarry; and,
- the North Pile.

It should be noted that although the quarry has been a sizeable fugitive emission source in the past, it is now closed and has been rehabilitated. Natural re-vegetation is currently being monitored.

3.2.2 Methods

This section describes three methods that can be used to estimate Project emissions (depending on the compounds). The methods are:

- using a mass balance approach;
- using an emission factor approach (published or calculated); or,
- using available intermittent source stack testing data.

The mass balance approach is based on the law of conservation of mass in a system. Essentially, if there is no accumulation within the system, then all the materials that go into the system must come out. Fuel analysis data is a good example of the mass balance approach in predicting emissions. For example, if the sulphur content of a fuel is known, then the emissions of sulphur (in the form of SO_2) can be calculated by assuming that all of the sulphur in the gas is emitted from the system.

The second approach proposed for estimating Project emissions is the use of emission factors. Emission factors are available for many emission source categories and are based on the results of source tests performed at one or more facilities within an industry. An emission factor is the contaminant emission rate relative to the level of source activity. Generic emission factors are commonly used when site-specific source monitoring data are unavailable.

The use of source-specific stack testing data is appropriate for emission sources or compounds that may be difficult to characterize using either mass balance or emission factors. A stack test measures the amounts of specific compounds present in the stack exhaust gas.

The methods that can be used for estimating Project emissions are as follows:

- SO_2 – mass balance approach;
- NO_X – emission factor approach;
- Particulates – emission factor approach;

- GHGs – emission factor approach; and,
- Dioxins, furans and mercury – stack testing approach.

The following sections provide examples of how Project emissions will be calculated using each of aforementioned approaches. The recommended methods are consistent with those used in the Air Modelling Update.

3.2.2.1 SO_2 Emission Calculation Methods

SO_2 Combustion Emissions

The diesel fuel used at the Project contains sulphur. When the fuel is burned, the sulphur oxidizes to form SO_2. To estimate SO_2 emissions from the Project, the mass balance approach should be used. An example calculation of using this approach for a power plant is provided below. In the example calculation, a fuel sulphur content of 0.05 percent (%) by weight (500 parts per million weight [ppmw]) is assumed. Supplier documentation will be used to confirm the fuel sulphur content for each reporting period.

Example: Assume the engines in a power plant consume 24,000 cubic metres (m^3) of fuel per year, and that the fuel has a density of 881 kilograms per cubic metre (kg/m^3) and a sulphur content of 0.05% by weight.

$$M = \rho \times V_f \times f_S \times \frac{MW_{SO2}}{MW_S}$$

Where:

M = total emissions, (tonnes per year)
ρ = fuel density, (kg/m^3)
V_f = volume of fuel used, (m^3 per year)
f_S = fraction of sulphur in fuel, (unit-less)
MW_{SO2} = molecular weight of sulphur dioxide (SO_2), (64.06 kilograms per kilomol [kg/kmol])
MW_S = molecular weight of sulphur (S), (32.07 kg/kmol)

Note: The above is a general equation designed to estimate SO_2 emissions from the combustion of fuel based on known fuel sulphur content.

Calculate the total weight of the compound released in kilograms per year (kg/year).

$$M = \frac{881 kg}{m^3} \times \frac{24{,}000 m^3}{year} \times 0.0005 \times \frac{64.06 kg / kgmolSO_2}{32.07 kg / kgmolS} = 21{,}117.63 \frac{kgSO_2}{year}$$

Convert the annual release to a daily value in tonnes.

$$21{,}117.63 \frac{kgSO_2}{year} \times \frac{1 year}{365 days} \times \frac{1 tonnes}{1000 kg} = 0.058 \frac{tonnesSO_2}{day}$$

SO_2 Fugitive Emissions

In addition to Project combustion emissions, fugitive emissions should also be considered. In the case of SO_2, no fugitive emissions are expected from the Project.

3.2.2.2 NO_X Emission Calculation Methods

NO_X Combustion Emissions

Fuel burned in combustion equipment produces NO_X emissions at the Project. An example calculation of power plant NO_X emissions using the emission factor approach is provided below.

Example: Assume the engines in a power plant consume 24,000 m³ of fuel per year and the diesel specifications indicate that the heating value of diesel is 0.0449 gigajoules per kilogram (GJ/kg) of fuel consumed. Furthermore, the diesel has a density of 881 kg/m³ and the emission factor for NO_X is 1,376 grams per gigajoules (g/GJ).

$$M = \rho \times V_f \times HV \times E$$

Where:

M = total emissions, (tonnes per year)
ρ = fuel density, (kg/m³)
V_f = volume of fuel used, (m³ per year)
HV = fuel heating value, (GJ/kg)
E = emission factor, (g/GJ)

Note: The above is a general equation for emissions estimation using emission factors.

Calculate the total weight of the compound released in grams per year (g/year).

$$M = \frac{881kg}{m^3} \times \frac{24{,}000m^3}{year} \times \frac{0.0449GJ}{kg} \times \frac{1{,}376g}{GJ} = 1.306x10^9 \frac{g}{year}$$

Convert the annual release to a daily value in tonnes.

$$1.306x10^9 \frac{g}{year} \times \frac{1tonne}{10^6 g} \times \frac{1year}{365day} = 3.578 \frac{tonnes}{day}$$

NO_X Fugitive Emissions

In addition to Project combustion emissions, fugitive emissions should also be considered. In the case of NO_X, no fugitive emissions are expected from the Project.

3.2.2.3 Particulate Emission Calculation Methods

Particulate Combustion Emissions

Fuel burned in combustion equipment produces particulate emissions at the Project. An example calculation of power plant particulate emissions using the emission factor approach is provided below.

Example: Assume the engines in a power plant consume 24,000 m^3 of fuel per year and the diesel specifications indicate that the heating value of diesel is 0.0449 GJ/kg of fuel consumed. Furthermore the diesel has a density of 881 kg/m^3 and the emission factor for TSP is 42.99 g/GJ.

$$M = \rho \times V_f \times HV \times E$$

Where:

M = total emissions, (tonnes per year)
ρ = fuel density, (kg/m^3)
V_f = volume of fuel used, (m^3 per year)
HV = fuel heating value, (GJ/kg)
E = emission factor, (g/GJ)

Note: The above is a general equation for emissions estimation using emission factors.

Calculate the total weight of the compound released in g/year.

$$M = \frac{881kg}{m^3} \times \frac{24{,}000m^3}{year} \times \frac{0.0449GJ}{kg} \times \frac{42.99g}{GJ} = 4.081x10^7 \frac{g}{year}$$

Convert the annual release to a daily value in tonnes.

$$4.081x10^7 \frac{g}{year} \times \frac{1tonne}{10^6 g} \times \frac{1year}{365day} = 0.112 \frac{tonnes}{day}$$

Particulate Fugitive Emissions

In addition to Project combustion emissions, fugitive emissions should also be considered. Fugitive particulate emissions are expected from the Project, particularly from vehicle traffic.

Vehicle Traffic Particulate Emissions

An example calculation of TSP emissions from vehicle traffic using the emission factor approach is provided below. The road dust emission calculation takes into consideration the following factors:

- the particle size;
- the silt content of the road surface;
- the mean vehicle weight;
- the surface material moisture content; and,
- the number of days of precipitation per year.

The calculation is used to generate a site-specific emission factor, in this case kilograms (kg) of TSP released per vehicle kilometre travelled (VKT). The site-specific emission factor is then multiplied by the number of vehicle kilometres travelled on-site over the reporting period to obtain a mass emission rate.

$$E = FVKT \times k \times \left(\frac{s}{12}\right)^a \times \left(\frac{W}{3}\right)^b \times \left(\frac{M}{1}\right)^c \times \left[\frac{365-(p+snow)}{365}\right]$$

Where:

E = emission factor, (kg per VKT)
k = particle size multiplier, (pound [lb] per VMT)
s = silt content of road surface material, (%)
W = mean vehicle weight, (tonnes)
M = surface material moisture content, (%)
p = number of days with at least 0.01 inches of precipitation per year (dimensionless)
snow = number of days of snow cover per year (dimensionless)
FVKT = conversion from (lb per VMT) to (kg per VKT)
a, b, c = constants

The above equation can be found in the Environment Canada Road Dust Guidance Document (Environment Canada 1998).

All of the above terms, except mean vehicle weight (W), which will be specific to the vehicle type, can be found in regulatory guidance documents (i.e., Environment Canada Road Dust Guidance Document (Environment Canada 1998) and U.S. EPA AP-42 (U.S. EPA 1995).

$$E = 0.2819 \times 5.3 \times \left(\frac{8.3}{12}\right)^{0.8} \times \left(\frac{20}{3}\right)^{0.5} \times \left(\frac{0.7}{1}\right)^{-0.4} \times \left[\frac{365-(118+181)}{365}\right] = 0.599 kg/VKT$$

Wind Erosion Particulate Emissions

Fugitive particulate emissions generated by wind erosion of open aggregate storage piles are also expected from the Project. The wind-generated particulate emission calculation takes into consideration various factors, such as the particle size, the number of disturbances over the reporting period, amount of precipitation and the surface erosion potential. The calculated site-specific emission factor for the North Pile is 3.504×10^{-5} kilograms per square metre per day (kg/m^2/day), which is then multiplied by the exposed North Pile surface area over the reporting period to obtain a mass emission rate.

3.2.2.4 Greenhouse Gas Emission Calculation Methods

GHGs are emitted from the combustion sources at the Project. The GNWT has implemented a Greenhouse Gas Management Strategy (GNWT 2001). Significant emitters of GHGs must report their emissions on an annual basis.

Diesel combustion at the Project is the largest contributor to GHG emissions. The GHGs that are expected to be released as a result of the Project include carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Though the emissions of CH_4 and N_2O are expected in much smaller volumes than CO_2, their global warming potentials are much greater than that of CO_2. To maintain a valid comparison of the relative contribution of each compound to the overall total GHG emissions from the Project, CH_4 and N_2O emissions are converted to CO_2 equivalent (CO_2E) units. Global warming potential factors are used to convert non-CO_2 greenhouse gases to CO_2E. The global warming potential factor for CH_4 and N_2O are 21 and 310 respectively (Environment Canada 2006). An example calculation is provided below.

Example: Assume the engines in a power plant consume 24,000 m^3 of fuel per year. The GHG emission factors for CO_2, CH_4 and N_2O are 2,730, 0.133 and 0.4 kg/m^3 respectively (Environment Canada 2006).

$$M = Vf \times E$$

Where:

M = total emissions, (tonnes per year)
V_f = volume of fuel used, (m^3 per year)
E = emission factor, (kg/m^3)

Calculate the total CO_2 emissions in tonnes/year.

$$M_{CO_2} = \frac{24{,}000 m^3}{year} \times \frac{2{,}730 kg}{m^3} \times \frac{1 tonne}{1{,}000 kg} = 65{,}520 \frac{tonnes CO_2}{year}$$

Calculate the total CH_4 emissions in tonnes/year.

$$M_{CH4} = \frac{24{,}000 m^3}{year} \times \frac{0.133 kg}{m^3} \times \frac{1 tonne}{1{,}000 kg} = 3.192 \frac{tonnes CH_4}{year}$$

Calculate the total N_2O emissions in tonnes/year.

$$M_{N2O} = \frac{24{,}000 m^3}{year} \times \frac{0.4 kg}{m^3} \times \frac{1 tonne}{1{,}000 kg} = 9.600 \frac{tonnes N_2O}{year}$$

Calculate the total CO_2E emissions in tonnes/year using the global warming potential factors for CH_4 and N_2O.

$$65{,}520 tonnesCO_2 + (3.192 tonnesCH_4 \times 21) + (9.600 tonnesN_2O \times 310) = 68{,}563 \frac{tonnesCO_2E}{year}$$

3.2.2.5 Dioxins, Furans and Mercury Calculation Methods

Combustion of waste in the Project incinerator has the potential to release dioxins, furans, and mercury to the atmosphere. The emissions of these compounds are regulated under the Canada-Wide Standards.

The emissions of dioxins, furans, and mercury in the Project incinerator will be highly dependent on the quantities and types of waste that will be burned. For this reason, emission estimates based on mass balance or emission factors are difficult to calculate. The proposed approach for estimating emissions from the incinerator is to use intermittent stack sampling data for the incinerator and compare this data to the Canada-Wide Standards in the annual reports.

In addition to Project combustion emissions, fugitive emissions should also be considered. In the case of dioxins, furans, and mercury, no fugitive emissions are expected from the Project.

3.3 FUEL USE SUMMARY

Fuel usage for the main Project combustion sources, identified in Section 3.2.1, will be documented monthly and presented in the annual report. Table 3-3 provides an example of a table that could be used to track fuel usage per source on a monthly basis. This table also allows for year by year comparisons of the annual fuel usage so that trends can be identified in the annual reports. In addition to fuel usage at the site, the amount of waste burned in the incinerator will be provided in the annual report. An example of a table that could be used to track waste tonnage and liquid fuel use in the incinerator is presented as Table 3-4.

Table 3-3 Example of Table for Tracking Monthly Fuel Usage from Major Combustion Sources (cubic metres [m³])

Month	Power Generation	Mine Heaters	Mobile Fleet	Incineration	Total	Air Modelling Update	2007 Total	2008 Total
January								
February								
March								
April								
May								
June								
July								
August								
September								
October								
November								
December								
Total								

Table 3-4 Example of Table for Tracking Monthly Waste Tonnage Burned (tonnes) and Liquid Fuel Usage (cubic metres [m³])

Month	Waste Tonnage Burned	Liquid Fuel Usage	Total	Air Modelling Update	2007 Total	2008 Total
January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						
Total						

3.4 EMISSIONS MITIGATION STRATEGIES

There are a number of mitigation measures that will be integrated into the operations phase of the Project to minimize air emissions. These mitigation measures primarily focus on minimizing fugitive dust emissions. This is because fugitive dust can be effectively managed through operational strategies to a greater degree than the other air emission compounds released from the Project. A fugitive dust abatement program has been incorporated as Section 3.4.1 of this document. As for the other compounds released from the Project, particularly combustion compounds (i.e., SO_2, NO_X, particulate, dioxins, furans, and mercury), the following mitigation measures are used:

- fuel conservation measures to reduce SO_2, NO_X and particulate emissions;
- CCME compliant equipment to reduce NO_X emissions;
- waste diversion methods to minimize dioxins, furans, and mercury emissions from the incinerator;
- operation of combustion equipment, particularly the incinerator, at optimal conditions (e.g., manufacturer recommended temperature, pressure etc); and,
- regular maintenance of the vehicle fleet and limiting of engine idling.

3.4.1 Fugitive Dust Abatement Program

3.4.1.1 Objectives

The objective of the fugitive dust abatement program is to effectively manage dust generation from surface dust sources. The dominant fugitive dust sources are expected to be road traffic, activities at the North Pile, and wind erosion.

3.4.1.2 Methods

Section 7.4 of the Project EAR (De Beers 2002a) presented mitigation measures to minimize dust from the drilling, blasting, ore handling, and primary crushing activities associated with the Project. A discussion of these and other fugitive dust abatement measures is provided in this section. These measures may be revisited pending results of the annual Air Quality and Emissions Report.

3.4.1.3 Watering Surfaces

De Beers will control dust through watering surfaces that have high dust generation potential. Water controls dust in two ways:

1. The surface tension of the water present between dust particles will increase the cohesiveness of the surface material making it less susceptible to becoming suspended in the air.
2. Water droplets in the form of a spray will also knock or wash out suspended particles from the air at a more defined source such as crushers and exposed conveyor transfer points.

Dust is expected to be most significant during the warm, dry periods of the year. During these months (typically late May through late September) the application of water to dust-prone surfaces will be an effective approach to managing fugitive dust. This would not only be effective for controlling dust on the site roads and airstrip, but a water mist would also be effective for controlling dust in other dust production areas and exposed conveyor transfer points.

3.4.1.4 Wind Protection

Where practical, De Beers will also protect surfaces that may erode and potentially high dust generation areas from the wind. This action can take various forms including the following:

- Using fabric discharge chutes to shield conveyor drop and transfer points from the effects of the wind, thereby reducing the amount of particulate that is exposed to the effects of the wind. Enclosing high dust generation potential activities within buildings has the same effect and can considerably reduce the amount of dust that leaves the immediate area. Examples that are planned include underground ore crushing, and enclosing the surface ore stockpile within a building.
- The application of coarse material on roadways and stockpiles (e.g., the North Pile) physically separates the fine material that would make dust if it were exposed to wind or traffic. In areas where high traffic activity is expected, road surfaces should be prepared to include a surface layer that does not have a high erosion potential. Plans for the reclamation of the North Pile include protecting it from the effects of the wind by placing coarse material on the completed surfaces.

3.4.1.5 Managing Activity Intensity

De Beers will also limit the intensity of certain activities that have the potential to generate significant fugitive dust. For example, speed limits will be strictly enforced to ensure that dust generation from motor vehicles is minimized. The maximum speed is 35 km/hour.

3.4.1.6 Other Measures

There are other activities that could be undertaken to reduce the potential for dust generation; however, the indirect effects of undertaking these activities can result in other less desirable environmental consequences. For example, during the winter months, when watering surfaces is impractical, other liquid chemicals could be used to control dust. Chemical dust control with salt solutions (most frequently, calcium, magnesium, or sodium chloride) may be investigated and used depending upon the environmental consequence.

4 RESPONSE PLANNING

As indicated by the GNWT and EC (GNWT and EC 2006), one of the purposes of the AQEMP should be to identify trends in ambient air quality and to use this information to inform management decisions around emissions mitigation. This type of proactive management requires that a clear and well-documented system be established. This section provides details on how such a system would operate.

For the system to operate effectively the following parameters must be clearly defined:

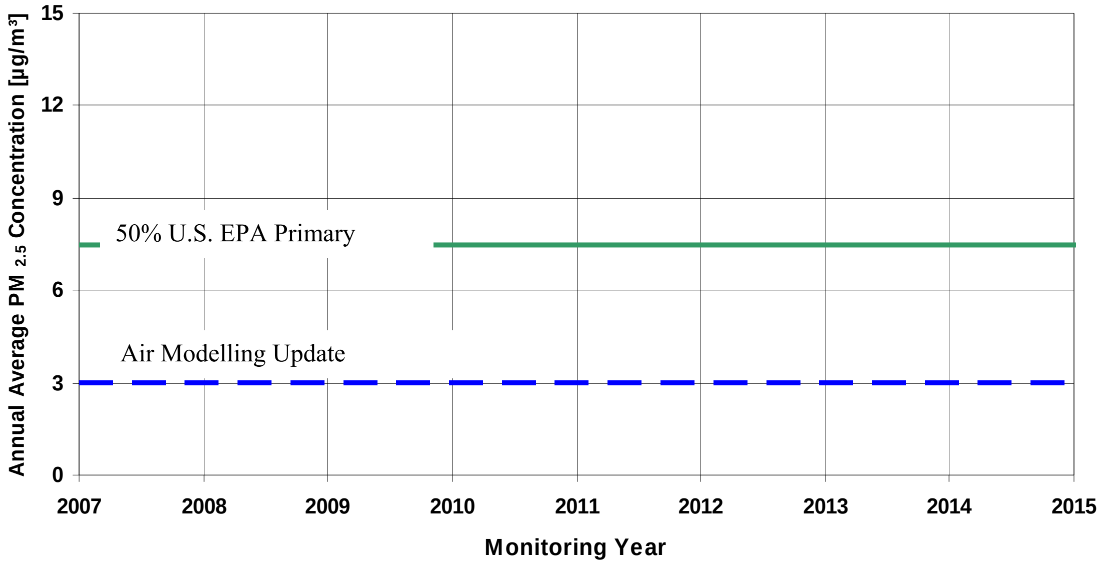
- the methodology for determining trends and identifying when emissions mitigation is necessary;
- the monitoring timeframe over which emissions mitigation decisions will be made; and,
- the action levels at which emissions mitigation will be employed.

Each year the annual average concentrations for each of the monitored compounds will be summarized as part of the annual report. These concentrations will be plotted on a graph, similar to the example plot shown for SO_2 in Figure 4-1, so that the magnitude and trends in concentration over time can be easily observed. To evaluate the magnitude and trends in concentrations, a series of pre-determined action levels will also be presented on the figure. These action levels indicate a range or percent change (year to year) in concentrations at which emissions mitigation should be considered. A description of how the action levels should be applied to each of the compounds emitted by the Project is provided below.

A systematic approach was taken to develop action levels for each compound based on the Air Modelling Update (De Beers 2006a) predictions, the applicable ambient air quality criteria and a percent change (year to year) in measured concentrations. For example, the action levels for SO_2 are as follows:

- Action Level I – concentrations below the maximum Air Modelling Update prediction or less than ±10% year to year change;
- Action Level II – concentrations above the maximum Air Modelling Update prediction but below 50% of the applicable ambient air quality criteria or from ±10% to ±20% year to year change; and,
- Action Level III – concentrations above 50% of the applicable ambient air quality criteria or more than ±20% year to year change.

Figure 4-1 Action Levels for Annual Ambient SO_2 Concentrations



The above action levels are applicable to TSP, PM_{10} and $PM_{2.5}$, but are not applicable to NO_2. This is because the NO_2 concentrations predicted in the Air Modelling Update are high relative to the ambient air quality criteria and therefore require more proactive emissions management. This proactive management entails setting the action levels for NO_2 to respond to a smaller percentage change in concentrations as follows:

- Action Level I – concentrations below the maximum Air Modelling Update prediction or less than ±5% year to year change;
- Action Level II – concentrations above the maximum Air Modelling Update prediction but below 90% of the applicable ambient air quality standard or from ±5% to ±10% year to year change; and,
- Action Level III – concentrations above 90% of the applicable ambient air quality standard or more than ±10% year to year change.

Table 4-1 shows each of the Action Levels and the criteria required to trigger the appropriate management action.

The management action that will be implemented for each of the action levels is as follows:

- Action Level I – continue monitoring, no mitigation necessary;
- Action Level II – internal review and development of action plan; and,
- Action Level III – external review and development of action plan.

Table 4-1 Action Level Triggering Criteria

Criteria	Action Level I	Action Level II	Action Level III
SO_2, TSP, PM_{10}, $PM_{2.5}$			
Concentration Below the Maximum Air Modelling Update Prediction	✓		
Concentration Above the Maximum Air Modelling Update Prediction but Below 50% of the Applicable Air Quality Criteria		✓	
Concentration Greater Than 50% of Applicable Air Quality Criteria			✓
Concentration Less Than 10% Change Year to Year	✓		
Concentration Between 10% and 20% Change Year to Year		✓	
Concentration Greater Than 20% Change Year to Year			✓
NO_2			
Concentration Below the Maximum Air Modelling Update Prediction	✓		
Concentration Above the Maximum Air Modelling Update Prediction but Below 90% of the Applicable Air Quality Criteria		✓	
Concentration Greater Than 90% of Applicable Air Quality Criteria			✓
Concentration Less Than 5% Change Year to Year	✓		
Concentration Between 5% and 10% Change Year to Year		✓	
Concentration Greater Than 10% Change Year to Year			✓

This is a general approach that can be applied to any of the monitored compounds. If either an internal or external review is necessary, then this will likely include a review of ambient monitoring data and Project emissions to determine whether the elevated concentrations or trend is related to Project equipment or operations. In this manner, the potential issues can be resolved before the ambient air quality standards are reached, which is the primary benefit of this type of proactive management system.

5 ANNUAL REPORT

De Beers will provide an annual report that summarizes the air quality monitoring and air emissions data collected during each year. Consistent with the other environmental requirements under the Water License, the annual Air Quality and Emissions requirements will be submitted by the legislated date of March 31 of each calendar year as part of the Water License Annual Report. The Annual Air Quality and Emissions Report will be submitted to the signatories of the Environmental Agreement by the proposed date of June 30 of each calendar year. In addition, De Beers will report annual emission estimates to the National Pollutant Release Inventory (NPRI) and GHG emissions to the appropriate federal program. To ensure that the AQEMP is effective, it will be reviewed every 5 years in cooperation with the signatories to the Environmental Agreement.

Examples of air emissions and ambient air monitoring tracking tables that could be used in the annual reports are provided as Tables 5-1 and 5-2 respectively.

Table 5-1 Example of Table for Tracking SO_2 Emissions (tonnes/year)

Sources	Air Modelling Update	2007	2008
Power Generation			
Mine Heaters			
Mobile Fleet			
Incineration			

Table 5-2 Example of Table for Tracking Monitored Total Suspended Particulate (micrograms per cubic metre [μg/m³])

Monitoring Sites	Applicable Guideline	Air Modelling Update	2007	2008

Meteorological data will be summarized and presented by parameter, including seasonal and annual wind roses. Comparisons to applicable climate normals (30-year average) for Yellowknife and past site monitoring will also be included.

Data summaries for each of the ambient monitoring stations and compounds (TSP, PM_{10}, $PM_{2.5}$, dustfall, SO_2 and NO_2) will also be presented. Due to the configuration of the particulate monitoring program, data through the end of the calendar year may not be available for inclusion in the annual report. Therefore, each annual report will include a listing of the monthly results since the program commenced.

Consistent with Section 6.3 item e) of the Environmental Agreement, and other commitments made by De Beers, the annual report will include the following information:

- annual NO_X, SO_2, particulate and greenhouse gas emissions;
- confirmation of use of low sulphur (0.05% or less) diesel fuel through supplier specification sheets;
- an annual fuel use summary apportioned by the major sources using the same methods as the Air Modelling Update;
- an assessment of the effectiveness of the emissions mitigation measures including the fugitive dust abatement program;
- comparisons of annual emission estimates to previous years and the estimates used in the Air Modelling Update;
- comparisons of ambient air quality and deposition monitoring results to previous years, the predictions of the Air Modelling Update dispersion modelling and all applicable federal and territorial criteria, standards, objectives and guidelines;
- analysis of ambient air quality trends to determine if emissions mitigation is necessary;
- responses (either initiated and/or planned) to air quality issues (e.g., equipment failure, data loss, increasing trends or exceedences of air quality critical/dispersion modelling predictions); and,
- monitoring results made available to the GNWT for the data storage system.

Data will be managed in accordance with De Beers' EMS Data Management System (De Beers 2002b).

6 REGIONAL AND CUMULATIVE EFFECTS MONITORING PROGRAMS

De Beers will make available the results of the air quality monitoring programs and emissions estimates to the recognized administering agency of the yet to be developed regional cumulative effects monitoring program.

7 REFERENCES

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U.S. EPA (United States Environmental Protection Agency). 1995. Compilation of Air Pollutant Emission Factors. Volume 1: Stationary Point and Area Sources. Document AP-42. Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

8 GLOSSARY

ambient	existing or present in the surrounding air
Hi-Vol sampling	an approved method for collecting total suspended particulate data in the NWT and other jurisdictions
inhalable particles (PM_{10})	fine particulate matter that can reach the lungs
North Pile	an area for storing and containing the processed kimberlite material and potentially acid generating rock
relative humidity	the ration of the amount of water vapour 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})
total suspended particulate (TSP)	the fraction of airborne particulates that will remain airborne after their release in the atmosphere; the average diameter is nominally of 100 µm (micrometres) and below

APPENDIX I

CONCORDANCE TABLE SHOWING AIR MONITORING REQUIREMENTS OUTLINED IN THE ENVIRONMENTAL AGREEMENT AND THE WATER LICENSE AND WHERE COMMITMENTS ARE ADDRESSED IN THE AIR QUALITY AND EMISSIONS MANAGEMENT PLAN

Table I-1 Concordance Table Showing Air Monitoring Requirements Outlined in the Environmental Agreement and the Section Where Commitments are Addressed in the Air Quality and Emissions Management Plan

Section	Requirement/Commitment	AQEMP Section	AQEMP Section Heading
7.1	a) DBCMI shall undertake compliance and environmental effects monitoring of the Project through the Environmental Monitoring Programs.	All	All
	b) DBCMI shall provide the Parties and the Monitoring Agency (when established) with copies of its Environmental Monitoring Programs. The Environmental Monitoring Programs contemplated by this Article shall be reviewed in accordance with Article 7.5 of this agreement. The Environmental Monitoring Programs shall be revised on an ongoing basis as necessary and where appropriate in response to changing circumstances and additional information.		
	c) The Environmental Monitoring Programs shall include activities designed to:		
	i. meet the monitoring requirements of all Regulatory Instruments;		
	ii. verify the accuracy of the impact predictions from the Environmental Assessment Report of the Project;		
	iii. determine the effectiveness of measures taken to mitigate any adverse environmental effects of the Project;		
	iv. consider; and incorporate where possible, traditional knowledge;		
	v. establish thresholds or early warning signs;		
	vi. trigger action by adaptive mitigation measures where appropriate;		
	vii. provide opportunities for the involvement or active participation of members of each of the Aboriginal Parties in the implementation of the monitoring programs;		
	viii. provide training opportunities for members of each of the Aboriginal Parties;		
	ix. include hypothesis testing during the analysis of data to facilitate Adaptive Management where appropriate; and,		
	x. provide for appropriate monitoring during any suspension of operations.		

Table I-1 Concordance Table Showing Air Monitoring Requirements Outlined in the Environmental Agreement and the Section Where Commitments are Addressed in the Air Quality and Emissions Management Plan (continued)

Section	Requirement/Commitment	AQEMP Section	AQEMP Section Heading
7.2	For each Environmental Management Plan there should be a complementary Environmental Monitoring Program to support the process of Adaptive Management. The Environmental Monitoring Program shall include: a) The Air Quality Monitoring Program shall include but not be limited to:” i) Monitoring of total suspended particulate (TSP), PM10 and PM25; ii) Monitoring of fugitive dust to determine the effects of dust deposition on the surrounding environment; iii) Documentation of quality assurance and quality control (QA/QC) procedures used to ensure valid data collection; and iv) Contingency plans to respond to increasing trends or exceedences of the air quality criteria/dispersion model predictions. The Air Emissions Monitoring Program shall include, but not be limited to: i) Annual estimation of emissions from the facility, apportioned by major sources, using the same methodology as that used in February 2002 Environmental Assessment Report. Emissions include at a minimum: ii) Annual summary of fuel use, apportioned by major sources, and confirmation of use of low sulphur (0.05% or less) diesel fuel. iii) A fugitive dust abatement program to minimize the generation of non-point source particulate (e.g., from roads, waste rock piles, quarries, etc). iv) Documentation of mitigation measures and pollution prevention strategies (e.g., best management /environmental plans, energy conservation strategies, best available control technology) used to ensure emissions are minimized. v) Contingency or response plans to increasing trends or exceedences of emission estimates used in the Environmental Assessment Report.	Section 2.4 Section 2.5 Section 2.7 Section 4.0 Section 3.0	Total Suspended Particulate, Pm10 and Pm2.5 Monitoring Dustfall Monitoring Quality Assurance/Quality Control Procedures Response Planning Air Emissions Monitoring Program
7.4	a) DBCMI shall deliver monitoring data and information to the Parties and the Monitoring Agency in time-frames and in formats developed in consultation with the Monitoring Agency. b) With respect to data and information pertaining to wildlife matters within the jurisdiction of the GNWT, the time-frames and format for reporting shall be developed in consultation with the GNWT. c) The formats for submission of monitoring program results and analysis shall not be inconsistent with reporting requirements established under legislation, regulations, and Regulatory Instruments and the requirements of such legislation, regulations, and Regulatory Instruments shall apply to the extent of any inconsistency. d) Reporting dates will be established to conform with the requirements of the appropriate Regulatory Instruments. e) DBCMI shall carry out the monitoring in a manner which will provide data consistent with any cumulative effects monitoring programs undertaken or authorized by GNWT and Canada.	Section 5	Annual Report
10.1	a) DBCMI shall prepare and submit an Annual Report to the Parties and the Monitoring Agency, for each calendar year for the term of this Agreement.	Section 5	Annual Report

Table I-2 Concordance Table Showing Air Monitoring Requirements Outlined in the Water Licence and the Section Where Commitments are Addressed in the Air Quality and Emissions Management Plan

Water License Subsection and Requirement	AQEMP Section	AQEMP Heading
Part B		
5. a) ix.: monthly and annual estimates and measurements of precipitation and runoff	Monthly and annual estimates of precipitation will be documented in the Air Quality and Emissions Annual Report. See Section 2.3 and Section 5 of the AQEMP	Hydro-Meteorological Monitoring Annual Report
Surveillance Network Program Part D		
1. The Licencee shall measure and record the following meteorological data:		
a) precipitation, measured and recorded in hourly and daily totals;	Further to discussion with Bob Reid in June/04 – Rainfall, not total precipitation, will be measured as input to evaporation calculations. The data are presented in Section 2.3.	Hydro-meteorological Monitoring
b) evaporation, as calculated from the parameters listed below with hourly and daily averages: - wind speed at approximately 2.0 meters above the water surface, including daily minima and maxima; - wind direction on an hourly basis; - Air temperature at approximately 0.75 and 2.0 metres above the water surface, including daily minima and maxima; - Relative humidity at approximately 075 and 2.0 metres above the water surface; - Water temperature at one (1) and two (2) meters depths below surface; - Net solar radiation over the water surface; and - Water level.	Section 2.3	Hydro-meteorological Monitoring
c) The weather data for evaporation calculations shall be measured and recorded at a site on Snap Lake near mine operations and away from any man made structures;	Section 2.3	Hydro-meteorological Monitoring
2. The Licensee shall submit to the Board for approval, the location, methods and frequency for measuring and recording meteorological data identified in Section D, item 1	Section 2.3	Hydro-meteorological Monitoring