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REPORT ON

DE BEERS SNAP LAKE MINE

AIR QUALITY, METEOROLOGICAL MONITORING AND EMISSIONS REPORTING

2007 ANNUAL REPORT

Submitted to:

De Beers Canada Inc.
Yellowknife, Northwest Territories

December 2008 **08-1349-0003/5530**

EXECUTIVE SUMMARY

The Snap Lake Mine, (Mine), is a diamond mine owned and operated by De Beers Canada Inc. (De Beers). The mine is located approximately 220 kilometres (km) northeast of Yellowknife, 30 km south of MacKay Lake and 100 km south of Lac de Gras. Final regulatory approvals for construction and operation of the Mine were granted in May 2004, and construction began in April 2005. Mining began in 2007 and will continue for 22 years.

Why do we conduct air quality and meteorological monitoring at Snap Lake?

The principal objective of the Air Quality, Meteorological Monitoring and Emissions Reporting Annual Summary is to comply with the Surveillance Network Program (SNP) Section D of the Water License (MV2001L2-0002), Article VI Sections 6.3 items d) and e) and Article VI Section 7.2 part a) of the Environmental Agreement, and related corporate commitments including the Snap Lake Environmental Management System (EMS).

This report provides the results of the air quality and meteorological monitoring programs that were active at Snap Lake during 2007. This document fulfills the annual reporting requirements outlined in the Air Quality and Emissions Management and Monitoring Plan (AQEMMP) (De Beers 2008). Changes to the original Plan (De Beers 2005) were made in 2007 and 2008 to align with design recommendations from Environment Canada and the Government of the Northwest Territories (GNWT) Ministry of Environment and Natural Resources (GNWT and Environment Canada 2006).

What did we monitor in 2007?

In 2007, the monitoring program included the following components:

- Meteorological monitoring – Hourly measurements of wind speed, wind direction, solar radiation, temperature, relative humidity, and rainfall were collected from instruments mounted on a 10 metre (m) tower;
- Particulate monitoring – 24-hour average values of total suspended particulate (TSP) every six days;
- Dustfall monitoring – normalized monthly values of total and fixed dustfall were calculated at five monitoring stations near the Mine; and
- Passive gas monitoring – passive gas sampling began in November and continued through December; sampling was conducted for nitrogen dioxide (NO_2) and sulphur dioxide (SO_2).

What were the results of the 2007 meteorological and air quality monitoring program?

- Meteorological monitoring – Wind speed, wind direction, and relative humidity fell within the long-term ranges for the area, while rainfall was slightly higher than the long-term normal average and temperatures indicated a warming pattern over the last four years.
- Particulate monitoring – The maximum monitored TSP concentration at was 333 micrograms per cubic metre (µg/m^3), observed at station HV004. The average concentration observed at these stations was 47 µg/m^3. There is a NWT 24-hour TSP standard of 120 µg/m^3 (GNWT 2002), which is equivalent to the Federal Maximum Acceptable 24-hour Air Quality Objective. There were seven occurrences above the NWT standard for TSP, which are not readily explained by any specific activity at the Mine. However, the stations that recorded these higher numbers are located in high traffic areas near the heart of the developed area of the site.
- Snap Lake Mine emissions – Fuel consumption was comprised of 17,991,181 litres (L) of diesel fuel. The site consumed 16,473,165 L of regular sulphur diesel (1200 parts per million [ppm]) and 1,419,512 L of low sulphur diesel (15 ppm). Compared to the 2006 emission rates, the emission rates of all compounds increased in 2007. The increase is coincident with a 9.7 percent (%) increase in diesel fuel consumption.

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ACRONYMS

AQEMMP	Air Quality and Emissions Management and Monitoring Plan
AQMP	Air Quality Monitoring Program
CCME	Canadian Council of Ministers of the Environment
CH_4	Methane
CI	Continuous Improvement
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
De Beers	De Beers Canada Inc.
DFIRG	Dioxins and Furans Incineration Canada-wide Standards Review Group
e.g.	for example
EAR	Environmental Assessment Report
EMP	Emissions Management Plan
EMS	Environmental Management System
ENR	Environment and Natural Resources
GHG	Greenhouse Gas
GNWT	Government of Northwest Territories
Golder	Golder Associates Ltd.
Hi-Vol	High Volume Air Sampling
HV	Hi-Vol Station
i.e.	that is
KCAC	Keeping Clean Air Clean
LSD	Low Sulphur Diesel
Mine	Snap Lake Mine
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
NWT	Northwest Territories
PCDD	Polychlorinated Dibenzo-p-dioxins
PCDF	Polychlorinated Dibenzofurans
PM	Particulate matter
PM_{10}	Particulate matter nominally less than or equal to 10 microns (µm) aerodynamic diameter

$PM_{2.5}$	Particulate matter nominally less than or equal to 2.5 µm aerodynamic diameter
QA/QC	Quality Assurance/ Quality Control
RSD	Regular Sulphur Diesel
SLEMA	Snap Lake Environmental Monitoring Agency
SNP	Surveillance Network Program
SO_2	Sulphur Dioxide
TSP	Total Suspended Particulate
US EPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator geographic coordinate system

UNITS

%	percent
°C	degrees Celsius
$\mu g/m^3$	micrograms per cubic metre
µm	micrometres
km	kilometres
km/hr	kilometres per hour
kph	kilometres per hour
Kt	kilotonnes
L	litres
L/yr	litres per year
lb/cycle/unit	pounds per cycle per unit
lb/cycle	pounds per cycle
m	metres
mm	millimetres
ppm	parts per million
t/d	tonnes per day
W/m^2	watts per square metre
pg I-TEQ/Rm^3	picograms per international toxicity equivalents per reference cubic metre

1 INTRODUCTION

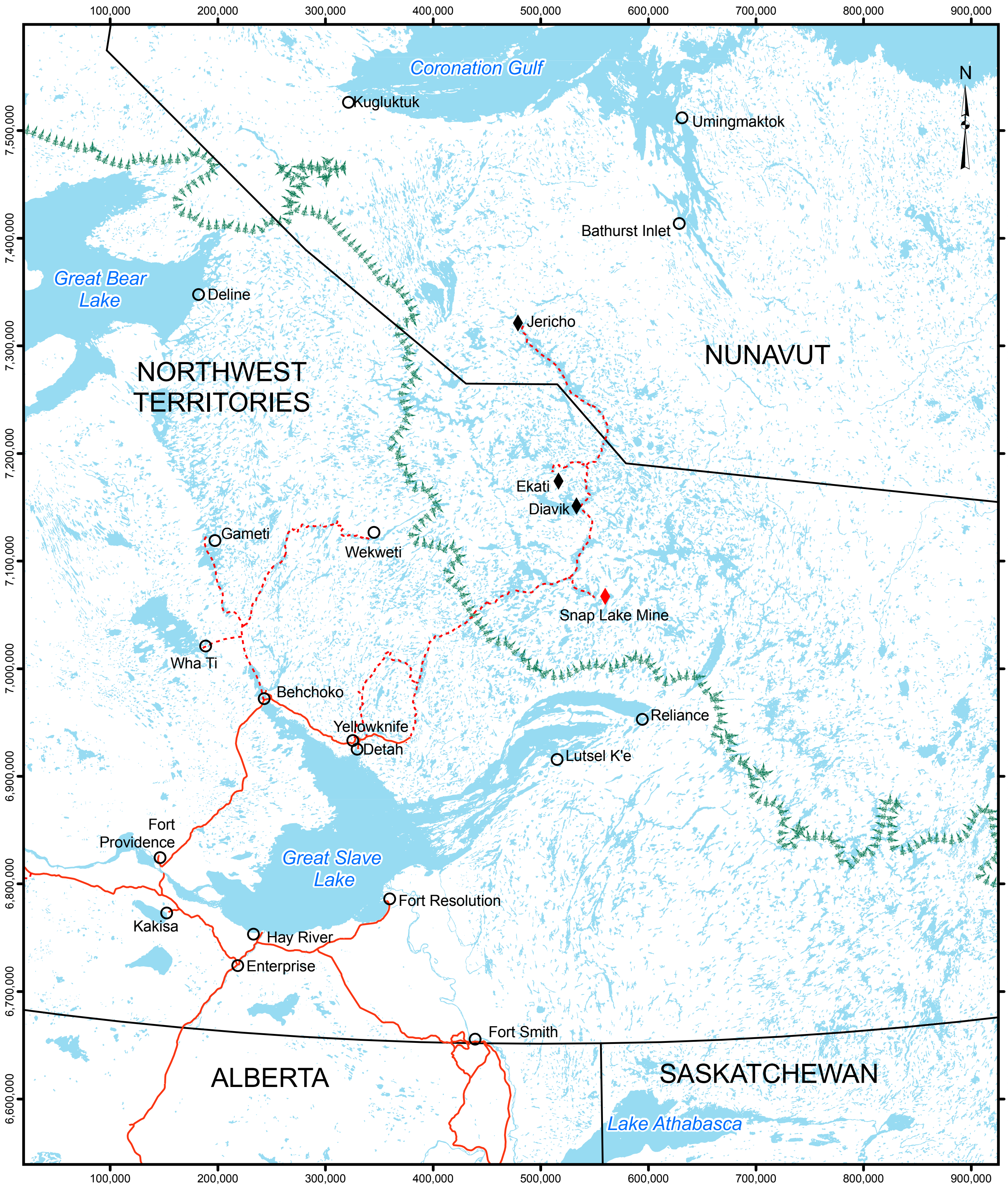
1.1 BACKGROUND

De Beers Canada Inc. (De Beers) owns and operates the Snap Lake Mine (Mine) in the Northwest Territories (NWT). The Mine is located approximately 220 kilometres (km) northeast of Yellowknife, 30 km south of MacKay Lake, and 100 km south of Lac de Gras where the Diavik Diamond Mine and the Ekati Diamond Mine are located (Figure 1-1). Final regulatory approvals for construction and operation of the Mine were granted in May 2004, and construction began in April 2005. Operation of the Mine began in 2007 and will continue for 22 years.

The Mine includes the development of underground workings, a kimberlite storage facility (the North Pile), mine facilities and accommodations, an airstrip, water treatment facilities, fuel and ammonium nitrate storage facilities and a winter access road spur off the Tibbitt-Contwoyto winter road that is built each winter.

De Beers has conducted ambient air quality and meteorological monitoring at the Mine since 1998 when the Advanced Exploration Program began. The programs reflect a commitment by De Beers to identify and mitigate impacts during planning, construction and operation of the Mine (De Beers 2002a). Golder Associates Ltd. (Golder) has assisted De Beers with their air quality and meteorological monitoring needs since 2000.

This report provides the results of the air quality and meteorological monitoring programs that were active at Snap Lake during 2007. It fulfills the annual reporting requirements outlined in the Air Quality and Emissions Management and Monitoring Plan (AQEMMP) (De Beers 2008). Changes to the original Plan (De Beers 2005) were made in 2007 and 2008 to become aligned with design recommendations from the Government of the Northwest Territories (GNWT) Ministry of Environment and Natural Resources (ENR) and Environment Canada (GNWT and Environment Canada 2006).



LEGEND

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

REFERENCE

Projection: UTM Zone 12 Datum: NAD 83

100 50 0 100

SCALE 1:5,000,000 KILOMETRES

PROJECT

DE BEERS CANADA SNAP LAKE MINE

TITLE

LOCATION OF THE SNAP LAKE MINE

Golder Associates
Yellowknife, Northwest Territories

PROJECT	08.1349.0003.5100		SCALE AS SHOWN	REV. 0
DESIGN	LC	18 Feb. 2008		
GIS	LC	23 May 2008		
CHECK	GH	21 May 2008		
REVIEW	SH	21 May 2008		

FIGURE: 1-1

Project: N:\Active\GIS\2007\07-1328-0012 De Beers Snap Lake\mxd\Figure 1-1 Location of Snap Lake_feb2008.mxd

1.2 LEGISLATION, REGULATORY AND POLICY REQUIREMENTS

An Environmental Assessment Report (EAR) for the 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 Mine proceed subject to the implementation of measures to mitigate environmental impacts (MVEIRB 2003). MVEIRB's report and recommendation were submitted to the Minister of Indian and Northern Affairs Canada in July 2003 and received ministerial approval in October 2003. De Beers received the necessary Water License (MV2001L2-0002), 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:

- develop an Air Quality Monitoring Program (AQMP), as outlined in Article VII, Section 7.2 item a) of the Environmental Agreement;
- develop 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; and
- meet the meteorological monitoring requirements specified in the General Conditions (Part B) and the Surveillance Network Program (SNP) section of the Water License (MV2001L2-0002).

1.3 SCOPE

An initial draft of the AQMP was prepared in September 2003 and updated in September 2005 based on feedback from the GNWT and Environment Canada. A draft of the EMP was submitted to the Snap Lake Environmental Monitoring Agency (SLEMA), GNWT and Environment Canada in February 2006. Upon receipt of feedback on this draft (GNWT and Environment Canada 2006), the AQMP and EMP were harmonized into one document, the AQEMMP 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 AQEMMP was submitted for review in October 2007.

De Beers, Environment and Natural Resources (ENR), and Golder met on March 6, 2008 to discuss the harmonized AQEMMP and comments made by ENR in February 2008. Subsequently, the AQEMMP has been finalized (De Beers 2008) to reflect the comments made by ENR in the February 2008 letter and during the

March 2008 meeting, as well as comments made by the SLEMA in a letter submitted to De Beers in January 2008 (SLEMA 2008).

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. The AQEMMP is a "living" document that may need to be adapted as the Mine itself evolves, consistent with the Mine's Adaptive Management Plan (De Beers 2004).

An important component of the AQEMMP is the requirement for a comparison of annual monitoring data to emission estimates and dispersion modelling predictions presented in the EAR (De Beers, 2002a). 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 also referred to as the basis for comparing with monitoring data.

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 emissions;
- provide information required for the 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 2007);
- 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
- facilitate data gathering necessary to develop an approach for emissions mitigation, which includes the fugitive dust abatement program.

To achieve these objectives, Sections 2 and 3 of the report concentrate on the following three main components:

- on-site meteorological monitoring;
- 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 ($PM_{2.5}$); and
- passive monitoring of sulphur dioxide (SO_2) and nitrogen dioxide (NO_2).

Section 4 focuses on the following three main components:

- emissions estimates;
- fuel use summary; and
- emissions mitigation strategies, including the fugitive dust abatement program.

1.5 METHODOLOGY AND APPROACH

De Beers has conducted ambient air quality and meteorological monitoring at the Mine site since 1998 when the Advanced Exploration Program began. De Beers understands the need for adaptive management of the monitoring programs and acknowledges that the monitoring sites may change as the Mine 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 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 Mine site indicating the active mine area and current air monitoring locations is provided in Section 2 (Figure 2-1).

The focus of the AQEMMP is on off-site monitoring for consistency with the applicable ambient air quality standards, which are based on off-site concentrations measured at or beyond 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. The effectiveness of the AQEMMP is dependent, in part, on selecting appropriate criteria against which Mine emissions and the resulting ambient air concentrations should be compared. Currently no provision for air quality is included in permits for mines in the NWT, and there is no requirement to monitor for compliance within permit limits. In lieu of air quality permit requirements, the Mine will be required to comply with the relevant NWT ambient air quality standards for TSP, $PM_{2.5}$ (24-hour and annual) and SO_2 (1-hour, 24-hour and annual) (GNWT 2002), as well as the National Ambient Air Quality Objectives (NAAQO) for NO_2 (1-hour, 24-hour and annual "Acceptable") (Environment Canada 1981). Table 1-1 presents the relevant air quality criteria.

Table 1-1 Relevant Ambient Air Quality Criteria

Parameter	NWT Standards[a]	Canada-Wide Standards[b]	National 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	120	—	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]	—	80	—	—	—	65[h]
Annual[h]	—	30	—	—	—	15[h]

[a] Source: GNWT 2002.
[b] Source: Canadian Council of Ministers of the Environment (CCME) 2000a.
[c] Source: Environment Canada 1981.
[d] "—" = not applicable.
[e] As a geometric mean.
[f] Newfoundland, Ontario, Saskatchewan and BC have established a 24-hour PM_{10} guideline of 50 µg/m³ (Government of British Columbia 1995, Government of Newfoundland and Labrador 2004).
[g] United States Environmental Protection Agency (US EPA) primary PM_{10} standards are 150 µg/m³ for 24 hours and 60 µg/m³ annually (U.S. Government 1998).
[h] US EPA primary PM2.5 standards are 65 µg/m³ for 24 hours and 15 µg/m³ annually (U.S. Government 1998).

In addition to demonstrating that Mine 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" (KCAC), as described in the Canada-Wide Standards for Particulate Matter and Ozone (Environment Canada 2000). Therefore, the ambient air quality monitoring and trends in emissions is an important component of the AQEMMP, as discussed in Sections 2 to 4.

De Beers has incorporated a number of design features that demonstrate their commitment to KCAC and CI. These include, but are not limited to, the following:

- selection of highly-efficient combustion equipment;
- use of low-sulphur diesel;
- underground and wet primary ore crushing;
- conveyor-based, covered ore transport systems;
- short haul route to tailings facility;
- investigation of alternate energy sources to offset diesel combustion;
- modern incineration facilities and waste segregation policies;
- worker education;
- on-site recycling programs; and
- development of management plans to guide actions and documentation needs around air quality.

Implementation of these policies and practices demonstrates De Beers' ongoing commitment to reducing emissions through the use of the best available, economically feasible technology and systems.

2 METEOROLOGICAL MONITORING

2.1 OBJECTIVE

Meteorological data were measured at Snap Lake during 2007 to contribute to the maintenance of an accurate record of weather conditions at the site. The data may also be used to support future air quality dispersion modelling. Temperature, relative humidity, solar radiation and precipitation data may contribute to a regional data bank. Furthermore precipitation data will be used in hydrological studies.

As indicated in the 2006 annual report, De Beers installed a hydro-meteorological monitoring station to provide data specifically for the calculation of lake evaporation. This station is located just northeast of the construction camp and collects meteorological data from the lake-side including total precipitation (rain and snow). However, throughout 2007 the sensor periodically malfunctioned, and as a result, there was not enough valid data to present in the 2007 report. To correct the problem the sensor was re-calibrated at the factory and re-installed in March 2008. Preliminary 2008 data from this sensor are promising and the total precipitation data (snow, fog, and rainfall) from this station will be incorporated into future air quality annual reports.

2.2 MONITORING STATION LOCATION

The meteorological station is located on an elevated point of land immediately west of the water management pond (Universal Transverse Mercator [UTM] 506 052E, 7 052 492N NAD83 Zone 12) (Figure 2-1). Rainfall, temperature, wind, relative humidity, and solar radiation data were collected at Snap Lake in 2007. Data were collected from instruments mounted on a 10 metre (m) tower. Table 2-1 provides details of each of the sensors installed at Snap Lake to collect meteorological data. Summaries of monitoring results for each parameter are provided in this section. Figure 2-2 is a photograph of the station looking north.

Table 2-1 Meteorological Station Components

Parameter	Instrumentation
Temperature	Temperature sensor is housed in a radiation shield that is mounted on the tower at approximately 2 m above ground level
Air temperature -55 degrees Celsius [°C] to +50°C	Campbell Scientific YSI 44002A thermistor
Winds	Anemometer is located at 10 m above the ground (avoids some of the effects of surface friction and is consistent with many other sites in North America)
Wind speed in kilometres per hour [km/hr]	R.M. Young 05103 Wind Monitor (10 m)
Wind direction degrees [°]	R.M. Young 05103 Wind Monitor
Standard deviation of wind direction degrees	R.M. Young 05103 Wind Monitor (calculated internally in the datalogger using the Yamartino algorithm)
Solar Radiation	Device was mounted at 2.5 m on the meteorological station tower
Incoming solar radiation in watts per square metre [W/m²]	Licor LI 200S Silicon Pyranometer
Precipitation	Device was mounted at 2.5 m on the meteorological station tower
Rainfall in millimetres [mm]	Texas Electronics: TE525 WS Tipping Bucket Rain Gauge
Relative Humidity	Relative humidity sensor was housed in a radiation shield that was mounted at approximately 2 m above the ground at the meteorological station
Relative humidity in percent [%]	Vaisala capacitive relative humidity sensor
Data Storage and Retrieval	
Datalogger	Campbell Scientific CR10X (Cold Spec)
Power supply	Solar panel and battery back-up
Instrument mounting	10 m tower

LEGEND

- PASSIVE AIR QUALITY MONITORING STATION
- PARTISOL MONITORING STATION
- METEOROLOGICAL MONITORING STATION
- MINE AIR HEATER
- POWER GENERATOR
- TURBINE
- SNAP LAKE MINE 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. DIGITAL IMAGERY OBTAINED FROM DIGITAL GLOBE (QUICK BIRD, AUGUST 2006), USED UNDER LICENCE. ORIGINAL DATA WAS CORRECTED TO LANDSAT7 SATELLITE IMAGE 45/15 FROM SEPT 2, 2000 PROVIDED BY GEOBASE.

500 0 500
SCALE METRES

PROJECT
DE BEERS CANADA
SNAP LAKE MINE

TITLE

AIR QUALITY AND METEOROLOGICAL MONITORING STATIONS

Golder Associates
Calgary, Alberta

PROJECT	08.1349.0003.5120		FILE No. 2006 Air Monitoring	
DESIGN	GH	21/05/08	SCALE AS SHOWN	REV. 0
CADD	YAW	21/05/08	FIGURE: 2-1	
CHECK	GH	21/05/08		
REVIEW	SH	21/05/08		

Figure 2-2 Snap Lake Meteorological Monitoring Station

2.3 MONITORING METHODS

Meteorological monitoring is being conducted at the site using Campbell Scientific meteorological monitoring equipment. Sensors are mounted on a 10 m 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.

2.3.1 Monitoring Frequency

Meteorological monitoring was conducted year-round throughout 2007. Meteorological data were measured continuously and recorded hourly. The data were downloaded approximately bi-weekly by De Beers' site staff.

2.3.2 Monitoring Parameters

The tower system continuously measures the following meteorological parameters:

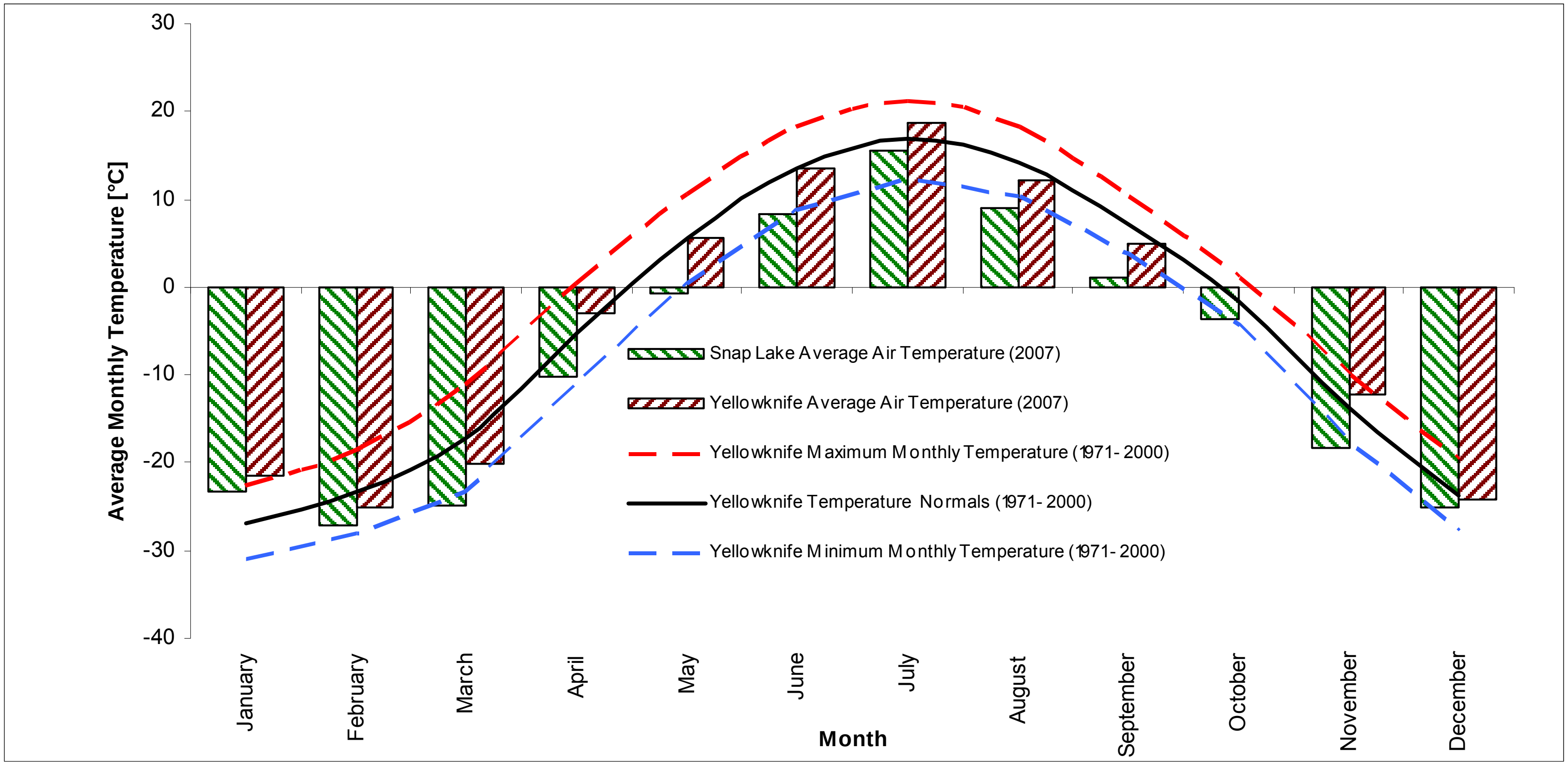
- wind speed at 10 m above the ground;
- wind direction at 10 m above the ground;
- temperature at 2 m above the ground;
- relative humidity at 2 m above the ground;
- solar radiation at 2.5 m above the ground; and
- rainfall at 2 m above the ground.

2.4 TEMPERATURE

2.4.1 Results

Hourly temperature values were measured for the entire year, and the data recovery rate was 100.0 percent (%). A summary of temperature data at Snap Lake is presented in Figure 2-3. Monthly mean temperatures ranged from -27.2 degrees Celsius (°C) in February to +15.4 °C in July. The annual average temperature at Snap Lake in 2007 was -8.3 °C , which was 0.4 °C warmer than 2002 (-8.7 °C), 1.0 °C cooler than in 2003 (-7.3 °C), 2.0 °C warmer than in 2004 (-10.3 °C), 0.5 °C cooler than in 2005 (7.8 °C), and 3.2 °C cooler than in 2006 (-5.1 °C). The 1971 to 2000 long-term data for Yellowknife are also provided for comparison.

Figure 2-3 Snap Lake Temperature Summary, 2007



ºC= degrees Celsius.

2.4.2 Discussion

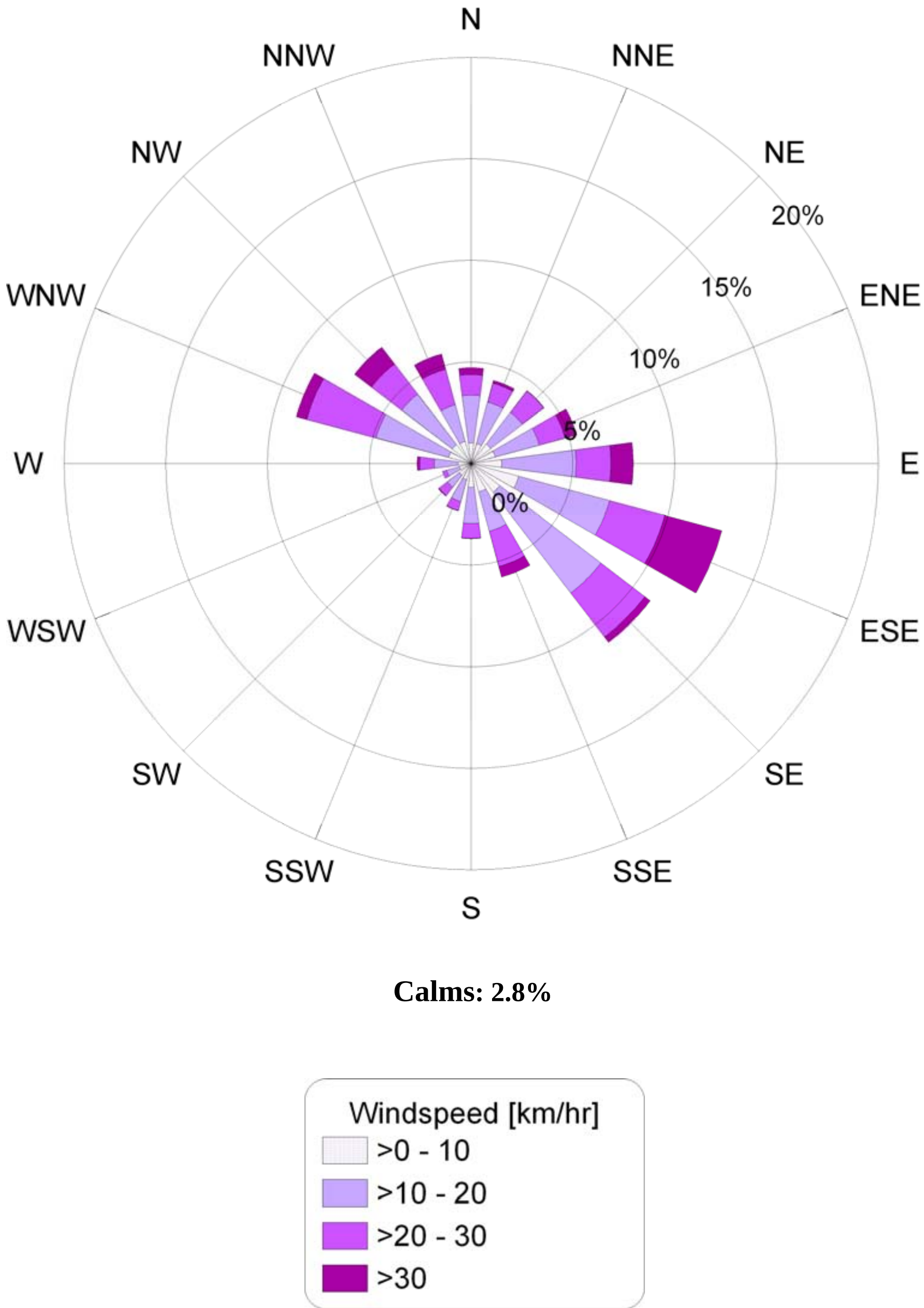
The average annual temperature of -8.3 °C in 2007 for Snap Lake was 5.3 °C cooler than the annual temperature of -4.6 °C for Yellowknife during 1971 to 2000. The long-term average from Yellowknife shows slightly warmer than average temperatures in 2007. For example, Yellowknife was 0.3 °C warmer in 2007 (-4.3 °C) than the long-term average (1971 to 2000) average (-4.6 °C).

2.5 WIND SPEED AND WIND DIRECTION

2.5.1 Results

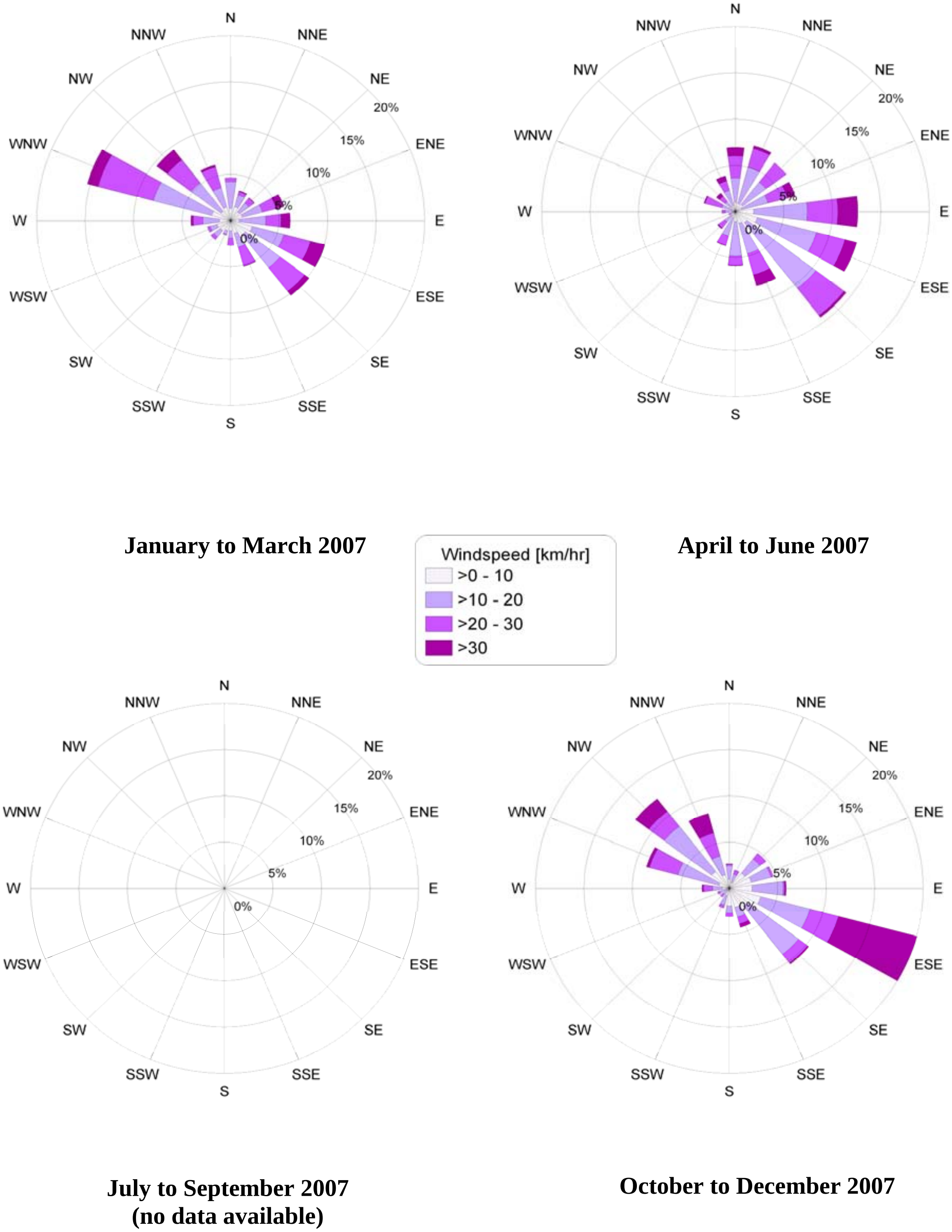
Data recovery for 2007 was 58.0 %. The 42.0 % loss was a result of the wind sensor malfunction. Figure 2-4 presents a windrose showing frequencies of wind direction and wind speed for 2007. Figure 2-5 shows a series of windroses representing the four quarterly records of wind at Snap Lake. The quarterly figure shows January through March, April through June, July through September, and October through December 2007 data in separate windroses. The January through March and October through December quarters nominally represent typical fall and winter conditions and the April through June and July through September quarters represent typical spring and summer conditions in the north. The January to March windrose shows that winds predominantly originated from the west-northwest and were also relatively frequent from the southeast quadrant. During April to June, the winds were predominantly from the southeast quadrant. There was no data available for the July to September period, due to a failed wind sensor. Therefore, the third quarterly windrose is blank. For October to December, the winds predominantly originated from the east-northeast.

Figure 2-4 Snap Lake Annual Wind Speed and Wind Direction Summary, 2007



km/hr = kilometres per hour

Figure 2-5 Quarterly Snap Lake Wind Speed and Wind Direction Summary, 2007



km/hr = kilometres per hour

2.5.2 Discussion

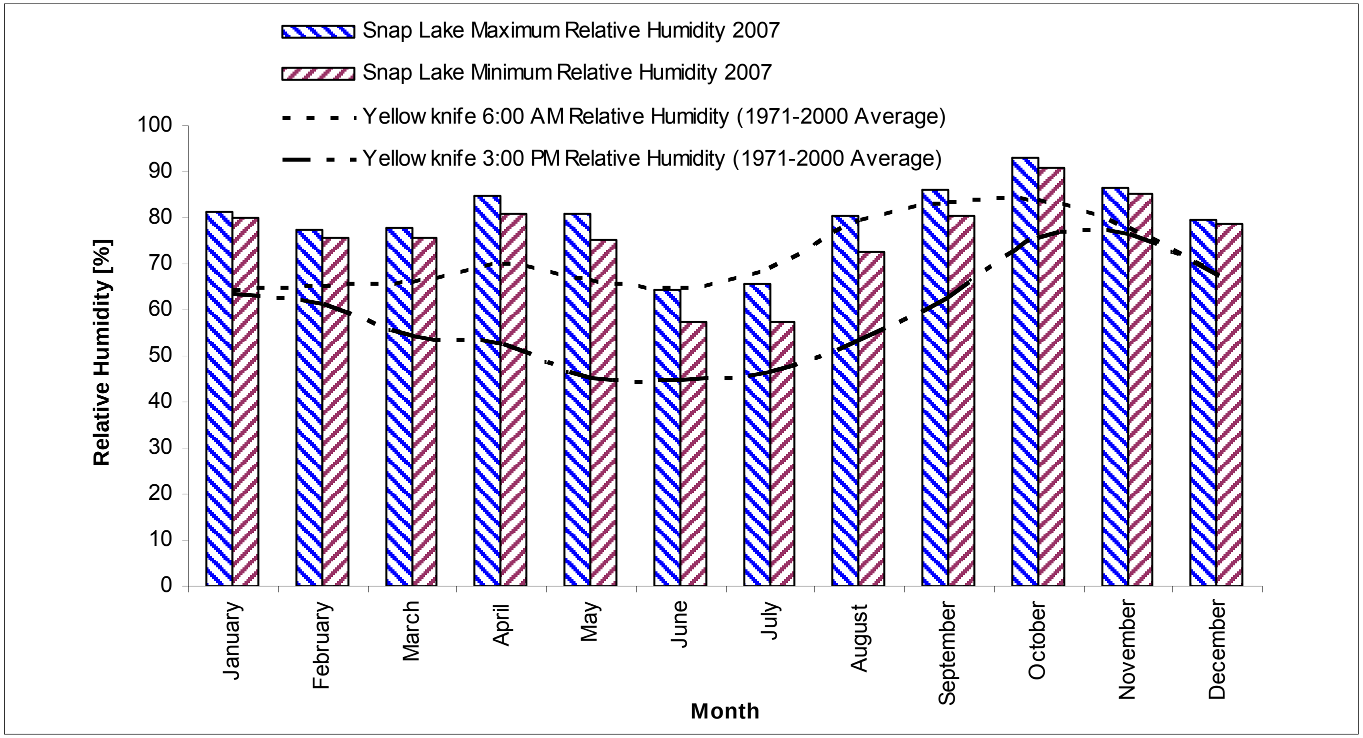
The annual windrose shows a similar pattern to previous years' monitoring with frequent winds from the east-southeast. The quarterly windroses illustrate a more diverse range in wind direction throughout the year, but as in previous years, winds are dominantly from the east and southeast for much of the year and the winter period sees winds frequently from the northwest. This can be attributed to the different seasonal weather patterns that occur because annual wind predominance is influenced by the pattern of large scale weather systems that move through the region.

2.6 RELATIVE HUMIDITY

2.6.1 Results

Relative humidity values were measured for the entire year, and the data recovery rate was 100.0%. Average monthly relative humidity values ranged from 60.8% in June to 91.9% in October. Figure 2-6 presents the mean monthly relative humidity at Snap Lake. Long-term (1971 to 2000) data for Yellowknife are also provided for comparison.

Figure 2-6 Snap Lake Relative Humidity Summary, 2007



2.6.2 Discussion

Relative humidity is a measure of the amount of water vapour present in the air at a given temperature and pressure relative to the maximum amount of vapour that could be present at the same temperature and pressure. If the amount of vapour remains constant and the temperature rises, relative humidity will fall.

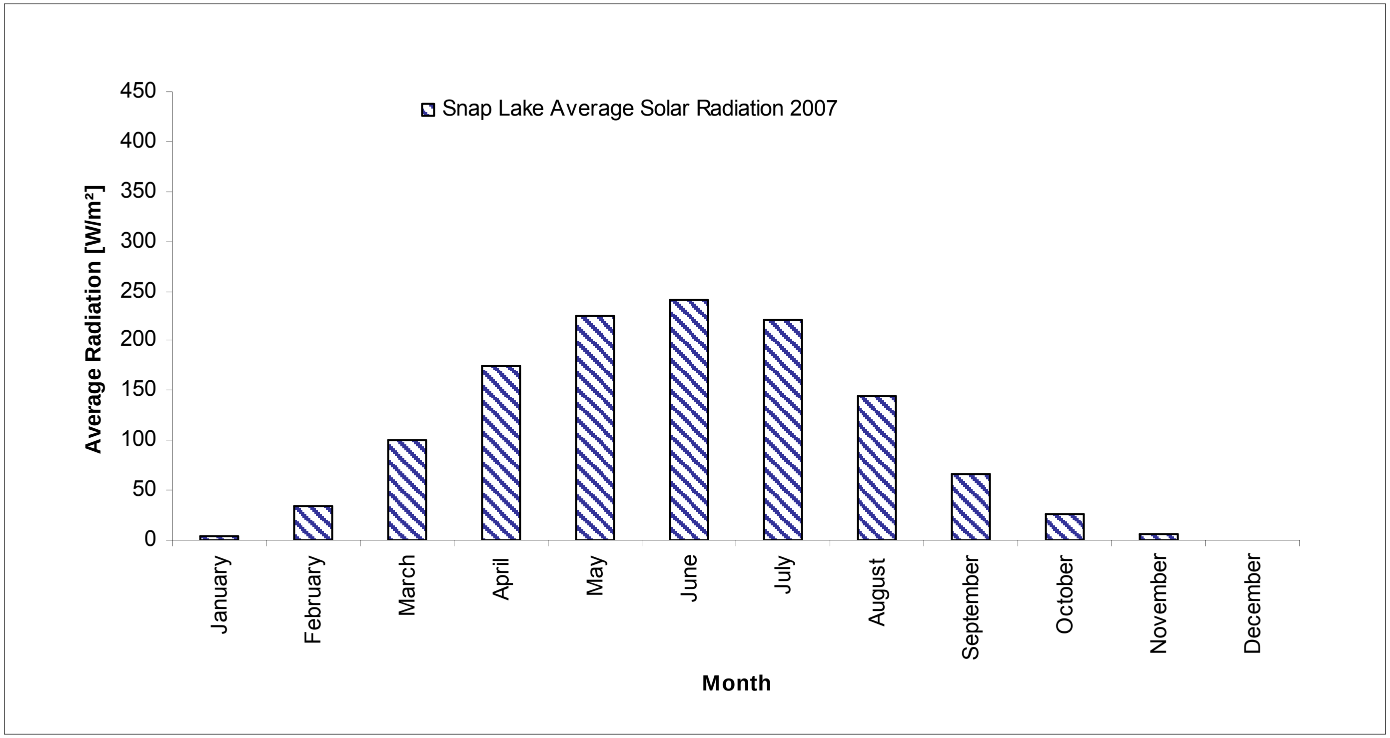
Long-term averages are provided for 6:00am and 3:00pm measurements. Morning humidity readings are typically higher than afternoon readings due to cooler temperatures. The relative humidity data show a pattern and range consistent with that of the Yellowknife data. That the relative humidity data are consistently slightly higher on average at Snap Lake than in Yellowknife could be attributed to overall slightly lower ambient temperatures.

2.7 SOLAR RADIATION

2.7.1 Results

The data recovery rate for 2007 was 100.0%. Figure 2-7 presents the monthly solar radiation summary. Values ranged from an average of 0.8 watt per square metre (W/m^2) in December to an average of 240 W/m^2 in June.

Figure 2-7 Snap Lake Solar Radiation Summary, 2007



W/m^2 = watts per square metre

2.7.2 Discussion

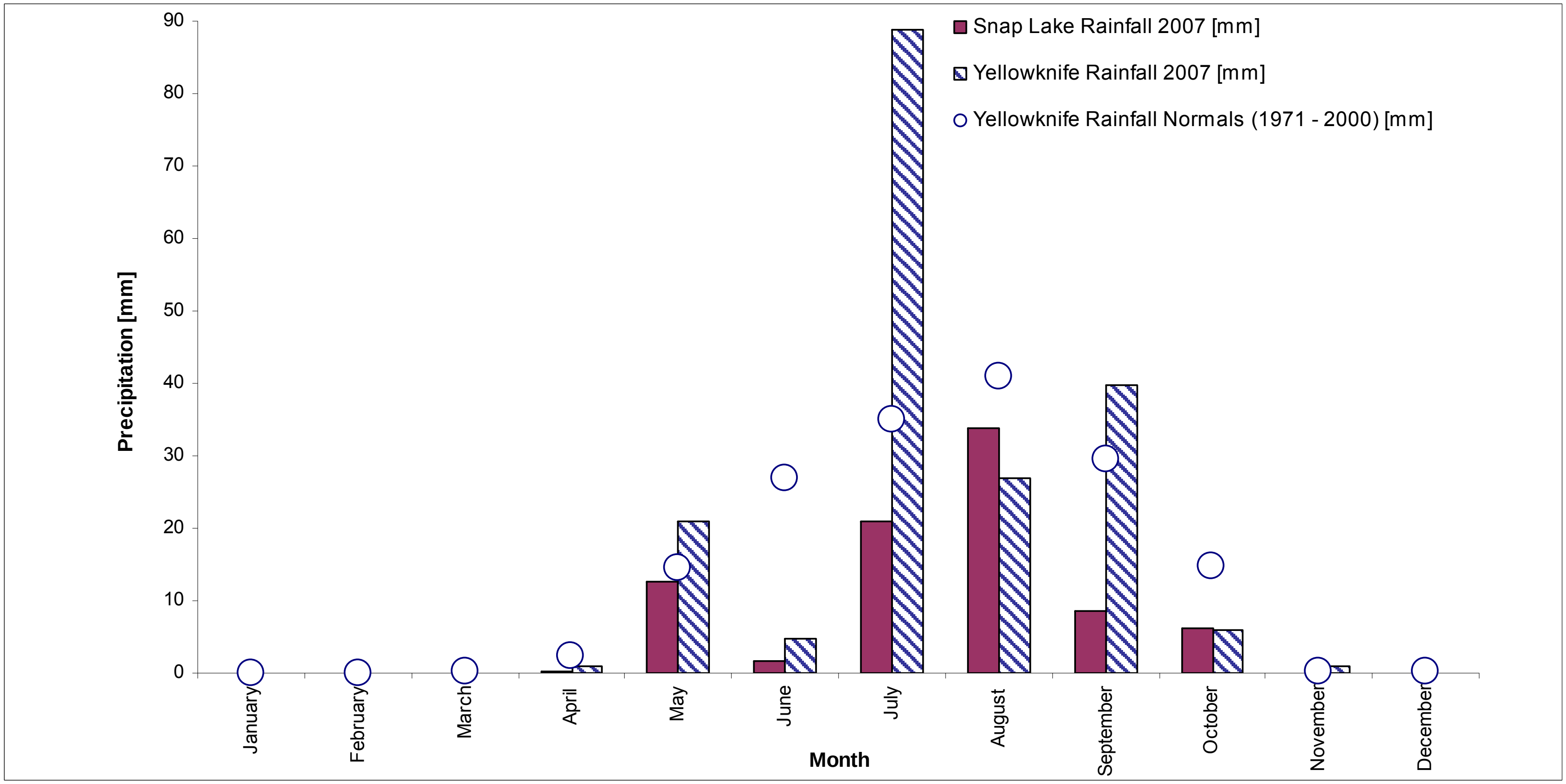
Solar radiation levels measured at the surface are a function of hours of sunlight and sun azimuth angle, as well as a function of local weather conditions including relative humidity, cloud cover, cloud type, and cloud depth. Changes in the weather variables may cause the annual peak to fluctuate from year to year. The peak occurred in May for both 2004 and 2005, but in June for both 2006 and 2007.

2.8 PRECIPITATION

2.8.1 Results

In general, rainfall is collected between April and October when temperatures exceed 0 ºC. The rainfall sensor was operational throughout the year. Rainfall rates ranged from 0 mm through the winter months to 34 mm in August. Figure 2-8 provides a comparative summary of the monthly rainfall readings in millimetres (mm) for Snap Lake in 2007 versus the monthly rainfall for Yellowknife in 2007 and from 1971 to 2000.

Figure 2-8 Snap Lake Rainfall Summary, 2007



mm = millimetres.

2.8.2 Discussion

Total annual rainfall at Snap Lake was 84.0 mm which is 56% lower than the Yellowknife total for 2007 (189.2 mm) and 49% lower than the Yellowknife long-term (1971 to 2000) annual rainfall average of 164.5 mm. The monthly rainfall totals from May through to September at Snap Lake were 104 mm lower than those for Yellowknife in 2007, while the month of October were almost equal. The monthly rainfall at Yellowknife were above the corresponding 1971 to 2000 monthly rainfall averages for the months of May, July and August and below for the months of April, June and August, while the monthly rainfall at Snap Lake did not exceed the 1971 to 2000 monthly average for Yellowknife (Figure 2-8). The rainfall measured at Snap Lake in 2007 was substantially lower than observed in 2006 and 2005. The recorded totals for those years were 172.7 and 150.6 mm respectively

3 AIR QUALITY MONITORING

3.1 INTRODUCTION

As indicated by the Government of Northwest Territories (GNWT) and Environment Canada (GNWT and Environment Canada 2006), one of the purposes of the Air Quality and Emissions Management and Monitoring Plan (AQEMMP) 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 total suspended particulate (TSP) and particulate matter less than 10 and 2.5 microns diameter, respectively (PM_{10} and $PM_{2.5}$) will be summarized as part of the annual report. Where applicable, the trend analysis that guides response planning will incorporate shorter than annual monitoring periods. Where the monitoring that is conducted at Snap Lake permits direct comparison. For example, there are 24-hour criteria for $PM_{2.5,}$ PM_{10} and TSP, against which the 24-hour monitoring data collected at Snap Lake can be compared. To evaluate the magnitude and trends in concentrations, a series of pre-determined action levels will also be presented on the figure that presents the data observed over the course of the year. 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 Mine is provided below.

A systematic approach was taken to develop action levels for each compound based on the Air Modelling Update (De Beers 2007) predictions, the applicable ambient air quality criteria and a percent change (year to year) in measured concentrations. The action levels for sulphur dioxide (SO_2), TSP, PM_{10}, and $PM_{2.5}$ are as follows:

- Action Level I – annual concentrations below the maximum Air Modelling Update prediction or less than ±10 % year to year change;
- Action Level II – concentrations above the applicable short-term ambient air quality criteria; (e.g., 24-hour particulates) or above the maximum annual concentrations predicted in the Air Modelling Update but below 50% of the applicable ambient air quality criteria or from ±10% to ±20% year to year change; and
- Action Level III – annual concentrations above 50% of the applicable ambient air quality criteria or more than ±20% year to year change.

The above action levels are not applicable to nitrogen dioxide (NO_2), as 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 more 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.

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 3-1 indicates that criteria that will be used to trigger actions as defined above. 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 emissions to determine whether the elevated concentrations or trend is related to Mine 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.

Table 3-1 Criteria Used to Trigger Action Levels

Parameter	Criteria [μg/m³]	Source
Annual SO_2	30	NWT Ambient Air Quality Standard
Annual NO_2	100	National Ambient Air Quality Objective
24-Hour TSP	120	NWT Ambient Air Quality Standard
Annual TSP	60	NWT Ambient Air Quality Standard
24-Hour PM_{10}	50	objective in British Columbia, Saskatchewan, Ontario, and Newfoundland and Labrador
24-Hour $PM_{2.5}$	30	NWT Ambient Air Quality Standard

SO_2 = sulphur dioxide; NO_2 = nitrogen dioxide; TSP = total suspended particulate; PM_{10} = particulate matter less than 10 microns diameter; $PM_{2.5}$ = particulate matter less than 2.5 microns diameter; NWT = Northwest Territories

3.2 ESTABLISHING THE ACTION LEVEL BASIS

As an official ambient air quality response plan was not introduced in the 2006 annual report, 2007 represents the starting point and therefore basis from which future trends in SO_2, TSP, PM_{10}, and $PM_{2.5}$ concentrations will be compared. The three air quality components that were examined in 2007 include SO_2, NO_2 and TSP. The SO_2 and NO_2 passives monitoring program was initiated in November of 2007, and therefore the average annual data derived from these tests should not be viewed as statistically equivalent to a proper annual average value.

3.3 PASSIVE SO_2 AND NO_2 MONITORING

SO_2 and NO_2 emissions will be generated by the combustion of diesel fuel and the incineration of solid waste materials sources at the Mine. De Beers has agreed to monitor these compounds on a monthly basis using passive sampling technology.

3.3.1 Monitoring Station Locations

Passive monitoring is being undertaken at the Snap Lake Mine at seven separate locations. These sites include four off-site locations to demonstrate that ambient ground level concentrations are consistent with the criteria and three on-site locations used to inform decisions around occupational health and safety. The off-site locations are:

- at the east end and south of the airstrip, co-located with the partisol samplers;
- south of the emulsion plant, co-located with the partisol samplers in that location;
- at the west end of Snap Lake (distant reference site); and
- on the north shore of Snap Lake, adjacent to the Mine.

The onsite locations are:

- in the wetland immediately north of the worker accommodations complex;
- immediately north of the fire hall, just west of the three large fuel storage tanks; and
- along the south edge of the road leading to the emulsion plant, north of the airstrip.

3.3.2 Monitoring Methods

Passive monitoring is a system that has been established the over the past several years to generate ambient air quality data for these compounds and others. Sampling is conducted using “charged” cartridges containing material that is both reactive and selective to the target gases. After 30 days of exposure in a rain shelter, the samples are retrieved from the field and sent to the laboratory for analysis. Results are reported in parts per billion and can be nominally compared to the annual ambient air quality criteria for the respective compounds.

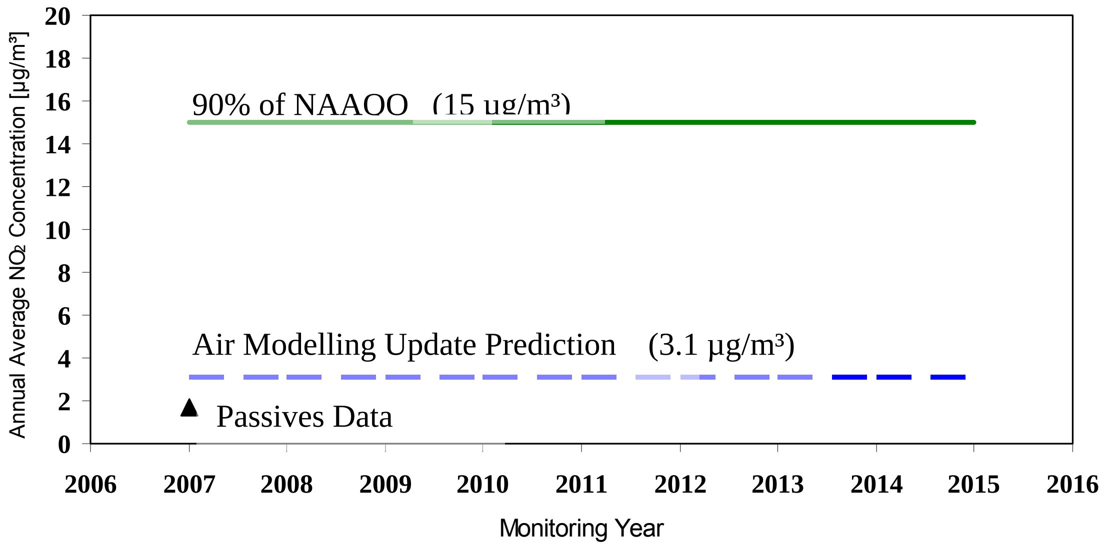
3.3.3 Monitoring Frequency

Sampling is conducted continuously, year-round with sample cartridges being sent to the laboratory for analysis and reporting every 30 days.

3.3.4 Data Analysis

Figure 3-1 compares the SO_2 passives data to the 50% National Ambient Air Quality Objective (NAAQO) and the Air Modelling Update Prediction (Levels II and I, respectively). Based upon the two months of passives data collected in 2007, Action Level I is applicable for SO_2 based upon the criteria defined in Section 3.1.

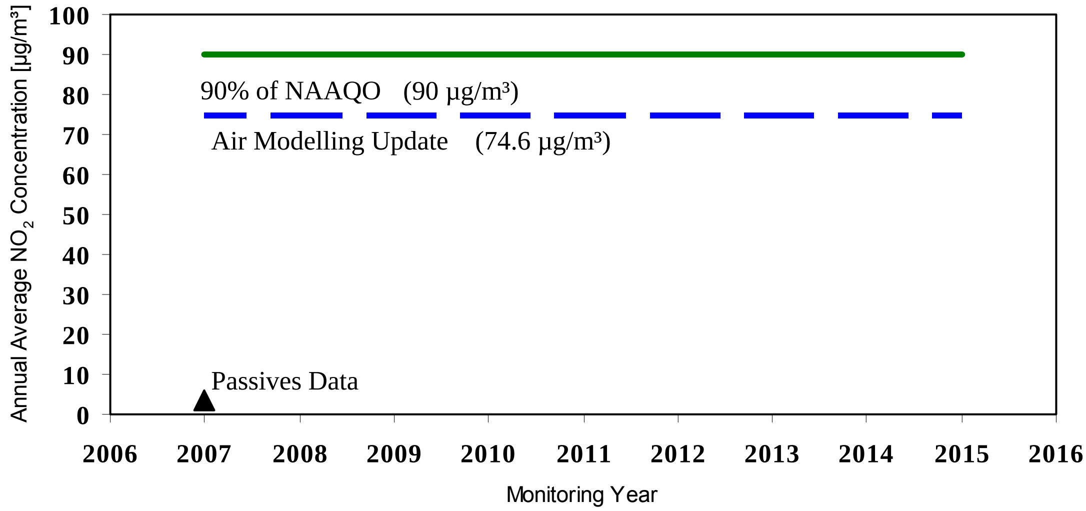
Figure 3-1 Action Levels for Annual Ambient SO_2 Concentrations



µg/m³ = micrograms per cubic metres; NO_2 = nitrogen dioxide; NAAQO = National Ambient Air Quality Objective.

Figure 3-2 compares the NO_2 passives data to the 90% National Ambient Air Quality Objective (NAAQO) and the Air Modelling Update Prediction, (Levels II and I, respectively). Based upon the two months of passives data collected in 2007, Action Level I is applicable for NO_2 based upon the criteria defined in Section 3.1.

Figure 3-2 Action Levels for Annual Ambient NO_2 Concentrations



$\mu g/m^3$ = micrograms per cubic metres; NO_2 = nitrogen dioxide; NAAQO = National Ambient Air Quality Objective.

3.4 TSP, PM_{10} AND $PM_{2.5}$ MONITORING

Suspended particulate matter (fine 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 the incineration of solid waste materials.

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 was carried out in 2007 to address the AQEMMP requirements outlined in Article VI, Section 6.3 (item e) (ii & iii) of the Environmental Agreement.

6.3 (e) DBCMI shall prepare and provide to the Parties and the Monitoring Agency an Air Quality and Emission Management annual report summarizing and analyzing the emissions and ambient monitoring information, including:

(ii) Comparisons of ambient air quality and deposition monitoring results to previous years, the predictions of the Environmental Assessment Report dispersion modeling and all applicable federal and territorial ambient air quality criteria, standards, objectives and guidelines;

(iii) Analysis of emissions and ambient air quality trends and effectiveness of strategies employed to minimized emissions.

It also fulfills the requirements ascribed to the AQEMMP in Article VI, Section 7.2 item (a) of the Environmental Agreement for the Mine:

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.

(iv) Contingency plans to respond to increasing trends or exceedences of air quality criteria/dispersion modelling predictions.

3.4.1 Monitoring Station Locations

The early 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. Demonstrate compliance with ambient air quality standards at these locations should extrapolate to compliance at off-site locales.

In response to Environment Canada and GNWT guidance regarding siting ambient monitoring stations off-site, the ambient particulate matter monitoring program was relocated in 2007 to new locations (Partisol stations 1 and 2), 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. Partisol station 3 is intended to provide additional information to De Beers about on-site particulate levels and provide input to occupational health and safety planning personnel.

Partisol station sites 1 and 2 are located off site, directly adjacent to the facility boundary. These locations were identified as areas of potentially higher off-site particulate concentrations from 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 Partisol sampler (Partisol), co-located with a PM_{10} and $PM_{2.5}$ dichotomous partisol sampler (Dichot Partisol). These locations are intended to be permanent stations and should not need to be moved in the future. Establishing permanent locations is an important part of producing consistent data suitable for comparison purposes.

3.4.2 Monitoring Methods

Partisols and Dichot Partisols 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, PM_{10} and $PM_{2.5}$ concentrations can be determined using the measured volume of air and the weight difference between the pre-weighed and exposed filter.

The TSP Partisols 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 the GNWT ambient air quality standards of 120 and 60 $\mu g/m^3$, respectively (GNWT 2002).

The Partisol sampling system has a number of operational advantages when compared to other particulate samplers. This type of monitoring is a United States Environmental Protection Agency (US 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).

The TSP, PM_{10} and $PM_{2.5}$ Partisols were not installed until early 2008, and therefore this data is not included in this report. Only high volume air sampling (Hi-Vol) TSP data was available during 2007; therefore, discussion will be limited to this technique throughout this report.

3.4.3 Monitoring Frequency

The monitoring of TSP was carried out according to the National Air Pollution Surveillance (NAPS) schedule. This schedule followed a monitoring cycle where a single 24-hour sample was collected every sixth day. This monitoring schedule has been followed at the Mine since April 2000 when the original Hi-Vol monitoring program was initiated.

Particulate sampling is being conducted year-round. Sampling during extreme winter conditions (-20 °C and colder with winds greater than 15 kilometres per hour [kph]), which typically occurs between the months of October and 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 climate-controlled shelters in the spring of 2008 to contain the Partisol sampling 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 Mine.

3.4.4 Data Analysis

The TSP data from the three monitoring locations was 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 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 3.1. Managing trends in ambient particulate concentrations on an annual basis is appropriate given the scale of the Mine 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.

3.4.5 TSP High Vol Monitoring Results

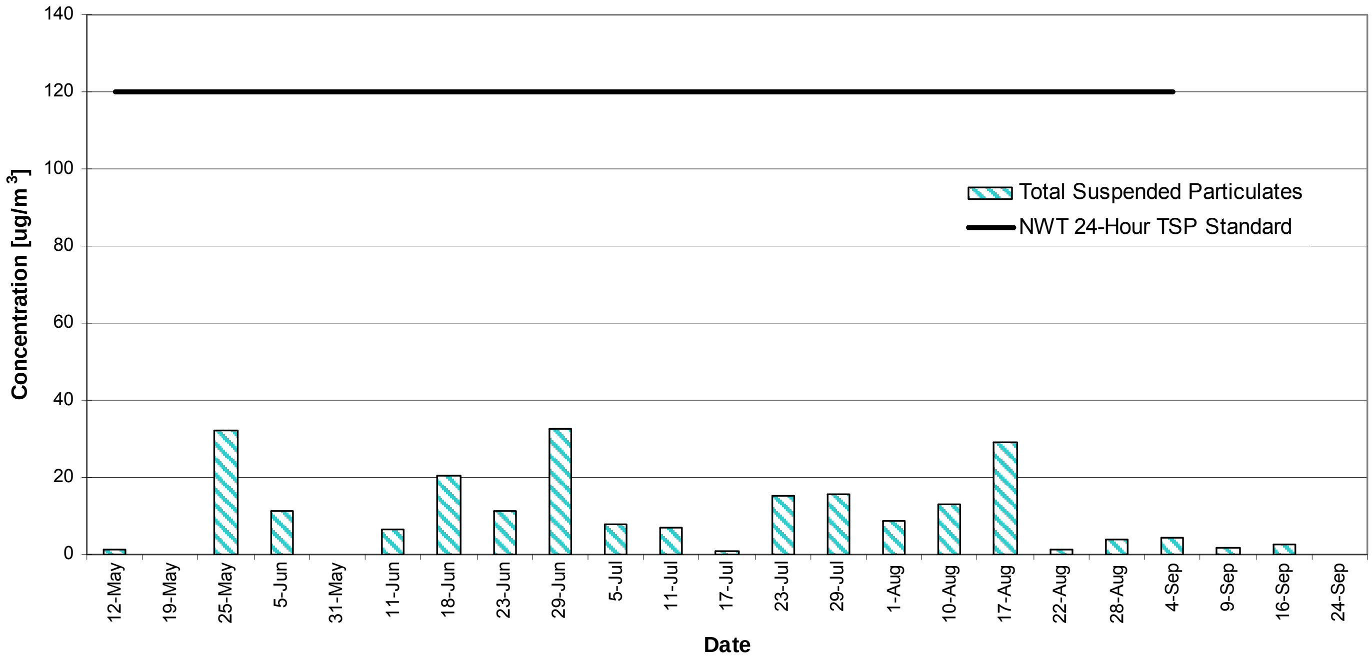
The data recovery rate for TSP in 2007 was 33.8%, with 61 of a possible 180 samples recorded. The bulk of the missed samples can be attributed to the Hi-Vol samplers not operating properly during periods of cold weather (less than -20 °C.)

The TSP monitoring results from each location are provided in Figures 3-3, 3-4, and 3-5. The maximum recorded TSP concentration was 333 µg/m³, which occurred at station Hi-Vol Station (HV)-004 on May 19, 2007. The average concentration over the monitoring period was 47 µg/m³. This is an increase of 62.1% from the 2006 results (29 µg/m³), and 147.4% from the 2004 average TSP results (19 µg/m³).

Figure 3-6 compares the TSP data to one half of the National Ambient Air Quality Objective (NAAQO) and the Air Modelling Update Prediction. Based upon TSP data collected in 2007, Action Level III is appropriate for TSP based upon the criteria defined in Section 3.1.

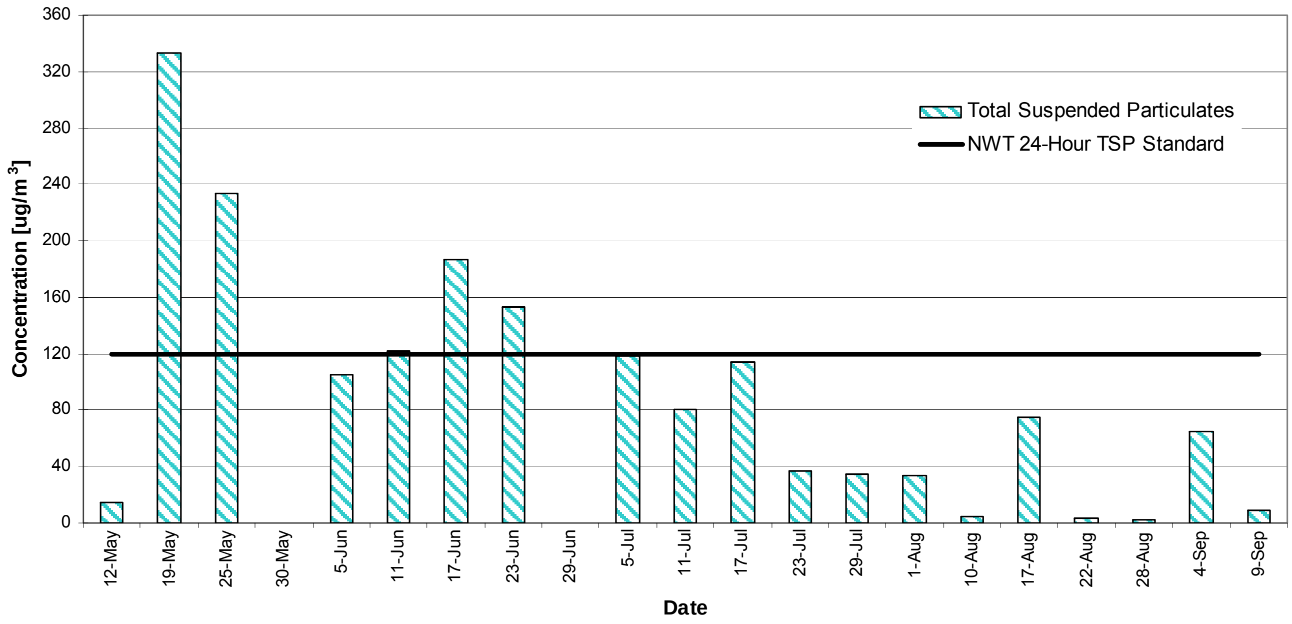
The AQEMMP also requires that ambient concentrations of measured particulate be compared to predictions made in the Air Modelling Update. Table 3-6 presents this comparison. Higher than average crushing rates in 2007 resulted in atypical maximum TSP concentrations. PM_{10} and $PM_{2.5}$ concentrations were not available for comparison in 2007. The principal factor affecting data collection was equipment failure associated with the cold weather experienced in 2007.

Figure 3-3 Total Suspended Particulate (TSP) Concentrations at HV-002 Summary, 2007



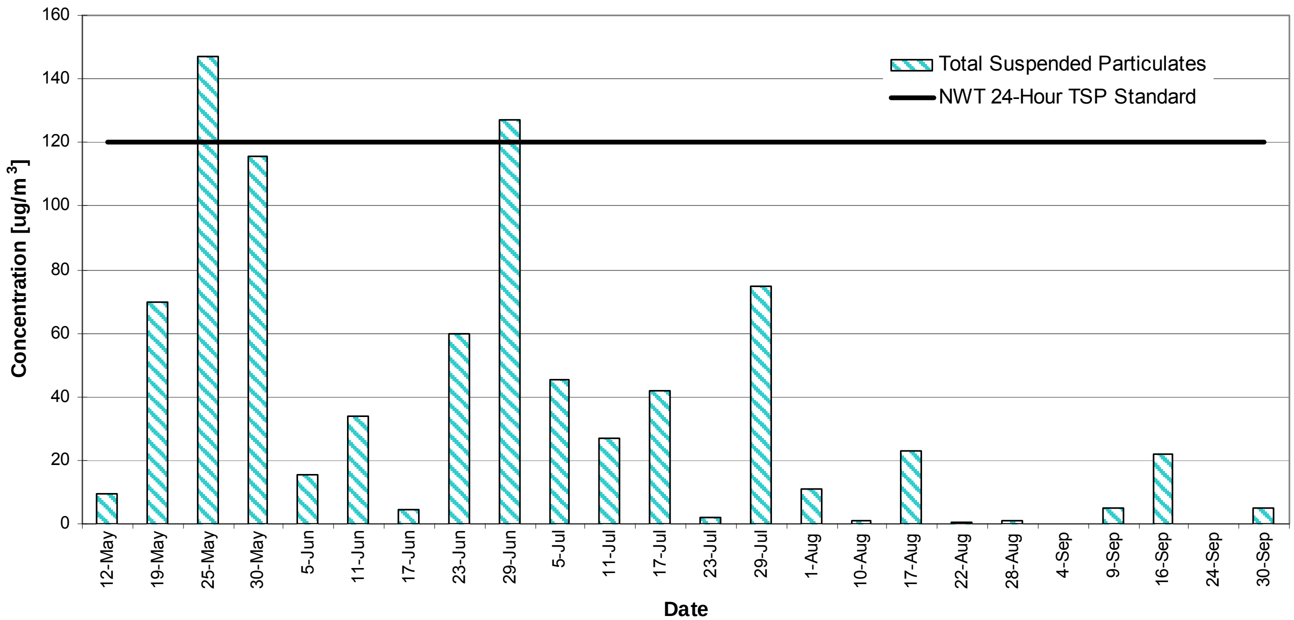
μg/m^3=micrograms per cubic meter.

Figure 3-4 Total Suspended Particulate (TSP) Concentrations at HV-004 Summary, 2007



µg/m^3=micrograms per cubic meter.

Figure 3-5 Total Suspended Particulate (TSP) Concentrations at HV-005 Summary, 2007



µg/m^3=micrograms per cubic meter

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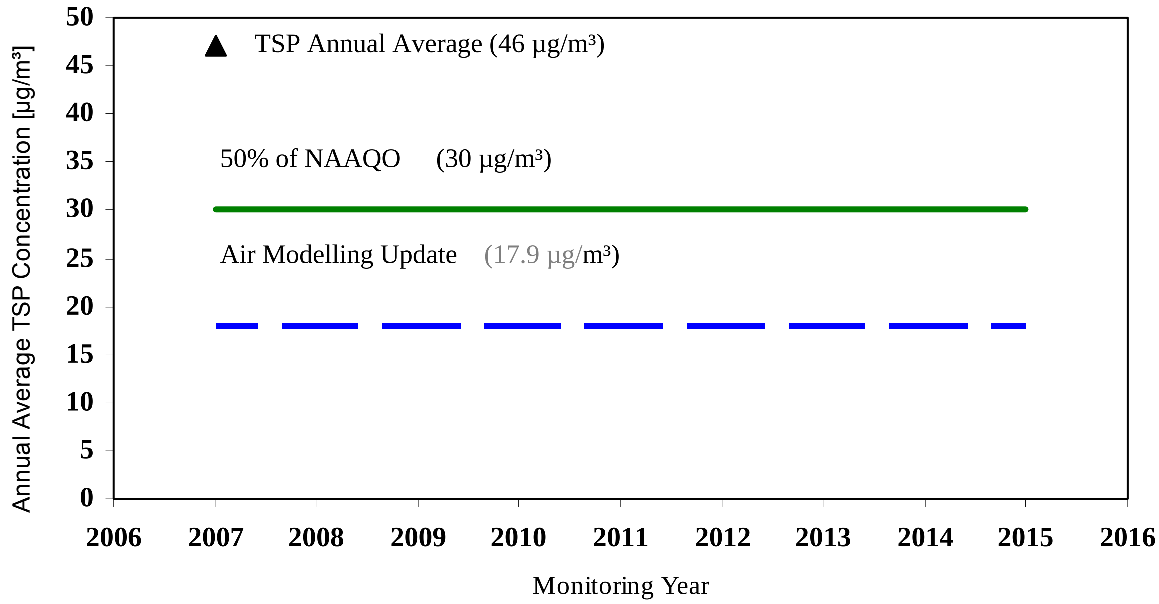
Figure 3-6 Action Levels for Annual Ambient Total Suspended Particulate (TSP) Concentrations



µg/m³ = micrograms per cubic metres; TSP = total suspended particulate; NAAQO = National Ambient Air Quality Objective.

Table 3-2 Snap Lake Total Suspended Particulate (TSP) Particulate Concentrations [µg/m³])

Compound	Monitoring Sites	Applicable Guideline		Air Modelling Update[(a)]		2007[(b)]	
		Hourly	Annual	Hourly	Annual	Hourly	Annual
TSP	HV-002	120	60	145.2	18.7	33.0	11.0
	HV-004					333.0	91.0
	HV-005					147.0	38.0

(a) Excluding active mine area.

(b) 2007 was an unusually active construction year with higher than average dust generating activities (crushing) resulting in atypically high TSP hourly concentrations.

3.4.6 Discussion

There were seven exceedances that were recorded above the NWT 24-hour TSP standard of 120 µg/m³ (GNWT, 2002). Five of these seven exceedances occurred at station HV-004 and the other two at station HV-005 during the months of May and June.

The stations that recorded these higher numbers are located in high traffic areas near the heart of the developed area of the site. The highest TSP concentrations would be expected in these locations. These locations have been revised and the TSP stations have been moved offsite in the beginning of 2008. Data from the new locations further from the areas of high activity will help to demonstrate compliance with the NWT standard beyond the Mine footprint.

Because the annual average TSP concentration is greater than 50% of the applicable ambient air quality standard, De Beers is required to arrange an external review of the higher than expected measurements and develop an action plan to reduce the concentrations.

In early 2008, the Hi-Vol samplers were replaced with TSP Partisol samplers housed inside climate-controlled shelters. Sampling with Partisols (for TSP, PM_{10} and $PM_{2.5}$) housed indoors is an approach that has been endorsed and employed by the GNWT in Yellowknife to improve the data recovery rate of particulate sampling conducted by them. The option to bring the Partisols indoors is new and unique to the north, and is available with the revision of the federal reference method for fine particulate sampling.

4 SUMMARY OF 2007 EMISSIONS

4.1 INTRODUCTION

The Air Quality and Emissions Management and Monitoring Plan (AQEMMP) is used to coordinate the monitoring of emissions from the Mine, which were compared to the Air Modelling Update (De Beers 2006a). The three main components of the emissions summary, and the sections in which they are discussed, are as follows:

- emissions estimates (Section 4.2);
- fuel use summary (Section 4.3); and
- emissions mitigation strategies, which include the dust abatement program (Section 4.4).

4.2 EMISSION ESTIMATES

The emissions estimate component of the annual report has the following objectives:

- to demonstrate De Beers' commitment to ongoing monitoring of emissions at the Mine site;
- to provide an overview of the appropriate methodology for calculating emissions from the Mine;
- to show that Mine emissions do not exceed those modelled in the Air Modelling Update (De Beers 2006a); and
- to demonstrate De Beers' commitment to minimizing emissions.

4.2.1 Types of Emissions

4.2.1.1 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 Mine:

- power generators;
- mine air heaters;

- underground fleet;
- surface fleet; and
- incinerators.

Compounds such as sulphur dioxide (SO_2), oxides of nitrogen (NO_X), particulates and greenhouse gases (GHGs) are common combustion by-products from the Mine 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 Government of Northwest Territories (GNWT) standards, National Ambient Air Quality Objectives (NAAQO) and Canada-Wide standards that apply to these compounds. The applicable criteria are provided in Table 4-1.

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 4-1 and these apply to municipal waste incineration at new facilities such as the Mine. The achievement of these Canada-Wide Standards requires that the best available control techniques, such as a waste diversion program be used.

Table 4-1 Canada-Wide Standards for Municipal Waste Incineration Emissions

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

(a) Canadian Council of Ministers of the Environment (CCME) 2001; corrected to 11 % O_2 content.
(b) CCME 2003.

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).

4.2.1.2 Fugitive Emissions

Fugitive emissions are substances that are released to the atmosphere without passing through a stack, vent, or functionally equivalent opening. Fugitive emissions are expected as a result of the Mine construction and operation activities and are expected to consist primarily of fugitive dust.

Fugitive dust emissions can result from Mine 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 Mine:

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

4.3 FUEL USE AND WASTE SUMMARY

As mentioned in the 2006 annual report, a comparison with Environmental Assessment Report (EAR) (De Beers 2002a) emissions can be made. However, comparison of the emissions estimates for 2007 and the emissions from the 2007 Air Modelling Update (Table 4-2) does show that total fuel consumption and emissions at Snap Lake are well below levels used to predict ground-level concentrations.

Table 4-2 Snap Lake Diesel Fuel Consumption Comparisons

Source	Diesel Consumption Rate (L/yr)				
	Air Modelling Update (De Beers 2007)	2006	2007		
			RSD	LSD	Total
Power Generators[a]	28,321,880	7,725,162	5,700,943	82,002	5,782,945
Mine Heaters/Incinerators	8,333,333	1,773,822	5,170,410	205,813	5,376,223
Fleet	7,225,000	6,665,210	5,601,812	1,230,201	6,832,013
Total	**43,880,213**	**16,164,194**	**16,473,165**	**1,518,016**	**17,991,181**

(a) includes pumps, compressors, welders etc.

L/yr = Litres per year; RSD = regular sulphur diesel fuel (1200 ppm); LSD = low sulphur diesel fuel (15 ppm); EAR = Environmental Assessment Report.

Table 4-3 reports the monthly fuel usage for the Mine combustion sources, identified in Section 4.2.1, and compares these values to the 2007 Air Modelling Update (De Beers 2007). Table 4-4 provides a break down of the monthly solid waste incineration in metric tonnes at the Mine and compares these values to the monthly allocations as outlined in the 2006 Air Modelling Update. These tables allow for year by year comparisons of the monthly and annual fuel usage so that trends can be identified in the annual reports. For example, it can be seen that while the monthly fuel usage in 2007 did not exceed the allowed monthly fuel usage as defined in the 2006 Air Modelling Update, the monthly waste incineration program was in exceedance by approximately a factor of 3.

Table 4-3 Monthly Fuel Usage from Major Combustion Sources - 2007

Month	Power Generation (m^3)	Mine Heaters (m^3)	Mobile Fleet (m^3)	Incineration (m^3)	Total (m^3)	Air Modelling Update (De Beers, 2007a) (m^3)
January	696	797	606	8	2,107	**3,303**
February	763	699	753	12	2,216	**3,303**
March	737	669	153	19	2,944	**3,303**
April	447	361	938	16	1,751	**3,303**
May	746	395	363	32	1,527	**3,303**
June	583	219	543	29	1,363	**3,303**
July	549	223	313	21	1,095	**3,303**
August	378	150	312	19	848	**3,303**
September	163	225	357	17	752	**3,303**
October	202	377	325	18	914	**3,303**
November	315	584	418	17	1,334	**3,303**
December	205	541	278	16	1,040	**3,303**
Total	**5,783**	**5,249**	**6,734**	**225**	**17,991**	**39,636**

m^3 = cubic metres

De Beers uses two ecoWaste Solutions model CA 600 incinerators, which are rated for a maximum loading of 750 pounds per cycle per unit (lbs/cycle/unit) with an average of 5 hours/cycle (including holding, heating and cooling times). Taking into account these operational parameters, as well as the monthly tonnage burned (Table 4-3) the average incinerator loading factor per cycle is 80% of the maximum rating. An 80% loading factor assumes that each incinerator operated 24 hours per day and for 365 days in 2007.

Table 4-4 Monthly Waste Tonnage Burned, 2007 (tonnes)

Month	Waste Tonnage Burned (t)	Air Modelling Update (De Beers, 2007a) (t)
January	70.14	27.31
February	74.90	25.55
March	80.52	27.31
April	83.22	26.43
May	89.30	27.31
June	88.41	26.43
July	90.90	27.31
August	87.48	27.31
September	83.33	26.43
October	78.58	27.31
November	70.71	27.31
December	55.88	27.31
Total	**971.65**	**323.33**

t = tonnes

4.3.1 Incinerator Stack Testing Results

Maxxam Analytics Inc. was retained by De Beers in August 2007 to conduct thermal oxidizer stack testing of the Mine's incinerator in accordance with stack testing protocols as outlined in the Canadian-Wide Standards for Dioxins and Furans (CCME 2001). Table 4-5 summarizes the thermal oxidizer stack testing results and compares these findings to the Canada-Wide Standards for Dioxin and Furan concentrations from municipal waste incineration emissions.

Table 4-5 Incinerator Stack Testing Results, 2007

Component	CCME Canada-Wide Standard (pg I-TEQ/Rm³)[a]	Average Stack Testing Results (pg I-TEQ/Rm³)
Total PCDD[b]	80	14.38[c]
Total PCDF[b]		109.48[c]
Total		**123.86**

[a] Volume referenced to 25 ºC, 760 mmHg & 11 % O2 content.
[b] Polychlorinated dibenzo-para-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF).
[c] Average of three stack test results.
pg I-TEQ/Rm³ = picograms per international toxicity equivalent per reference cubic metre.

As shown in Table 4-5, the sum total of all polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) compounds was found to exceed the CCME Canada-Wide Standard for total PCDD and PCDF incinerator emission concentrations by 54.8%.

The PCDD and PCDF emission specifications from ecoWaste Solutions model CA 600 incinerators are guaranteed to be below the CCME guidelines (Table 4-5) pending proper device utilization as defined in part in the previous section. Based upon feed-back from De Beers, it appears that the CA 600 incinerators where typically operated in 10-hour cycles during 2007. As a result, the loading of solid waste would have exceeded the recommended 750 pounds per cycle (lb/cycle), which according to ecoWaste Solutions would cause PCDD and PCDF emissions to be above the 80 pg I-TEQ/Rm^3 level. From the reported waste tonnage burned (Table 4-4), and the manufacturer's loading specifications (i.e., 750 lb/cycle), the actual average loading factor per unit is 60% above the maximum rating. Therefore, it is reasonable to attribute the 54.8% exceedance in PCDD and PCDF emissions to the overloading of the incinerator.

4.4 EMISSIONS MITIGATION STRATEGIES

There are a number of mitigation measures that will be integrated into the operations phase of the Mine to minimize air emissions. As for the other compounds released from the Mine, 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 (see details in Section 3.1 of the Domestic Waste and Sewage Management Plan [De Beers 2006b]);
- 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.

4.5 FACILITY EMISSIONS

4.5.1.1 Methods

This section describes three methods that can be used to estimate Mine 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 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 were used for estimating 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 the data from the emissions calculations resulting from the use of each of the aforementioned approaches. The methodology is consistent with that used in the Air Modelling Update.

4.5.1.2 Emission Calculation Results

Article VI Section 7.2 (part a item i) of the Environmental Agreement requires annual estimation of emissions from the facility, apportioned by major sources. Emission estimates of NO_X, SO_2, and particulate matter (PM) (apportioned into TSP, PM_{10} and $PM_{2.5}$) are required.

Emission calculations are based on fuel consumption and emission factors for the equipment at the Mine. The emission factors used are consistent with those used to develop the emissions profile that was simulated in the EAR (De Beers 2002a) and the update. Fuel consumption data provided by De Beers in 2007 indicate that 16,473,165 litres (L) of regular sulphur diesel (RSD), 1,419,512 L of low sulphur diesel (LSD) were consumed. The RSD and LSD fuels used by De Beers in 2007 had a sulphur content of 1200 and 15 parts per million (ppm), respectively. Therefore, emission rates for SO_2 were calculated separately for each type of diesel fuel and then summed together to give a total SO_2 emission rate. The 2007 emission estimates of the Mine are presented in Table 4-6.

Table 4-6 Estimated Mine Emission Rates, 2007

Source	Diesel Consumption [L/yr]	Emission Rates [t/d]				
		SO_2	NO_X	TSP	PM_{10}	$PM_{2.5}$
Power Generators	5,782,945	0.033	0.958	0.027	0.022	0.018
Mine Heaters/Incinerators	5,376,223	0.035	0.035	0.025	0.020	0.017
Fleet	6,832,013	0.032	1.541	0.032	0.026	0.021
Total	**17,991,181**	**0.068**	**2.535**	**0.084**	**0.068**	**0.057**

L/yr = Litres per year; SO_2 = sulphur dioxide; NOx = nitrogen oxides; TSP = total suspended particulate; PM_{10} =particulate matter nominally less than or equal to 10 micrometres aerodynamic diameter; $PM_{2.5}$ = particulate matter nominally less than or equal to 2.5 micrometres aerodynamic diameter; t/d = tonnes/day.

Table 4-7 presents the 2007 emission rates in tonnes per day (t/d) from the EAR (De Beers, 2002a) and compares these against the emission rates for the years 2005 and 2006. Overall, the emission rates for all compounds in 2007 are above those for 2006. This can be contributed to an 11% increase in diesel fuel consumption relative to 2006 (Table 4-2).

Table 4-7 Estimated Mine Emission Rates Comparisons

Compound	Sources	Air Modelling Update (De Beers 2007)	2005	2006	2007
SO_2 [t/d]	Power Generators	0.085	0.013	0.014	0.033
	Mine Heaters/Incinerators	0.171	0.002	0.003	0.035
	Fleet	0.048	0.007	0.007	0.032
	Subtotal	*0.304*	*0.022*	*0.024*	*0.068*
NO_X [t/d]	Power Generators	6.215	0.811	1.151	0.958
	Mine Heaters/Incinerators	0.658	0.005	0.012	0.035
	Fleet	1.763	0.384	0.897	1.563
	Subtotal	*8.636*	*1.201*	*2.06*	*2.557*
TSP [t/d]	Power Generators	0.064	0.025	0.036	0.027
	Mine Heaters/Incinerators	0.032	0.001	0.002	0.025
	Fleet	0.229	0.014	0.033	0.032
	Subtotal	*0.325*	*0.04*	*0.071*	*0.084*
PM_{10} [t/d]	Power Generators	0.053	0.021	0.03	0.022
	Mine Heaters/Incinerators	0.027	0.001	0.001	0.020
	Fleet	0.102	0.014	0.033	0.026
	Subtotal	*0.182*	*0.035*	*0.064*	*0.068*
$PM_{2.5}$ [t/d]	Power Generators	0.051	0.02	0.029	0.018
	Mine Heaters/Incinerators	0.024	0.001	0.001	0.017
	Fleet	0.068	0.014	0.033	0.021
	Subtotal	*0.143*	*0.035*	*0.063*	*0.057*
Total		**9.59**	**1.332**	**2.282**	**2.709**

SO_2 = sulphur dioxide; NO_x = nitrogen oxides; TSP = total suspended particulate; PM_{10} =particulate matter nominally less than or equal to 10 micrometres aerodynamic diameter; $PM_{2.5}$ = particulate matter nominally less than or equal to 2.5 micrometres aerodynamic diameter; t/d = tonnes/day.

4.6 GREENHOUSE GAS EMISSIONS

Greenhouse gasses are emitted from the combustion sources at the Mine. Article 7.2 (part a item i-D) of the Environmental Agreement requires reporting of GHG emissions from Mine activities and specifies that GHGs must be apportioned as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

Estimates of the Mine's GHG emissions in 2007 were based on emission factors published by Environment Canada (Environment Canada 2006) and on fuel consumption data listed in Table 4-2. Each compound has a different Global Warming Potential; therefore, emissions of CH_4 and N_2O were converted to a CO_2 equivalent (CO_2e) value. GHG emissions are reported in kilotonnes (kt) CO_2e per year. Table 4-8 presents 2007 GHG emissions due to fuel combustion at the Mine. The total GHG emissions were estimated to be 51.39 kt.

Table 4-9 presents a comparison of 2004, 2005 and 2006 GHGs. It is evident that GHG emissions have increased considerably from 2004. The increase is due to the higher diesel fuel consumption.

Table 4-8 Snap Lake Greenhouse Gas Emissions, 2007

Source	CO_2	CH_4	N_2O	Total CO_2e
Global Warming Potential	1	21	310	—
Emissions [kt/yr]	49.11	0.05	2.23	**51.39**

kt/yr = kilotonnes per year; CO_2 = carbon dioxide; CH_4 =methane; N_2O = nitrous oxides; CO_2e = carbon dioxide equivalent.

Table 4-9 Annual Snap Lake Greenhouse Gas Emission Comparisons (2004 to 2007)

Compound	2004	2005	2006	2007
CO_2 [kt/yr]	8.21	24.72	44.13	49.11
CH_4 [kt/yr]	0.01	0.03	0.05	0.05
N_2O [kt/yr]	0.37	1.12	2	2.23
Total CO_2**e** [kt/yr]	**8.59**	**25.87**	**46.18**	**51.39**

kt/yr = kilotonnes per year; CO_2 = carbon dioxide; CH_4 =methane; N_2O = nitrous oxides; CO_2e = carbon dioxide equivalent.

5 CONCLUSIONS

A summary of the meteorological and air quality programs for the Mine have been provided. Additionally, summaries of emissions at the Mine, including greenhouse gases have been provided. Meteorological data collected included wind speed, wind direction, temperature, relative humidity, solar radiation, and rainfall. Except for the wind data, all of the meteorological data were collected with a greater than 90% retrieval rate. The total precipitation data sensor on the secondary meteorological station near the fresh water intake at the lake-shore needs to be fully incorporated into the data-logging system for the station.

Particulate monitoring was completed in 2007 with data being collected successfully for TSP. There were seven exceedances that were recorded above the NWT 24-hour TSP standard of 120 μg/m³ (GNWT, 2002). Five of the seven exceedances occurred at station HV004 and the other two at station HV005 during the months of May and June. The particulate monitoring program was reviewed to determine how the system and procedures can be improved to increase the data recovery rate. The option to take advantage of the new exemption for northern applications in the federal reference method that permits housing partisol samplers indoors proceeded late in 2007.

A review of the solid waste incineration records and the incinerator stack testing data produced by Maxxam Analytics demonstrates a 54.8% exceedance of Canada-wide Standards for dioxins and furans. Additionally, the average monthly waste tonnage burned was found to exceed the 2007 Air Modelling Update by a factor of 3.

A comparison of emission rates to 2006 and 2007 totals indicates an overall increase in all compounds. Further, there has also been an upward trend in emissions since 2004 as fuel consumption has continued to increase. This is consistent with increased diesel consumption in 2007. All emission rates are still considerably lower than those used in the EAR (De Beers 2002a).

6 CLOSURE

We trust the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

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7 REFERENCES

Canadian Council of Ministers of the Environment (CCME). 1998. CCME Policy Statement for the Management of Toxic Substances. January 29, 1998.

CCME. 2001. Canada-wide Standards for Dioxins and Furans Emissions from Waste Incinerators and Coastal Pulp and Paper Boilers.

CCME. 2003. Canada-wide Standards for Dioxins and Furans conical Waste Combustion of Municipal Waste. Endorsed by the Council of Ministers of the Environment. November 23, 2003. Victoria.

CCME. 2007. Review of Dioxins and Furans from Incineration in Support of a Canada-Wide Standard Review. April 2007.

De Beers Canada Inc. (De Beers). 2002a. Snap Lake Diamond Project: Environmental Assessment Report. Submitted to the Mackenzie Valley Environmental Impact Review Board. February 2002.

De Beers. 2002b. Snap Lake Diamond Project Environmental Management System.

De Beers. 2004. Snap Lake Diamond Project: Adaptive Management Plan. Submitted to the Mackenzie Valley Land and Water Board as required by the Water License MV2001L2-0002. August 2004.

De Beers. 2005. Snap Lake Project. Air Quality Monitoring Program. Submitted to the GNWT and Environment Canada. September 2005.

De Beers. 2006a. De Beers Snap Lake Project: Quality Assurance and Quality Control (QA/QC) Plan. Submitted to the Mackenzie Valley Land and Water Board as required by the Water License MV2001L2-0002. March 2006.

De Beers. 2006b. The Domestic Waste and Sewage Management Plan. Snap Lake Project. Submitted to the Mackenzie Valley Land and Water Board. December 2006.

De Beers. 2007. Snap Lake Project: Air Dispersion Modelling Update. February 2007.

De Beers. 2008. Air Quality and Emissions Management and Monitoring Plan. August 2008.

Environment Canada. 1981. The Clean Air Act – Compilation of Regulations And Guidelines. Regulations, Codes And Protocols Report EPS 1-AP-81-1. Air Pollution Control Division.

Environment Canada. 2000. Canada-Wide Standards for Particulate Matter and Ozone. Endorsed by the Canadian Council of Ministers of the Environment, June 5-6, 2000. Quebec City.

Environment Canada. 2006. National Inventory Report: 1990-2004, Greenhouse Gas Sources and Sinks in Canada. Greenhouse Gas Division. April 2006.

Government of British Columbia. 1995. Interim Air Quality Objective for Fine Particulate: PM10. January 1995.

Government of Newfoundland and Labrador. 2004. Newfoundland and Labrador Regulation 39/04. Filed May 20, 2004.Government of the Northwest Territories (GNWT). 2002. Guideline for Ambient Air Quality Standards in the Northwest Territories. Department of Resources, Wildlife and Economic Development. December 2002.

Government of Ontario 2008. Ontario’s Ambient Air Quality Criteria (Sorted by Chemical Name). Standards Development Branch Ontario Ministry of the Environment. February 2008. PIBS # 6570e

Government of Saskatchewan 2007. Air Monitoring Directive for Saskatchewan (Draft). Saskatchewan Environment. Environmental Protection Branch.

GNWT and Environment Canada. 2006. Response Letter to De Beers Canada Inc: Re: Snap Lake Project – Air Quality and Emissions Management Plan and Air Quality Monitoring Plan. April 3, 2006.

MVEIRB (Mackenzie Valley Environmental Impact Review Board). 2003. Report of Environmental Assessment and Reasons for Decision on the De Beers Canada Mining Inc. Snap Lake Diamond Project. July 24, 2003.U.S. Government. 1998. Code of Federal Regulations (CFR): Title 40, Part 50.50.7 National Primary and Secondary Air Quality Standards for Particulate Matter.