DE BEERS
GROUP OF COMPANIES

Gahcho Kué Project
Air Quality and Emissions Monitoring and Management Plan

May

2013

EXECUTIVE SUMMARY

This document comprises the De Beers Gahcho Kué Project (Project) Air Quality and Emissions Monitoring and Management Plan (AQEMMP). This integrated approach to management and monitoring 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 air quality monitoring component will be used to coordinate monitoring of ambient air quality at the Project during the construction, operations, and closure phases. This ambient air quality monitoring data will be compared to applicable air quality criteria to provide an indication of the Project's performance with respect to air quality and it will be analyzed for trends each year in the annual report. Further, the integrated air quality data will be used to support the conclusions and to validate the terrestrial and aquatic impact assessment. The air quality data will be drawn upon specifically to support the monitoring plans for soils, vegetation, caribou and water quality.

The emissions management component presents the approaches that will be used in the annual report to provide a summary of emissions from the Project. 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 Environmental Impact Statement (EIS) Updated Air Quality Assessment (De Beers 2012a) to evaluate emissions performance.

An important outcome of evaluating 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 relative to pre-determined action levels. The action levels for each compound are based on the Updated Air Quality Assessment (De Beers 2012a) predictions, the applicable ambient air quality standards and objectives and a percent change (year to year) in measured concentrations. When these factors are considered collectively, potential issues can be resolved before the ambient air quality standards are reached, which is the primary benefit of this type of proactive and adaptive management system.

TABLE OF CONTENTS

SECTION **PAGE**

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

De Beers Canada Inc. (De Beers) will conduct open pit mining, milling and associated activities at the Gahcho Kué Diamond Mine (Mine), located approximately 280 kilometres (km) northeast of Yellowknife, and approximately 80 km southeast of the Snap Lake Mine (centered at 63°25’48” N, 109°12’00” W) (Figure 1-1). The three phases of the mine life include construction (2 years), operations (11 years) and closure (8+ years). Activities at the Mine will include:

- extraction of mine rock and ore from three locations (5034 Pit, Hearne Pit and Tuzo Pit);
- construction of berms and dykes for water management and dewatering/drawdown of areas within Kennady Lake;
- the development, operation and closure of site facilities and infrastructure (including the airstrip and pipelines);
- the use of water for construction, processing, operations and domestic purposes;
- disposal of waste and treated effluent;
- construction and operation of a winter road;
- the storage of fuel and explosives;
- exploration activities; and
- site closure, including progressive reclamation.

Further details on Mine activities are provided in the Consolidated Project Description (De Beers 2013a).

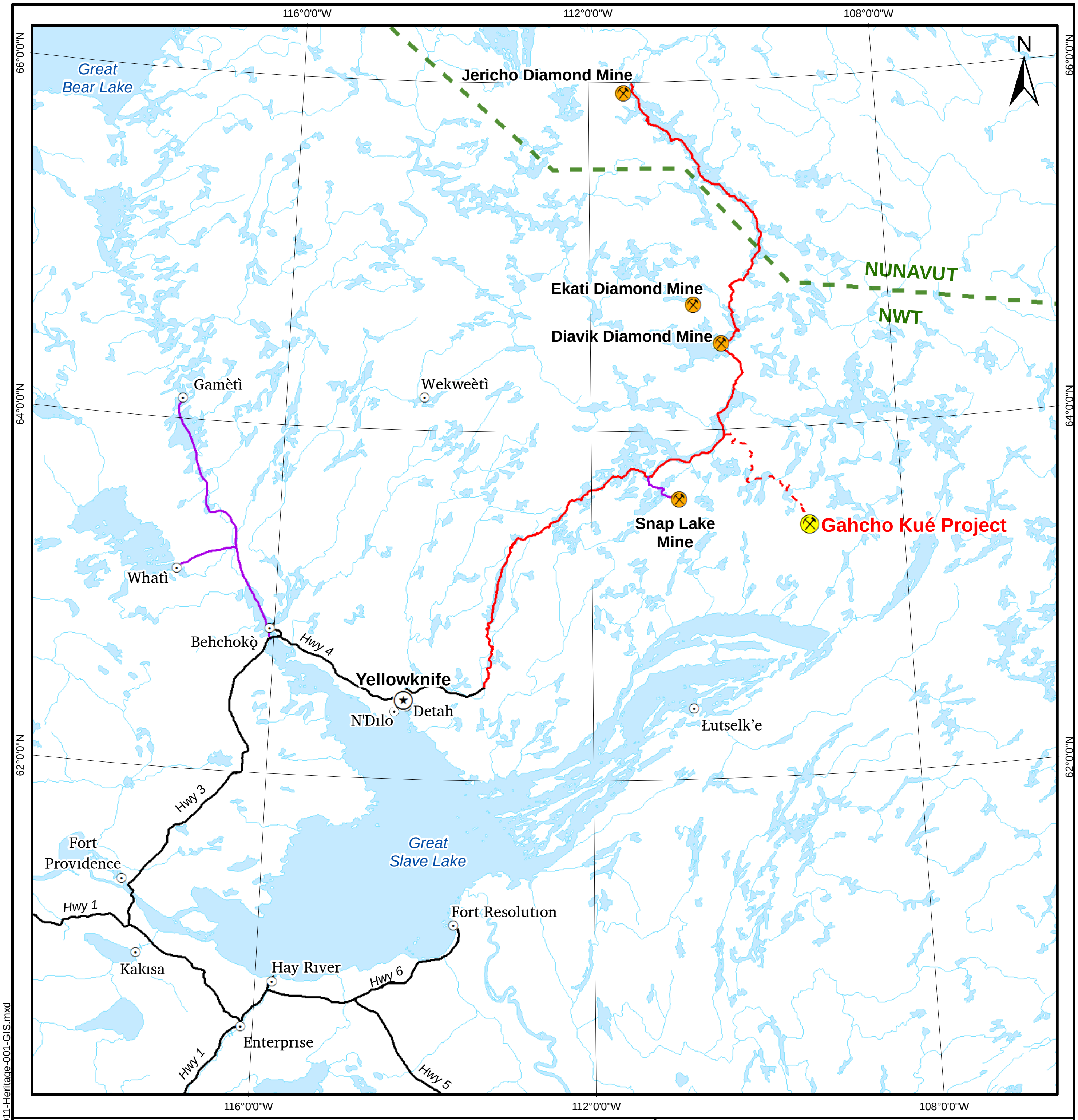
This document comprises the draft Air Quality and Emissions Monitoring and Management Plan (AQEMMP) for the Project. Section 1 provides information on the scope, objectives, methods and approach used in this plan. Section 2 describes the air quality monitoring program, while Section 3 provides details on the emissions monitoring program. Response planning is described in Section 4, while Section 5 provides information on annual reporting. The content of Section 6 relates to regional and cumulative effects monitoring programs. Section 7 describes engagement, while Section 8 identifies regulatory requirements.

1.1 SCOPE

The air quality monitoring and emissions management activities and planning are harmonized into one document, this AQEMMP, to demonstrate the linkages between the two programs and because the data from each will be presented together each year in an annual report.

The data generated from air quality monitoring serves a distinct purpose as does the data generated from the emissions management component of this plan. The ambient monitoring data collected through the execution of the monitoring plan will be used to validate the predicted concentrations derived through dispersion modelling assessment and compared to applicable Federal and Territorial ambient air quality standards to demonstrate compliance as well as determine the effectiveness of mitigation strategies (i.e., road watering to reduce dust. This data will be provided to other assessment disciplines tasked with monitoring additional ecological receptors (i.e., soil, vegetation, water and wildlife). The emissions data generated will validate the inputs to the dispersion modelling and will continue to demonstrate the conservative nature of the air quality assessment, but will not contribute directly to the monitoring of other ecological receptors.

The overall purpose of the AQEMMP is to provide an overview of the activities involved in the monitoring and management of emissions and air quality and to provide a template for the annual monitoring reports. This report is a “living” document that may need to be adaptively managed over the life of mine.



I:\CLIENTS\DE BEERS\11-1365-0001\Mapping\MXD\General\Section1\B2011-Heritage-001-GIS.mxd

LEGEND

- ⚒ Gahcho Kué Project
- ⚒ Existing Mine
- ★ Territorial Capital
- ⊙ Populated Place
- — Highway
- — Existing Winter Road
- — Tibbitt-to-Contwoyto Winter Road
- - - Winter Access Road
- — Watercourse
- ▨ Waterbody
- - - Territorial/Provincial Boundary

NOTES
Source: Figure 1.1-1 in De Beers 2010
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Location of the Gahcho Kué Project

PROJECTION: Canadian Lambert Conf. Conic
DATUM: NAD83
Scale: 1:3,500,000
50 25 0 50
Kilometres
DE BEERS CANADA
FILE No: B2012-Heritage-001-GIS
DATE: February 7, 2012
JOB NO: 11-1365-0012
REVISION NO: 8
OFFICE: GOLD-CAL
DRAWN: JH
CHECK:

Figure 1-1

1.2 OBJECTIVES

The AQEMMP has been prepared not only to address ambient air quality matters specifically, but also to provide data that will support the study of the linkages between air quality and other terrestrial and aquatic areas of study. For example, it has been proposed that caribou avoid mine sites in part because of dust that may be present on vegetation and in the air in the vicinity of the mine. This document and the monitoring program provide a framework for air quality monitoring that can be used to support cross-disciplinary study. 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;
- verify the accuracy of impact predictions made in the Updated Air Quality Assessment (De Beers 2012a);
- outline response plans to respond to increasing trends, exceedences of air quality criteria and/or occurrences above emission estimates and dispersion modelling predictions presented in the Updated Air Quality Assessment;
- provide data that can make a meaningful contribution to a regional cumulative effects monitoring data bank developed by government
- provide data including dust deposition to evaluate effects to aquatic and terrestrial ecological receptors;
- 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, but is not limited to the fugitive dust abatement program.

To achieve these objectives, Section 2 of the AQEMMP concentrates on the following three main components:

- on-site meteorological monitoring;
- ambient monitoring of total suspended particulate (TSP) and fine particulate matter with mean aerodynamic diameter 2.5 micrometres (µm) or smaller ($PM_{2.5}$); and
- passive monitoring of sulphur dioxide (SO_2) and nitrogen dioxide (NO_2).

Section 3 focuses on the following three main components:

- emissions estimates and measurement;
  - GHGs – emission factor approach; and
  - dioxins, furans, and mercury – stack testing approach
- fuel use summary; and
- emissions mitigation strategies, which includes the fugitive dust abatement program.

1.3 METHODS AND APPROACH

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 reference monitoring locations, as this is an important consideration in conducting trend analysis. In addition, De Beers will consult with communities on providing their input on monitoring locations.

Monitoring activities will consist of "off-site" monitoring. "Off-site" monitoring is expected to occur a short distance outside of the active, developed area. The locations will be chosen based on areas of maximum off-site predictions from the dispersion modelling assessment and with consideration to areas of interest from other disciplines, e.g., potentially sensitive vegetation communities and wildlife habitat. A map of the Project site indicating the proposed active mine area and the proposed air monitoring locations is provided in Section 2 (Figure 2-1).

The monitoring focus of the AQEMMP 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 or beyond the Project 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 Project emissions and the resulting ambient air concentrations should be compared. The Project will comply with the applicable Northwest Territories (NWT) Ambient Air Quality Standards, Canada Wide Standards and National Air Quality Objectives for TSP (24-hour and annual), $PM_{2.5}$ (24-hour), and NO_2 and SO_2 (1-hour, 24-hour and annual) (GNWT 2011, CCME 2000a, CCME 2000b, CCME 2001, Environment Canada 1981). Table 1-1 provides 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	—	—	400	1,000	—
24-Hour	200	—	—	200	300	—
Annual	60	—	60	100	—	—
TSP [µg/m³]						
24-Hour	120	—	—	120	400	—
Annual[e]	60	—	60	70	—	—
$PM_{2.5}$ [µg/m³]						
24-Hour	30	30	—	—	—	35[f]
Annual	—	—	—	—	—	15[f]

[a] Source: GNWT 2011.

[b] Source: CCME 2000a.

[c] Source: Environment Canada 1981.

[d] "—" = not applicable.

[e] As a geometric mean.

[f] US EPA primary $PM_{2.5}$ standards are 35 µg/m³ for 24 hours and 15 µg/m³ annually (U.S. EPA 2006).

SO_2 = sulphur dioxide; NO_2 = nitrogen dioxide; TSP = total suspended particulate; $PM_{2.5}$ = fine particulate matter with mean aerodynamic diameter less than 2.5 micrometres; NWT = Northwest Territories; US EPA = United States Environmental Protection Agency; µg/m³ = microgram per cubic metre.

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" and "Keeping Clean Areas Clean", as described in the Canada-Wide Standards for Particulate Matter and Ozone (CCME 2000a). Therefore, the monitoring of trends in emissions and ambient air quality is an important component of the AQEMMP, as discussed in Sections 2 and 3.

De Beers has incorporated a number of design features that demonstrate their commitment to "Continuous Improvement" and "Keeping Clean Areas Clean". These include, but are not limited to, the following:

- selection of highly-efficient combustion equipment including the use of tier 4 engines for most new construction and mining equipment;

- use of low-sulphur diesel;
- conveyor-based, covered ore transport systems;
- shortest haul routes to tailings facilities;
  - the mine plan design minimizes haul distances and therefore reduces fuel consumption;
  - mine operating practices that minimize idling of equipment during cold weather, i.e. large equipment will be shut down rather than allowed to idle during breaks and shift changes; small equipment will have plug-in block heaters to avoid idling;
- continue to investigate economic alternate energy sources to offset diesel combustion;
- modern incineration facilities and waste segregation policies;
- worker education;
- on-site recycling programs;
- development of management plans to guide actions and documentation needs around air quality.
- design waste heat recovery systems to capture heat that can be used for building heating coupled with modern heating and ventilation equipment for all enclosed workplaces and living environments; and
- the design of highly insulated buildings including camp to minimize heat loss.

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.

The AQEMMP covers the three main phases of the Project; construction, operations, and closure. As the construction, operations, and closure phases of monitoring will occur over many years, the annual report will evolve as management and monitoring needs change.

2 AIR QUALITY MONITORING PROGRAM

2.1 INTRODUCTION

The AQEMMP will be used to coordinate monitoring of ambient air quality at the Project during the construction, operations, and closure phases. Air quality monitoring will be used to validate the effect of emissions on water quality, and deposition on plants and soil in the local study area. Air quality monitoring will also be compared to applicable air quality criteria and the updated Air Quality Assessment (De Beers 2012a) and analyzed for trends each year in the annual report. In this way, the implementation of the AQEMMP will be able to provide an indication of the Project's performance with respect to air quality.

The main components of the air quality monitoring program, AQEMMP, and the sub-sections in which they are discussed, are as follows:

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

Figure 2-1[1] shows the proposed monitoring station locations at the Project during the construction phase of the Project. As the Project evolves, the proposed monitoring station locations, excluding background or reference stations, may change.

For each of the AQEMMP 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 is critical for the reliable interpretation of air quality data. Meteorological parameters are also used by other disciplines (e.g., hydrology, wildlife) to aid in the analysis of monitoring data by either De Beers or government. Meteorological monitoring is a vital input for any subsequent emissions dispersion modelling assessments that may be required

---

[1] Monitoring station locations to be determined as Project planning advances.

during the lifetime of the Project. 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 Location

A meteorological station is currently installed at the Project site. It is located approximately 300 metres (m) north of the existing Kennady Lake exploration site. A permanent and robust meteorological station is planned for the Project site, and will be located at an appropriate location, which has negligible influence from the Project activities.

2.2.2 Monitoring Methods

Meteorological data are currently collected at the site using Campbell Scientific meteorological monitoring equipment on a 7 m tower. A permanent station would also consist of sensors mounted on a 10 m tower, consistent with current accepted practice in Canada. The station would operate independently using a battery/solar panel power supply. A wireless link permitting communications between the station and the on-site De Beers' Environmental technicians' office can be installed.

2.2.3 Monitoring Frequency

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

2.2.4 Monitoring Parameters

The tower system will continuously measure 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;
- precipitation at 2 m above the ground; and

- soil temperature and moisture sensors at appropriate soil depths.

2.2.5 Data Analysis

A summary of the meteorological monitoring will be presented each year in the annual report. Extreme meteorological events and trends will be identified, where necessary, and discussed in the annual report.

2.3 TOTAL SUSPENDED PARTICULATE AND $PM_{2.5}$ MONITORING

Suspended particulate matter (dust) emissions will be generated by wind erosion of local landscapes, removal and displacement of rock and overburden from the mining pits, 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 a number of different size fractions. The particulate matter size fractions considered in this plan are as follows:

- TSP – which includes particulate matter nominally less than 100 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 $PM_{2.5}$. Consideration will also be given to the potential for a visible plume to contribute to other ecological effects.

2.3.1 Monitoring Station Locations

The proposed monitoring locations during the construction phase of the Project were selected to provide a conservative management approach to ambient particulate concentrations. These locations were selected based on areas of maximum off-site particulate predictions from the dispersion modelling assessment. Consideration was also given to areas of interest from other disciplines, e.g., potentially sensitive vegetation communities and wildlife habitat.

The station locations are intended to be permanent stations for construction, operations and early closure phases while reclamation activities are being conducted 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.

2.3.2 Monitoring Methods

De Beers will be evaluating the Sharp 5014i Continuous Ambient Particulate Monitors (CAPM) for TSP or fine particulate matter with mean aerodynamic diameter 10 µm or smaller (PM_{10}) and $PM_{2.5}$ for use in the Project.

Continuous Ambient Particulate Monitors operate on the principle that a stream of ambient air at a controlled flow rate is drawn through a size-selective inlet and deposited onto an auto-advancing filter tape. Detection of beta particles passed through the filter tape allows for a measurement of the accumulation of particulate deposited onto the filter tape. The measurement of the accumulated particles and air volume are used to derive the measured ambient concentrations for a given time period.

The 5014i CAPM at the Project, should it determined to be suitable, will collect particulates with a nominal aerodynamic diameter of 100 µm or smaller. The collection of TSP provides a good measure of airborne particulate matter. The 24-hour and annual average TSP concentrations are subject to the NWT ambient air quality standards of 120 and 60 micrograms per cubic metre (µg/m³), respectively (GNWT 2011).

The CAPM at the Project will continuously measure particulates with a nominal aerodynamic diameter of 2.5 µm or smaller. The measurement of $PM_{2.5}$ provides a good measure of aerosolized particulate matter. The 24-hour average $PM_{2.5}$ concentrations are subject to the NWT Ambient Air Quality Standards of 30 µg/m³ (GNWT 2011).

2.3.3 Monitoring Frequency

Particulate sampling will be conducted year-round including during extreme winter conditions (-20 degrees Celsius [°C] and colder with winds greater than 15 kilometres per hour [kph]), which typically occurs between the months of October and April. 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 will construct climate-controlled shelters to contain the sampling equipment to minimize this problem.

Continuous monitoring allows for the detection of outlier events and for a robust continuous data set. As well, analysis of the continuous data can be performed readily when compared to discrete, filter-based methods, and alert the analyst to conditions of interest or equipment faults.

Monitoring of TSP and fine particulate matter will continue beyond construction, into the operations and closure phases of the Project.

2.3.4 Data Analysis

The TSP and $PM_{2.5}$ data from each of the monitoring locations will be analyzed for indications of air quality concerns (e.g., increasing trends, measured concentrations above the Updated Air Quality Assessment 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 Environmental Management System (EMS), if necessary.

The analysis of spatial particulate trends will compare measured particulate concentrations from each of the monitoring stations. The possibility exists that unusual events in the region (e.g., a dust storm or forest fire transporting airborne particulate) could result in higher measured particulate concentrations. 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 a 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.

2.4 DUSTFALL MONITORING

The main dust generation processes at the Project will be wind erosion of fugitive sources, removal and displacement of rock and overburden from the mining pits, 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 waterbodies. The dustfall monitoring program measures the quantities of dust deposited near the Project. This information will be used to evaluate potential effects to ecological receptors.

2.4.1 Monitoring Station Locations

Dustfall monitoring locations are discussed in the Vegetation and Soils Monitoring Program (De Beers 2013b).

2.5 PASSIVE MONITORING OF SULPHUR DIOXIDE AND NITROGEN DIOXIDE

The main sources of SO_2 and NO_2 emissions from the Project will be the power plant, mine and quarry activities, and the incinerators. De Beers intends to incorporate passive monitoring of SO_2 and NO_2 compounds into the AQEMMP to demonstrate compliance with the NWT Ambient Air Quality Standards (GNWT 2011).

2.5.1 Monitoring Station Locations

The proposed passive SO_2 and NO_2 monitoring stations are co-located with the dustfall monitoring stations as indicated in Figure 2-1[2]. 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. Additional passive monitoring stations will be evaluated as necessary.

2.5.2 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] Monitoring station locations to be determined as Project planning advances.

2.5.3 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 Updated Air Quality Assessment, 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.

2.5.4 Monitoring Parameters

The passive samples will be analyzed for the potential presence of SO_2 and NO_2.

2.5.5 Data Analysis

The ambient SO_2 and NO_2 concentrations measured at the passive stations will be analyzed for indications of air quality concerns (e.g., increasing trends or measured concentrations above the Updated Air Quality Assessment 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 Ambient Air Quality Standards (GNWT 2011). However, since the passive sampling data are collected on a monthly basis and the NWT standards do not have monthly criteria, the annual average of the monthly data will be compared to the annual NWT standards for SO_2 and NO_2. The passive monitoring will be used to supplement the data generated through emissions calculations that are presented each year in the annual report.

Analysis of spatial trends will 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.

2.6 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. 2012). As QC procedures implemented as part of the AQEMMP are variable and program-specific, the procedures have been summarized in this section on a program component basis.

2.6.1 Meteorological Monitoring

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

- Data are to be downloaded from the station bi-weekly and manually checked by qualified personnel 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 12 to 24 months) based on manufacturer specifications and professional experience.
- 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.

2.6.2 Total Suspended Particulate and $PM_{2.5}$ Monitoring

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

- 5014i CAPM samplers will be calibrated and maintained annually or on the recommended schedule as set by the manufacturer.
- Data will be downloaded consistent with detailed written operating instructions from qualified personnel.

2.6.3 Passive Monitoring

The QA/QC procedures for the passive SO_2 and NO_2 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.
- Duplicate samples will be exposed and analysed.
- Laboratory blanks will be analysed.
- 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. Qualified personnel (i.e., a certified laboratory technician, professional air quality scientist or engineer) will calculate ambient SO_2 and NO_2 concentrations based on laboratory results.

3 EMISSIONS MONITORING PROGRAM

3.1 INTRODUCTION

The AQEMMP will be used to coordinate the monitoring of emissions during the construction, operations and closure phases of the Project. Emissions calculated for these phases will be compared to the Updated Air Quality Assessment (De Beers 2012a) emission estimates to evaluate the emissions performance. This process will be done on an annual basis and will be summarized in the annual report. If the results of the AQEMMP 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 emissions monitoring program of the AQEMMP, and the sub-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 emissions at the Project. This section identifies the various types of emissions from the Project and provides examples of approaches for calculating these emissions. The calculated emissions will be compared to those in the Updated Air Quality Assessment (De Beers 2012a), to evaluate emissions performance.

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

- to demonstrate De Beers' commitment to ongoing monitoring of emissions at the Project site;
- to provide an overview of the appropriate methods for calculating emissions from the Project;
- to show that Project emissions do not exceed those modelled in the Updated Air Quality Assessment (De Beers 2012a); and
- to demonstrate De Beers' commitment to minimizing 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 three primary combustion sources at the Project:

- power generators;
- mine 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 Ambient Air Quality Standards (GNWT 2011) that apply to these compounds. The applicable criteria are provided in Table 1-1.

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 3-1 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.

By calculating and reporting annual emissions in an annual report and further to Environment Canada’s National Pollutant Release Inventory (NPRI), De Beers can determine whether operational emissions are at or below the accepted standards and the emission estimates provided in the Updated Air Quality Assessment (De Beers 2012a).

Table 3-1 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 (pg/m^3)
Mercury[b]	20 micrograms per cubic metre (µg/m^3)

[a] CCME 2001.

[b] CCME 2000b.

3.2.1.2 Fugitive Emissions

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, and vegetation removal. The main natural process that generates fugitive dust is wind erosion. There are three main potential fugitive emission sources at the Project:

- the roads;
- the quarry; and
- the mine rock and processed kimberlite (PK) piles.

3.2.1.3 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 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 appropriate/recommended methods that can be used for estimating emissions of specific compounds are as follows based on professional experience:

- 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 emissions will be calculated using each of aforementioned approaches at the Project. The recommended methods are consistent with those used in the Updated Air Quality Assessment and with other northern Canadian mines.

3.2.1.4 Sulphur Dioxide Emission Calculation Methods

3.2.1.4.1 Sulphur Dioxide 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 is recommended.

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_{SO_2} = molecular weight of SO_2, (64.06 kilograms per kilomol [kg/kmol])
MW_S = molecular weight of sulphur, (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).

$$M = \frac{881 kg}{m^3} \times \frac{24{,}000 m^3}{year} \times 0.0005 \times \frac{64.06 kg / kgmol SO_2}{32.07 kg / kgmol S} = 21{,}117.63 \frac{kg SO_2}{year}$$

Convert the annual release to a daily value in tonnes.

$$21{,}117.63 \frac{kg SO_2}{year} \times \frac{1 year}{365 days} \times \frac{1 tonnes}{1000 kg} = 0.058 \frac{tonnes SO_2}{day}$$

3.2.1.4.2 Sulphur Dioxide 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.

3.2.1.5 Oxides of Nitrogen Emission Calculation Methods

3.2.1.5.1 *Oxides of Nitrogen 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, (cubic metres per year [m³/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.

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

3.2.1.5.2 *Oxides of Nitrogen 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.

3.2.1.6 Particulate Emission Calculation Methods

3.2.1.6.1 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 in the following paragraphs.

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 GJ/kg of fuel consumed. Furthermore the diesel has a density of 881 kg/m³ 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/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 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.

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

The same type of calculation would be used to determine $PM_{2.5}$ emissions with a modified emission factor based on published data (e.g., the United States Environmental Protection Agency's AP-42 compendium of emission factors for TSP and $PM_{2.5}$). For example; to complete the calculation for $PM_{2.5,}$ an emission factor of 35.34 g/GJ would be used instead of 42.99 g/GJ.

$$M = \frac{881kg}{m^3} \times \frac{24{,}000m^3}{year} \times \frac{0.0449GJ}{kg} \times \frac{35.34g}{GJ} = 3.35x10^7 \frac{g}{year}$$

Convert the annual release to a daily value in tonnes.

$$3.35x10^7 \frac{g}{year} \times \frac{1tonne}{10^6 g} \times \frac{1year}{365day} = 0.0.092 \frac{tonnes}{day}$$

3.2.1.6.2 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, mine pits, and rock storage areas.

3.2.1.6.3 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 VKT 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 vehicle miles travelled [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 United States Environmental Protection Agency [US EPA] AP-42 [US 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, drained lake beds, and processed kimberlite 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. Site-specific emission factors are calculated for the piles in kilograms per square metre per day (kg/m^2/day), which are then multiplied by the exposed pile surface area over the reporting period to obtain a mass emission rate.

3.2.1.7 Greenhouse Gas Emission Calculation Methods

Greenhouse gas emissions are emitted from the combustion sources at the Project. 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 in the following paragraphs.

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.

$$65{,}520 tonnes CO_2 + (3.192 tonnes CH_4 \times 21) + (9.600 tonnes N_2O \times 310) = 68{,}563 \frac{tonnes CO_2 E}{year}$$

3.2.1.8 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 from 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. Additional details on the operation of the incinerator are presented in the Incinerator Management Plan.

3.3 FUEL USE AND WASTE SUMMARY

Fuel usage for the Project combustion sources, identified in Section 3.2.1, will be documented monthly and presented in the annual report. Table 3-2 provides a summary table 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 and also to the assumptions in the 2012 re-assessment of air quality. In addition to fuel usage at the site, the amount of waste burned in the incinerator will be provided in the annual report. A summary table for tracking waste tonnage and liquid fuel use in the incinerator is presented as Table 3-3.

Table 3-2 Summary Table for Tracking Monthly Fuel Usage from Major Combustion Sources (cubic metres [m³])

Month	Power Generation	Mobile Fleet	Incineration	Total	Updated Air Quality Assessment
January					
February					
March					
April					
May					
June					
July					
August					
September					
October					
November					
December					
Total					

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

Month	Waste Tonnage Burned	Liquid Fuel Usage	Total	Updated Air Quality Assessment
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				
Total				

3.4 EMISSIONS MITIGATION STRATEGIES

There are a number of mitigation strategies that will be integrated into the operations phase of the Project to minimize air emissions. These mitigations 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 is used:

- mine design features that minimize equipment hours and fuel burn;
- fuel conservation measures to reduce SO_2, NO_X, and particulate emissions;
- Canadian Council of Ministers of the Environment (CCME), US EPA (2016 standard compliance), and internationally compliant equipment to reduce NO_X emissions. All new equipment will be equipped with Tier 4 Engines;
- CCME compliant equipment to reduce dioxins and furans emissions;
- waste diversion methods to minimize dioxins, furans, and mercury emissions from the incinerator;
- operation of combustion equipment, particularly Mine equipment, power plant, auxiliary boiler and incinerator, at optimal conditions (e.g., manufacturer recommended temperature, pressure etc.);
- regular maintenance of the vehicle fleet; and
- operational practices to limit equipment 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 from mine blasting in the pits, and haul road traffic. Other fugitive dust generating sources are expected to be road traffic, mining activities at the South and West Mine Rock Piles, mine, drilling, loading, hauling and dumping activities at the mine pits, aircraft landing and takeoff activities and wind erosion from exposed surface. Winter dust emissions (when road conditions and the landscape in the mine area are dominated by snow and ice) are mitigated naturally by approximately 95% and summer dust emission from road traffic are mitigated through regular road watering by approximately 80% (De Beers 2012a).

3.4.1.2 Methods

A discussion of fugitive dust abatement measures is provided in this section, as relating to mitigation to minimize dust from the drilling, blasting, ore handling, and primary crushing activities associated with the Project. These measures may be revisited pending results of the annual report.

3.4.1.3 Watering Surfaces

De Beers will control dust through watering surfaces that have high dust generation potential. Water controls dust on roads by increasing the cohesiveness of the surface material making it less susceptible to becoming suspended in the air.

During the summer months (typically late May through late September) the application of water to dust-prone surfaces will be an effective approach to managing fugitive dust for road surfaces. Winter dust emissions (when road conditions are dominated by snow and ice) are mitigated naturally by approximately 95%.

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:

- Mine blasting activities for operations will be naturally shielded as the pits deepen and dust created by blasting and pit mining activities will be confined within the pits. Progressive reclamation of the Fine Processed Kimberlite Containment Facility by placing erosion resistant, coarse material cover layers to limit exposure of fine processed kimberlite to wind erosion, would lower dust erosion potential.
- The application of coarse material on stockpiles (e.g., the West and South Mine Rock Piles) and lightly-travelled surfaces physically separates the fine material that would generate dust if it were exposed to wind or traffic. Plans for the reclamation of the piles include protecting them from the effects of the wind by placing coarse material on the completed surfaces. Regular road and airstrip maintenance, including applications of gravel and compacting operations, would lower dust erosion potential.

- Allowing mine pits to re-fill with water upon closure.

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, utilizing large mining equipment will result in minimizing the number of active mining faces as well as the number of truck movements required for mining

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. However, natural mitigation during the winter months due to snow and ice cover is expected to substantially reduce the potential for dust emissions from the airstrip and haul roads. Other dust control solutions may be investigated and used depending upon the environmental consequence. New surfactants for dust suppression with low unbound salt concentrations have been recently developed which may also be investigated.

4 RESPONSE PLANNING

One of the purposes of (AQEMMP) should be to identify trends in ambient (beyond the Project boundary) 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 methods 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. Where applicable, the trend analysis that guides response planning will incorporate shorter monitoring periods (e.g., TSP and $PM_{2.5}$), where the monitoring that is conducted at the Project permits direct comparison. 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.

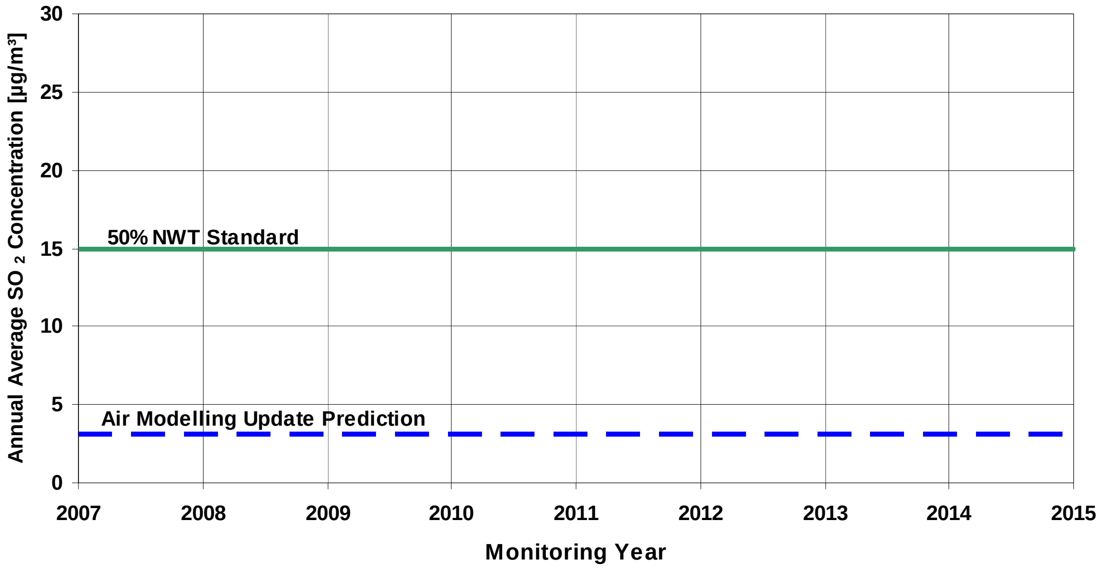
A systematic approach was taken to develop action levels for each compound based on the Updated Air Quality Assessment (De Beers 2012a) predictions, the applicable ambient air quality criteria and a percent change (year to year) in measured concentrations. For example, the action levels for SO_2 are as follows:

- Action Level I – 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), 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.

- Action Level III – annual 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 SO_2, but are not applicable to NO_2, TSP, and $PM_{2.5}$. This is because the NO_2, TSP, and $PM_{2.5}$ concentrations predicted in the Updated Air Quality Assessment 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, TSP, and $PM_{2.5}$ 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.
- 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.
- 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			
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, TSP, and $PM_{2.5}$			
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			✓

SO_2 =sulphur dioxide; NO_2 = nitrogen dioxide; TSP = total suspended particulate; $PM_{2.5}$ = fine particulate matter concentrations with mean aerodynamic diameter less than 2.5 micrometres; % = percent.

Table 4-2 indicates that criteria that will be used to determine “compliance” that will trigger actions as defined above.

Table 4-2 Criteria Used to Determine Compliance

Parameter	Criteria [μg/m³]	Source
Annual SO_2	30	NWT Ambient Air Quality Standard
Annual NO_2	60	NWT Ambient Air Quality Standard
24-Hour TSP	120	NWT Ambient Air Quality Standard
Annual TSP	60	NWT Ambient Air Quality Standard
24-Hour $PM_{2.5}$	30	NWT Ambient Air Quality Standard

SO_2 =sulphur dioxide; NO_2 = nitrogen dioxide; TSP = total suspended particulate; $PM_{2.5}$ = fine particulate matter concentrations with mean aerodynamic diameter less than 2.5 micrometres; NWT = Northwest Territories; μg/m³ = micrograms per cubic metre.

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 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 include in the water licence annual report a summary of outcomes from the air quality monitoring program and air emissions data collected during each year. In addition, De Beers will report annual emission estimates to the NPRI and GHG emissions to the appropriate federal program. 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 Sulphur Dioxide Emissions (tonnes/year)

Sources	Updated Air Quality Assessment	Year 1	Year 2
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	Updated Air Quality Assessment	Year 1	Year 2

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, $PM_{2.5}$, dustfall, SO_2, and NO_2) will also be provided.

The annual report will include the following information:

- annual NO_X, SO_2, particulate, and GHG 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 Updated Air Quality Assessment (De Beers 2012a);
- an assessment of the effectiveness of the emissions mitigation including the fugitive dust abatement program;
- comparisons of annual emission estimates to previous years and the estimates used in the Updated Air Quality Assessment (De Beers 2012a);
- comparisons of ambient air quality and deposition monitoring results to previous years, the predictions of the Updated Air Quality Assessment dispersion modelling (De Beers 2012a) 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 Government of Northwest Territories (GNWT) for the data storage system.

Data will be managed in accordance with De Beers' EMS Data Management System.

6 REGIONAL AND CUMULATIVE EFFECTS MONITORING PROGRAMS

De Beers will make available the results of the air quality monitoring programs and emissions estimates through public submission of the annual report to Aboriginal Affairs and Northern Development Canada (AANDC), Environment Canada, and GNWT for regional cumulative effects monitoring initiatives.

7 ENGAGEMENT

De Beers is committed to an inclusive and collaborative stakeholder engagement process. A number of stakeholders have been consulted in the course of the development of this monitoring plan.

8 REGULATORY REQUIREMENTS

Air quality at the Project is subject to a number of regulatory mechanisms. De Beers has committed to meeting the NWT Ambient Air Quality Standards, the National Ambient Air Quality Objectives and the CCME requirements related to emissions from various combustion sources, such as boilers, heaters and incinerators. An annual air quality report will be produced and submitted to the MVLWB public registry, GNWT, and Environment Canada. Further, De Beers will produce a NPRI report. It will contain information consistent with the annual report, configured to the requirement of the NPRI reporting system.

9 REFERENCES

American Public Health Association, American Water Works Association, and Water Environment Federation. 2012. Standard Methods for the Examination of Water and Wastewater. American Public Health Association, Washington, D.C.

CCME (Canadian Council of Ministers of the Environment). 2000a. Canada-Wide Standards for Particulate Matter (PM) and Ozone. June 2000.

CCME. 2000b. Canada-Wide Standards for Mercury Emissions. June 2000.

CCME. 2001. Canada-Wide Standards for Dioxins and Furans. May 2001. De Beers (De Beers Canada Inc.). 2010. Environmental Impact Statement for the Gahcho Kué Project. Volumes 1, 2, 3a, 3b, 4, 5, 6a, 6b, 7 and Annexes A through N. Submitted to Mackenzie Valley Environmental Impact Review. December 2010.

De Beers (De Beers Canada Inc.). 2010. Environmental Impact Statement for the Gahcho Kué Project. Volumes 1, 2, 3a, 3b, 4, 5, 6a, 6b, 7, and Annexes A through N. Submitted to Mackenzie Valley Environmental Impact Review Board. December 2010.

De Beers. 2011. Environmental Impact Statement for the Gahcho Kué Project. Volumes 3a Revision 2, 3b Revision 2, 4 Revision 2, and 5 Revision 2. Submitted to Mackenzie Valley Environmental Impact Review Board in response to the Environmental Impact Statement Conformity Review. July 2011.

De Beers. 2012a. Environmental Impact Statement for the Gahcho Kué Project - 2012 Updated Air Quality Assessment. Submitted to the Mackenzie Valley Environmental Impact Review Board, Yellowknife, NT, Canada. August 2012.

De Beers. 2012b. Environmental Impact Statement Supplemental Information Submission for the Gahcho Kué Project. Submitted to the Mackenzie Valley Environmental Impact Review Board, Yellowknife, NT, Canada.

De Beers. 2013a. Consolidated Project Description for the Gahcho Kué Project. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT, Canada. May 2013.

De Beers. 2013b. Vegetation and Soils Monitoring Program. Gahcho Kué Project. Submitted to the Mackenzie Valley Land and Water Board, Yellowknife, NT. May 2013.

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

Environment Canada. 1998. Road Dust Guidance Document. Prepared by National Emissions Inventory and Projections Task Group (NEIPTG).

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

GNWT (Government of the Northwest Territories). 2011. Guideline for Ambient Air Quality Standards in the Northwest Territories. Department of Environment and Natural Resources. 5 pp.

US 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.

US EPA. 2006. Code of Federal Regulations (CFR): Title 40, Part 50. 50.7 National Primary and Secondary Air Quality Standards for Particulate Matter.

WLWB (Wek’èezhìi Land and Water Board). 2010. Guidelines for adaptive management - a response framework for aquatic effects monitoring. Yellowknife, NT, Wek’èezhìi Land and Water Board.

10 ACRONYMS AND GLOSSARY

10.1 ACRONYMS AND ABBREVIATIONS

AANDC	Aboriginal Affairs and Northern Development Canada
AQEMMP	Air Quality and Emissions Monitoring and Management Plan
CAPM	Continuous Ambient Particulate Monitors
CCME	Canadian Council of Ministers of the Environment
CH_4	methane
CO_2	carbon dioxide
CO_2E	carbon dioxide equivalent
De Beers	De Beers Canada Inc.
EC	Environment Canada
EIS	Environmental Impact Statement
EMS	Environmental Management System
GHG	greenhouse gas
GNWT	Government of the Northwest Territories
Project	Gahcho Kué Project
Mine	Gahcho Kué Diamond Mine
MVEIRB	Mackenzie Valley Environmental Impact Review Board
N_2O	nitrous oxide
NO_2	nitrogen dioxide
NO_X	oxides of nitrogen
NPRI	National Pollutant Release Inventory
NWT	Northwest Territories
PK	processed kimberlite
$PM_{2.5}$	particulate matter with mean aerodynamic diameter 2.5 micrometres or smaller
PM_{10}	particulate matter with mean aerodynamic diameter 10 micrometres or smaller
QA	quality assurance
QC	quality control
SO_2	sulphur dioxide
TSP	total suspended particulate
US EPA	United States Environmental Protection Agency

10.2 UNITS OF MEASURE

%	percent
°C	degrees Celsius
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	kilometre(s)
kph	kilometres per hour
lb	pounds
m	metres
m^3	cubic metres
$m^3/year$	cubic metres per year
pg/m^3	pictograms per cubic metre
ppmw	parts per million weight
VKT	vehicle kilometres travelled
VMT	vehicle miles travelled
$μg/m^3$	micrograms per cubic metres
μm	micrometers

10.3 GLOSSARY

adaptive management	The exact definition of adaptive management varies among monitoring components, but typically adheres to having four themes as follows (WLWB 2010): 1) learning in order to reduce management uncertainties; 2) using what is learned to change policy and practice; 3) focusing on improving management; and 4) doing the above in a formal, structured and systematic way.
ambient	Existing or present in the surrounding air.
dioxins	A variety of chemical compounds that can be described by the chemical formula: C4H4O2.
emission	Release of substances to atmosphere (can be fugitive emission, stack emission, diesel exhaust, mechanical ground disturbance, etc.).
furans	One of a group of colorless, volatile, heterocyclic organic compounds containing a ring of four carbon atoms and one oxygen atom.

habitat	The physical location or type of environment in which an organism or biological population lives or occurs.
I-TEQ	International Toxic Equivalency Quotients (relative to 2,3,7,8 tetrachlorodibenzo-para-dioxin) are internationally established (through NATO) multiplication factors that are used to collectively express the toxicity of various dioxins, furans and co-planar PCBs (polychlorinated biphenyls) to humans, mammals, fish and birds relative to most toxic of these substances: 2,3,7,8-tetrachlorodibenzo-para-dioxin. The multiplication factors range from 0.000001 to 1.000000.
mercury	A heavy, silvery potentially toxic transition metal.
mine rock	Excavated bed rock surrounding the kimberlite deposits. Mine rock consists primarily of granitic rock material. It is also sometimes referred to as country rock or waste rock.
PM_{10}	Airborne particulate matter with a mean aerodynamic diameter less than 10 µm (microns). This represents the fraction of airborne particles that can be inhaled into the upper respiratory tract.
$PM_{2.5}$	Airborne particulate matter with a mean aerodynamic diameter less than 2.5 µm (microns). This represents the fraction of airborne particles that can be inhaled deeply into the pulmonary tissue.
processed kimberlite	The material that remains after all economically and technically recoverable diamonds have been removed from the kimberlite during processing.
Processed Kimberlite Containment	Man-made impoundment structure required to contain processed kimberlite slurry. Processed Kimberlite Containments are enclosed dykes made with granite rock and overburden materials, constructed to stringent geotechnical standards.
relative humidity	The ration of the amount of water vapour actually present in the air to the greatest amount possible at the same temperature.
total suspended particulate	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.
west/south Rock Pile	An area for storing and containing the mine rock and potentially acid generating rock.
zone of influence	Defined as the area surrounding a development that changes the behaviour, movement and distribution of wildlife.