APPENDIX B

Air quality impact assessment
(Airshed Planning Professionals)

Project done on behalf of
Softchem (Pty) Ltd

AIR QUALITY IMPACT ASSESSMENT FOR THE PROPOSED OMAHOLA PROJECT, REPTILE URANIUM NAMIBIA

Report No.: APP/10/SOF-01 Rev 1

October 2010

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REPORT DETAILS

Reference	APP/10/SOF
Status	Final Report Revision 1
Report Title	Air Quality Impact Assessment for the Proposed Omahola Project, Reptile Uranium Namibia
Date Submitted	October 2010
Client	Softchem (Pty) Ltd
Prepared by	Hanlie Liebenberg-Enslin, MSc (RAU, now University of Johannesburg) Lerato Khumalo, MSc (University of Witwatersrand)
Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighborhood concerns to regional air pollution impacts. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
Declaration	Airshed is an independent consulting firm with no interest in the project other than to fulfil the contract between the client and the consultant for delivery of specialised services as stipulated in the terms of reference.
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Acknowledgements	The authors would like to express their sincere appreciation for the invaluable discussions and technical input from Craig De Jager of SNC-Lavalin (Pty) Ltd

EXECUTIVE SUMMARY

INTRODUCTION

Airshed Planning Professionals (Pty) Ltd was appointed by Softchem (Pty) Ltd (Softchem) to undertake an air quality impact assessment for the proposed Omahola Project, Reptile Uranium Namibia (RUN). This proposed project will involve the mining of two open cast mines, Inca and Tubas Red Sand, which are located ~40 km east-southeast of Swakopmund in the Erongo Region in Namibia.

The open cast mining operations at Inca will include drilling and blasting within the open pit, removal and transfer of material, truck movement on unpaved haul roads, crushing and screening, processing and generation of waste material such as waste rock and tailings. The Tubas Red Sand will mainly include excavation of soft uranium bearing material, with drilling but no blasting. The excavated material will be transported via haul truck to the main processing plant located at Inca. The uranium recovery processing plant will include utilities such as a diesel-fired boiler to start the autoclave. The autoclave will be a 6 stage mechanically agitated horizontal pressure vessel whose main functions include increasing the overall uranium recovery process (due to the very high uranium leach efficiency inside the autoclave) and production of heat that will increase the atmospheric leach circuit temperature.

TERMS OF REFERENCE

The terms of reference for the *baseline air quality characterisation* component of the assessment were as follows:

A ***baseline air quality characterisation***, including the following:

- Determination of the regional climate and site-specific atmospheric dispersion potential through the analysis of meteorological data as obtained from Bannerman Resources' Etango Project.
- Identification of potential sensitive receptors within the vicinity of the proposed project site (ecologically and human health).
- Identification of existing sources of dust emissions in the area (relating to ecological sensitive areas and human health).
- Reporting on legislative and regulatory requirements pertaining to air quality for Namibia, including dust fall classifications. International criteria for the World Bank (WB) and World Health Organisation (WHO) and the South African National Ambient Standards were included.
- Use of the Erongo Region SEA Air Quality results to inform the baseline situation at the proposed Omahola Project site.

An ***air quality impact study****,* including the assessment of*:*

- Quantification of all sources of atmospheric emissions that would result from the proposed mining operations. These included the following sources:
  - o Opencast mining operations;
  - o Vehicle activity of the unpaved haul roads from the open pits to the processing plant

    - and stockpiles (ROM, waste dumps and tailings),
    - Crushing and screening operations;
    - Materials handling operations (i.e. tipping, loading and off-loading);
    - Wind erosion from exposed areas such as the waste rock dump, ROM and tailings/slimes dam; and,
    - In-pit emissions due to drilling, blasting and excavation activities.
- Dispersion simulations of ground level PM10 concentrations and dust fallout for the proposed Inca and Tubas Red Sand mining operations reflecting highest daily and annual average PM10 concentrations and dust deposition due to *routine* and *upset* emissions from the opencast mining operations. Atmospheric Dispersion Modelling System (ADMS) developed by the Cambridge Environmental Research Consultants (CERC) was used for the study.
- Analysis of dispersion modelling results, including:
    - Determination of zones of maximum incremental ground level impacts (concentrations and dust fallout from each source); and,
    - Determination of zones of maximum predicted cumulative ground level impacts (concentrations and dust fallout from all sources at the proposed mines).
- Evaluation of potential for human health and environmental impacts.
- Preparation of predicted PM10 concentrations and dust fallout level model output files (for the proposed operations) to be used by the Radiation Specialists to determine the potential impacts from radiation within the modelling domain.

A ***dust management plan*** for the proposed mining operations including*:*

- Identification of significant sources based on emission rates and ranked according to existing knowledge on impact significance.
- Estimation of emission control efficiencies required for each significant source;
- Identification of suitable pollution abatement measures able to realise the required dust control efficiencies, and possible contingency measures;
- Specification of source-based performance indicators, targets, and monitoring methods applicable for each source;
- Recommendation of receptor-based performance indicators comprising of a monitoring network and targets; and,
- Recommendations pertaining to record keeping, environmental reporting and community liaison.

ASSUMPTIONS AND LIMITATIONS

While emissions inventories and dispersion simulations for existing mining operations are normally based on actual activities, proposed operations are based on design specifications. This usually results in limited data and calls for certain assumptions to be made. It is important to understand these constraints specifically when interpreting the simulated results. Data limitations and assumptions associated with the proposed Omahola Project are listed below:

- The impact assessment was limited to airborne particulates (including TSP and PM10). Although the proposed activities will also emit gaseous pollutants from vehicle exhausts, the impact of these compounds are regarded to be low and was omitted from this study. Emissions emanating from the proposed diesel-fired boiler were not quantified due to limited information available at the time of the study. However, it is highly likely that the emissions from the proposed boiler will be low due to the fact the boiler will be used for start-up of the autoclave and will only effectively operate approximately 72hrs per year.

- No measured long-term ambient monitored concentration data were available for the proposed project site. Reference was made of the limited ambient concentration and dust fallout data reported on in the SEA study and simulated baseline results.

- The dispersion model (ADMS) cannot compute real time mining processes, therefore average mining process throughputs were utilised. Thus even though the nature of the open pit mining operations (pit utilisation and roads) change over the life of mine, the proposed open pit mining areas were modelled to reflect the worst case condition (i.e. resulting in the highest impacts).

- Routine emissions for the proposed operations were simulated. Atmospheric releases occurring as a result of non-routine conditions were not accounted for. Blasting is seen as an intermittent source of emissions (non-routine) but was included in the routine simulations. The reason being that ambient air quality standards and guidelines for particulates are limited to 24-hour averages and cannot determine the significance of short-term releases such as blasting.

- Since the mining operations are proposed, particle size distributions for stockpiles (overburden, ROM and road surfaces) were not available and therefore particle sizes from the Langer Heinrich Mine operations were utilised for the purposes of the study.

- The range of uncertainty of the model predictions could to be -50% to 200%. There will always be some error in any geophysical model, but it is desirable to structure the model in such a way to minimise the total error. A model represents the most likely outcome of an ensemble of experimental results. The total uncertainty can be thought of as the sum of three components: the uncertainty due to errors in the model physics; the uncertainty due to data errors; and the uncertainty due to stochastic processes (turbulence) in the atmosphere.

- In the Erongo Region, particularly in the western parts, a distinct thin crust on the surface binds the material reducing the potential for wind erosion when undisturbed. When disturbed, very fine loose material are exposed to wind erosion. The effect of natural crusting were accounted for in the estimation of wind erodible material through a set of equations (Section 6.3).

- Radiation (radon and various radionuclides) associated with the proposed future operations has not been covered as part of the air quality study and will be addressed by the Radiation Specialist. The predicted PM10 concentrations and dust fallout levels were used by the Radiation Specialist to determine the potential impacts from radiation within the modelling domain. For radon, separate dispersion simulations were conducted.

EVALUATION CRITERIA

Air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. Ambient air quality guidelines and standards aim to protect public health therefore these are applied to off-site areas rather than on-site occupational impacts. However, no sensitive receptors located relatively close to the proposed project site were identified. Thus, the predicted impacts at the proposed project site boundary were the main focus of the assessment. To date no ambient air quality guidelines or standards, or emission limits have been developed for Namibia. Reference was therefore made to the proposed evaluation criteria from the Strategic Environmental Assessment (SEA) based on the World Health Organisation guidelines..

BASELINE ASSESSMENT

Anthropogenic sources of emission in the vicinity of the proposed Omahola Project site mostly include mining activities. Current operating mines in the Erongo Region include Rössing Uranium Mine, located ~40 km to the north northeast of the Omahola Project site, Langer Heinrich Uranium Mine, situated ~44 km to the east. Valencia Uranium and Trekkopje mines are approved proposed uranium mines in the region and will also utilise opencast mining methods.

With the two mining licenses falling within the Namib Naukluft Park, there are no permanent residential areas in close proximity to the proposed Inca and Tubas Red Sand mine sites. The largest town in the Erongo region is Swakopmund (located ~40 km to the west-northwest) of the project, with Walvis Bay located more or less the same distance to the southwest. The Rooikop Airport is approximately 30 km to the southwest of Inca and closer to Tubas Red Sand.

Dispersion Potential of the Site

Meteorological data were obtained for the period November 2007 to June 2010 from the Bannerman Etango Project on-site meteorological station. The prevailing wind direction is from the northwest and the southwest with very little airflow from the southeast. The summer months are dominated by winds from the northwest, with almost no flow from the easterly and southerly sectors while autumn is dominated by winds from the east-northeast. East-northeasterly winds, characterised by very high wind speeds, are very prominent during winter. The prevailing wind field returns to the dominant northwesterly flow during the spring months, with frequent northerly winds.

Existing Air Quality in the Region

Predicted background concentrations and measured dust deposition rates were obtained from the SEA study recently undertaken for the Erongo Region. Background concentrations predicted around the proposed Omahola Project site are in the region of 180 μg/m³ (highest daily) and 40 μg/m³ (annual average).

A dust fallout monitoring network, comprising of 20 single dust fallout buckets, was established in August 2009 for the Erongo Region. The sites were selected to capture all background dust sources such as natural wind erosion, dust from unpaved roads and current mining and exploration activities. Dust fallout data for eleven months (August 2009 to June 2010) were available for inclusion into the SEA report.

Three dust fallout buckets (SEA_03, SEA_05 and SEA_17) located relatively close to Reptile Uranium's Omahola Project site were selected as representative of the site. The collected average background dust fallout rates (average for the period August 2009 to June 2010) are in the region of 44 mg/m²/day.

EMISSIONS INVENTORY

Emissions from the proposed project's construction phase were not quantified due to limited information. However, all pollution generating sources for the proposed Inca and Tubas Red Sand open cast mines were identified and emissions quantified. The establishment of an emissions inventory is necessary to provide the source and emissions data required as input to the dispersion simulations. The proposed mining activities' sources of emissions included vehicle activity on the unpaved haul roads, wind erosion from waste rock dumps, tailings dam and ROM stockpile, materials transfer points, and crushing and screening. In-pit operations' sources accounted for included excavation of ore and waste rock, drilling, blasting and equipment movement within the pits. Gaseous emissions from vehicles and equipment were regarded as insignificant and omitted from the study.

The following scenarios were included in the dispersion modelling:

- *Scenario 1*: Proposed Inca and Tubas Red Sand operational phases assuming unmitigated emissions for all sources.
- *Scenario 2*: Proposed Inca and Tubas Red Sand operational phases assuming 75% control efficiency for the unpaved roads, 60% crushing and screening, 30% for all wind erosion stockpiles and 90% for the ROM stockpile.

The main sources of *emissions* were as follows:

Scenario 1

- Unpaved roads were predicted to be the most contributing source to PM10 and TSP emissions (84% and 83% respectively).
- The second most significant source of PM10 and TSP was predicted to be excavating activities, with a contribution of 11% to PM10 and 8% to TSP.
- Drilling was predicted to be the third most significant source and fourth most significant source of TSP emissions, with a contribution of 3% and 1% respectively.

Scenario 2

- Despite the application of a control efficiency of 75%, the unpaved roads were still predicted to be the most contributing source to PM10 and TSP emissions (58% and 63% respectively).
- The second most significant source of PM10 and TSP emissions was predicted to be excavating activities, with a contribution of 30% to PM10 and 24% to TSP.
- Drilling was predicted to be the third most significant source and fourth most significant source of TSP emissions, with a contribution of 7% and 3% respectively.

IMPACT ASSESSMENT

In addition to being the most significant sources of emissions (PM10 and TSP), the unpaved roads were also predicted to be the most impacting sources at the proposed project site boundary for all the modelled *scenarios.*

Proposed Construction Phase

Although a quantitative assessment for the construction phase of the proposed Omahola Project was not undertaken, *incremental* concentrations and dust deposition rates were estimated to be of medium environmental significance when the Softchem impact assessment methodology was applied (Table A).

Table A: Significance rating of proposed construction phase impacts

Environmental aspect	Air quality					Phase	Construction
Description: The construction phase will comprise land clearing, site development operations and erecting the associated infrastructure. Each of these activities will have a potential for dust generation							
Mitigation: General mitigation measures for dust include wet suppression and wind speed reduction							
Confidence level	Mitigation required	Evaluation of impacts					
		Nature	Extent	Duration	Intensity	Probability	Significance
Low*	yes	negative	3	1	2	6	36
Potential for irreplaceable loss of resources		N/A	Cumulative impacts		yes	Reversibility	yes

Detailed information on the proposed construction phase was not available at the time the study was undertaken.

N/A- Not applicable to air quality

Scenario 1 and Scenario 2: Unmitigated and Mitigated Proposed Mining Operations

The predicted unmitigated highest average daily ground level concentrations for the proposed Omahola Project operations exceeded the selected evaluation criteria at the proposed project site boundary (at Inca). However, with mitigation measures in place for major contributing sources such as unpaved roads, resulted in a significant reduction in the predicted impacts. not exceeding the evaluation criteria at the proposed project site boundary. No exceedances of the PM10 daily and annual evaluation criteria were predicted at Rooikop Airport. . However, when background concentrations in the region were taken into consideration, exceedances of the relevant daily and annual PM10 criteria were predicted for the all modelled *scenarios.*

The predicted maximum daily dust deposition rates did not exceed the SANS residential limit or German standard at the proposed project site boundary or Rooikop Airport. The consideration of background dust fallout in the region also did not result in exceedances of these evaluation criteria for the unmitigated and mitigated *scenarios.*

The potential impacts due to the proposed mitigated operational phase will be of medium significance (Table B). There is a high potential for additive cumulative impacts occurring due to the proposed Omahola Project and the existence of similar uranium mining operations in the Erongo Region that will have a high significance.

Table B: Significance rating of proposed operational phase impacts

Environmental aspect	Air quality					Phase	Operational
Description: The proposed operational phase for the Omahola Project will include dust generating activities such as excavation, drilling, blasting, materials handling activities, wind erosion of stockpiles, hauling of ore and waste on unpaved roads and crushing and screening.							
Mitigation: General mitigation measures for dust include wet suppression on unpaved roads, materials handling activities and crushing and screening							
Confidence level	Mitigation required	Evaluation of impacts					
		Nature	Extent	Duration	Intensity	Probability	Significance
medium*	**yes**	**negative**	**3**	**3**	**2**	**6**	48
Potential for irreplaceable loss of resources		**N/A**	Cumulative impacts		**yes**	Reversibility	**yes**

Assumptions were made (based on similar mining operations in the region) where information on the proposed operational phase was not available at the time the study was undertaken.

N/A- Not applicable to air quality

Closure Phase

The potential for impacts during the closure phase are dependent on the extent of demolition and rehabilitation efforts during closure and on features which remain and these include the tailings dam and waste dumps. The potential impacts due to the closure phase of the Omahola Project would be of medium significance (Table C).

Table C: Significance rating of closure phase impacts

Environmental aspect	**Air quality**					Phase	**Closure**
Description: The closure phase will comprise demolition and rehabilitation activities. Each of these activities has a potential for dust generation							
Mitigation: General mitigation measures for dust include wet suppression							
Confidence level	Mitigation required	Evaluation of impacts					
		Nature	Extent	Duration	Intensity	Probability	Significance
Low*	yes	positive	3	1	2	6	36
Potential for irreplaceable loss of resources		N/A	Cumulative impacts		yes	Reversibility	yes

Detailed information on the proposed closure phase was not available at the time the study was undertaken.

N/A- Not applicable to air quality

CONCLUSIONS

The main conclusion is that exceedances of the relevant evaluation criteria for average highest daily PM10 concentrations were predicted at the proposed project site boundary as a result of the unmitigated mining operations (without taking background concentrations into consideration). However, the application of suitable mitigation measures to the main contributing sources of PM10 and TSP emissions, i.e. the unpaved roads, would result in the reduction of impacts at the proposed project site boundary. With the consideration of background concentrations, exceedances of the relevant evaluation criteria for PM10 were predicted for all the modelled scenarios. It should be noted that this is primarily due to windblown dust from natural background sources with the additional contribution from the Omahola Project at Walvis Bay for instance, at about 1% (Liebenberg-Enslin et.al., 2010)..

Reference data on the impacts of particulates on plants and animals are scarce and therefore the impacts of the proposed operations on vegetation and animals could not be quantified. Given that it is a desert area, it is expected that the natural vegetation will have a tolerance for dust impacts. This however, will have to be confirmed through monitoring certain species in the region.

RECOMMENDATIONS

Target controls for the Main Sources

Proposed Construction Phase

- Construction of the tailings dam wall, processing plant, crusher area – 50% control efficiency through effective water sprays.
- Vehicle entrainment on temporary unpaved roads – 75% control efficiency through effective water sprays (assuming use of extracted salt water) on haul roads.

Proposed Operational Phase

- Vehicle entrainment on unpaved haul roads –~90% control efficiency through the application of chemical surfactants for surface paving.
- Vehicle entrainment on in-pit haul roads – these roads change depending on the area to be mined and hence it is not practical to apply chemicals. It is recommended that a minimum of 75% control efficiency be achieved through affective water sprays (assuming use of extracted salt water).
- Open pit operations- all materials handling operations within the open pit will reduce dust generation by 62% by merely doubling the moisture content of the material handled.

Closure Phase

It is assumed that all mining activities and processing operations will have ceased by the closure phase of the project. The potential for impacts during this phase will depend on the extent of demolition and rehabilitation efforts of the remaining features such as waste dumps and tailings dam.

Suitable Mitigation Measures

Unpaved haul roads

One of the main benefits of chemical stabilisation in conjunction with wet suppression is the management of water resources. Given the extraction of salt water from the mining areas, it is recommended that this be used for dust suppression for the salt will have a similar effect as water combined with chemicals (as is currently the case on the road between Walvis Bay and Swakopmund).

Open Pit Sources

All materials handling operations within the open pit will reduce dust generation by 62% by merely doubling the moisture content of the material handled.

Monitoring Requirements

Key performance indicators against which progress may be assessed form the basis for all effective environmental management practices.

Source based performance indicators include the following:

- No visible dust on unpaved roads when trucks/vehicles drive on the roads. It is recommended that dust fallout in the immediate vicinity of the road perimeter be less than 1,200 mg/m^2/day.
- The absence of visible dust plume at all tipping points and outside the primary crusher would be the best indicator of effective control equipment in place. In addition the dust fallout in the immediate vicinity of the tipping and crushing sources should be less than 1,200 mg/m^2/day.
- From all activities associated with the current, proposed 2016 operational phases and closure phase, dust fallout levels should not exceed 600 mg/m^2/day at the proposed project site boundary.

It is also recommended that dust fallout monitoring be undertaken downwind of the proposed processing plant, primary crusher, tailings, waste dump stockpiles and open pits. Single dust buckets can also be located close to the unpaved roads as these have been predicted to be the major contributing sources to particulates, especially the proposed long unpaved haul road from Tubas Red Sand to Inca.

Record-keeping and Environmental Reporting

It is recommended that site inspections and progress reporting be undertaken at regular intervals (at least quarterly) when mining operations commence, with annual environmental audits being conducted. Annual environmental audits should form part of the overall Environmental Management System (EMS) for the proposed Omahola Project. A budget should be drawn to provide a clear indication of the capital and annual maintenance costs associated with dust control measures and dust monitoring plans.

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LIST OF ACRONYMS AND SYMBOLS

ADMS	Atmospheric Dispersion Modelling System
Airshed	Airshed Planning Professionals (Pty) Ltd
amsl	above mean sea level
APCS	Air Pollution Control System
APIA	Air Pollution Impact Assessment
APPA	The Atmospheric Pollution Prevention Act (No.45 of 1965)
ADMS	Atmospheric Dispersion Modelling System
C	Carbon
CH_4	Methane
CERC	Cambridge Environmental Research Consultants
CO	Carbon Monoxide
DEA	Department of Environmental Affairs
DME	The Department of Minerals and Energy
EMP	Environmental Management Programme
EHS	Environmental, Health, and Safety Guidelines
EC	European Community
GDP	Gross Domestic Product
GIIP	Good international industry practice
HSE	UK Health and Safety Executives
IFC	International Finance Corporation
MWth	Megawatt thermal
m^3	Cubic metre
NEMAQA	South Africa National Environment Management Air Quality Act (No. 39 of 2004)
NO_x	Oxides of Nitrogen
PM10	Particulate Matter with an aerodynamic diameter of less than 10μ
PM2.5	Particulate Matter with an aerodynamic diameter of less than 2.5μ
PPM	Parts per Million
ROM	Run Of Mine
SA	South Africa
SANS	South African National Standards
SO_2	Sulphur Dioxide
tpd	Tons Per Day
TSP	Total Suspended Particles
μ	Microns
μ**g**	Micrograms
US-EPA	United States Environmental Protection Agency
WB	The World Bank Group
WHO	The World Health Organisation

AIR QUALITY IMPACT ASSESSMENT FOR THE PROPOSED OMAHOLA PROJECT, REPTILE URANIUM NAMIBIA

1 INTRODUCTION

Airshed Planning Professionals (Pty) Ltd was appointed by Softchem (Pty) Ltd (Softchem) to undertake an air quality impact assessment for the proposed Omahola Project, Reptile Uranium Namibia (RUN). This proposed project will involve the mining of two open cast mines, Inca and Tubas Red Sand, which are located ~40 km east southeast of Swakopmund in the Erongo Region in Namibia (Figure 1-1). The mining licensing areas are shown in Figure 1-2.

The open cast mining operations at Inca will include drilling and blasting within the open pit, removal and transfer of material, truck movement on unpaved haul roads, crushing and screening, processing and generation of waste material such as waste rock and tailings (Figure 1-3). The Tubas Red Sand will mainly include excavation of soft uranium bearing material, with drilling but no blasting. The excavated material will be transported via haul truck to the main processing plant located at Inca. The uranium recovery processing plant will include utilities such as a diesel-fired boiler to start the autoclave. The autoclave will be a 6 stage mechanically agitated horizontal pressure vessel whose main functions include increasing the overall uranium recovery process (due to the very high uranium leach efficiency inside the autoclave) and production of heat that will increase the atmospheric leach circuit temperature.

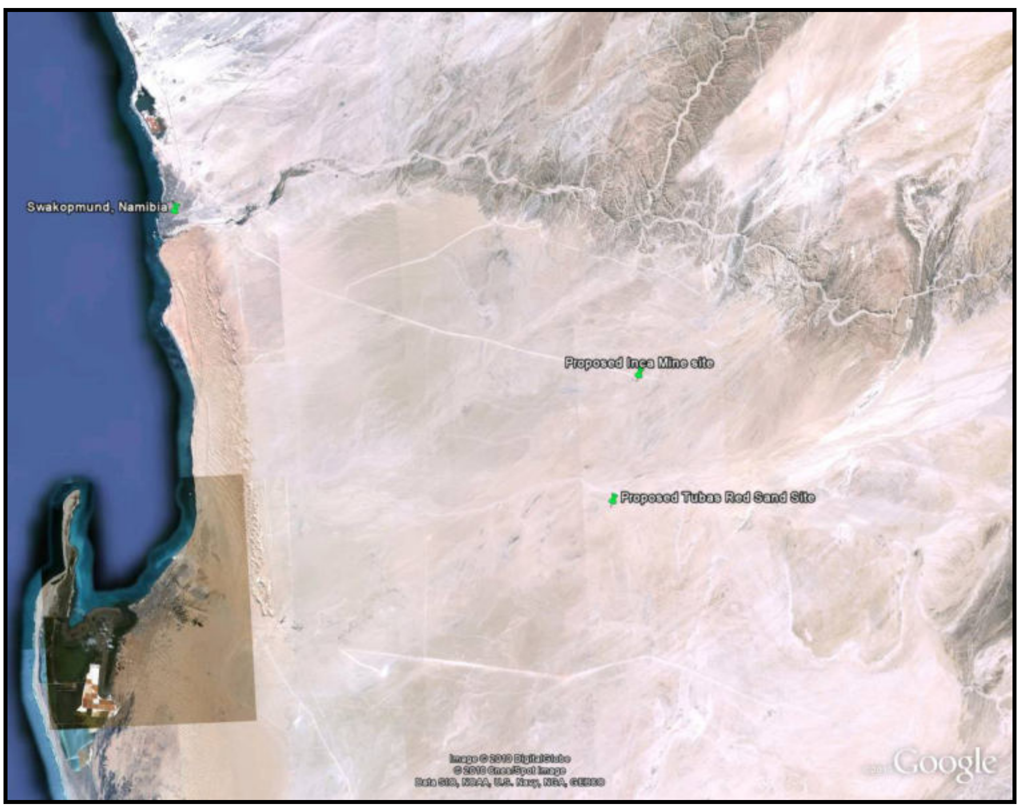

Figure 1-1: Location of proposed Inca and Tubas Red Sand open cast mines in relation to Swakopmund

The main concern regarding opencast mining operations is the generation of dust, impacting both on the environment and human health. However, given the location of the proposed project site away from sensitive receptors, concerns for off-site impacts are reduced.

1.1 Site Description and Sensitive Receptors

The proposed project site is located on the eastern edge of the Desert Zone and elevation on the mine site varies from 144 m above mean sea level to 170 m above mean sea level.

With the two mining licenses falling within the Namib Naukluft Park, there are no permanent residential areas in close proximity to the proposed Inca and Tubas Red Sand mine sites. The largest town in the Erongo region is Swakopmund (located ~40 km to the west-northwest) of the project with Walvis Bay located more or less the same distance to the southwest. The Rooikop Airport is approximately 30 km to the southwest of Inca and closer to Tubas Red Sand (Figure 1-4).

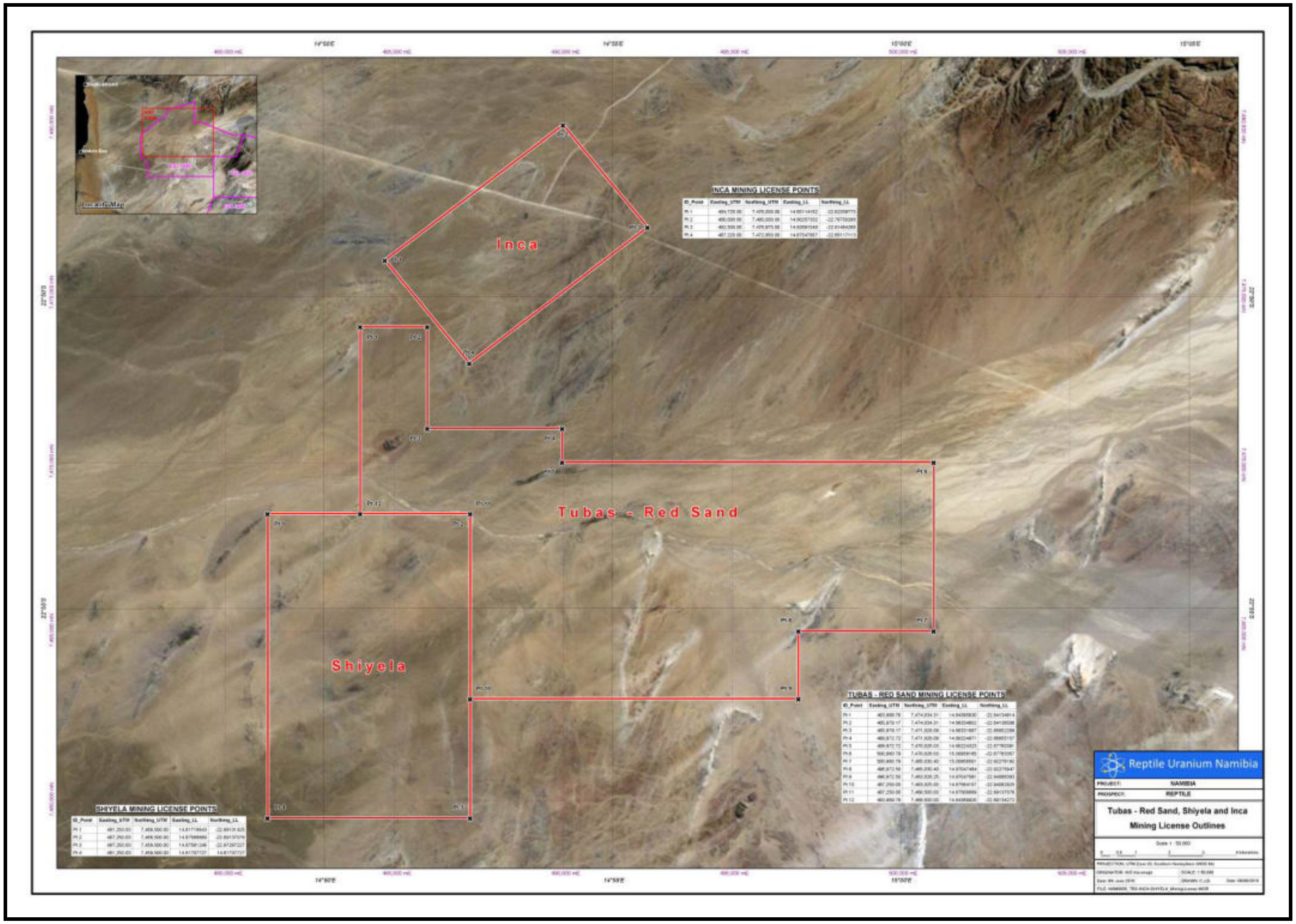

Figure 1-2: Mining licensing areas for Reptile Uranium's proposed Inca and Tubas Red Sand open cast mines.

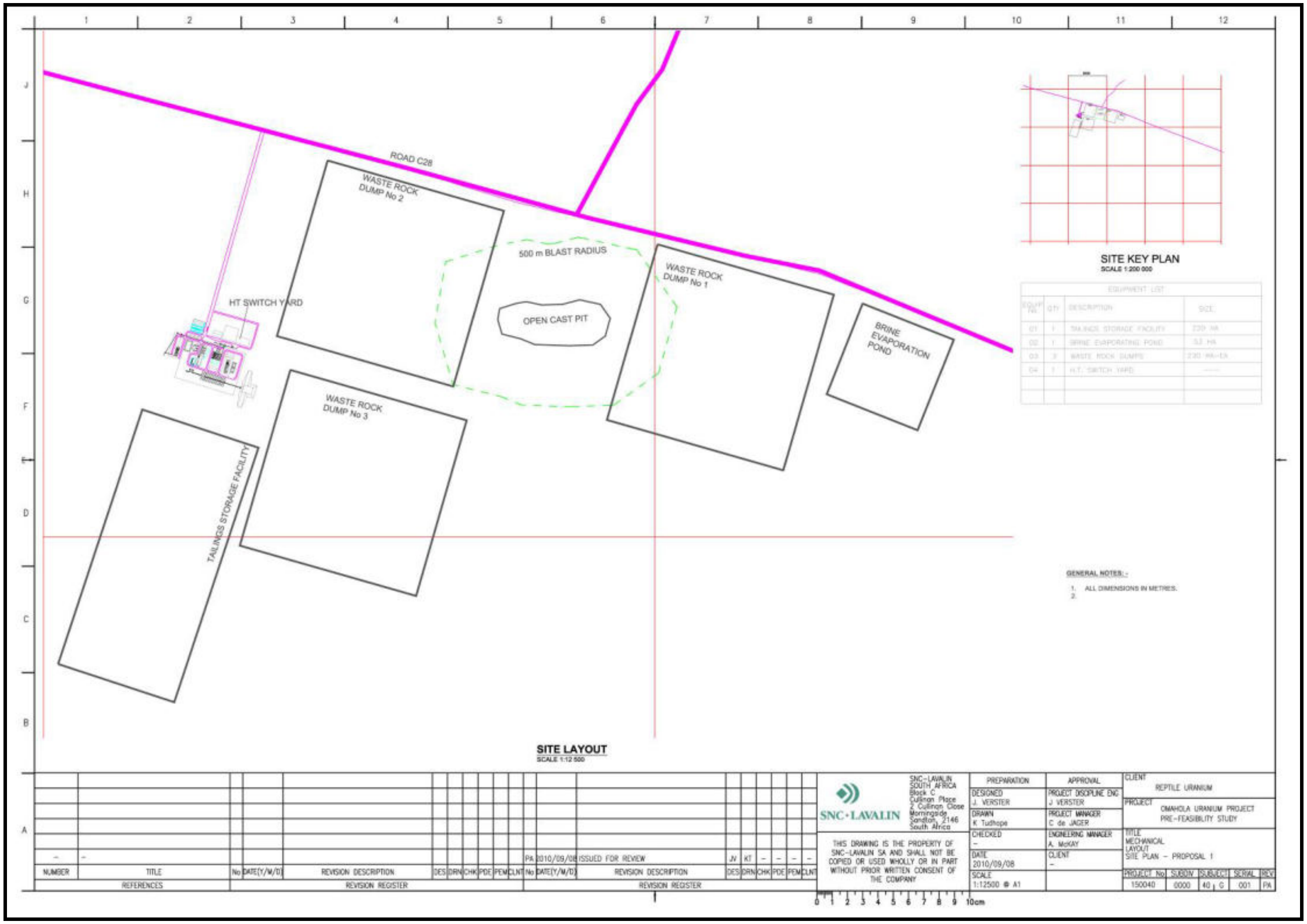

Figure 1-3: Mine layout for the proposed Inca mining operations

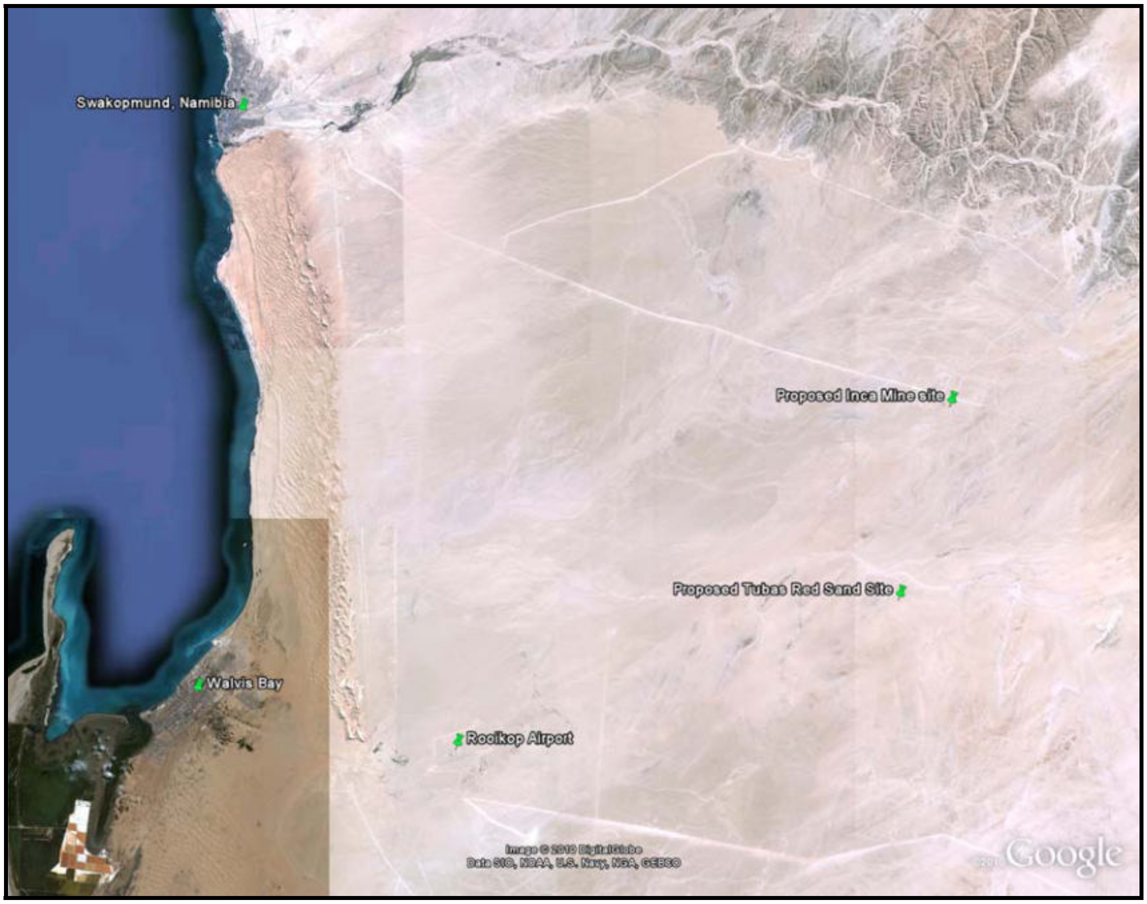

Figure 1-4: Location of sensitive receptors in relation to the proposed Omahola Project

1.2 Terms of Reference

A ***baseline air quality characterisation***, including the following:

- Determination of the regional climate and site-specific atmospheric dispersion potential through the analysis of meteorological data as obtained from the on-site weather station or closest weather station.
- Identification of potential sensitive receptors within the vicinity of the proposed mine sites (ecologically and human health).
- Identification of existing sources of dust emissions in the area (relating to ecological sensitive areas and human health).
- Report on legislative and regulatory requirements pertaining to air quality for Namibia, including dust fall classifications. International criteria will also be included such as the World Bank (WB) and World Health Organisation (WHO).
- Use the Erongo Region SEA Air Quality results to inform the baseline situation at the Omahola Project.

An ***air quality impact study****,* including the assessment of*:*

- Quantification of all sources of atmospheric emissions that would result from the proposed mining operations. These include the following sources:

  - Opencast mining operations;
  - Vehicle activity of the unpaved haul roads from the open pits to the processing plant and stockpiles (ROM, waste dumps and tailings),
  - Crushing and screening operations;
  - Materials handling operations (i.e. tipping, loading and off-loading);
  - Wind erosion from exposed areas such as the waste rock dump, ROM and tailings/slimes dam; and
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- Evaluation of potential for human health and environmental impacts.
- Preparation of predicted PM10 concentrations and dust fallout rate output files (for the proposed operations) to be used by the Radiation Specialist to determine the potential impacts from radiation within the modelling domain.

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  - Specification of source-based performance indicators, targets, and monitoring methods applicable for each source;
  - Recommendation of receptor-based performance indicators comprising of a monitoring network and targets; and
  - Recommendations pertaining to record keeping, environmental reporting and community liaison.

1.3 Report Structure

Chapter 2	Outlines the methodology and approach utilised in this study.
Chapter 3	Comprises a description of the legislative overview and the guidelines and standards to which the results are referenced.
Chapter 4	Addresses the atmospheric dispersion potential of the region.
Chapter 5	Discussion on the background sources of atmospheric pollution in the region as well as available air quality data.
Chapter 6	Emissions inventory pertaining to the quantification of atmospheric sources for the proposed mining operations are discussed.

Chapter 7	Provides a qualitative impact assessment for the proposed construction phase of the Omahola Project.
Chapter 8	The impact assessment for the proposed operational phase of the Omahola Project is provided in this section
Chapter 9	Provides a qualitative impact assessment for the closure phase of the proposed project
Chapter 10	Conclusions and recommendations
Chapter 11	Air Quality Management Plan for the proposed Omahola Project based on the study main findings and recommendations.

2 METHODOLOGY

In assessing atmospheric impacts from the proposed mining operations, an emissions inventory was undertaken, atmospheric dispersion modelling conducted and predicted air pollutant concentrations evaluated.

2.1 Baseline Assessment

The baseline assessment served to give a detailed description of the state of the environment and existing levels of pollution within the region.

2.1.1 Dispersion Potential of the Site

Meteorological mechanisms govern the dispersion, transformation, and eventual removal of pollutants from the atmosphere. Meteorological data from Bannerman Mining Resources Namibia (Pty) Ltd's (Bannerman) Etango Project's on-site meteorological station were obtained for the period November 2007 to June 2010. This station is located a mere 11 km directly north-northwest of Inca. Meteorological data included hourly average wind speed, wind direction and temperature. Mixing heights were estimated for each hour, based on prognostic equations. Wind speed and solar radiation were used to calculate hourly stability classes. The analysis of the meteorological data included diurnal temperature profiles, wind roses, atmospheric stability classifications. For the purposes of establishing the local climatology, it was necessary to analyse the period data (November 2006 to June 2010), however, the US.EPA stipulates a five-year database. An analysis of the data served to provide a general description of the local climate and to calculate fugitive airborne dust emissions to be used in the dispersion simulations.

2.1.2 Ambient Concentrations and Dust Fallout levels

For the completion of a baseline investigation, a good understanding of the existing ambient air quality in the region is required. Existing measured dust fallout data obtained from the Erongo Region SEA study were included in this study. Ambient monitored PM10 concentrations from the Etango project (located at the weather station) were used to provide an indication of the background together with simulated results from the SEA study (Liebenberg-Enslin *et.al*., 2010).

2.2 Emissions Inventory

An emissions inventory was established and comprised emissions for the proposed operational phases of Inca and Tubas Red Sand open cast mines. An emissions inventory is necessary to provide the source and emissions data required as input to the dispersion simulations. The release of particulates represents the most significant emission and is the focus of the study.

In the quantification of emissions (Section 6), use was made of predictive emission factor equations published by the US-EPA (EPA, 1996) and NPi (2001). An emission factor is a representative value that relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. Emission rates for pollutants (PM10 and TSP) from the proposed mining operations were calculated using US-EPA and NPi emission factors.

2.3 Selection of dispersion model

Dispersion models compute ambient concentrations as a function of source configurations, emission strengths and meteorological characteristics, thus providing a useful tool to ascertain the spatial and temporal patterns in the ground level concentrations arising from the emissions of various sources. Increasing reliance has been placed on concentration estimates from models as the primary basis for environmental and health impact assessments, risk assessments and emission control requirements. It is therefore important to carefully select a dispersion model for the purpose.

For the purpose of the study, it was decided to use the Atmospheric Dispersion Modelling System developed by the Cambridge Environmental Research Consultants (CERC). CERC was established in 1986, with the aim of making use of new developments in environmental research from Cambridge University and elsewhere for practical purposes. CERC's leading position in environment software development and associated consultancy has been achieved by encapsulating advanced scientific research into a number of computer models which include ADMS 4. This model simulates a wide range of buoyant and passive releases to the atmosphere either individually or in combination. It has been the subject of a number of inter-model comparisons (CERC 2000, Hall *et.al.,* 2001), one conclusion of which is that it tends to provide conservative values under unstable atmospheric conditions in that it predicts higher concentrations than the older models close to the source.

ADMS 4 is a new generation air dispersion model which means that it differs from the regulatory models traditionally used in a number of aspects, the most important of which are the description of atmospheric stability as a continuum rather than discrete classes (the atmospheric boundary layer properties are described by two parameters; the boundary layer depth and the Monin-Obukhov length, rather than in terms of the single parameter Pasquill Class) and in allowing more realistic asymmetric plume behaviour under unstable atmospheric conditions. Dispersion under convective meteorological conditions uses a skewed Gaussian concentration distribution (shown by validation studies to be a better representation than a symmetric Gaussian expression).

ADMS 4 is currently used in many countries worldwide and users of the model include Environmental Agencies in the UK and Wales, the Scottish Environmental Protection Agency (SEPA) and regulatory authorities including the UK Health and Safety Executive (HSE).

Concentration and deposition distributions for various averaging periods may be calculated. It has generally been found that the accuracy of off-the-shelf dispersion models improve with increased averaging periods. The accurate prediction of instantaneous peaks are the most difficult and are normally performed with more complicated dispersion models specifically fine-tuned and validated for the location. For purposes of this report, the shortest time period modelled is one hour.

There will always be some error in any geophysical model, but it is desirable to structure the model in such a way to minimise the total error. The total uncertainty can be thought of as the sum of three components: the uncertainty due to errors in the model description of atmospheric physics; the uncertainty due to data errors; and the uncertainty due to stochastic processes (turbulence) in the atmosphere.

Nevertheless, dispersion modelling is generally accepted as a valid tool to quantify and analyse the atmospheric impact of existing installations and for determination of the impact of future installations.

2.4 Meteorological data requirements

ADMS 4 requires hourly average meteorological data as input, including wind speed, wind direction, a measure of atmospheric turbulence, ambient air temperature and mixing height. Although an on-site meteorological station has been operational at the Inca site since June 2010, the monitored data (from June to August 2010) was not sufficient for a comprehensive baseline assessment and dispersion modelling. Hourly meteorological data for the period November 2007 to June 2010 from the Etango Project's on-site weather station was therefore used in the dispersion simulations. The mixing height for each hour of the day, as well as atmospheric stability, is estimated by the ADMS meteorological pre-processor.

2.5 Preparation of source data

ADMS 4 is able to model point, area, volume and line sources. For the proposed operational phase of the Inca and Tubas Red Sand open cast mines, the unpaved roads, drilling, blasting, excavation and the various storage piles were modelled as area sources. Materials handling and crushing and screening activities were modelled as volume sources. Due to the lack of detailed information for the proposed construction activities e.g., number of dozers to be used, size and locations of temporary stockpiles and temporary roads, rate of on–site vehicle activity, emissions were qualitatively assessed.

2.6 Preparation of receptor grid

The dispersion of pollutants was modelled for an area covering 35 km (north-south) by 35 km (east-west) for the study. This area was further divided into a receptor grid matrix with a resolution of 350 m. ADMS simulates ground-level concentrations for each of the receptor grid points. No sensitive receptors were included as discrete receptors as none are located relatively close to the proposed Omahola Project site.

2.7 Model input and execution

Input into the dispersion model includes prepared surface meteorological data, source data, information on the nature of the receptor grid and emissions input data. The model inputs were verified before the model was executed.

2.8 Predicted PM10 Concentrations and Dust Deposition rates due to background levels

Highest daily PM10 concentrations and maximum dust deposition rates due to the background levels were predicted by adding twice the predicted annual mean background concentration and average dust deposition rate (obtained from the SEA study for the Erongo Region) to the predicted highest daily concentrations/dust deposition rates (MFE, 2001). Annual PM10 concentrations due to background levels were predicted by adding the predicted annual PM10 concentration to the predicted background annual PM10 concentration.

2.9 Plotting of model outputs

Simulated outputs for PM10 (daily and annual), TSP (maximum daily) were plotted for the following *scenarios:*

- *Scenario 1*: Proposed Inca and Tubas Red Sand operational phases assuming unmitigated emissions for all sources.
- *Scenario 2*: Proposed Inca and Tubas Red Sand operational phases assuming 75% control efficiency for the unpaved roads, 60% for crushing and screening, 30% for all wind erosion stockpiles and 90% for the ROM stockpile.

2.10 Compliance analysis and impact assessment

The predicted air pollution concentrations and dustfall rates were compared to international air quality limits and health and welfare thresholds to facilitate compliance and impact assessments. These concentrations were summarised and form the basis of the compliance assessment and evaluation. The SOFTCHEM impact assessment methodology was used in the study.

2.11 Assumptions and Limitations

While emissions inventories and dispersion simulations for existing mining operations are normally based on actual activities, proposed operations are based on design specifications. This usually results in limited data and calls for certain assumptions to be made. It is important to understand these constraints specifically when interpreting the simulated results. Data limitations and assumptions associated with the proposed Omahola Project are listed below:

- The impact assessment was limited to airborne particulates (including TSP and PM10). Although the proposed activities will also emit gaseous pollutants from vehicle exhausts, the impact of these compounds are regarded to be low and was omitted from this study. Emissions emanating from the proposed diesel-fired boiler were not quantified due to limited information available at the time of the study. However, it is highly likely that the emissions from the proposed boiler will be low due to the fact the boiler will be used for start-up of the autoclave and will only effectively operate approximately 72hrs per year.
- No measured long-term ambient monitored concentration data were available for the proposed project site. Reference was made of the limited ambient concentration and dust fallout data reported on in the SEA study and simulated baseline results.
- The dispersion model (ADMS) cannot compute real time mining processes, therefore average mining process throughputs were utilised. Thus even though the nature of the open pit mining operations (pit utilisation and roads) change over the life of mine, the proposed open pit mining areas were modelled to reflect the worst case condition (i.e. resulting in the highest impacts).
- Routine emissions for the proposed operations were simulated. Atmospheric releases occurring as a result of non-routine conditions were not accounted for. Blasting is seen as an intermittent source of emissions (non-routine) but was included in the routine simulations. The reason being that ambient air quality standards and guidelines for particulates are limited to 24-hour averages and cannot determine the significance of short-term releases such as blasting.

- Since the mining operations are proposed, particle size distributions for stockpiles (overburden, ROM and road surfaces) were not available and therefore particle sizes from the Langer Heinrich Mine operations were utilised for the purposes of the study.
- The range of uncertainty of the model predictions could to be -50% to 200%. There will always be some error in any geophysical model, but it is desirable to structure the model in such a way to minimise the total error. A model represents the most likely outcome of an ensemble of experimental results. The total uncertainty can be thought of as the sum of three components: the uncertainty due to errors in the model physics; the uncertainty due to data errors; and the uncertainty due to stochastic processes (turbulence) in the atmosphere.
- In the Erongo Region, particularly in the western parts, a distinct thin crust on the surface binds the material reducing the potential for wind erosion when undisturbed. When disturbed, very fine loose material are exposed to wind erosion. The effect of natural crusting were accounted for in the estimation of wind erodible material through a set of equations (Section 6.3).
- Radiation (radon and various radionuclides) associated with the proposed future operations has not been covered as part of the air quality study and will be addressed by the Radiation Specialist. The predicted PM10 concentrations and dust fallout levels were used by the Radiation Specialist to determine the potential impacts from radiation within the modelling domain. For radon, separate dispersion simulations were conducted.

3 LEGAL REQUIREMENTS AND HUMAN HEALTH CRITERIA

In addressing the impact of air pollution emanating from the proposed operations, some background on the health effects of the various pollutants relevant to the study need to be provided. Since the terms of reference exclude a detailed toxicological study, this discussion is limited to the most important health impact aspects.

Air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. The ambient air quality guideline values and standards indicate safe daily exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. Air quality guidelines and standards are normally given for specific averaging periods. These averaging periods refer to the time-span over which the air concentration of the pollutant was monitored at a location. Generally, five averaging periods are applicable, namely an instantaneous peak, 1-hour average, 24-hour average, 1-month average, and annual average. The application of these standards varies, with some countries allowing a certain number of exceedances of each of the standards per year.

Reference is made to the ambient air quality guidelines as stipulated locally and internationally for criteria pollutants. This is discussed in more detail in the sections below.

3.1 Namibian Legislation

As far as could be ascertained, Namibia has adopted the South African air pollution legislation for air quality control in the form of the Atmospheric Pollution Prevention Act (Act No 45 of 1965) (APPA). Based on the stipulations of this act, the following parts are applicable:

- Part II : Controls of noxious or offensive gases;
- Part III : Atmospheric pollution by smoke;
- Part IV : Dust control; and
- Part V : Air pollution by fumes emitted by vehicles.

The Namibian Atmospheric Pollution Prevention Ordinance (No. 11 of 1976) does not include any ambient air standards to comply with, but the Chief Air Pollution Officer (CAPCO) provides air quality guidelines for consideration during the issuing of Air Pollution Certificates (APC). Air Pollution Certificates are only issued for so called “Scheduled Processes” which are processes resulting in noxious or offensive gasses and typically pertain to point source emissions. The air pollution guidelines included in the APC are primarily for criteria pollutants namely, sulphur dioxide, oxides of nitrogen, carbon monoxide, ozone, lead and particulate matter. Mining operations do not fall under “Scheduled Processes” and hence do not require an APC resulting in no specified ambient air quality guidelines.

3.2 International Requirements

Typically, when no local ambient air quality criteria exists, or are in the process of being developed, reference is made to international health screening criteria. This serves to provide an indication of the severity of the potential impacts from the proposed activities. The most widely referenced international air quality criteria are those published by the World Bank Group, the World Health Organisation and the European Community. The newly promulgated South African ambient air quality standards are also referenced since it is regarded more representative indicators for Namibia due to the similar environmental, social and economic characteristics between the two countries.

3.2.1 World Bank Requirements

As of April 30, 2007, new versions of the World Bank Group Environmental, Health, and Safety Guidelines (known as the 'EHS Guidelines') are now in use. They replace those documents previously published in Part III of the Pollution Prevention and Abatement Handbook and on the International Finance Corporation (IFC) website.

The new EHS Guidelines were developed as part of a two and a half year review process. The EHS Guidelines are intended to be 'living documents', and will be updated on a regular basis going forward.

When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures are appropriate in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

3.2.2 World Health Organisation

During the 1990s the World Health Organisation (WHO) stated that no safe thresholds could be determined for particulate exposures and responded by publishing linear dose-response relationships for PM10 and PM2.5 concentrations (WHO, 2005). This approach was not well accepted by air quality managers and policy makers. As a result the WHO Working Group of Air Quality Guidelines recommended that the updated WHO air quality guideline document contain guidelines that define concentrations which, if achieved, would be expected to result in significantly reduced rates of adverse health effects. These guidelines would provide air quality managers and policy makers with an explicit objective when they were tasked with setting national air quality standards. **Given that air pollution levels in developing countries frequently far exceed the recommended WHO air quality guidelines (AQGs), the Working Group also proposed interim targets (IT) levels, in excess of the WHO AQGs themselves, to promote steady progress towards meeting the WHO AQGs** (WHO, 2005).

3.2.3 European Community

The European Community (EC) air quality criteria represent objectives/standards to be achieved by the year 2004/2005 and were designed primarily to protect human health. The EC standards have superseded the European Union (EU) standards. The current EU standards were determined through consultation with due regard to environmental conditions, the economic and social development of various regions, and the importance of a phased approach to attaining compliance.

3.2.4 South Africa

It is not clear how the legal developments in South Africa will affect the Namibian legislation. It is however regarded more representative of the environmental, social and economic situation than the

European criteria. The South African Bureau of Standards (SABS) was engaged to assist the Department of Environmental Affairs (DEA) in the facilitation of the development of ambient air quality standards. This included the establishment of a technical committee to oversee the development of standards. Standards were determined based on international best practice for particulate matter less than 10 µm in aerodynamic diameter (PM_{10}), dustfall, sulphur dioxide, nitrogen dioxide, ozone, carbon monoxide, lead and benzene (SANS 69, 2006). These standards were published for comment in the Government gazette on 9 June 2007. The final standards were published on the 24th of December 2009 and include a margin of tolerance (i.e. frequency of exceedances) and implementation timelines linked to it.

3.3 Ambient Air Quality Standards and Guidelines

In this section, the guidelines and standards as stipulated by the World Bank Group (WBG) and the Namibian Government are discussed. The newly updated EHS guidelines published by the IFC in April 2007 reference the WHO guidelines or other internationally recognised sources (US and EC) in the absence of national legislated standards. The new South African ambient air quality standards are also referenced.

3.3.1 Suspended Particulate Matter

The impact of particles on human health is largely dependent on (i) particle characteristics, particularly particle size and chemical composition, and (ii) the duration, frequency and magnitude of exposure. The potential of particles to be inhaled and deposited in the lung is a function of the aerodynamic characteristics of particles in flow streams. The aerodynamic properties of particles are related to their size, shape and density. The deposition of particles in different regions of the respiratory system depends on their size.

Air quality guidelines for particulates are given for various particle size fractions, including total suspended particulates (TSP), thoracic dust or PM_{10} (i.e. particulates with an aerodynamic diameter of less than 10 µm), and respirable particulates of $PM_{2.5}$ (i.e. particulates with an aerodynamic diameter of less than 2.5 µm). Although TSP is defined as all particulates with an aerodynamic diameter of less than 100 µm, and effective upper limit of 30 µm aerodynamic diameter is frequently assigned. PM_{10} and $PM_{2.5}$ are of concern due to their health impact potentials. As indicated previously, such fine particles are able to be deposited in, and damaging to, the lower airways and gas-exchanging portions of the lung. PM_{10} limits and standards for the World Bank Group, EC and South Africa are documented in Table 3-1. The air quality guidelines and interim targets issued by the WHO in 2005 for particulate matter are given in Table 3-2 and Table 3-3.

Table 3-1: Air quality guidelines and standards for inhalable particulates (PM10).

Authority	Maximum 24-hour concentration (µg/m³)	Annual Average concentration (µg/m³)
World Bank Group	[(a)]	[(a)]
European Community (EC)	50 [(b)]	40 [(c)]
Current SA Standards [(d)]	120 [(e)(g)] 75 [(f)(g)]	50 [(e)] 40 [(f)]

Notes:

(a) WBG, 2007. EHS Guidelines (http://www.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines). Guidelines state that pollutant concentrations do not reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards, or in their absence, the current WHO Air Quality Guidelines, or other internationally recognized sources.

(b) EC Directive, 2008/50/EC (http://ec.europa.eu/environment/air/quality/legislation/directive.htm). In force since 1 January 2005. Not to be exceeded more than 35 times per calendar year.
(c) EC Directive, 2008/50/EC (http://ec.europa.eu/environment/air/quality/legislation/directive.htm). In force since 1 January 2005.
(d) Promulgated on the 24 December 2009 (Gazette No. 32816).
(e) Applicable immediately to 31 December 2014.
(f) Applicable from 1 January 2015.
(g) Not to be exceeded more than 4 times per year.

Table 3-2: Annual average WHO AQG and IT for particulate matter (WHO, 2005)

Annual Mean Level	PM10 (µg/m³)	PM2.5 (µg/m³)	Basis for the selected level
WHO interim target-1 (IT-1)	70	35	These levels were estimated to be associated with about 15% higher long-term mortality than at AQG
WHO interim target-2 (IT-2)	50	25	In addition to other health benefits, these levels lower risk of premature mortality by approximately 6% (2-11%) compared to WHO-IT1
WHO interim target-3 (IT-3)	30	15	In addition to other health benefits, these levels reduce mortality risks by another approximately 6% (2-11%) compared to WHO-IT2 levels.
WHO Air Quality Guideline (AQG)	20	10	These are the lowest levels at which total, cardiopulmonary and lung cancer mortality have been shown to increase with more than 95% confidence in response to PM2.5 in the American Cancer Society (ACS) study (Pope *et al.*, 2002 as cited in WHO 2005). The use of the PM2.5 guideline is preferred.

Table 3-3: Daily average WHO AQG and IT for particulate matter (daily mean) (WHO, 2005)

Daily Mean Level	PM10 (µg/m³)	PM2.5 (µg/m³)	Basis for the selected level
WHO interim target-1 (IT-1)	150	75	Based on published risk coefficients from multi-centre studies and meta-analyses (about 5% increase of short-term mortality over AQG)
WHO interim target-2 (IT-2)[(a)]	100	50	Based on published risk coefficients from multi-centre studies and meta-analyses (about 2.5% increase of short-term mortality over AQG)
WHO interim target-3 (IT-3) [(b)]	75	37.5	Based on published risk coefficients from multi-centre studies and meta-analyses (about 1.2% increase of short-term mortality over AQG)
WHO Air Quality Guideline (AQG)	50	25	Based on relation between 24-hour and annual levels

__Notes:__
(a) 99th percentile (3 days per year).
(b) For management purposes, based on annual average guideline values; precise number to be determined on basis of local frequency distribution of daily means.

3.3.2 Dust Deposition

Foreign dust deposition standards issued by various countries are given in Table 3-4. It is important to note that the limits given by Argentina, Australia, Canada, Spain and the USA are based on annual average dustfall. The standards given for Germany are given for maximum monthly dustfall and therefore comparable to the dustfall categories issued in South Africa. Based on a comparison of the annual average dustfall standards it is evident that in many cases a threshold of ~200 mg/m^2-day to ~300 mg/m^2-day is given for residential areas.

Table 3-4: Dust deposition standards issued by various countries

Country	Annual Average Dust Deposition Standards (based on monthly monitoring) (mg/m^2-day)	Maximum Monthly Dust Deposition Standards (based on 30 day average) (mg/m^2-day)
Argentina	133	
Australia	133 (onset of loss of amenity) 333 (unacceptable in New South Wales)	
Canada Alberta: Manitoba	179 (acceptable) 226 (maximum acceptable) 200 (maximum desirable)	
Germany		350 (maximum permissible in general areas) 650 (maximum permissible in industrial areas)
Spain	200 (acceptable)	
USA: Hawaii Kentucky New York: Pennsylvania Washington: Wyoming:	 200 175 200 (urban, 50 percentile of monthly value) 300 (urban, 84 percentile of monthly value) 267 183 (residential areas) 366 (industrial areas) 167 (residential areas) 333 (industrial areas)	

Air quality standards are not defined by all countries for dust deposition, although some countries may make reference to annual average dustfall thresholds above which a 'loss of amenity' may occur. In the South African context, widespread dust deposition impacts occur as a result of windblown mine tailings material and other fugitive dust sources. It is for this reason that the SABS Technical Committee on air quality standards has recommended the establishment of target levels and alert thresholds for dustfall. The South African Department of Minerals and Energy (DME) uses the 1200 mg/m^2/day threshold level as an action level. In the event that on-site dustfall exceeds this threshold, the specific causes of high dustfall should be investigated and remedial steps taken.

According to the proposed SA dustfall limits, an enterprise may submit a request to the authorities to operate within the Band 3 ACTION band for a limited period, providing that this is essential in terms of the practical operation of the enterprise (for example the final removal of a tailings deposit) and provided that the best available control technology is applied for the duration. No margin of tolerance will be granted for operations that result in dustfall rates in the Band 4 ALERT. The SANS four-band scale is presented in Table 3-5. Proposed target, action and alert thresholds for ambient dust deposition are given in Table 3-6.

Table 3-5: Bands of dustfall rates proposed for adoption

Band Number	Band Description Label	30 Day Average Dustfall Rate (mg/m^2-day)	Comment
1	RESIDENTIAL	D < 600	Permissible for residential and light commercial
2	INDUSTRIAL	600 < D < 1 200	Permissible for heavy commercial and industrial
3	ACTION	1 200 < D < 2 400	Requires investigation and remediation if two sequential months lie in this band, or more than three occur in a year.
4	ALERT	2 400 < D	Immediate action and remediation required following the first exceedance. Incident report to be submitted to relevant authority.

Table 3-6: Target, action and alert thresholds for ambient dustfall

Level	Dustfall Rate (mg/m^2-day)	Averaging Period	Permitted Frequency of Exceedence
TARGET	300	Annual	
ACTION RESIDENTIAL	600	30 days	Three within any year, no two sequential months.
ACTION INDUSTRIAL	1 200	30 days	Three within any year, not sequential months.
ALERT THRESHOLD	2 400	30 days	None. First exceedance requires remediation and compulsory report to authorities.

3.4 Adopted Evaluation Criteria for Reptile Uranium's Proposed Omahola Project

For the purpose of this study the evaluation criteria used are provided in Table 3-7. The WHO Air Quality Guidelines (AQG) provide the initial screening criteria for the proposed Omahola Project assessment. The WHO does however state that these AQG and interim targets should be used to guide standard-setting processes and should aim to achieve the lowest concentrations possible in the context of local constraints, capabilities, and public health priorities. These guidelines were also aimed at urban environments within developed countries (WHO, 2005). It is in this light that the WHO IT3 and South African Standards were selected as representative screening criteria. The South African Standards agree with the WHO IT3 guidelines and were developed for example with the knowledge that the background PM10 concentrations are higher than in Europe and should be achievable within a semi-arid environment. These also correlate with the evaluation criteria recommended for the Erongo Region (Liebenberg-Enslin et.al., 2010).

Also, due to the limited international guidelines for dust fallout, the South African SANS residential action limit is referenced.

Table 3-7: Proposed evaluation criteria for the proposed Omahola Project

Pollutant	Averaging Period	Selected Criteria	Country of Origin
PM_{10}	24-hour Mean ($\mu g/m^3$)	75(a)	WHO IT3 & SA Standard
	Annual Mean ($\mu g/m^3$)	30	WHO IT3
Dust fallout	30-day average ($mg/m^2/day$)	600(b)	SA SANS residential action limit
		350	German limit in general areas

Notes:

(a) Not to be exceeded more than 4 times per year (SA).
(b) Not to be exceeded more than 3 time per year of 2 consecutive months.

4 REGIONAL CLIMATE AND ATMOSPHERIC DISPERSION POTENTIAL

4.1 Atmospheric Dispersion Potential of the Region

The Erongo Region falls within the west coast arid zone of Southern Africa. Historical meteorological data are limited, with the Gobabeb Research Station (located ~100 km to the south of the site on the border with the Namib Desert) being in operation since 1962. Information on the climatic conditions of the region is therefore primarily focussed on the Central Namib.

The main focus of this section on the local meteorology with a summary of the main regional climatic features influencing the local meteorology is provided within this section. Additional information on the regional climate is provided in Appendix B.

Rainfall represents an effective removal mechanism of atmospheric pollutants and is therefore frequently considered during air pollution studies. Evaporation is a function of ambient temperature, wind and the saturation deficit of the air. Evaporation rates have important implications for the design and implementation of effective dust control programmes. The average rainfall in the west coast region is slight with an annual average of 23 mm measured over the period 1962 - 1967 at Gobabeb. Historical records for Swakopmund, dating as far back as 1899, indicate an annual average of 14 mm. As is typical of arid areas, rainfall can vary considerably and can be of great intensity. The highest daily total rainfall measured in 1972 was 16.5 mm at Gobabeb and 22 mm at Goanikontes with Swakopmund receiving 153 mm in 1934 (Goudie, 1972). More recent statistics for Swakopmund indicate the total annual rainfall for 2008 to be 30 mm (http://weather.namsearch.com). According to the Directorate of Environmental Affairs, Ministry of Environment and Tourism Digital Atlas of Namibia, rainfall within the Erongo Region ranges between 0-50 mm at the coast to 400 mm in the northeast of the region. The Omahola Project falls within the 50-100 mm/year rainfall belt and in the 3000-3200 mm per year evaporation rate region. Evaporation rates are between 2400-3400 mm per year increasing from the coast inland reaching a maximum in the central part of the Erongo Region (http://209.88.21.36/Atlas/Atlas_web.htm).

Fog, a form of precipitation, is characteristic of this region. Swakopmund, for instance, has high incidences of fog days of more than 125 days per year (http://209.88.21.36/Atlas/Atlas_web.htm). Within the Erongo Region, fog can extend up to 110 km inland with an average number of days per annum recorded at Gobabeb of 102 between 1964 and 1967 (Goudie, 1972). The annual fog precipitation at Swakopmund was estimated to be 35-45 mm in relation to 20 mm 40 km inland (Goudie, 1972).

Air temperature is an important parameter for the development of the mixing and inversion layers with relative humidity being the inverse function of ambient air temperature, increasing as ambient air temperature decreases. Historical data for the region indicate similar average monthly and annual temperatures along the Namib Coast. The range between the coldest and warmest months is also small being 9°C at both Swakopmund and Walvis Bay. Frost is not associated with the region but extreme temperatures of over 40°C have been linked to strong easterly “berg” winds (Goudie, 1972). The number of sunshine hours in the Erongo Region also increases rapidly from the coast towards the east, ranging from less than 5 hours at Swakopmund to more than 10 hours just a few kilometres inland. Relative humidity for the Erongo Region varies between <10% to 70% during both the least humid month and the most humid month. The relative humidity is the highest along the coast and lowest inland (http://209.88.21.36/Atlas/Atlas_web.htm). The average humidity recorded at Swakopmund for the year 2008 ranged between 22% and 96% (http://weather.namsearch.com).

Incoming solar radiation increases from sunrise (06:00) to reach a maximum at midday (12:00 – 13:00) and then decreases till sunset (19:00). Within the Erongo Region solar radiation is on average <5.4 kWhr per m² per day at the coast and up to 5.8 kWhr per m² per day further east. The Husab Project falls within the 5.6-5.8 kWhr per m² per day category (http://209.88.21.36/Atlas/Atlas_web.htm).

The wind field of the region represents a combination of the synoptic-scale circulation and the local land-sea breeze circulation. Wind data recorded during 2008 at Swakopmund indicate on average wind speeds below 4 m/s. Periods of high wind incidents (above 10 m/s) did however occur with the highest wind speeds measured during 2008 of 36 m/s (http://weather.namsearch.com). The wind field varies significantly within the Erongo Region with wind direction in the central northern part predominantly easterly and north-easterly and south-westerly. The easterly and north-easterly winds are also associated with high wind speeds. The wind field changes slightly around the project area with a shift towards northerly and north-westerly winds but keeping the strong presence of south-easterly winds. Wind speed for the region also varies but most of the stations records wind speeds between 0-10 m/s.

4.1.1 Meso-Scale Atmospheric Dispersion Potential

The meteorological characteristics of a site govern the dispersion, transformation and eventual removal of pollutants from the atmosphere (Pasquill and Smith, 1983; Godish, 1990). The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer. Dispersion comprises vertical and horizontal components of motion. The stability of the atmosphere and the depth of the surface-mixing layer define the vertical component. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field and atmospheric stability. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume 'stretching'. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. The wind direction, and the variability in wind direction, determines the general path pollutants will follow, and the extent of cross-wind spreading (Shaw and Munn, 1971; Pasquill and Smith, 1983; Oke, 1990).

Pollution concentrations therefore fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth, and to shifts in the wind field. Spatial variations, and diurnal and seasonal changes, in the wind field and stability regime are functions of atmospheric processes operating at various temporal and spatial scales (Goldreich and Tyson, 1988). Atmospheric processes at macro and meso-scales therefore need be taken into account in order to accurately parameterise the atmospheric dispersion potential of a particular area.

The analysis of meteorological data observed for the site provides the basis for the parameterisation of the meso-scale ventilation potential of the site, and to provide the input requirements for the dispersion simulations. Parameters that need to be taken into account in the characterisation of meso-scale ventilation potentials include wind speed, wind direction, extent of atmospheric turbulence, ambient air temperature and mixing depth. A comprehensive data set for at least one year of site-specific hourly average wind speed, wind direction and temperature data are needed for the dispersion simulations.

4.1.2 Site Specific Wind Field

In order to understand the potential for dispersion at a given site, it is preferred to have an on-site meteorological station. Although an on-site meteorological station has been operational at the Inca site since June 2010, the monitored data (from June to September 2010) was not sufficient for a comprehensive baseline assessment and dispersion modelling. Meteorological data was therefore obtained from the Bannerman Etango Project's on- site weather station which is located ~11 km to the east-northeast of the proposed Omahola Project site (Figure 4-1). Meteorological data for the period November 2007 to June 2010 were used for the study. Data availability for wind speed and wind direction over the three year period was 71%. This can be regarded as adequate, with data availability in excess of 80% being preferred.

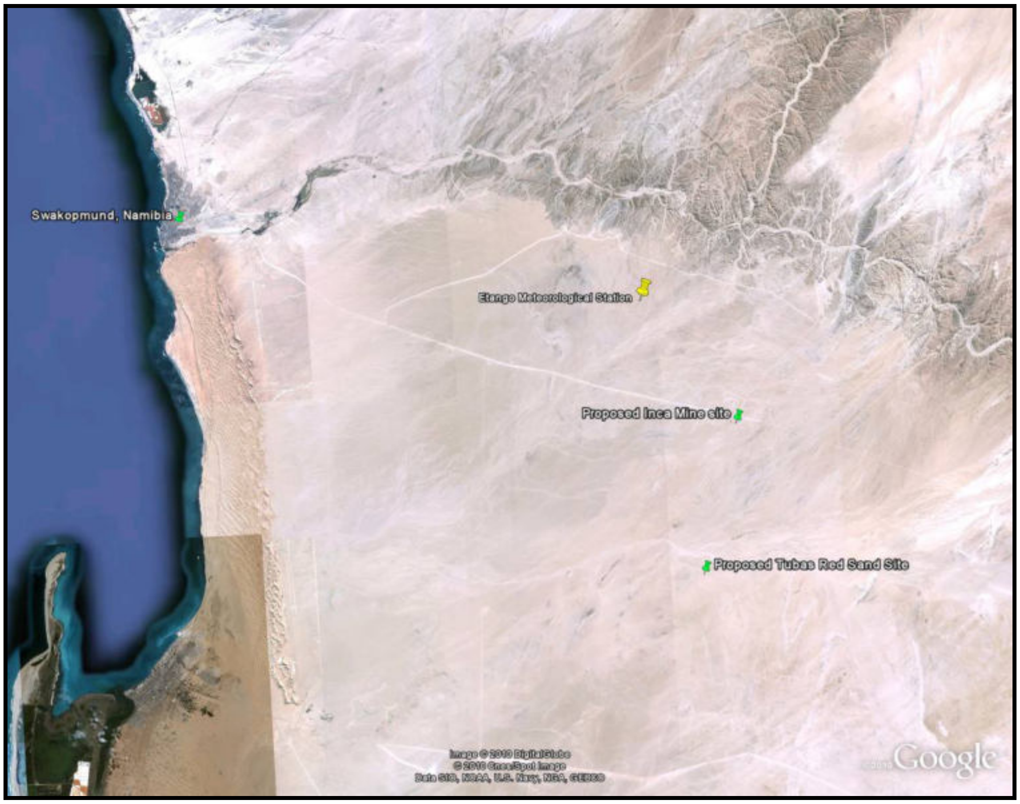

Figure 4-1: Location of the Etango meteorological station in relation to the proposed Inca and Tubas Red Sand sites

Wind roses comprise 16 spokes, which represent the direction from which winds blew during the period. The colours reflected the different categories of wind speeds with the dotted circles indicating the frequency of occurrence, and each circle representing a 5% frequency of occurrence. Period, daytime and night-time average wind roses generated based on meteorological data from the Etango Project meteorological station are depicted in Figure 4-2.

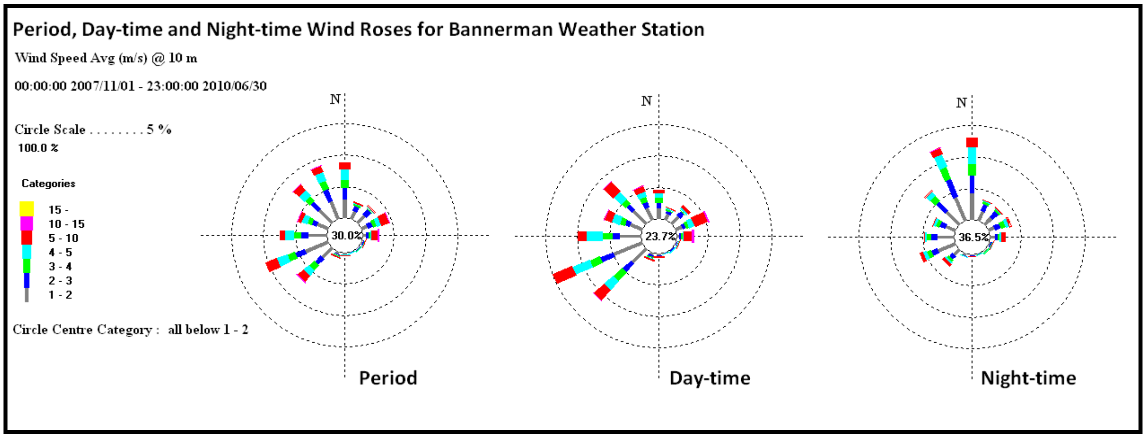

Figure 4-2: Average period, day-time and night-time wind roses for the Bannerman's Etango Project (November 2007 to June 2010)

The prevailing wind direction is from the northwest and the west-southwest with very little airflow from the southeast. Infrequent winds are also noted from the east-northeast. On average, the winds are strong ranging between 2 m/s and 13 m/s for most of the time with winds in excess of 5 m/s occurring for 10% of the time. The strongest winds are from the east-northeast though for a limited period. During the daytime, prevailing winds are from the west-southwest. Less frequent winds were recorded from the southeast. The night-time airflow shows a distinct shift towards the north and north-northwest, with a decrease in airflow from the other sectors. The percentage calm conditions increase (to 36%) as is typical of night-time conditions with an overall decrease in wind speeds.

Figure 4-3 shows the seasonal wind roses, providing an indication in the shift of the wind regime between the main seasons and between months. During the summer months, the prevailing winds are from the northwest and to a lesser extent from the southwest with almost no flow from the easterly and southerly sectors. During autumn the wind field changes completely with a distinct shift in airflow from the southwest and noticeable winds from the east-northeast. Similar wind patterns are noted for the winter months but with very prominent east-northeasterly flow. These winds are also characterised by very high speeds. The prevailing wind field returns to the dominant northwesterly flow during the spring months, with frequent northerly winds.

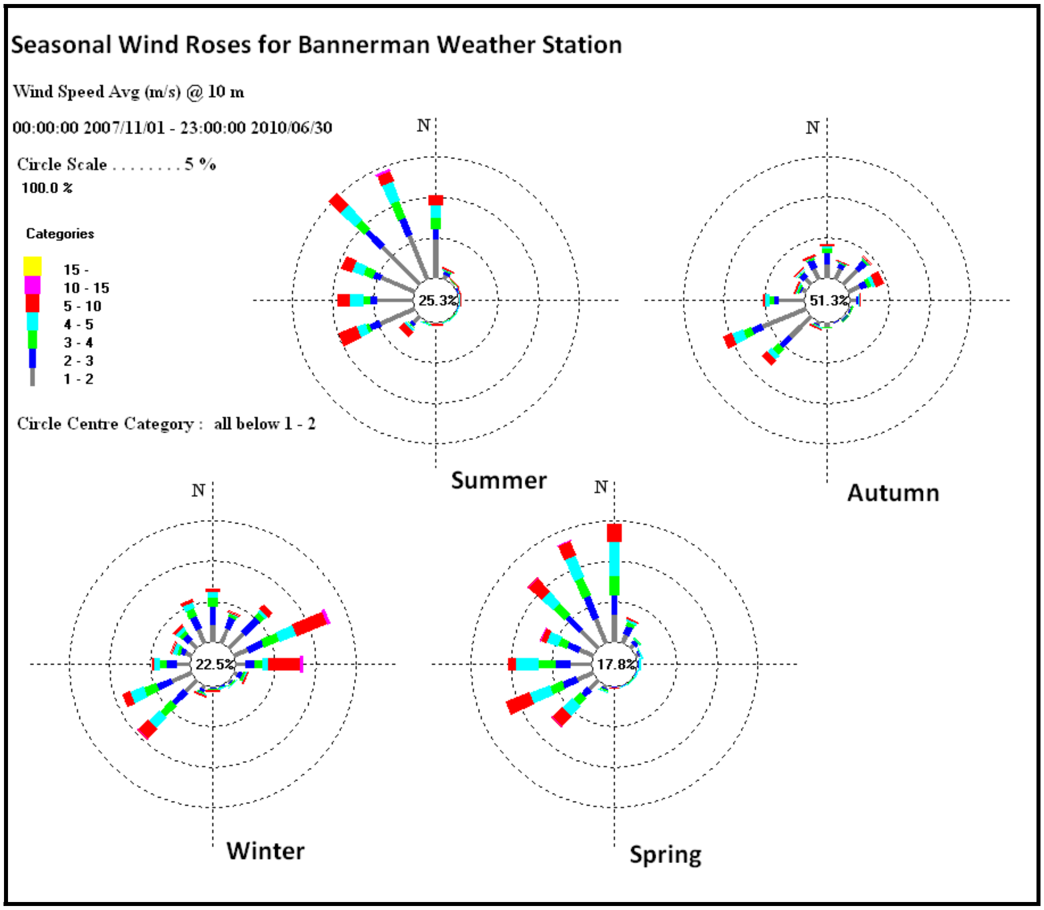

Figure 4-3: Seasonal wind roses for the Bannerman's Etango Project (November 2007 to June 2010)

4.1.3 Air Temperature

Air temperature is important, both for determining the effect of plume buoyancy (the larger the temperature difference between the plume and the ambient air, the higher the plume is able to rise), and determining the development of the mixing and inversion layers. The temperature trends for the Etango Project site for the year 2009 are presented in Figure 4-4.

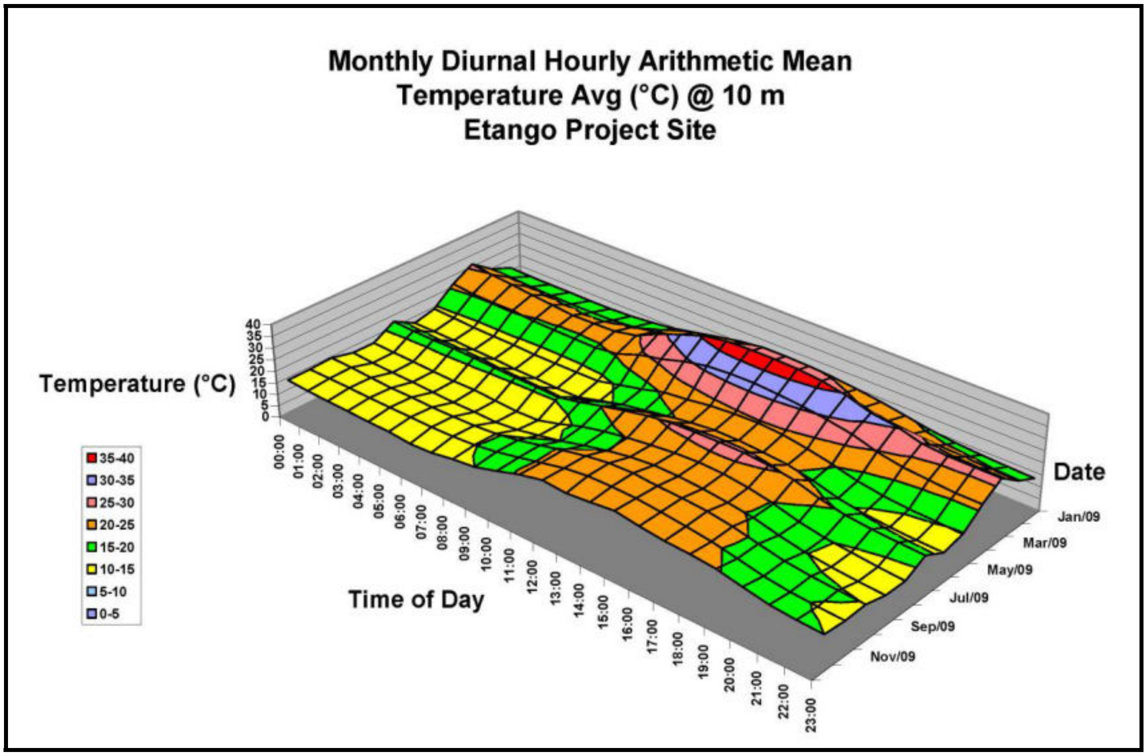

Figure 4-4: Air temperature trends for Bannerman's Etango Project site for the year 2009

The monthly temperature trends recorded at the Etango Project on-site weather station for the year 2009 are presented in Table 4-1. Minimum temperatures have been recorded as ranging from 4.9°C to 28.9C with maximum temperatures ranging between 24.4°C and 40.4°C. Mean temperatures range between 15.3°C and 28.9°C.

Table 4-1: Minimum, maximum and mean temperature for Etango Project site for 2009

Station		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Etango Project Site	Maximum	30.1	33.9	40.4	39.1	35.9	33	33.1	34.1	30.9	36.2	28.2	24.4
	Mean	19.7	22.8	28.9	24.6	17.4	15.3	20	15.5	15.3	17.7	17.6	16
	Minimum	12.6	15.9	16.8	10.1	7.2	6.1	5.6	4.9	5.2	8.9	9.3	10.4

4.1.4 Atmospheric Stability and Mixing Depth

The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. This layer is directly affected by the earth's surface, either through the retardation of flow due to the frictional drag of the earth's surface, or as result of the heat and moisture exchanges that take place at the surface. During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface and the extension of the mixing layer to the lowest elevated inversion. Radiative flux divergence during the night usually results in the establishment of ground-based inversions and the erosion of the mixing layer. Night times are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds, hence less dilution potential.

The mixed layer (i.e. layer within which air pollutants are able to mix) therefore ranges in depth from a few metres during the evening and early morning to the base of the lowest-level elevated inversion during unstable, daytime conditions. Elevated inversions may occur for a variety of reasons, and on some occasions as many as five may occur in the first 1000 m above the surface. The lowest-level elevated inversion is located at a mean height above ground of 1 550 m during winter months with a 78 % frequency of occurrence. By contrast, the mean summer subsidence inversion occurs at 2 600 m with a 40% frequency.

For elevated releases, the highest ground level concentration is likely to occur during unstable, daytime conditions. The wind speed resulting in the highest ground level concentration depends on the plume buoyancy. If the plume is considerably buoyant (high emission velocity and temperature) together with a low wind, the plume will reach the ground relatively far downwind. With stronger wind speeds, on the other hand, the plume may reach the ground closer, but due to the increased ventilation, it would be more diluted. A wind speed between these extremes would therefore be responsible for the highest ground level concentrations. The highest concentrations for low level releases would occur during weak wind speeds and stable (night-time) atmospheric conditions, with the exception of wind dependent sources where high wind speeds are needed to generate emissions.

5 BASELINE AIR QUALITY ASSESSMENT

Various components of the bio-physical and socio-economic environment may be impacted by atmospheric emissions associated with the various phases of the project. These components include the possible impact on:

- ambient air quality;
- the aesthetic environment;
- local residents and neighbouring communities; and,
- employees

5.1 Existing Air Quality within the Erongo Region

The identification of existing sources of emissions in the Erongo Region and the characterisation of existing ambient pollutant concentrations is fundamental to the assessment of the potential for cumulative impacts and synergistic effects given the proposed mining operations and their associated emissions.

The Erongo Region is located in the central, western part of Namibia and is bounded by the Atlantic Ocean to the west and the Escarpment to the east (approximately 180 km inland). To the south, the Erongo Region is bound by the Kuiseb River separating the stony desert and the Namib sand dunes. The region is drained by the deeply-incised Swakop and Khan rivers in the central part and the Kuiseb River in the south (Tyson & Seely, 1980). The Namib-Naukluft Park comprises a large part of the Erongo Region.

The region falls within the west coast arid zone of Southern Africa and is characterised by low rainfall with extreme temperature ranges and unique climatic factors influencing the natural environment and biodiversity (Goudie, 1972). Episodic dust storms associated with strong easterly winds is a common phenomenon during the winter months and is derived primarily from natural sources. These sources are intermittent sources, giving rise to dust emissions only under conditions of high wind speeds. Anthropogenic sources such as unpaved roads and mining operations continuously contribute to the atmospheric dust load in the Erongo Region.

A comprehensive emissions inventory has been compiled for the region as part of the Strategic Environmental Assessment (SEA) recently undertaken for the region. The SEA considered likely sector development scenarios and their implications (economical, social and environmental) for the region (SEA, 2010).

Sources identified as possibly impacting on air quality in the region include, but are not limited to:

- Fugitive emissions from mining operations;
- Vehicle tailpipe emissions from national and main roads;
- Windblown dust from natural mineral sources; and

- Various miscellaneous fugitive dust sources (agricultural activities, wind erosion of open areas, vehicle-entrainment of dust along paved and unpaved roads).

5.1.1 Predicted Baseline PM10 Concentrations for the Erongo

The predicted highest daily and annual average baseline particulate concentrations in the region for all current sources according to the SEA are shown in Figure 5-1 and Figure 5-2 respectively. The predicted baseline concentrations are interpreted as background concentrations for the region. Background highest daily PM10 concentrations were estimated to be between 50 µg/m³ and 120 µg/m³ while the annual average concentrations were estimated to be about 20 µg/m³ to 50 µg/m³ for the Erongo Region.

The predicted highest daily background concentration for the proposed site is about 180 µg/m³ while the predicted annual average background concentration is around 40 µg/m³.

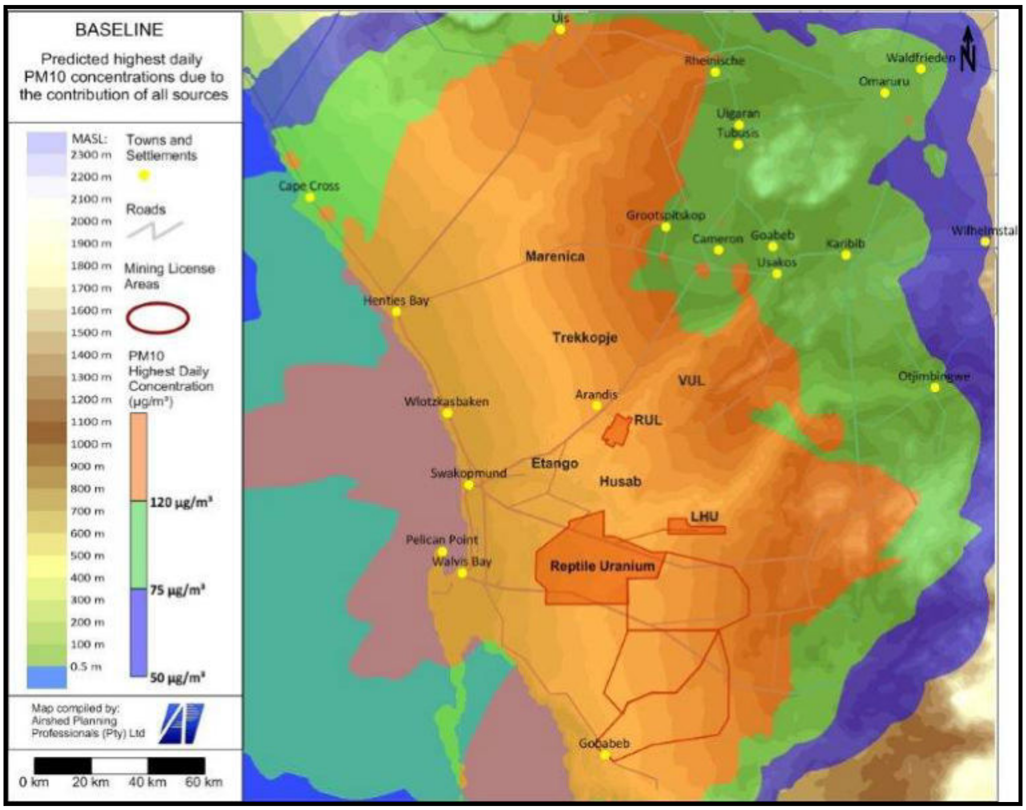

Figure 5-1: Predicted baseline PM10 highest daily average concentrations for the Erongo Region (Liebenberg-Enslin *et.al.*, 2010)

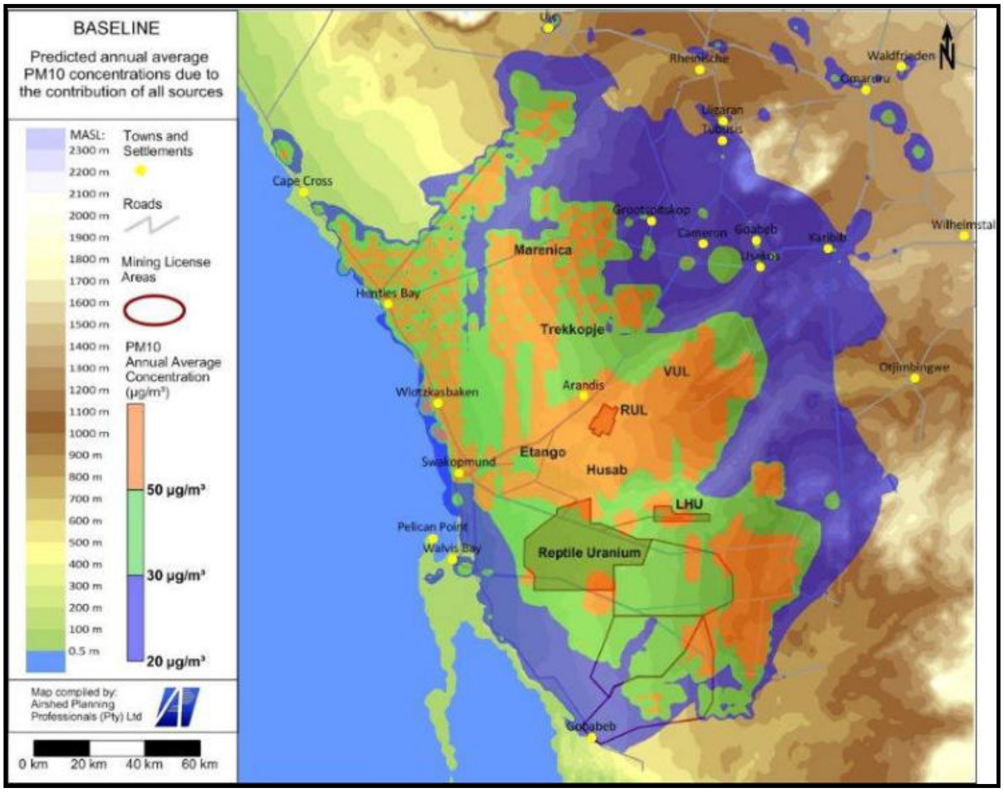

Figure 5-2: Predicted baseline PM10 annual average concentrations for the Erongo Region (Liebenberg-Enslin *et.al.*, 2010)

5.1.2 Baseline Dust Deposition for the Erongo Region

A monitoring network, comprising of 20 single dust fallout buckets, was established in August 2009 for the Erongo Region (Figure 5-3). Sites were selected to capture all background dust sources such as natural wind erosion, dust from unpaved roads and current mining and exploration activities. Dust fallout data for eleven months (August 2009 to June 2010) were available for inclusion into the SEA report. Dust buckets located relatively close to Reptile Uranium's Omahola Project and whose collected dust fallout levels are more representative of the background at the proposed site were identified as SEA_D03, SEA D05 and SEA_D17 (Figure 5-3). The collected dust fallout from the three dust buckets is presented in Figure 5-4 (SEA, 2010).

The average dust deposition rates for the three dust buckets for the period August 2009 to June 2010 is 44 mg/m²/day and this is assumed to be the background dust deposition at the proposed Omahola Project site (Table 5-1).

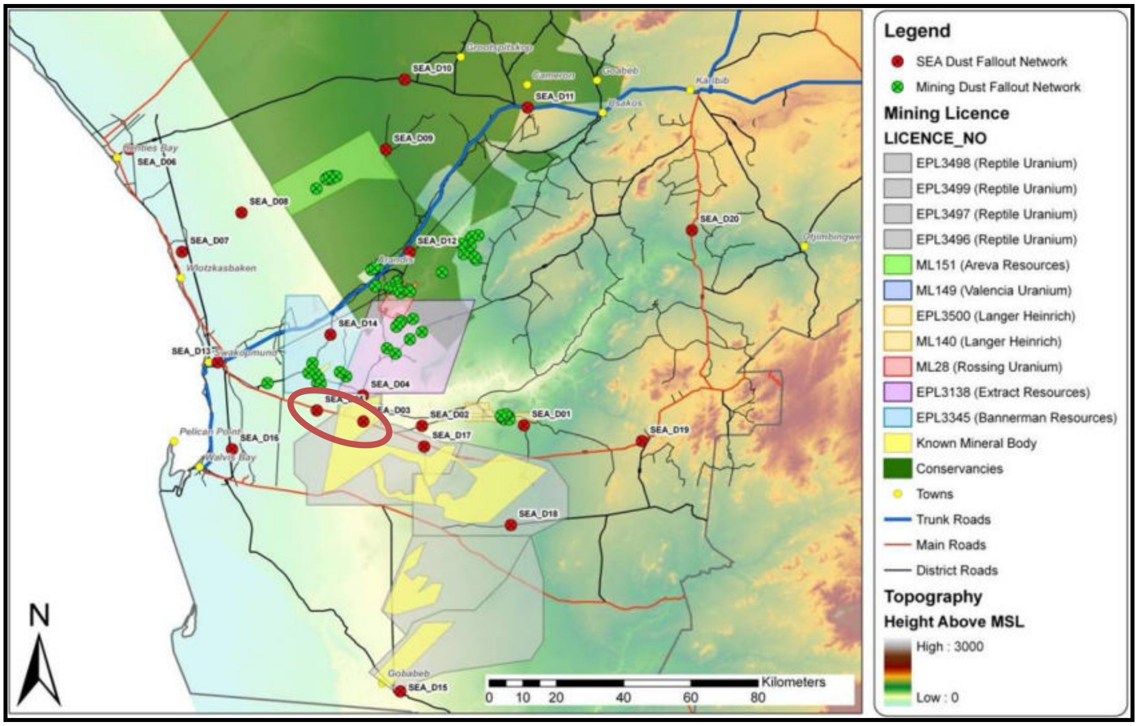

Figure 5-3: Dust fallout monitoring sites for the Erongo Project

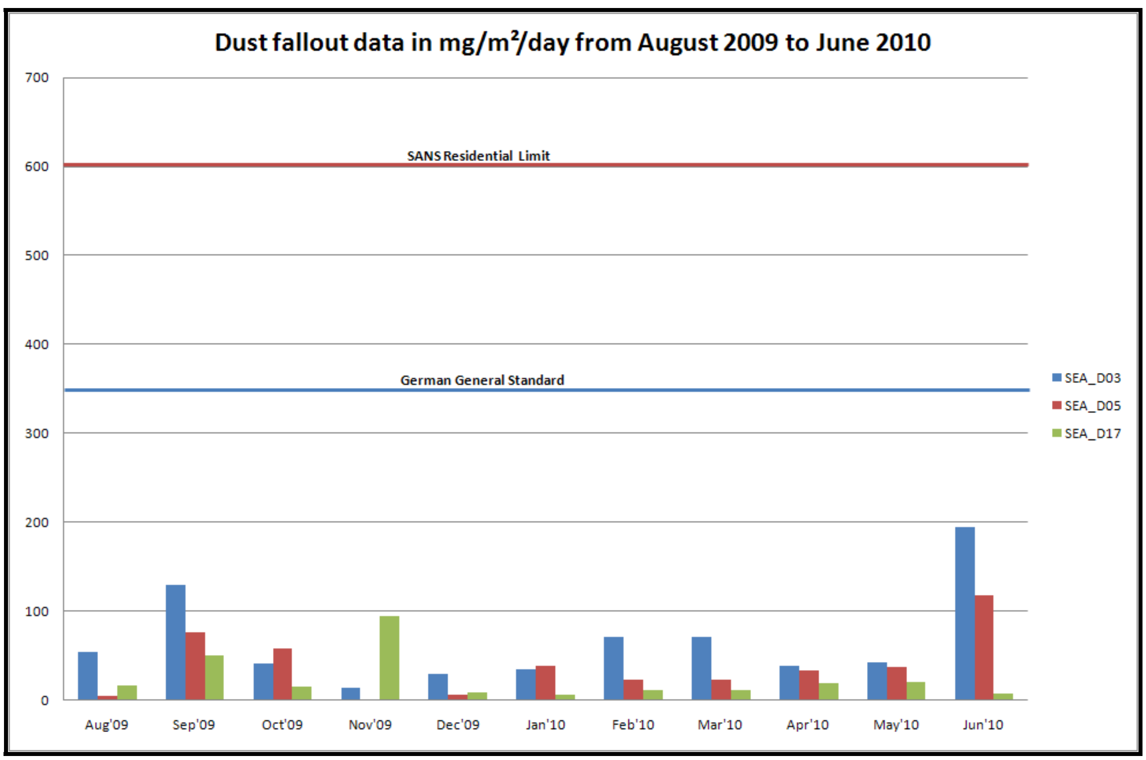

Figure 5-4: Measured dust fallout from dust buckets SEA_D03, SEA_DO5 and SEA_D17

Table 5-1: Monthly average dust fallout rates in mg/m²/day for the period August 2009 to June 2010 from the Erongo SEA network (Liebenberg-Enslin *et.al*, 2010)

Site ID	Monthly average dust fallout rates (mg/m²/day)											
	Aug'09	Sep'09	Oct'09	Nov'09	Dec'09	Jan'10	Feb'10	Mar'10	Apr'10	May'10	Jun'10	Average
SEA_D03	54	129	41	14	30	35	71	71	39	42	194	65
SEA_D05	5	76	58	ND	6	38	23	23	34	37	118	42
SEA_D17	16	50	15	95	9	6	11	11	19	21	8	24
Average	**25**	**85**	**38**	**55**	**15**	**26**	**35**	**35**	**31**	**33**	**107**	**44**

Notes: ND is No Data

5.1.3 Mining Operations in the Region

Fugitive dust sources associated with mining activities include drilling and blasting operations, materials handling activities, vehicle-entrainment by haul vehicles and wind-blown dust from tailings impoundments and stockpiles. Mining operations represent potentially the most significant sources of fugitive dust emissions (PM2.5, PM10 and TSP) with small amounts of oxides of nitrogen (NO_x), carbon monoxide (CO), sulphur dioxide (SO_2), methane, and carbon dioxide (CO_2) being released during blasting operations and from mine trucks.

Experience has shown that fugitive dust emissions due to on-site operations are typically only of concern within 3 km of the mine boundary, depending on the location of the mine boundary and extent of the mining operations. This is the reason for the current manner in which atmospheric emissions are treated for mining operations. Dust suppression methods that are most frequently used in local mining operations include wet suppression and chemical stabilisation of haul roads and storage piles, and the vegetation or rock cladding of tailings impoundments.

Current operating mines in the Erongo Region include Rössing Uranium Mine, located approximately 50 km to the north-northeast of the Omahola Project site (Figure 5-5). Rössing Mine comprises of open-pit mining and is one of the largest uranium mines in the world. The only other operational uranium mine in the region, Langer Heinrich Uranium Mine, is situated ~44 km to the east-north east. Valencia Uranium and Trekkopje mines are approved proposed uranium mines in the region and will also utilise opencast mining methods. Trekkopje is located approximately 66 km to the north-northeast of the proposed Omahola Project, with Valencia located ~59 km to the northeast.

The existing Langer Heinrich Uranium Mine is regarded relatively far away and expected not to have a significant influence on the ambient air quality in the vicinity of the proposed Omahola Project. However, the close proximity of the proposed Etango Project mining operations (located ~11 km to the north will add to the cumulative impacts from the Omahola Project). In addition there are a number of small scale stone operations throughout the region with two large salt works located north of Swakopmund and south of Henties Bay. These sources are however located too far away to have a significant influence on the air quality at the Omahola Project site.

Fugitive dust sources associated with mining activities include drilling and blasting operations, materials handling activities, vehicle-entrainment by haul vehicles and wind-blown dust from tailings impoundments and stockpiles. Mining operations represent potentially the most significant sources of fugitive dust emissions ($PM_{2.5}$, PM_{10} and TSP) with small amounts of oxides of nitrogen (NO_x), carbon monoxide (CO), sulphur dioxide (SO_2), methane, and carbon dioxide (CO_2) being released during blasting operations and from mine trucks.

5.1.4 Vehicle Tailpipe Emissions

Air pollution from vehicle emissions may be grouped into primary and secondary pollutants. Primary pollutants are those emitted directly into the atmosphere, and secondary, those pollutants formed in the atmosphere as a result of chemical reactions, such as hydrolysis, oxidation, or photochemical reactions. The significant primary pollutants emitted by vehicles include CO_2, CO, hydrocarbons (HCs), SO_2, NO_x, particulates and lead. Secondary pollutants include: nitrogen dioxide (NO_2), photochemical oxidants (e.g. ozone), HCs, sulphur acid, sulphates, nitric acid, nitric acid and nitrate aerosols. Toxic hydrocarbons emitted include benzene, 1.2-butadiene, aldehydes and polycyclic aromatic hydrocarbons (PAH). Benzene represents an aromatic HC present in petrol, with 85% to 90% of benzene emissions emanating from the exhaust and the remainder from evaporative losses.

Vehicle tailpipe emissions are also localised sources and unlikely to impact far-field. A network of roads exists close to the proposed Omahola Project site and these include the gravel C28 through the Namib Naukluft Park, linking Swakopmund and Windhoek. This road is primarily utilised by tourists. Other public roads located to the proposed site include the C14 and B2.

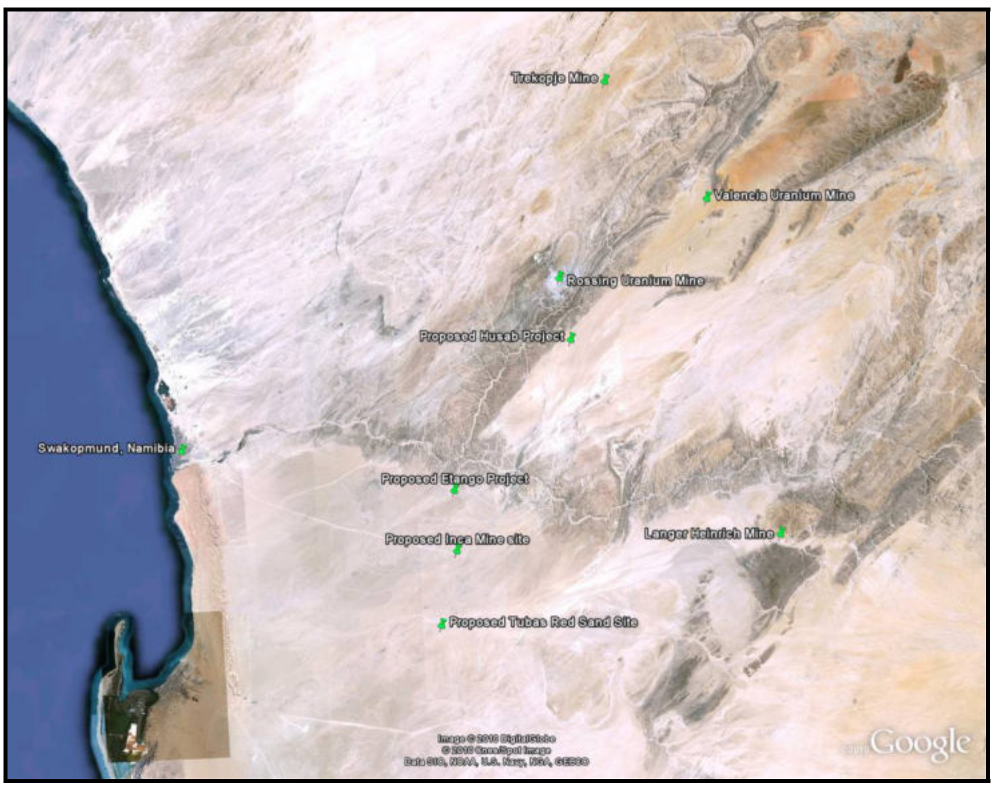

Figure 5-5: Various existing and proposed mines located close to Reptile Uranium's proposed Omahola project in the region

5.1.5 Fugitive Dust Sources

Fugitive dust emissions may occur as a result of vehicle entrained dust from local paved and unpaved roads, and wind erosion from open areas. The extent of particulate emissions from the main roads will depend on the number of vehicles using the roads and on the silt loading on the roadways. The extent, nature and duration of agricultural activities and the moisture and silt content of soils are required to be known in order to quantify fugitive emissions from this source. The quantity of wind-blown dust is similarly a function of the wind speed, the extent of exposed areas and the moisture and silt content of such areas.

The Air Quality study (Liebenberg-Enslin et.al., 2010) as part of the Erongo Region Uranium Rush Strategic Environmental Assessment (quantified the emissions from both the unpaved and paved roads in the region and windblown dust from the natural environment. The baseline assessment indicated that the main contributing source to background PM10 concentrations and dust fallout rates is windblown dust from natural sources (82% on average). Dust generated by traffic on unpaved roads is the second largest source contributing 13% to the total dust load.

6 IMPACT ASSESSMENT FOR THE PROPOSED CONSTRUCTION PHASE

The construction phase will comprise land clearing and site development operations at the proposed Omahola Project site and the associated infrastructure. This is specially going to be the case at the proposed Inca site where construction activities will include construction of the processing plant and other associated infrastructure.

Activities associated with this phase will comprise a series of different operations including land clearing, topsoil removal, material loading and hauling, stockpiling, grading, bulldozing, compaction, (etc.). Each of these operations has its own duration and potential for dust generation. It is anticipated therefore that the extent of dust emissions would vary substantially from day to day depending on the level of activity, the specific operations, and the prevailing meteorological conditions. This is in contrast to most other fugitive dust sources where emissions are either relatively steady or follow a discernible annual cycle. Aspects associated with the proposed construction phase in terms of air quality are outlined in Table 6-1.

Table 6-1: Environmental impacts and associated activities during the construction phase

Impact	Source	Activity
	Unpaved roads	Vehicle entrainment on unpaved roads surface
		Clearing and levelling of roads
	Mine sites	Clearing of groundcover
		Drilling and blasting
		Materials handling (loading and hauling)
		Wind erosion from topsoil and other stockpiles
		Vehicle entrainment on unpaved road surfaces
		Establishment of infrastructure
Gases and particulates	Vehicles	Tailpipe emissions from construction vehicles at the site

The construction activities required for the proposed operations will include the development of an unpaved road network which would be required for access to the processing plant, transportation of waste to the waste dumps and the transportation of ore to the primary crusher. Topsoil and overburden storage piles prone to wind erosion will result from land clearing activities.

Vehicle-entrainment of dust from the proposed construction site/s represents a relatively large source of fugitive dust emissions during construction. Gaseous and particulate emissions from vehicle tailpipes are far lower and therefore of less significance in terms of their impacts. Surface blasting activities is another main source of concern resulting mainly in particulate emissions and to a lesser extent gaseous emissions which are directly related to the type of explosives used.

6.1 Qualitative assessment of potential impacts from the proposed construction activities

A detailed construction plan is required to quantitatively assess air pollution. Due to the lack of information and the relatively short duration of most of the activities associated with the construction phase, no dispersion simulations were undertaken and a qualitative assessment was therefore undertaken.

The main pollutant of concern from construction operations is particulate matter, including PM10, PM2.5 and TSP. PM10 and PM2.5 concentrations are associated with potential health impacts due to the size of the particulates being small enough to be inhaled. Nuisance effects are caused by the TSP fraction (20 µm to 75 µm in diameter) resulting in soiling of materials and visibility reductions. This could in effect also have financial implications due to the requirement for more cleaning materials.

From the proposed operations, the main construction activities likely to result in noticeable impacts of PM10 and TSP include vehicle entrainment from unpaved roads, drilling and blasting and wind erosion from the topsoil stockpiles. According to the Australian Environment Protection Agency's guidelines for separation distances (AEPA, 2001), a generic buffer zone of 500m is set for quarrying or processing activities where blasting takes place. In addition, dustfall impacts are generally confined to the near-field (<1 km to 3 km) of sources. This is due to the fact that larger particles, which contribute most to dustfall rates given their mass, are likely to settle out in close proximity to the source (assuming a ground-based source). The area influenced by the operations of course depends on the dispersion potential of the site and the extent of the construction operations.

Blasting is considered an upset emission source due to the intermittent nature of the activity (usually once or twice per day). Furthermore, drilling and blasting will only be conducted for a limited period of time.

Vehicle entrainment from unpaved roads is likely to be one of the main sources resulting in impacts of sensitive receptors (Liebenberg-Enslin & Petzer, 2006). The magnitude of the impacts will depend on the distances travelled between the various construction operations, the number of vehicles and the average travelling speed. Since the roads within the proposed construction site are unlikely to be paved during the construction phase, the force of the wheels travelling on unpaved roadways causes pulverisation of surface material. Particles are lifted and dropped from the rotating wheels, and the road surface is exposed to strong air currents in turbulent shear with the surface. The turbulent wake behind the vehicle continues to affect the road surface once the vehicle has passed. The quantity of dust emissions from unpaved roads varies linearly with the volume of traffic. In addition to traffic volumes, emissions also depend on a number of parameters which characterise the condition of a particular road and the associated vehicle traffic, including average vehicle speed, mean vehicle weight, average number of wheels per vehicle, road surface texture, and road surface moisture (EPA, 2003). Wind-blown dust from open and exposed surfaces could result in considerable emissions under high wind speeds. Significant emissions arise due to the mechanical disturbance of granular material from open areas and storage piles. Parameters which have the potential to impact on the rate of emission of fugitive dust include the extent of surface compaction, moisture content, ground cover, the shape of the storage pile, particle size distribution, wind speed and precipitation. As with blasting, these incidences usually occur for limited time periods, but when it occurs the impacts could be significant.

6.2 Proposed mitigation measures

Although the construction phase activities generally occur for a relatively short period of time for most mining projects, it is recommended that effective dust control measures be implemented based on good practice. The implementation of effective controls during this phase would also serve to set the precedent for mitigation during the operational phase.

Control techniques for fugitive dust sources generally involve watering, chemical stabilisation, and the reduction of surface wind speed though the use of windbreaks and source enclosures. Proposed dust control measures which may be implemented during the construction phase are as follows:

- Debris handling - wind speed reduction through sheltering and wet suppression.
- Truck transport - wet suppression or chemical stabilization of unpaved roads;
- Dust entrainment – reduction of unnecessary traffic and strict speed control, require haul trucks to be covered, and ensure material being hauled is wet.
- Materials storage, handling and transfer operations - wet suppression.
- Earthmoving and dozing operations - wet suppression.
- General construction - wind speed reduction, wet suppression and early paving of permanent roads. Phasing of earthmoving activities to reduce source size.
- Open areas (wind-blown emissions) - early vegetation, compaction and stabilization of disturbed soil and reduction of the frequency of disturbance.

6.3 Significance rating of proposed construction phase impacts

Potential impacts that will be associated with the proposed construction phase for the Omahola Project are rated using the methodology set up by MET (2009) in conjunction with assessment criteria from DEA (1998), Friend *et al*, (2005), DEA (2006) and Friend (2009).

The potential impacts due to the proposed construction phase will be of medium significance (Table 6-2). This implies that the impact could influence the decision to develop in the area unless it is effectively mitigated.

Table 6-2: Significance rating of proposed construction phase impacts

<table>
<tr><td colspan="2">Environmental aspect</td><td colspan="4">Air quality</td><td>Phase</td><td>Construction</td></tr>
<tr><td colspan="8">Description: The construction phase will comprise land clearing, site development operations and erecting the associated infrastructure. Each of these activities will have a potential for dust generation</td></tr>
<tr><td colspan="8">Mitigation: General mitigation measures for dust include wet suppression and wind speed reduction</td></tr>
<tr><td rowspan="2">Confidence level</td><td rowspan="2">Mitigation required</td><td colspan="6">Evaluation of impacts</td></tr>
<tr><td>Nature</td><td>Extent</td><td>Duration</td><td>Intensity</td><td>Probability</td><td>Significance</td></tr>
<tr><td>Low*</td><td>yes</td><td>negative</td><td>3</td><td>1</td><td>2</td><td>6</td><td>36</td></tr>
<tr><td colspan="2">Potential for irreplaceable loss of resources</td><td>N/A</td><td colspan="2">Cumulative impacts</td><td>yes</td><td>Reversibility</td><td>yes</td></tr>
</table>

Detailed information on the proposed construction phase was not available at the time the study was undertaken.

N/A- Not applicable to air quality

7 IMPACT ASSESSMENT FOR THE PROPOSED OPERATIONAL PHASE

7.1 Emissions inventory for the proposed operations

The release of emissions represents the environmental impact of concern during the proposed Omahola Project operations. In the development of an emissions inventory, the first approach is to establish a comprehensive list of all sources that would generate the pollutants of concern. Such sources were identified by firstly utilising the inputs and outputs to the proposed operational processes and secondly considering the disturbance to the environment. Emissions that could result from the proposed construction phase of the Omahola Project are not quantified due to limited information on the various activities associated with this phase.

Impacts and their associated sources and activities associated with the proposed project are outlined in Table 7-1.

Table 7-1: Activities and aspects identified for the proposed operational phase of the Omahola Project (Proposed Inca and Tubas Red Sand)

Impact	Source	Activity	Relevant section
	Materials handling operations	Tipping of ore onto haul trucks	6.1
		Tipping of waste rock to respective stockpiles	
		Tipping of ore into primary crusher	
		Backfilling of waste material into open pits	
	Vehicle activity on unpaved roads	Vehicles travelling on the unpaved roads to and from the open pits, waste rock dumps and processing plant. Haul trucks transporting ROM from Tubas to Inca.	6.2
	Wind erosion	Tailings dam	6.3
		Overburden/ waste stockpiles	
		ROM storage pile	
	Crushing and screening	Primary crushing and screening activities at Inca	6.4
	Drilling	Drilling activities at the open pits	6.5
	Blasting	Blasting activities at Inca	6.6
ases and Particul ates[1]	Vehicle activity[1]	Tailpipe emissions from haul vehicles	n/a
		Tailpipe emissions from further transport mediums private motor vehicles, mine personnel movement etc)	

Notes:
1. Gases and particulates resultant from the listed vehicle activity were not simulated

7.1.1 *Materials Handling Operations*

Materials handling operations associated with mining and predicted to result in significant fugitive dust emissions include the transfer of material by means of tipping, loading and offloading trucks. The quantity of dust which will be generated from such loading and off-loading operations will depend on various climatic parameters, such as wind speed and precipitation, in addition to non-climatic parameters such as the nature (moisture content) and volume of the material handled.

Fine particulates are more readily disaggregated and released to the atmosphere during the material transfer process, as a result of exposure to strong winds. Increase in the moisture content of the material being transferred would decrease the potential for dust emission, since moisture promotes the aggregation and cementation of fines to the surfaces of larger particles.

Equation 1, as depicted and discussed in Appendix A is used to calculate the emissions from tipping. The PM10 fraction of the TSP is taken to be 35% as is indicated in the US-EPA AP42 documentation. The parameters used in the calculation of emissions as a result of materials handling activities are depicted in Table 7-2.

No control efficiencies were assumed for materials handling activities for the mitigated and unmitigated *scenarios (Scenario 1 and Scenario 2)*. It was however, assumed that the three proposed waste dumps at Inca will be operational simultaneously and that 25% of the ROM at Tubas Red Sand will be hauled to Inca.

Table 7-2: Material handling operations for the proposed Omahola Project mining operations

Operation	Location	Throughput (t/hr)
Tipping of ore to truck	Inca	214
Tipping of ore to truck (Tubas Red Sand)	Tubas Red Sand	143
Tipping of waste to truck (Inca)	Inca	1071
Tipping of waste to truck (Tubas Red Sand)	Tubas Red Sand	143
Tipping of waste to waste dump 1	Inca	357
Tipping of waste to waste dump 2	Inca	357
Tipping of waste to waste dump 3	Inca	357
Tipping of backfill into Tubas Red Sand pit	Tubas Red Sand	143
Tipping of ROM to ROM Pad (Inca and Tubas Red Sand)	Inca ROM pad	250

7.1.2 Vehicle Activity on Unpaved Roads

Vehicle-entrained dust emissions from the unpaved haul roads within the proposed mining area potentially represent a significant source of fugitive dust. Such sources have been found to account for the greatest portion of fugitive emissions from many mining operations. The quantification of the release of fugitive dust from the unpaved roads was calculated assuming no control measures (such as wet suppression) for the unmitigated *scenario* and with a control efficiency of 75% for the mitigated scenario. The unpaved roads for the mine were split into segments for purposes of dispersion simulation. The parameters of the unpaved roads used in the dispersion model are presented in Table 7-3. The unpaved road size-specific emission factor equation of the US.EPA, used in the quantification of emissions for the study, is given in Appendix A, Equation 2.

In addition to traffic volumes, emissions also depend on a number of parameters which characterise the condition of a particular road and the associated vehicle traffic. Such parameters include average vehicle speed, mean vehicle weight, average number of wheels per vehicle, road surface texture, and road surface moisture (EPA, 1996). The silt percentage utilised for the unpaved roads is 25.2% and this was obtained from similar operations located close to the proposed project site. Unpaved haul roads to and from the proposed open pits, haul roads to and from the ROM stockpile (including the unpaved haul road from Tubas Red Sand to Inca) and the waste rock dumps were modelled (Table 7-3).

Since the locations of the proposed haul roads were not known at the time of the study, these were assumed, taking into consideration the shortest possible routes.

Table 7-3: Parameters of the unpaved haul roads simulated for the proposed Omahola Project mining operations

Description of Unpaved Road	Length (m)	Width (m)
Unpaved road 1 from Inca open pit to waste dump 1	625	10
Unpaved road 2 from Inca open pit to waste dump 2	1126	10
Unpaved road 3 from Inca open pit to waste dump 3 (also used for ROM to plant)	750	10
Unpaved road 4 ROM to primary crusher (Inca ROM and Tubas ROM)	1427	10
Unpaved road 5 ROM to primary crusher (Inca)	150	10
Unpaved road 1 from Tubas to Inca	8500	10
Unpaved road 2 from Tubas to Inca	428	10

In addition to traffic volumes, emissions also depend on a number of parameters which characterise the condition of a particular road and the associated vehicle traffic. Such parameters include average vehicle speed, mean vehicle weight, average number of wheels per vehicle, road surface texture, and road surface moisture (EPA, 1996).

7.1.3 Wind erosion from Exposed Areas

Significant emissions arise due to the mechanical disturbance of granular material from open areas and storage piles. Parameters which have the potential to impact on the rate of emission of fugitive dust include the extent of surface compaction, moisture content, ground cover, the shape of the storage pile, particle size distribution, wind speed and precipitation. Any factor that binds the erodible material, or otherwise reduces the availability of erodible material on the surface, decreases the erosion potential of the fugitive source. High moisture content, whether due to precipitation or deliberate wetting, promote the aggregation and cementation of fines to the surfaces of larger particles, thus decreasing the potential for dust emissions. Surface compaction and ground cover similarly reduces the potential for dust generation. The shape of a storage pile or disposal dump influences the potential for dust emissions through the alteration of the airflow field. The particle size distribution of the material on the disposal site is important since it determines the rate of entrainment of material from the surface, the nature of dispersion of the dust plume, and the rate of deposition, which may be anticipated (Burger, 1994; Burger et al., 1995).

The waste dumps, tailings dam and the run of mine (ROM) stockpile are identified to be sources that are prone to wind erosion.

The calculation of an emission rate for every hour of the simulation period was carried out using the ADDAS model. This model is based on the dust emission model proposed by Marticorena and Bergametti (1995). The model attempts to account for the variability in source erodibility through the parameterisation of the erosion threshold (based on the particle size distribution of the source) and the roughness length of the surface. Equations used for calculating emission rates from wind erosion sources are shown in Appendix A (Equations 3 to 6).

In the quantification of wind erosion emissions, the model incorporates the calculation of two important parameters, viz. the threshold friction velocity of each particle size, and the vertically integrated horizontal dust flux, in the quantification of the vertical dust flux (i.e. the emission rate).

Wind erosion sources are modelled with and without mitigation measures. A control efficiency of 30% (assumed to be due to crusting) is assumed for the waste dumps and tailings dam while a 90% control efficiency is assumed for the ROM stockpile as worst case scenario (as provided by the client).

Information pertaining to the stockpiles utilised for the proposed operational phase of the Omahola Project is shown in Table 7-4.

Table 7-4: Stockpile parameters used in the ADDAS emission model for the proposed Omahola Project mining operations

Source	Height (m)	Width (m)	Length (m)	Bulk Density (kg/m³)	Moisture (%)
Waste rock dump 1	15	1000	975	2700	3
Waste rock dump 2	15	975	975	2700	3
Waste rock dump 3	15	975	1000	2700	3
Tailings dam	14	650	1425	2092	5.8
ROM stockpile	5	75	125	2783	3

7.1.4 Crushing and Screening Activities

Primary crushing operations represent significant dust-generating sources if uncontrolled. Dust fallout in the vicinity of crushers also gives rise to the potential for the re-entrainment of emitted dust by vehicles or by the wind at a later date. The large percentage of fines in this dustfall material enhances the potential for it to become airborne (Equations 7 and 8, Appendix A for low moisture content ore) are used in the calculation of emissions from primary crushing and screening activities.

The parameters used for the calculation of emissions for primary crushing and screening activities for the proposed operational phase are shown in Table 7-5. Crushing and screening activities are modelled as unmitigated and mitigated. A control efficiency of 60% is assumed for crushing and screening in the mitigated scenario as it is proposed that the primary crusher will be located in an enclosed area.

ROM from Tubas Red Sand (25%) will be crushed in addition to the Inca ROM at the primary crusher located at Inca.

Table 7-5: Parameters used in the calculation of emissions from crushing and screening operations for the proposed Omahola Project mining operations

Crushing and screening	Tonnes per day	Moisture (%)
Primary crushing and screening	5996	3

7.1.5 Drilling

Fugitive dust emissions due to drilling operations during the operational phase of the proposed Omahola Project are quantified using the Australian NPI single value emission factors for mining (Equations 11 and 12 in Appendix A). The drilling parameters that are utilised for the proposed operations are presented in Table 7-6 (Inca) and Table 7-7 (Tubas Red Sand). No mitigation measures are assumed for drilling activities however, the reduction of emissions due to pit retention is taken into consideration (50% reduction for PM10 and 5% reduction for PM10).

Table 7-6: Drilling source specific information for the proposed Inca operational phase

Drilling Parameter	Unit
Drilling area	8000m²
No of drill holes	320
Depth of each drill hole	9

Table 7-7: Drilling source specific information for the proposed Tubas Red Sand operational phase

Drilling Parameter	Unit
Drilling area	5500m²
No of drill holes	220
Depth of each drill hole	9

7.1.6 Blasting

Source specific information used in the calculation of emissions due to blasting activities at the proposed Inca open pit is presented in Table 7-8. Equation 13 in Appendix A is used in the calculation of emissions from blasting. It is proposed that blasting activities will be undertaken at Inca, with excavating and free digging activities at Tubas Red Sand. No mitigation measures are assumed for blasting activities but similar to drilling activities, pit retention is taken into consideration.

Table 7-8: Blasting source specific information for the proposed Inca operational phase

Blasting parameter	Parameter units/ value
Blasting area	8000m²
Blasts per day	1
No of holes per blast	320

7.1.7 Excavating

The US–EPA equation (Equation 14 in Appendix A) is used to calculate emissions due to excavating activities for the proposed mining operations. Table 7-9 depicts the parameters used in calculating emissions due to excavating activities in each open pit. No control efficiency is assumed for excavation.

It is assumed that the area to be excavated at any given time is equivalent to the area drilled or blasted as this information was not available at the time the study was conducted.

Table 7-9: Parameters used in the calculation of emissions from excavating activities for the proposed Omahola Project open pits

Source	Parameters of excavated area		
	Length (m)	Width (m)	Total area (m^2)
Inca open pit	89	89	8000
Tubas Red Sand open pit	74	74	5500

7.1.8 Synopsis of Estimated Emissions for the Proposed Omahola Project Operational Phase

7.1.8.1 Scenario 1

A synopsis of the estimated particulate emissions as a result of the unmitigated proposed mining activities is presented in Table 7-10 and depicted in Figure 7-1 (PM10 source contributions) and Figure 7-2 (TSP source contributions). Unpaved roads are predicted to be the most contributing source to PM10 and TSP emissions (84% and 83% respectively). The second most significant source of PM10 and TSP is predicted to be excavating activities, with a contribution of 11% to PM10 and 8% to TSP. Drilling is predicted to be the third most significant source of PM10 and fourth most significant source of TSP emissions, with a contribution of 3% and 1% respectively. The fourth most significant source of PM10 and third most significant source of TSP is predicted to be crushing and screening, with a contribution of 2% to PM10 emissions and 7% to TSP emissions. Materials handling is predicted to be the fifth most significant source of PM10 (0.4%) to PM10 and sixth most significant source of TSP emissions (0.4%). Wind erosion is predicted to be the sixth most significant source of PM10 (0.3%) and fifth most significant source of TSP (0.4%). Blasting activities are predicted to be the least contributing source to particulate emissions (0.2% PM10 and 0.1% TSP).

Table 7-10: Source group contribution to unmitigated PM10 and TSP emissions (tpa) for the proposed Omahola Project

Source	PM10	TSP	PM10 %	TSP %	Rank PM10	Rank TSP
Crushing and screening	44	438	2	7	4	3
Materials handling	8.0	22.3	0.4	0.4	5	6
Wind erosion	6	23	0.3	0.4	6	5
Unpaved roads	1825	5140	84	83	1	1
Blasting	3.98	4.01	0.2	0.1	7	7
Excavating	236	490	11	8	2	2
Drilling	58	60	3	1	3	4
Total	**2181**	**6177**	**100.00**	**100.00**		

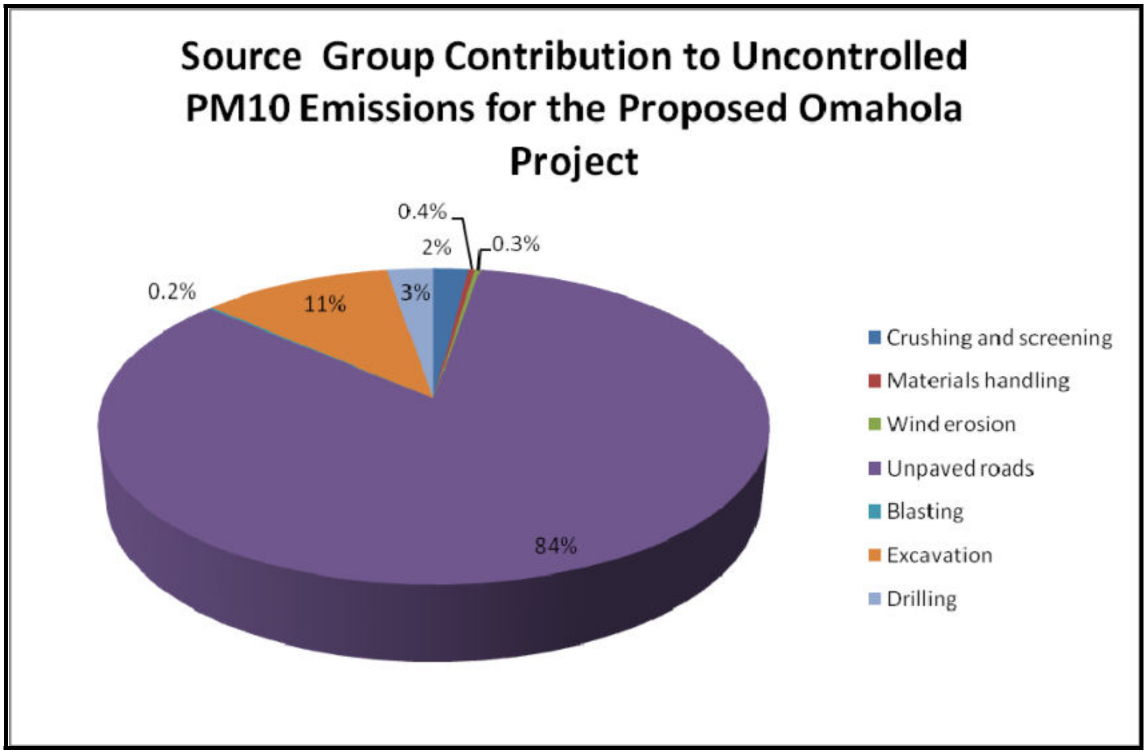

Figure 7-1: Source group contribution to estimated unmitigated PM10 emissions for the proposed Omahola Project

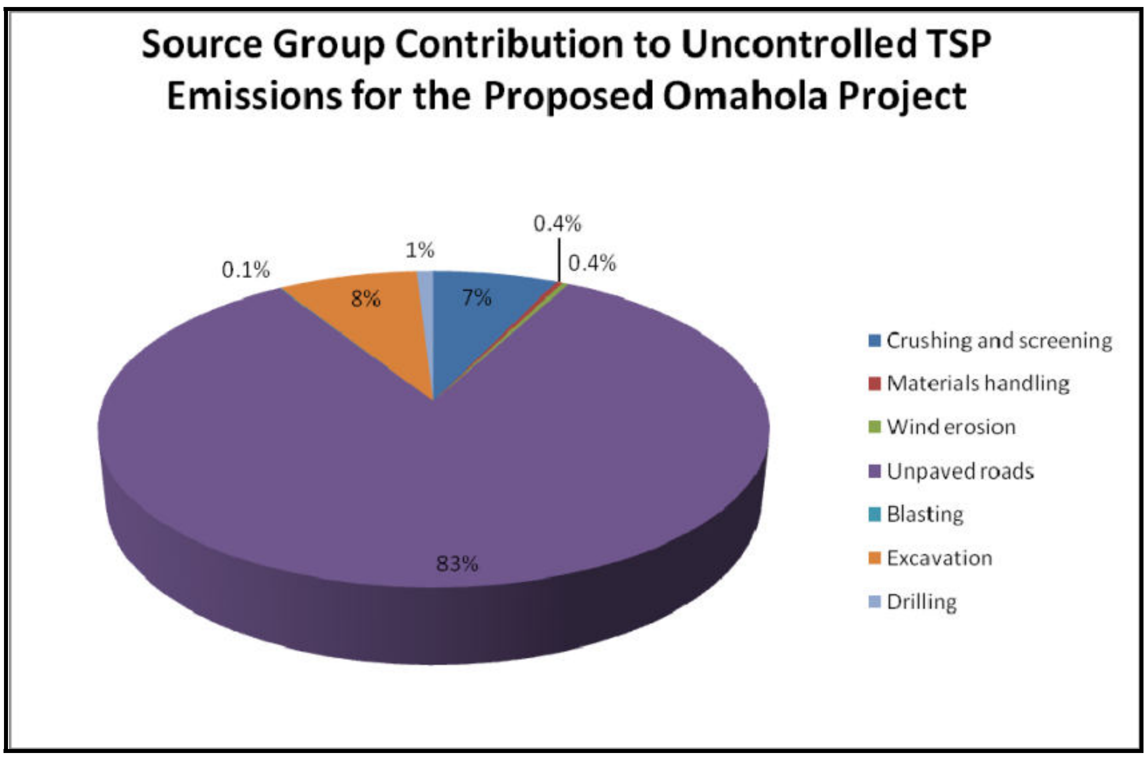

Figure 7-2: Source group contribution to estimated unmitigated TSP emissions for the proposed Omahola Project

7.1.8.2 Scenario 2

A synopsis of the estimated particulate emissions as a result of the mitigated proposed mining activities is presented in Table 7-11 and depicted in Figure 7-3 (PM10 source contributions) and Figure 7-4 (TSP source contributions). Unpaved roads are still predicted to be the most contributing source to PM10 and TSP emissions (58% and 63% respectively). With the application of mitigation measures, a significant reduction in particulate emissions due to unpaved roads is noted and hence the reduction in percentage contribution. The second most significant source of PM10 and TSP is predicted to be excavating activities, with a contribution of 30% to PM10 and 24% to TSP. Drilling is predicted to be the third most significant source of PM10 and fourth most significant source of TSP emissions, with a contribution of 7% and 3% respectively. The fourth most significant source of PM10 and third most significant source of TSP is predicted to be crushing and screening, with a contribution of 2% to PM10 emissions and 9% to TSP emissions. Materials handling is predicted to be the fifth most significant source of both PM10 and TSP emissions (1% each). Wind erosion is predicted to be the sixth most significant source of particulates (0.6% PM10 and 0.8% TSP). Blasting activities are predicted to be the least contributing source to particulate emissions (1% PM10 and 0.2% TSP).

Table 7-11: Source group contribution to mitigated PM10 and TSP emissions (tpa) for the proposed Omahola Project

Source	PM10	TSP	PM10 %	TSP %	Rank PM10	Rank TSP
Crushing and screening	18	175	2	9	4	3
Materials handling	8	22	1	1	5	5
Wind erosion	4	16	0.6	0.8	6	6
Unpaved roads	456	1285	58	63	1	1
Blasting	4	4	1	0.2	7	7
Excavation	236	490	30	24	2	2
Drilling	58	60	7	3	3	4
Total	**784**	**2052**	**100.00**	**100.00**		

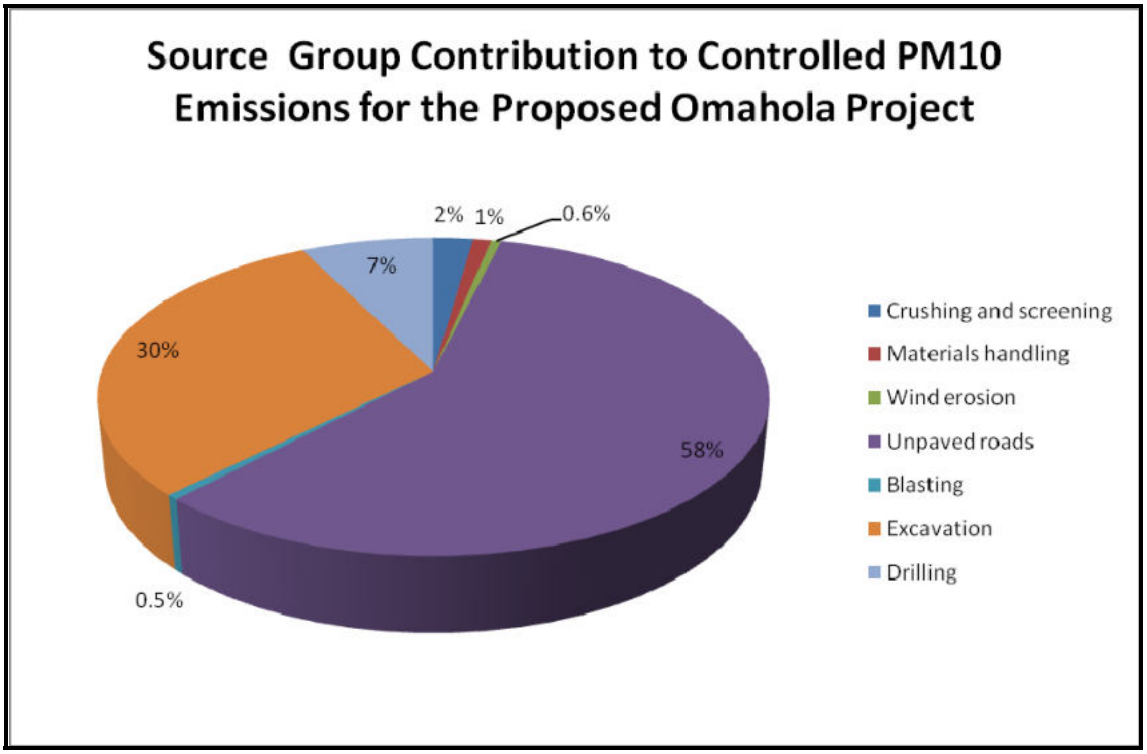

Figure 7-3: Source group contribution to estimated mitigated PM10 emissions for the proposed Omahola Project

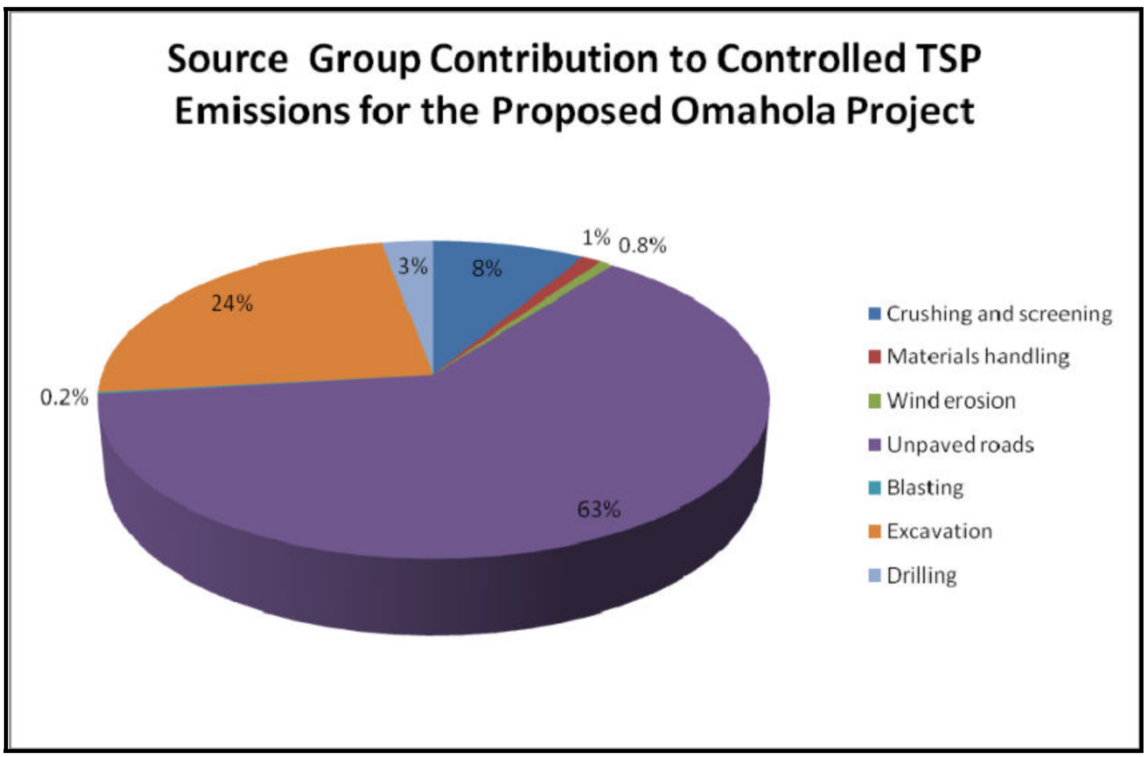

Figure 7-4: Source group contribution to estimated mitigated TSP emissions for the proposed Omahola Project

7.2 Dispersion Model Results for the Proposed Omahola Project Mining Operations

This section focuses on potential impacts due to the proposed Omahola Project mining activities at the site boundary and the sensitive receptor area of Rooikop Airport.

The cumulative impacts were derived based on the methodology as proposed by the UK Environment Agency (MFE, 2001). Whereas annual average concentrations can be added together for cumulative representation, daily averages cannot. This is because the location of highest daily concentrations may not be the same for the baseline and incremental simulations. The methodology therefore proposes adding double the annual baseline concentration to the incremental daily concentration. Thus, the cumulative daily concentrations should be viewed as an average daily ground level concentration (GLC), and not the highest daily GLC as with incremental.

7.2.1 Predicted PM10 concentrations due to the proposed mining operations

- The predicted unmitigated highest average daily ground level concentrations for the proposed Omahola Project operations exceed the WHO IT-3 air quality guideline and South African Standard of 75 µg/m³ at the proposed project site boundary (at Inca). No exceedances of the guideline or standard are predicted at Rooikop Airport (Table 7-12 and Figure 7-5).
- With mitigation measures in place for the unpaved roads, wind erosion and crushing and screening, a significant reduction in predicted impacts is noted and the predicted mitigated highest average daily ground level concentrations do not exceed the WHO IT-3 air quality guideline and South African Standard of 75 µg/m³ at the proposed project site boundary and Rooikop Airport (Table 7-12 and Figure 7-6 respectively).
- Over an annual average, the predicted unmitigated ground level concentrations exceed the WHO IT-3 annual guideline of 30 µg/m³ but do not exceed the South African annual Standard of 40 µg/m³ at the proposed project site boundary. No exceedances are predicted at Rooikop Airport (Table 7-12, Figure 7-7).
- With mitigation measures in place, the predicted ground level impacts do not exceed the WHO IT-3 annual guideline and the South African annual Standard at the proposed project site boundary and Rooikop Airport (Table 7-12 and Figure 7-8).

Table 7-12: Predicted highest daily average and annual PM10 concentrations (µg/m³) at the proposed Omahola Project site boundary and Rooikop Airport

Area	*Scenario*	PM10 Concentration (µg/m³)	
		Daily	Annual
Project site boundary	Unmitigated proposed operations	89	36
	Mitigated proposed operations	72	20
Rooikop Airport	Unmitigated proposed operations	5	1
	Mitigated proposed operations	2	0.3

7.2.2 Predicted cumulative PM10 concentrations due to the proposed mining operations and background concentrations

Although *incremental* impacts have been predicted in the study, it is important to take into consideration background concentrations for the determination of cumulative impacts. The predicted highest daily and annual average concentrations at the proposed project site boundary, taking the predicted SEA background annual concentrations into consideration, are discussed in this section.

- When background PM10 concentrations in the region are taken into consideration (Section 5.1.1), the WHO IT-3 air quality guideline and South African Standard of 75 µg/m³ are predicted to be exceeded at the project site boundary for both the unmitigated and mitigated *scenarios* (Table 7-13).
- Over an annual average, the consideration of background concentrations results in exceedances of the WHO IT3 annual air quality guideline of 30 µg/m³ and the South African annual Standard of 40 µg/m³ for all the modelled *scenarios* (Table 7-13).

Table 7-13: Predicted highest daily average and annual PM10 concentrations (µg/m³) (including predicted SEA background concentrations) at the proposed Omahola Project site boundary and Rooikop Airport

Area	*Scenario*	PM10 concentrations (including background concentrations) µg/m³)	
		Daily	Annual
Project site boundary	Unmitigated proposed operations	169	76
	Mitigated proposed operations	152	60
Rooikop Airport	Unmitigated proposed operations	85	41
	Mitigated proposed operations	82	40

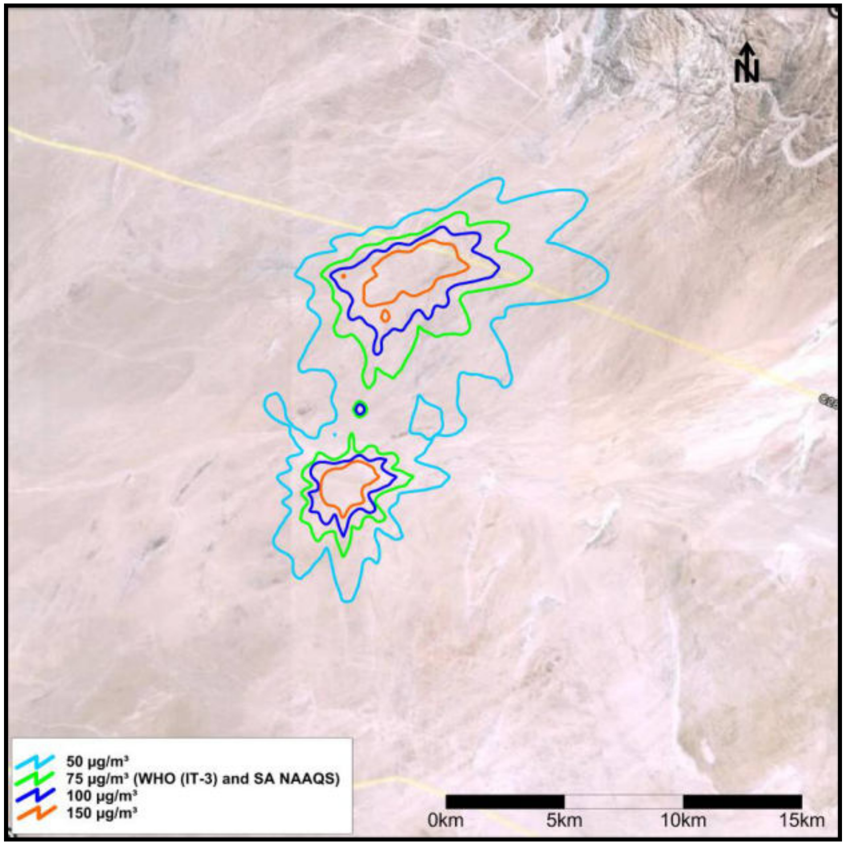

Figure 7-5: Highest daily average predicted PM10 ground level concentrations (µg/m³) for all sources due to unmitigated emissions from the proposed Omahola Project mining operations

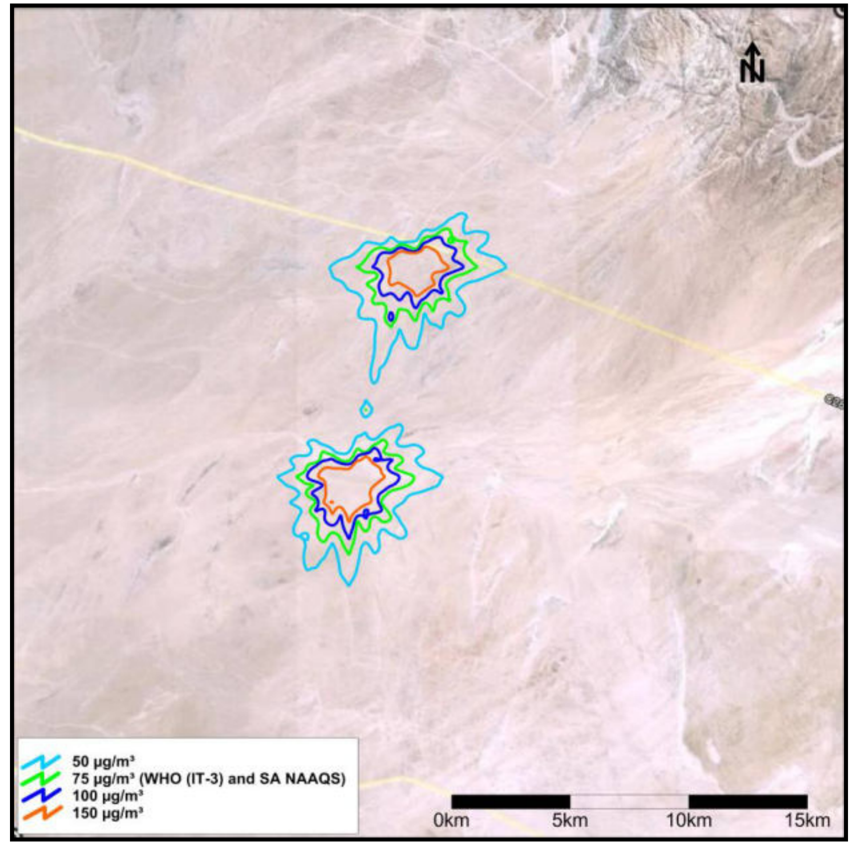

Figure 7-6: Highest daily average predicted PM10 ground level concentrations (µg/m³) for all sources due to mitigated emissions from the proposed Omahola Project mining operations

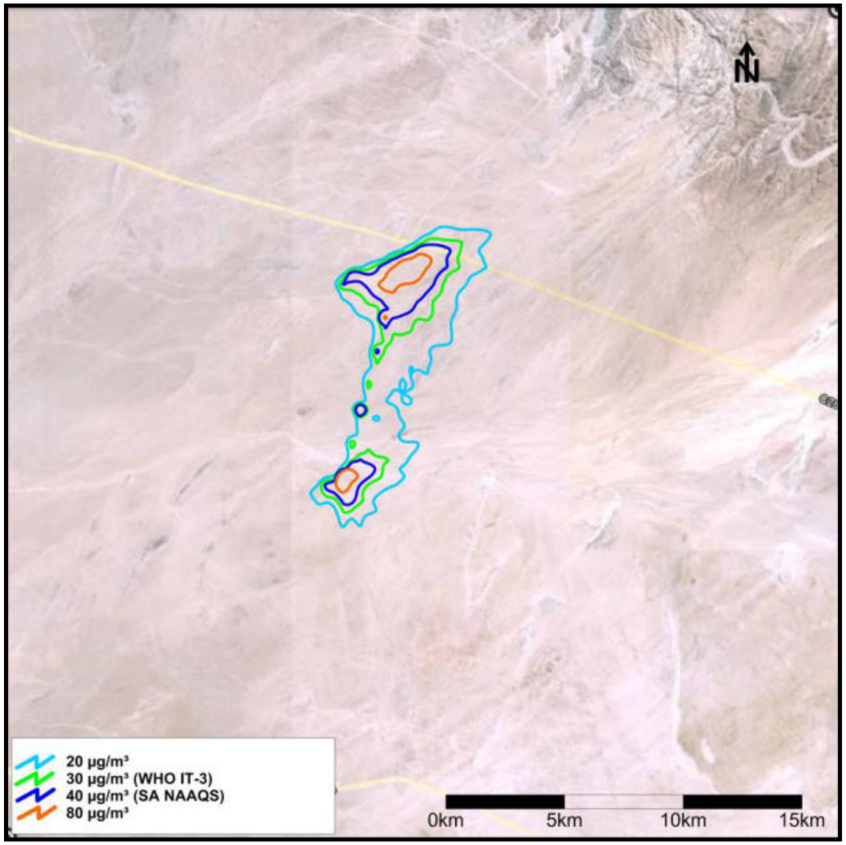

Figure 7-7: Average daily predicted PM10 ground level concentrations (µg/m³) for all sources due to unmitigated emissions from the proposed Omahola Project mining operations

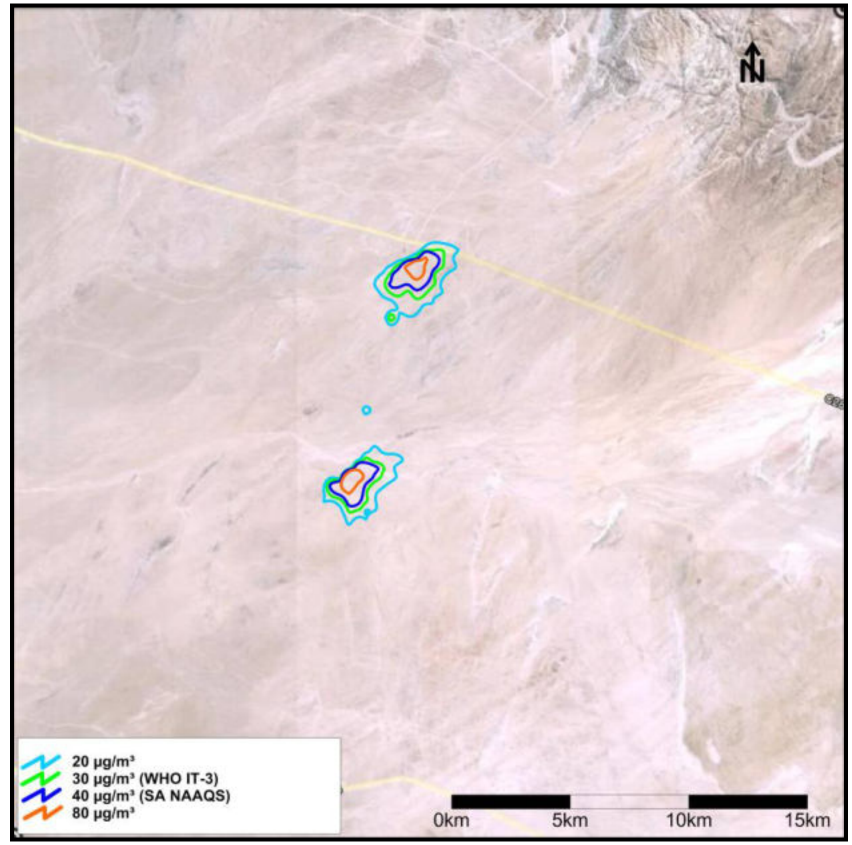

Figure 7-8: Average daily predicted PM10 ground level concentrations (µg/m³) for all sources due to mitigated emissions from the proposed Omahola Project mining operations

7.2.3 Predicted dust fallout levels due to the proposed mining operations

- The predicted unmitigated and mitigated maximum daily dust fallout levels at the proposed Omahola Project site boundary and Rooikop Airport Airport fall within the SANS residential limit of 600 mg/m²/day (Table 7-14, Figure 7-9 and Figure 7-10).
- Even when background dust fallout levels are taken into consideration (Section 5.1.2), the SANS residential limit is predicted not to be exceeded at the project site boundary and Rooikop Airport for both the unmitigated and mitigated *scenarios* (Table 7-15). The cumulative dust fallout rates also remained below the German limit of 350 mg/m²/day.

Table 7-14: Predicted maximum daily dust fallout levels (mg/m²/day) at the proposed Omahola Project site boundary and Rooikop Airport

Area	*Scenario*	Maximum daily dust deposition (mg/m²/day)
Project site boundary	Unmitigated proposed operations	100
	Mitigated proposed operations	48
Rooikop Airport	Unmitigated proposed operations	0.3
	Mitigated proposed operations	0.1

Table 7-15: Predicted maximum dust fallout levels (mg/m²/day) (including predicted SEA background dust fallout) at the proposed Omahola Project site boundary and Rooikop Airport

Area	*Scenario*	Maximum daily dust deposition (mg/m²/day)
Project site boundary	Unmitigated proposed operations	144
	Mitigated proposed operations	92
Rooikop Airport	Unmitigated proposed operations	44
	Mitigated proposed operations	44

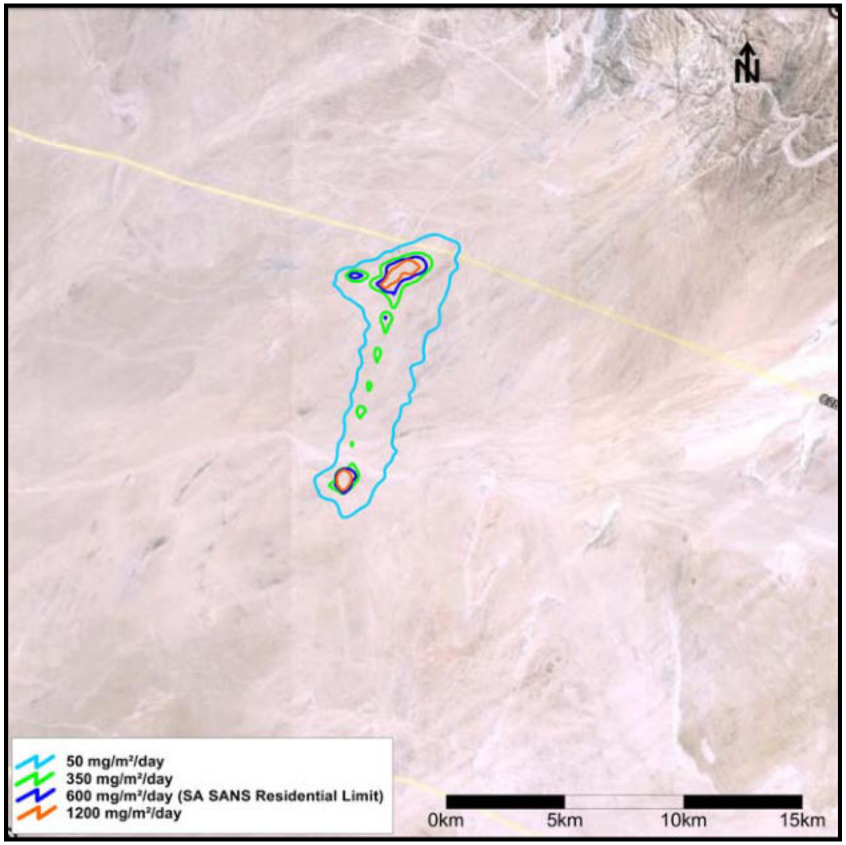

Figure 7-9: Predicted maximum daily dust deposition (mg/m²/day) for all sources due to unmitigated emissions from the proposed Omahola Project mining operations

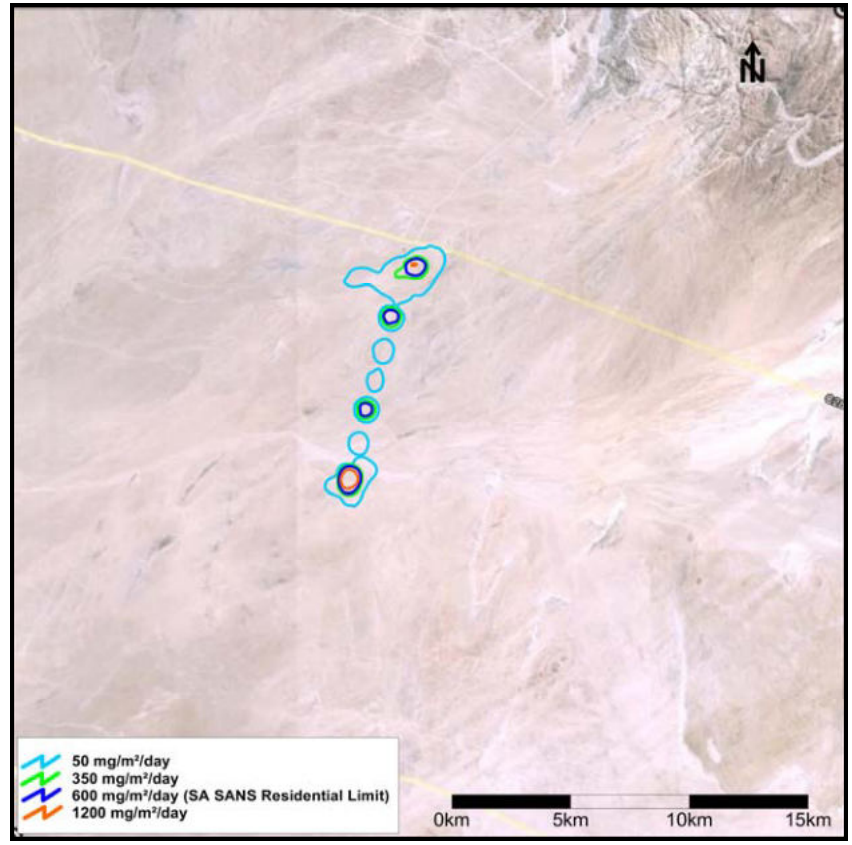

Figure 7-10: Predicted maximum daily dust deposition (mg/m²/day) for all sources due to mitigated emissions from the proposed Omahola Project mining operations

7.3 Significance rating of proposed operational phase impacts

The potential impacts due to the proposed operational phase will be of medium significance (Table 7-16). This implies that the impact could influence the decision to develop in the area unless it is effectively mitigated. There is a high potential for additive cumulative impacts occurring due to the proposed Omahola Project and the existence of similar uranium mining operations in the Erongo Region.

Table 7-16: Significance rating of proposed operational phase impacts

<table>
<tr><td colspan="2">Environmental aspect</td><td colspan="4">Air quality</td><td>Phase</td><td>Operational</td></tr>
<tr><td colspan="8">Description: The proposed operational phase for the Omahola Project will include dust generating activities such as excavation, drilling, blasting, materials handling activities, wind erosion of stockpiles, hauling of ore and waste on unpaved roads and crushing and screening.</td></tr>
<tr><td colspan="8">Mitigation: General mitigation measures for dust include wet suppression on unpaved roads, materials handling activities and crushing and screening</td></tr>
<tr><td rowspan="2">Confidence level</td><td rowspan="2">Mitigation required</td><td colspan="6">Evaluation of impacts</td></tr>
<tr><td>Nature</td><td>Extent</td><td>Duration</td><td>Intensity</td><td>Probability</td><td>Significance</td></tr>
<tr><td>medium*</td><td>yes</td><td>negative</td><td>3</td><td>3</td><td>2</td><td>6</td><td>48</td></tr>
<tr><td colspan="2">Potential for irreplaceable loss of resources</td><td>N/A</td><td colspan="2">Cumulative impacts</td><td>yes</td><td>Reversibility</td><td>yes</td></tr>
</table>

Assumptions were made (based on similar mining operations in the region) where information on the proposed operational phase was not available at the time the study was undertaken.

N/A- Not applicable to air quality

7.4 Impacts of Particulates on Plants and Animals

Limited reference data exists on the impacts of particulates on plants and animals. Most of the studies done on the effects of particulate matter on animals, particularly cattle, have concurred that the main impact of dusty environments is causing animal stress which is detrimental to their health. However, no threshold levels exist to indicate at what levels the negative effects begin to occur.

The Canadian Environmental Protection Act (CEPA) has published a document on the effects of particulates on vegetation. The conclusion was however that the information about the effects of particulates on vegetation is quite limited and that dose-response information is lacking. Research found that the primary mechanisms by which particles affect vegetation are by physical smothering of the leaf surface. The main impacts are on the physical blocking of stomata through particle lodging or penetration of stomata apertures. The chemical composition of the dust particles can also affect the plant and have indirect effects on the soil pH and ionic composition.

8 IMPACT ASSESSMENT: CLOSURE PHASE

It is assumed that all mining activities and processing operations will have ceased by the closure phase of the proposed project. The potential for impacts during this phase will depend on the extent of demolition and rehabilitation efforts during closure and on features which will remain, such as the tailings impoundment and waste dumps.

Aspects and activities associated with the closure phase of the proposed Omahola Project mining operations are listed in Table 8-1.

Table 8-1: Activities and aspects identified for the closure phase of the proposed Omahola Project mining operations

Impact	Source	Activity
Generation of TSP and PM10	Tailings facility	Reshaping and rehabilitation of tailings dams to reflect the natural surroundings
	Waste rock dumps	Rehabilitation and re-vegetation
	Plant site/s	Infrastructure removal at processing plant site
	Unpaved roads	Vehicle entrainment on unpaved road surfaces
Gas emissions (1)	Blasting	Demolition of infrastructure may necessitate the use of blasting.
	Vehicles	Tailpipe emissions from vehicles utilised during the closure phase.
Notes: (1) Gaseous emissions from tailpipes typically include: sulphur dioxide, oxides of nitrogen, carbon monoxide, hydrocarbons, lead (petrol powered vehicles only), potentially carbon dioxide.		

8.1 Significance rating of closure phase impacts

The potential impacts due to the closure phase will be of medium significance (Table 8-2). Dust will be generated due to the activities associated with the closure phase and additive cumulative impacts will be most likely to occur due to the other dust generating activities in the region.

Table 8-2: Significance rating of closure phase impacts

Environmental aspect	**Air quality**					Phase	**Closure**
Description: The closure phase will comprise demolition and rehabilitation activities. Each of these activities has a potential for dust generation							
Mitigation: General mitigation measures for dust include wet suppression							
Confidence level	Mitigation required	Evaluation of impacts					
		Nature	Extent	Duration	Intensity	Probability	Significance
Low*	yes	positive	3	1	2	6	36
Potential for irreplaceable loss of resources		N/A	Cumulative impacts		yes	Reversibility	yes

Detailed information on the proposed closure phase was not available at the time the study was undertaken.

N/A- Not applicable to air quality

9 CONCLUSIONS

An air quality impact assessment was conducted for Reptile Uranium's proposed Omahola Project. The main objective of this study was to determine the significance of the predicted impacts from proposed mining operations at Inca and Tubas Red Sand open cast mines on the surrounding environment and on human health.

To achieve this objective, the local climate was characterised. Particulates were identified to be the main pollutant of concern resulting from the proposed mining operations and all potential sources of fugitive dust have been identified and quantified. Dispersion simulations were undertaken to reflect both incremental (separate sources) and cumulative (all sources combined) impacts for the proposed operational phases.

9.1 Main Impact Assessment Findings

The comparison of predicted pollutant concentrations to ambient air quality standards facilitated a preliminary screening of the potential health and nuisance impacts. Although no residences are located close to the site, predicted impacts were assessed at the proposed project site boundary and Rooikop Airport.

When interpreting the modelling results, it is important to take cognisance of the assumptions and limitations (Section 2.11) and the inherent range of uncertainty of the dispersion model (between -50% to 200%). The predicted results are a function of the meteorological data and the source strengths (emissions data). For the purpose of this proposed project, meteorological data and maximum emissions rates (based on the production rate for the proposed operations) were used thus providing a conservative approach (worst-case scenario) in the predicted results.

9.1.1 Baseline Assessment

Over the period (November 2007 to June 2010), the prevailing wind direction is from the northwest and west southwest with very little airflow from the east-northeast. Infrequent winds are also noted from the east-northeast. The summer months are dominated by winds from the northwest, with almost no flow from the easterly and southerly sectors while autumn is dominated by winds from the east-northeast. East-northeasterly winds, characterised by very high wind speeds, are prominent during winter. The prevailing wind field returns to the dominant north-westerly flow during the spring months, with frequent northerly winds.

9.1.2 Impact Assessment: Proposed Construction Phase

Although a quantitative assessment for the construction phase of the proposed Omahola Project was not undertaken due to limited information, *incremental* concentrations and dust deposition rates are estimated to be of medium environmental significance. This is even more so given the relatively short duration of most of the activities associated with the construction phase. The significance of cumulative impacts is likely to be of high significance.

9.1.1 Impact Assessment: Proposed Operational Phase

The predicted unmitigated highest average daily ground level concentrations for the proposed Omahola Project operations exceeded the WHO IT-3 air quality guideline and South African Standard of 75 µg/m³ at the proposed project site boundary (at Inca). No exceedances of the evaluation criteria were predicted at Rooikop Airport. However, with mitigation measures in place for major contributing sources such as unpaved roads, a significant reduction in the predicted impacts was noted. As a result, the predicted mitigated highest average daily ground level concentrations did not exceed the evaluation criteria of 75 µg/m³ at the proposed project site boundary. No exceedances of the PM10 daily evaluation criteria were predicted at Rooikop Airport. Over an annual average, the predicted unmitigated ground level concentrations exceed the guideline of 30 µg/m³ at the proposed project site boundary. No exceedances were predicted at Rooikop Airport. With mitigation measures in place, the predicted ground level impacts did not exceed the annual guideline at the proposed project site boundary and Rooikop Airport. However, when background concentrations in the region were taken into consideration, exceedances of the relevant daily and annual PM10 evaluation criteria were predicted for the all modelled *scenarios.*

The predicted maximum daily dust deposition rates did not exceed the SANS residential limit or German limit at the proposed project site boundary and Rooikop Airport. The consideration of background dust fallout in the region also did not result in exceedances of the evaluation criteria at the proposed project site boundary and Rooikop Airport for the unmitigated and mitigated *scenarios.*

Incremental impacts associated with the proposed operational phase (mitigated) were of medium environmental significance. Cumulative impacts during the operation phase will potentially have a high significance.

9.1.1 Impact Assessment: Closure Phase

The potential for impacts during the closure phase are dependent on the extent of demolition and rehabilitation efforts during closure and on features which remain and these include the tailings dam and waste dumps. Impacts due to the closure phase would be of medium significance.

9.2 Conclusions

The main conclusion is that exceedances of the relevant evaluation criteria for average highest daily PM10 concentrations were predicted at the proposed project site boundary as a result of the unmitigated mining operations (without taking background concentrations into consideration). However, the application of suitable mitigation measures to the main contributing sources of PM10 and TSP emissions, i.e. the unpaved roads, would result in the reduction of impacts at the proposed project site boundary. With the consideration of background concentrations, exceedances of the relevant evaluation criteria for PM10 were predicted for all the modelled scenarios. It should be noted that this is primarily due to windblown dust from natural background sources with the additional contribution from the Omahola Project at Walvis Bay for instance, at about 1% (Liebenberg-Enslin et.al., 2010)..

Reference data on the impacts of particulates on plants and animals are scarce and therefore the impacts of the proposed operations on vegetation and animals could not be quantified. Given that it is a desert area, it is expected that the natural vegetation will have a tolerance for dust impacts. This however, will have to be confirmed through monitoring certain species in the region.

10 AIR QUALITY MANAGEMENT PLAN FOR THE PROPOSED OMAHOLA PROJECT

10.1 Project-specific Management Measures

Air Quality Management measures will ensure that the proposed operational phase of Reptile Uranium's Omahola Project will have the lowest possible impacts on the surrounding environment. This can be achieved through a combination of mitigation measures and ambient monitoring. Mitigation measures are usually implemented at the main sources of pollution with the monitoring network designed as such to track the effectiveness of the mitigation measures. To identify the most significant sources, these need to be ranked according to source strengths (emissions) and impacts. Once the main sources have been identified, target control efficiencies for each source can be defined to ensure acceptable cumulative ground level concentrations.

10.1.1 Source Ranking by Emissions

The main pollutant of concern for the proposed unmitigated and mitigated mining operations is particulates (PM10 and TSP). The main sources of *emissions* for the proposed operational phase of the project were identified as follows:

- Vehicle entrainment on the unpaved haul roads
- Excavating activities
- Crushing and screening
- Drilling

10.1.2 Source Ranking by Impacts

The main impacting sources at the proposed project boundary were in order of importance:

- Vehicle entrainment from the unpaved roads
- Excavating
- Crushing and screening
- Drilling

10.1.3 Target Controls for the Main Sources

The main sources of emissions for the modelled *scenarios* are the unpaved haul roads, excavating, drilling and crushing and screening. The main pollutant of concern is particulates, specifically PM10 and TSP. The proposed target controls on the various sources are provided below. This will mainly apply during the dry season.

10.1.3.1 Proposed Construction Phase

- Construction of the tailings dam wall, processing plant, crusher area – 50% control efficiency through effective water sprays.
- Vehicle entrainment on temporary unpaved roads – 75% control efficiency through effective water sprays (assuming use of extracted salt water) on haul roads.

10.1.3.2 Proposed Operational Phase

- Vehicle entrainment on unpaved haul roads –~90% control efficiency through the application of chemical surfactants for surface paving.
- Vehicle entrainment on in-pit haul roads – these roads change depending on the area to be mined and hence it is not practical to apply chemicals. It is recommended that a minimum of 75% control efficiency be achieved through affective water sprays (assuming use of extracted salt water).
- Open pit operations – all materials handling operations within the open pit will reduce dust generation by 62% by merely doubling the moisture content of the material handled.

10.1.3.3 Closure Phase

The potential impacts during the closure phase are dependent on the extent of demolition and rehabilitation efforts during closure and on features which remain (viz. the tailings dams and waste rock dumps). It is however, important to note that the potential for fugitive dust impacts could be rendered negligible (and proven to be so) through comprehensive rehabilitation prior to closure.

10.1.4 Identification of Suitable Mitigation Measures

10.1.4.1 Vehicle Entrainment on Unpaved Haul Roads

Three types of measures may be taken to reduce emissions from unpaved roads: (a) measures aimed at reducing the extent of unpaved roads, e.g. paving, (b) traffic control measures aimed at reducing the entrainment of material by restricting traffic volumes and reducing vehicle speeds, and (c) measures aimed at binding the surface material or enhancing moisture retention, such as wet suppression and chemical stabilization (Cowhert *et al.*, 1988; APCD, 1995).

The main dust generating factors on unpaved road surfaces include:

- Vehicle speeds
- Number of wheels per vehicle
- Traffic volumes
- Particle size distribution of the aggregate
- Compaction of the surface material
- Surface moisture
- Climate

When quantifying emissions from unpaved road surfaces, most of these factors are accounted for. Vehicle speed is one of the significant factors influencing the amount of fugitive dust generated from unpaved roads surfaces. According to research conducted by the Desert Research Institute at the University of Nevada, an increase in vehicle speed of 10 miles per hour resulted in an increase in PM10 emissions of between 1.5 and 3 times. A similar study found a decrease in PM10 emissions of 42±35% with a speed reduction from 40 km/hr to 24 km/hr (Stevenson, 2004). The control efficiency obtained by speed reduction can be calculated by varying the vehicle speed input parameter in the predictive emission factor equation given for unpaved roads. An evaluation of control efficiencies resulting from reductions in traffic volumes can be calculated due to the linear relationship between traffic volume, given in terms of vehicle kilometres travelled, and fugitive dust emitted. Similar affects will be achieved by reducing the truck volumes on the roads. Thus, by increasing the payload of the truck, fewer trips will be required to transport the same amount of material.

Water sprays on unpaved roads is the most common means of suppressing fugitive dust due to vehicle entrainment at mines, but it is not necessarily the most efficient means (Thompson and Visser, 2000). Thompson and Visser (2000) developed a model to determine the cost and management implications of dust suppression on mine haul roads using water or other chemical palliatives. The study was undertaken at 10 mine sites in Southern Africa. The model was first developed looking at the re-application frequency of water required for maintaining a specific degree of dust palliation. From this the cost effectiveness of water spray suppression could be determined and compared to other strategies. Factors accounted for in the model included climate, traffic, vehicle speed and the road aggregate material. A number of chemical palliative products, including hygroscopic salts, lignosulponates, petroleum resins, polymer emulsions and tar and bitumen products were assessed to benchmark their performance and identify appropriate management strategies. Cost elements taken into consideration included amongst others capital equipment, operation and maintenance costs, material costs and activity related costs. The main findings were that water-based spraying is the cheapest dust suppression option over the short term. Over the longer term however, the polymer-emulsion option is marginally cheaper with added benefits such as improved road surfaces during wet weather, reduced erosion and dry skid resistance (Thompson and Visser, 2000).

An empirical model, developed by the US-EPA (EPA, 1996), was used to estimate the average control efficiency of certain quantifies of water applied to a road. The model takes into account rainfall, evaporation rates and traffic. Water and chemical sprays resulting in at least 90% control efficiency would be a requirement to result in a significant reduction in ground level concentrations and dustfall levels. Should only water be applied, the average amounts needed to ensure 75% control efficiency on the main and in-pit haul roads (assuming 50 trucks/hour) during the dry months of the year is 1l/m²/hour.

Chemical suppressant has been proven to be affective due to the binding of fine particulates in the road surface, hence increasing the density of the surface material. In addition, dust control additives are beneficial in the fact that it also improves the compaction and stability of the road. The effectiveness of a dust palliative include numerous factors such as the application rate, method of application, moisture content of the surface material during application, palliative concentrations, mineralogy of aggregate and environmental conditions. Thus, for different climates and conditions you need different chemicals, one chemical might not be as effective as another under the same conditions and each product comes with various advantages and limitations of each own. In general, chemical suppressants are given to achieve a PM10 control efficiency of 80% when applied regularly on the road surfaces (Stevenson, 2004).

There is however no cure-all solution but rather a combination of solutions. A cost-effective chemical control programme may be developed through establishing the minimum control efficiency required on a particular roadway, and evaluating the costs and benefits arising from various chemical stabilization practices. Appropriate chemicals and the most effective relationships between application intensities, reapplication frequencies, and dilution ratios may be taken into account in the evaluation of such practices.

Spillage and track-on from the surrounding unpaved areas may result in the deposition of materials onto the chemically treated or watered road resulting in the need for periodic “housekeeping” activities (Cowherd et al., 1988; EPA, 1996). In addition, the gradual abrasion of the chemically treated surface by traffic will result in loose material on the surface which would have to be controlled. The minimum frequency for the reapplication of watering or chemical stabilizers thus depends not only on the control efficiency of the suppressant but also on the degree of spillage and track-on from adjacent areas, and the rate at which the treated surface is abraded. The best way to avoid dust generating problems from unpaved roads is to properly maintain the surface by grading and shaping for cross sectional crowing to prevent dust generation caused by excessive road surface wear (Stevenson, 2004).

One of the main benefits of chemical stabilisation in conjunction with wet suppression is the management of water resources (MFE, 2001). Given the extraction of salt water from the mining areas, it is recommended that this be used for dust suppression for the salt will have a similar effect as water combined with chemicals (as is currently the case on the road between Walvis Bay and Swakopmund).

10.1.4.2 Materials Handling Operations

Materials handling operations including primary crushing and screening of ore and materials transfer point were identified as significant sources of emissions during the proposed mining operations.

The control efficiency of pure water suppression can be estimated based on the US-EPA emission factor which relates material moisture content to control efficiency. This relationship is illustrated in Figure 10-1. From the relationship between moisture content and dust control efficiency it is apparent that by doubling the moisture content of the material an emission reduction of 62% could be achieved. Thus chemicals mixed into the water will not just save on water consumption but also improve the control efficiency of the application even further.

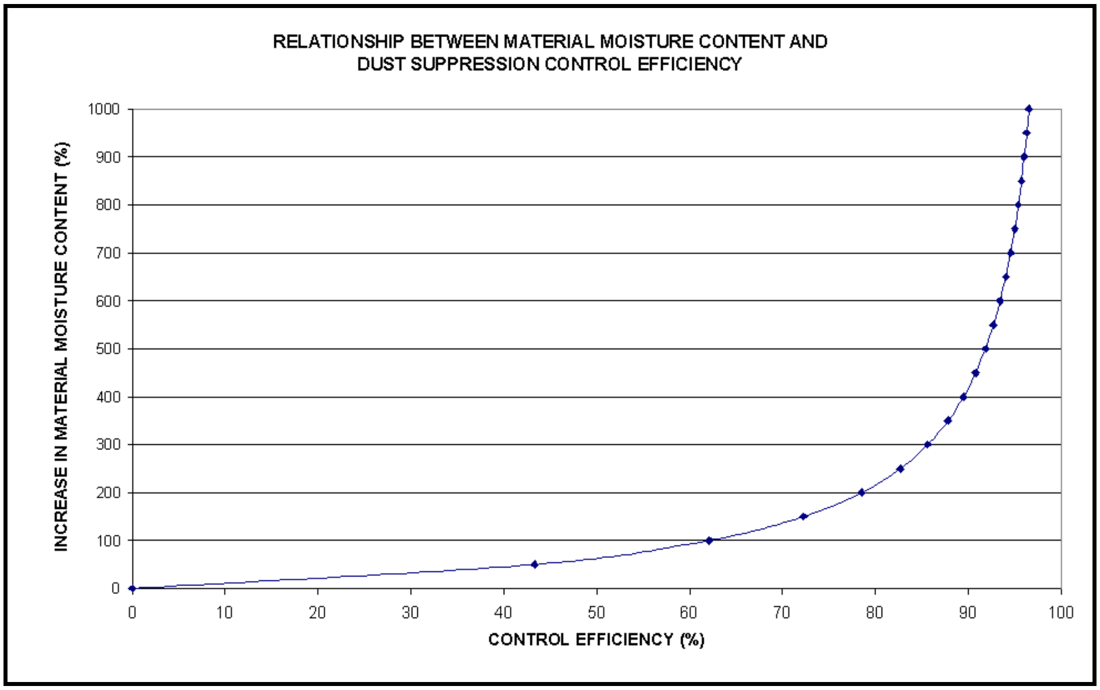

Figure 10-1: Relationship between the moisture content of the material handled and the dust control efficiency (calculated based on the US-EPA predictive emission factor equation for continuous and batch drop operations)

The crusher design for the proposed Omahola Project indicates that the crusher will be partially enclosed and will most likely include water sprays at all transfer points and at the crushing area. This would ensure 50% control efficiency, reducing the impacts to negligible levels.

10.1.4.3 Open Pit Operations

All materials handling operations within the open pit will reduce dust generation by 62% by merely doubling the moisture content of the material handled. A 75% reduction in dust emissions from unpaved in-pit haul roads can be achieved through effective water sprays combined with chemicals. The Australian NPi in their Emission Estimation Technique Manual for Mining states that a 70% and 95% reduction in dust emissions from drilling can be achieved through effective water sprays and fabric filters respectively.

In addition, the Australian NPi stipulates a 50% reduction of TSP emissions due to pit retention, and 5% for PM10 emissions. This is based on the increase in volume (the deeper the pit becomes) and thus resulting in better dispersion potential for specifically PM10 emissions before reaching the surface. Similarly for TSP, the potential for deposition on the surface becomes smaller for more dust would settle within the pit. This as the pit becomes bigger and deeper; the impacts from the in-pit operations should reduce.

10.1.5 Monitoring Requirements

Key performance indicators against which progress may be assessed form the basis for all effective environmental management practices. Performance indicators are usually selected to reflect both the source of the emission directly and the impact on the receiving environment. Ensuring that no visible evidence of windblown dust exists represents an example of a source-based indicator, whereas maintaining off-site dustfall levels to below 250 mg/m^2/day represents an impact- or receptor-based performance indicator. Source-based performance indicators have been included in regulations abroad.

- Source based performance indicators for the unpaved roads would be no visible dust when trucks/vehicles drive on the roads. It is recommended that dust fallout in the immediate vicinity of the road perimeter be less than 1,200 mg/m^2/day.
- The absence of visible dust plume at all tipping points and outside the primary crusher would be the best indicator of effective control equipment in place. In addition the dust fallout in the immediate vicinity of the tipping and crushing sources should be less than 1,200 mg/m^2/day.
- From all activities associated with the proposed Omahola Project, dust fallout levels should not exceed 1200 mg/m^2/day outside the project boundary.

In addition to the above-mentioned monitoring requirements, a dust control checklist by Environment Australia can also be used in the monitoring and management of dust emissions due to the proposed operational activities. Detail on this dust control checklist is provided in Appendix B.

10.1.5.1 Proposed operational phase dust fallout monitoring network

A dust fallout network provides management with an indication of what the reduction in fugitive dust levels are once mitigation measures are implemented. In addition, a dust fallout network can serve to meet various objectives, such as:

- Compliance monitoring;
- Validate dispersion model results;
- Use as input for health risk assessment;
- Assist in source apportionment;
- Temporal trend analysis;
- Spatial trend analysis;
- Source quantification; and,
- Tracking progress made by control measures

It is recommended that a dust fallout monitoring network, consisting of single dust buckets be implemented for the proposed Omahola Project, taking into consideration the predicted impacts and prevalent wind direction in the area. Since there are no sensitive receptors located relatively close to the proposed mining operations, the dust buckets are mainly recommended as indicators for management.

Single dust bucket 1 can be placed downwind of the Inca processing plant and primary crushing operations for potential impacts from these sources (Figure 10-2). It is also recommended that single dust bucket 2 be located downwind, close to the tailings dam, while single dust bucket three can be placed downwind of waste dump 2, waste dump 3 and the open cast pit. Single dust bucket 4 is recommended for the purposes of monitoring potential impacts from waste dump 1. It is proposed that single dust bucket 5 be located close to the C28 for potential impacts from this public road. Single dust buckets can also be placed close to the unpaved haul roads (predicted to be major contributing sources to particulates) once the locations of these have been determined as they had not been finalised at the time the study was undertaken. It is recommended that dust fallout in the immediate vicinity of the unpaved road perimeter be less than 1,200 mg/m^2/day.

Although a detailed mine layout has not been finalised for Tubas Red Sand, it is recommended that single dust buckets be positioned downwind of the open pit mining operations for potential impacts from these sources. Single dust buckets can also be placed close to the unpaved roads. It is especially recommended that a single dust bucket be placed next to the proposed unpaved haul road from Tubas Red Sand to Inca once the final location of the road has been determined.

The single dust fallout buckets should be designed according to the American Society for Testing and Materials standard method for collection and analysis of dustfall (ASTM D1739-98). The ASTM method employs a simple device consisting of a cylindrical container (not less than 150 mm in diameter) exposed for one calendar month (30 ±2 days). The bucket is placed at a height of 2 m above the ground. A detailed discussion on dust fallout monitoring is included in Appendix C.

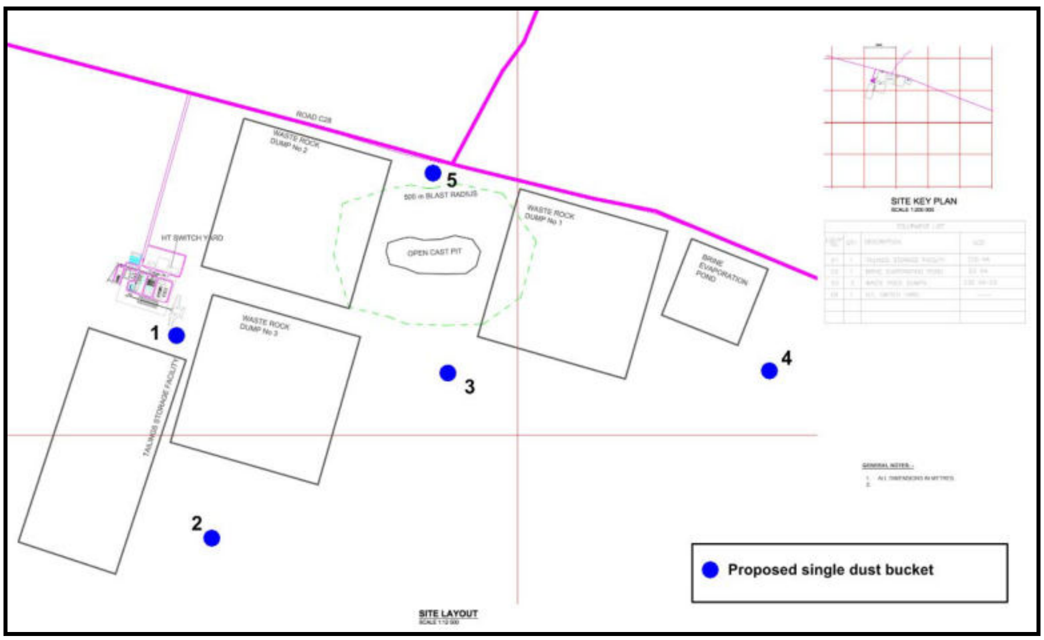

Figure 10-2: Proposed dust fallout monitoring network for the proposed Omahola Project

10.2 Record-keeping, Environmental Reporting and Community Liaison

10.2.1 Periodic Inspections and Audits

It is recommended that site inspections and progress reporting be undertaken at regular intervals (at least quarterly) during operations, with annual environmental audits being conducted. Annual environmental audits should form part of the overall Environmental Management System (EMS) for the proposed Omahola Project. Results from site inspections and off-site monitoring efforts should be combined to determine progress against source- and receptor-based performance indicators. Progress should be reported to all interested and affected parties, including authorities and persons affected by pollution.

Corrective action or the implementation of contingency measures must be proposed to the stakeholder forum in the event that progress towards targets is indicated by the quarterly/annual reviews to be unsatisfactory.

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APPENDIX A:
TECHNICAL DESCRIPTION OF EMISSIONS QUANTIFICATION

A.1: Fugitive Dust Emissions from Materials Handling Operations

The following predictive equation was used to estimate emissions from anticipated material tipping operations:

$$E_{TSP} = 0.0016 \frac{(U/2.2)^{1.3}}{(M/2)^{1.4}} \tag{1}$$

where,

E_{TSP}	=	Total Suspended Particulate emission factor (kg dust / t transferred)
U	=	mean wind speed (m/s)
M	=	material moisture content (%)
k	=	particle size multiplier (dimensionless)

The particle size multiplier varies with aerodynamic particle sizes and is given as a fraction of TSP. For PM30 the fraction is 74%, with 35% of TSP given to be equal to PM10, and the PM2.5 fraction is 11% of TSP (EPA, 1998a). Hourly emission factors, varying according to the prevailing wind speed, were used as input in the dispersion simulations. Moisture content for the different types of material were not available and use was made of the typical moisture contents given by US-EPA in the section pertaining aggregate handling and storage piles (EPA, 1998a).

Hourly emission rates, varying according to the prevailing wind speed, were used as input in the dispersion simulations.

A.2: Vehicle –Entrained Emissions from Unpaved Roads

The force of the wheels of vehicles travelling on unpaved roadways causes pulverisation of surface material. Particles are lifted and dropped from the rotating wheels, and the road surface is exposed to strong air currents in turbulent shear with the surface. The turbulent wake behind the vehicle continues to affect the road surface once the vehicle has passed. The quantity of dust emissions from unpaved roads varies linearly with the volume of traffic. In addition to traffic volumes, emissions also depend on a number of parameters which characterise the condition of a particular road and the associated vehicle traffic, including average vehicle speed, mean vehicle weight, average number of wheels per vehicle, road surface texture, and road surface moisture (EPA, 1998b).

The unpaved road size-specific emission factor equation of the US-EPA was revised in their 1998 AP42 document on Unpaved Roads and was used in the quantification of emissions for the current study. It is given as follows:

$$E = k(\frac{s}{12})^a (\frac{W}{3})^b \tag{2}$$

where,

E = emissions in kg of particulates per vehicle kilometre travelled (lb/VMT)

K,a,b and c = empirical constants (Table C-1)

s = surface material silt content (%)
W = mean vehicle weight (tons)

A.3 Wind Erosion from Exposed Areas

In the quantification of wind erosion emissions, the model incorporates the calculation of two important parameters, viz. the threshold friction velocity of each particle size, and the vertically integrated horizontal dust flux, in the quantification of the vertical dust flux (i.e. the emission rate). The equations used are as follows:

$$E_i = G_i 10^{(0.134C-6)} \qquad \textbf{(3)}$$

where,

$$G_i = 0.261 \frac{\rho_a}{g} U_*^3 (1+R_i)(1-R_i{}^2) \qquad \textbf{(4)}$$

$$R_i = \frac{U_{t*i}}{U_*} \qquad \textbf{(5)}$$

and,

$\mathbf{E_i}$	= Emission rate (size category i)
C	= clay content (%)
ρ_a	= air density
g	= gravitational acceleration
$\mathbf{U_*}$	= frictional velocity
$\mathbf{U_{t*i}}$	= threshold frictional velocity (size category i)

Dust mobilisation occurs only for wind velocities higher than a threshold value, and is not linearly dependent on the wind friction and velocity. The threshold friction velocity, defined as the minimum friction velocity required to initiate particle motion, is dependent on the size of the erodible particles and the effect of the wind shear stress on the surface. The threshold friction velocity decreases with a decrease in the particle diameter, for particles with diameters >60 µm. Particles with a diameter <60 µm result in increasingly high threshold friction velocities, due to the increasingly strong cohesion forces linking such particles to each other (Marticorena and Bergametti, 1995). The relationship between particle sizes ranging between 1 µm and 500 µm and threshold friction velocities (0.24 m/s to 3.5 m/s), estimated based on the equations proposed by Marticorena and Bergametti (1995), is illustrated in Figure A.1.

The logarithmic wind speed profile may be used to estimate friction velocities from wind speed data recorded at a reference anemometer height of 10 m (EPA, 1996):

$$U^* = 0.053 U_{10}^+ \qquad \textbf{(6)}$$

(This equation assumes a typical roughness height of 0.5 cm for open terrain, and is restricted to large relatively flat piles or exposed areas with little penetration into the surface layer.)

The wind speed variation over the dump was based on the work of Cowherd et al. (1988). With the aid of physical modelling, the US-EPA has shown that the frontal face of an elevated pile (i.e.

windward side) is exposed to wind speeds of the same order as the approach wind speed at the top of the pile. The ratios of surface wind speed (u_s) to approach wind speed (u_r), derived from wind tunnel studies for two representative pile shapes, are indicated in Figure A.2 (viz. a conical pile, and an oval pile with a flat top and 37° side slope. The contours of normalised surface wind speeds are indicated for the oval, flat top pile for various pile orientations to the prevailing direction of airflow (The higher the ratio, the greater the wind exposure potential.)

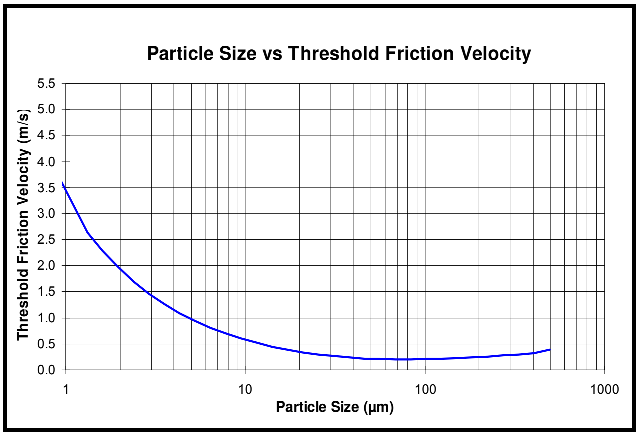

Figure A.1: Relationship between particle sizes and threshold friction velocities using the calculation methods proposed by Marticorena and Bergametti (1995)

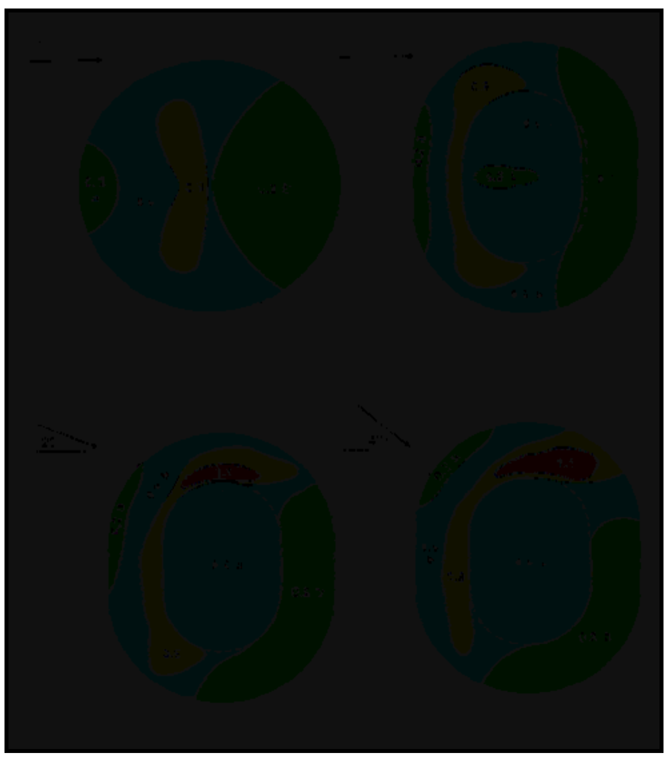

Figure A.2: Contours of normalised surface wind speeds (i.e. surface wind speed / approach wind speed (After EPA, 1996)

A.4 Crushing and Screening

Fugitive dust emissions due to the crushing and screening operations of the proposed 2011 construction and 2016 operational phase of the proposed Belfast project were quantified using US-EPA single valued emission factors for such operations (Table A-1).

Table A-1: US-EPA emission factors for crushing and screening

Source	Emission Factor (kg/ton material processed)			
	Low Moisture Material[a]		High Moisture Material [b]	
	PM10	TSP	PM10	TSP
Primary crushing	0.02	0.2 **(7)**	0.004	0.01 **(9)**
Secondary crushing	0.04	0.6 **(8)**	0.012	0.03 **(10)**

A.5: Drilling

Australian NPI emission factors for drilling operations

E_{TSP} = 0.59 kg TSP/hole drilled **(11)**

E_{PM10} = 0.31 kg PM10/hole drilled **(12)**

A.6: Blasting

Fugitive dust emissions due to blasting were quantified using the NPI predictive emission factor for mining:

$$E_{TSP} = 344\left(\frac{A^{0.8}}{M^{1.9} \times D^{1.8}}\right) \qquad \textbf{(13)}$$

This equation takes into account other variables that are likely to be important in the generation of dust. Thus the equation was used to calculate emissions for the study. The PM10 fraction constitutes 52% of the TSP for blasting (US-EPA, 1998).

Where,
M is the moisture content of the material
D is the depth of the hole
A is the blasting area

A.7 Excavating

The excavation equation used in the study is shown below

$$EF = k * 0.0056 * M^{-0.9} \qquad \textbf{(14)}$$

Where,

$k=1.56$ for TSP
$k=0.75$ for PM10

APPENDIX B:
CHECKLIST FOR DUST CONTROL (AFTER ENVIRONMENT AUSTRALIA, 1998).

Table B-1: Checklist for Dust Control (After Environment Australia, 1998)

ISSUE	OUTPUTS	PERFORMANCE MEASURES	IMPROVEMENT
Information and Planning			
HAVE YOU, determined the sources of dust in the operations?	Potential sources of dust identified in the EIA	Comprehensive list of individual sources	Sources considered for each stage of the mine (i.e. exploration, construction, operation, decommissioning, rehabilitation and closure)
HAVE YOU attempted to characterise the types of dust and quantities produced (modelling)?	Estimates of dust types and levels to be produced Dust emission inventory and determination of dust emission factors	Estimates based on typical measured levels for a mining plant. Dust inventory is derived by analysing the mine plan to establish potential dust sources and estimate the level of dust-producing activity associated with each source. Emission factors are derived by assessing the quantifiable activities or aspects which generate dust, such as vehicle size, speed and distance travelled on haul roads.	Estimates, inventory and emission factors made for all potential sources for each stage of the mine (emission factors are only applicable when emissions are to be modelled).
DOES YOUR characterisation of the types and quantities of dust include diffuse dust sources?	All types and locations of dust emissions can be ranked and controls planned in a systematic manner	Quantitative estimates of dust emission rates from different classes of mining activity and land surface types	Use of models to produce estimates of dust types and levels across a wide range of operating and climatic conditions
HAVE YOU undertaken an impact assessment?	Identification of sensitive receptor areas Assessment of maximum levels to avoid impacts, significant concerns or discomfort	Assessment identifies dust levels likely to be experienced by workers and at key locations.	The potential health risk from dust is related to the size of dust particles. Mine dust lies in the range of 1-100 µ
HAVE YOU developed a draft management strategy, based on the impact assessment?	Incorporates input from the community and the regulatory authorities Addresses all environmental and social issues likely to arise from dust at the proposed project	Initial planning should include development of a draft management strategy which: • Identifies all the potential sources and risks • Sets out objectives for environmental protection and risk minimisation • Provides a framework for evaluating different options and choosing a design which reflects site conditions and environmental sensitivities	Consultation with key stakeholders during preparations of the draft management strategy
HAVE YOU devised approaches to mitigate impacts to acceptable levels?	Strategy incorporates "built in" design features to minimise the generation of dust at source	Strategy includes addressing the mitigation of dust	The EIA and mine plan for the project set out in a framework based upon: Mine design to avoid the generation of dust Systems design and management to minimise the generation of dust during operations Treatment of dust problems through active monitoring and response, and redesign of strategies if required.
Information and Planning Continued			
HAVE YOU considered the probable regulatory requirements?	Level to which targets in the strategy conform to standards and regulations taking into account estimates of inputs from all probable sources of dust.	Dust strategy describes relevant standards and regulations	
ARE THE target levels developed in consultation with the community?	Documented agreement on maximum permissible levels between company and key community group/s	Maximum dust levels explained and agreed with the community	Establishment of formal and frequent consultation with the local community early in the planning process.

ISSUE	OUTPUTS	PERFORMANCE MEASURES	IMPROVEMENT
DO THE provisions of the dust management plan also apply to the decommissioning, rehabilitation, and closure stages?	Smooth transition from operational to decommissioning stages, with low risk of exceedance of dust control targets.	Decommissioning, rehabilitation and closure plans for all include provisions for control of dust.	Plans incorporate provisions which must reflect the specific activities involved at the end of mining.
Management and Operation			
HAVE YOU prepared an operational dust management plan?	Dust management plan	The management plan: • sets out targets and management strategies for all issues identified in the impact assessment and in community consultations • must be integrated with other operational plans into an overall environmental management system	ISO 14001 accreditation may help to demonstrate the environmental commitment to regulators and other stakeholders.
IS the management plan known and understood by all staff including plant operators?	Staff awareness of the management plan and its contents	Relevant documentation must be available to staff, regulators and auditors.	Management plan available to staff, staff instructions on the control of dust, regular checks on effectiveness of operational systems, dust included in environmental awareness training seasons.
HAVE YOU selected appropriate options to minimise the generation of dust?	Few significant issues related to dust at site	Evidence of good design to reduce dust generation through mine design, choice of equipment, and work practices Consistent application of good design across all types of dust sources, including road transport outside the mining area.	The use of computer modelling to investigate the control measures needed to achieve targets.
HAVE YOU incorporated design features to mitigate the potential impacts from the dust generated at site?	Few significant issues related to dust at the site	Evidence of installation of engineering works, equipment modification etc to minimise dust Any significant dust sources identified via monitoring have been objectively evaluated and remedial action taken.	All reasonable measures taken to reduce from all fixed and mobile equipment
DO YOU have operational systems to control dust in all areas with dust potential?	Procedures described in the mine plan and EIA implemented correctly, and dust control targets achieved.	The EIA and related manuals will set out procedures for dust management in all relevant areas of the site	Documented procedures need to cover all mining activities.
Management and Operation Continued			
IS THERE documentation to demonstrate that the dust management plan is carried out properly?	Assurance to managers that dust control targets for the operation are being met.	Regular reports (monthly) of dust management activities and assessment against control targets and requirements of the management plan.	Standard operating procedures for staff working in dusty areas, operating dusty equipment, and involved in drilling and blasting activity, setting out responsibilities, and methods for limiting and reporting dust levels and incidents.
DO YOU have a system in place to incorporate improvement?	Continual improvement and reduced probability of recurrence of undesirable dust events	Evidence of review and update of systems and equipment where unsatisfactory dust levels have been recorded.	Assessment of the adequacy of dust control should be incorporated in annual environmental audits of the project.
Monitoring and Assessment			
IS THERE a monitoring regime in place which addresses all of the possible areas for environmental and social impact from dust identified at the planning stage?	The level of performance of dust control and potential impacts on workers, the public and environment is well known to managers	Comprehensive monitoring regime which includes measurement of levels in worker areas and areas of the community sensitivity. Monitoring regime sets out: • Parameters to be monitored • Monitoring locations	Reporting and record keeping includes: Recording intervals Location of attended and unattended monitoring instruments Comparison of monitoring results with those from

ISSUE	OUTPUTS	PERFORMANCE MEASURES	IMPROVEMENT
		• Monitoring interval • Data and data analysis requirements for monitoring reports • Reporting interval	modelling (if applicable)
ARE environmental and community targets set, and are the layout, techniques, frequency, quality and sensitivity of monitoring and sampling appropriate to these targets?	Low probability of community concern provided dust is controlled to within levels agreed by the community.	Control targets agreed with the community are set out in the management plan and monitoring regime and are used as key benchmarks to evaluate adequacy of performance in regular monitoring reports.	Tools for effective dust monitoring include: Baseline sampling Control site sampling Dust deposition gauges (provides long term data) High volume samplers (quantitative data over 24hr periods) Continuous particle monitors (provides data relevant to sort term events) Size-selective samplers (samples dust in size fractions) Personal exposure samplers (worn by workers)
IS monitoring undertaken in accordance with appropriate standards?	High level of assurance or the reliability of dust monitoring results	Evidence that monitoring techniques accord with appropriate standards	Measures outlined in the South African National Standards, SANS 1929:2004 are recommended.
Monitoring and Assessment Continued			
DOES monitoring include meteorological data?	Proactive management of site activities can be undertaken to avoid significant dust events in periods of bad weather.	Routine collection of data on predicted rainfall, temperature and wind velocity	The erection of a site specific meteorological is highly recommended.
ARE data collected in accordance with the requirements of the monitoring regime?	Low risk of regulatory non-compliance or of community concerns regarding dust.	Monthly and annual reports of dust data, which cross refer to monitoring requirements	
ARE the data analysed and regularly reported to the regulatory authorities?	Assurance that all regulatory requirements for dust are being met continuously	Regular reports (i.e., monthly) provided, where deemed necessary.	Dust control performance is reported against community-agreed targets in public reports.
ARE non-compliance issues or abnormalities in the data routinely recorded?	Management aware of any areas of poor performance Management provides an ongoing measure of effectiveness of the current system and past improvements	Register of non-compliance and unplanned events, indicates time of event, time of action, type of action, result and interaction with authorities.	Regulatory authority advised immediately of all non-compliance and sign cant unplanned events.
IS THERE a system in place for significant dust events or issues to be addressed to reduce prospects of recurrence?	Reduced risk of recurrence of significant dust events	Evidence that entries in the register of non-compliance and unplanned events are investigated properly and appropriate remedial action is identified and implemented promptly.	Standard deadline set for completion of actions to remedy dust events. Number of entries in the register and speed of actioning improvements can be used as reporting criteria to staff, management, regulators, and the community.
IS liaison with the community maintained in relation to dust issues?	Good community relationships maintained	Documentation of regular community liaison that addresses issues of dust.	Community meetings / stakeholder forum held regularly with dust standing as an agenda item. Special meeting held immediately after a significant event raising community concern
IS a complaints register maintained and are complaints investigated?	Areas of poor dust control are addressed quickly so that the risk of recurrence is minimised Good community relationships must be maintained.	Documented complaints register which records details of complaints and any follow-up action.	Register records date, time, and type of event, which is the subject of the complaint; follow-up action, risk of recurrence. Reporting back to the complainant

Appendix C:
Monitoring Procedure for Dust Fallout for the Proposed Omahola Project

C.1 DUST FALLOUT MONITORING

A dust fallout network was recommended for the proposed Reptile Uranium Omahola Project to provide management with an indication of what the fugitive dust levels are once the project commences.

This section provides dust fallout monitoring procedures to ensure that the dust fallout network is properly maintained and that the results from the monitoring are reported in the correct manner.

C.1.1 Dustfall Monitoring Apparatus

Dust fallout monitoring is a crude and non-specific test method primarily focused to study long-term trends and to obtain samples of settleable particulate matter for further chemical analysis. It is not suitable for determining dust fallout in small areas affected by specific sources. The advantage of dust fallout buckets is the simplicity of the method, the relative low costs associated with it and that it can be operated without a large technically-skilled staff (ASTM D1739-98).

Two types of dustfall monitors are used, viz. (i) single dust bucket monitors; and (ii) four-bucket wind directional monitors.

The single dust bucket monitors are deployed following the American Society for Testing and Materials standard method for collection and analysis of dustfall (ASTM D1739-98). This method employs a simple device consisting of a cylindrical container (not less than 150 mm in diameter, with height not less than twice its diameter) half-filled with de-ionised water exposed for one calendar month (30 ±2 days). The water is treated with an inorganic biocide to prevent algal growth in the buckets. The most common reagent used for this is a 10% copper sulphate solution (approximately 3 ml per litre of water bucket).

The bucket stand should comprise a wind shield at the level of the rim of the bucket to provide an aerodynamic shield (Figure C-1). The bucket holder is connected to a 2 m galvanized steel pole, which is either directly attached to a fence post or can be attached to a galvanized steel base plate. This allows for a variety of placement options for the fallout samplers. Exposed buckets, when returned to the laboratories, are rinsed with deionised water to remove residue from the sides of the bucket, and the bucket contents filtered through a coarse (>1 mm) filter to remove insects and other course organic detritus. The sample is then filtered through a pre-weighed paper filter to remove the insoluble fraction, or dust fallout. This residue and filter are dried, and gravimetrically analysed to determine the insoluble fraction (dust fallout).

Figure C-1: Single dust bucket monitor

The four bucket wind directional bucket monitors also comprises cylindrical 5 L containers half-filled with de-ionised, treated water which are exposed for one calendar month (30 ±2 days). The monitor however comprises a cluster of four buckets, a rotating lid above the buckets and a wind vane (Figure C-2). The lid is designed so as to close three of the buckets whilst allowing the fourth bucket to be open. The prevailing wind direction determines which of the buckets is open at any given time. E.g. the monitor could be installed so that northerly, southerly, easterly and westerly winds result in buckets 1, 2, 3 and 4 being open respectively. The aim of using this monitor is to link dust deposition to different airflow field and hence to sources located in the direction from which the wind is blowing. Wind directional bucket monitors are typically used to identify neighbouring source contributions to dust deposition at the monitoring location according to the relative quantity of dust collect in each of the buckets. The quantitative results are however not directly comparable to the results of the ASTM method.

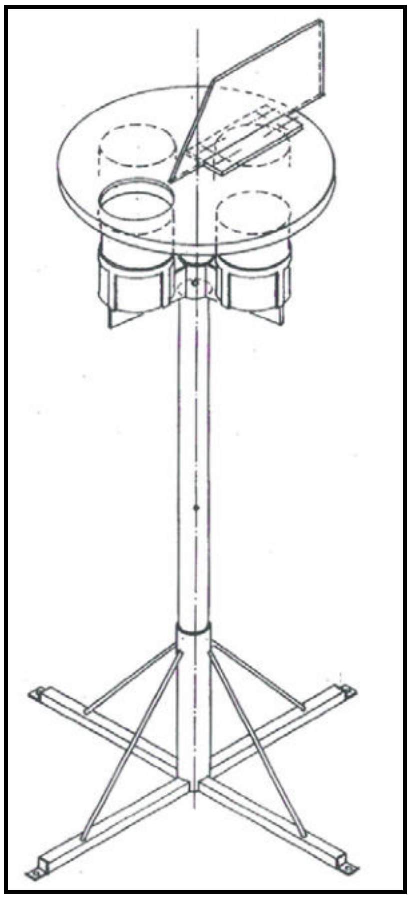

Figure C-2: Four bucket wind directional bucket monitor

C.1.2 Dust Fallout Monitoring Procedure

Table C-1: Dust Fallout Monitoring Guidelines

Heading	Description	Comments
Operating procedures (collection of dustfall and its measurement)	1. The dust buckets must be prepared and sealed in a laboratory and then opened and set up at the appropriately chosen sites so that particulate matter can settle into them for periods of about 30 days. 2. The dust bucket must be on a stand located at a height of 2m above ground. 3. A file containing information specific to each dust bucket site, such as the bucket number, the time and date set out and the map co-ordinates should be maintained. 4. During the sampling period any unusual events such as construction, fires, etc., should be recorded, as they may be helpful in interpreting the results obtained. 5. The sampling period shall be one calendar month with an allowance of ± 2 days (i.e. 28-32 days). 6. At the end of the sampling period, the date and time of collection, and the bucket number should be recorded, and the bucket should be resealed and returned to the laboratory for analysis. 7. Rain will collect in and evaporate from the container during the exposure period, and containers may have liquid in them when they are picked up. This liquid is later processed and therefore should not be discarded. 8. After the 30 days of exposure, the containers are then closed and returned to the laboratory. 9. The new bucket can be set up as the old bucket is collected.	Method obtained from the American Society for Testing and Materials (ASTM) standard test method for collection and measurement of dustfall (Settleable Particulate Matter) - D1739-98 (1998).
Reporting procedures	1. The masses of the water-soluble and insoluble components of the material collected are determined (see ASTM D1739-98 for a detailed description of determining mass). 2. The results should be reported as mg/m²/day on a monthly basis. 3. The average filter weight needs to be subtracted from the initial filter weight to determine the mass of dust collected in mg. 4. The collection area is the cross sectional area of the inside diameter of the top of the container (if the inside diameter of the top of the container is 27.5 cm, the collection area is πr^2 or $\pi d^2/4$, which is 0.059 m². 5. The dust fallout can be calculated by mass/number of days/area of bucket to obtain dust fallout per bucket in mg/m²/day.	See reporting example in Table C-2.

	6. The results should be reported to the environmental manager every month on the results from the previous production month. This report should include a table with the bucket locations and descriptions, a dust fallout graph indicating the bucket results expressed in mg/m²/day and a comparison to the dust fallout guidelines (see Tables 3-5 and Table 3-6). 7. Any missing buckets or damage to buckets should be reported immediately. 8. The replacement of the missing or damaged buckets should be within one month from logging the report.	
Monitoring objectives	1. Compliance monitoring. 2. Validation of dispersion modelling results. 3. Assist in source apportionment. 4. Facilitate the measurement of progress against environmental targets within the main impact zone of the operation. 5. Temporal trend analysis to determine the potential for nuisance impacts within the main impact zone of the operation. 6. Tracking of progress due to pollution control measure implementation. 7. Informing the public of the extent of localised dust nuisance impacts occurring in the vicinity of the operations.	
Performance indicators	Dust fallout should be less than 1 200 mg/m²/day over a monthly average	Key performance indicators against which progress may be assessed are usually selected to reflect both the source of the emission directly and the impact on the receiving environment

Table C-2: Example of dust fallout reporting (exceedances over 1200 mg/m²/day highlighted)

Single dust buckets (April 2009)							
Bucket identification	**Dust bucket location**	**Date and time set out**	**Date and time collected**	**Number of days exposed**	**Mass dust collected (mg)**	**Collection area (m²)**	**Dust fallout (mg/m²/day)**
Dust bucket number 2	ROM stockpiles 22.93°S, 15.24°E	1 April 2009 10:00 AM	30 April 2009 2:00 PM	30	860	0.059	486
Dust bucket number 4	East of tailings ___°S, ___°E	Etc.	Etc.	30	400	0.059	226
Dust bucket number 5	Etc.	Etc.	Etc.	30	2 030	0.059	1 147
Dust bucket number 6	Etc.	Etc.	Etc.	30	2 130	0.059	**1 203**
Dust bucket number 7	Etc.	Etc.	Etc.	30	4 560	0.059	**2 576**