Rayten
ENGINEERING SOLUTIONS
Environmental and Engineering Consultants

CABANGA ENVIRONMENTAL - KANAKIES MINE

AIR QUALITY IMPACT ASSESSMENT

July 2018

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DECLARATION

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

	(For official use only)
File Reference Number:	12/12/20/ or 12/9/11/L
NEAS Reference Number:	DEA/EIA
Date Received:	

Application for integrated environmental authorisation and waste management licence in terms of the-

(1) National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2014; and

(2) National Environmental Management Act: Waste Act, 2008 (Act No. 59 of 2008) and Government Notice 921, 2013

PROJECT TITLE

Cabanga Environmental – Kanakies Mine, Air Quality Impact Assessment

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4.2 The specialist appointed in terms of the Regulations_

I, Sophia Rosslee, declare that -- General declaration:

I act as the independent specialist in this application;
I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
I declare that there are no circumstances that may compromise my objectivity in performing such work;
I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
I will comply with the Act, Regulations and all other applicable legislation;
I have no, and will not engage in, conflicting interests in the undertaking of the activity;
I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
All the particulars furnished by me in this form are true and correct; and
I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the specialist:

Rayten Engineering Solutions cc

Name of company (if applicable):

29 June 2018

Date:

EXECUTIVE SUMMARY

Rayten Engineering Solutions CC was appointed by Cabanga Environmental to compile an Air Quality Impact Assessment report for the proposed Kanakies Gypsum Mine located approximately 45km west of the town of Loeriesfontein and 40km north-north-west of the town of Nieuwoudtville, within the Hantam Local Municipality, Northern Cape Province.

The main objective of the Air Quality Impact Assessment is to determine the potential impact of emissions from the construction and operational activities associated with the proposed project on ambient air quality in terms of the criteria air pollutants and dust fallout.

As part of the Air Quality Impact Assessment, a Baseline Air Quality Assessment was undertaken to determine the following:

- the prevailing meteorological conditions at the site;
- establish baseline concentrations of key air pollutants of concern;
- identify existing sources of emissions; and
- identify key sensitive receptors surrounding the project site.

MM5 meteorological data for the project area for the period 01 January 2015 – 31 December 2017 was used. The Air Quality Impact Assessment consisted of an emissions inventory and subsequent dispersion modelling simulations to determine TSP (as dust fallout), PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO concentrations associated with mining activities during the construction and operational phases of the project. Comparison of the modelled concentrations was made with the South African Ambient Air Quality Standards and the South African National Dust Control Regulations, 2013, to determine compliance.

The Kanakies gypsum mine is located on Portion 0, Kanakies Farm, 332 Calvinia Road, within the Hantam Local Municipality, Northern Cape, South Africa. The land use immediately surrounding the site consists predominantly of natural vegetation and bare non-vegetated land. Urban built-up, grasslands and cultivated land are additionally observed around the project site. The urban areas of Nieuwoudtville and Loeriesfontein are located approximately 40 km south-south-east and 45 km east, respectively, of the site. The area is classified as rural in nature.

Existing key sources of air pollution surrounding (<10km) the proposed project site mostly include wind erosion from exposed areas such as open degraded land. Vehicle dust entrainment on surrounding unpaved roads will also contribute to dust emissions in the area. No industrial, mining or domestic fuel burning activities were identified within 10km from the project site.

Based on the prevailing wind fields for the period January 2015 to December 2017, emissions from operations at Kanakies mine will likely be transported towards the westerly, west-north-westerly and north-easterly quadrants. Moderate to fast wind speeds observed during all the time periods may result in effective dispersion and dilution of emissions from Kanakies mine; however, higher wind speeds can also facilitate fugitive dust emissions from open exposed areas such as stockpiles.

The existing air quality situation is usually evaluated using available monitoring data from permanent ambient air quality monitoring stations and dust fallout networks operated near the project site. However, there was no data available (that could be determined) to present background concentrations for SO_2, NO_2, CO, PM_{10} and $PM_{2.5}$ concentrations at the study site. The nearest, Karoo ambient air quality monitoring station, is located more than 40 km away near the town of Nieuwoudtville.

The main conclusions of the Air Quality Impact Assessment for the project site can be summarised as follows for the operational phase.

Dust is a key pollutant of concern associated with proposed operations at Kanakies mine and will be emitted from the following key sources:

- Heavy construction activities;
- Materials handling operations (excavators, front-end loaders and truck loading/offloading operations);
- Material storage: Stockpiling;
- Crushing and screening;
- Wind erosion from exposed areas (i.e. open pit);
- Vehicle dust entrainment on unpaved roads.

For both the construction and operational phases of the project, predicted incremental concentrations for PM_{10} and $PM_{2.5}$ and dust fallout rates are low and comply with the applicable standards over most of the project area and beyond the mine boundary. Higher concentrations of dust and particulates are expected near to the emission source (i.e. area of construction and mining activity).

Predicted incremental concentrations of CO and SO_2 associated with truck exhaust emissions are low, falling well below the applicable standards. Predicted incremental concentrations of NO_x comply with the applicable standards beyond the mine boundary, with exceedances observed near the hauling road.

Predicted incremental concentrations at identified discrete receptors comply with the National ambient air quality standards and Dust Control Regulations, 2013.

Mitigation measures that were considered in this modelling study were limited and included dust suppression using water on the main unpaved routes used for truck hauling and vehicle activity. As dust is the key pollutant of concern associated with proposed operations, dust suppression should be conducted at the mine where possible, to reduce additional levels in background concentrations at the site. This can be achieved by developing a dust management plan specific to the mine. The plan should be updated annually to allow for additional mitigation measures to be incorporated in the long term, specifically for the mine block areas.

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LIST OF ABBREVIATIONS

AEL	Atmospheric Emissions License
AQA	Air Quality Act
AQIA	Air Quality Impact Assessment
AQMP	Air Quality Management Plan
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_{2-eq}	Carbon dioxide equivalent
DEA	Department of Environmental Affairs
GHG	Greenhouse gas
GMT	Greenwich Meridian Time
HFC	Hydrofluorocarbons
HPA	Highveld Priority Area
NAEIS	National Atmospheric Emissions Inventory System
NEMA	National Environmental Management Act
NPI	National Pollutant Inventory
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
N_2O	Nitrous Oxide
Mtpa	Million tonnes per annum
O_3	Ozone
PBL	Planetary Boundary Layer
PFC	Perfluorocarbons
PCD	Pollution Control Dam
PRA	Prospecting Right Area
PM_{10}	Particulate Matter, aerodynamic diameter equal to or size less than 10µm
$PM_{2.5}$	Particulate Matter, aerodynamic diameter size equal to or less than 2.5µm
PRIME	Plume Rise Model Enhancements
ROM	Run of Mine
SAAQIS	South African Air Quality Information System
SF_6	Sulphur hexafluoride
SO_2	Sulphur Dioxide
TSP	Total Suspended Particles
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds

1. INTRODUCTION

Rayten Engineering Solutions CC (hereafter referred to as "Rayten") was appointed by Cabanga Environmental to compile an Air Quality Impact Assessment report for the proposed Kanakies Gypsum Mine (hereafter referred to as "Kanakies Mine") located approximately 45km west of the town of Loeriesfontein and 40km north-north-west of the town of Nieuwoudtville, within the Hantam Local Municipality, Northern Cape Province.

The main objective of the Air Quality Impact Assessment is to determine the potential impact of emissions from the operational activities associated with the proposed project on ambient air quality in terms of the criteria air pollutants and dust fallout.

As part of the Air Quality Impact Assessment for the mine, a baseline air quality assessment was undertaken through a review of meteorological monitoring data, available air quality monitoring data, air quality legislation and the identification of nearby sensitive receptors and existing emissions sources surrounding the project site. The potential impact of emissions from the operational activities on air quality is evaluated through the compilation of an emissions inventory and subsequent dispersion modelling simulations using AERMOD. Comparison of predicted concentrations for key criteria air pollutants is made with the South African Ambient Air Quality Standards and the South African National Dust Control Regulations, 2013 where applicable.

1.1 Project Detail

Applicant	Witkop Fluorspar (Pty) Ltd
Physical Address	Portion 0, Kanakies Farm, 332 Calvinia Road, Northern Cape.
AEL number	N/A
EA reference number	NC30/5/1/2/3/2/1 (10136)
Modelling contractor	Rayten Engineering Solutions CC *Sophia Rosslee (MSc.)* *Senior Air Quality specialist* *5 years working experience*

1.2 Brief Project Description

The proposed Kanakies mining operations will be undertaken by means of surface trench mining. A single mining block will be approximately 50m x 100m. The powder will be screened to remove foreign materials and is expected to be recovered by a margin of at least 90%. The clay layer will be roll-crushed and screened by means of a high frequency screening plant at an estimated recovery of ~50%.

The following key mining activities will be associated with emissions of Particulate Matter (PM) at the site:

- Vehicle dust entrainment on unpaved roads;
- Wind erosion from exposed areas (i.e. overburden, stockpiles);
- Material handling including haulage of powder gypsum from wind rows to a central stockpiling and processing area within the mine block, and material offloading by dump trucks; and

- Crushing and screening.

A basic site layout diagram is given in Figure 1-1 below.

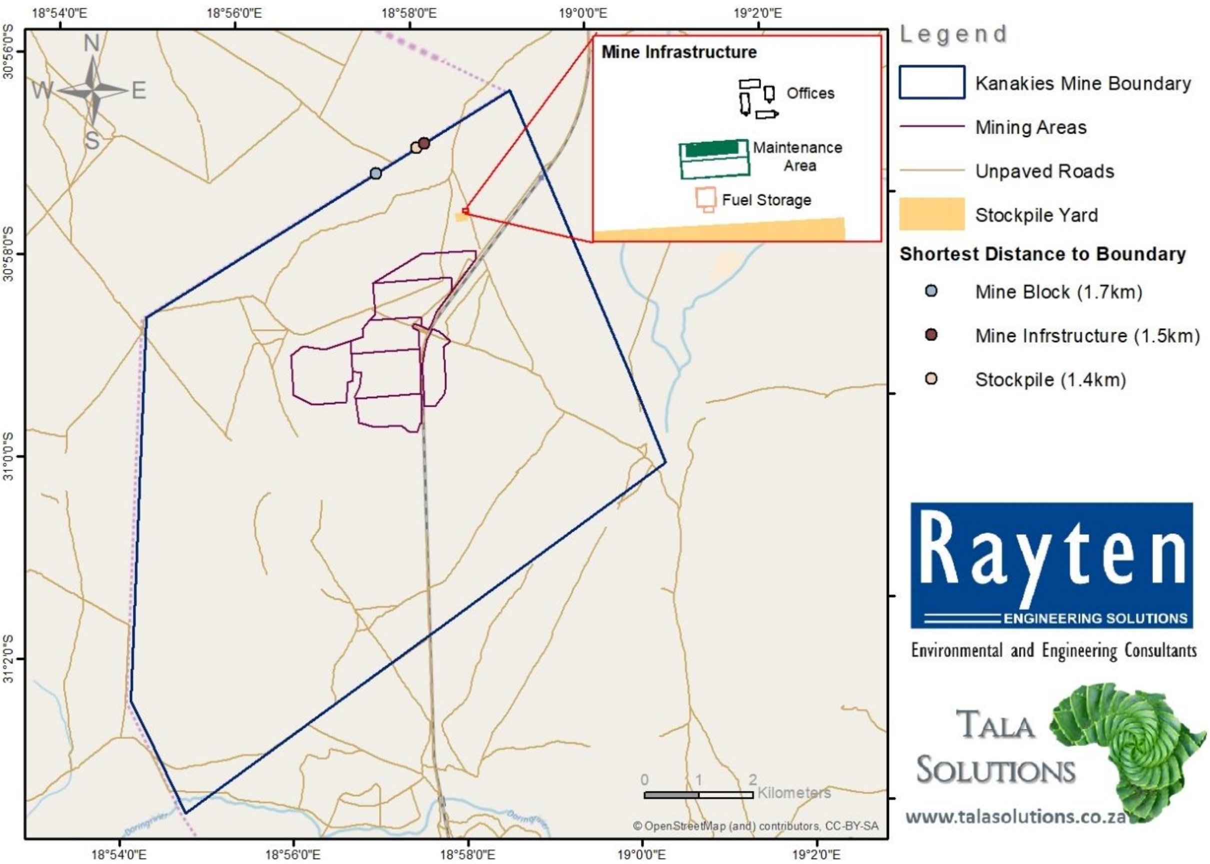


Figure 1-1: The Proposed Kanakies Mine Site Layout Diagram.

1.3 Terms of Reference

The scope of work for the Air Quality Impact Assessment is as follows:

- A review of the study site and proposed activities;
- An overview of the prevailing meteorological conditions in the area which influence the dilution and dispersion of pollutants in the atmosphere;
- The identification of existing sources of emissions;
- The identification of key air pollutants of concern that may be emitted from proposed activities (criteria air pollutants);
- Characterisation of the ambient air quality within the area using available air quality monitoring data;
- A review of the current South African legislative and regulatory requirements for air quality;
- The identification of sensitive receptors, such as local communities, surrounding the study area;
- The compilation of an emission inventory for key sources of emissions;
- Dispersion modelling simulations of ground level particulate and gaseous emissions for incremental impacts; and

- Provision of general recommendations for the mitigation and management of identified potential impacts.

1.4 Outline of Report

An overview of the site location including surrounding receptors is given in **Section 2**. National ambient air quality standards, dust fallout regulations and associated health impacts for the relevant criteria pollutants are discussed in **Section 3**. The local meteorological conditions and baseline air pollutants concentrations are provided in **Section 4**. Potential emissions and their impact on air quality associated with operations are outlined in **Section 5**. Mitigation measures, recommendations and a summary report are detailed in **Section 6**.

2. SITE CHARACTERISTICS

2.1 Site Location

The proposed Kanakies mine is located on Portion 0, Kanakies Farm, 332 Calvinia Road, Hantam Local Municipality, Northern Cape, South Africa (Figure 2-1). The project area does not fall within any of the South African Air Quality Priority Areas.

2.2 Surrounding Land Use

The land use immediately surrounding the project site consists predominantly of natural vegetation and bare non-vegetated land (Figure 2-2). Urban built-up, grasslands and cultivated land are additionally observed around the project site. The urban areas of Nieuwoudtville and Loeriesfontein are located approximately 40 km south-south-east and 45 km east, respectively, of the site. The area is classified as rural in nature.

2.3 Topography

The topography surrounding the proposed mine is shown in Figure 2-3 below. Surrounding elevations range from approximately 192 – 853 m above sea level. The project site is situated approximately 192 m above sea level; with increasing elevation towards the north-east, east and south-south-east.

2.4 Sensitive Receptors

A sensitive receptor is defined as a person or place where involuntary exposure to air pollutants released by the site's activities could occur. Identified urban/residential receptors which are located within 10 km from the proposed mine are given in Figure 2-4 below.

There are no schools, hospitals or old age homes located within 10 km of the site boundary.

The discrete receptors detailed in Table 2-1 below were used for modelling purposes.

Table 2-1: Discrete receptors within 10 km of the proposed Kanakies mine. Receptors were identified through a desktop study.

Receptor	Co-ordinate		Elevation	Type	Approx. Distance	Direction from site
	x	Y	m		km	
DR1	282307.44	6532594.35	236.94	Res	~ 9	SW
DR2	282093.38	6538267.00	281.19		~ 8	W
DR3	275858.81	6539792.19	288		~ 2	W
DR4	279524.63	6544715.62	355.65		~ 6.5	W
DR5	273959.01	6547873.04	385.3		~ 3	N
DR6	270801.59	6544367.77	354.65		Inside boundary	n/a
DR7	268714.48	6556542.56	747.82		~ 9	N
DR8	266547.10	6551966.98	396.5		~ 3	N
DR9	266065.46	6547177.34	362.52		On boundary	E
DR10	263148.86	6542628.51	350.32		< 1	E
DR11	256512.65	6541130.04	494.33		~ 7	SE
DR12	254024.12	6539899.15	544.59		~ 10	E
DR13	260579.92	6537330.35	321.92		~ 5.5	SE
DR14	258920.90	6536581.11	347.64		~ 7.5	SE
DR15	267858.20	6536233.26	285.41		~ 2	S
DR16	263202.24	6534386.93	302.63		~ 6.5	S
DR17	261141.85	6532326.54	312.03		~ 7.5	S
DR18	270052.38	6533129.29	279.59		~ 5	S
DR19	268018.75	6532915.22	306.35		~ 5.5	S
DR20	271443.82	6529142.29	282.51		~ 7	S
DR21	270373.48	6527831.13	320.85		~ 9	S

Notes:
DR = Discrete receptor
Res = residential/building
No healthcare/hospital/clinic facilities identified
No educational/training facilities identified
No old age homes identified
Distance = indicated from site boundary

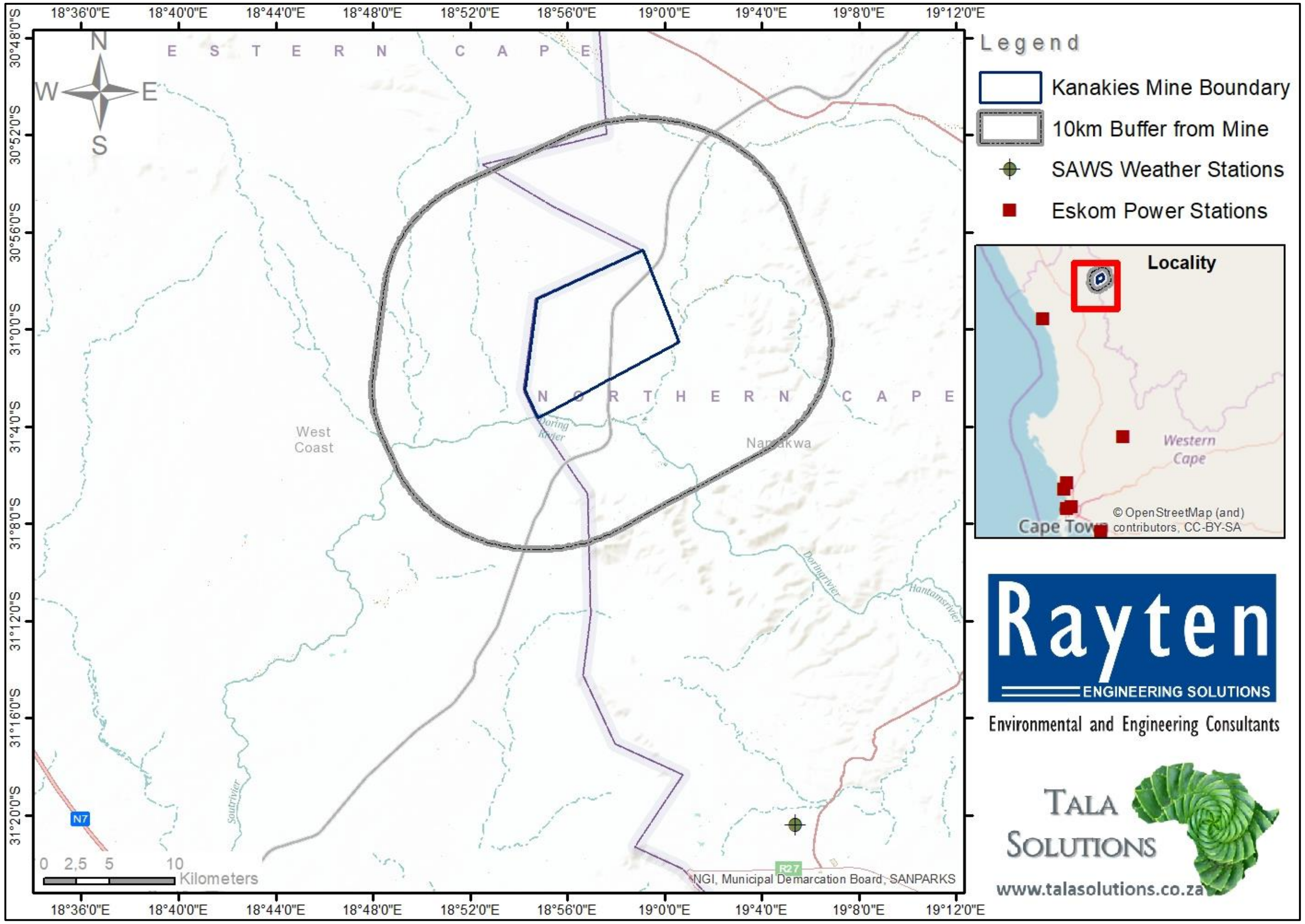


Figure 2-1: Site locality for the proposed Kanakies Mine.

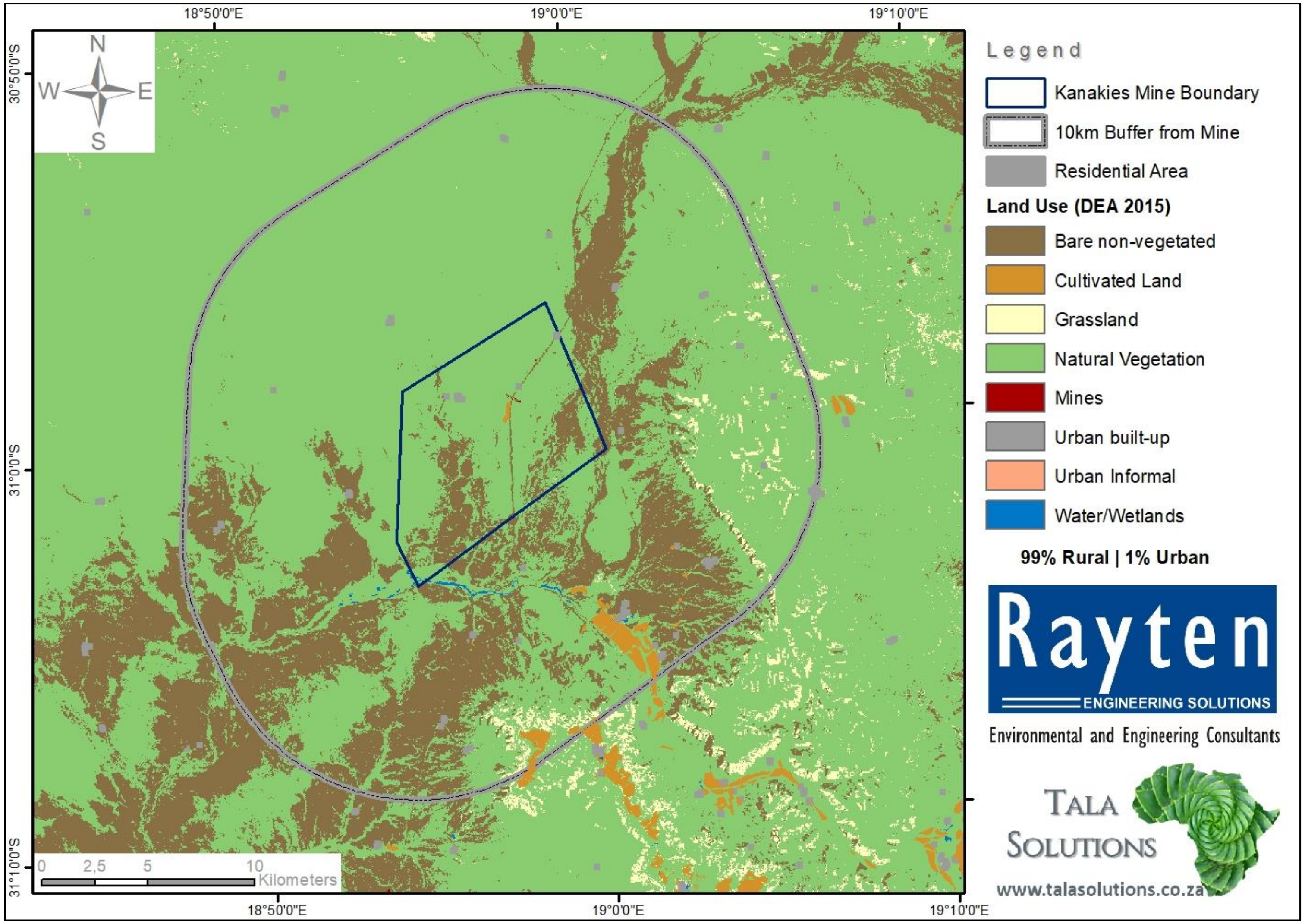


Figure 2-2: Land use surrounding the proposed Kanakies Mine.

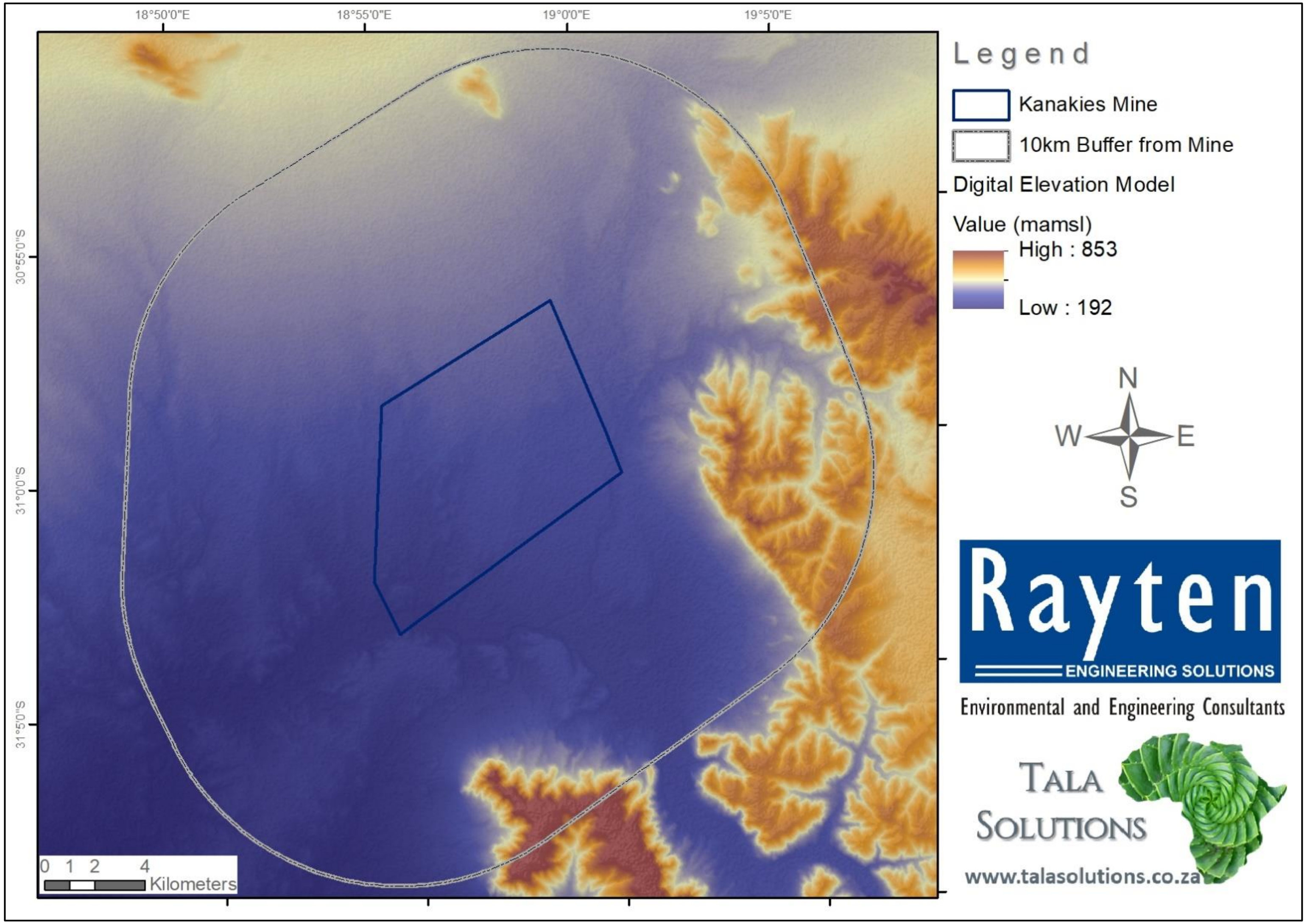


Figure 2-3: Topography surrounding proposed Kanakies Mine.

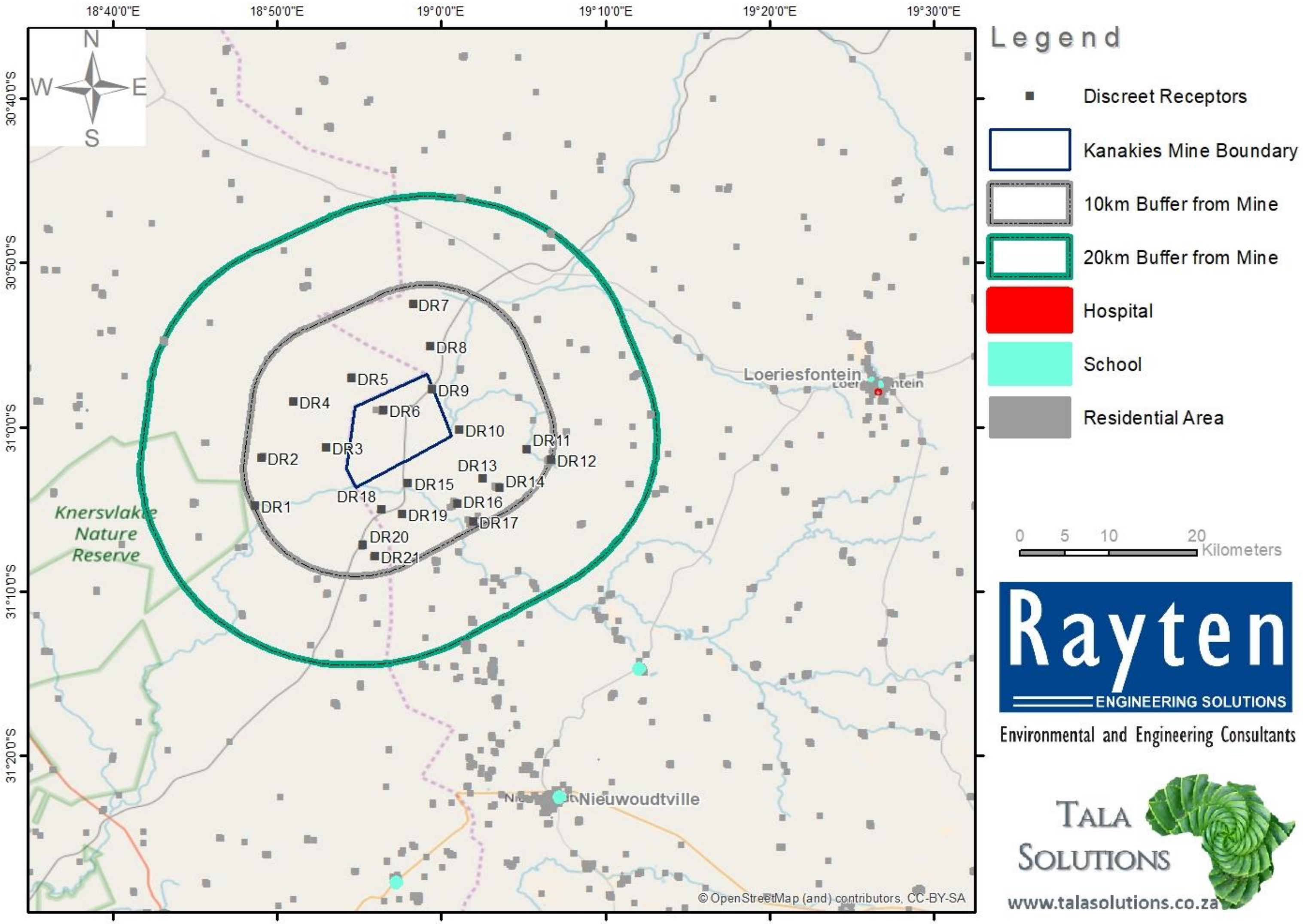


Figure 2-4: Residential receptors surrounding the proposed Kanakies Mine.

3. LEGISLATION, POLICIES AND GUIDELINES

3.1 National Environmental Management: Air Quality Act

The National Environmental Management: Air Quality Act (NEM: AQA) No. 39 of 2004, has shifted the approach of air quality management from source-based control to receptor-based control. The main objectives of the Act are to;

- Give effect to everyone's right "to an environment that is not harmful to their health and wellbeing".
- Protect the environment by providing reasonable legislative and other measures that;

  i. Prevent pollution and ecological degradation,
  ii. Promote conservation, and
  iii. Secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

The Act makes provisions for the setting and formulation of National ambient air quality standards for "substances or mixtures of substances which present a threat to health, well-being or the environment". More stringent standards can be established at the provincial and local levels.

The control and management of emissions in the NEM: AQA relates to the listing of activities that are sources of emissions and the issuing of emission licences. Listed activities are defined as activities which "result in atmospheric emissions and are regarded as having a significant detrimental effect on the environment, including human health". Listed activities have been identified by the Minister of the Department of Environmental Affairs (DEA) and atmospheric emission standards have been established for each of these activities. These listed activities now require an Atmospheric Emission Licence (AEL) to operate. The issuing of AELs for listed activities will be the responsibility of the Metropolitan and District Municipalities.

In addition, the Minister may declare any substance contributing to air pollution as a priority pollutant. Any industries or industrial sectors that emit these priority pollutants will be required to implement a Pollution Prevention Plan. Municipalities are required to "designate an air quality officer to be responsible for co-ordinating matters pertaining to air quality management in the Municipality". The appointed Air Quality Officer is responsible for the issuing of atmospheric emission licences.

3.2 Listed Activities and Minimum Emission Standards

The NEM: AQA requires all persons undertaking listed activities in terms of Section 21 of the Act to obtain an AEL. The listed activities and associated minimum emission standards were issued by the DEA on 31 March 2010 (Government Gazette No. 33064 of 31 March 2010) and were amended in 2013 (Government Gazette No. 37054 of 22 November 2013) and 2015 (Government Gazette No. 38863 of 12 June 2015).

Based on the information provided it does not appear as if the mine will trigger any of the listed activities. However, should the mine wish to commence with any of the listed activities in the future; an Atmospheric Emission Licence would need to be applied for prior to the commencement of the activity. Minimum emission standards identified in terms of Section 21 of the National Environmental

Management: Air Quality Act (Act No. 39 of 2004) and stipulated in GNR 893 must be complied with for any listed activities that may become relevant in the future.

South Africa launched an online national reporting system, referred to as the National Atmospheric Emissions Inventory System (NAEIS). The NEM: AQA requires all emission source groups identified in terms of the National Atmospheric Reporting Regulations (Government Gazette No. 38633 of 02 April 2015), to register and report emissions on the NAEIS. Mines are classified as Group C emitters and thus are required to report annually and comply with the National Atmospheric Reporting Regulations.

3.3 Ambient Air Quality Standards

National ambient air quality standards, including allowable frequencies of exceedance and compliance timeframes, were issued by the Minister of Water and Environmental Affairs on 24 December 2009 (Table 3-1). National standards for $PM_{2.5}$ were established by the Minister of Water and Environmental Affairs on 29 June 2012.

Table 3-1: National Ambient Air Quality Standards for Criteria Pollutants.

POLLUTANT	AVERAGING PERIOD	CONCENTRATION (µg/m³)	FREQUENCY OF EXCEEDANCE
Sulphur dioxide (SO_2)	10 minutes	500 (191)	526
	1 hour	350 (134)	88
	24 hours	125 (48)	4
	1 year	50 (19)	0
Nitrogen dioxide (NO_2)	1 hour	200 (106)	88
	1 year	40 (21)	0
Particulate Matter (PM_{10})	24 hours	75	4
	1 year	40	0
Particulate Matter ($PM_{2.5}$)	24 hours	40(1) 25(2)	0
	1 year	20(1) 15(2)	0
Ozone (O_3)	8 hours (running)	120 (61)	11
Benzene (C_6H_6)	1 year	5 (1.6)	0
Lead (Pb)	1 year	0.5	0
Carbon monoxide (CO)	1 hour	30 000 (26 000)	88
	8 hours (calculated on 1 hourly averages)	10 000 (8 700)	11

Notes:

*Values indicated in blue are expressed in PPB.

(1) Compliance required by 1 January 2016 – 31 December 2029.

(2) Compliance required by 1 January 2030.

3.4 Dust Deposition Standards

The Department of Environmental Affairs issued National dust control regulations on 1 November 2013 (Table 3-2). The purpose of the regulations is to prescribe general measures for the control of dust in all areas. The regulations prohibit activities which give rise to dust in such quantities and concentrations that the dust fall at the boundary or beyond the boundary of the premises where it originates exceeds -

a) 600 $mg/m^2/day$ averaged over 30 days in residential areas measured using reference method ASTM D1739.
b) 1200 $mg/m^2/day$ averaged over 30 days in non-residential areas measured using reference method ASTM D1739.

Table 3-2: South African Dust Fallout Regulations.

RESTRICTION AREAS	DUST FALLOUT RATE (D) (1)	REQUENCY OF EXCEEDANCE
Residential Areas	D < 600	Two within a year, no two sequential months (2)
Non-residential areas	600 < D < 1200	Two within a year, no two sequential months (2)

Notes:

(1) Averaged over 1 month (30±2-day average) ($mg/m^2/day$)

(2) Per dust fallout monitoring site.

Any person who has exceeded the dust fallout standard must, within three months after submission of a dust fallout monitoring report, develop and submit a dust management plan to the air quality officer for approval. The dust management plan must:

a) Identify all possible sources of dust within the affected site;
b) Detail the best practicable measures to be undertaken to mitigate dust emissions;
c) Develop an implementation schedule;
d) Identify the line management responsible for implementation;
e) Incorporate the dust fallout monitoring plan;
f) Establish a register for recording all complaints received by the person regarding dust fall, and for recording follow up actions and responses to the complainants.

The dust management plan must be implemented within a month of the date of approval. An implementation progress report must be submitted to the air quality officer at agreed time intervals.

3.5 GHG Emissions

On 14 March 2014, the following six greenhouse gases were declared as priority air pollutants in South Africa:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF_6)

National GHG Emission Reporting Regulations (Government Gazette No. 40762 of 3 April 2017), were published by the Department of Environmental Affairs. A person identified as a Category A data provider in terms Annexure 1 of these regulations, must register their facilities by filling in the form under Annexure 2 and must submit a GHG emissions inventory and activity data in the required format given under Annexure 3 on an annual basis. All data must be provided annually, by the 31 March of the following year. Data providers are required to register on the NAEIS and report on their direct GHG emissions on an annual basis and comply with the reporting requirements as detailed in the National GHG Emission Reporting Regulations.

Updated draft National Pollution Prevention Plan Regulations (Draft Gazette No. 40996) were published on 21 July 2017 by the Department of Environmental Affairs (DEA). A pollution prevention plan will be required should the development:

a) Undertake any of the following activities identified in Annexure A of the National GHG Emission Reporting Regulations (Government Gazette No. 40762 of 3 April 2017), which involves the direct emission of GHG in excess of 0.1 Megatonnes (Mt) annually measured as carbon dioxide equivalents ($CO_{2\text{-eq}}$); or
b) Undertake any of the following activities identified in Annexure A of the Draft National Pollution Prevention Plan Regulations (Gazette No. 40996 of 21 July 2017) as a primary activity, which involves the direct emission of GHG in excess of 0.1 Megatonnes (Mt) annually measured as carbon dioxide equivalents ($CO_{2\text{-eq}}$);

Annexure A activities in terms of the Draft National Pollution Prevention Plan Regulations include:

- Coal mining
- Production and /or refining of crude oil
- Production and/or processing of natural gas
- Production of liquid fuels from coal or gas
- Cement production
- Glass production
- Carbon black production
- Iron & steel production
- Ferro-alloys production
- Aluminium production
- Polymers production
- Pulp and paper production
- Electricity production

- Ammonia production
- Nitric acid production

Mining falls under category 1A2i in terms of Annexure 1 of the National GHG emission reporting regulations (Government Gazette No. 40762 of 3 April 2017). All facilities conducting this activity are required to register and report on their GHG emissions by the 31 March of every year.

3.6 Human Health Effects

3.6.1 Dust Fallout (TSP)

Dust fallout are particles with an aerodynamic diameter greater than 20µm that have been entrained into the air by a physical process such as wind, movement of vehicles, stack emissions and from fugitive dust. These particles are generally too heavy to remain in suspension in the air for any period of time and fall out of the air over a relatively short distance depending on a combination of various factors such as particle size, density, temperature (of the air and particle), emission velocity or method, ambient wind speed and humidity. These particles are therefore commonly known as “dust fallout”. Particulates in this range are generally classified as a nuisance dust and can cause physical damage to property and physical irritation to plants, animals and humans.

3.6.2 Particulates (PM_{10} & $PM_{2.5}$)

Particles can be classified by their aerodynamic properties into coarse particles, PM_{10} (particulate matter with an aerodynamic diameter equal to or less than 10 µm) and fine particles, $PM_{2.5}$ (particulate matter with an aerodynamic diameter equal to or less than 2.5 µm). The fine particles mostly contain secondary formed aerosols such as sulphates and nitrates, combustion particles and re-condensed organic and metal vapours. The coarse particles mostly contain earth crust materials and fugitive dust from roads and industries (Harrison and van Grieken, 1998) (Fenger, 2002).

In terms of health impacts, particulate air pollution is associated with effects on the respiratory system (WHO, 2000). Particle size is important for health because it controls where in the respiratory system a given particle deposits. Fine particles are thought to be more damaging to human health than coarse particles as larger particles do not penetrate deep into the lungs compared to smaller particles. Larger particles are deposited into the extra thoracic part of the respiratory tract while smaller particles are deposited into the smaller airways leading to the respiratory bronchioles (WHO, 2000).

Recent studies suggest that short-term exposure to particulate matter leads to adverse health effects, even at low concentrations of exposure (below 100 $\mu g/m^3$). Morbidity effects associated with short-term exposure to particulates include increases in lower respiratory symptoms, medication use and small reductions in lung function. Long-term exposure to low concentrations (~10 $\mu g/m^3$) of particulates is associated with mortality and other chronic effects such as increased rates of bronchitis and reduced lung function (WHO, 2000). Those most at risk include the elderly, individuals with pre-existing heart or lung disease, asthmatics and children.

3.6.3 Sulphur Dioxide (SO_2)

SO_2 originates from the combustion of sulphur-containing fuels and is a major air pollutant in many parts of the world. Health effects associated with exposure to SO_2 are also associated with the respiratory system. Being soluble, SO_2 is readily absorbed in the mucous membranes of the nose and upper respiratory tract.

Most information on the acute (short-term) effects of SO_2 is derived from short-term exposure in controlled chamber experiments. These experiments have demonstrated a wide range of sensitivity amongst individuals. Acute exposure of SO_2 concentrations can lead to severe bronchoconstriction in some individuals, while others remain completely unaffected. Response to SO_2 inhalation is rapid with the maximum effect experienced within a few minutes. Continued exposure does not increase the response. Effects of SO_2 exposure are short-lived with lung function returning back to normal within a few minutes to hours (WHO, 2000). Exposure to SO_2 over a 24-hour period has shown that when SO_2 concentrations exceed 250 µg/m^3 in the presence of PM (such as sulphates), an exacerbation of symptoms is observed in selected sensitive patients. More recent studies of health impacts in ambient air polluted by industrial and vehicular activities have demonstrated at low levels effects on mortality (total, cardiovascular and respiratory) and increases in hospital admissions. Long-term exposure to SO_2 has been found to be associated with an exacerbation of respiratory symptoms and a small reduction in lung function in children in some cases. In adults, respiratory symptoms such as wheezing, and coughing are increased (WHO, 2000).

3.6.4 Nitrogen Dioxide (NO_2)

Nitric oxide (NO) is a primary pollutant emitted from the combustion of stationary sources (heating, power generation) and from motor vehicles. Nitrogen dioxide (NO_2) is formed through the oxidation of NO. Oxides of nitrogen (NO_x) are made up of NO, NO_2 and NO_x of which NO_2 is the most important from a human health point of view. NO_2 is an irritating gas that is absorbed into the mucous membrane of the respiratory tract. The most adverse health effect occurs at the junction of the conducting airway and the gas exchange region of the lungs. The upper airways are less affected because NO_2 is not very soluble in aqueous surfaces. Exposure to NO_2 is linked with increased susceptibility to respiratory infection, increased airway resistance in asthmatics and decreased pulmonary function.

Short term exposure of NO_2, at concentrations greater than 1880 µg/m^3, results in changes in the pulmonary function of adults. Normal healthy people exposed at rest or with light exercise for less than 2 hours to concentrations above 4700 µg/m^3, experience pronounced decreases in pulmonary function (WHO, 2000). Long-term epidemiological studies have been undertaken on the indoor use of gas cooking appliances and health effects. Studies on adults and children under 2 years of age found no association between the use of gas cooking appliances and respiratory effects. Children aged 5 – 12 years have a 20% increased risk for respiratory symptoms and disease for each increase of 28 µg/m^3 NO_2 concentration, where the weekly average concentrations are in the range of 15 – 128 µg/m^3. Outdoor studies consistently indicate that children with long-term ambient NO_2 exposures exhibit increased respiratory symptoms that are of a longer duration. However, no evidence is provided for the association of long-term exposures with health effects in adults (WHO, 2000).

3.6.5 Carbon Monoxide (CO)

Carbon monoxide (CO) is a tasteless, odourless and colourless gas which has a low solubility in water. In the human body, after reaching the lungs it diffuses rapidly across the alveolar and capillary membranes and binds reversibly with the haem proteins. Approximately 80 - 90% of CO binds to haemoglobin to form carboxyhaemoglobin. This causes a reduction in the oxygen-carrying capacity of the blood which leads to hypoxia as the body is starved of oxygen. Severe hypoxia due to acute poisoning results in headaches, nausea and vomiting, muscular weakness, loss of consciousness, shortness of breath and finally death, depending on the concentration and time of exposure. Poisoning may cause both reversible, short-lasting neurological deficits and severe, often delayed, neurological damage. Neurobehavioral effects include impaired co-ordination, tracking, driving ability, vigilance and cognitive ability (WHO, 2000).

4. BASELINE ASSESSMENT

4.1 Meteorological Overview

Meteorological processes will determine the dispersion and dilution potential of pollutants emitted into the atmosphere. The vertical dispersion of pollution is governed by the stability of the atmosphere as well as the depth of the surface mixing layer. Horizontal dispersion of pollution is defined by dominant wind fields. Therefore, meteorological parameters including temperature, precipitation, wind speed and wind direction are of significance as they will influence the degree to which pollution will accumulate or disperse in the atmosphere.

As per the Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa (DEA, 2014), representativeness of the meteorological data is influenced by the following four factors:

- Proximity of the meteorological site to the area being modelled;
- Complexity of the terrain;
- Exposure of the meteorological measurement site; and
- Period of data collection.

A comprehensive meteorological dataset, considering the above-mentioned factors for the project area could not be obtained from a South African weather station, therefore, MM5 modelled meteorological data was used for the project area. The nearest weather station to the project site is Nieuwoudtville, which is located approximately 42km from the project site, which is too far away to be representative of the site for dispersion modelling purposes. In the event that a comprehensive meteorological dataset cannot be obtained, MM5 data can be used.

MM5 meteorological data was obtained from Lakes Environmental for the period January 2015 to December 2017. MM5 is a PSU/NCAR meso-scale model used to predict meso-scale and regional-scale atmospheric circulation. The model provides integrated model meteorological data, which can be used in a wide range of applications. This model is often used to create weather forecasts and climate projections. Details of the meteorological data obtained is summarised in Table 4-1 below.

The South African dispersion modelling regulations requires a minimum of 3-years of meteorological data for input into the dispersion model. The meteorological overview given below is with reference to the data used for input into the model. The meteorological data is representative of recent prevailing weather conditions that will likely be experienced at the project site.

Table 4-1: Meteorological Data Details.

Meteorological Data Details	
Met Data Information	**Description**
Met data type	MM5 AERMET-Ready (Surface & Upper Air Data)
Datum	WGS 84
Closest Town	West Coast DC - South Africa
Latitude	30 S
Longitude	18 E
Time zone	UTC +2 hours
Period of record	January 2015 - December 2017
Met Station Parameters	**Description**
Anemometer height	14 m
Station base elevation	768 m
Upper air adjustment	-2 hours
Grid Cell Information	
Cell centre	30 S, 18 E
Cell dimension	12km x 12km
Surface Met Data	**Description**
File format	SAMSON file
Output interval	Hourly
Upper Air Data	**Description**
Format	TD-6201- Fixed Length
Reported in	GMT
Output interval	00Z and 12Z
Models used to process met data	
Model used to process data for wind roses	WR Plot
Model used to process data for AERMOD	AERMET

4.1.1 Local Wind Field

Figure 4-1 below provides the period wind rose plot for the proposed mine for the period January 2015 to December 2017. The predominant wind directions for the period are observed from east (~14.5% of the time), east-south-east (~10.5%), and south-west (~9%). Wind speeds for the three-year period were generally moderate to fast with calm conditions, defined as wind speeds less than 1 m/s, observed for 5.67 % of the time (Figure 4-1).

The morning (AM) and evening (PM) period wind rose plots for the period January 2015 to December 2017 are given in Figure 4-2 below and show diurnal variation in the wind field data. During the morning (AM) period, high frequency winds are observed from the east and east-south-east as opposed to the evening (PM) period, where winds are predominantly observed from the south-west, west-south-west, and south-south-west (Figure 4-2).

Seasonal variation in winds at the proposed Kanakies mine is shown in Figure 4-3 below. During the autumn and winter seasons, winds originated predominantly from the east and east-south-east. During the summer season, winds originated predominantly from the south-westerly, west-south-westerly and south-south-westerly sectors. Spring months are characterised by south-westerly, south-south-westerly and easterly winds.

Based on the prevailing wind fields for the period January 2015 to December 2017, emissions from operations at the proposed Kanakies mine will likely be transported towards the westerly, west-north-westerly and north-easterly quadrants. Moderate to fast wind speeds observed during all the time periods, may result in effective dispersion and dilution of emissions from the proposed Kanakies mine; however, higher wind speeds can also facilitate fugitive dust emissions from open exposed areas such as stockpiles.

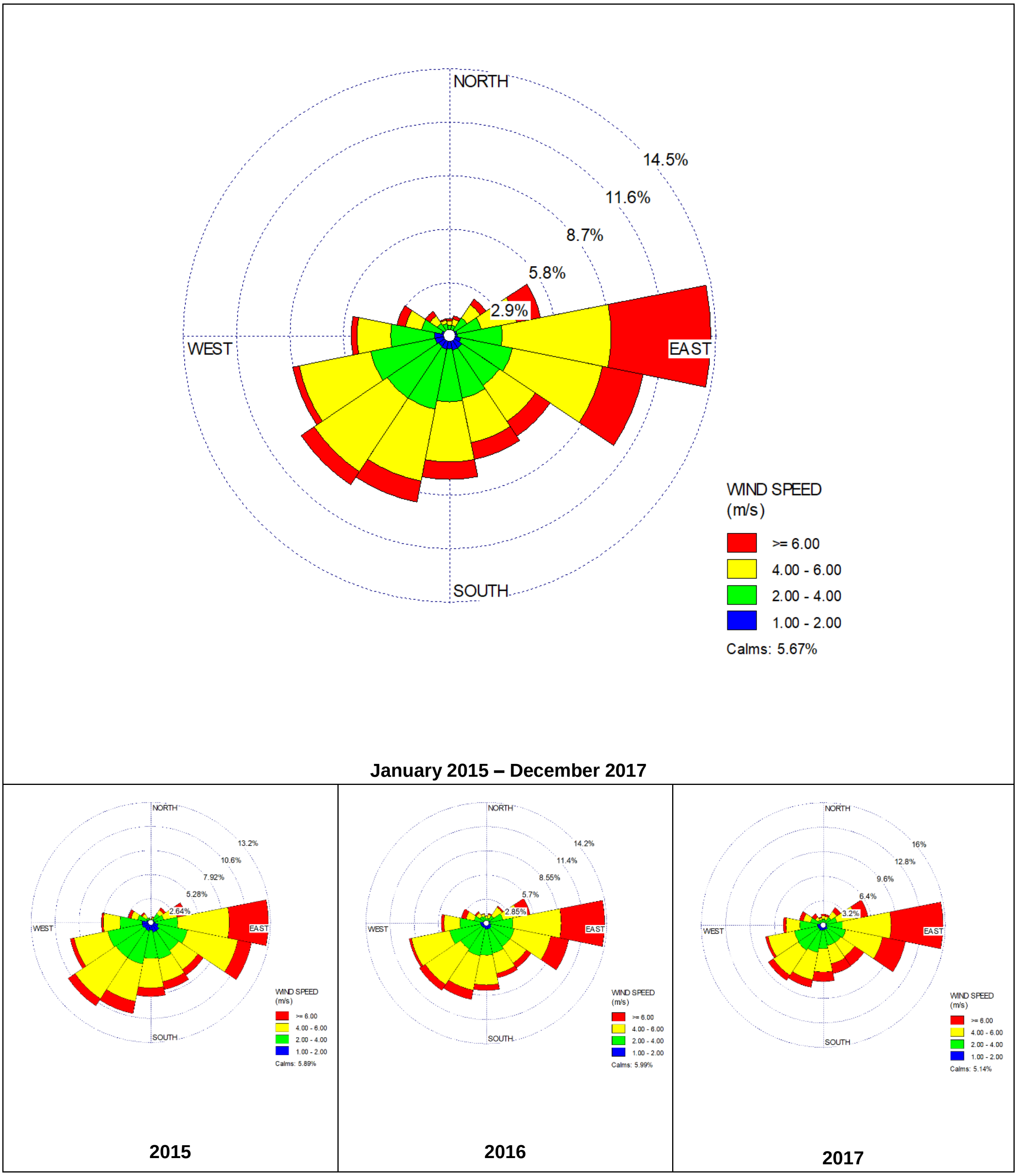
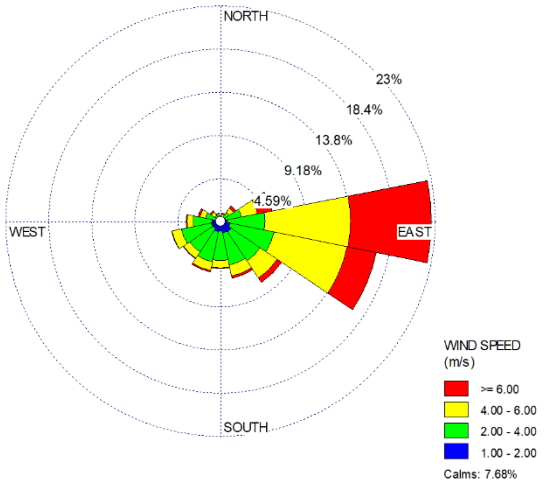
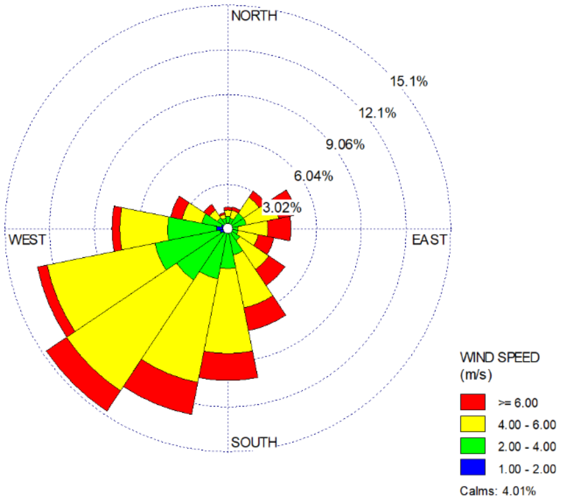


Figure 4-1: Period Wind Rose Plots for the project site for the period January 2015 - December 2017.



Morning (AM) (00:00 – 12:00)



Evening (PM) (12:00 – 23:00)

Figure 4-2: Morning (AM) (00:00 - 12:00) and Evening (PM) (12:00 - 23:00) Period Wind Rose Plots for the project site for the Period January 2015 - December 2017.

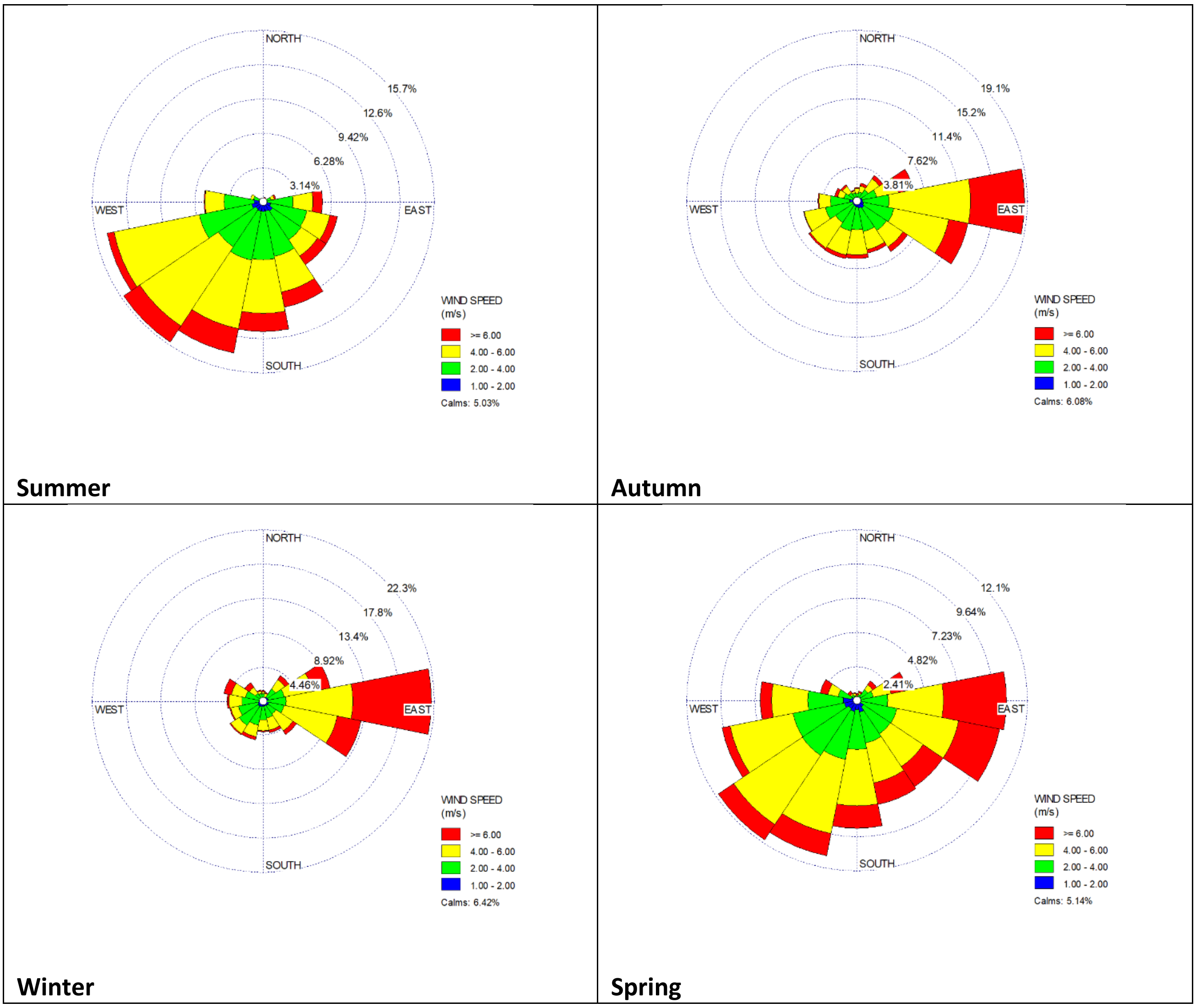


Figure 4-3: Seasonal Variation of Winds for the Project Site for the Period January 2015 - December 2017.

4.1.2 Temperature and Relative Humidity

Temperature affects the formation, action and interactions of pollutants in various ways. Temperature provides an indication of the rate of development and dissipation of the mixing layer, which is largely controlled by surface inversions. Surface temperature inversions play a major role in air quality, especially during the winter months when these inversions are the strongest. Higher ambient temperatures will facilitate the dispersion of air pollutants which can result in lower ambient concentrations.

Chemical reaction rates also tend to increase with temperature and the warmer the air, the more water it can hold and therefore the higher the humidity. When relative humidity exceeds 70%, light scattering by suspended particles begins to increase, as a function of increased water uptake by the particles. This results in decreased visibility due to the resultant haze. Many pollutants may also dissolve in water to form acids.

Monthly average temperatures and relative humidity profiles at the project site for the period January 2015 to December 2017 are presented in Figure 4-4 below. Average monthly temperatures range from 8.2 – 20.7ºC (Table 4-2). Highest temperatures are observed during the summer months (December – February) and minimum temperatures are observed during the late autumn to winter months (May – August). Relative humidity is slightly higher in winter (i.e. June – August), but shows consistency throughout the year.

Table 4-2: Hourly Minimum, Maximum and Monthly Average Temperatures for January 2015 - December 2017.

MINIMUM, MAXIMUM AND MONTHLY AVERAGE TEMPERATURES (ºC)												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Minimum	9.2	9.6	6.9	5.6	5.1	3.6	0.9	3.0	4.0	3.0	4.5	8.4
Maximum	34.4	34.9	34.0	30.1	26.9	24.1	22.8	28.1	29.9	33.2	32.1	34.8
Average	20.5	20.5	18.8	15.3	11.8	8.9	8.2	11.8	15.0	17.3	18.8	20.7

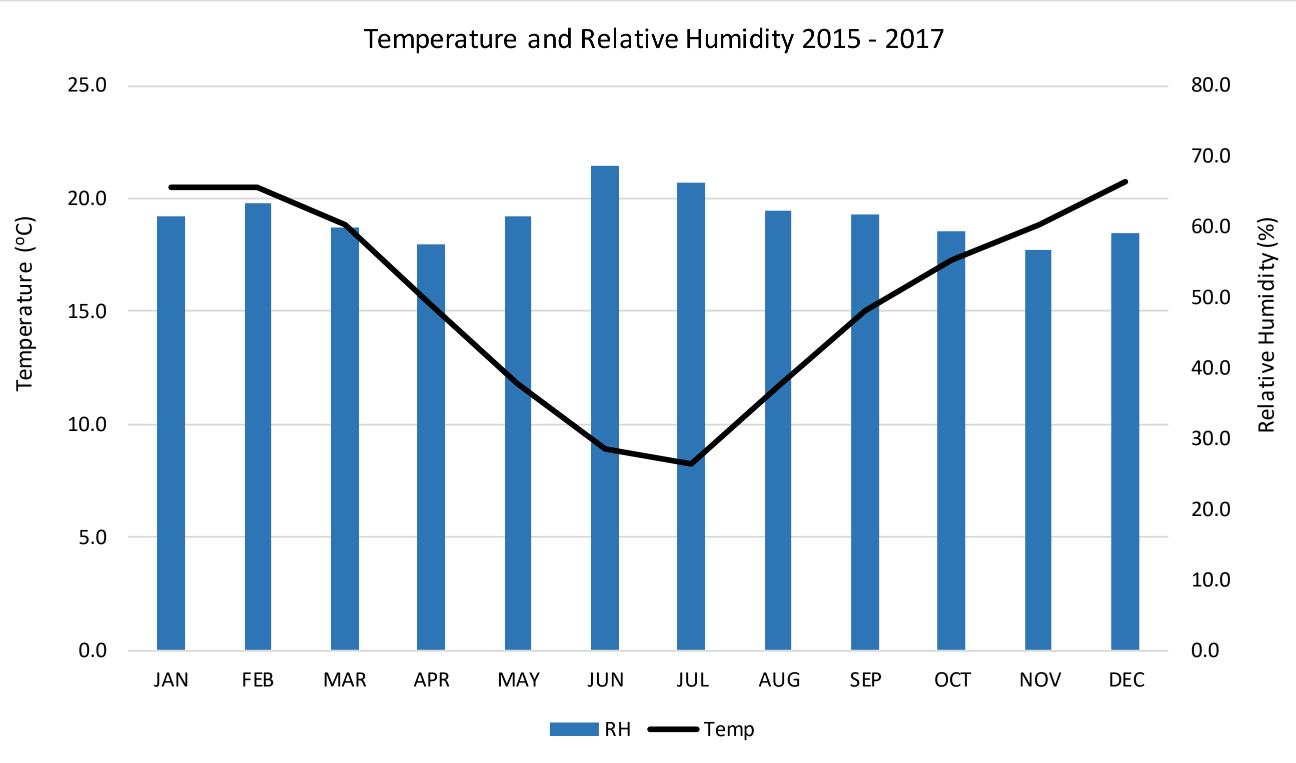


Figure 4-4: Monthly Average Temperature and Relative Humidity profiles for the project site for January 2015 - December 2017.

4.1.3 Precipitation

Precipitation has an overall dilution effect and cleanses the air by washing out particles suspended in the atmosphere. Monthly total rainfall at the project site for the period January 2015 to December 2017 is presented in Figure 4-5. The MM5 meteorological data for the project site indicates higher rainfall during the winter season, with the exception of a higher rainfall period in January 2016. Overall, low rainfall is experienced in the area (Table 4-3.).

Table 4-3: Total Monthly Rainfall for January 2015 - December 2017.

TOTAL MONTHLY RAINFALL (mm)												
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2015	13.21	3.05	0	0.76	0	53.09	8.64	5.08	4.06	0	4.06	7.37
2016	69.85	5.84	7.11	7.37	0.51	3.56	27.18	5.84	11.43	0	0	0.51
2017	4.06	0	0	2.03	0	21.08	6.10	1.52	0	13.46	16.51	0.25

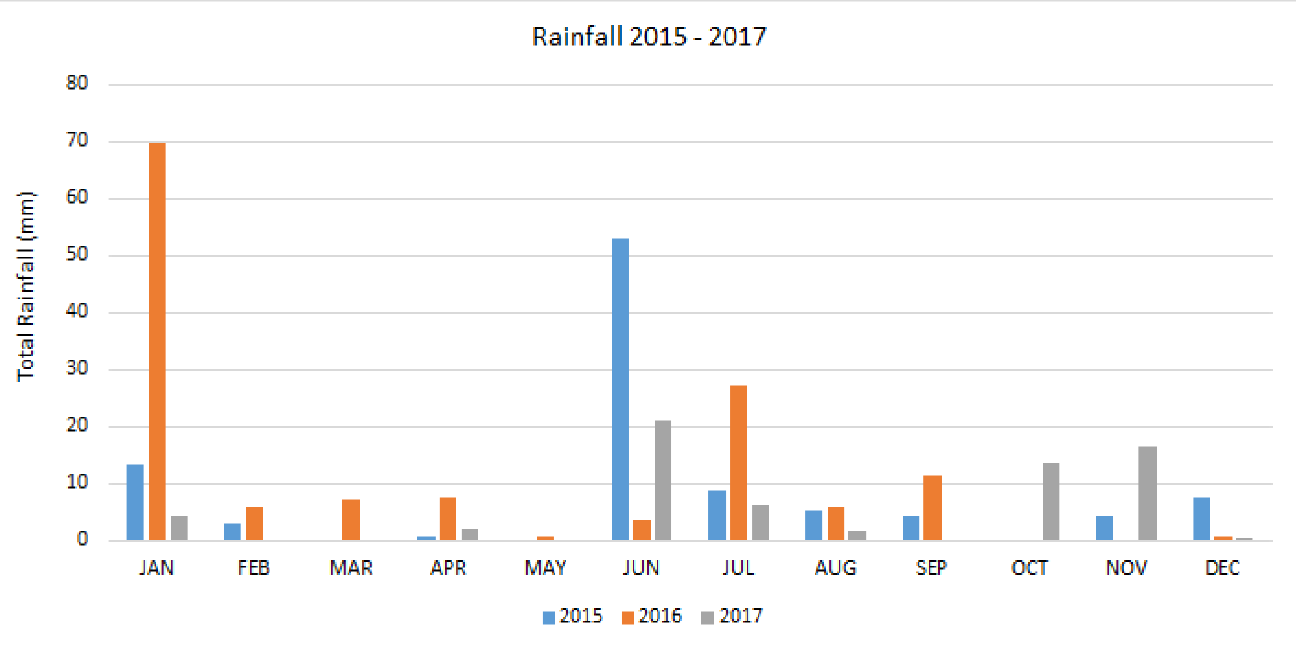


Figure 4-5: Total Monthly and Average Rainfall (MM) for the project site for the period January 2015 - December 2017.

4.2 Baseline Air Quality Concentrations

The existing air quality situation is usually evaluated using available monitoring data from permanent ambient air quality monitoring stations and dust fallout networks operated near the project site. However, there was no data available (that could be determined) to present background concentrations for SO_2, NO_2, CO, PM_{10} and $PM_{2.5}$ concentrations at the study site. The nearest, Karoo ambient air quality monitoring station, is located more than 40 km away near the town of Nieuwoudtville. Data from this station would not be representative of ambient air quality at the study site as it is located too far away.

4.3 Surrounding Sources of Air Pollution

Existing key sources of air pollution surrounding the proposed project site were identified during a desktop exercise and mostly include wind erosion from exposed areas such as open degraded land (Figure 4-6). Vehicle dust entrainment on surrounding unpaved roads will also contribute to dust emissions in the area.

No industrial, mining or domestic fuel burning activities were identified within 10km from the project site.

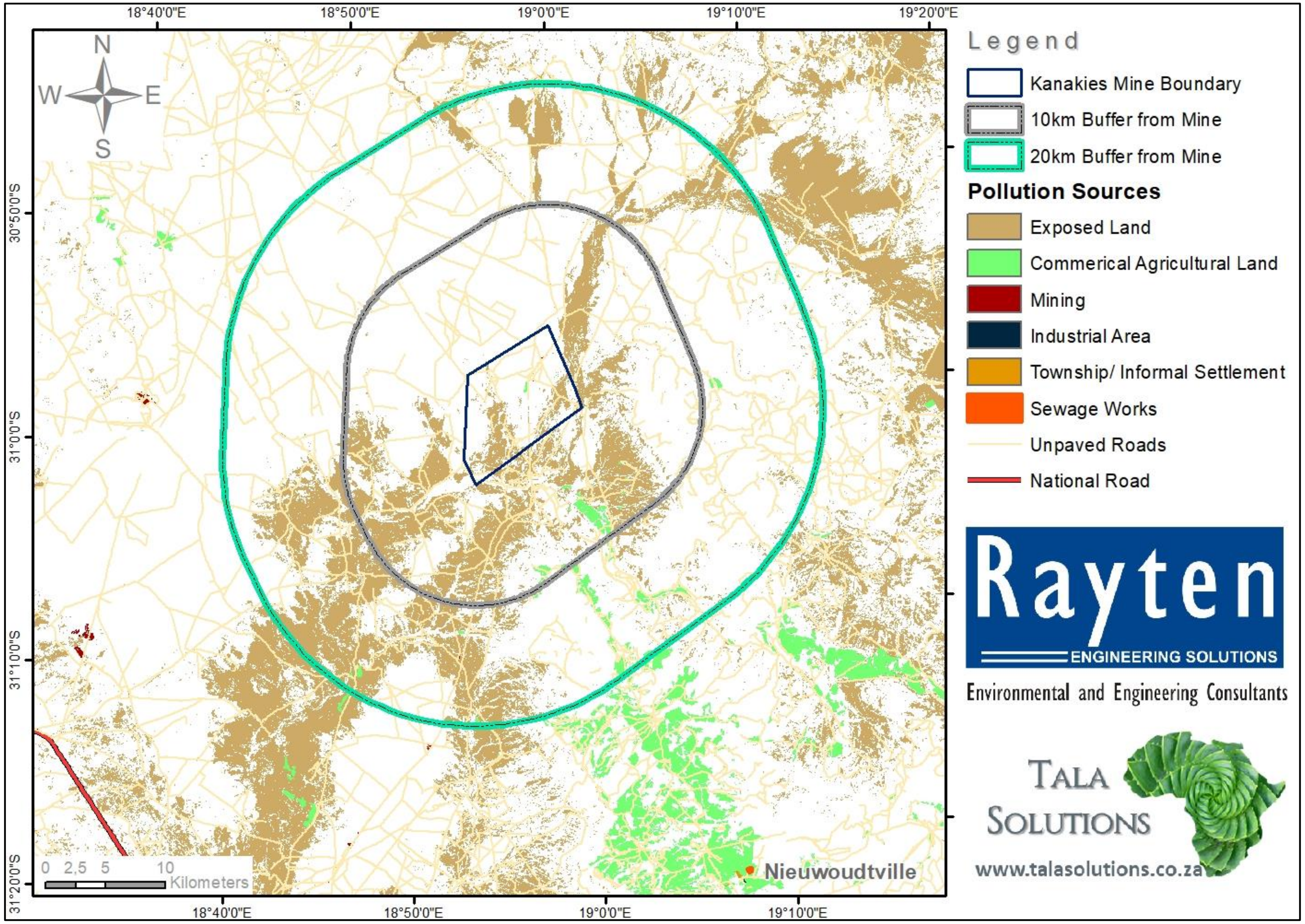


Figure 4-6: Identified surrounding emission sources within 10 and 20 km of the proposed Kanakies Mine.

4.3.1. Vehicle Dust Entrainment on Unpaved Roads

Vehicle-entrained dust emissions from the surrounding unpaved roads in the area potentially represent a source of fugitive dust. When a vehicle or truck travels on an unpaved road, the force of the wheels on the road surface causes the pulverisation of surface material. Particles are lifted and dropped from the rolling 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 act on the road surface after the vehicle has passed.

4.3.2. Wind Erosion from Exposed Areas

There are open exposed areas such as bare soil and eroded natural land surrounding the site (north, east, south-east, south and south-west of the project site) which represent a source of dust in the area. Dust emissions due to the erosion of exposed areas occur when the threshold wind speed is exceeded. The threshold wind speed is dependent on the erosion potential of the exposed surface, which is expressed in terms of the availability of erodible material per unit area (mass/area). Any factor which binds the erodible material or otherwise reduces the availability of erodible material on the surface thus decreases the erosion potential of the surface. Studies have shown that when the threshold wind speeds are exceeded, particulate emission rates tend to decay rapidly due to the reduced availability of erodible material.

5. AIR QUALITY IMPACT ASSESSMENT

Dust is a key pollutant of concern associated with proposed operations at the proposed Kanakies mine and is emitted from the following key sources:

- Heavy construction activities;
- Materials handling operations (excavators, front-end loaders and truck loading/offloading operations);
- Material storage: Stockpiling;
- Crushing and screening;
- Wind erosion from exposed areas (i.e. open pit);
- Vehicle dust entrainment on unpaved roads.

The above-mentioned sources were identified for the mine based on the information provided by the client. A detailed questionnaire was given to the client prior to modelling to obtain specific details needed for input into the model and for calculation of emission rates. The worst-case scenario was assumed where information was not known for input into the model. Please refer to Section 5.5 for more details about the assumptions made in this study.

To investigate the potential impact of operations associated with the mine on local ambient air quality, the following criteria air pollutants were chosen in the quantification of emissions for the construction and operational phase of the project.

- Dust fallout (TSP)
- Particulate matter (PM_{10} and $PM_{2.5}$)
- Sulphur dioxide (SO_2)
- Carbon monoxide (CO)

- Nitrogen dioxide (NO_2)

In the quantification of emissions for the construction and operational phase of the mine, use was made of published predictive emission factor equations given in the United States Environmental Protection Agency (USEPA) AP-42 documents, Australian NPI and Missouri Department of Natural Resources, Haul Road Fugitive Emissions Worksheet Instructions. The South African Regulations regarding Air Dispersion Modelling recommends the use of published emission factors for national consistency, such as the USEPA AP-42 emissions factors.

An emission factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. Emission factors are always expressed as a function of the weight, volume, distance or duration of the activity emitting the pollutant. The general equation used for the estimation of emissions is:

$$\mathrm{E} = \mathrm{A} \times \mathrm{EF} \times \left(1 - \frac{\mathrm{ER}}{100}\right)$$

Where:
E = emission rate
A = activity rate
EF = emission factor
ER = overall emission reduction efficiency (%)

The emission factors and equations used in the assessment for the mine are described in the section 5.1 below. Only activities that occurred within the mine boundary were considered in this study.

Material throughputs were based on the information provided by the client and include:

- an annual throughput of approximately 234 000 tons/year for ROM;
- an annual throughput of approximately 58 000 tons/year for product that is sold;
- an annual throughput of approximately 176 000 tons/year for waste material;
- an annual throughput of approximately 60 000 tons/year for product material transported by truck;

A summary of activities modelled is given below.

Table 5-1: Modelled sources of emissions at the proposed Kanakies Mine for the construction and operational phases.

POLLUTANT	SOURCES OF EMISSIONS	
	CONSTRUCTION PHASE	OPERATIONAL PHASE
Dust fallout (TSP)	**Construction Activity:** ○ Heavy construction activities of mine infrastructure area	**Mining Activity:** ○ Wind erosion from exposed areas and stockpiling; ○ Material handling (excavators, front-end loaders, loading/offloading operations); ○ Vehicle dust entrainment due to hauling material on site (unpaved roads); ○ Crushing & screening
Particulate emissions (PM_{10} & $PM_{2.5}$)		
Gases (SO_2, NO_2 & CO)	Not modelled (assessed for operational phase only as worst-case).	**Truck Hauling Activity:** ○ Truck exhaust emissions due to hauling material

5.1 Construction Phase

5.1.1 Heavy Construction Activities

The USEPA provides an emissions equation for general heavy construction operations. Dust is the main pollutant of concern emitted during heavy construction activities. The impact of dust emissions associated with heavy construction is generally limited to the period of construction where the impact is significantly reduced once construction activities have stopped. Dust emissions from construction activities is associated with land clearing, ground excavation, drilling and blasting, cut and fill operations, vehicle dust entrainment from trucks and the construction of infrastructure. Dust emissions from construction activities will vary depending on the level of activity and prevailing meteorological conditions (USEPA, 1995).

Emissions from the construction activities were calculated using the following equation:

$$E = 2.69 \text{ Mg/hectare/month of activity}$$

The emission factor and equation used to estimate emissions from construction activities were obtained from the USEPA AP-42 document, Section 13.2.3 Heavy Construction Operations (USEPA, 1995). The value is most applicable to construction operations with medium activity level, moderate silt contents and semi-arid climate. Construction was assumed to occur for 10 hours a day for 5 days a week. The worst-case scenario was modelled, where it was assumed that no fugitive dust control measures would be implemented during construction activity. Input parameters for construction activities are summarised in Table 5-2. The input parameters and dimensions were based on the Google Earth kml files provided by the client.

Table 5-2: Input parameters for heavy construction activities.

SOURCE	EMISSION RATE (G/S)		
	TSP	PM_{10}	$PM_{2.5}$
Construction Phase			
Stockpile yard area	8.37	4.18	0.42
Infrastructure area 1	0.06	0.03	0.003
Infrastructure area 2	0.01	0.005	0.0005
Infrastructure area 3	0.08	0.04	0.004

5.2 Operational Phases

5.2.1 Wind Erosion from Stockpiles/Exposed Areas

Stockpiles, open storage areas and exposed areas are potentially a significant source of dust emissions. Physical properties namely the shape, size, height, the surface area coverage, moisture content and the surface compaction of the stockpiles together with prevailing meteorological conditions will influence the rate at which dust is emitted. Significant amounts of dust will be eroded from the stockpiles under wind speeds greater than 5.4 m/s (i.e. threshold friction velocity of 0.26 m/s). Fugitive dust generation resulting from wind erosion under high winds (i.e. > 5.4 m/s) is directly proportional to the wind speed.

In the estimation of fugitive dust emissions from the product storage stockpiles and open pit exposed area, emissions were calculated by use of the emission factors for wind erosion from other exposed areas given in the NPI, emission estimate technique manual for mining (NPI, 2012). The emission factors for TSP, PM_{10} and $PM_{2.5}$ used are given below:

$$E_{TSP} = 0.4 \text{ kg/Ha/hr}$$

$$\mathrm{E_{PM10}} = 0.2 \text{ kg/Ha/hr}$$

$$E_{PM2.5} = 5\% \; of \; TSP$$

Where:
E = Emission rate (Kg/Hectare/hour)

The emission rates for TSP, PM_{10} and $PM_{2.5}$ and the input parameters for the product stockpiles and open pit exposed area are given in Table 5-3. Overburden, topsoil and waste rock will be temporarily stored within the mining open exposed area. Once the exposed area has been completely mined, overburden and waste rock will be used to backfill the mined section. Previously mined sections will be rehabilitated while mining takes place in new unmined sections.

Table 5-3: Input parameters for stockpiles and exposed areas.

SOURCE	EMISSION RATE (g/s)			MAX HEIGHT (m)	MAX LENGTH (m)	MAX WIDTH (m)
	TSP	PM_{10}	$PM_{2.5}$			
Operation Phase						
Product stockpile 1	0.086	0.047	0.004	3	50 (radius)	50 (radius)
Product stockpile 2	0.086	0.047	0.004	3	50 (radius	50 (radius)
Exposed area (open pit mine area)	0.055	0.03	0.003	Ground level	100	100

Notes:

1. No control efficiency was considered for the stockpiles and exposed area (worst-case scenario).
2. Max heights were provided by client. The source, dimensions & locality were based on the information provided by client and Google Earth

5.2.2. Excavation and Front-End-Loaders

A surface miner will be used to harvest material from the open pit area. As there is no specific emission factor for a surface miner, the emission factor for excavation was used instead to represent emissions from this activity. Front-end loaders will be used in different areas of the mine to load material onto trucks, the crushing unit, the rail wagon and stockpiles. The USEPA does not have an emission factor or equation specific for calculating emissions from excavators, front-end-loaders or shovels. The Australian NPI, however, provides the same equation as for tipping to be applied to excavators, shovels and front-end-loaders.

In this study, it was assumed that one surface miner will be used to harvest material over the whole open pit mine exposed area. It was also assumed that a total of four front-end loaders will be used at any given time for loading operations.

Emissions of TSP, PM_{10} and $PM_{2.5}$ due to surface mining and front-end-loading activities at the mine were quantified using the NPI emission factors for excavators, shovels and front-end-loaders on overburden:

<u>Excavators/shovels & front-end-loaders – Overburden (NPI Table 2):</u>

$$E_{TSP} = 0.025 \text{ kg/ton}$$

$$E_{PM10} = 0.012 \text{ kg/ton}$$

$$E_{PM2.5} = 5\% \text{ of TSP}$$

The emission rates for TSP, PM_{10} and $PM_{2.5}$ for the surface mining and front-end-loader activity at the proposed Kanakies mine are given in Table 5-4.

Table 5-4: Input parameters for surface mining and front-end loader activity.

SOURCE	EMISSION RATE (g/s)			THROUGHPUT (TONNES/HOUR)
	TSP	PM_{10}	$PM_{2.5}$	
Operation Phase				
Surface miner (mine exposed area)	0.52	0.25	0.03	75
X1 front-end loader at mine block	0.52	0.25	0.03	75
X1 front-end loader at mobile crusher plant	0.52	0.25	0.03	75
X1 front-end loader at product storage area	0.13	0.06	0.007	18.6
X1 front-end loader at rail wagon	0.13	0.06	0.007	18.6

Notes:
- No emission control efficiency was considered for material handling (worst case).
- The dimensions of source were based on the specifications provided for the equipment.
- Operations assumed to occur 10 hrs for 6 days a week
- Material throughputs based on the information provided by the client (see section 5). Hourly material throughput was calculated based on the number of days of operation, which was assumed to be 312 days per year (10 hours per day).

5.2.3 Truck Offloading Activities

Mined material will be distributed on site via hauling trucks from the mining areas to the mobile plant, thereafter to the product storage area. Material offloading from the trucks will result in dust emissions. Hauling activities are said to take place for 10 hours per day for 6 days a week (07:00 – 17:00). Emissions of TSP, PM_{10} and $PM_{2.5}$ due to truck offloading activities during the operational phase were quantified using the NPI emission factors provided in the Emission Estimation Manual for Mining for:

<u>Truck dumping – Overburden (NPI, Mining, Table 2):</u>

$$E_{TSP} = 0.012 \text{ kg/ton}$$

$$E_{PM10} = 0.0043 \text{ kg/ton}$$

$$E_{PM2.5} = 5\% \text{ of TSP}$$

<u>Where:</u>
E = Emission rate (kg/ton)

Emission rates for TSP, PM_{10} and $PM_{2.5}$ from truck offloading operations at the mine are given in Table 5-5 below.

Table 5-5: Input parameters for truck offloading activities.

SOURCE	Material Type	THROUGHPUT TONNES/HOUR	EMISSION RATE (g/s)		
			TSP	PM_{10}	$PM_{2.5}$
Operation Phase					
X1 truck offloading at mobile plant	Mined material	75	0.25	0.09	0.013
X1 truck offloading at product storage area	Product	18.6	0.06	0.02	0.003

Notes:

- No emission control efficiency was considered for material handling (worst case).
- The dimensions of source were based on the specifications provided for a 25T ADT truck.
- Operations assumed to occur 10 hrs for 6 days a week
- Material throughputs based on the information provided by the client (see section 5). Hourly material throughput was calculated based on the number of days of operation, which was assumed to be 312 days per year (10 hours per day).

5.2.4. Crushing and Screening

Crushing and screening of mined material will occur at the mobile plant, to obtain the required product. One complete mobile plant will be used, including crushing and screening units. Emissions of TSP, PM_{10} and $PM_{2.5}$ due to primary crushing activity and screening at the mine were quantified using the NPI emission factors provided in Emission Estimation Manual for Mining for crushing and screening low moisture content ores:

<u>Primary Crushing (dry) low moisture content ores (NPI Table 2):</u>

$$E_{TSP} = 0.2 \text{ kg/ton}$$

$$E_{PM10} = 0.02 \text{ kg/ton}$$

$$E_{PM2.5} = \text{assumed to be 5\% of TSP}$$

<u>Screening (dry) low moisture content ores (NPI Table 2):</u>

$$E_{TSP} = 0.08 \text{ kg/ton}$$

$$E_{PM10} = 0.06 \text{ kg/ton}$$

$$E_{PM2.5} = \text{assumed to be 5\% of TSP}$$

The emission rates for TSP, PM_{10} and $PM_{2.5}$ and the input parameters for the crushing and screening are given Table 5-6.

Table 5-6: Input parameters for crushing and screening activities.

SOURCE	EMISSION RATE (g/s)			THROUGHPUT (TONNES/HOUR)
	TSP	PM_{10}	$PM_{2.5}$	
Operational Phase				
Primary crushing	2.22	0.22	0.11	40
Screening	0.89	0.67	0.04	40

Notes:
1. One mobile plant will be used. The size of the crushing and screening sources were assumed to be the same size (i.e. half the mobile plant size). The dimensions for the mobile plant were provided by the client.
2. No control efficiency was considered at the mobile plant (worst case).
3. Material throughputs given by client for the mobile plant specifically.
4. Operations assumed to occur 10 hrs for 6 days a week
5. Moisture % assumed to be less than 4% thus low moisture. Actual moisture content of material unknown.

5.2.5 Vehicle Dust Entrainment on Unpaved Roads

Mined material will be transported to the mobile plant via trucks. Product will then be hauled from the mobile plant to the product storage area. From the storage area, material will also likely be transported to an existing rail siding located on the mine premises. An exact haul route was not known at the time of the modelling. Therefore, to account for emissions associated with truck hauling activity, a theoretical hauling route was assumed along existing unpaved roads located within the mine boundary. Vehicle-entrained dust emissions from the movement of hauling trucks and working vehicles on unpaved haul roads potentially represent a significant source of fugitive dust at the site.

The quantity of dust emissions from a given segment of unpaved road varies linearly with the volume of traffic. In addition to the volume of traffic, emissions also depend on source parameters which characterise the condition of a road and the associated vehicle traffic. These parameters include vehicle speeds, mean vehicle weight, average number of wheels per vehicle and road surface moisture (EPA, 1995). Although vehicle entrainment on unpaved roads is found to result in high fugitive dust emissions, these impacts are often limited close to the source.

- ***Truck Hauling Route***

Fugitive dust emissions from hauling trucks, were quantified using the following equations provided in the Missouri Department of Natural Resources, Haul Road Fugitive Emissions Worksheet Instructions (Missouri Department of Natural Resources, 2009):

$$E = K \left(\frac{s}{12}\right)^a x \left(\frac{W1 + W2}{6}\right)^b$$

$$Annual\ VMT = \frac{2\ x\ (length\ of\ haul\ road)\ x\ (annual\ amount\ hauled)}{(average\ weight\ of\ material\ per\ load)}$$

Where:
E = emission factor (lb/VMT) (lb/VMT x 281.9 = g/VKT)
VMT = Vehicle miles travelled
VKT = Vehicle kilometres travelled
s = surface material silt content (%)
K = empirical constant (K_{TSP}, K_{PM10} & $K_{PM2.5}$)
a = empirical constant (a_{TSP}, a_{PM10} & $a_{PM2.5}$)
b = empirical constant (b_{TSP}, b_{PM10}, $b_{PM2.5}$)
W1 = Weight of unloaded truck
W2 = Weight of loaded truck

A surface material silt content of 4.8 % was assumed for the haul road. This value was assumed based on the typical silt content value provided by the USEPA for a sand and gravel processing plant road and can be found in Table 13.2.2-1 of the USEPA AP-42 document. The weights of the trucks were estimated based on a CAT 725 (25T) haul truck based on the information provided by the client. The empirical constants K, a and b were chosen for industrial roads based on the values provided in the USEPA, AP-42 document, Section 13.2 unpaved haul roads (Table 5-7).

A summary of input parameters for the hauling trucks at the mine is given in Table 5-8 . Emission rates for TSP, PM_{10} and $PM_{2.5}$ due to vehicle dust entrainment from hauling trucks during the operational phase are given in Table 5-9 below.

The mine will make use of water (water bowser/water sprays) to control dust emissions from hauling activities. It was assumed that at least 50% emission reduction efficiency will be achieved. This assumption was only made for modelling purposes; dust suppression on the haul routes at the mine will depend on the weather conditions and operational activities at the time.

Table 5-7: Empirical constants used in the calculation for dust emissions from hauling trucks (USEPA, 1995: Section 13.2, Table 13.2.2).

Constant	Industrial Roads (Equation 1a)			Public Roads (Equation 1b)		
	PM-2.5	PM-10	PM-30*	PM-2.5	PM-10	PM-30*
k (lb/VMT)	0.15	1.5	4.9	0.18	1.8	6.0
a	0.9	0.9	0.7	1	1	1
b	0.45	0.45	0.45	-	-	-
c	-	-	-	0.2	0.2	0.3
d	-	-	-	0.5	0.5	0.3
Quality Rating	B	B	B	B	B	B

*Assumed equivalent to total suspended particulate matter (TSP)
"-" = not used in the emission factor equation

Table 5-8: Source parameters for hauling trucks.

SOURCE	TRUCK PARAMETERS				
	UNLOADED WEIGHT (Ton)	LOADED WEIGHT (Ton)	LENGTH (m)	WHEEL WIDTH (m)	HEIGHT (m)
Operational Phase					
Truck Hauling Activity on unpaved haul road	22.3	45.9	10	3	3.4
Notes: 1. Parameters were based on the specifications provided for a CAT 725 ADT haul truck					

Table 5-9: Input parameters for vehicle dust entrainment due to truck hauling activities on unpaved road surfaces.

SOURCE	VKT	EMISSION RATE (g/s)		
		TSP	PM_{10}	$PM_{2.5}$
Operational Phase				
Truck Hauling Activity on unpaved haul road	15 254	1.475	0.575	0.025
Notes: 1. Truck hauling hours: 10 hours/day for 6 days/week (assumed Mon – Sat) 2. 50% control efficiency applied due to water spraying for dust suppression. The percentage control efficiency was based on the Australian NPI document (NPI, 2012). 3. VKT = vehicle kilometres travelled and was based on annual throughput of approx. 60,000 tons/year (product)				

5.2.6 Truck Exhaust Emissions

Hauling activities will result in truck exhaust emissions of gases. Truck exhaust emissions of gases were estimated using the equations provided in the NPI, Emission Estimation Technique Manual for Combustion Engines, Section 5.4.1.2. Industrial Vehicles (NPI, 2008). The following equation was used to calculate truck exhaust emissions of CO, NO_2 and SO_2 for the operational phase:

$$E_i = P \ x \ OpHrs \ x \ LF \ x \ EF_i$$

Where:
E_i = Emission Rate for the substance (i) for a specific engine type (Kg/year)
P = Average rated engine power (KW)
OpHrs = Vehicle operating hours (hours/year)
LF = Load Factor (assumed to be 0.5)
EF_i = Emission factor for substance (i), for a given engine and fuel type
i = substance

Emission factors for diesel industrial vehicles (off-highway truck) exhaust emissions were used in the assessment and were sourced from the NPI, Emission Estimation Technique Manual for Combustion

Engines, Table 33 (NPI, 2008). Truck exhaust emissions associated with hauling activities onsite were only assessed in this study for the operational phase (worst case scenario).

A summary of input parameters and emission factors used to calculate emission rates of CO, NO_2 and SO_2 due to trucks at the proposed mine are given in Table 5-10, with emission rates provided in Table 5-11.

Table 5-10: Input parameters for truck exhaust emissions.

<table>
<tr><th rowspan="3">SOURCE</th><th colspan="6">INPUT PARAMETERS (1)</th></tr>
<tr><th rowspan="2">ENGINE POWER (KW) (2)</th><th rowspan="2">OPERATING HOURS (HOURS/YEAR)</th><th rowspan="2">LOAD FACTOR (4)</th><th colspan="3">EMISSION FACTOR (KG/KWH)</th></tr>
<tr><th>CO</th><th>NO_x</th><th>SO_2</th></tr>
<tr><td colspan="7">Operational Phase – Truck hauling activity</td></tr>
<tr><td>Truck exhaust emissions due to hauling activity</td><td>230.4</td><td>3120(3)</td><td>0.5</td><td>0.0047</td><td>0.011</td><td>0.0000077</td></tr>
<tr><td colspan="7">Notes:
1) A total of ten (10) trucks were assumed to be driving on the road per hour.
2) Engine power was based on the specifications provided by Richie Specs for a CAT 725 Articulated Dump Truck (35 T capacity).
3) Hauling is proposed to occur for only 10 hours a day for 6 days a week.
4) Load factor was provided by the NPI, estimation manual, Table 5 for industrial vehicles. A load factor of 0.5 was chosen for an off-highway truck.</td></tr>
</table>

Table 5-11: Emission rates (g/s) for truck exhaust emissions.

<table>
<tr><th rowspan="2">SOURCE</th><th colspan="3">EMISSION RATES (G/S)</th></tr>
<tr><th>CO</th><th>NO_x</th><th>SO_2</th></tr>
<tr><td colspan="4">Operational Phase – Truck hauling activity</td></tr>
<tr><td>Truck exhaust emissions due to hauling activity</td><td>1.504</td><td>3.52</td><td>0.002</td></tr>
</table>

5.3 Model Overview

5.3.1 AERMOD View

AERMOD, a state-of-the-art Planetary Boundary Layer (PBL) air dispersion model, was developed by the American Meteorological Society and USEPA Regulatory Model Improvement Committee (AERMIC). AERMOD utilizes a similar input and output structure to ISCST3 and shares many of the same features, as well as offering additional features. AERMOD fully incorporates the PRIME building downwash algorithms, advanced depositional parameters, local terrain effects, and advanced meteorological turbulence calculations.

The AERMOD atmospheric dispersion modelling system is an integrated system that includes three modules:

- A steady-state dispersion model designed for short-range (up to 50 km) dispersion of air pollutant emissions from stationary industrial sources.
- A meteorological data pre-processor (AERMET) for surface meteorological data, upper air soundings, and optionally, data from on-site instrument towers. It then calculates atmospheric parameters needed by the dispersion model, such as atmospheric turbulence characteristics, mixing heights, friction velocity, Monin-Obukov length and surface heat flux.
- A terrain pre-processor (AERMAP) which provides a physical relationship between terrain features and the behaviour of air pollution plumes. It generates location and height data for each receptor location. It also provides information that allows the dispersion model to simulate the effects of air flowing over hills or splitting to flow around hills.

AERMOD includes Plume Rise Model Enhancements (PRIME) building downwash algorithms which provide a more realistic handling of building downwash effects. PRIME algorithms were designed to address two fundamental features associated with building downwash; enhanced plume dispersion coefficients due to the turbulent wake and to reduce plume rise caused by a combination of the descending streamlines in the lee of the building and the increased entrainment in the wake. AERMOD is suitable for a wide range of near field applications in both simple and complex terrain. The evaluation results for AERMOD, particularly for complex terrain applications, indicate that the model represents significant improvements compared to previously recommended models (USEPA, 2005).

AERMOD has been used in various dispersion modelling studies in the United States and around the world (Perry *et al*., 2004).

5.3.2 Model Requirements

The approach to this dispersion modelling study is based on the Code *of Practice for Air Dispersion Modelling in Air Quality Management in South Africa* (DEA, 2014). As per the *Code of Practice*, this assessment is a Level 2 assessment. Level 2 assessments should be used for air quality impact assessment in standard/generic licence or amendment processes where:

- The distribution of pollutant concentrations and depositions are required in time and space;
- Pollutant dispersion can be reasonably treated by a straight-line, steady-state, Gaussian plume model with first order chemical transformation. Although more complicated processes may be occurring, a more complicated model that explicitly treats these processes may not be necessary depending on the purposes of the modelling and the zone of interest.
- Emissions are from sources where the greatest impacts are in the order of a few kilometres (less than 50 km) downwind.

A summary of the key variables input into the AERMOD model is given in Table 5-12 below. Data input into the model includes MM5 modelled meteorological data (surface and upper air) for 01 January 2015 – 31 December 2017. Terrain data at a resolution of 90 m (SRTM90) is used for input into the model, as generated by the terrain pre-processor, AERMAP. A modelling domain of 15 km × 15 km is used. A multi-tier grid with a grid receptor spacing of 100 m (5 km from facility), 250 m (10 km from facility) and 1000 m (15 km from facility) (3 tiers) was used.

Table 5-12: Key Variables to be used in the modelling study.

Parameter	Model Input
Model	**Input**
Assessment level	Level 2
Dispersion model	AERMOD Version 9.6
Supporting models	AERMET Version 9.6 AERMAP Version 9.6
Emissions	**Input**
Pollutants to be modelled	Dust Fallout (TSP), PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO
Scenarios	Construction & Operational
Chemical transformations	N/A
Exponential decay	Rural
Settings	**Input**
Terrain setting	Elevated
Terrain data	SRTM90
Terrain data resolution (m)	90
Land characteristics	Grassland
Grid receptors	**Input**
Modelling domain (km)	15 km x 15 km
Fine grid resolution (m)	100 (5 km from facility)
Medium grid resolution (m)	250 (10 km from facility)
Large grid resolution (m)	1000 (beyond 10 km from facility)

5.4 Dispersion Modelling Results

Dispersion simulations were undertaken for the following scenarios to determine:

- Predicted ground-level impacts from all key sources for TSP (as dust fallout), PM_{10} and $PM_{2.5}$ for construction activities associated with the proposed Kanakies mine.
- Predicted ground-level impacts from all key sources for TSP (as dust fallout), PM_{10} and $PM_{2.5}$ for mining activities associated with the proposed Kanakies mine.
- Predicted ground-level impacts from all key sources for CO, SO_2 and NO_2 for truck exhaust emissions associated with truck hauling activity at the proposed Kanakies mine.

The Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa (DEA, 2014), recommends the use of the 99th percentile concentrations for short-term assessment with the National Ambient Air Quality Standards since the highest predicted ground-level concentrations can be considered outliers due to complex variability of meteorological processes. This might cause exceptionally high concentrations that the facility may never actually exceed in its lifetime.

Isopleth plots of predicted concentrations for dust fallout, PM_{10} and $PM_{2.5}$ for the construction phase are given in Figure 5-1 to Figure 5-5 below. Isopleth plots of predicted concentrations for PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO for the operational phase are given in Figure 5-6 to Figure 5-17. For short term averaging periods, the predicted 99^{th} percentile concentrations are provided.

Comparison of the predicted PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO ambient concentrations are made with the South African National ambient air quality standards to determine compliance. Comparison of the predicted TSP (as dust fallout) rates are made with the South African National Dust Control Regulations, 2013 to determine compliance. In determining compliance, predicted incremental concentrations (as determined beyond the site's boundary) are compared against the applicable standards. Inside the site boundary, air pollutant concentrations are required to comply with occupational health and safety standards.

The maximum predicted incremental PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO concentrations and dust fallout rates at the identified nearby sensitive receptors and maximum concentrations at the mine site boundary for the construction and operational phase of the mine are given in Table 5-13 to Table 5-16.

5.4.1. Dispersion Model Output Plots for Construction Phase

Predicted incremental dust fallout rates due to construction activity comply with the residential and non-residential area standards of 600 mg/m^2/day and 1200 mg/m^2/day over the project area, except for a small area at the emission source. Higher dust fallout rates, including exceedances, are observed at the area of construction activity (Figure 5-1).

Predicted incremental concentrations for PM_{10} comply with the daily average standard of 75 µg/m^3 over most of the project area. Exceedances of the daily limit are observed; however, these occur within the mine boundary near to the area of construction activity (Figure 5-2). Predicted incremental concentrations for PM_{10} comply with the annual standard of 40 µg/m^3, with localised exceedances observed at the emission source (Figure 5-3).

Predicted incremental concentrations for $PM_{2.5}$ comply with the daily standard of 40 µg/m^3, with a small area of exceedance near the area of construction activity (Figure 5-4). No exceedances of the annual standard of 20 µg/m^3 are observed (Figure 5-5).

Low predicted concentrations of PM_{10}, $PM_{2.5}$ and dust fallout rates are observed at surrounding discrete receptors (Table 5-13).

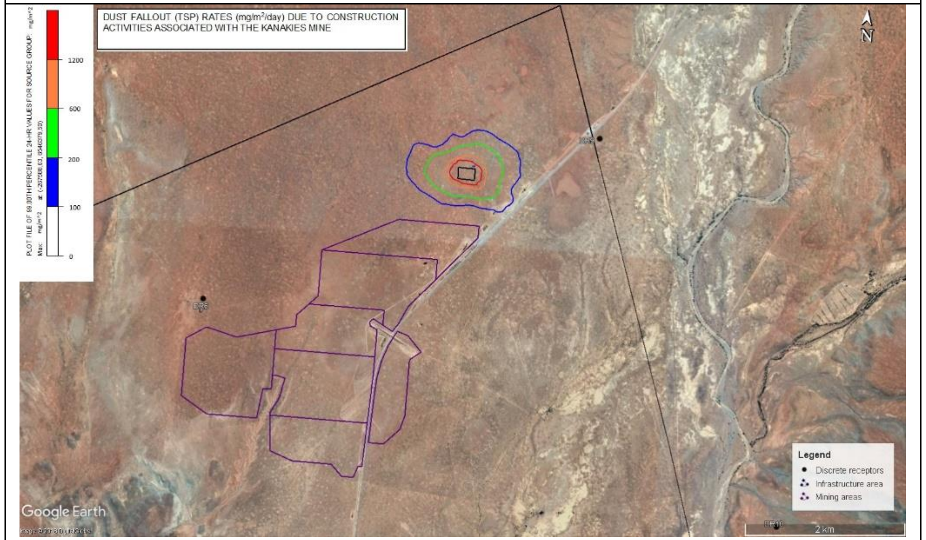
Predicted Incremental Dust Fallout (TSP) Rates (Construction Phase)		
		
COMMENTS: Red band - exceedances of the non-residential area standard of 1200 $mg/m^2/day$. Orange band - exceedances of the residential area standard of 600 $mg/m^2/day$.	**GRID SIZE:** 15 x 15 km	**MODEL:** AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** 99^{th} Percentile Deposition Rates
	NUMBER OF SOURCES: X 4 area	**ASSUMPTIONS:**
	DUST FALLOUT STANDARD: 1200 $mg/m^2/day$ (non-residential areas) 600 $mg/m^2/day$ (residential areas) **DATE:** 21/06/2018	

Figure 5-1: Predicted Dust Fallout (TSP) Rates at the proposed Kanakies Mine –Construction Phase.

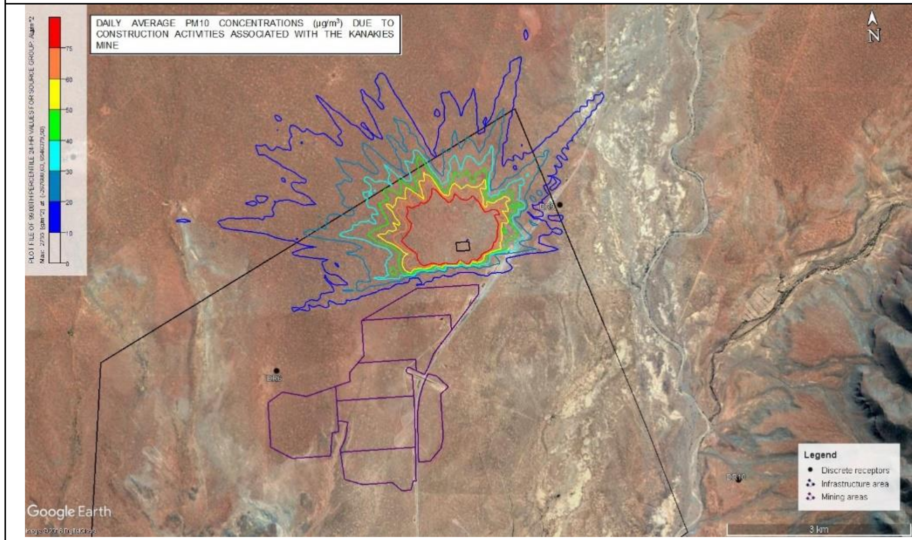
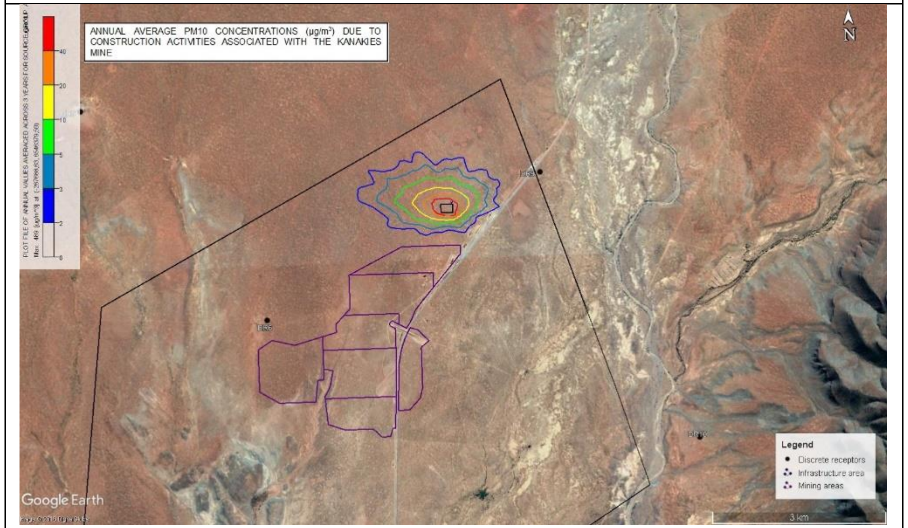
Predicted Incremental 24-Hour PM_{10} Concentrations (Construction Phase)		
		
COMMENTS: Red band - exceedances SA 24-H PM_{10} standard of 75 $\mu g/m^3$.	**GRID SIZE:** 15 x 15 km	**MODEL:** AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** 99^{th} Percentile Ground Level Concentrations
	NUMBER OF SOURCES: X 4 area	**ASSUMPTIONS:**
	AMBIENT STANDARD: 75 $\mu g/m^3$ (SA 24-Hour standard) **DATE:** 21/06/2018	

Figure 5-2: Predicted Daily Average PM_{10} Concentrations at the proposed Kanakies Mine – Construction Phase.

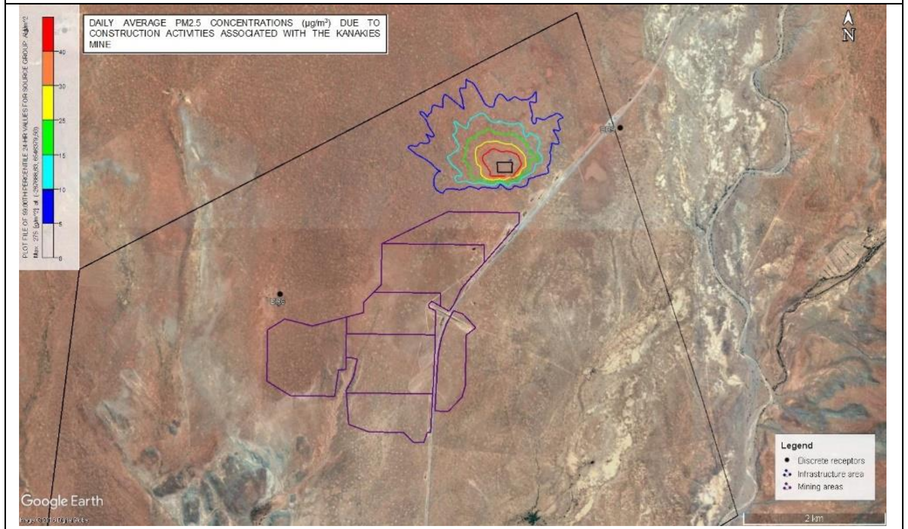
Predicted Incremental Annual PM_{10} Concentrations (Construction Phase)



COMMENTS: Red band - exceedances of the SA-annual PM_{10} standard of 40 µg/m³.	**GRID SIZE:** 15 x 15 km	**MODEL:** AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** Ground Level Concentrations
	NUMBER OF SOURCES: X 4 area	**ASSUMPTIONS:**
	AMBIENT STANDARD: 40 µg/m³ (SA annual standard) **DATE:** 21/06/2018	

Figure 5-3: Predicted Annual Average PM_{10} Concentrations at the proposed Kanakies Mine – Construction Phase.

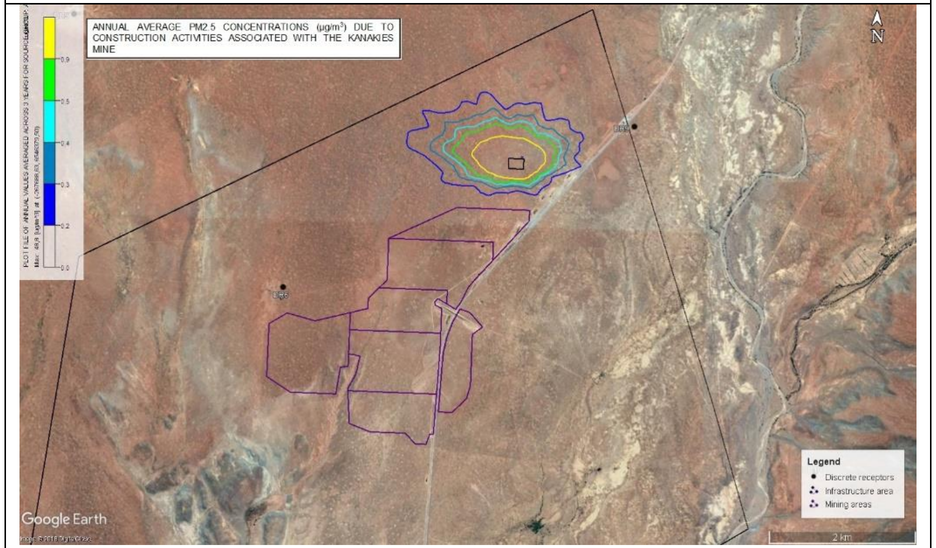
Predicted Incremental 24-Hour $PM_{2.5}$ Concentrations (Construction Phase)



COMMENTS: Red band - exceedances of the SA-24H $PM_{2.5}$ standard of 40 µg/m³.	**GRID SIZE:** 15 x 15 km	**MODEL:** AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** 99th Percentile Ground Level Concentrations
	NUMBER OF SOURCES: X 4 area	**ASSUMPTIONS:**
	AMBIENT STANDARD: 40 µg/m³ (SA 24-Hour standard) (current) 25 µg/m³ (SA 24-Hour standard) (By 1 Jan 2030) **DATE:** 21/06/2018	

Figure 5-4: Predicted Daily Average $PM_{2.5}$ Concentrations at the proposed Kanakies Mine – Construction Phase.

Predicted Incremental Annual $PM_{2.5}$ Concentrations (Construction Phase)



<table>
<tr><td rowspan="4"><u>COMMENTS:</u>

No exceedances of the SA $PM_{2.5}$ annual standard of 20 µg/m³.</td><td><u>GRID SIZE:</u>
15 x 15 km</td><td><u>MODEL:</u>
AERMOD View</td></tr>
<tr><td><u>GRID:</u>
Multi-tier – 3 tiers</td><td><u>OUTPUT TYPE:</u>
Ground Level Concentrations</td></tr>
<tr><td><u>NUMBER OF SOURCES:</u>
X 4 area</td><td><u>ASSUMPTIONS:</u></td></tr>
<tr><td colspan="2"><u>AMBIENT STANDARD:</u>
20 µg/m³ (SA annual standard) (Current)
15 µg/m³ (SA annual standard) (By 1 Jan 2030)
<u>DATE:</u>
21/06/2018</td></tr>
</table>

Figure 5-5: Predicted Annual Average $PM_{2.5}$ Concentrations at the proposed Kanakies Mine – Construction Phase.

5.4.2. Dispersion Model Output Plots for Operational Phase

Predicted incremental dust fallout rates due to proposed mining operations comply with the residential and non-residential area standards of 600 mg/m^2/day and 1200 mg/m^2/day over most of the project area. Higher dust fallout rates, including exceedances, are observed near the open pit area, where mining activity takes place (Figure 5-6). No exceedances are observed beyond the mine boundary.

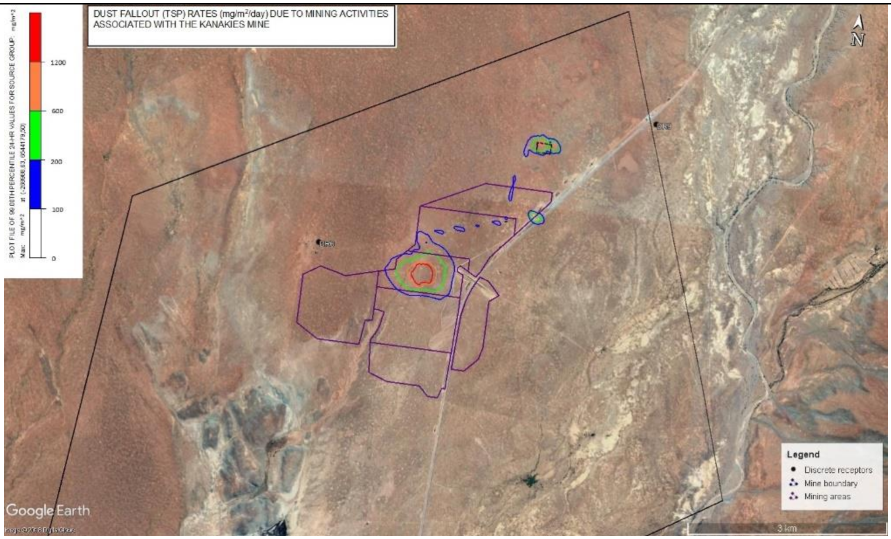
Predicted incremental concentrations for PM_{10} comply with the daily average standard of 75 µg/m^3 and the annual standard of 40 µg/m^3 over most of the project area (Figure 5-7 and Figure 5-8). Higher PM_{10} concentrations, including exceedances, are observed at the mining area and product storage area. No exceedances of the standard are observed outside the mine boundary.

Predicted incremental concentrations for $PM_{2.5}$ comply with the daily standard of 40 µg/m^3, with a small area of exceedance near the area of mining activity and product storage area (Figure 5-9Figure 5-4). No exceedances of the annual standard of 20 µg/m^3 are observed (Figure 5-10).

Predicted incremental concentrations of CO and SO_2 due to truck exhaust emissions associated with truck hauling (to and from the product storage area) fall well below the applicable acceptable ambient air quality standards (Figure 5-11 to Figure 5-12) (Figure 5-15 to Figure 5-17). Predicted incremental concentrations of NO_x are slightly higher compared to CO and SO_2 and comply with the hourly and annual limits beyond the mine boundary. Higher concentrations of NO_x can be expected near the hauling route (Figure 5-13 and Figure 5-14).

Predicted incremental concentrations at surroundings sensitive receptors are low and comply with the applicable ambient air quality standards (Table 5-14 and Table 5-15).

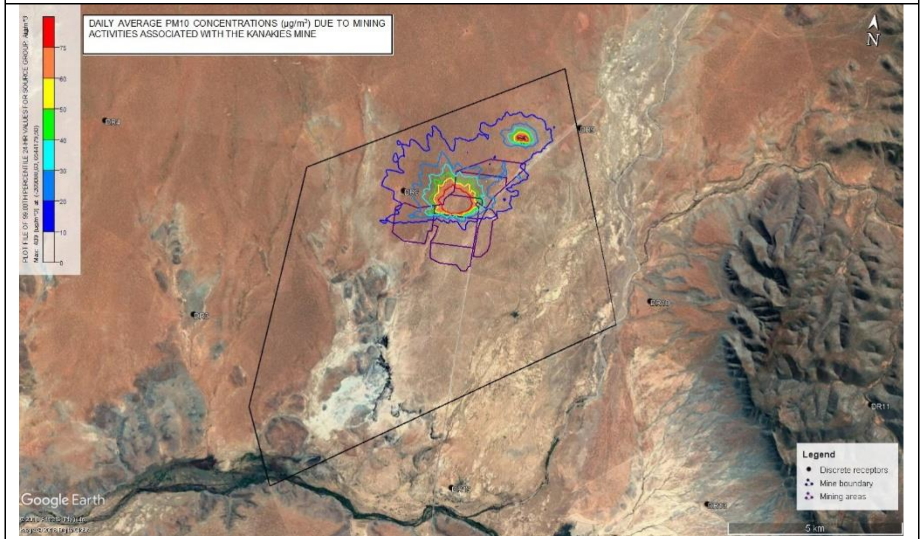
Predicted Incremental Dust Fallout (TSP) Rates (Operational Phase)



COMMENTS:	**GRID SIZE:** 15 x 15 km	**MODEL:** AERMOD View
Red band - exceedances of the non-residential area standard of 1200 mg/m^2/day.	**GRID:** Multi-tier – 3 tiers	**OUTPUT TYPE:** 99th Percentile Deposition Rates
Orange band - exceedances of the residential area standard of 600 mg/m^2/day.	**NUMBER OF SOURCES:** X 12 area X 1 line	**ASSUMPTIONS:** 50% control efficiency on unpaved road
	DUST FALLOUT STANDARD: 1200 mg/m^2/day (non-residential areas) 600 mg/m^2/day (residential areas) **DATE:** 21/06/2018	

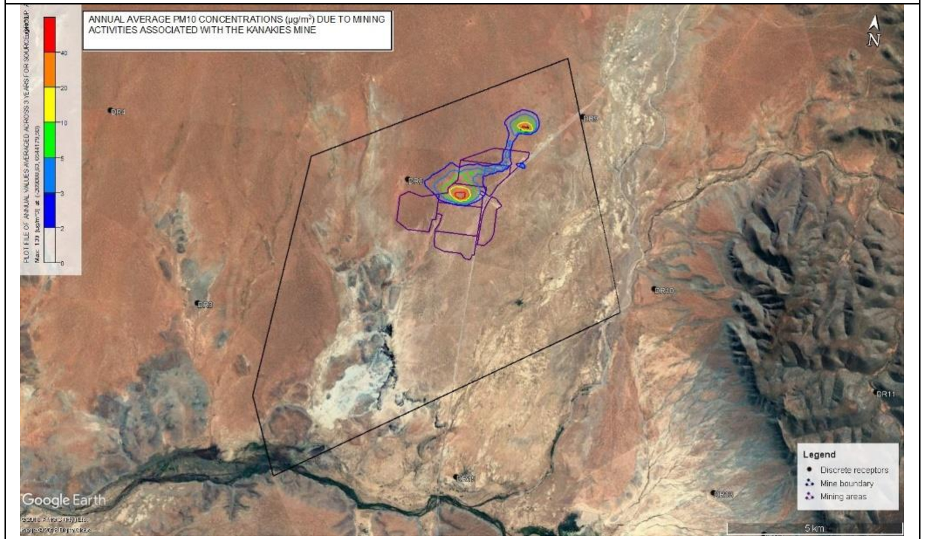
Figure 5-6: Predicted Dust Fallout (TSP) Rates at the proposed Kanakies Mine –Operational Phase.

Predicted Incremental 24-Hour PM_{10} Concentrations (Operational Phase)



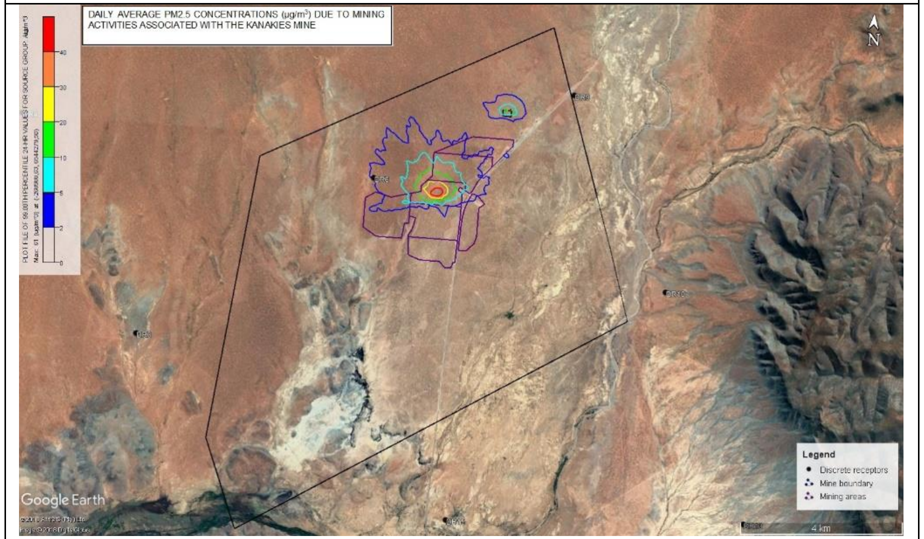
COMMENTS:	**GRID SIZE:** 15 x 15 km	**MODEL:** AERMOD View
Red band - exceedances SA 24-H PM_{10} standard of 75 µg/m^3.	**GRID:** Multi-tier – 3 tiers	**OUTPUT TYPE:** 99th Percentile Ground Level Concentrations
	NUMBER OF SOURCES: X 12 area X 1 line	**ASSUMPTIONS:** 50% control efficiency on unpaved road
	AMBIENT STANDARD: 75 µg/m^3 (SA 24-Hour standard) **DATE:** 21/06/2018	

Figure 5-7: Predicted Daily Average PM_{10} Concentrations at the proposed Kanakies Mine – Operational Phase.

<table>
<tr><th colspan="3">Predicted Incremental Annual PM_{10} Concentrations (Operational Phase)</th></tr>
<tr><td colspan="3">
</td></tr>
<tr><td rowspan="4"><u>COMMENTS:</u>

Red band - exceedances of the SA-annual PM_{10} standard of 40 µg/m^3.</td><td><u>GRID SIZE:</u>
15 x 15 km</td><td><u>MODEL:</u>
AERMOD View</td></tr>
<tr><td><u>GRID:</u>
Multi-tier – 3 tiers</td><td><u>OUTPUT TYPE:</u>
Ground Level Concentrations</td></tr>
<tr><td><u>NUMBER OF SOURCES:</u>
X 12 area
X 1 line</td><td><u>ASSUMPTIONS:</u>
50% control efficiency on unpaved road</td></tr>
<tr><td colspan="2"><u>AMBIENT STANDARD:</u>
40 µg/m^3 (SA annual standard)
<u>DATE:</u>
21/06/2018</td></tr>
</table>

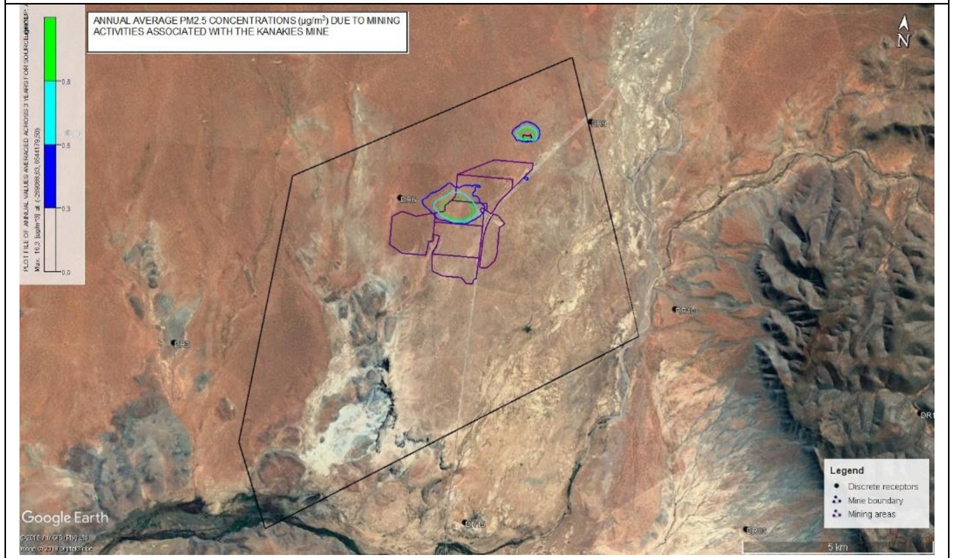
Figure 5-8: Predicted Annual Average PM_{10} Concentrations at the proposed Kanakies Mine – Operational Phase.

<table>
<tr><th colspan="3">Predicted Incremental 24-Hour $PM_{2.5}$ Concentrations (Operational Phase)</th></tr>
<tr><td colspan="3">
</td></tr>
<tr><td rowspan="4"><u>COMMENTS:</u>

Red band - exceedances of the SA-24H $PM_{2.5}$ standard of 40 µg/m^3.</td><td><u>GRID SIZE:</u>
15 x 15 km</td><td><u>MODEL:</u>
AERMOD View</td></tr>
<tr><td><u>GRID:</u>
Multi-tier – 3 tiers</td><td><u>OUTPUT TYPE:</u>
99th Percentile Ground Level Concentrations</td></tr>
<tr><td><u>NUMBER OF SOURCES:</u>
X 12 area
X 1 line</td><td><u>ASSUMPTIONS:</u>
50% control efficiency on unpaved road</td></tr>
<tr><td colspan="2"><u>AMBIENT STANDARD:</u>
40 µg/m^3 (SA 24-Hour standard) (current)
25 µg/m^3 (SA 24-Hour standard) (By 1 Jan 2030)
<u>DATE:</u>
21/06/2018</td></tr>
</table>

Figure 5-9: Predicted Daily Average $PM_{2.5}$ Concentrations at the proposed Kanakies Mine – Operational Phase.

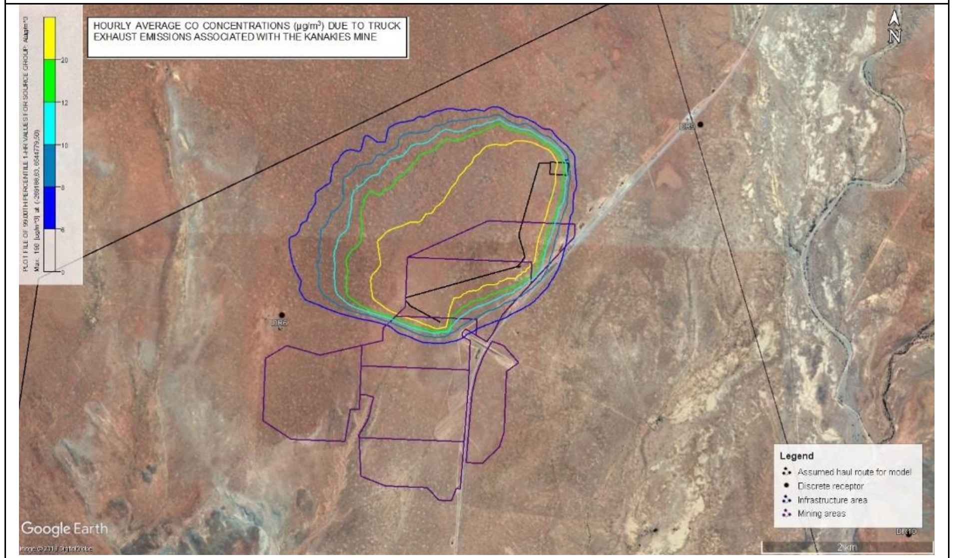
Predicted Incremental Annual $PM_{2.5}$ Concentrations (Operational Phase)



COMMENTS:	GRID SIZE:	MODEL:
No exceedances of the SA $PM_{2.5}$ annual standard of 20 µg/m³.	15 x 15 km	AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** Ground Level Concentrations
	NUMBER OF SOURCES: X 12 area X 1 line	**ASSUMPTIONS:** 50% control efficiency on unpaved road
	AMBIENT STANDARD: 20 µg/m³ (SA annual standard) (Current) 15 µg/m³ (SA annual standard) (By 1 Jan 2030) **DATE:** 21/06/2018	

Figure 5-10: Predicted Annual Average $PM_{2.5}$ Concentrations at the proposed Kanakies Mine – Operational Phase.

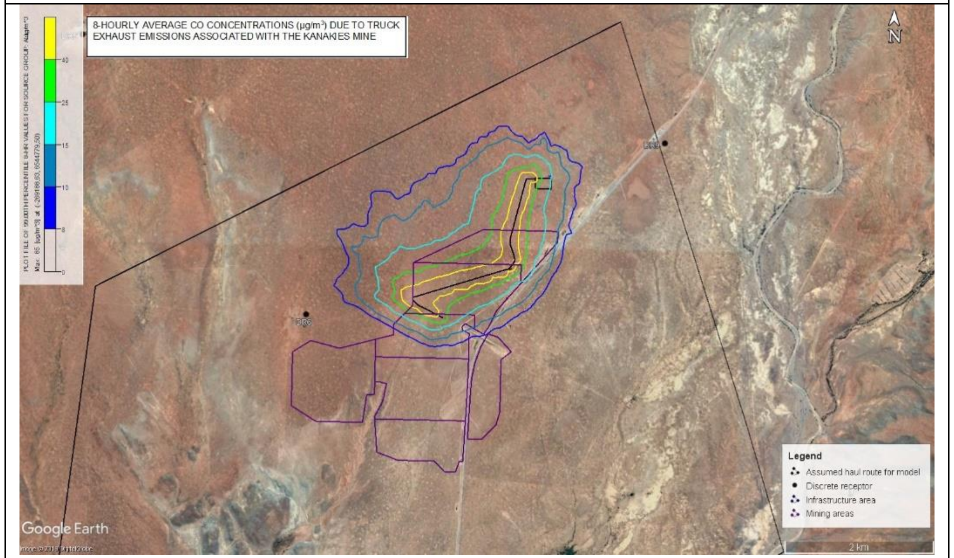
Predicted Incremental Hourly CO Concentrations (Operational Phase)



COMMENTS:	GRID SIZE:	MODEL:
No exceedances of the SA CO hourly standard of 30,000 µg/m³.	15 x 15 km	AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** 99th Percentile Ground Level Concentrations
	NUMBER OF SOURCES: X 1 line	**ASSUMPTIONS:** Assumed truck haul route
	AMBIENT STANDARD: 30,000 µg/m³ (SA hourly standard) 10,000 µg/m³ (SA 8-hourly standard) **DATE:** 21/06/2018	

Figure 5-11: Predicted Hourly Average CO Concentrations at the proposed Kanakies Mine – Operational Phase.

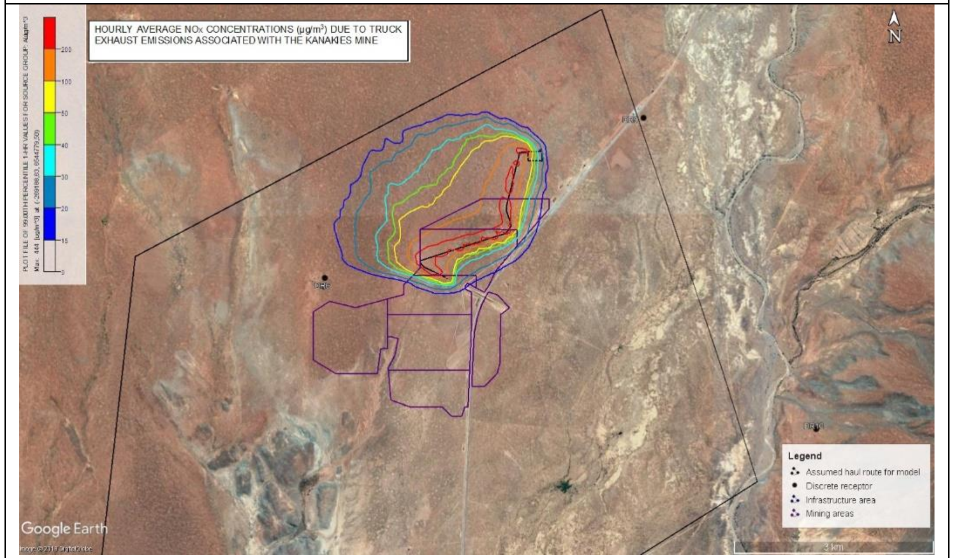
Predicted Incremental 8-Hourly CO Concentrations (Operational Phase)



COMMENTS:	**GRID SIZE:** 15 x 15 km	**MODEL:** AERMOD View
No exceedances of the SA CO 8-hourly standard of 10,000 µg/m^3.	**GRID:** Multi-tier – 3 tiers	**OUTPUT TYPE:** 99^{th} Percentile Ground Level Concentrations
	NUMBER OF SOURCES: X 1 line	**ASSUMPTIONS:** Assumed truck haul route
	AMBIENT STANDARD: 30,000 µg/m^3 (SA hourly standard) 10,000 µg/m^3 (SA 8-hourly standard) **DATE:** 21/06/2018	

Figure 5-12: Predicted 8-Hourly Average CO Concentrations at the proposed Kanakies Mine – Operational Phase.

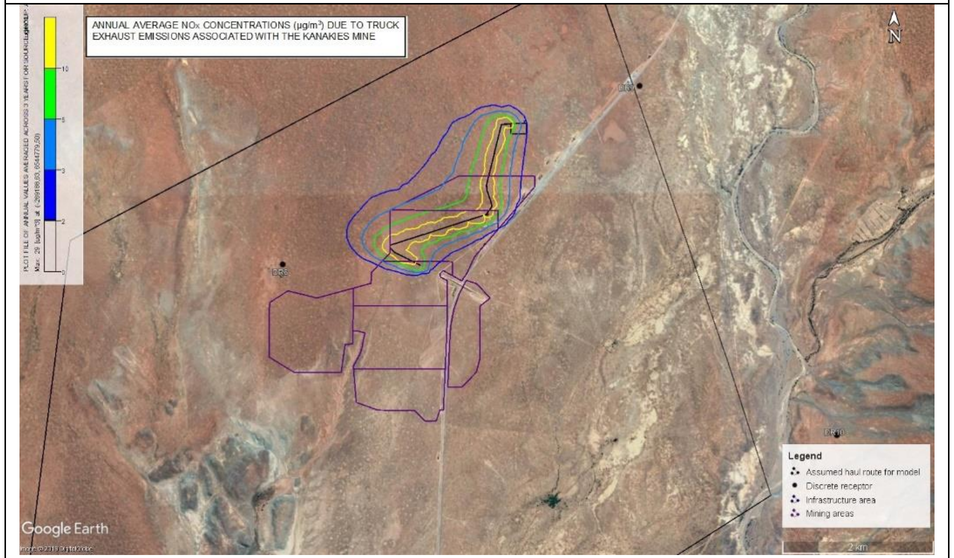
Predicted Incremental Hourly NO_x Concentrations (Operational Phase)



COMMENTS:	**GRID SIZE:** 15 x 15 km	**MODEL:** AERMOD View
Red band - exceedances of the SA NO_x hourly standard of 200 µg/m^3.	**GRID:** Multi-tier – 3 tiers	**OUTPUT TYPE:** 99^{th} Percentile Ground Level Concentrations
	NUMBER OF SOURCES: X 1 line	**ASSUMPTIONS:** Assumed truck haul route
	AMBIENT STANDARD: 200 µg/m^3 (SA hourly standard) 40 µg/m^3 (SA annual standard) **DATE:** 21/06/2018	

Figure 5-13: Predicted Hourly Average NO_x Concentrations at the proposed Kanakies Mine – Operational Phase.

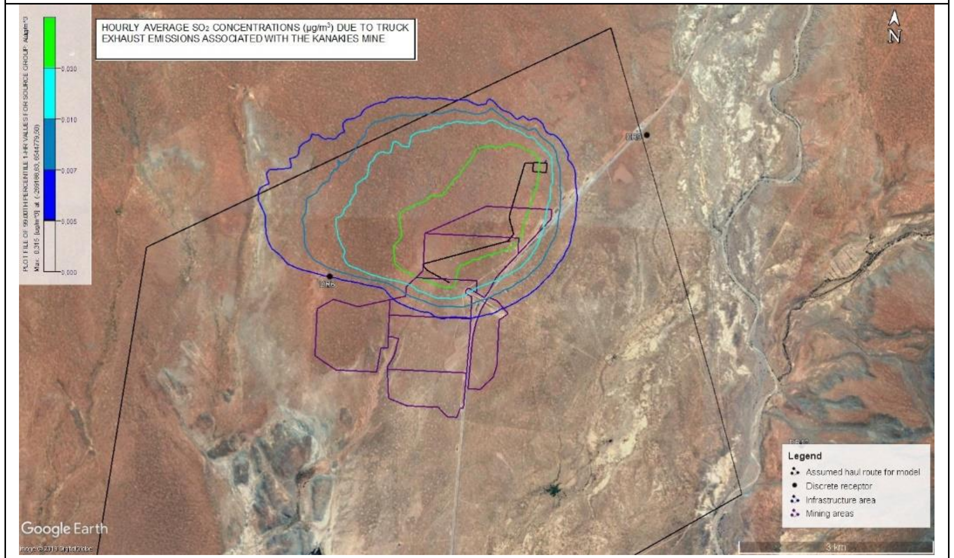
Predicted Incremental Annual NO_x Concentrations (Operational Phase)



COMMENTS:	GRID SIZE:	MODEL:
No exceedances of the SA NO_x annual standard of 40 µg/m³.	15 x 15 km	AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** 99th Percentile Ground Level Concentrations
	NUMBER OF SOURCES: X 1 line	**ASSUMPTIONS:** Assumed truck haul route
	AMBIENT STANDARD: 200 µg/m³ (SA hourly standard) 40 µg/m³ (SA annual standard) **DATE:** 21/06/2018	

Figure 5-14: Predicted Annual Average NO_x Concentrations at the proposed Kanakies Mine – Operational Phase.

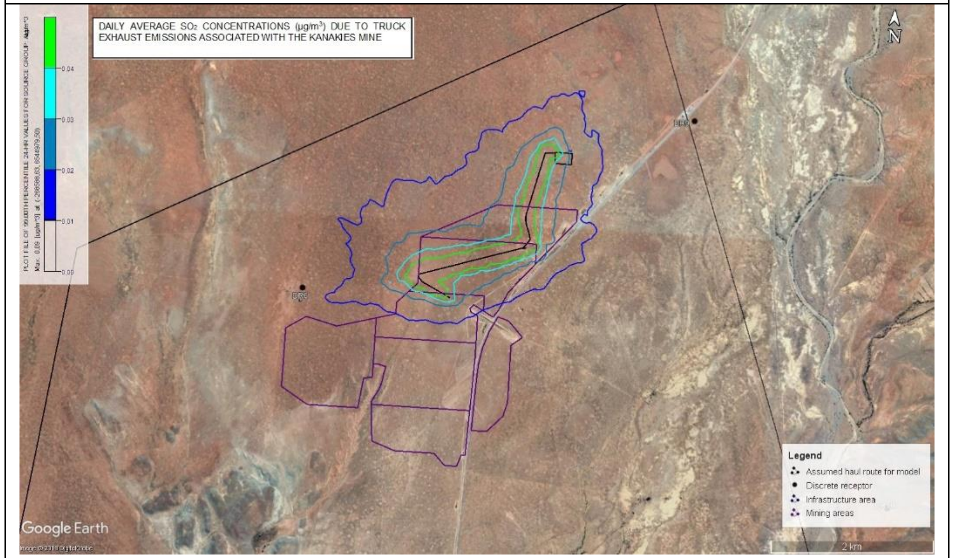
Predicted Incremental Hourly SO_2 Concentrations (Operational Phase)



COMMENTS:	GRID SIZE:	MODEL:
No exceedances of the SA SO_2 hourly standard of 350 µg/m³.	15 x 15 km	AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** 99th Percentile Ground Level Concentrations
	NUMBER OF SOURCES: X 1 line	**ASSUMPTIONS:** Assumed truck haul route
	AMBIENT STANDARD: 350 µg/m³ (SA hourly standard) 125 µg/m³ (SA daily standard) 50 µg/m³ (SA annual standard) **DATE:** 21/06/2018	

Figure 5-15: Predicted Hourly Average SO_2 Concentrations at the proposed Kanakies Mine – Operational Phase.

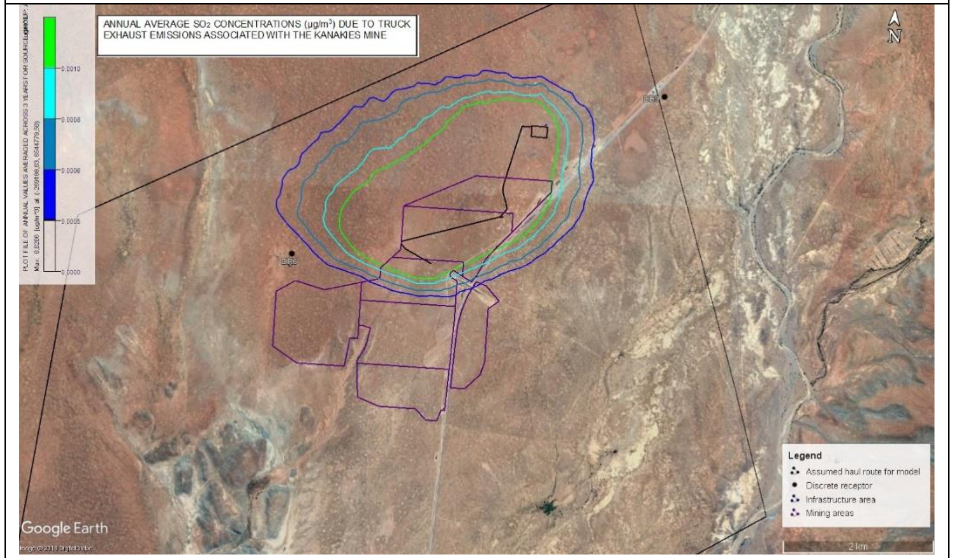
Predicted Incremental Daily SO_2 Concentrations (Operational Phase)



COMMENTS:	GRID SIZE:	MODEL:
No exceedances of the SA SO_2 daily standard of 125 µg/m³.	15 x 15 km	AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** 99th Percentile Ground Level Concentrations
	NUMBER OF SOURCES: X 1 line	**ASSUMPTIONS:** Assumed truck haul route
	AMBIENT STANDARD: 350 µg/m³ (SA hourly standard) 125 µg/m³ (SA daily standard) 50 µg/m³ (SA annual standard) **DATE:** 21/06/2018	

Figure 5-16: Predicted Daily Average SO_2 Concentrations at the proposed Kanakies Mine – Operational Phase.

Predicted Incremental Annual SO_2 Concentrations (Operational Phase)



COMMENTS:	GRID SIZE:	MODEL:
No exceedances of the SA SO_2 annual standard of 50 µg/m³.	15 x 15 km	AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** 99th Percentile Ground Level Concentrations
	NUMBER OF SOURCES: X 1 line	**ASSUMPTIONS:** Assumed truck haul route
	AMBIENT STANDARD: 350 µg/m³ (SA hourly standard) 125 µg/m³ (SA daily standard) 50 µg/m³ (SA annual standard) **DATE:** 21/06/2018	

Figure 5-17: Predicted Annual Average SO_2 Concentrations at the proposed Kanakies Mine – Operational Phase.

5.4.3. Maximum Predicted Incremental Concentrations

Maximum predicted incremental concentrations at nearby sensitive receptors located within 10km from the site boundary are given in the below section (Table 5-13 to Table 5-15). A spatial representation of the identified discrete receptors is shown below in Figure 5-18. The receptors were identified during a desktop study (please refer to section 2.4).

Maximum predicted incremental concentrations at the mine boundary are given in Table 5-16.

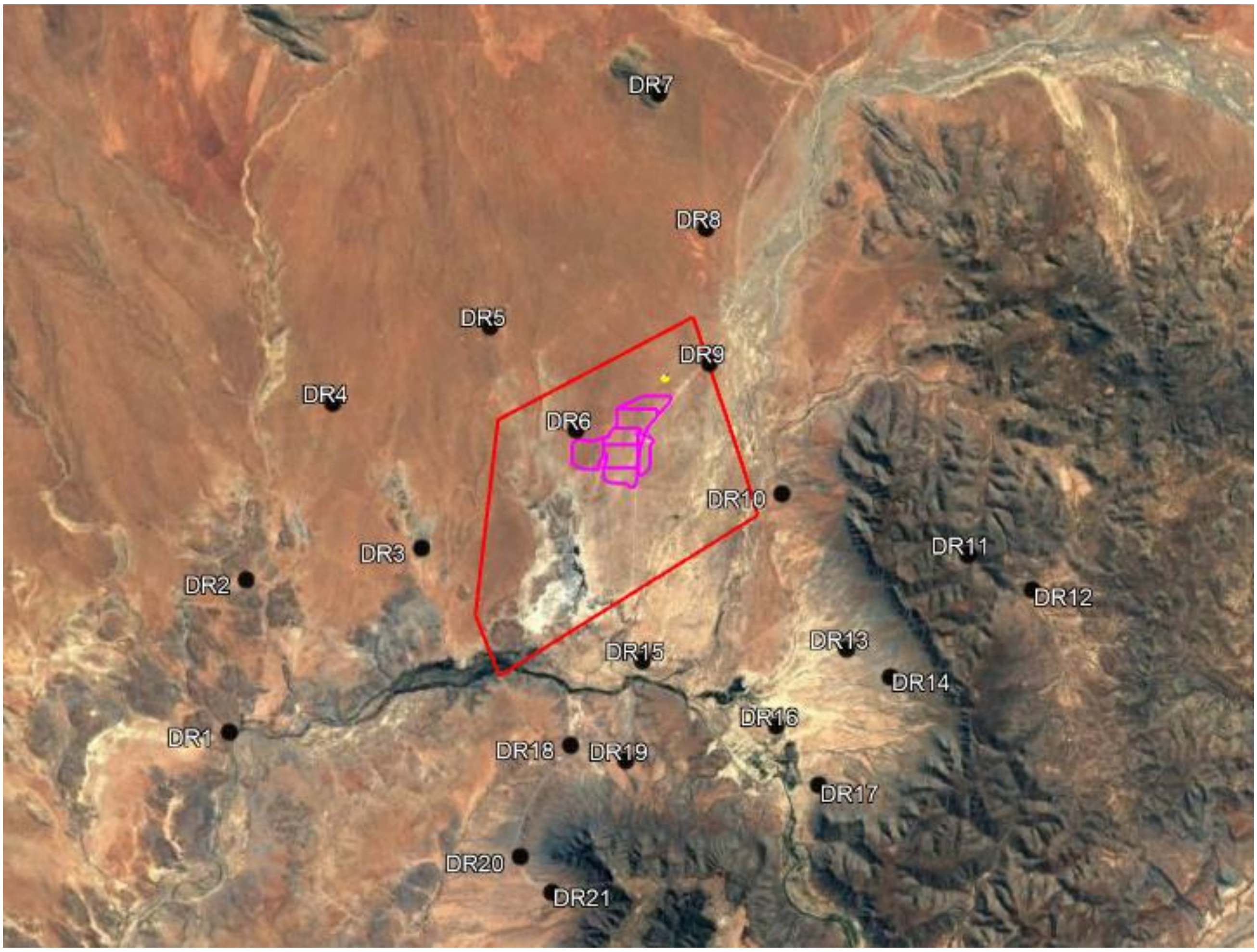


Figure 5-18: Spatial representation of discrete receptors included in dispersion model (<10km from site boundary).

Table 5-13: Maximum predicted incremental PM_{10}, $PM_{2.5}$ concentrations and Dust Fallout rates at nearby sensitive receptors, located within ~10km - Construction Phase.

INCREMENTAL CONCENTRATIONS (µg/m³)							
SENSITIVE RECEPTOR	Co-ordinates		PM_{10}		$PM_{2.5}$		DUST FALLOUT (mg/m²/day)
			24H	Annual	24H	Annual	
STANDARD (µg/m³)	X	Y	75	40	40	20	Residential: 600 mg/m²/day Non-residential: 1200 mg/m²/day
Construction Phase							
DR1	282307.44	6532594.35	0.1	0.01	0.01	<0.01	<1
DR2	282093.38	6538267.00	0.18	0.02	0.02	<0.01	<1
DR3	275858.81	6539792.19	0.2	0.01	0.02	<0.01	<1
DR4	279524.63	6544715.62	0.47	0.04	0.04	<0.01	<1
DR5	273959.01	6547873.04	2.6	0.16	0.26	0.01	3.5
DR6	270801.59	6544367.77	0.85	0.13	0.09	<0.01	3.5
DR7	268714.48	6556542.56	0.28	0.01	0.03	<0.01	<1
DR8	266547.10	6551966.98	0.9	0.04	0.09	<0.01	3.1
DR9	266065.46	6547177.34	5.6	0.66	0.56	0.06	23
DR10	263148.86	6542628.51	0.5	0.03	0.05	<0.01	1.6
DR11	256512.65	6541130.04	0.2	0.01	0.02	<0.01	1.2
DR12	254024.12	6539899.15	0.2	0.01	0.02	<0.01	<1
DR13	260579.92	6537330.35	0.2	0.01	0.01	<0.01	<1
DR14	258920.90	6536581.11	0.1	0.01	0.01	<0.01	<1
DR15	267858.20	6536233.26	0.1	0.01	0.01	<0.01	<1
DR16	263202.24	6534386.93	0.2	0.01	0.01	<0.01	<1
DR17	261141.85	6532326.54	0.1	0.01	0.02	<0.01	<1
DR18	270052.38	6533129.29	0.1	0.01	0.01	<0.01	<1
DR19	268018.75	6532915.22	0.1	0	0.01	<0.01	<1
DR20	271443.82	6529142.29	0.1	0.01	0.01	<0.01	<1
DR21	270373.48	6527831.13	0.2	0.01	0.01	<0.01	<1

Notes:
DR = discrete receptor (residential/building)
No hospital/clinics or healthcare facilities were identified
No educational or training facilities were identified
Please refer to appendix B for date of maximum impacts at each receptor

Table 5-14: Maximum predicted incremental PM_{10}, $PM_{2.5}$ concentrations and Dust Fallout rates at nearby sensitive receptors, located within ~10km - Operational Phase.

INCREMENTAL CONCENTRATIONS (µg/m³)							
SENSITIVE RECEPTOR	Co-ordinates		PM_{10}		$PM_{2.5}$		DUST FALLOUT (mg/m²/day)
			24H	Annual	24H	Annual	
STANDARD (µg/m³)	X	Y	75	40	40	20	Residential: 600 mg/m²/day Non-residential: 1200 mg/m²/day
Operation Phase							
DR1	282307.44	6532594.35	0.1	0.01	0.01	<0.01	<0.01
DR2	282093.38	6538267.00	0.4	0.02	0.05	<0.01	<0.01
DR3	275858.81	6539792.19	0.27	0.02	0.04	<0.01	<0.01
DR4	279524.63	6544715.62	0.92	0.07	0.1	0.01	<0.01
DR5	273959.01	6547873.04	1.07	0.09	0.1	0.01	<0.01
DR6	270801.59	6544367.77	13.9	0.98	1.99	0.13	0.01
DR7	268714.48	6556542.56	0.15	0.01	0.02	<0.01	<0.01
DR8	266547.10	6551966.98	0.47	0.04	0.05	<0.01	<0.01
DR9	266065.46	6547177.34	4.3	0.27	0.4	0.03	<0.01
DR10	263148.86	6542628.51	0.58	0.05	0.06	0.01	<0.01
DR11	256512.65	6541130.04	0.11	0.01	0.01	<0.01	<0.01
DR12	254024.12	6539899.15	0.08	0.01	<0.01	<0.01	<0.01
DR13	260579.92	6537330.35	0.18	0.01	0.03	<0.01	<0.01
DR14	258920.90	6536581.11	0.19	0.01	0.02	<0.01	<0.01
DR15	267858.20	6536233.26	0.09	0.01	0.01	<0.01	<0.01
DR16	263202.24	6534386.93	0.17	0.01	0.02	<0.01	<0.01
DR17	261141.85	6532326.54	0.1	0.01	0.01	<0.01	<0.01
DR18	270052.38	6533129.29	0.1	0.01	0.01	<0.01	<0.01
DR19	268018.75	6532915.22	0.06	0.01	0.01	<0.01	<0.01
DR20	271443.82	6529142.29	0.08	0.01	0.01	<0.01	<0.01
DR21	270373.48	6527831.13	0.06	0.01	0.01	<0.01	<0.01

Notes:
DR = discrete receptor (residential/building)
No hospital/clinics or healthcare facilities were identified
No educational or training facilities were identified
Please refer to appendix B for date of maximum impacts at each receptor

Table 5-15: Maximum predicted incremental CO, NO_x and SO_2 concentrations at nearby sensitive receptors, located within ~10km - Operational Phase.

INCREMENTAL CONCENTRATIONS (µg/m³)									
SENSITIVE RECEPTOR	Co-ordinates		CO		NO_x		SO_2		
			1H	8H	1H	Annual	1H	24H	Annual
STANDARD (µg/m³)	X	Y	30,000	10,000	200	40	350	125	50
Operation Phase									
DR1	282307.44	6532594.35	0.08	0.08	0.2	0.01	Negligible (<0.01)		
DR2	282093.38	6538267.00	0.1	0.2	0.3	0.02			
DR3	275858.81	6539792.19	0.2	0.2	0.5	0.03			
DR4	279524.63	6544715.62	0.5	0.4	1.11	0.06			
DR5	273959.01	6547873.04	0.8	1.1	1.9	0.1			
DR6	270801.59	6544367.77	2.9	3.9	6.9	0.5			
DR7	268714.48	6556542.56	0.09	0.06	0.2	0.01			
DR8	266547.10	6551966.98	0.2	0.3	0.5	0.03			
DR9	266065.46	6547177.34	1.1	2.1	2.6	0.3			
DR10	263148.86	6542628.51	0.4	0.56	0.9	0.06			
DR11	256512.65	6541130.04	0.1	0.07	0.2	0.01			
DR12	254024.12	6539899.15	0.08	0.05	0.2	0.01			
DR13	260579.92	6537330.35	0.1	0.17	0.3	0.02			
DR14	258920.90	6536581.11	0.1	0.16	0.3	0.02			
DR15	267858.20	6536233.26	0.2	0.19	0.4	0.02			
DR16	263202.24	6534386.93	0.1	0.16	0.3	0.02			
DR17	261141.85	6532326.54	0.1	0.1	0.2	0.02			
DR18	270052.38	6533129.29	0.1	0.1	0.3	0.02			
DR19	268018.75	6532915.22	0.1	0.1	0.3	0.01			
DR20	271443.82	6529142.29	0.1	0.01	0.2	0.01			
DR21	270373.48	6527831.13	0.1	0.01	0.2	0.04			
Notes: DR = discrete receptor (residential/building) No hospital/clinics or healthcare facilities were identified No educational or training facilities were identified Please refer to appendix B for date of maximum impacts at each receptor									

Table 5-16: Summary of Predicted Maximum Modelled Incremental Concentrations at Site Boundary

POLLUTANT	AVERAGING TIME	MAXIMUM MODELLED CONCENTRATION (µg/m³) (3)	COMPLIANCE (4) AIR QUALITY STANDARD (µg/m³)
Construction Phase			
Dust Fallout (1)	Daily	20	1200(2)
PM_{10}	Daily	47.4	75
	Annual	1.01	40
$PM_{2.5}$	Daily	4.7	40
	Annual	0.06	20
Operational Phase			
Dust Fallout	Daily	0	1200
PM_{10}	Daily	8.5	75
	Annual	0.4	40
$PM_{2.5}$	Daily	1.06	40
	Annual	0.05	20
CO	Hourly	5	30,000
	8-Hourly	5	10,000
NO_2	Hourly	11	200
	Annual	0.6	40
SO_2	Hourly	0.01	350
	Daily	0.01	125
	Annual	<0.01	50

Notes:
1. Dust fallout given in mg/m²/day
2. Non residential area dust fallout standard
3. Along the mine boundary
4. No exceedances of the limits are observed at the boundary.

5.4.4. Cumulative Impacts

Emissions from sources need to be assessed in terms of the cumulative impacts in an area. The *Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa (DEA, 2014),* outlines the following for sources influenced by background concentrations e.g. in urban areas and priority areas:

- For annual averages, sum of the highest predicted concentration (C_P) and background concentration (C_B) must be less than the National ambient air quality standards, no exceedances allowed;
- For short-term averages (24 hours or less), sum of the 99th percentile concentrations and background C_B must be less than the National ambient air quality standards. Wherever one year is modelled, the highest concentrations shall be considered.

In determining the cumulative impacts, predicted incremental concentrations should be added to the measured concentrations for the applicable pollutant averaging periods.

Background data for dust fallout rates and PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO concentrations were not available for the mine (please refer to section 4.2). Therefore, the cumulative impact on these pollutants could not be assessed.

5.4.5. Impact Analysis

The level of impact of construction and operational activities associated with the mine is assessed in Table 5-17 to Table 5-19 below. The overall impact is identified to result in low to medium negative impacts.

Table 5-17: Description of Terms for the Impact Rating System.

Extent =E (The area over which the proposed impact will be experienced.)	***Reversibility=R (The degree to which the proposed impact can be revered upon completion of the proposed development / activity.)***
5: International	
4: National	**4:** Irreversible
3: Regional	**3:** Barely Reversible
2: Local	**2:** Partly Reversible
1: Site	**1:** Completely Reversible
Status of Impact	
+: Positive (A benefit to the receiving environment)	
N: Neutral (No cost or benefit to the receiving environment)	
-: Negative (A cost to the receiving environment)	
Magnitude:=M (The severity of the proposed development / activity.)	***Duration:=D (The time frame for which the proposed impact will be experience)***
5: Very high/don't know	5: Permanent
4: High	4: Long-term (ceases with the operational life)
3: Moderate	3: Medium-term (5-15 years)
2: Low	2: Short-term (0-5 years)
1: Minor	1: Immediate
0: Not applicable/none/negligible	0: Not applicable/none/negligible
Probability:=P (The likelihood / degree of certainty of the proposed impact occurring.)	***Cumulative Effect = C (The impact of the proposed development / activity on the environmental parameter being assessed when added to other existing or potential impacts.)***
5: Definite/don't know	
4: Highly probable	4: High Cumulative Impact
3: Medium probability	3: Medium Cumulative Impact
2: Low probability	2: Low Cumulative Impact
1: Improbable	1: No Cumulative Impact
	0: Not applicable

Loss of Resources = L (The degree to which a given resource will be lost as a result of the proposed development / activity.)
4: Complete Loss of Resources
3: Intermediate Loss of Resources
2: Low loss of resoures
1: No Loss of resources

Significance	***Environmental Significance Points***	***Colour Code***
High (positive)	>90	H
Medium (positive)	30 to 90	M
Low (positive)	<20	L
Neutral	0	N
Low (negative)	<-30	L
Medium (negative)	-30 to - 90	M
High (negative)	>-90	H

Table 5-18: Rating of Air Quality Impacts associated with construction activities at the proposed Kanakies Mine.

POTENTIAL ENVIRONMENTAL IMPACT	APPLICABLE AREA	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION										RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION									
			E	P	R	L	D	C	M	TOTAL	STATUS	SP		E	P	R	L	D	C	M	TOTAL	STATUS	SP
AREAS: 1. Mine Infrastructure Area; 2. Stockpile Yard																							
CONSTRUCTION PHASE ACTIVITIES: 1.Heavy construction activities																							
Air Quality: Construction Phase																							
Dust Fallout - daily	1 & 2	1	1	3	3	2	2	3	2	28	-	L	Dust control plan during construction phase	1	3	3	2	2	2	2	26	-	L
PM10 - daily	1 & 2	1	2	3	3	3	2	3	2	32	-	M	Dust control plan during construction phase	2	3	3	2	2	2	2	28	-	L
PM10 - annual	1 & 2	1	1	3	3	2	2	3	2	28	-	L	Dust control plan during construction phase	1	3	3	2	2	2	2	26	-	L
PM2.5 - daily	1 & 2	1	2	3	3	2	2	3	2	30	-	M	Dust control plan during construction phase	1	3	3	2	2	2	2	26	-	L
PM2.5 annual	1 & 2	1	1	3	3	1	2	3	2	26	-	L	Dust control plan during construction phase	1	3	3	2	2	2	2	26	-	L

Table 5-19: Rating of Air Quality Impacts associated with operational activities at the proposed Kanakies Mine.

POTENTIAL ENVIRONMENTAL IMPACT	APPLICABLE AREA	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION										RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION									
			E	P	R	L	D	C	M	TOTAL	STATUS	SP		E	P	R	L	D	C	M	TOTAL	STATUS	SP
AREAS: 1. Mine block (open pit); 2. Mobile plant (crusher & screening); 3. Stockpile yard; 4. Haul road																							
OPERATIONAL PHASE ACTIVITIES: 1.Mining activities 2. Crushing & Screening 3. Wind erosion exposed areas (open pit and stockpiles) 4. Material handling 5. Loading & offloading operations 6. Vehicle dust entrainment unpaved roads 7. Truck exhaust																							
Air Quality: Operational Phase																							
Dust Fallout - 24H	1-4	1-6	1	3	3	2	4	2	2	30	-	M	Dust control plan for operational phase.	1	3	3	2	4	2	2	30	-	M
PM10 - 24H	1-4	1-6	2	3	3	2	4	3	2	34	-	M	Dust control plan for operational phase.	2	3	3	2	4	2	2	32	-	M
PM10 - annual	1-4	1-6	1	3	3	2	4	2	2	30	-	M	Dust control plan for operational phase.	1	3	3	2	4	2	2	30	-	M
PM2.5 - 24H	1-4	1-6	2	3	3	2	4	2	2	32	-	M	Dust control plan for operational phase.	1	3	3	2	4	2	2	30	-	M
PM2.5 annual	1-4	1-6	1	3	3	1	4	1	2	26	-	L	Dust control plan for operational phase.	1	3	3	1	4	1	2	26	-	L
CO - 1H	4	7	1	3	3	2	4	2	1	15	-	L	Truck maintenance plan, speed limit control, driver training, road maintenance, use newer trucks with improved combustion efficiency & technologies, use cleaner fuels	1	3	3	2	4	2	1	15	-	L
CO - 8H	4	7	1	3	3	2	4	2	1	15	-	L		1	3	3	2	4	2	1	15	-	L
NOx - 1H	4	7	2	3	3	2	4	3	2	34	-	M		2	3	3	2	4	2	2	32	-	M
NOx - annual	4	7	2	3	3	2	4	2	2	32	-	M		2	3	3	2	4	2	2	32	-	M
SO2 - 1H	4	7	1	3	3	1	4	1	1	13	-	L		1	3	3	1	4	1	1	13	-	L
SO2 - 24H	4	7	1	3	3	1	4	1	1	13	-	L		1	3	3	1	4	1	1	13	-	L
SO2 - annual	4	7	1	3	3	1	4	1	1	13	-	L		1	3	3	1	4	1	1	13	-	L

5.5 Assumptions, Limitations and Exclusions

The following key assumptions, limitations and exclusions of the study are given below:

Assumptions

- Data/information provided by the client and used as input into the model were assumed to be accurate and complete at the time of modelling;
- Mine construction and operation hours were assumed to occur for 10 hours a day for 6 days a week (Mon – Sat from 07:00 – 17:00), unless otherwise specified by the client;
- Hauling operations (on site) were assumed to occur for 10 hours a day for 6 days a week;
- Material throughputs were based on the information provided by the client and include:
    - an annual throughput of approximately 234 000 tons/year for ROM;
    - an annual throughput of approximately 58 000 tons/year for product that is sold;
    - an annual throughput of approximately 176 000 tons/year for waste material;
    - an annual throughput of approximately 60 000 tons/year for product material transported by truck.
- Mitigation measures were not considered for the construction and operational phases of the project, except for:
    - water spraying on unpaved routes (achieve at least 50% control efficiency).
- The location and dimensions for all modelled sources were based on the information provided by client and Google Earth kml files;
- A specific hauling route was not known at the time of the modelling. Therefore, a theoretical haul route was assumed for modelling purposes to account for emissions associated with truck hauling activity;
- Distribution of product offsite was assumed to occur via the rail.

Limitations

- Detailed information for each emission source is required for input into the model, such as the dimensions, material throughputs, material characteristics and the exact locality of the sources. In some instances, not all these details are known. To account for the emissions, assumptions and estimates were made where necessary.
- The study is limited by the amount of detailed information that could be provided at the time of modelling.

Exclusions

- A cumulative assessment could not be conducted as there is no background air quality data available for the project site.
- Activities that are not associated with the project and occur outside the project area were not included in the assessment. These may include any potential background emission sources. Background sources are excluded as detailed information for these is required for input into the model and is not readily available. Furthermore, the assessment focused on the impact of emissions attributable to emission source activities associated with the project specifically.

6. MITIGATION MEASURES

The recommendations provided below are only briefly outlined within a general context. A detailed dust management plan, using a combination of the recommendations provided as a tool, would need to be developed and compiled specifically for the mine. The choice of mitigation measures for inclusion in the dust management plan will depend on several factors such as the availability of resources, practicality, effectiveness and affordability. Recommended control measures and their efficiency for reduced dust emissions are given in Table 6-1.

Dust generated from material handling operations and mining operations can be significantly reduced by wet suppression with the use of water sprays. However, the combined use of water sprays with chemical surfactants provide more extensive wetting making it a more effective technique than water suppression alone. The loading, transfer and discharge of materials should take place with a minimum height of fall and be shielded against the wind.

Controls to reduce emissions from unpaved roads can include vehicle restrictions which limit the speed, weight and number of vehicles on the road, surface improvements (paving or adding gravel to the road) and surface treatments (wet suppression or surface treatments) (USEPA, 1996). However, reducing the vehicle speeds is not always feasible as it decreases the overall mine productivity while paving is not economically attractive as many of the haul roads are not permanent. The use of materials with low silt content (such as gravel) also requires regular maintenance and replacement.

Wet suppression increases the moisture content which causes particles to agglomerate, thereby decreasing the likelihood of particles becoming suspended due to vehicle entrainment. However, the efficiency of watering depends on the amount of water added during each application, the application frequency, the weight, speed and number of vehicles travelling on the road and the prevailing meteorological conditions. Other methods such as chemical suppression reduce emissions by changing the physical characteristics of the existing road surface. However, chemical suppressants can be costly, but they have less frequent reapplication requirements. A control efficiency of approximately 80% can be achieved when applied at a regular interval of 2 weeks to 1 month (USEPA, 1996).

Wind erosion from stockpiles and open areas can be minimised using water sprays, wind breaks, vegetation and enclosures.

A general summary of recommendations made, and air quality monitoring requirements is provided in Table 6-2.

Table 6-1: Control measures to control dust emissions during Operational Phase (NPI, 2012).

SOURCE	RECOMMENDED CONTROL MEASURES	CONTROL EFFICIENCY (%)
Offloading trucks	Water sprays	70
Loading stockpiles	Variable height stacker	25
	Water sprays	50
	Telescopic chute with sprays	75
	Total enclosure	99
Unloading from stockpiles	Water Sprays	50
	Wind breaks	30
Loading to trains/rail wagons	Enclosure	70
	Enclosure and use of fabric filters	99
Miscellaneous transfer and conveying	Water sprays with chemicals	90
	Enclosure	70
	Enclosure and use of fabric filters	99
Hauling	Level 1 watering (2 litres/m^2/hr)	50
	Level 2 watering (>2 litres/m^2/hr)	75
	Sealed or salt encrusted roads	100
Wind erosion from stockpiles	Water sprays	50
	Wind breaks	30
	Total enclosure	99
	Rock armour and/or topsoil applied	30
Wind erosion	Primary rehabilitation	30
	Secondary rehabilitation	60
	Vegetation	40
	Re-vegetation	90
	Fully rehabilitated	100

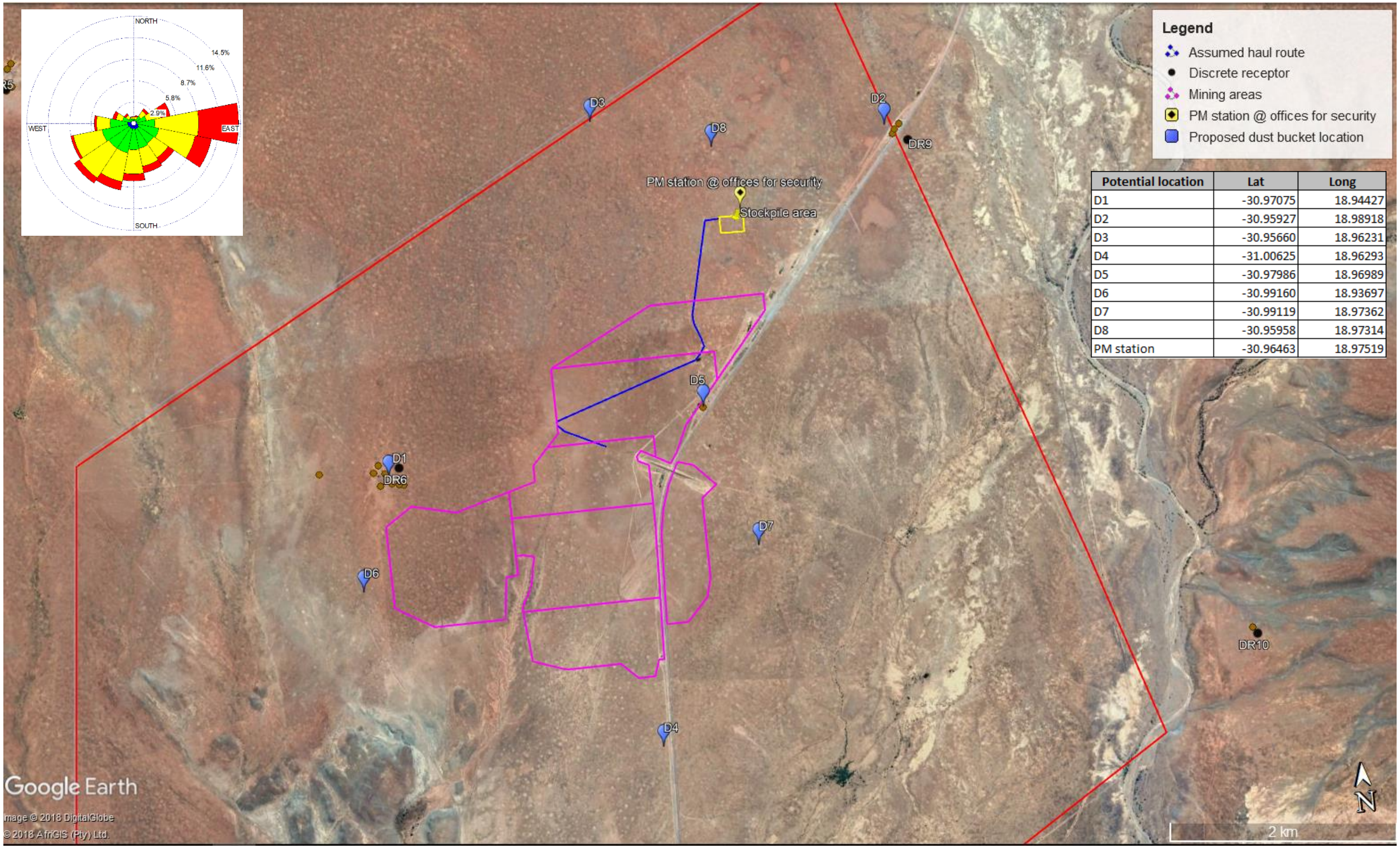
Table 6-2: Summary of Recommendations and Monitoring Requirements.

POLLUTANT	ACTIVITIES	MITIGATION MEASURE	MONITORING PROGRAM			
			MONITORING	TIMEFRAME (✓ = yes) (X = no)		
				Pre - operation	During - operation	Post – operation
Fugitive Dust – TSP, PM_{10} & $PM_{2.5}$	Material handling operations; exposed areas, stockpiles, mining activity (excavators, front-end loaders, etc.); loading and offloading operations, crushing and screening.	▪ A dust management plan will need to be developed for onsite activities. ▪ Dust control measures need to be assessed in detail and incorporated into the plan. ▪ The plan should include appropriate mitigation measures as described in Table 6-1 for all key dust emission sources. ***Note, the plan and choice of mitigation measures will depend on the availability of resources, practicality, effectiveness and affordability.*	Dust fallout monitoring as per the National Dust Control Regulations (2013) and reporting. Monthly PM_{10} & $PM_{2.5}$ ambient monitoring and reporting.	X	✓ – For dust fallout & PM_{10}/$PM_{2.5}$	X (not required if mining areas are rehabilitated)
Fugitive Dust – TSP, PM_{10} & $PM_{2.5}$ **& Gases**	Vehicle dust entrainment, truck exhaust emissions and any other mining vehicle/equipment exhaust emissions	▪ Have clearly defined hauling routes/vehicle access areas. These areas should preferably be paved (e.g. using surface coating such as bitumen), where possible or treated for dust suppression. ▪ All main hauling roads should be treated for dust suppression. ▪ Conduct regular cleaning/sweeping of paved road surfaces to prevent the accumulation of dust. ▪ Conduct regular maintenance and checks for haul road surfaces. ▪ Immediate clean-up of any spillage.	Dust fallout monitoring as per the National Dust Control Regulations (2013) and reporting. Monthly PM_{10} & $PM_{2.5}$ ambient monitoring and reporting.	X	✓ – For dust fallout & PM_{10}/$PM_{2.5}$ ✓ - For truck exhaust emissions (if required as per internal emission control strategy)	X

		▪ All material that is being transported should be covered during transport (where possible). ▪ Control the number of trucks on the road, weight of trucks and the travelling speed. Implement strict vehicle speed limits (e.g. 40 km/h). ▪ Consider use of cleaner fuel types and more fuel-efficient vehicles/mobile equipment/trucks. ▪ Make use of more modern, fuel efficient trucks/vehicles; which have improved exhaust emission control devices/systems in place; ▪ Switch off engines whilst not in use; ▪ Determine desired emission rates and measure/monitor truck exhaust emissions against these desired levels (if practical). ▪ Establish a maintenance schedule to ensure proper maintenance of the trucks & mobile equipment; ▪ Conduct regular maintenance and quality checks (engines/tyres) for all heavy mobile equipment/trucks. ▪ Ensure optimal fuel combustion efficiency; ▪ Develop an integrated emission control strategy that involves all departments of mine (i.e. management, production, maintenance and environment, health & safety).				

6.1 Recommendations for Monitoring Locations

Dust fallout monitoring and PM_{10} and $PM_{2.5}$ ambient monitoring is recommended for the proposed mine. The potential dust fallout monitoring sites are given in Figure 6-1. The PM ambient station can be installed by the office area, where there will be access to security. General areas for the dust buckets and the PM station have been provided. The recommended sites may change depending on accessibility, security, practicality, etc. The proposed potential sites were chosen during a desktop study considering accessibility (based on Google Earth), the locality of proposed emission sources and activities, existing sensitive receptors, prevailing wind directions and the output of the modelling assessment.



Potential location	Lat	Long
D1	-30.97075	18.94427
D2	-30.95927	18.98918
D3	-30.95660	18.96231
D4	-31.00625	18.96293
D5	-30.97986	18.96989
D6	-30.99160	18.93697
D7	-30.99119	18.97362
D8	-30.95958	18.97314
PM station	-30.96463	18.97519

Figure 6-1: Recommended dust fallout & PM monitoring points at the proposed Kanakies Mine.

6.2 Summary and Conclusions

Rayten Engineering Solutions CC was appointed by Cabanga Environmental to compile an Air Quality Impact Assessment report for the proposed Kanakies Gypsum Mine located approximately 45km west of the town of Loeriesfontein and 40km north-north-west of the town of Nieuwoudtville, within the Hantam Local Municipality, Northern Cape Province.

The main objective of the Air Quality Impact Assessment is to determine the potential impact of emissions from the construction and operational activities associated with the proposed project on ambient air quality in terms of the criteria air pollutants and dust fallout.

As part of the Air Quality Impact Assessment, a Baseline Air Quality Assessment was undertaken to determine the following:

- the prevailing meteorological conditions at the site;
- establish baseline concentrations of key air pollutants of concern;
- identify existing sources of emissions; and
- identify key sensitive receptors surrounding the project site.

MM5 meteorological data for the project area for the period 01 January 2015 – 31 December 2017 was used. The Air Quality Impact Assessment consisted of an emissions inventory and subsequent dispersion modelling simulations to determine TSP (as dust fallout), PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO concentrations associated with mining activities during the construction and operational phases of the project. Comparison of the modelled concentrations was made with the South African Ambient Air Quality Standards and the South African National Dust Control Regulations, 2013, to determine compliance.

The Kanakies gypsum mine is located on Portion 0, Kanakies Farm, 332 Calvinia Road, within the Hantam Local Municipality, Northern Cape, South Africa. The land use immediately surrounding the site consists predominantly of natural vegetation and bare non-vegetated land. Urban built-up, grasslands and cultivated land are additionally observed around the project site. The urban areas of Nieuwoudtville and Loeriesfontein are located approximately 40 km south-south-east and 45 km east, respectively, of the site. The area is classified as rural in nature.

Existing key sources of air pollution surrounding (<10km) the proposed project site mostly include wind erosion from exposed areas such as open degraded land. Vehicle dust entrainment on surrounding unpaved roads will also contribute to dust emissions in the area. No industrial, mining or domestic fuel burning activities were identified within 10km from the project site.

Based on the prevailing wind fields for the period January 2015 to December 2017, emissions from operations at Kanakies mine will likely be transported towards the westerly, west-north-westerly and north-easterly quadrants. Moderate to fast wind speeds observed during all the time periods may result in effective dispersion and dilution of emissions from Kanakies mine; however, higher wind speeds can also facilitate fugitive dust emissions from open exposed areas such as stockpiles.

The existing air quality situation is usually evaluated using available monitoring data from permanent ambient air quality monitoring stations and dust fallout networks operated near the project site. However, there was no data available (that could be determined) to present background concentrations for SO_2, NO_2, CO, PM_{10} and $PM_{2.5}$ concentrations at the study site. The nearest, Karoo ambient air quality monitoring station, is located more than 40 km away near the town of Nieuwoudtville.

The main conclusions of the Air Quality Impact Assessment for the project site can be summarised as follows for the operational phase.

Dust is a key pollutant of concern associated with proposed operations at Kanakies mine and will be emitted from the following key sources:

- Heavy construction activities;
- Materials handling operations (excavators, front-end loaders and truck loading/offloading operations);
- Material storage: Stockpiling;
- Crushing and screening;
- Wind erosion from exposed areas (i.e. open pit);
- Vehicle dust entrainment on unpaved roads.

For both the construction and operational phases of the project, predicted incremental concentrations for PM_{10} and $PM_{2.5}$ and dust fallout rates are low and comply with the applicable standards over most of the project area and beyond the mine boundary. Higher concentrations of dust and particulates are expected near to the emission source (i.e. area of construction and mining activity).

Predicted incremental concentrations of CO and SO_2 associated with truck exhaust emissions are low, falling well below the applicable standards. Predicted incremental concentrations of NO_x comply with the applicable standards beyond the mine boundary, with exceedances observed near the hauling road.

Predicted incremental concentrations at identified discrete receptors comply with the National ambient air quality standards and Dust Control Regulations, 2013.

Mitigation measures that were considered in this modelling study were limited and included dust suppression using water on the main unpaved routes used for truck hauling and vehicle activity. As dust is the key pollutant of concern associated with proposed operations, dust suppression should be conducted at the mine where possible, to reduce additional levels in background concentrations at the site. This can be achieved by developing a dust management plan specific to the mine. The plan should be updated annually to allow for additional mitigation measures to be incorporated in the long term, specifically for the mine block areas.

7. REFERENCES

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APPENDIX A

AIR DISPERSION MODELLING CHECKLIST

Table A 1: Information Required in Air Dispersion Modelling Report.

Information Required in Plan of Study Report				
Description	**Included (Y/N)**	**Section**	**Page no.**	**Comments**
1. Facility and Modellers Information				
Project Identification Information				
Applicant details	Y	1.1	1	
Facility Identification	Y	1.1	1	
Physical address of facility	Y	1.1	1	
AEL number	N	1.1	1	No AEL
EIA reference	N	1.1	1	In process applying
Modelling contractors	Y	1.1	1	
Project Background				
Objectives of Baseline Assessment	Y	1	1&2	
Process description	Y	1.2	1&2	
Project Location				
Site layout plan	Y	1.2	2	
Regional map	Y	2	5-8	
Adjacent area map	Y	2	5-8	
Surrounding land use map	Y	2	5-8	
Elevation data (DEM)	Y	2	5-8	
2. Emission Characterisation				
Proposed emissions & source parameters				
All identifiable emissions listed	Y	5.1 & 5.2	27-35	
Parameters for each operating scenario	Y	5.1 & 5.2	27-35	
Proposed emissions calculations	Y	5.1 & 5.2	27-35	
3. Meteorological Data				
Surface Data				
Source of data	Y	4.1	16	
Seasonal wind roses	Y	4.1	18-20	
3-year representative data	Y	4.1	18-20	
Program used to process data	Y	4.1	16	
Description of station	Y	4.1	16	
Period of record	Y	4.1	16	
Spatial representativeness	Y	4.1	16	

Data complies with Code of Practice	Y	4.1	15	
Upper Air Data				
Source of data	Y	4.1	16	
4. Ambient Impact Analysis and Ambient Levels				
Standard Levels				
National Ambient Air Quality Standards	Y	3.3	10	
Background Concentrations				
Background values specified	N	4.2.	22	No data avialable
5. Modelling Procedures				
Proposed Model				
Assessment level proposed	Y	5.3.2	36	
Dispersion model to be used	Y	5.3.1	35-37	
Supporting models to be used	Y	5.2	35-37	
Version of models to be used	Y	5.2	35-37	
Proposed Emissions to be Modelled				
Pollutants specified	Y	5.3.1	37	
Scenarios to be modelled	Y	5.3.1	37	
Conversion factor utilized	N			Not used
Proposed Settings				
Settings to be utilized	Y	5.3.1	37	
Terrain settings	Y	5.3.1	37	
Land characteristics	Y	5.3.1	37	
Grid Receptors				
Property line resolution	Y	5.3.1	37	
Fine grid resolution	Y	5.3.1	37	
Medium grid resolution	Y	5.3.1	37	
Large grid resolution	Y	5.3.1	37	
6. Ambient Impact Results Documentation				
Tables of Modelling Results				
Pollutant	Y	5.4.3	49-53	
Averaging time	Y	5.4.3	49-53	
Operating scenario	Y	5.4.3	49-53	
Maximum modelled concentration	Y	5.4.3	49-53	
Receptor location	Y	5.4.3	49-53	
Receptor elevation	Y	5.4.3	49-53	
Date of maximum impact	Y	Appendix B	68-73	
Name of output e-files	Y	Appendix C	74	
Source Impact Area Figures				
UTM co-ordinates	Y	5.4	38-49	
Modelled facility	Y	5.4	38-49	

Topography features	Y	2	7	
Isopleths	Y	5.4	38-49	
Value of maximum impact	Y	5.4	38-49	
Value of maximum cumulative impact	N	5.4.4	53	No data available
7. Ambient Impact Supporting Documentation				
Electronic Files				
Electronic files can be provided upon request				
Input & output files for models	Y	Appendix C	74	name of files specified
Input & output files for pre-processors	Y	Appendix C	74	name of files specified
Input & output files for post-processors	Y	Appendix C	74	name of files specified
Digital terrain files	N			
Plot files	Y	Appendix C	74	name of files specified
Final report	Y			

APPENDIX B

MAXIMUM PREDICTED INCREMENTAL CONCENTRATIONS

Table B1: Maximum Predicted Incremental Dust Fallout Rates at Sensitive Receptors – Operational & Construction Phases.

Select Plot File: C:\Users\Rayten\Documents\Kanakies_TSP_Con\Kanakies_TSP_Con.AD\Percentile\24_P099_00_GALL.plt

PLOT FILE OF 99.00TH PERCENTILE 24-HR VALUES FOR SOURCE GROUP: ALL

#	Discrete Receptor ID (Group Name)	X	Y	Dry Deposition (DRY DEPO) [g/m^2]	Elevation (ZELEV)	Hill Heights (ZHILL)	Flagpole (ZFLAG)	Averagi... (AVE)	Source Gro... (GRP)	Net ID	Date	Rank
1	1	-282307,44	6532594,35	0,0003383	236,94	236,94	0,00	24-HR	ALL		2015-05-07 24 hr	
2	2	-282093,38	6538267,00	0,00053966	281,19	281,19	0,00	24-HR	ALL		2017-04-17 24 hr	
3	3	-275858,81	6539792,19	0,00067861	288,00	288,00	0,00	24-HR	ALL		2017-11-10 24 hr	
4	4	-279524,63	6544715,62	0,00088488	355,65	355,65	0,00	24-HR	ALL		2015-08-05 24 hr	
5	5	-273959,01	6547873,04	0,0035026	385,30	385,30	0,00	24-HR	ALL		2017-07-21 24 hr	
6	6	-270801,59	6544367,77	0,0035045	354,65	354,65	0,00	24-HR	ALL		2016-12-05 24 hr	
7	7	-268714,48	6556542,56	0,00068707	474,82	545,00	0,00	24-HR	ALL		2016-08-03 24 hr	
8	8	-266547,10	6551966,98	0,0030988	396,50	396,50	0,00	24-HR	ALL		2016-02-26 24 hr	
9	9	-266065,46	6547177,34	0,023194	362,52	362,52	0,00	24-HR	ALL		2015-02-18 24 hr	
10	10	-263148,86	6542628,51	0,0016467	350,32	759,00	0,00	24-HR	ALL		2017-05-16 24 hr	
11	11	-256512,65	6541130,04	0,0012094	494,33	767,00	0,00	24-HR	ALL		2016-09-26 24 hr	
12	12	-254024,12	6539899,15	0,00083055	544,59	700,00	0,00	24-HR	ALL		2016-03-29 24 hr	
13	13	-260579,92	6537330,35	0,00048132	321,98	767,00	0,00	24-HR	ALL		2015-01-26 24 hr	
14	14	-258920,90	6536581,11	0,00064728	347,64	767,00	0,00	24-HR	ALL		2015-08-03 24 hr	
15	15	-267858,20	6536233,26	0,00044266	285,41	285,41	0,00	24-HR	ALL		2017-06-02 24 hr	
16	16	-263202,24	6534386,93	0,00041725	302,63	302,63	0,00	24-HR	ALL		2016-01-20 24 hr	
17	17	-261141,85	6532326,54	0,00026056	312,03	798,00	0,00	24-HR	ALL		2017-05-01 24 hr	
18	18	-270052,38	6533129,29	0,00044649	279,59	828,00	0,00	24-HR	ALL		2016-06-23 24 hr	
19	19	-268018,75	6532915,22	0,0003266	306,35	828,00	0,00	24-HR	ALL		2015-10-27 24 hr	
20	20	-271443,82	6529142,29	0,00024547	282,51	832,00	0,00	24-HR	ALL		2017-06-29 24 hr	
21	21	-270373,48	6527831,13	0,00024819	320,85	832,00	0,00	24-HR	ALL		2016-07-13 24 hr	

Select Plot File: C:\Users\Rayten\Documents\Kanakies_TSP_Op\Kanakies_TSP_Op.AD\Percentile\24_P099_00_GALL.plt

PLOT FILE OF 99.00TH PERCENTILE 24-HR VALUES FOR SOURCE GROUP: ALL

#	Discrete Receptor ID (Group Name)	X	Y	Dry Deposition (DRY DEPO) [g/m^2]	Elevation (ZELEV)	Hill Heights (ZHILL)	Flagpole (ZFLAG)	Averagi... (AVE)	Source Gro... (GRP)	Net ID	Date	Rank
1	1	-282307,44	6532594,35	0,00027137	236,94	236,94	0,00	24-HR	ALL		2015-06-22 24 hr	
2	2	-282093,38	6538267,00	0,0003931	281,19	281,19	0,00	24-HR	ALL		2015-07-27 24 hr	
3	3	-275858,81	6539792,19	0,00068453	288,00	288,00	0,00	24-HR	ALL		2015-06-11 24 hr	
4	4	-279524,63	6544715,62	0,00067208	355,65	355,65	0,00	24-HR	ALL		2015-10-05 24 hr	
5	5	-273959,01	6547873,04	0,0011952	385,30	385,30	0,00	24-HR	ALL		2017-12-19 24 hr	
6	6	-270801,59	6544367,77	0,011236	354,65	354,65	0,00	24-HR	ALL		2017-06-26 24 hr	
7	7	-268714,48	6556542,56	0,00046976	474,82	545,00	0,00	24-HR	ALL		2015-08-18 24 hr	
8	8	-266547,10	6551966,98	0,0013502	396,50	396,50	0,00	24-HR	ALL		2017-09-29 24 hr	
9	9	-266065,46	6547177,34	0,0038136	362,52	362,52	0,00	24-HR	ALL		2015-11-26 24 hr	
10	10	-263148,86	6542628,51	0,001465	350,32	759,00	0,00	24-HR	ALL		2016-07-20 24 hr	
11	11	-256512,65	6541130,04	0,00068764	494,33	767,00	0,00	24-HR	ALL		2017-07-14 24 hr	
12	12	-254024,12	6539899,15	0,00048533	544,59	700,00	0,00	24-HR	ALL		2015-03-18 24 hr	
13	13	-260579,92	6537330,35	0,0005011	321,98	767,00	0,00	24-HR	ALL		2017-05-16 24 hr	
14	14	-258920,90	6536581,11	0,00042644	347,64	767,00	0,00	24-HR	ALL		2015-06-23 24 hr	
15	15	-267858,20	6536233,26	0,00042678	285,41	285,41	0,00	24-HR	ALL		2017-05-01 24 hr	
16	16	-263202,24	6534386,93	0,00035046	302,63	302,63	0,00	24-HR	ALL		2017-08-28 24 hr	
17	17	-261141,85	6532326,54	0,00024627	312,03	798,00	0,00	24-HR	ALL		2015-05-08 24 hr	
18	18	-270052,38	6533129,29	0,00032073	279,59	828,00	0,00	24-HR	ALL		2016-03-05 24 hr	
19	19	-268018,75	6532915,22	0,00028011	306,35	828,00	0,00	24-HR	ALL		2015-11-04 24 hr	
20	20	-271443,82	6529142,29	0,00022774	282,51	832,00	0,00	24-HR	ALL		2016-08-10 24 hr	
21	21	-270373,48	6527831,13	0,00019358	320,85	832,00	0,00	24-HR	ALL		2015-04-09 24 hr	

Table B2: Maximum Predicted Incremental PM_{10} Daily Concentrations at Sensitive Receptors – Construction & Operational Phase.

Select Plot File: C:\Users\Rayten\Documents\Kanakies_PM10_Con\Kanakies_PM10_Con.AD\Percentile\24_P099_00_GALL.plt

PLOT FILE OF 99.00TH PERCENTILE 24-HR VALUES FOR SOURCE GROUP: ALL

#	Discrete Receptor ID (Group Name)	X	Y	Concentration (AVERAGE CONC) [ug/m^3]	Elevation (ZELEV)	Hill Heights (ZHILL)	Flagpole (ZFLAG)	Averagi... (AVE)	Source Gro... (GRP)	Net ID	Date	Rank
1	1	-282307,44	6532594,35	0,10644	236,94	236,94	0,00	24-HR	ALL		2015-12-22 24 hr	
2	2	-282093,38	6538267,00	0,18295	281,19	281,19	0,00	24-HR	ALL		2015-04-24 24 hr	
3	3	-275858,81	6539792,19	0,20591	288,00	288,00	0,00	24-HR	ALL		2017-03-29 24 hr	
4	4	-279524,63	6544715,62	0,47351	355,65	355,65	0,00	24-HR	ALL		2015-01-20 24 hr	
5	5	-273959,01	6547873,04	2,63584	385,30	385,30	0,00	24-HR	ALL		2015-07-20 24 hr	
6	6	-270801,59	6544367,77	0,85378	354,65	354,65	0,00	24-HR	ALL		2015-04-24 24 hr	
7	7	-268714,48	6556542,56	0,27511	474,82	545,00	0,00	24-HR	ALL		2017-05-25 24 hr	
8	8	-266547,10	6551966,98	0,91032	396,50	396,50	0,00	24-HR	ALL		2015-02-12 24 hr	
9	9	-266065,46	6547177,34	5,62529	362,52	362,52	0,00	24-HR	ALL		2015-12-02 24 hr	
10	10	-263148,86	6542628,51	0,49	350,32	759,00	0,00	24-HR	ALL		2017-03-30 24 hr	
11	11	-256512,65	6541130,04	0,23749	494,33	767,00	0,00	24-HR	ALL		2016-03-30 24 hr	
12	12	-254024,12	6539899,15	0,20395	544,59	700,00	0,00	24-HR	ALL		2016-03-30 24 hr	
13	13	-260579,92	6537330,35	0,15286	321,98	767,00	0,00	24-HR	ALL		2015-06-23 24 hr	
14	14	-258920,90	6536581,11	0,12194	347,64	767,00	0,00	24-HR	ALL		2016-09-06 24 hr	
15	15	-267858,20	6536233,26	0,078462	285,41	285,41	0,00	24-HR	ALL		2016-05-02 24 hr	
16	16	-263202,24	6534386,93	0,12113	302,63	302,63	0,00	24-HR	ALL		2015-07-17 24 hr	
17	17	-261141,85	6532326,54	0,20721	312,03	798,00	0,00	24-HR	ALL		2015-03-09 24 hr	
18	18	-270052,38	6533129,29	0,11898	279,59	828,00	0,00	24-HR	ALL		2015-03-05 24 hr	
19	19	-268018,75	6532915,22	0,06187	306,35	828,00	0,00	24-HR	ALL		2016-05-02 24 hr	
20	20	-271443,82	6529142,29	0,09175	282,51	832,00	0,00	24-HR	ALL		2016-12-02 24 hr	
21	21	-270373,48	6527831,13	0,08931	320,85	832,00	0,00	24-HR	ALL		2017-12-28 24 hr	

Select Plot File: C:\Users\Rayten\Documents\Kanakies_PM10_Op\Kanakies_PM10_Op.AD\Percentile\24_P099_00_GALL.plt

PLOT FILE OF 99.00TH PERCENTILE 24-HR VALUES FOR SOURCE GROUP: ALL

#	Discrete Receptor ID (Group Name)	X	Y	Concentration (AVERAGE CONC) [ug/m^3]	Elevation (ZELEV)	Hill Heights (ZHILL)	Flagpole (ZFLAG)	Averagi... (AVE)	Source Gro... (GRP)	Net ID	Date	Rank
1	1	-282307,44	6532594,35	0,098806	236,94	236,94	0,00	24-HR	ALL		2017-09-06 24 hr	
2	2	-282093,38	6538267,00	0,4093	281,19	281,19	0,00	24-HR	ALL		2016-04-15 24 hr	
3	3	-275858,81	6539792,19	0,27326	288,00	288,00	0,00	24-HR	ALL		2017-03-04 24 hr	
4	4	-279524,63	6544715,62	0,91773	355,65	355,65	0,00	24-HR	ALL		2016-05-12 24 hr	
5	5	-273959,01	6547873,04	1,07327	385,30	385,30	0,00	24-HR	ALL		2017-07-14 24 hr	
6	6	-270801,59	6544367,77	13,87742	354,65	354,65	0,00	24-HR	ALL		2016-06-27 24 hr	
7	7	-268714,48	6556542,56	0,14822	474,82	545,00	0,00	24-HR	ALL		2017-09-20 24 hr	
8	8	-266547,10	6551966,98	0,47445	396,50	396,50	0,00	24-HR	ALL		2015-09-07 24 hr	
9	9	-266065,46	6547177,34	4,28844	362,52	362,52	0,00	24-HR	ALL		2015-09-07 24 hr	
10	10	-263148,86	6542628,51	0,58176	350,32	759,00	0,00	24-HR	ALL		2017-03-23 24 hr	
11	11	-256512,65	6541130,04	0,10958	494,33	767,00	0,00	24-HR	ALL		2015-10-24 24 hr	
12	12	-254024,12	6539899,15	0,076562	544,59	700,00	0,00	24-HR	ALL		2017-08-09 24 hr	
13	13	-260579,92	6537330,35	0,18404	321,98	767,00	0,00	24-HR	ALL		2017-03-30 24 hr	
14	14	-258920,90	6536581,11	0,18704	347,64	767,00	0,00	24-HR	ALL		2015-01-15 24 hr	
15	15	-267858,20	6536233,26	0,08634	285,41	285,41	0,00	24-HR	ALL		2016-04-14 24 hr	
16	16	-263202,24	6534386,93	0,16813	302,63	302,63	0,00	24-HR	ALL		2017-08-01 24 hr	
17	17	-261141,85	6532326,54	0,09735	312,03	798,00	0,00	24-HR	ALL		2015-07-04 24 hr	
18	18	-270052,38	6533129,29	0,10409	279,59	828,00	0,00	24-HR	ALL		2016-06-20 24 hr	
19	19	-268018,75	6532915,22	0,056245	306,35	828,00	0,00	24-HR	ALL		2016-12-17 24 hr	
20	20	-271443,82	6529142,29	0,080971	282,51	832,00	0,00	24-HR	ALL		2016-12-17 24 hr	
21	21	-270373,48	6527831,13	0,060783	320,85	832,00	0,00	24-HR	ALL		2016-06-18 24 hr	

Table B3: Date of Maximum Predicted Incremental $PM_{2.5}$ Daily Concentrations at Sensitive Receptors – Construction & Operational Phase.

Select Plot File: C:\Users\Rayten\Documents\Kanakies_PM25_Con\Kanakies_PM25_Con.AD\Percentile\24_P099_00_GALL.plt

PLOT FILE OF 99.00TH PERCENTILE 24-HR VALUES FOR SOURCE GROUP: ALL

#	Discrete Receptor ID (Group Name)	X	Y	Concentration (AVERAGE CONC) [ug/m^3]	Elevation (ZELEV)	Hill Heights (ZHILL)	Flagpole (ZFLAG)	Averagi... (AVE)	Source Gro... (GRP)	Net ID	Date	Rank
1	1	-282307,44	6532594,35	0,010616	236,94	236,94	0,00	24-HR	ALL		2015-12-22 24 hr	
2	2	-282093,38	6538267,00	0,018247	281,19	281,19	0,00	24-HR	ALL		2015-04-24 24 hr	
3	3	-275858,81	6539792,19	0,020537	288,00	288,00	0,00	24-HR	ALL		2017-03-29 24 hr	
4	4	-279524,63	6544715,62	0,047227	355,65	355,65	0,00	24-HR	ALL		2015-01-20 24 hr	
5	5	-273959,01	6547873,04	0,26289	385,30	385,30	0,00	24-HR	ALL		2015-07-20 24 hr	
6	6	-270801,59	6544367,77	0,085153	354,65	354,65	0,00	24-HR	ALL		2015-04-24 24 hr	
7	7	-268714,48	6556542,56	0,027439	474,82	545,00	0,00	24-HR	ALL		2017-05-25 24 hr	
8	8	-266547,10	6551966,98	0,090792	396,50	396,50	0,00	24-HR	ALL		2015-02-12 24 hr	
9	9	-266065,46	6547177,34	0,56105	362,52	362,52	0,00	24-HR	ALL		2015-12-02 24 hr	
10	10	-263148,86	6542628,51	0,048869	350,32	759,00	0,00	24-HR	ALL		2017-03-30 24 hr	
11	11	-256512,65	6541130,04	0,023687	494,33	767,00	0,00	24-HR	ALL		2016-03-30 24 hr	
12	12	-254024,12	6539899,15	0,020342	544,59	700,00	0,00	24-HR	ALL		2016-03-30 24 hr	
13	13	-260579,92	6537330,35	0,015245	321,98	767,00	0,00	24-HR	ALL		2015-06-23 24 hr	
14	14	-258920,90	6536581,11	0,012162	347,64	767,00	0,00	24-HR	ALL		2016-09-06 24 hr	
15	15	-267858,20	6536233,26	0,0078255	285,41	285,41	0,00	24-HR	ALL		2016-05-02 24 hr	
16	16	-263202,24	6534386,93	0,012082	302,63	302,63	0,00	24-HR	ALL		2015-07-17 24 hr	
17	17	-261141,85	6532326,54	0,020666	312,03	798,00	0,00	24-HR	ALL		2015-03-09 24 hr	
18	18	-270052,38	6533129,29	0,011867	279,59	828,00	0,00	24-HR	ALL		2015-03-05 24 hr	
19	19	-268018,75	6532915,22	0,0061707	306,35	828,00	0,00	24-HR	ALL		2016-05-02 24 hr	
20	20	-271443,82	6529142,29	0,0091509	282,51	832,00	0,00	24-HR	ALL		2016-12-02 24 hr	
21	21	-270373,48	6527831,13	0,0089075	320,85	832,00	0,00	24-HR	ALL		2017-12-28 24 hr	

Select Plot File: C:\Users\Rayten\Documents\Kanakies_PM25\Kanakies_PM25.AD\Percentile\24_P099_00_GALL.plt

PLOT FILE OF 99.00TH PERCENTILE 24-HR VALUES FOR SOURCE GROUP: ALL

#	Discrete Receptor ID (Group Name)	X	Y	Concentration (AVERAGE CONC) [ug/m^3]	Elevation (ZELEV)	Hill Heights (ZHILL)	Flagpole (ZFLAG)	Averagi... (AVE)	Source Gro... (GRP)	Net ID	Date	Rank
1	1	-282307,44	6532594,35	0,011999	236,94	236,94	0,00	24-HR	ALL		2017-09-06 24 hr	
2	2	-282093,38	6538267,00	0,047839	281,19	281,19	0,00	24-HR	ALL		2016-04-20 24 hr	
3	3	-275858,81	6539792,19	0,035213	288,00	288,00	0,00	24-HR	ALL		2016-06-27 24 hr	
4	4	-279524,63	6544715,62	0,095992	355,65	355,65	0,00	24-HR	ALL		2016-02-17 24 hr	
5	5	-273959,01	6547873,04	0,14399	385,30	385,30	0,00	24-HR	ALL		2015-07-16 24 hr	
6	6	-270801,59	6544367,77	1,99012	354,65	354,65	0,00	24-HR	ALL		2016-06-27 24 hr	
7	7	-268714,48	6556542,56	0,019379	474,82	545,00	0,00	24-HR	ALL		2017-09-20 24 hr	
8	8	-266547,10	6551966,98	0,050555	396,50	396,50	0,00	24-HR	ALL		2016-10-20 24 hr	
9	9	-266065,46	6547177,34	0,41605	362,52	362,52	0,00	24-HR	ALL		2015-05-15 24 hr	
10	10	-263148,86	6542628,51	0,059379	350,32	759,00	0,00	24-HR	ALL		2016-06-15 24 hr	
11	11	-256512,65	6541130,04	0,012846	494,33	767,00	0,00	24-HR	ALL		2015-10-24 24 hr	
12	12	-254024,12	6539899,15	0,0092083	544,59	700,00	0,00	24-HR	ALL		2015-03-18 24 hr	
13	13	-260579,92	6537330,35	0,025164	321,98	767,00	0,00	24-HR	ALL		2017-03-30 24 hr	
14	14	-258920,90	6536581,11	0,019969	347,64	767,00	0,00	24-HR	ALL		2015-01-15 24 hr	
15	15	-267858,20	6536233,26	0,0099104	285,41	285,41	0,00	24-HR	ALL		2015-05-30 24 hr	
16	16	-263202,24	6534386,93	0,016492	302,63	302,63	0,00	24-HR	ALL		2017-05-16 24 hr	
17	17	-261141,85	6532326,54	0,011268	312,03	798,00	0,00	24-HR	ALL		2016-06-10 24 hr	
18	18	-270052,38	6533129,29	0,01005	279,59	828,00	0,00	24-HR	ALL		2016-04-20 24 hr	
19	19	-268018,75	6532915,22	0,0067653	306,35	828,00	0,00	24-HR	ALL		2016-09-24 24 hr	
20	20	-271443,82	6529142,29	0,0086752	282,51	832,00	0,00	24-HR	ALL		2017-10-11 24 hr	
21	21	-270373,48	6527831,13	0,0073395	320,85	832,00	0,00	24-HR	ALL		2016-06-18 24 hr	

Table B4: Date of Maximum Predicted Incremental CO Hourly & 8-Hourly Concentrations at Sensitive Receptors – Operational Phase.

Select Plot File: C:\Users\Rayten\Documents\Kanakies_CO_Truck\KANAKIES_CO_TRUCK.AD\01H4GALL.PLT

PLOT FILE OF HIGH 4TH HIGH 1-HR VALUES FOR SOURCE GROUP: ALL

#	Discrete Receptor ID (Group Name)	X	Y	Concentration (AVERAGE CONC) [ug/m^3]	Elevation (ZELEV)	Hill Heights (ZHILL)	Flagpole (ZFLAG)	Averagi... (AVE)	Source Gro... (GRP)	Rank	Net ID	Date (DATE(CON))
1	1	-282307,44	6532594,35	3,4487	236,94	236,94	0,00	1-HR	ALL	4TH		2015-03-26 08 hr
2	2	-282093,38	6538267,00	5,71708	281,19	281,19	0,00	1-HR	ALL	4TH		2016-04-15 07 hr
3	3	-275858,81	6539792,19	9,05467	288,00	288,00	0,00	1-HR	ALL	4TH		2017-10-11 07 hr
4	4	-279524,63	6544715,62	17,09336	355,65	355,65	0,00	1-HR	ALL	4TH		2016-05-18 08 hr
5	5	-273959,01	6547873,04	12,7478	385,30	385,30	0,00	1-HR	ALL	4TH		2017-06-27 09 hr
6	6	-270801,59	6544367,77	81,94178	354,65	354,65	0,00	1-HR	ALL	4TH		2016-03-29 08 hr
7	7	-268714,48	6556542,56	3,03915	474,82	545,00	0,00	1-HR	ALL	4TH		2017-12-30 08 hr
8	8	-266547,10	6551966,98	11,477	396,50	396,50	0,00	1-HR	ALL	4TH		2016-03-17 08 hr
9	9	-266065,46	6547177,34	82,22699	362,52	362,52	0,00	1-HR	ALL	4TH		2016-09-08 08 hr
10	10	-263148,86	6542628,51	10,50644	350,32	759,00	0,00	1-HR	ALL	4TH		2016-06-15 07 hr
11	11	-256512,65	6541130,04	1,06218	494,33	767,00	0,00	1-HR	ALL	4TH		2015-06-16 09 hr
12	12	-254024,12	6539899,15	0,68076	544,59	700,00	0,00	1-HR	ALL	4TH		2017-03-23 09 hr
13	13	-260579,92	6537330,35	4,49291	321,98	767,00	0,00	1-HR	ALL	4TH		2017-09-05 07 hr
14	14	-258920,90	6536581,11	3,82499	347,64	767,00	0,00	1-HR	ALL	4TH		2017-09-05 07 hr
15	15	-267858,20	6536233,26	1,85163	285,41	285,41	0,00	1-HR	ALL	4TH		2016-03-12 08 hr
16	16	-263202,24	6534386,93	4,50246	302,63	302,63	0,00	1-HR	ALL	4TH		2016-03-26 07 hr
17	17	-261141,85	6532326,54	3,12126	312,03	798,00	0,00	1-HR	ALL	4TH		2017-06-10 08 hr
18	18	-270052,38	6533129,29	1,74837	279,59	828,00	0,00	1-HR	ALL	4TH		2015-05-29 10 hr
19	19	-268018,75	6532915,22	1,13048	306,35	828,00	0,00	1-HR	ALL	4TH		2016-03-12 08 hr
20	20	-271443,82	6529142,29	1,05196	282,51	832,00	0,00	1-HR	ALL	4TH		2015-09-09 09 hr
21	21	-270373,48	6527831,13	1,45458	320,85	832,00	0,00	1-HR	ALL	4TH		2015-05-29 10 hr

Select Plot File: C:\Users\Rayten\Documents\Kanakies_CO_Truck\KANAKIES_CO_TRUCK.AD\08H4GALL.PLT

PLOT FILE OF HIGH 4TH HIGH 8-HR VALUES FOR SOURCE GROUP: ALL

#	Discrete Receptor ID (Group Name)	X	Y	Concentration (AVERAGE CONC) [ug/m^3]	Elevation (ZELEV)	Hill Heights (ZHILL)	Flagpole (ZFLAG)	Averagi... (AVE)	Source Gro... (GRP)	Rank	Net ID	Date (DATE(CON))
1	1	-282307,44	6532594,35	0,50112	236,94	236,94	0,00	8-HR	ALL	4TH		2015-03-26 08 hr
2	2	-282093,38	6538267,00	1,13574	281,19	281,19	0,00	8-HR	ALL	4TH		2016-05-12 08 hr
3	3	-275858,81	6539792,19	1,13257	288,00	288,00	0,00	8-HR	ALL	4TH		2017-10-11 08 hr
4	4	-279524,63	6544715,62	1,78963	355,65	355,65	0,00	8-HR	ALL	4TH		2016-05-18 16 hr
5	5	-273959,01	6547873,04	1,99186	385,30	385,30	0,00	8-HR	ALL	4TH		2016-07-20 16 hr
6	6	-270801,59	6544367,77	15,48836	354,65	354,65	0,00	8-HR	ALL	4TH		2017-07-08 08 hr
7	7	-268714,48	6556542,56	0,37993	474,82	545,00	0,00	8-HR	ALL	4TH		2017-12-30 08 hr
8	8	-266547,10	6551966,98	1,50527	396,50	396,50	0,00	8-HR	ALL	4TH		2016-08-12 08 hr
9	9	-266065,46	6547177,34	10,68445	362,52	362,52	0,00	8-HR	ALL	4TH		2016-09-08 08 hr
10	10	-263148,86	6542628,51	1,77827	350,32	759,00	0,00	8-HR	ALL	4TH		2016-01-23 08 hr
11	11	-256512,65	6541130,04	0,18046	494,33	767,00	0,00	8-HR	ALL	4TH		2017-07-15 16 hr
12	12	-254024,12	6539899,15	0,17345	544,59	700,00	0,00	8-HR	ALL	4TH		2016-03-29 16 hr
13	13	-260579,92	6537330,35	0,53579	321,98	767,00	0,00	8-HR	ALL	4TH		2017-06-10 08 hr
14	14	-258920,90	6536581,11	0,50037	347,64	767,00	0,00	8-HR	ALL	4TH		2017-06-27 16 hr
15	15	-267858,20	6536233,26	0,39614	285,41	285,41	0,00	8-HR	ALL	4TH		2016-03-16 08 hr
16	16	-263202,24	6534386,93	0,57236	302,63	302,63	0,00	8-HR	ALL	4TH		2015-08-24 08 hr
17	17	-261141,85	6532326,54	0,41353	312,03	798,00	0,00	8-HR	ALL	4TH		2016-04-21 08 hr
18	18	-270052,38	6533129,29	0,31636	279,59	828,00	0,00	8-HR	ALL	4TH		2017-09-07 08 hr
19	19	-268018,75	6532915,22	0,26069	306,35	828,00	0,00	8-HR	ALL	4TH		2016-06-14 08 hr
20	20	-271443,82	6529142,29	0,20868	282,51	832,00	0,00	8-HR	ALL	4TH		2017-09-07 08 hr
21	21	-270373,48	6527831,13	0,19099	320,85	832,00	0,00	8-HR	ALL	4TH		2017-09-07 08 hr

Table B5: Date of Maximum Predicted Incremental NOx Hourly Concentrations at Sensitive Receptors – Operational Phase.

Select Plot File: C:\Users\Rayten\Documents\Kanakies_NOX_Truck\Kanakies_NOX_Truck.AD\Percentile\01_P099_00_GALL.plt

PLOT FILE OF 99.00TH PERCENTILE 1-HR VALUES FOR SOURCE GROUP: ALL

#	Discrete Receptor ID (Group Name)	X	Y	Concentration (AVERAGE CONC) [ug/m^3]	Elevation (ZELEV)	Hill Heights (ZHILL)	Flagpole (ZFLAG)	Averagi... (AVE)	Source Gro... (GRP)	Net ID	Date	Rank
1	1	-282307,44	6532594,35	0,19442	236,94	236,94	0,00	1-HR	ALL		2015-02-27 11 hr	
2	2	-282093,38	6538267,00	0,3209	281,19	281,19	0,00	1-HR	ALL		2017-06-05 11 hr	
3	3	-275858,81	6539792,19	0,4512	288,00	288,00	0,00	1-HR	ALL		2017-06-16 12 hr	
4	4	-279524,63	6544715,62	1,11309	355,65	355,65	0,00	1-HR	ALL		2016-05-17 07 hr	
5	5	-273959,01	6547873,04	1,87261	385,30	385,30	0,00	1-HR	ALL		2015-11-30 07 hr	
6	6	-270801,59	6544367,77	6,86042	354,65	354,65	0,00	1-HR	ALL		2017-04-28 08 hr	
7	7	-268714,48	6556542,56	0,19961	474,82	545,00	0,00	1-HR	ALL		2015-12-28 10 hr	
8	8	-266547,10	6551966,98	0,46701	396,50	396,50	0,00	1-HR	ALL		2016-03-11 10 hr	
9	9	-266065,46	6547177,34	2,56063	362,52	362,52	0,00	1-HR	ALL		2017-01-11 08 hr	
10	10	-263148,86	6542628,51	0,85302	350,32	759,00	0,00	1-HR	ALL		2017-01-23 10 hr	
11	11	-256512,65	6541130,04	0,22306	494,33	767,00	0,00	1-HR	ALL		2015-10-26 09 hr	
12	12	-254024,12	6539899,15	0,17665	544,59	700,00	0,00	1-HR	ALL		2016-12-20 09 hr	
13	13	-260579,92	6537330,35	0,31658	321,98	767,00	0,00	1-HR	ALL		2016-02-19 09 hr	
14	14	-258920,90	6536581,11	0,30155	347,64	767,00	0,00	1-HR	ALL		2016-04-20 11 hr	
15	15	-267858,20	6536233,26	0,35143	285,41	285,41	0,00	1-HR	ALL		2016-03-02 07 hr	
16	16	-263202,24	6534386,93	0,28366	302,63	302,63	0,00	1-HR	ALL		2015-10-29 09 hr	
17	17	-261141,85	6532326,54	0,22879	312,03	798,00	0,00	1-HR	ALL		2016-11-30 09 hr	
18	18	-270052,38	6533129,29	0,25469	279,59	828,00	0,00	1-HR	ALL		2017-07-12 11 hr	
19	19	-268018,75	6532915,22	0,25917	306,35	828,00	0,00	1-HR	ALL		2016-05-11 12 hr	
20	20	-271443,82	6529142,29	0,18649	282,51	832,00	0,00	1-HR	ALL		2016-02-27 09 hr	
21	21	-270373,48	6527831,13	0,18602	320,85	832,00	0,00	1-HR	ALL		2016-09-14 07 hr	

Table B6: Date of Maximum Predicted Incremental SO_2 Hourly & Daily Concentrations at Sensitive Receptors – Operational Phase.

Select Plot File: C:\Users\Rayten\Documents\Kanakies_SO2_Truck\Kanakies_SO2_Truck.AD\Percentile\01_P099_00_GALL.plt

PLOT FILE OF 99.00TH PERCENTILE 1-HR VALUES FOR SOURCE GROUP: ALL

#	Discrete Receptor ID (Group Name)	X	Y	Concentration (AVERAGE CONC) [ug/m^3]	Elevation (ZELEV)	Hill Heights (ZHILL)	Flagpole (ZFLAG)	Averagi... (AVE)	Source Gro... (GRP)	Net ID	Date	Rank
1	1	-282307,44	6532594,35	0,00013808	236,94	236,94	0,00	1-HR	ALL		2015-02-27 11 hr	
2	2	-282093,38	6538267,00	0,00022791	281,19	281,19	0,00	1-HR	ALL		2017-06-05 11 hr	
3	3	-275858,81	6539792,19	0,00032046	288,00	288,00	0,00	1-HR	ALL		2017-06-16 12 hr	
4	4	-279524,63	6544715,62	0,00079055	355,65	355,65	0,00	1-HR	ALL		2016-05-17 07 hr	
5	5	-273959,01	6547873,04	0,00133	385,30	385,30	0,00	1-HR	ALL		2015-11-30 07 hr	
6	6	-270801,59	6544367,77	0,0048725	354,65	354,65	0,00	1-HR	ALL		2017-04-28 08 hr	
7	7	-268714,48	6556542,56	0,00014177	474,82	545,00	0,00	1-HR	ALL		2015-12-28 10 hr	
8	8	-266547,10	6551966,98	0,00033168	396,50	396,50	0,00	1-HR	ALL		2016-03-11 10 hr	
9	9	-266065,46	6547177,34	0,0018186	362,52	362,52	0,00	1-HR	ALL		2017-01-11 08 hr	
10	10	-263148,86	6542628,51	0,00060584	350,32	759,00	0,00	1-HR	ALL		2017-01-23 10 hr	
11	11	-256512,65	6541130,04	0,00015842	494,33	767,00	0,00	1-HR	ALL		2015-10-26 09 hr	
12	12	-254024,12	6539899,15	0,00012546	544,59	700,00	0,00	1-HR	ALL		2016-12-20 09 hr	
13	13	-260579,92	6537330,35	0,00022484	321,98	767,00	0,00	1-HR	ALL		2016-02-19 09 hr	
14	14	-258920,90	6536581,11	0,00021417	347,64	767,00	0,00	1-HR	ALL		2016-04-20 11 hr	
15	15	-267858,20	6536233,26	0,00024959	285,41	285,41	0,00	1-HR	ALL		2016-03-02 07 hr	
16	16	-263202,24	6534386,93	0,00020146	302,63	302,63	0,00	1-HR	ALL		2015-10-29 09 hr	
17	17	-261141,85	6532326,54	0,00016249	312,03	798,00	0,00	1-HR	ALL		2016-11-30 09 hr	
18	18	-270052,38	6533129,29	0,00018089	279,59	828,00	0,00	1-HR	ALL		2017-07-12 11 hr	
19	19	-268018,75	6532915,22	0,00018407	306,35	828,00	0,00	1-HR	ALL		2016-05-11 12 hr	
20	20	-271443,82	6529142,29	0,00013245	282,51	832,00	0,00	1-HR	ALL		2016-02-27 09 hr	
21	21	-270373,48	6527831,13	0,00013211	320,85	832,00	0,00	1-HR	ALL		2017-08-02 07 hr	

Select Plot File: C:\Users\Rayten\Documents\Kanakies_SO2_Truck\Kanakies_SO2_Truck.AD\Percentile\24_P099_00_GALL.plt

PLOT FILE OF 99.00TH PERCENTILE 24-HR VALUES FOR SOURCE GROUP: ALL

#	Discrete Receptor ID (Group Name)	X	Y	Concentration (AVERAGE CONC) [ug/m^3]	Elevation (ZELEV)	Hill Heights (ZHILL)	Flagpole (ZFLAG)	Averagi... (AVE)	Source Gro... (GRP)	Net ID	Date	Rank
1	1	-282307,44	6532594,35	0,00010548	236,94	236,94	0,00	24-HR	ALL		2016-06-10 24 hr	
2	2	-282093,38	6538267,00	0,00015665	281,19	281,19	0,00	24-HR	ALL		2016-06-27 24 hr	
3	3	-275858,81	6539792,19	0,00025334	288,00	288,00	0,00	24-HR	ALL		2016-05-12 24 hr	
4	4	-279524,63	6544715,62	0,00055366	355,65	355,65	0,00	24-HR	ALL		2015-07-28 24 hr	
5	5	-273959,01	6547873,04	0,00089249	385,30	385,30	0,00	24-HR	ALL		2017-08-09 24 hr	
6	6	-270801,59	6544367,77	0,0052334	354,65	354,65	0,00	24-HR	ALL		2017-02-28 24 hr	
7	7	-268714,48	6556542,56	0,00012539	474,82	545,00	0,00	24-HR	ALL		2016-10-24 24 hr	
8	8	-266547,10	6551966,98	0,00055063	396,50	396,50	0,00	24-HR	ALL		2015-08-31 24 hr	
9	9	-266065,46	6547177,34	0,0035222	362,52	362,52	0,00	24-HR	ALL		2015-02-23 24 hr	
10	10	-263148,86	6542628,51	0,00061959	350,32	759,00	0,00	24-HR	ALL		2016-07-05 24 hr	
11	11	-256512,65	6541130,04	7,194E-5	494,33	767,00	0,00	24-HR	ALL		2017-06-19 24 hr	
12	12	-254024,12	6539899,15	5,3393E-5	544,59	700,00	0,00	24-HR	ALL		2015-10-24 24 hr	
13	13	-260579,92	6537330,35	0,00017682	321,98	767,00	0,00	24-HR	ALL		2016-06-20 24 hr	
14	14	-258920,90	6536581,11	0,00019301	347,64	767,00	0,00	24-HR	ALL		2015-01-15 24 hr	
15	15	-267858,20	6536233,26	0,00020951	285,41	285,41	0,00	24-HR	ALL		2016-03-29 24 hr	
16	16	-263202,24	6534386,93	0,00020413	302,63	302,63	0,00	24-HR	ALL		2017-07-14 24 hr	
17	17	-261141,85	6532326,54	0,00014574	312,03	798,00	0,00	24-HR	ALL		2016-06-10 24 hr	
18	18	-270052,38	6533129,29	0,00014638	279,59	828,00	0,00	24-HR	ALL		2016-03-16 24 hr	
19	19	-268018,75	6532915,22	0,0001363	306,35	828,00	0,00	24-HR	ALL		2015-04-25 24 hr	
20	20	-271443,82	6529142,29	9,5283E-5	282,51	832,00	0,00	24-HR	ALL		2016-03-16 24 hr	
21	21	-270373,48	6527831,13	9,3956E-5	320,85	832,00	0,00	24-HR	ALL		2016-06-20 24 hr	

APPENDIX C

OUTPUT E-FILES

Table C1: List of output e-files used.

Summary of electronic modelling files				
Output File Number	Output File Name	Description	Date Created	Model
Construction Phase				
1	Kanakies_TSP_Con	Dispersion modelling E-file for dust fallout (TSP) associated with construction activities	May - June 2018	AERMOD
2	Kanakies_PM10_Con	Dispersion modelling E-file for PM_{10} associated with construction activities	May - June 2018	AERMOD
3	Kanakies_PM2.5_Con	Dispersion modelling E-file for $PM_{2.5}$ associated with construction activities	May - June 2018	AERMOD
Other				
4	Kanakies_TSP_Op	Dispersion modelling E-file for dust fallout (TSP) associated with operational activities	May - June 2018	AERMOD
5	Kanakies_PM10_Op	Dispersion modelling E-file for PM_{10} associated with operational activities	May - June 2018	AERMOD
6	Kanakies_PM2.5	Dispersion modelling E-file for $PM_{2.5}$ associated with operational activities	May - June 2018	AERMOD
7	Kanakies_CO_Truck	Dispersion modelling E-file for CO associated with operational activities	May - June 2018	AERMOD
8	Kanakies_SO_2_Truck	Dispersion modelling E-file for CO associated with operational activities	May - June 2018	AERMOD
9	Kanakies_NOx_Truck	Dispersion modelling E-file for CO associated with operational activities	May - June 2018	AERMOD
Other				
10	AERMET_Kanakies	AERMET meteorological data file used for input into AERMOD	May – June 2018	AERMOD

Note: a copy of the modelling files can be provided upon request.