Air Quality Impact Assessment for Dorstfontein Coal Mine East Pit 1 Extension

Report Prepared for

Exxaro Coal Central (Pty) Ltd

Report Number 499507/AQIA

Report Prepared by

srk consulting

August 2017

Air Quality Impact Assessment for Dorstfontein East Coal Mine Pit 1 Extension

Exxaro Coal Central (Pty) Ltd

SRK Consulting (South Africa) (Pty) Ltd.
Section A Second Floor
Norfolk House
54 Norfolk Terrace
Westville 3630
South Africa

e-mail: Durban@srk.co.za
website: www.srk.co.za

Tel: +27 (0) 31 279 1200
Fax:+27 (0) 31 279 1204

SRK Project Number 499507

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Compiled by:

D. Naidoo (Pr. Sci. Nat.)
Senior Scientist

Email: dnaidoo@srk.co.za

Peer Reviewed by:

V.S. Reddy (Pr. Sci. Nat.)
Partner

Authors:

D. Naidoo and A. Murray-Rogers

Executive Summary

Introduction

SRK Consulting (South Africa) (Pty) Ltd was appointed by Exxaro Coal Central (Pty) Ltd to undertake the necessary Environmental Impact Assessment in support of an application for an Environmental Authorisation for the expansion of its Dorstfontein East Mine in Mpumalanga.

This report provides a baseline description of the air quality and meteorological conditions for the study area and assesses potential impacts associated with the proposed expansion may have on the air quality in the area of the mine. The outcomes of the impact assessment were used to identify management measures required to manage potential negative impacts.

Background and Project Description

Exxaro plans to undertake the necessary EA process for the extension of Pit 1, the pipeline from Dorstfontein West to Dorstfontein East. This supplementary footprint does not fall within the existing Environmental Management Plan (EMP), thus, authorization will be sought for the proposed infrastructure in terms of the National Environmental Management Act (Act No 107 of 1998) (NEMA) and National Water Act (Act No. 38 of 1996) (NWA).

Dorstfontein East is an opencast mine located approximately 18 km from Ga-Nala, formerly known as Kriel. The mine is located within the Emalahleni Municipality and began operations in 2011. Currently, only opencast mining is practised and underground mining is an option that is currently being investigated. Two opencast pits are currently mined on the eastern and western sides of the resource area with mining taking place both in the 2 and 4 coal seams. The current activities have been approved by both the Department of Mineral Resources (DMR) and the Department of Water and Sanitation (DWS).

Dorstfontein Coal Mines (Pty) Ltd is now planning to extend its operations on the western side of the mine referred to as Pit 1 Extension. The area is part of the current approved mining right area but it has not been included in the current Environmental Management Programme Report and Life of Mine.

Impact Assessment Summary

The impact is considered to be of low significance before and after management (Table ES 1). The impact is insignificant as the expected emissions of dust and expected contribution to ambient air quality during the construction phase for the proposed project with management will be below the NAAQS and NDCR. The impacts will be closer to construction activities and will decrease further away. Towns and surrounding farms in range of the construction activities will not be impacted as the expected contribution to levels of dust are expected to be low.

Table ES 1: Construction phase impact rating

Impact	Consequence			Likelihood		Significance Rating	Mitigation Rating
	Severity	Spatial	Duration	Frequency of Activity	Frequency of Impact		
Impact before management	1	1	2	3	2	20	Low
Impact after management	1	1	2	3	2	20	Low

For the construction phase the impact is considered to be of medium-high significance before management and of low significance after management (Table ES 2).

The impact before management is significant because the expected emissions of dust and expected contribution to ambient air quality during the operational phase are above the 24 hour NAAQS for PM_{10} and $PM_{2.5}$, however below the NDCR for dust pollutants. The impact after management measures are implemented is insignificant as the expected emissions of dust and expected contribution to ambient air quality during the operational phase for are low and below the 24 hour NAAQS and the NDCR for dust pollutants beyond the fenceline of the mine. The impacts are closer to operational activities and decrease further away. Towns and surrounding farms in range of the operational activities will not be impacted as the expected contribution to levels of dust is not harmful.

Table ES 2: Operational phase impact assessment

Impact	Consequence			Likelihood		Significance Rating	Mitigation Rating
	Severity	Spatial	Duration	Frequency of Activity	Frequency of Impact		
Impact before management	3	3	2	4	4	64	Medium-high
Impact after management	1	1	1	4	1	20	Low

Conclusions

Based on the findings of this assessment the following were concluded:

- Based on the meteorological data from the on-site weather station, the climate in the project area is expected to be seasonal, with distinct warm months (September to February) and cool months (March to August). Rainfall is higher during the months from October to April and lower from May to September. The prevailing winds for this period are from the north, west-southwest and southeast, with lower occurrences from the east, east-southeast and south-southeast. The average wind speed measured for all hours is 4.47 m/s with maximum speeds less than 11.1 m/s and with calms (<0.5 m/s) of 1.72%.
- The monthly dust fallout concentrations shows that dust fallout concentration have exceeded the Residential Area limit of 600 mg/m^2/day 361 times out of 1118 (32.3%) recorded dust fallout measurements. The Non-residential Area limit was exceeded 27 times out of 119 (22.7%) dust fallout measurements.
- The towns in the surrounding area i.e. Kriel, Tubelihle and Boskrans, have been identified as potential areas of impact, at the commencement of the study. The dispersion model was set up to predict PM_{10}, $PM_{2.5}$ and dust fallout concentrations from the proposed development at these towns and surrounding areas. Based on the nature of the activities and the dispersion modelling results, the receptors are unlikely to be impacted should management measures be implemented.
- With respect to dust (dust fallout, PM_{10} and $PM_{2.5}$) concentrations, the predicted emissions resulting from the proposed operations were determined to be medium-high without management and low with management measures in place. Dust fallout concentrations will not exceed the NDCR limits at the closest sensitive receptors.
- Based on the findings of this assessment the proposed project will result in dust generation, however, the concentrations will be low and below the NAAQS (PM_{10} and $PM_{2.5}$) and the NDCR (dust fallout) at the closest receptors, should management measures be implemented. Receptors in close proximity will not be impacted by the proposed project as impacts are predicted to be low beyond the boundary of the mine. In addition the peak concentrations are predicted to occur closer to the new activities.

Recommendations

Based on the findings of this assessment the following are recommended:

- Maintain the current monitoring network and where necessary make minor adjustments to accommodate the installation of new infrastructure from the proposed project.
  - In instances where activities change the monitoring network may be adjusted accordingly.
  - When the proposed project is operational an annual monitoring program should be maintained to determine whether the proposed project is having an impact on the surrounding environment with respect to dust fallout.
- A continuous PM_{10} and $PM_{2.5}$ monitor should be installed at the mine or if possible at sensitive receptors in close proximity to the mine.
- Conduct periodic independent audits of monitoring systems and the implementation of management plans to ensure that the system is maintained and that suitable data is obtained for decision making.
- When fugitive dust can be observed leaving the area additional dust suppression should be applied to the affected areas. The following mitigation measures are proposed and may be considered, if practicable, for the new activities:
  - Regular irrigation by water, especially during windy conditions at the site, of the access road and construction material and debris with just enough moisture to keep the dust down without creating runoff. Should water not be available as a result of drought conditions then chemical suppressants need to be considered.
  - Reduction of speed on unpaved roads to reduce the entrainment of dust into the atmosphere.
  - During grading activities, any exposed earth should be watered if it is going to be exposed for long periods, especially during windy conditions.
  - On windy days, or when fugitive dust is dispersed from the Site of Works, additional application of water to the affected areas should be implemented.
  - When and where applicable, soil stockpiles that will not be used should be re-vegetated as soon as possible, or kept wet during windy periods.
  - During the operational phases for the proposed project any bare ground surrounding the main operational area but within the boundaries of the facility must be covered with suitable vegetation that will be able to grow in the area.
  - When fugitive dust can be observed dispersing from the site, additional dust suppression should be applied to the affected areas.
  - If possible, additional dust monitoring equipment needs to be installed in order to effectively monitor dust related impacts from the project area and thereafter dust emissions can be managed better.
  - In places of high vehicular traffic on unpaved roads, dust suppression measures on the roads may be implemented to reduce dust levels from the entrainment of dust. These measures will range from watering of roads, application of a chemical dust suppressant where watering is impractical, and/or paving of roads.
  - Reduce the possibility of spillage from vehicles by ensuring all loads are covered, for example, with tarpaulin.

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Disclaimer

The opinions expressed in this Report have been based on the information supplied to SRK Consulting (South Africa) (Pty) Ltd (SRK) by Exxaro Coal Central (Pty) Ltd (Exxaro). The opinions in this Report are provided in response to a specific request from Exxaro to do so. SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them. Opinions presented in this report apply to the site conditions and features as they existed at the time of SRK's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report, about which SRK had no prior knowledge nor had the opportunity to evaluate.

List of Abbreviations

AIR - Atmospheric Impact Report

AQIA - Air quality Impact Assessment

CO - Carbon Monoxide

CO_2 - Carbon Dioxide

DEA - Department of Environmental Affairs

EA - Environmental Authorisation

EAP - Environmental Assessment Practitioner

EIA - Environmental Impact Assessment

EMPR- Environmental Management Programme

GN - Government Notice

I&AP's - Interested and Affected Parties

MPRDA - Minerals and Petroleum Resources Development Act

Mamsl - meters above mean sea level

NAAQS - National Ambient Air Quality Standards

NEM AQA - National Environmental Management Air Quality Act

NEMA - National Environmental Management Act

NEM: AQA - National Environmental Management Air Quality Act

NO_2 - Nitrogen Dioxide

PM - Particulate Matter

ROM - Run of mine

SO_2 - Sulfur Dioxide

US-EPA - United States Environmental Protection Agency

VOC's - Volatile Organic Compounds

1 Introduction

1.1 Introduction

SRK Consulting (South Africa) (Pty) Ltd (SRK SA) was appointed by Exxaro Coal Central (Pty) Ltd (Exxaro) to undertake the necessary Environmental Impact Assessment (EIA) in support of an application for an Environmental Authorisation (EA) for the expansion of its Dorstfontein East Mine in Mpumalanga.

This report provides a baseline description of the air quality and meteorological conditions for the study area and assesses potential impacts associated with the proposed expansion may have on the air quality in the area of the mine. The outcomes of the impact assessment were used to identify management measures required to manage potential negative impacts.

1.2 Background of the Project

Exxaro plans to undertake the necessary EIA process for the extension of Pit 1, the pipeline from Dorstfontein West to Dorstfontein East. This supplementary footprint does not fall within the existing Environmental Management Plan (EMP), thus, authorisation will be sought for the proposed infrastructure in terms of the National Environmental Management Act (Act No 107 of 1998) (NEMA) and National Water Act (Act No. 38 of 1996) (NWA).

1.3 Project Description

Dorstfontein East is an opencast mine located approximately 18 km from Ga-Nala, formerly known as Kriel. The mine is located within the Emalahleni Municipality and began operations in 2011. Currently, only opencast mining is practised and underground mining is an option that is currently being investigated. Two opencast pits are currently mined on the eastern and western sides of the resource area with mining taking place both in the 2 and 4 coal seams. The current activities have been approved by both the Department of Mineral Resources (DMR) and the Department of Water and Sanitation (DWS).

Dorstfontein Coal Mines (Pty) Ltd is now planning to extend its operations on the western side of the mine referred to as Pit 1 Extension. The area is part of the current approved mining right area but it has not been included in the current Environmental Management Programme Report and Life of Mine (LOM).

1.4 Scope of report

In terms of Section 53(f) of NEM: AQA, the Department of Environmental Affairs (DEA), developed and published "*Regulations Regarding Air Dispersion Modelling, 2014*". The regulations were published in Government Gazette No. 37804 on 11 July 2014 under Government Notice (GN) No. 533.

The "*Code of Practice*", contained in Appendix A of the regulations (of GN533 of Government Gazette No. 37804), is prescribed as the technical Code of Practice for air dispersion modelling, and provides technical standards on the application of air dispersion models.

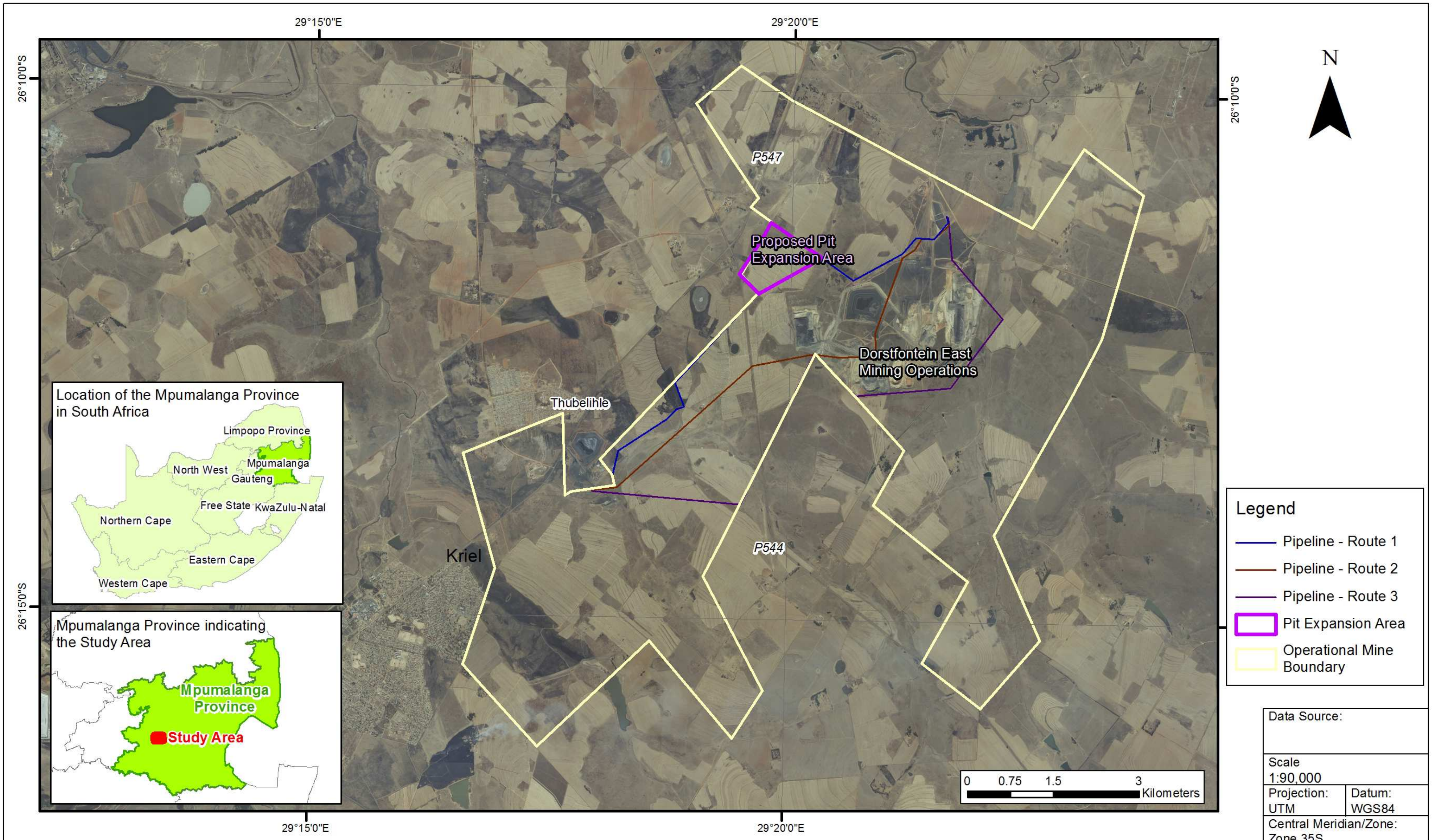
The Code of Practice is applicable to:

a) The development of an air quality management plan, as contemplated in Chapter 3 of the Act.
b) The development of a priority area air quality management plan, as contemplated in Section 19 of the Act.
c) The development of an Atmospheric Impact Report (AIR report), as contemplated in Section 30 of the Act.

d) The development of a specialist AQIA study, as contemplated in Section 37(2)(b) of the Act.

In accordance with the application of the requirements of the Code of Practice to an AIR report or a specialist AQIA study (as per points *c)* and *d)* above), this assessment is submitted in accordance with the prescribed format Air Dispersion Modelling Study.

The Scope of Report for this assessment will therefore follow the regulations prescribing the format of an Air Dispersion Modelling Study Report, and will provide all the information available and relevant in order to comply with the requirements of the regulations regarding air dispersion modelling (Code of Practice).



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Projection: UTM	Datum: WGS84
Central Meridian/Zone: Zone 35S	
Date: 18/04/2017	Compiled by: DAVA
Project No. 499507	Fig No. 1-1

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DORSTFONTEIN EAST: AIR QUALITY IMPACT ASSESSMENT

LAYOUT OF DORSTFONTEIN EAST

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Revision: A Date: 13 07 2017

2 Project Identification Requirements

2.1 Enterprise Details

The details for the East Dorstfontein Mine are presented in Table 2-1 and the details of the relevant persons that can be contacted at the mine are in Table 2-2.

Table 2-1: Enterprise details

Criteria	Details
Enterprise Name	Dorstfontein Coal Mines (Pty) Ltd
Trading As	Dorstfontein Coal Mines
Type of Enterprise, e.g. Company/Close Corporation/Trust	Private Company
Company/Close Corporation/Trust Registration Number (Registration Numbers if Joint Venture)	1952/003176/07
Registered Address	Private Bag X 5007 Ganala 2271
Postal Address	Private Bag X 5007 Ganala 2271
Telephone Number (General)	011 441 6890
Fax Number (General)	N/A
Industry Type/Nature of Trade	Mining
Land Use Zoning as per Town Planning Scheme	No
Land Use Rights if outside Town Planning Scheme	Mining

Table 2-2: Details of responsible person

Criteria	Details
Responsible Person	Daniel Jacobus Chrisstofel Stapelberg
Emission Control Officer	William Seabi
Telephone Number	011 441 6857
Cell Phone Number	079 496 3304
Fax Number	N/A
E-mail Address	William.Seabi@exxaro.com
After Hours Contact Details	079 496 3304

2.2 Project Location

The location and extent of Dorstfontein East Coal Mine is presented in Table 2-3. The closest towns to the project are presented in Table 2-4. The activities taking place within 10 km of the mine are presented in Figure 2-1 and activities on a regional scale in Figure 2-2.

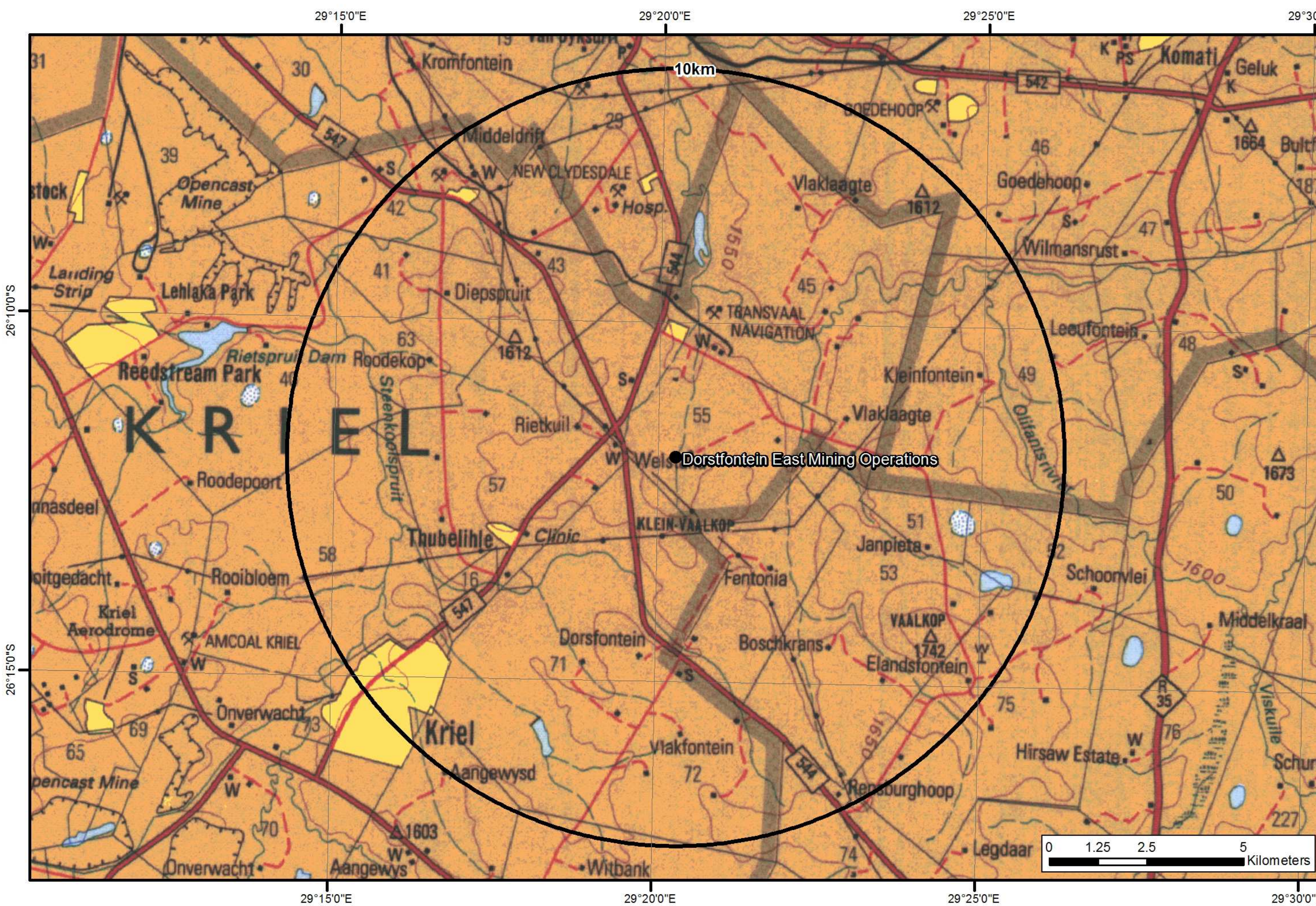
Table 2-3: Location and extent of Dorstfontein East

Criteria	Details
Physical Address of the Mine	N/A
Description of Site (Where No Street Address)	Plant and associated structure, opencast operations (Pit 1, 2, 3), discard facility, roads and conveyors, water pipelines, clean and dirty water infrastructure, power supply, sewage treatment works and a railway line and associated power supply
Coordinates of Approximate Centre of Operations	26˚ 11' 37" S 29˚ 21' 13" E
Extent (km²)	17.2 km²
Elevation Above Mean Sea Level (m)	1581 m
Province	Mpumalanga
Metropolitan/District Municipality	Nkangala District Municipality
Local Municipality	Emalahleni Local Municipality
Designated Priority Area (if applicable)	Highveld Priority Area

The current land uses in the region include coal mining, farming and power generation. The major town in close proximity to the mine include Witbank with smaller towns such as Middelburg, Bethal and Kriel and Ogies. In addition, there are various farms and homesteads surrounding the mining area. Besides the farmers, there are numerous farm workers residing on the farms.

Table 2-4: Nearest towns and villages to the project area

Town/Village	Distance (km)	Direction
Kriel	10.4	Southwest
Hendrina	37.1	East
Ogies	34.1	Northwest
Springbok	16.8	North
Bethal	30.6	Southwest
Emalahleni	37.5	North
Reedstream Park	17.2	West-northwest
Thubelihle	6.0	West-southwest
Evander	38.2	South-southwest
Secunda	38.1	Southwest



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Legend

- Dorstfontein East Mining Operations
- Radius (10km)

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Central Meridian/Zone: Zone 35S	
Date: 18/04/2017	Compiled by: DAVA
Project No. 499507	Fig No. 2-1

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DORSTFONTEIN EAST: AIR QUALITY IMPACT ASSESSMENT

AREA MAP - ADJACENT AREA (10 km RADIUS FROM SOURCE)

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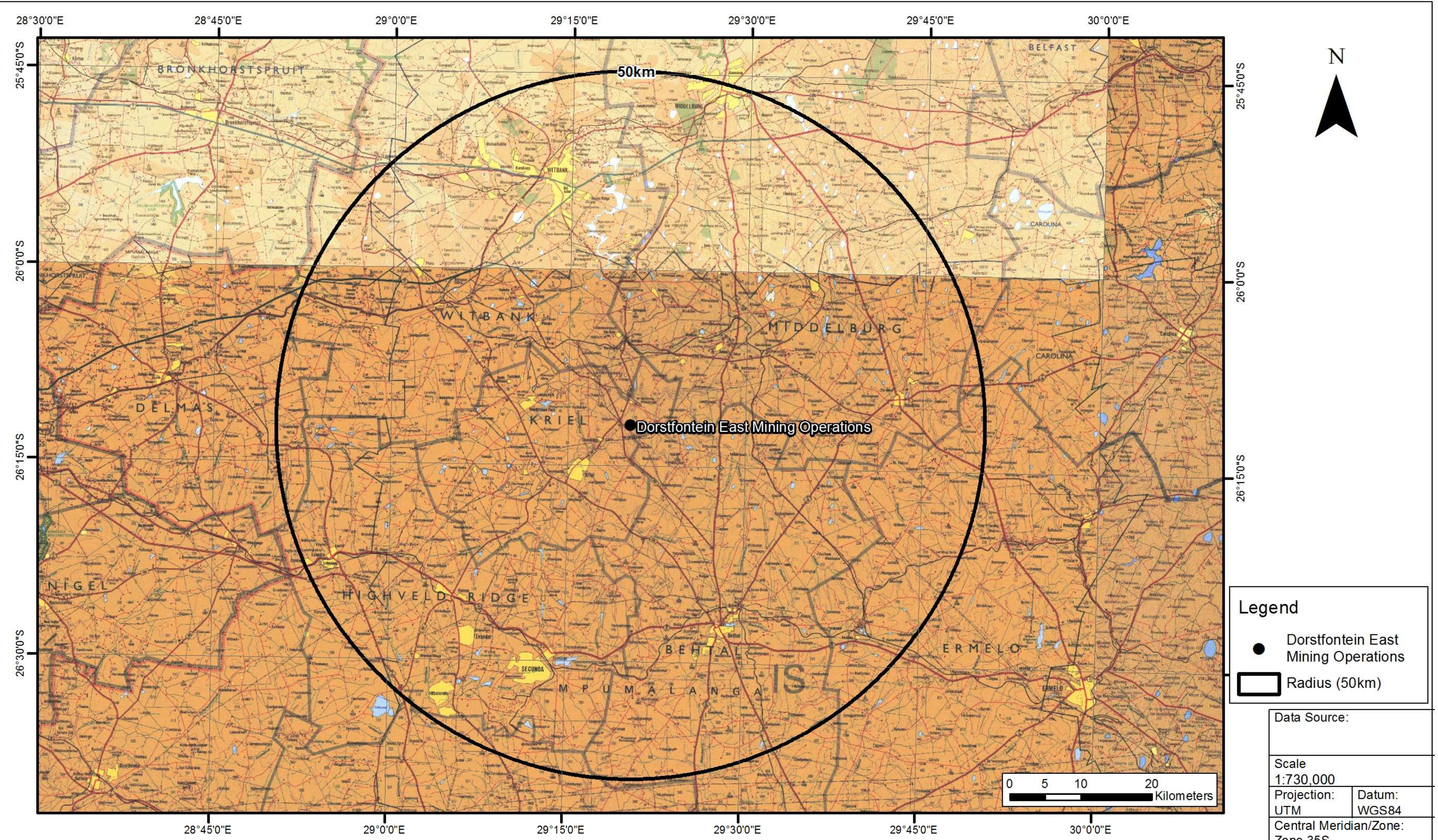
Revision: A Date: 13 07 2017



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Projection: UTM	Datum: WGS84
Central Meridian/Zone: Zone 35S	
Date: 18/04/2017	Compiled by: DAVA
Project No. 499507	Fig No. 2-2

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DORSTFONTEIN EAST: AIR QUALITY IMPACT ASSESSMENT

REGIONAL MAP OF THE AREA (50 km RADIUS FROM SOURCE)

Path: G:\499507_Doorstfontein_AQIA_assisting_PTA\8GIS\GISPROJ\MXD\13072017\499507_F2_2_Dorst_East_AQIA_Regional_50km_A4L_C_13072017.mxd

Revision: A Date: 13 07 2017

3 Emissions Characterisation

3.1 Emission Characteristics

Identifying the sources that contribute to airborne particulate emissions in the project area is important for establishing sources of air pollution and cumulative impacts associated within the East Dorstfontein Mining Area, and the impact that the activities at the facility could have on air quality.

3.1.1 Existing Emission Sources

The project area and surrounding land can be described as rural/industrial with large scale industrial activities in the area. The area is characterised by one large town (Witbank), smaller towns such as Ogies, Bethal, Kriel, and smaller settlements and farms in the area. The following sources of air emissions have been identified in the area:

- Mining activities.
- Power generation.
- Vehicle emissions.
- Fugitive dust sources (windblown dust especially during the dry season).
- Farming activities such as land preparation and harvesting.
- Biomass burning

Mining Activities

Numerous coal mines and activities at these mines such as drilling and blasting, crushing, hauling, and materials handling all contribute to pollutants in the atmosphere. The main pollutant of concern is particulate matter as this dust is inhalable and can cause respiratory illnesses. The main mines that are within 50km of East Dorstfontein are:

- New Clydesdale Coal.
- Douglas Colliery.
- Goedehoop Colliery.
- Ilanga Colliery.
- Dorstfontein Coal Mine.
- Arthur Taylor Colliery.
- Polmaise Colliery.
- Anglo Coal SA (Pty) Ltd – Kriel.
- Waterpan Colliery
- South Witbank Colliery.
- Koorfontein Mines.
- Siyanda.
- Coal Kleinkopje Colliery.
  Exxaro Coal (Pty) Ltd – Matla Colliery.

Power Generation

Coal is the main product mined in the area and coal power stations have been built in close proximity to these mines. These power stations supply electricity to the national power grid. The main pollutants emitted from these power stations are sulfur dioxide (SO_2), carbon monoxide (CO), carbon dioxide (CO_2), nitrogen dioxide (NO_2) and particulate matter (PM). The closest power stations to East Dorstfontein are:

- Matla (23 km southwest).

- Kriel (18 km southwest).
- Duvha (27km north).
- Komati (17 km northeast).
- Kendal (40 km northwest).and
- Hendrina (31 km northeast).

Vehicle Emissions

Vehicle tailpipe emissions are always present and depending on whether the vehicle is maintained efficiently, the tailpipe emissions can contribute heavily or minimally to air pollution. Vehicle emissions can be classified into two groups, namely, primary and secondary pollutants. Pollutants such as carbon monoxide (CO), carbon dioxide (CO_2), sulfur dioxide (SO_2), oxides of nitrogen (NO_x), particulates and lead are generally released into the atmosphere depending on the type of fuel that is used. These pollutants are termed primary pollutants. Secondary pollutants exist only because of the chemical reactions that take place in the atmosphere. Pollutants formed during this process include nitrogen dioxide (NO_2), photochemical oxidants (e.g. ozone), sulfates and nitrates. Vehicle tailpipe emissions are expected to be medium-high due to the relatively vehicle usage in the area.

Fugitive Dust Sources

All pollutants that arise from fugitive dust sources are termed primary pollutants as they are unlikely to undergo any physical or chemical reactions. Fugitive dust sources can be the vehicle entrainment of dust from gravel or unpaved roads and wind erosion of open areas. Particulate emissions from roadways depend on the road and the number of vehicles using the road. Windblown dust resulting from the erosion of bare ground depends on the velocity of the wind, the size of the exposed area and moisture and silt content of such areas. Areas that receive high amounts of rainfall will experience lower levels of fugitive dust being released into the air as higher moisture content makes the soil heavier and more compact, resulting in the soil being more resistant to wind erosion. At Dorstfontein East, fugitive dust emissions are expected to be low as the rainy season is from October to March and the wind speeds are generally low during the winter months. However, based on dust fallout monitoring results, there are instances where higher dust fallout concentrations are observed in the wet months when compared to the drier months. Fugitive dust from the roads network in the area is expected to be low-medium as a result of the frequency and number of vehicles that use the roads in the area.

Farming Activities such as Land Preparation and Harvesting

Farming is one of the main activities that occurs in the project area and include -land preparation and harvesting. Tractors are used to prepare large areas of land for cultivation. Dust emissions related to this activity is expected to be high as soils are loosened and suspended thereby allowing wind to easily transport the finer particles. The remaining vegetation is burned prior to the preparation of land and gases such as SO_2, NO_x, CO and CO_2 are released from this activity. Dust is also generated during the harvesting activity and this adds to the ambient dust load. The fields are left bare at the end of the harvesting and before the preparation of land and this could increase windblown dust in the area, especially during the warmer months when wind speeds tend to increase. However lost dust emissions are expected during the wet season

Biomass Burning

The burning of crop residue and veld fires are sources of emissions that can be associated with areas that are densely vegetated. Biomass burning, such as the grasslands in Witbank, is significant as these areas are cleared for agricultural purposes by slash and burn methods. Biomass burning is an incomplete combustion process with carbon monoxide, methane and nitrogen dioxide emitted during the process. Biomass burning in the local area and regionally could negatively impact on air quality, albeit on a seasonal basis.

3.1.2 Emission Sources from Proposed Development

This assessment is based on plans for the construction and operational phases of the proposed development, notably the proposed extension of the opencast mining area. This assessment represents a conservative (worst case, full production) approach to the evaluation of the impact of potential emissions arising from the activities.

Construction activities include the following:

- Clearing of land i.e. topsoil and vegetation.
- Grading and bulldozing.
- Haulage of topsoil and vegetation.
- Vehicle entrainment of dust on access roads.
- Stockpiling of topsoil.
- Materials handling of topsoil.
- Vehicle tailpipe emissions.

Operations activities for the project include the following:

- Mining at the open pit. Mining at the open pit may be undertaken by the following methods (that are still to be investigated):
  - In Pit Crushing with underground feeder breakers and Conveying;
  - Dragline Overburden Removal; and
  - Truck and Shovel Operations (preferred alternative).
- The various mining processes in the general operational cycle will include:
  - Top soil removal;
  - Drill and blast of the hard overburden;
  - Dozing;
  - Loading (truck and shovel or dragline);
  - Coal removal (blast and haul);
  - Transporting (hauling or conveying);
  - Placing (dumping and/or spreading); and
  - Rehabilitation.
- Road transport of coal from the pit to the plant.
- Materials handling.
- Coal storage at the ROM stockpile.
- On-site vehicle movements associated with mining activities.
- Vehicle tailpipe emissions.

Based on observations during the site visit in February 2016, dust is considered to be the predominant pollutant type that will be generated from the various activities listed above. Materials handling, wind erosion (e.g. discard dumps, coal stockpiles, roads) and vehicle entrainment of dust from unpaved roadways are expected to be the main sources of dust in the area during the operational phase of the mine.

Table 3-1: Summary of Pollutant Sources at and in the vicinity of East Dorstfontein Mine

Activity	Timing	Pollutant Type	Comment
Clearing of land and excavation	Construction	Dust	The clearing of land will be a source of dust as winds may blow dust off bare ground.
Haulage of material	Construction	Dust	Dust may be blown off haul trucks transporting excavated material to stockpile areas.
Windblown dust from stockpiles	Construction and operational	Dust	Whilst the land is being cleared, it is highly likely that soil will be stockpiled. Wind erosion of the stockpiles will occur resulting in the dispersion of dust.
Mining activities	Current, construction, operational and post operational	Dust	Mining activities will include drilling and blasting, tipping and crushing. Hauling of coal from the opencast mine to the plant are also part of the mining activities.
Plant	Current and operational	Dust	Tipping, loading, crushing and screening are the main processes at the plant. Most of the process are wet, therefore, dust emissions are expected to be low.
Roads & motor vehicles	Current, construction, operational, and post-operational	Dust, SO_2, NOx, Volatile Organic Compounds (VOCs)	Source of particulate matter resulting from the re-suspension of dust from the unpaved road surfaces. Since there is a relatively low vehicle count in the area, this is currently considered to be a minor source of air pollution. Dust will be reduced further when hauling of coal by trucks to the discard dump stops and a conveyor will be constructed instead. Diesel vehicle will also be a source of gaseous (SO_2 and NO_x) and particulate emissions within the mine area.
ROM stockpile	Operational and operational	Dust	Low fine particle content and hence not a major dust source. Dust will be limited to active areas of the stockpiles.
Materials handling	Current, Operational	Dust	The handling of coal is the main dust generating activity at the mine. Fine particulate matter can be easily generated when handling the coal. The coal material has limited erodibility, however, as the movement of coal between the mine, plant and discard dump becomes more frequent, dust will easily be generated from this activity as the coal materials collide together.
Farming	Current, Operational, Post Operational	Dust	Dust is generated through the clearing of land and harvesting. Burning of vegetation will release gases such as SO_2, NO_x, CO and CO_2. Bare ground after harvesting is a source of windblown dust in the area especially during the months of August when wind speeds tend to increase.

3.2 Modelling Scenarios

3.2.1 Construction Activities

No dispersion model model was simulated for dust emissions during the preconstruction/construction phase as activities undertaken during these phases are short-lived in nature and the entire phase has short term duration. Hence, emissions during this phase are deemed to be low to negligible and short lived in nature.

3.2.2 Operational Activities

The models were set up based on the project description for the proposed activities and only new infrastructure i.e. opencast pit, materials handling (Discard dump and open pit) and haul roads were modelled. Two scenarios were run, a scenario without the implementation of management measures and a scenario with the implementation of management measures for activities such as the vehicle entrainment of dust from the haul roads. The scenarios are outlined as follows:

Scenario 1 without management measures:

- For the proposed operational conditions dust emissions were modelled for open pits, materials handling and the haul road.
- The dust sources that were modelled during the operational phase were without any management measures in place and, hence, this scenario is viewed as the worst case scenario.
- No chemical suppressant or chemical sprayers will be used on the haul road.

Scenario 2 with management measures:

- It is assumed that, during the proposed operational conditions, management measures will be used to reduce dust emissions within the mine license boundary.
- Dust emissions from the haul road are suppressed due to rainfall (as natural mitigation) in the area as a form of natural mitigation as well as wet suppression through water bowsers.

The emission rates for each source for each scenario are presented in Table 3-2.

3.3 Proposed Emissions and Source Parameters

Table 3-2: Emission rates for proposed operations

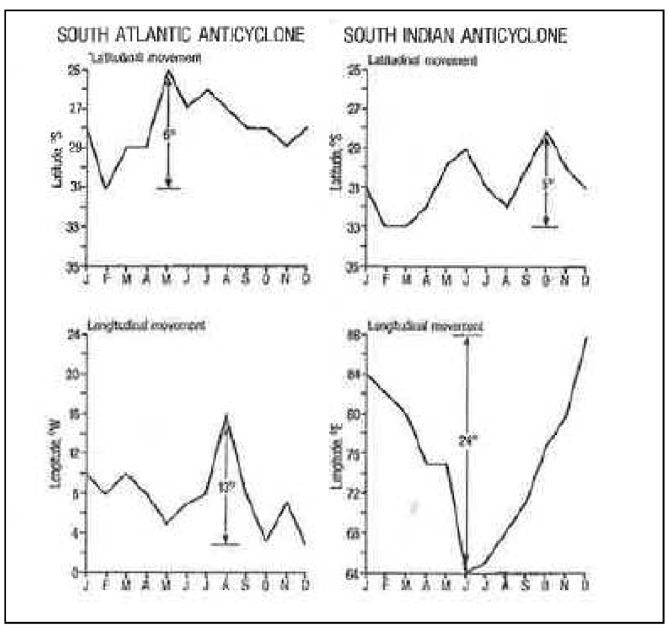
Source	Scenario 1 – without management			Scenario 2 – with management		
	PM_{10}	$PM_{2.5}$	Dust fallout	PM_{10}	$PM_{2.5}$	Dust fallout
Units	tpa	tpa	tpa	tpa	tpa	tpa
Open Pit	637.66	95.55	1310.64	114.79	17.34	235.89
Haul Road	25.23	3.15	78.84	6.31	0.63	15.77
Materials handling (Truck Dumping)	6.31	0.22	11.60	1.14	0.04	2.32
Materials handling (Bulldozer)	12.61	0.58	26.27	2.52	0.11	5.27
Materials handling (FEL)	15.77	0.58	30.49	2.93	0.12	6.10
Discard dump (active stockpile)	176.92	7.79	354.15	51.72	1.55	1.55

4 Meteorological Data

4.1 Description of Climate in Southern Africa

South Africa has a temperate climate with warm sunny days occurring most of the year. South Africa's summer runs from November to February when most of the country is characterised by hot weather and afternoon thunderstorms. The winter season, which occurs from May to August, is usually mild and dry except for the south-western parts of the country. South Africa is influenced by two oceanic currents, the warm south flowing Mozambique-Agulhas current and the north flowing Benguela current. These two currents have an influence on the climate and vegetation between the eastern and western sides of the country. The east coast generally has the higher temperatures and rainfall when compared to the west coast. Climate conditions in South Africa range from Mediterranean in the south-western part of the country to temperate in the interior plateau and subtropical in the north-east. There is also evidence of a desert climate in the north-western part of the country.

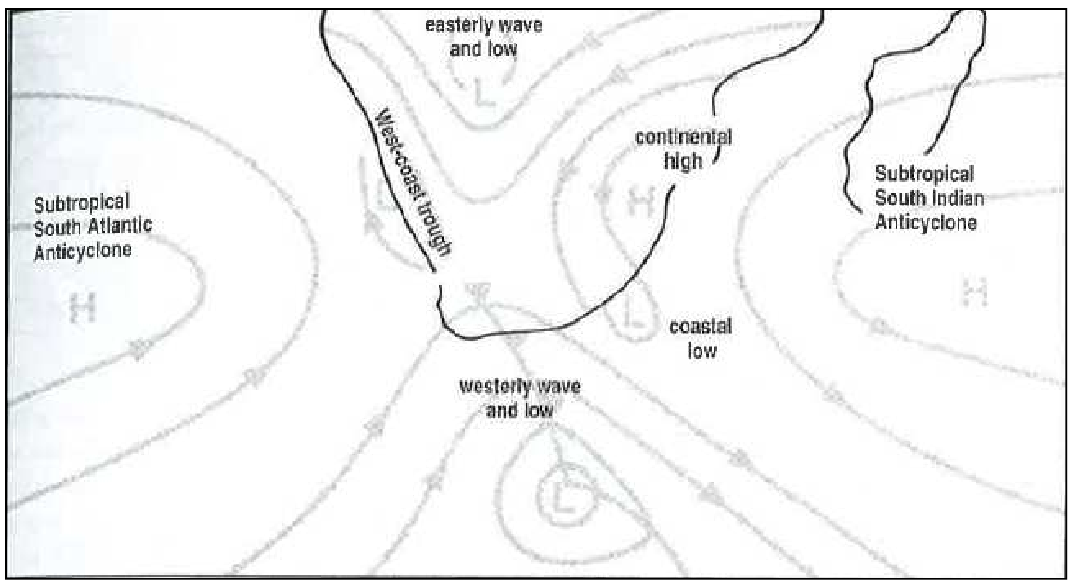
South Africa is located in the subtropical high pressure belt, where subsidence, high pressure and atmospheric stability are predominant features. Three high pressure (HP) cells dominate over South Africa. The South Atlantic HP cell is located off the west coast, the Continental HP cell reigns over the interior of the country and the South Indian HP cell resides over the east coast. This results in the annual mean circulation of the atmosphere over South Africa being anticyclonic (Steynor, 2006). During winter, the anticyclonic circulation over South Africa is well established and is at its most intense. The Continental HP cell migrates north over the country and the South Indian HP cell shifts westward towards the east coast from the summer position of 88°E to 65°E in winter. The South Atlantic HP cell moves from its summer position at 4°W to its winter position at 16°W, migrating away from the western coast (Preston-Whyte et al., 1976). Anticyclones result in subsidence in the atmosphere, which increase the incidence and duration of calm winds, clear skies, lowered humidity and little precipitation (Preston-Whyte et al., 1980) (Figure 4-1).



srk consulting	East Dorstfontein Air Quality Study Annual variations	Project No. 499507

Figure 4-1: Annual variations in the positions of the South Atlantic and South Indian high pressure cells (Source: Preston-Whyte *et al*., 2000)

Conversely, during summer, a low pressure system dominates over the interior of the country due to the slight southward shift of the continental HP cell (Figure 4-2). The South Atlantic HP cell moves towards the east, over the Western Cape, and the South Indian HP shifts eastwards, causing the high pressure conditions over the eastern coast to diminish. Extremely stable atmospheric conditions that can persist for long periods are the result of the semi-permanent and subtropical continental anticyclones. These are found to occur at a frequency of 70% and 20% in winter and summer, respectively.



srk consulting	East Dorstfontein Air Quality Study Surface atmospheric ciculation	Project No. 499507

Figure 4-2: Important features of the surface atmospheric circulation over southern Africa (Source: Preston-Whyte *et al*., 2000)

The south-easterly trade winds generally affect South Africa throughout the year. However, during winter, the high pressure cells shift northward, causing the circumpolar westerly waves to displace the easterly trade winds and dominate over South Africa. The westerly belt is associated with the migration of isolated low pressure cells and cyclones around the coast or across the country towards the east. During summer, the high pressure belt shifts southwards and the easterly trade winds displace the westerly waves to resume its influence over the country.

During summer, localised weather systems to the east of the south-easterly trade winds causes turbulence and uplift and the potential for precipitation over the eastern part of the country, resulting in summer rains. On the western side of the easterly waves, upper-level convergence and surface-level divergence causes clear conditions with no precipitation over the western part of the country.

During winter, westerly waves significantly influence the weather of the country. Upper-level divergence and surface-level convergence occurs to the rear of the trough, which causes uplift and cloud formation resulting in precipitation and winter rains over the western coast. Rainfall will also occur with the passing of cold fronts, which are associated with the westerly waves. Rainfall has a positive effect on pollution control as the water droplets act as nuclei onto which dust and pollutants will collect and deposit onto the ground. This is known as “scrubbing” of the atmosphere.

Along the coastline, sea and land breeze circulations influence the diurnal wind variation and ultimately govern the transport of atmospheric pollutants. During the daytime, the land heats rapidly while the sea retains its cool temperature. The warm air over the land rises causing a low pressure to develop. The cool air over the sea subsides and flows down the pressure gradient, causing a sea-land breeze to develop. The converse is true for night time conditions, where the air above the land cools due to a lack of insulation, while the air above the sea remains warm. A land-sea breeze will therefore prevail during the night (Diab, *pers comm*., 2007).

4.2 Climate Conditions at the Project Site

According to the Koppen Climate Classification System the project area is classified as the Category "C" climate type which is characteristically a moist mid latitude climate with mild winters. Annual precipitation is less than 760 mm.

The project site itself falls into subcategory "Cwb" within the "C" category. The "Cwb" climate type can be classified as mild temperate with dry winters and warm summers.

Weather data for the project site has been acquired from the on-site weather station for the period January 2015 to February 2017 and from Lakes Environmental for the period January 2013 to December 2015.

4.2.1 Rainfall

Rainfall is an important parameter with respect to air quality. During the rainy season, air pollution, and more specifically in this case, dust particles, are removed from the atmosphere. Dust emissions are suppressed due to increases in soil moisture content and increased vegetation cover during the rainy season. During the cooler dry and hot dry seasons, dust emission levels are generally higher.

The average annual rainfall measured at the on-site weather station for the period from January 2015 to February 2017 is 471 mm (Table 4-1). The majority of rainfall is received from October to March. There is low to negligible rainfall from April to September. The month with the highest average rainfall is November (124.5 mm).

The average annual modelled rainfall from Lakes Environmental for the period from January 2013 to December 2015 is 657.5 mm (Table 4-1). The majority of rainfall is received from October to March. There is low to negligible rainfall from April to September. The month with the highest average rainfall is December (145.8 mm).

The average monthly rainfall is presented in Figure 4-3.

Table 4-1: Average monthly rainfall from the on-site weather station and Lakes Environmental

Month	On-site weather station (Jan15 to Feb17)	Lakes Environmental (Jan13 to Dec15)
Units	mm	mm
January	64.9	104.1
February	30.8	52.7
March	73.8	112.4
April	20.3	28.8
May	13.4	4.6
June	5.7	0.5
July	3.6	1.4
August	0.6	10.4
September	20.7	18.9
October	57.4	82.4
November	124.5	95.7
December	55.3	145.8
Total	**471.0**	**657.5**

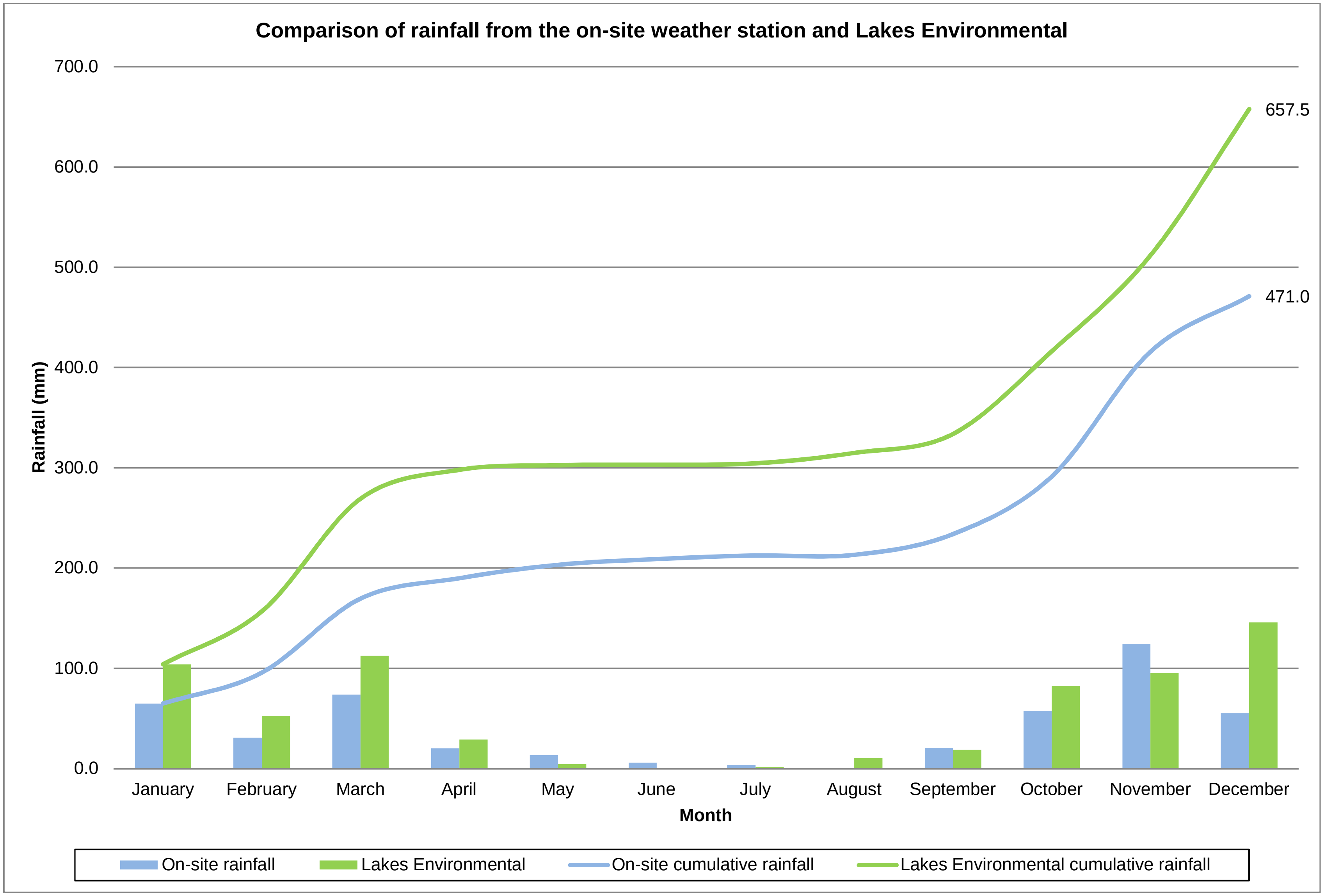


Figure 4-3: Comparison of rainfall figures from the on-site weather station and Lakes Environmental

4.2.2 Temperature

Similar to rainfall, temperature data has been acquired from the on-site weather station and modelled temperature data has been sourced from Lakes Environmental. The monthly average, highest maximum and lowest minimum temperatures are presented in the Table 4-2 and the daily average temperatures are presented in Figure 4-4.

The data from the on-site weather station shows average temperatures range from 10.1-21.4°C with maximum temperatures reaching a high of 44°C (February) and minimum temperatures at a low of --3.7 °C (June).

The data from Lakes Environmental shows average temperatures range from 8.5-20.4°C with maximum temperatures reaching a high of 30.1°C (December) and minimum temperatures at a low of -3.4 °C (July).

Table 4-2: Comparison between on-site and Lakes Environmental temperature data

Month	On-site weather station			Lakes Environmental		
	Average	Maximum	Minimum	Average	Maximum	Minimum
January	20.1	36.1	7.4	20.3	29.6	10.8
February	20.5	44.0	11.5	20.1	29.4	10.6
March	19.0	30.7	6.8	18.3	26.8	9.6
April	16.7	28.9	4.6	14.5	25.1	4.1
May	13.9	26.9	2.5	11.8	20.6	1.4
June	10.1	23.0	-3.7	8.8	18.5	-1.1
July	10.2	22.5	-2.3	8.5	17.9	-3.4
August	14.1	29.0	-3.3	11.0	23.6	-1.1
September	17.3	32.3	4.5	14.8	25.2	0.6
October	19.8	33.5	2.0	16.6	27.9	3.1
November	19.6	30.9	4.8	18.6	28.1	4.9
December	21.4	34.2	12.8	20.4	30.1	9.9

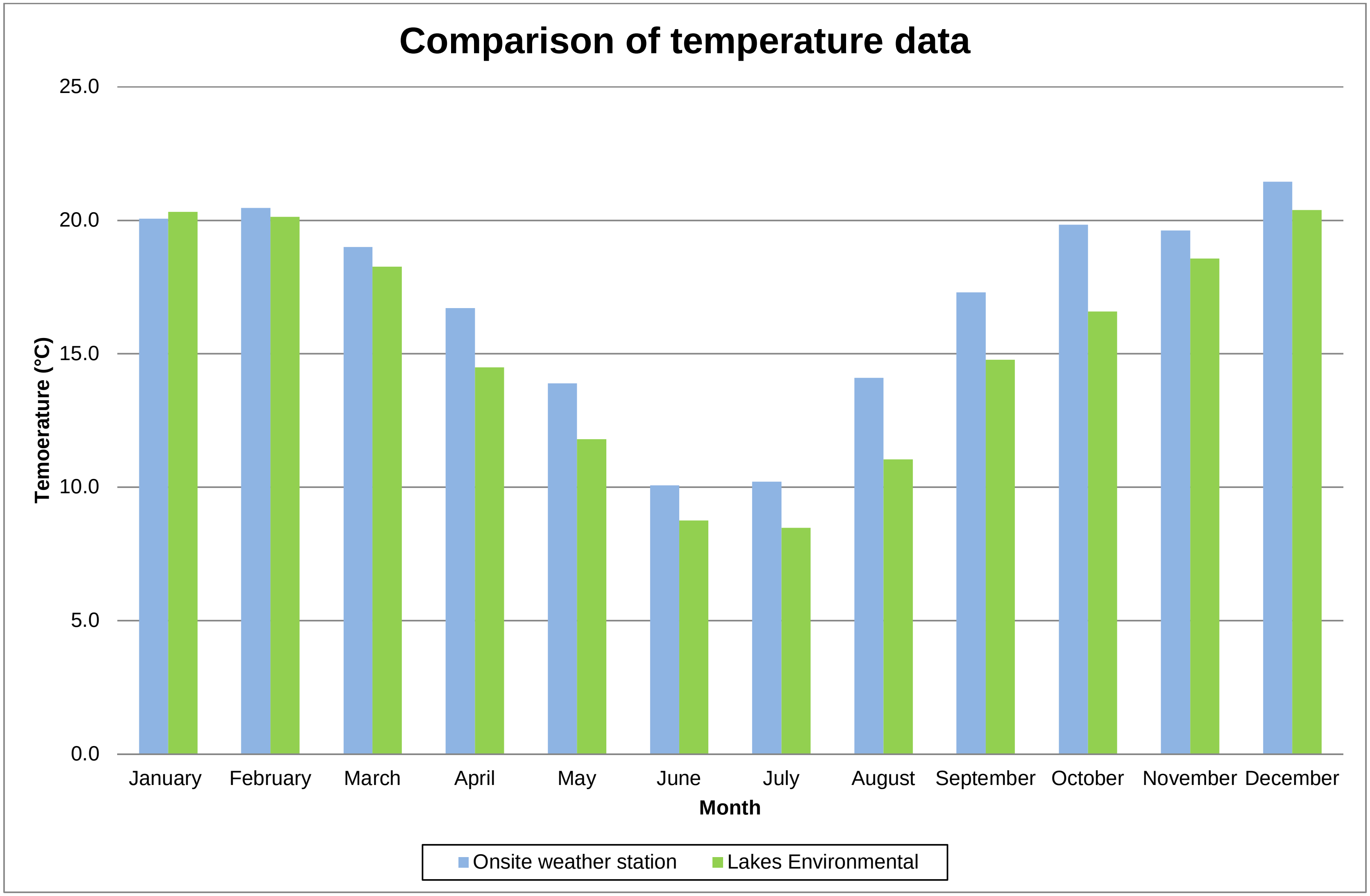


Figure 4-4: Comparison of average daily temperature data

4.3 Wind Field

The wind field for an area is an important parameter with respect to air quality and winds can generate dust emissions as well as control the dispersion of an emissions plume. The degree to which winds can influence dispersion depends on the wind speed. Higher wind speeds result in longer travel distance and dilution of the pollutants and lower, more stable wind conditions result in shorter travel distance and build-up of pollutant levels (especially gases) over a smaller area.

4.3.1 On-Site Weather Station

Wind meteorological data from the on-site weather station for the period January 2015 to February 2017 was used to generate wind roses.

The wind roses for all hours, day and night time for the site for the period January 2015 to February 2017 are presented in Figure 4-5. The prevailing winds are relatively constant throughout the year in the project area. The prevailing winds for this period are from the north, west-southwest and southeast, with lower occurrences from the east, east-southeast and south-southeast (Figure 4-5a). Wind patterns observed during the day (Figure 4-5b) and earlier parts of the night (18h00-00h00) (Figure 4-5) are similar, however, with winds from the southeast becoming more pronounced during the latter period. Winds during the latter parts of the night (00h00-06h00) the prevailing winds are from the west-southwest with lower occurrences from the southwest, southeast, north and west.

The average wind speed measured for all hours is 4.47 m/s with maximum speeds less than 11.1 m/s and with calms (<0.5 m/s) of 1.72%. The average wind speeds for daytime (06h00-18h00) during the year is 5.28 m/s with calms of 1.22%. The average wind speed during the earlier parts of the night (18h00-23h00) is 4.14 m/s with calms of 0.45% and the average wind speed decreases during the latter parts of the night to 3.05 m/s with calms prevailing 4.21% of the time.

Seasonal wind roses were also created for the period (Figure 4-6). The main prevailing wind directions during the seasons general resemble the annual wind rose with the most variation in wind directions and higher wind speeds occurring during spring. The highest average wind speeds of 5.56 m/s occurs during the spring with calms prevailing 0.53% of the time. The lowest average wind speeds occur during winter with an average wind speed of 3.77 m/s with calm conditions prevailing 4.19% of the time. The winds during summer and autumn are 4.65 and 3.87 m/s respectively.

Figure 5-5 represents the wind class frequency distribution which shows that 70.8% of wind speeds are below 5.7 m/s (low speeds) with 29.2% of winds above 5.7 m/s (high speeds).

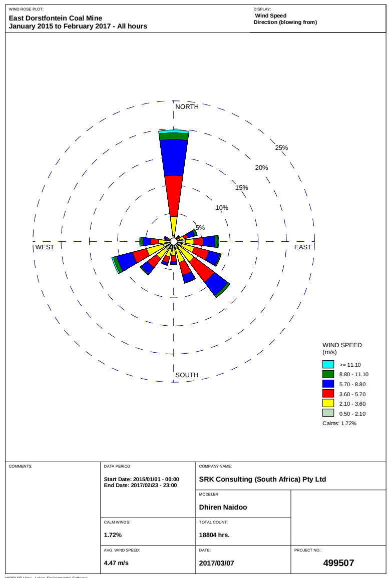


Figure 4-5a: January 2013 to December 2015 (All hours)

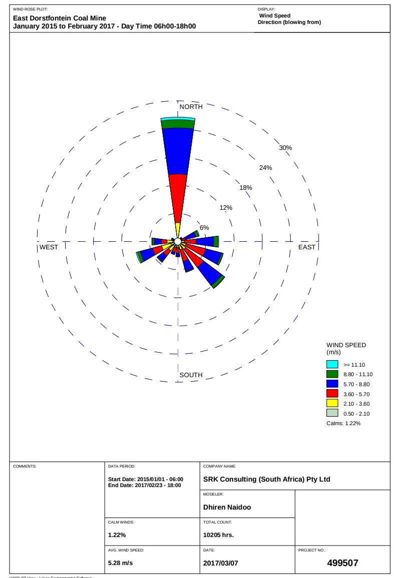


Figure 4-5b: January 2013 to December 2015 (Day Time 06h00-18h00)

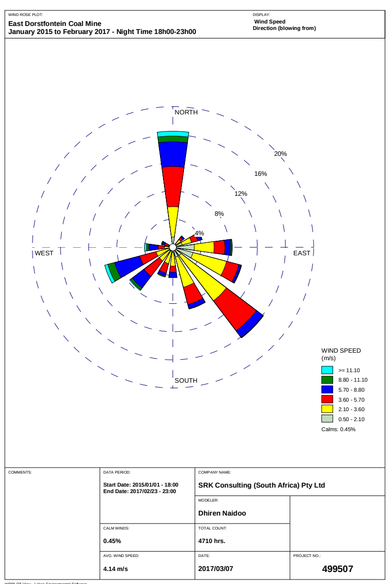


Figure 4-5c: January 2013 to December 2015 (Night Time 18h00-00~~23~~h00)

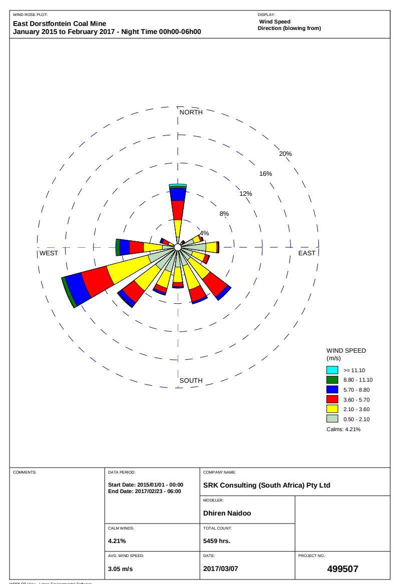


Figure 4-5d: January 2013 to December 2015 (Night Time 00h00-06h00)

srk consulting	**East Dorstfontein Air Quality Study** On-site all hours, day time and night time wind roses	Project No. 499507

Figure 4-5: All hours, day time and night time wind roses (Source: Lakes Environmental)

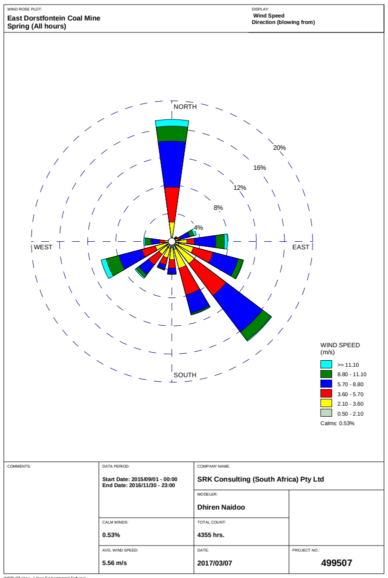


Figure 4-6a: Spring (All hours)

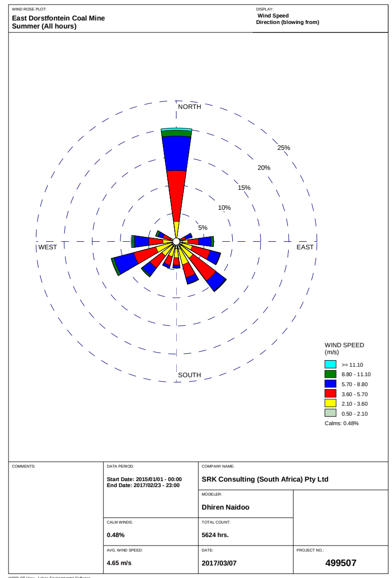


Figure 4-6b: Summer (All hours)

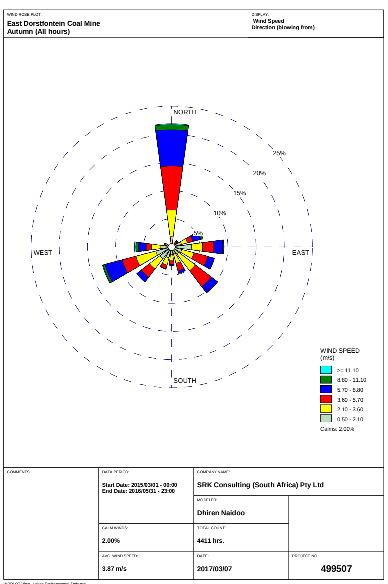


Figure 4-6c: Autumn (All hours)

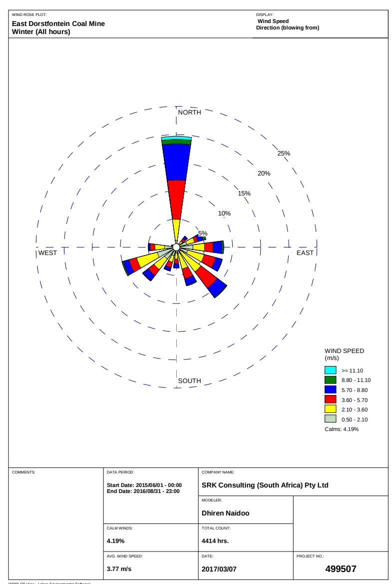
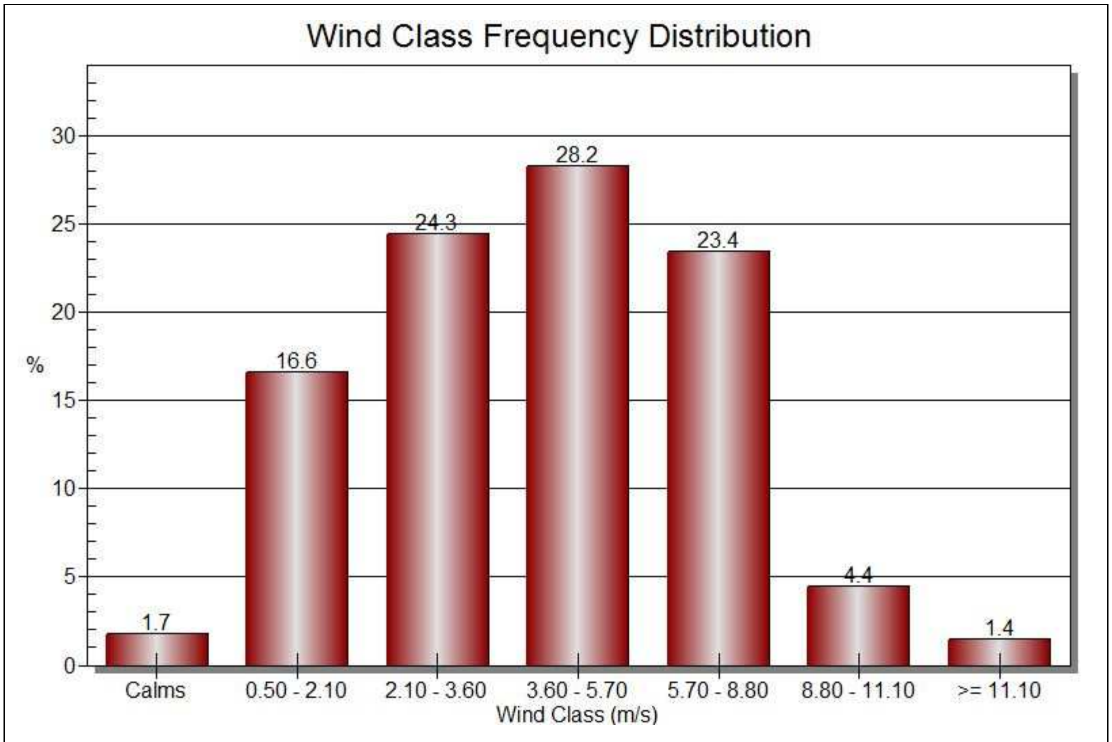


Figure 4-6d: Winter (All hours)

srk consulting	**East Dorstfontein Air Quality Study** Seasonal wind roses	Project No. 499507

Figure 4-6: Seasonal wind roses (Source: Lakes Environmental)



srk consulting	East Dorstfontein Air Quality Study Wind class frequency distribution	Project No. 499507

Figure 4-7: Wind class frequency distribution (Source: Lakes Environmental)

4.3.2 Lakes Environmental Data

Modelled hourly meteorological data for the period January 2013 to December 2015 was acquired from Lakes Environmental.

The wind roses for all hours, day and night time for the site for the period January 2013 to December 2015 are presented in Table 4-8. The prevailing winds are relatively constant throughout the year in the project area. The prevailing winds for this period are from the north-northwest, northwest and north, with lower occurrences from the east, east-northeast and east-southeast (Figure 4-8a). Wind patterns observed during the day (Figure 4-8) and earlier parts of the night (18h00-23h00) (Figure 4-8) are similar, however, with winds from the east becoming more pronounced at night. Prevailing winds during the latter parts of the night (00h00-06h00) are become predominantly easterly, east-northeasterly and northerly with lower occurrences from the northeast and east-southeast.

The average wind speed measured for all hours is 2.93 m/s with maximum speeds less than 11.1 m/s and with calms (<0.5 m/s) of 10.98%. The average wind speeds for daytime (06h00-18h00) during the year is 2.83 m/s with calms of 12.84%. The average wind speed during the earlier parts of the night (18h00-23h00) is 3.05 m/s with calms of 8.52% and the average wind speed decreases during the latter parts of the night to 2.93m/s with calms prevailing 8.83% of the time.

Seasonal wind roses were also created for the period (Figure 4-9). The main prevailing wind directions during spring resemble the annual wind rose. However, during summer the prevailing winds are from the north, north-northwest, north-northwest and east with a lower occurrence from the northeast, north-northeast and east-southeast. The prevailing winds for autumn and winter are similar, however there are a higher frequency of winds from the west during autumn when compared to winter. However it should be noted that winds speeds during winter are higher when compared to autumn. The highest average wind speeds of 3.54 m/s occurs during the spring with calms prevailing 5.63% of the time.

The lowest average wind speeds occur during autumn with an average wind speed of 2.46m/s with calm conditions prevailing 15.81% of the time. The winds during summer and winter are 2.95 and 2.76 m/s respectively.

Figure 5-5 represents the wind class frequency distribution which shows that 93.2% of wind speeds are below 5.7 m/s (low speeds) with 6.8% of winds above 5.7 m/s (high speeds).

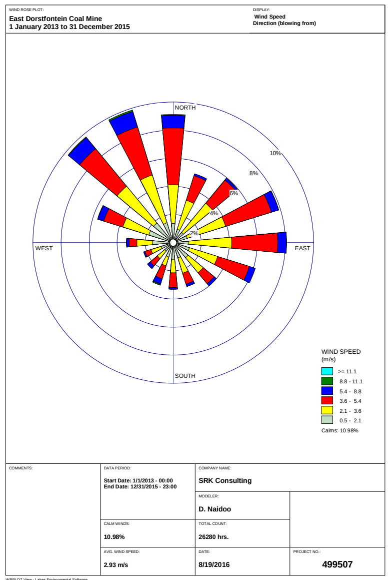


Figure 4-8a: January 2013 to December 2015 (All hours)

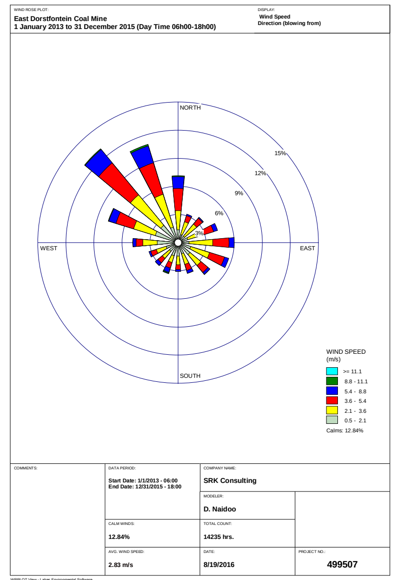


Figure 4-8b: January 2013 to December 2015 (Day Time 06h00-18h00)

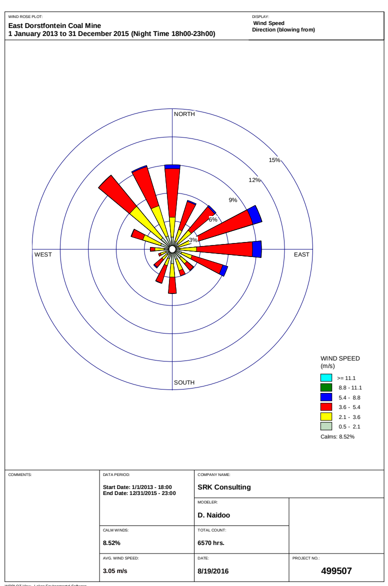


Figure 4-8c: January 2013 to December 2015 (Night Time 18h00-23h00)

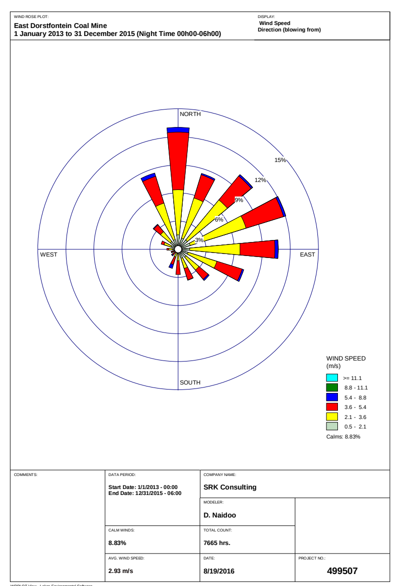


Figure 4-8d: January 2013 to December 2015 (Night Time 00h00-06h00)

srk consulting	**East Dorstfontein Air Quality Study** On-site all hours, day time and night time wind roses	Project No. 499507

Figure 4-8: All hours, day time and night time wind roses (Source: Lakes Environmental)

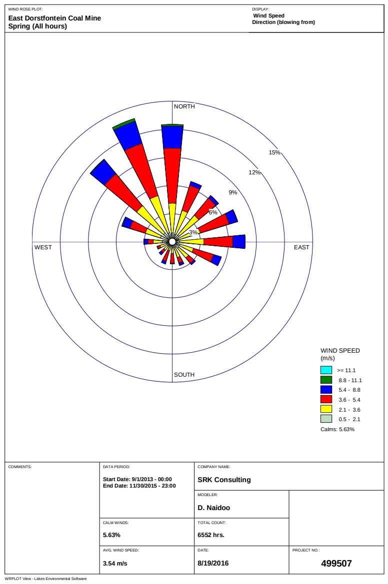


Figure 4-9a: Spring (All hours)

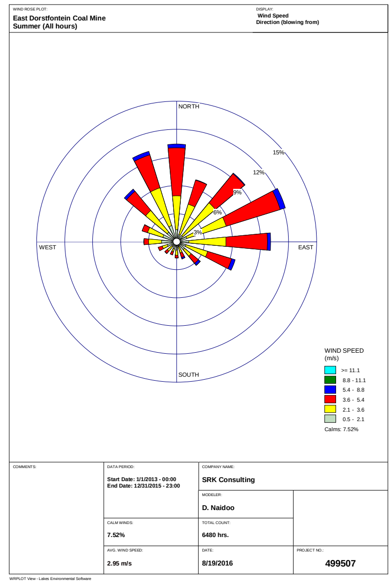


Figure 4-9b: Summer (All hours)

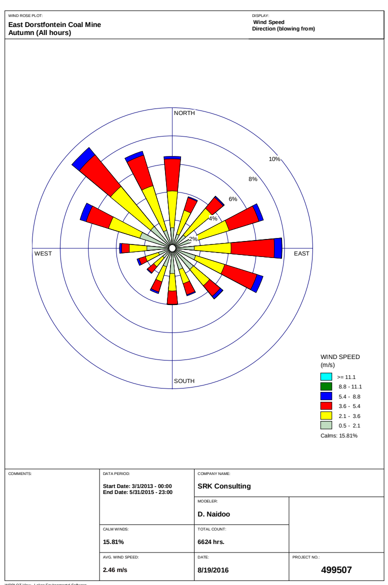


Figure 4-9c: Autumn (All hours)

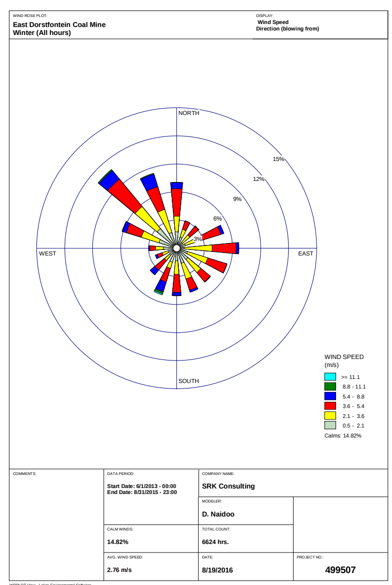
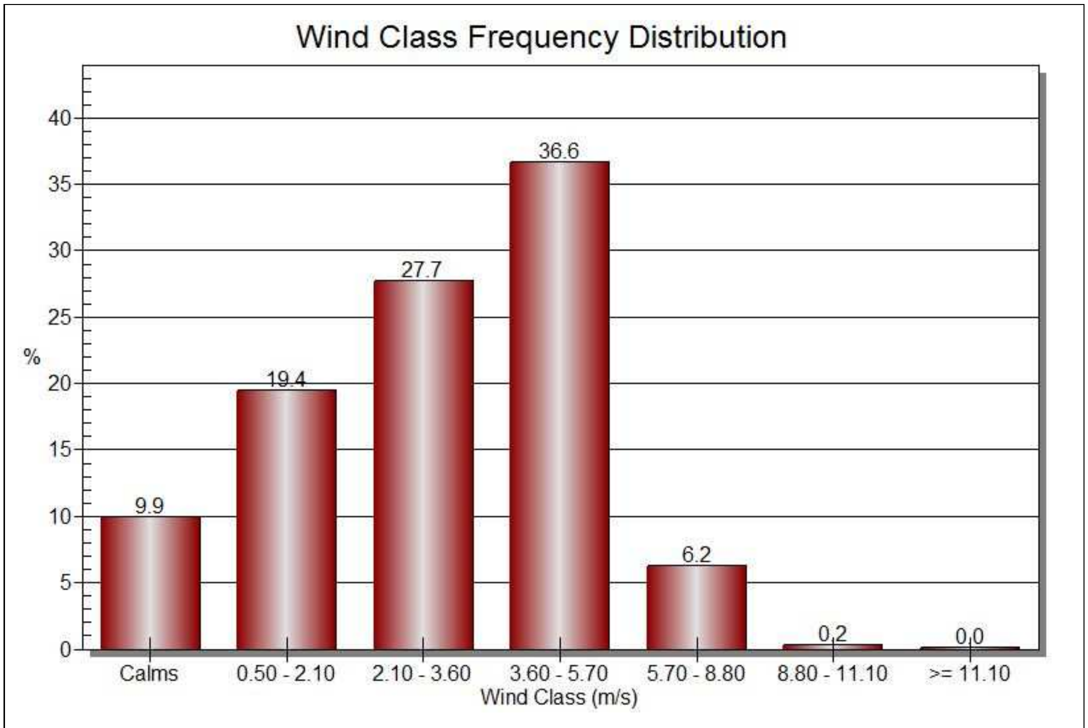


Figure 4-9d: Winter (All hours)

srk consulting	**East Dorstfontein Air Quality Study** Seasonal wind roses	Project No. 499507

Figure 4-9: Seasonal wind roses (Source: Lakes Environmental)



srk consulting	East Dorstfontein Air Quality Study Wind class frequency distribution	Project No. 499507

Figure 4-10: Wind class frequency distribution (Source: Lakes Environmental)

4.4 Summary of Meteorological Data

Based on the meteorological data from the on-site weather station the climate in the project area is expected to be seasonal, with distinct warm months (September to February) and cool months (March to August). Rainfall is higher during the months from October to April and lower from May to September. The prevailing winds for this period are from the north, west-southwest and southeast, with lower occurrences from the east, east-southeast and south-southeast as observed on the site windroses. The average wind speed measured for all hours is 4.47 m/s with maximum speeds less than 11.1 m/s and with calms (<0.5 m/s) of 1.72%.

5 Ambient Impact Analysis and Ambient Levels

5.1 Ambient Air Quality Legislation

In South Africa, the main legislation governing air quality is the National Environment Management: Air Quality Act, No. 39 of 2004 (NEM: AQA). An important factor in the approach to air quality has been the promulgation of regulations with respect to ambient air quality standards under NEM: AQA. These standards provide the goals for air quality management plans and the context within which the effectiveness of these management plans are measured. The NEM: AQA identifies priority pollutants, determination of priority areas affected by these pollutants and the setting of ambient standards with respect to these pollutants within these areas. This Section provides standards for priority pollutants i.e. PM_{10}, SO_2 etc. All ambient air quality monitoring data will be compared against the South African National Ambient Air Quality Standards (NAAQS) that came into effect on 24 December 2009 (Notice No.: 1210. Government Gazette No. 32816. 24 December 2009).

5.2 Air Quality Standards

5.2.1 PM_{10}

Particulate matter (PM) is airborne particles that include dust, smoke and soot. Particulate matter can either be emitted naturally (e.g. windblown dust of stockpiles) or through human activity (e.g. stack emissions). It is defined by size, with coarse particles being between 2.5-10 microns, fine particles less than 2.5 microns, and ultrafine particles less than 0.1 microns in diameter.

Particulate matter can have adverse effects on humans such as respiratory illnesses (asthma and bronchitis) or cardiovascular diseases. It can also affect vegetation in two ways, namely, by inhibiting the plant's photosynthetic properties by coating the leaves thereby blocking the penetration of natural light. Furthermore deposition onto soils of various metals that could be in the particulate matter can be which are absorbed by vegetation thereby hindering plant growth. The uptake of metals by plants also has the potential to contaminate vegetables and fruit that may be consumed by humans and animals.

Ambient air quality standards for PM_{10} and $PM_{2.5}$ are presented in Table 5-1 and Table 5-2 respectively. PM_{10} and $PM_{2.5}$ are important as it provides a measure of respirable dust, which has the potential to affect human health.

Table 5-1: Ambient air quality standards for PM_{10}

Standard	24-hour	Annual Average
Units	µg/m³	µg/m³
South African Standard (Effective from 1 January 2015)[1]	75	40
Frequency of exceedance	4	0
1) As listed in the NEM: AQA. Government Gazette No. 32816. 24 December 2009		

Table 5-2: Ambient air quality standards for $PM_{2.5}$

Standard	24-hour	Annual Average
Units	µg/m³	µg/m³
South African Standard (Effective from 1 January 2016 to 31 December 2029)[1]	40	20
Frequency of exceedance	4	0
1) As listed in the NEM: AQA. Government Gazette No. 35463. 29 June 2012		

5.2.2 Dust fallout

This Section provides standards for priority pollutants i.e. dust fallout. The National Dust Control Regulations came into effect on 1 November 2013. In terms of the NEM: AQA the acceptable dust fallout rates are presented in Table 5-3.

Table: 5-3: NEM: AQA, 2004 Acceptable Dust Fallout Rates given in mg/m²/day

Restriction Area	Dust fall rate (D) (mg/m²/day, 30-day average)	Permitted frequency of exceeding dust fall rate
Residential Area	D < 600	Two within a year, not sequential months
Non-residential Area	600 < D < 1,200	Two within a year, not sequential months

Two exceedances of the Residential Area and Non-residential area are permitted within a year, but not for two sequential months. If there are more than two exceedances within a year, or two in consecutive months, then within three months after the submission of the dust fallout monitoring report a dust management plan must be submitted to the air quality office for approval.

5.3 Ambient Air Quality Monitoring Data

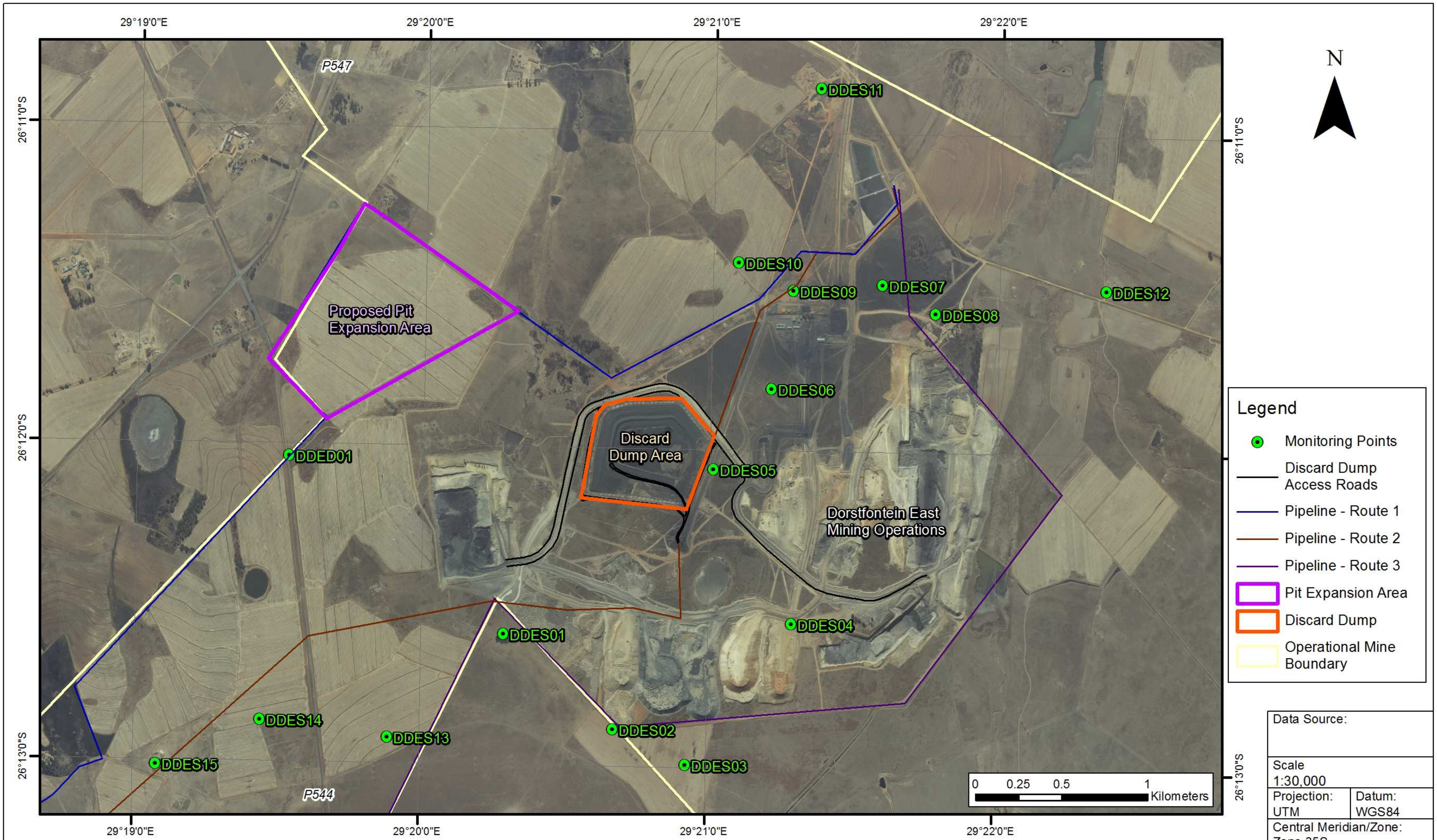
Dust fallout monitoring is being undertaken at the East Dorstfontein Mine. SRK received monitoring data for the period March 2012 to February 2017 from the mine. Dust buckets have been added to the network over the course of the monitoring period. The monitoring locations are presented in Table 5-4 and Figure 5-1. The dust fallout monitors installed in and around the mining area are classified as Residential Area and Non-residential Area dust buckets in accordance with the National Dust Control Regulations. All dust bucket locations are classified as Residential Area except DDES 5 and DDES 6 which are classified as Non-residential Area.

Annual dust fallout concentrations for each location are presented in Table 5-5. The monthly concentrations for the period are presented in Figure 5-2. A detailed description of the monthly dust fallout concentrations is included in Appendix A.

The monthly dust fallout concentrations (Figure 5-2) shows that dust fallout concentrations exceeded the Residential Area limit of 600 $mg/m^2/day$ 361 times out of 1118 (32.3%) recorded dust fallout measurements at Residential Area monitoring locations. The Non-residential Area limit was exceeded 27 times out of 119 (22.7%) dust fallout measurements at Non-residential points. Rainfall does not appear to play a significant role in reducing dust fallout concentrations since numerous instances of dust fallout concentrations exceeding the Residential Area and Non-residential Area limits are noted during spring and summer when the majority of rainfall for the area is received.

Table 5-4: Dust monitoring locations

Monitoring Point	Location		Designated Area
DDES 1	26°21'54,6"	29°35'80,4"	Residential Area
DDES 2	26°19'99,1"	29°33'98,5"	Residential Area
DDES 3	26°24'02,1"	29°28'47,9"	Residential Area
DDES 4	26°20'88,0"	29°35'31,1"	Residential Area
DDES 5	26°20'04,2"	29°35'13,5"	Non-residential Area
DDES 6	26°20'04,9"	29°35'53,3"	Non-residential Area
DDES 7	26°19'46,1"	29°36'26,8"	Residential Area
DDES 8	26°11.52,5"	29°21.85,5"	Residential Area
DDES 9	26°11.46,6"	29°21,37.5"	Residential Area
DDES 10	26°11.39,7"	29°21.22,2"	Residential Area
DDES 11	26°10.86,0"	29°21.40,4"	Residential Area
DDES 12	26°11,29,9”	29°22'21.8”	Residential Area
DDES 13	26°10,93,8”	29°19,60.0”	Residential Area
DDES 14	26°11,60,7”	29°19,34.2”	Residential Area
DDES 15	26°12,59,2”	29°19,05.3”	Residential Area
DRL 1	26°11'14,5"	29°34'20,2"	Residential Area
DRL 2	26°11'09,8"	29°35'04,1"	Residential Area
DDED 1N	26°20'05,9"	29°32'57,0"	Residential Area
DDED 1E	26°20'05,9"	29°32'57,0"	Residential Area
DDED 1S	26°20'05,9"	29°32'57,0"	Residential Area
DDED 1W	26°20'05,9"	29°32'57,0"	Residential Area
DDED 2N	26°21'49,0"	29°34'49,4"	Residential Area
DDED 2E	26°21'49,0"	29°34'49,4"	Residential Area
DDED 2S	26°21'49,0"	29°34'49,4"	Residential Area
DDED 2W	26°21'49,0"	29°34'49,4"	Residential Area



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Central Meridian/Zone: Zone 35S	
Date: 18/04/2017	Compiled by: DAVA
Project No. 499507	Fig No. 5-1

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DORSTFONTEIN EAST: AIR QUALITY IMPACT ASSESSMENT

LOCATION OF MONITORING POINTS

Path: G:\499507_Doorstfontein_AQIA_assisting_PTA\8GIS\GISPROJ\MXD\13072017\499507_F5_1_Dorst_East_AQIA_Monitoring_Points_A4L_C_13072017.mxd

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Table 5-5: Average monthly dust fallout concentrations for each year for the period March 2012 to February 2017

Monitoring Point	2012	2013	2014	2015	2016	2017
DDES 1	354	487	269	442	575	190
DDES 2	639	734	1200	1367	973	471
DDES 3	496	369	307	580	363	266
DDES 4	695	860	420	871	553	224
DDES 5	1158	691	594	769	852	803
DDES 6	1841	828	736	956	591	609
DDES 7	1272	384	345	715	667	409
DDES 8	164	386	405	564	371	452
DDES 9	280	495	323	824	880	472
DDES 10	310	542	393	697	927	464
DDES 11	336	786	472	706	452	246
DDES 12	NM	550	294	373	383	163
DDES 13	NM	NM	NM	458	323	44
DDES 14	NM	NM	NM	340	451	35
DDES 15	NM	NM	NM	372	387	81
DRL 1	236	319	296	442	459	514
DRL 2	251	408	188	502	377	510
DDED 1N	493	619	508	485	563	90
DDED 1E	821	588	486	652	534	158
DDED 1S	635	467	591	702	555	242
DDED 1W	605	584	490	598	512	144
DDED 2N	1022	539	300	669	296	100
DDED 2E	1376	693	350	482	357	106
DDED 2S	1471	582	333	514	460	136
DDED 2W	848	564	269	547	313	107
Residential Area	600	600	600	600	600	600
Non-residential Area	1200	1200	1200	1200	1200	1200

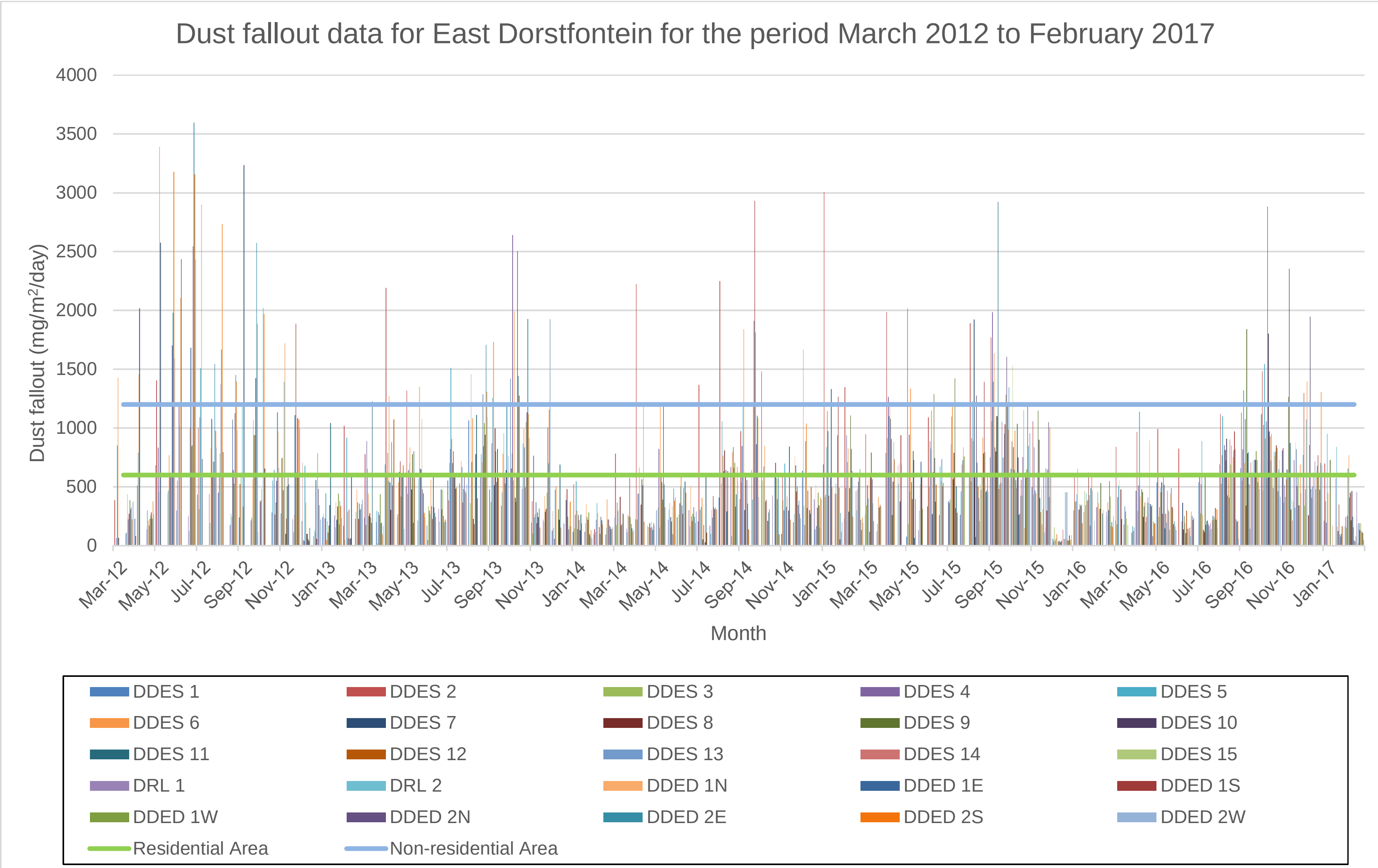


Figure 5-2: Monthly dust fallout concentrations at East Dorstfontein for the period March 2012 to February 2017

6 Dispersion Modelling Methodology

Dispersion models compute ambient concentrations and deposition levels as a function of source configuration, emission strengths and meteorological characteristics thus, providing useful tools to ascertain the spatial and temporal patterns in the ground level concentrations and deposition arising from the emissions of various sources. The US-EPA AERMOD modelling software package was used to model PM_{10}, $PM_{2.5}$ and dust fallout emissions, respectively, resulting from the proposed development.

6.1 Model Used

Dispersion models compute ambient concentrations and deposition levels as a function of source configuration, emission strengths and meteorological characteristics, thus providing useful tools to ascertain the spatial and temporal patterns in the ground level concentrations and deposition arising from the emissions of various sources that are modelled. The US EPA AERMOD modelling software package (AERMOD View 8.2) was used to model PM_{10} $PM_{2.5}$ and dust fallout emissions, respectively, resulting from the proposed development. The AERMOD model is included in a suite of models used by the US-EPA for regulatory purposes. The models have also been approved for use in South Africa.

6.2 Quantification of Emissions

Data used in the modelling of emissions should ideally come from source-specific emission tests or continuous emission monitors. However, for a few sources such the haul roads and open pits measured data were not available for this project. Therefore, emission factors were used as they are the best surrogate measure available for quantifying emissions. In order to calculate emission rates, information regarding the proposed project activities were used determine emission factors. In this case, the US EPA emission factors in its AP 42 document, "Compilation of Air Pollution Emission Factors" were used. The AP 42 emission factors are the most widely used in the field of air pollution and are regularly subjected to revision and review as more effective modelling techniques are developed. Empirically derived, predictive emission factor equations are available for dust entrained by vehicles from both paved and unpaved roads, material handling operations and wind erosion.

The impact of fugitive dust on air quality depends largely on the extent of the drift potential of the particles. The drift potential of particles depends in turn on the initial height of the emission, the terminal settling velocity of the particle (which in turn is a function of the particle diameter) and the degree of atmospheric turbulence. Larger dust particles tend to settle out near the source, creating a local nuisance problem, whereas finer particles are more likely to be dispersed over greater distances since their settling rate is retarded by atmospheric turbulence. Predictive emission factor equations allow for the estimation of emissions for particular particle size ranges, i.e. PM_{10}, $PM_{2.5}$ and dust fallout (US EPA, 2005). Appendix B includes a detailed description how the emissions used for the dispersion model were quantified.

6.3 Specify Model Settings

6.3.1 Land Use Classification

For most applications, the Code of Practice recommends the Land Use Procedure as sufficient for determining the urban/rural status of a modelling domain. The alternative approach on urban/rural classification using the Population Density Procedure is not encouraged as the approach can be rather subjective.

The classification of a site as urban or rural is based on the Auer method specified in the US EPA guideline on air dispersion models.

From the Auer's method, areas typically defined as Rural include:

- Residences with grass lawns and trees.
- Large estates.
- Metropolitan parks and golf courses.
- Agricultural areas.
- Undeveloped land.
- Water surfaces.

An area is defined as Urban if it has less than 35 percent vegetation coverage or the area falls into one of the use types described in Table 6-1.

Table 6-1: Land types, -use, structures and vegetation cover

Type	Use and Structures	Vegetation
I1	Heavy Industrial	Less than 5 %
I2	Light/moderate industrial	Less than 5 %
C1	Commercial	Less than 15 %
R2	Dense single / multi-family	Less than 30 %
R3	Multi-family, two-story	Less than 35 %

Note: Source – DEA, Code of Practice for Air Dispersion Modelling

The area within and surrounding the project area has the following land uses: urban, cultivated land, water surfaces and natural land.

6.3.2 Surface Roughness

The surface roughness length is not a physical height but a theoretical one based on the wind profile. It is the height at which the mean horizontal wind speed approaches zero. For many modelling applications, the surface roughness length is typically about an order of magnitude (factor of 10 or so) smaller than the average heights of the roughness elements. The surface roughness length can be adequately estimated from the land use categories as a function of the season. The average surface roughness included into the model for each land use is presented in Table 6-2.

Table 6-2: Surface roughness

Land use	Surface roughness
Urban	1
Cultivation	0.0725
Water	0.0001
Natural	0.04025

6.3.3 Albedo

Noon-time albedo is the fraction of the incoming solar radiation that is reflected from the ground when the sun is directly overhead. For practical purposes, the selection of a single value for noon-time albedo to process a complete year of meteorological data is desirable. If other conditions are used, the regulatory agency must review the proposed noon-time albedo values used to pre-process the meteorological data. The average albedo included into the model for each land use is presented in Table 6-3.

Table 6-3: Albedo

Land use	Albedo
Urban	0.2075
Cultivation	0.28
Water	0.14
Natural	0.29

6.3.4 Bowen Ration

The daytime Bowen ratio, an indicator of surface moisture, is the ratio of sensible heat flux to latent heat flux and is used for determining planetary boundary layer parameters for convective conditions driven by the surface sensible heat flux. The presence of moisture at the Earth's surface alters the energy balance, which in turn alters the sensible heat flux and Monin-Obukhov length. Bowen ratio values vary depending on the surface wetness. The average moisture conditions must be used normally, and the regulatory agency should review any other proposed Bowen ratio values used to pre-process the meteorological data. The average Bowen ratio included into the model for each land use is presented in Table 6-4.

Table 6-4: Bowen Ration

Land use	Bowen Ration
Urban	1.625
Cultivation	0.75
Water	0.45
Natural	0.925

6.4 Description of Modelled Meteorological Data

The AERMOD model requires hourly average meteorological data as input, including wind speed, wind direction, a measure of atmospheric turbulence, ambient air temperature and mixing height. In the absence of suitable long term hourly on-site data sets for all the input parameters required for modeling, a 3-year model ready meteorological dataset was purchased from Lakes. The Lakes data are based on synoptic weather data prepared using the MM5 model, which is used to forecast weather. For this model simulation exercise hourly meteorological data for the period 1 January 2013 to 31 December 2015 were used.

6.5 Discussion on Upper Air Data Utilised

The upper air data is modelled data included in the package for the Modelled MM5 data. The data is in the prescribed TD-6201 - Fixed length format which is ready for processing in AERMET. For this model simulation exercise upper air data for the period 1 January 2013 to 31 December 2015 was used.

6.6 Description of Receptor Grid

The receptor grid for the dispersion of dust emissions from the proposed project, under various operating scenarios, covers an area of 400 km^2. The size of the Cartesian (X:Y) grid area is larger than the mining concession area so that when the model runs the extent of the concentration plume levels beyond the concession boundary can be determined. The modelling domain extends for 20 km from east to west and 20 km from north to south with the proposed project area in the center. The extent of the modelling also includes the closest sensitive receptors.

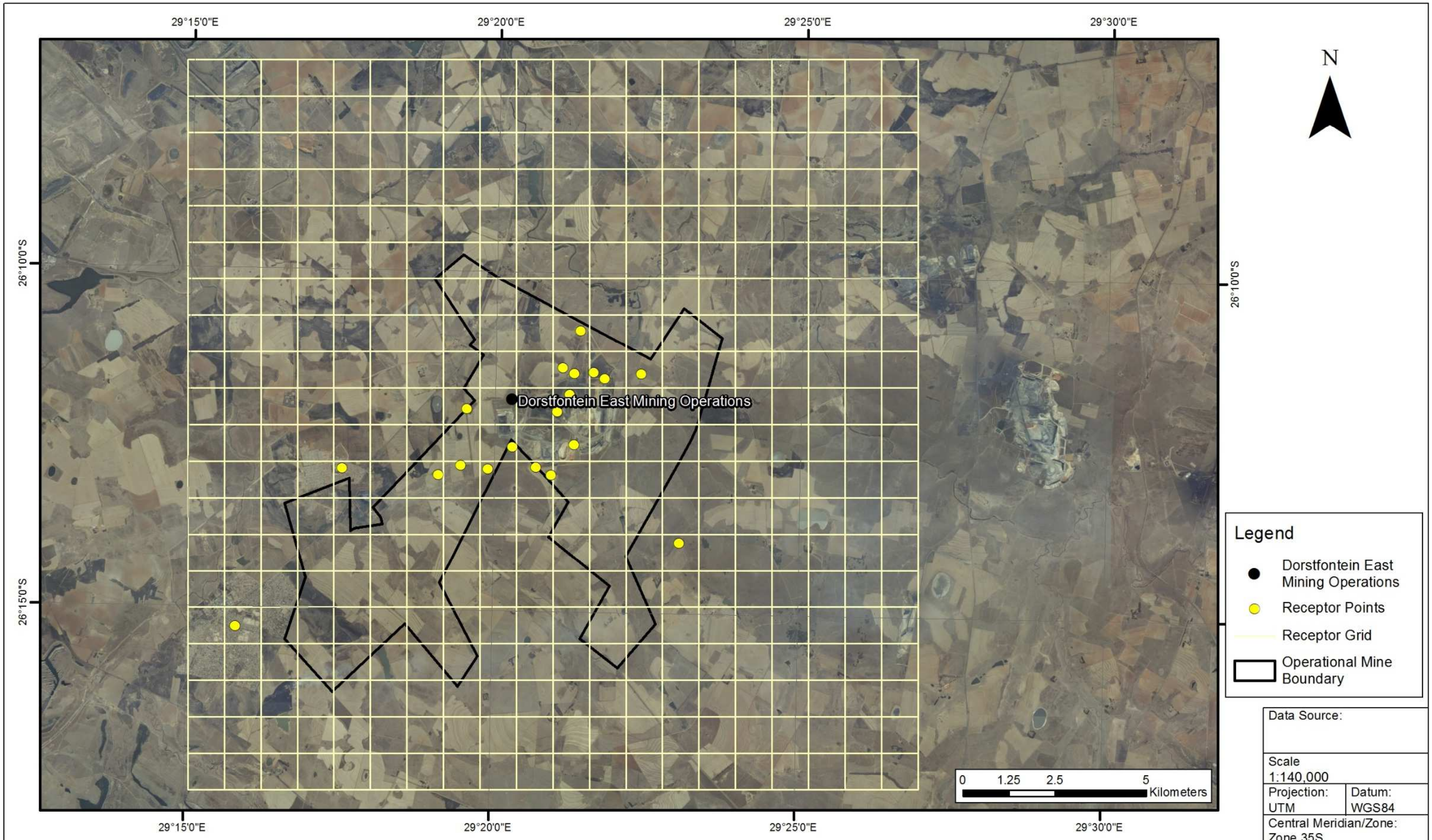
Discrete receptors i.e. villages and existing monitoring locations, were also added into the model. The discrete receptor locations are the center points of villages in close proximity to the mine area. The towns/villages/homesteads included in the model are presented in Table 6-5. Figure 6-1 presents the modelling domain and receptor grid together with the discrete receptors.

Table 6-5: Receptors in close proximity to the site

Town/Village	X - co-ordinate	Y- co-ordinate
Kriel	726055	7094102
Thubelihle	728971	7098402
Boskrans	738150	7096354
Monitoring locations		
DDES01	733613	7098972
DDES02	734247	7098417
DDES03	734666	7098209
DDES04	735286	7099027
DDES05	734834	7099927
DDES06	735174	7100393
DDES07	735820	7100993
DDES08	736128	7100826
DDES09	735302	7100963
DDES10	734984	7101126
DDES11	735466	7102136
DDES12	737123	7100952
DDES13	732935	7098373
DDES14	732196	7098478
DDES15	731587	7098220
DDED01	732370	7100011

6.7 Description of Topographical Data

The AERMOD model was set up in such a way as to incorporate the topography of the study area. Topography can influence meteorological parameters (such as temperature inversions, local wind circulations, etc.) that may worsen or improve air quality on a local scale. The “Terrain Height Options” section in the model was set to elevated terrain, which assumes that the receptors, such as towns/villages, may potentially be above the source base. Terrain data downloaded from WebGIS (www.webgis.com) for the study area were processed using the “Terrain” processor function in AERMOD and imported into the model, yielding a 3D-model and because of this, all identified receptors were assigned heights when inserted into the model. A topographical map is presented in Figure 6-2. In a west to east direction across the site, there is undulating topography which varies in elevation between 1540-1640 meters above mean sea level (mamsl). In a north to south direction across the site, higher elevations are observed to the south and decreases towards the north. Elevations across the north to south profile range from 1531-1660 mamsl.



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Date: 18/04/2017	Compiled by: DAVA
Project No. 499507	Fig No. 6-1

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DORSTFONTEIN EAST: AIR QUALITY IMPACT ASSESSMENT

RECEPTOR GRID

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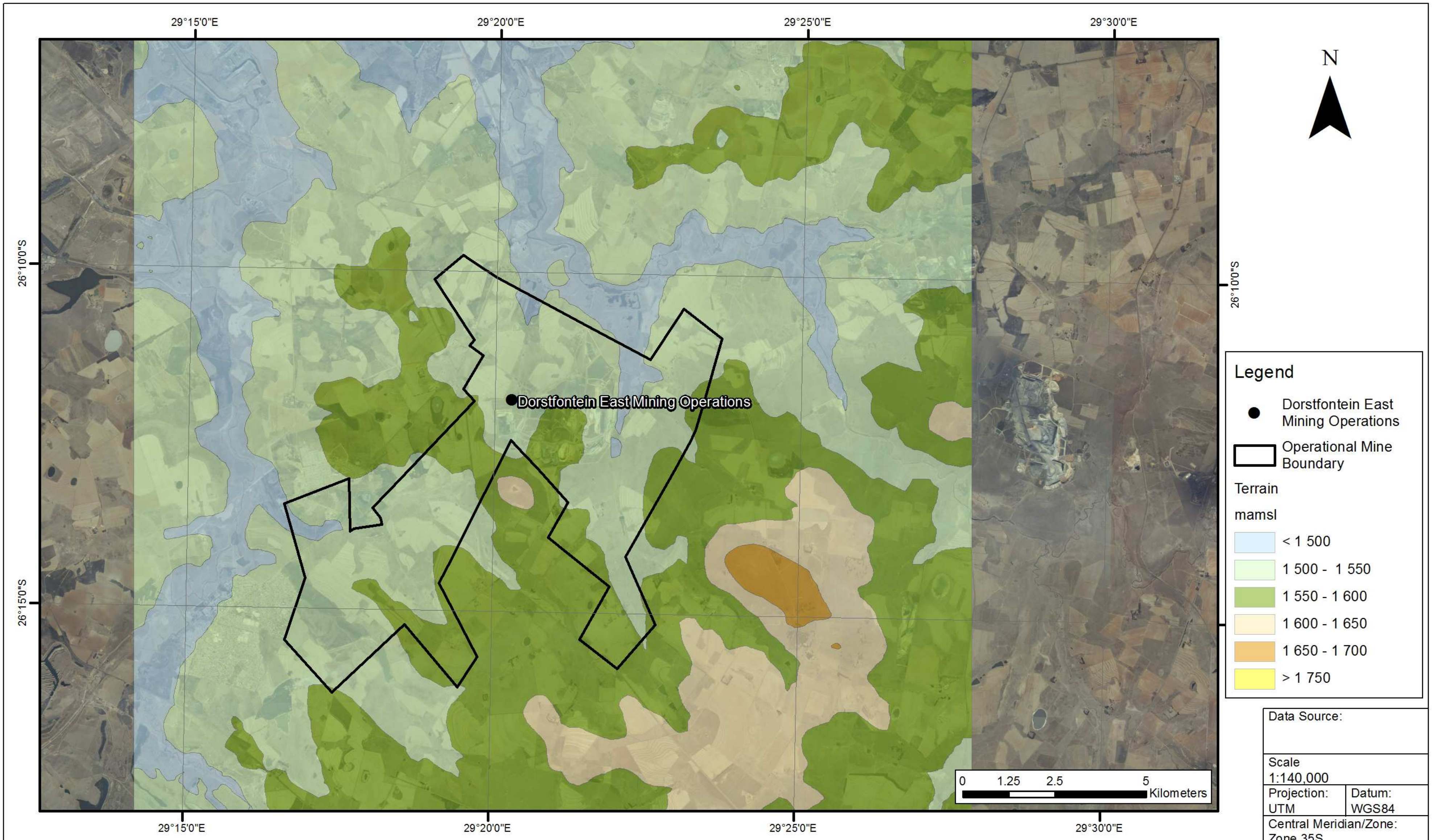
Revision: A Date: 13 07 2017



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Date: 18/04/2017	Compiled by: DAVA
Project No. 499507	Fig No. 6-2

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DORSTFONTEIN EAST: AIR QUALITY IMPACT ASSESSMENT

TERRAIN IN THE PROJECT AREA

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Revision: A Date: 13 07 2017

7 Dispersion Modelling Results

Predicted 99th percentile daily and annual average concentrations for PM_{10}, $PM_{2.5}$ and maximum predicted daily averages for dust fallout were simulated using the US EPA approved AERMOD model. Isopleth maps showing PM_{10}, $PM_{2.5}$ and dust fallout concentrations are presented in the sections that follow. It should be noted that only sources from the proposed development have been modelled, all sources from existing operations have been excluded.

Modelled ambient ground level concentration isopleths represent interpolated values from the concentrations predicted by the AERMOD model for each of the receptor grid points. It should be noted that the plots reflecting daily averaging periods contain only the highest average predicted ground level concentrations over the entire period for which the simulations were undertaken. These high concentrations are usually associated with extreme meteorological conditions such as high winds and low level inversions.

Prior to the interpretation of the results it is important to reiterate the degree of uncertainty associated with emissions inventory preparation and dispersion simulation in general. Various assumptions have been made regarding the nature, location and extent of certain activities during the operational phase of the project. Of importance, however, are the trends and the areas that are likely to be impacted.

The 99th percentile values were chosen for predicted PM_{10} and $PM_{2.5}$ emission concentrations, as this is a normal statistical method to exclude anomalous predicted concentrations. This in turn identifies emission concentrations in a range that is most likely to be observed during the proposed project's operational phase and excludes outliers.

7.1 PM_{10}

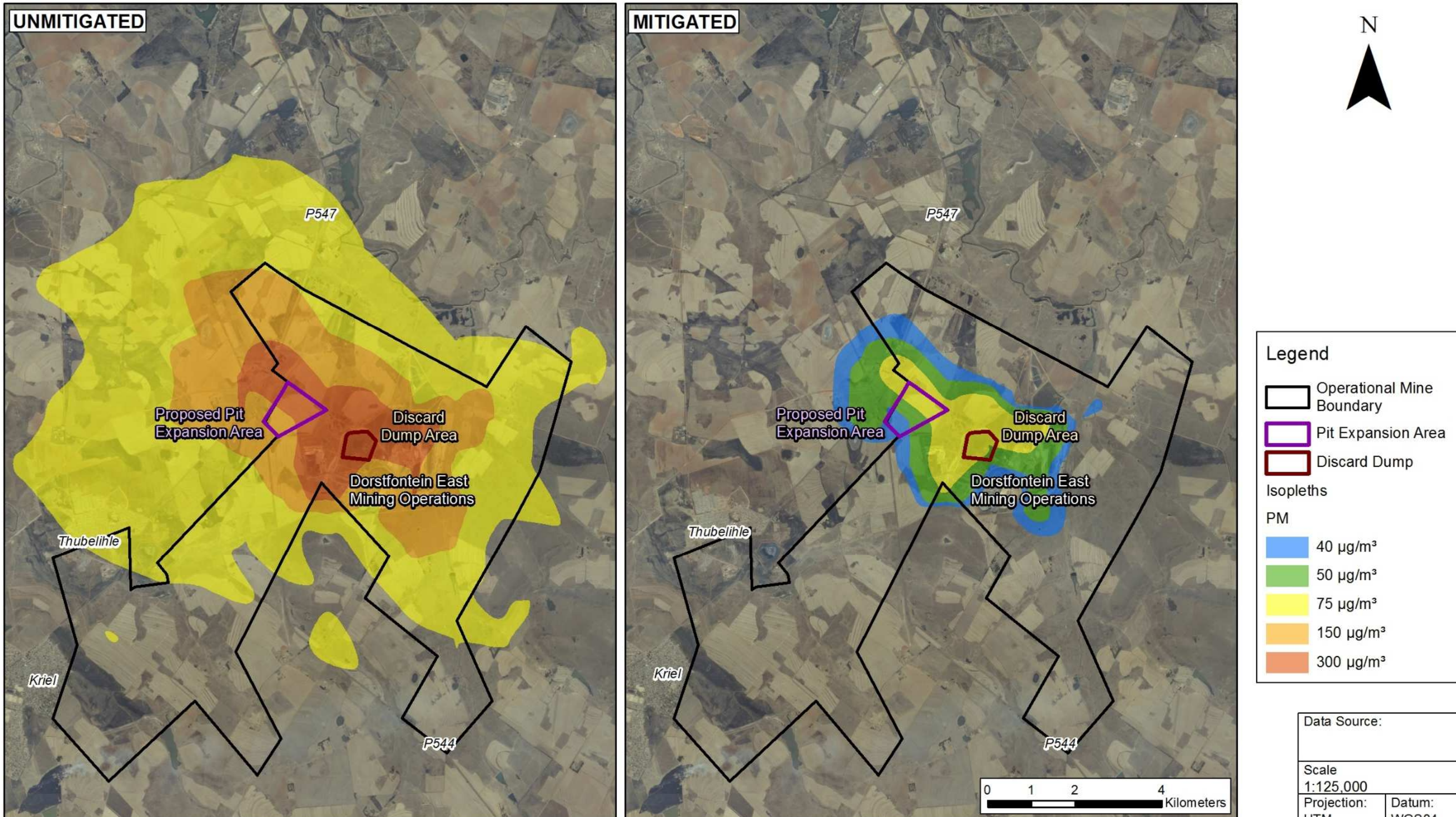
The PM_{10} dispersion modelling results for the proposed operations are presented in Table 7-1. Predicted concentrations at the receptors identified in close proximity have also been included.

Without management: The maximum predicted 99th percentile 24-hr PM_{10} concentration for the scenario with management is 646 µg/m³ (Figure 7-1). This concentration is observed to be c.481 meters to the northeast of the discard dump which is within the boundary of the mining area. The maximum predicted 99th percentile PM_{10} concentration is above the South African Standard of 75 µg/m³. The PM_{10} concentrations decrease to below 75 µg/m³ with distance from the mine area. The annual predicted PM_{10} concentration of 85 µg/m³ is above the NAAQS of 40 µg/m³ (Figure 7-2). Predicted 99th percentile and annual PM_{10} concentrations at the sensitive receptors i.e. Kriel, Thubelihle and Boskrans, are presented in Table 7-1. Predicted concentrations at Thubelihle and Boskrans exceed the 24 hour NAAQS of 75 µg/m³. It should be noted that the scenario without management represents a worst case scenario.

With management: Based on information received from the client, it is expected that management measures will be implemented at the mine during the proposed project. The maximum predicted 99th percentile PM_{10} concentration with management measures in place decreases to 129 µg/m³. The maximum concentration also occurs to the northeast of the discard dump. The concentration is above the South African standard of 75 µg/m³, however concentrations above 75 µg/m³ only occur on-site. Predicted PM_{10} concentrations decrease to levels well below the NAAQS. Predicted concentrations will continue to decrease to concentrations that are low to negligible beyond the boundaries of the mine. Predicted annual concentrations are also below the NAAQS, with concentrations at the receptors decreasing with management. Maximum predicted 99th percentile concentrations at the sensitive receptors decrease to levels well below the 24 and annual NAAQS.

Table 7-1: Predicted PM_{10} concentrations at selected receptor locations for the proposed project

PM_{10}			Without management		With Management	
			24 hour (99^{th})	Annual	24 hour (99^{th})	Annual
Units			**µg/m^3**	**µg/m^3**	**µg/m^3**	**µg/m^3**
Maximum predicted concentration			646	85	129	16
Village	Coordinates		24 hour	Annual	24 hour	Annual
	X	Y				
Kriel	726055	7094102	28	3	5	1
Thubelihle	728971	7098402	111	10	20	2
Boskrans	738150	7096354	96	6	19	1
South African Standard			**75**	**40**	**75**	**40**



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Date: 18/04/2017	Compiled by: DAVA
Project No. 499507	Fig No. 7-1

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DORSTFONTEIN EAST: AIR QUALITY IMPACT ASSESSMENT

MAXIMUM PREDICTED 99th PERCENTILE PM_{10} CONCENTRATIONS FOR THE PROPOSED PROJECT

Path: G:\499507_Doorstfontein_AQIA_assisting_PTA\8GIS\GISPROJ\MXD\13072017\499507_F7_1_Dorst_East_AQIA_PM10_A4L_C_13072017.mxd

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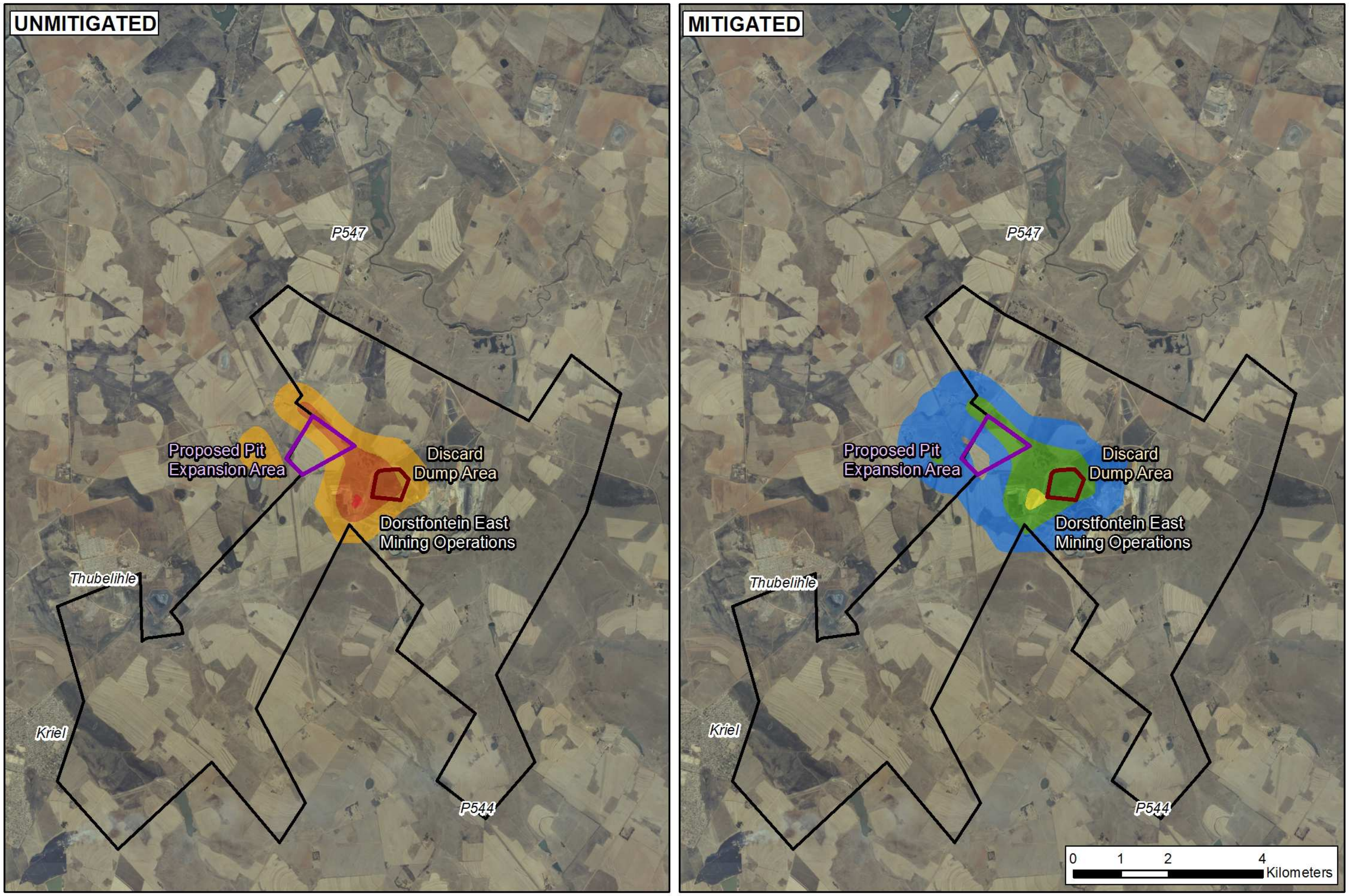

N

Legend

- Operational Mine Boundary
- Pit Expansion Area
- Discard Dump

Isopleths

PM

- 5 µg/m³
- 10 µg/m³
- 15 µg/m³
- 40 µg/m³
- 60 µg/m³
- 80 µg/m³

Data Source:	
Scale 1:125,000	
Projection: UTM	Datum: WGS84
Central Meridian/Zone: Zone 35S	
Date: 18/04/2017	Compiled by: DAVA
Project No. 499507	Fig No. 7-2

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DORSTFONTEIN EAST: AIR QUALITY IMPACT ASSESSMENT

MAXIMUM PREDICTED ANNUAL PM_{10} CONCENTRATIONS FOR THE PROPOSED PROJECT

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Revision: A Date: 13 07 2017

7.2 PM2.5

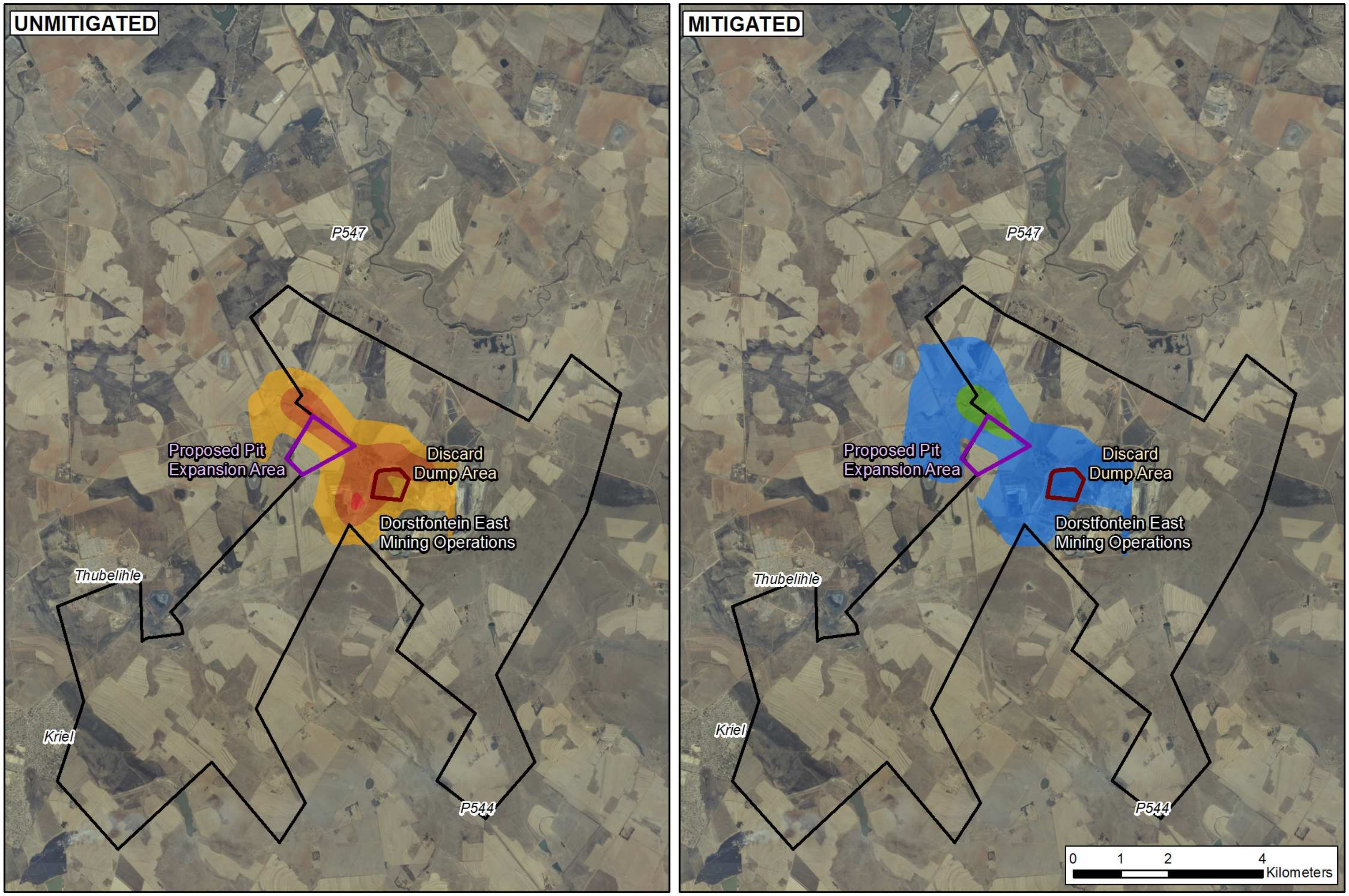
The $PM_{2.5}$ dispersion modelling results for the proposed project are presented in Table 7-2. Predicted concentrations at the receptors identified in close proximity have also been included.

Without management: The maximum predicted 99th percentile 24-hr $PM_{2.5}$ concentration for the scenario with management is 86.4 µg/m³ (Figure 7-3). This concentration is observed to be c.571 m to the southwest of the discard dump. The maximum predicted 99th percentile $PM_{2.5}$ concentration is above the South African Standard of 40 µg/m³. The $PM_{2.5}$ concentrations decrease to levels below 40 µg/m³ within the mine footprint and the plume disperses adequately so as to not have an impact on any sensitive receptors. The annual predicted $PM_{2.5}$ concentration of 15.3 µg/m³ is below the NAAQS of 20 µg/m³. Predicted concentrations at the sensitive receptors are below the 24 hour NAAQS of 40 µg/m³. It should be noted that the scenario without management represents a worst case scenario.

With management: The maximum predicted 99th percentile $PM_{2.5}$ concentration with management is 15.05 µg/m³. The maximum concentration occurs to the northeast of the proposed open pit. The concentration is below the South African standard of 40 µg/m³. The $PM_{2.5}$ footprint around the proposed activities decreases with management. Predicted concentrations will continue to decrease to concentrations that are low to negligible beyond the boundaries of the mine. Predicted annual concentrations are also below the NAAQS, with concentrations at the receptors decreasing with management.

Table 7-2: Predicted $PM_{2.5}$ concentrations for the proposed project

$PM_{2.5}$			**Without management**		**With Management**	
			24 hour (99th)	**Annual**	**24 hour (99th)**	**Annual**
Units			**µg/m^3**	**µg/m^3**	**µg/m^3**	**µg/m^3**
Maximum predicted 99th percentile			86.4	15.3	15.0	1.7
Village	Coordinates		24 hour	Annual	24 hour	Annual
	X	Y				
Kriel	726055	7094102	4.3	0.4	0.7	0.1
Thubelihle	728971	7098402	15.2	1.5	2.5	0.2
Boskrans	738150	7096354	11.8	0.9	1.9	0.1
South African Standard			**40**	**20**	**40**	**20**



N

Legend

- Operational Mine Boundary
- Pit Expansion Area
- Discard Dump

Isopleths

PM

- 5 µg/m³
- 10 µg/m³
- 15 µg/m³
- 40 µg/m³
- 60 µg/m³
- 80 µg/m³

Data Source:	
Scale 1:125,000	
Projection: UTM	Datum: WGS84
Central Meridian/Zone: Zone 35S	
Date: 18/04/2017	Compiled by: DAVA
Project No. 499507	Fig No. 7-3

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DORSTFONTEIN EAST: AIR QUALITY IMPACT ASSESSMENT

MAXIMUM PREDICTED 99th PERCENTILE $PM_{2.5}$ CONCENTRATIONS FOR THE PROPOSED PROJECT

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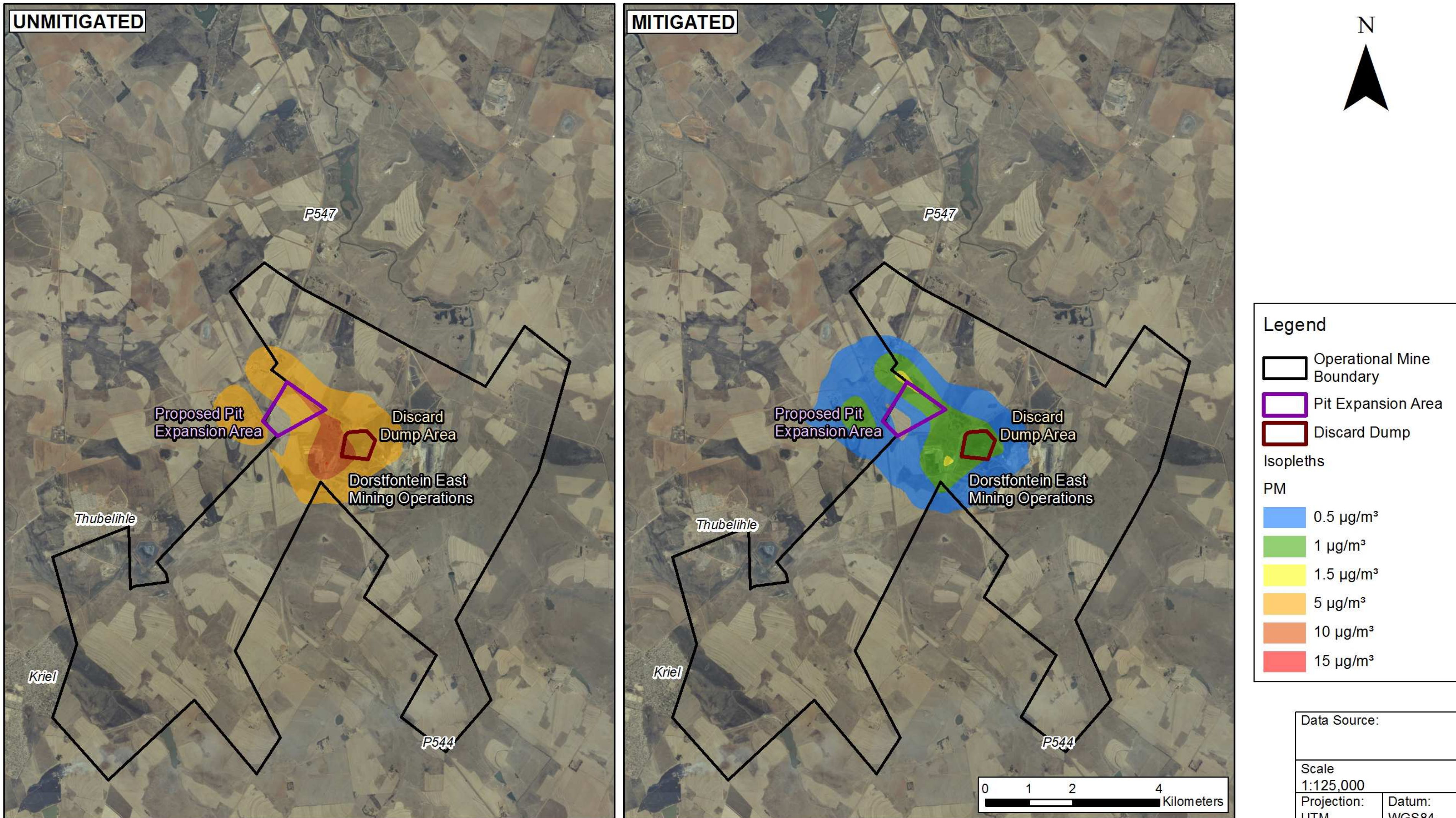
Revision: A Date: 13 07 2017



Data Source:

Scale 1:125,000

Projection: UTM | Datum: WGS84

Central Meridian/Zone: Zone 35S

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DORSTFONTEIN EAST: AIR QUALITY IMPACT ASSESSMENT

MAXIMUM PREDICTED ANNUAL $PM_{2.5}$ CONCENTRATIONS FOR THE PROPOSED PROJECT

Date: 18/04/2017	Compiled by: DAVA
Project No. 499507	Fig No. 7-4

Path: G:\499507_Doorstfontein_AQIA_assisting_PTA\8GIS\GISPROJ\MXD\13072017\499507_F7_4_Dorst_East_AQIA_Annual_PM2_5_A4L_C_13072017.mxd

Revision: A Date: 13 07 2017

7.3 Dust Fallout

The dust fallout dispersion modelling results for the proposed project are presented in Table 7-3. Predicted concentrations at the receptors identified in close proximity have also been included.

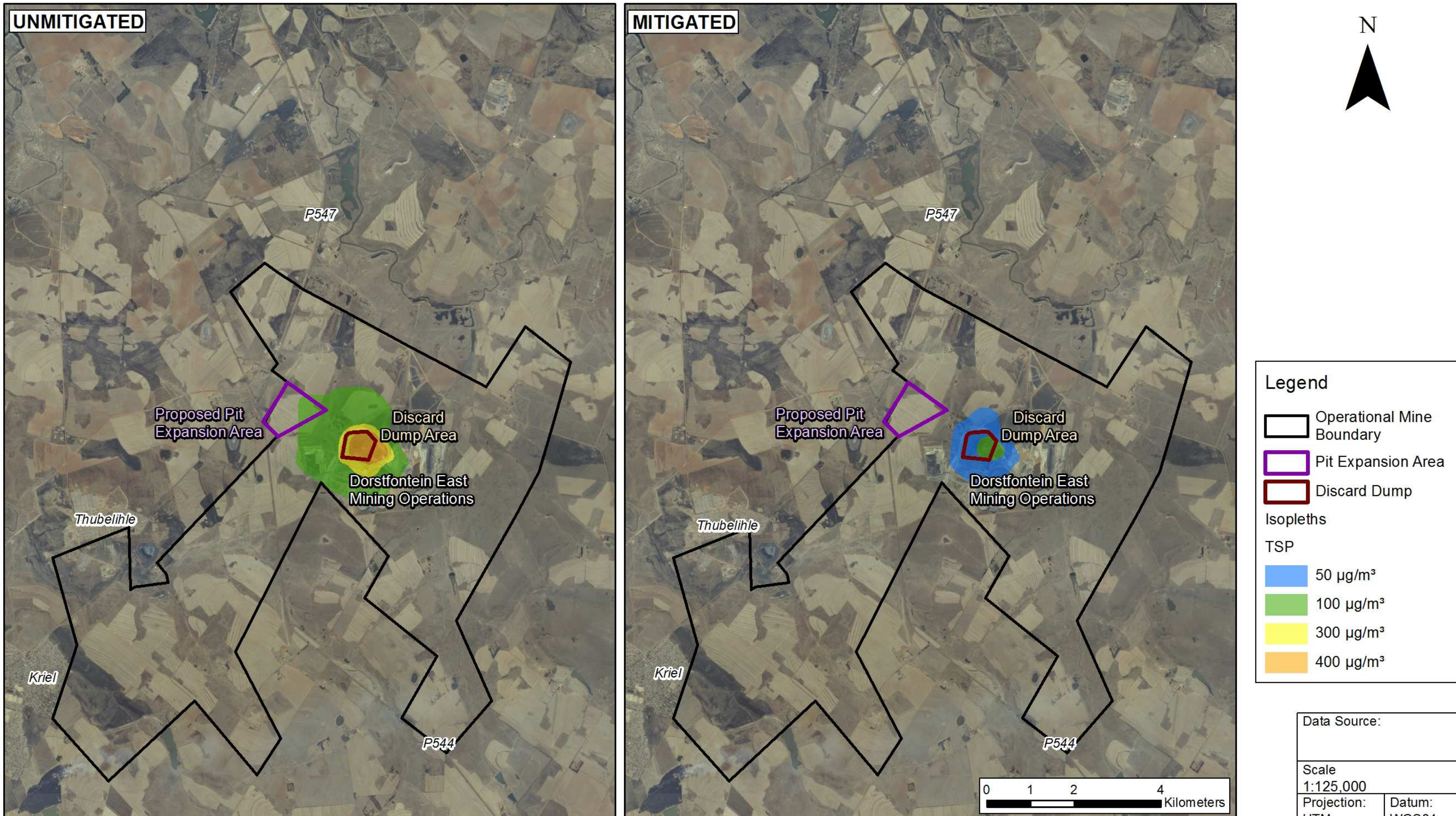
Without management: The maximum predicted dust fallout concentration for the scenario with management is 651 mg/m^2/day (Figure 7-3). The maximum predicted concentration occurs at monitoring point DDES05. The maximum predicted dust fallout concentration is below the National Dust Control Regulations (NDCR) Non-residential Area Standard of 1,200 mg/m^2/day. The dust fallout concentrations decrease within the footprint of the road and the plume disperses adequately so as to not have an impact on any sensitive receptors. Predicted dust fallout concentrations at the sensitive receptors are below the NDCR Residential Area standard of 1,200 mg/m^2/day at all receptors. At the towns of Kriel, Thubelihle and Boskrans, the predicted 24 hour dust fallout concentrations are well below the NCDR.

With management: The maximum predicted dust fallout concentration with management is 136 mg/m^2/day. The maximum concentration also occurs at monitoring point DDES05. The concentration is below the NDCR Non-residential area standard of 1,200 mg/m^2/day. The dust fallout footprint around the road decreases with management. Predicted concentrations will continue to decrease to concentrations that are low to negligible beyond the boundaries of the mine. Predicted concentrations at the receptors decrease with management.

Table 7-3: Predicted dust fallout concentrations

Dust fallout			**Without management**	**With management**
			24 hour	**24 hour**
Units			**mg/m^2/day**	**mg/m^2/day**
Maximum predicted concentration			651	136
Village	Coordinates		24 hour	24 hour
	X	Y		
Kriel	726055	7094102	2	1
Thubelihle	728971	7098402	11	2
Boskrans	738150	7096354	12	2
DDES01	733613	7098972	71	16
DDES02	734247	7098417	62	14
DDES03	734666	7098209	73	16
DDES04	735286	7099027	90	20
DDES05	734834	7099927	651	136
DDES06	735174	7100393	99	22
DDES07	735820	7100993	30	7
DDES08	736128	7100826	17	4
DDES09	735302	7100963	65	15
DDES10	734984	7101126	104	24
DDES11	735466	7102136	31	7
DDES12	737123	7100952	11	2
DDES13	732935	7098373	42	9
DDES14	732196	7098478	27	6

Dust fallout			Without management	With management
			24 hour	24 hour
Units			mg/m²/day	mg/m²/day
DDES15	731587	7098220	15	3
DDED01	732370	7100011	61	14
NDCR Residential Area Limit			600	600
NDCR Non-residential Area Limit			1,200	1,200



Data Source:	
Scale 1:125,000	
Projection: UTM	Datum: WGS84
Central Meridian/Zone: Zone 35S	
Date: 18/04/2017	Compiled by: DAVA
Project No. 499507	Fig No. 7-5

srk consulting

DORSTFONTEIN EAST: AIR QUALITY IMPACT ASSESSMENT

MAXIMUM PREDICTED 99th PERCENTILE DUST FALLOUT CONCENTRATIONS FOR THE PROPOSED PROJECT

Path: G:\499507_Doorstfontein_AQIA_assisting_PTA\8GIS\GISPROJ\MXD\13072017\499507_F7_5_Dorst_East_AQIA_Annual_TSP_A4L_C_13072017.mxd

Revision: A Date: 13 07 2017

8 Impact Assessment

The impact assessment focuses on the proposed operational phases of the project. The change in air quality as a result of a change in ambient PM_{10}, $PM_{2.5}$ and dust fallout levels during the proposed operational phase of the mine were the only impacts that were assessed.

Residents in the towns surrounding the mining areas are the potential sensitive receptors for this study. This includes the surrounding towns of Kriel, Thubelihle and Boskrans.

The impact assessment methodology used for this study was provided by SRK. The significance of the impacts was assessed according to the following criteria:

- Severity – magnitude or intensity.
- Duration (temporal influence) – Temporal influence.
- Spatial scope – Scale.

8.1 Methodology

Table 8-1: Criteria for Assessing Significance of Impacts

SEVERITY OF IMPACT (magnitude)	**RATING**
Insignificant / non-harmful	1
Small / potentially harmful	2
Significant / slightly harmful	3
Great / harmful	4
Disastrous / extremely harmful	5

SPATIAL SCOPE OF IMPACT (Extent)	**RATING**
Activity specific	1
Mine specific (within the mine boundary)	2
Local area	3
Regional	4
National	5

DURATION OF IMPACT (temporal scale)	**RATING**
One day to one month	1
One month to one year	2
One year to ten years	3
Life of operation	4
Post closure / permanent	5

CONSEQUENCE

FREQUENCY OF ACTIVITY / DURATION OF ASPECT	**RATING**
Annually or less / low	1
6 monthly / temporary	2
Monthly / infrequent	3
Weekly / life of operation / regularly / likely	4
Daily / permanent / high	5

FREQUENCY OF IMPACT	**RATING**
Almost never / almost impossible	1
Very seldom / highly unlikely	2
Infrequent / unlikely / seldom	3
Often / regularly / likely / possible	4
Daily / highly likely / definitely	5

LIKELIHOOD (Probability)

Table 8-2: Interpretation of Impact Rating

Consequence

Likelihood

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
10	20	30	40	50	60	70	80	90	100	110	120	1	140	150

	High	76 to 150	Improve current management
	Medium High	40 to 75	Maintain current management
	Medium Low	26 to 39	
	Low	1 to 25	No management required

SIGNIFICANCE = CONSEQUENCE x LIKELIHOOD

8.1.1 Construction

Impacts associated with dust (dust fallout, PM_{10} and $PM_{2.5}$) – no management measures

The impact is considered to be of low significance before management and determined as follows:

- **Severity:** The severity of the impact is insignificant as the expected emissions of dust and expected contribution to ambient air quality during the construction phase for the proposed project should be below the NAAQS and NDCR. The impacts will be closer to construction activities and will decrease further away. Towns and surrounding farms in range of the construction activities will not be impacted as the expected contribution to levels of dust are expected to be low.
- **Spatial:** The impact will be activity specific as the dust concentrations will occur around the sources and decrease significantly away from the operational activities.
- **Duration:** Dust emissions are expected to impact from one month to a year and mainly during the dry season. The wet season may act as a natural mitigation measure, hence the duration of the impact is over a shorter period; however the effectiveness of this will need to be determined.
- **Frequency of activity:** The activity will occur for a set period as it only involves the construction phase of the project.
- **Frequency of impact:** The impact will be highly unlikely as dust generated may be of low concentrations.

Impacts associated with dust (dust fallout, PM_{10} and $PM_{2.5}$) – with management measures

The impact is considered to be of low significance after management and determined as follows:

- **Severity:** The severity of the impact is insignificant as the expected emissions of dust and expected contribution to ambient air quality during the construction phase for the proposed project with management will be below the NAAQS and NDCR. The impacts will be closer to construction activities and will decrease further away. Towns and surrounding farms in range of the construction activities will not be impacted as the expected contribution to levels of dust are expected to be low.

- **Spatial:** The impact will be activity specific as the dust concentrations will occur around the sources and decrease significantly away from the operational activities.
- **Duration:** Dust emissions are expected to impact from one month to a year and mainly during the dry season. The wet season will act as a natural mitigation measure, hence the duration of the impact is over a shorter period.
- **Frequency of activity:** The activity will occur for a set period as it only involves the construction phase of the project.
- **Frequency of impact:** The impact will be highly unlikely because dust generated may be of low concentrations.

Table 8-3: Impacts during the construction phase

Impact	Consequence			Likelihood		Significance Rating	Mitigation Rating
	Severity	Spatial	Duration	Frequency of Activity	Frequency of Impact		
Impact before management	1	1	2	3	2	20	Low
Key management measures: • Regular irrigation by water especially during windy conditions at the site, access road and construction material and debris with just enough moisture to keep the dust down without creating significant runoff. Should water not be available as a result of drought conditions then chemical suppressants need to be considered. • Reduction of speed on unpaved roads to reduce the entrainment of dust into the atmosphere. • During grading activities, any exposed earth should be watered if it is going to be exposed for long periods. • If dust generating material such as soil, waste rock is hauled from the site, vehicles should be covered with a tarpaulin to reduce spillages. • On windy days, or when fugitive dust is dispersed from the Site of Works, additional application of water to the affected areas should be applied.							
Impact after management	1	1	2	3	2	20	Low

8.2 Operational phase

Impacts associated with dust (dust fallout, PM_{10} and $PM_{2.5}$) – No management measures

The impact is considered to be of medium-high significance before management and determined as follows:

- **Severity:** The severity of the impact is significant because the expected emissions of dust and expected contribution to ambient air quality during the operational phase are above the 24 hour NAAQS for PM_{10} and $PM_{2.5}$, however below the NDCR for dust pollutants. The impacts are closer to operational activities and decrease further away. Towns and surrounding farms in range of the operational activities but will not be impacted as the expected contribution to levels of dust is not harmful.
- **Spatial:** The impact will be local area specific as the predicted dust concentrations are above the NAAQS for PM_{10} beyond the fence line of the mine.
- **Duration:** PM_{10} and $PM_{2.5}$ emissions are expected to impact from one month to a year and mainly during the dry season. The wet season will act as a natural mitigation measure, hence the duration of the impact is over a shorter period.
- **Frequency of activity:** The activity will occur during the life of operation of the mine as there will always be exposed areas and dust generating activities at the mine that will allow dust to be emitted into the atmosphere.
- **Frequency of impact:** The impact will be often because the predicted concentrations are significantly higher than the NAAQS.

Impacts associated with dust (dust fallout, PM_{10} and $PM_{2.5}$) – With management measures

The impact is considered to be of low significance after management determined as follows:

- **Severity:** The severity of the impact is insignificant as the expected emissions of dust and expected contribution to ambient air quality during the operational phase for are low and below the 24 hour NAAQS and the NDCR for dust pollutants beyond the fenceline of the mine. The impacts are closer to operational activities and decrease further away. Towns and surrounding farms in range of the operational activities will not be impacted as the expected contribution to levels of dust is not harmful.
- **Spatial:** The impact will be activity specific as the predicted dust concentrations occur around the source but decrease significantly away from the operational activities.
- **Duration:** PM_{10} and $PM_{2.5}$ emissions are expected to impact from one day to one month and mainly during the dry season. The wet season will act as a natural mitigation measure, hence the duration of the impact is over a shorter period.
- **Frequency of activity:** The activity will occur during the life of operation of the mine as there will always be exposed areas and dust generating activities at the mine that will allow dust to be emitted into the atmosphere.

  Frequency of impact: The impact will be almost impossible as the low levels that are currently observed are well below the NAAQS standards and NDCR.

Table 8-4: Impacts during the operational phase

<table>
<tr><th rowspan="2">Impact</th><th colspan="3">Consequence</th><th colspan="2">Likelihood</th><th rowspan="2">Significance Rating</th><th rowspan="2">Mitigation Rating</th></tr>
<tr><th>Severity</th><th>Spatial</th><th>Duration</th><th>Frequency of Activity</th><th>Frequency of Impact</th></tr>
<tr><td>Impact before management</td><td>3</td><td>3</td><td>2</td><td>4</td><td>4</td><td>64</td><td>Medium-high</td></tr>
<tr><td colspan="8">Key management measures:
When and where applicable, soil stockpiles that will not be used should be re-vegetated as soon as possible, or kept wet during windy periods.
During the operational phases for the proposed project any bare ground surrounding the main operational area but within the boundaries of the facility must be covered with suitable vegetation that will be able to grow in the area.
When fugitive dust can be observed leaving the area, additional dust suppression should be applied to the affected areas.
If possible, additional dust monitoring equipment needs to be installed in order to effectively monitor dust related impacts from the proposed project area to the northwest and thereafter dust emissions can be managed better.
In places of high vehicular traffic on unpaved roads, dust suppression measures on the roads should be implemented to reduce dust levels from the entrainment of dust. These measures will range from watering of roads, application of a chemical dust suppressant where watering is impractical, and/or paving of roads.
Reduce the possibility of spillage from vehicles by ensuring all loads are covered, for example, with tarpaulin.
</td></tr>
<tr><td>Impact after management</td><td>1</td><td>1</td><td>1</td><td>4</td><td>1</td><td>20</td><td>Low</td></tr>
</table>

9 Conclusions and Recommendations

9.1 Conclusions

Based on the findings of this assessment the following were concluded:

- Based on the meteorological data from the on-site weather station, the climate in the project area is expected to be seasonal, with distinct warm months (September to February) and cool months (March to August). Rainfall is higher during the months from October to April and lower from May to September. The prevailing winds for this period are from the north, west-southwest and southeast, with lower occurrences from the east, east-southeast and south-southeast. The average wind speed measured for all hours is 4.47 m/s with maximum speeds less than 11.1 m/s and with calms (<0.5 m/s) of 1.72%.
- The monthly dust fallout concentrations shows that dust fallout concentration have exceeded the Residential Area limit of 600 $mg/m^2/day$ 361 times out of 1118 (32.3%) recorded dust fallout measurements. The Non-residential Area limit was exceeded 27 times out of 119 (22.7%) dust fallout measurements.
- The towns in the surrounding area i.e. Kriel, Tubelihle and Boskrans, have been identified as potential areas of impact, at the commencement of the study. The dispersion model was set up to predict PM_{10}, $PM_{2.5}$ and dust fallout concentrations from the proposed development at these towns and surrounding areas. Based on the nature of the activities and the dispersion modelling results, the receptors are unlikely to be impacted should management measures be implemented.
- With respect to dust (dust fallout, PM_{10} and $PM_{2.5}$) concentrations, the predicted emissions resulting from the proposed operations were determined to be medium-high without management and low with management measures in place. Dust fallout concentrations will not exceed the NDCR limits at the closest sensitive receptors.
- Based on the findings of this assessment the proposed project will result in dust generation, however, the concentrations will be low and below the NAAQS (PM_{10} and $PM_{2.5}$) and the NDCR (dust fallout) at the closest receptors, should management measures be implemented. Receptors in close proximity will not be impacted by the proposed project as impacts are predicted to be low beyond the boundary of the mine. In addition the peak concentrations are predicted to occur closer to the new activities.

9.2 Recommendations

Based on the findings of this assessment the following are recommended:

- Maintain the current monitoring network and where necessary make minor adjustments to accommodate the installation of new infrastructure from the proposed project.
  - In instances where activities change the monitoring network may be adjusted accordingly.
  - When the proposed project is operational an annual monitoring program should be maintained to determine whether the proposed project is having an impact on the surrounding environment with respect to dust fallout.
- A continuous PM_{10} and $PM_{2.5}$ monitor should be installed at the mine or if possible at sensitive receptors in close proximity to the mine.
- Conduct periodic independent audits of monitoring systems and the implementation of management plans to ensure that the system is maintained and that suitable data is obtained for decision making.
- When fugitive dust can be observed leaving the area additional dust suppression should be applied to the affected areas. The following mitigation measures are proposed and may be considered, if practicable, for the new activities:
  - Regular irrigation by water, especially during windy conditions at the site, of the access road and construction material and debris with just enough moisture to keep the dust down without creating runoff. Should water not be available then chemical suppressants need to be considered.
  - Reduction of speed on unpaved roads to reduce the entrainment of dust into the atmosphere.

- During grading activities, any exposed earth should be watered if it is going to be exposed for long periods, especially during windy conditions.
- On windy days, or when fugitive dust is dispersed from the Site of Works, additional application of water to the affected areas should be implemented.
- When and where applicable, soil stockpiles that will not be used should be re-vegetated as soon as possible, or kept wet during windy periods.
- During the operational phases for the proposed project any bare ground surrounding the main operational area but within the boundaries of the facility must be covered with suitable vegetation that will be able to grow in the area.
- When fugitive dust can be observed dispersing from the site, additional dust suppression should be applied to the affected areas.
- If possible, additional dust monitoring equipment needs to be installed in order to effectively monitor dust related impacts from the project area and thereafter dust emissions can be managed better.
- In places of high vehicular traffic on unpaved roads, dust suppression measures on the roads may be implemented to reduce dust levels from the entrainment of dust. These measures will range from watering of roads, application of a chemical dust suppressant where watering is impractical, and/or paving of roads.
- Reduce the possibility of spillage from vehicles by ensuring all loads are covered, for example, with tarpaulin.

Prepared by

D. Naidoo (Pr. Sci. Nat)

Senior Scientist

Reviewed by

V.S. Reddy (Pr. Sci. Nat)

Partner

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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Appendices

Appendix A: Quantification of emissions

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