|  |  |
| --- | --- |
|  |  |

**Air Quality Impact Assessment for the EIA for the proposed Beeshoek Mine Optimisation Project**

|  |  |
| --- | --- |
| **Prepared by:**  uMoya-NILU Consulting (Pty) Ltd  P O Box 20622, Durban North, 4016  Email: mark@umoya-nilu.co.za  Tel: 031 262 3265  Fax: 031 262 3266 | **Prepared for:**  EnviroGistics (Pty) Ltd  PO Box 22014, Helderkruin, 1733  Email:  [tanja@envirogistics.co.za](mailto:tanja@envirogistics.co.za)  Cell:  082 412 1799  Fax:  086 551 5233 |

****

**Report details:**

|  |  |
| --- | --- |
| Client: | EnviroGistics (Pty) Ltd |
| Report title: | Air Quality Impact Assessment for the EIA for the Beeshoek Mine Optimisation Project |
| Project number: | uMN375-19 |
| Report number: | uNN003-21 |
| Issued: | 17 June 2021 |
| Version: | Final (Revised) |

**Author details:**

|  |  |
| --- | --- |
| Author: | Mark Zunckel and Atham Raghunandan |

|  |
| --- |
| This report has been produced by uMoya-NILU Consulting (Pty) Ltd for EnviroGistics (Pty) Ltd on behalf of Assmang’s Beeshoek Iron Ore Mine. No part of the report may be reproduced in any manner without written permission from Assmang Limited, EnviroGistics (Pty) Ltd and uMoya-NILU Consulting (Pty) Ltd. |

When used as a reference, this report should be cited as follows:

|  |
| --- |
| uMoya-NILU (2021): Air Quality Impact Assessment for the EIA for the Beeshoek Mine Optimisation Project, No. uMN003-21, June 2021 |

# EXECUTIVE SUMMARY

Beeshoek is actively investigating opportunities for the continued and sustainable mining of iron ore reserves within the approved Mining Rights Area and has applied for Environmental Authorisation for several infrastructure improvement projects. EnviroGistics (Pty) Ltd has been appointed to conduct the EIA for the proposed projects. Beeshoek Mine’s application for Environmental Authorisation includes the following projects which have potential air quality impacts:

* Project 1: Consolidation of Run of Mine (ROM) Stockpiles on South Mine
* Project 2: Amendments to the design of existing Waste Rock Dumps (WRDs) in terms of the increase in heights, and allowance for final slope, which will result in extension of footprints
* Project 3: Increase of Opencast Footprint Areas, as well as the undertaking of detrital mining for shallow iron ore reserves, including transportation routes (Haul roads)
* Project 4: Development of the Beneficiation Project which will comprise of a WHIMS Plant and Jig Plant at Beeshoek

The total estimate emission of total suspended particulates (TSP) from Beeshoek Mine activities in 2019 was 5 224 tons (Table E-1). The estimate emission from PM10 was 1 545 tons in 2019 and for PM2.5 was 172 tons per annum. The largest source of particulates is vehicle entrainment from the mine roads. Assuming that mine roads are watered twice daily, approximately 90% of all TSP and PM10 emissions are attributed to the entrainment of dust by vehicles, and 80% of the PM2.5 emission. Crushing and screening is the second largest source of particulate emissions at Beeshoek, but it is relatively small and accounts for only 5.4% of the total TSP and PM10 emission. The total emission of particulates increases with the implementation of the optimisation projects (Table E-1).

Table E-1: Particulate emissions in tonnes per annum for the current year of assessment in 2019

|  |  |  |  |
| --- | --- | --- | --- |
| Mining activity | TSP | PM10 | PM2.5 |
| 2019 Emissions | **5 224** | **1 545** | **172** |
| Emissions post optimisation projects | **7 039** | **2 118** | **230** |

The US-EPA approved and DEFF recommended CALPUFF dispersion model was used to predict the ambient particulate concentrations and dust fallout rates from the four optimisation projects and from the Beeshoek Mine after their implementation.

The maximum predicted ambient PM10 and PM2.5 concentrations and TSP deposition for the optimisation projects and for Beeshoek Mine following their implementation are presented in Table E-2. In all cases the predicted maximum occurs close to the respective project site on the mine property. Exceedance of the NAAQS (shown in bold) are predicted for Project 3: Opencast Pits and result from haul road emissions. This contribution implies that the predicted ambient concentrations for Beeshoek Mine following the implementation of the projects are also exceeded at the point of maximum.

Table E-2: Maximum predicted annual average and 99th percentile of 24-hour PM10 and PM2.5 concentrations in μg/m3 and maximum dust fallout in mg/m2/day

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Annual PM10 | 24-hour PM10 | Annual PM2.5 | 24-hour PM2.5 | Dust fallout |
| Project 1: Consolidation of ROM stockpiles | 7.2 | 30 | 2.8 | 11.6 | 16.3 |
| Project 2: Amendments to WRDs | 1.4 | 4.4 | 0.2 | 0.7 | 2.8 |
| Project 3: Opencast footprints | **439** | **1 239** | **45** | **127** | **1 175** |
| Project 4: Beneficiation plant upgrade | 33 | 271 | 6.5 | 21 | 509 |
| Beeshoek Mine post improvements | **793** | **2 617** | **80** | **263** | **2 457** |

The predicted maximum ambient concentration at identified sensitive receptors are shown in Table E-3 and compared with the NAAQS. Noteworthy is that in all case they are well below the respective NAAQS at all sensitive receptors.

Table E-3: Predicted annual average and 99th percentile of 24-hour PM10 and PM2.5 concentrations in μg/m3 and dust fallout in mg/m2/day at sensitive reseptors

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Receptor | Annual PM10 | 24-hour PM10 | Annual PM2.5 | 24-hour PM2.5 | Dust fallout |
| Aukampsrus | 8.0 | 65.0 | 0.8 | 7.0 | 75 |
| Boichoco | 2.1 | 21.1 | 0.2 | 2.0 | 22 |
| Maranteng | 1.1 | 12.3 | 0.1 | 1.3 | 12 |
| Newtown | 1.4 | 14.7 | 0.2 | 1.5 | 15 |
| Postdene | 0.9 | 10.1 | 0.1 | 0.9 | 12 |
| Postmasburg-North | 1.1 | 13.0 | 0.1 | 1.3 | 13 |
| Postmasburg-South | 1.2 | 13.2 | 0.1 | 1.4 | 14 |
| NAAQS | 40 | 75 | 20 | 40 | 600 |

The following points on the predicted ambient PM10 concentrations are noteworthy:

* The predicted annual PM10 concentrations from Project 1 (ROM consolidation), Project 2 (WRD amendments) and Project 4 (beneficiation plants) are low and below the NAAQS. The highest concentrations for each of these source projects occur in the immediately vicinity of these individual sources.
* The predicted annual PM10 concentrations for Project 3 (pit expansion) exceed the NAAQS. The exceedances are predicted in the vicinity of the Village Pit and occur within the mine boundary. The relatively high predicted concentrations are a result of dust generated on the haul roads.
* The predicted annual PM10 concentrations resulting from emissions from all sources at the Beeshoek Mine following implementation of the optimisation projects exceed the NAAQS over most of the mine and extend a little beyond the southern and eastern boundary of the mine. The exceedances do not extend into any commercial or residential areas.

The following points on the predicted ambient PM2.5 concentrations are noteworthy:

* The predicted annual PM2.5 concentrations from Project 1 (ROM consolidation), Project 2 (WRD amendments) and Project 4 (beneficiation plants) are low and below the NAAQS. The highest concentrations for each of these source projects occur in the immediately vicinity of these individual sources.
* The predicted annual PM10 concentrations for Project 3 (pit expansion) exceed the NAAQS at the Village Pit. The relatively high predicted concentrations here are a result of dust generated on the haul roads.
* The predicted annual PM10 concentrations resulting from emissions from all sources at the Beeshoek Mine following implementation of the optimisation projects exceed the NAAQS over the Village Pit and the East Pit. The predicted exceedances occur within the mine boundary.

The following points on the predicted dust fallout rates are noteworthy:

* The predicted dust fallout resulting from Project 1 (ROM consolidation) and Project 2 (WRD amendments) and Project 4 (beneficiation plants) is low relative to standards and highest fallout rates occur in the immediately vicinity of these individual sources.
* The predicted dust fallout for Project 3 (pit expansion) is low relative to the national standard for non-residential areas. The highest fallout rates compare with the residential standard and occur in the immediate vicinity of the Village Pit where the non-residential standard is shown by the red line.
* The predicted dust fallout resulting from emissions from all sources at the Beeshoek Mine following implementation of the optimisation projects are relatively low and comply with the standard for residential areas. The only predicted exceedance of the non-residential standard occurs within the mine perimeter and over the Village Pit where the residential standard is also predicted to be exceeded. The dust fallout standard for residential areas is also predicted to be exceeded over the East Pit.

The significance of air quality impacts associated with the optimisation projects and for Beeshoek after the optimisation were assessed using the predicted ambient concentrations.

The impact significance for Project 1 (ROM consolidation), Project 2 (WRD amendments), and Project 4 (beneficiation plant) is considered low (Table E-3). The impact significance for Project 3 (pit expansion) is considered medium. For all activities at the Beeshoek Mine following the implementation of the optimisation projects is considered medium.

Table E-3: Air quality Impact Assessment summary scores

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Description | Pollutants | Extent | Intensity | Duration | Significance | Status |
| Project 1: ROM consolidation | PM10 | 1 | -1 | 3 | Low (-3) | -ve |
| PM2.5 | 1 | -1 | 3 | Low (-3) | -ve |
| Dust fallout | 1 | -1 | 3 | Low (-3) | -ve |
| Project 2: WRD amendments | PM10 | 1 | -1 | 3 | Low (-3) | -ve |
| PM2.5 | 1 | -1 | 3 | Low (-3) | -ve |
| Dust fallout | 1 | -1 | 3 | Low (-3) | -ve |
| Project 3: Opencast footprint | PM10 | 1 | -2 | 3 | Medium (-6) | -ve |
| PM2.5 | 1 | -1 | 3 | Low (-1) | -ve |
| Dust fallout | 1 | -1 | 3 | Low (-1) | -ve |
| Project 4: Beneficiation plant | PM10 | 1 | -1 | 3 | Low (-3) | -ve |
| PM2.5 | 1 | -1 | 3 | Low (-3) | -ve |
| Dust fallout | 1 | -1 | 3 | Low (-3) | -ve |
| Beeshoek Mine after optimisation | PM10 | 2 | -2 | 3 | Medium (-6) | -ve |
| PM2.5 | 2 | -1 | 3 | Low (-1) | -ve |
| Dust fallout | 2 | -1 | 3 | Low (-1) | -ve |

From an air quality perspective, it is the reasonable opinion of the authors that the Beeshoek Mine optimisation project should be authorised considering the findings of this assessment.

# ABBREVIATIONS AND ACRONYMS

µg/m3 micrograms per cubic metre

µm micrometres

CALPUFF California Puff Model

EPA United States Environmental Protection Agency

FDMP Fugitive Dust Management Plan

NO Nitrous oxide

NO2 Nitrogen dioxide

NOx Oxides of nitrogen

PM Particulate matter

PM10 Particulate matter of aerodynamic diameter less than 10 micrometres

PM2.5 Particulate matter of aerodynamic diameter less than 2.5 micrometres

ppb parts per billion

ppm parts per million

SO2 Sulphur dioxide

Ton 1,000 kilograms

t/a Tons per annum

TAPM The Air Pollution Model

TSP Total suspended particulates

WHO World Health Organisation

# TABLE OF CONTENTS

[EXECUTIVE SUMMARY i](#_Toc74924042)

[ABBREVIATIONS AND ACRONYMS v](#_Toc74924043)

[TABLE OF CONTENTS vi](#_Toc74924044)

[FIGURES vii](#_Toc74924045)

[TABLES viii](#_Toc74924046)

[1. INTRODUCTION 1](#_Toc74924047)

[2. DESCRIPTION OF THE PROJECT 2](#_Toc74924048)

[3. SCOPE OF WORK 5](#_Toc74924049)

[4. RELEVANT LEGISLATION 5](#_Toc74924050)

[4.1 Ambient air quality standards 6](#_Toc74924051)

[4.2 National dust control regulation 6](#_Toc74924052)

[4.3 Listed activities 7](#_Toc74924053)

[4.4 Emission reporting regulation 7](#_Toc74924054)

[5. POLLUTANTS OF CONCERN 7](#_Toc74924055)

[6. BASELINE CONDITIONS 8](#_Toc74924056)

[6.1 Climate description 8](#_Toc74924057)

[6.2 Ambient air quality 10](#_Toc74924058)

[6.3 Emissions 11](#_Toc74924059)

[7. ASSESSMENT METHODOLOGY 12](#_Toc74924060)

[7.1 Emission inventory 12](#_Toc74924061)

[7.2 Dispersion modelling 13](#_Toc74924062)

[7.2.1 Model selection 13](#_Toc74924063)

[7.2.2 TAPM and CALPUFF parameterisation 14](#_Toc74924064)

[7.2.3 Model scenarios 16](#_Toc74924065)

[7.2.4 Model accuracy 16](#_Toc74924066)

[7.3 Impact assessment methodology 17](#_Toc74924067)

[8. EMISSION INVENTORY 20](#_Toc74924068)

[9. DISPERSION MODELLING RESULTS 21](#_Toc74924069)

[9.1 Maximum predicted concentrations 21](#_Toc74924072)

[9.2 Predicted PM10 concentrations 23](#_Toc74924073)

[9.2.1 Annual concentrations 23](#_Toc74924074)

[9.2.2 24-hour concentrations 30](#_Toc74924075)

[9.3 Predicted PM2.5 concentrations 36](#_Toc74924076)

[9.3.1 Annual concentrations 36](#_Toc74924077)

[9.3.2 24-hour concentrations 42](#_Toc74924078)

[9.4 Predicted TSP deposition 48](#_Toc74924079)

[10. RECOMMENDATIONS DUST MINIMISATION FOR THE EMP FOR THE OPTIMISATION PROJECTS 54](#_Toc74924080)

[11. IMPACT ASSESSMENT 54](#_Toc74924081)

[11.1 Project 1: Consolidation of Run of Mine (ROM) Stockpiles on South Mine 54](#_Toc74924082)

[11.2 Project 2: Amendments to the existing Waste Rock Dumps (WRDs) 55](#_Toc74924083)

[11.3 Project 3: Increase of Opencast Footprint Areas 55](#_Toc74924084)

[11.4 Project 4: Development of the Beneficiation Project (Jig Plant) 56](#_Toc74924085)

[11.5 Beeshoek Mine after implementation of the optimisation projects 56](#_Toc74924086)

[12. SUMMARY AND CONCLUSION 58](#_Toc74924087)

[REFERENCES 61](#_Toc74924088)

# FIGURES

[Figure 1‑1: Local and regional setting of the surface operations (mine boundary in red), EnviroGistics (2021) 2](#_Toc74924089)

[Figure 6‑1: Average monthly maximum and minimum temperatures at Postmasburg and the average monthly rainfall (https://www.meteoblue.com) 9](#_Toc74924090)

[Figure 6‑2: Windrose for 2020 at Postmasburg with wind speed in m/s and frequency bands of 6% (data provided by SAWS) 9](#_Toc74924091)

[Figure 6‑3: Location of the dust fallout buckets at Beeshoek (DustWatch, 2019), the PM10/PM2.5 sampler and the SAWS weather station 10](#_Toc74924092)

[Figure 6‑4: Daily PM10 (top) and PM2.5 in July 2020 (bottom) concentrations measured at Beeshoek, showing the respective national ambient air quality standards 11](#_Toc74924093)

[Figure 7‑1: TAPM and CALPUFF modelling 15](#_Toc74924094)

[Figure 9‑1: Location of identified sensitive receptors 23](#_Toc74924095)

[Figure 9‑2: Predicted annual average ambient PM10 concentrations resulting from emissions from Project 1 in μg/m3 25](#_Toc74924096)

[Figure 9‑3: Predicted annual average ambient PM10 concentrations resulting from emissions from Project 2 in μg/m3 26](#_Toc74924097)

[Figure 9‑4: Predicted annual average ambient PM10 concentrations resulting from emissions from Project 3 in μg/m3 – the NAAQS are shown in red 27](#_Toc74924098)

[Figure 9‑5: Predicted annual average ambient PM10 concentrations resulting from emissions from Project 4 in μg/m3 28](#_Toc74924099)

[Figure 9‑6: Predicted annual average ambient PM10 concentrations resulting from emissions from all sources at Beeshoek after the optimisation projects in μg/m3 – the NAAQS are shown in red 29](#_Toc74924100)

[Figure 9‑7: 99th percentile of the predicted 24-hour ambient PM10 concentrations resulting from emissions from Project 1 in μg/m3 31](#_Toc74924101)

[Figure 9‑8: 99th percentile of the predicted 24-hour ambient PM10 concentrations resulting from emissions from Project 2 in μg/m3 32](#_Toc74924102)

[Figure 9‑9: 99th percentile of the predicted 24-hour ambient PM10 concentrations resulting from emissions from Project 3 in μg/m3 – the NAAQS are shown in red and the permitted number of exceedances per annum of the limit value (12) is shown in blue 33](#_Toc74924103)

[Figure 9‑10: 99th percentile of the predicted 24-hour ambient PM10 concentrations resulting from emissions from Project 4 in μg/m3 – the NAAQS are shown in red and the permitted number of exceedances per annum of the limit value (12) is shown in blue 34](#_Toc74924104)

[Figure 9‑11: 99th percentile of the predicted 24-hour ambient PM10 concentrations resulting from emissions from all sources at Beeshoek after the optimisation projects in μg/m3 – the NAAQS are shown in red and the permitted number of exceedances per annum of the limit value (12) is shown in blue 35](#_Toc74924105)

[Figure 9‑12: Predicted annual average ambient PM2.5 concentrations resulting from emissions from Project 1 in μg/m3 37](#_Toc74924106)

[Figure 9‑13: Predicted annual average ambient PM2.5 concentrations resulting from emissions from Project 2 in μg/m3 38](#_Toc74924107)

[Figure 9‑14: Predicted annual average ambient PM2.5 concentrations resulting from emissions from Project 3 in μg/m3 – the NAAQS are shown in red 39](#_Toc74924108)

[Figure 9‑15: Predicted annual average ambient PM2.5 concentrations resulting from emissions from Project 4 in μg/m3 40](#_Toc74924109)

[Figure 9‑16: Predicted annual average ambient PM2.5 concentrations resulting from emissions from all sources at Beeshoek after the optimisation projects in μg/m3 – the NAAQS are shown in red 41](#_Toc74924110)

[Figure 9‑17: 99th percentile of the predicted 24-hour ambient PM2.5 concentrations resulting from emissions from Project 1 in μg/m3 43](#_Toc74924111)

[Figure 9‑18: 99th percentile of the predicted 24-hour ambient PM2.5 concentrations resulting from emissions from Project 2 in μg/m3 44](#_Toc74924112)

[Figure 9‑19: 99th percentile of the predicted 24-hour ambient PM2.5 concentrations resulting from emissions from Project 3 in μg/m3 – the NAAQS are shown in red 45](#_Toc74924113)

[Figure 9‑20: 99th percentile of the predicted 24-hour ambient PM2.5 concentrations resulting from emissions from Project 4 in μg/m3 46](#_Toc74924114)

[Figure 9‑21: 99th percentile of the predicted 24-hour ambient PM2.5 concentrations resulting from emissions from all sources at Beeshoek after the optimisation projects in μg/m3 – the NAAQS are shown in red 47](#_Toc74924115)

[Figure 9‑22: Predicted dust fallout rate resulting from emissions from Project 1 in mg/m2/day 49](#_Toc74924116)

[Figure 9‑23: Predicted dust fallout rate resulting from emissions from Project 2 in mg/m2/day 50](#_Toc74924117)

[Figure 9‑24: Predicted dust fallout rate resulting from emissions from Project 3 in mg/m2/day – the dust fallout standard for residential areas is shown in red 51](#_Toc74924118)

[Figure 9‑25: Predicted dust fallout rate resulting from emissions from Project 4 in mg/m2/day 52](#_Toc74924119)

[Figure 9‑26: Predicted dust fallout rate resulting from emissions from all sources at Beeshoek after the optimisation projects in mg/m2/day – the dust fallout standard for residential and non-residential areas are shown in red and blue respectively 53](#_Toc74924120)

# TABLES

[Table 2‑1: Description of optimisation projects 3](#_Toc74924121)

[Table 4‑1: NAAQS for PM10 (DEA, 2009) and PM2.5 (DEA, 2012) in μg/m3 6](#_Toc74924122)

[Table 4‑2: National limit values for dust fallout rates in mg/m2/day as 30-day average (DEA, 2013) 6](#_Toc74924123)

[Table 6‑1: Particulate emissions in tonnes per annum for the current year of assessment in 2019 12](#_Toc74924124)

[Table 6‑2: Particulate emissions in tonnes per annum for 2018 and 2019 12](#_Toc74924125)

[Table 7‑1: Parameterisation of key variables in CALMET 17](#_Toc74924126)

[Table 7‑2: Parameterisation of key variables in CALPUFF 17](#_Toc74924127)

[Table 7‑3: Impact parameter definitions 18](#_Toc74924128)

[Table 7‑4: Impact magnitude and significance 19](#_Toc74924129)

[Table 8‑1: Particulate emissions from the optimisation projects and Beeshoek Mine after project implementation in tonnes per annum 20](#_Toc74924130)

[Table 8‑2: Percentage contribution to the total Beeshoek Mine emission 21](#_Toc74924131)

[Table 9‑1: Maximum predicted annual average and 99th percentile of 24-hour PM10 and PM2.5 concentrations in μg/m3 and maximum dust fallout in mg/m2/day 22](#_Toc74924132)

[Table 9‑2: Predicted annual average and 99th percentile of 24-hour PM10 and PM2.5 concentrations in μg/m3 and dust fallout in mg/m2/day at sensitive reseptors 22](#_Toc74924133)

[Table 11‑1: Air quality Impact Assessment summary scores 57](#_Toc74924134)

# INTRODUCTION

Beeshoek is situated in the Northern Cape in the Tsantsabane Local Municipality, with Postmasburg the closest town located 7 km east of the mine (Figure 1-1). Assmang (Pty) Ltd is the holder of the new order rights in terms of the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA) in respect of high-grade hematite iron ore deposits at Beeshoek on the farms Beeshoek and Olynfontein.

Mining at Beeshoek was established in 1964 with a basic hand sorting operation. In 1975 a full Washing and Screening Plant was installed. Because of increased production, Beeshoek South, a southern extension of the Beeshoek Mine, was commissioned during 1999 on the farms Beeshoek and Olynfontein. Currently the mining method entails an opencast mining operation, which consists of five (5) active opencast pits (Village Opencast Pit, HF Opencast Pit, BF Opencast Pit, East Opencast Pit, and BN Opencast Pit). Although other opencast pits are currently, these are continuously assessed in terms of their economic value. The current resources of the Mine are approximately 87 million tonnes with a reserve of about 26 million tonnes.

Beeshoek can be categorised into three areas, i.e.:

* Northern mining area (North Mine) which comprises active and historical mining areas with several small quarries and mine residue dumps of various categories. The area also includes the existing iron ore beneficiation plant, tailings storage facility (slimes dam), as well as the North Opencast Pit (BN Opencast Pit).
* Main Offices and recreational area.
* Southern mining area (South Mine) which comprises large opencast pits and associated Waste Rock Dumps (WRDs). The Village Opencast Pit and associated WRD are the main activities in this area. This area also includes a crushing and screening area as pre-preparation of the Run of Mine (ROM) iron ore before being routed by overland conveyor to the Iron Ore Beneficiation Plant located at North Mine.

Beeshoek is actively investigating opportunities for the continued and sustainable mining of iron ore reserves within the approved Mining Rights Area and has applied for Environmental Authorisation for several infrastructure improvement projects. EnviroGistics (Pty) Ltd has been appointed to conduct the EIA for the proposed projects. In turn, uMoya-NILU has been sub-contracted to undertake the supporting air quality assessment.

|  |
| --- |
|  |
| Figure 1‑1: Local and regional setting of the surface operations (mine boundary in red), EnviroGistics (2021) |

# DESCRIPTION OF THE PROJECT

Beeshoek Mine’s application for Environmental Authorisation includes the following projects:

* Project 1: Consolidation of Run of Mine (ROM) Stockpiles on South Mine
* Project 2: Amendments to the design of existing Waste Rock Dumps (WRDs) in terms of the increase in heights, and allowance for final slope, which will result in extension of footprints
* Project 3: Increase of Opencast Footprint Areas, as well as the undertaking of detrital mining for shallow iron ore reserves, including transportation routes (Haul roads)
* Project 4: Development of the Beneficiation Project which will comprise of a WHIMS Plant and Jig Plant at Beeshoek
* Project 5: Water Management

The projects are described in Table 2‑1 and the potential air quality impacts are highlighted.

Table 2‑1: Description of optimisation projects

| **NAME OF ACTIVITY** | **Aerial extent of the Activity (Ha or m²)** | **Air quality impacts** |
| --- | --- | --- |
| **Project 1: Consolidation of Run of Mine (ROM) Stockpiles on South Mine** | The ROM stockpile area on South Mine will be demarcated as a combined ROM stockpile area for both on-grade, off-grade and BIS. Overall Area is 35 ha.  No clearance of vegetation is required; this area is located on the north-eastern perimeter of the West Pit WRD in a legally disturbed area.  The current WUL allows for the following ROM deposition on the stockpile, note that the deposition of ROM will not increase in annual throughput:   * South Contaminated ROM 1: 4 450 000 t/a * South Contaminated ROM 2 Off-Grade ROM Stockpile, including BIS: 1 920 000 t/a * ROM Stockpile: 720 000 t/a | Potential for increased ambient PM concentrations and dust fall out from construction, operations from vehicle and wind entrainment |
| **Project 2: Amendments to the design of existing Waste Rock Dumps (WRDs) in terms of the increase in heights, and allowance for final slope, which will result in extension of footprints** | * *Village Waste Rock Dump (VP1):* Village Pit North Waste Rock Dump (VP1): Current area approximate 70 ha, to be increased with approximately 26 ha (final area 96 ha) to allow for final slope and footprint upon rehabilitation (area pending designs, but will involve clearance of about 25 ha) – this will also remove the required Storm Water Dam, which was a recommendation in its associated EMPr for the Village Pit WRD EMPr, but has as yet not been constructed, due to the low run-off in this area and subsequent storm water management studies - The decommissioning of the SWD will not trigger a listed activity as the “active activity” does not entail an “operational component”). Planned operational height is 111 m (upon rehabilitation 112 m). * *GF Waste Rock Dump:* Current area approximately 48 ha, to be increased by about 6ha (final area about 54 ha) to allow for final slope and footprint upon rehabilitation (area pending designs). Based on the location of this WRD between the Discard Dump and the existing Slimes Dam it is unlikely that any clearance will be triggered. Planned operational height is 82 m (upon rehabilitation 84 m). * *East Pit Waste Rock Dump:* Current area approximately 144 ha, to be increased by about 26 ha (final area about 170 ha) to allow for final slope and footprint upon rehabilitation (area pending designs, but will involve clearance in excess of 25 ha). Planned operational height is 94 m (upon rehabilitation 94 m). * *West Pit Waste Rock Dump (VP2):* Current area approximately 80ha, to be increased with about 55 ha (final area 135 ha) to allow for final slope and footprint upon rehabilitation (area pending designs, but will likely involve clearance of about 35 ha). Planned operational height is 98 m (upon rehabilitation 106 m).   *HF Waste Rock Dump (new dump on historic dump footprint):* Current area approximately 20 ha and used for BIS stockpiling, to be reused to allow for HF Pit waste rock disposal, as well as final slope and footprint upon rehabilitation (area pending designs). This area is located on an existing WRD footprint (no additional clearance therefore required). Planned operational height is 39 m (upon rehabilitation 63m).   * *Discard Dump:* Current area approximately 28 ha, to be increased to about 60 ha. This area is located within the mining area, between WRDs, Slimes Dam and Opencast Pits, no clearance will be required. The heigh of the facility is planned to be up to 60m.   Current WUL allows for the following deposition noting that deposition of material will not increase in annual throughput:   * Village WRD: 31 500 000 t/a * West Pit WRD: 21 413 403 t/a * GF WRD: 7 721 766 t/a * HL Waste Rock Dump: 10 983 334 t/a * BIS ROM North 1 – 2 +50 000 t/a * East Pit Waste Rock Dump: 68 850 000 t/a * Discard Dump: 9 000 000 t/a | Potential for increased ambient PM concentrations and dust fall out from construction, operations, and from vehicle and wind entrainment |
| **Project 3: Increase of Opencast Footprint Areas, as well as the undertaking of detrital mining for shallow iron ore reserves, including transportation routes (Haul roads)** | * *Village Pit* (VP North), will be expanded by 203 ha in the future to 269 ha and will further include two satellite pits: Pit East and Pit South, each with and area of about 37 ha and 22 ha respectively. Clearance of vegetation will be required. The depth of the VP North is planned at 180 m, with VP East and VP South 160 m and 60 m respectively. To the west of the proposed Village Pit expansion area, an areas for specific target exploration drilling has been demarcated. This area is about 170ha in extent. * *EP Opencast Pit*, will not result in an increase in the footprint but rather in the depth of mining within the mining shell. The depth of East Pit is planned at approximately 220 m.   Around the East Pit potential strategic iron ore resources have been identified. The area in question is about 976ha. Various wetland systems are present within this area, as well as a potential recharge zone. Due to the presence of these sensitive ecosystems, strategic exploration drilling will be undertaken to determine the potential resources within this area. The drilling will be undertaken in terms of a management plan to ensure the least amount of disturbance to these systems.   * *The BF Pit* will be expanded from about 30 ha (comprising of 3 pits) to about 86 ha. Approximately 25 ha may require clearance. The dept of the BF Pit is planned at 180 m. * *A Detrital Mining* area of about 238 ha will be established, but – it should be noted that entire area will not be utilised, only where minerals are found economically viable. Clearance of vegetation will be required.   *Village Haul Road:* New haul road 1 100 m long and 30 m wide. The road will be located in areas mostly disturbed with exiting mining activities or along exiting roads. | Potential for increased ambient PM concentrations and dust fall out from construction, operations and vehicle and wind entrainment |
| **Project 4: Development of the Beneficiation Project which will comprise of a WHIMS Plant and Jig Plant at Beeshoek** | * *WHIMS Plant:*   + Within the WHIMS Laydown Area a 50 m2 Low-Grade Feed Stockpile will be located. This raw material will be processed material derived from the first stage screening process of the WHIMS Plant. All waste (slimes) will be disposed onto the existing Slimes Dam and no new Mine Residue Stockpiles will be developed. WHIMS Plant footprint, including access road of 160m in length (approximately 4ha). * *Jig Plant:*   + Jig Plant footprint of approximately 2.6ha on already disturbed areas.   + Stockpiles created within footprint of existing Low Grade Stockpile.     - Feed Stockpile (Arising Stockpile): North - 0.3 ha on existing Discard Stockpile Footprint: South-East of feed conveyer (Reclaimed Stockpile) - 0.3 ha on existing Discard Stockpile Footprint.     - Jig Plant Conveyors: Approximately 100 m conveyor from existing plant conveyor system to feed Jig Plant to transport low grade material and discard (not considered dangerous goods). Approximately 330m conveyer to feed Jig Plant from Discard Dump.   + Jig Plant Roads interlinked:     - Road 1: 240m with a width of approximately 16 m.     - Jig Plant Road 2: 700 m with a width of approximately 16 m.     - Road 3: 280 m with a width of 16 m.     - Road 4: 135 m with a width of about 30 m     - Decommissioning of existing haul road: about 800-1000 m length of about 30 m width. * Clearance potentially 5.6ha:   + Road 1 – potential clearance of 0.1ha (considered disturbed area).   + WHIMS Laydown Area: approximately 1.5ha.   + WHIMS Plant footprint, including access road of 160m: approximately 4ha.   + WHIMS Plant Central Process Water Dam: 0.4ha, capacity less than 50 000m3. | No impacts foreseen as this is a wet process  A wet process, but potential for increased ambient PM concentrations and dust fall out from crushing and vehicle entrainment |
|
|
|
|
|
|
| **Project 5: Water Management** | The mine will also establish additional water storage tanks on site which will include:   * A new additional storage tank near the existing BN Tank of 500m3. The purpose is to provide sufficient storage space for water from the approved in-pit dewatering activities; * 4x 10m3 plastic tanks at the existing clarifier, thickener area. To allow for the storage of water in the water balance system of the mine to capacitate the plant process to start up without delay; * 1 x 2000 m3 process water tank adjacent to the existing Clarifier connected with a “balancing pipe”. To allow for the storage of water in the water balance system of the mine to capacitate the plant process to start up without delay; * Existing Dam: Steel Dam 250m3 with capacity to store process water and allow for the storage of top-up water; * Existing Dam: Zinc Dam: 90m3 with capacity to store input water where required. | No impacts foreseen |

# SCOPE OF WORK

The air quality specialist study therefore assesses the potential impacts associated with particulate emissions from Projects 1, 2, 3 and 4 and includes the following tasks:

1. The revision of the baseline emission inventory for the Beeshoek Mine (i.e. developed in 2017) to include the proposed infrastructure and operational changes.
   1. Emission estimates are based primarily on activity information and related emission factors. A questionnaire will be used to guide the information collection process and interviews with mine personnel.
   2. Emission estimates will be done for each project, using emission factors recommended by the US-EPA.
2. Dispersion modelling using the model set-up for the 2017 dispersion modelling for Beeshoek Mine, i.e. the US-EPA approved and DEA recommended CALPUFF dispersion model.
   1. Modelling will be conducted for each of the relevant projects. This approach will provide input on effect of the changes of the relative contribution of each project to ambient dust concentrations. Collectively the total contribution of the projects will be assessed and the impact to ambient concentrations.
3. Preparation of an atmospheric impact report that will include a description of the receiving environment, the modelling methodology and inputs, the model outputs per project showing the relative contribution and zone of impacts, as well as for the mine as a whole.

# RELEVANT LEGISLATION

In South Africa ambient air quality is regulated in terms of the National Environmental Management: Air Quality Act (No. 39 0f 2004) (NEM: AQA), the Air Quality Amendment Act (Act No. 20 of 2014) and supporting regulations.

## 4.1 Ambient air quality standards

National Ambient Air Quality Standards (NAAQS) apply for common air pollutants (DEA, 2009 and 2012). These are listed in Table 4‑1. They consist of a limit value and a permitted frequency of exceedance. The limit value is the fixed concentration level aimed at reducing the harmful effects of the pollutant. The tolerance represents the permitted number of exceedances of the limit value per annum. Compliance with the NAAQS therefore implies compliance with the tolerance. The NAAQS for particulate matter (PM10 and PM2.5) are relevant to the Beeshoek Mine Optimisation Project and are listed in Table 4‑1.

***Table 4‑1: NAAQS for PM10 (DEA, 2009) and PM2.5 (DEA, 2012) in μg/m3***

|  |  |  |  |
| --- | --- | --- | --- |
| Pollutant | Averaging Period | Limit value (µg/m3) | Number of exceedances per annum |
| PM10 | 24 hour | 75 | 4 |
| 1 year | 40 | 0 |
| PM2.5 | 24 hour | 40  251 | 0  0 |
| 1 year | 20  151 | 0  0 |
| 1: Effective date is 1 January 2030 | | | |

## 4.2 National dust control regulation

The National Dust Control Regulations (DEA, 2013) provide guidance on the requirements for monitoring dust fallout and provides limit values for acceptable dust fallout rates for residential and non-residential areas (Table 4‑2).

***Table 4‑2: National limit values for dust fallout rates in mg/m2/day as 30-day average (DEA, 2013)***

|  |  |  |
| --- | --- | --- |
| Area | Dust fall rate (D) | Permitted frequency of exceedance |
| Residential | D < 600 | Two within a year, not in sequential months |
| Non-residential | 600 < D < 1 200 | Two within a year, not in sequential months |

Beeshoek Mine implements a dust control program through the Environmental Management Program (EMP). A dust fallout monitoring program was initiated in 2005 and results are reported routinely to the Provincial Air Quality Officer (AQO).

## 4.3 Listed activities

Section 21 of the NEM: AQA required that the Minister publishes a list of activities which result in atmospheric emissions which the Minister believes have or may have a significant detrimental effect on the environment, including health, social conditions, economic conditions, ecological conditions or cultural heritage, so-called Listed Activities. The first list was published in Government Notice No. 248 of 31 March 2010 (DEA, 2010), and a revised list followed on 22 November 2013 (DEA, 2013). A further amendment was published on 12 June 2015 (DEA, 2015). Listed Activities include Combustion Installations, the Petroleum Industry, and Mineral Processing, amongst others for which Minimum Emission Standards apply.

None of the proposed optimisation projects at Beeshoek Mine trigger Listed Activities in terms of the NEM: AQA.

## 4.4 Emission reporting regulation

The emission reporting regulations (DEA, 2015) provides requirements for registration and annual reporting on the National Atmospheric Emission Information System (NAEIS), including any person that holds a mining right or permit in terms of the Minerals and Petroleum Resources Act (Act No. 28 of 2002).

Beeshoek Mine holds a mining right and routinely reports annual emissions to the NAEIS.

# POLLUTANTS OF CONCERN



Particulate matter is a broad term used to describe the fine particles that occur in the atmosphere, including soil dust, dirt, soot, smoke, pollen, ash, aerosols and liquid droplets. The most distinguishing characteristic of PM is the particle size and the chemical composition. Particle size has the greatest influence on the behaviour of PM in the atmosphere with smaller particles tending to have longer residence times than larger ones. PM is categorised, according to particle size, into TSP, PM10 and PM2.5.

*Total suspended particulates (TSP)* consist of all sizes of particles suspended within the air smaller than 100 micrometres (µm). TSP is useful for understanding nuisance effects of PM, e.g. settling on houses, deposition on and discolouration of buildings, and reduction in visibility.

*PM10* describes all particulate matter in the atmosphere with a diameter equal to or less than 10 µm. Sometimes referred to simply as coarse particles, they are generally emitted from motor vehicles (primarily those using diesel engines), factory and utility smokestacks, construction sites, tilled fields, unpaved roads, stone crushing, and burning of wood. Natural sources include sea spray, windblown dust and volcanoes. Coarse particles tend to have relatively short residence times as they settle out rapidly and PM10 is generally found relatively close to the source except in strong winds.

**PM2.5** describes all particulate matter in the atmosphere with a diameter equal or less than 2.5 µm. They are often called fine particles, and are mostly related to combustion (motor vehicles, smelting, incinerators), rather than mechanical processes as is the case with PM10. PM2.5 may be suspended in the atmosphere for long periods and can be transported over large distances. Fine particles can form in the atmosphere in three ways: when particles form from the gas phase, when gas molecules aggregate or cluster together without the aid of an existing surface to form a new particle, or from reactions of gases to form vapours that nucleate to form particles.

Particulate matter may contain both organic and inorganic pollutants. The extent to which particulates are considered harmful depends on their chemical composition and size, e.g. particulates emitted from diesel vehicle exhausts mainly contain unburned fuel oil and hydrocarbons that are known to be carcinogenic. Very fine particulates pose the greatest health risk as they can penetrate deep into the lung, as opposed to larger particles that may be filtered out through the airways’ natural mechanisms.

Particulates can produce a wide variety of effects on the physiology of vegetation, depending mostly on the composition of the particles. Deposition can reduce light transmission and the occlusion of stomata, disrupting physiological processes and light adsorption and reflectance.

# BASELINE CONDITIONS

## 6.1 Climate description

Postmasburg, the closest town to the Beeshoek Mine, is situated at approximately 28˚33’ S and 23˚07’ E, at an elevation of 1 305 m. According to the Köppen-Geiger climate classification system Postmasburg experiences a hot desert climate which is well described by the 30-year historical data record available from the Meteoblue archived weather model data. Meteoblue models historical data from 1985 onwards and generated a continuous 30-year global history with hourly weather data at a grid resolution of 30 km.

The average summer maximum temperatures are hot and exceed 30˚C from November to March (Figure 6‑1). The winter temperatures are relatively mild and the average minimum temperature drops below 10˚C from May through to September.

Postmasburg receives an annual average rainfall of only 283 mm with most of the rain falling between December and March (Figure 6‑1).

|  |
| --- |
|  |
| Figure 6‑1: Average monthly maximum and minimum temperatures at Postmasburg and the average monthly rainfall (https://www.meteoblue.com) |

The hourly wind speed and direction at Postmasburg in 2020 are presented as a windrose in Figure 6‑2. A windrose illustrates the frequency of hourly wind from the 16 cardinal wind directions, with wind indicated from the direction it blows, i.e. easterly winds blow from the east. It also illustrates the frequency of average hourly wind speed in six wind speed classes in m/s.

In 2020, 76% of all winds were either calm or light with and 76% of all winds were less than 3.6 m/s, i.e. (6 658 hours of the possible 8 760 hours in a year). 24% of winds exceeded 3.6 m/s with just 0.1% of winds reaching more than 8.8 m/s, i.e. for just longer than 8 hours. The predominant wind direction in 2020 was from the sector east-northeast (ENE) to easterly (E), accounting for approximately 36% of all winds.

The predominant wind direction is northwest to north-northeast with winds from other sectors less frequent. Winds are generally light with most of hourly winds less than 3.4 m/s. Stronger winds reaching more than 8 m/s are occur occasionally from the west-northwest to north-northwest sector.

|  |  |
| --- | --- |
| Chart, radar chart  Description automatically generated | **Figure 6‑2: Windrose for 2020 at Postmasburg with wind speed in m/s and frequency bands of 6% (data provided by SAWS)** |

## 6.2 Ambient air quality

Beeshoek Mine has been measuring dust fallout since 2005. Monitoring is currently done at nine sites using the SANS 1929:2005 and ASTM Standard, D1739-98: Standard Test Method for the Collection and Measurement of Dust fall (Settleable Particulate Matter). The location of the monitoring sites is shown in Figure 6‑3.

The measured dust fallout is generally low compared with the limit value of the dust fallout standard of 1200 mg/m2/day (Table 4‑2). Exceedances in the drier winter months have been reported at some monitoring points.

|  |
| --- |
| Map  Description automatically generated |
| **Figure 6‑3: Location of the dust fallout buckets at Beeshoek (DustWatch, 2019), the PM­10/PM2.5 sampler and the SAWS weather station** |

Beeshoek Mine established a PM10 and PM2.5 monitoring station on the mine in July 2020, also measuring meteorological parameters. The performance of the monitors has been inconsistent with limited data capture. Nevertheless, some data was captured and is presented in Figure 6‑4. Generally ambient PM10 concentrations are shown to be low relative to the 24-hour ambient standard of 75 µg/m3. There was one exceedance of the standard in March 2021. Four exceedance are permitted per year. For PM2.5 the data appears reliable in July 2020 only (Figure 6‑4). Ambient PM2.5 concentrations were below the ambient standard of 40 µg/m3 except on 10 July 2020 when it was exceeded. No exceedances are permitted for PM2.5.

|  |
| --- |
|  |
|  |
| **Figure 6‑4: Daily PM10 (top) and PM2.5 in July 2020 (bottom) concentrations measured at Beeshoek, showing the respective national ambient air quality standards** |

## 6.3 Emissions

A comprehensive emission inventory was developed for the Beeshoek Mine for a dispersion modelling study for 2018 (uMoya-NILU, 2018), using a bottom-up approach and providing a reliable estimation of emissions. This inventory is also documented in the 2018 emission inventory report (uMoya-NILU, 2019). It was updated for the 2019 reporting year (uMoya-NILU, 2020).

The Beeshoek emission inventory focuses on particulates (TSP, PM10, PM2.5) was been developed using US-EPA emission factors and actual mine activity data. Emissions from overburden removal, blast hole drilling and blasting were estimated for the BN Pit, East Pit, Village Pit and HF Pit. Materials handling in the four pits referred to loading of overburden and ore, and at the waste rock dumps and ROMs it refers to dumping. Emissions from crushing and screening include the North Process Plant and South Process Plant. Mine roads are divided into 17 different segments and entrainment of dust by vehicles was estimated based on the length of the segments and the average daily traffic on each.

The total estimate emission of total suspended particulates (TSP) from Beeshoek Mine activities in 2019 was 5 224 tons (Table 6‑1). The estimate emission from PM10 was 1 545 tons in 2019 and for PM2.5 was 172 tons per annum. The largest source of particulates is vehicle entrainment from the mine roads. Approximately 90% of all TSP and PM10 emissions are attributed to the entrainment of dust by vehicles, and 80% of the PM2.5 emission. Crushing and screening is the second largest source of particulate emissions at Beeshoek, but it is relatively small and accounts for only 5.4% of the total TSP and PM10 emission.

Table 6‑1: Particulate emissions in tonnes per annum for the current year of assessment in 2019

|  |  |  |  |
| --- | --- | --- | --- |
| Mining activity | TSP | PM10 | PM2.5 |
| Overburden Removal | 12.6 | 2.4 | 1.3 |
| Blast Hole Drilling | 14.9 | 7.8 | 7.8 |
| Blasting | 5 | 3 | 0 |
| Crushing and screening | 267.6 | 79.6 | 0.0 |
| Wind entrainment: Stockpiles | 27.7 | 13.8 | 5.5 |
| Wind erosion: ROMS | 86.9 | 43.4 | 17.4 |
| Materials handling: Pits | 10.5 | 5.0 | 0.8 |
| Material handling: Waste rock dumps | 46.4 | 21.9 | 3.3 |
| Materials handling: Stockpiles and ROMS | 4.2 | 2.0 | 0.3 |
| Vehicle road dust entrainment | 4 748 | 1 366 | 135.0 |
| TOTAL | **5 224** | **1 545** | **172** |

The 2018 emissions resulting from activities at the Beeshoek Mine were similar to those reported in 2019 (Table 6‑2).

Table 6‑2: Particulate emissions in tonnes per annum for 2018 and 2019

|  |  |  |  |
| --- | --- | --- | --- |
| **Reporting year** | **TSP** | **PM10** | **PM2.5** |
| **2018** | 5 229 | 1 544 | 169 |
| **2019** | 5 224 | 1 545 | 172 |

# ASSESSMENT METHODOLOGY

## 7.1 Emission inventory

The methodology to estimate emission rates of particulates (TSP, PM10, PM2.5) from these optimisation projects is described here.

A comprehensive source of information on this industry and related emission sources may be found in "U.S. EPA Fifth Edition, Volume I Chapter 11, section 11.19: Introduction to Construction and Aggregate Processing" and "U.S. EPA Fifth Edition, Volume I Chapter 13, Miscellaneous Sources" (USEPA, 2009a and 2009b).

The general equation for emissions estimation is: E = A x EF x (1-ER/100)

where: E = emissions;

A = activity rate;

EF = emission factor; and

ER = overall emission reduction efficiency (%)

The proxy for the activity rate, in terms of loading and unloading at stockpiles, tipping and crushing, is the tonnage of ore that is processed and is different for different materials, and is a function of the activity and the silt content of the material. In terms of vehicle entrained dust, the activity is characterised by the vehicle kilometres travelled, and is a function of the vehicle mass and the characteristic of the road surface.

An emission factor is a representative value that relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., kg of particulate emitted per tonne of rock crushed). Such factors facilitate estimation of emissions from various sources of air pollution.

The emission factors used for the calculation of PM10 and TSP in baseline are the most recent factors published in the United States Environmental Protection Agency (US EPA), AP 42, Fifth Edition, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Chapter 11: Mineral Products Industry (Section 11.9 Western Surface Coal Mining; Section 11.19.1 Sand and Gravel Processing; Section 11.19.2 Crushed Stone Processing and Pulverized Mineral Processing) (USEPA, 2009a) and Chapter 13: Miscellaneous Sources (Section 13.2.2 Unpaved Roads; Section 13.2.4 Aggregate Handling and Storage Piles; Section 13.2.5 Industrial Wind Erosion; Section 13.3 Explosive detonations) (USEPA, 2009b).

This methodology is be used to estimate emission resulting from each of the infrastructure improvement projects described in Section 7.1. Activity information required for the estimation of emissions was provided by Tanja Bekker from EnviroGistics and Msimelelo Silomntu and Chrystal Vries from the Beeshoek Mine.

## 7.2 Dispersion modelling

### 7.2.1 Model selection

The CALPUFF dispersion model (http://www.src.com/calpuff/calpuff1.htm) was used together with the Air Pollution Model (TAPM) (Hurley, 2000; Hurley *et al*., 2001; Hurley *et al*., 2002) at Beeshoek to estimate the ambient concentrations resulting from the different emission sources (uMoya-NILU, 2018). The same model set-up is used for assessment of the infrastructure improvement projects.

CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollution transport, transformation and removal.  CALPUFF can be applied on scales of tens to hundreds of kilometres.  It includes algorithms for sub-grid scale effects (such as terrain impingement), as well as, longer range effects (such as pollutant removal due to wet scavenging and dry deposition, chemical transformation, and visibility effects of particulate matter concentrations). CALPUFF is an appropriate air dispersion model for the purpose of this assessment as it well suited to simulate dispersion from the complex array of area sources.

The Air Pollution Model (TAPM) (Hurley, 2000; Hurley *et al*., 2001; Hurley *et al*., 2002) is used to model meteorological data for the study domain. TAPM uses global gridded synoptic-scale meteorological data with observed surface data to simulate surface and upper air meteorology at given locations in the domain, taking the underlying topography and land cover into account. The global gridded data sets that are used are developed from surface and upper air data that are submitted routinely by all meteorological observing stations to theGlobal Telecommunication System of the World Meteorological Organisation. TAPM has been used successfully in many countries (Hurley, 2000; Hurley *et al*., 2001; Hurley *et al*., 2002). It is ideal for modelling applications where meteorological data does not adequately meet requirements for dispersion modelling.

Dust deposition is difficult to model due the wide range of particle sizes and the need to apply a size dependant deposition velocity. It is not possible to apply such a range in CALPUFF. Therefor a fixed deposition velocity is applied to the predicted TSP concentration to estimate dust deposition. This approach illustrates the deposition pattern adequately but may underestimates deposition.

### 7.2.2 TAPM and CALPUFF parameterisation

For the Beeshoek Mine TAPM is set-up in a nested configuration of three domains, centred on the mine. The outer domain is 480 km by 480 km with a 24 km grid resolution, the middle domain is 240 km by 240 km with a 12 km grid resolution and the inner domain is 60 km by 60 km with a 3 km grid resolution (Figure 7-1). The nesting configuration ensures that topographical influences on meteorology are captured and that meteorology is well resolved and characterised across the boundaries of the inner domain. Twenty-seven vertical levels are modelled in each nest from 10 m to 5 000 m, with a finer resolution in the lowest 1 000 m.

The 3-dimensional TAPM meteorological output on the inner grid includes hourly wind speed and direction, temperature, relative humidity, total solar radiation, net radiation, sensible heat flux, evaporative heat flux, convective velocity scale, precipitation, mixing height, friction velocity and Obukhov length. The Monin-Obukhov length is that height at which turbulence is generated more by buoyancy than by wind shear. The spatially and temporally resolved TAPM surface and upper air meteorological data is used as input to the CALPUFF meteorological pre-processor, CALMET.

A CALPUFF modelling domain of 900 km2 is 30 km (west-east) by 30 km (north-south) and is centred on the Beeshoek Mine (Figure 7‑1). It consists of a uniformly spaced receptor grid with 0.5 km spacing, giving 3 600 grid cells (60 X 60 grid cells).

The topographical and land use data for the respective modelling domains is obtained from the dataset accompanying the CSIRO’s TAPM modelling package. This dataset includes global terrain elevation and land use classification data on a longitude/latitude grid at 30-second grid spacing from the US Geological Survey, Earth Resources Observation Systems (EROS) Data Centre Distributed Active Archive Centre (EDC DAAC). The EROS data has been adjusted to include the waste rock dumps and TSF1 and TSF2.

|  |
| --- |
|  |
| Figure 7‑1: TAPM and CALPUFF modelling |

### 7.2.3 Model scenarios

Dispersion modelling is conducted to predicted PM10 and PM2.5 concentrations and TSP deposition for the four optimisation projects described in Section 6.2 and for Beeshoek Mine as a whole after the implementation of the improvement projects.

The following scenarios are modelled:

* Project 1: Consolidation of Run of Mine (ROM) Stockpiles
* Project 2: Amendments to the design of existing Waste Rock Dumps (WRDs)
* Project 3: Increase of Opencast Footprint Areas
* Project 4: Development of the Beneficiation Project
* Beeshoek with the optimisation projects plus other sources.

### 7.2.4 Model accuracy

Air quality models attempt to predict ambient concentrations based on “known” or measured parameters, such as wind speed, temperature profiles, solar radiation and emissions. There are however, variations in the parameters that are not measured, the so-called “unknown” parameters as well as unresolved details of atmospheric turbulent flow. Variations in these “unknown” parameters can result in deviations of the predicted concentrations of the same event, even though the “known” parameters are fixed.

There are also “reducible” uncertainties that result from inaccuracies in the model, errors in input values and errors in the measured concentrations. These might include poor quality or unrepresentative meteorological, geophysical and source emission data, errors in the measured concentrations that are used to compare with model predictions and inadequate model physics and formulation used to predict the concentrations. “Reducible” uncertainties can be controlled or minimised. This is achieved by making use of the most appropriate input data, preparing the input files correctly, checking and re-checking for errors, correcting for odd model behaviour, ensuring that the errors in the measured data are minimised and applying appropriate model physics.

For the dispersion modelling for the Beeshoek Mine the reducible uncertainty in CALMET and CALPUFF is minimised by:

* Using 3-years of spatially and temporally continuous surface and upper air meteorological data fields for the modelling domain.
* Appropriate parameterisation of CALMET and CALPUFF (Table 7‑1 and Table 7‑2).
* Using representative emission data.

Table 7‑1: Parameterisation of key variables in CALMET

| Parameter | Model value |
| --- | --- |
| 12 vertical cell face heights (m) | 0, 20, 40, 80, 160, 320, 640, 1000, 1500, 2000, 2500, 3000, 4000 |
| Coriolis parameter (per second) | 0.0001 |
| Empirical constants for mixing height equation | Neutral, mechanical: 1.41  Convective: 0.15  Stable: 2400  Overwater, mechanical: 0.12 |
| Minimum potential temperature lapse rate (K/m) | 0.001 |
| Depth of layer above convective mixing height through which lapse rate is computed (m) | 200 |
| Wind field model | Diagnostic wind module |
| Surface wind extrapolation | Similarity theory |
| Restrictions on extrapolation of surface data | No extrapolation as modelled upper air data field is applied |
| Radius of influence of terrain features (km) | 5 |
| Radius of influence of surface stations (km) | Not used as continuous surface data field is applied |

Table 7‑2: Parameterisation of key variables in CALPUFF

|  |  |
| --- | --- |
| Parameter | Model value |
| Chemical transformation | Default NO2 conversion factor of 0.75 is applied (DEA, 2012c). |
| Wind speed profile | Rural |
| Calm conditions | Wind speed < 0.5 m/s |
| Plume rise | Transitional plume rise, stack tip downwash, and partial plume penetration is modelled |
| Dispersion | CALPUFF used in PUFF mode |
| Dispersion option | Dispersion coefficients use turbulence computed from micrometeorology |
| Terrain adjustment method | Partial plume path adjustment |

## 7.3 Impact assessment methodology

The various impacts and benefits of this project in terms of ambient air quality are discussed in terms of impact status, extent, duration, probability, and intensity. Impact significance is regarded as the sum of the impact extent, duration, probability and intensity and a numerical rating system has been applied to evaluate impact significance. Therefore, an impact magnitude and significance rating are applied to rate each identified impact in terms of its overall magnitude and significance.

The nature or status of the impact is determined by the conditions of the environment prior to construction and operation. The nature of the impact includes a description of what causes the effect, what will be affected and how it will be affected. The nature of the impact can therefore be described as negative, positive or neutral.

The definitions for the extent, duration, probability and intensity of the air quality impacts are listed in Table 7‑3. The impact magnitude and significance rating are utilised to rate each identified impact in terms of its overall magnitude and significance (Table 7‑4).

Table 7‑3: Impact parameter definitions

| **Evaluation Component** | **Rating** | **Description** | **Qualitative rating** |
| --- | --- | --- | --- |
| **EXTENT OF IMPACT** | Low | Site Specific; Occurs within the site boundary. | 1 |
| Medium | Local; Extends beyond the site boundary; Affects the immediate surrounding environment (i.e. up to 5 km from the Project Site boundary). | 2 |
| High | Regional; Extends far beyond the site boundary; Widespread effect (i.e. 5 km and more from the Project Site boundary). | 3 |
| Very High | National and/or international; Extends far beyond the site boundary; Widespread effect. | 4 |
| **DURATION OF IMPACT** | Low | Short term; Quickly reversible; Less than the project lifespan; 0 – 5 years. | 1 |
| Medium | Medium term; Reversible over time; Approximate lifespan of the project; 5 – 17 years. | 2 |
| High | Long term; Permanent; Extends beyond the decommissioning phase; >17 years. | 3 |
| **PROBABILITY OF IMPACT** | **Improbable** | Possibility of the impact materialising is negligible; Chance of occurrence <10%. | 1 |
| **Probable** | Possibility that the impact will materialise is likely; Chance of occurrence 10 – 49.9%. | 2 |
| **Highly Probable** | It is expected that the impact will occur; Chance of occurrence 50 – 90%. | 3 |
| **Definite** | Impact will occur regardless of any prevention measures; Chance of occurrence >90%. | 4 |
| **Definite and Cumulative** | Impact will occur regardless of any prevention measures; Chance of occurrence >90% and is likely to result in in cumulative impacts | 5 |
| **IMPACT INTENSITY** | Maximum Benefit | Where natural, cultural and / or social functions or processes are positively affected resulting in the maximum possible and permanent benefit. | + 5 |
| Significant Benefit | Where natural, cultural and / or social functions or processes are altered to the extent that it will result in temporary but significant benefit. | + 4 |
| Beneficial | Where the affected environment is altered but natural, cultural and / or social functions or processes continue, albeit in a modified, beneficial way. | + 3 |
| Minor Benefit | Where the impact affects the environment in such a way that natural, cultural and / or social functions or processes are only marginally benefited. | + 2 |
| Negligible Benefit | Where the impact affects the environment in such a way that natural, cultural and / or social functions or processes are negligibly benefited. | + 1 |
| Neutral | Where the impact affects the environment in such a way that natural, cultural and / or social functions or processes are not affected. | 0 |
| Negligible | Where the impact affects the environment in such a way that natural, cultural and / or social functions or processes are negligibly affected | - 1 |
| Minor | Where the impact affects the environment in such a way that natural, cultural and / or social functions or processes are only marginally affected. | - 2 |
| Average | Where the affected environment is altered but natural, cultural and / or social functions or processes continue, albeit in a modified way. | - 3 |
| Severe | Where natural, cultural and / or social functions or processes are altered to the extent that it will temporarily cease. | - 4 |
| Very Severe | Where natural, cultural and / or social functions or processes are altered to the extent that it will permanently cease. | - 5 |

Table 7‑4: Impact magnitude and significance

| **Impact** | **Rating** | **Description** | **Quantitative rating** |
| --- | --- | --- | --- |
| Positive | High | Of the highest positive order possible within the bounds of impacts that could occur. | + 12 – 16 |
| Medium | Impact is real, but not substantial in relation to other impacts that might take effect within the bounds of those that could occur. Other means of achieving this benefit are approximately equal in time, cost and effort. | + 6 – 11 |
| Low | Impacts is of a low order and therefore likely to have a limited effect. Alternative means of achieving this benefit are likely to be easier, cheaper, more effective and less time-consuming. | + 1 – 5 |
| No Impact | No Impact | Zero impact. | 0 |
| Negative | Low | Impact is of a low order and therefore likely to have little real effect. In the case of adverse impacts, mitigation is either easily achieved or little will be required, or both. Social, cultural, and economic activities of communities can continue unchanged. | - 1 – 5 |
| Medium | Impact is real, but not substantial in relation to other impacts that might take effect within the bounds of those that could occur. In the case of adverse impacts, mitigation is both feasible and fairly possible. Social cultural and economic activities of communities are changed but can be continued (albeit in a different form). Modification of the project design or alternative action may be required. | - 6 – 11 |
| High | Of the highest order possible within the bounds of impacts that could occur. In the case of adverse impacts, there is no possible mitigation that could offset the impact, or mitigation is difficult, expensive, time-consuming or a combination of these. Social, cultural and economic activities of communities are disrupted to such an extent that these come to a halt. | - 12 - 16 |

# EMISSION INVENTORY

Particulate emissions resulting from the four optimisation projects and the expanded Beeshoek Mine were estimated using the methodology described in Section 7.1. The 2019 emission inventory was used as the base and changed according to the physical dimensions of each project and the proposed activities. The information for the optimisation projects were provided by Beeshoek Mine. Estimated particulate emissions resulting from the four optimisation projects, from other sources at Beeshoek Mine and from the optimised operations are listed in Table 8‑1 in tonnes per annum.

Table 8‑1: Particulate emissions from the optimisation projects and Beeshoek Mine after project implementation in tonnes per annum

|  |  |  |  |
| --- | --- | --- | --- |
| **Operation** | **TSP** | **PM10** | **PM2.5** |
| **Project 1: Consolidation of Run of Mine (ROM) Stockpiles on South Mine** | | | |
| Includes North ROMs and Consolidated South ROM |  |  |  |
| **Wind Erosion: ROMS** | 60 | 30 | 12 |
| **Materials Handling: ROMS** | 4 | 2 | 0 |
|  | **64** | **32** | **12** |
| **Project 2: Amendments to the design of existing Waste Rock Dumps (WRDs) in terms of the increase in heights, and allowance for final slope, which will result in extension of footprints** | | | |
|  |
| Includes the following WRDs: Village WRD, West Pit WRD, GF WRD, HF Waste Rock Dump, BIS ROM North 1, BIS ROM North 2, East Pit Waste Rock Dump and Discard Dump | | | |  |
|  |
| **Material handling: Waste Rock Dumps** | **366** | **173** | **26** |  |
| **Project 3: Increase of Opencast Footprint Areas, as well as the undertaking of detrital mining for shallow iron ore reserves, including transportation routes (Haul roads)** | | | |  |
|  |
| Includes the following Pits: BN Pit, East Pit, Village Pit, HF Pit, BF Pit, Detrital Mining Area |  |  |  |  |
| **Overburden Removal** | 13 | 2 | 1 |  |
| **Blast Hole Drilling** | 13 | 7 | 7 |  |
| **Blasting** | 5 | 3 | 0 |  |
| **Materials handling: Pits** | 14 | 7 | 1 |  |
| **Proposed New Village Pit Haul Road** | 1 401 | 398 | 40 |  |
|  | **1 445** | **417** | **49** |  |
| **Project 4: Development of the Beneficiation Project which will comprise of a WHIMS Plant and Jig Plant at Beeshoek** | | | |  |
| Includes emissions from the Jig Plant Crushing and Screening and Stockpiles. WHIMS Plant Processes considered a wet process - emissions are therefore negligible. | | | |  |
|  |
| **Crushing and screening** | 94 | 27 | 0 |  |
| **Wind entrainment: Stockpiles** | 10 | 5 | 2 |  |
|  | **104** | **32** | **2** |  |
| **Other Sources at Beeshoek Mine** | | | |  |
| Includes North and South Mine Processing Plants, Product Stockpile and Vehicle entrained dust from Haul Roads. Dust control on haul roads is assumed to be wetting twice daily. | |  |  |  |
| **Crushing and screening (North and South Processing Plants)** | **282** | **84** | **0** |  |
| **Wind entrainment: Stockpiles** | **27** | **13** | **5** |  |
| **Materials handling: Stockpiles** | **2** | **1** | **0** |  |
| **Road dust** | **4 748** | **1 366** | **135** |  |
|  | **5 059** | **1 464** | **141** |  |
| **TOTAL MINE EMISSIONS** | **7 039** | **2 118** | **230** |  |

The significant contribution to the particulate emissions from the entrainment of dust by vehicles on haul roads is noteworthy. The particulate emission estimate for haul roads assumes wetting twice daily.

Noteworthy is the added contribution of the respective projects to the total emission. After implementation of the consolidation projects the total emissions from Beeshoek Mine increase from the current emissions. of the ROS (Project 1). The total annual TSP emission in 2019 was 5 224 tons per annum (Table 6‑2), which will increase to 7 039 tons per annum. Similarly, the PM10 emission will increase from 1 545 to 2 118 tons per annum and the PM2.5 emission will increase from 172 to 230 tons per annum.

Noteworthy is the relative contribution of each of the four optimisation projects to the total mine emission (Table 8‑2). The proposed increase to the footprint of the opencast pit makes the largest contribution to the increased TSP, PM10 and PM2.5 emission, followed by the amendments to the waste rock dumps. The emission contribution from Project 1 and Project 4 are small.

Table 8‑2: Percentage contribution to the total Beeshoek Mine emission

|  |  |  |  |
| --- | --- | --- | --- |
| **Operation** | **TSP** | **PM10** | **PM2.5** |
| Project 1: Consolidation of ROMS | 1 | 2 | 5 |
| Project 2: Amendments to the WRDs | 5 | 8 | 11 |
| Project 3: Opencast footprint increase | 21 | 20 | 21 |
| Project 4: Beneficiation plant | 1 | 2 | 1 |
| Other Sources at Beeshoek Mine | 72 | 69 | 61 |
| **TOTAL** | **100** | **100** | **100** |

# DISPERSION MODELLING RESULTS

The results of the dispersion modelling are presented here.

Firstly, the maximum predicted PM10 and PM2.5 concentrations and the maximum predicted dust fallout resulting from emissions from the four optimisation projects and for all sources at Beeshoek following the implementation of the optimisation projects are shown in Table 9‑1.

Secondly, for PM10 and PM2.5 the predicted annual average and the 99th percentile of the predicted 24-hour concentrations are presented as isopleth maps for the four optimisation projects and for all sources at Beeshoek following the optimisation projects. Isopleths are lines of equal concentration for the pollutant of concern.



## Maximum predicted concentrations

The maximum predicted ambient PM10 and PM2.5 concentrations and TSP deposition for the optimisation projects and for Beeshoek Mine following their implementation are presented in Table 9‑1. Exceedance of the NAAQS (shown in bold) are predicted for Project 3: Opencast Pits and result from haul road emissions. In all cases the predicted maximum occurs close to the respective project site on the mine property. This contribution implies that the predicted ambient concentrations for Beeshoek Mine following the implementation of the projects are also exceeded at the point of maximum.

Table 9‑1: Maximum predicted annual average and 99th percentile of 24-hour PM10 and PM2.5 concentrations in μg/m3 and maximum dust fallout in mg/m2/day

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Annual PM10 | 24-hour PM10 | Annual PM2.5 | 24-hour PM2.5 | Dust fallout |
| Project 1: Consolidation of ROM stockpiles | 7.2 | 30 | 2.8 | 11.6 | 16.3 |
| Project 2: Amendments to WRDs | 1.4 | 4.4 | 0.2 | 0.7 | 2.8 |
| Project 3: Opencast footprints | **439** | **1 239** | **45** | **127** | **1 175** |
| Project 4: Beneficiation plant upgrade | 33 | 271 | 6.5 | 21 | 509 |
| Beeshoek Mine post improvements | **793** | **2 617** | **80** | **263** | **2 457** |

Sensitive receptors include, but are not limited to, hospitals, schools, day care facilities, elderly housing and convalescent facilities. These are areas where the occupants are more susceptible to the adverse effects of exposure to toxic chemicals, pesticides, and other pollutants. Areas where sensitive may occur near Beeshoek Mine were identified and listed in Table 9‑2. The relative location of these to Beeshoek Mine is shown in Figure 9‑1. The closest sensitive receptor is the farm Aukampsrus which borders Beeshoek Mine to the west and the homestead on the farm is approximately 2.8 km west of the Beeshoek Mine fenceline.

The predicted ambient concentration at identified sensitive receptors are shown in Table 9‑2 and compared with the NAAQS. Noteworthy is that in all case the predicted maximum ambient concentrations and dust fallout are well below the respective NAAQS.

Table 9‑2: Predicted annual average and 99th percentile of 24-hour PM10 and PM2.5 concentrations in μg/m3 and dust fallout in mg/m2/day at sensitive reseptors

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Receptor | Annual PM10 | 24-hour PM10 | Annual PM2.5 | 24-hour PM2.5 | Dust fallout |
| Aukampsrus | 8.0 | 65.0 | 0.8 | 7.0 | 90 |
| Boichoco | 2.1 | 21.1 | 0.2 | 2.0 | 22 |
| Maranteng | 1.1 | 12.3 | 0.1 | 1.3 | 12 |
| Newtown | 1.4 | 14.7 | 0.2 | 1.5 | 15 |
| Postdene | 0.9 | 10.1 | 0.1 | 0.9 | 12 |
| Postmasburg-North | 1.1 | 13.0 | 0.1 | 1.3 | 13 |
| Postmasburg-South | 1.2 | 13.2 | 0.1 | 1.4 | 14 |
| NAAQS | 40 | 75 | 20 | 40 | 600 |

|  |
| --- |
| Map  Description automatically generated |
| ***Figure 9‑1: Location of identified sensitive receptors*** |

## Predicted PM10 concentrations

### Annual concentrations

The predicted annual PM10 concentrations resulting from emissions from the four optimisation projects are shown in Figure 9‑2 to Figure 9‑5, and for Beeshoek Mine after the implementation of all projects in Figure 9‑6. They may be compared with the NAAQS of 40 μg/m3.

The predicted annual PM10 concentrations from Project 1 (ROM consolidation), Project 2 (WRD amendments) and Project 4 (beneficiation plants) are low and below the NAAQS. The highest concentrations for each of these source projects occur in the immediately vicinity of these individual sources.

The predicted annual PM10 concentrations for Project 3 (pit expansion) exceed the NAAQS. The exceedances are predicted in the vicinity of the Village Pit and occur within the mine boundary. The relatively high predicted concentrations are a result of dust generated on the haul roads.

The predicted annual PM10 concentrations resulting from emissions from all sources at the Beeshoek Mine following implementation of the optimisation projects exceed the NAAQS over most of the mine and extend a little beyond the southern and eastern boundary of the mine (Figure 9‑6). The exceedances do not extend into any commercial or residential areas. The homestead on the farm Aukampsrus is located 2.8 km west of Beeshoek Mine. The predicted annual average PM10 concentrations are well below the NAAQS of 40 µg/m3 at the farm (Table 9‑1).

|  |
| --- |
|  |
| Figure 9‑2: Predicted annual average ambient PM10 concentrations resulting from emissions from Project 1 in μg/m3 |

|  |
| --- |
|  |
| Figure 9‑3: Predicted annual average ambient PM10 concentrations resulting from emissions from Project 2 in μg/m3 |

|  |
| --- |
|  |
| Figure 9‑4: Predicted annual average ambient PM10 concentrations resulting from emissions from Project 3 in μg/m3 – the NAAQS are shown in red |

|  |
| --- |
|  |
| Figure 9‑5: Predicted annual average ambient PM10 concentrations resulting from emissions from Project 4 in μg/m3 |

|  |
| --- |
|  |
| Figure 9‑6: Predicted annual average ambient PM10 concentrations resulting from emissions from all sources at Beeshoek after the optimisation projects in μg/m3 – the NAAQS are shown in red |

### 24-hour concentrations

The 99th percentile of the maximum predicted 24-hour PM10 concentrations resulting from emissions from the four optimisation projects are shown in Figure 9‑7 to Figure 9‑10 and for Beeshoek Mine following their implementation in Figure 9‑11. They may be compared with the NAAQS of 75 μg/m3.

The predicted annual PM10 concentrations from Project 1 (ROM consolidation) and Project 2 (WRD amendments) are low and below the NAAQS. The highest concentrations for each of these source projects occur in the immediately vicinity of these individual sources.

The predicted annual PM10 concentrations for Project 3 (pit expansion) and Project 4 (beneficiation plants) exceed the NAAQS. In Figure 9‑9 and Figure 9‑10 the limit value of the NAAQS is shown by the red line, and the tolerance is shown by the blue line. The NAAQS is exceeded if the tolerance is exceeded.

For Project 3 exceedances of the NAAQS are predicted around the Village Pit and extend over the eastern boundary of the mine. The relatively high predicted concentrations are a result of dust generated on the haul roads. For Project 4 the predicted exceedances occur at the beneficiation plants and are contained within the mine boundary.

The predicted 24-hour PM10 concentrations resulting from emissions from all sources at the Beeshoek Mine following implementation of the optimisation projects are shown in Figure 9‑11. Exceedances of the 24-hour NAAQS are predicted over most of the mine and beyond the mine perimeter to the west and south. There are no permanent dwellings where the exceedances are predicted to the south towards the Kolomela Mine. The exceedances are do not extend into any commercial or residential areas. The maximum predicted 24-hour ambient PM10 concentration at the homestead on the farm Aukampsrus is 65 µg/m3 (Table 9‑1), which is below the NAAQS of 75 µg/m3.

|  |
| --- |
|  |
| Figure 9‑7: 99th percentile of the predicted 24-hour ambient PM10 concentrations resulting from emissions from Project 1 in μg/m3 |

|  |
| --- |
|  |
| Figure 9‑8: 99th percentile of the predicted 24-hour ambient PM10 concentrations resulting from emissions from Project 2 in μg/m3 |

|  |
| --- |
|  |
| Figure 9‑9: 99th percentile of the predicted 24-hour ambient PM10 concentrations resulting from emissions from Project 3 in μg/m3 – the NAAQS are shown in red and the permitted number of exceedances per annum of the limit value (12) is shown in blue |

|  |
| --- |
|  |
| Figure 9‑10: 99th percentile of the predicted 24-hour ambient PM10 concentrations resulting from emissions from Project 4 in μg/m3 – the NAAQS are shown in red and the permitted number of exceedances per annum of the limit value (12) is shown in blue |

|  |
| --- |
|  |
| Figure 9‑11: 99th percentile of the predicted 24-hour ambient PM10 concentrations resulting from emissions from all sources at Beeshoek after the optimisation projects in μg/m3 – the NAAQS are shown in red and the permitted number of exceedances per annum of the limit value (12) is shown in blue |

## Predicted PM2.5 concentrations

### Annual concentrations

The predicted annual PM2.5 concentrations from resulting from emissions from the infrastructure improvement projects are shown in Figure 9‑12 to Figure 9‑15 and from Beeshoek Mine after their implementation in Figure 9‑16. They may be compared with the NAAQS of 20 μg/m3.

The predicted annual PM2.5 concentrations from Project 1 (ROM consolidation), Project 2 (WRD amendments) and Project 4 (beneficiation plants) are low and below the NAAQS. The highest concentrations for each of these source projects occur in the immediately vicinity of these individual sources.

The predicted annual PM10 concentrations for Project 3 (pit expansion) exceed the NAAQS at the Village Pit. The relatively high predicted concentrations here are a result of dust generated on the haul roads.

The predicted annual PM10 concentrations resulting from emissions from all sources at the Beeshoek Mine following implementation of the optimisation projects exceed the NAAQS over the Village Pit and the East Pit (Figure 9‑16). The predicted exceedances occur within the mine boundary. The maximum predicted annual average PM2.5 concentrations of 0.8 µg/m3 at the homestead on the farm Aukampsrus is well below the NAAQS of 25 µg/m3 at the farm (Table 9‑1).

|  |
| --- |
|  |
| Figure 9‑12: Predicted annual average ambient PM2.5 concentrations resulting from emissions from Project 1 in μg/m3 |

|  |
| --- |
|  |
| Figure 9‑13: Predicted annual average ambient PM2.5 concentrations resulting from emissions from Project 2 in μg/m3 |

|  |
| --- |
|  |
| Figure 9‑14: Predicted annual average ambient PM2.5 concentrations resulting from emissions from Project 3 in μg/m3 – the NAAQS are shown in red |

|  |
| --- |
|  |
| Figure 9‑15: Predicted annual average ambient PM2.5 concentrations resulting from emissions from Project 4 in μg/m3 |

|  |
| --- |
|  |
| Figure 9‑16: Predicted annual average ambient PM2.5 concentrations resulting from emissions from all sources at Beeshoek after the optimisation projects in μg/m3 – the NAAQS are shown in red |

### 24-hour concentrations

The 99th percentile of the maximum predicted 24-hour PM2.5 concentrations resulting from emissions from the different source activities are shown in Figure 9‑17 to Figure 9‑20 and the Beeshoek Mine after the implementation of the optimisation projects in Figure 9‑21. They may be compared with the NAAQS of 40 μg/m3.

The predicted annual PM2.5 concentrations from Project 1 (ROM consolidation) and Project 2 (WRD amendments) and Project 4 (beneficiation plants) are low and below the NAAQS. The highest concentrations for each of these source projects occur in the immediately vicinity of these individual sources.

The predicted annual PM10 concentrations for Project 3 (pit expansion) exceed the NAAQS. In Figure 9‑19 the limit value of the NAAQS is shown by the red line. For PM2.5 the NAAQS does not provide a tolerance, i.e. the NAAQS for PM2.5 is exceeded if the limit value is exceeded.

For Project 3 the predicted exceedances occur around the Village Pit and extend towards the eastern mine boundary, but occur on the mine property only (Figure 9‑19). The relatively high predicted concentrations are a result of dust generated on the haul roads.

The predicted 24-hour PM2.5 concentrations resulting from emissions from all sources at the Beeshoek Mine following implementation of the optimisation projects exceed the NAAQS over the Village Pit and the East Pit and are predicted to occur on the mine property (Figure 9‑21). They exceedances do not extend into any commercial or residential areas. The maximum predicted 24-hour ambient PM2.5 concentration at the homestead on the farm Aukampsrus is 7.0 µg/m3 (Table 9‑1), which is below the NAAQS of 40 µg/m3.

|  |
| --- |
|  |
| Figure 9‑17: 99th percentile of the predicted 24-hour ambient PM2.5 concentrations resulting from emissions from Project 1 in μg/m3 |

|  |
| --- |
|  |
| Figure 9‑18: 99th percentile of the predicted 24-hour ambient PM2.5 concentrations resulting from emissions from Project 2 in μg/m3 |

|  |
| --- |
|  |
| Figure 9‑19: 99th percentile of the predicted 24-hour ambient PM2.5 concentrations resulting from emissions from Project 3 in μg/m3 – the NAAQS are shown in red |

|  |
| --- |
|  |
| Figure 9‑20: 99th percentile of the predicted 24-hour ambient PM2.5 concentrations resulting from emissions from Project 4 in μg/m3 |

|  |
| --- |
|  |
| Figure 9‑21: 99th percentile of the predicted 24-hour ambient PM2.5 concentrations resulting from emissions from all sources at Beeshoek after the optimisation projects in μg/m3 – the NAAQS are shown in red |

## Predicted TSP deposition

The predicted dust fallout resulting from emissions from the four optimisation projects shown in Figure 9‑22 to Figure 9‑25 and from Beeshoek following the implementation of these projects in Figure 9‑26. They may be compared with the national dust fallout standard of 600 mg/m2/day for residential areas and 1 200 mg/m2/day for non-residential areas.

The predicted dust fallout resulting from Project 1 (ROM consolidation) and Project 2 (WRD amendments) and Project 4 (beneficiation plants) is low relative to standards and highest fallout rates occur in the immediately vicinity of these individual sources.

The predicted dust fallout for Project 3 (pit expansion) is low relative to the national standard for non-residential areas. The highest fallout rates compare with the residential standard and occur in the immediate vicinity of the Village Pit (Figure 9‑24) where the non-residential standard is shown by the red line.

The predicted dust fallout resulting from emissions from all sources at the Beeshoek Mine following implementation of the optimisation projects are relatively low (Figure 9‑26). The only predicted exceedance of the non-residential standard occurs over the Village Pit where the residential standard is also exceeded. The residential standard is also predicted to be exceeded over the East Pit.

The predicted dust fallout is low beyond the mine boundary and no exceedances are predict to occur in any commercial or residential areas. The maximum predicted dust fallout at the homestead on the farm Aukampsrus is 75 mg/m2/day (Table 9‑1). This is well below the national standard for residential areas of 600 mg/m2/day. Along the eastern fenceline of the farm Aukampsrus with Beeshoek Mine the predicted dust fallout is approximately 200 mg/m2/day. This is well below the residential standard of 600 mg/m2/day.

|  |
| --- |
|  |
| Figure 9‑22: Predicted dust fallout rate resulting from emissions from Project 1 in mg/m2/day |

|  |
| --- |
|  |
| Figure 9‑23: Predicted dust fallout rate resulting from emissions from Project 2 in mg/m2/day |

|  |
| --- |
|  |
| Figure 9‑24: Predicted dust fallout rate resulting from emissions from Project 3 in mg/m2/day – the dust fallout standard for residential areas is shown in red |

|  |
| --- |
|  |
| Figure 9‑25: Predicted dust fallout rate resulting from emissions from Project 4 in mg/m2/day |

|  |
| --- |
|  |
| Figure 9‑26: Predicted dust fallout rate resulting from emissions from all sources at Beeshoek after the optimisation projects in mg/m2/day – the dust fallout standard for residential and non-residential areas are shown in red and blue respectively |

# RECOMMENDATIONS DUST MINIMISATION FOR THE EMP FOR THE OPTIMISATION PROJECTS

Recommendations are made here to control dust generation at the four optimisation projects and so reduce the resultant ambient PM­10 and PM2.5 concentrations and dust fallout, and any associated impacts.

The development and implementation of a fugitive dust management plan (FDMP) is recommended. The FDMP must define the responsible persons and should include, but not be limited to the following.

* Strict enforce speed limits on all mine roads.
* Limiting site clearance to design areas.
* Rehabilitation of all areas on completion of construction activities.
* Routine damping of denuded areas during construction, particularly when strong winds are forecast.
* Monitoring of activities causing high dust fallout and manage these specific activities accordingly by actively using the existing dust fallout network.
* Implementation of dust control measures in the form of slope stability and slope a vegetation program.
* Installation, operation and maintenance of dust extraction systems at the secondary and tertiary crushing and screening plants. For crushing and screening operations at metallic mineral processing plants, fugitive dust can be controlled with wet scrubbers or baghouses.
* The application of chemical dust suppression systems at the primary crushing and screening plants.
* Covering all product transported by vehicles using tarpaulins.

# IMPACT ASSESSMENT

The air quality impacts associated with the four optimisation projects and for Beeshoek after the optimisation are asses here using the methodology described in Chapter 7 and using the predicted ambient concentrations, the NAAQS for PM10 and PM2.5 (Table ***4‑1***), and the dust fallout standard for non-residential areas (Table 4‑2).

## Project 1: Consolidation of Run of Mine (ROM) Stockpiles on South Mine

* Air pollutants may have negative health effects even at low concentration. The status of the impact is therefore negative.
* For PM10, PM2.5 and dust fallout the extent of the potential impact is limited to the ROMs and does not extend beyond the mine boundary.
* The predicted ambient concentrations resulting from the consolidated ROM activities are very low and the intensity is rated as very low for PM10, PM2.5 and dust fallout.
* Although the intensity is very low, any impact will endure for the life of the consolidated ROM activities. The duration is therefore long term.
* The consequence of the potential impact is very low for PM10, PM2.5 and dust fallout from the consolidated ROM activities.
* As the intensity is low, the probability of air quality impacts beyond the mine boundary from the consolidated ROM are improbable for all pollutants.
* The significance rating is considered low for PM10, PM2.5 and dust fallout.

## Project 2: Amendments to the existing Waste Rock Dumps (WRDs)

* Air pollutants may have negative health effects even at low concentration. The status of the impact is therefore negative.
* For PM10, PM2.5 and dust fallout the extent of the potential impact is limited to the WRDs and does not extend beyond the mine boundary.
* The predicted ambient concentrations resulting from the amended WRD emissions are very low and the intensity is rated as very low for PM10, PM2.5 and dust fallout.
* Although the intensity is low, any impact will endure for the life of the amended WRD. The duration is therefore long term.
* The consequence of the potential impact is therefore very low for PM10, PM2.5 and dust fallout from the amended WRD.
* As the intensity is low, the probability of air quality impacts from the amended WRD beyond the mine are improbable for all pollutants.
* The significance rating is considered low for PM10, PM2.5 and dust fallout.

## Project 3: Increase of Opencast Footprint Areas

* Air pollutants may have negative health effects even at low concentration. The status of the impact is therefore negative.
* For PM10, PM2.5 and dust fallout the extent of the potential impact is concentrated over the Village Pit and extends over the eastern mine boundary. It does not extend to commercial or residential areas.
* The predicted ambient concentrations resulting from the increased opencast emissions are low and the intensity is rated as low for PM10, PM2.5 and dust fallout.
* Although the intensity is low, any impact will endure for the life of the increased opencast. The duration is therefore long term.
* The consequence of the potential impact is therefore low for PM10, PM2.5 and dust fallout from the increased opencast.
* The intensity is regarded as low, but as the predicted concentrations are exceeded beyond the eastern mine boundary air quality impacts from the increased opencast are probable for PM10.
* The significance rating is considered medium for PM10 and low for PM2.5 and dust fallout.

## Project 4: Development of the Beneficiation Project (Jig Plant)

* Air pollutants may have negative health effects even at low concentration. The status of the impact is therefore negative.
* For PM10, PM2.5 and dust fallout the extent of the potential impact is limited to the jig plant and does not extend beyond the mine boundary.
* The predicted ambient concentrations resulting from the jig plant emissions are very low and the intensity is rated as very low for PM10, PM2.5 and dust fallout.
* Although the intensity is very low, any impact will endure for the life of the jig plant. The duration is therefore long term.
* The consequence of the potential impact is therefore very low for PM10, PM2.5 and dust fallout from the jig plant.
* As the intensity is very low, the probability of air quality impacts from the increased opencast are improbable for all pollutants.
* The significance rating is considered low for PM10, PM2.5 and dust fallout.

## Beeshoek Mine after implementation of the optimisation projects

* Air pollutants may have negative health effects even at low concentration. The status of the impact is therefore negative.
* For particulates the extent of the potential impact is concentrated on the mine property, but extends beyond the boundary to the east and south of the mine.
* The predicted ambient concentrations resulting from emissions from Beeshoek Mine after implementation of the optimisation projects are low beyond the mine boundary and the intensity is rated as low for PM10, PM2.5 and dust fallout.
* Although the intensity is low, any impact will endure for the life of the Beeshoek Mine. The duration is therefore long term.
* The consequence of the potential impact is therefore low for PM10, PM2.5 and dust fallout from the from Beeshoek Mine after implementation of the optimisation projects.
* While intensity is low, exceedances of the NAAQS are predicted beyond the mine boundary to the east and south of the mine, so air quality impacts from the increased opencast are improbable are probable for all pollutants.
* The significance rating is however considered medium for PM10 and low for PM2.5 dust fallout.

Table 11‑1: Air quality Impact Assessment summary scores

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Description | Pollutants | Extent | Intensity | Duration | Consequence | Probability | Significance | Status | Confidence | Reversibility |
| Project 1: ROM consolidation | PM10 | 1 | -1 | 3 | Very low | Improbable | Low (-3) | -ve | High | Yes |
| PM2.5 | 1 | -1 | 3 | Very low | Improbable | Low (-3) | -ve | High | Yes |
| Dust fallout | 1 | -1 | 3 | Very low | Improbable | Low (-3) | -ve | High | Yes |
| Project 2: WRD amendments | PM10 | 1 | -1 | 3 | Very low | Improbable | Low (-3) | -ve | High | Yes |
| PM2.5 | 1 | -1 | 3 | Very Low | Improbable | Low (-3) | -ve | High | Yes |
| Dust fallout | 1 | -1 | 3 | Very low | Improbable | Low (-3) | -ve | High | Yes |
| Project 3: Opencast footprint | PM10 | 1 | -2 | 3 | Low | Probable | Medium (-6) | -ve | High | Yes |
| PM2.5 | 1 | -1 | 3 | Low | Improbable | Low (-1) | -ve | High | Yes |
| Dust fallout | 1 | -1 | 3 | Low | Improbable | Low (-1) | -ve | High | Yes |
| Project 4: Beneficiation plant | PM10 | 1 | -1 | 3 | Very low | Improbable | Low (-3) | -ve | High | Yes |
| PM2.5 | 1 | -1 | 3 | Very Low | Improbable | Low (-3) | -ve | High | Yes |
| Dust fallout | 1 | -1 | 3 | Very low | Improbable | Low (-3) | -ve | High | Yes |
| Beeshoek Mine after optimisation | PM10 | 2 | -2 | 3 | Low | Probable | Medium (-6) | -ve | High | Yes |
| PM2.5 | 2 | -1 | 3 | Low | Improbable | Low (-1) | -ve | High | Yes |
| Dust fallout | 2 | -1 | 3 | Low | Improbable | Low (-1) | -ve | High | Yes |

# SUMMARY AND CONCLUSION

Beeshoek is actively investigating opportunities for the continued and sustainable mining of iron ore reserves within the approved Mining Rights Area and has applied for Environmental Authorisation for several infrastructure improvement projects. EnviroGistics (Pty) Ltd has been appointed to conduct the EIA for the proposed projects. Beeshoek Mine’s application for Environmental Authorisation includes the following projects which have potential air quality impacts:

* Project 1: Consolidation of Run of Mine (ROM) Stockpiles on South Mine
* Project 2: Amendments to the design of existing Waste Rock Dumps (WRDs) in terms of the increase in heights, and allowance for final slope, which will result in extension of footprints
* Project 3: Increase of Opencast Footprint Areas, as well as the undertaking of detrital mining for shallow iron ore reserves, including transportation routes (Haul roads)
* Project 4: Development of the Beneficiation Project which will comprise of a WHIMS Plant and Jig Plant at Beeshoek

The total emission of particulates increases with the implementation of the optimisation projects (Table E-1).

Table E-1: Particulate emissions in tonnes per annum for the current year of assessment in 2019

|  |  |  |  |
| --- | --- | --- | --- |
| Mining activity | TSP | PM10 | PM2.5 |
| 2019 Emissions | **5 224** | **1 545** | **172** |
| Emissions post optimisation projects | **7 039** | **2 118** | **230** |

The US-EPA approved and DEFF recommended CALPUFF dispersion model was used to predict the ambient particulate concentrations and dust fallout rates from the four optimisation projects and from the Beeshoek Mine after their implementation.

The maximum predicted ambient PM10 and PM2.5 concentrations and TSP deposition for the optimisation projects and for Beeshoek Mine following their implementation are presented in Table E-2. In all cases the predicted maximum occurs close to the respective project site on the mine property. Exceedance of the NAAQS (shown in bold) are predicted for Project 3: Opencast Pits and result from haul road emissions. This contribution implies that the predicted ambient concentrations for Beeshoek Mine following the implementation of the projects are also exceeded at the point of maximum. The predicted ambient concentration at identified sensitive receptors within the modelling domain are significantly below the respective NAAQS.

The following points on the predicted ambient PM10 concentrations are noteworthy:

* The predicted annual PM10 concentrations from Project 1 (ROM consolidation), Project 2 (WRD amendments) and Project 4 (beneficiation plants) are low and below the NAAQS. The highest concentrations for each of these source projects occur in the immediately vicinity of these individual sources.
* The predicted annual PM10 concentrations for Project 3 (pit expansion) exceed the NAAQS. The exceedances are predicted in the vicinity of the Village Pit and occur within the mine boundary. The relatively high predicted concentrations are a result of dust generated on the haul roads.
* The predicted annual PM10 concentrations resulting from emissions from all sources at the Beeshoek Mine following implementation of the optimisation projects exceed the NAAQS over most of the mine and extend a little beyond the southern and eastern boundary of the mine. The exceedances do not extend into any commercial or residential areas.

The following points on the predicted ambient PM2.5 concentrations are noteworthy:

* The predicted annual PM2.5 concentrations from Project 1 (ROM consolidation), Project 2 (WRD amendments) and Project 4 (beneficiation plants) are low and below the NAAQS. The highest concentrations for each of these source projects occur in the immediately vicinity of these individual sources.
* The predicted annual PM10 concentrations for Project 3 (pit expansion) exceed the NAAQS at the Village Pit. The relatively high predicted concentrations here are a result of dust generated on the haul roads.
* The predicted annual PM10 concentrations resulting from emissions from all sources at the Beeshoek Mine following implementation of the optimisation projects exceed the NAAQS over the Village Pit and the East Pit. The predicted exceedances occur within the mine boundary.

The following points on the predicted dust fallout rates are noteworthy:

* The predicted dust fallout resulting from Project 1 (ROM consolidation) and Project 2 (WRD amendments) and Project 4 (beneficiation plants) is low relative to standards and highest fallout rates occur in the immediately vicinity of these individual sources.
* The predicted dust fallout for Project 3 (pit expansion) is low relative to the national standard for non-residential areas. The highest fallout rates compare with the residential standard and occur in the immediate vicinity of the Village Pit where the non-residential standard is shown by the red line.
* The predicted dust fallout resulting from emissions from all sources at the Beeshoek Mine following implementation of the optimisation projects are relatively low. The only predicted exceedance of the non-residential standard occurs over the Village Pit where the residential standard is also exceeded. The residential standard is also predicted to be exceeded over the East Pit.

The significance of air quality impacts associated with the optimisation projects and for Beeshoek after the optimisation were assessed using the predicted ambient concentrations.

The impact significance for Project 1 (ROM consolidation), Project 2 (WRD amendments), and Project 4 (beneficiation plant) is considered low. The impact significance for Project 3 (pit expansion) is considered medium. For all activities at the Beeshoek Mine following the implementation of the optimisation projects is considered medium.

From an air quality perspective, it is the reasonable opinion of the authors that the Beeshoek Mine optimisation project should be authorised considering the findings of this assessment.

# REFERENCES

DEA, 2009. National Ambient Air Quality Standards, Government Gazette, 32861, Vol. 1210, 24 December 2009.

DEA, 2010. Listed Activities and Associated Minimum Emission Standards identified in terms of Section 21 of the Air Quality Act, Act No. 39 of 2004, Notice 248, Government Gazette, 35894, 31 March 2010.

DEA, 2012. National Ambient Air Quality Standard for Particulate Matter of Aerodynamic Diameter less than 2.5 micrometers, Notice 486, 29 June 2012, Government Gazette, 35463.

DEA, 2013. Listed Activities and Associated Minimum Emission Standards identified in terms of Section 21 of the Air Quality Act, Act No. 39 of 2004, Notice 893, Government Gazette, 37054, 22 November 2013.

DEA, 2014. Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa, Government Notice R.533, Government Gazette, no. 37804, 11 July 2014.

DEA, 2015. Amendments to the List of Activities which result in atmospheric emissions which have a significant detrimental effect on the environment, etc, Notice 511, Government Gazette, 38863, 12 June 2015.

DustWatch, 2019. Assmang Beeshoek Dust Fallout Monitoring Program, DustWatch Annual Report 2018, Report No.: 02119191819, 19 Feb 2019.

Hurley, P. (2000): Verification of TAPM meteorological predictions in the Melbourne region for a winter and summer month. Australian Meteorological Magazine, 49, 97-107.

Hurley, P.J., Blockley, A. and Rayner, K. (2001): Verification of a prognostic meteorological and air pollution model for year-long predictions in the Kwinana industrial region of Western Australia. Atmospheric Environment, 35(10), 1871-1880.

Hurley, P.J., Physick, W.L. and Ashok, K.L. (2002): The Air Pollution Model (TAPM) Version 2, Part 21: summary of some verification studies, CSIRO Atmospheric Research Technical Paper No. 57, 46 p.

uMoya-NILU, 2018. Air Quality Dispersion Modelling Study for the Beeshoek Iron Ore Mine, Postmasburg, Report No. uMN216-17, February 2018

uMoya-NILU, 2019. Emission Inventory Report for the Beeshoek Iron Ore Mine, Postmasburg – Year 2018, Report No. uMN047-19, March 2019

uMoya-NILU, 2020.: Emission Inventory Report for the Beeshoek Iron Ore Mine, Postmasburg – Year 2019, Report No. uMN025-2020, February 2020

United States Environmental Protection Agency (US EPA) (2009a): Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources. Chapter 11: Mineral Products Industry. <http://www.epa.gov/ttn/chief/ap42/ch11/index.html>.

United States Environmental Protection Agency (US EPA) (2009b): Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources. Chapter 13: Miscellaneous Sources. [http://www.epa.gov/ttn/chief/ap42/ch13/index.html.](http://www.epa.gov/ttn/chief/ap42/ch13/index.html.%20Visited%201%20May%202009)