Project done on behalf of

Terra Pacis Environmental (Pty) Ltd

Air Quality Impact Assessment for the Proposed M14 Furnace at Metalloys

Report No.: 09TPE02 Rev 3

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REPORT DETAILS

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Acknowledgements	The authors would hereby like to thank Tim Knights from Knights Environmental and Heiko Stoelting from Metalloys for technical input to the project.

Technical Terms and Abbreviations

AEL	Atmospheric Emission License
Airshed	Airshed Planning Professionals (Pty) Ltd
APPA	South African Air Pollution Prevention Act
AQA	South African Air Quality Act
AQMP	Air Quality Management Plan
ATSDR	Agency for Toxic Substances and Disease Registry
BPM	Best Practicable Means
C_6H_6	Benzene
CAPCO	Chief Air Pollution Control Officer in terms of APPA
C	Carbon
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DEA	Department of Environmental Affairs
DEAT	Department of Environmental Affairs and Tourism
DME	Department of Minerals and Energy
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency (United States)
ERS	Emission Reduction Strategy
FEL	Front End Loader
FeMn	Ferromanganese
g	gram
h	hour
H_2	Hydrogen
H_2O	Water
HCFeMn	High Carbon Ferromanganese
HSE	Health and Safety Executive (United Kingdom)
IP&WM	Integrated Pollution and Waste Management
IRIS	Integrated Risk Information System (operated by the US EPA)
l	litre
m	meter
MEC	Member of the Executive Council
MEI	Maximally Exposed Individual
MMD	Materials Management Department

Mn	Manganese
MnO	Manganese Oxide
MVA	Mega Volt Ampere
MW	Mega Watt
NEMA	National Environmental Management Act
NO	Nitrogen Monoxide
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
NP	North Plant
NPI	National Pollutant Inventory (Australia)
O_3	Ozone
OBC	Oxygen Blown Converter
Pb	Lead
PM10	Particulate Matter with an aerodynamic diameter of less than 10 µm
RfC	Reference Concentration
SA	South Africa
SABS	South African Bureau of Standards
SANS	South African National Standards
SAWS	South African Weather Services
SEPA	Scottish Environmental Protection Agency
SO_2	Sulphur Dioxide
SP	South Plant
STASA	Solutions Technology Alliance of South Africa
tpa	tons per annum
TPE	Terra Pacis Environmental (Pty) Ltd
TSP	Total Suspended Particulate
UK	United Kingdom
URF	Unit Risk Factor
US EPA	United States Environmental Protection Agency
µ	Micro ($1x10^{-6}$)
VTAPA	Vaal Triangle Airshed Priority Area
WB	World Bank
WHO	World Health Organisation
WP	West Plant

Executive Summary

Introduction

Metalloys (operated by BHP Billiton) plans the construction and operation of a new submerged arc ferromanganese (FeMn) furnace at the existing West Plant operations near Meyerton. FeMn is currently manufactured at the Metalloys North Plant (Furnaces M10 and M11) and West Plant (Furnace M12). The proposed 81 MVA M14 furnace will produce approximately 146 000 tons of high carbon ferromanganese (HCFeMn) per annum. The M14 furnace design and operation will be similar to the existing M12 furnace.

Operational alternatives include the production of silicomanganese (SiMn) and medium carbon ferromanganese (MCFeMn). The capacity of West Plant's oxygen blown converter (OBC) to produce MCFeMn matches the HCFeMn production rates of either M12 or proposed M14. Currently, all the HCFeMn from M12 is sent to the OBC to produce MCFeMn. Product from M14 is however intended to be cast, crushed and sold as HCFeMn. The timing of the OBC operation may however determine whether the HCFeMn feed will come from M12 or M14.

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Terra Pacis Environmental (Pty) Ltd (TPE) to undertake an air quality impact assessment for the proposed operation. The main objective of the study was to determine potential impacts on the surrounding environment and human health.

Study Approach and Methodology

The establishment of a comprehensive emission inventory formed the basis for the assessment of the impacts from of the proposed operation's emissions on the receiving environment. The establishment of an emissions inventory comprises the identification of sources of emission, and the quantification of each source's contribution to ambient air pollution concentrations.

In the quantification of fugitive dust emissions use was made of emission factors which associate the quantity of a pollutant to the activity associated with the release of that pollutant. Due to the absence of locally generated emission factors, use was made of the comprehensive set of emission factors and equations published by the US Environmental Protection Agency (US-EPA) in its AP-42 document Compilation of Air Pollution Emission Factors. The US-EPA AP-42 emission factors are the most widely used in the field of air pollution. Particulate and gaseous emissions from point sources were calculated using a combination of emission limits, design specifications, mass balance calculations and emission factors.

In the estimation of emissions and the simulation of patterns of dispersion, a distinction was made between Total Suspended Particulates (TSP) and thoracic particulates (PM10, particulate matter with an aerodynamic diameter of less than 10 µm). Whereas TSP is of interest due to its implications in terms of nuisance dust impacts, the PM10 fraction is taken into account to determine the potential for human health impacts.

In characterising the dispersion potential of the site reference was made to hourly average meteorological data recorded at the South African Weather Service (SAWS) Station in Vereeniging for the period January 2005 to December 2007.

Particulate and gaseous concentrations and dustfall rates were simulated for the proposed operations for various operational scenarios representative of a range of ERS projects planned by Metalloys. The simulation of ambient air pollutant concentrations and dust deposition due to the proposed operation was undertaken through the application of the United States Environmental Protection Agency (US EPA) AERMOD (version 5).

NO_2, SO_2, PM10 and Mn health impacts as well as nuisance dust impacts for the proposed operation were assessed. Various operational scenarios were included in the investigation. These scenarios were selected to reflect:

- impacts associated with proposed M14 operations incrementally;
- cumulative impacts associated with proposed M14 and existing Metalloys operations; and
- the effect of emission reduction strategies on incremental and cumulative impacts.

Limitations and Assumptions

Limitations and assumptions pertaining to the project were:

- Predicted air pollution impacts only include those air emissions associated with existing Metalloys and proposed M14 operations.
- The proposed M14 furnace will be built within a partially constructed area within the West Plant building. Fugitive dust emissions from construction activities are expected to be minimal and were omitted from the air quality impact assessment.
- The study focussed on the proposed M14 furnace and the production of HCFeMn. The production of MCFeMn was taken into account in existing Metalloys operations where it was assumed that all HCFeMn from M12 will be fed to the OBC.
- It was assumed that all processing operations will have ceased by the closure phase of the project. The potential for impacts during this phase will depend on the extent of demolition and rehabilitation efforts during closure and on features which will remain in

place. Information regarding the extent of demolition and/or rehabilitation procedures were limited and therefore not included in the emissions inventory or the dispersion modelling.

- The dispersion model cannot compute real-time processes; average consumption and production rates were therefore used. Operational locations and periods were selected to reflect the worst case scenarios.

- The quantification of current sulphur dioxide (SO_2), nitrogen oxides (NO_x) and carbon monoxide (CO) emissions associated with existing Metalloys operations did not form part of the scope of this study. The baseline emissions inventory only included particulates (TSP, PM10 and Mn).

- In the current study, pollutants of health concern that are regulated by South African Standards were included in the assessment. Carbon dioxide (CO_2) emissions on the other hand are related to global warming effects and are of a global problem with global impacts. These impacts were therefore not included as the impacts from these emissions should be dealt with on a global scale.

- The availability of molten slag carriers is expected to be at least 98%. Emergency slag casting operations at the proposed M14 furnace are expected to be limited to 175 hours (7.3 days) per year and were therefore not considered a routine operation.

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

- NO is rapidly converted in the atmosphere into the much more toxic nitrogen dioxide (NO_2). The rate of this conversion process is determined by both the rate of the physical processes of dispersion and mixing of the plume and the chemical reaction rates. As a conservative measure, and in the absence of accurate O_3 data, all long- and short term NO_x impacts were assumed to be NO_2.

- Carbon monoxide rich furnace off gas from M14 will be combusted at the Elgen plant to generate electricity. It was assumed that all CO will be converted to CO_2 during combustion.

Conclusions

PM10 and manganese were found to be the pollutants of concern based on predicted air quality impacts and elevated background particulate concentrations.

The additional particulate emissions from proposed M14 furnace operations were predicted to result in a potentially significant increase in ambient PM10 concentrations specifically at the Metalloys plant boundary and at Meyerton Park. The implementation of the emission reduction strategy as intended by Metalloys was however calculated to reduce emissions from existing Metalloys operations and proposed M14 furnace operations to such an extent that predicted PM10 concentrations at Meyerton Park may be acceptable according to SA ambient air quality standards taking into account modelling uncertainties.

In the absence of South African standards regulating ambient manganese concentrations, manganese impacts were screened against the WHO annual average guideline. Elevated manganese concentrations were predicted as a result of incremental and cumulative operations. The potential health effects of manganese on the receiving environment should however be assessed in detail by a health risk professional.

Recommendations

Based on the abovementioned findings, the following recommendations are made:

- To minimize potential cumulative air quality impacts it is recommended that the operation of the proposed M14 furnace coincide with implementation of the ERS.
- As point source and secondary fume emissions associated with M14 were estimated based on theoretical values and methods, it is recommended that emissions be confirmed through stack and furnace building fugitive monitoring once M14 is in operation.
- A specialist health risk assessment is required for manganese exposures.
- The existing monitoring network established by Metalloys is considered sufficient to record changes in ambient particulate concentrations associated with the proposed M14 project. It is therefore recommended that the already established monitoring network be maintained in order to assess the effectiveness of the ERS on ambient particulate concentrations as well as impacts associated with M14. It may be valuable to analyse collected PM10 data for manganese to confirm predicted manganese impacts.

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Air Quality Impact Assessment for the Proposed M14 Furnace at Metalloys

1 Introduction

Metalloys (operated by BHP Billiton) plans the construction and operation of a new submerged arc ferromanganese (FeMn) furnace, at the existing West Plant operations near Meyerton. FeMn is currently manufactured at the Metalloys North Plant (Furnaces M10 and M11) and West Plant (Furnace M12). The proposed 81 MVA M14 furnace will produce approximately 146 000 tons of high carbon ferromanganese (HCFeMn) per annum. The M14 furnace design and operation will be similar to the existing M12 furnace (Knights, 2009).

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1.1 Terms of Reference

The air quality impact assessment for the proposed project will form part of the Environmental Impact Assessment (EIA) undertaken by TPE. In order to determine the possible impacts from the proposed operations on the surrounding environment and human health, a baseline study, impact assessment and mitigation recommendation study was undertaken.

The **baseline air quality characterisation** included:

- Identification of the potential sensitive receptors within the vicinity of the proposed site;
- The regional climate and site-specific atmospheric dispersion potential; and
- Identification and quantification of existing sources of emission at Metalloys based on the previously conducted baseline air quality impact assessment for the plant as part of an Emission Reduction Strategy (ERS) (Report number: APP/08/CYM – 02 Rev 0);

- Characterisation of ambient air quality and dustfall levels in the region based on observational data recorded to date.

The **impact prediction study** included the following:

- Compilation of an emissions inventory for M14, comprising the identification and quantification of potential routine and upset sources of atmospheric emission;
- Dispersion simulations of thoracic particulate and gaseous emissions and dust-fall levels;
- An analysis of the dispersion modelling results;
- The evaluation of potential for human health and environmental impacts based on ambient air quality guidelines and standards; and
- Recommendations of mitigation and management measures.

1.2 Study Approach and Methods

The establishment of a comprehensive emission inventory formed the basis for the assessment of the impacts from of the proposed operation's emissions on the receiving environment. The establishment of an emissions inventory comprises the identification of sources of emission, and the quantification of each source's contribution to ambient air pollution concentrations.

In the quantification of fugitive dust emissions use was made of emission factors which associate the quantity of a pollutant to the activity associated with the release of that pollutant. Due to the absence of locally generated emission factors, use was made of the comprehensive set of emission factors and equations published by the US Environmental Protection Agency (US-EPA) in its AP-42 document Compilation of Air Pollution Emission Factors. The US-EPA AP-42 emission factors are of the most widely used in the field of air pollution. Particulate and gaseous emissions from point sources were calculated using a combination of emission limits, design specifications, mass balance calculations and emission factors.

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- The dispersion model cannot compute real-time processes; average consumption and production rates were therefore used. Operational locations and periods were selected to reflect the worst case scenarios.
- The quantification of current sulphur dioxide (SO_2), nitrogen oxides (NO_x) and carbon monoxide (CO) emissions associated with existing Metalloys operations did not form part of the scope of this study. The baseline emissions inventory only included particulates (TSP, PM10 and Mn).
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1.4 Report Outline

Section 2	Legal Requirements and Human Health Criteria
Section 3	Baseline Characterisation
Section 4	Impact Assessment
Section 5	Conclusions and Recommendations
Section 6	References

2 Legal Requirements and Human Health Criteria

2.1 Legal Requirements According to the New Air Quality Act (No 39 of 2004)

The National Environmental Management: Air Quality Act (Act no.39 of 2004) commenced on the 11th of September 2005 as published in the Government Gazette on the 9th of September 2005. Sections omitted from the implementation are Sections 21, 22, 36 to 49, 51(1)(e),51(1)(f), 51(3),60 and 61. The sections previously omitted have come into affect on the 1st of April 2010 (Government Gazette, 26 March 2010)

The AQA was developed to reform and update air quality legislation in South Africa with the intention to reflect the overarching principles within the National Environmental Management Act. It also aims to comply with general environmental policies and to bring legislation in line with local and international good air quality management practices.

The most significant change under AQA to the previous approach in air quality management (as under the APPA of 1965) is the control of impacts on the receiving environment. Previously APPA focussed on managing air quality from a national government level by controlling specific sources. Under AQA this responsibility has been delegated down to district and metropolitan municipality level with the Air Quality Officer responsible for issuing Atmospheric Emissions Licenses. Thus, the implication for industry is that all Listed Activities (previously known as scheduled processes) will require Atmospheric Emissions Licences (AEL).

The National Framework states that aside from the various spheres of government responsibility towards good air quality, industry too has a responsibility not to impinge on everyone's right to air that is not harmful to health and well-being. Industries therefore should take reasonable measures to prevent such pollution order degradation from occurring, continuing or recurring.

In terms of AQA, certain industries have further responsibilities, including:

- Compliance with any relevant national standards for emissions from point, non-point or mobile sources in respect of substances or mixtures of substances identified by the Minister, MEC or municipality.

- Compliance with the measurements requirements of identified emissions from point, non-point or mobile sources and the form in which such measurements must be reported and the organs of state to whom such measurements must be reported.

- Compliance with relevant emission standards in respect of controlled emitters if an activity undertaken by the industry and/or an appliance used by the industry is identified as a controlled emitter.

- Compliance with any usage, manufacture or sale and/or emissions standards or prohibitions in respect of controlled fuels if such fuels are manufactured, sold or used by the industry.

- Comply with the Minister's requirement for the implementation of a pollution prevention plan in respect of a substance declared as a priority air pollutant.

- Comply with an Air Quality Officer's legal request to submit an atmospheric impact report in a prescribed form.

- Taking reasonable steps to prevent the emission of any offensive odour caused by any activity on their premises.

- Furthermore, industries identified as Listed Activities have further responsibilities, including:

  - Making application for an AEL and complying with its provisions.

  - Compliance with any minimum emission standards in respect of a substance or mixture of substances identified as resulting from a listed activity.

  - Designate an Emission Control Officer if required to do so.

2.2 Roll out of the Air Quality Act

Given the specific requirements of the Air Quality Act various projects had to be initiated to ensure these requirements are met. The following provides a brief description of these projects:

- *National Framework for Air Quality Management* – according to the Air Quality Act, the Minister must within two years of the date on which this section took effect, establish a national framework for achieving the object of the Act. The project provides the norms and standards to guide air quality management initiatives at national, provincial and local government levels throughout the country. The National Framework is a medium- to long term plan on how to implement the Air Quality Act to ensure the objectives of the act are met. The first generation plan was published in the Government Gazette on the 11th of September 2007.

- *Listed Activities and Minimum Emissions Standard Setting Project* – the minister must in accordance to the act publish a list of activities which result in atmospheric emissions and which is believed to have significant detrimental effects on the environment and human health and social welfare. The project aims to establish minimum emission limits for all the listed activities identified through a consultative process at several forums. All current scheduled processes as stipulated under the APPA are included as listed activities with additional activities being added to the list. An initial list of activities forms part of the National Framework.

A first draft was published in February 2008 after which it was reviewed by the STANSA Technical Committee for Air Quality for finalization. The Listed Activities and Minimum National Emission Standards were published on the 31st of March 2010 (Government Gazette No. 33064).

- *The APPA permit review pro*ject – the project commenced in January 2006 and has been completed. The project aimed to develop a Registration Certificate template that is in line with the requirements of the Air Quality Act and to issue revised Registration Certificates that will ensure ambient air quality improvement. This project also aims to capacitate the provincial and local authorities to apply procedures, protocols; standard formats etc. for developing an AEL. The project included the capturing of all current APPA Registration Certificates into a central database at DEAT. The database was used to sort and assess the various industries and develop a prioritisation matrix from where 9 industry sectors were identified for review resulting in a total of 69 individual industries, excluding the almost 200 brickworks. The Registration Certificate was used to test the template and to review the current industries within the various sectors.

2.3 Listed Activities and Minimum Emission Standards

The ferroalloy industry is a Listed Activity under the NEMAQA of 2004. Metalloys has been part of the APPA permit review project and has been issued with a draft Atmospheric Emission Licence for North Plant, South Plant, West Plant, Elgen and MMD (personal communication, H. Stoelting, HSEC Metalloys, 2010). M14 will be incorporated into the AEL. Minimum Emission Standards as published on the 31st of March 2010 for ferroalloy production are summarised in Table 2-1 below.

Note that "New Plant" relates per definition to any plant or process where the application for authorisation in terms of the National Environmental Management Act, 1998 (Act No 107 of 1998) (as amended) was made after the date on which the Notice was published viz. 31 March 2010.

Table 2-1: Minimum emission standards: Ferro-alloy Production

Category:	**Subcategory 4.9: Metallurgical Industry, Ferro-alloy Production**		
Description:	Production of alloys of iron with chromium, manganese, silicon or vanadium. The separation of titanium slag from iron containing minerals using heat.		
Application:	All installations.		
Substance or Mixture of Substances		**Plant Status**	**mgN/m³ under normal conditions of 273 K and 101.3 kPa**
Common Name	**Chemical Symbol**		
Sulphur Dioxide	SO_2	New	500
		Existing	500
Oxides of Nitrogen	NO_x expressed as NO_2	New	400
		Existing	750
Particulate matter from primary fume capture system, open and semi-closed furnaces			
Particulate Matter	N/A	New	30
		Existing	100
Particulate matter from primary fume capture system, closed furnaces			
Particulate Matter	N/A	New	50
		Existing	100
Particulate matter from secondary fume capture system, all furnaces			
Particulate Matter	N/A	New	50
		Existing	100

Notes:

(a) The following special arrangements shall apply:

i. Secondary fume capture installations shall be fitted to all new furnace installations.

ii. Emissions of Cr(VI), Mn and V from primary fume capture systems of ferrochrome, ferromanganese and ferrovanadium furnaces respectively to be measures and reported to licensing authority annually.

2.4 Ambient Air Quality Criteria

Prior to assessing the impact of the proposed M14 furnace and associated operations, reference needs to be made to the environmental regulations and guidelines governing the impact of such operations. Air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. The ambient air quality standards and guideline values indicate safe daily exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. Air quality guidelines and standards are normally given for specific averaging or exposure periods.

A more detailed discussion of potential effects of pollutants relevant to the study on human health is provided in Appendix B.

2.4.1 South African Ambient Air Quality Standards

The South African Bureau of Standards (SABS) was engaged to assist DEAT in the facilitation of the development of ambient air quality standards. This included the establishment of a technical committee to oversee the development of standards. Standards were determined based on international best practice for PM10, dustfall, sulphur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), carbon monoxide (CO), lead (Pb) and benzene (C_6H_6)[1]. These standards were published for comment in the Government Gazette on 9 June 2007. The proposed revised national ambient standards were published for comment in the Government Gazette on the 13th of March 2009. The final revised national ambient standards, as published in the Government Gazette on the 24th of December 2009, are listed in Table 2-2.

For the purpose of compliance assessment reference is made to the strictest ambient air quality standard for pollutants for which interim standards are specified.

[1] *SANS 69 - South African National Standard* - Framework for setting & implementing national ambient air quality standards, and *SANS 1929 - South African National Standard* - Ambient Air Quality - Limits for common pollutants.

Table 2-2: National Ambient Air Quality Standards

Pollutant	Averaging Period	Limit Value ($\mu g/m^3$)	Limit Value (ppb)	Frequency of Exceedance	Compliance Date
Benzene (C_6H_6)	1 year	10	3.2	0	Immediate – 31 Dec 2014
	1 year	5	1.6	0	1 Jan 2015
Carbon Monoxide (CO)	1 hour	30000	26000	88	Immediate
	8 hour[(a)]	10000	8700	11	Immediate
Lead (Pb)	1 year	0.5	-	0	Immediate
Nitrogen Dioxide (NO_2)	1 hour	200	106	88	Immediate
	1 year	40	21	0	Immediate
Ozone (O_3)	8 hour[(b)]	120	61	11	Immediate
PM10	24 hour	120	-	4	Immediate – 31 Dec 2014
	24 hour	75	-	4	1 Jan 2015
	1 year	50	-	0	Immediate – 31 Dec 2014
	1 year	40	-	0	1 Jan 2015
Sulphur Dioxide (SO_2)	10 minutes	500	191	526	Immediate
	1 hour	350	134	88	Immediate
	24 hour	125	48	4	Immediate
	1 year	50	19	0	Immediate

Notes:

(a) Calculated on 1 hour averages.
(b) Running average.

2.4.2 International Inhalation Guidelines for Manganese

Inhalation related health threshold published for public exposures to manganese are summarised in Table 2-3.

For the purpose of the health risk screening of manganese impacts, reference is made to the WHO chronic guideline value of 0.15 µg/m³

Table 2-3: International health thresholds and guidelines for thoracic manganese

Regulatory Agency	Description	Threshold/Guideline (µg/m³)	Reference
US EPA[a]	Chronic Inhalation Reference Concentration	0.05	EPA, 2007
WHO[b]	Chronic Guideline Value	0.15	WHO, 2000
California OEHHA[c]	Chronic Reference Exposure Level	0.2	OEHHA, 2006
US ATSDR[d]	Chronic Minimal Risk Level	0.3	ASTDR, 2009

Notes:

(a) US EPA – United States Environmental Protection Agency
(b) WHO – World Health Organisation
(c) OEHHA – Office of Environmental Health Hazard Assessment
(d) US ATSDR – United States Agency for Toxic Substances and Disease Registry

2.4.3 Dust Deposition Limits

It has been proposed (as part of the SANS air quality standard setting processes) that dustfall rates be evaluated against a four-band scale, as presented in Table 2-4. Proposed target, action and alert thresholds for ambient dust deposition are given in Table 2-5.

According to the proposed SA dustfall limits an enterprise may submit a request to the authorities to operate within the Band 3 ACTION band for a limited period, providing that this is essential in terms of the practical operation of the enterprise (for example the final removal of a tailings deposit) and provided that the best available control technology is applied for the duration. No margin of tolerance will be granted for operations that result in dustfall rates in the Band 4 ALERT.

Table 2-4: Bands of dustfall rates proposed for adoption

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

Table 2-5: Target, action and alert thresholds for ambient dustfall

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

3 Baseline Characterisation

In characterising baseline air quality, reference is made to details concerning the study area, atmospheric dispersion potential and other potential sources of atmospheric emissions in the area. The consideration of the existing air quality is important so as to facilitate the assessment of the potential for cumulative air pollutant concentrations arising due to the proposed development.

3.1 Study Area

The local study area for the air quality impact assessment was selected based on the expected extent of air quality impacts and possible sensitive receptors such as individual homes and communities. A study area of 20 km east-west and 20 km north-west was identified, with Metalloys operations approximately in the centre. The closest residential area, Meyerton Park, is situated directly north-east of West Plant (Figure 3-1). The topography of study area is shown in Figure 3-2.

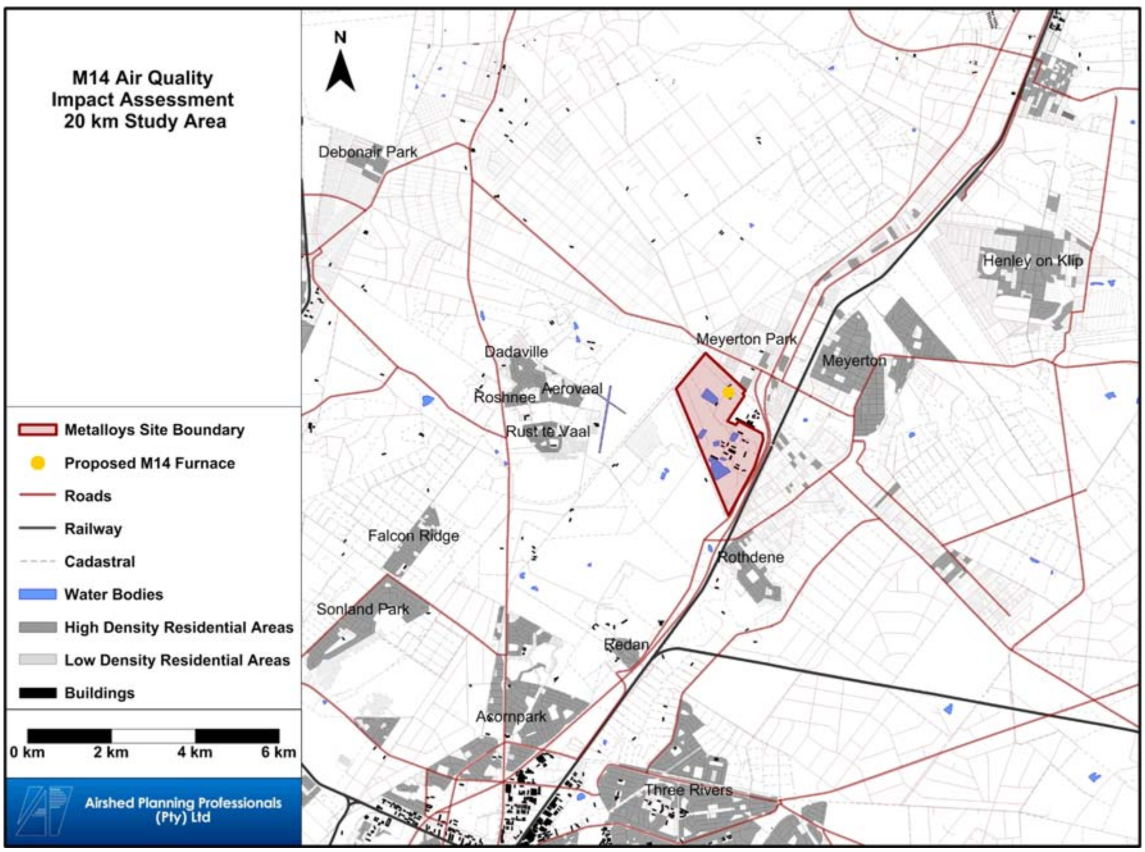

Figure 3-1: Study area (20 x 20 km)

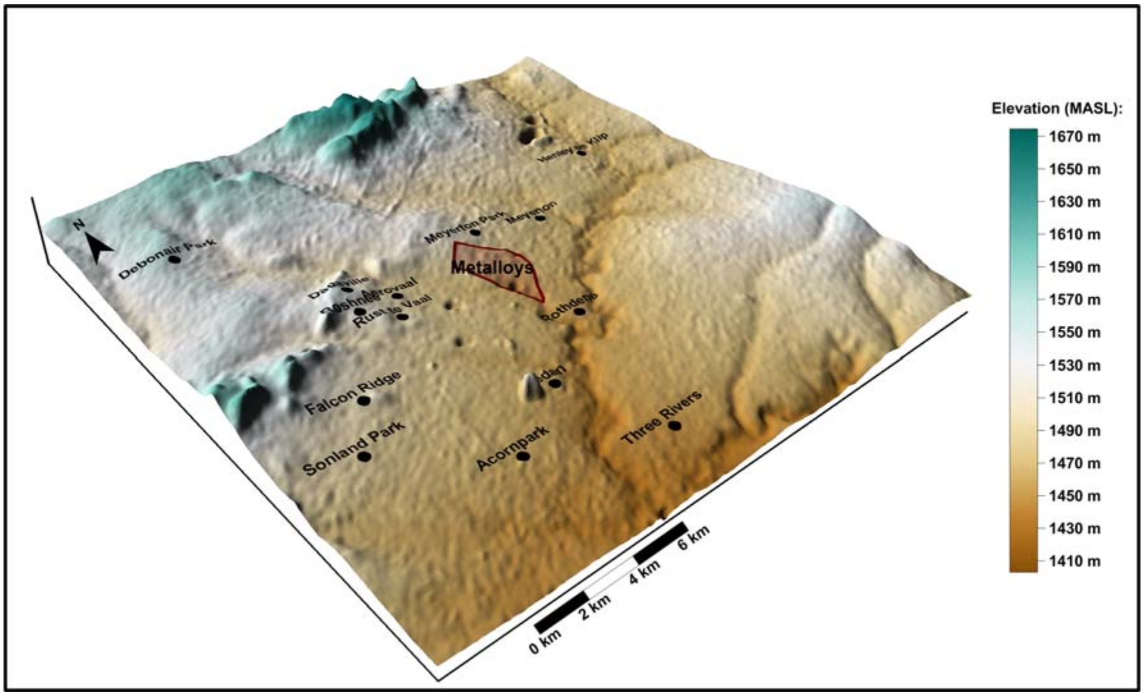

Figure 3-2: Terrain elevation of study area

3.2 Atmospheric Dispersion Potential

In the assessment of the possible impacts from air pollutants on the surrounding environment and human health, a good understanding of the regional climate and local air dispersion potential of a site is essential.

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

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

Parameters that need to be taken into account in the characterisation of meso-scale ventilation potentials include wind speed, wind direction, extent of atmospheric turbulence, ambient air temperature and mixing depth. In the description of the atmospheric dispersion potential of the study area, reference was made to SAWS meteorological data for Vereeniging for the period January 2005 to December 2007.

3.2.1 Mixing Height and Atmospheric Stability

The vertical component of dispersion is a function of the extent of thermal turbulence and the depth of the surface mixing layer. Unfortunately, the mixing layer is not easily measured, and must therefore often be estimated using prognostic models that derive the depth from some of the other parameters that are routinely measured, e.g. solar radiation and temperature. During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface and the extension of the *mixing layer* to the lowest elevated inversion. Radiative flux divergence during the night usually results in the establishment of ground based inversions and the erosion of the mixing layer. The mixing layer ranges in depth from ground level (i.e. only a stable or neutral layer exists) during night-times to the base of the lowest-level elevated inversion during unstable, day-time conditions. Atmospheric stability is frequently categorised into one of six stability classes. These are briefly described in Table 3-1. In the model used here, atmospheric stability is described as a continuous variable in terms of the Monin-Obukhov length and the mixing height.

Table 3-1: Atmospheric Stability Classes

A	very unstable	calm wind, clear skies, hot daytime conditions
B	moderately unstable	clear skies, daytime conditions
C	unstable	moderate wind, slightly overcast daytime conditions
D	neutral	high winds or cloudy days and nights
E	stable	moderate wind, slightly overcast night-time conditions
F	very stable	low winds, clear skies, cold night-time conditions

The atmospheric boundary layer is normally unstable during the day as a result of the turbulence due to the sun's heating effect on the earth's surface. The thickness of this mixing layer depends predominantly on the extent of solar radiation, growing gradually from sunrise to reach a maximum at about 5-6 hours after sunrise. This situation is more pronounced during the winter months due to strong night-time inversions and a slower developing mixing layer. During the night a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral.

For elevated releases, the highest ground level concentrations would occur during unstable, daytime conditions. The wind speed resulting in the highest ground level concentration depends on the plume buoyancy. If the plume is considerably buoyant (high emission velocity and temperature) together with a low wind, the plume will reach the ground relatively far downwind. With stronger wind speeds, on the other hand, the plume may reach the ground closer, but due to the increased ventilation, it would be more diluted. A wind speed between these extremes would therefore be responsible for the highest ground level concentrations. The highest concentrations for low level releases would occur during low wind speeds and stable (night-time) atmospheric conditions. Air pollution episodes frequently occur just prior to the passage of a frontal system that is characterised by calm winds and stable conditions.

The occurrence of the various stability classes associated with the 16 main wind directions are presented in Figure 3-3. Stable atmospheric conditions tend to result in high ground level concentrations for ground level emitters such as fugitive dust from unpaved roads and crushers. High frequency of very stable (F – stability) conditions occurred predominantly from the north to the north-western sector.

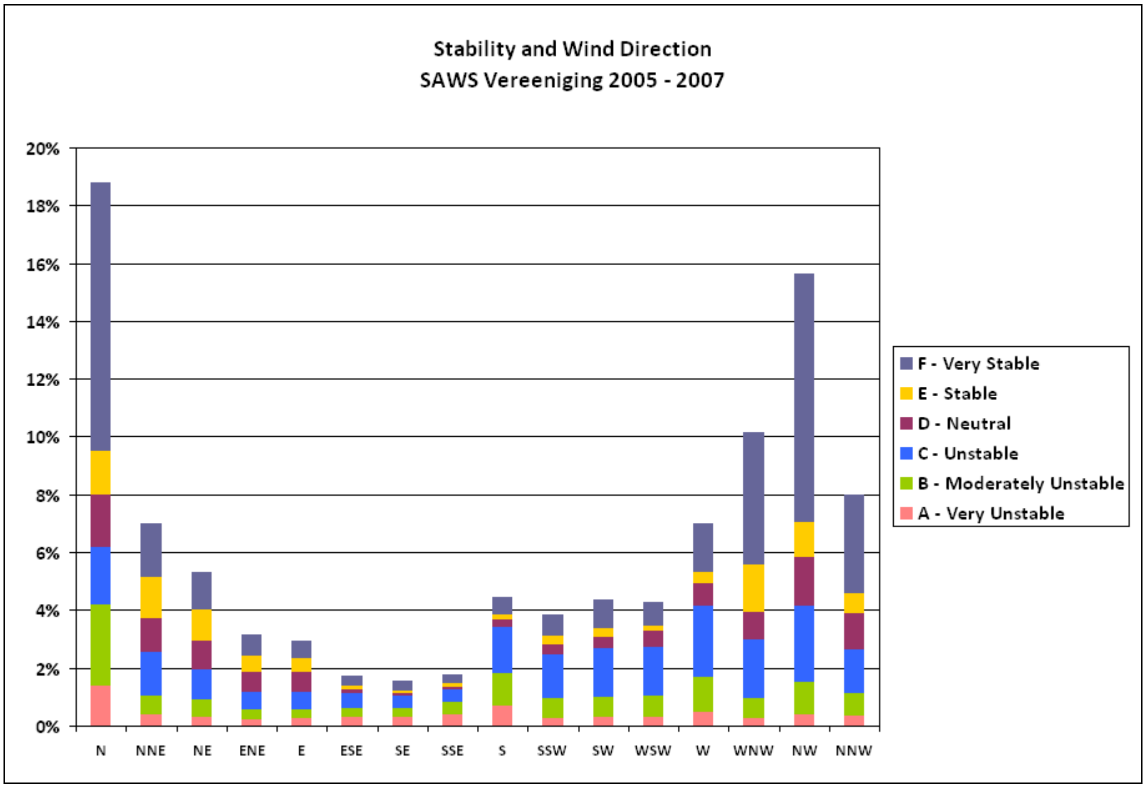

Figure 3-3: Wind direction and stability class

3.2.2 Local Wind Field

Wind roses comprise 16 spokes, which represent the directions from which winds blew during a specific period. The colours used in the wind roses below, reflect the different categories of wind speeds; the red area, for example, representing winds of 6 to 10 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s are also indicted.

The period wind field and diurnal variability in the wind field are shown in Figure 3-4 and Figure 3-5. Seasonal variations in the wind field are provided in Figure 3-6. The wind field is characterised by dominant north-westerly winds. Wind from the north-west occurred 15% of the time with calm conditions occurring 12% of the time.

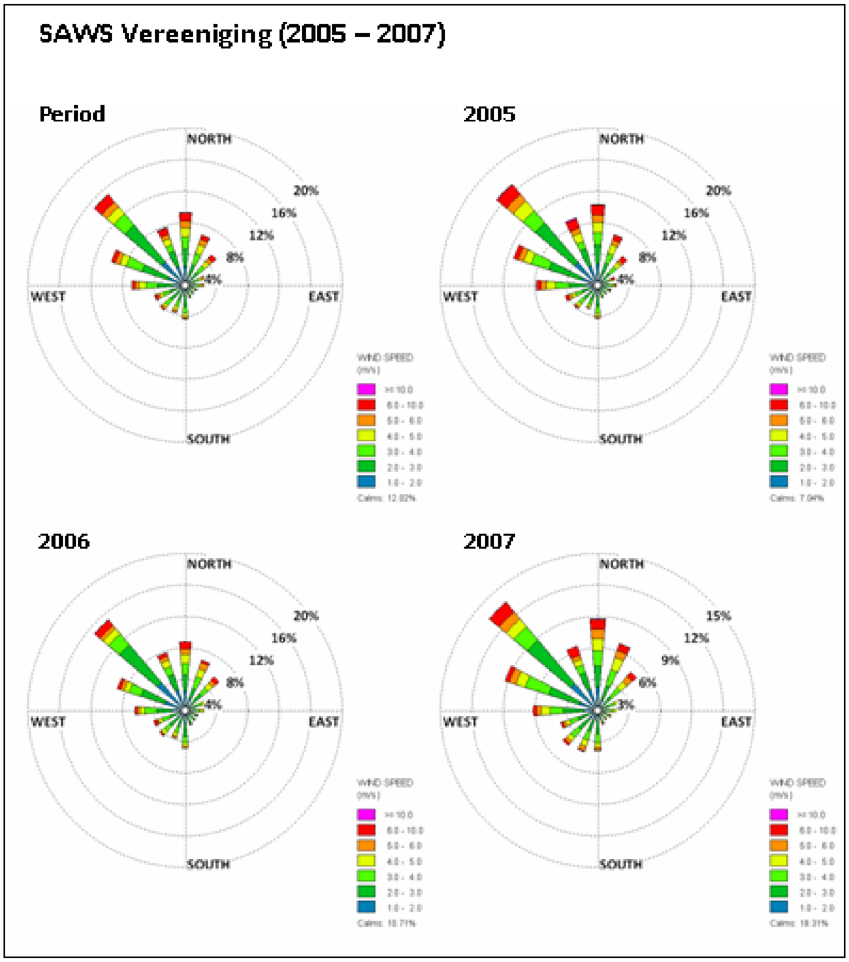

Figure 3-4: Period average wind roses (Vereeniging, Jan 2005 – Dec 2007)

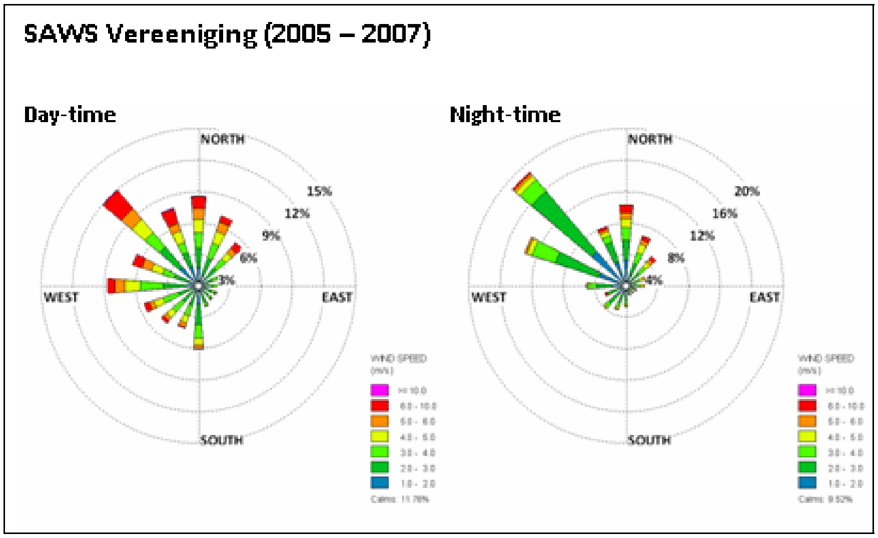

Figure 3-5: Diurnal wind roses (Vereeniging, Jan 2005 – Dec 2007)

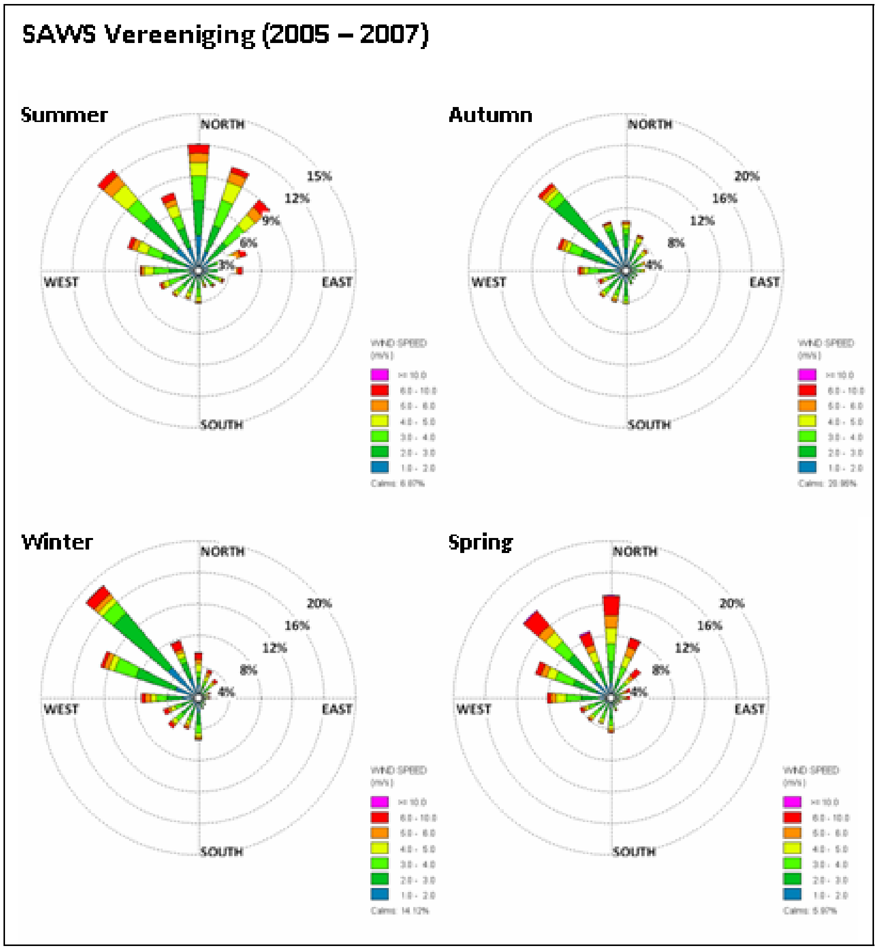

Figure 3-6: Seasonal wind roses (Vereeniging, Jan 2005 – Dec 2007)

3.2.3 Temperature

Air temperature is important, both for determining the effect of plume buoyancy (the larger the temperature difference between the plume and the ambient air, the higher the plume is able to rise), and determining the development of the mixing and inversion layers. The diurnal temperature trend is presented in Figure 3-7.

3.2.4 Rainfall

Precipitation is important to air pollution studies since it represents an effective removal mechanism of atmospheric pollutants. Monthly rainfall recorded at Vereeniging is presented in Figure 3-8.

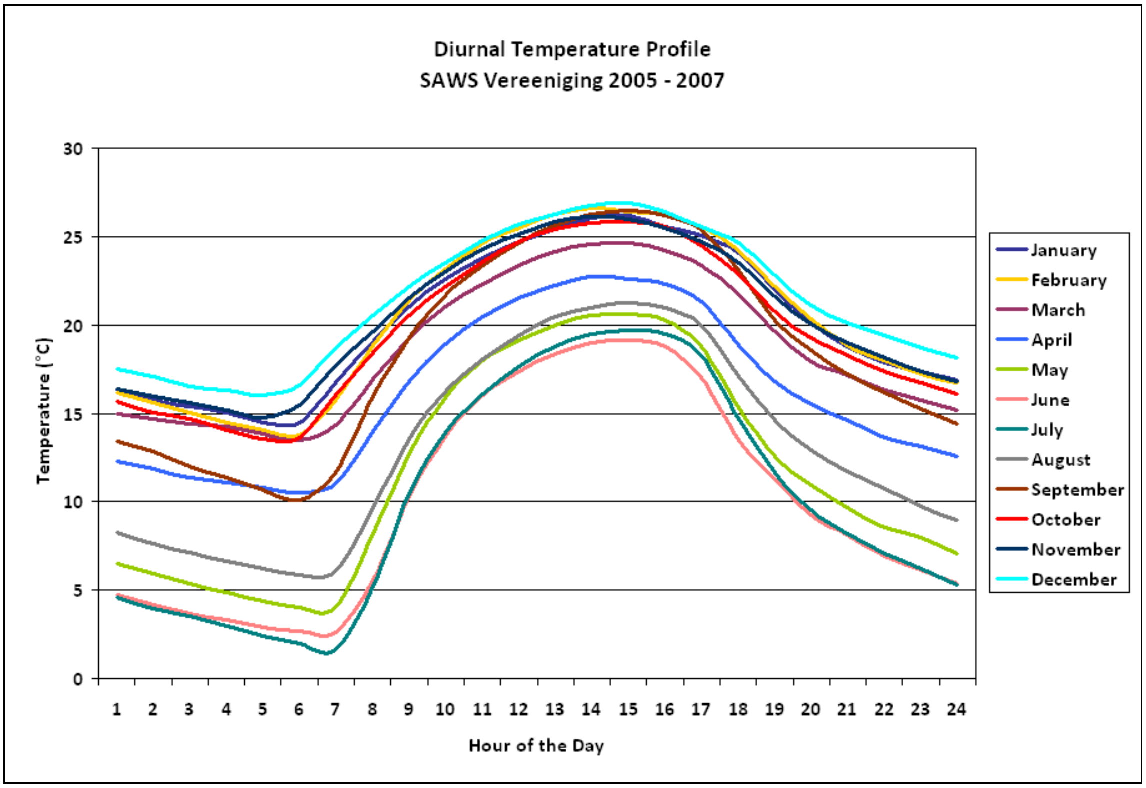

Figure 3-7: Diurnal temperature profile (Vereeniging, Jan 2005 – Dec 2007)

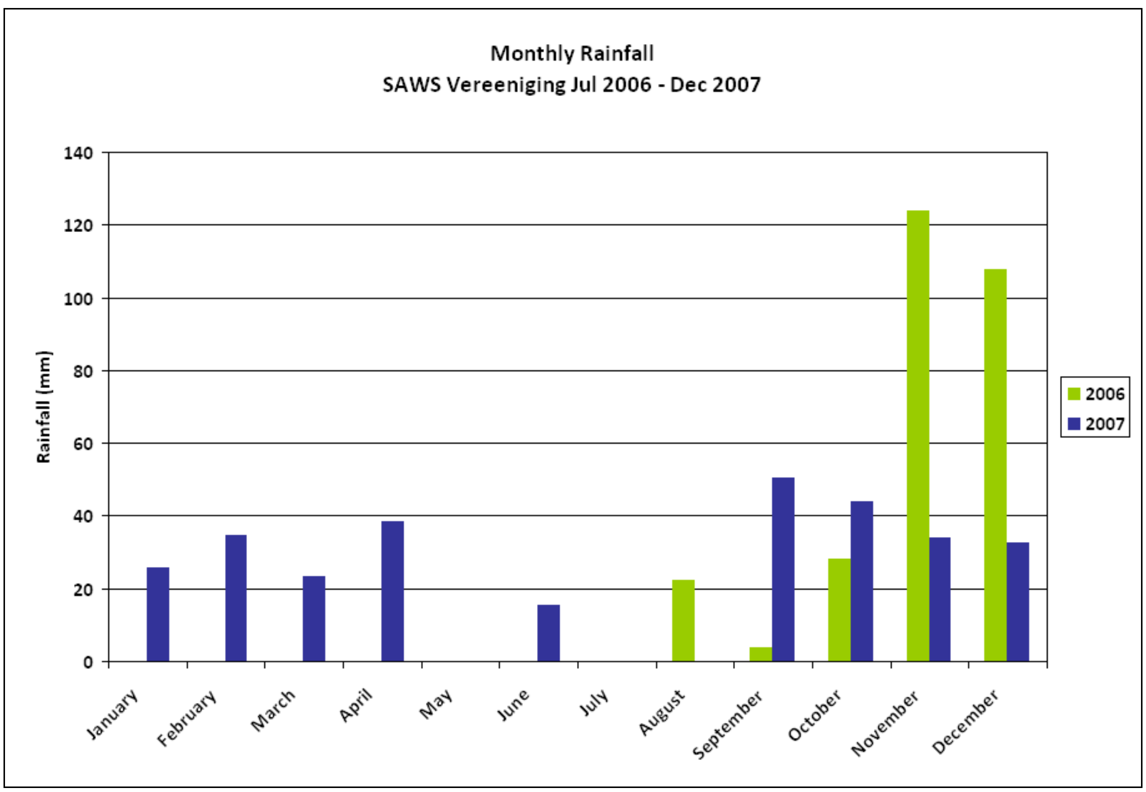

Figure 3-8: Monthly rainfall (Vereeniging, Jul 2006 – Dec 2007)

3.3 Existing Air Quality

3.3.1 Existing Sources of Emission within the Area

Sources of atmospheric emission which contribute to air pollutant concentrations within the study region include industrial emissions, vehicle tailpipe releases, household fuel burning and fugitive dust sources. In addition to which pollution emitted outside of the area is dispersed into the area from distant natural and anthropogenic sources. A description of the major source types is given in subsequent subsections and the main air pollutants released listed.

3.3.1.1 Industrial and Mining Sources within Meyerton

Based on the emission estimates the largest sources of industrial/mining related emissions within Meyerton include the existing industries of Metalloys, Blitz Concrete Works and EMSA in addition to various ceramic processes, viz. Ocon Bricks, Vaal Potteries and Meyerton Brick & Tile. The Glen Douglas Dolomite Quarry is the only known quarrying/mining activity in the area.

- **Metalloys** - Emissions from existing operations at Metalloys are discussed in detail as part of the impact assessment for the proposed M14 furnace in Section 4.

- **EMSA** - EMSA undertakes the manufacture of graphite electrodes by a process of baking and graphitising in five baking furnaces and 8 E-type graphitising furnaces. Bagfilters, electrostatic precipitators and incinerators are used as the main air pollution control equipment for process off-gases. Three gas-fired incinerators are in operation. Upsets, such as the breakdown of one of the incinerators, typically results in a short episode of elevated emissions. Such episodes, when they do occur, are readily visible and result in complaints by local residents.

- **Blitz Concrete Works** - Fugitive dust represents the main emission from this plant, with fugitive releases occurring due to materials handling (including sand, stone and cement) and product mixing.

- **Ceramic Processes** - Ocon Bricks produce about 2.5 million bricks per month in a coal-fired kiln. Meyerton Brick & Tile is permitted to produce not more than 1 million bricks per month with only partly burned coal (not coal) allowed to be used in the clam ovens used. Vaal Potteries fire ceramic articles (~1000 t/month) in a Sasol gas fired kiln. The manufacture of brick and related products such as clay pipe, pottery typically involves the mining, grinding, screening, and blending of the raw materials, and the forming, cutting or shaping, drying or curing, and firing of the final product. In all kilns, firing takes place in 6 steps: evaporation of free water, dehydration, oxidation, vitrification, flashing, and cooling. Coal, gas or residual oil can be used for heating. Total heating time varies with the type of product. Particulate matter is the primary emission in the manufacture of bricks. The main source of dust is the materials handling procedure, which includes drying, grinding, screening, and storing the raw material. Combustion products are emitted from the fuel consumed in the dryer and the kiln. Fluorides, largely in gaseous form, are also emitted from brick manufacturing operations depending on the fluoride content of the clays used. Sulphur dioxide may be emitted from the bricks when temperatures reach or exceed 1370°C, but no data on such emissions are available.

- **Letabo Power Station** – Letabo Power Station is located approximately 20 km south of Metalloys and consists of six 618 MW units. Emissions include products of combustion such as NO_x and SO_2 as well as particulates and other trace elements.

3.3.1.2 Household Fuel Burning

Energy use within the residential sector is given as falling within three main categories, viz.: (i) traditional - consisting of wood, dung and bagasse, (ii) transitional - consisting of coal, paraffin and LPG, and (iii) modern - consisting of electricity (increasingly includes use of renewable energy). The typical universal trend is given as being from (i) through (ii) to (iii).

Although most households use electricity, where available, fuels as coal, wood, paraffin and candles are shown to still be important energy sources. Paraffin is used for heating and cooking (also for lighting in unelectrified areas), whereas wood and coal are used primarily for space heating and cooking purposes. The continued use of coal and wood by a large section of the population within Gauteng represents a cause for concern with regard to air pollution and health risk potentials. These fuels continue to be used for primarily two reasons: (i) rapid urbanisation and the growth of informal settlements has exacerbated backlogs in the distribution of basic services such as electricity and waste removal, and (ii) various electrified households continue to use coal due particularly to its cost effectiveness for space heating purposes and its multi-functional nature (supports cooking, heating and lighting functions).

Coal is relatively inexpensive and is easily accessible in the region due to the proximity of the region to coal mines and the well-developed local coal merchant industry. Coal burning emits a large amount of gaseous and particulate pollutants including sulphur dioxide, heavy metals, total and respirable particulates including heavy metals and inorganic ash, carbon monoxide, polycyclic aromatic hydrocarbons, and benzo(a)pyrene. Polyaromatic hydrocarbons are recognised as carcinogens.

Pollutants arising due to the combustion of wood include respirable particulates, nitrogen dioxide, carbon monoxide, polycyclic aromatic hydrocarbons, particulate benzo(a)pyrene and formaldehyde. Particulate emissions from wood burning within South Africa have been found to contain about 50% elemental carbon and about 50% condensed hydrocarbons. Wood burning is less widely used compared to coal burning. The main pollutants emitted from the combustion of paraffin are NO_2, particulates carbon monoxide and polycyclic aromatic hydrocarbons. The use of paraffin is of concern not only due to emissions from its combustion within the home, but also due to its use being associated with accidental poisonings (primarily of children), burns and fires.

3.3.1.3 Traffic Related Emissions

The study area is transacted by various high traffic roads. The residential and industrial areas within the region further comprise numerous secondary roads. Although most of the roads are paved, unpaved roads do occur within certain residential areas (e.g. settlement to the northwest of the Metalloys Plant).

Tailpipe emissions resulting from motor vehicles can be grouped into primary and secondary pollutants. While primary pollutants are emitted directly into the atmosphere, secondary pollutants form in the atmosphere as a result of chemical reactions. Significant primary pollutants emitted combustion engines include carbon dioxide (CO_2), carbon (C), SO_2, oxides of nitrogen (mainly NO), particulates and lead. Secondary pollutants include NO_2, photochemical oxidants such as ozone, sulphur acid, sulphates, nitric acid, and nitrate aerosols (particulate matter). Diesel-powered vehicles also emit particulate matter consisting of soot formed during combustion, heavy hydrocarbons condensed or adsorbed on the soot, and sulphates. In older diesel-fuelled vehicles the contribution of soot to particulate emissions is between 40% and 80%. The black smoke observed to emanate from poorly maintained diesel-fuelled vehicles is caused by oxygen deficiency during the fuel combustion or expansion phase. Vehicle (i.e. model-year, fuel delivery system), fuel (i.e. type, oxygen content), operating (i.e. vehicle speed, load), and environmental parameters (i.e. altitude, humidity) influence vehicle emission rates (Onursal, 1997).

3.3.1.4 Fugitive Dust Sources

These sources are termed fugitive because they are not discharged to the atmosphere in a confined flow stream. Sources of fugitive dust in the project vicinity include vehicle entrainment from paved and unpaved roads and wind erosion of sparsely vegetated surfaces. These fugitive dust sources are associated with coarse and fine particulate emissions.

Vehicles travelling on unpaved roads cause pulverization of the surface material on unpaved roads. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong turbulent air shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed. Dust emissions from unpaved roads vary in relation to the vehicle traffic and the silt content of the road bed material. Emission from paved roads are significantly less than those originating from unpaved roads, however they do contribute to the particulate load of the atmosphere. Particulate emissions occur whenever vehicles travel over a paved surface. The fugitive dust emissions are due to the re-suspension of loose material on the road surface. In intersections where unpaved roads intersect paved roads significant quantities of material can be tracked onto the paved road surface, increasing the silt loading and hence the potential for emissions from the paved road surface.

3.3.1.5 Biomass Burning

Biomass burning includes the burning of evergreen and deciduous forests, woodlands, grasslands, and agricultural lands. Within the project vicinity wild fires (locally known as veld fires) may further represent a source of combustion-related emissions. Based on the analysis of burn scar data from satellite imagery it has been determined that approximately 25% of total area making up the Vaal Triangle burns over a five year period.

Biomass burning is an incomplete combustion process, with CO, methane and NO_2 gases being emitted. Approximately 40% of the nitrogen in biomass is emitted as nitrogen, 10% is left is the ashes, and it may be assumed that 20% of the nitrogen is emitted as higher molecular weight nitrogen compounds. The visibility of the smoke plumes is attributed to the aerosol (particulate matter) content. In addition to the impact of biomass burning within the vicinity of the proposed development, long-range transported emissions from this source can further be expected to impact on the air quality between the months August to October. It is impossible to control this source of atmospheric pollution loading; however, it should be noted as part of the background or baseline condition before considering the impacts of other local sources.

3.3.1.6 Trans-boundary Sources

The atmospheric dispersion of pollutants does not respect political boundaries. Sources located not only immediately on the outskirts of the study area, but also large sources located much further afield impact on the air quality of the region. Source apportionment studies have identified four major contributing source types of regional significance to the atmospheric aerosol loading. The four source types include aeolian crustal material consisting of mineral soil dust, marine aerosols from the two adjacent oceans, biomass burning particles occurring mainly north of 20° S and finally, aerosols from industrial emissions. Emissions from these four sources have been observed in the past at remote sites across South Africa (Annegarn, *et al.*, 1992; Piketh, 1995; Piketh *et al.,* 1996; Salma *et al.*, 1992; Maenhaut *et al.*, 1996).

3.3.2 Vaal Triangle Airshed Priority Area Air Quality Management Plan

The Vaal Triangle Airshed Priority Area (VTAPA) was declared in April 2006. As part of the requirements for priority areas according to the National Environmental Management Air Quality Act of 2004 (NEM AQA, 2004) an Air Quality Management Plan (AQMP) was developed. The main objective of the AQMP is to ensure, once implemented, compliance with national ambient air quality standards (DEAT, 2007).

Ambient monitoring is currently conducted by the Department of Environmental Affairs (DEA) as part of the VTAPA AQMP at various locations within the Vaal Triangle. Data obtained from Sebokeng and Three Rivers, the nearest stations to Metalloys (Figure 3-9), for the period January 2007 to December 2009 are discussed in this Section.

Reference is also made to ambient pollutant concentrations predicted by the VTAPA AQMP Baseline Characterisation (DEAT, 2007). Due to the nature of the pollutants expected from the proposed project, reference is made only to ambient NO_2, SO_2 and PM10 measurements and predictions.

Elevated PM10 concentrations in exceedance of the SA daily standard were recorded at Sebokeng and Three Rivers. Measured NO_2 and SO_2 concentrations at Sebokeng and Three Rivers were within compliance with SA ambient air quality standards.

Table 3-2: Ambient air quality measurements at Sebokeng and Three Rivers

Pollutant	Averaging Period	SA Ambient Air Quality Standard (µg/m³)	Ambient Air Quality Measurements (µg/m³) [Jan 2007 – Dec 2009]	
			Sebokeng	Three Rivers
CO	Highest Hourly Concentration *(Hours of Exceedance)*	30 000 *(88)*	9560 *(0)*	2430 *(0)*
NO_2	Highest Hourly Concentration *(Hours of Exceedance)*	200 *(88)*	170 *(0)*	123 *(0)*
	Annual Average Concentration	40	12.8	8.5
SO_2	Highest Hourly Concentration *(Hours of Exceedance)*	350 *(88)*	236 *(0)*	354 *(2)*
	Highest Daily Concentration *(Days of Exceedance)*	125 *(4)*	113 *(0)*	70 *(0)*
	Annual Average Concentration	50	17.8	6.6
PM10	Highest Daily Concentration *(Days of Exceedance)*	75 *(4)*	171 *(91)*	147 *(47)*
	Annual Average Concentration	40	39.1	33.3

Figure 3-9: Sebokeng and Three Rivers ambient monitoring locations

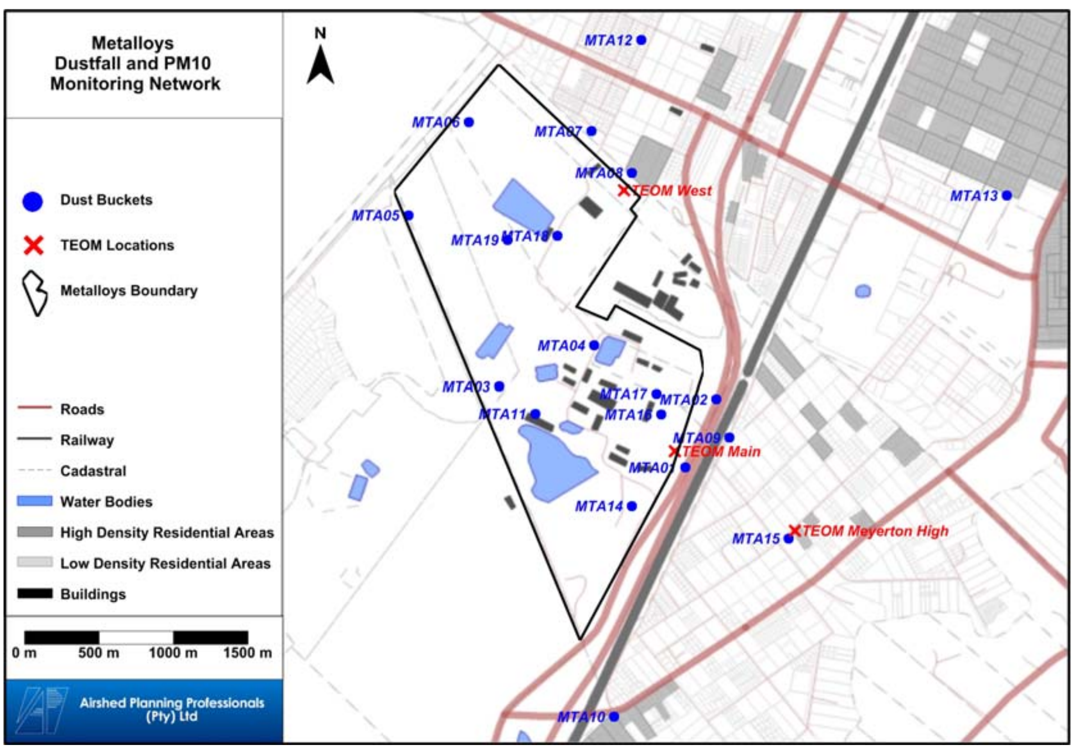

Figure 3-10: Metalloys PM10 and dustfall monitoring network

3.3.3 Metalloys Ambient PM10 and Dustfall Monitoring

Metalloys has established a monitoring network consisting of three PM10 monitoring stations, of which one also measures meteorological parameters, and 19 dust buckets (Figure 3-10). The results of monitoring conducted for the period July 2007 to December 2009 are discussed below.

3.3.3.1 Measured PM10 Concentrations

Metalloys has established three PM10 monitoring stations around their operation. These are:

- Main Station – Located on the south eastern side of the Metalloys plant boundary downwind of the final product handling section of the MMD;
- West Station – Located on the north eastern side of the Metalloys plant boundary between West Plant and Meyerton Park; and
- Meyerton High Station – Located to the south-east of Metalloys at Meyerton High School.

A summary of recorded annual average, highest daily average and the frequency that the SA daily 75 µg/m³ were exceeded are summarised per year in Table 3-3. Elevated PM10 concentrations, in exceedance of the SA annual and daily standards, were recorded at Main, West and Meyerton High.

Average daily PM10 concentrations recorded at Main, West and Meyerton High are graphically presented in Figure 3-11. A distinct annual trend is observed with the highest PM10 concentrations recorded during the dry and windy months of July, August and September when sources such as domestic fuel burning and biomass burning may contribute significantly to background levels.

When evaluated against wind direction[2] the source of PM10 concentrations may be identified. At Main, hourly average PM10 concentrations of up to 100 µg/m³ are uniformly distributed across all wind directions (Figure 3-12) which could be indicative of general background PM10 levels. Very high hourly average PM10 concentrations (200 to 500 µg/m³) were recorded to coincide with winds from the north-west to the north. As this station is located directly south-east of the final product processing area of the MMD, these concentrations may be as a result of the crushing, screening, loading and transport of final product at Metalloys. Similar background trends can be observed for Meyerton High (Figure 3-13) and West (Figure 3-14). At West, PM10 concentrations coinciding with winds from the south-west to west may however be as a result of West Plant operations.

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[2] Wind direction in only recorded at Main. For the evaluation of PM10 concentration against wind direction it was assumed that the wind field at West and Meyerton High is similar to the wind field recorded at Main.

Table 3-3: Metalloys ambient PM10 monitoring results

Year	Data Availability	Annual Average Concentration (µg/m³)	Highest Daily Average Concentration (µg/m³)	Frequency of Exceedance of 75 µg/m³ (days per period)
SA Ambient Air Quality Standards :		***40 µg/m³***	***75 µg/m³***	***4 days per calendar year***
Main (Sept 2007 – Dec 2009)				
2007	33%	103	327	66
2008	96%	107	615	208
2009	100%	70	276	131
West (Sept 2007 – Dec 2009)				
2007	30%	58	145	29
2008	93%	77	258	148
2009	88%	54	162	75
Meyerton High (Sept 2007 – Dec 2009)				
2007	32%	58.94	144	30
2008	56%	88.75	285	100
2009	96%	63.47	167	107

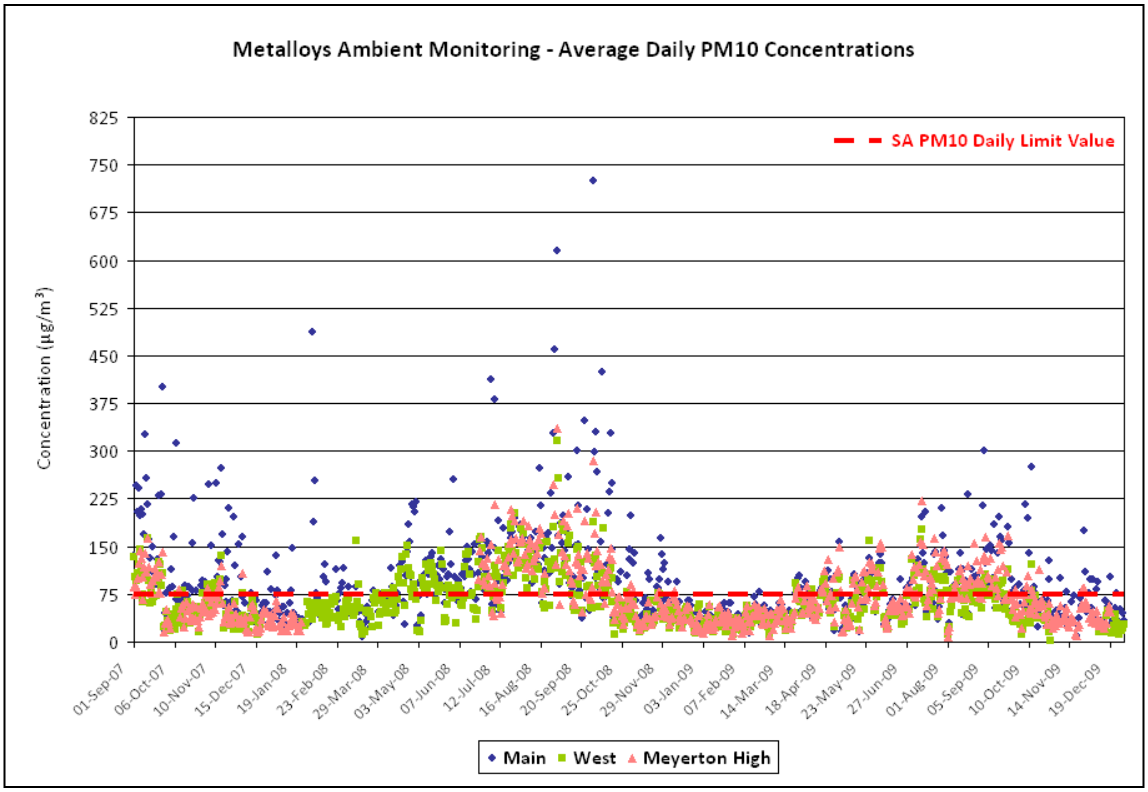

Figure 3-11: Daily average PM10 concentrations recorded at Metalloys stations

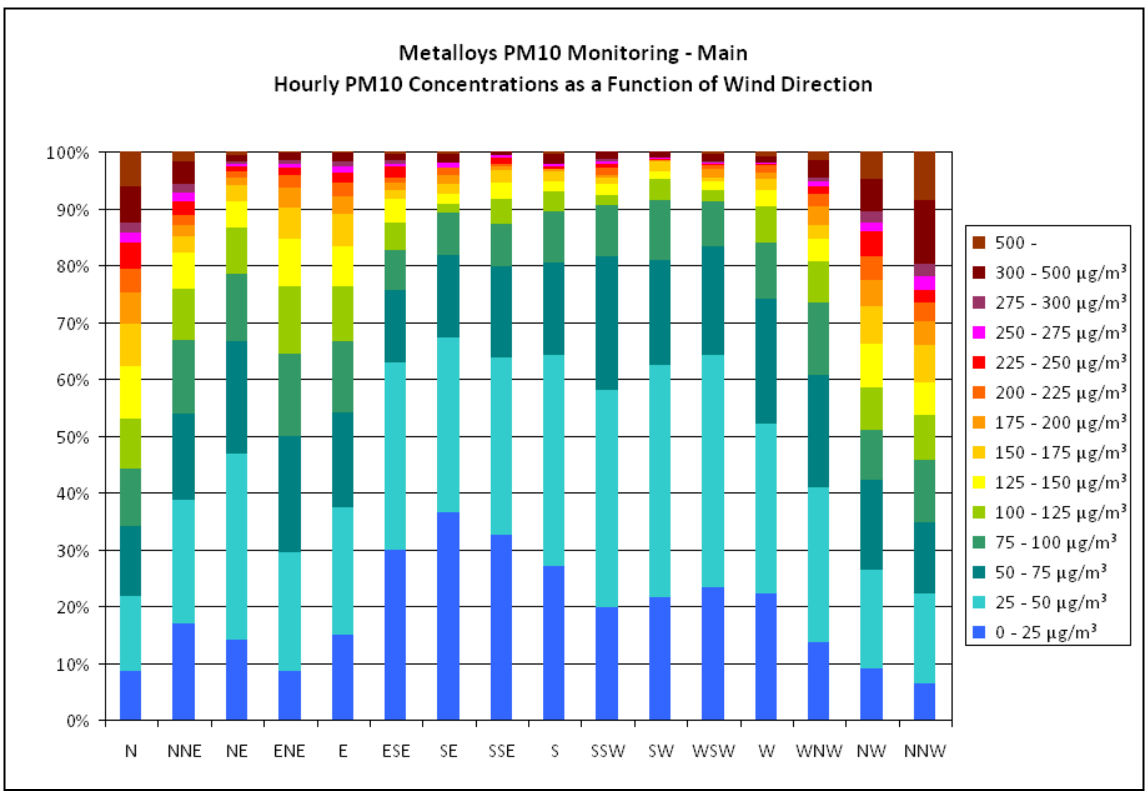

Figure 3-12: Hourly PM10 concentrations as a function of wind direction (Main)

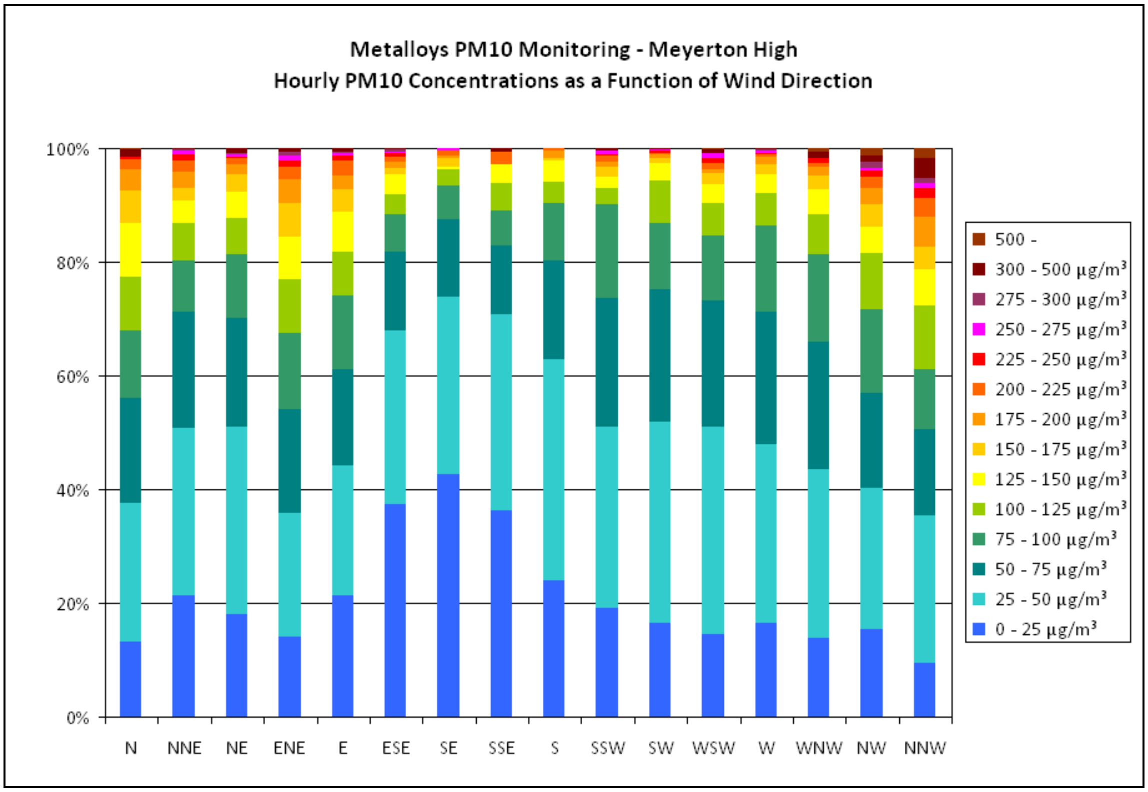

Figure 3-13: Hourly PM10 concentrations as a function of wind direction (Meyerton High)

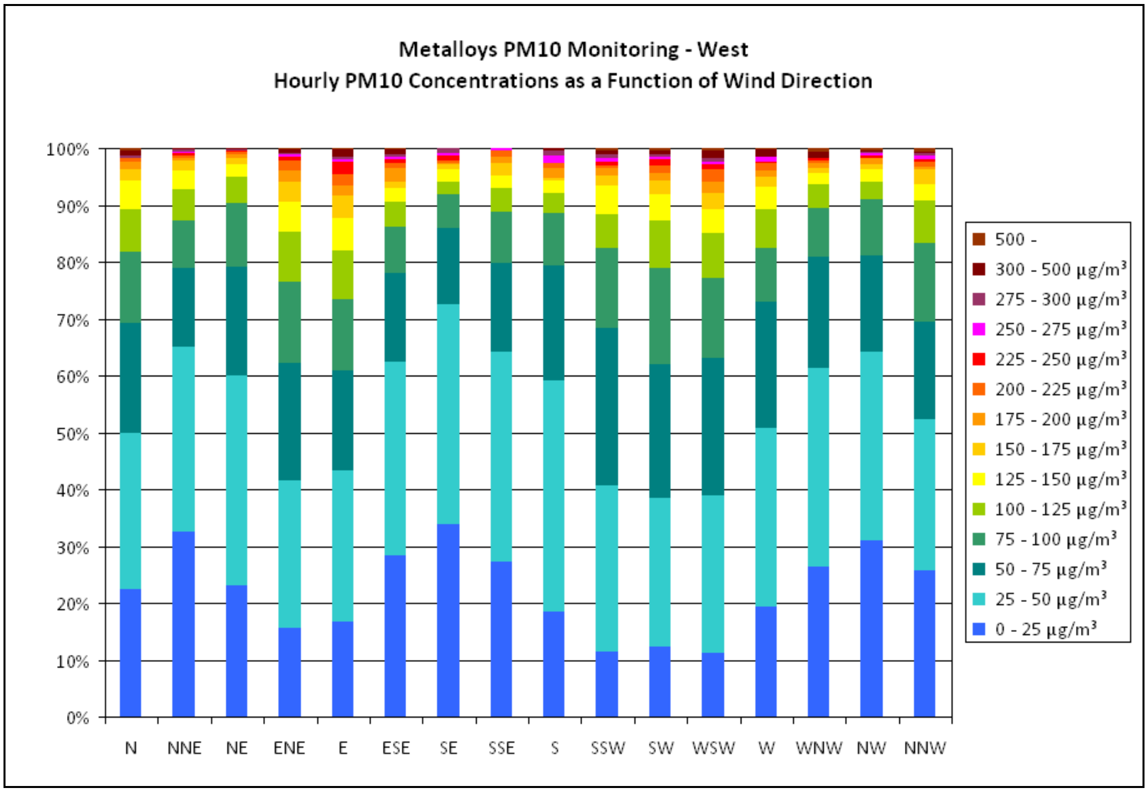

Figure 3-14: Hourly PM10 concentrations as a function of wind direction (West)

3.3.3.2 Measured Dustfall levels

Metalloys has established a dustfall monitoring network consisting of 19 dust buckets on and around their operations as indicated in Figure 3-10. For reporting purposes a distinction is made between on-site and off-site dustfall monitoring locations and results. Daily dustfall levels based on a 30 day average monitoring period, recorded during 2009 are presented in Figure 3-15 and Figure 3-16 for on- and off-site monitoring locations respectively.

Dustfall levels of less than 600 mg/m²-day occurred at most on-site dustfall monitoring locations. During 2009, off-site dustfall levels were below 600 mg/m²-day which is permissible for residential and light commercial areas. The highest dustfall levels were recorded during September.

Table 3-4 summarises daily dustfall levels based on an annual average recorded from 2003 to 2009 for off-site monitoring locations. No exceedances of the SANS target value of 300 mg/m²-day for ambient dustfall were recorded during 2009. It should be noted that dustfall levels recorded at the off-site locations in Table 3-4 are not necessarily a direct result of Metalloys operations. The area surrounding the Metalloys site is characterised by open veld, farmland and low density residential areas which may contribute significantly to measured dust fall levels.

Table 3-4: Daily dustfall (annual average) measured at Metalloys

Location		Daily Dustfall (Annual Average)[(a)] (mg/m²-day)						
		2003	2004	2005	2006	2007	2008	2009
Off-Site	MTA09 Kookfontein	280	**380**[(b)]	**410**[(b)]	260	**320**[(b)]	230	110
	MTA10 House #24	200	240	240	220	280	**310**[(b)]	180
	MTA11 Community Centre	-	-	**370**[(b)]	**320**[(b)]	260	280	150
	MTA12 Shabe	-	-	**540**[(b)]	**330**[(b)]	290	**310**[(b)]	240
	MTA13 Malan School	-	-	210	130	190	130	150
	MTA15 Meyerton High	-	-	-	-	-	230	120

Notes:
(a) SANS target value for ambient dustfall levels – 300 mg/m²-day (annual average)
(b) Exceeds the SANS ambient dustfall target value

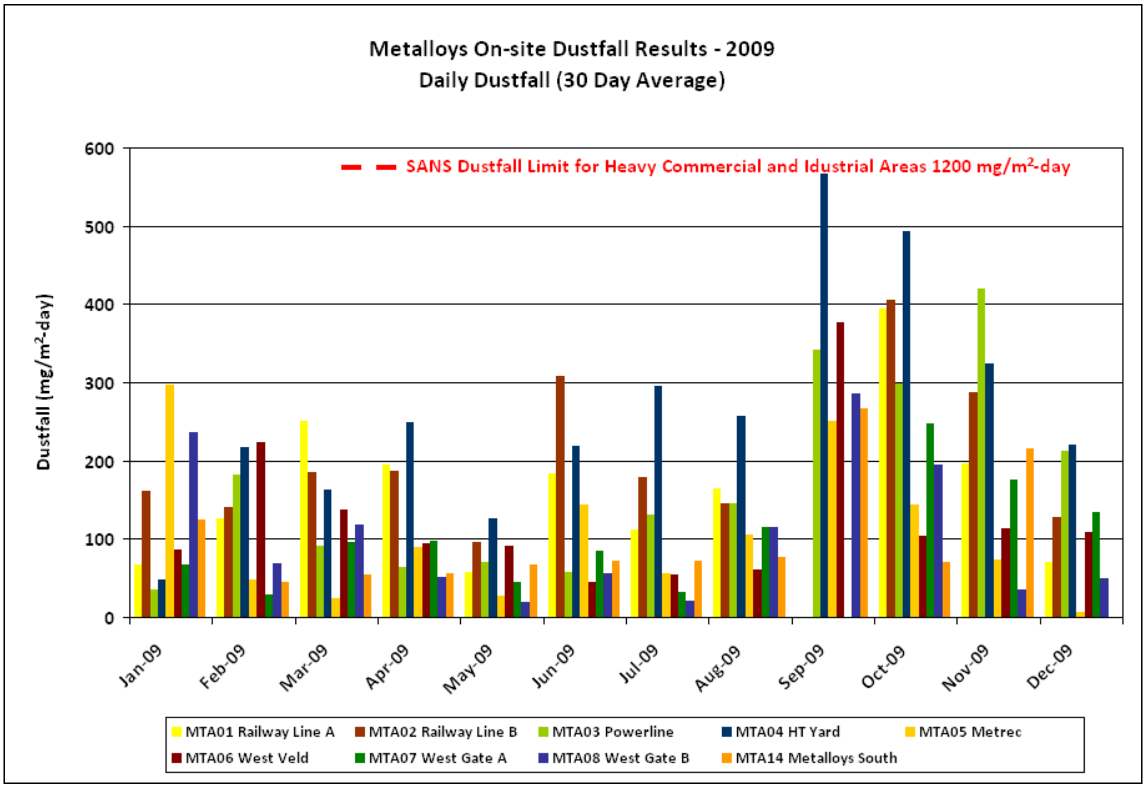

Figure 3-15: **Daily dustfall recorded at on-site/fence line Metalloys dust monitoring locations**

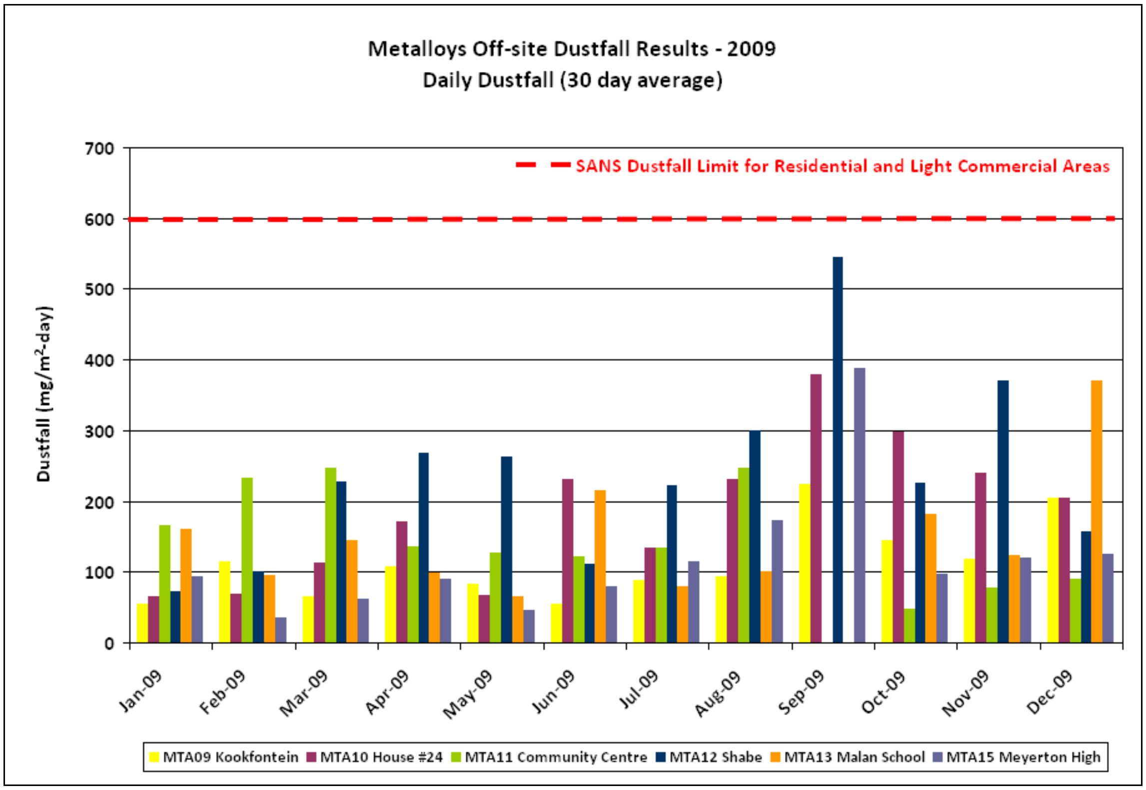

Figure 3-16: **Daily dustfall recorded at off-site Metalloys dust monitoring locations**

4 Impact Assessment

The proposed M14 furnace will be constructed at Metalloys' West Plant within the existing furnace building. All auxiliary operations, incl. raw materials handling, product and slag handling, crushing and dispatch will utilize existing infrastructure on the Metalloys site.

Metalloys has embarked on an emissions reduction strategy that aims to identify and reduce emissions from significant sources of atmospheric emissions. Mitigation measures identified and applied during this campaign will influence emissions from existing activities as well as activities associated with proposed M14 operations.

Due to M14's integration into existing infrastructure at Metalloys as well as the potential effects of the ERS on the proposed project, baseline (including existing sources of emission at Metalloys) and M14 processes, emissions and impacts are discussed in this section to account for incremental and cumulative effects.

4.1 Process Description

4.1.1 Existing Metalloys Operations

Current activities at Metalloys include five distinct areas of operations. These are:

- **South Plant** – South Plant produces silicomanganese (SiMn) in five submerged arc furnaces (M1, M2, M3, M4 and M5);
- **North Plant** – North Plant produces high carbon ferromanganese (HCFeMn) in two 75 MVA submerged arc furnaces (M10 and M11);
- **West Plant** – West plant produces HCFeMn as well as medium carbon ferromanganese (MCFeMn) in an 81 MVA submerged arc furnace (M12) and an oxygen blown converter (OBC);
- **Materials Management Department (MMD)** – MMD is responsible for logistics pertaining to all raw materials received on site as well as handling, preparation and dispatch of all products leaving from the central product area and West Plant. MMD also includes Roshcon (a slag crushing plant), a pelletising plant and a briquetting plant.
- **Elgen Plant** – Elgen generates electricity through the combustion of carbon monoxide (CO) rich furnace off-gas in a steam generating boiler.

A generalised process flow diagram summarising existing activities at Metalloys is provided in Figure 4-1. A detailed process description can be found in the Technical Review document by Knights Environmental (Knights, 2009). Current raw material consumption, slag and product production rates are provided in Table 4-1.

4.1.2 Proposed M14 Operations

M14 will be an 81 MVA (48 MW) furnace producing approximately 146 000 tons of FeMn alloy per year. M14 will be similar to the existing M12 furnace currently in operation at West Plant.

Raw materials will enter the Metalloys by road and rail and stored on site at the raw materials section of the MMD. Raw materials will be conveyed from the stockyard to the raw material bunkers of West Plant where it will be weighed and placed in a mixing bin before being fed to M14.

The submerged arc process is a reduction smelting operation. Iron and manganese oxides in the ores are reduced by carbon reductants (coal and coke) to FeMn alloy. The molten alloy moves to the bottom of the furnace while slag floats on the surface. When the level of molten metal has grown sufficiently, tap holes are made in the side of the furnace to remove slag and alloy separately.

The alloy is tapped into a ladle which after being weighed is cast on the ground to cool and solidify. Front end loaders will load trucks with solidified alloy for transport to the final product area where it will be crushed, sized and packaged for dispatch and sales.

Molten slag tapped from the furnace will be transported to the existing FeMn slag dump by means of a molten slag carrier. After cooling and solidifying it may be processed at Roshcon an existing slag processing plant. Should problems be experienced with molten slag carriers, slag will be cast into casting bed similar to metal casting beds. Emergency slag casting operations will generate additional dust emissions. The availability of the molten slag carrier system is expected to be at least 98%.

M14 will also be able to produce SiMn (64-65% Mn) should it be required. Another operational alternative includes the use of HCFeMn from M14 as feed into the OBC to produce MCFeMn. The capacity of the OBC currently matches production rates of either M12 or the proposed M14 furnace. All of the HCFeMn currently produced by M12 is fed to the OBC. It may however occur that the timing of the OBC operation will determine whether the HCFeMn feed will come from M12 or M14. The HCFeMn from M14 is however intended to be cast, crushed and sold as HCFeMn.

Expected raw material consumption, slag and product production rates associated with M14 are provided in Table 4-1.

Table 4-1: Raw material consumption and ferroalloy production rates

Material	Thousands of tons per annum		
	Metalloys Currently	Proposed M14	Total
Manganese Ore	1100	275	**1375**
Quartz	180	14	**194**
Reductants (Coal and Coke)	350	73	**423**
FeMn	390	146	**536**
FeMn Slag	510	120	**630**
SiMn	240	-(a)	**240**
SiMn Slag	300	-(a)	**300**

Notes:

(a) This investigation focussed on the production of HCFeMn in the proposed M14 furnace. See Limitations and Assumptions.

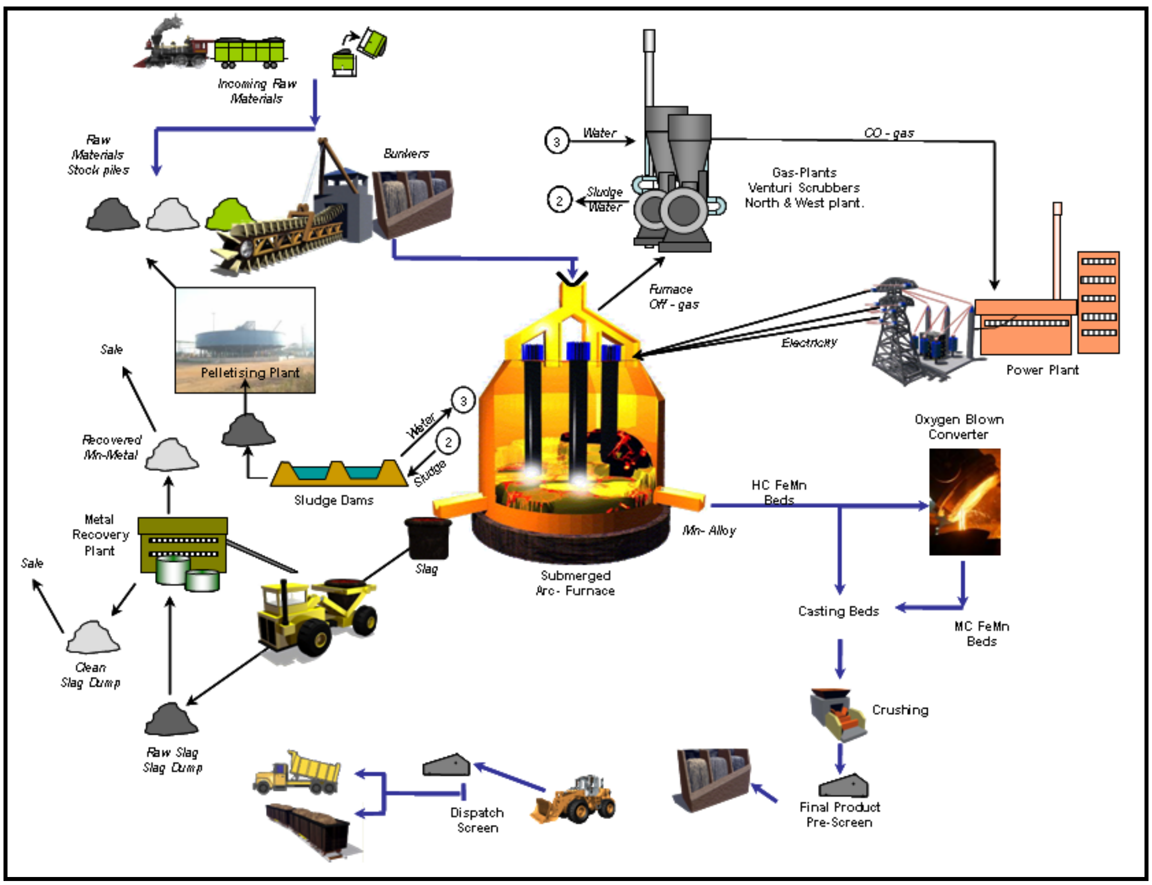

Figure 4-1: General process flow diagram (Knights, 2009)

4.2 Emissions Inventory

Based on the process description for existing Metalloys and proposed M14 operations (Knights, 2009), the following potential sources of atmospheric emission were identified:

- fugitive dust emissions as a result of handling of raw materials, wastes and products;
- fugitive dust emissions as a result of conveyor transfer points;
- fugitive dust entrained by vehicles travelling unpaved roads;
- fugitive dust entrained by vehicles travelling paved roads;
- fugitive dust emissions from the crushing and screening of manganese alloys and slag;
- fugitive dust and gaseous emissions from the tapping and casting of molten alloy and slag;
- routine particulate and gaseous emissions from smelting processes; and
- upset particulate and gaseous emissions from smelting processes.

Emissions were estimated for the following scenarios:

- **Scenario 1** – Including emissions from current Metalloys operations and potential increase in emissions as a result of proposed M14 operations. This scenario does not include any of the measures that form part of the ERS.
- **Scenario 2** – Including emissions from current Metalloys operations and potential increase in emissions as a result of proposed M14 operations. This scenario includes mitigation measures in the ERS planned for implementation up to July 2015.

The ERS projects, as provided by Metalloys and the implications on estimated emissions are discussed in more detail in Section 4.2.1.

In the estimation of emissions, a distinction was made between Total Suspended Particulates (TSP) and thoracic particulates (PM10, particulate matter with an aerodynamic diameter of less than 10 µm). Whereas TSP is of interest due to its implications in terms of nuisance dust impacts, the PM10 fraction is taken into account to determine the potential for human health impacts.

The quantification of current SO_2 and NO_x emissions associated with existing Metalloys operations did not form part of the scope of this study. The baseline emissions inventory only included particulates (TSP, PM10 and Mn). A three month passive diffusive ambient monitoring campaign for baseline SO_2 and NO_2 concentrations is currently being conducted at Metalloys.

4.2.1 Metalloys Emissions Reduction Strategy

Airshed has been provided with a list of ERS projects proposed for implementation up to 2015. Descriptions of these projects as well as estimated reduction efficiencies (with specific reference to PM10) are provided in Table 4-3. The effects of these projects on baseline emissions have been assessed and are summarised in Table 4-2.

It should be noted that expected control efficiencies assumed for the proposed control measures in the ERS are theoretical and were obtained from the Australian Emissions Estimation Technique for Mining, Version 2.3 (2003).

In all cases where an ERS project specified the installation of a new baghouse, the following specifications were assumed:

- Volumetric Flow Rate – 120 kNm^3/hour; and
- Design Dust Load – 10 mg/Nm^3.

Table 4-2: The anticipated effect of ERS projects on baseline emissions

Scenario	Description	Estimated Emissions (tpa)		
		PM10	TSP	Mn
Scenario 1	Current Baseline	376	860	161
Scenario 2	Future Baseline Emissions including ERS projects for implementation up to July 2015	237	502	99.1
% Overall Reduction		37%	42%	39%

Table 4-3: ERS projects (Metalloys, 2010) (Krause and Kornelius, 2008)

ID	Plant	Project	Effected Sources of Emission	Current Metalloys Operations		Metalloys Operations Including ERS	
				Estimated Control Efficiency	Estimated PM10 Emissions (tpa)	Estimated Control Efficiency	Estimated PM10 Emissions (tpa)
ERS01	MMD	Dust suppression or extraction equipment at CV08 and CV05 at raw materials handling	Reduced emissions from conveyor transfer points CV05 and CV08	30%	0.86	99%	0.01
ERS02	MMD	Optimisation of chemical dust suppression at the raw materials yard	Reduced materials handling emissions in the raw materials area of MMD	22.9%	10.15	90%	1.23
ERS03	MMD	Upgrade of extraction system at primary crusher and improved dust handling secondary dust extraction system	Reduced emissions from final product crushing and conveyor transfer points	65.2%	12.6	99%	0.24
ERS04	MMD	Dust-a-Side of untreated roads at the product truck loading area	Reduced emissions from roads in the product truck leading area	0%	8.15	90%	0.82
ERS05	MMD	Installation of fogging new fogging system at road and rail loading areas	Reduced materials handling emissions from product dispatch area	0%	0.72	50%	0.36
ERS06	North Plant	Installation of dedicated hoods and an additional baghouse for tapping and casting areas	Reduced furnace fugitive emissions from NP	13%	12.4	50%	6.2
ERS07	North Plant	Redirection of smoke hood stack emissions to the additional baghouse	Reduced NP smoke hood stack emissions	-	12.1	-	0
ERS08	North Plant	Enclosure of casting areas to contain emissions	Reduced materials handling emissions in the casting area	0%	0.13	70%	0.04
ERS09	South Plant	Paving	Reduced emissions SP unpaved area	0%	9.71	80%	1.94

ID	Plant	Project	Effected Sources of Emission	Current Metalloys Operations		Metalloys Operations Including ERS	
				Estimated Control Efficiency	Estimated PM10 Emissions (tpa)	Estimated Control Efficiency	Estimated PM10 Emissions (tpa)
ERS10	South Plant	Building enclosure and extraction to additional secondary baghouse	Reduced Furnace fugitive emissions from SP	75%	33.5	88%	16.1
ERS11	South Plant	Furnace off-gas to Elgen Plant	Reduced SP stack emissions	-	74.9	-	0
ERS12	West Plant	Expansion of secondary pollution plant for OBC and Casting Bays	Reduced furnace fugitive emissions from OBC	50%	25	75%	12.5
ERS13	West Plant	Installation of secondary fume extraction of casting areas	Reduced furnace fugitive emissions from WP	50%	37.4	75%	18.7
Totals				**-**	**238**	**-**	**58.1**

ID	Plant	Project	Estimated Additional PM10 Emissions (tpa)
ERS14	North Plant	Additional baghouse associated with ERS06	11.4
ERS15	South Plant	Additional baghouse associated with ERS10	11.4
ERS16	Elgen	Increased throughput from SP, ERS11	6.30
Totals			**29.1**

4.2.2 Stack Emissions

4.2.2.1 Existing Metalloys Stacks

Stack parameters and emissions from the various Metalloys plants were calculated based on data provided by Metalloys personnel as well as information from the APPA Registration Certificate Application Forms. Stacks, and parameters, associated with existing Metalloys operations as well as additional stacks associated with the ERS are indicted in Table 4-7.

4.2.2.2 Proposed M14 Stacks

The primary off-gas system for M14 will be similar to the existing M12 primary off-gas system. Furnace off-gas will be passed though a venturi scrubber system that will reduce the concentration of particulates in the gas stream to less than 50 mg/Nm³. As the primary furnace off-gas will be rich in hydrogen (H_2) and carbon monoxide (CO) it will be used to generate electricity at the Elgen plant.

The composition of M14 furnace off-gas is presented in Table 4-4. Stack parameters pertaining to the modelling of emissions from Elgen as a result of M14 operations only is provided in Table 4-5.

As a conservative measure, all particulate emissions from the M14 primary off-gas system were assumed to be in the 10 µm particle size fraction (i.e. PM10). Manganese emissions were calculated based on the percentage Mn in FeMn bagfilter dust (43% MnO, i.e. 33% Mn, (Knights, 2009)). SO_2 emissions were estimated by conservatively assuming that all the sulphur in the reductants entering the furnace will be converted to and emitted as SO_2. The sulphur content of reductants to be used at M14 is reported as 0.98% (DME, 2009). In the absence of process specific emission factors, NO_x emissions were estimated based on emission factors published by the NPI for the combustion of blast furnace gas (1.1 kg of NO_x per ton of gas combusted). It was conservatively assumed that all NO_x would be emitted as NO_2.

Table 4-4: M14 furnace off-gas composition (Knights, 2009)

Compound	% by Volume
H_2	14.1 %
CO	50.8 %
O_2	0.40 %
CO_2	16.4 %
N_2	0.00 %
H_2O	14.5 %

Fugitive emissions arise as a result of activities such as tapping of metal and slag from the furnace and the transfer from launders to ladles and casting. Extraction hoods will be positioned over these activities to remove fugitive emissions from the furnace building to the secondary pollution plant baghouse via ducting. Stack parameters pertaining to the secondary pollution plant is provided in Table 4-5.

As a conservative measure, all particulate emissions from the M14 secondary pollution plant were assumed to be in the 10 µm particle size fraction (i.e. PM10). Manganese emissions were calculated based on the percentage Mn in FeMn bagfilter dust (33%).

Table 4-5: Parameters pertaining to M14 stack emissions

Parameter	Elgen Stack[(a)]	M14 Secondary Pollution Plant Baghouse Stack
Volumetric Flow Rate (Nm^3/h)	14 000 (M14 furnace off-gas)[(b)] 47 420 (off-gas and air)[(c)]	250 000
Release Height (m)	35.5	22
Diameter (m)	2.5	2.5
Gas Exit Temperature (°C)	154	125
Exit Velocity (m/s)	-[(d)]	35
Particulate Concentration (mg/Nm^3)	30 (M14 cleaned furnace off-gas)[(e)] 8.9 (Elgen stack emission)[(f)]	30

Notes:

(a) Elgen emissions as a result of the combustion of furnace off-gas from M14 only.
(b) M14 cleaned furnace off-gas flow rate (Knights, 2009).
(c) Based on an air fuel ration of 2.4:1 obtained from Elgen Registration certificate.
(d) The combined flow rate from M14 and other furnaces will result in a total volumetric flow rate of 163 000 Nm^3/hour (Elgen design specification) which corresponds to an exit velocity of 17 m/s as applied in the dispersion modelling
(e) M14 primary off-gas cleaning system design specification (Knights, 2009)
(f) Based on an undiluted concentration of 30 mg/Nm^3 and air fuel ratio of 2.4:1

Table 4-6: Estimated M14 stack emissions

Pollutant	Estimated M14 Stack Emissions (tpa)	
	Elgen Stack[(a)]	M14 Secondary Pollution Plant Baghouse Stack
NO_x	161	-
Mn	1.20	22.2
PM10	3.61	66.7
SO_2	944	-

Table 4-7: Source parameters pertaining to existing and ERS stack emissions

Plant	Source	Volumetric Flow Rate (Nm³/hour)	Dust Load (mg/Nm³)	Exit Velocity (m/s)	Release Height (m)	Exit Diameter (m)	Exit Temperature (°C)
North Plant	M10 Smokehood Stack	57.4	9 700	0.01	45.0	1.60	170
	M11 Smokehood Stack	58.1	9 700	0.02	45.0	1.60	170
	A Clean Gas Stack	26 800	50.0	8.22	31.2	1.25	60.0
	B Clean Gas Stack	28 400	50.0	8.72	31.2	1.25	60.0
	C Clean Gas Stack	31 400	50.0	18.5	42.2	0.90	60.0
	Baghouse Stack	161 000	10.0	9.84	18.0	3.54	40.0
West Plant	M12 Clean Gas Stack[(a)]	13 900	117	14.0	55.0	1.00	54.9
	OBC Baghouse Stack	955	50.0	16.9	24.5	1.40	98.0
	Secondary Pollution Plant Stack	59 100	20.0	9.9	30.0	1.80	105
South Plant	Bag Filter Plant 1 Stack 1	110 000	10.0	9.47	30.0	2.56	120
	Bag Filter Plant 1 Stack 2	110 000	10.0	9.47	30.0	2.56	120
	Bag Filter Plant 1 Stack 3	110 000	10.0	9.47	30.0	2.56	120
	Bag Filter Plant 2 Stack 1	132 000	10.0	11.4	25.0	2.56	123
	Bag Filter Plant 2 Stack 2	132 000	10.0	11.4	25.0	2.56	123
	Bag Filter Plant 2 Stack 3	132 000	10.0	11.4	25.0	2.56	123
	Bag Filter Plant 3 Stack	130 000	10.0	11.0	22.6	2.56	114
Elgen	Elgen Boiler Stack	117 000	0.69	11.5	35.5	2.5	154
North Plant	New Bag Filter Plant	130 000	10	11.0	23.0	2.56	114
South Plant	New Bag Filter Plant	130 000	10	11.0	23.0	2.56	114

(a) M12 Furnace Clean Gas Stack Sampling Campaign at Metalloys by Levago March 2010 (Report Number: LEV 819M).

4.2.3 Furnace Building Fugitive Emissions

Furnace building fugitive emissions for closed furnaces occur mainly as a result of tapping and casting as well as other ancillary operations within the building.

4.2.3.1 Existing Metalloys Furnaces

North plant furnace building fugitive emissions were estimated based on measurements conducted by Ecoserv (Pty) Ltd in 2006. The PM10 fraction of 14% and manganese content of 25% were determined from measurements.

West Plant furnace building fugitives were estimated based on an emission factor of 6 kg of TSP per ton of FeMn produced in a covered EAF (US EPA, 1995).

South Plant furnace building fugitives were initially estimated based on an emission factor of 96 kg of TSP per ton of SiMn produced in a covered EAF (US EPA, 1995). This was found to significantly over estimate the degree of particulates from South Plant, as was evident from measured on-site personal monitoring and ambient PM10 monitoring. Emissions were therefore estimated based on baghouse stack emissions and baghouse dust control efficiencies.

No emission factors are available for the estimation of fugitive building emissions from the OBC. It was therefore necessary to estimate emissions based on baghouse stack emissions and baghouse dust control efficiencies.

OBC, West and South Plant manganese emissions were calculated based on the Mn percentage in FeMn (78% Mn) and SiMn (67% Mn).

4.2.3.2 Proposed M14 Furnace

M14 furnace building fugitives were estimated based on an emission factor of 6 kg of TSP per ton of FeMn produced in a covered EAF (US EPA, 1995). Hoods extracting fugitives from tapping and casting areas will be installed at M14. The efficiency of the removal of fugitives from these areas was assumed to be 50%

4.2.4 Fugitive Dust Emissions

Fugitive dust (PM10 and TSP) emissions as a result of vehicle-entrainment from unpaved roads, material handling operations, crushing and screening operations were quantified through the application of emission factors which associate the quantity of a pollutant to the activity associated with the release of that pollutant. Due to the absence of locally generated emission factors, use was made of emission factors including those published by the US Environmental Protection Agency (US-EPA) in its AP-42 document Compilation of Air Pollution Emission Factors and the Australian NPI Emission Estimation Technique Manual for Mining. A detailed discussion of these emission factors and equations are provided in Appendix A. Raw material consumption rates and alloy production rates as provided in Table 4-1 were used in the calculation of fugitive dust emission.

Fugitive particulate manganese emissions were in most cases, as a conservative approach, assumed to be in the PM10 particle size fraction. Manganese emissions were estimated based on the manganese content of materials being processed and applied as a fraction of estimated PM10 emissions. The manganese content of the various materials processed at existing Metalloys operations and proposed M14 operations as obtained from Knights Environmental are provided in Table 4-8.

Table 4-8: Manganese content of alloys and slag (Knights, 2009)

Material	% Manganese
Manganese Ore	49%
FeMn	78%
FeMn Slag	17%
SiMn	67%
SiMn Slag	13%

4.2.4.1 Vehicle Entrained Dust from Unpaved Roads

Vehicle-entrained dust emissions have been found to generally account for a great portion of fugitive dust emissions. The force of the wheels of the vehicles travelling on unpaved surfaces causes the pulverisation of surface material. Particles are lifted and dropped from the rotating wheels and the road surface is exposed to strong air currents in the wake of the passing vehicle. The amount of dust from unpaved roads varies linearly with traffic volumes.

Fugitive dust emissions from unpaved roads were calculated using the US EPA predictive emission factor equation (Equation 1, Appendix A) assuming the transport of material volumes as given in Table 4-1.

The unpaved road network at Metalloys, estimated to be approximately 3 km was included in the baseline emissions inventory. The M14 project is expected to increase traffic on approximately 2.3 km of the unpaved road network. The unpaved roads are approximately 8 m wide.

The silt content (fraction of particles less than 75 μm in diameter) of road surface material were obtained from site specific particle size analyses of surface materials and ranged from 3% to 25%. The average weight of vehicles travelling on each section was based on gross vehicle weights and capacities as provided by Metalloys.

Estimated fugitive dust emissions as a result of vehicles travelling on unpaved roads are summarised in Table 4-9.

4.2.4.2 Vehicle Entrained Dust from Paved Roads

Fugitive dust emissions from unpaved roads were calculated using the US EPA predictive emission factor equation (Equation 2, Appendix A) assuming the transport of material volumes as given in Table 4-1.

The paved road network at Metalloys, estimated to be approximately 3.3 km was included in the baseline emissions inventory. The M14 project is expected to increase traffic on most of these paved roads. The paved roads are approximately 8 m wide.

The silt loading (the amount of particles less than 75 μm in diameter per m^2) of road surface were obtained from site specific particle size analyses of surface materials and ranged from 12 to 17 g/m^2. The average weight of vehicles travelling on each section was based on gross vehicle weights and capacities as provided by Metalloys.

Estimated fugitive dust emissions as a result of vehicles travelling on paved roads are summarised in Table 4-9.

4.2.4.3 Dust from Materials Handling Activities and Conveyor Transfer Points

Materials handling activities associated with existing Metalloys operations as well as proposed M14 operations include raw material offloading at tippler stations, front end loader (FEL) transfer of raw materials, products and slag, materials off-loaded from trucks and conveyor transfer points.

The US EPA AP42 predictive equation (Equation 3, Appendix A) was used to estimate emissions from material transfer operations.

The material volumes used in the calculation of fugitive dust materials handling emissions are presented in Table 4-1. The moisture content of all materials was assumed to be 1%. Emissions from materials handling and conveyor transfer points were calculated using the hourly average wind speed of 2.9 m/s as measured at the SWAS Vereeniging station. Estimated materials handling emissions are summarised in Table 4-9.

4.2.4.4 Dust from Crushing and Screening Operations

Crushing and screening plants represent significant dust-generating sources if uncontrolled. Dust fallout in the vicinity of crushers also give rise to the potential for the re-entrained of dust emitted by vehicles or by the wind at a later date. The large percentage of fines in this deposited material enhances the potential for it to become airborne. Fugitive dust emissions due to the crushing and screening operations were quantified using US-EPA single valued emission factors for such operations (Table 7-1, Appendix A).

Emissions include crushing operations at West Plant, MMD and at Roshcon. M14 is expected to increase crushing emissions at MMD and Roshcon. Emissions were estimated for low moisture material volumes provided in Table 4-1.

Estimated emissions from crushing and screening operations are provided in Table 4-9.

4.2.5 Summary of Routine Particulate Emissions

A summary of estimated routine particulate emissions (TSP, PM10 and Mn) for the two Scenarios investigated in this study are provided in Table 4-9.

4.2.5.1 PM10 Emissions

PM10 emissions as a result of proposed M14 operations **without** the additional mitigation associated with the ERS amounted to 169 tpa. Emissions associated with M14 stacks and furnace building fugitives were estimated to contribute most significantly (43% and 23% respectively) to estimated PM10 emissions. Existing Metalloys and proposed M14 operations associated with Scenario 1 were estimated to account for 69% and 31% of cumulative PM10 emissions of 543 tpa (Figure 4-2).

PM10 emissions as a result of proposed M14 operations **with** the additional mitigation associated with the ERS amounted to 155 tpa. Emissions associated with M14 stacks and furnace building fugitives were estimated to contribute most significantly (46% and 25% respectively) to estimated PM10 emissions. Existing Metalloys and proposed M14 operations associated with Scenario 2 were estimated to account for 60% and 40% of cumulative PM10 emissions of 390 tpa (Figure 4-3).

4.2.5.2 TSP Emissions

TSP emissions as a result of proposed M14 operations **without** the additional mitigation associated with the ERS amounted to 364 tpa. Emissions associated with the crushing and screening of FeMn and slag from M14 and vehicle entrained dust from unpaved roads were estimated to contribute most significantly (27% and 26% respectively) to estimated TSP emissions. Existing Metalloys and proposed M14 operations associated with Scenario 1 were estimated to account for 70% and 30% of cumulative TSP emissions of 1 220 tpa (Figure 4-4).

TSP emissions as a result of proposed M14 operations **with** the additional mitigation associated with the ERS amounted to 273 tpa. Emissions associated with M14 stacks and vehicle entrained dust from unpaved roads were estimated to contribute most significantly (27% each) to estimated TSP emissions. Existing Metalloys and proposed M14 operations associated with Scenario 2 were estimated to account for 64% and 35% of cumulative TSP emissions of 773 tpa (Figure 4-5).

4.2.5.3 Mn Emissions

Mn emissions as a result of proposed M14 operations **without** the additional mitigation associated with the ERS amounted to 60.0 tpa. Emissions associated with M14 stacks and furnace building fugitives were estimated to contribute most significantly (40% and 50% respectively) to estimated Mn emissions. Existing Metalloys and proposed M14 operations associated with Scenario 1 were estimated to account for 72% and 27% of cumulative Mn emissions of 209 tpa (Figure 4-6).

Mn emissions as a result of proposed M14 operations **with** the additional mitigation associated with the ERS amounted to 56.7 tpa. Emissions associated with M14 stacks and furnace building fugitives were estimated to contribute most significantly (41% and 53% respectively) to estimated Mn emissions. Existing Metalloys and proposed M14 operations associated with Scenario 1 were estimated to account for 63% and 37% of cumulative Mn emissions of 155 tpa (Figure 4-7).

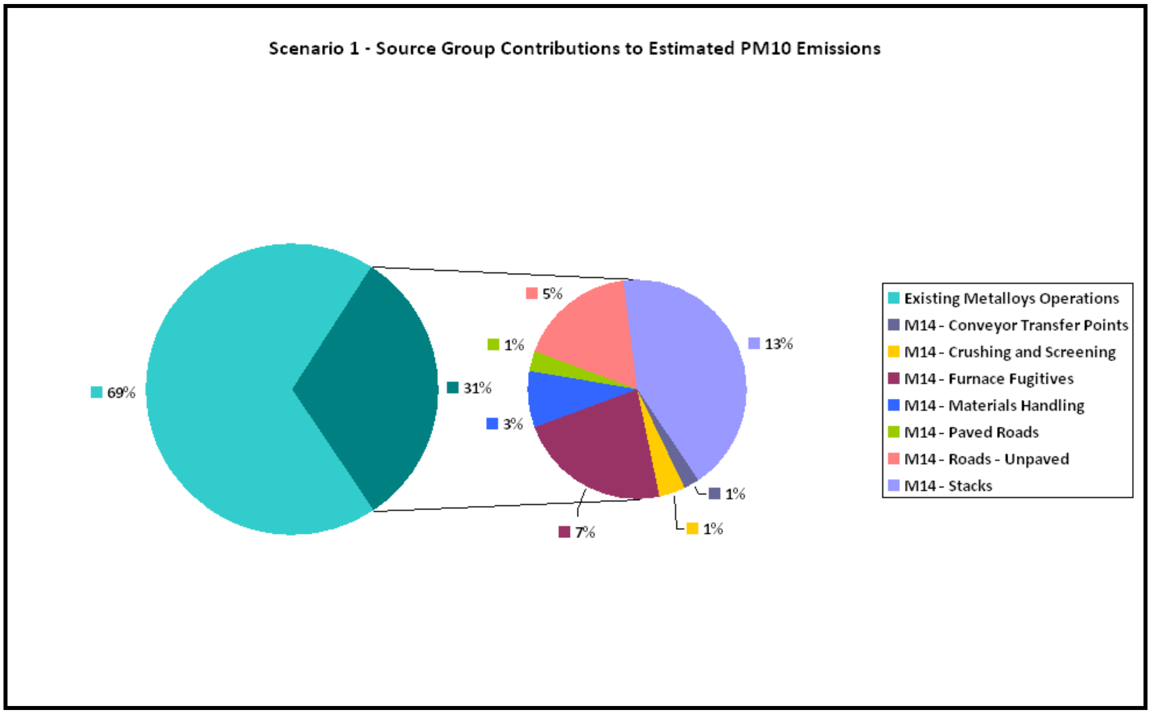

Figure 4-2: Scenario 1 – Source group contributions to estimated PM10 emissions

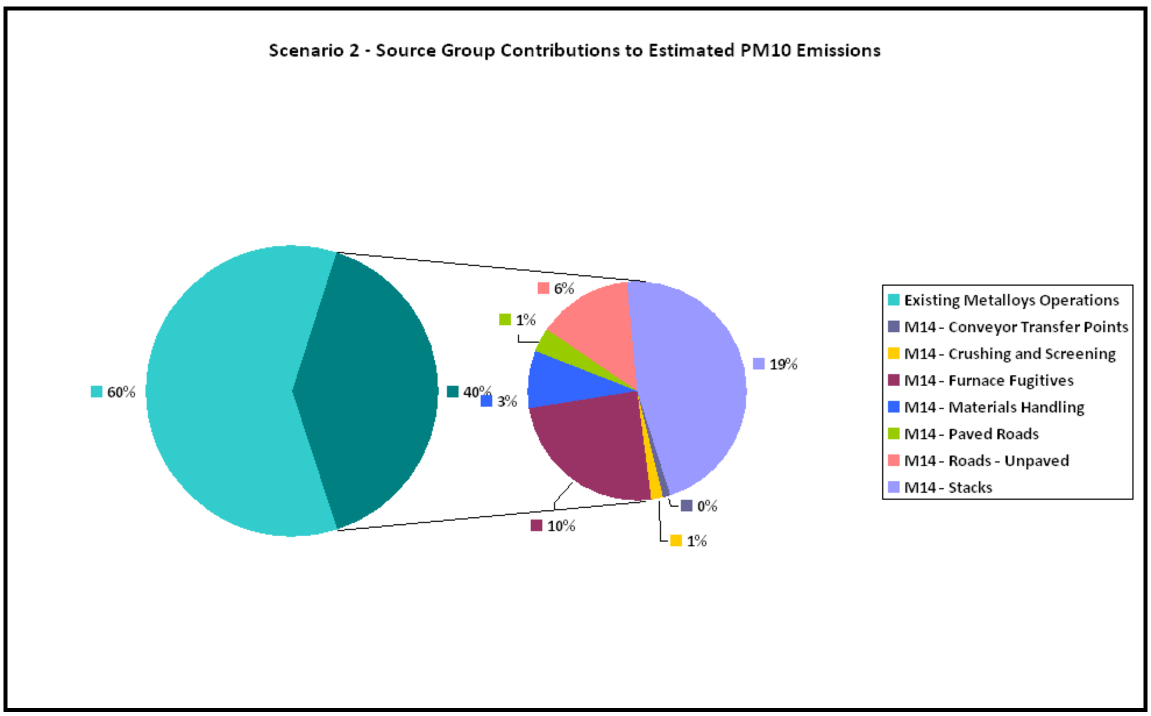

Figure 4-3: Scenario 2 – Source group contributions to estimated PM10 emissions

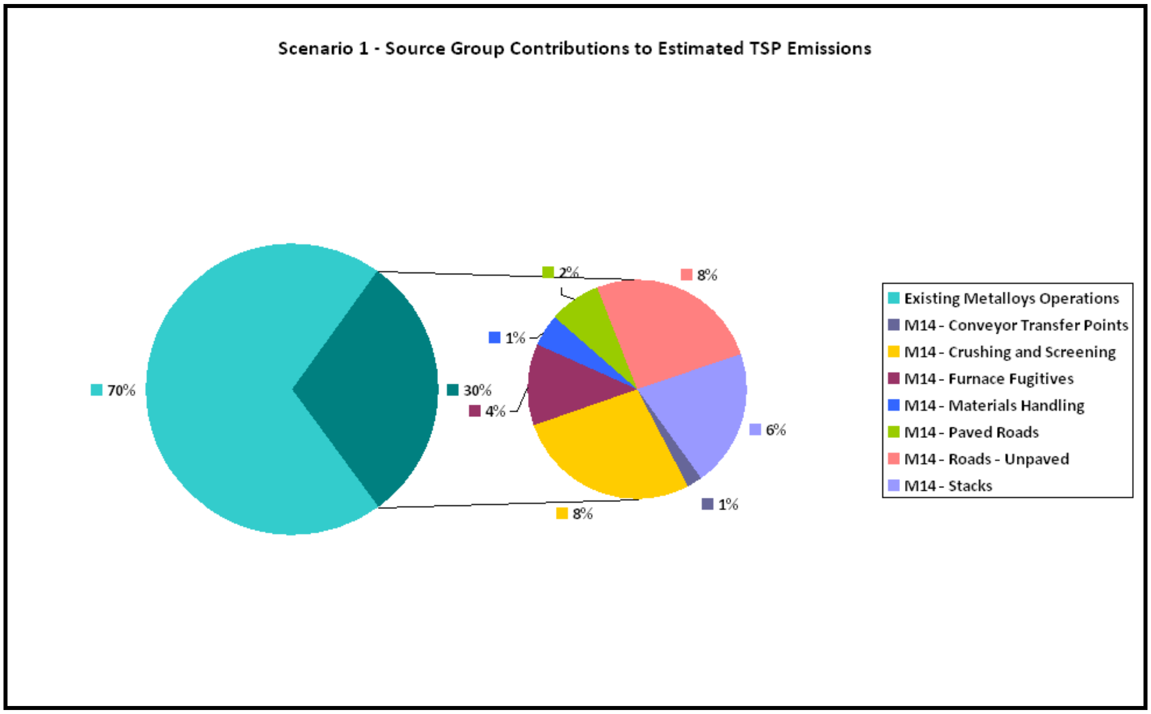

Figure 4-4: Scenario 1 – Source group contributions to estimated TSP emissions

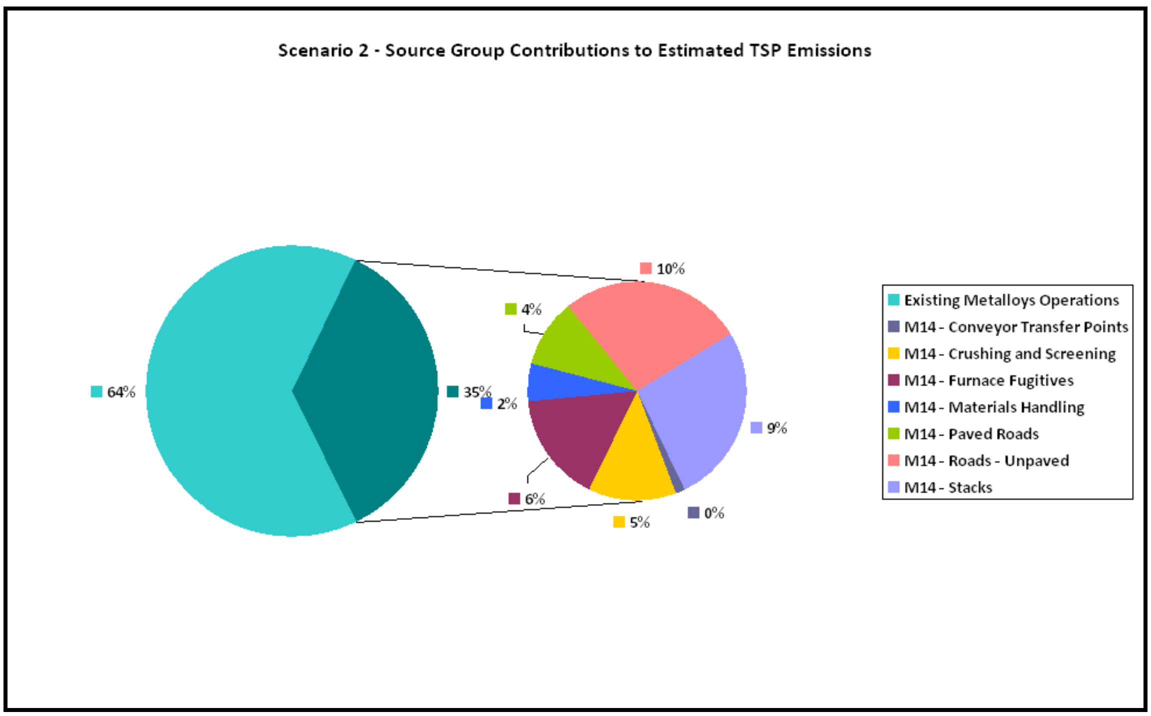

Figure 4-5: Scenario 2 – Source group contributions to estimated TSP emissions

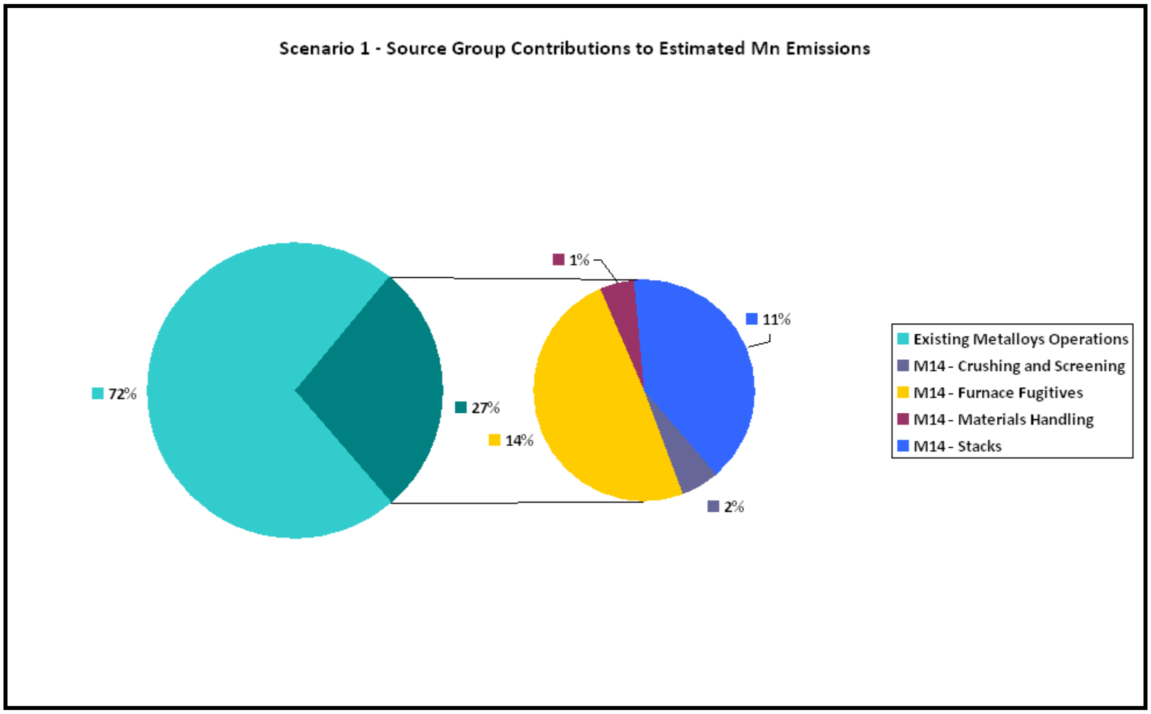

Figure 4-6: Scenario 1 – Source group contributions to estimated Mn emissions

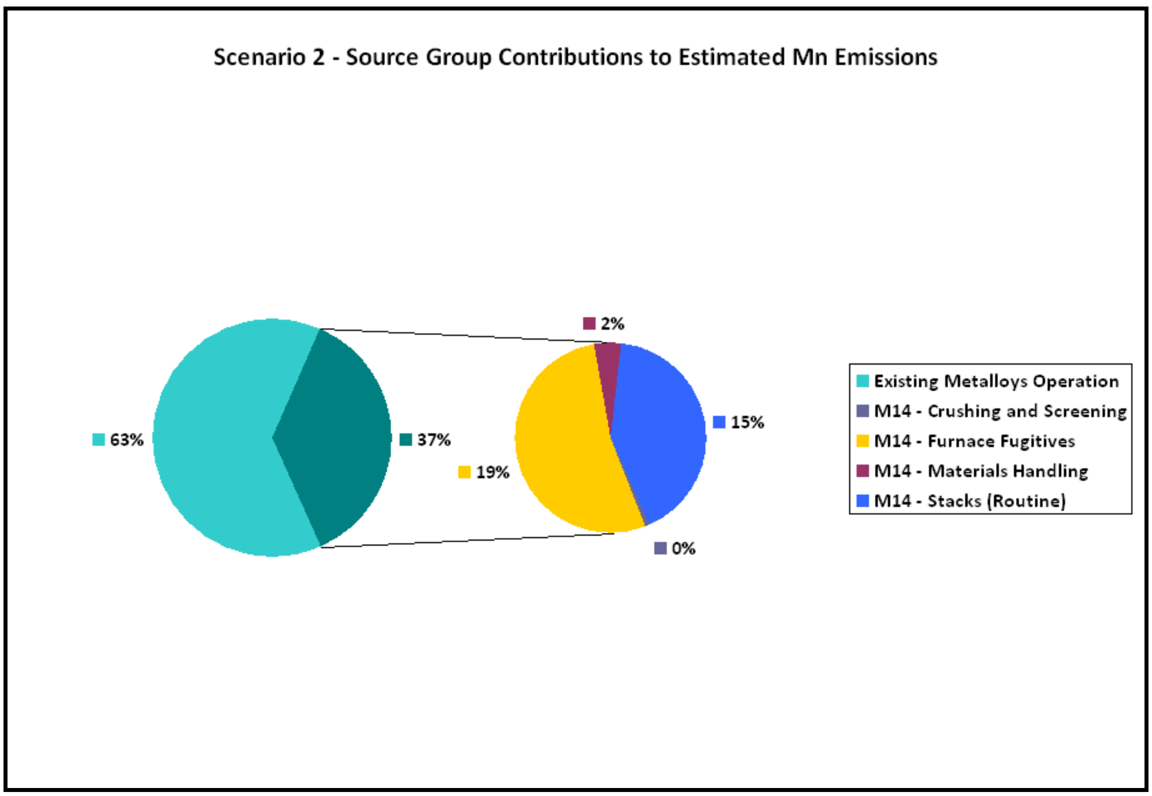

Figure 4-7: Scenario 2 – Source group contributions to estimated Mn emissions

Table 4-9: Summary of estimated particulate emissions

Scenario	Source Group	PM10			TSP			Mn		
		Existing Metalloys Operations	Proposed M14 Operations	Total per Source Group	Existing Metalloys Operations	Proposed M14 Operations	Total per Source Group	Existing Metalloys Operations	Proposed M14 Operations	Total per Source Group
Scenario 1[(a)]	Conveyor Transfer Points	12.3	3.95	16.2	26.0	8.36	34.3	-	-	-
	Crushing and Screening	18.6	6.45	25.0	264	99.4	363	7.44	3.43	10.9
	Furnace Fugitives	108	38.5	147	182	44.8	227	74.2	30.1	104
	Materials Handling	57.3	14.4	71.7	81.3	17.4	98.8	13.7	3.08	16.8
	Roads - Paved	7.88	5.38	13.3	41.1	28.1	69.2	-	-	-
	Roads - Unpaved	43.7	29.7	73.4	137	95.4	233	-	-	-
	Stacks	127	70.3	197	127	70.3	197	53.6	23.4	77.0
	Total	**375**	**169**	**543**	**858**	**364**	**1 220**	**149**	**60.0**	**209**
Scenario 2[(b)]	Conveyor Transfer Points	7.37	1.74	9.11	15.6	3.69	19.3	-	-	-
	Crushing and Screening	9.50	2.66	12.2	116	35.6	152	1.67	0.48	2.15
	Furnace Fugitives	53.5	38.5	92.0	90.2	44.8	135	38.2	30.1	68.3
	Materials Handling	48.3	13.5	61.8	62.3	15.7	78.0	11.2	2.78	14.0
	Roads - Paved	7.88	5.38	13.3	41.1	28.1	69.2	-	-	-
	Roads - Unpaved	28.6	22.4	51.0	94.8	74.7	170	-	-	-
	Stacks	80.1	70.3	150	80.1	70.3	150	46.7	23.4	70.2
	Total	**235**	**155**	**390**	**500**	**273**	**773**	**97.9**	**56.7**	**155**

Notes:

(a) Scenario 1 includes sources of emission associated with existing Metalloys and proposed M14 operations ***without*** the implementation of the ERS projects.

(b) Scenario 2 includes sources of emission associated with existing Metalloys and proposed M14 operations ***with*** the implementation of the ERS projects listed in Table 4-3.

4.2.6 Upset Conditions

The quantification of upset conditions associated with existing Metalloys operations fell outside the scope of this study.

Upset conditions may occur as a result of the failure or shut-down of control measures implemented at the proposed M14 furnace. Such conditions would result in the release of raw furnace off-gas into the atmosphere as well as the uncontrolled release of furnace fugitives as a result of tapping, casting and other operations within the furnace building.

The pollutants of concern with regards upset emissions from the furnace are TSP, PM10 (89% of TSP (US EPA, 1995)) and Mn. Upset PM10 emissions were calculated based on the US EPA emission factor for uncontrolled sealed FeMn furnace of 37 kg per ton of FeMn. Manganese emissions were estimated based on the assumption that 33% of the particulates in the raw gas stream would be manganese.

The conservative way in which SO_2 emissions were estimated for normal operating conditions will also be representative of SO_2 emissions associated with upset conditions. The high temperature of the furnace off-gas will most likely result the spontaneous combustion of the gas as it comes into contact with ambient air. NO_x emissions are therefore expected to be similar to emissions calculated under normal operating conditions.

PM10 and Mn furnace fugitive emissions were estimated assuming no secondary fume extraction from the furnace building. A summary of estimated TSP, PM10 and Mn emissions as a result of upset conditions based on the 97% availability of primary and secondary control equipment, are provided in Table 4-10 (proven availability in the 2009 financial year, personal communication H. Stoelting, 2010).

It should be noted that the quantification of upset conditions associated with existing Metalloys operations fell outside the scope of this study.

Table 4-10: Estimated particulate emissions during upset conditions

Source	Estimated Upset Emissions (tpa)		
	PM10	TSP	Mn
Furnace Raw Gas	143	166	47.1
Furnace Building Fugitives	2.31	2.69	1.81

4.3 Dispersion Model Selection and Data Requirements

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

Gaussian-plume models are best used for near-field applications where the steady-state meteorology assumption is most likely to apply. The most widely used Gaussian plume model is the US-EPA Industrial Source Complex Short Term model (ISCST3). This model has however been replaced by the new generation AERMOD model and was used in this study.

AERMOD is a model developed with the support of the AMS/EPA Regulatory Model Improvement Committee (AERMIC), whose objective has been to include state-of the-art science in regulatory models (Hanna et al, 1999). AERMOD is a dispersion modelling system with three components, namely: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD terrain pre-processor), and AERMET (AERMOD meteorological pre-processor).

AERMOD is an advanced new-generation model. It is designed to predict pollution concentrations from continuous point, flare, area, line, and volume sources. AERMOD offers new and potentially improved algorithms for plume rise and buoyancy, and the computation of vertical profiles of wind, turbulence and temperature however retains the single straight line trajectory limitation of ISCST3 (Hanna *et al,* 1999).

AERMET is a meteorological pre-processor for AERMOD. Input data can come from hourly cloud cover observations, surface meteorological observations and twice-a-day upper air soundings. Output includes surface meteorological observations and parameters and vertical profiles of several atmospheric parameters.

AERMAP is a terrain pre-processor designed to simplify and standardise the input of terrain data for AERMOD. Input data includes receptor terrain elevation data. The terrain data may be in the form of digital terrain data. The output includes, for each receptor, location and height scale, which are elevations used for the computation of air flow around hills.

Similar to the ISCST3 a disadvantage of the model is that spatial varying wind fields, due to topography or other factors cannot be included. Also, the range of uncertainty of the model predictions could to be -50% to 200%. The accuracy improves with fairly strong wind speeds and during neutral atmospheric conditions.

Input data types required for the AERMOD model include: source data, meteorological data (pre-processed by the AERMET model), terrain data and information on the nature of the receptor grid.

4.3.1 Meteorological Requirements

For the purpose of the current study use was made of surface meteorological data recorded at the SAWS station Vereeniging and modelled Unified Model upper data for the period January 2005 to December 2007 (Section 3.2).

4.3.2 Source Data Requirements

AERMOD is able to model point, flare, area, line and volume sources. Sources in the current study were modelled as follows:

- Stacks – modelled as point sources;
- Flares – modelled as flare sources;
- Paved and unpaved roads – modelled as area sources;
- Furnace fugitive emissions, materials handling, conveyor transfer points and crushing – modelled as volume sources.

4.3.3 Modelling Domain

The dispersion of pollutants expected to arise from proposed operations was modelled for an area covering approximately 20 km (east-west) by 20 km (north-south). The area was divided into a grid matrix with a resolution of 400 m by 400 m, with the proposed operation located approximately in the centre of the receptor area. The Metalloys plant boundary and nearby residential areas (Figure 3-1) were also included as discrete receptors. AERMOD calculates ground-level concentrations for each of the grid and discrete receptors.

4.4 Dispersion Model Results and Assessment

Dispersion modelling was undertaken to determine highest hourly, highest daily and annual average ground level concentrations for each pollutant. These averaging periods were selected to facilitate the comparison of predicted pollutant concentrations with relevant air quality guidelines and health effect screening levels.

4.4.1 Predicted NO_2 Concentrations

Nitrogen monoxide (NO) emissions are rapidly converted in the atmosphere into the much more poisonous nitrogen dioxide (NO_2) which is regulated by NEMAQA. As a conservative measure all nitrogen oxide (NO_x) emissions and impacts were assumed to be NO_2.

Nitrogen dioxide (NO_2) impacts were only determined for emissions associated with the proposed M14 furnace. Predicted highest hourly and annual average NO_2 concentrations as a result of routine M14 operations at the Metalloys plant boundary and residential areas in the study area are presented in Table 4-11. No exceedances of the SA hourly limit of 200 µg/m³ or annual standard of 40 µg/m³ for NO_2 were predicted at the boundary or at any of the residential receptors.

4.4.2 Predicted SO_2 Concentrations

Sulphur dioxide (SO_2) impacts were only determined for emissions associated with the proposed M14 furnace. Predicted highest hourly, highest daily and annual average SO_2 concentrations as a result of routine M14 operations at the Metalloys plant boundary and residential areas in the study area are presented in Table 4-12. No exceedances of the SA standards for SO_2 were predicted at the boundary or at any of the residential receptors.

Table 4-11: Predicted NO_2 concentrations

Receptor	Proposed M14 Operations	
	Highest Hourly NO_2 Concentrations (µg/m³)[(a)]	Annual Average NO_2 Concentrations (µg/m³)[(b)]
Metalloys Boundary	16.7	0.74
Acorn Park	3.18	0.04
Aerovaal	1.84	0.02
Dadaville	3.78	0.02
Debonair Park	4.36	0.01
Falcon Ridge	2.79	0.02
Henley on Klip	2.41	0.02
Meyerton	4.62	0.09
Meyerton Park	10.1	0.30
Redan	3.84	0.05
Roshnee	2.19	0.01
Rothdene	6.53	0.10
Rust te Vaal	3.50	0.03
Sebokeng	3.43	0.01
Sonland Park	1.77	0.02
Three Rivers	3.33	0.04

Notes:
(a) SA Hourly NO_2 Standard: limit value - 200 µg/m³, permissible frequency of exceedance - 88 hours per year.
(b) SA Annual NO_2 Standard: 40 µg/m³.

Table 4-12: Predicted SO_2 concentrations

Receptor	Proposed M14 Operations		
	Highest Hourly SO_2 Concentrations ($\mu g/m^3$)[(a)]	Highest Daily SO_2 Concentrations ($\mu g/m^3$)[(a)]	Annual Average SO_2 Concentrations ($\mu g/m^3$)[(b)]
Metalloys Boundary	95.3	27.6	4.25
Acorn Park	18.2	2.01	0.24
Aerovaal	10.5	1.34	0.10
Dadaville	21.6	1.11	0.09
Debonair Park	24.9	1.26	0.07
Falcon Ridge	15.9	2.13	0.12
Henley on Klip	13.8	0.96	0.11
Meyerton	26.4	3.55	0.50
Meyerton Park	57.7	13.6	1.72
Redan	22.0	2.33	0.31
Roshnee	12.6	1.10	0.08
Rothdene	37.3	7.26	0.56
Rust te Vaal	20.0	2.80	0.15
Sebokeng	19.6	1.01	0.06
Sonland Park	10.1	1.61	0.10
Three Rivers	19.0	1.67	0.22

Notes:
(a) SA Hourly SO_2 Standard: limit value - 350 $\mu g/m^3$, permissible frequency of exceedance - 88 hours per year.
(b) SA Daily SO_2 Standard: limit value - 125 $\mu g/m^3$, permissible frequency of exceedance - 4 days per year.
(c) SA Annual SO_2 Standard: 50 $\mu g/m^3$.

4.4.3 Predicted PM10 Concentrations

PM10 impacts were determined for existing Metalloys and proposed M14 operations without and with the implementation of the ERS (Scenario 1 and Scenario 2 respectively). Cumulative PM10 impacts are described in terms of the combined effect of M14 and existing Metalloys operations on the receiving environment.

4.4.3.1 Scenario 1

Incrementally, proposed M14 operations were predicted to result in non-compliance with the SA standard at the Metalloys plant boundary. A maximum annual and highest daily average PM10 concentration of 52.8 and 235 µg/m³ respectively were predicted at the Meyerton plant boundary. It was predicted that the SA daily PM10 limit value of 75 µg/m³ will be exceeded 85 days per year (Table 4-13 and Figure 4-8).

Cumulatively, existing Metalloys and proposed M14 operations were predicted to result in non-compliance with the SA standard for PM10 at the Metalloys plant boundary and at Meyerton Park. A maximum annual and highest daily average PM10 concentration of 159 and 752 µg/m³ respectively were predicted at the Meyerton plant boundary. A maximum annual and highest daily average PM10 concentration of 14.7 and 120 µg/m³ respectively were predicted at Meyerton Park. It was predicted that the SA daily PM10 limit value of 75 µg/m³ will be exceeded 211 days per year at the Metalloys plant boundary and 10 days per year at Meyerton Park (Table 4-13 and Figure 4-8).

Predicted highest daily and annual average PM10 concentrations as a result of routine operations at the Metalloys plant boundary and residential areas in the study area are presented in Table 4-14. The areas of exceedance of the SA daily and annual ambient air quality standards for PM10 are presented in Figure 4-10 and Figure 4-11.

4.4.3.2 Scenario 2

Incrementally, proposed M14 operations were predicted to result in PM10 concentrations within the SA daily and annual standards. A maximum annual and highest daily average PM10 concentration of 9.06 and 50.6 µg/m³ respectively were predicted at the Meyerton plant boundary.

Cumulatively, existing Metalloys and proposed M14 operations were predicted to result in non-compliance with the SA standard at the Metalloys plant boundary and at Meyerton Park. A maximum annual and highest daily average PM10 concentration of 37.7 and 171 µg/m³ respectively were predicted at the Meyerton plant boundary. A maximum annual and highest daily average PM10 concentration of 11.6 and 100 µg/m³ respectively were predicted at Meyerton Park. It was predicted that the SA daily PM10 limit value of 75 µg/m³ will be exceeded 48 days per year at the Metalloys plant boundary and 5 days per year at Meyerton Park (Table 4-13 and Figure 4-9).

Predicted highest daily and annual average PM10 concentrations as a result of routine operations at the Metalloys plant boundary and residential areas in the study area are presented in Table 4-15. The areas of exceedance of the SA daily and annual ambient air quality standards for PM10 are presented in Figure 4-12 and Figure 4-13.

Table 4-13: PM10 daily frequency of exceedance

Receptor	Existing Metalloys Operations	Proposed M14 Operations	Existing Metalloys and Proposed M14 Operations
Scenario 1 – Predicted Number of Days of Exceedance per Year			
Metalloys Boundary	**176(b)**	**85(b)**	**211(b)**
Meyerton Park	3	0	**10(b)**
Scenario 2 – Predicted Number of Days of Exceedance per Year			
Metalloys Boundary	**18(b)**	0	**48(b)**
Meyerton Park	1	0	**5(b)**

Notes:
(a) SA daily PM10 Standard: limit value - 75 µg/m³, permissible frequency of exceedance - 4 days per year.
(b) Exceeds the SA daily PM10 standard for PM10.

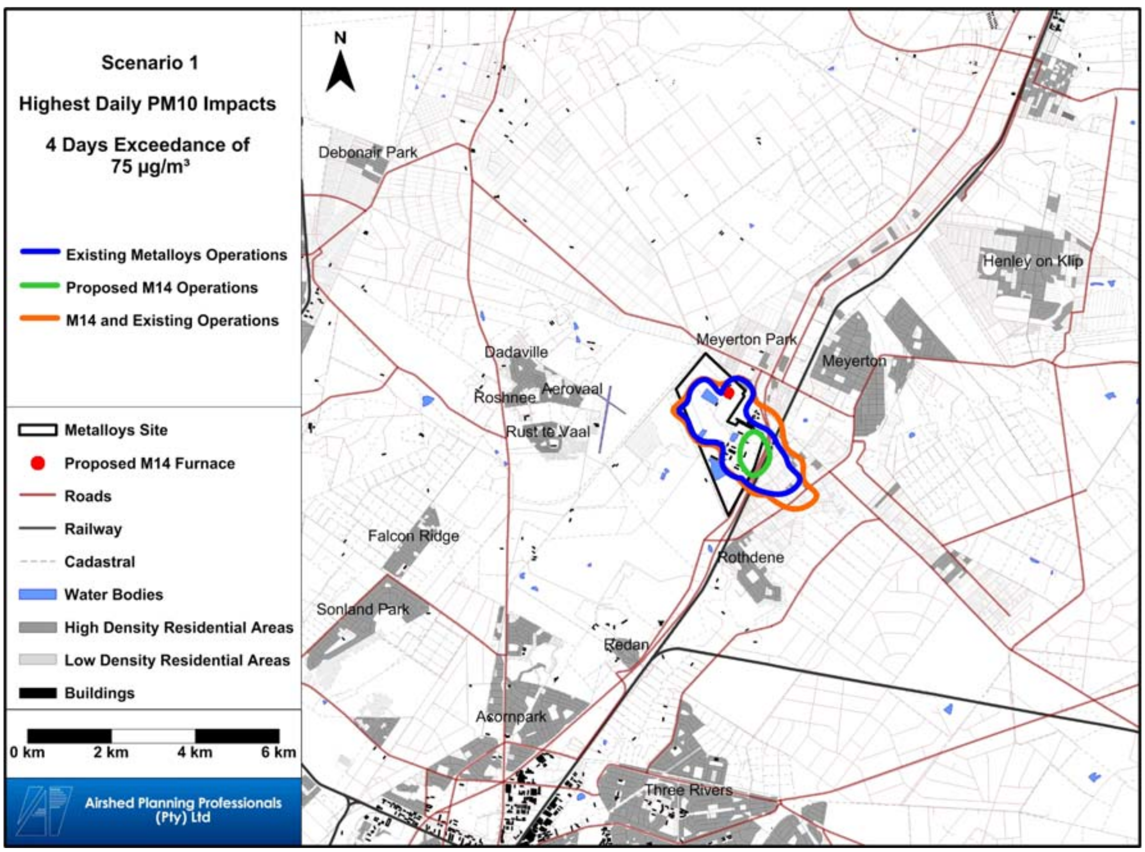

Figure 4-8: Scenario 1 – Frequency of exceedance of the SA daily standard for PM10

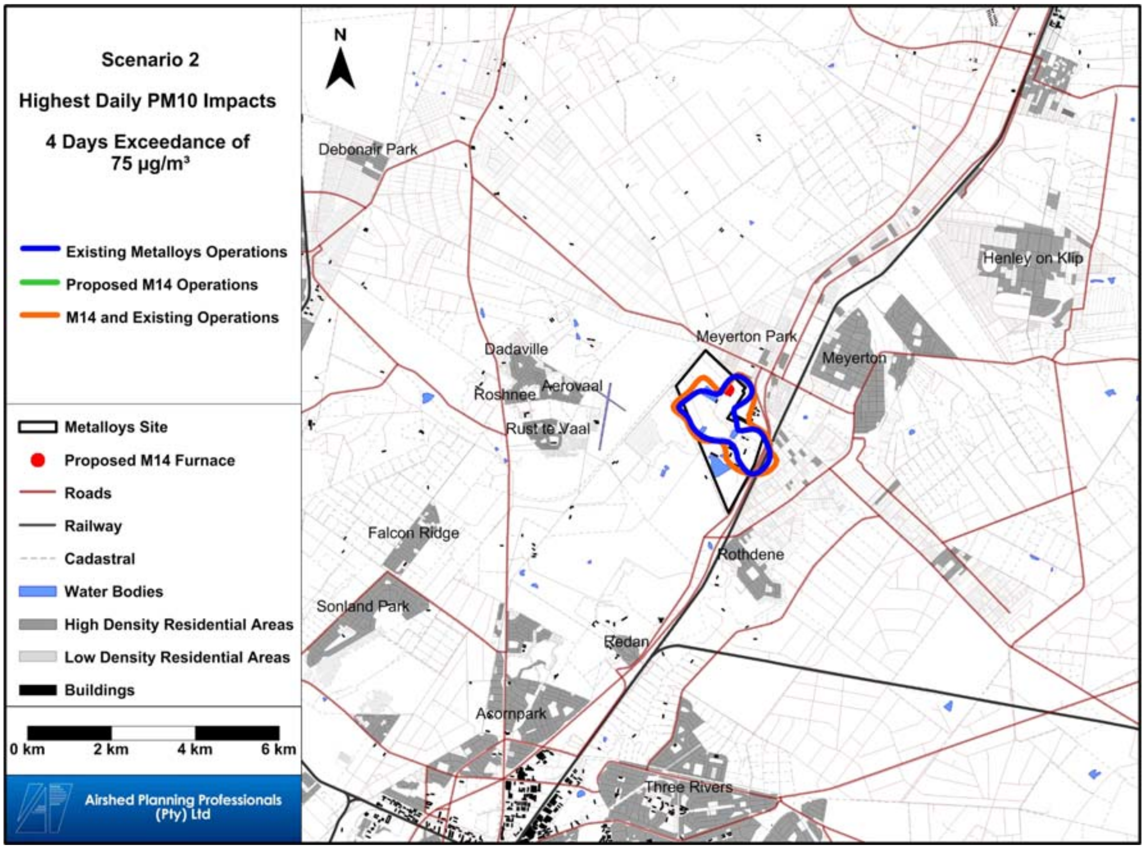

Figure 4-9: Scenario 2 – Frequency of exceedance of the SA daily standard for PM10

Table 4-14: Scenario 1 – Predicted PM10 Concentrations

Receptor	Existing Metalloys Operations		Proposed M14 Operations		Metalloys and Proposed M14 Operations	
	Highest Daily PM10 Concentrations (µg/m³)	Annual Average PM10 Concentrations (µg/m³)	Highest Daily PM10 Concentrations (µg/m³)	Annual Average PM10 Concentrations (µg/m³)	Highest Daily PM10 Concentrations (µg/m³)	Annual Average PM10 Concentrations (µg/m³)
Metalloys Boundary	**493**[(c)]	**107**[(c)]	**235**[(c)]	**52.8**[(c)]	**752**[(c)]	**159**[(c)]
Acorn Park	8.41	0.91	3.31	0.29	11.6	1.20
Aerovaal	21.1	0.96	6.81	0.33	27.9	1.29
Dadaville	8.03	0.27	2.96	0.09	10.0	0.36
Debonair Park	3.65	0.13	1.05	0.04	4.70	0.17
Falcon Ridge	7.12	0.39	3.03	0.15	10.5	0.53
Henley on Klip	8.86	0.50	3.93	0.18	12.8	0.67
Meyerton	28.2	2.72	11.8	1.01	38.3	3.73
Meyerton Park	**81.5**[(c)]	10.1	38.9	4.53	**120**[(c)]	14.7
Redan	12.2	1.37	3.92	0.43	15.8	1.79
Roshnee	10.6	0.43	3.69	0.17	12.9	0.59
Rothdene	40.2	6.91	12.8	2.18	53.0	9.08
Rust te Vaal	12.7	0.76	5.65	0.27	17.3	1.02
Sebokeng	2.53	0.08	1.31	0.03	3.92	0.11
Sonland Park	5.90	0.34	1.97	0.13	7.56	0.46
Three Rivers	11.7	1.16	3.26	0.37	14.9	1.53

Notes:

(a) SA Daily PM10 Standard: limit value - 75 µg/m³, permissible frequency of exceedance - 4 days per year.
(b) SA Annual PM10 Standard: 40 µg/m³.
(c) Exceeds SA PM10 Standard/Limit Value

Table 4-15: Scenario 2 – Predicted PM10 Concentrations

Receptor	Existing Metalloys Operations		Proposed M14 Operations		Metalloys and Proposed M14 Operations	
	Highest Daily PM10 Concentrations (µg/m³)	Annual Average PM10 Concentrations (µg/m³)	Highest Daily PM10 Concentrations (µg/m³)	Annual Average PM10 Concentrations (µg/m³)	Highest Daily PM10 Concentrations (µg/m³)	Annual Average PM10 Concentrations (µg/m³)
Metalloys Boundary	**115**[(c)]	28.9	50.6	9.06	**171**[(c)]	37.7
Acorn Park	5.50	0.54	2.69	0.21	8.12	0.74
Aerovaal	9.50	0.65	4.43	0.27	12.5	0.92
Dadaville	6.20	0.18	2.30	0.07	7.98	0.25
Debonair Park	2.44	0.09	0.71	0.03	3.15	0.12
Falcon Ridge	4.84	0.24	2.69	0.11	7.23	0.35
Henley on Klip	5.66	0.30	2.77	0.13	9.06	0.43
Meyerton	17.6	1.60	11.6	0.73	29.2	2.33
Meyerton Park	63.7	7.30	38.6	4.35	**100**[(c)]	11.6
Redan	6.80	0.81	2.57	0.30	9.23	1.10
Roshnee	6.11	0.31	3.62	0.15	9.49	0.46
Rothdene	21.2	3.83	8.31	1.35	29.2	5.18
Rust te Vaal	8.32	0.50	4.52	0.22	12.9	0.71
Sebokeng	1.99	0.06	1.25	0.03	3.35	0.09
Sonland Park	2.89	0.21	1.68	0.10	4.24	0.30
Three Rivers	6.31	0.69	2.74	0.27	8.86	0.95

Notes:

(a) SA Daily PM10 Standard: limit value - 75 µg/m³, permissible frequency of exceedance - 4 days per year.
(b) SA Annual PM10 Standard: 40 µg/m³.
(c) Exceeds SA PM10 Standard/Limit Value.

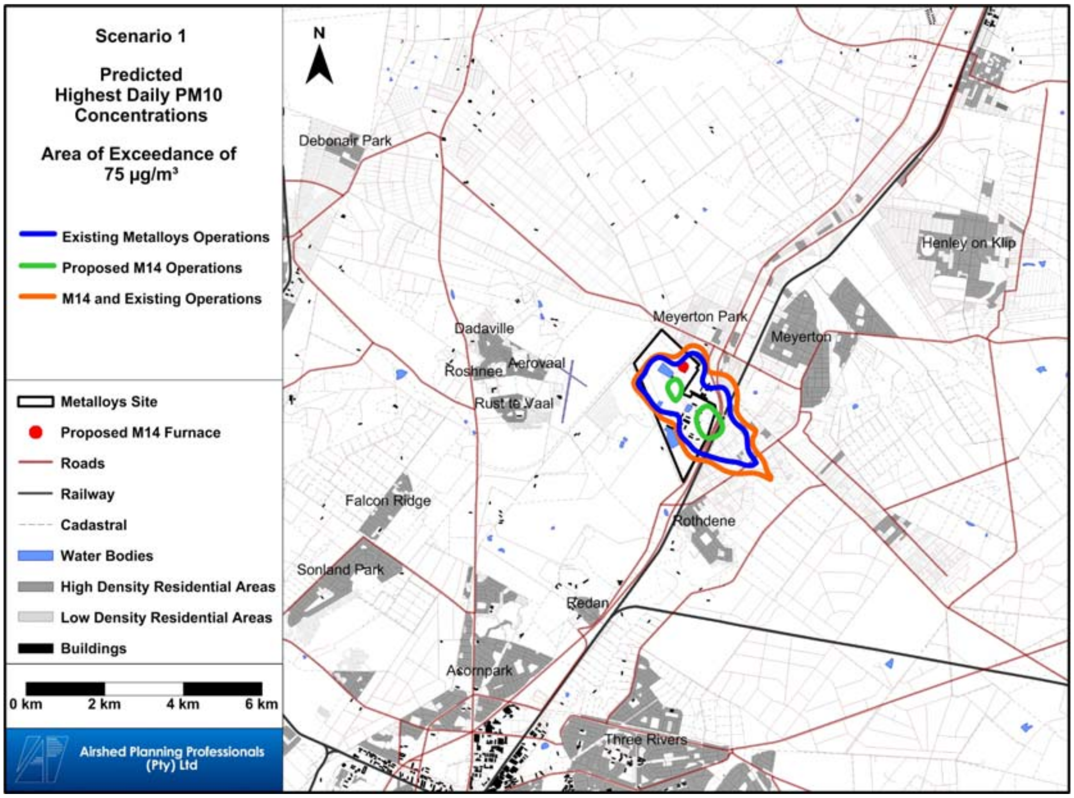

Figure 4-10: Scenario 1 – Predicted highest daily PM10 concentrations

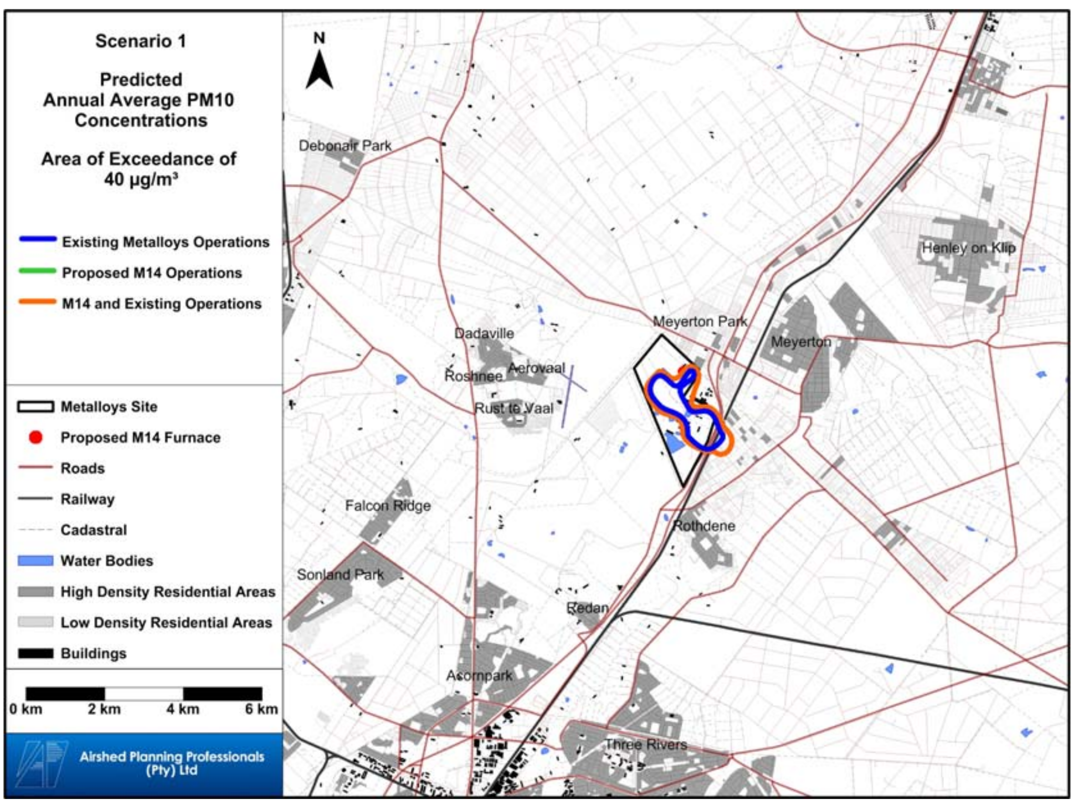

Figure 4-11: Scenario 1 – Predicted annual average PM10 concentrations

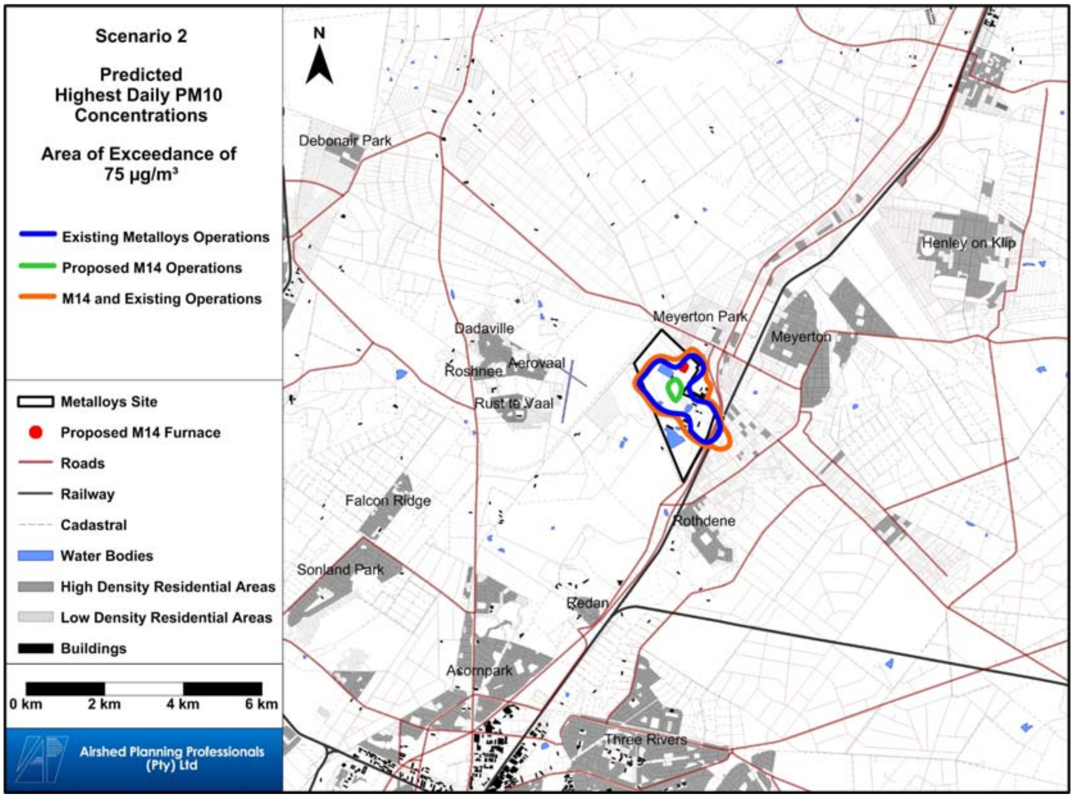

Figure 4-12: Scenario 2 – Predicted highest daily PM10 concentrations

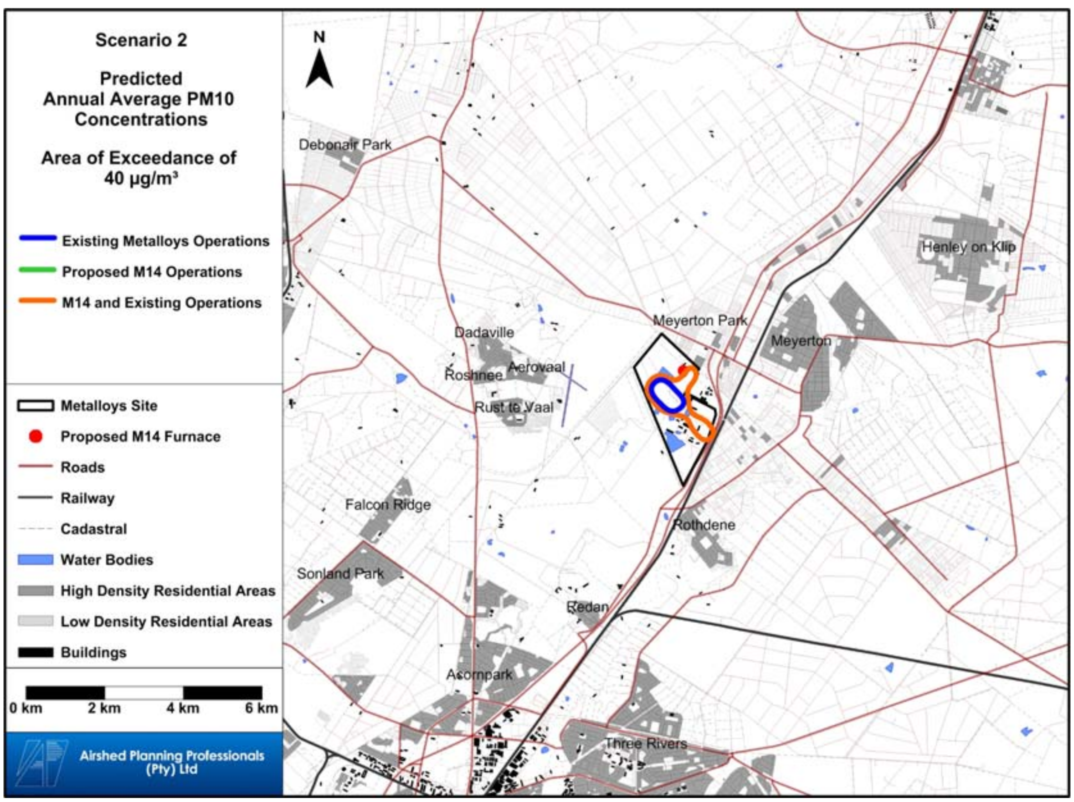

Figure 4-13: Scenario 2 – Predicted annual average PM10 concentrations

4.4.4 Predicted Mn Concentrations

Mn impacts were determined for existing Metalloys and proposed M14 operations without and with the implementation of the ERS (Scenario 1 and Scenario 2 respectively). Cumulative Mn impacts are described in terms of the combined effect of M14 and existing Metalloys operations on the receiving environment. In the absence of South African ambient air quality standards for Mn reference was made to the WHO guideline of 0.15 µg/m³. Predicted Mn concentrations were screened against this criterion and flagged if exceeded.

4.4.4.1 Scenario 1

Predicted annual average Mn concentrations as a result of routine operations at the Metalloys plant boundary and residential areas in the study area are presented in Table 4-16. The areas of exceedance of the WHO guideline for Mn are presented in Figure 4-14.

Incrementally, proposed M14 operations were predicted to result in annual average Mn concentrations in exceedance with the WHO guideline at the Metalloys plant boundary, Meyerton, Meyerton Park and Rothdene. A maximum annual average Mn concentration of 11.2 µg/m³ was predicted at the Meyerton plant boundary.

Cumulatively, existing Metalloys and proposed M14 operations were predicted to result in exceedances of the WHO guideline for Mn at the plant boundary and most of the residential receptors included in the study. A maximum annual average Mn concentration of 38.1 µg/m³ was predicted at the Meyerton plant boundary.

4.4.4.2 Scenario 2

Predicted annual average Mn concentrations as a result of routine operations at the Metalloys plant boundary and residential areas in the study area are presented in Table 4-17. The areas of exceedance of the WHO guideline for Mn are presented in Figure 4-15.

Incrementally, proposed M14 operations were predicted to result in annual average Mn concentrations in exceedance with the WHO guideline at the Metalloys plant boundary, Meyerton, Meyerton Park and Rothdene. A maximum annual average Mn concentration of 2.36 µg/m³ was predicted at the Meyerton plant boundary.

Cumulatively, existing Metalloys and proposed M14 operations were predicted to result in exceedances of the WHO guideline for Mn at the plant boundary and most of the residential receptors downwind of Metalloys. A maximum annual average Mn concentration of 8.93 µg/m³ was predicted at the Meyerton plant boundary.

Table 4-16: Scenario 1 - Predicted Mn Concentrations

Receptor	Predicted Annual Average Mn Concentrations (µg/m³)[a]		
	Existing Metalloys Operations	Proposed M14 Operations	Existing Metalloys and Proposed M14 Operations
Metalloys Boundary	**26.9**[b]	**11.2**[b]	**38.1**[b]
Acorn Park	**0.30**[b]	0.10	**0.40**[b]
Aerovaal	**0.28**[b]	0.10	**0.37**[b]
Dadaville	0.10	0.04	0.14
Debonair Park	0.04	0.01	0.05
Falcon Ridge	0.12	0.05	**0.17**[b]
Henley on Klip	**0.17**[b]	0.06	**0.23**[b]
Meyerton	**0.97**[b]	**0.39**[b]	**1.36**[b]
Meyerton Park	**4.05**[b]	**2.04**[b]	**6.09**[b]
Redan	**0.46**[b]	0.14	**0.59**[b]
Roshnee	0.13	0.04	**0.17**[b]
Rothdene	**2.30**[b]	**0.68**[b]	**2.98**[b]
Rust te Vaal	**0.24**[b]	0.08	**0.32**[b]
Sebokeng	0.03	0.01	0.05
Sonland Park	0.10	0.04	0.14
Three Rivers	**0.41**[b]	0.12	**0.53**[b]

Notes:
(a) WHO Guideline Value for Mn – 0.15 µg/m³.
(b) Exceeds the WHO Guideline Value for Mn.

Table 4-17: Scenario 2 - Predicted Mn Concentrations

Receptor	Predicted Annual Average Mn Concentrations (µg/m³)[(a)]		
	Existing Metalloys Operations	Proposed M14 Operations	Existing Metalloys and Proposed M14 Operations
Metalloys Boundary	**7.67**[(b)]	**2.36**[(b)]	**8.93**[(b)]
Acorn Park	**0.17**[(b)]	0.07	**0.24**[(b)]
Aerovaal	**0.17**[(b)]	0.07	**0.24**[(b)]
Dadaville	0.06	0.03	0.10
Debonair Park	0.03	0.01	0.03
Falcon Ridge	0.07	0.04	0.10
Henley on Klip	0.10	0.05	**0.15**[(b)]
Meyerton	**0.51**[(b)]	**0.30**[(b)]	**0.82**[(b)]
Meyerton Park	**2.38**[(b)]	**1.96**[(b)]	**4.34**[(b)]
Redan	**0.26**[(b)]	0.10	**0.35**[(b)]
Roshnee	0.08	0.04	0.12
Rothdene	**1.14**[(b)]	**0.36**[(b)]	**1.50**[(b)]
Rust te Vaal	0.14	0.07	**0.21**[(b)]
Sebokeng	0.02	0.01	0.03
Sonland Park	0.06	0.03	0.09
Three Rivers	**0.23**[(b)]	0.10	**0.32**[(b)]

Notes:
(a) WHO Guideline Value for Mn – 0.15 µg/m³.
(b) Exceeds the WHO Guideline Value for Mn.

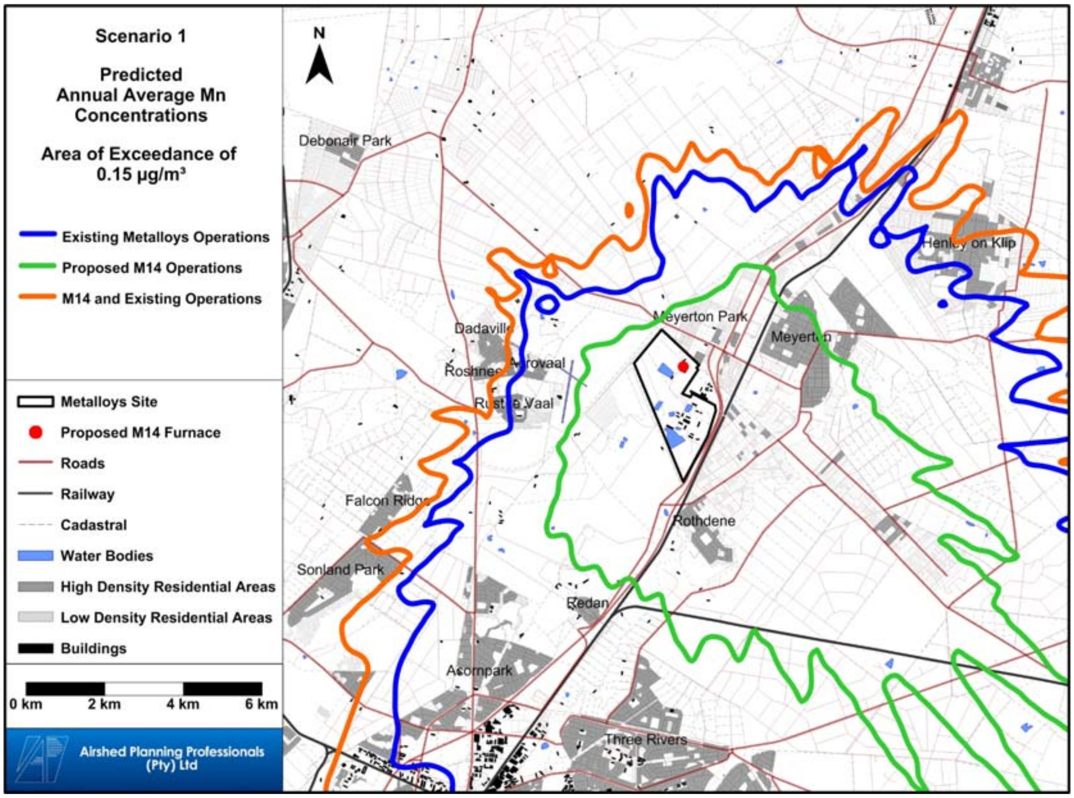

Figure 4-14: Scenario 1 - Predicted Mn Concentrations

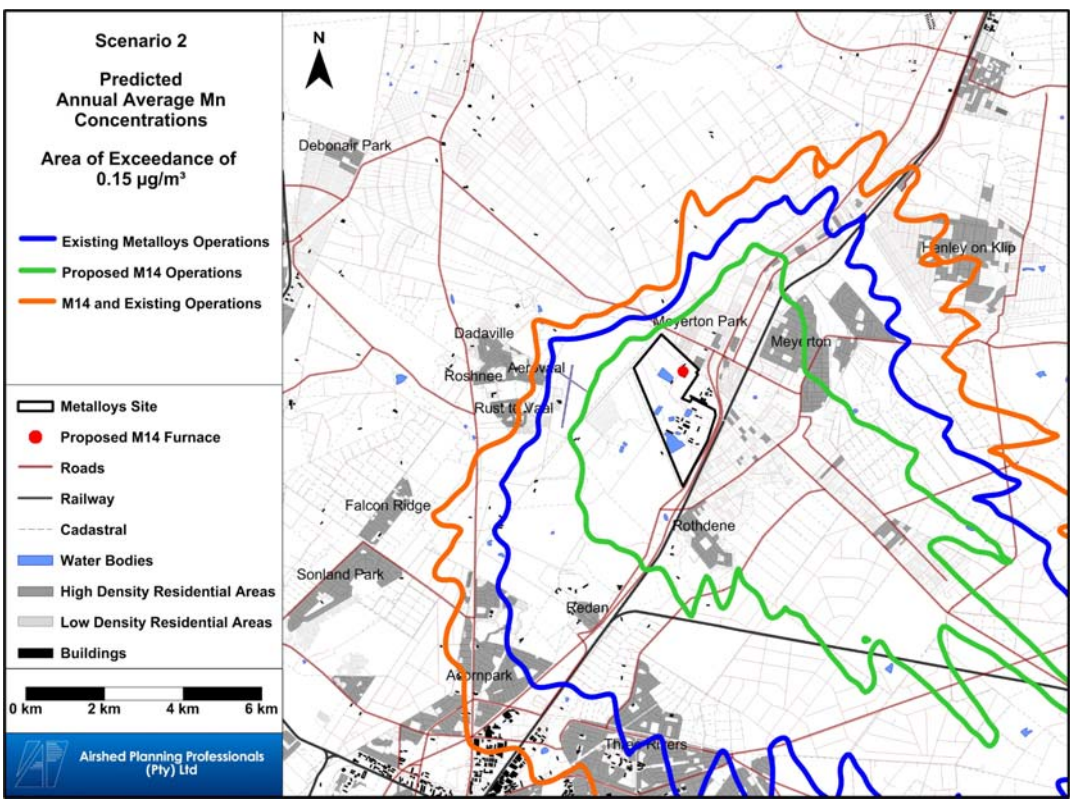

Figure 4-15: Scenario 2 - Predicted Mn Concentrations

4.4.5 Predicted Dustfall Levels

Dustfall impacts were determined for existing Metalloys and proposed M14 operations without and with the implementation of the ERS (Scenario 1 and Scenario 2 respectively). Cumulative dustfall impacts are described in terms of the combined effect of M14 and existing Metalloys operations on the receiving environment.

4.4.5.1 Scenario 1

Predicted average and highest daily dustfall as a result of routine operations at the Metalloys plant boundary and residential areas in the study area are summarised in Table 4-18 and graphically presented in Figure 4-16 and Figure 4-17 respectively.

Incrementally, proposed M14 operations were predicted to result in average and highest daily dustfall of 382 and 610 mg/m²-day at the Metalloys plant boundary. Dustfall levels predicted at the residential receptors were below the respective SANS Target and Residential Action levels of 300 and 600 mg/m²-day.

Cumulatively, existing Metalloys and proposed M14 operations were predicted to result in average and highest daily dustfall of 1300 and 2120 mg/m²-day at the Metalloys plant boundary. Dustfall levels predicted at the residential receptors were below the respective SANS Target and Residential Action levels of 300 and 600 mg/m²-day.

4.4.5.2 Scenario 2

Predicted average and highest daily dustfall as a result of routine operations at the Metalloys plant boundary and residential areas in the study area are summarised in Table 4-19 and graphically presented in Figure 4-18 and Figure 4-19 respectively.

Incrementally, proposed M14 operations were predicted to result in average and highest daily dustfall of 153 and 275 mg/m²-day at the Metalloys plant boundary. Dustfall levels predicted at the residential receptors were below the respective SANS Target and Residential Action levels of 300 and 600 mg/m²-day.

Cumulatively, existing Metalloys and proposed M14 operations were predicted to result in average and highest daily dustfall of 528 and 946 mg/m²-day at the Metalloys plant boundary. Dustfall levels predicted at the residential receptors were below the respective SANS Target and Residential Action levels of 300 and 600 mg/m²-day.

Table 4-18: Scenario 1 – Predicted dustfall levels

Receptor	Existing Metalloys Operations		Proposed M14 Operations		Metalloys and Proposed M14 Operations	
	Average Daily Dustfall (mg/m²-day)[a]	Highest Daily Dustfall (mg/m²-day)[b]	Average Daily Dustfall (mg/m²-day)[a]	Highest Daily Dustfall (mg/m²-day)[b]	Average Daily Dustfall (mg/m²-day)[a]	Highest Daily Dustfall (mg/m²-day)[b]
Metalloys Boundary	**923**[c]	**1510**[c]	**382**[c]	**610**[c]	**1300**[c]	**2120**[c]
Acorn Park	2.29	4.68	0.76	1.54	3.05	6.22
Aerovaal	2.87	5.37	1.00	1.93	3.87	7.18
Dadaville	1.39	3.08	0.49	1.13	1.88	4.21
Debonair Park	0.41	1.47	0.15	0.54	0.56	2.01
Falcon Ridge	1.13	2.63	0.42	0.99	1.54	3.61
Henley on Klip	1.45	2.21	0.52	0.78	1.97	2.99
Meyerton	12.7	17.3	4.14	5.90	16.9	23.1
Meyerton Park	66.4	87.9	34.6	47.9	101	136
Redan	3.72	7.49	1.19	2.33	4.91	9.82
Roshnee	1.66	3.46	0.61	1.23	2.27	4.66
Rothdene	24.7	43.7	6.35	11.7	31.0	55.4
Rust te Vaal	2.73	5.95	1.05	2.41	3.77	8.35
Sebokeng	0.34	0.94	0.13	0.35	0.47	1.29
Sonland Park	0.87	1.82	0.33	0.64	1.19	2.46
Three Rivers	2.51	4.82	0.79	1.57	3.30	6.39

Notes:

(a) SANS dustfall target level – 300 mg/m²-day (annual average).
(b) SANS residential action level – 600 mg/m²-day (30day average).
(c) Exceeds SANS dustfall level.

Table 4-19: Scenario 2 – Predicted dustfall levels

Receptor	Existing Metalloys Operations		Proposed M14 Operations		Metalloys and Proposed M14 Operations	
	Average Daily Dustfall (mg/m²-day)[a]	Highest Daily Dustfall (mg/m²-day)[b]	Average Daily Dustfall (mg/m²-day)[a]	Highest Daily Dustfall (mg/m²-day)[b]	Average Daily Dustfall (mg/m²-day)[a]	Highest Daily Dustfall (mg/m²-day)[b]
Metalloys Boundary	**376**[c]	**671**[c]	153	275	**528**[c]	**946**[c]
Acorn Park	1.17	2.41	0.46	0.98	1.63	3.34
Aerovaal	1.90	3.44	0.75	1.55	2.63	4.82
Dadaville	0.81	1.88	0.32	0.80	1.13	2.68
Debonair Park	0.23	0.81	0.09	0.33	0.32	1.14
Falcon Ridge	0.63	1.48	0.28	0.66	0.91	2.14
Henley on Klip	0.73	1.14	0.31	0.55	1.03	1.68
Meyerton	5.73	8.19	2.01	3.37	7.73	11.6
Meyerton Park	43.3	57.7	32.6	45.1	75.8	101
Redan	1.88	3.78	0.70	1.38	2.58	5.16
Roshnee	1.04	2.12	0.44	0.90	1.48	2.96
Rothdene	10.5	17.6	2.42	4.1	12.9	21.7
Rust te Vaal	1.78	4.13	0.81	1.96	2.59	6.09
Sebokeng	0.20	0.56	0.08	0.24	0.28	0.80
Sonland Park	0.47	0.89	0.21	0.38	0.69	1.26
Three Rivers	1.26	2.48	0.46	0.95	1.72	3.43

Notes:
(a) SANS dustfall target level – 300 mg/m²-day (annual average).
(b) SANS residential action level – 600 mg/m²-day (30day average).
(c) Exceeds SANS dustfall level.

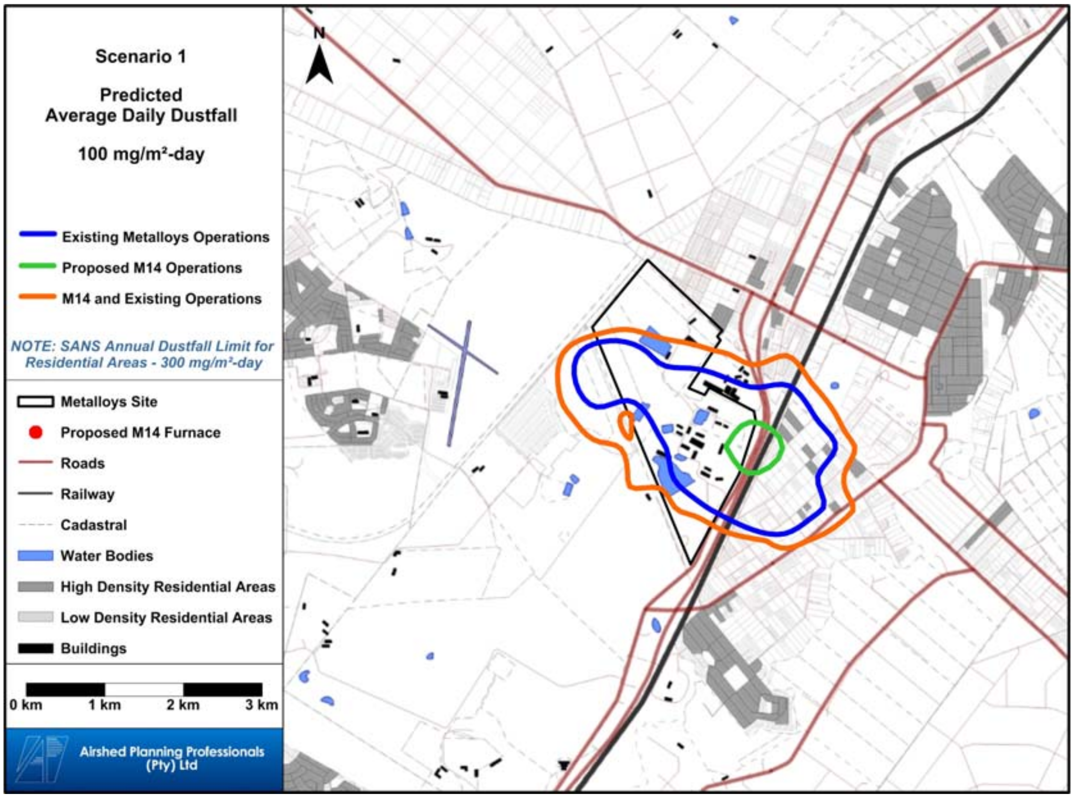

Figure 4-16: Scenario 1 – Predicted average daily dustfall

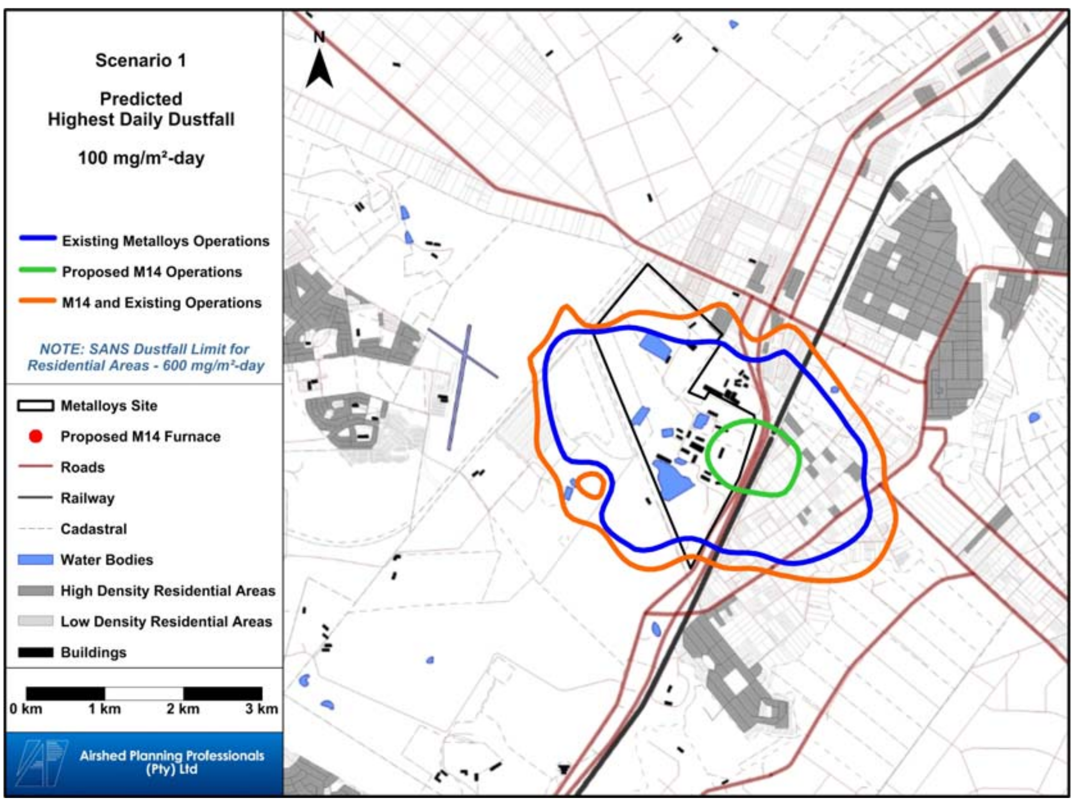

Figure 4-17: Scenario 1 – Predicted highest daily dustfall

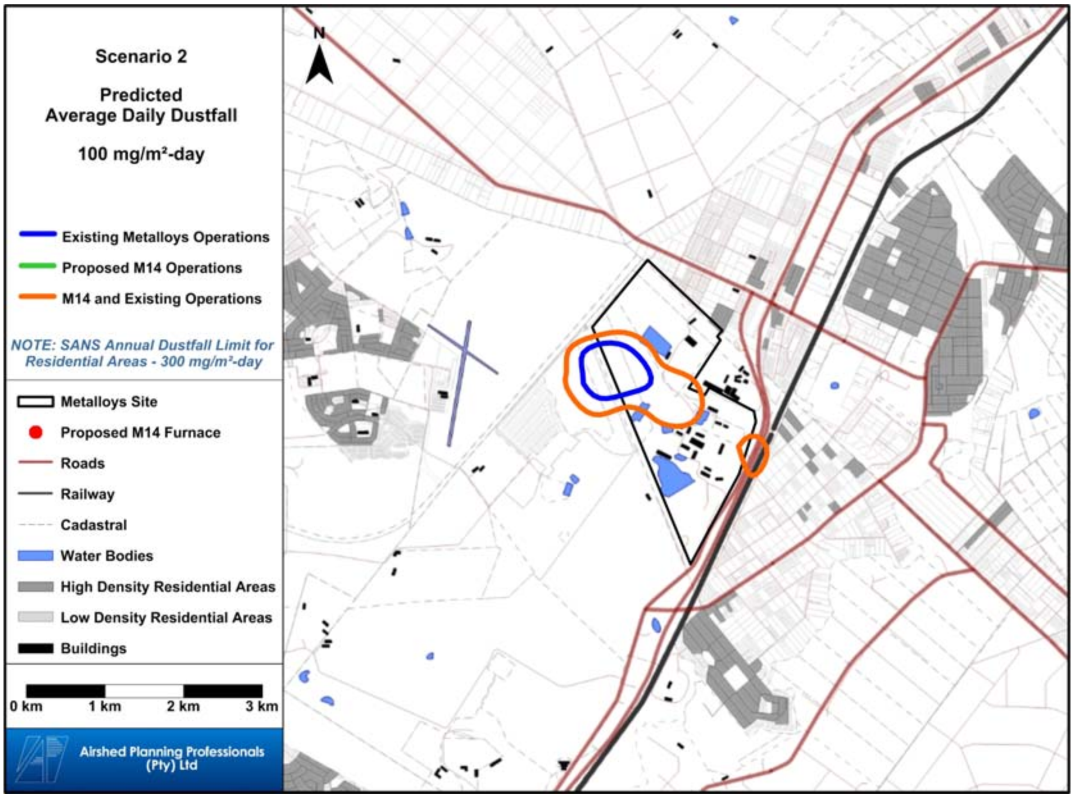

Figure 4-18: Scenario 2 – Predicted average daily dustfall

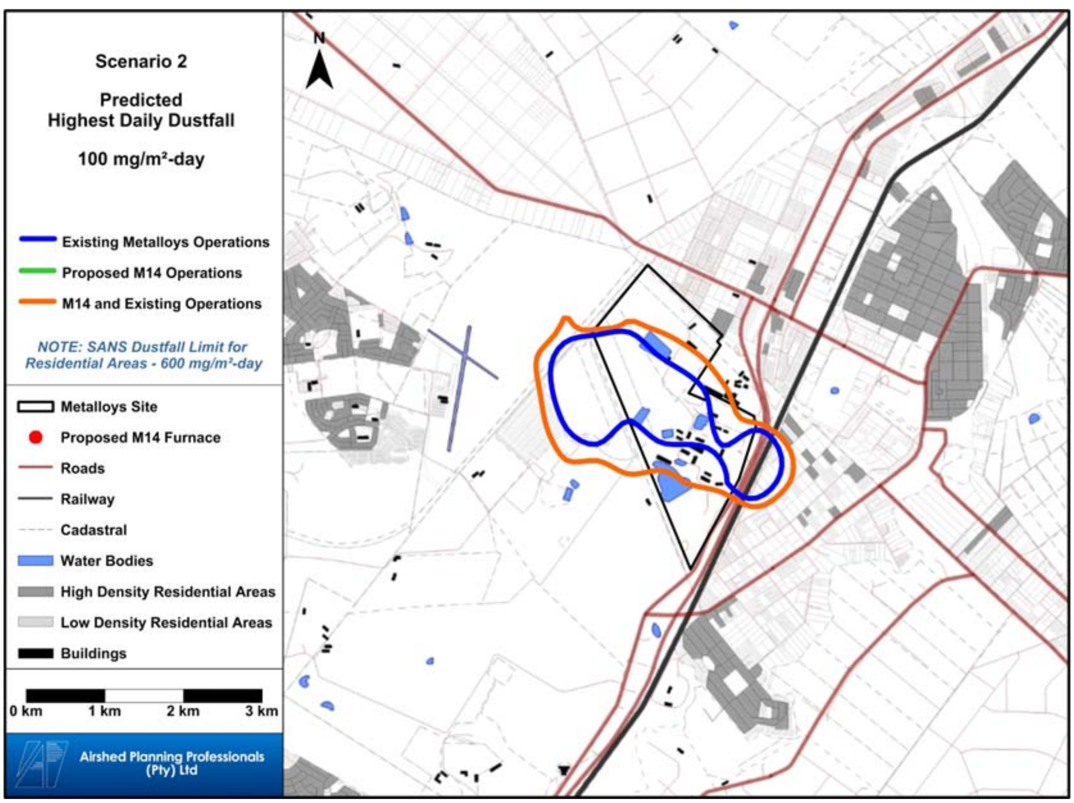

Figure 4-19: Scenario 2 – Predicted highest daily dustfall

5 Conclusion and Recommendations

An air quality impact assessment has been undertaken for the proposed M14 furnace operation. NO_2, SO_2, PM10 and Mn health impacts as well as nuisance dust impacts for the proposed operation were assessed in order to identify all possible detrimental impacts on the surrounding environment and sensitive receptors.

Various operational scenarios were included in the investigation. These scenarios were selected to reflect:

- impacts associated with proposed M14 operations incrementally;
- cumulative impacts associated with proposed M14 and existing Metalloys operations; and
- the effect of emission reduction strategies on incremental and cumulative impacts.

PM10 and manganese were found to be the pollutants of concern based on predicted air quality impacts and elevated background particulate concentrations.

The additional particulate emissions from proposed M14 furnace operations were predicted to result in a potentially significant increase in ambient PM10 concentrations specifically at the Metalloys plant boundary and at Meyerton Park. The implementation of the emission reduction strategy as intended by Metalloys was however calculated to reduce emissions from existing Metalloys operations and proposed M14 furnace operations to such an extent that predicted PM10 concentrations at Meyerton Park may be acceptable according to SA ambient air quality standards taking into account modelling uncertainties.

In the absence of South African standards regulating ambient manganese concentrations, manganese impacts were screened against the WHO annual average guideline. Elevated manganese concentrations were predicted as a result of incremental and cumulative operations. The potential health effects of manganese on the receiving environment should however be assessed in detail by a health risk professional.

Based on the abovementioned findings, the following recommendations are made:

- To minimize potential cumulative air quality impacts it is recommended that the operation of the proposed M14 furnace coincide with implementation of the ERS.
- As point source and secondary fume emissions associated with M14 were estimated based on theoretical values and methods, it is recommended that emissions be confirmed through stack and furnace building fugitive monitoring once M14 is in operation.
- A specialist health risk assessment is required for manganese exposures.

- The existing monitoring network established by Metalloys is considered sufficient to record changes in ambient particulate concentrations associated with the proposed M14 project. It is therefore recommended that the already established monitoring network be maintained in order to assess the effectiveness of the ERS on ambient particulate concentrations as well as impacts associated with M14. It may be valuable to analyse collected PM10 data for manganese to confirm predicted manganese impacts.

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7 Appendix A – Fugitive Dust Emission Factors

7.1 Vehicle Entrained Dust from Unpaved Roads

Vehicle-entrained dust emissions have been found to account for a great portion of fugitive dust emissions from open pit mining operations. The force of the wheels of vehicles travelling on unpaved haul roads causes the pulverisation of surface material. Particles are lifted and dropped from the rotating wheels, and the road surface is exposed to strong air currents in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed. The quantity of dust emissions from unpaved roads varies linearly with the volume of traffic.

The unpaved road size-specific emission factor equation of the US-EPA, used in the quantification of emissions, is given as follows:

$$E = k\left(\frac{s}{12}\right)^{a} \cdot \left(\frac{W}{3}\right)^{b} \cdot 281.9$$ (Equation 1)

Where,

E = *emissions in lb of particulates per vehicle mile travelled (g/VMT)*

K = *particle size multiplier (dimensionless);*

S = *silt content of road surface material (%);*

W = *mean vehicle weight (tons)*

The particle size multiplier in the equation (k) varies with aerodynamic particle size range and is given as 1.5 for PM10 and 4.9 for total suspended particulates (TSP). The constants a and b are given as 0.9 and 0.45 respectively for PM10 and as 0.7 and 0.45 respectively for TSP.

7.2 Vehicle Entrained Dust from Paved Roads

The paved road size-specific emission factor equation of the US-EPA, used in the quantification of emissions, is given as follows:

$$\boxed{E = k \cdot \left(\frac{sL}{2}\right)^{0.65} \cdot \left(\frac{W}{3}\right)^{1.5} - C} \text{ (Equation 2)}$$

Where,

E	=	*emissions in lb of particulates per vehicle kilometre travelled (g/VKT)*
K	=	*particle size multiplier (dimensionless);*
S	=	*silt loading of road surface material (g/m²);*
W	=	*mean vehicle weight (tons)*
C	=	*emission factor for 1980's vehicle fleet exhaust, break and tire wear*

The particle size multiplier in the equation (k) varies with aerodynamic particle size range and is given as 4.6 for PM10 and 24 for total suspended particulates (TSP). The constant C are given as 0.1317 for PM10 and TSP.

7.3 Materials Handling

The quantity of dust that will be generated from materials handling operations will depend on various climatic parameters, such as wind speed and precipitation, in addition to non-climatic parameters such as the nature and volume of the material handled. Fine particulates are most readily disaggregated and released to the atmosphere during the material transfer process, as a result of exposure to strong winds. Increases in the moisture content of the material being transferred would decrease the potential for dust emission, since moisture promotes the aggregation and cementation of fines to the surfaces of larger particles. The following US EPA AP42 predictive equation was used to estimate emissions from material transfer operations:

$$E = k \cdot 0.0016 \cdot \left(\frac{U}{2.3}\right)^{1.3} \cdot \left(\frac{M}{2}\right)^{-1.4}$$ (Equation 3)

where,

E = *Emission factor (kg dust / tons of material transferred)*

U = *mean wind speed (m/s)*

M = *material moisture content (%)*

k = *particle size multiplier (kPM10 = 0.35; kTSP = 0.74)*

7.4 Crushing and Screening

Fugitive dust emissions due to the crushing and screening operations were quantified using US-EPA single valued emission factors for such operations (Table 7-1). These emission factors include emissions from the loading of crusher hoppers and screening.

Table 7-1: Emission factors for metallic minerals crushing and screening

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

Notes:
(a) Moisture content less than 4%
(b) Moisture content more than 4%

8 Appendix B – The Impact of Various Pollutants on Human Health

8.1 Sulphur Dioxide

Sulphur dioxide is damaging to the human respiratory function. Exposure to sulphur dioxide concentrations above certain threshold levels increases the prevalence of chronic respiratory disease and the risk of acute respiratory illness. Due to it being highly soluble, sulphur dioxide is more likely to be adsorbed in the upper airways rather than penetrate to the pulmonary region.

8.2 Nitrogen Dioxide

Nitrogen oxides (NO_x), primarily in the form of nitrogen oxide (NO), are one of the primary pollutants emitted during combustion. Nitrogen dioxide (NO_2) is formed through oxidation of these oxides once released in the air. NO_2 is an irritating gas that is absorbed into the mucous membrane of the respiratory tract. The most adverse health effect occurs at the junction of the conducting airway and the gas exchange region of the lungs. The upper airways are less affected because NO_2 is not very soluble in aqueous surfaces. Exposure to NO_2 is linked with increased susceptibility to respiratory infection, increased airway resistance in asthmatics and decreased pulmonary function.

8.3 Suspended Particulate Matter

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

The nasal openings permit very large dust particles to enter the nasal region, along with much finer airborne particulates. Larger particles are deposited in the nasal region by impaction on the hairs of the nose or at the bends of the nasal passages. Smaller particles (PM10) pass through the nasal region and are deposited in the tracheobronchial and pulmonary regions. Particles are removed by impacting with the wall of the bronchi when they are unable to follow the gaseous streamline flow through subsequent bifurcations of the bronchial tree. As the airflow decreases near the terminal bronchi, the smallest particles are removed by Brownian motion, which pushes them to the alveolar membrane (CEPA/FPAC Working Group, 1998; Dockery and Pope, 1994).

8.4 Manganese

Manganese is an essential trace element and is necessary for good health. The human body typically contains small quantities of manganese, and under normal circumstances, the body controls these amounts so that neither too little nor too much is present. In addition to occurring naturally in the environment, manganese can be introduced by human activity. Manganese can be released into the air by industry and by the burning of fossil fuels. More specifically, sources of airborne manganese include iron- and steel-producing plants, power plants, coke ovens, and dust from uncontrolled mining operations.

The main route of human exposure to manganese is normally in food, primarily in cereals although all foods contain trace amounts of manganese. The typical daily intake of manganese in European and American diets has been reported to vary between 2 and 5 mg/day. Small amounts of manganese typically occur in drinking water (typically daily intake of 10 to 50 µg).

When inhaled, manganese that enters the bloodstream passes first to the brain before being processed by the liver. Depending on its ability to cross the blood-brain barrier, this manganese may reach areas of the central nervous system and produce the characteristic neurotoxic effects of manganese. Although manganese is eliminated primarily by biliary excretion, it appears that inhaled manganese may not be as well regulated by this mechanism as is ingested manganese (WHO, 2000).

High occupational exposure to manganese is known to result in severe neurotoxic signs and symptoms, some of which resemble those of idiopathic Parkinson's diseases (e.g. disturbances in the control of hand movements and the speed of movement). This syndrome, which may also include psychiatric effects, is known as *manganism* (Levy *et al*., 2004). The clinical symptoms associated with manganism, such as movement disorders and neurological dysfunction have not been reported to occur at exposure levels below 5 mg/m^3.

Reproductive effects have included a smaller number of children born to manganese-exposed workers compared to matched controls, and various self-reported symptoms of sexual dysfunction. In recent studies at low to moderate occupational exposure levels, respiratory effects have been reflected primarily in self-reported symptoms of respiratory tract illnesses rather than in differences between objective spirometric measurements in manganese-exposed and control workers (WHO, 2000).

Although pulmonary effects and adverse effects on the cardiovascular system have been associated with manganese exposure, but neither would be expected at inhalation exposures of 1 mg/m^3 or less (Levy *et al*., 2004).

Increasing attention has recently been placed on more subtle, sub-clinical neurobehavioral / neurotoxicological effects that may occur at much lower levels of occupational exposure (e.g. deterioration in motor function and co-ordination. According to Levy *et al* (2004) it is considered overall that these small non-clinical neuron-motor effects do represent biologically significant events of relevant to human health.

It is possible that the compensatory or reserve capacity of certain neurological mechanisms may be stressed by manganese exposure earlier in life, with manifestations of impairments only becoming evident much later, perhaps at a geriatric stage. One reason for the latter concern is that Parkinson's disease is typically a geriatric disease, in which the symptoms are only seen when the loss of brain cells that produce dopamine (which is also apparently involved in manganese toxicity) reaches 80% or more. Indeed, some neurologists think that a long latency period of perhaps several decades may precede various parkinsonian syndromes. These points lead to a concern that if manganese reduces the compensatory or reserve capacity of the nervous system, Parkinson-type effects might occur earlier in life than they would otherwise (WHO, 2000).

Given the involvement of the dopaminergic system and extrapyramidal motor system in both Parkinson's disease and manganism, symptoms of the two diseases are somewhat similar, and several writers have suggested the possibility of a common etiology. Nevertheless, many neurological specialists make a clear distinction in the etiologies and clinical features of Parkinson's disease and manganism (WHO, 2000).

Most people who inhale manganese are involved in jobs where they are exposed to the metal. There is a possibility that people can be exposed to manganese in the air if they live near a plant that uses manganese, or if they live in a high traffic area and the automobiles burn manganese in the gasoline. A recent study showed that people who inhaled manganese from the air and who had high levels of manganese in their blood showed signs of neurological problems that were similar to those reported in occupationally-exposed persons. The neurological problems were most significant in the people aged 50 years and older (ASTD, 2003).