ATMOSPHERIC IMPACT REPORT:
Zero-Waste Recovery Plant near Emalahleni, Mpumalanga

Project done on behalf of: **Savannah Environmental (Pty) Ltd**

Project Compiled by:
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Project Reviewed by:
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Report No: 18SAV01b Revision 1 | **Date:** April 2021

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Report Details

Project Name	Atmospheric Impact Report: Zero-Waste Recovery Plant near Emalahleni, Mpumalanga
Client	Savannah Environmental (Pty) Ltd
Report Number	18SAV01b
Report Version	Revision 1
Date	April 2021
Prepared by	Nick Grobler, BEng (Chem), BEng (Hons) (Env) (University of Pretoria)
Reviewed by	Terri Bird, Pr.Sci.Nat, PhD (Wits)
Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighbourhood concerns to regional air pollution impacts as well as noise impact assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
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Revision Record

Version	Date	Section(s) Revised	Summary Description of Revision(s)
Draft	March 2021		Draft report for client review
Revision 1	April 2021	Section 3, Section 7, Section 9	• Description of Site • Relevance of Goal 7 of the HPA AQMP to project • EMPr tables • Minor layout and typographical updates

NEMA Regulation (2017), Appendix 6

NEMA Regulations (2017) - Appendix 6	Relevant section in report
Details of the specialist who prepared the report.	Report details, Section 1
The expertise of that person to compile a specialist report including curriculum vitae.	Section 1.1, Annexure C
A declaration that the person is independent in a form as may be specified by the competent authority.	Report details, Appendix B
An indication of the scope of, and the purpose for which, the report was prepared.	Section 2
Indication of the quality and age of base data used in the report	Sections 7.1.5 and 7.1.7
A description of existing impacts on the site, cumulative impacts for the proposed development and levels of acceptable change	Sections 7.1.7, 7.1.9.2 and 7.1.2.
The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment.	Section 7.1.5
A description of the methodology adopted in preparing the report or carrying out the specialised process.	Section 7.1.1
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure.	Section 7.1.6 and 7.2.
An identification of any areas to be avoided, including buffers.	Not applicable
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers.	Section 7.1.9
A description of any assumptions made and any uncertainties or gaps in knowledge.	Section 7.1.8
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment.	Section 11
Any mitigation measures for inclusion in the environmental management programme report	Section 9
Any conditions for inclusion in the environmental authorisation	Section 9
Any monitoring requirements for inclusion in the environmental management programme report or environmental authorisation.	Section 9
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised.	Section 10
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the environmental management programme report, and where applicable, the closure plan.	Section 10, 9
A description of any consultation process that was undertaken during the course of carrying out the study.	As per EIA Public Participation Process
A summary and copies if any comments that were received during any consultation process.	None
Any other information requested by the competent authority.	Not applicable.

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1 Company Introduction

Airshed Planning Professionals (Pty) Ltd, a South African company, was established in 2003, specialising in all aspects of air quality, ranging from nearby neighbourhood concerns to regional air pollution impacts. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003. Airshed comprises a team of professional air quality scientists drawn from a range of disciplines including chemical and mechanical engineering, meteorology, geography and environmental management. Our team holds extensive expertise and experience in all aspects of air pollution impact assessments and air quality management. Airshed is at the forefront of air quality science encouraging and facilitating further study and skills development among our staff and through our association with universities and research organisations. The team is motivated, capable and well equipped to meet the challenge of managing air quality within the sustainable development concept.

Airshed Planning Professionals (Pty) Ltd was appointed by Savannah Environmental (Pty) Ltd to undertake an Air Quality Impact Assessment AQIA, presented in the form of an Atmospheric Impact Report (AIR), and to assist with the compilation of the Atmospheric Emissions Licence application for the proposed Zero-Waste Recovery Plant at Highveld Steel near Emalahleni in the Mpumalanga province of South Africa.

1.1 Specialist team introduction

Report author: NB Grobler, BEng (Chemical Engineering), BEng (Hons) (Environmental Engineering) (Pretoria)

Nick Grobler joined Airshed Planning Professionals after finishing his BEng degree in Chemical Engineering and BEng (Hons) in Environmental Engineering, both from the University of Pretoria. For the past ten years, Nick has been actively involved in all facets off air quality management, including ambient air quality monitoring, dispersion modelling, air quality impact assessments, and the compilation of air quality management plans. Nick also expanded into conducting environmental noise baseline and impact assessments in 2017. Nick is an associate member of the Institution of Chemical Engineers (IChemE) and a member of Golden Key international.

Nick has been actively involved with projects for the opencast and underground mining of: copper, platinum, chrome, gold, iron, coal, limestone, potash, graphite, lead, mineral sands, aggregate stone, clay and zinc. Furthermore, he's also conducted air quality or noise studies for the production of: copper, platinum, PGM metals, gold, base metals, iron, steel, coal, coke, heavy mineral sands, vanadium, solder, lime, urea, chrome, gypsum, asphalt, acetylene, LNG liquefaction, vegetable oil, fertilizer, explosives, wood pulp, cement, grease, oil recycling, tyre and general waste pyrolysis, power generation, fuel storage as well as crematoriums, general waste landfills, meat processing and rendering at abattoirs and animal waste incineration. Nick has experience in working with projects in South Africa, Zimbabwe, Namibia, Mozambique, Republic of Congo, Democratic Republic of Congo, Ghana, Liberia, Guinea, Mali, Suriname and Saudi Arabia.

Report reviewer: Dr Theresa (Terri) Bird, Pr. Sci. Nat., PhD (University of the Witwatersrand)

Dr Terri Bird holds a PhD from the School of Animal, Plant and Environmental Sciences, University of the Witwatersrand, Johannesburg. The focus of her doctoral research was on the impact of sulfur and nitrogen deposition on the soil and waters of the Mpumalanga Highveld. Since March 2012, she has been employed at Airshed Planning Professionals (Pty) Ltd. In this time, she has been involved in air quality impact assessments for various mining operations (including coal, mineral sand, diamond and platinum mines); coal-fired power station and ash disposal facilities; gas-to-power facilities; and various industrial processes. She has been a team member on the development of Air Quality Management Plans, for air quality priority areas, provincial, metropolitan areas, and for specific industries. She has also been in various air quality and dustfall monitoring projects.

2 Scope of Work

- Determine and document the baseline, ambient air quality conditions of the study area based on available data. This will include description of the pre-project pollutant levels where possible and a qualitative description of existing sources of emissions to ambient air quality (if any) associated with the project area;
- Review legal requirements pertaining to air quality and specifically referring to IFC Standards and The National Environmental Management Air Quality Act (NEMAQA) Act No. 39 of 2004.
- Model the concentrations of pollutants of concern and emissions from the operations, and determine the zones of influence around emission sources accordingly;
- Describe any sensitive receptors (e.g. local communities) within the zones of influence identified above;
- Assess the significance of impacts to the receiving air quality environment and sensitive receptors within the zone of influence according to criteria to be provided by the client (based on the nature, extent, duration, extent, magnitude and probability of the impacts);
- Identify and assess any potential cumulative impacts in terms of the above criteria;
- Provide practical and implementable mitigation measures by which to manage the identified impacts. Any changes to the significance of impacts resulting from implementation of mitigation or management measures must be illustrated;
- Report on all legislation, provincial legislation and any ordinances at a local or municipal level that will impact this project and what permits this project will require going forward;
- Describe a monitoring protocol to be implemented;
- Compile an AIR report;
- Provide shapefiles illustration sensitive receptors, zones of impact, etc.; and
- Assist with completion of an AEL application.

3 Enterprise Details

3.1 Enterprise Details

The details of the operations are summarised in Table 1. The contact details of the responsible person are provided in Table 2.

Table 1: Enterprise details

Enterprise Name	Anglo African Metals (Pty) Ltd
Trading as	Anglo African Metals
Type of Enterprise	Mining Waste Recycling
Company Registration Number	2016/28548/107
Registered Address	Nelson Mandela Square, 2nd floor West Tower, Maude Street, Sandton, 2196
Telephone Number (General)	011 881 5483
Industry Type/Nature of Trade	Waste Recycling and Ore Beneficiation
Land Use Zoning as per Town Planning Scheme	Industrial
Land Use Rights if Outside Town Planning Scheme	Industrial

Table 2: Contact details of responsible person

Responsible Person	Anette Pocock
Telephone Number	0840266774
Cell Number	0840266774
Fax Number	N.A.
Email Address	anettepocock@foderegroup.com
After Hours Contact Details	0840266774

3.2 Location and Extent of the Plant

Table 3: Location and extent of the plant

Physical Address of the Plant	
Description of Site (Where no Street Address)	Highveld Industrial Park No 1230 JS
Coordinates of Approximate Centre of Operations	25°53'0.61"S 29° 4'52.54"E
Extent	4.1 ha

Elevation Above Sea Level	1555
Province	Mpumalanga
Metropolitan/District Municipality	Nkangala District Municipality
Local Municipality	Emalahleni Local Municipality
Designated Priority Area	Highveld Priority Area

3.3 Description of Surrounding Land Use

The waste recovery plant is located on Highveld Industrial Park No 1230 JS, and comprises an area of approximately 4.10 ha footprint within the Highveld Steel property, located in the Emalahleni Local Municipality (LM) within the Nkangala District Municipality (DM) in Mpumalanga, approximately 17 km west of eMalahleni town. The site may be reached directly off the R104, from the N4 turnoff near Kwa-Guqa settlement (Figure 1).

Sensitive receptors within a 10 km radius (Figure 2) of the proposed operations include the residential areas of Kwa-Guqa, eMumelelweni and Hlalanikahle to the north, the residential areas of Ackerville, Thushanang, Schoongezicht and Lynnville to the east and Clewer to the south. KwaGuqa is a township west of the industrial town of eMalahleni and is the largest populated area within close proximity to the proposed development site (approximately 1 500 m north of the proposed development site at its closest point). There are also numerous schools, clinics and hospitals in the nearby residential areas, as shown in Figure 2. There are a large number of operations within a 50 km radius that are sources of major emissions, including seven power stations and numerous mines (Figure 3).

The proposed project site lies at an altitude between 1480 and 1560 metres above sea level (masl) (Figure 4). In general, the topography of the site slopes downwards from north to south at a gradient of approximately 1 m per 70 m and from west to east at a gradient of approximately 1 m per 30 m.

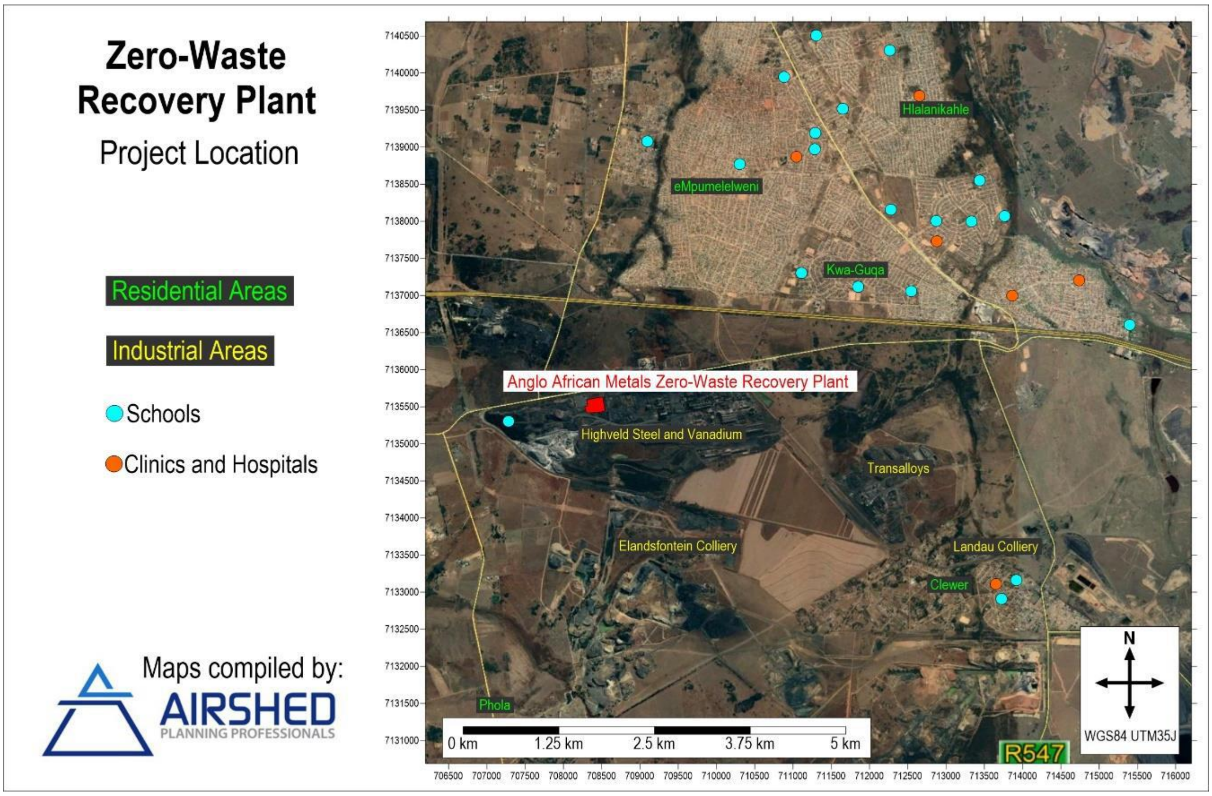

Figure 1: Project location with surrounding land use and sensitive receptor locations shown - 5 km radius

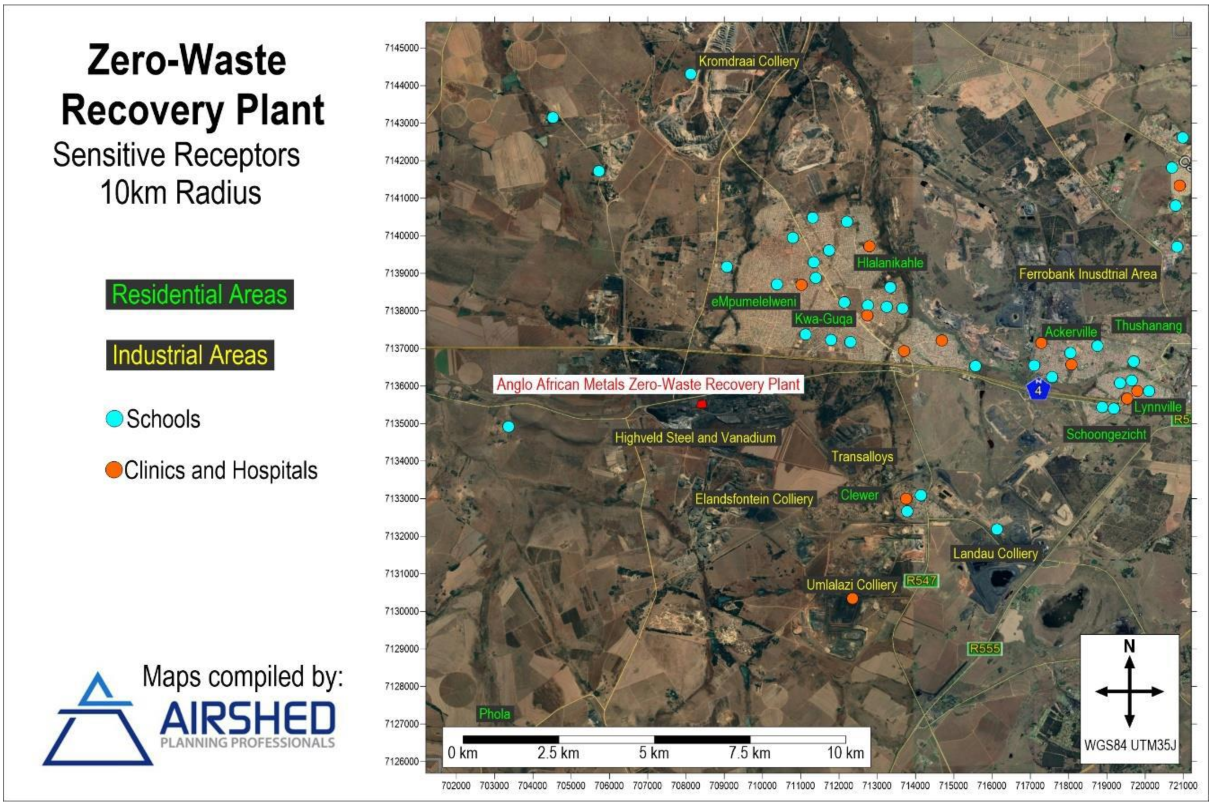

Figure 2: Project location with nearby industries, residential areas, schools and hospitals shown – 10 km radius

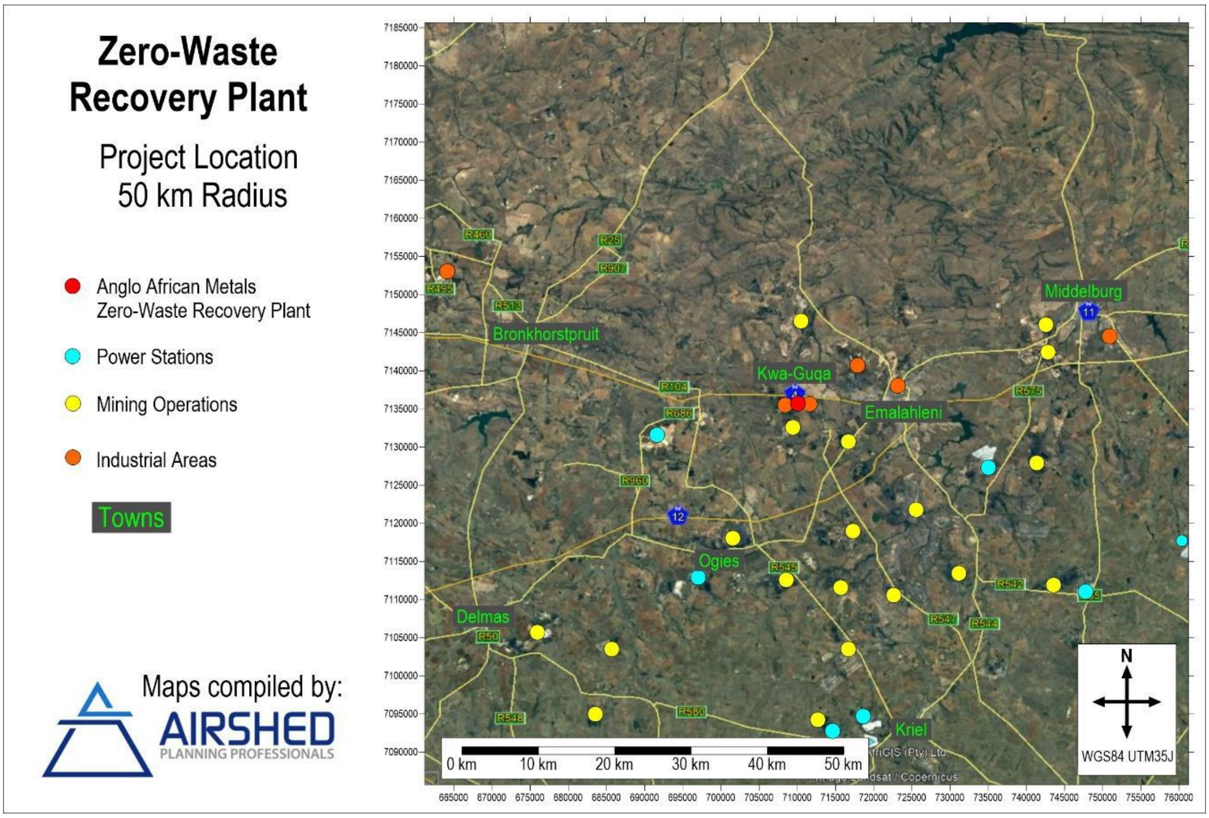

Figure 3: Project location with major emission sources and major towns shown – 50 km radius

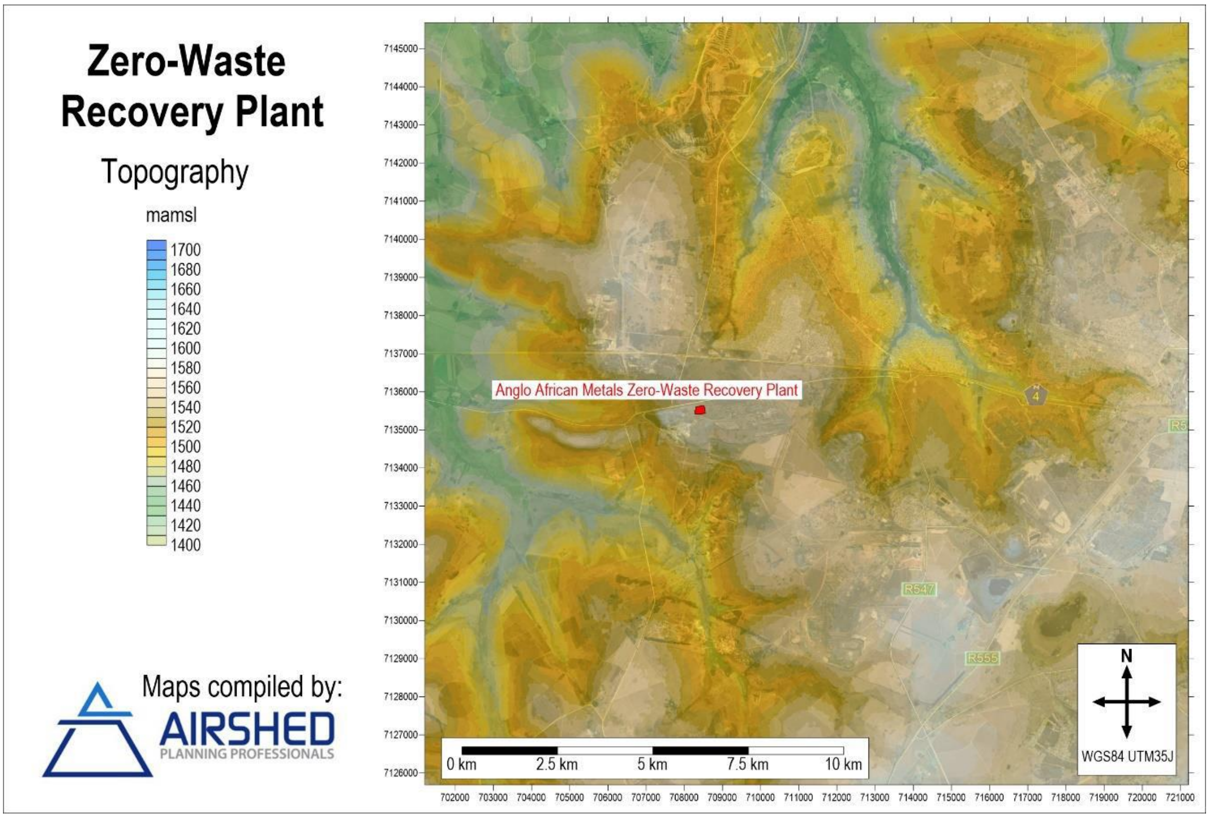

Figure 4: Project location with topography

3.4 Atmospheric Emission Licence and other Authorisations

The processing and recovery of metallurgical slag by the application of heat will be conducted at the operations, which is classified as a listed activity in terms of Section 21 of the National Environmental Management: Air Quality Act (Act No 39 of 2004). This AIR report will accompany the AEL application for the operations, and is submitted to the public as part of the EIA process for review and comment.

4 NATURE OF THE PROCESS

Anglo African Metals (Pty) Ltd, the South African registered company of Fodere Titanium has developed a disruptive technology for the economic extraction of valuable minerals from mining ore and waste materials. The process offers solutions for simultaneously extracting both vanadium and titanium oxides from slag materials. The technology developed by the Anglo African Metals is also demonstrated to extract aluminium - as aluminium oxide (Al_2O_3), magnesium - as magnesium oxide (MgO), and calcium - as calcium sulfate/gypsum ($CaSO_4$).

Anglo African Metals has identified a suitable tailings/slag resource at Highveld Steel in Mpumalanga between Balmoral and Emalahleni. A site for a small-scale industrial plant has been defined within the Highveld Steel property. It is understood that the following is relevant to the proposed facility:

- The plant would be developed to process 2000 tonnes of tailings/slag per month, approximately 3 tons per hour. This plant would be developed within the Highveld Industrial Park . The purpose of this plant would be to confirm the process inputs and outputs and refine the extraction processes as necessary.
- The plant would be primarily fuelled by LNG, LPG or Sasol methane-rich gas (dependent on the gas pricing) brought into site by dedicated transport truck deliveries.

The plant will comprise the following infrastructure:

- Acid plant area, where process chemicals are produced, stored and handled as required by the waste recovery process;
- Substation and plant utility unit as interface and controlling unit for the electricity utilised by the plant during operation;
- Slag stockpile;
- Crushing plant;
- Mill;
- Product area for storage of the various products produced through the recovery process;
- Reagent area, for the storage and handling of reactants utilised in the waste recovery process;
- A security area;
- Parking lot;
- Admin and control room including offices and ablutions for staff.

Operation of the hydrometallurgical plant is anticipated for 24 hours per day, 28 days per month (i.e. non-stop operation), while the milling plant will only be operational for 9 hours per day. The plant will utilise the slag produced by the Highveld Steel operations. The process offers solutions for simultaneously extracting both vanadium and titanium oxide from slag materials. The technology developed by the Anglo African Metals is also demonstrated to extract aluminium as aluminium oxide (Al_2O_3), magnesium as magnesium oxide (MgO) and calcium as calcium sulfate/gypsum ($CaSO_4$), and involves the following approximate process (due to intellectual property and commercial sensitivity of this process, various technical details have been omitted):

» Crushing and milling of titanium dioxide (TiO_2) slag to the appropriate size for further treatment;
» Magnetic separation of entrained metallic iron from the crushed slag, which is used in a separate ferroalloy production processes;
» Alkali roasting of the remaining feedstock using a gas fired kiln. Off-gases from the kiln is a combination of carbon monoxide (CO) and sulfur[1] dioxide (SO_2). By comparison, sulfur dioxide (SO_2) is only 3-5% of the carbon monoxide gas. These off gases are passed through the off-gas scrubber to remove SO_2 and the remaining CO is reused in the kiln to supply part of the required heat.
» The material produced during alkali roasting from the kiln is then leached in water to dissolve vanadium and alumina.
» A further process produces vanadium pentoxide and recovers aluminium oxide from the leached products in the steps above.
» The remaining solid or residue after extracting vanadium is treated via leaching and roasting with sulfuric acid. The SO_2 gases or fumes given out during leaching or roasting are scrubbed off.
» Iron, magnesium and TiO_2 are recovered from solution via precipitation steps.
» Precipitated TiO_2 is heated in order to remove water of hydration.
» The leach solution is neutralised with lime from calcium sulfate and respective sulfates. The mixture of sulfates is heated in the furnace to produce sulfuric acid which is then used in the leaching step. The solid material after heating in the furnace is mainly calcium silicate which is used for cement production and construction.
» The remaining material after leaching of titanium, magnesium, and aluminium oxide etc., is mainly silica sand which can be also used for construction.

This process therefore recovers vanadium and titanium oxide from slag materials, with water, carbon dioxide, gypsum and synthetic rutile produced at the various stages. These materials are all useful in other processes and are collected and sold to third parties, and thus the process itself results in no further waste production, while simultaneously utilising a common waste type – slag.

[1] The spelling of "sulfur" has been standardised to the American spelling throughout the report. The International Union of Pure and Applied Chemistry, the international professional organisation of chemists that operates under the umbrella of UNESCO, published, in 1990, a list of standard names for all chemical elements. It was decided that element 16 should be spelled "sulfur". This compromise was to ensure that in future searchable data bases would not be complicated by spelling variants. (IUPAC. Compendium of Chemical Terminology, 2nd ed. (the "Gold Book"). Compiled by A. D. McNaught and A. Wilkinson. Blackwell Scientific Publications, Oxford (1997). XML on-line corrected version: http://goldbook.iupac.org (2006) created by M. Nic, J. Jirat, B. Kosata; updates compiled by A. Jenkins. ISBN 0-9678550-9-8.doi: 10.1351/goldbook)"

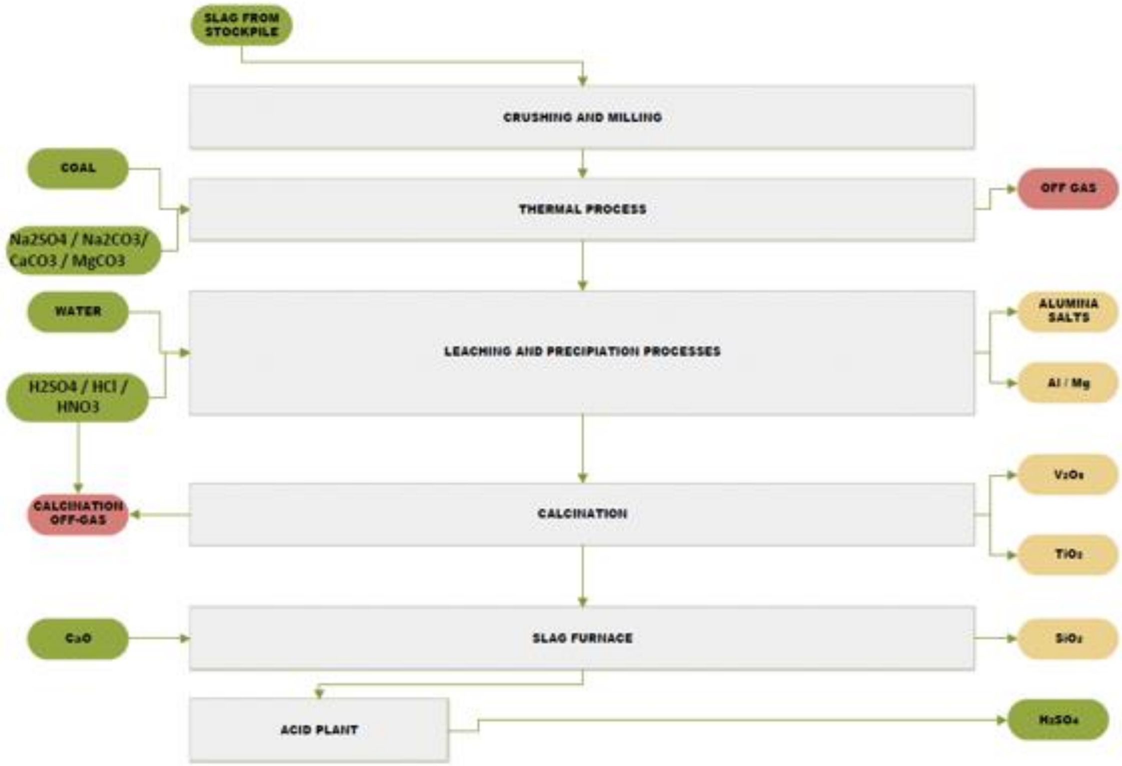

Figure 5: Process flow diagram (part 1 of 3)

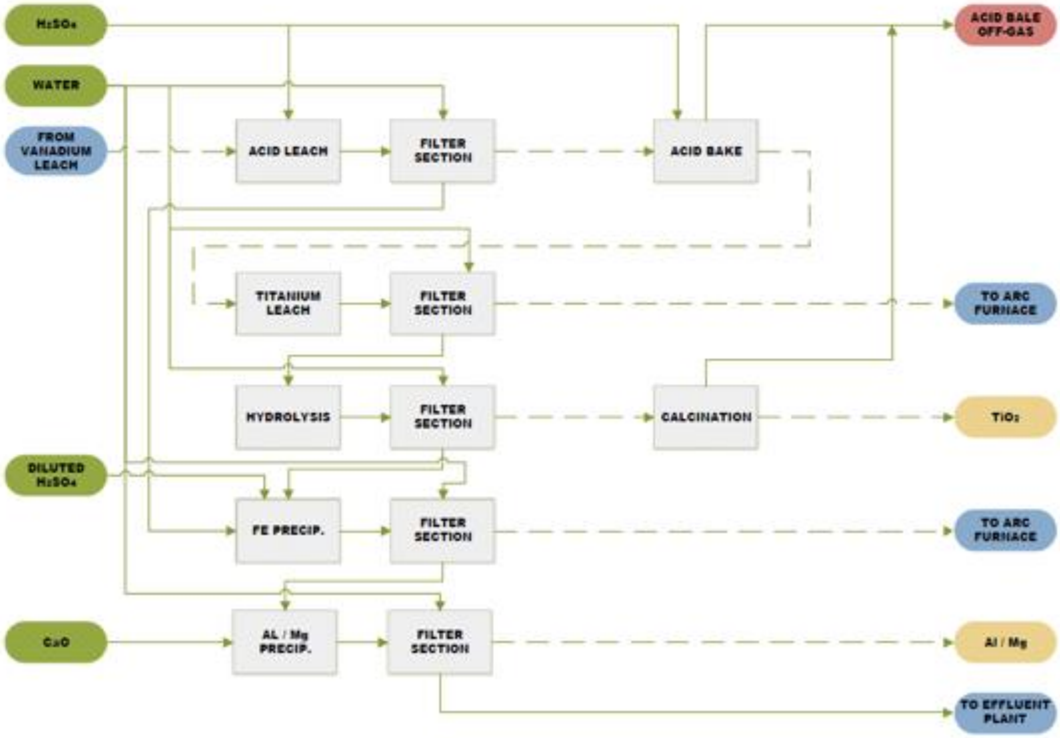

Figure 6: Process flow diagram (part 2 of 3)

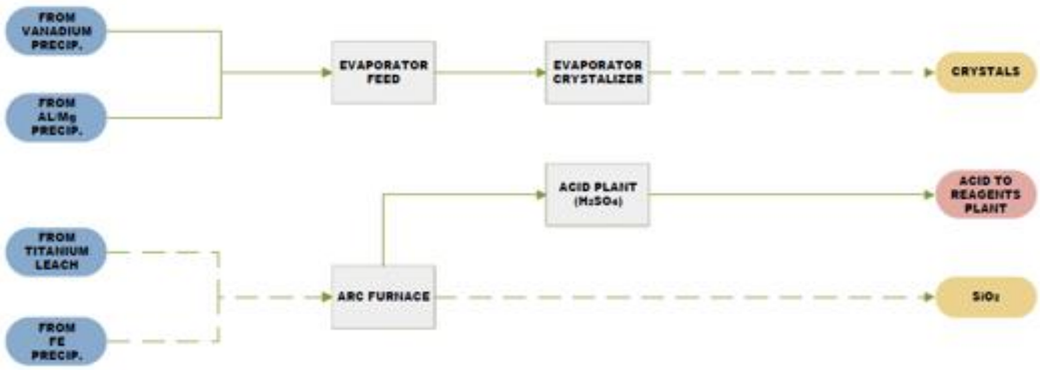

Figure 7: Process flow diagram (part 3 of 3)

Figure 8: Plant Layout

4.1 Listed Processes

All listed processes, as specified in the Air Quality Act, conducted at the premises in terms of this application are given in Table 4.

Table 4: Listed activities at the operations

Process Number:	Listed Process Description:
Subcategory 4:20	Slag Processes – The processing or recovery of metallurgical slag by the application of heat

4.2 Unit Processes

The unit processes associated with the listed activity in operation at the premises are shown in Table 5. Other processes conducted are shown in Table 6.

Table 5: Listed Activity and Controlled Emitter unit processes

Unit Process	Description of the Unit Process
Alkali Roasting	Alkali roasting of feedstock using a gas or coal fired kiln
Calcination	Recovery of V_2O_5 and TiO_2
Slag Furnace	Production of sulfuric acid and calcium silicate

Table 6: Other Unit Processes

Unit Process	Description of the Unit Process
Crushing and milling	Size reduction of input material
Leaching and precipitation	Recovery of Alumina salts, aluminium and magnesium
Acid plant	Treatment of off-gas and production of sulfuric acid

5 TECHNICAL INFORMATION

Raw material consumption, production rates and hours of operation are tabulated in Table 7, Table 8 and Table 9.

5.1 Raw Materials Used and Production Rates

Table 7: Raw materials used

Raw Material Type	Design Consumption Rate (Volume)	Units (quantity/period)
Slag	3	t/h
Coal	0.107	t/h
Sodium Carbonate	0.432	t/h
H_2SO_4	3.7	t/h
Ammonia Sulphate	0.023	t/h
Sodium Hydroxide	1.278	t/h
Lime	0.322	t/h

5.2 Production Rates

Table 8: Production rates

Production Name	Actual Production Capacity (Volume)	Units (quantity/period)
V_2O_5 Cake	0.016	t/h
TiO_2	0.737	t/h
Iron	1.3	t/h
Al/Mg	1.22	t/h
Al	0.049	t/h

Table 9: Hours of operation

Unit Process	Hours of Operation
All hydrometallurgical processes	24 hours, 7 days a week
Milling	9 hours per day, 7 days a week

6 Atmospheric Emissions

The establishment of a comprehensive emissions inventory formed the basis for the assessment of the air quality impacts from the proposed operations on the receiving environment. The emissions inventory for the operations, based on the design of the plant and the Subcategory 4.20 Minimum Emission Standards are shown in Table 10 to Table 14.

6.1 Point Source Parameters

Table 10: Point sources of atmospheric pollutant emissions

Point Source Number	Point Source Name	Point Source Coordinates	Height of Release above Ground (m)	Height above Nearby Building (m)	Diameter at Stack Tip or Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow Rate (m^3/hr)	Actual Gas Exit Velocity (m/s)	Type of Emission (Continuous /Batch)
STK1	Scrubber Stack	25°52'57.3"S 29°04'48.4"E	20	8	0.5	300	12723.45	18	Continuous
STK2	Acid Plant Stack	25°53'01.3"S 29°04'55.5"E	13	1	0.5	300	12723.45	18	Continuous

Table 11: Atmospheric pollutant emission rates for the point sources

Point Source Number	Point Source Name	Pollutant Name	Average Emission Rate				
			Emission Concentration (mg/Nm^3)	Averaging Period	Emission Rate (g/s)	Emission Rate (t/a)	Duration of Emission
STK1	Scrubber Stack	SO_2	1500	24-hours	5.30	167.2	Continuous
		PM	50	24-hours	0.18	5.6	Continuous
		NOx	350	24-hours	1.24	39.0	Continuous
STK2	Acid Plant Stack	SO_2	1500	24-hours	5.30	167.2	Continuous
		PM	50	24-hours	0.18	5.6	Continuous
		NOx	350	24-hours	1.24	39.0	Continuous

Table 12: Information sources used to estimate emission rates for point source emissions

Point Source code	Basis for Emission Rates
STK1	Design specifications and subcategory 4.20 Minimum Emission Standards
STK2	Design specifications and subcategory 4.20 Minimum Emission Standards

6.2 Fugitive Emissions

Parameters and emission rates for fugitive emission sources at the waste recovery plant are given in Tables 13 and 14. The emission factors used in the estimation of fugitive emissions is given in Table 15. In the absence of local emission factors, reference is made to emission factors published by the United States Environmental Protection Agency in their AP42 database, and the Australian National Pollutant Inventory.

Table 13: Area and/or line source parameters

Unique Area Source ID	Source Description	Latitude (decimal degrees) of SW corner	Longitude (decimal degrees) of SW corner	Height of Release Above Ground (m)	Length of Area (m)	Width of Area (m)	Angle of Rotation from True North (°)
Unpaved Roads	Vehicle entrainment from on-site unpaved roads	-25.88425	29.08059	0	528.5	6	35
Crushing Plant	Fugitive dust emissions from crushing and screening at the crushing plant, controlled with a baghouse	-25.883331	29.08119	2	80	26	35
Raw Material Stockpile	Fugitive dust emissions from materials handling and wind erosion at the slag stockpile	-25.88295	29.0815	3	23	23	35
Processing Plant	Fugitive emissions from the processing plant	-25.88373	29.08045	12	75	55	35
Product Area	Fugitive dust emissions from materials handling and wind erosion at the product area	-25.88336	29.08177	2	24	8	35

Unique Area Source ID	Source Description	Latitude (decimal degrees) of SW corner	Longitude (decimal degrees) of SW corner	Height of Release Above Ground (m)	Length of Area (m)	Width of Area (m)	Angle of Rotation from True North (°)
Generator	Small 7 kW generator for kiln winddown	-25.88373	29.08045	12	75	55	35

Table 14: Area and line source emissions

Unique Area Source ID	Pollutant Name	Maximum Release Rate (g/s)	Average Annual Release Rate (t/annum)	Emission Hours	Type of Emission (Continuous / Intermittent)	Wind Dependent (Yes / No)
Unpaved Roads	TSP	0.477	15.0	24-hours	Intermittent	Yes
	PM_{10}	0.141	4.4	24-hours	Intermittent	Yes
	$PM_{2.5}$	0.013	0.4	24-hours	Intermittent	Yes
Crushing Plant	TSP	0.694	21.9	9-hours	Intermittent	Yes
	PM_{10}	0.139	4.4	9-hours	Intermittent	Yes
	$PM_{2.5}$	0.014	0.4	9-hours	Intermittent	Yes
Raw Material Stockpile	TSP	0.173	5.4	24-hours	Intermittent	Yes
	PM_{10}	0.088	2.8	24-hours	Intermittent	Yes
	$PM_{2.5}$	0.008	0.3	24-hours	Intermittent	Yes
Processing Plant	TSP	0.972	30.7	24-hours	Intermittent	Yes
	PM_{10}	0.486	15.3	24-hours	Intermittent	Yes
	$PM_{2.5}$	0.049	1.5	24-hours	Intermittent	Yes
Product Area	TSP	0.169	5.3	24-hours	Intermittent	Yes
	PM_{10}	0.085	2.7	24-hours	Intermittent	Yes
	$PM_{2.5}$	0.008	0.3	24-hours	Intermittent	Yes
Generator	SO_2	0.000	0.0	24-hours	Intermittent	No

Unique Area Source ID	Pollutant Name	Maximum Release Rate (g/s)	Average Annual Release Rate (t/annum)	Emission Hours	Type of Emission (Continuous / Intermittent)	Wind Dependent (Yes / No)
	NO_x	0.037	1.2	24-hours	Intermittent	No
	PM_{10}	0.003	0.1	24-hours	Intermittent	No
	$PM_{2.5}$	0.003	0.1	24-hours	Intermittent	No

Table 15: Area Source Emission Estimation Information

As per Table 13ID	Basis for Emission Rates
Unpaved Roads	US.EPA AP42 Section 13.2.2 Emission factors for Unpaved Roads
Crushing Plant	Australian NPI Emission Estimation Technique Manual for Mining Version 3.1
Raw Material Stockpile	US.EPA AP42 Section 13.2.4 Emission factors for aggregate handling and storage piles
Processing Plant	US.EPA AP42 Section 12.5 Emission factors for Iron and Steel production
Product Area	US.EPA AP42 Section 13.2.4 Emission factors for aggregate handling and storage piles
Generator	Australian NPI Emission Estimation Technique Manual for Combustion Engines Version 3.0

6.3 Emission Summary

A summary of estimated emissions from all quantified sources at the proposed Zero-Waste Recovery Plant operations is given in Table 16.

Table 16: Summary of Quantified Emissions

Estimated Annual Emissions (tonnes per annum)					
Emission Source	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NO_x**
Stack 1	5.57	5.57	5.57	167.19	39.01
Stack 2	5.57	5.57	5.57	167.19	39.01
Unpaved Roads	15.04	4.44	0.40	n/a	n/a
Crushing Plant	21.90	4.38	0.44	n/a	n/a
Raw Material Stockpile	5.44	2.77	0.26	n/a	n/a
Processing Plant	30.66	15.33	1.53	n/a	n/a
Product Area	5.32	2.68	0.26	n/a	n/a
Generator	0.08	0.08	0.08	0.01	1.17

7 Impact of Enterprise on the Receiving Environment

7.1 Analysis of Emissions' Impact on Human Health

7.1.1 Study Methodology

The study methodology may be divided into a "preparatory phase" and an "execution phase".

The preparatory phase included the flowing basic steps prior to performing the actual dispersion modelling and analyses:

1. Understand Scope of Work
2. Assign Appropriate Specialists (See Annexure B)
3. Review of legal requirements (see Section 5.1.2)
4. Decide on Dispersion Model (see Section 5.1.1)

The Regulations Regarding Air Dispersion Modelling (Gazette No 37804 published 11 July 2014) (DEA, 2014) was referenced for the dispersion model selection.

Three levels of assessment are defined in the Regulations regarding Air Dispersion Modelling:

- Level 1: where worst-case air quality impacts are assessed using simpler screening models
- Level 2: for assessment of air quality impacts as part of license application or amendment processes, where impacts are the greatest within a few kilometres downwind (less than 50 km)
- Level 3: requires more sophisticated dispersion models (and corresponding input data, resources and model operator expertise) in situations:
  - where a detailed understanding of air quality impacts, in time and space, is required;
  - where it is important to account for causality effects, calms, non-linear plume trajectories, spatial variations in turbulent mixing, multiple source types, and chemical transformations;
  - when conducting permitting and/or environmental assessment process for large industrial developments that have considerable social, economic and environmental consequences;
  - when evaluating air quality management approaches involving multi-source, multi-sector contributions from permitted and non-permitted sources in an airshed; or,
  - when assessing contaminants resulting from non-linear processes (e.g. deposition, ground-level ozone (O_3), particulate formation, visibility).

This study was considered to meet the requirements of a Level 2 assessment, and AERMOD was selected on the basis that this Gaussian plume model is well suited to simulate dispersion where transport distances are likely to be less than 50 km.

The execution phase (i.e. dispersion modelling and analyses) firstly involves gathering specific information in relation to the emission source(s) and site(s) to be assessed. This includes:

- Source information: Emission rate, exit temperature, volume flow, exit velocity, etc.;
- Site information: Site building layout, terrain information, land use data;
- Meteorological data: Wind speed, wind direction, temperature, cloud cover, mixing height;
- Receptor information: Locations using discrete receptors and/or gridded receptors.

The model uses this specific input data to run various algorithms to estimate the dispersion of pollutants between the source and receptor. The model output is in the form of a predicted time-averaged concentration at the receptor. These predicted concentrations are added to suitable background concentrations and compared with the relevant ambient air quality standard or guideline. In some cases, post-processing can be carried out to produce percentile concentrations or contour plots that can be prepared for reporting purposes.

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. 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.

A disadvantage of the model is that spatial varying wind fields, due to topography or other factors cannot be included. 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.

The stochastic uncertainty includes all errors or uncertainties in data such as source variability, observed concentrations, and meteorological data. Even if the field instrument accuracy is excellent, there can still be large uncertainties due to unrepresentative placement of the instrument (or taking of a sample for analysis). Model evaluation studies suggest that the data input error term is often a major contributor to total uncertainty. Even in the best tracer studies, the source emissions are known only with an accuracy of ±5%, which translates directly into a minimum error of that magnitude in the model predictions. It is also well known that wind direction errors are the major cause of poor agreement, especially for relatively short-term predictions (minutes to hourly) and long downwind distances. All the above factors contribute to the inaccuracies not even associated with the mathematical models themselves.

Similar to the ISC model, a disadvantage of the model is that spatial varying wind fields, due to topography or other factors cannot be included. Although the model has been shown to be an improvement on the ISC model, especially short-term predictions, the range of uncertainty of the model predictions is -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: meteorological data, source data, and information on the nature of the receptor grid. Each of these data types will be described below.

7.1.1.1 *Meteorological Requirements*

AERMOD requires two specific input files generated by the AERMET pre-processor. Meteorological data for the closest South African Weather Service Station (SAWS), the Emalahleni station, for the period January 2016 to December 2018 was selected for use in the simulations (the Dispersion Modelling Guidelines require that if the meteorological station is located off-site, 3 years of meteorological data no older than 5 years be used for dispersion modelling simulations). This station is located to the north of Ackerville in Emalahleni, approximately 12.3km east-northeast of the project location.

7.1.1.2 *Topographical Data*

The topography of the modelling domain around the operations is generally flat with an average slope of less than 10% (Figure 4). The AERMOD Implementation Guide recommends that slopes less than 10% terrain be excluded from the dispersion model (US-EPA, 2009). On this basis, the flat terrain option was used in the AERMOD model during the model runs.

7.1.1.3 *Receptor Grid*

Based on the expected spatial extent of impact from the Zero-Waste Recovery Plant, the dispersion of pollutants was modelled for an area covering 5 km (north-south) by 5 km (east-west) with the Zero-Waste Recovery Plant at the centre. This area was divided into a grid with a resolution of 50 m (north-south) by 50 m (east-west). AERMOD simulates ground-level concentrations for each of the receptor grid points.

7.1.1.4 *Emission Quantification*

The AERMOD model is able to model point, line, area and volume sources. All identified point source and fugitive emissions as described in Section 6 were included in the dispersion modelling simulations. Fugitive sources were modelled as area and line sources.

The pollutants of concern from the plant that were modelled are the three criteria pollutants for which there are Subcategory 4.20 Minimum Emission Standards (Table 19) namely particulates (PM_{10} and $PM_{2.5}$), oxides of nitrogen (NO_2) and sulfur dioxide (SO_2). In the absence of local emission factors, fugitive emissions were estimated from material throughput rates using internationally published emission factor from sources such as the US EPA AP42 or the Australian NPI.

7.1.1.5 *Cumulative Assessment*

Cumulative impacts from the Highveld Steel Zero-Waste Recovery Plant were assessed by adding modelled impacts from the operations to baseline pollutant concentrations (Table 21).

7.1.2 Legal Requirements

7.1.2.1 *Atmospheric Impact Report*

According to the National Environmental Management (NEM) Air Quality Act (AQA), an Air Quality Officer (AQO) may require the submission of an Atmospheric Impact Report (AIR) in terms of section 30, if:

- The AQO reasonably suspects that a person has contravened or failed to comply with the AQA or any conditions of an AEL and that detrimental effects on the environment occurred, or there was a contribution to the degradation in ambient air quality.
- A review of a provisional AEL or an AEL is undertaken in terms of section 45 of the AQA.

The format of the Atmospheric Impact Report is stipulated in the Regulations Prescribing the Format of the Atmospheric Impact Report, Government Gazette No. 36904, Notice Number 747 of 2013 (11 October 2013).

7.1.2.2 *National Ambient Air Quality Standards*

The National Framework provided a stepped approach in setting ambient air quality standards. Based on this the standard for a specific pollutant must include limit values for specific exposures, the number of allowed exceedances and a timetable for compliance. The limit values (concentrations) are based on scientific evidence. National Ambient Air Quality Standards (NAAQS) were determined based on international best practice for particulate matter less than 10 and 2.5 µm in aerodynamic diameter (PM_{10} and $PM_{2.5}$), dust fall, SO_2, NO_2, ozone (O_3), CO, lead and benzene. These standards were published for comment in the Government Gazette on 9 June 2007 with the new standards, which include frequency of exceedance and implementation timeframes, published on the 24th of December 2009 (Government Gazette 32816). $PM_{2.5}$ standards were gazetted and passed in June 2012 (*Government Gazette 35463*).

Based on the minimum emission standards for slag processing (Section 7.1.2.4), the main criteria pollutants of concern for this study are NO_2, SO_2, CO, PM_{10} and $PM_{2.5}$, all of which have South African standards, which are listed in Table 17. The 2016 to 2029 standards will be used to evaluate the impact of $PM_{2.5}$.

Table 17: National ambient air quality standards for PM_{10}, $PM_{2.5}$, NO_2, CO and SO_2

Pollutant	Averaging Period	Limit Value (µg/m³)	Frequency of Exceedance
PM_{10}	24 hours	75	4
	1 year	40	0
$PM_{2.5}$	24 hours	40	4
	1 year	20	0
NO_2	1 hour	200	88
	1 year	40	0
CO	1 hour	30 000	88
	8 hours (calculated on	10 000	11
SO_2	1 hour	350	88
	24 hours	125	4
	1 year	50	0

7.1.2.3 *National Dust Control Regulations*

South Africa's National Dust Control Regulations (NDCR) were published on 1 November 2013 (Government Gazette No 36974). The purpose of the regulations is to prescribe general measures for the control of dust in all areas, including residential and light commercial areas. Acceptable dust fallout rates according to the regulations are summarised in Table 18.

Table 18: Acceptable dust fallout rates

Restriction areas	Dust fallout rate (D) in mg/m²-day over a 30 day average	Permitted frequency of exceedance
Residential areas	D < 600	Two within a year, not sequential months.
Non-residential areas	600 < D < 1 200	Two within a year, not sequential months.

Simulated dust fallout rates will be assessed against the non-residential standard for the immediate area surrounding the operations and against the residential standard at the closest sensitive receptor locations. The regulations also specify that the method to be used for measuring dust fallout and the guideline for locating sampling points shall be ASTM D1739 (1970), or equivalent method approved by any internationally recognized body. **It is important to note that dust fallout is assessed for nuisance impact and not inhalation health impact**.

Revised Draft National Dust Control Regulations were published on 25 March 2018 (Government Gazette No. 41650) which references the same acceptable dust fallout rates but refers to the latest version of the ASTM D1739 method to be used for sampling.

7.1.2.4 *Listed Activities and Minimum Emission Standards*

In 2010 the Department of Environmental Affairs (now the Department of Environment, Forestry and Fisheries - DEFF) published, under Section 21 of the National Environmental Management: Air Quality Act (NEM:AQA), a List of Activities which result in Atmospheric Emissions which have, or may have, a significant detrimental effect on the environment, including health, social conditions, economic conditions, ecological conditions or cultural heritage (Government Gazette No 33064). Amendments to Section 21 of the Act were published in 2013 (Government Gazette No 37054), 2015 (Government Gazette No 38863), 2018 (Government Gazette No 42013) and 2020 (Government Gazette No 43174).

Under Section 21 of NEM:AQA any permanent or experimental plant with a design capacity equal to or greater than the threshold for the listed activity needs to comply with the Minimum Emission Standards for that activity.

Under Section 22 of NEM:AQA no person may without a Provisional Atmospheric Emissions Licence (PAEL) or Atmospheric Emissions Licence (AEL) conduct a listed activity.

The processing or recovery of metallurgical slag is a listed activity as per Subcategory 4.20 of Section 21 of the National Environmental Management: Air Quality Act (NEM:AQA) (Act no 39 of 2004) and will require an Atmospheric Emissions Licence (AEL) to operate. The plant will be required to comply with the New Plant Minimum Emission Standards (MES) for Subcategory 4.20 as described in Table 19.

Table 19: Listed Activity Subcategory 4.20: Slag Processes

Category 4.20	**Slag Processes**	
Description:	The processing or recovery of metallurgical slag by the application of heat	
Application:	All installations	
Substance or Mixture of Substances		**New Plant emission limits: mg/Nm³ under normal conditions of 273 Kelvin and 101.3 kPa**
Common Name	**Chemical Symbol**	
Particulate Matter	PM	50
Oxides of nitrogen	NO_x expressed as NO_2	350
Sulfur dioxide	SO_2	1500

7.1.3 Highveld Priority Area

The Highveld airshed was the second priority area declared by the minister. This required that an Air Quality Management Plan for the area be developed. The plan includes the establishment of emissions reduction strategies and intervention programmes based on the findings of a baseline characterisation of the area. The implication of this is that all contributing sources in the area will be assessed to determine the emission reduction targets to be achieved over the following few years.

The project area is located within the footprint demarcated as the Highveld Priority Area (HPA). The Department of Environmental Affairs (DEA – now DEFF) published the management plan for the Highveld Priority Area in September 2011. Included in this management plan are seven goals, each of which has a further list of objectives that have to be met. The goals for the Highveld Priority area are as follows:

- Goal 1: By 2015, organisational capacity in government is optimised to efficiently and effectively maintain, monitor and enforce compliance with ambient air quality standards.
- Goal 2: By 2020, industrial emissions are equitably reduced to achieve compliance with ambient air quality standards and dust fallout limit values.
- Goal 3: By 2020, air quality in all low-income settlements is in full compliance with ambient air quality standards.
- Goal 4: By 2020, all vehicles comply with the requirements of the National Vehicle Emission Strategy.
- Goal 5: By 2020, a measurable increase in awareness and knowledge of air quality exists.
- Goal 6: By 2020, biomass burning and agricultural emissions will be 30% less than current.
- Goal 7: By 2020, emissions from waste management are 40% less than current.

Goal 2 applies directly to the project, the objectives associated with this goal (as well as the activities applicable to industries for each objective) include:

- Emissions are quantified from all sources;
  - Establish and maintain a site emissions inventory that includes all point and diffuse sources for all significant pollutants.
  - Submit emissions inventory report as per emission reporting regulations.
- Gaseous and particulate emissions are reduced;
  - Submit AIR report using a regulated modelling approach.
  - Develop and implement a maintenance plan for each plant.
  - Schedule and conduct repairs to coincide with plant offline times.
  - Incorporate equipment changes into the maintenance schedule.
  - Operate plants with minimum disruption e.g. back-up plan for energy consumption/generation.
- Fugitive emissions are minimised;
  - Develop fugitive emission management plan.
  - Implement appropriate interventions, e.g. a leak detection and repair program.
- Emissions from dust generating activities are reduced;
  - Develop and implement dust reduction programmes in line with industry best practice, considering technology and management interventions.
  - Investigate feasibility of using alternative means for haulage, e.g. conveyors, rail.
  - Plan and carry out regular fleet maintenance.
  - Investigate opportunities to market waste as raw material inputs to other industries.
- Greenhouse gas emissions are reduced;

    - Include greenhouse gas emissions in site emissions inventory.
    - Develop and implement a site energy efficiency plan.
    - Consider climate change implications in air quality management (AQM) decision making.
    - Investigate opportunities for co-generation.
    - Investigate feasibility of renewable energy.
- Incidences of spontaneous combustion are reduced;
- Abatement technology is appropriate and operational;
    - Install and/or maintain appropriate air pollution abatement technology compliant with requirements of AEL and achieving Section 21 emission standards.
    - Train operators to ensure optimal operation of abatement equipment.
- Industrial AQM decision making is robust and well-informed, with necessary information available;
    - Establish sector information sharing fora.
    - Conduct international benchmarking within the sectors.
    - Make sector emission performance information available for company benchmarking.
- Clean technologies and processes are implemented;
    - Investigate feasibility of introducing clean technologies on plant-specific basis.
    - Implement feasible technology options on plant-specific basis.
    - Investigate possibility of switching to clean fuels at times of poor dispersion.
    - Investigate alternative design and process options to improve plume dispersion.
    - Implement feasible alternative design and process options.
- Adequate resources are available for AQM in industry;
    - Revise organograms to create air quality structure and designation, where needed.
    - Optimise environmental management resource availability to accommodate air quality function.
    - Fill AQM posts with appropriately skilled staff, where needed.
    - Input into financial planning to implement emission abatement and measurement requirements of AEL and Section 21 emission standards.
    - Investigate the possible use of offset programs to reduce financial investments.
- Ambient air quality standard and dust fallout limit value exceedances as a result of industrial emissions are assessed; and,
    - Conduct ambient air quality monitoring in accordance with AEL requirements.
    - Conduct dust fallout monitoring in accordance with legislative requirements, and consider advances in monitoring technology.
    - Report ambient monitoring results to relevant AQO and publish on SAAQIS.
    - Update AIR submissions.
- A line of communication exists between industry and communities.
    - Conduct quarterly consultative community meetings.

Goal 7 is also applicable since the project processes slag, and thereby reduces waste. Goal 7 was primarily focussed on landfilling activities and the informal burning of domestic waste, however, one objective and two activities are applicable to the project:

- Management of waste processing sites considers air pollutant and greenhouse gas emission reductions:

- Develop emission reduction plan for all process and fugitive sources.
- Implement emission reduction and maintenance plan for all emission sources resulting from waste management activities

Each of these objectives and activities has a timeframe, responsibility and indicator. Further details are available in the DEA (2012) Highveld Priority Management Plan.

7.1.4 Regulations Regarding Air Dispersion Modelling

Air dispersion modelling provides a cost-effective means for assessing the impact of air emission sources, the major focus of which is to determine compliance with the relevant ambient air quality standards. Regulations regarding Air Dispersion Modelling were promulgated in Government Gazette No. 37804 and recommend a suite of dispersion models to be applied for regulatory practices as well as guidance on modelling input requirements, protocols and procedures to be followed. The Regulations Regarding Air Dispersion Modelling are applicable:

(a) in the development of an air quality management plan, as contemplated in Chapter 3 of the AQA;
(b) in the development of a priority area air quality management plan, as contemplated in Section 19 of the AQA;
(c) in the development of an atmospheric impact report, as contemplated in Section 30 of the AQA; and,
(d) in the development of a specialist air quality impact assessment study, as contemplated in Chapter 5 of the AQA.

The Regulations have been applied to the development of this report. The first step in the dispersion modelling exercise requires a clear objective of the modelling exercise, and thereby gives clear direction to the choice of the dispersion model most suited for the purpose. Chapter 2 of the Regulations present the typical levels of assessments, technical summaries of the prescribed models (SCREEN3, AERSCREEN, AERMOD, SCIPUFF, and CALPUFF) and good practice steps to be taken for modelling applications.

Dispersion modelling provides a versatile means of assessing various emission options for the management of emissions from existing or proposed installations. Chapter 3 of the Regulations prescribe the source data input to be used in the models.

Dispersion modelling can typically be used in the:

- Apportionment of individual sources for installations with multiple sources. In this way, the individual contribution of each source to the maximum ambient predicted concentration can be determined. This may be extended to the study of cumulative impact assessments where modelling can be used to model numerous installations and to investigate the impact of individual installations and sources on the maximum ambient pollutant concentrations.
- Analysis of ground level concentration changes as a result of different release conditions (e.g. by changing stack heights, diameters and operating conditions such as exit gas velocity and temperatures).

- Assessment of variable emissions as a result of process variations, start-up, shut-down or abnormal operations.
- Specification and planning of ambient air monitoring programmes which, in addition to the location of sensitive receptors, are often based on the prediction of air quality hotspots.

The above options can be used to determine the most cost-effective strategy for compliance with the NAAQS. Dispersion models are particularly useful under circumstances where the maximum ambient concentration approaches the ambient air quality limit value. They also provide a means for establishing the preferred combination of mitigation measures that may be required, including:

- Stack height increases;
- Reduction in pollutant emissions through the use of air pollution control systems (APCS) or process variations;
- Switching from continuous to non-continuous process operations or from full to partial load.

Chapter 4 of the Regulations prescribe meteorological data input from onsite observations to simulated meteorological data. The chapter also gives information on how missing data and calm conditions are to be treated in modelling applications. Meteorology is fundamental for the dispersion of pollutants because it is the primary factor determining the diluting effect of the atmosphere. Therefore, it is important that meteorology is carefully considered when modelling.

New generation dispersion models, including models such as AERMOD and CALPUFF simulate the dispersion process using planetary boundary layer (PBL) scaling theory. PBL depth and the dispersion of pollutants within this layer are influenced by specific surface characteristics such as surface roughness, albedo and the availability of surface moisture:

- Roughness length (z_o) is a measure of the aerodynamic roughness of a surface and is related to the height, shape and density of the surface as well as the wind speed.
- Albedo is a measure of the reflectivity of the Earth’s surface. This parameter provides a measure of the amount of incident solar radiation that is absorbed by the Earth/atmosphere system. It is an important parameter since absorbed solar radiation is one of the driving forces for local, regional, and global atmospheric dynamics.
- The Bowen ratio provides measures of the availability of surface moisture injected into the atmosphere and is defined as the ratio of the vertical flux of sensible heat to latent heat, where sensible heat is the transfer of heat from the surface to the atmosphere via convection, and latent heat is the transfer of heat required to evaporate liquid water from the surface to the atmosphere.

Topography is also an important geophysical parameter. The presence of terrain can lead to significantly higher ambient concentrations than would occur in the absence of the terrain feature. In particular, where there is a significant relative difference in elevation between the source and off-site receptors large ground level concentrations can result. Thus, the accurate determination of terrain elevations in air dispersion models is very important.

The modelling domain would normally be decided on the expected zone of influence; the latter extent being defined by the predicted ground level concentrations from initial model runs. The modelling domain must include all areas where the ground level concentration is significant when compared to the air quality limit value (or other guideline). Air dispersion models require a receptor grid at which ground-level concentrations can be calculated. The receptor grid size should include the entire modelling domain to ensure that the maximum ground-level concentration is captured and the grid resolution (distance between grid points) sufficiently small to ensure that areas of maximum impact are adequately covered. No receptors however should be located within the property line as health and safety legislation (rather than ambient air quality standards) is applicable within the site.

Chapter 5 of the regulations provides general guidance on geophysical data, model domain and coordinates system required in dispersion modelling, whereas Chapter 6 elaborates more on these parameters as well as the inclusion of background air concentration data. The chapter also provides guidance on the treatment of NO_2 formation from NO_x emissions, chemical transformation of sulfur dioxide into sulfates and deposition processes.

Chapter 7 of the Regulations outline how the plan of study and modelling assessment reports are to be presented to authorities.

7.1.5 Dispersion Potential

Meteorological mechanisms govern the dispersion, transformation, and eventual removal of pollutants from the atmosphere. The analysis of hourly average meteorological data is necessary to facilitate a comprehensive understanding of the dispersion potential of the site. The horizontal dispersion of pollution is largely a function of the wind field. The wind speed determines both the distance of downward transport and the rate of dilution of pollutants.

The South African Weather Services (SAWS) operates a meteorological station in Emalahleni. For this assessment data for the period January 2016 to December 2018 was evaluated. Parameters useful in describing the dispersion and dilution potential of the site, i.e. wind speed, wind direction, temperature and atmospheric stability, are subsequently discussed.

7.1.5.1 *Surface 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 >6 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 indicated.

The Emalahleni period wind roses (Figure 9) depict the predominance of the northerly, easterly and east-south-easterly winds with wind speeds of greater than 5 m/s, especially during the day. Winds from the north-westerly sector winds are also predominant during the day, albeit at slightly lower overall wind speed. The night-time wind rose shows a decrease in the northerly and the north-westerly winds and an increase in the easterly and east-south-easterly winds. The night-time is also characterised by an increase in the frequency of calm wind conditions.

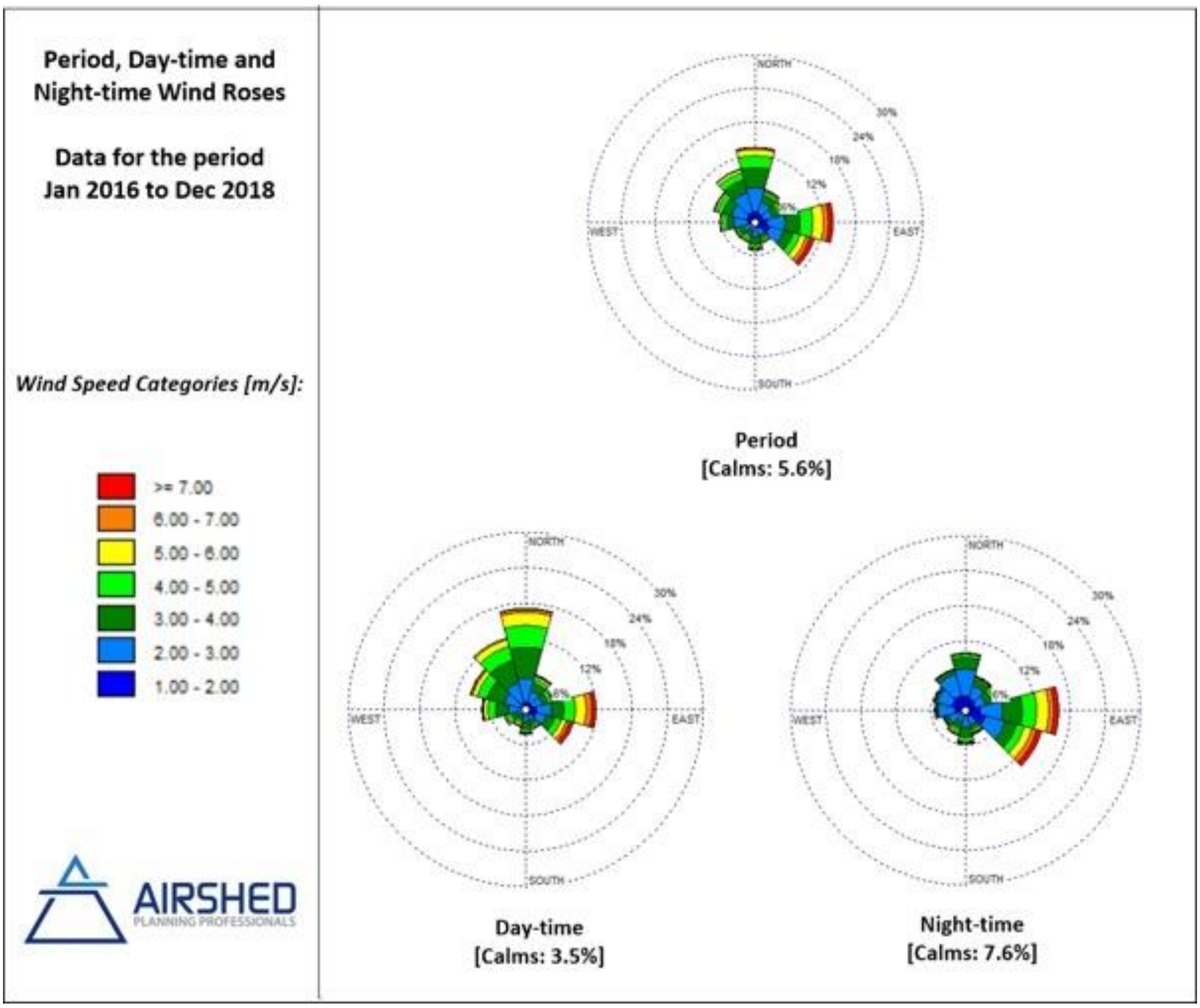

Figure 9: Period, day- and night-time wind rose for Emalahleni for the period 2016 – 2018

7.1.5.2 *Temperature*

Air temperature is important, both for determining the effect of plume buoyancy (the larger the temperature difference between the emission plume and the ambient air, the higher the plume can rise), and determining the development of the mixing and inversion layers.

The average monthly temperature trends are presented in Figure 10. Monthly mean and hourly maximum and minimum temperatures are given in Table 20. Average temperatures ranged between 11.3°C and 20.7°C. The highest temperatures occurred in January and the lowest in June/July. During the day, temperatures increase to reach maximum at around 15:00 in the afternoon. Ambient air temperature decreases to reach a minimum at around 05:00 i.e. just before sunrise.

Table 20: Monthly temperature summary (2016 - 2018)

Hourly Minimum, Hourly Maximum and Monthly Average Temperatures (°C)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	9.1	11.5	7.8	5.3	2.4	0.2	-2.1	0.2	0.4	4.1	5	11.1
Maximum	35.8	33.5	31.2	30.1	24.5	23.9	23.3	28	33.1	33.6	3.4	34
Average	20.5	20.4	19.3	17.2	13.6	11.8	11.3	14.2	18.2	18.4	19.2	20.7

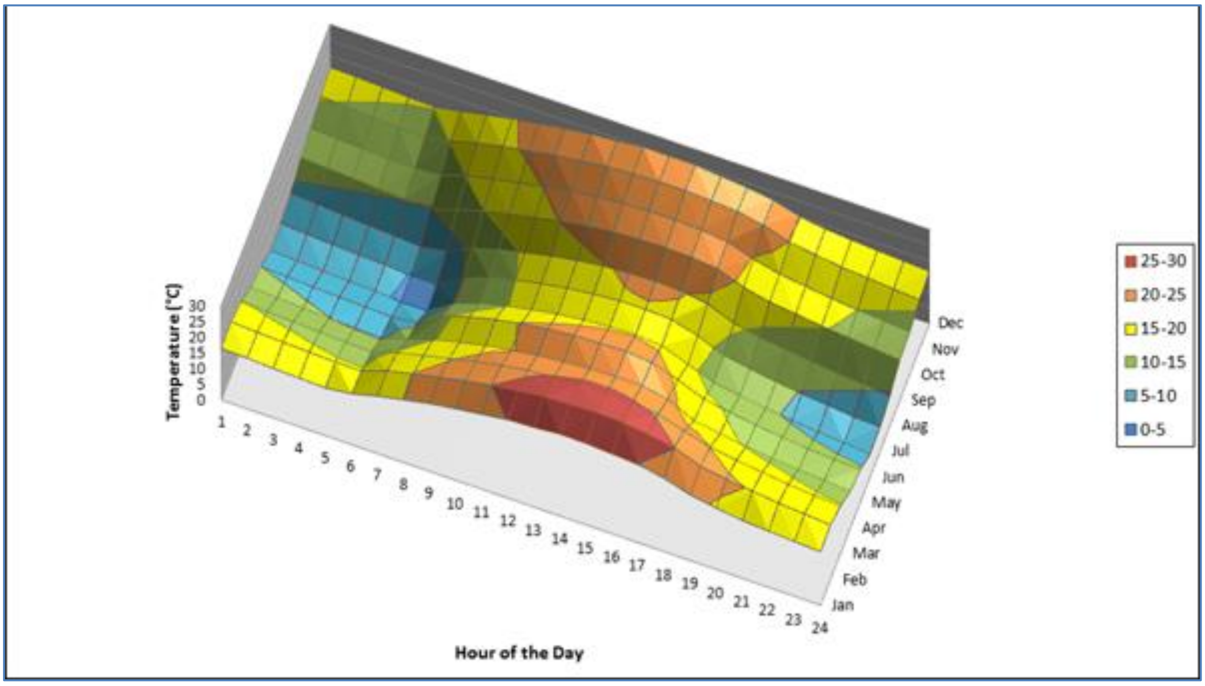

Figure 10: Monthly average temperature profile for SAWS Emalahleni

7.1.6 Health Impacts of Pollutants of Concern for this Study

7.1.6.1 *Effects of Suspended Particulates on Human Health*

The World Health Organization states that the evidence on airborne particulates and public health is consistent in showing adverse health effects at exposures experienced by urban populations throughout the world. The range of effects is broad, affecting the respiratory and cardiovascular systems and extending to children and adults and to a number of large, susceptible groups within a general population. The epidemiological evidence shows adverse effects of particles after both short-term and long-term exposures. However, current scientific evidence indicates that guidelines cannot be proposed that will lead to complete protection against adverse health effects as thresholds have not been identified.

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 (PM_{10} and $PM_{2.5}$) 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).

The Agency for Toxic Substances and Disease Registry states that particulate matter causes a wide variety of health and environmental impacts. Many scientific studies have linked breathing particulate matter to a series of significant health problems, including:

- aggravated asthma
- increases in respiratory symptoms like coughing and difficult or painful breathing
- chronic bronchitis
- decreased lung function
- premature death

7.1.6.1 *Effects of NO_2 on Human Health*

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. Exposure to high concentrations of NO_2 can lead to pulmonary oedema and pneumonitis (Reprotext, 1999). Subjects reported slight to moderate nasal irritation at 13 ppm (21.7 mg/m³) (Meyers and Hine, 1961).

The Californian Office of Environmental Health Hazard Assessments (OEHHA) has published an reference concentration (RfC) of 470 µg/m³ for NO_2.

Hine *et al*. (1970) found that NO_2 concentrations upward of 40 ppm (72 mg/m³) resulted in signs of toxicity (eye irritation, lacrimation and laboured breathing) in various animals (mice, rats, guinea pigs, rabbits and dogs). Below concentrations of 20 ppm (36 mg/m³) signs of irritation were minimal and no effects on behaviour were noted.

7.1.6.2 *Effects of SO_2 on Human Health*

Exposure to sulfur 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, sulfur dioxide is more likely to be adsorbed in the upper airways rather than penetrate to the pulmonary region. Horstman *et al.* (1986) reported increased airway resistance in asthmatics at exposures to concentrations of 0.5 ppm (0.66 mg/m³). Bedi *et al.* (1986) reported no adverse effects on fourteen healthy non-smokers exposed to 2 ppm for 30-minutes, and concluded that lack of changes in pulmonary function test indicated that 2 ppm did not adversely affect normal subjects.

Short-period exposures (less than 24 hours): Most information on the acute effects of SO_2 comes from controlled chamber experiments on volunteers exposed to SO_2 for periods ranging from a few minutes up to one hour (WHO, 2000). Acute responses occur within the first few minutes after commencement of inhalation. Further exposure does not increase effects. Effects include reductions in the mean forced expiratory volume over one second (FEV1), increases in specific airway resistance, and symptoms such as wheezing or shortness of breath. These effects are enhanced by exercise that increases the volume of air inspired, as it allows SO_2 to penetrate further into the respiratory tract. A wide range of sensitivity has been demonstrated, both among normal subjects and among those with asthma. People with asthma are the most sensitive group in the community. Continuous exposure-response relationships, without any clearly defined threshold, are evident.

Sub-chronic exposure over a 24-hour period: Information on the effects of exposure averaged over a 24-hour period is derived mainly from epidemiological studies in which the effects of SO_2, suspended particulate matter and other associated pollutants are considered. Exacerbation of symptoms among panels of selected sensitive patients seems to arise in a consistent manner when the concentration of SO_2 exceeds 250 μg/m³ in the presence of suspended particulate matter. Several more subsequent studies in Europe have involved mixed industrial and vehicular emissions now common in ambient air. At low levels of exposure (mean annual levels below 50 μg/m³; daily levels usually not exceeding 125 μg/m³) effects on mortality (total, cardiovascular and respiratory) and on hospital emergency admissions for total respiratory causes and chronic obstructive pulmonary disease (COPD), have been consistently demonstrated. These results have been shown, in some instances, to persist when black smoke and suspended particulate matter levels were controlled for, while in others no attempts have been made to separate the pollutant effects. In these studies no obvious threshold levels for SO_2 has been identified.

Long-term exposure: Earlier assessments, using data from the coal-burning in Europe judged the lowest-observed-adverse-effect level of SO_2 to be at an annual average of 100 μg/m³, when present with suspended particulate matter. More recent studies related to industrial sources of SO_2, or to the changed urban mixture of air pollutants, have shown adverse effects below this level. There is, however, some difficulty in finding this value. Dose-response coefficients for SO_2 used by the UK Department of Environment, Transport and the Regions in a recent study were given as follows (Stedman *et al.*, 1999):

Health Outcome:	**Dose-Response Coefficient:**
Deaths brought forward (all causes)	+0.6% per 10 µg/m³ (24 hour mean)
Respiratory hospital admissions	+0.5% per 10 µg/m³ (24 hour mean)

California has published a 660 µg/m³ RfC for SO_2, for a one-hour exposure, but states that co-exposure to other irritants such as sulfuric acid, nitrogen dioxide and ozone may potentiate the irritant effect of SO_2 on pulmonary function in asthmatics (OEHHA, 2007).

7.1.7 Baseline Air Quality Monitoring data

A summary of ambient data measured at the SAWS managed Emalahleni station (located approximately 12.3 km northeast of the proposed project location) for the period 2020 is provided in Table 21 (with exceedances of the NAAQS shown in red). These measured concentrations will be used together with simulated concentrations to estimate cumulative impacts.

Table 21: Summary of the ambient measurements at Emalahleni for 2020 (units: µg/m³)

Period	Availability	Maximum	Annual Average	No of recorded hourly exceedances
Hourly Concentrations				
NO_2				
2020	64%	122.7	23.2	0-
SO_2				
2020	95%	730.3	34.6	38
Daily Concentrations				
SO_2				
2020	100%	166.2	34.6	9
PM_{10}				
2020	37%	199.5	52.1	28
$PM_{2.5}$				
2020	48%	103.5	23.7	28

Note: Exceedances of the NAAQS are provided in red.

During 2020, the hourly 99th percentiles for SO_2 and NO_2 were below the limit values of 350 µg/m³ and 2020 µg/m³ respectively, but daily SO_2 concentrations exceeded the limit value of 125 µg/m³ on 9 occasions, while only 4 exceedances are allowed by the NAAQS.

The daily 99th percentiles for PM_{10} during 2020 exceeded the limit value (75 µg/m³). The daily 99th percentiles for $PM_{2.5}$ exceeded also the limit value (40 µg/m³). While the SO_2 and NO_2 annual averages were below the NAAQS, the PM_{10} and $PM_{2.5}$ annual averages exceeded the limit value of 40 µg/m³ and 20 µg/m³ respectively for 2020 at the SAWS Emalahleni monitoring station. Current baseline particulate concentrations already exceed the NAAQS, reference will therefore be made to the simulated percentage increase from baseline concentrations during the cumulative assessment.

Hourly time series for the measured pollutant concentrations are shown in

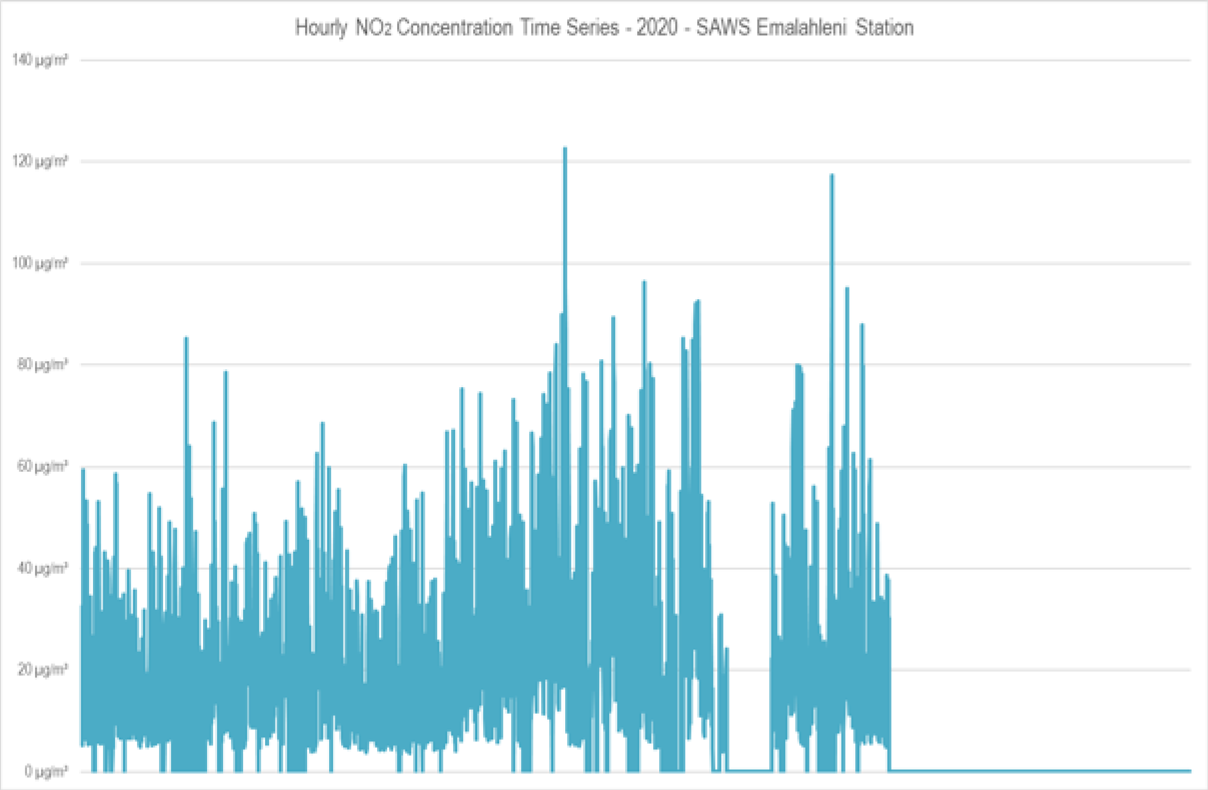

Figure 11: Time series – Hourly NO_2 concentrations – 2020 – SAWS Emalahleni Station

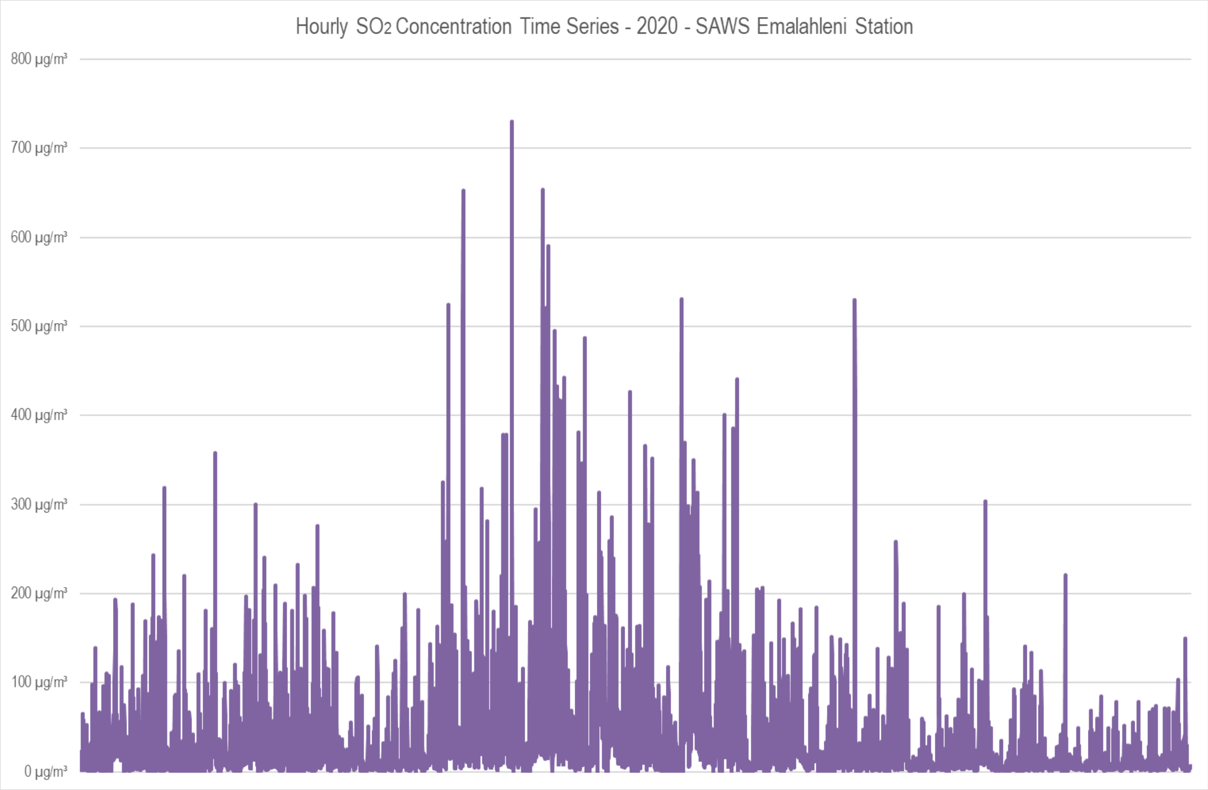

Figure 12: Time series – Hourly SO_2 concentrations – 2020 – SAWS Emalahleni Station

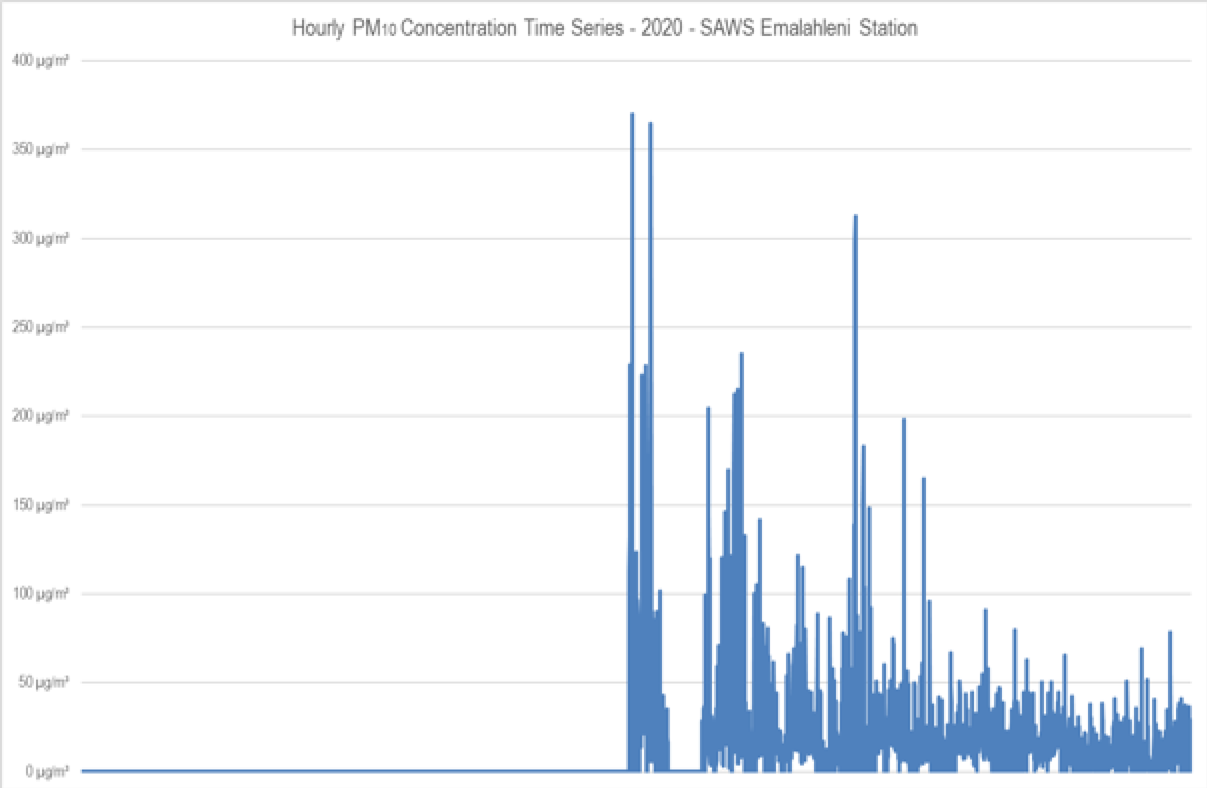

Figure 13: Time series – Hourly PM_{10} concentrations – 2020 – SAWS Emalahleni Station

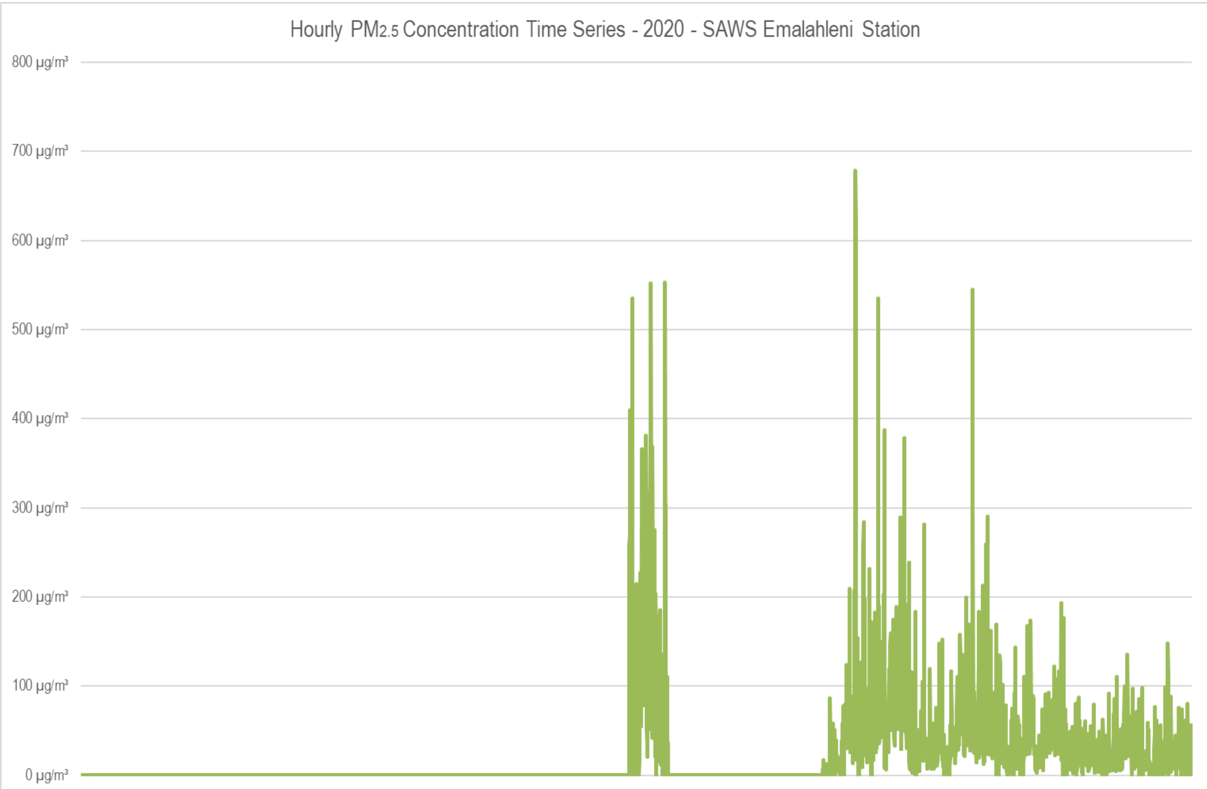

Figure 14: Time series – Hourly $PM_{2.5}$ concentrations – 2020 – SAWS Emalahleni Station

7.1.8 Assumptions and Limitations

- The quantification of sources of emission is restricted to the proposed Zero-Waste Recovery Plant. Although other sources were identified, such sources were not quantified.
- Expected routine emissions from the Zero-Waste Recovery Plant were simulated. Atmospheric releases occurring as a result of non-routine conditions were not included in the dispersion modelling.
- The Zero-Waste Recovery Plant is a proposed operation, and therefore all calculations and simulations were based on design information and layout plans.
- Point source emission concentrations, flow rates, temperatures and stack parameters were provided by the client. It is assumed that the plant is designed such that provided emission concentrations are achievable.
- Process fugitive emissions were based on material throughputs and internationally published emission factors.
- No on-site meteorological or air quality data was available. Use was made of meteorological and ambient air quality data from the SAWS Emalahleni station (~10 km east of the project area).
- 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. Nevertheless, dispersion modelling is generally accepted as a necessary and valuable tool in air quality management.
- No site-specific particle size fraction data, moisture content or silt loading information was available, and use was made of information from similar processes.

7.1.9 Dispersion Modelling Results

Dispersion modelling simulations were undertaken to determine highest hourly, highest daily and annual average ground level concentrations of each of the pollutants considered for the operational phase (as per the emission rates in Section 6). Construction and post-closure impacts were qualitatively assessed in Section 11. Averaging periods were selected to facilitate the comparison of simulated pollutants to the SA NAAQS.

The dispersion modelling results are presented as isopleth plots that represent normal operating conditions as described in Section 6.

Ambient air quality criteria apply to areas where the Occupational Health and Safety regulations do not apply, which are generally outside the property or lease area. Ambient air quality criteria are therefore not occupational health indicators but applicable to areas where the general public has access. For this assessment the ambient criteria were assumed to be applicable for all areas outside the plant boundary.

A summary of the isopleth plots presented is given in Table 22.

Table 22: Summary of Isopleth Plots

Scenario	Pollutant	Averaging Period	SA NAAQS	Isopleth Plot / Notes
Incremental	PM_{10}	24 Hour	75 µg/m³	Figure 15
		1 Year	40 µg/m³	Figure 16
	$PM_{2.5}$	24 Hour	40 µg/m³	Figure 17
		1 Year	25 µg/m³	Figure 18
	SO_2	1 Hour	350 µg/m³	Figure 19
		24 Hour	125 µg/m³	Figure 20
		1 Year	50 µg/m³	Figure 21
	NO_2	1 Hour	200 µg/m³	Figure 22
		1 Year	40 µg/m³	Figure 23
	Dustfall	1 Month	600 / 1200 mg/m²/day	Figure 24
Cumulative	PM_{10}	24 Hour	75 µg/m³	Figure 25
		1 Year	40 µg/m³	Figure 26
	$PM_{2.5}$	24 Hour	40 µg/m³	Figure 27
		1 Year	25 µg/m³	Figure 28
	SO_2	1 Hour	350 µg/m³	Figure 29
		24 Hour	125 µg/m³	Figure 30
		1 Year	50 µg/m³	Figure 31
	NO_2	1 Hour	200 µg/m³	Figure 32
		1 Year	40 µg/m³	Figure 33

7.1.9.1 *Incremental Impacts*

Simulated incremental highest daily (Figure 15) and annual (Figure 16) PM_{10} concentrations could exceed the SA NAAQS in the immediate viciinity of the plant, dependent on the amount of dust generated by fugitive dust generating sources such as the crushing plant, the slag stockpile, the on-site unpaved roads and the projects area. Dust generated by the sources will be dependent on various factors, such as material moisture content, wind speed and direction, tipping heights, vehicle speeds, silt loading on unpaved roads as well as the effectiveness of implemented mitigation measures. These factors will be adressed in more detail in Section 9. Despite the abovementioned possible exceedances of the PM_{10} NAAQS in the immediate vicinity of the operations, simulated PM_{10} concentrations are well below (<10%) of the daily and annual NAAQS at all identified sensitive receptors.

If the plant is operated at the Subcategories 4.20 Minimum Emission Standards, simulated incremental daily (Figure 17) and annual (Figure 18) $PM_{2.5}$ concentrations, hourly (Figure 19), daily (Figure 20) and annual average (Figure 21) SO_2 concentrations as well as the hourly (Figure 22) and annual average (Figure 23) NO_2 concentrations are well below the SA NAAQS for all of these polutants and averaging periods for all areas outside the plant boundary, including at all sensitive receptor locations.

Simulated highest monthly dust fallout due to the Zero-Waste Recovery Plant sources is below the NDCR non-residential limit of 1200 mg/m²/day for all areas outside the plant boundary, and well below the NDCR residential limit at all identified sensitive receptor locations.

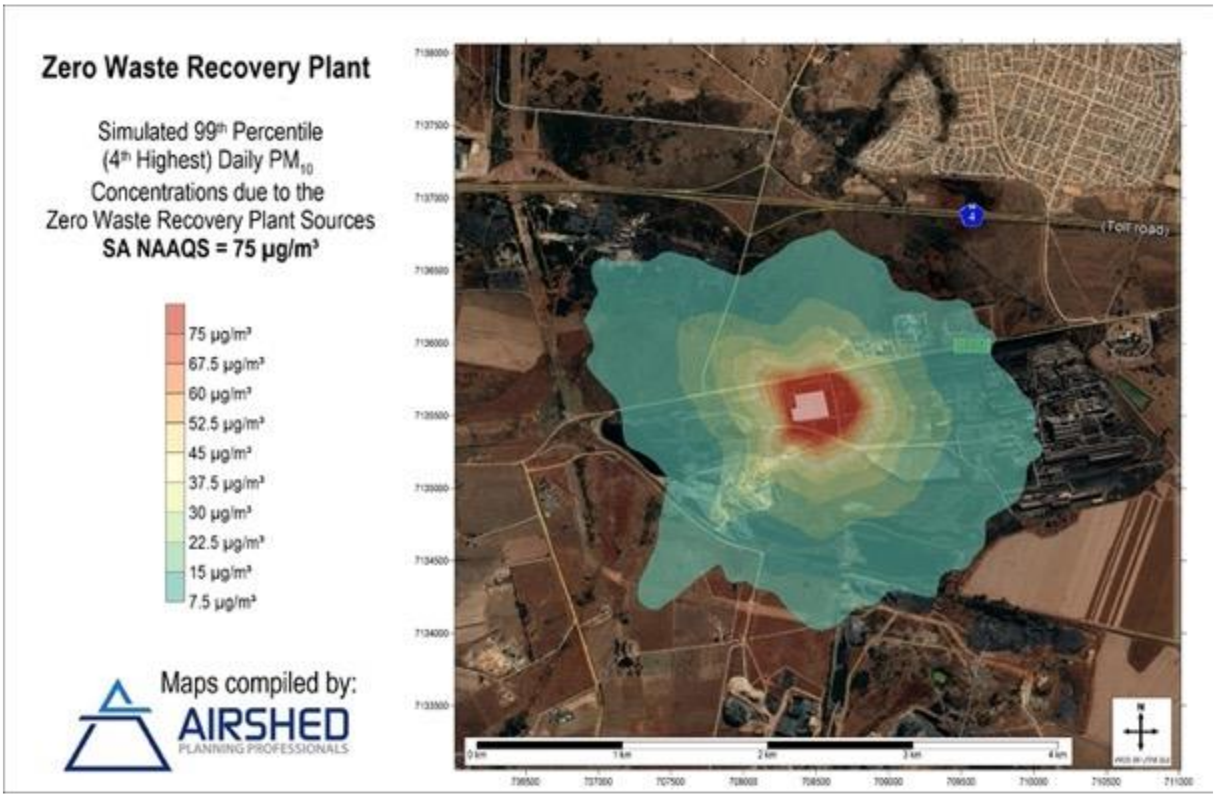

Figure 15: Simulated ground-level 99th Percentile Daily PM_{10} Concentrations – Incremental Impact of Zero-Waste Plant Sources Only

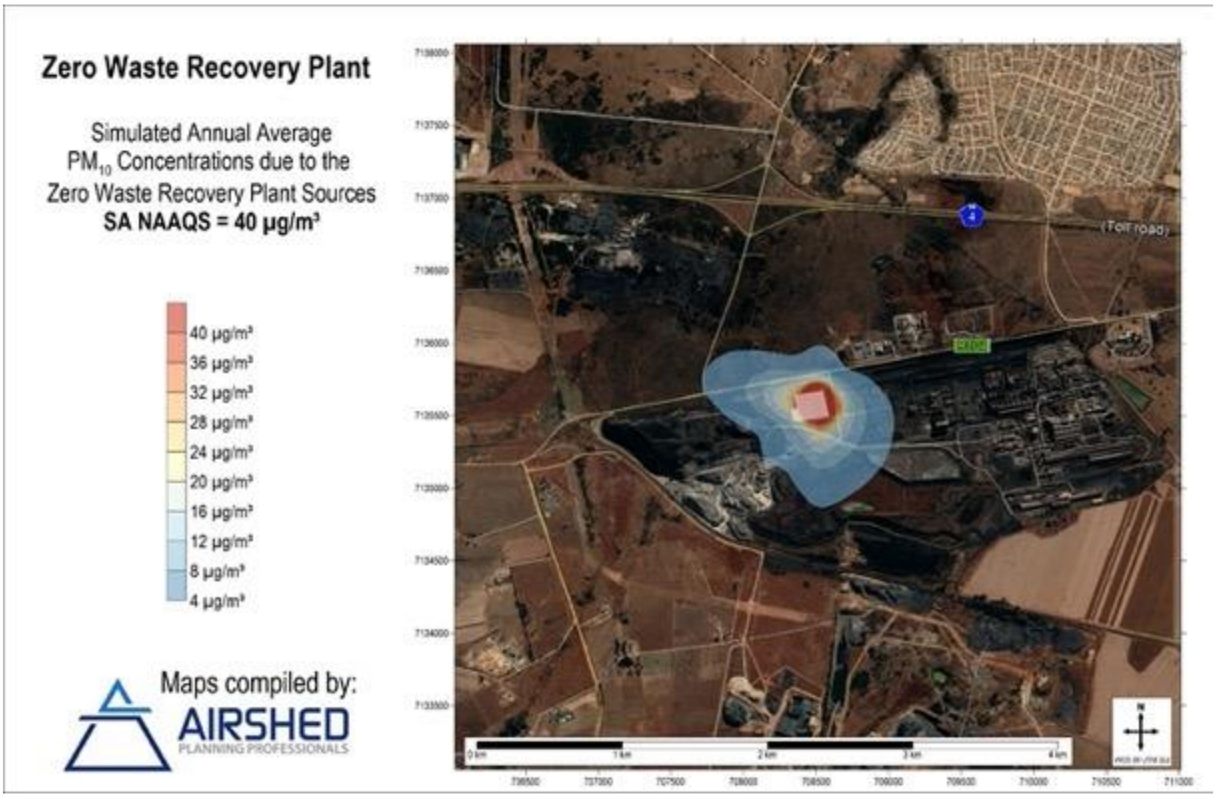

Figure 16: Simulated ground-level Annual Average PM_{10} Concentrations– Incremental Impact of Zero-Waste Plant Sources Only

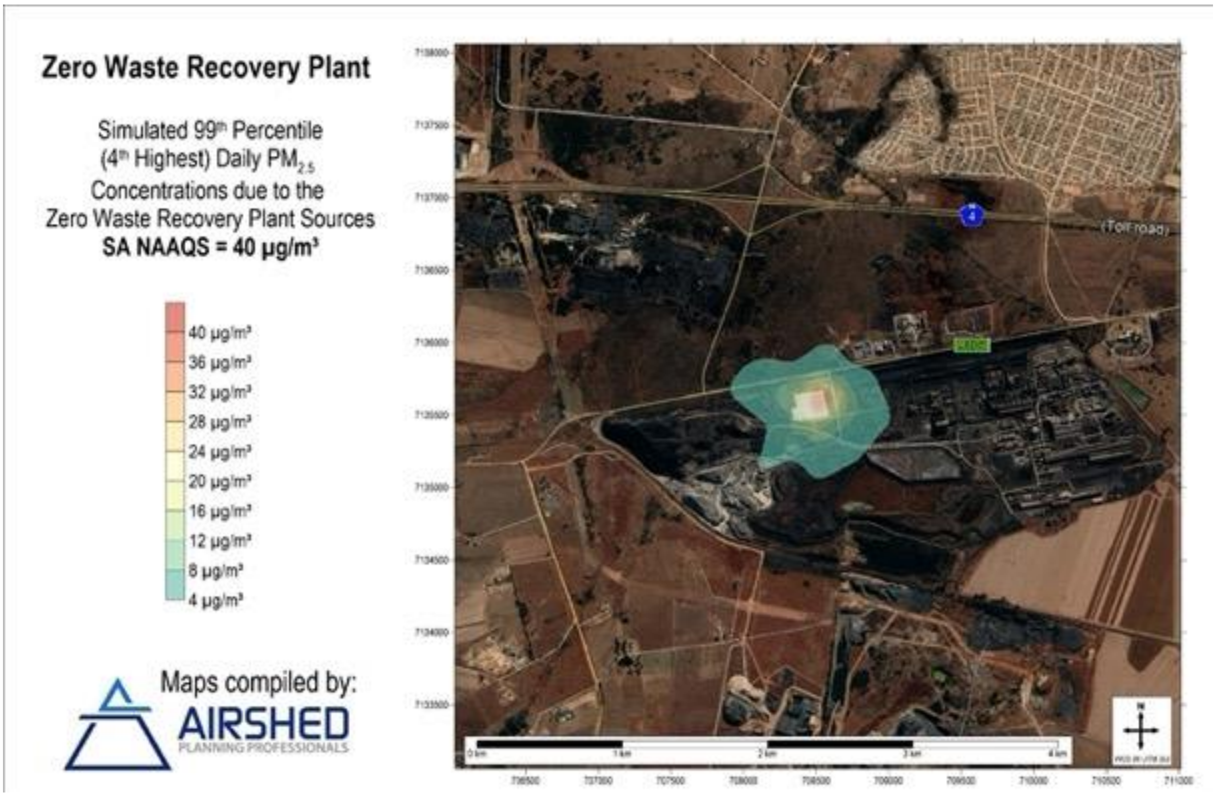

Figure 17: Simulated Ground-level 99th Percentile Daily $PM_{2.5}$ Concentrations – Incremental Impact of Zero-Waste Plant Sources Only

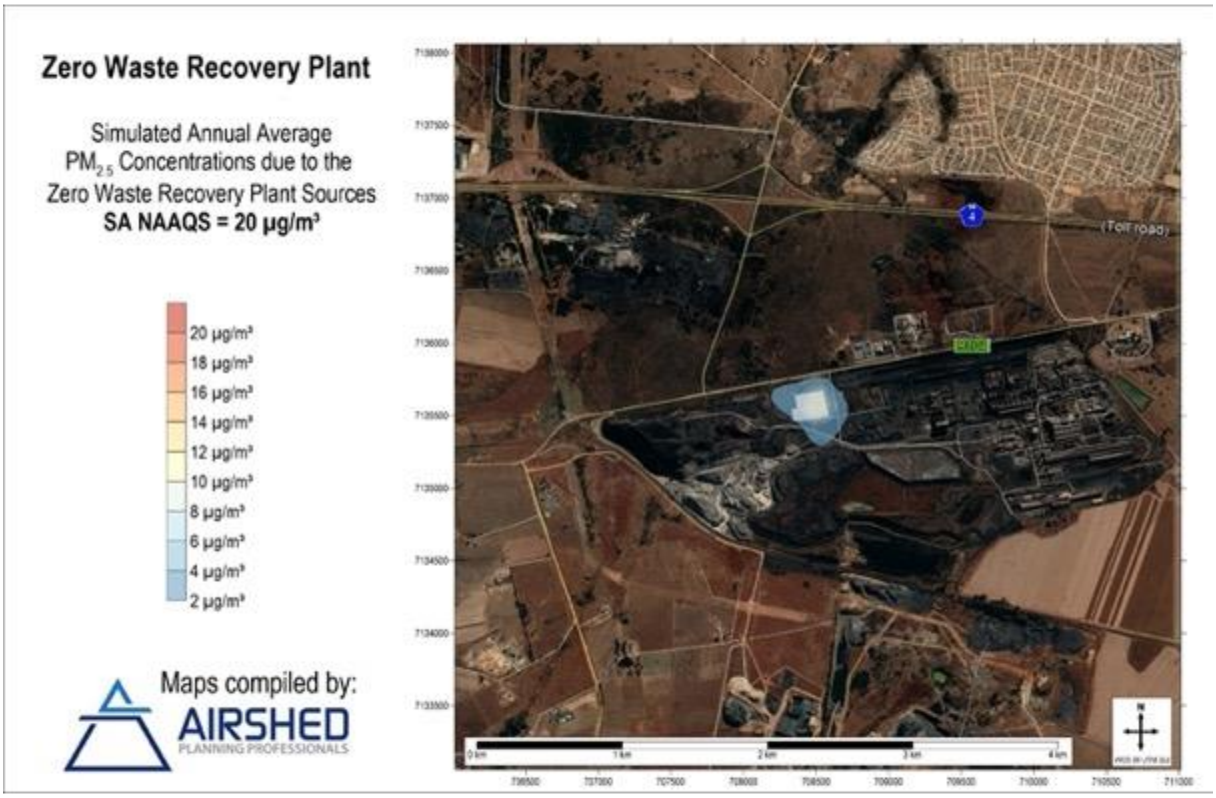

Figure 18: Simulated ground-level Annual Average $PM_{2.5}$ Concentrations– Incremental Impact of Zero-Waste Plant Sources Only

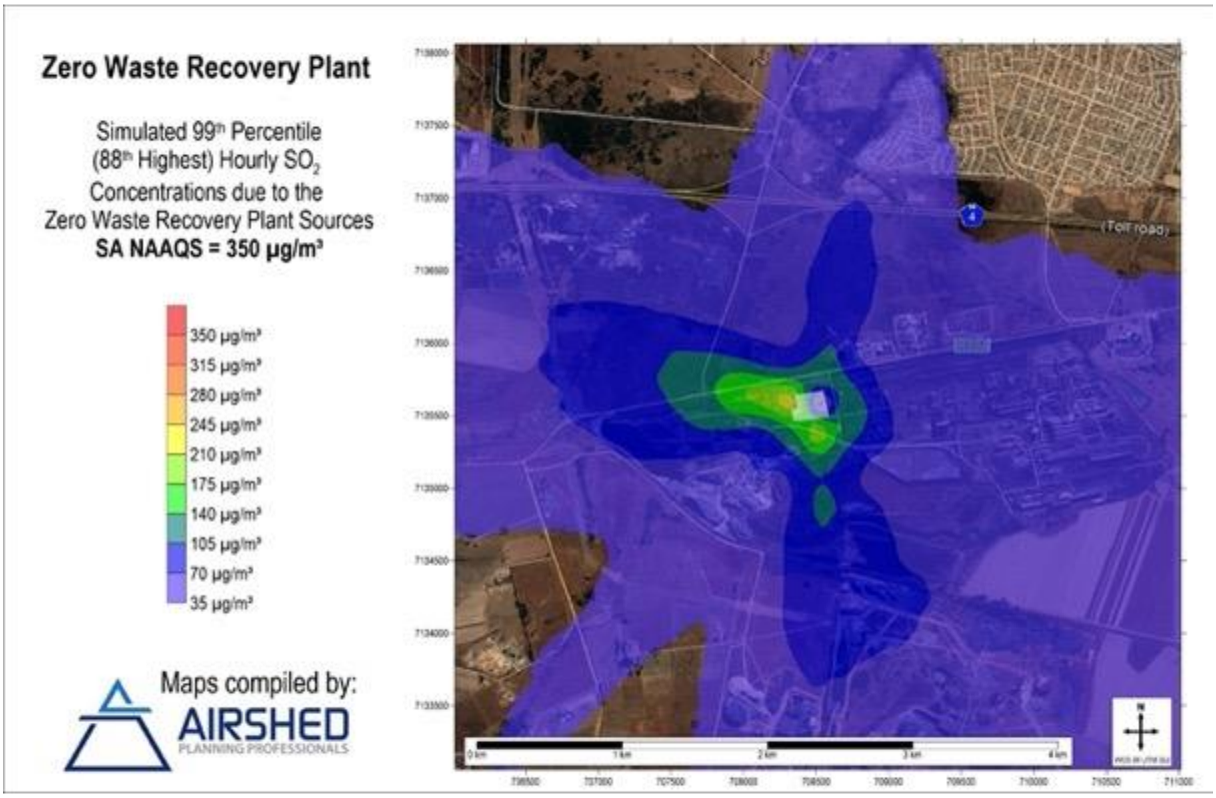

Figure 19: Simulated ground-level 99th Percentile Hourly SO_2 Concentrations – Incremental Impact of Zero-Waste Plant Sources Only

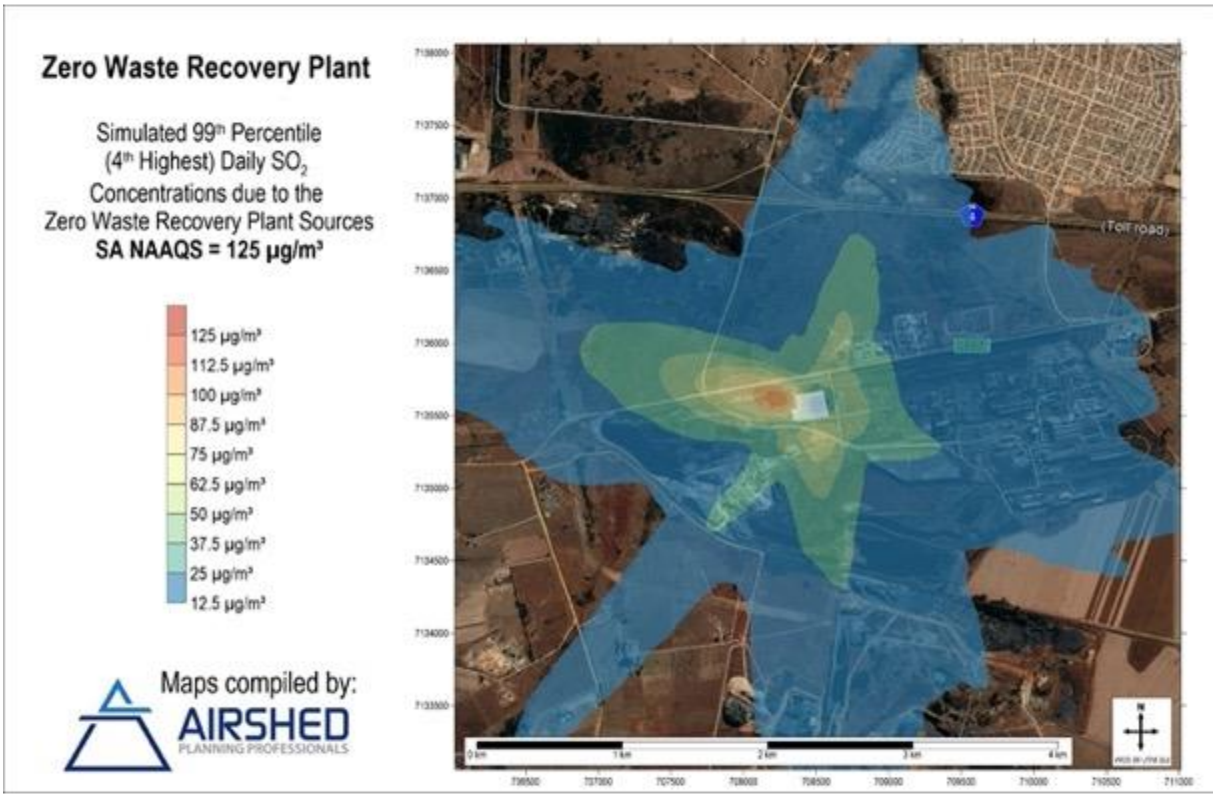

Figure 20: Simulated ground-level 99th Percentile Daily SO_2 Concentrations – Incremental Impact of Zero-Waste Plant Sources Only

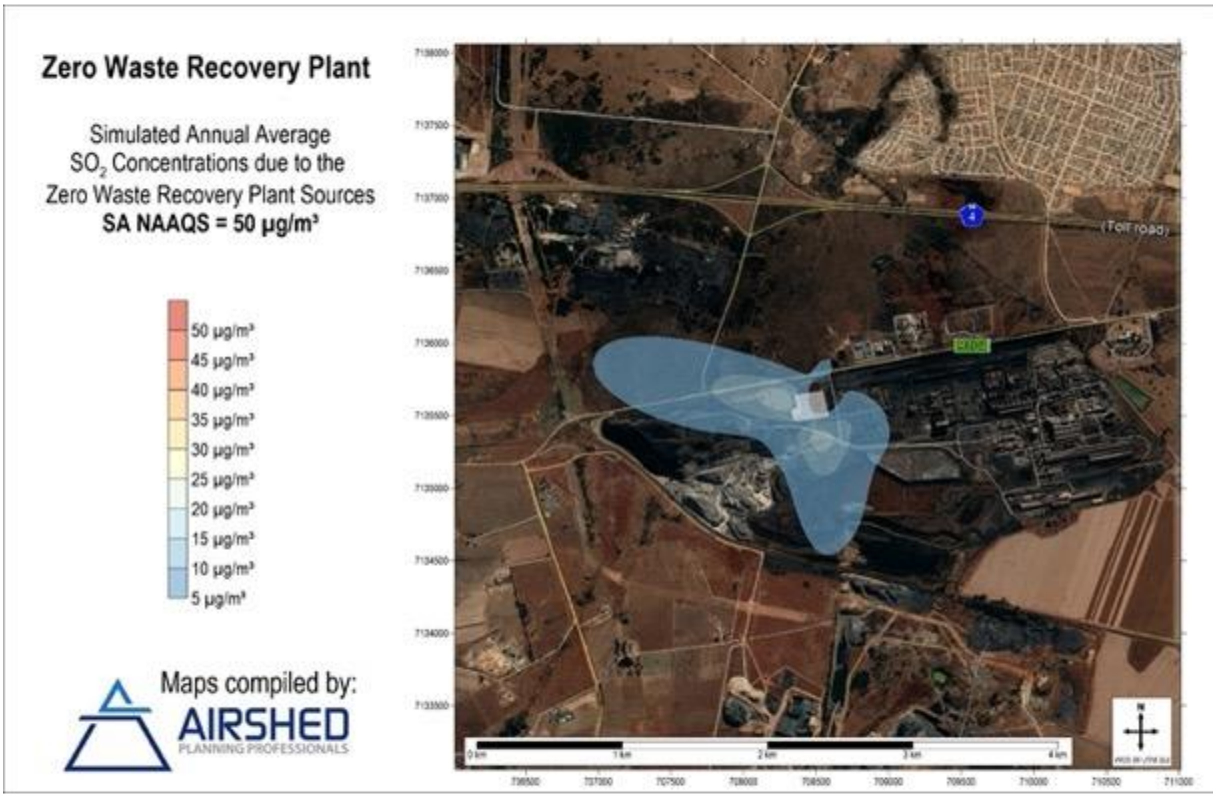

Figure 21: Simulated ground-level Annual Average SO_2 Concentrations – Incremental Impact of Zero-Waste Plant Sources Only

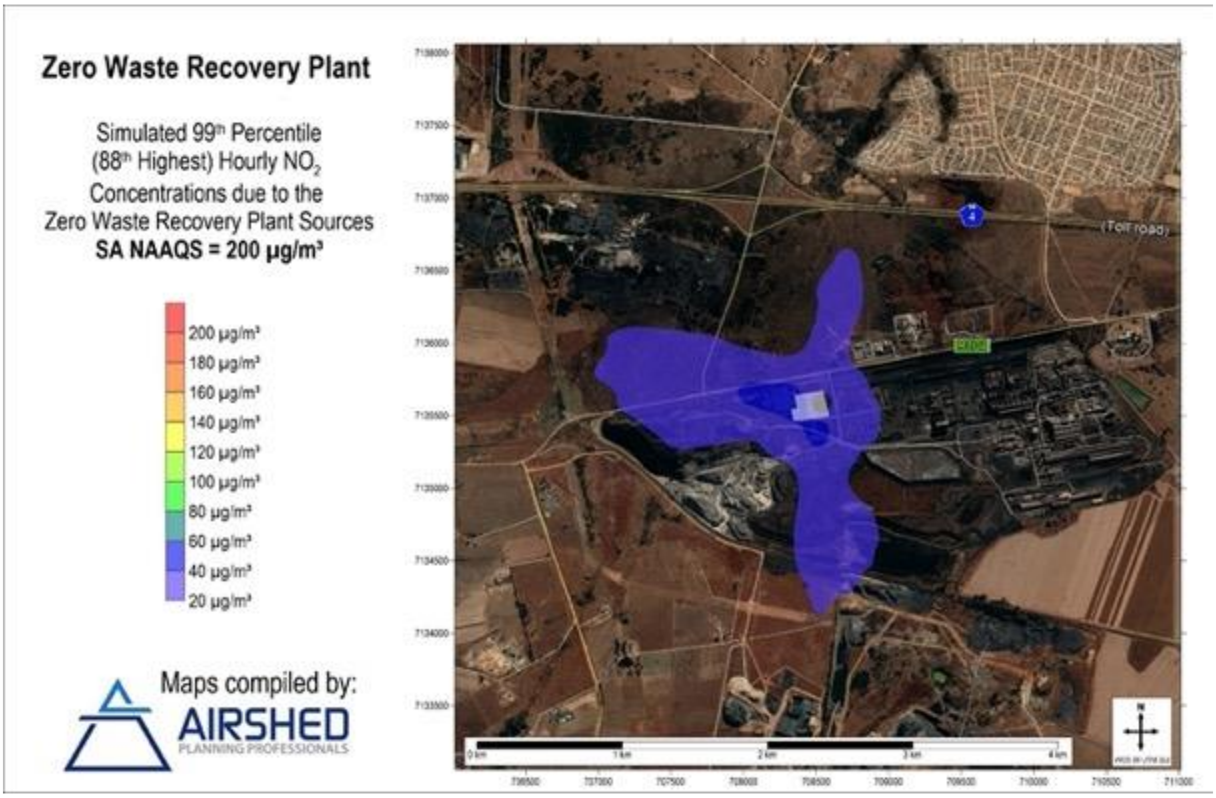

Figure 22: Simulated ground-level 99th Percentile Hourly NO_2 Concentrations – Incremental Impact of Zero-Waste Plant Sources Only

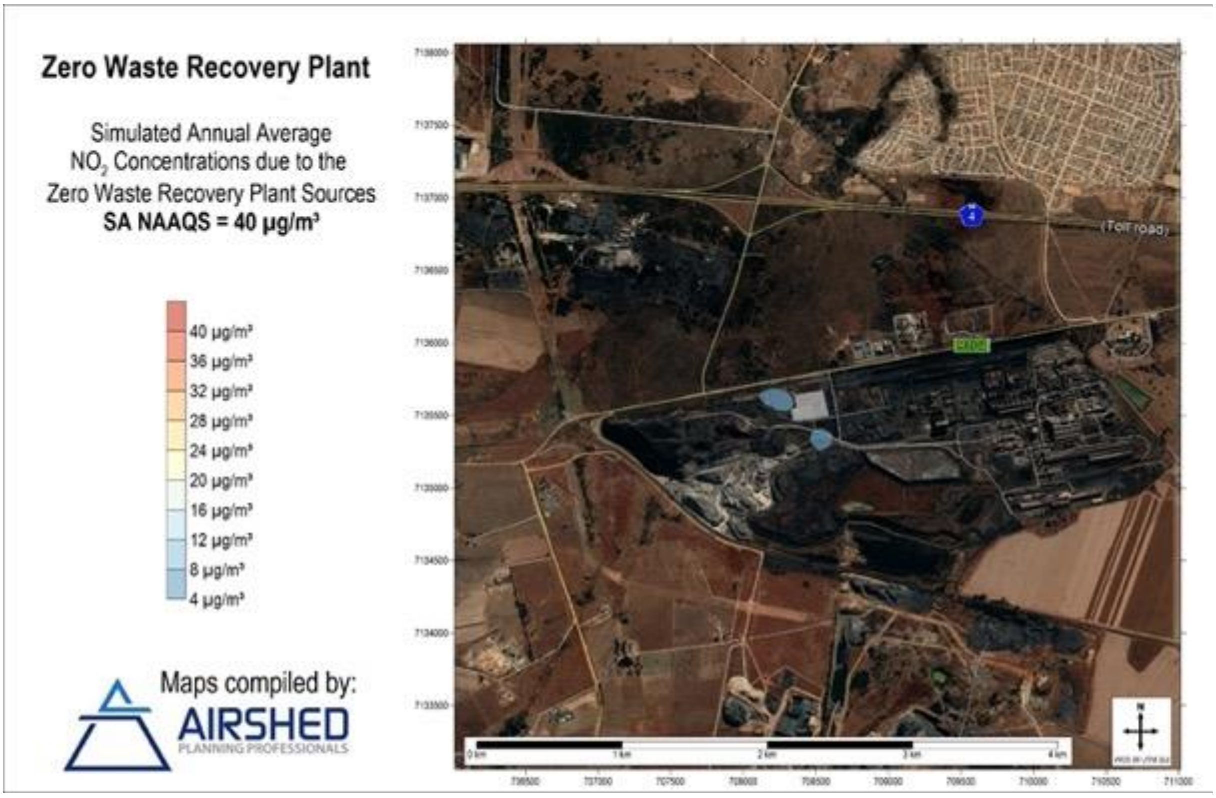

Figure 23: Simulated ground-level Annual Average NO_2 Concentrations – Incremental Impact of Zero-Waste Plant Sources Only

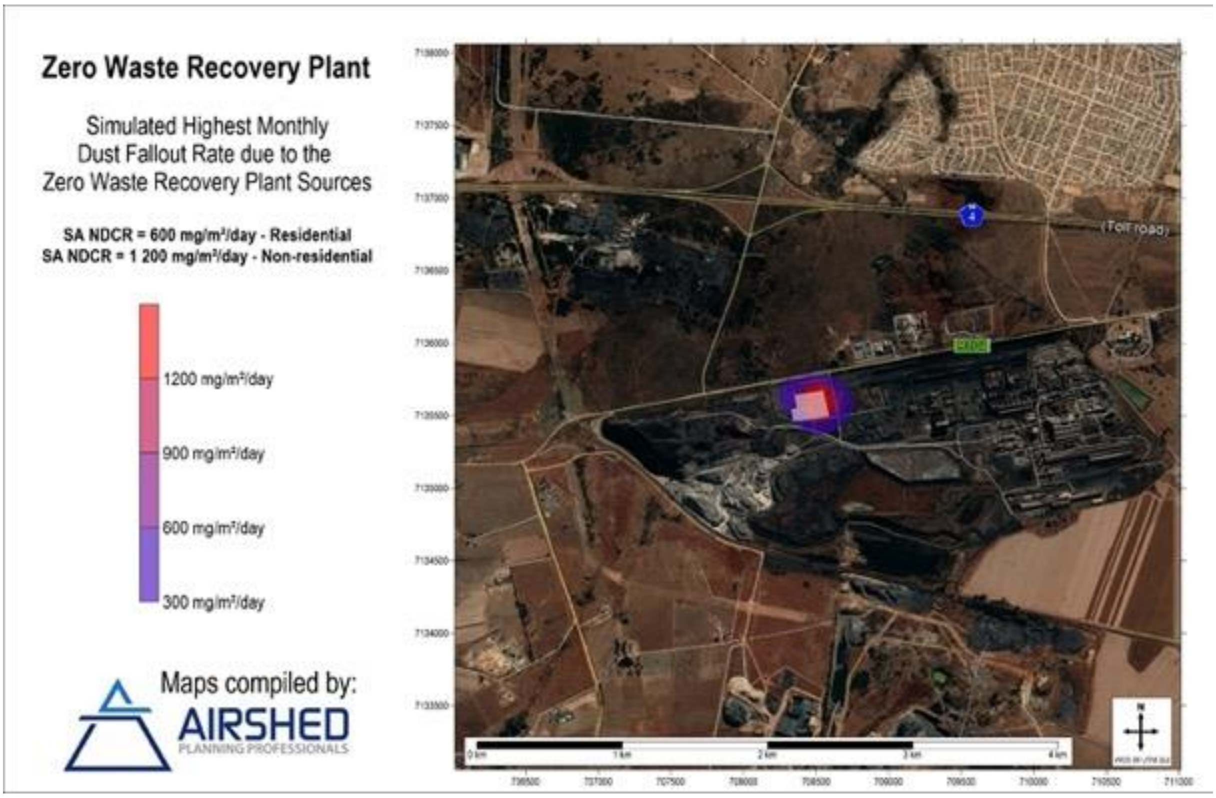

Figure 24: Simulated ground-level Highest Monthly Dust Fallout Rate – Incremental Impact of Zero-Waste Plant Sources Only

7.1.9.2 *Cumulative Impacts*

Because particulate concentrations measured at the SAWS Emalahleni station during 2020 were in exceedance of the SA NAAQS (Table 21), instead of accessing cumulative particulate concentrations, the simulated increase from baseline concentrations as a percentage increase are assessed. Cumulative SO_2 and NO_2 impacts were assessed by adding simulated concentrations to average background concentrations measured at SAWS Emalahleni station.

Particulate emissions from the Zero-Waste Recovery Plant could result in an increase in PM_{10} concentrations of more than 100% from baseline concentrations in the immediate vicinity (<200 m) to the north, east and south of the plant (Figure 25 and Figure 26), especially when the milling plant is active. Further away from the plant, the increase from baseline concentrations is expected to be low, with a 10% increase from baseline concentrations simulated up to 1 km from the plant, and a negligible increase in PM_{10} at all identified sensitive receptor locations.

Simulated $PM_{2.5}$ emissions from the Zero-Waste Recovery Plant lead to a very low increase from baseline concentrations, with an increase of 10% simulated up to 200 m from the plant and a negligible increase from baseline concentrations at all sensitive receptor locations (Figure 27 and Figure 28).

Simulated cumulative SO_2 and NO_2 concentrations (Figure 29 to Figure 33) are in compliance with the SA NAAQS at all sensitive receptor location for all averaging periods, but if the plant is operated at or above the Subcategory 4.20 Minimum Emission Standards, short-term (hourly and daily) cumulative SO_2 concentrations could exceed the SA NAAQS up to 250 m to the northwest of the plant due to fairly high background SO_2 concentrations.

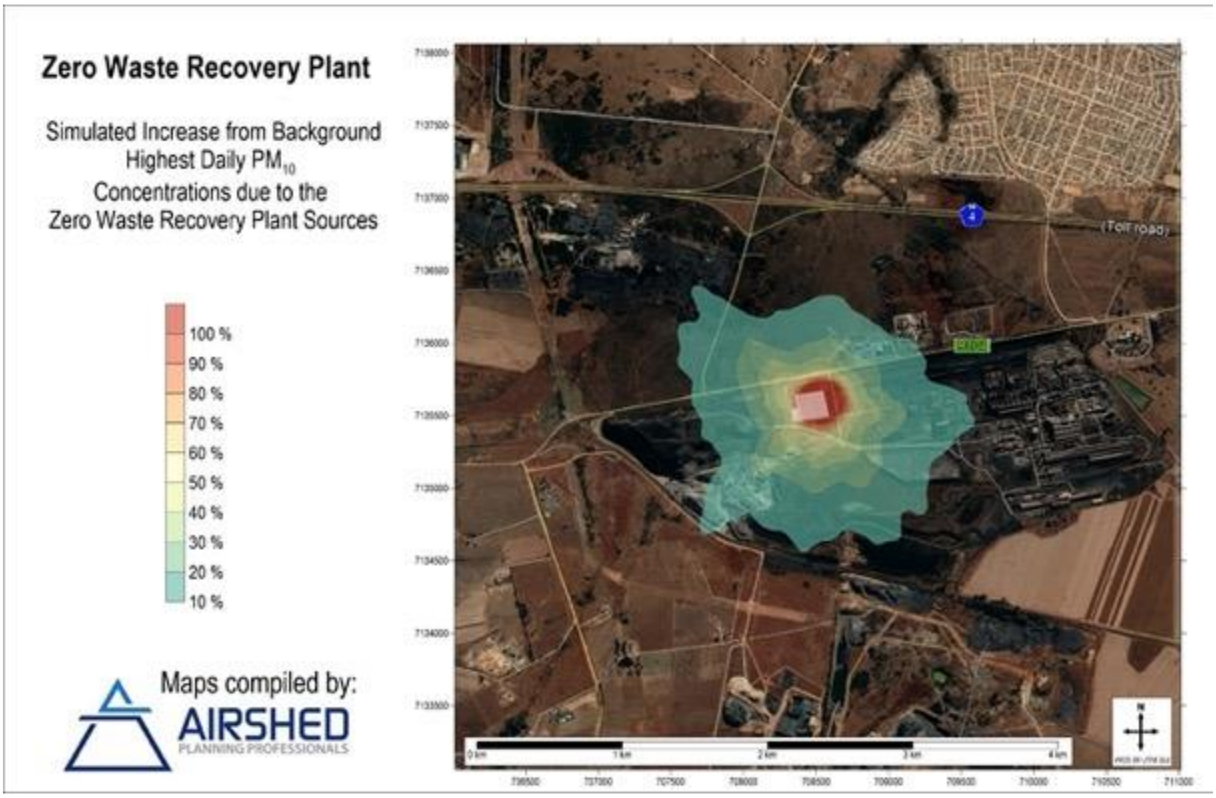

Figure 25: Simulated Increase from Baseline Highest Daily PM_{10} Concentrations – Cumulative Impact

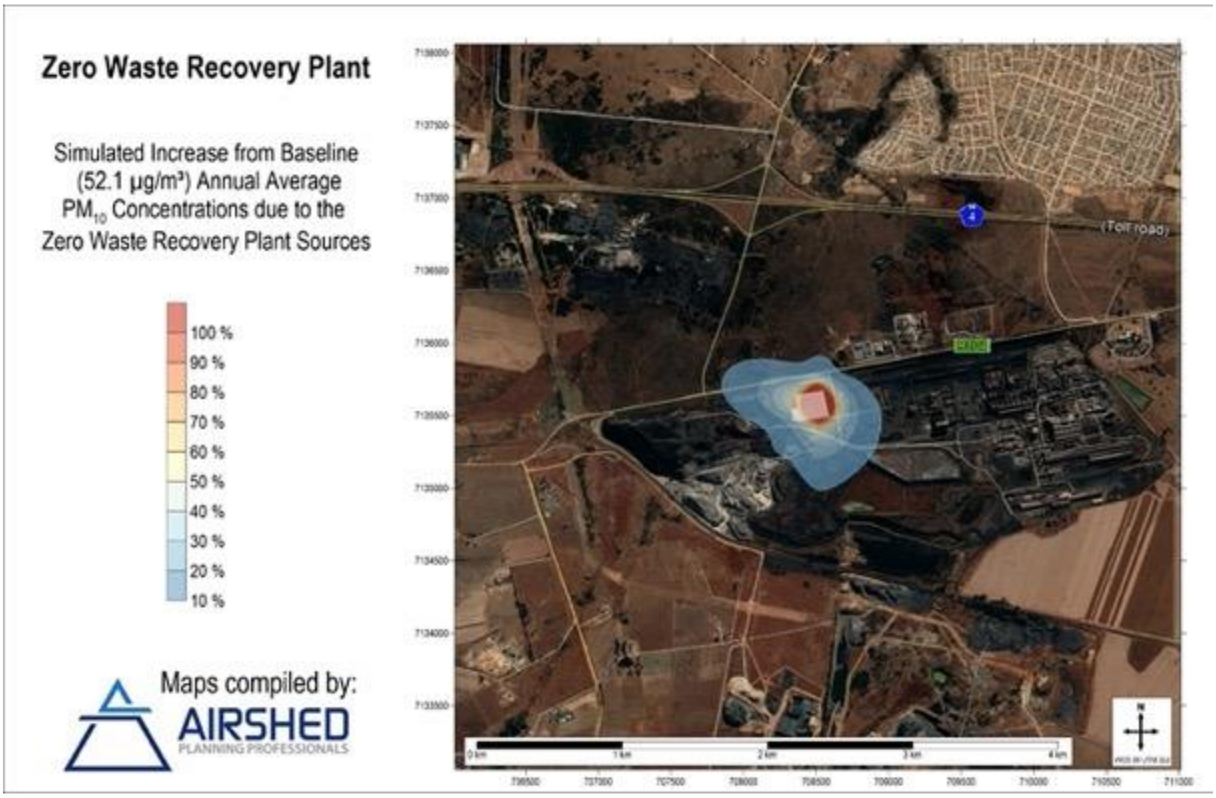

Figure 26: Simulated Increase from Baseline Annual Average PM_{10} Concentrations–Cumulative Impact

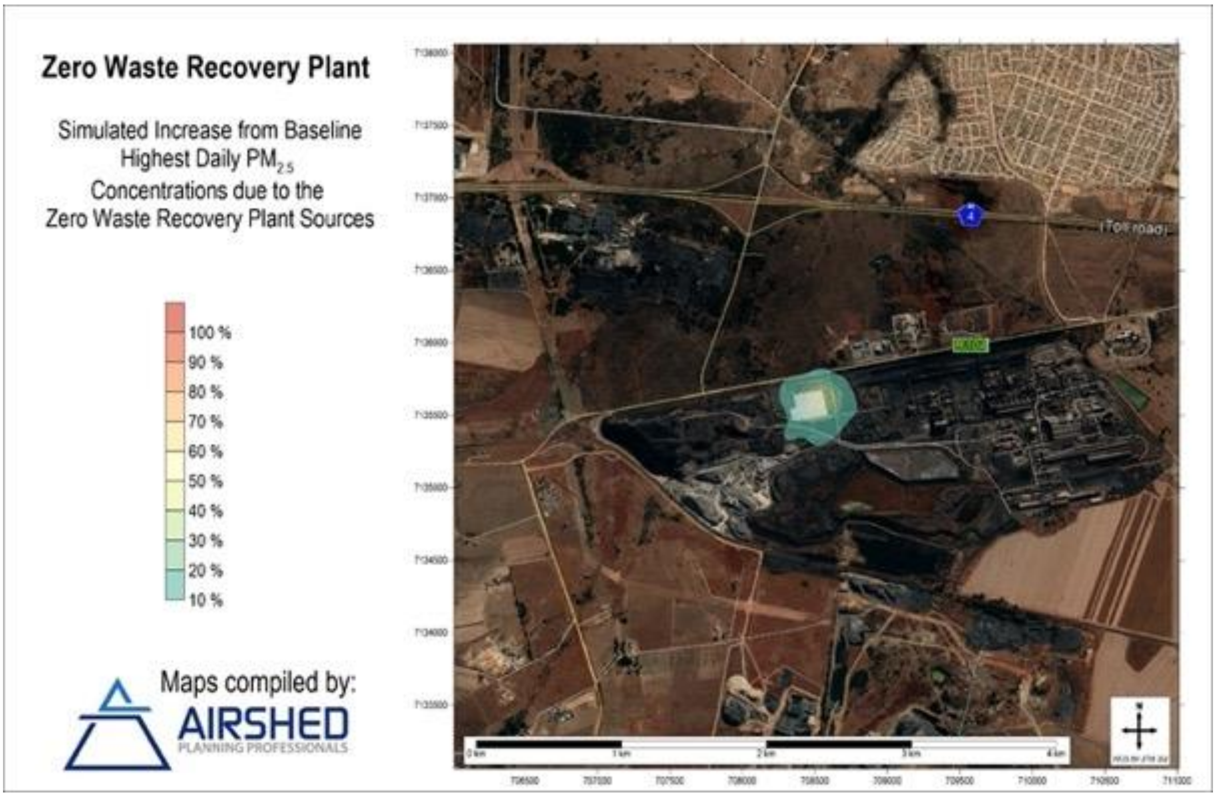

Figure 27: Simulated Increase from Baseline Highest Daily $PM_{2.5}$ Concentrations – Cumulative Impact

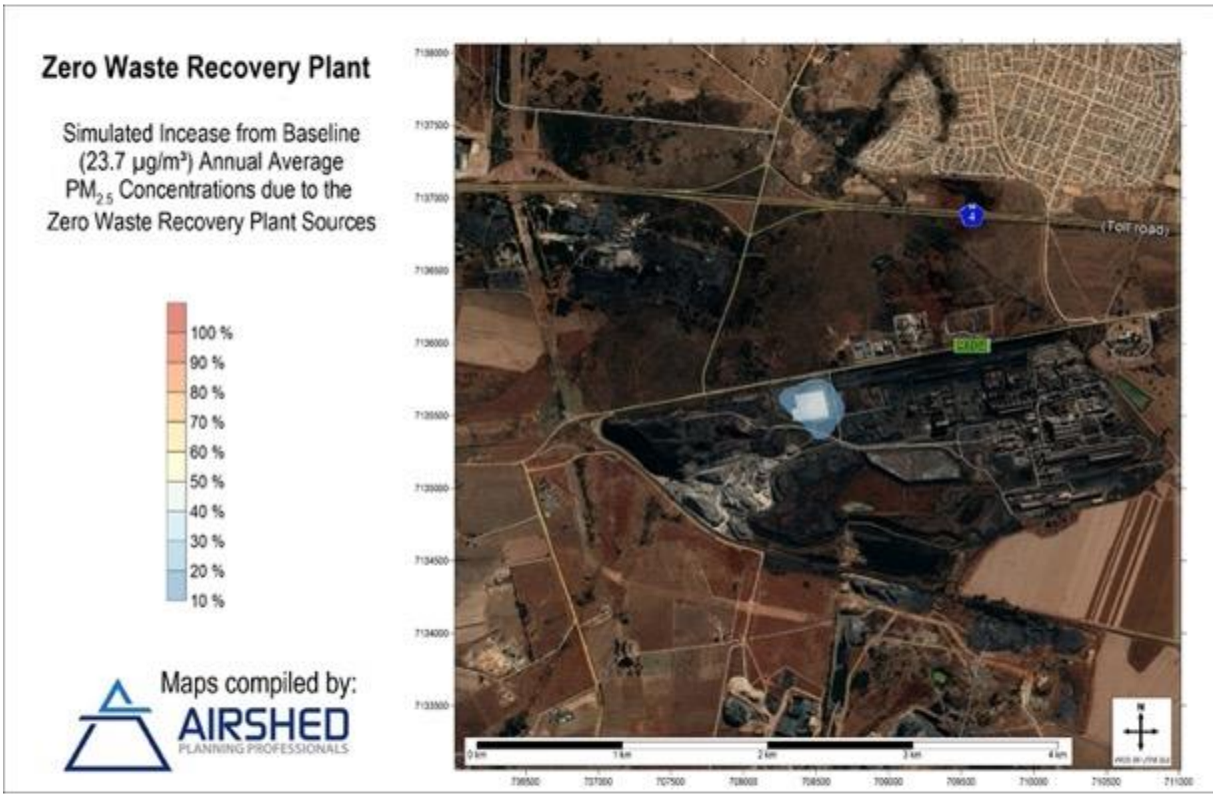

Figure 28: Simulated Increase from Baseline Annual Average $PM_{2.5}$ Concentrations–Cumulative Impact

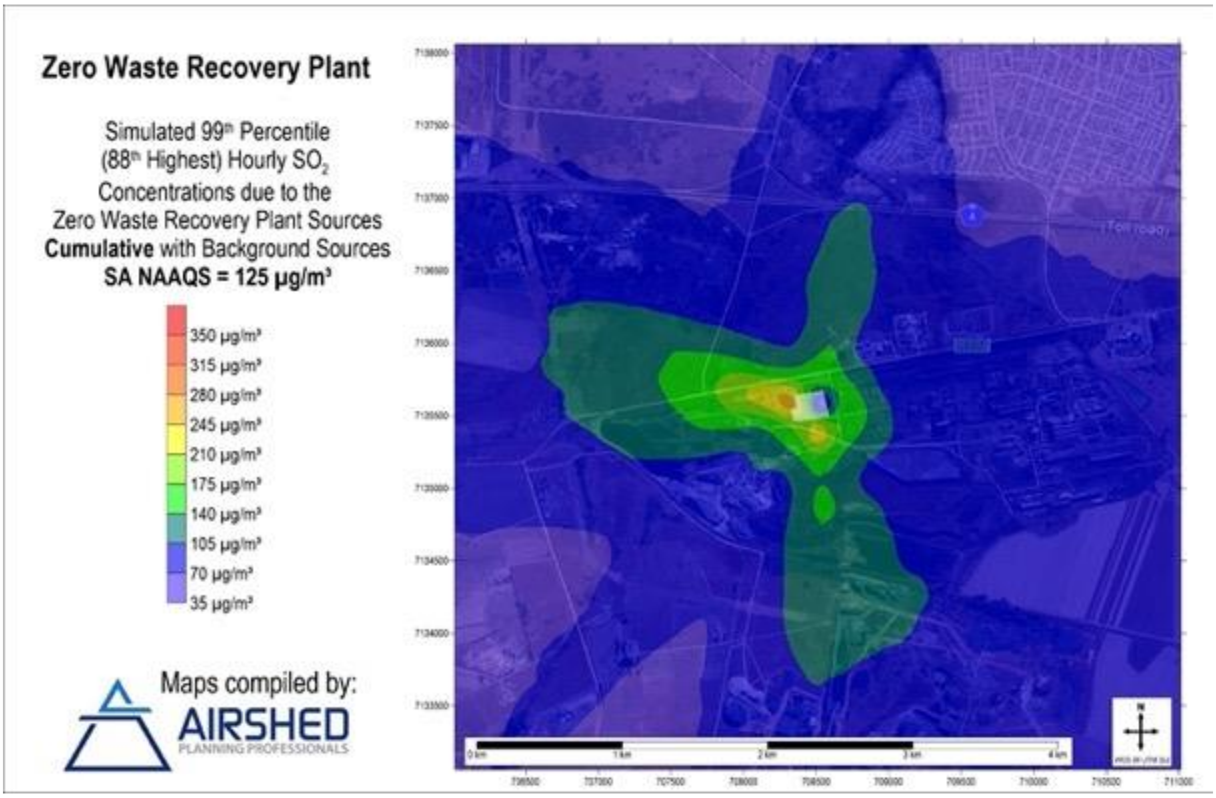

Figure 29: Simulated ground-level 99th Percentile Hourly SO_2 Concentrations - Cumulative Impact of Zero-Waste Plant Sources Together with Background Concentrations

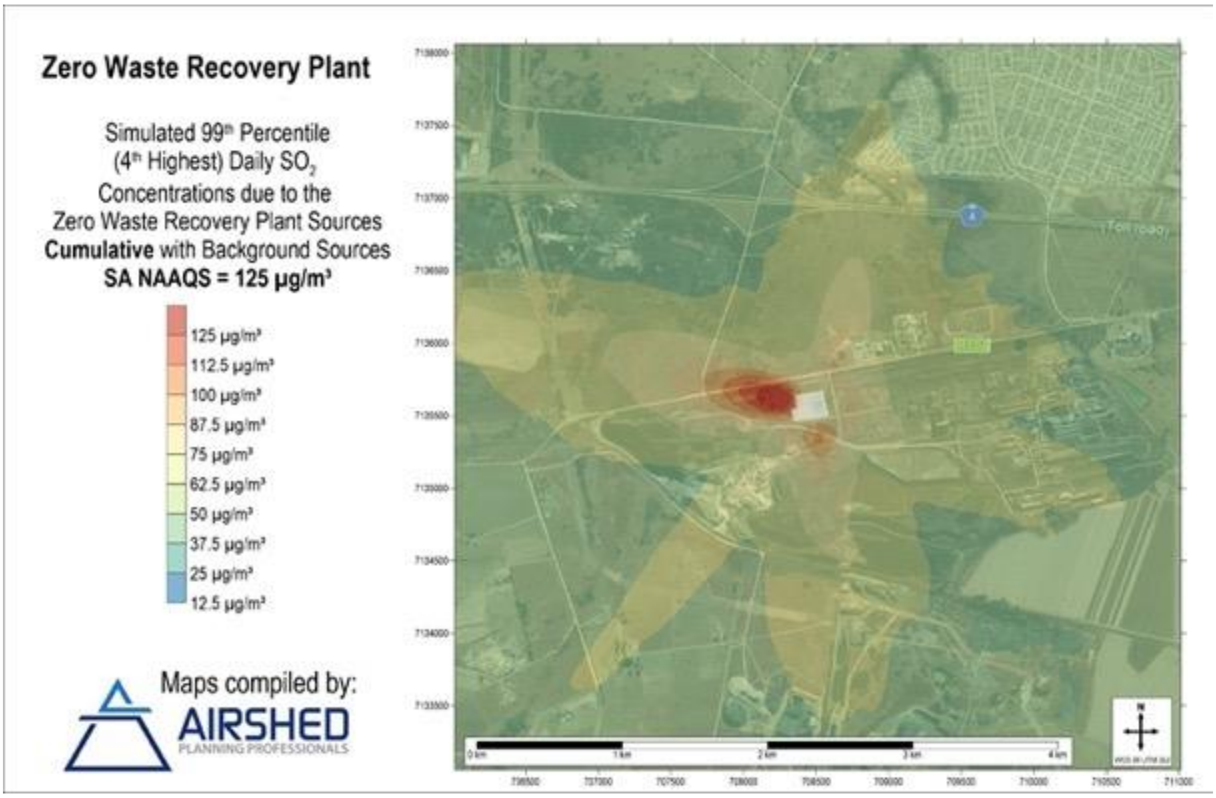

Figure 30: Simulated ground-level 99th Percentile Daily SO_2 Concentrations - Cumulative Impact of Zero-Waste Plant Sources Together with Background Concentrations

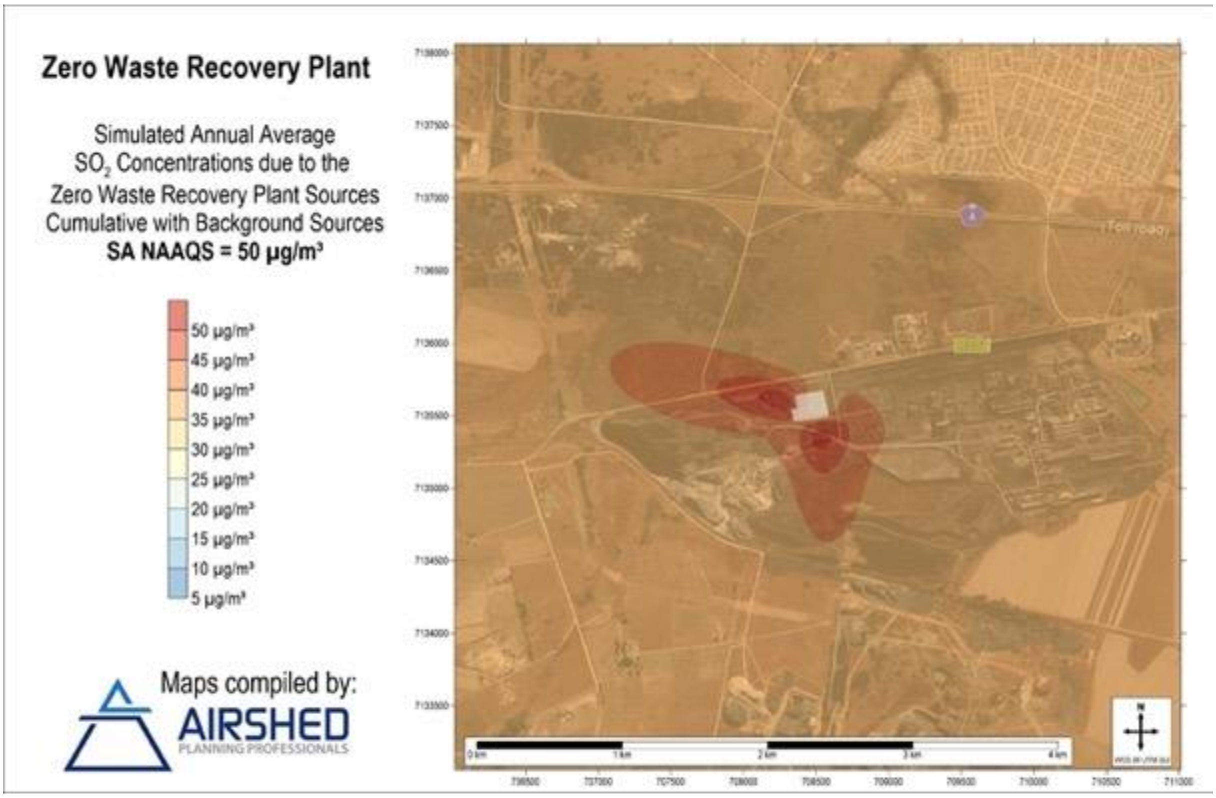

Figure 31: Simulated ground-level Annual Average SO_2 Concentrations – Cumulative Impact of Zero-Waste Plant Sources Together with Background Concentrations

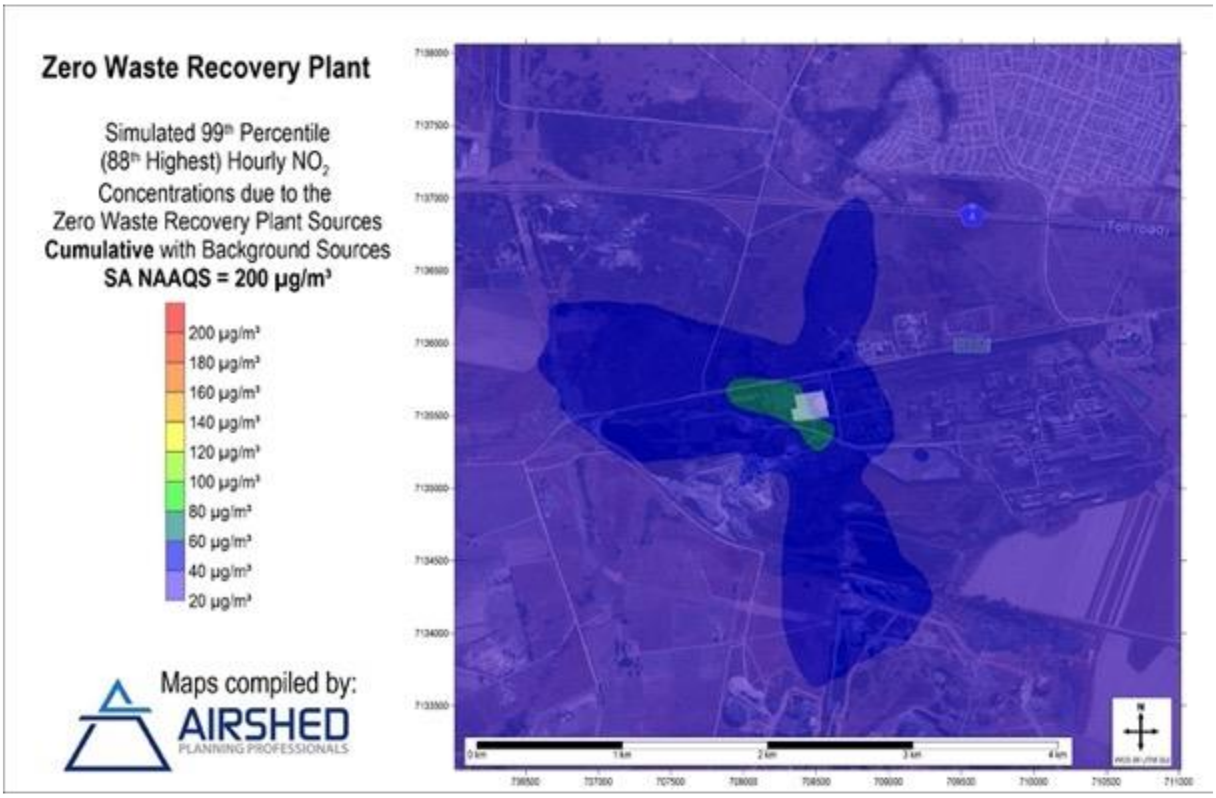

Figure 32: Simulated ground-level 99th Percentile Hourly NO_2 Concentrations - Cumulative Impact of Zero-Waste Plant Sources Together with Background Concentrations

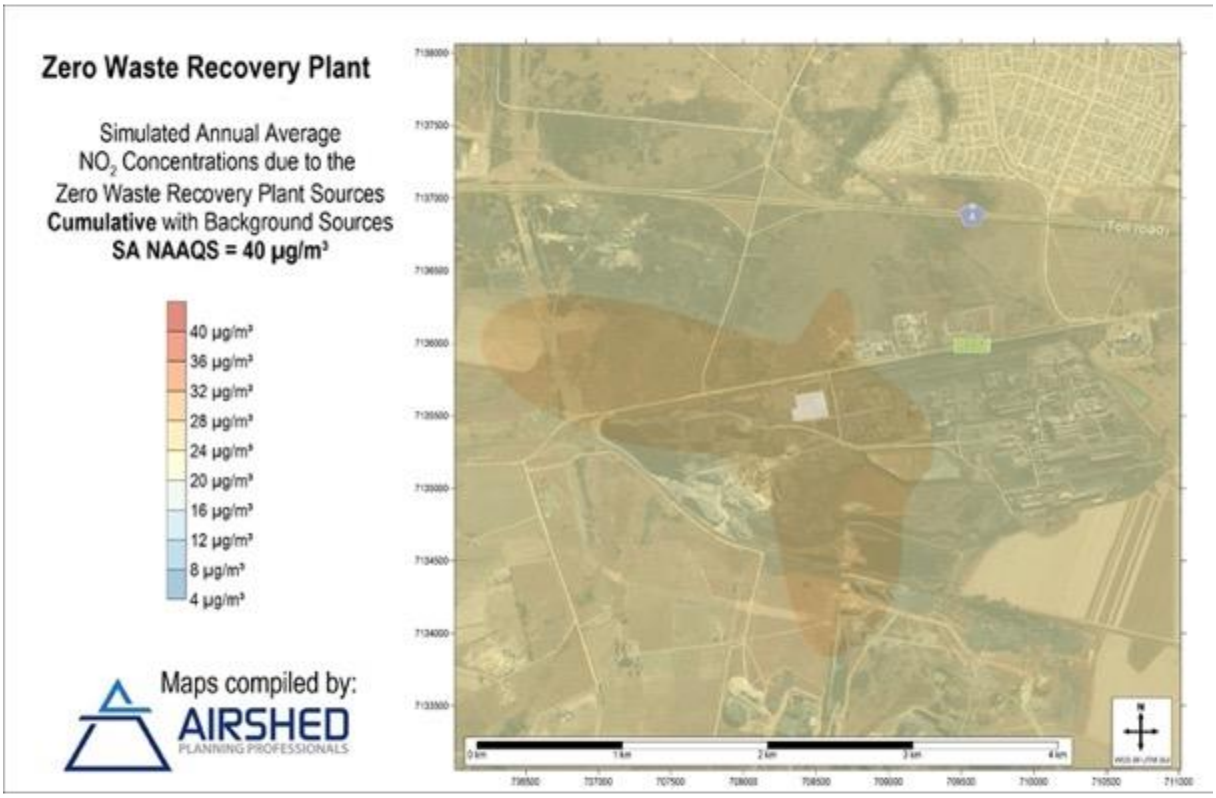

Figure 33: Simulated ground-level Annual Average NO_2 Concentrations - Cumulative Impact of Zero-Waste Plant Sources Together with Background Concentrations

7.2 Analysis of Emissions' Impact on the Environment

7.2.1 Critical Levels for Vegetation

The impact of the proposed Zero-Waste Recovery Plant emissions on surrounding vegetation was assessed by comparing the simulated annual SO_2 and NO_2 concentrations against the critical levels for vegetation as defined by the United Nations Economic Commission for Europe (UNECE) Convention on Long Range Trans-boundary Air Pollution Limits (CLRTAP, 2015) (Table 23).

Table 23: Critical levels for SO_2 and NO_2 by vegetation type (CLRTAP, 2015)

Pollutant	Vegetation type	Critical Level (µg/m³)	Time Period[a]
SO_2	Cyanobacterial lichens	10	Annual average
	Forest ecosystems (including understorey vegetation)	20	Annual average and Half-year mean (winter)
	(Semi-)natural vegetation	20	Annual average and Half-year mean (winter)
	Agricultural crops	30	Annual average and Half-year mean (winter)
NO_2	All	30	Annual average and Half-year mean (winter)
		75	Daily average

Notes:
(a) For the purposes of mapping of critical levels and exceedances CLRTAP recommend using only the annual average, due to increased reliability of mapped and simulated data for the longer time period. It is also noted that long-term effects of NO_X are considered to be more significant than short-term effects (CLRTAP, 2015).

The simulated off-site annual concentrations of SO_2 and NO_2 are well below the critical levels for all vegetation types with maximum simulated off-site annual average SO_2 and NO_2 concentrations of approximately 9 µg/m³ and 4 µg/m³ respectively. The operations are therefore expected to result in a negligible impact on surrounding vegetation.

7.2.2 Effects of Particulate Matter on Animals

As presented by the Canadian Environmental Protection Agency (CEPA, 1999) experimental studies using animals have not provided convincing evidence of particle toxicity at ambient levels. Acute exposures (4-6 hour single exposures) of laboratory animals to a variety of types of particles, almost always at concentrations well above those occurring in the environment have been shown to cause decreases in lung function, changes in airway defence mechanisms and increased mortality rates.

The epidemiological finding of an association between 24-hour ambient particle levels below 100 µg/m³ and mortality has not been substantiated by animal studies as far as PM_{10} and $PM_{2.5}$ are concerned. With the exception of ultrafine particles (0.1 µm), none of the other particle types and sizes used in animal inhalation studies cause such acute dramatic effects, including high mortality at ambient concentrations. The lowest concentration of $PM_{2.5}$

reported that caused acute death in rats with acute pulmonary inflammation or chronic bronchitis was 250 g/m^3 (3 days, 6 hr/day), using continuous exposure to concentrated ambient particles. Based on simulated concentrations and the distance to any agricultural activities, the operations are not expected to have any impact on the health of nearby animals.

7.2.3 Effects of SO_2 on Animals

Experimental studies on animals have shown the acute inhalation of SO_2 produces bronchioconstriction, increases respiratory flow resistance, increases mucus production and has been shown to reduce abilities to resist bacterial infection in mice (Costa and Amdur, 1996). Short exposures to low concentrations of SO_2 (~2.6 mg/m^3) have been shown to have immediate physiological response without resulting in significant or permanent damage. In rabbits, acute exposures (16 mg/m^3 for 4 hours) to SO_2 gas was irritating to the eyes and resulted in conjunctivitis, infection and lacrimation (Von Burg, 1995). Short exposures (<30 min) to concentrations of 26 mg/m^3 produced more significant respiratory changes in cats but were usually completely reversible once exposure had ceased (Corn *et al*., 1972).

Sulfur dioxide can produce mild bronchial constriction, changes in metabolism and irritation of the respiratory tract and eyes in cattle (Blood and Radostits, 1989 as cited in Coppock and Nostrum, 1997). An increase in airway resistance was reported in sensitized sheep after four hours of exposure to 13 mg/m^3. Studies report chronic exposure can affect mucus secretions and result in respiratory damage similar to chronic bronchitis. These effects were reported at concentrations above typical ambient concentrations (26-1053 mg/m^3) (Dalhamn, 1956 as cited in Amdur, 1978).

Exposure to air pollutants is expected to result in similar adverse effects in wildlife as in laboratory and domestic animals (Newman, 1979).

The simulated off-site annual concentrations of SO_2 are very low and expected to have a negligible impact on animal health.

7.2.4 Dust Effects on Vegetation

Suspended particulate matter can produce a wide variety of effects on the physiology of vegetation that in many cases depend on the chemical composition of the particle. Heavy metals and other toxic particles have been shown to cause damage and death of some species as a result of both the phytotoxicity and the abrasive action during turbulent deposition (Harmens *et al*., 2005). Heavy loads of particle can also result in reduced light transmission to the chloroplasts and the occlusion of stomata (Harmens *et al*., 2005; Naidoo and Chirkoot, 2004, Hirano *et al*., 1995, Ricks and Williams, 1974), decreasing the efficiency of gaseous exchange (Harmens *et al*., 2005; Naidoo and Chirkoot, 2004, Ernst, 1981) and hence water loss (Harmens *et al*., 2005). They may also disrupt other physiological processes such as bud break, pollination and light absorption/reflectance (Harmens *et al*., 2005). The chemical composition of the dust particles can also affect the plant and have indirect effects on the soil pH (Spencer, 2001).

Naidoo and Chirkoot conducted a study during the period October 2001 to April 2002 to investigate the effects of coal dust on Mangroves in the Richards Bay harbour. The investigation was conducted at two sites where 10 trees of the Mangrove species (*Avicennia marina)* were selected and mature leaves, fully exposed to the sun were tagged as being covered or uncovered with coal dust. From the study it was concluded that coal dust significantly reduced photosynthesis of upper and lower leaf surfaces. The reduced photosynthetic performance was expected to reduce growth and productivity. In addition, trees in close proximity to the coal stockpiles were in poorer health than those further away. Coal dust particles, which are composed predominantly of carbon, were not toxic to the leaves; neither did they occlude stomata as they were larger than fully open stomatal apertures (Naidoo and Chirkoot, 2004).

In general, according to the Canadian Environmental Protection Agency (CEPA), air pollution adversely affects plants in one of two ways; either the quantity of output or yield is reduced, or the quality of the product is lowered. The former (invisible) injury results from pollutant impacts on plant physiological or biochemical processes and can lead to significant loss of growth or yield in nutritional quality (e.g. protein content). The latter (visible) may take the form of discolouration of the leaf surface caused by internal cellular damage. Such injury can reduce the market value of agricultural crops for which visual appearance is important (e.g. lettuce and spinach). Visible injury tends to be associated with acute exposures at high pollutant concentrations, whilst invisible injury is generally a consequence of chronic exposures to moderately elevated pollutant concentrations. However, given the limited information available, specifically the lack of quantitative dose-effect information, it is not possible to define a Reference Level for vegetation and particulate matter (CEPA, 1999).

While there is little direct evidence of what the impact of dust fall on vegetation is under an African context, a review of European studies has shown the potential for reduced growth and photosynthetic activity in Sunflower and Cotton plants exposed to dust fall rates greater than 400 mg/m²/day (Farmer, 1991).

Estimated dust fallout rates due to the Zero-Waste Recovery Plant are very low and expected to be limited to the areas around the operations. While dust fallout can have a negative effect on both plant growth and the economic value of crops, the low dust fallout rates associated with the Zero-Waste Recovery Plant are expected to have a negligible impact on the surrounding environment.

8 COMPLAINTS

The Zero-Waste Recovery Plant is a proposed operation, and as such no complaints have been received in the past. **It is required that a complaints register will be kept on-site once the construction of the operations commence.**

9 CURRENT OR PLANNED AIR QUALITY MANAGEMENT INTERVENTIONS

9.1 Point Source Emissions

The Zero-Waste Recovery Plant needs to be designed to comply with the Subcategory 4.20 Minimum Emission Standards.

9.2 Fugitive Dust Management Plan

The following mitigation measures are recommended to control fugitive dust emissions from the operations and minimise the impact of particulate emissions on the receiving environment:

- Paving of all on-site roads. While the surface moisture content of unpaved roads can be increased with water bowsers, it is much easier to control the silt loading on paved roads.
- Regular sweeping of on-site paved roads to reduce silt loading on the road surface, higher silt loading results in higher vehicle entrainment emissions.
- Cleanup of all spillages to avoid re-entrainment by vehicles.
- Implementation of strict on site speed limits.
- Mitigation of crushing plant emissions. The design of the plant includes dust extraction and abatement with a bag house.
- Control of dust emissions from stockpiles during periods of high wind speeds, either by increasing moisture content of material with water sprays, or by decreasing wind speeds using enclosures or bund walls

9.3 Monitoring Plan

Stack testing will need to be conducted as indicated on the Atmospheric Emissions Licence for the operations.

It is recommended that dust fallout sampling be conducted on the facility boundary in the four cardinal wind directions. Dust fallout sampling is a cost-effective method of evaluating whether nearby particulate emission sources possibly result in elevated particulate concentrations.

10 Compliance and Enforcement Actions

The proposed Zero-Waste Recovery Plant's simulated compliance with the national ambient air quality standards and compliance with minimum emission limits are shown in Table 24.

Table 24: Compliance with Minimum Emission Standards and NAAQS

Pollutant	Minimum Emission Standards	National Ambient Air Quality Standards
All pollutants as per Subcategory 4.20	The Zero-Waste Recovery Plant will be designed to comply with Subcategory 4.20 Minimum Emission Standards.	While simulated ground level particulate emissions result in an increase in particulate concentrations (which baseline measurements indicate are in exceedance of the SA NAAQS) in the immediate vicinity of the plant, the resultant cumulative impact due to the operations is negligible at all identified sensitive receptor locations. Simulated ground level SO_2 and NO_2 concentrations, both cumulative and incremental, are in compliance with the SA NAAQS, with possible exceedances of the SA NAAQS for SO_2 to the immediate northwest of the plant because of high background SO_2 concentrations.

11 Impact Significance Rating and Environmental Management Programme

Because this Atmospheric Impact Report will form part of the Environmental Impact Assessment for the Zero-Waste Recovery Plant, this section is included to assess the significance of all air quality impacts using the methodology provided by Savannah Environmental (see Annexure E).

It is assumed that all point sources from the operations will comply with the MES for processing or recovery of metallurgical slag as required by legislation.

The **extent** of incremental impacts due to the Zero-Waste Recovery Plant are expected to be localised to the vicinity of the operations, with possible exceedances of the SA NAAQS simulated outside the property boundary, but simulated impacts are negligible at all sensitive receptor locations. The **duration** of the impacts is expected to be long-term (for the life of the project) while the **magnitude** of impacts is expected to be medium for particulate emissions, low to medium for gaseous pollutants (SO_2 and NO_2), and low for dust fallout. If all fugitive sources are properly managed, no residual impact is expected post closure.

Impacts during the construction phase are expected to be transient and highly variable from day to day, depending on the construction activities being performed. For this reason, construction phase **impacts are expected to be low** (Table 27).

Given that particulate concentrations in the study area are already elevated, it is possible that cumulative impacts could be high in magnitude. It is therefore recommended that best available technologies be employed to mitigate point source and fugitive particulate emissions.

Table 25: Incremental Potential Impact Associated with the Operation phase of the Zero-Waste Recovery Plant

<table>
<tr><td colspan="3">Nature:
Elevated ambient concentrations of pollutants as a result of Zero-Waste Recovery Plant operational activities as described in Section 6.</td></tr>
<tr><td></td><td>Without mitigation</td><td>With mitigation</td></tr>
<tr><td>Extent</td><td>Low-Medium (2)</td><td>Low-Medium (2)</td></tr>
<tr><td>Duration</td><td>Long-term (4)</td><td>Long-term (4)</td></tr>
<tr><td>Magnitude</td><td>Medium (6)</td><td>Low (4)</td></tr>
<tr><td>Probability</td><td>Probable (3)</td><td>Probable (3)</td></tr>
<tr><td>Significance</td><td>Medium (36)</td><td>Medium (30)</td></tr>
<tr><td>Status (positive or negative)</td><td>Negative</td><td>Negative</td></tr>
<tr><td>Reversibility</td><td>Low</td><td>Low</td></tr>
<tr><td>Irreplaceable loss of resources?</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Can impacts be mitigated?</td><td>Yes</td><td>Yes</td></tr>
<tr><td colspan="3">Mitigation:
• The Zero-Waste Recovery plant must be designed and suitable abatement technologies implemented to ensure that point source emissions comply with the Subcategory 4.20 MES (Section 7.1.2.4)
• Best available technology mitigation measures are recommended for fugitive dust sources, these include:
o Paving of all on-site roads.
o Regular sweeping of on-site paved roads.
o Cleanup of all spillages to avoid re-entrainment.
o Implementation of strict on site speed limits.
o Mitigation of crushing plant emissions with dust extraction and bag filters.
o Control of dust emissions from stockpiles during periods of high wind speeds.</td></tr>
<tr><td colspan="3">Residual Risks:
If all fugitive dust sources are properly managed, no residual impact is expected post closure.</td></tr>
</table>

Table 26: Cumulative Potential Impact Associated with the Operation phase of the Zero-Waste Recovery Plant

<table>
<tr><td colspan="3">Nature:
Elevated ambient concentrations of particulate and gaseous atmospheric pollutants as a result of Zero-Waste Recovery Plant operational activities as described in Section 6 cumulative with elevated background pollution.</td></tr>
<tr><td></td><td>Overall impact of the proposed project considered in isolation</td><td>Cumulative impact of the project and other projects in the study area</td></tr>
<tr><td>Extent</td><td>Low-Medium (2)</td><td>Low-Medium (2)</td></tr>
<tr><td>Duration</td><td>Long-term (4)</td><td>Long-term (4)</td></tr>
<tr><td>Magnitude</td><td>Medium (6)</td><td>High (10)</td></tr>
<tr><td>Probability</td><td>Probable (3)</td><td>Probable (3)</td></tr>
<tr><td>Significance</td><td>Medium (36)</td><td>Medium (48)</td></tr>
<tr><td>Status (positive or negative)</td><td>Negative</td><td>Negative</td></tr>
<tr><td>Reversibility</td><td>Low</td><td>Low</td></tr>
<tr><td>Irreplaceable loss of resources?</td><td>Yes</td><td>Yes</td></tr>
</table>

Can impacts be mitigated?	Yes	Yes
Mitigation: As per Table 25 on the previous page.		
Residual Risks: If all fugitive dust sources are properly managed, no residual impact is expected post closure.		

Table 27: Potential Incremental Impact Associated with the Construction and Decommissioning phases of the Zero-Waste Recovery Plant

Nature: Construction (and decommissioning) activities are likely to result in emissions of pollutants due to civil and building work and from vehicle traffic. The nature of emissions from construction activities is highly variable in terms of temporal and spatial distribution and is also transient. Increased ambient concentrations of fine particulates and gaseous pollutants may result in negative human health impacts. Increased nuisance dustfall is likely as a result of wind-blown dust emissions from the working areas. Increased nuisance dustfall rates will likely result in negative impact on dustfall in the immediate vicinity of the construction area. Incremental unmitigated particulate emissions could result in higher particulate concentrations and dust fallout in the immediate vicinity of the plant, but are unlikely to result in any noticeable impact at any identified sensitive receptor locations. The impact of gaseous pollutants is likely to be negligible.		
	Without mitigation	**With mitigation**
Extent	Low (1)	Low (1)
Duration	Short-term (2)	Short-term (2)
Magnitude	Medium (6)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	**Low (27)**	**Low (27)**
Status (positive or negative)	Negative	Negative
Reversibility	Reversible	Reversible
Irreplaceable loss of resources?	Possible	Possible
Can impacts be mitigated?	Yes with minimum control efficiency of 50%.	
Proposed mitigation measures:		
• Wet suppression at key handling points or cleared areas, and on unpaved roads. • Trucks to be restricted to specified roads and using the most direct route. • Reduce unnecessary traffic. • Strict on-site speed control. • Reduction of extent of open areas to minimised the time between clearing and infrastructure construction, and/or use of wind breaks and water suppression to reduce emissions from open areas. • Restriction of disturbance to periods of low wind speeds (less than 5 m/s). • Stabilisation of disturbed soil (for example, chemical, rock cladding, or vegetation). • Re-vegetation of cleared areas as soon as practically feasible.		
Residual impacts:		
Expected to be low if mitigation measures are properly implemented.		

Table 28: Potential Cumulative Impact Associated with the Construction and Decommissioning phases of the Zero-Waste Recovery Plant

Nature: Construction (and decommissioning) activities are likely to result in emissions of particulate and gaseous pollutants due to civil and building work and from vehicle traffic. The nature of emissions from construction activities is highly variable in terms of temporal and spatial distribution and is also transient. Increased ambient concentrations of fine particulates and gaseous pollutants may result in negative human health impacts. Increased nuisance dustfall is likely as a result of wind-blown dust emissions from the working areas. Increased nuisance dustfall rates will likely result in negative impact on dustfall in the immediate vicinity of the construction area. Unmitigated particulate emissions could result in higher particulate concentrations and dust fallout in the immediate vicinity of the plant. Although baseline particulate concentrations are already elevated, construction operations are still unlikely to result in any noticeable impact at any identified sensitive receptor locations,. The impact of gaseous pollutants is likely to be minor.		
	Without mitigation	**With mitigation**

Extent	Low (1)	Low (1)
Duration	Short-term (2)	Short-term (2)
Magnitude	Medium (6)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	**Low (27)**	**Low (27)**
Status (positive or negative)	Negative	Negative
Reversibility	Reversible	Reversible
Irreplaceable loss of resources?	Possible	Possible
Can impacts be mitigated?	Yes with minimum control efficiency of 50%.	
Proposed mitigation measures:		
• Wet suppression at key handling points or cleared areas, and on unpaved roads. • Trucks to be restricted to specified roads and using the most direct route. • Reduce unnecessary traffic. • Strict on-site speed control. • Reduction of extent of open areas to minimised the time between clearing and infrastructure construction, and/or use of wind breaks and water suppression to reduce emissions from open areas. • Restriction of disturbance to periods of low wind speeds (less than 5 m/s). • Stabilisation of disturbed soil (for example, chemical, rock cladding, or vegetation). • Re-vegetation of cleared areas as soon as practically feasible.		
Residual impacts:		
Expected to be low if mitigation measures are properly implemented.		

Environmental Management Programme for the Construction (and decommissioning) Phase(s)

Objective:	Minimise impact on ambient air quality through effective management, mitigation, and monitoring during construction phase
Project component/s	All project components
Potential Impact	Heavy vehicles and construction equipment can generate dust and fine particulate matter and release air pollutants (NO_2, CO, PM, SO_2) due to movement on-site and movement of materials on-site.
	Construction activities such as vegetation clearing, temporary stockpiles, foundation excavation, and road construction can result in dust and particulate release potentially affecting human health on nearby communities or result in nuisance dustfall and reduced visibility during active construction.
Activity/risk source	The use of heavy vehicle and construction equipment
	Clearing of vegetation and topsoil
	Excavation, grading, and scraping
	Transport and movement of materials, equipment, and materials to site and around site (as required)
	Wind erosion from cleared areas, temporary stockpiles, and unsealed roads
	Combustion of fuel in construction equipment (e.g. generators) and heavy vehicles.
Mitigation: Target/Objective	Minimise potential particulate matter impacts associated with vehicles and construction equipment use
	Minimise potential health and nuisance impacts to communities and adjacent landowners from particulate emissions
	Minimise emissions from combustion engines (stationary or mobile) during the construction phase

Mitigation: Action/control	Responsibility	Timeframe
Establish a complaints register and/or incident reporting system where personnel, communities and adjacent landowners can lodge complaints regarding construction activities. Ideal location would be security post at point of site access.	EO	Prior to construction

Mitigation: Action/control	Responsibility	Timeframe
Appropriate dust suppression measures on cleared areas, temporary stockpiles, and unsealed roads such as water suppression (using non-potable water if possible), chemical stabilisation, or revegetation (as soon as practically feasible), especially during high wind speed events	EPC Contractor(s) and EO	During construction
Use minimum safe drop heights when transferring material on-site	EPC Contractor(s) and EO	During construction
Cover material stockpiles with tarpaulins or story in protected temporary bunkers	EPC Contractor(s) and EO	During construction
Limit cleared area for bulk earthworks to minimum as practically feasible	EPC Contractor(s) and EO	During construction
Heavy vehicles and construction equipment to be road worthy and regularly maintained.	EPC Contractor(s), transportation contractor(s) and EO	During construction
All vehicles leaving site with loose material must have load-bins covered with tarpaulins.	EPC Contractor(s) and EO	During construction
All vehicles associated with the construction phase must adhere to the designated speed limits on- and off-site.	EPC Contractor(s), transportation contractor(s) and EO	Duration of contract
Revegetation (as soon as practically feasible)	EPC Contractor(s) and EO	At completion of construction phase (or before if practically feasible)
Investigate inadequate mitigation and control measures if monitoring or complaints potential issues are indicated by non-conformance with performance indicators	EPC Contractor(s) and EO	During construction

Performance Indicator	Appropriate dust suppression measures are implemented during construction phrase. No visible dust plumes from cleared areas and temporary stockpiles during high wind speed events. No visible plumes from unsealed roads when in use or during high wind speed events.
	Drivers are aware of potential safety issues and strict enforcement of on-site speed limits when employed and when entering site.
	Vehicle roadworthy certificates and maintenance records for all heavy vehicles are made available prior to construction and updated regularly. No or minimal visible exhaust fumes during normal operation.
Monitoring	The performance indicators listed above should be met during the construction phase by the responsible parties.
	Any potential or actual issues that could results in non-conformance with the performance indicator must be reported by on-site personnel to the Site Manager immediately.
	An incident reporting system must be used to record non-conformances to the EMPr.
	A complaints register must be used to record complaints from the public.

Environmental Management Programme for the Operational Phase

Objective:	Minimise impact on ambient air quality through effective management, mitigation, and monitoring during the operational phase

Project component/s	All project components
Potential Impact	The normal operation of the Zero Waste Recovery Solution will result in emission of gaseous and particulate pollutants including: SO_2, NO_2, and PM. Increased ambient concentrations of these pollutants may result in negative human health impacts, and nuisance dustfall.
Activity/risk source	Alkali roasting of feedstock using a gas or coal fired kiln.
	Recovery of V_2O_5 and TiO_2.
	Production of sulfuric acid and calcium silicate.
	Fugitive dust emissions from crushing and screening at the crushing plant.
	Recovery of Alumina salts, aluminium and magnesium.
	Treatment of off-gas and production of sulfuric acid.
	Vehicle entrainment from on-site unpaved roads.
	Fugitive dust emissions from materials handling and wind erosion at the slag stockpile.
	Fugitive dust emissions from materials handling and wind erosion at the product area.
Mitigation: Target/Objective	Ensure compliance with minimum emission limits as applicable to the scrubber and acid plant stacks.
	Ensure compliance with ambient air quality and dustfall standards at the property boundary.

Mitigation: Action/control	**Responsibility**	**Timeframe**
Establish a complaints register and/or incident reporting system where personnel, communities and adjacent landowners can lodge complaints regarding construction activities. Ideal location would be security post at point of site access.	EO and Plant Manager	Prior to commissioning
Regular maintenance and inspection of scrubber and acid plants as per original equipment manufacturer requirements.	EO and Plant Manager	During operations
Annual emissions monitoring campaign (as per conditions of the AEL), by independent contractor, on all stationary point sources.	EO, Contractor and Plant Manager	During operations
Annual emissions reporting (as per conditions of the AEL).	EO, Contractor and Plant Manager	During operations
Dust fallout sampling be conducted on the facility boundary in the four cardinal wind directions according to the ASTMD1739 standard method.	EO, Contractor and Plant Manager	During operations
Appropriate dust suppression measures on access road, including regularly sweeping and or wet suppression, to minimise particulate matter build-up.	EO and Plant Manager	During operations
All product haul vehicles to be road worthy and regularly maintained.	Transportation contractor(s) and EO	Duration of contract
All vehicles accessing the site during the operational phase must adhere to the designated speed limits on- and off-site.	Transportation contractor(s) and EO	Duration of contract

Investigate inadequate mitigation and control measures if monitoring or complaints potential issues are indicated by non-conformance with performance indicators.	EPC Contractor(s) and EO	During operations

Performance Indicator	Appropriate dust suppression measures are implemented during along access road, including the consideration of paving all on-site roads. No visible dust plumes from roads when in use or during high wind speed events.
	Drivers are aware of potential safety issues and strict enforcement of on-site speed limits when employed and when entering site.
	Vehicle roadworthy certificates and maintenance records for haul vehicles are made available prior to construction and updated regularly. No or minimal visible exhaust fumes during normal operation.
	Compliance with emission limits applicable to the process during normal operation.
	Compliance with National Dustfall Control Regulations based on dustfall sampling campaign.
Monitoring	The performance indicators listed above should be met during the operational phase by the responsible parties.
	Any potential or actual issues that could results in non-conformance with the performance indicator must be reported by on-site personnel to the Site Manager immediately.
	An incident reporting system must be used to record non-conformances to the EMPr.
	A complaints register must be used to record complaints from the public
	Annual emissions monitoring campaign (as per conditions of the AEL), by independent contractor, on all stationary point sources.
	Annual emissions reporting (as per conditions of the AEL).
	Dust fallout sampling be conducted on the facility boundary in the four cardinal wind directions according to the ASTMD1739 standard method.

12 CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of the dispersion modelling study, the specialist could find no reason from an air quality perspective why the project should not be authorised, assuming that the plant will be operated within the Section 21 limits for Subcategory 4.20 activities and best practice mitigation measures will be employed.

The following are recommended:

- Paving of all on-site roads. While the surface moisture content of unpaved roads can be increased with water bowsers, it is much easier to control the silt loading on paved roads.
- Regular sweeping of on-site paved roads to reduce silt loading on the road surface, higher silt loading results in higher vehicle entrainment emissions.
- Cleanup of all spillages to avoid re-entrainment by vehicles.
- Implementation of strict on site speed limits.
- Mitigation of crushing plant emissions. The design of the plant includes dust extraction and abatement with a bag house.
- Control of dust emissions from stockpiles during periods of high wind speeds, either by increasing moisture content of material with water sprays, or by decreasing wind speeds using enclosures or bund walls.
- Establishment of a complaints register before construction activities commenced, and maintained throughout the life of the project. Neighboring residents and business should be made aware of the means by which complaints can be lodged and recorded.
- Dust fallout sampling should be conducted on the facility boundary in the four cardinal wind directions.

13 REFERENCES

Amdur, MO (1978) Effects of Sulfur Oxides on Animals. Sulphur in the Environment. Part II: Environmental Impacts. John Wiley and Sons, Toronto. pp 61-74.

Bedi, J.F., Folinsbee, L.J. and Horvath, S.M. (1984). Pulmonary function effects of 1.0 and 2.0 ppm sulphur dioxide exposure in active young male non-smokers. J. Air Pollut. Control Assoc. 34: 1117-1121.

CEPA/FPAC Working Group. (1999). National Ambient Air Quality Objectives for Particulate Matter. Part 1: Science Assessment Document. Gatineau, Quebec: Canadian Environmental Protection Agency (CEPA) Federal-Provincial Advisory Committee (FPAC) on Air Quality Objectives and Guidelines.

CLRTAP, (2015). Mapping Critical Levels for Vegetation, Chapter III of Manual on methodologies and criteria for modelling and mapping critical loads and levels and air pollution effects, risks and trends. UNECE Convention on Long-range Transboundary Air Pollution; accessed on 2016/12/12 at www.icpmapping.org. (http://www.rivm.nl/media/documenten/cce/manual/binnenop17Juni/Ch3-MapMan-2016-05-03_vf.pdf)

Coppock, RW and Nostrum MS, (1997) Toxicology of oilfiend pollutants in cattle and other species. Alberta Research Council, ARCV97-R2, Vegreville, Alberta pp 45-114.

Corn M, Kotsko N, Stanton D, Bell W, Thomas AP (1972). Response of Cats to Inhaled Mixtures of SO2 and SO2-NaCl Aerosol in Air. *Arch. Environ. Health,* 24:248-256.

Costa, DL and MO Amdur. (1996) Air Pollution. In: Klaasen, CD, Amdur, MO, Doull, J (eds) *Casarett and Doull's Toxicology. The Basic Science of Poisons.* 5th ed. pp 857-882

Dockery, D. W., & Pope, C. A. (1994). Acute Respiratory Effects of Particulate Air Pollution. Annual Review of Public Health, 15, 107 - 132.

EPA. (1999). *Compilation of Air Pollution Emission (AP-42).* North Carolina: Environemntal Protection Agency.

DEA (2009) National Environmental Management: Air Quality Act, 2004 (ACT no 39 of 2004): National Ambient Air Quality Standards. Government Gazette 1210 of 2009.

DEA (2012) National Environmental Management: Air Quality Act, 2004 (ACT no 39 of 2004): List of activities which result in atmospheric emissions which have or may have a significant detrimental effect on the environment, including health, social conditions, economic conditions, ecological conditions or cultural heritage. Government Gazette 964 of 2012.

DEA (2014) National Environmental Management: Air Quality Act, 2004 (ACT no 39 of 2004): Regulations regarding air dispersion modelling. Government Gazette 589 of 2014).

Hanna SR., Egan BA. Purdum J and Wagler J (1999) Evaluation of the ADMS, AERMOD, and ISC3 Dispersion Models with the Optex, Duke Forest, Kincaid, Indianapolis, and Lovett Field Data Sets, International Journal of Environment and Pollution (Volume 16, Nos. 1-6, 2001).

Harmens H, Mills G, Hayes F, Williams P and De Temmerman L (2005), Air Pollution and Vegetation. The International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops Annual Report 2004/2005.

Hine CH, Meyers FH, Wright RW (1970). Pulmonary changes in animals exposed to nitrogen dioxide, effects of acute exposure. Toxicol Appl Pharmacol 1970;16:201-213.

Horstman, D.H., Seal, E.Jr., Folinsbee, L.J., Ives, P., Roger, L.J. (1988). The relationship between exposure duration and sulphur dioxide-induced bronchoconstriction in asthmatic subjects. Am. Ind. Hyg. Assoc. J. 49: 38-47.

OEHHA (2007). OEHHA Office of Environmental Health Hazard Assessment. 2007. http://www.oehha.ca.gov/air.html (Accessed 9 April 2014)

Meyers FH, Hine CH (1961). *Some experiences with nitrogen dioxide in animals and man*. Presented at the Fifth Air Pollution Medical Research Conferences, Dec. 4-7, 1961

Naidoo G and Chirkoot D (2004). The effects of coal dust on photosynthetic performance of the mangrove, Avicennia marina in Richards Bay, South Africa. Environmental Pollution 127 359–366.

Newman, JR and Schreiber (1984). Animals as Indicators of Ecosystem Responses to Air Emissions. *Environ. Mgmt.,* 8(4)309-324.

Reprotext® System (1999). Dabney BJ, editor. Denver (CO): Micromedex, Inc.

Ricks, GR, and RJH Williams (1974) *"Effects of atmospheric pollution on deciduous woodland part 2: effects of particulate matter upon stomatal diffusion resistance in leaves of Quercus petraes (Mattuschka) Leibl."* Environmental Pollution, 1974: 87–109.

Spencer S (2001). Effects of coal dust on species composition of mosses and lichens in an arid environment. Arid Environments 49, 843-853.

Stedman J R, Linehan E And King K (1999). *Quantification of the Health Effects of Air Pollution in the UK for the Review of the National Air Quality Strategy*, A Report produced for the Department of Environment, Transport and Regions, January 1999.

Von Burg, R (1995). Toxicological Update. *J .Appl. Toxicol 16(4):365-371*

WHO (2000). Air Quality Guidelines, World Health Organisation, Geneva.

14 ANNEXURE A

DECLARATION OF ACCURACY OF INFORMATION – APPLICANT

Name of Enterprise: ____

Declaration of accuracy of information provided:

Atmospheric Impact Report in terms of section 30 of the Act.

I, [*duly authorised*], declare that the information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality officer is a criminal offence in terms of section 51(1)(g) of this Act.

Signed at on this day of

SIGNATURE

CAPACITY OF SIGNATORY

15 ANNEXURE B

DECLARATION OF INDEPENDENCE - PRACTITIONER

Name of Practitioner: Nick Grobler

Name of Registration Body: Institution of Chemical Engineers

Professional Registration No.: 99963196 – Associate Member

Declaration of independence and accuracy of information provided:

Atmospheric Impact Report in terms of section 30 of the Act.

I, **Nick Brian Grobler** , declare that I am independent of the applicant. I have the necessary expertise to conduct the assessments required for the report and will perform the work relating the application in an objective manner, even if this results in views and findings that are not favourable to the applicant. I will disclose to the applicant and the air quality officer all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by the air quality officer. The information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality officer is a criminal offence in terms of section 51(1)(g) of this Act.

Signed at **Johannesburg** on this **17th** day of **March 2021**

SIGNATURE

Senior Air Quality Specialist
CAPACITY OF SIGNATORY

16 ANNEXURE C

CURRICULUM VITAE

Name	Nick Brian Grobler
Date of Birth	14 August 1986
Nationality	South African
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Senior Air Quality and Noise Specialist
Profession	Chemical Engineer employed as an Air Quality Specialist
Years with Firm	10 Years

Membership of Professional Societies

- Institution of Chemical Engineers (IChemE) – Associate Member – 2014 to present.
- Golden Key International Honour Society - 2011 to present.

Experience

- Project management, proposal preparation and project invoicing.
- Emissions inventory compilation. Proficient in quantifying emissions using:
- Engineering calculations, isokinetic and continuous stack sampling results, US EPA AP42 emission factors, Australian NPI emission factors, IPCC emission factors, ADDAS model (wind erosion), US EPA TANKS, Water9, GasSim.
- Meteorological, topographical and land use data processing and preparation.
- Dispersion modeling: experienced in SCREEN, AERMOD, ADMS, CALPUFF, SLAB and HAWK dispersion models.
- Proficient with the following specialist air quality / noise software: R, OpenAir, WRPlot, Surfer, ADDAS, TANKS, GasSim, CadnaA.
- Impact and compliance assessment.
- Air quality and dust management plan preparation.
- Air quality monitoring program design and implementation.
- Air quality monitoring set-up, training, processing and interpretation of:
- SO_2, NO_2, CO, CH_4, O_3, HCl, VOCs, BTEX, H_2S, NH_3, PAHs, PM_{10}, $PM_{2.5}$, dust fallout, salt deposition, chloride deposition and meteorological parameters.
- Environmental noise monitoring campaign design.
- Environmental noise monitoring and data processing.
- Noise source monitoring and sound power level estimation.
- Ground vibration and overblast monitoring and reporting.
- Compilation of noise source inventories.
- Noise impact and compliance assessments.
- Atmospheric Emission License application.
- Greenhouse gas emissions inventories and pollution prevention plan preparation.
- Experienced in the compilation of:
- Monthly, quarterly and annual air quality monitoring reports,
- Noise survey reports,
- Baseline, scoping and air quality impact assessment reports,
- Air quality management plans,
- Emission reduction plans, pollution prevention plans, greenhouse gas and climate change impact assessments
- Health impact assessments, odour assessments and radiation studies.

- Online NAEIS (National Atmospheric Emissions Inventory System) and SAGERS (South African Greenhouse Gas Emissions Reporting System) completion and submission.
- Industry sectors in which experience have been gained with specific reference to air quality include:
- Opencast and underground mining of: copper, platinum, chrome, gold, iron, coal, limestone, potash, graphite, lead, mineral sands, aggregate stone, clay and zinc.
- Production of: copper, platinum, PGM metals, gold, base metals, iron, steel, coal, coke, heavy mineral sands, vanadium, solder, lime, urea, chrome, gypsum, asphalt, acetylene, LNG liquefaction, vegetable oil, fertilizer, explosives, wood pulp, cement, grease, oil recycling, tyre and general waste pyrolysis, power generation, fuel storage as well as crematoriums, general waste landfills, meat processing and rendering at abattoirs and animal waste incineration.

Software Proficiency

- Atmospheric Dispersion Models: AERMOD, ISC, CALPUFF, ADMS (United Kingdom), HAWK, TANKS
- Other: Golden Software Surfer, Lakes Environmental WRPlot, MS Word, MS Excel, MS PowerPoint, Adobe Dreamweaver

Education

- BEng (Chemical Engineering) University of Pretoria – Completed in 2009
- BEng (Hons) (Environmental Engineering) University of Pretoria – Completed in 2010

Courses Completed

- Spreadsheets as an Engineering Tool, Presented by the University of Pretoria, RSA (September 2012)

Courses Presented

- NWU Centre for Environmental Management Essential Air Quality Management Course
- North-West University Centre for Environmental Management Integrated Waste Law Course – Air Quality Aspects

Countries of Work Experience

South Africa, Zimbabwe, Namibia, Mozambique, Zambia, Democratic Republic of Congo, Republic of Congo, Ghana, Mali, Guinea, Saudi Arabia

Languages

Language	Proficiency
English	Full proficiency
Afrikaans	Full proficiency

17 ANNEXURE D: IMPACT ASSESSMENT METHODOLOGY

Direct, indirect and cumulative impacts of the issues identified through the EIA process, as well as all other issues identified due to the amendment must be assessed in terms of the following criteria:

» The **nature**, which shall include a description of what causes the effect, what will be affected and how it will be affected.
» The **extent**, wherein it will be indicated whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high):
» The **duration**, wherein it will be indicated whether:
  * the lifetime of the impact will be of a very short duration (0–1 years) – assigned a score of 1;
  * the lifetime of the impact will be of a short duration (2-5 years) - assigned a score of 2;
  * medium-term (5–15 years) – assigned a score of 3;
  * long term (> 15 years) - assigned a score of 4; or
  * permanent - assigned a score of 5;
» The **consequences (magnitude)**, quantified on a scale from 0-10, where 0 is small and will have no effect on the environment, 2 is minor and will not result in an impact on processes, 4 is low and will cause a slight impact on processes, 6 is moderate and will result in processes continuing but in a modified way, 8 is high (processes are altered to the extent that they temporarily cease), and 10 is very high and results in complete destruction of patterns and permanent cessation of processes.
» The **probability** *of occurrence*, which shall describe the likelihood of the impact actually occurring. Probability will be estimated on a scale of 1–5, where 1 is very improbable (probably will not happen), 2 is improbable (some possibility, but low likelihood), 3 is probable (distinct possibility), 4 is highly probable (most likely) and 5 is definite (impact will occur regardless of any prevention measures).
» the **significance**, which shall be determined through a synthesis of the characteristics described above and can be assessed as low, medium or high; and
» the **status**, which will be described as either positive, negative or neutral.
» the degree to which the impact can be reversed.
» the degree to which the impact may cause irreplaceable loss of resources.
» the *degree* to which the impact can be *mitigated.*

The **significance** is calculated by combining the criteria in the following formula:

S = (E+D+M)P

S = Significance weighting

E = Extent

D = Duration

M = Magnitude

P = Probability

The **significance weightings** for each potential impact are as follows:

» < 30 points: Low (i.e. where this impact would not have a direct influence on the decision to develop in the area),

- 30-60 points: Medium (i.e. where the impact could influence the decision to develop in the area unless it is effectively mitigated),
- > 60 points: High (i.e. where the impact must have an influence on the decision process to develop in the area).

Assessment of impacts must be summarised in the following table format. The rating values as per the above criteria must also be included. The table must be completed and associated ratings for **each** impact identified during the assessment should also be included.

Example of Impact table summarising the significance of impacts (with and without mitigation):

Nature: **[Outline and describe fully the impact anticipated as per the assessment undertaken]**		
	Without mitigation	**With mitigation**
Extent	High (3)	Low (1)
Duration	Medium-term (3)	Medium-term (3)
Magnitude	Moderate (6)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	**Medium (36)**	**Low (24)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	Yes
Mitigation: "Mitigation", means to anticipate and prevent negative impacts and risks, then to minimise them, rehabilitate or repair impacts to the extent feasible. Provide a description of how these mitigation measures will be undertaken keeping the above definition in mind.		
Cumulative impacts: "Cumulative Impact", in relation to an activity, means the past, current and reasonably foreseeable future impact of an activity, considered together with the impact of activities associated with that activity, that in itself may not be significant, but may become significant when added to existing and reasonably foreseeable impacts eventuating from similar or diverse activities[2].		
Residual Risks: "Residual Risk", means the risk that will remain after all the recommended measures have been undertaken to mitigate the impact associated with the activity (Green Leaves III, 2014).		

[2] Unless otherwise stated, all definitions are from the 2014 EIA Regulations (as amended on 07 April 2017), GNR 326.