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ATMOSPHERIC IMPACT REPORT: Hyperion 75 MW Thermal Dual Fuel Power Generation Facility, near Kathu, Northern Cape Province

Project done on behalf of **Savannah Environmental (Pty) Ltd**
on behalf of **Hyperion Solar Development (Pty) Ltd.**

Project Compiled by:
T Bird

Reviewed by:
L Burger

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Report Details

Project Name	Atmospheric Impact Report: Hyperion 75 MW Thermal Dual Fuel Power Generation Facility, near Kathu, Northern Cape Province
Client	Savannah Environmental (Pty) Ltd
On behalf of	Hyperion Solar Development (Pty) Ltd
Report Number	20SAV10
Report Version	Revision 1
Date	February 2021
Prepared by	**Terri Bird**, (Pr.Sci.Nat), PhD (Wits) Dr (Theresa) 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) as well as coal-fired power station ash disposal facilities. She has been a team member on the development of Air Quality Management Plans, both provincial and for specific industries. Recent projects include assessing the impact of Postponement and/or Exemption of Emission Standards for various Listed Activities.
Reviewed by	Lucian Burger, (Pr.Eng., FSACheE, FIChemE), PhD (Natal), MScEng (Chem) BScEng (Chem)
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.
Declaration	I, Theresa (Terri) Bird, as authorised representative of Airshed Planning Professionals (Pty) Ltd hereby confirm my independence as a specialist and declare that neither I nor Airshed Planning Professionals (Pty) Ltd have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of which Airshed Planning Professionals (Pty) Ltd was appointed as air quality specialists in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998); other than fair remuneration for worked performed, specifically in connection with the assessment summarised in this report. I also declare that I have expertise in undertaking the specialist work as required, possessing working knowledge of the acts, regulations and guidelines relating to the application. I further declare that I am able to perform the work relating to the application in an objective manner, even if this result in views and findings that is not favourable to the application; and that I am confident in the results of the studies undertaken and conclusions drawn as a result of it – as is described in this report.
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Revision Record

Revision Number	Date	Reason for Revision
Draft	02 February 2021	First draft for client review
Revisions 1	05 February 2021	Minor text updates based on client comments

Abbreviations

AEL	Atmospheric Emissions Licence
AIR	Atmospheric Impact Report
Airshed	Airshed Planning Professionals (Pty) Ltd
AMS	American Meteorological Society
AQMS	Air Quality Monitoring Stations
AQO	Air Quality Officer
AQSRs	Air Quality Sensitive Receptors
ASTM	American Society of the International Association for Testing and Materials
CLRTAP	Convention on Long Range Trans-boundary Air Pollution
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
DEFF	Department of Environment, Forestry and Fisheries
EMP	Environmental Management Programme
GHG	Greenhouse gases
IPCC	Intergovernmental Panel on Climate Change
IPP Office	Independent Power Producer Office
LPG	Liquified Petroleum Gas
MES	(National) Minimum Emission Standard(s) (as defined in Section 21 of the National Environmental Management: Air Quality Act)
NAAQ limit value	National Ambient Air Quality limit value
NAAQS	National Ambient Air Quality Standards (as a combination of the NAAQ Limit and the allowable frequency of exceedance)
NEM:AQA	National Environmental Management: Air Quality Act 2004
NDCR	National Dust Control Regulations
PV	Photovoltaic
RMIPPPP	Risk Mitigation Independent Power Producer Procurement Programme
UNECE	United Nations Economic Commission for Europe
US EPA	United States (of America) Environmental Protection Agency
UTM	Universal Transverse Mercator
WRF	Weather Research and Forecasting model

Glossary

Air pollution[(a)]	The presence of substances in the atmosphere, particularly those that do not occur naturally
Dispersion[(a)]	The spreading of atmospheric constituents, such as air pollutants
Dust[(a)]	Solid materials suspended in the atmosphere in the form of small irregular particles, many of which are microscopic in size
Frequency of exceedance	Permissible margin of tolerance of the Limit Concentration
Instability[(a)]	A property of the steady state of a system such that certain disturbances or perturbations introduced into the steady state will increase in magnitude, the maximum perturbation amplitude always remaining larger than the initial amplitude
Limit value	Maximum allowable concentration of a pollutant applicable for an applicable averaging period
Mechanical mixing[(a)]	Any mixing process that utilizes the kinetic energy of relative fluid motion
Oxides of nitrogen (NO_x)	The sum of nitrogen oxide (NO) and nitrogen dioxide (NO_2) expressed as nitrogen dioxide (NO_2)
Particulate matter (PM)	Total particulate matter, that is solid matter contained in the gas stream in the solid state as well as insoluble and soluble solid matter contained in entrained droplets in the gas stream
$PM_{2.5}$	Particulate Matter with an aerodynamic diameter of less than 2.5 µm
PM_{10}	Particulate Matter with an aerodynamic diameter of less than 10 µm
Stability[(a)]	The characteristic of a system if sufficiently small disturbances have only small effects, either decreasing in amplitude or oscillating periodically; it is asymptotically stable if the effect of small disturbances vanishes for long time periods
Standard	A combination of the Limit Concentration and the allowable frequency of exceedance

Notes:

(a) Definition from American Meteorological Society's glossary of meteorology (AMS, 2014)

Symbols and Units

°C	Degree Celsius
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
g	Gram(s)
g/m^2	Grams per square metre
g/s	Grams per second
$g/s.m^2$	Grams per second per square metre
HAP	Hazardous air pollutants
kg	Kilograms
kg/day	Kilograms per day
km	Kilometre
kPa	Kilopascal
kV	Kilo Volt
kW	Kilo Watt
K	Temperature in Kelvin
1 kilogram	1 000 grams
m	Metre
m/s	Metres per second
mamsl	Metres above mean sea level
µg	Microgram(s)
$µg/m^3$	Micrograms per cubic metre
m^2	Square metre
m^3	Cubic metre
m^3/hr	Cubic metre per hour
$mg/m^2.day$	Milligram per square metre per day
mg/m^3	Milligram per (actual) cubic metre
mg/Nm^3	Milligram per normal cubic metre (normalised at 273 K; 101.3 kpa)
MW	Mega Watt
NO	Nitric oxide
N_2O	Nitrous oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
O_2	Oxygen
O_3	Ozone
ppm	Parts per million
PM	Particulate matter
$PM_{2.5}$	Inhalable particulate matter (aerodynamic diameter less than 2.5 µm)
PM_{10}	Thoracic particulate matter (aerodynamic diameter less than 10 µm)
SO_2	Sulfur dioxide
t/a	Tonnes per annum
TSP	Total suspended particulates
(T)VOCs	(Total) volatile organic compounds

Note:
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)"

EXECUTIVE SUMMARY

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Savannah Environmental (Pty) Ltd (Savannah) to undertake an Atmospheric Impact Report (AIR) for the Hyperion 75MW Thermal Dual Fuel Power Generation Facility near Kathu, Northern Cape Province. The AIR will be used in support of the application for an Atmospheric Emissions License (AEL) under the National Environmental Management: Air Quality Act, 2004 (AQA) and an environmental authorisation (EA) under the National Environmental Management Act, 1998 (NEMA) addressing the impact significance rating as required by the environmental authorisation process. The plant will use liquified petroleum gas (LPG) delivered to site by tanker truck for thermal generation of electricity in reciprocating engines. The LPG will be stored in on-site pressure vessels. The plant will include gas engines, exhaust stacks, water demineralisation plant, LPG storage, ancillary infrastructure, offices and other buildings. thermal generation plant that will work in combination with the authorised Hyperion 1 and 2 Solar Energy Facility complexes.

Baseline air quality at the site was assessed for thoracic particulates (with a diameter less than 10 µm – PM_{10}), inhalable particulates (with an aerodynamic diameter less than 2.5 µm – $PM_{2.5}$), sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) using data for the period 2018 to 2020, from the Karoo monitoring stations managed by the Department of Environment, Fisheries and Forestry. Compliance with hourly, daily and annual compliance with National Ambient Air Quality Standards (NAAQS) for all pollutants assessed across the period assessed. In addition, ambient PM_{10} concentrations at two monitoring stations near the iron ore mine (approximately 17 km south-west of the proposed thermal power generation facility) were included and indicate elevate particulate concentrations close to the mining operations.

The impact of the project on ambient air quality was simulated using the United States Environmental Protection Agency (US EPA) AERMOD modelling suite. Simulated meteorological data for the project area was acquired for the period 2017 to 2019. The wind field showed generally north to north-easterly dominance. The assessment of the impact of the project assumed that emissions from the power station would primarily be vented to the atmosphere via the exhaust stacks where the emissions would meet the minimum emission standards (MES) for Subcategory 1.5 – Reciprocating Engine facilities using gas. Simulated pollutant concentrations were compared against the NAAQS and various environmental screening levels for ecosystem impacts. Simulated nuisance dust-fall rates were compared against the National Dust Control Regulations (NDCR) for non-residential and residential areas.

The main findings of the simulated incremental assessment were:

1. During the construction phase, compliance with NAAQS for PM_{10} and NDCR for daily dustfall rates is likely.
    a. A "**low**" rating was determined for the impact associated with the construction phase of the project.
2. Compliance with hourly, daily, and annual NAAQS under normal operations is likely across the domain and at the receptors for NO_2, particulate matter, (PM_{10} and $PM_{2.5}$), and carbon monoxide (CO).
3. The MES scenario showed simulated SO_2 concentrations above the hourly and daily NAAQ limit values up to 250 m and 180 m off-site, respectively but not at any receptors. Annual concentrations were simulated to be lower than the NAAQS across the domain.
4. It is unlikely that gas combustion will result in SO_2 emissions at the emission standard and therefore the facility's impact on SO_2 was also assessed using mass balance calculations for LPG boilers using actual sulfur content of the fuel (0.014%)
    a. Compliance the NAAQS was simulated for hourly, daily, and annual average SO_2.
5. The impact of the facility was simulated to be below the NDCR.

   a. However, mitigation measures for control vehicle entrainment dust emissions are recommended along the delivery route, especially near the homesteads.
6. The United Nations Economic Commission for Europe (UNECE) Convention on Long Range Trans-boundary Air Pollution Limits) critical levels were used to assess the potential for impact of annual SO_2 and NO_2 concentrations on vegetation via various measures of productivity and reproductive success.
   a. Impacts to vegetative productivity are unlikely due to the thermal power generation facility across in the domain or at any receptors.
7. A "**medium**" rating was determined for the impact of criteria air pollutants associated with the normal operation of the project. The impact could be reduced to "**low**" with additional mitigation to along the access road.
8. Cumulative impact of the proposed thermal power generation facility and the other sources in the area are likely to be compliant with the NAAQS.
   a. A "**low**" rating was determined for the mitigated impact of the project in isolation and "**medium**" in the context of other air pollution sources in the vicinity.
9. Annual greenhouse gas (GHG) emissions for the operational phases of the plant were estimated to represent 0.026% of the published South African National 2015 GHG Inventory, contributing to the Energy sector.
   a. A "**medium**" rating was determined for the GHG emissions associated with the project.

From an air quality perspective, it is the opinion of the specialist that the Hyperion 75 MW Thermal Power Generation Facility be authorised and licensed to operate, on condition that:

- Emissions be monitored as per standard practice for the appropriate listed activity;
- Emissions are maintained at or lower than the Minimum Emission Standards appropriate for the listed activity;
- Conformance with the other environmental management programme requirements for air quality (Appendix C) are met.

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NEMA Regulations (2014, as amended) - Appendix 6	Relevant section in report
Details of the specialist who prepared the report.	Report Details (page i)
The expertise of that person to compile a specialist report including curriculum vitae.	Appendix D
A declaration that the person is independent in a form as may be specified by the competent authority.	Report Details (page i)
An indication of the scope of, and the purpose for which, the report was prepared.	Preface (page 1)
An indication of quality and age of base data used.	Sections 5.1.3, 5.1.4 and 5.1.5
A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change.	Sections 5.1.3, 5.1.4 and 5.1.5 Sections 5.1.6 and 5.1.7 Section 5.1.2.2
The date and season of the site investigation and the relevance of the season to the outcome of the assessment.	Description of the current land use in the region, simulations undertaken for the proposed operations and meteorological data included used in the study are considered representative of all seasons.
A description of the methodology adopted in preparing the report or carrying out the specialised process.	Section 5.1.1
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure.	Section 5.1.6
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 1.3 and 2.2
A description of any assumptions made and any uncertainties or gaps in knowledge.	Preface (page 2)
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment.	Sections **Error! Reference source not found.**, 5.2, and 5.3
Any mitigation measures for inclusion in the EMPr.	Sections 5.4 and Appendix C
Any conditions for inclusion in the environmental authorisation	Sections 5.5
Any monitoring requirements for inclusion in the EMPr or environmental authorisation.	Sections 5.4 and Appendix C
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised.	Sections 5.5
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 EMPr, and where applicable, the closure plan.	Not applicable.
A description of any consultation process that was undertaken during the course of carrying out the study.	Not applicable.
A summary and copies if any comments that were received during any consultation process.	Draft; not yet received.
Any other information requested by the competent authority.	None

PREFACE

Background and Context

Hyperion Solar Development (Pty) Ltd proposed the development of a 75 MW thermal dual fuel power generation facility, near Kathu in the Northern Cape Province. Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Savannah Environmental (Pty) Ltd (Savannah) to assess the potential impacts on the atmospheric environment by compiling an Atmospheric Impact Report (AIR) for the gas to power plant (hereafter referred to as 'the project') in support of the application for an Atmospheric Emissions License (AEL) under the National Environmental Management: Air Quality Act, 2004 (AQA) and an environmental authorisation (EA) under the National Environmental Management Act, 1998 (NEMA) addressing the impact significance rating as required by the environmental authorisation process. The plant will use liquified petroleum gas (LPG) delivered to site by tanker truck for thermal generation of electricity in reciprocating engines. The LPG will be stored in on-site pressure vessels. The plant will include gas engines, exhaust stacks, water demineralisation plant, LPG storage, ancillary infrastructure, offices and other buildings. thermal generation plant that will work in combination with the authorised Hyperion 1 and 2 Photovoltaic (PV) Solar Energy Facility (SEF) complex. The format of the assessment meets the prescribed format of an AIR, as set out in the Regulations gazetted on 11th of October 2013 (Gazette No. 36904 and amendments in Gazette No. 38633 R284 of 2nd April 2015). The report includes a statement of climate change impacts (Section 5.3).

Terms of Reference for the Atmospheric Impact Report

The Terms of Reference, as a list of tasks, to prepare the AIR and Climate Change Impact Statement will include:

1. A review and identification of legal requirements pertaining to air quality;
2. A desktop study of the receiving atmospheric environment (baseline) including:
    - the identification of air quality sensitive receptors;
    - an analysis of regional climate and site-specific atmospheric dispersion taking into account local meteorology, land-use and topography; and
    - and analysis and assessment of existing (baseline) ambient air quality.
3. The establishment of the facility's emissions inventory;
4. Atmospheric dispersion simulations of the expanded operational phase of the facility;
5. A human health risk and nuisance impact screening assessment based on dispersion simulation results;
6. Compile a Climate Change Impact Statement in line with the Equator Principles IV for Climate Change Risk Assessments, by:
    - Identifying of the Transitional and Physical Risks associated with the project (as per the Task Force on Climate-related Financial Disclosures.
    - Quantifying the greenhouse gas (GHG) emissions during the construction and operation of the project compared to the global and national emission inventories; and compared to international benchmarks for the project.
    - Discussing the robustness of the project in terms of forecasted climate change impacts to the area over the lifetime of the project.
    - Discussing the vulnerability of communities in the immediate vicinity of the project to climate change.
    - Proposing management and mitigation strategies.
    - Including this information as a section in the AIR, already in preparation, to support the AEL application for this facility.

7. Preparation of an AIR in the prescribed format, to support the application for an Atmospheric Emissions License (AEL).

Management of Uncertainty

The following assumptions, exclusions, and limitations are applicable to the assessment:

1. The AIR is limited to the proposed thermal power generation facility during construction and normal operation only.
2. The thermal power generation facility impact was estimated to operate 16.5 hours per day (05:00 to 21:30), 7 days per week to meet mid-merit electricity demands (as per the conditions of the Risk Mitigation Independent Power Producer Procurement Programme (RMIPPPP) administered by the Independent Power Producer Office (IPP Office).
3. Emergency events were assumed to result in engine unit or plant shut down. No alternative fuel is proposed for use during emergency events. No suboptimal operation of the plant is therefore anticipated under emergency conditions. Health and safety programmes and controls of the plant are to be implemented as per industry best practice, including monitoring, controls and maintenance of fuel handling and storage, as well as general plant operation for the facility lifetime.
4. The parameters of exhaust stacks were provided by the Original Equipment Manufacturer via Hyperion Solar Development (Pty) Ltd.
5. Building downwash was not included after screening of the relative distances between buildings and generator units compared with Good Engineering Practice guidelines.
6. It is planned that LPG will be delivered by tanker truck during operational hours of the plant. Delivery of LPG was assumed to be via tanker truck (engine capacity 324 kW, 44 tonne tanker capacity, with a maximum of 44 trips per week). A load factor for actual time vehicles use the access road for delivery of fuel: 0.5 (30 minute per hour at a speed of 40 kilometres/hour). Vehicles off-loading LPG were assumed to be powered off (i.e. no idling).
7. Silt loading on the sealed access road as assumed to be 2 g/m² due to the semi-arid savanna with low vegetation cover, sandy nature of soils, and frequency of high wind speeds resulting in increased silt loading on road surfaces.
8. On-site LPG storage will be in pressure vessels. Fugitive emissions from the delivery of LPG, as well as ventilation emissions from storage tanks, pipework and fittings, are expected to be controlled through proper safety systems as well as regular maintenance and repair protocols. The emissions are therefore expected to be negligible and were not quantified.
9. It was assumed that the addition of odourants (such as mercaptan) will be added at the point of manufacture or distribution. No additional odourants will be added at the point of use.
10. The sulfur content of the LPG was assumed to be 0.014% (140 ppm).
11. Dispersion model setup included simulated (Weather Research and Forecasting model) meteorological data for the period 2017 to 2019.
12. The baseline air quality was described based on measured air pollutant concentrations (2018 to 2020) based on data from the Karoo monitoring stations managed by the Department of Environment, Fisheries and Forestry and supplemented with publicly available data for ambient PM_{10} concentrations at two monitoring stations near the iron ore mine (approximately 17 km south-west of the proposed thermal power generation facility).
13. Other sources in the domain were not re-quantified.

1 ENTERPRISE DETAILS

1.1 Enterprise Details

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

Table 1-1: Enterprise details

Enterprise Name	Hyperion Solar Development (Pty) Ltd
Trading as	N/A
Type of Enterprise	Private Company
Company Registration Number	2015/236590/07
Registered Address	14th floor, Pier Place, Heerengracht Street, Cape Town, 8001, SOUTH AFRICA
Telephone Number (General)	+27 (0)21 418 3940
Industry Type/Nature of Trade	Electricity Generation
Land Use Zoning as per Town Planning Scheme	Agricultural, however the project area is being rezoned to Special Use zoning.
Land Use Rights if Outside Town Planning Scheme	n/a

Table 1-2: Contact details of responsible person

Responsible Person	Matteo Brambilla
Telephone Number	+27 (0)21 418 3940
Cell Number	+27 (0)72 212 1531
Fax Number	N/A
Email Address	m.logan@redrocket.energy
After Hours Contact Details	+27 (0)72 212 1531

1.2 Location and Extent of the Plant

Table 1-3: Location and extent of the plant

Physical Address of the Plant	n/a
Description of Site (Where no Street Address)	Remainder of Farm Lyndoch 432 (with the T26 Vlermuisleegde access road affecting Farm Cowley) 15 km north of Kathu in the Northern Cape Province
Coordinates of Approximate Centre of Operations	Latitude: 27.554334° S Longitude: 23.064714° E
Extent	Property: 1 610 ha Hyperion 1 and 2 solar areas: ~351 ha Thermal power generation facility and associated infrastructure: 5 ha
Elevation Above Sea Level	1182 metres above mean sea level
Province	Northern Cape
Metropolitan/District Municipality	John Taolo Gaetsewe District Municipality
Local Municipality	Gamagara Local Municipality
Designated Priority Area	None

1.3 Description of Surrounding Land Use (within 5 km radius)

The project's proposed location is on the Remainder of Farm Lyndoch 432 (with the T26 Vlermuisleegde access road affecting Farm Cowley) 15 km north of Kathu in the Northern Cape Province (Figure 1-1). The surrounding land-use is predominantly small animal stock farming. Existing pollutant sources in the vicinity include: wind-blown dust from exposed or unvegetated areas; fugitive particulate matter entrainment by vehicles travelling on paved and unpaved roads; while further from site there are iron-ore and manganese mining operations; and, construction of solar power facilities.

The National Ambient Air Quality Standards (NAAQS) (detailed in Section 5.1.2.2) are based on human exposure to specific criteria pollutants and as such, sensitive receptors were identified where the public is likely to be unwittingly exposed. NAAQS are enforceable outside of the property boundary of the licensed facility, therefore the sensitive receptors identified (Table 1-4) included the nearby residential areas, hospitals and schools. There are 3 individual homesteads within 5 km of the proposed facility and 17 homesteads within 10 km of the proposed facility. Nearby residential areas include Kathu (south 15 km), Sesheng (south west 16 km), and Deben (west 20 km).

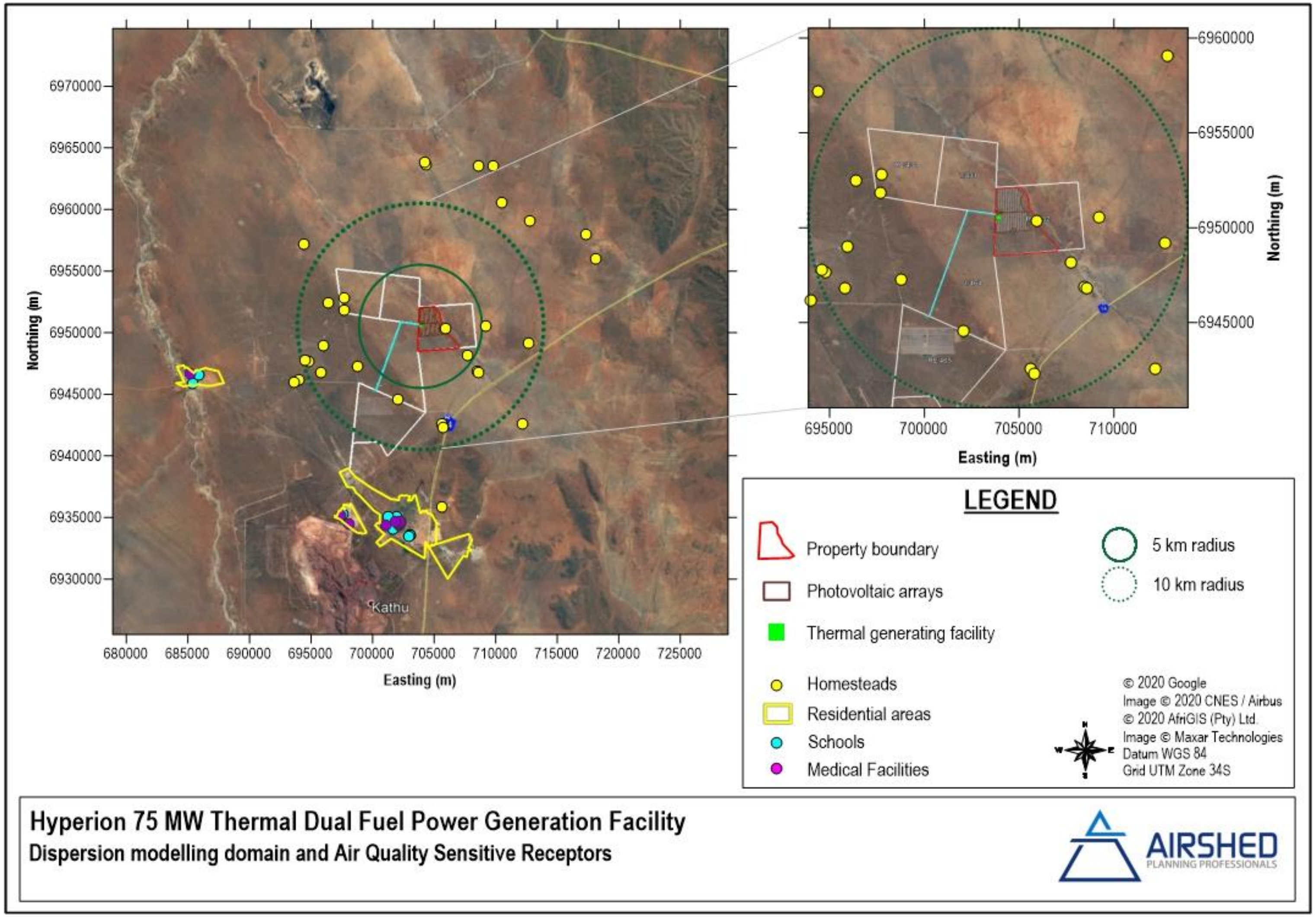

Figure 1-1: Location of the project in relation to the air quality sensitive receptors (AQSRs)

Table 1-4: Distance to the air quality sensitive receptors

Receptor name / details	Distance from proposed site (km)	Direction from proposed site
SR1	2.0	E
SR4	4.5	ESE
SR2	5.3	E
SR5	5.8	SE
SR12	6.0	SE
SR7	6.1	WSW
SR6	6.2	SSW
SR8	6.3	WNW
SR10	6.6	WNW
SR9	7.8	WNW
SR11	8.1	W
SR14	8.1	SSE
SR15	8.4	SSE
SR3	8.9	E
SR20	8.9	WSW
SR21	9.5	WSW
SR22	9.7	WSW
SR18	10.8	WSW
SR19	11.2	WSW
SR13	11.4	SE
SR17	11.6	NW
SR23	12.1	NNE
SR24	12.3	NE
SR29	13.1	N
SR30	13.3	N
SR28	13.9	NNE
SR27	14.3	NNE
SR16	14.7	S
SR26	15.2	ENE
SR25	15.4	ENE
Kathu High School	15.5	S
Tanelle Se Creche	15.7	S
UGM Clinic	15.9	S
Family Health Centre Kathu	16.0	S
Kathu Family Care Clinic	16.0	S
Kathu Medi-Clinic	16.0	S
Lenmed Kathu Private Hospital	16.2	S
Life Occupational Health - Assmang Ltd Khumani Mines Clinic	16.2	S
Kathu Clinic	16.4	S
Mpelega Pre-Primary School	16.5	SSW
Kathu Primary School	16.6	S
Sishen Intermediate Mine School	16.6	SSW
Sishen Occupational Health Clinic	16.7	SSW
Curro Kathu Independent School	16.9	S

Receptor name / details	Distance from proposed site (km)	Direction from proposed site
Curro Castle Kathu	16.9	S
Sishen Primary School	17.1	S
Unjani Clinic Kathu	17.1	SSW
Deben Primêre Skool	18.4	WSW
Hoerskool Gamagara	19.1	WSW
Jan Witbooi Clinic	19.1	WSW
Dingleton Clinic	26.9	SSW
Sishen Primary School	27.8	SSW

1.4 Atmospheric Emission Licence and other Authorisations

The project is a new facility and does not yet have an AEL. As an LPG-fired power station with design capacity greater than 10 MW heat input per unit, the project will require an AEL to operate (Subcategory 1.5; Section 21 of the National Environmental Management: Air Quality Act (NEM:AQA)). Emissions from the thermal power generation facility will be required to comply with the new plant Minimum Emission Standards (MES).

2 NATURE OF THE PROCESS

2.1 Listed Activities

All potential listed activities, as per Section 21 of NEM:AQA, for the project are given in Table 2-1.

Table 2-1: Listed activities at the project

Section 21 Subcategory	Listed Process Description:
1.5	Reciprocating engines
2.4	Storage and Handling of Petroleum Products

2.2 Process Description

The proposed facility will include a hybrid facility consisting of a dispatchable thermal generation plant that will work in combination with the authorised Hyperion PV1 and PV Solar Energy Facility (SEF) complexs. The power generated by the thermal facility and authorised Hyperion PV facility complex will connect via an overhead 132 kV power line to the Kalbas substation. The thermal generation plant will include the following infrastructure:

- Reciprocating Engines;
- Access road;
- Truck entrance and parking facility;
- Regasification plant;
- Dry cooling system;
- Fuel off-loading facility;
- Fuel storage facility;
- Water demineralisation plant;
- Substation[1], O&M building, fencing, warehouses and workshops.

From an air quality perspective, the project involves the installation and operation of 12 reciprocating engines (in two blocks of six) with total installed generating capacity of 75 MW. The operation of the power station will use reciprocating engines combusting LPG to generate electricity. Each engine is proposed to have a 27.5-metre-high stack to discharge combustion gases into the atmosphere.

Primary pollutants from gas engines will be oxides of nitrogen (NO_x), carbon monoxide (CO), and, to a lesser extent, volatile organic compounds (VOCs), and particulate matter (PM). NO_x formation is strongly dependent on the high temperatures developed in the combustor. CO, VOC, PM, and hazardous air pollutants (HAP) are primarily the result of incomplete combustion. Trace to low quantities of HAP and sulfur dioxide (SO_2) are emitted from gas engines. SO_2 emissions are directly related to the sulfur content of the fuel (US EPA, 2000). In addition to the above, VOC emissions will also be released during fuel delivery (from vehicles, off-loading and transfers), however, equipment service and maintenance as well as proper safe use of equipment will minimise losses. Air pollutants associated with all phases of the facility are given in Table 2-2.

[1] PV SEF substation will be used

Table 2-2: Identified air quality aspects

Aspect or Project Phase	Expected Atmospheric Sources of Emissions and Associated Pollutants						Rationale
	Source	CO	NO_x	PM[(a)]	SO_2	VOC	
Construction Phase	Fugitive dust from civil and building work such as excavations, piling, foundations, and buildings	n/a	n/a	✓	n/a	n/a	The nature of emissions from construction activities is highly variable in terms of temporal and spatial distribution and is also transient. Daily construction activity detail regarding construction activities and equipment movements was not available; however, impact of construction was included in the study simulated using generalised emission factors for heavy construction for the construction area over the construction timeline for the facility. Fugitive dust emissions are however mostly generated by land-clearing and bulk earthworks.
	Exhaust gases from mobile diesel construction equipment and trucks delivering materials.	✓	✓	✓	✓	✓	
Operational Phase	Exhaust gases from the turbine units	✓	✓	✓	✓	✓	The project is designed to operate on LPG. The focus of the assessment is on the operation of the engine units since it triggers Subcategory 1.5 MES. Vehicle entrainment and exhaust emissions are likely during LPG delivery. Negligible fugitive losses of VOCs are expected during LPG delivery, from storage vessels, and from pipework and fittings.
	Exhaust gases from the boiler units	✓	✓	✓	✓	✓	
	Fuel delivery trucks exhaust gases	✓	✓	✓	✓	✓	
	LPG storage	n/a	n/a	n/a	n/a	✓	
Upset Conditions	Unstable combustion conditions within turbine units	✓	✓	✓	✓	✓	Incomplete combustion and unstable combustion temperatures may result in higher than normal PM, CO, NO_x and VOC emissions. SO_2 emissions are directly related to the sulfur content of the fuel and are unlikely to be affected by any upset condition of the power plant operation. Additional VOC emissions because of the LPG leaks may occur. Vehicle entrainment and exhaust emissions are also likely during LPG delivery and will reduce or be absent during shut-down events when fuel is not needed.
	Fuel delivery trucks exhaust gases	✓	✓	✓	✓	✓	
	LPG leaks	n/a	n/a	n/a	n/a	✓	
Regular Shutdowns	LPG storage	n/a	n/a	n/a	n/a	✓	During shutdowns there will not be any emissions from the engine units. Emissions from LPG handling, storage, pipework and fittings as per normal operations. Vehicle entrainment and exhaust emissions are also likely during LPG delivery, if required during shutdowns.
	Fuel delivery trucks exhaust gases	✓	✓	✓	✓	✓	
Decommissioning Phase	Fugitive dust from civil work such as rehabilitation and demolition.	n/a	n/a	✓	n/a	n/a	The nature of emissions from decommissioning activities is highly variable in terms of temporal and spatial distribution and is also transient. Detail regarding the extent of decommissioning activities and equipment movements was also not available for inclusion in the study. Fugitive dust emissions are however mostly generated by demolition and rehabilitation activities.
	Exhaust gases from diesel mobile equipment and trucks removing materials.	✓	✓	✓	✓	✓	

Notes:
(a) PM includes PM_{10} and $PM_{2.5}$
(b) n/a – not applicable

2.3 Unit Processes

The unit processes associated with the listed activities (as per Section 21 of NEM:AQA) for the project are listed in Table 2-3.

Table 2-3: The unit processes for the project (Section 21 Listed Activities)

Unit Process	Function of Unit Process	Batch or Continuous Process
Reciprocating Engines	Gas combustion to generate electricity	Continuous (16.5 hours per day; 7 days per week)
LPG storage	Storage of LPG for use in reciprocating engines	Continuous

3 TECHNICAL INFORMATION

Raw material consumption rates are tabulated in Table 3-1. The project has an installed generation capacity of up to 118 MW of electricity, with waste streams of combustion off-gases.

3.1 Raw Material Consumption Rates

Table 3-1: Raw materials used

Raw Material Type Alternatives	Design Consumption Rate (Quantity)	Units (quantity/period)
LPG	45 000	tonnes per annum

3.2 Production Rates

Table 3-2: Production rates

Production Name	Maximum Production Capacity Permitted (Quantity)	Design Production Capacity (Quantity)	Actual Production Capacity (Quantity)	Units (Quantity/Period)
Electricity	75	75	To be confirmed	MW

Table 3-3: By-products

By-Product Name	Maximum Production Capacity Permitted (Quantity)	Design Production Capacity (Quantity)	Actual Production Capacity (Quantity)	Units (Quantity/Period)
None				

4 ATMOSPHERIC EMISSIONS

The establishment of a comprehensive emissions inventory, for the project, formed the basis for the assessment of air quality impacts from the project operations on the receiving environment. All stack parameters were provided by the applicant.

The following sections describe the location and parameters of the individual sources associated with the project (as per the prescribed format of an AIR - Gazette No. 36904, 2013).

4.1 Point Sources

The thermal power generation facility is planned to have 12 reciprocating engines venting off-gases via 12 stacks, with a release height of 27.5 m. The maximum operating cycle of the facility, to meet mid-merit electricity demand, is 16.5 hours per day, 7 days per week. Normal operations are assumed to occur 99% of the operating cycle and were assessed in two emission scenarios: (1) at the Minimum Emission Standards (Table 4-2), and (2) using Australian National Pollution Inventory (NPI) emission factors for LPG boilers (Table 4-4), as representations of the maximum allowable emissions (without being considered an emergency) and typical operating emissions, respectively.

4.2 Fugitive Sources

Fugitive particulate emissions are likely to result from: vehicle exhaust and entrainment emissions during delivery of LPG. Fugitive emissions from the delivery of LPG, as well as ventilation emissions from storage tanks, pipework and fittings are expected to be controlled through proper safety systems as well as regular maintenance and repair protocols. The constituents of LPG (predominantly propane) are non-volatile[2]. The emissions are therefore expected to be negligible and were not quantified. Only emissions from LPG delivery activities were estimated as other traffic, during normal operations, was assumed to be of low volumes using cars and light delivery vehicles only.

4.3 Start-up, Shut down and Emergency Events

According to Section 21 of the NEM:AQA (Government Gazette No. 37054), 'normal operating condition' is defined as any condition that constitutes operation as designed; where, 'upset conditions' are defined as any temporary failure of air pollution control equipment or process equipment or failure of process to operate in a normal or usual manner that leads to an emission standard being exceeded. Section 21 of the NEM:AQA further expands that if normal start-up, maintenance, upset, and shut-down conditions exceed a period of 48 hours, Section 30 of the National Environmental Management Act (Act no. 107 of 1998) shall apply unless otherwise specified by the Licensing Authority. The MES (as per Section 21 of the AQA) (unless otherwise specified) are expressed on a daily average basis, under normal (reference) conditions of 273 K, 101.3kPa, specific oxygen percentage and dry gas.

The proposed project design will facilitate start-up in between 3 and 10 minutes and shut down in 1 minute, representing a total of 1.1% of the operating day. During these start-up and shut-down periods emissions may be higher than during normal operating conditions, however, the variance from normal operating conditions is dependent on type of start-up (hot, warm, or cold) and the pollutant of concern. For gas-fired power plants, emissions at lower generating loads (for example 50% load) are generally 1.5 to 15 times higher than those at full capacity (Gonzalez-Salazar, Kirsten, & Prchlik, 2018). Shut-down emissions can vary between 1.1 and 9.3 times higher than normal operating conditions (Obaid, Ramadan, Elkamel, & Anderson, 2017).

[2] US EPA Compendium Method TO-14A https://www3.epa.gov/ttn/amtic/files/ambient/airtox/to-14ar.pdf (accessed 24-07-2020)

No emergency events were included in the emissions estimations or simulations. It was assumed that operation beyond normal capacities and emissions would result in engine unit shutdown until normal operations can be restored. The facility will shut down immediately should reserve fuel be insufficient or any unforeseen circumstance indicate that normal operation is not feasible. A collision of LPG tanker trucks or explosion of the LPG storage tanks would also result in a voluntary shutdown of the facility with no emissions related the shutdown. A Major Hazard Installation assessment will be conducted when final plant design is available and will specifically include controls for fuel storage, leak detection and prevention of explosions related to the project. Regular maintenance, control and emergency prevention for the facility will thus be incorporated in the operational health and safety programme implemented during operation.

Table 4-1: Parameters for point sources of atmospheric pollutant emissions at the project

Point Source code	Source name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Height Above Nearby Building (m)	Effective Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m^3/hr)	Actual Gas Exit Velocity (m/s)
STK01	Engine Stack 1	-27.5536	23.06456	27.5	Minimum 12.5	1.25	380	81 083	18.4
STK02	Engine Stack 2	-27.5536	23.06456	27.5	Minimum 12.5	1.25	380	81 083	18.4
STK03	Engine Stack 3	-27.5536	23.06456	27.5	Minimum 12.5	1.25	380	81 083	18.4
STK04	Engine Stack 4	-27.5536	23.06459	27.5	Minimum 12.5	1.25	380	81 083	18.4
STK05	Engine Stack 5	-27.5536	23.06459	27.5	Minimum 12.5	1.25	380	81 083	18.4
STK06	Engine Stack 6	-27.5536	23.06459	27.5	Minimum 12.5	1.25	380	81 083	18.4
STK07	Engine Stack 7	-27.5536	23.06527	27.5	Minimum 12.5	1.25	380	81 083	18.4
STK08	Engine Stack 8	-27.5536	23.06526	27.5	Minimum 12.5	1.25	380	81 083	18.4
STK09	Engine Stack 9	-27.5536	23.06526	27.5	Minimum 12.5	1.25	380	81 083	18.4
STK10	Engine Stack 10	-27.5536	23.06529	27.5	Minimum 12.5	1.25	380	81 083	18.4
STK11	Engine Stack 11	-27.5536	23.06529	27.5	Minimum 12.5	1.25	380	81 083	18.4
STK12	Engine Stack 12	-27.5536	23.06529	27.5	Minimum 12.5	1.25	380	81 083	18.4

4.4 Point Source Emission Rates during Normal Operating Conditions - MES

Table 4-2: Atmospheric pollutant emission rates for the project (MES)

Point Source code	Pollutant Name	Maximum Release Rate				Emissions Hours	Type of Emissions (Continuous / Routine but Intermittent / Emergency Only)
		mg/Nm³	mg/Am³(a)	g/s	Averaging period		
MAIN 1-12	Particulates (PM)	50	20.9	0.47	Hourly	16.5 hours per day; 7 days per week	Continuous during operation
	Sulfur dioxide (SO_2)	1 170	489.3	11.03	Hourly	16.5 hours per day; 7 days per week	Continuous during operation
	Oxides of Nitrogen (NO_X)	400	167.3	3.77	Hourly	16.5 hours per day; 7 days per week	Continuous during operation

Note:
(a) Varies depending on actual temperature

Table 4-3: Point Source Emission Estimation Information during Normal Operating Conditions (MES)

Point Source code	Pollutants	Basis for Emission Rates
MAIN 1- 12	PM, SO_2, NO_X	Minimum Emission Standards for Subcategory 1.5 – Reciprocating Engines (gas fired) (as per Section 21 NEM:AQA)

4.5 Point Source Maximum Emission Rates during Normal Operating Conditions – based on emission factors

Table 4-4: Atmospheric pollutant emission rates for the project (Emission Factors)

Point Source code	Pollutant Name	Maximum Release Rate				Emissions Hours	Type of Emissions (Continuous / Routine but Intermittent / Emergency Only)
		mg/Nm³	mg/Am³(a)	g/s	Averaging period		
MAIN 1 - 12	Particulates	50	20.9	0.47	Hourly	16.5 hours per day; 7 days per week	Continuous during operation
	Sulfur dioxide (SO_2)	1.06	0.44	0.01	Hourly	16.5 hours per day; 7 days per week	Continuous during operation
	Oxides of Nitrogen (NO_X)	400	167.3	3.77	Hourly	16.5 hours per day; 7 days per week	Continuous during operation
	Carbon monoxide (CO)	120.96	50.58	1.14	Hourly	16.5 hours per day; 7 days per week	Continuous during operation

Note:
(a) Varies depending on actual temperature

Table 4-5: Point Source Emission Estimation Information during Normal Operating Conditions (Emission Factors)

Point Source code	Pollutants	Basis for Emission Rates
MAIN 1- 12	PM, NO_X	Minimum Emission Standards for Subcategory 1.5 – Reciprocating Engines (gas fired) (as per Section 21 NEM:AQA)
	SO_2, NOx, CO,	EMEP/EEA Air Pollutant Emission Inventory Guidebook (2019) NFR 1.A.1 Energy industries. Tier 2 Emission Factors for Gas-fired stationary reciprocating engines (Table 3-20)

Table 4-6: Area and/or line source parameters

Area Source code	Source name	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 (°)
PVRD1	Access road portion 1	Tanker trucks LPG delivery route on paved road	-27.5963933	23.1219336	0.5	300.5	9	-133.0
PVRD2	Access road portion 2		-27.5944414	23.1198213	0.5	328.8	9	-129.8
PVRD3	Access road portion 3		-27.5921932	23.1176482	0.5	282.4	9	-129.0

Area Source code	Source name	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 (°)
PVRD4	Access road portion 4		-27.5902411	23.1158095	0.5	229.1	9	-119.7
PVRD5	Access road portion 5		-27.5884639	23.114624	0.5	152.5	9	-137.5
PVRD6	Access road portion 6		-27.5875527	23.1134673	0.5	56.0	9	-158.6
PVRD7	Access road portion 7		-27.5873762	23.1129356	0.5	30.8	9	-147.2
PVRD8	Access road portion 8		-27.5872297	23.112671	0.5	44.7	9	-122.3
PVRD9	Access road portion 9		-27.5868926	23.1124228	0.5	31.6	9	-111.2
PVRD10	Access road portion 10		-27.5866287	23.1123022	0.5	131.8	9	-126.0
PVRD11	Access road portion 11		-27.5856791	23.1114983	0.5	104.4	9	-123.1
PVRD12	Access road portion 12		-27.584899	23.110905	0.5	227.9	9	-133.8
PVRD13	Access road portion 13		-27.5834406	23.1092782	0.5	110.2	9	-122.3
PVRD14	Access road portion 14		-27.5826096	23.1086658	0.5	268.5	9	-116.3
PVRD15	Access road portion 15		-27.5804557	23.1074216	0.5	169.7	9	-111.2
PVRD16	Access road portion 16		-27.5790375	23.1067738	0.5	391.4	9	-118.3
PVRD17	Access road portion 17		-27.5759578	23.1048339	0.5	124.3	9	-129.0
PVRD18	Access road portion 18		-27.5750983	23.1040257	0.5	114.6	9	-127.8
PVRD19	Access road portion 19		-27.5742919	23.1033	0.5	123.1	9	-132.0
PVRD20	Access road portion 20		-27.5734797	23.1024501	0.5	63.8	9	-133.1
PVRD21	Access road portion 21		-27.5730661	23.1020002	0.5	476.0	9	-124.8
PVRD22	Access road portion 22		-27.5695805	23.0991839	0.5	22.1	9	-137.2
PVRD23	Access road portion 23		-27.5694476	23.0990173	0.5	28.4	9	-169.1
PVRD24	Access road portion 24		-27.5694033	23.098734	0.5	322.4	9	175.4
PVRD25	Access road portion 25		-27.569684	23.0954848	0.5	3156.5	9	175.9
PVRD26	Access road portion 26		-27.5721735	23.0636458	0.5	27.7	9	-145.5
PVRD27	Access road portion 27		-27.5720354	23.0634123	0.5	28.9	9	-134.2
PVRD28	Access road portion 28		-27.5718513	23.0632047	0.5	1175.8	9	-87.9
PVRD29	Access road portion 29		-27.5612436	23.0634467	0.5	722.6	9	-88.9
PVRD30	Access road portion 30	Tanker trucks LPG delivery access loop	-27.5547235	23.0634706	0.5	0.9	9	-62.0

Area Source code	Source name	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 (°)
PVRD31	Access road portion 31		-27.5547161	23.0634748	0.5	87.0	9	-0.1
PVRD32	Access road portion 32		-27.5547014	23.0643553	0.5	27.6	9	1.0
PVRD33	Access road portion 33		-27.5547015	23.0646348	0.5	36.1	9	-45.7
PVRD34	Access road portion 34		-27.5544647	23.0648852	0.5	44.5	9	-0.6
PVRD35	Access road portion 35		-27.5544537	23.0653359	0.5	23.9	9	-1.0
PVRD36	Access road portion 36		-27.5544463	23.0655779	0.5	11.1	9	42.8
PVRD37	Access road portion 37		-27.5545129	23.0656614	0.5	10.3	9	86.4
PVRD38	Access road portion 38		-27.5546054	23.0656697	0.5	13.0	9	119.3
PVRD39	Access road portion 39		-27.554709	23.0656071	0.5	21.6	9	173.3
PVRD40	Access road portion 40		-27.5547349	23.0653901	0.5	50.3	9	179.1
TNK1	Pressure Vessel 1	Pressure vessel storage of LPG	-27.5548	23.0651	1	40	4.5	90
TNK2	Pressure Vessel 2		-27.55486	23.0651	1	40	4.5	90
TNK3	Pressure Vessel 3		-27.55493	23.0651	1	40	4.5	90
TNK4	Pressure Vessel 4		-27.5548	23.06554	1	40	4.5	90
TNK5	Pressure Vessel 5		-27.55486	23.06554	1	40	4.5	90
TNK6	Pressure Vessel 6		-27.55493	23.06554	1	40	4.5	90

Table 4-7: Area source emissions (vehicle exhaust and entrainment emissions)

Area Source code	Pollutant Name	Maximum Hourly Release Rate (g/s.m^2)	Maximum Daily Release Rate (kg/day)	Average Annual Release Rate (t/a)	Emission Hours (e.g. 07h00 – 17h00)	Type of Emission (Continuous / intermittent)	Wind Dependent (yes/no)
PVRD1-40	CO	4.91E-06	25.13	9.17	05:30 and 21:00	Intermittent	No
	NOx	1.15E-05	58.81	21.46			
	$PM_{2.5}$	1.59E-06	8.14	2.97			
	PM_{10}	2.62E-06	13.40	4.89			
	TSP	6.35E-06	32.49	11.86			
	SO_2	8.04E-09	0.04	0.02			
	VOC	5.22E-07	2.67	0.98			

Area Source code	Pollutant Name	Maximum Hourly Release Rate (g/s.m²)	Maximum Daily Release Rate (kg/day)	Average Annual Release Rate (t/a)	Emission Hours (e.g. 07h00 – 17h00)	Type of Emission (Continuous / intermittent)	Wind Dependent (yes/no)
TNK1-8	Hydrocarbons	Not quantified. Considered to be negligible.			05:30 and 21:00	Intermittent when unloading	No

Table 4-8: Area Source Emission Estimation Information

Area Source code	Basis for Emission Rates
PVRD1-40	US EPA AP 42, 5th Edition, Volume I, Chapter 13: Miscellaneous Sources, 13.2.1 Paved Roads (2011) using an assumed silt content of 2 g/m² for silt content for roads where anti-skid abrasive has been applied. Assuming: • 44 trips per week • Deliveries between 05:30 and 21:00 daily • Double tanker trucks carrying a payload of 44 tonnes of LPG per trip • Load factor for actual vehicle time using the access road for delivery of fuel: 0.5 (30 minutes per hour at a speed of 40 kilometres/hour).
	NPI single valued emission factors (NPI, 2008), assuming: • Sulfur content of diesel fuel was conservatively assumed to be 500 ppm • Engine capacity of horse pulling tankers – 324 kW • 44 trips per week • Deliveries between 05:30 and 21:00 daily • Load factor for actual vehicle time using the access road for delivery of fuel: 0.5 (30 minutes per hour at a speed of 40 kilometres/hour).

5 IMPACT OF ENTERPRISE ON THE RECEIVING ENVIRONMENT

5.1 Analysis of Emissions' Impact on Human Health

5.1.1 Study Methodology

The study methodology may conveniently 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
3. Review of Legal Requirements (e.g. dispersion modelling guideline)
4. Prepare a Plan of Study for Peer Review
5. Decide on Dispersion Model

The Regulations Regarding Air Dispersion Modelling (Gazette No 37804 published 11 July 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: require 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 & chemical transformations;
  - when conducting permitting and/or environmental assessment processes 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 O_3, particulate formation, visibility)

Due to the short distance to sensitive receptors (especially to the north of the operations) the assessment of impact as a result of emissions from the proposed thermal generation plant was considered to fall within the scope of a Level 2 assessment.

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 compared with the relevant ambient air quality standard or guideline. Post-processing can be carried out to produce contour plots that can be prepared for reporting purposes.

The following steps were followed for the execution phase of the assessment:

- Select appropriate meteorological data input;
- Prepare all meteorological model input files;
- Select control options in meteorological model;
- Review emissions inventory and ambient measurements;
- Decide on modelling domain and receptor locations;
- Prepare all dispersion model input files:
    - Control options,
    - Meteorology,
    - Source data,
    - Receptor grid and discrete receptors;
- Review all modelling input data files and fix where necessary;
- Simulate source groups per pollutant and calculate air concentration levels for regular and discrete grid locations for the operational phase of the project;
- Compare against National Ambient Air Quality Standards (NAAQS) and international guidelines;
- Preparation of draft AIR;
- Finalise the AIR.

5.1.1.1 AERMOD Modelling Suite

It was decided to employ the US Environmental Protection Agency's (US EPA) approved regulatory model, AERMOD. The most widely used US EPA model has been the Industrial Source Complex Short Term model (ISCST3). This model is based on a Gaussian plume model. However, this model has been replaced by the new generation AERMET/AERMOD suite of models. AERMOD is a dispersion model, which was developed under the support of the AMS/EPA Regulatory Model Improvement Committee (AERMIC), whose objective has been to include state-of the-art science in regulatory models (Hanna et al., 1999). The AERMOD is a dispersion modelling system with three components, namely: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD terrain pre-processor), and AERMET (AERMOD meteorological pre-processor).

- AERMOD is an advanced new-generation model. It is designed to predict pollution concentrations from continuous point, flare, area, line, and volume sources (Trinity Consultants, 2004). AERMOD offers new and potentially improved algorithms for plume rise and buoyancy, and the computation of vertical profiles of wind, turbulence and temperature. However, it does retain the single straight-line trajectory limitation of ISCST3 (Hanna et al., 1999). The Breeze AERMOD executable 19191 was used for dispersion modelling.
- AERMET is a meteorological pre-processor for the AERMOD model. 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. AERMET version 7.9.0.3 was used to process the meteorological data.
- AERMAP is a terrain pre-processor designed to simplify and standardize the input of terrain data for the AERMOD model. Input data includes receptor terrain elevation data. The terrain data may be in the form of digital terrain data. Output includes, for each receptor, location and height scale, which are elevations used for the computation of air flow around hills.

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 and a summary of the model parameterisation is provided in Table 5-1.

5.1.1.2 Meteorological Requirements

AERMOD requires two specific input files generated by the AERMET pre-processor. In the absence of on-site measured data, Weather Research and Forecasting (WRF) simulated meteorological data for the period 2017 to 2019 were used in the simulations.

5.1.1.3 Topographical Data

Within 20 km of the project site, elevations vary between 1 110 to 1250 mamsl with gently undulating terrain with no major topographical features (Figure 5-1). The average slope across the study area is less than 10% and, based on the AERMOD Implementation Guide, terrain with slopes less than 10% should excluded topographic in the dispersion simulations (US EPA, 2009). The land use classification is considered to be rural.

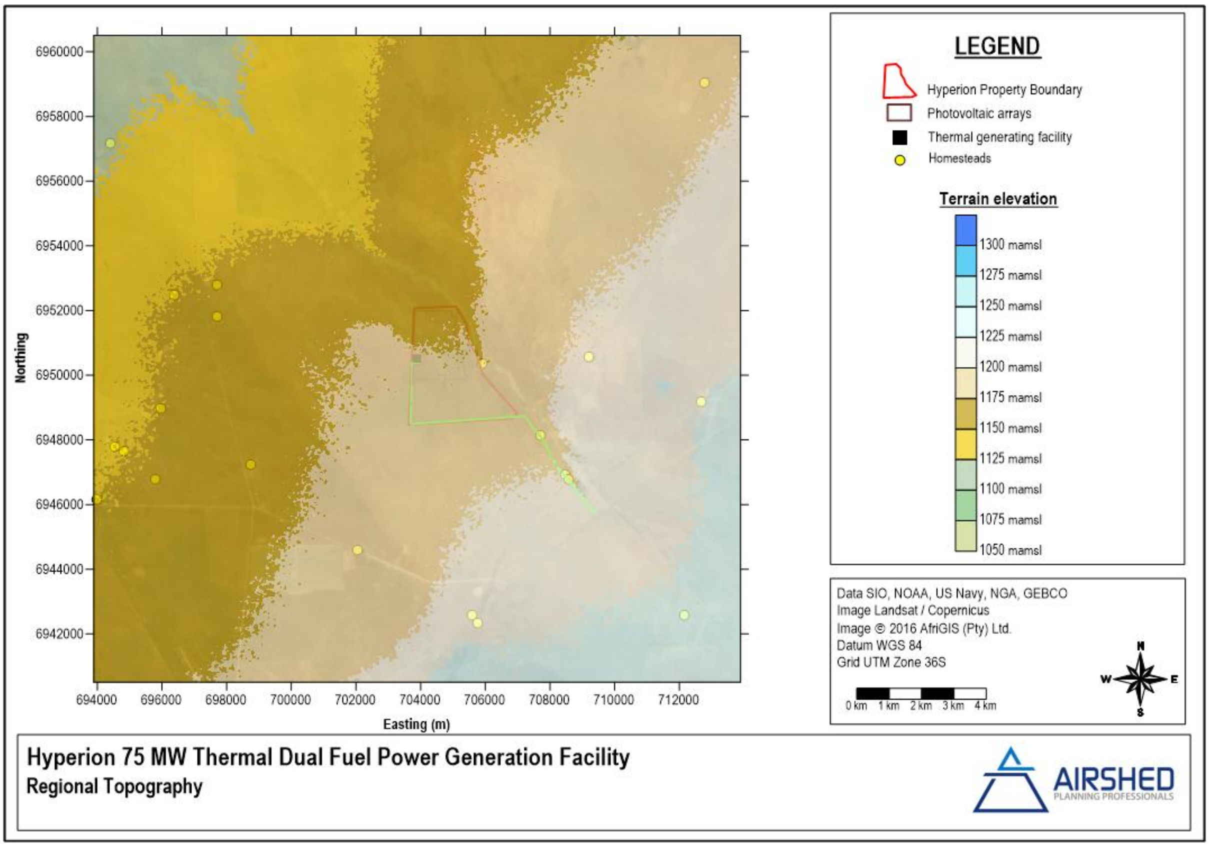

Figure 5-1: Terrain of the proposed project area

5.1.1.4 Receptor Grid

The dispersion of pollutants was modelled for an area covering 22.5 km (north-south) by 22.5 km (east-west) with the project at the centre. This area was divided into a grid with a resolution of 250 m (north-south) by 250 m (east-west). In order to assess impacts at nearby receptor points, a nested 5050 m by 6030 m grid with a resolution of 100 m by 100 m was also included. AERMOD simulates ground-level concentrations for each of the receptor grid points.

Table 5-1: Simulation domain and AERMOD parameter options

Parameter	Simulation domain
Projection	Grid: UTM Zone 34S, Datum: WGS-84
South-western corner of computational domain	693893 m (Easting); 6940509 m (Northing)
Computational domain size	22.5 x 22.5 km
Grid resolution	250 m
South-western corner of sampling domain	702667.9 m (Easting); 6947250.8 m (Northing)
Sampling domain size	5050 m x 6040 m
Grid resolution	100 m
Discrete receptors	52 homesteads, schools, hospitals, AQMS, and residential areas
Model options	Optimise area sources
	Flat terrain
	No depletion
	Flagpole height 1.5 m
Software	Breeze AERMOD by Trinity Consultants VERSION 9.0
Executable	AERMOD_BREEZE_19191_64.EXE

5.1.1.5 Nitrogen Dioxide Formation

Of the several species of nitrogen oxides, only NO_2 is specified in the NAAQS. Since most sources emit varying ratios of these species and these ratios change further in the atmosphere due to chemical reactions, a method for determining the amount of NO_2 in the plume must be selected. Estimation of this conversion normally follows a tiered approach, as discussed in the Regulations Regarding Air Dispersion Modelling (Government Gazette No. 37804, published 11 July 2014), which presents a scheme for annual averages:

> Tier 1: Total Conversion Method
> *Use any of the appropriate models recommended to estimate the maximum annual average NO_2 concentrations by assuming a total conversion of NO to NO_2. If the maximum NO_x concentrations are less than the NAAQS for NO_2, then no further refinement of the conversion factor is required. If the maximum NO_x concentrations are greater than the NAAQS for NO_2, or if a more "realistic" estimate of NO_2 is desired, proceed to the second-tier level.*
>
> *Tier 2: Ambient Ratio Method (ARM) - Multiply NO_x by a national ratio of NO_2/NO. = 0.80*
> *Assume a wide area quasi-equilibrium state and multiply the Tier 1 empirical estimate NO_x by a ratio of NO_2/NO_x = 0.80. The ratio is recommended for South Africa as the conservative ratio based on a review of ambient air quality monitoring data from the country. If representative ambient NO and NO_2 monitoring data is available (for at least one year of monitoring), and the data is considered to represent a quasi-equilibrium condition where further significant changes of the NO/NO_2 ratio is not expected, then the NO/NO_2 ratio based on the monitoring data can be applied to derive NO_2 as an alternative to the national ratio of 0.80.*

The Ambient Ratio Method (ARM), i.e. the second version of the DEA Tier 2 option, was selected for this project.

5.1.2 Legal Requirements

5.1.2.1 Atmospheric Impact Report

According to the NEM:AQA, an Air Quality Officer (AQO) may require the submission of an 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).

5.1.2.2 National Ambient Air Quality Standards

Modelled concentrations were assessed against NAAQS (Table 5-2) as prescribed by South African legislation. Due to the operational life-time of the power stations the most stringent $PM_{2.5}$ NAAQS were referred to which are enforceable from 1 January 2030.

Table 5-2: National Ambient Air Quality Standards applicable for the assessment of the facility

Pollutant	Averaging Period	Concentration (µg/m³)	Frequency of Exceedance	Compliance Date
Benzene (C_6H_6)	1 year	5	0	Currently enforceable
Carbon Monoxide (CO)	1 hour	30 000	88	Currently enforceable
	8 hour[(a)]	10 000	11	Currently enforceable
Nitrogen Dioxide (NO_2)	1 hour	200	88	Currently enforceable
	1 year	40	0	Currently enforceable
Inhalable particulate matter less than 2.5 µm in diameter ($PM_{2.5}$)	24 hours	40	4	Enforceable until 31 December 2029
	24 hours	25	4	1 January 2030
	1 year	20	0	Enforceable until 31 December 2029
	1 year	15	0	1 January 2030
Inhalable particulate matter less than 10 µm in diameter (PM_{10})	24 hours	75	4	Currently enforceable
	1 year	40	0	Currently enforceable
Sulfur Dioxide (SO_2)	10 minutes	500	526	Currently enforceable
	1 hour	350	88	Currently enforceable
	24 hours	125	4	Currently enforceable
	1 year	50	0	Currently enforceable

Air Quality Guidelines (AQGs) were published by the WHO in 1987 and revised in 1997. Since the completion of the second edition of the AQGs for Europe, which included new research from low-and middle-income countries where air pollution levels are at their highest, the WHO has undertaken to review the accumulated scientific evidence and to consider its implications for its AQGs. The result of this work is documented in 'Air Quality Guidelines – Global Update 2005' in the form of revised guideline values for selected criteria air pollutants, which are applicable across all WHO regions (WHO, 2005).

Given that air pollution levels in developing countries frequently far exceed the recommended WHO AQGs, interim target (IT) levels were included in the update. These are in excess of the WHO AQGs themselves, to promote steady progress towards meeting the WHO AQGs (WHO, 2005). There are two or three interim targets depending on the pollutant, starting at WHO interim target-1 (IT-1) as the most lenient and IT-2 or IT-3 as more stringent targets before reaching the AQGs (Table 5-3). The South African NAAQS are, for instance, in line with IT-1 for SO_2 and IT-3 targets for PM_{10} and $PM_{2.5}$. It should be noted that the WHO permits a frequency of exceedance of 1% per year (4 days per year) for 24-hour average PM_{10} and $PM_{2.5}$ concentrations.

Table 5-3: WHO Ambient Air Quality Interim Targets and Guidelines (bold text indicates applicable NAAQ limit concentration or standard)

Pollutant	Averaging Period	Guideline value (µg/m³)
Nitrogen Dioxide (NO_2)	1 hour	**200 (guideline)**
	1 year	**40 (guideline)**
Inhalable particulate matter less than 2.5 µm in diameter ($PM_{2.5}$)	24 hours	75 (interim target-1)
		50 (interim target-2)
		37.5 (interim target-3)

Pollutant	Averaging Period	Guideline value (µg/m³)
		25 (guideline)
	1 year	35 (interim target-1)
		25 (interim target-2)
		15 (interim target-3)
		10 (guideline)
Inhalable particulate matter less than 10 µm in diameter (PM_{10})	24 hours	150 (interim target-1)
		100 (interim target-2)
		75 (interim target-3)
		50 (guideline)
	1 year	70 (interim target-1)
		50 (interim target-2)
		30 (interim target-3)
		20 (guideline)
Sulfur Dioxide (SO_2)	10 minutes	500 (guideline)
	24 hours	125 (interim target-1)
		50 (interim target-2)
		20 (guideline)

5.1.2.3 Listed Activities and Minimum Emission Standards

The minister, in accordance with the National Environmental Management Air Quality Act (NEM:AQA) (Act No. 39 of 2004), published a list of activities which result in atmospheric emissions and which are believed to have significant detrimental effects on the environment and human health; and, social welfare. The Listed Activities and MES were published on the 31st of March 2010 (Government Gazette No. 33064) and revised MES on 22 November 2013 (Government Gazette No. 37054). MES applicable to the power station include:

- **Gas-fired Reciprocating Engine Installations** – Gas fuel stationary engines used for electricity generation (more than 10 MW) heat input per unit). MES subcategory 1.5 are applicable (Table 5-4) during normal operating conditions using liquid petroleum gas (LPG).
- **LPG Storage and Handling** – The storage and handling of petroleum products within permanent immobile liquid tanks larger than 1000 m^3 in total or loading and off-loading more than 50 000 m^3 of petroleum product at more than 14 kPa (true vapour pressure) triggers Subcategory 2.4 (Table 5-5).

Subcategory 2.4 NMES distinguishes between petroleum products with various vapour pressures. The vapour pressure of LPG is above 91 kPa (Table 5-5Table 5-5). However, LPG is in a liquid phase as a result of the application of pressure or low temperatures for the purposes of storage and transport and would not be liquid at room temperature and pressure.

Table 5-4: MES for gas combustion installations

Subcategory 1.5: Liquid and gas fuel stationary engines used for electricity generation		
Description	Liquid and gas fuel stationary engines used for electricity generation	
Application	All installation with design capacity equal to or greater than 10 MW heat input per unit, based on the lower calorific value of the fuel used.	
Substance or mixture of substances		**mg/Nm³ under normal conditions of 15% O_2, 273 K and 101.3 kPa**
Common Name	**Chemical Symbol**	**New plant**
Particulate matter (PM)	Not applicable	50
Sulfur dioxide	SO_2	1 170*
Oxides of nitrogen	NO_x expressed as NO_2	2000* 400**
Notes: * Liquid fuels fired ** Gas fired		

Table 5-5: MES for the storage and handling of petroleum products

Subcategory 2.4: Storage and Handling of Petroleum Products	
Description	Petroleum products storage tanks and product transfer facilities.
Application	All permanent immobile liquid storage tanks larger than 1 000 cubic metres cumulative tankage capacity at a site.

(a) The following transitional arrangement shall apply for the storage and handling of raw materials, intermediate and final products with a vapour pressure greater than 14 kPa at operating temperature:

– Leak detection and repair (LDAR) program must be instituted.

(b) The following special arrangements shall apply for control of TVOCs from storage of raw materials, intermediate and final products with a vapour pressure of up to 14 kPa at operating temperature, except during loading and offloading. (Alternative control measures that can achieve the same or better results may be used)

– Storage vessels for liquids shall be of the following type:

True vapour pressure of contents at storage temperature	Type of tank or vessel
Type 1: Up to 14 kPa	Fixed-roof tank vented to atmosphere, or as Type 2 and 3
Type 2: Above 14 kPa up to 91 kPa with a throughput of less than 50 000 m³ per annum	Fixed-roof tank with Pressure Vacuum Vents fitted s a minimum, to prevent "breathing" losses, or as per Type 3
Type 3: Above 14 kPa up to 91 kPa with a throughput greater than 50 000 m³ per annum	a) External floating roof tank with primary and secondary rim seals for tank diameter larger than 20 m, or b) fixed roof tank with internal floating deck / roof fitted with primary seal, or c) fixed roof tank with vapour recovery system
Type 4: Above 91 kPa	Pressure vessel

i. The roof legs, slotted pipes and/or dipping well on floating roof tanks (except for domed floating roof tanks or internal roof tanks) shall have sleeves fitted to minimise emissions.

ii. Relief valves on pressurised storage should undergo periodic checks for internal leaks. This can be carried out using portable acoustic monitors or if venting to atmosphere with an accessible open end, tested with a hydrocarbon analyser as part of an LDAR programme.

(c) The following special arrangements shall apply for control of TVOCs from storage, loading and unloading of raw materials, intermediate and final products with a vapour pressure of more than 14 kPa at operating temperatures, except during loading and unloading. Alternative control measures that can achieve the same or better results may be used:

iii. All installations with a throughput of 50 000 m³ per annum of products with a vapour pressure greater than 14 kPa, must be fitted with vapour recover / destruction units. Emission limits are set out in the table below –

Description	Vapour Recovery Units	
Application	All loading/ offloading facilities with a throughput greater than 50 000 m³ per annum	
Substance or mixture of substances	mg/Nm³ under normal conditions of 273 K and 101.3 kPa	
Common Name	Chemical Symbol	New plant
Total volatile organic compounds (TVOCs) from vapour recovery/destruction units (thermal treatment)	Not applicable	150
Total volatile organic compounds (TVOCs) from vapour recovery/destruction units (non-thermal treatment)	Not applicable	40 000

For context, a comparison of emission limits for gas fired gas engine facilities used to generate electricity is provided in Table 5-6 where it is worth noting that the South African NO_X emission limits are aligned with the International Finance Corporation (IFC) emission standards for dual-fuel engines. South Africa also has limits defined for particulate matter (both gas- and liquid fired engines) and SO_2 (for liquid fired engines), where limits are not defined by the IFC for these pollutants.

Table 5-6: Comparison of South African and IFC regulatory emission standards for gas-fired power stations using reciprocating engines

Source	Emission Concentration (mg/Nm³)			Note and Comments
	SO_2	NO_X	PM	
South Africa	1 170*	400	50	Subcategory1.5 (Reciprocating engines – gas-fired). Reference conditions: 15% O_2, 273K, 101.3 kPa
IFC	-	200	-	Spark ignition engine Natural Gas. Reference conditions: 15% O_2, 273K, 101.3 kPa
		400		Dual-fuel engines Natural Gas. Reference conditions: 15% O_2, 273K, 101.3 kPa
* Applicable to liquid fuels. No value given for gas fuels.				

5.1.3 Atmospheric Dispersion Potential

Physical and 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. Parameters useful in describing the dispersion and dilution potential of the site, include: wind speed, wind direction, temperature and rainfall. Since no on-site meteorological data was available, Weather Research and Forecasting (WRF) data for the period 2017 to 2019 was used for the assessment.

5.1.3.1 Surface Wind Field

The wind field for the study area is described with the use of wind roses. 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 yellow area, for example, representing winds in between 5 and 6 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories.

Calm conditions are periods when the wind speed was below 1 m/s. These low values can be due to “meteorological” calm conditions when there is no air movement; or, when there may be wind, but it is below the anemometer starting threshold (AST).

The WRF period wind roses (Figure 5-2) depict the predominance of the northerly, north-easterly, and north-westerly winds, however, wind direction can be variable. Wind speeds are frequently above 4 m/s and rarely calm (when the wind speeds are lower than 1 m/s). Winds from the north-westerly sector were also predominant during the day, while the night-time wind rose shows a decrease in the northerly and the north-westerly winds and an increase in the north-easterly and east-south-easterly winds. Night-time was also characterised by lower wind speeds.

Calm conditions were most frequently recorded in spring and most infrequently in autumn, however the seasonal differences are marginal (Figure 5-3). In summer and spring, south-easterly dominance is noted, while in autumn and winter north-easterly winds were more frequent.

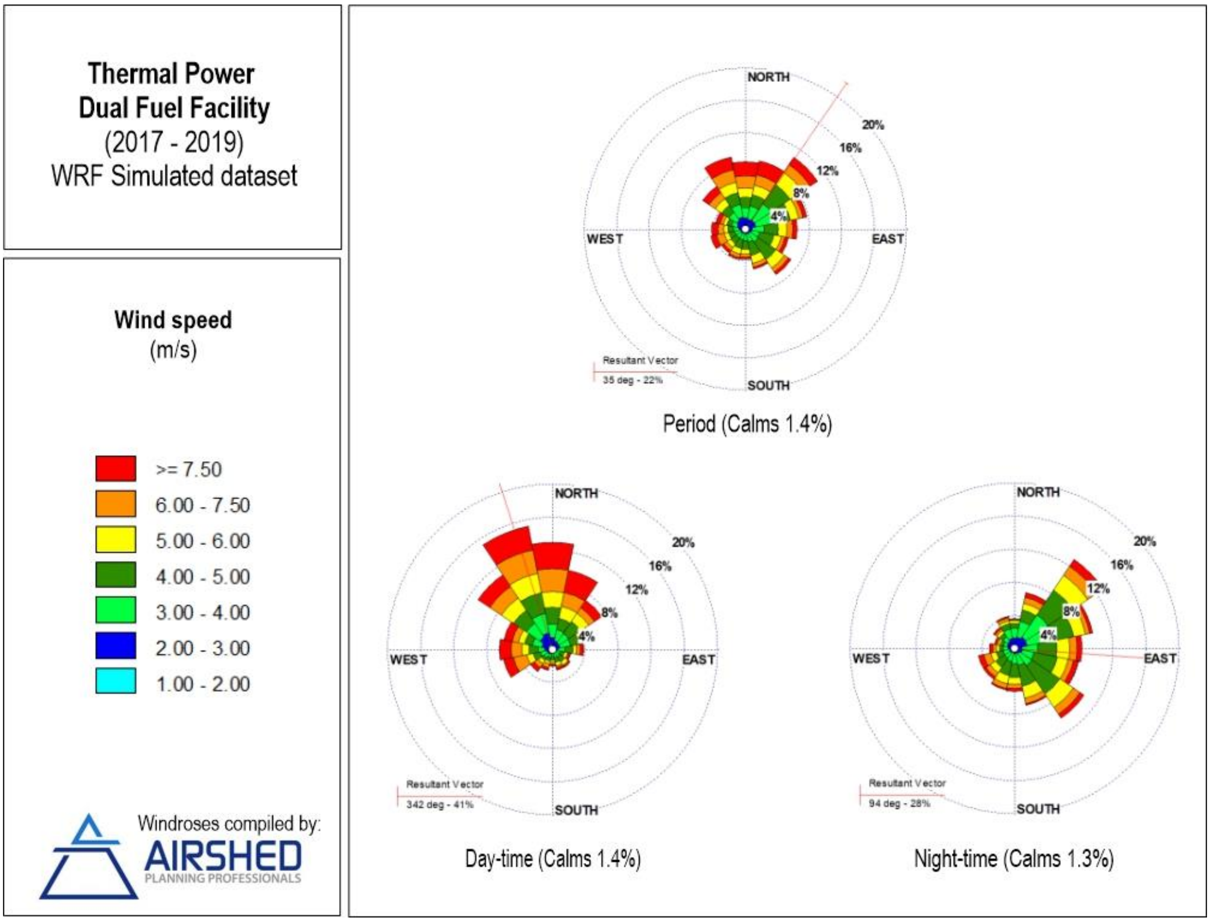

Figure 5-2: Period average, day-time and night-time wind roses (WRF simulated data; 2017 to 2019)

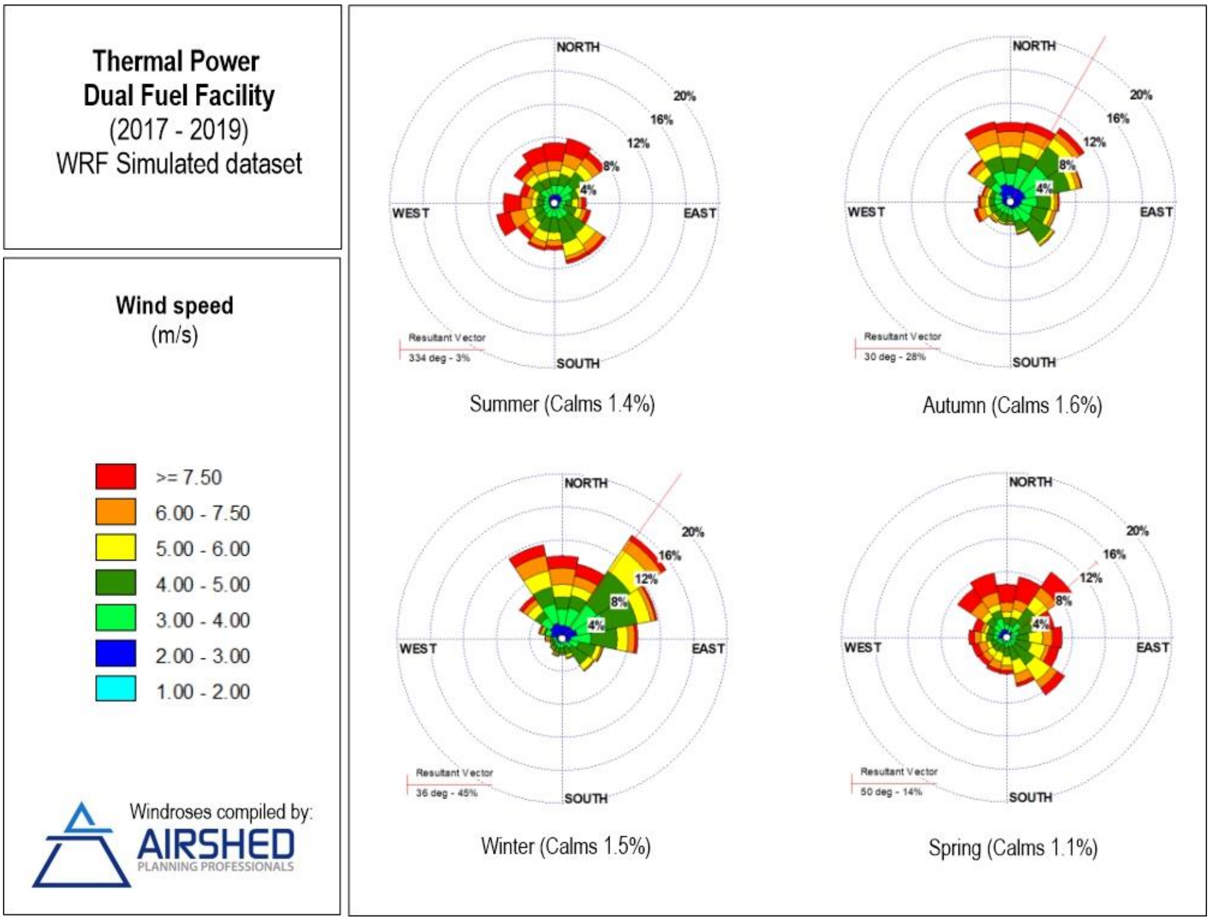

Figure 5-3: Seasonal wind roses (WRF simulated data; 2017 to 2019)

5.1.3.2 Temperature

Air temperature is important, both for determining the effect of plume buoyancy and determining the development of the mixing and inversion layers. The monthly temperature patterns from the WRF data are shown in Figure 5-4 and Table 5-7. Average temperatures ranged between 11.9°C and 26.8°C. The highest temperatures occurred in January and the lowest in July. During the day, temperatures increase to reach maximum at around 16:00 in the afternoon. Ambient air temperature decreases to reach a minimum at around 07:00, in winter.

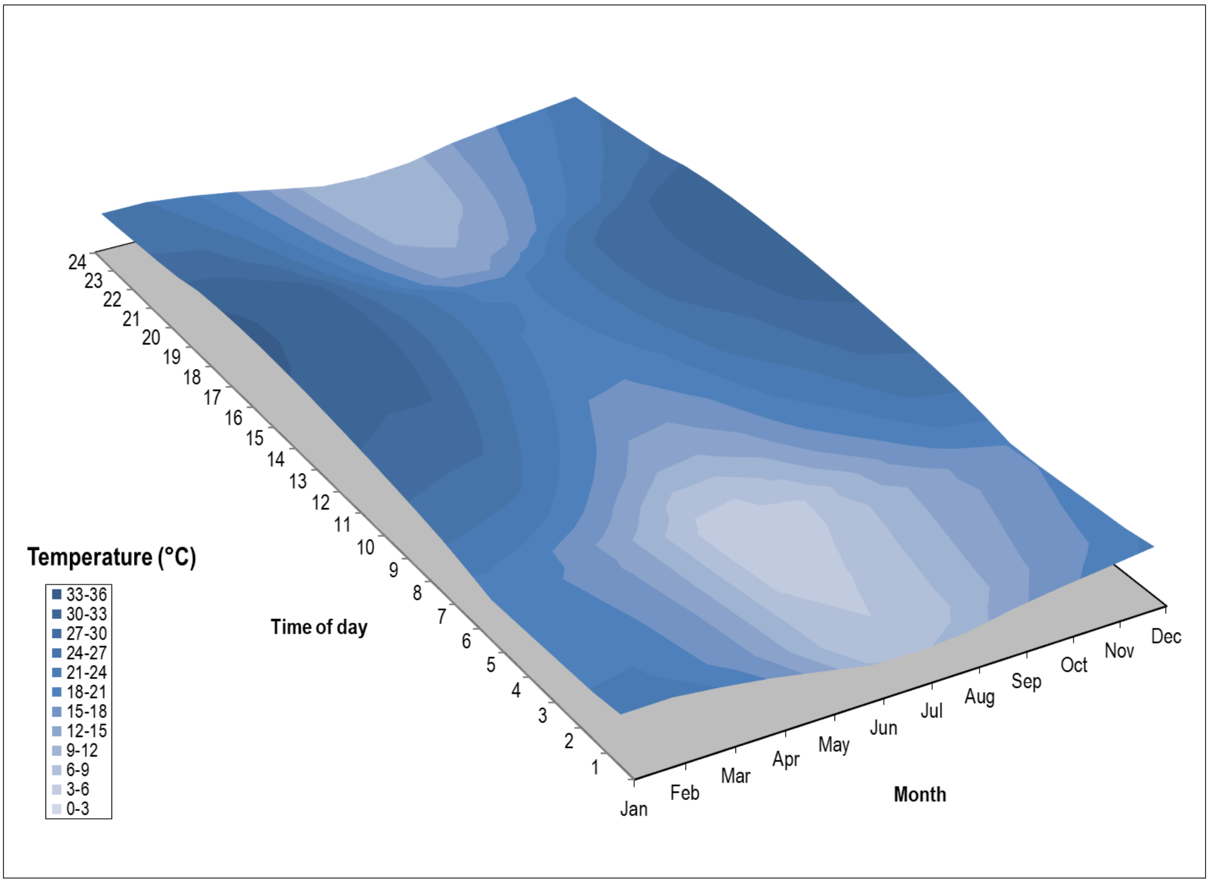

Figure 5-4: Monthly temperature profile (WRF simulated data; 2017 to 2019)

Table 5-7: Monthly temperature summary (2017 - 2019)

Hourly Minimum, Hourly Maximum and Monthly Average Temperatures (°C)												
Statistics	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Minimum	11.8	11.6	10.5	6.6	1.9	-1.8	-3.6	-3.5	-0.3	1.1	5.7	12.0
Average	26.8	26.2	24.6	20.7	16.7	12.5	11.9	14.1	18.6	21.5	24.4	26.1
Maximum	37.9	36.7	35.8	32.9	29.1	25.0	25.4	29.3	34.0	35.2	37.1	38.2

5.1.3.3 Atmospheric Stability

The atmospheric boundary layer properties are described by two parameters: the boundary layer depth and the Obukhov length.

The Obukhov length (LMo) provides a measure of the importance of buoyancy generated by the heating of the ground and mechanical mixing generated by the frictional effect of the earth's surface. Physically, it can be thought of as representing the depth of the boundary layer within which mechanical mixing is the dominant form of turbulence generation (CERC, 2004). The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. During daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface. Night-times are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds and lower dilution potential.

Diurnal variation in atmospheric stability as described by the inverse Obukhov length and the boundary layer depth is provided in Figure 5-5. The highest concentrations for ground level, or near-ground level releases from non-wind dependent sources would occur during weak wind speeds and stable (night-time) atmospheric conditions.

For elevated releases, unstable conditions can result in very high concentrations of poorly diluted emissions close to the stack. This is called looping and occurs mostly during daytime hours. Neutral conditions disperse the plume fairly equally in both the vertical and horizontal planes and the plume shape is referred to as coning. Stable conditions prevent the plume from mixing vertically, although it can still spread horizontally and is called fanning (Figure 5-5) (Tiwary & Colls, 2010).

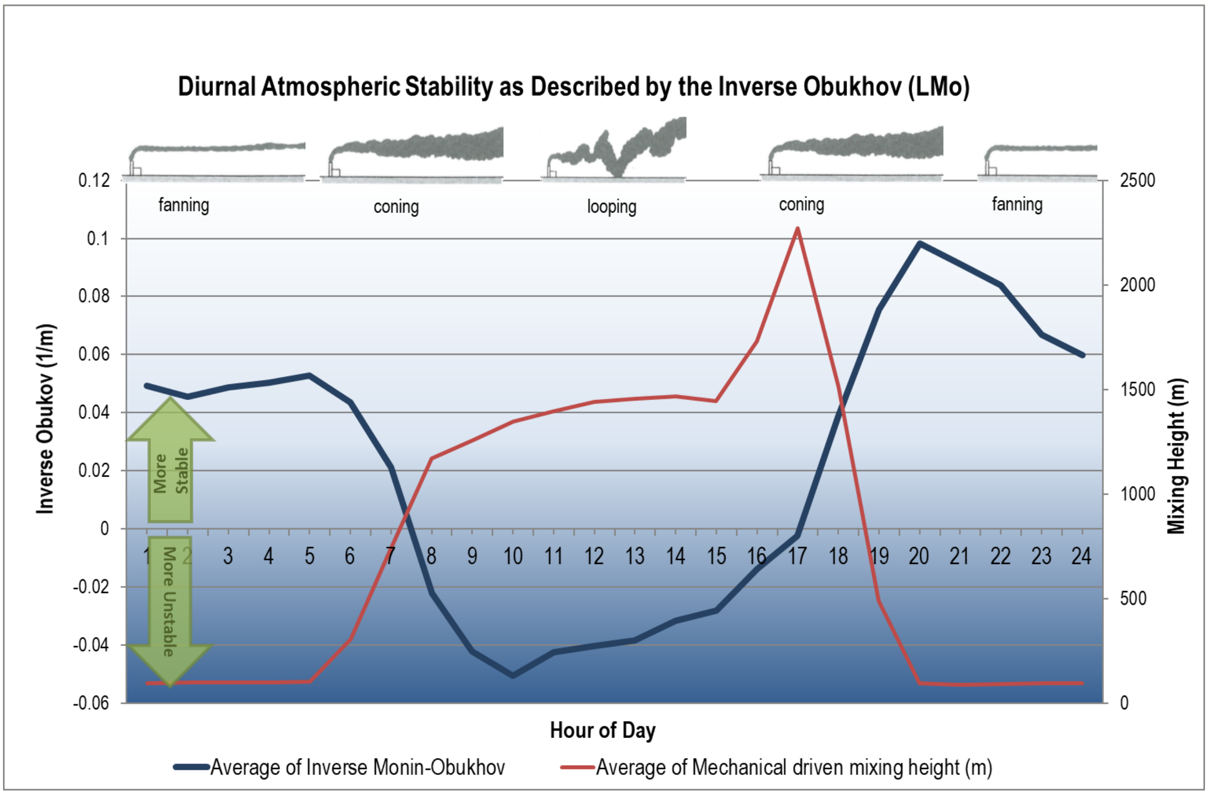

Figure 5-5: Diurnal atmospheric stability (extracted from simulated data at the project site)

5.1.4 Existing Sources of Emissions near the proposed Project Site

A comprehensive emissions inventory for the study area was not available for the assessment and the establishment of such an inventory was not within the scope of the current study. Instead, source types present in the area and the pollutants associated with such source types are noted with the aim of identifying pollutants which may be of importance in terms of cumulative impact potentials. Existing pollutant sources in the area surrounding the proposed project are discussed below.

5.1.4.1 Opencast Mining

Iron ore and manganese mining occurs within the vicinity of the proposed project. Opencast mines are associated with significant dust emissions, sources of which include land clearing, blasting and drilling operations, materials handling, vehicle entrainment, crushing, screening, among others. Existing monitoring networks in the area show that baseline ambient particulate concentrations are elevated in Kathu and Sesheng (Figure 5-6).

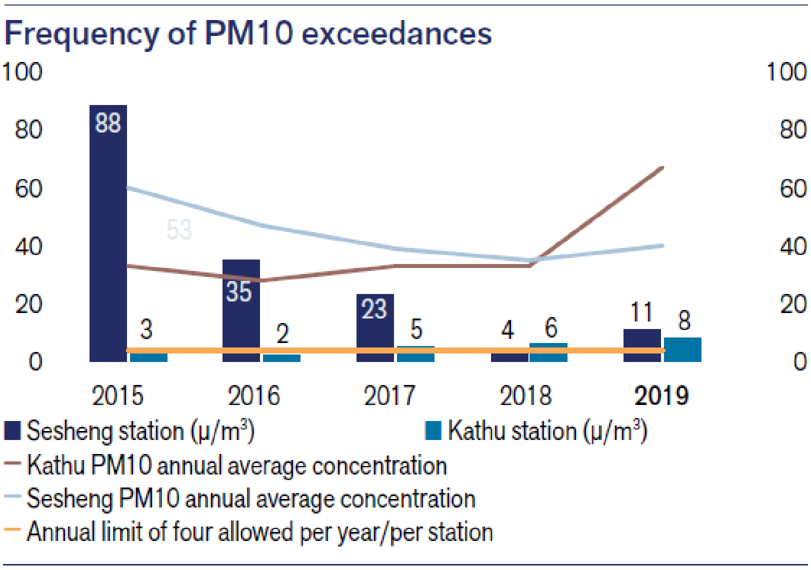

Figure 5-6: Ambient PM_{10} (daily frequency of exceedance and annual average) concentrations in Kathu and Sesheng[3]

5.1.4.2 Other Fugitive Dust Sources

Fugitive dust emissions may occur as a result of vehicle entrained dust from local paved and unpaved roads, wind erosion from open areas and dust generated by agricultural activities (e.g. tilling or movement of livestock) and mining. The extent of particulate emissions from the main roads will depend on the number of vehicles using the roads, and on the silt loading on the roadways.

5.1.5 Baseline Ambient Air Quality

Measured air quality data from the DEFF Karoo air quality monitoring station (AQMS) was accessed from the South African Air Quality Information System (SAAQIS) for use in this assessment. The station is located near the town of Nieuwoudtville, 575 km to the south-west of the proposed project site. The Karoo station is considered by the DEFF to be a station measuring background levels of pollutants for the country since it is not influenced by typical sources resulting in high pollution loads (for example, industry, domestic fuel burning in high density residential areas, vehicle exhaust emissions in heavy traffic zones). Although the AQMS is located far from the project site, the sources in the vicinity and the climatic zones are similar. The period April 2018 to October 2020 was available from this online database. Data availability for the period varied between 6% and 97%, depending on the pollutant (Table 5-8). The following is noted from the dataset:

- No exceedances of the hourly NAAQS were recorded for SO_2, NO_2, or CO during the period of assessment;
- No exceedances of the daily NAAQS were recorded for SO_2, $PM_{2.5}$, or PM_{10} during the period of assessment;
- Exceedances of the 8-hourly average O_3 NAAQ limit concentration occurred 22 times in 2018 and twice in 2020. The NAAQS allow for 11 exceedances of the 8-hourly O_3 limit concentration per year.
- Compliance with annual NAAQS for all relevant pollutants in 2019 – the only year where data availability was sufficient to assess compliance.

[3] AngloAmerican Kumba Iron Ore Limited, Sustainability Report 2019, accessed 29-09-2020; https://www.angloamericankumba.com/investors/annual-reporting/reports-archive/2019

Table 5-8: Summary of the ambient measurements at DEFF Karoo AQMS for the period 2018 – 2020

Karoo Background AQMS						
Period	Data Availability	Hourly	Daily	Annual Average	No of recorded hourly exceedances	No of recorded daily exceedances
		99th Percentile	99th Percentile			
SO_2 (ppb)						
Criteria		*134 ppb*	*48 ppb*	*19 ppb*	*88 hours per year*	*4 days per year*
2018(a)	47%	3.16	1.38	1.17	0	0
2019	95%	6.50	6.49	2.44	0	0
2020(b)	52%	5.20	4.76	1.59	0	0
NO_2 (ppb)						
Criteria		*106 ppb*		*21 ppb*	*88 hours per year*	
2018(a)	38%	7.84		1.17	0	
2019	82%	5.08		2.44	0	
2020(b)	48%	5.73		1.59	0	
CO (ppm)						
Criteria		*26 ppm*			*88 hours per year*	
2018(a)	41%	0.27			0	
2019	89%	0.50			0	
2020(b)	43%	2.00			0	
$PM_{2.5}$ (µg/m³)						
Criteria		*n/a*	*40 µg/m³*	*25 µg/m³*	*n/a*	*4 days per year*
2018(a)	47%		11.54	1.17		0
2019	97%		16.29	2.44		0
2020(b)	30%		8.97	1.59		0
PM_{10} (µg/m³)						
Criteria		*n/a*	*75 µg/m³*	*40 µg/m³*	*n/a*	*4 days per year*
2018(a)	47%		17.25	1.17		0
2019	97%		39.53	2.44		0
2020(b)	29%		30.10	1.59		0
O_3 (ppb)						
Criteria		*n/a*	*61 ppb*		*n/a*	
2018(a)	24%		97.06			22
2019	66%		50.03			0
2020(b)	6%		75.23			2

Notes:
(a) Incomplete year (April to December)
(b) Incomplete year (January to October)

Diurnal and seasonal variation plots – generated using openair (Carslaw & Ropkins, 2012; and Carslaw, 2019) - of ambient SO_2, NO_2, CO (Figure 5-7) along with $PM_{2.5}$ and PM_{10} (Figure 5-8) measured at the DEFF Karoo AQMS show the variation of ambient concentrations over daily, weekly and annual cycles (mean with 95% confidence interval). The data have been normalised by dividing by the respective mean values to allow comparison of the shape of diurnal trends for the variables on very different measurement scales (Carslaw, 2019). The pattern shows morning and late evening peak NO_2 concentrations possibly associated with vehicle traffic and domestic fuel burning. CO concentrations show a similar early morning and late afternoon peak possibly associated with vehicle traffic. A slight mid-day peak is evident for SO_2 and is likely associated with the break-up of an elevated inversion layer, in addition to the development of daytime convective conditions causing the plumes from stacks at small industry sources to be brought down to ground level. Particulate fractions (Figure 5-8) show increased concentrations in the late afternoon, possibly associated with domestic fuel burning or wind field patterns where higher wind speeds could result in entrainment of particulate matter from exposed areas. The only pollutant with a discernible seasonal pattern is CO which increases in late winter and spring and is possibly associated with veld fires.

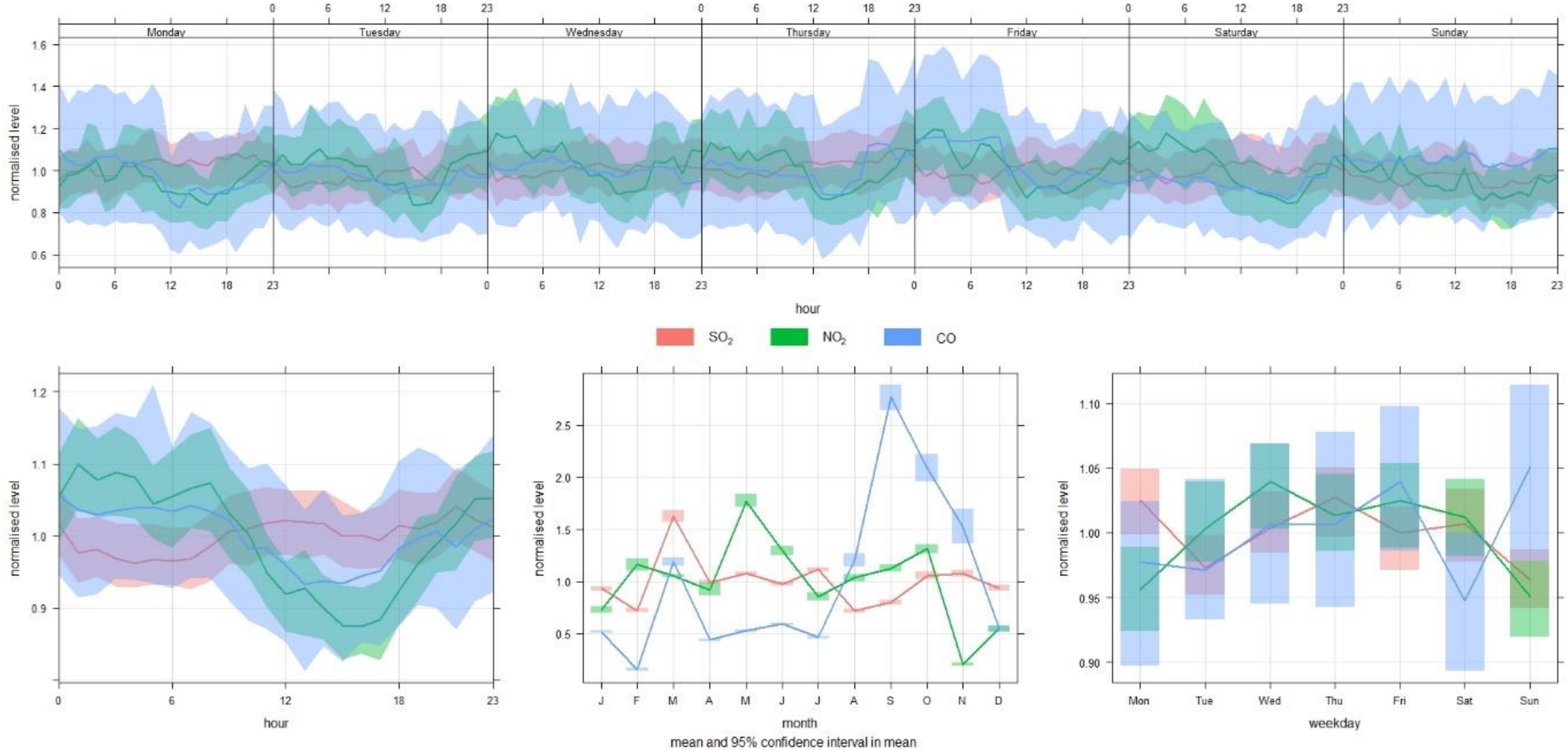

Figure 5-7: Diurnal and seasonal variation plots of observed SO_2, NO_2, and CO at the DEFF Karoo AQMS (shaded area indicates 95th percentile confidence interval)

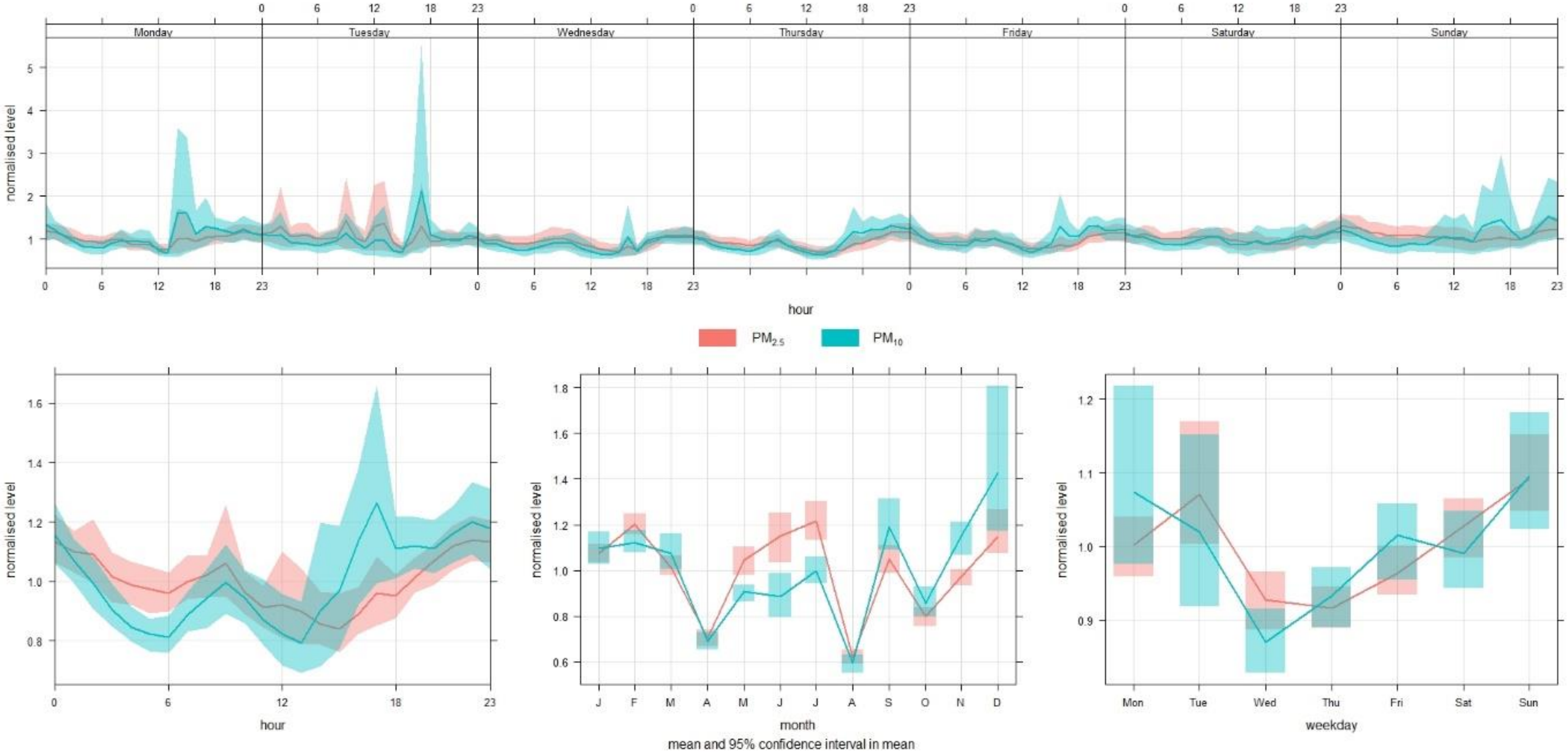

Figure 5-8: Diurnal and seasonal variation plots of observed $PM_{2.5}$ and PM_{10} at the DEFF Karoo AQMS (shaded area indicates 95th percentile confidence interval)

5.1.6 Dispersion Modelling of Project – Incremental Impacts

Impact of the operational phase was simulated using the parameters and emission rates given in Section 4.1 (Table 4-1, Table 4-2, Table 4-4, Table 4-6, and Table 4-7). Short-term (hourly or daily) concentrations were extracted at the 99th percentile, to account for the number of exceedances allowed by the NAAQS.

5.1.6.1 Construction Phase: Particulate Matter Impacts

Construction activities are potentially significant sources of dust emissions that may have a substantial temporary impact on local air quality, where emissions result from general site preparation. Construction activities that contribute to air pollution typically include: land clearing, excavation, material handling activities, wheel entrainment, operation of diesel or petrol engines etc. If not properly mitigated, construction sites could generate high levels of dust (typically from concrete, cement, wood, stone, silica) and this has the potential to travel for large distances.

Construction dust, in the larger TSP fraction, will generally impact close to the construction activities and is more responsible for soiling than health issues. Health impacts are more associated with the finer PM_{10} and $PM_{2.5}$ fractions, both of which are invisible to the naked eye. Combustion engines also emit emissions of CO, hydrocarbon, NOx and CO_2. However, these gaseous emissions may often not be as significant when compared to particulate emissions, and the quantification of particulate matter emissions (and the atmospheric dispersion thereof) is generally considered a better key-indicator pollutant for construction phase impacts than gaseous emissions.

Dust emissions can also vary substantially from day to day, depending on the level of activity, the specific operations, and the prevailing meteorological conditions. It is therefore often necessary to estimate area wide construction emissions, without regard to the actual plans of any individual construction process.

The US EPA documents emissions factors which aim to provide a general rule-of-thumb as to the magnitude of emissions which may be anticipated from construction operations. The quantity of dust emissions is assumed to be proportional to the area of land being worked and the level of construction activity. Based on field measurements of TSP concentrations surrounding apartment and shopping centre construction projects, the approximate emission factors for construction activity operations are given as:

$$E_{TSP} = 2.69 \text{ Mg/hectare/month of activity } (269 \text{ g/m}^2\text{/month})$$

The PM_{10} fraction is given as approximately 35% of the US EPA total suspended particulate factor. These emission factors are most applicable to construction operations with (i) medium activity levels, (ii) moderate silt contents, and (iii) semiarid climates. The emission factor for TSP considers 42 hours of work per week of construction activity. Test data were not sufficient to derive the specific dependence of dust emissions on correction parameters. Because the above emission factor is referenced to TSP, use of this factor to estimate PM_{10} emissions **will result in conservatively high estimates**. Also, because derivation of the factor assumes that construction activity occurs 30 days per month, the above estimate is somewhat conservatively high for TSP as well.

The information in Table 5-9 was used to estimate emissions during the Construction Phase.

Table 5-9: Parameters used to estimate Construction Phase emissions

Parameter	Value	Units of measurement	Source
Thermal Facility Construction area	11.6	hectares	given
Access Road Construction area	16.7[(a)]	hectares	given
Active construction area at any particular time	25	per cent	assumed
Period of construction	16[(b)]	months	given
Construction operations	9	hours	assumed
	21	days per month	
Emission rate – TSP	2.20×10^{-5}	g/s.m²	calculated
Emission rate – PM_{10}	7.69×10^{-6}	g/s.m²	calculated

Notes:
(a) Road length (18 500 m) multiplied by road width (9 m).
(b) Road construction assumed to take 6 months.

The unmitigated emissions associated with construction of the proposed project are unlikely to result in concentrations above the daily National Ambient Air Quality (NAAQ) limit value (Figure 5-9) or annual PM_{10} NAAQS (Figure 5-10), including during road construction (results not shown – maximum daily concentration <1 µg/m³).

Particulate matter control measures that can be implemented during the construction phase are outlined in Table 5-10. Control techniques for fugitive particulate sources generally involve watering, chemical stabilization, keeping cleared areas as small as possible to limit exposed areas, and the reduction of surface wind speed though the use of windbreaks and source enclosures.

Nuisance dustfall impacts of the Construction Phase are detailed in Section 5.2.4.

Table 5-10: Dust control measures that can be implemented during construction activities

Construction Activity	Recommended Control Measure(s)
Debris handling	Storage of debris in containers (skips) prior to waste removal. Cover containers when not in use (as far as practical).
	Wet suppression (hourly watering recommended).
Truck transport and road dust entrainment	Haul trucks to be restricted to specified haul roads using the most direct route.
	Reduction of unnecessary traffic.
	Wet suppression (hourly watering recommended) or chemical stabilization of unpaved roads.
	Strict on-site speed control (i.e. 20 km/hr for haul trucks).
Materials storage, handling and transfer operations	Cover materials stockpiles with tarpaulins or store in protected temporary bunkers.
	Wet suppression, where feasible.
	Use the minimum safe drop-heights for materials transfer.
Earthmoving operations	Use the minimum safe drop-heights for materials transfer.
	Wet suppression (hourly watering recommended), where feasible outside of rainy season.
	Limited area of bulk earthworks
Open areas (wind-blown emissions)	Reduction of extent of open areas to minimise the time between clearing and infrastructure construction; and/or use wind breaks and water suppression to reduce emissions from open areas
	Restriction of disturbances, such as materials transfer, to periods of low wind speeds (less than 5 m/s), where feasible.
	Stabilisation (chemical, rock cladding or vegetative) of disturbed soil
	Re-vegetation of cleared areas as soon as practically feasible

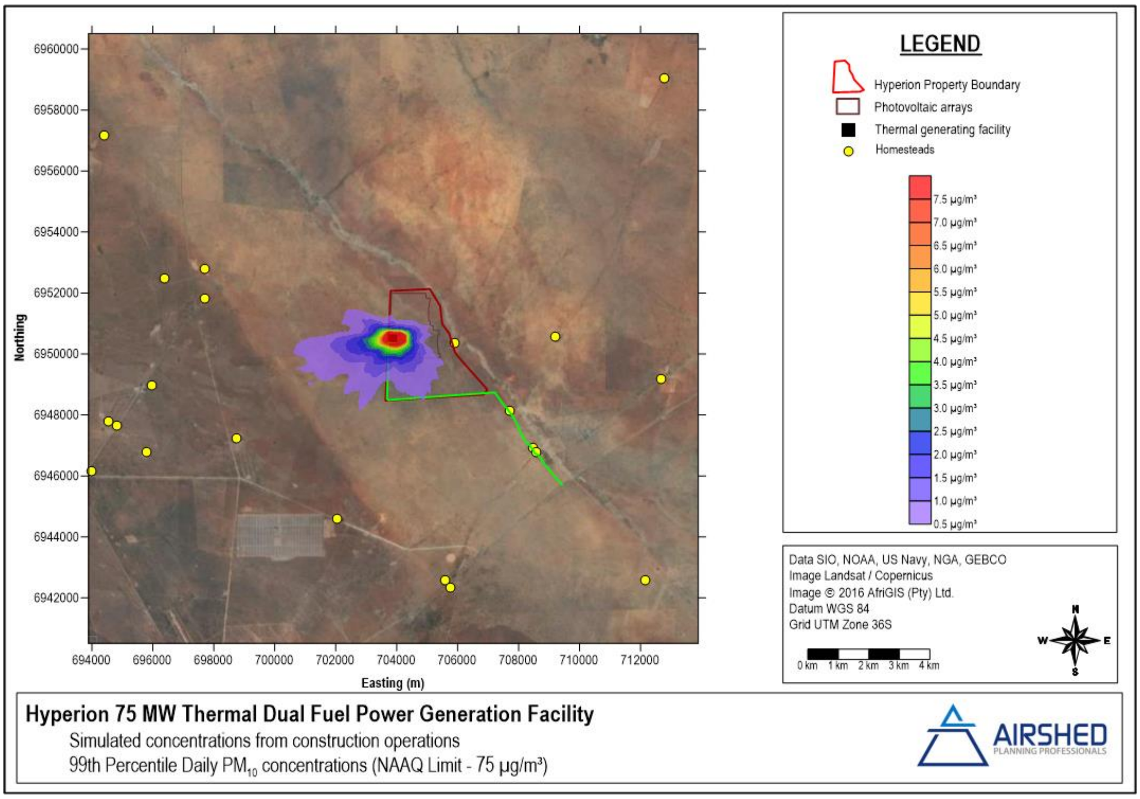

Figure 5-9: Simulated daily PM$_{10}$ concentrations due to construction operations

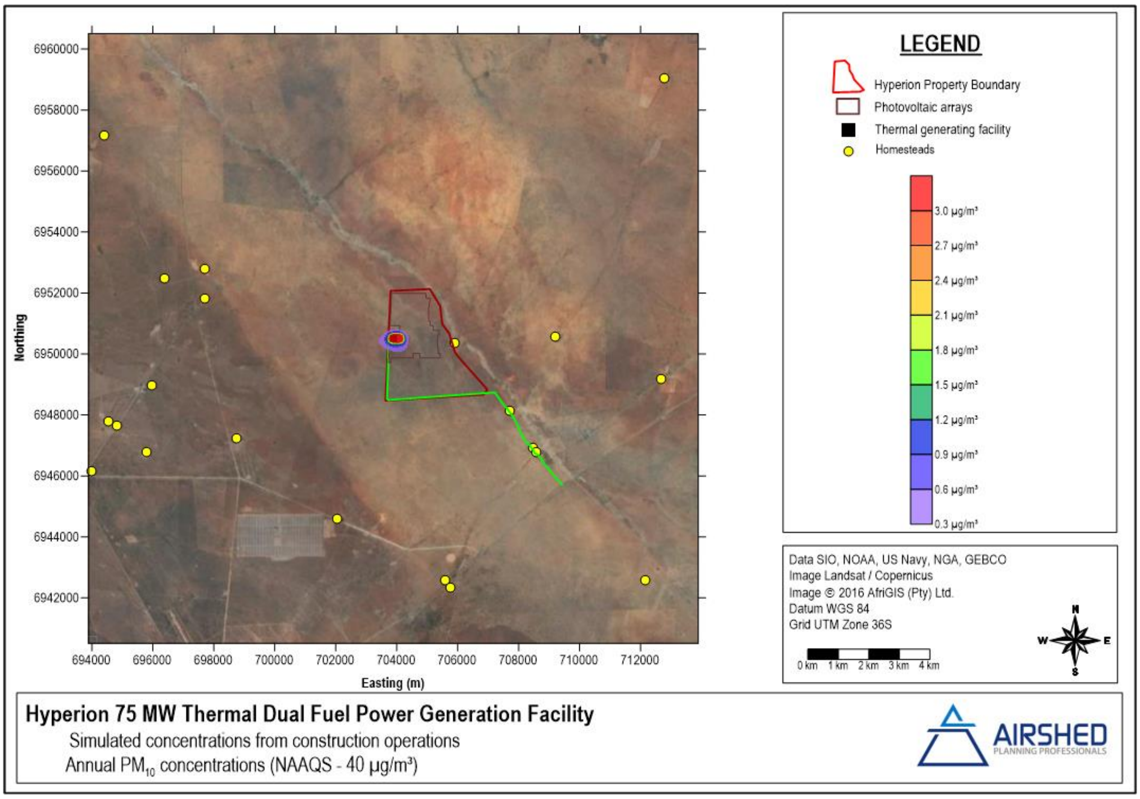

Figure 5-10: Simulated annual PM$_{10}$ concentrations due to construction operations

5.1.6.2 Operational Phase: Simulated Incremental SO_2 Impacts

Two emission scenarios were considered in the simulation of SO_2 impacts: a) emissions based on MES (Table 4-2), and, b) emissions calculated based on emission factors (Table 4-4). The MES scenario results showed simulated SO_2 concentrations that were above the hourly (Figure 5-13) and daily (Figure 5-15) National Ambient Air Quality (NAAQ) limit values up to 250 m and 180 m off-site, respectively but not at any receptors (Figure 5-11 and Figure 5-12). Hourly and daily average concentrations simulated using emission factors, and the sulfur content of the LPG fuel, were lower the applicable NAAQS (Figure 5-14 and Figure 5-16). Annual concentrations were simulated to be lower than the respective NAAQS for both scenarios (Figure 5-17 and Figure 5-18). Emissions calculated based on emission factors present a more realistic operational scenario, due to the inherently low sulfur content in LPG.

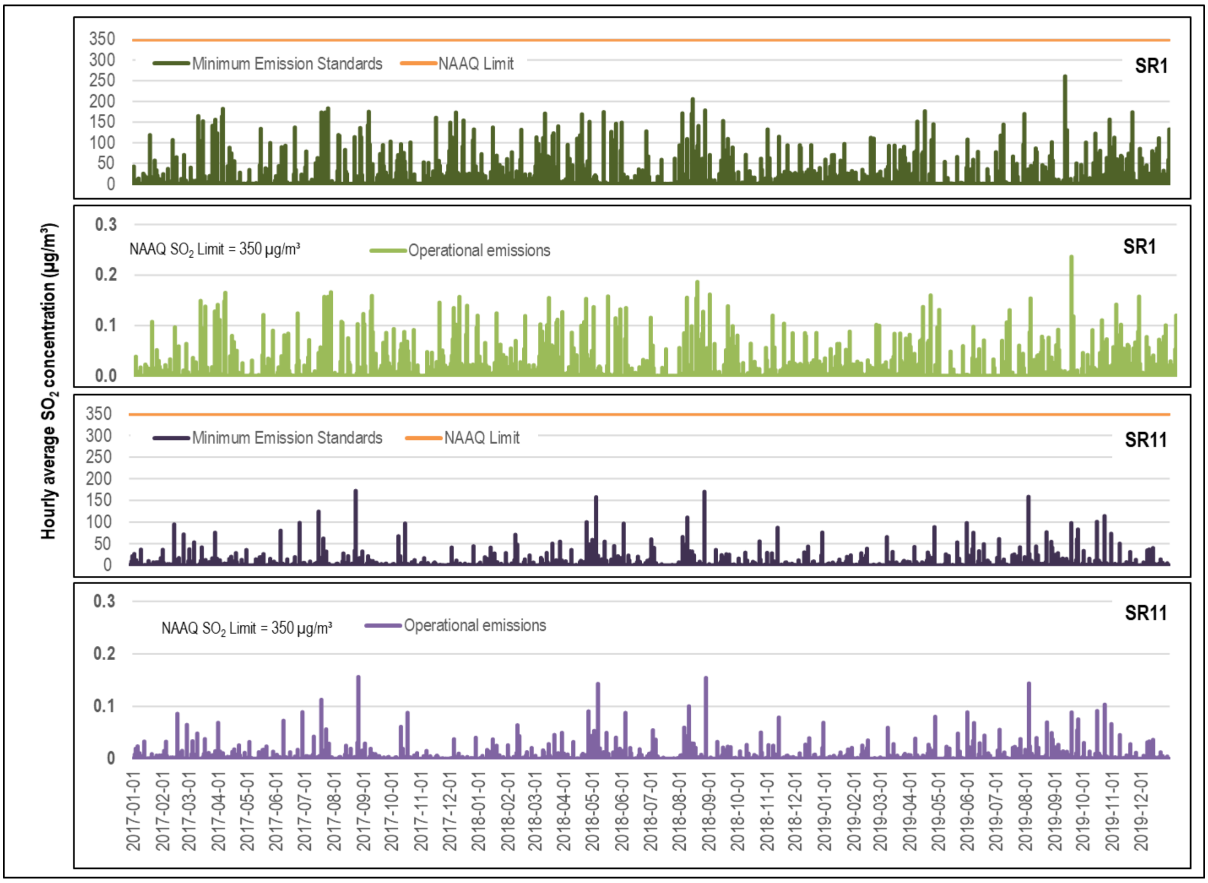

Figure 5-11: Time series of the hourly SO_2 concentrations simulated at the nearest receptors

Figure 5-12: Time series of the daily SO_2 concentrations simulated at the nearest receptors

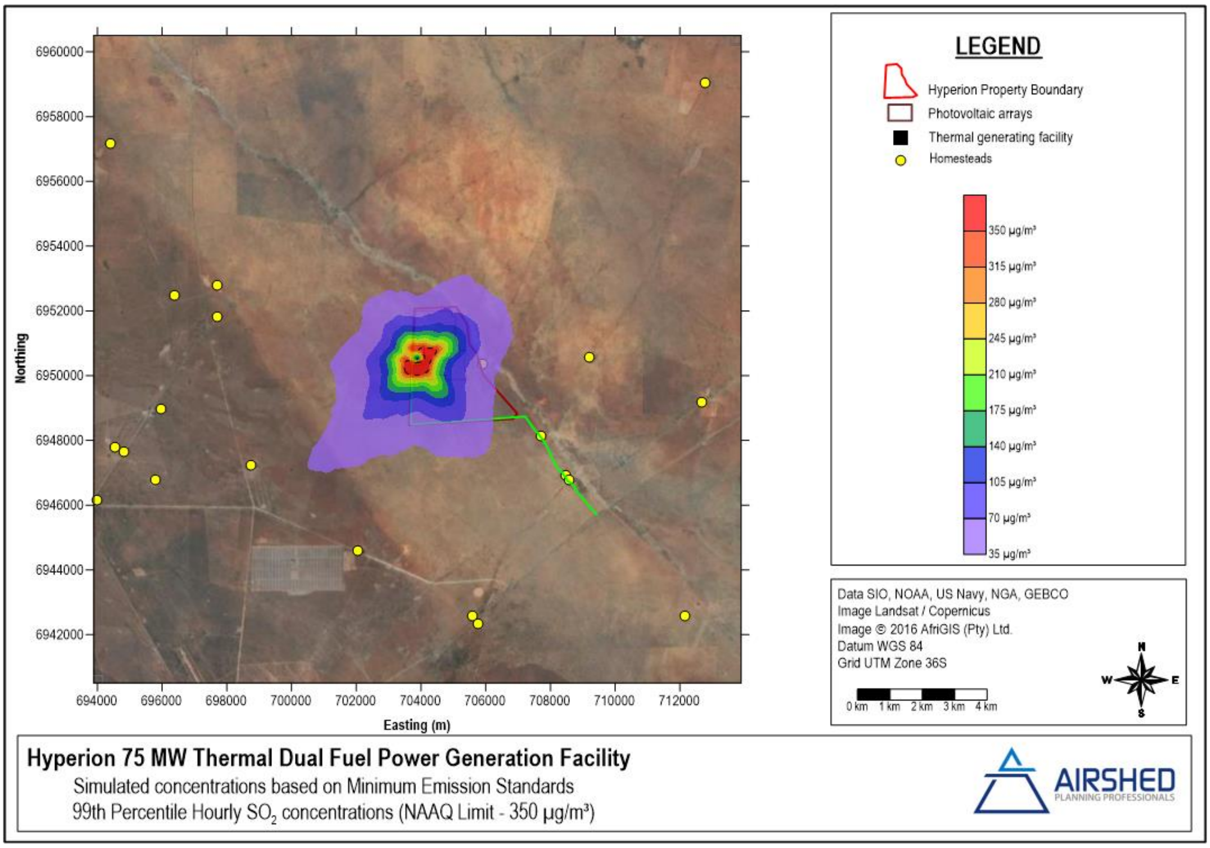

Figure 5-13: Simulated hourly average ambient SO_2 concentrations based on Minimum Emission Standards

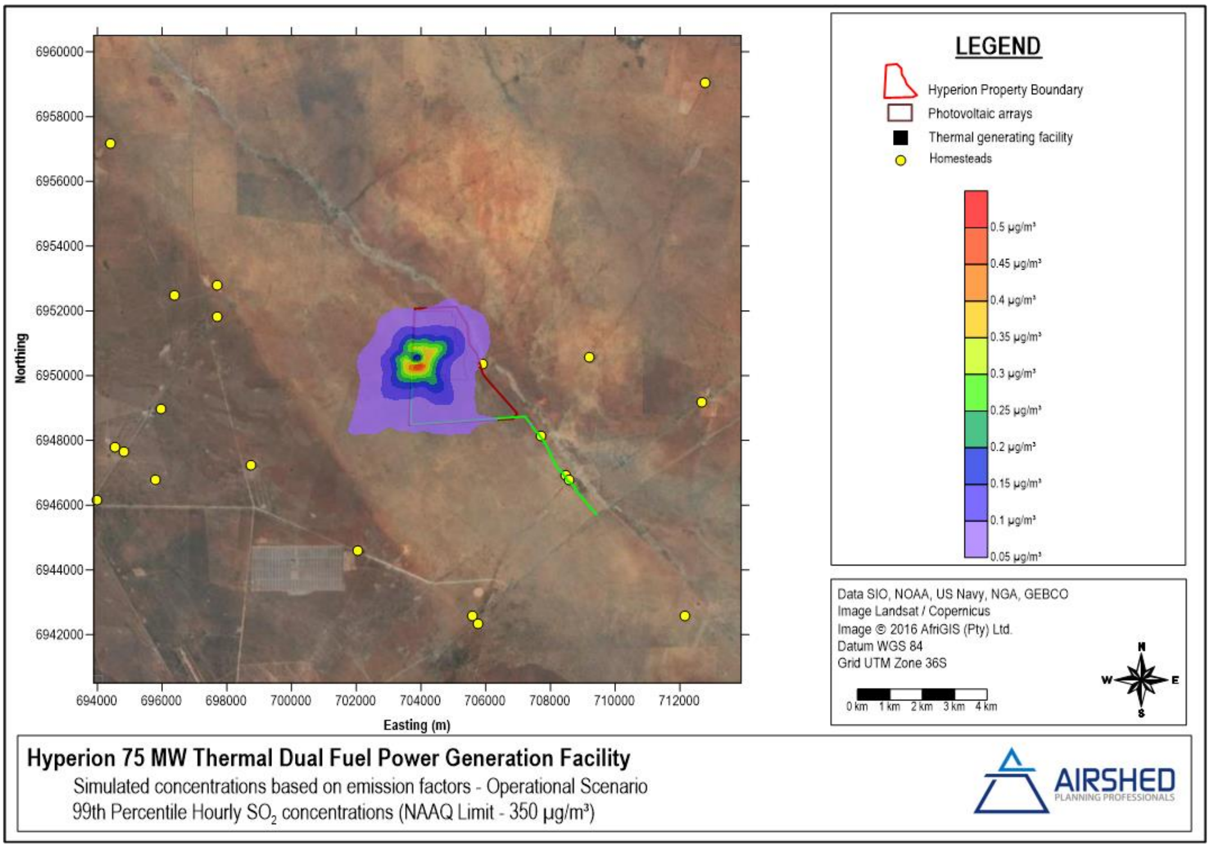

Figure 5-14: Simulated hourly average ambient SO_2 concentrations based on emission factors

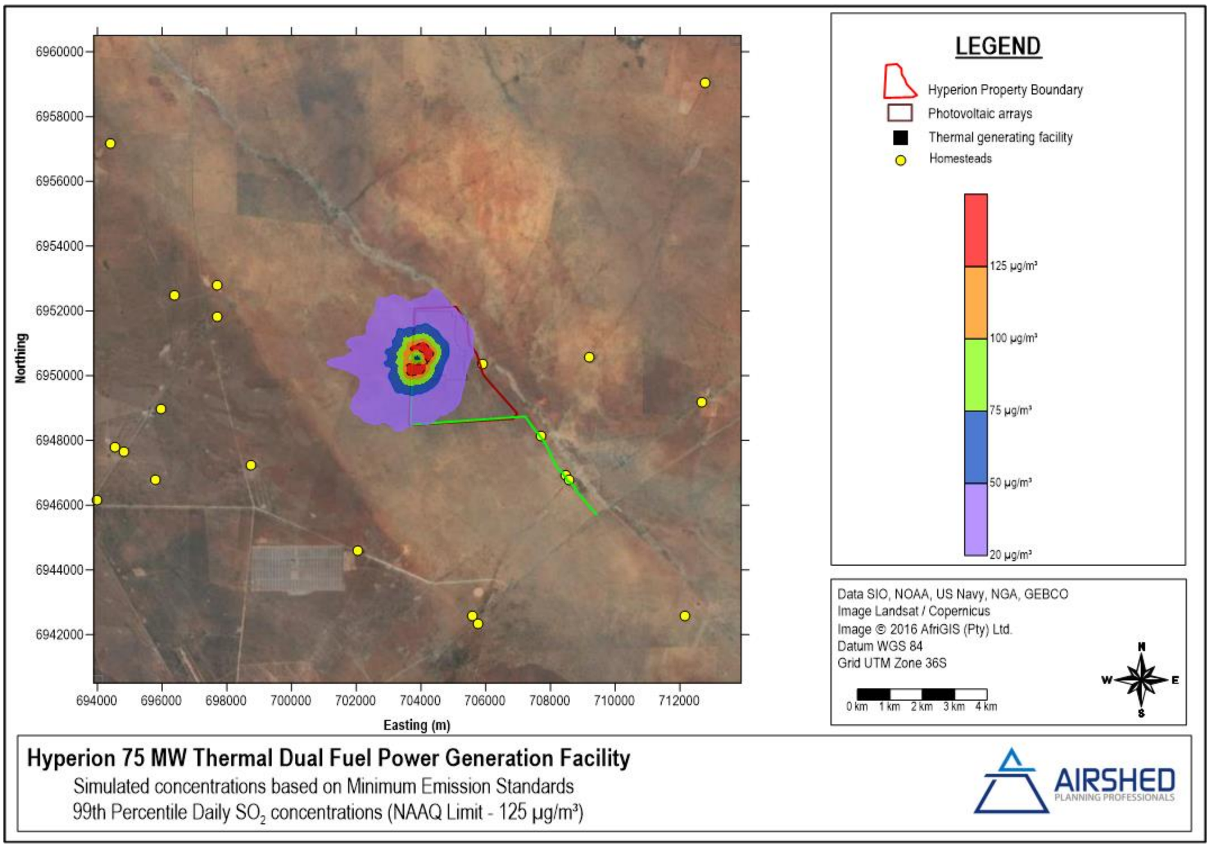

Figure 5-15: Simulated daily average ambient SO_2 concentrations based on Minimum Emission Standards

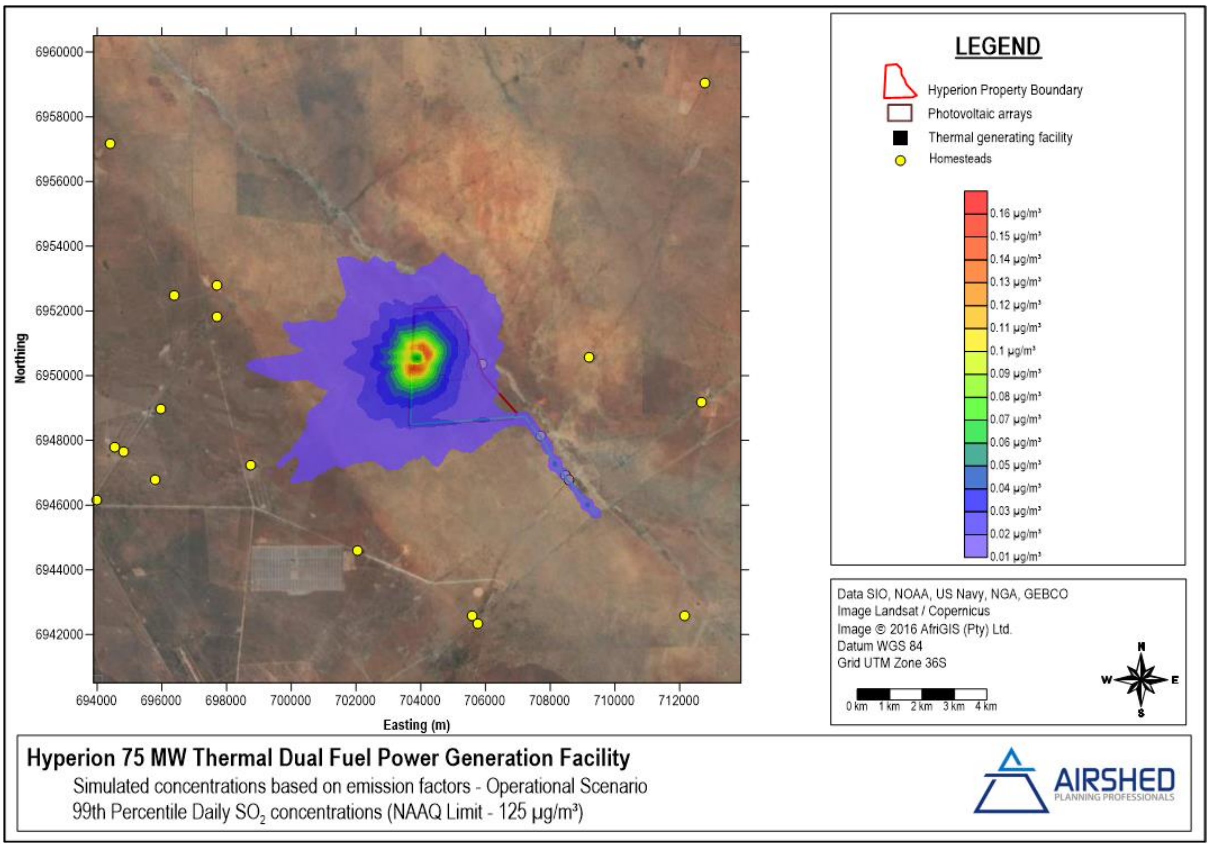

Figure 5-16: Simulated daily ambient average SO_2 concentrations based on emission factors

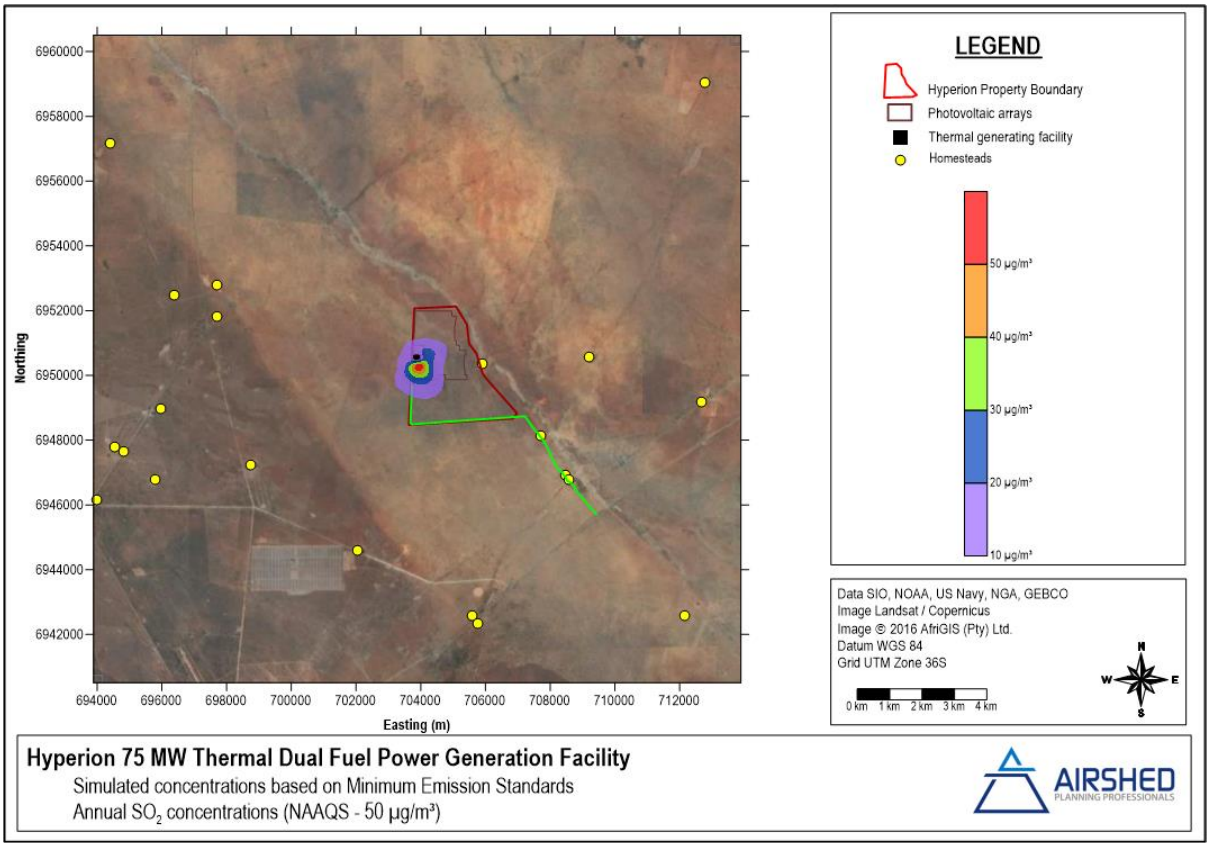

Figure 5-17: Simulated annual average ambient SO_2 concentrations based on Minimum Emission Standards

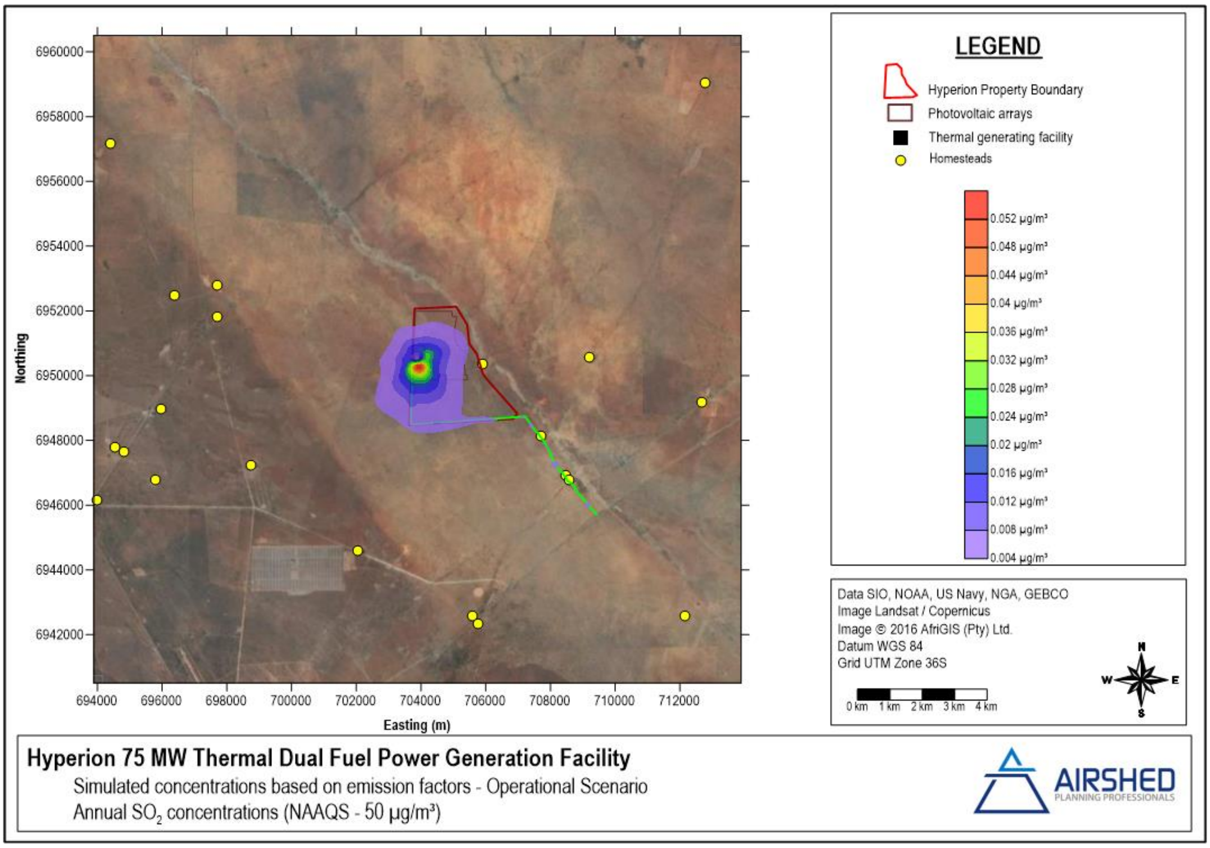

Figure 5-18: Simulated annual average ambient SO_2 concentrations based on emission factors

5.1.6.3 Operational Phase: Simulated Incremental NO_2 Impacts

AERMOD simulated oxides of nitrogen (NO_X). Hourly and annual average NO_2 concentrations were calculated from simulated NO_X concentrations assuming an 80% conversion ratio (as described in the Regulations regarding Air Dispersion Modelling - Government Gazette No. 37804 vol. 589; 11 July 2014). Simulated hourly NO_2 concentrations are lower than the NAAQS at all receptors (Figure 5-19) and within the domain (Figure 5-20). Simulated annual average NO_2 concentrations are lower than the NAAQS across the domain (Figure 5-21).

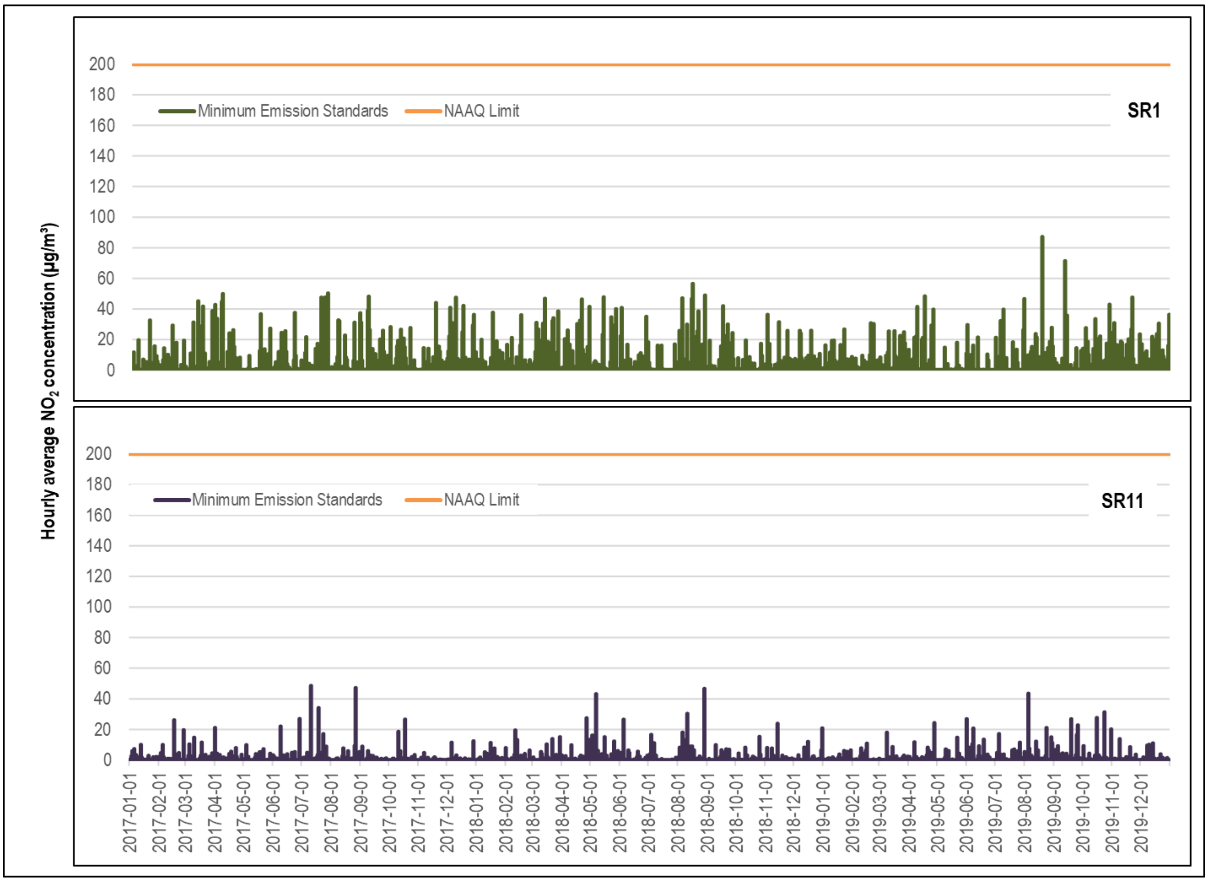

Figure 5-19: Time series of the hourly NO_2 concentrations simulated at the nearest receptors

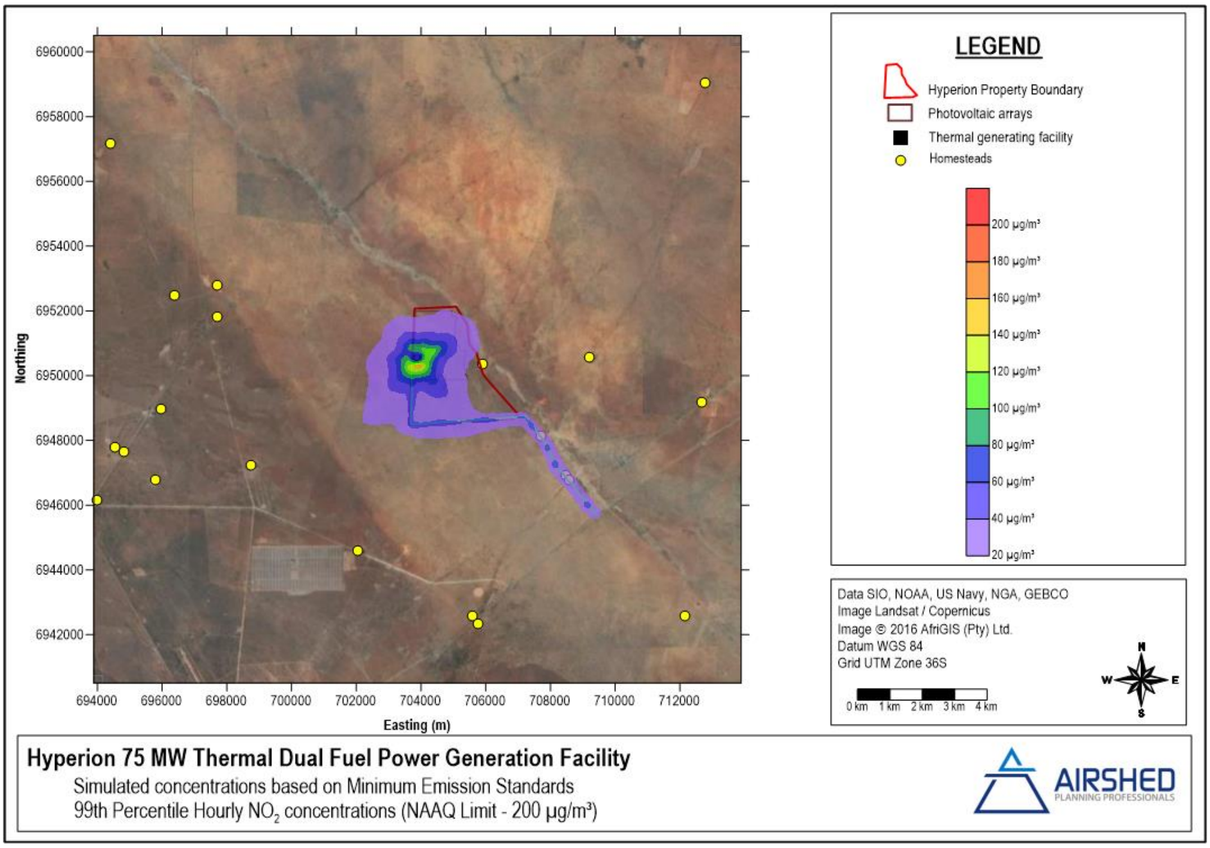

Figure 5-20: Simulated hourly average ambient NO_2 concentrations based on Minimum Emission Standards

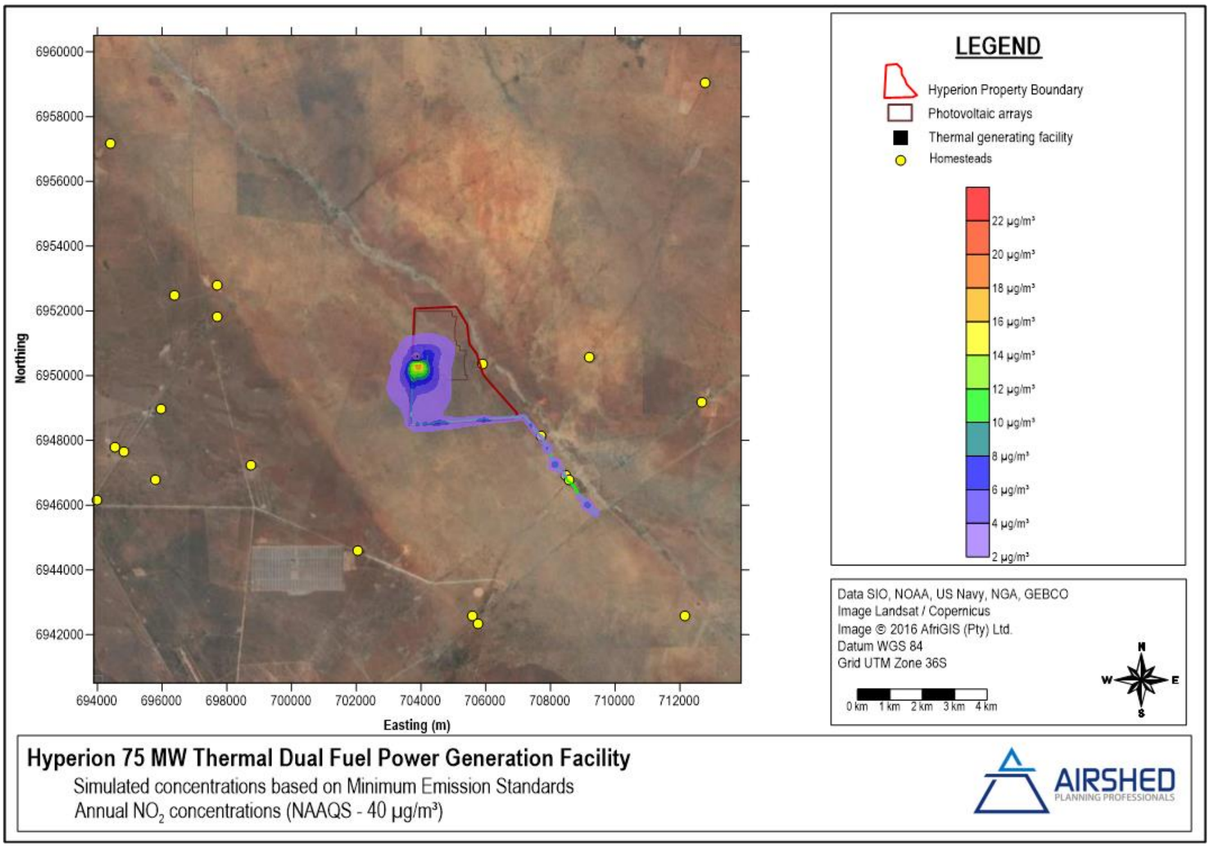

Figure 5-21: Simulated annual average ambient NO_2 concentrations based on Minimum Emission Standards

5.1.6.4 Operational Phase: Simulated Incremental Particulate Matter Impacts

Simulated particulate matter concentrations, in both the PM_{10} and $PM_{2.5}$ fractions, as a result of the Project were in below all the respective NAAQ limit values at all receptors (Figure 5-22, and

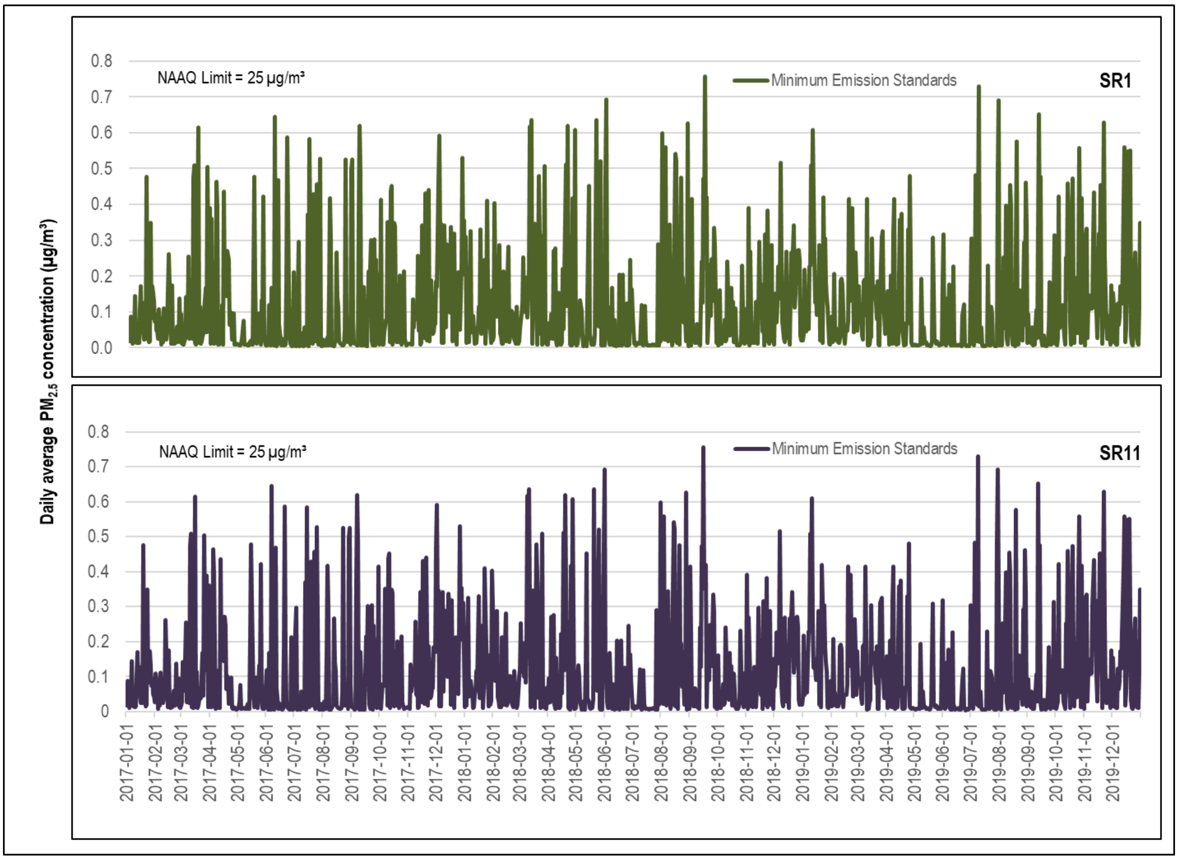

Figure 5-23) and across the entire domain (Figure 5-24, Figure 5-25, Figure 5-26, and Figure 5-27).

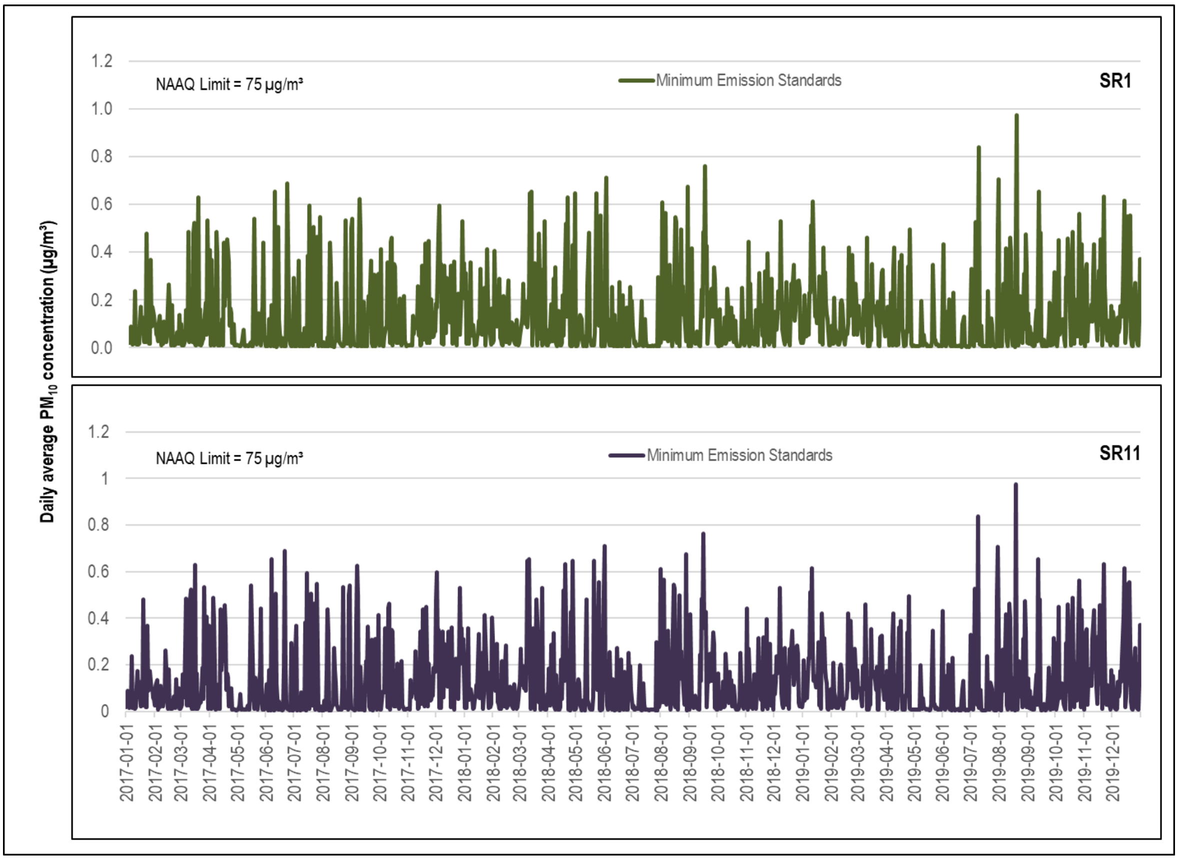

Figure 5-22: Time series of the daily PM_{10} concentrations simulated at the nearest receptors

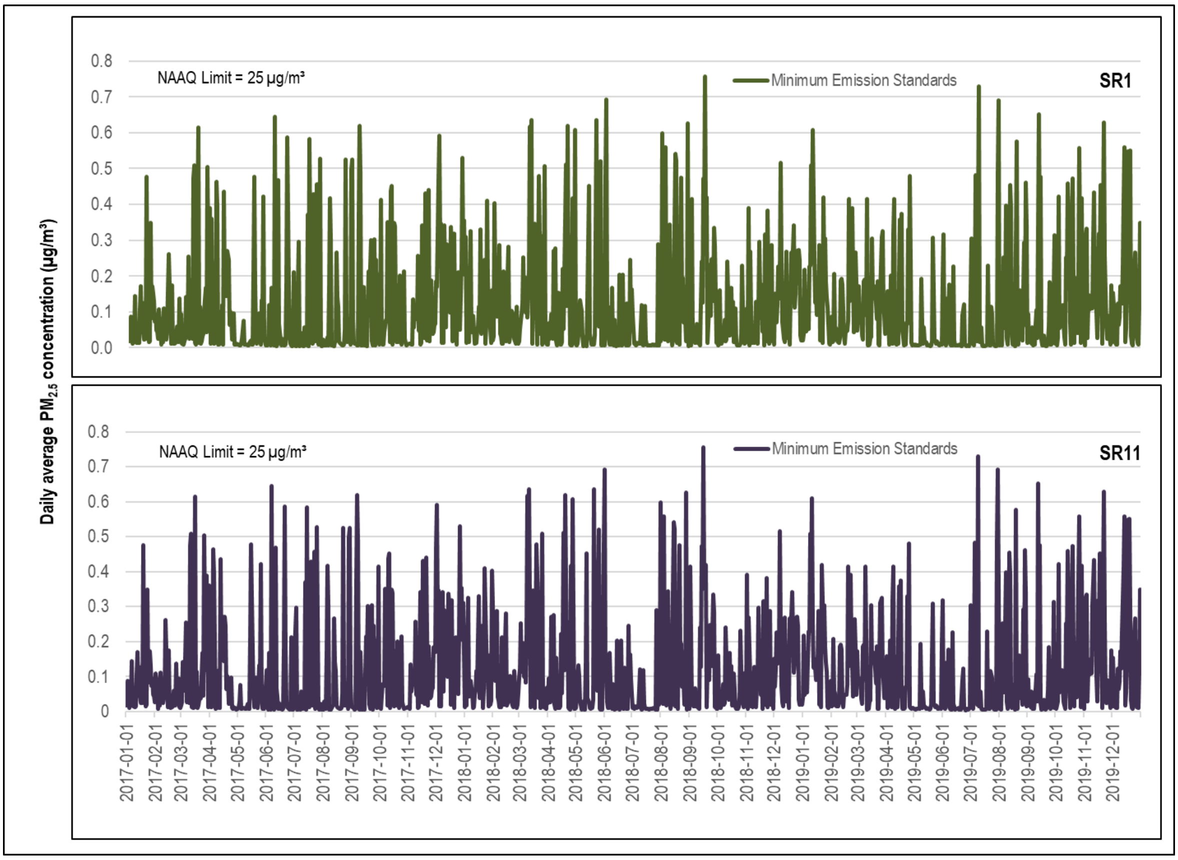

Figure 5-23: Time series of the daily $PM_{2.5}$ concentrations simulated at the nearest receptors

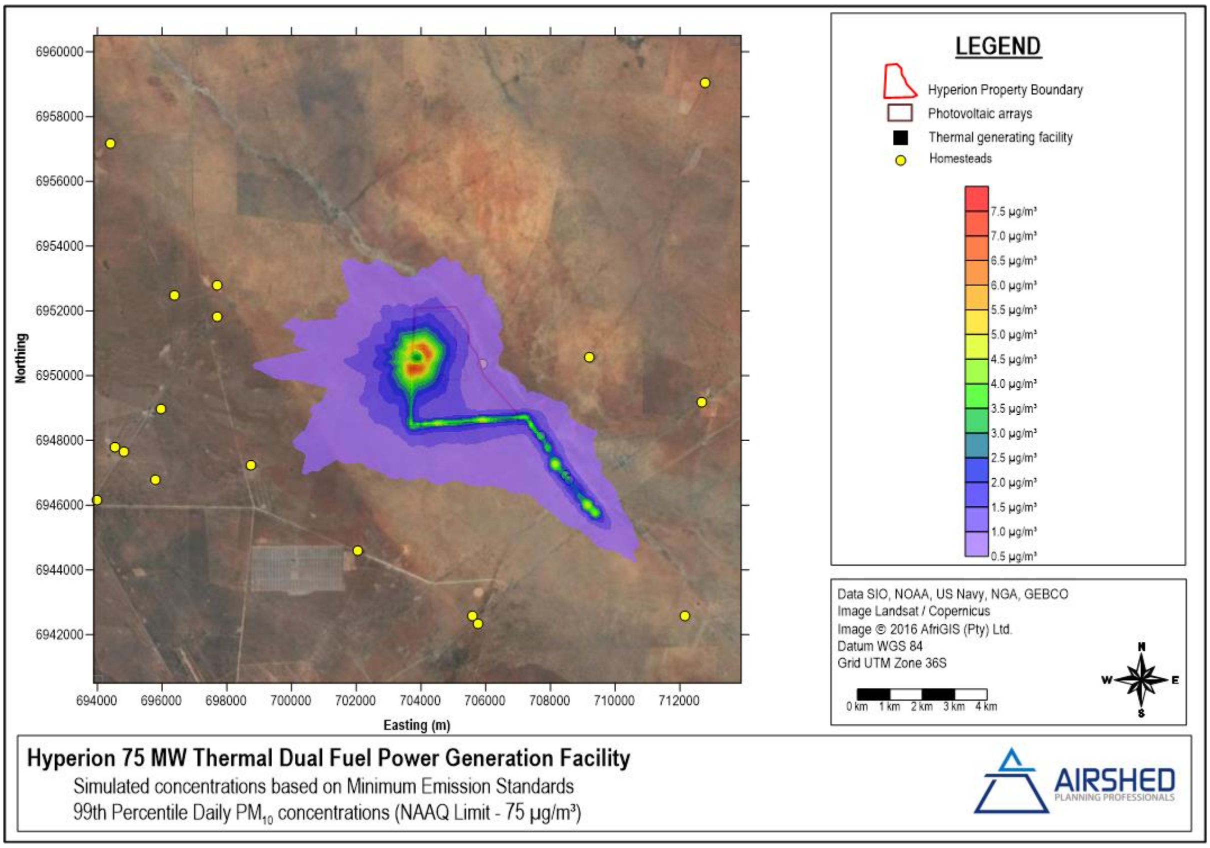

Figure 5-24: Simulated daily average ambient PM_{10} concentrations based on Minimum Emission Standards

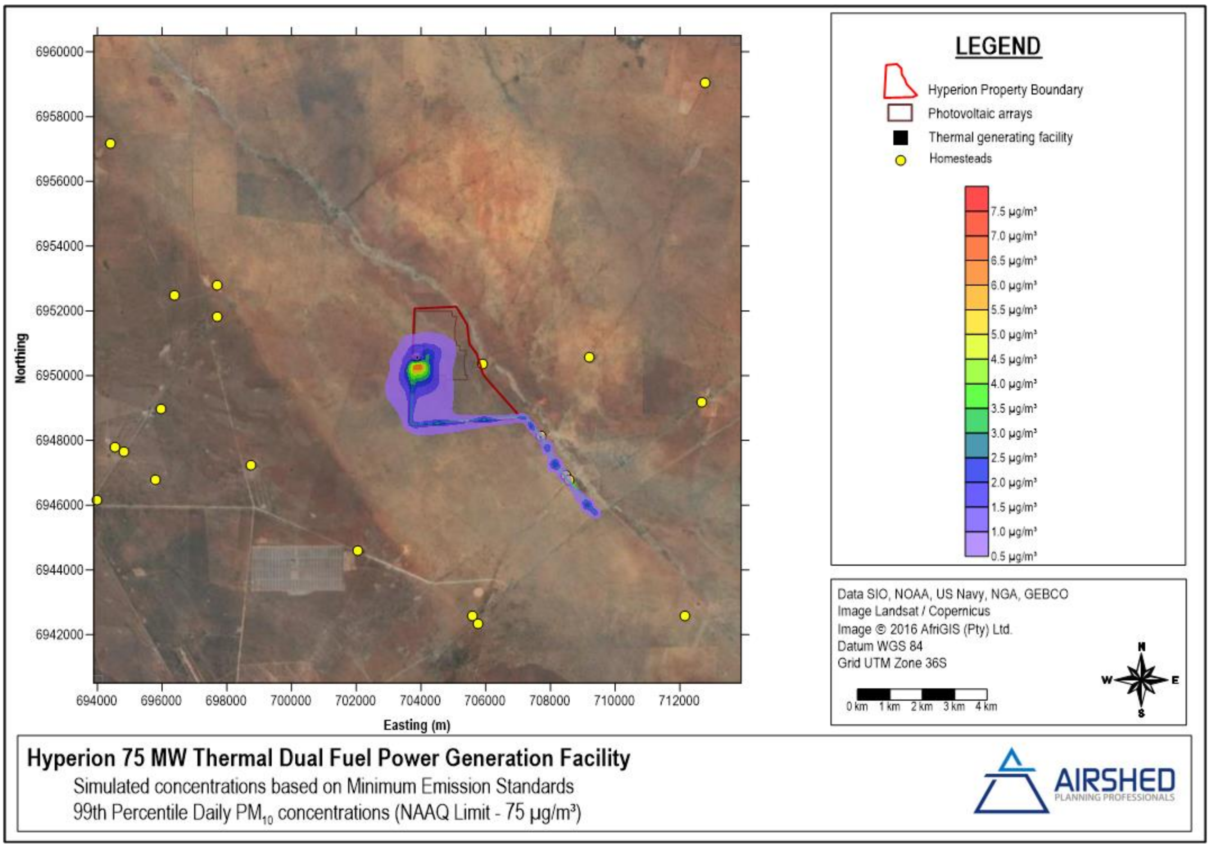

Figure 5-25: Simulated annual average ambient PM_{10} concentrations based on Minimum Emission Standards

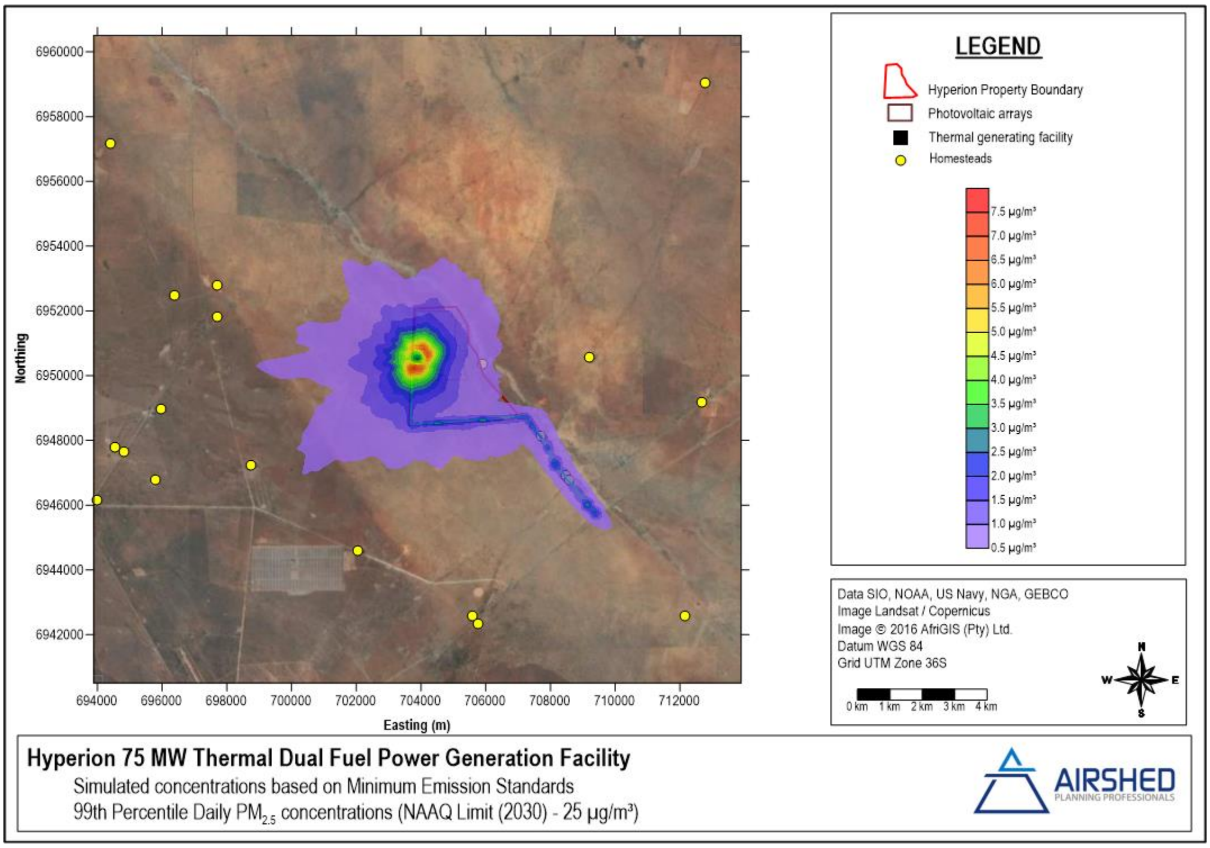

Figure 5-26: Simulated daily average ambient $PM_{2.5}$ concentrations based on Minimum Emission Standards

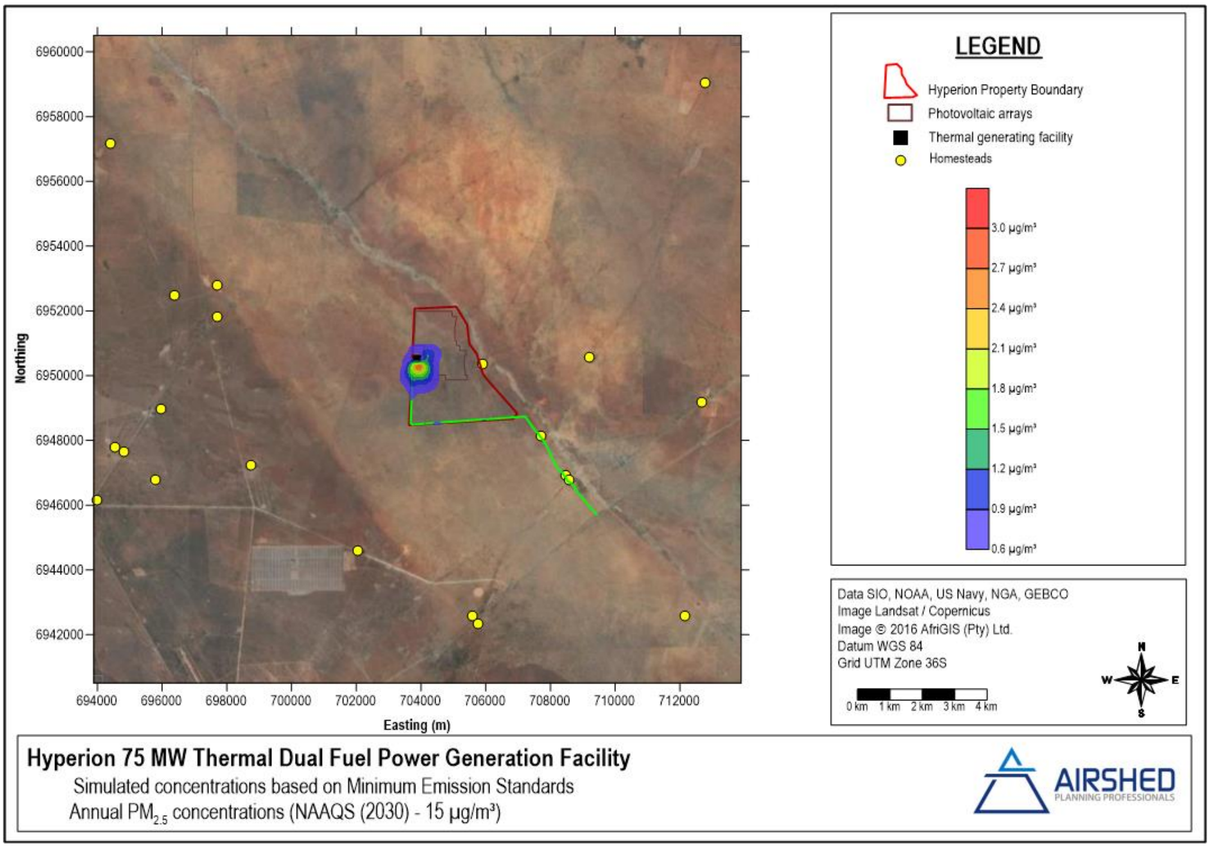

Figure 5-27: Simulated annual average ambient $PM_{2.5}$ concentrations based on Minimum Emission Standards

5.1.6.5 Operational Phase: Simulated Incremental CO Impacts

Simulated hourly CO concentrations as a result of the Project are lower than the NAAQ limit values at receptors (Figure 5-28) and across the entire domain (Figure 5-29).

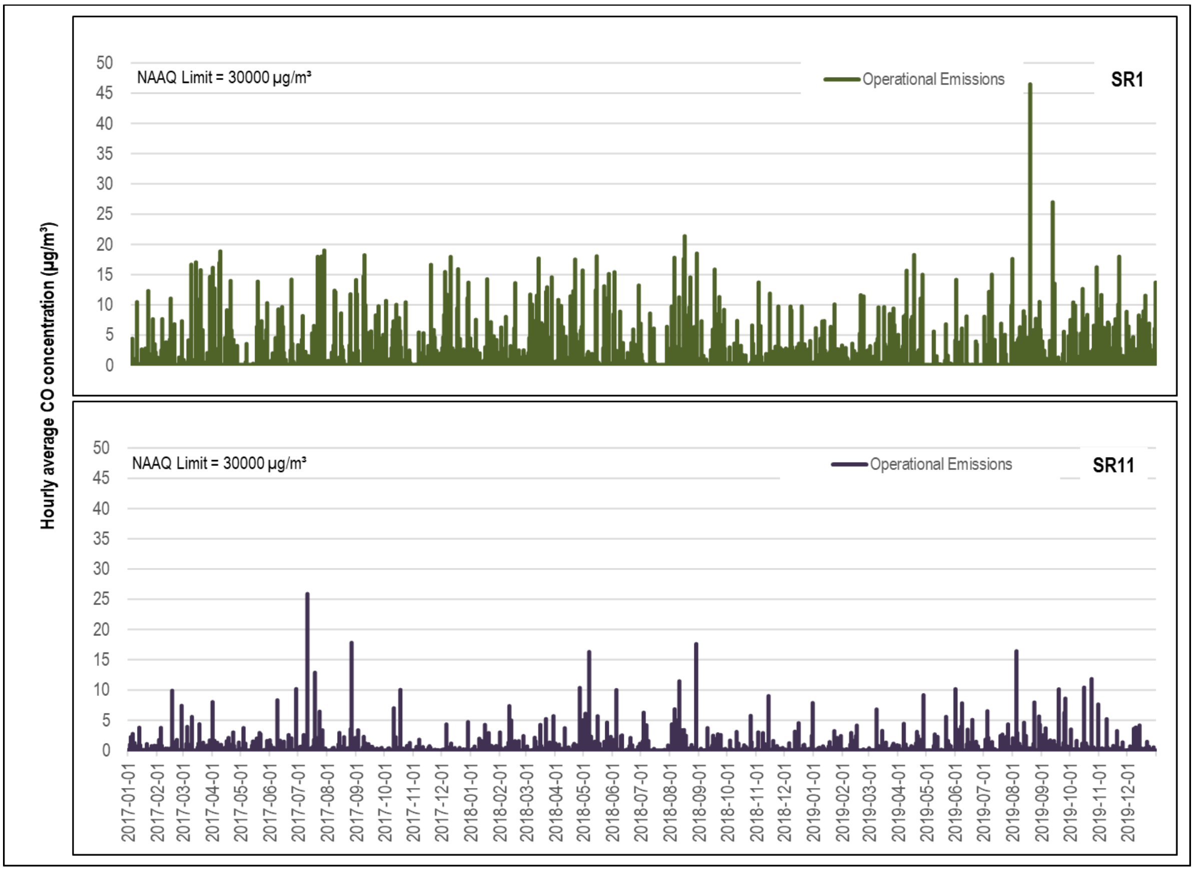

Figure 5-28: Time series of the hourly CO concentrations simulated at the nearest receptors

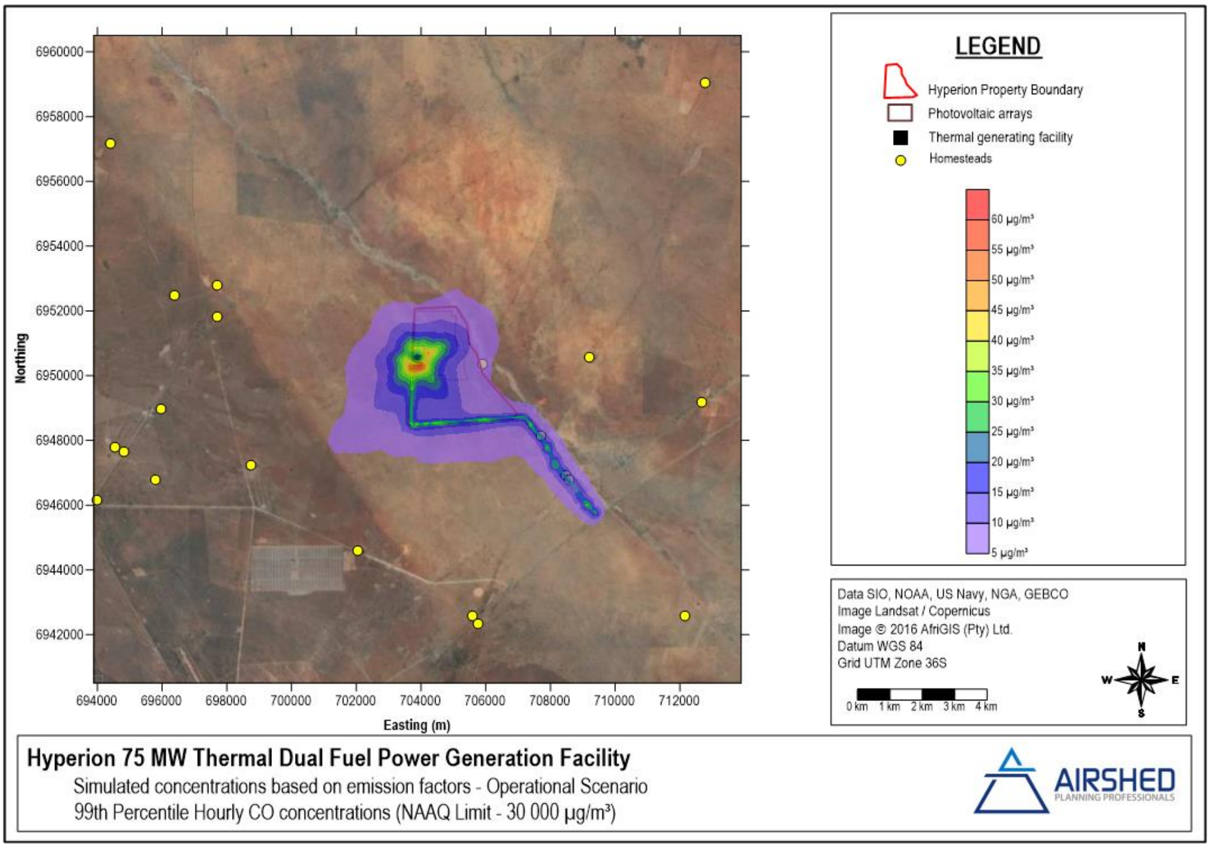

Figure 5-29: Simulated hourly average ambient CO concentrations based on emission factors

5.1.7 Cumulative Impacts

The cumulative impact of the proposed 75 MW thermal dual fuel power generation facility was assessed by adding the domain maximum simulated concentrations to the measured concentrations at the DEFF Karoo monitoring station (Table 5-11). The proposed facility is likely to make the largest impact on hourly average NO_2 concentrations, however, exceedances of the applicable NAAQS are unlikely. Open-cast mining occurs approximately 17 km to the south-west of the site, the ambient particulate concentrations measured near the mine (Section 5.1.4.1) are not considered to be representative of the project site.

Table 5-11: Estimated cumulative impact of the 75 MW thermal dual fuel power generation facility and existing baseline air pollutant concentrations.

Source group	SO_2 (µg/m³)			NO_2 (µg/m³)		PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)	
	Hourly	Daily	Annual	1 hour	Annual	24 hour	Annual	24 hour	Annual
Baseline – Karoo[(a)]	17.0	17.0	6.4	9.6	4.6	39.5	2.4	16.3	2.4
Hyperion 75 MW[(b)]	0.5	0.2	0.1	146.7	17.2	7.4	2.2	7.3	2.6
Cumulative	*17.5*	*17.2*	*6.4*	*156.3*	*21.8*	*46.9*	*4.6*	*23.6*	*5.0*

Notes:
(a) 2019 used as indicative year since data availability was acceptable and representative of a full year
(b) Conservatively uses domain maximum simulated concentration

5.2 Analysis of Emissions' Impact on the Environment

In the absence of a prescribed methodology (in the Regulations Prescribing the Format of the Atmospheric Impact Report, Government Gazette No. 36904, Notice Number 747 of 2013; 11 October 2013), the impact of emissions from the facility on the environment was assessed using the pollutant critical levels that may affect vegetative productivity, and nuisance dustfall. The same dispersion modelling approach was used as in the assessment of impact of the facility on human health (described in Section 5.1.1).

5.2.1 Critical Levels for Vegetation

The impact of emissions associated with the Project on the surrounding vegetation was assessed by comparing the simulated annual SO_2 and NO_2 concentrations for each of the emission scenarios 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 5-12). The annual concentrations of SO_2 (Figure 5-30) may affect cyanobacterial lichen via various measures of productivity and reproductive success[4] up to 450 m from site under the MES scenario; however no on-site or off-site vegetative impacts are likely due to the normal operation of the thermal power generation facility. Annual NO_2 concentrations are unlikely to affect vegetation via various measures of productivity and reproductive success off-site (Figure 5-31).

Table 5-12: 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 period. It is also noted that long-term effects of NO_X are more significant than short-term effects (CLRTAP, 2015).

[4] "The effects vary between vegetation type or species and pollutant, and include changes in growth for trees and (semi-) natural vegetation, yield (quality and quantity) for crops, flower number and seed production for (semi-)natural vegetation, and vulnerability to abiotic stresses such as frost or drought and biotic stresses such as pests and diseases" (CLRTAP, 2017, p. 4).

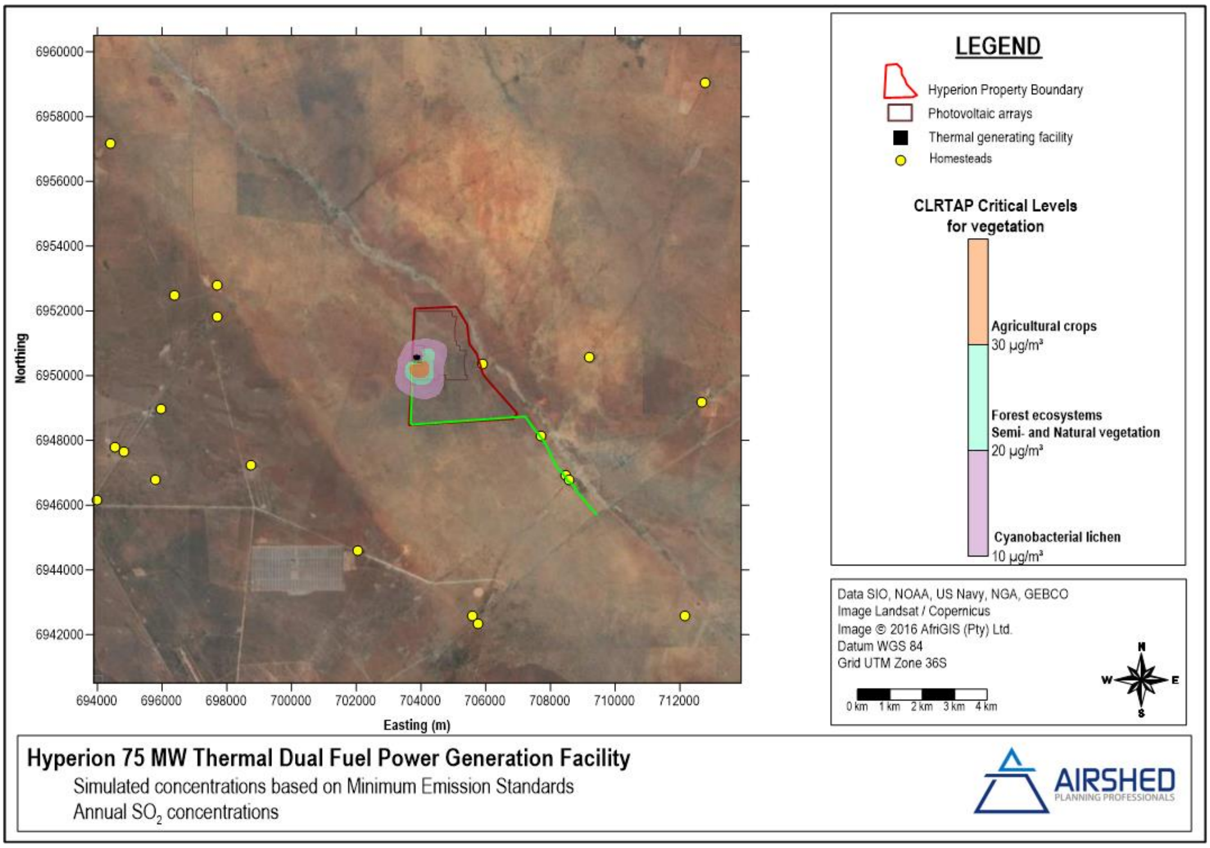

Figure 5-30: Annual SO_2 concentrations based on Minimum Emission Standards compared to CLRTAP critical levels

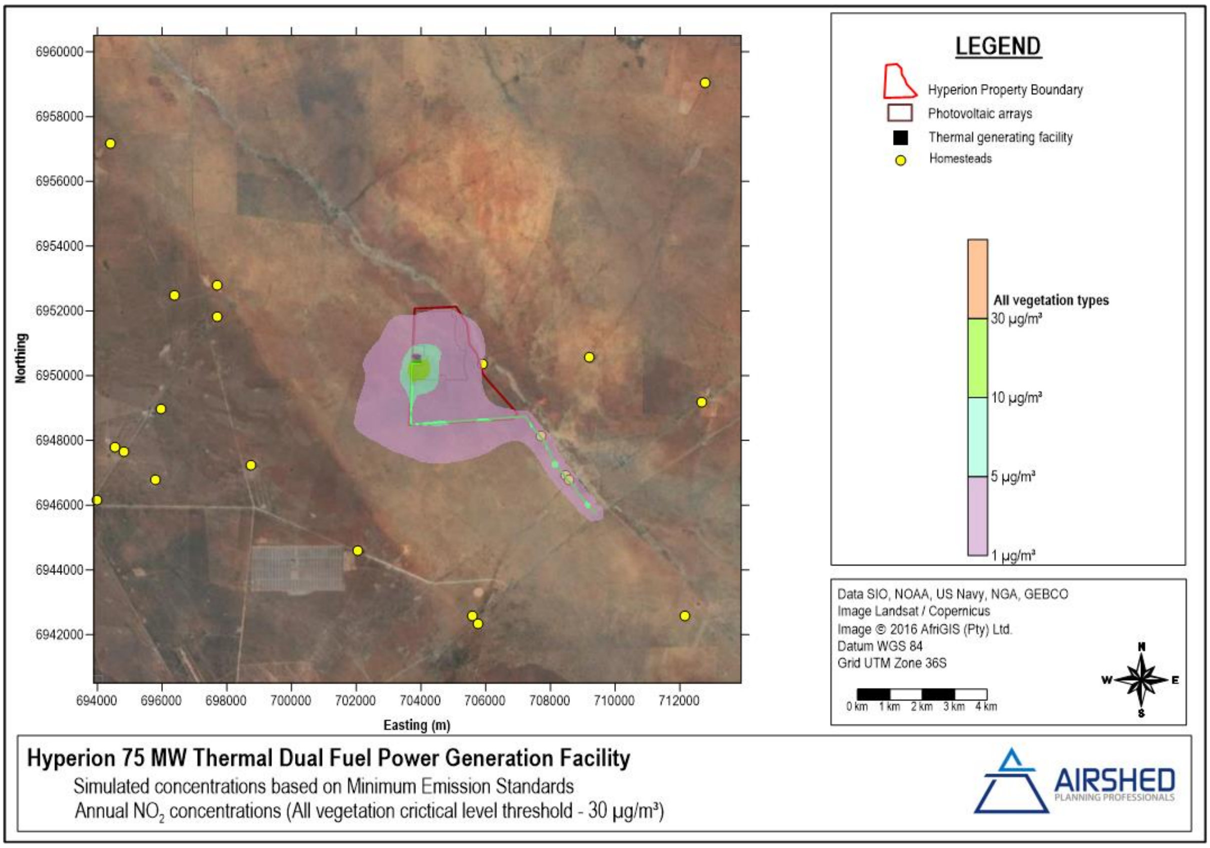

Figure 5-31: Annual NO_2 concentrations based on Minimum Emission Standards compared to CLRTAP critical levels

5.2.2 Effects of SO_2 and NO_2 on Animals

In addition to potential exposure to outdoor environmental air pollution, animals kept in large-scale husbandry facilities are exposed to, and often diseased by, self-made indoor air pollution that is a function of the conditions under which the animals are reared (Van den Hoven, 2011).

Experimental studies on animals have shown the acute inhalation of SO_2 produces bronchoconstriction, increases respiratory flow resistance, increases mucus production and has been shown to reduce abilities to resist bacterial infection in mice (Costa & Amdur, 1996). Short exposures to low concentrations of SO_2 (~2.6 mg/m³) have been shown to have immediate physiological response without resulting in significant or permanent damage. Short exposures (<30 min) to concentrations of 26 mg/m³ produced 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/m³. 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 (26-1 053 mg/m³) (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 annual concentrations of SO_2 associated with the project are very low (<1 µg/m³ across the domain) and are expected to have a negligible impact on animal health.

The toxicity of NO_2 is related to oxidation processes that form nitric acid with water in the eyes, lungs, mucous membranes and on the skin of animals (MFE, 2004) and result in oxidation of cell membrane lipids and proteins triggering inflammation (Menzel, 1994). Long term exposure to nitrogen oxides increases respiratory infections resulting in lowered resistance to diseases such as pneumonia and influenza (MFE, 2004). An acute association between ambient NO_2 concentrations and dairy cattle mortality was found in Belgium during cold and warm season exposure to NO_2, however, these acute associations did not influence cumulative exposure over a 26-day experimental period (Cox, et al., 2016)The daily average NO_2 concentrations to which for the dairy cattle studied by Cox *et al.* (2016) were exposed ranged between 7.8 and 60 µg/m³ in the warm season and between 21 and 93 µg/m³ in the cold season.

The hourly average simulated short-term concentrations of NO_2 due to the Hyperion 75 MW facility were lower than 150 µg/m³ within the domain. The estimated maximum daily average concentration is therefore likely to be lower than 60 µg/m³[5]. and likely to have a low impact on animal health.

5.2.3 Effects of Particulate Matter on Animals

As presented by the Canadian Environmental Protection Agency (CEPA/FPAC Working Group, 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

[5] Using the hourly to daily conversion factor (0.4) recommended in Table 8 of the Regulations Regarding Air Dispersion Modelling (Gazette No 37804 published 11 July 2014)

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 dramatic acute 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/m³ (3 days, 6 hours/day), using continuous exposure to concentrated ambient particles.

The simulated annual concentrations of PM_{10} and $PM_{2.5}$ associated with the project were very low (< 3 µg/m³ across the domain) and are expected to have a negligible incremental impact on animal health.

5.2.4 Nuisance Dustfall

5.2.4.1 National Dust Control Regulations

The National Dust Control Regulations (NDCR) was gazetted on 1 November 2013 (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. The standard for acceptable dustfall rate is set out in Table 5-13. The method to be used for measuring dustfall rate 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 dustfall is assessed for nuisance impact and not inhalation health impact.

Table 5-13: Acceptable dustfall rates

Restriction Area	Dustfall Rate (mg/m².day; 30-day average)	Permitted Frequency of Exceeding Dustfall Rate
Residential area [(a)]	D<600	Two in a year, not sequential months
Non-residential area [(b)]	600<D<1200	Two in a year, not sequential months
Notes:(a) Applicable at the sensitive receptors and residential areas near the facility (b) Applicable within the Richards Bay IDZ		

5.2.4.2 Simulated Incremental Nuisance Dustfall Impacts – Construction Phase

Simulated dustfall rates for the construction phase were compared to the acceptable dustfall rates defined in the NDCR (Table 5-13). Daily dustfall rates as a result of the Construction Phase of the Project are likely to be lower than 100 mg/m².day and no exceedances of the NDCR were simulated during construction of the thermal power generation facility (Figure 5-32) or during the road construction (results not shown – maximum dustfall rate 70 mg/m².day). It is advised that dust control measures (as per the EMP- Appendix F) be strictly implemented during the construction of the access road, especially near the homesteads located along the road (SR7, SR11 and SR18).

5.2.4.3 Simulated Incremental Nuisance Dustfall Impacts – Operational Phase

Simulated operational phase dustfall rates were compared to the acceptable dustfall rates defined by the NDCR (Table 5-13). Daily dustfall rates as a result of the Project are likely to be below the NDCR for residential (or non-residential) receptors along the access road during normal operations (Figure 5-33 – maximum dustfall rate <20 mg/².day). However, the implementation of dust control measures along the access road (such as sweeping, or wet suppression; screens or berms) is recommended near the homesteads (SR7, SR11 and SR18) during high traffic periods to minimise the nuisance impacts to residents.

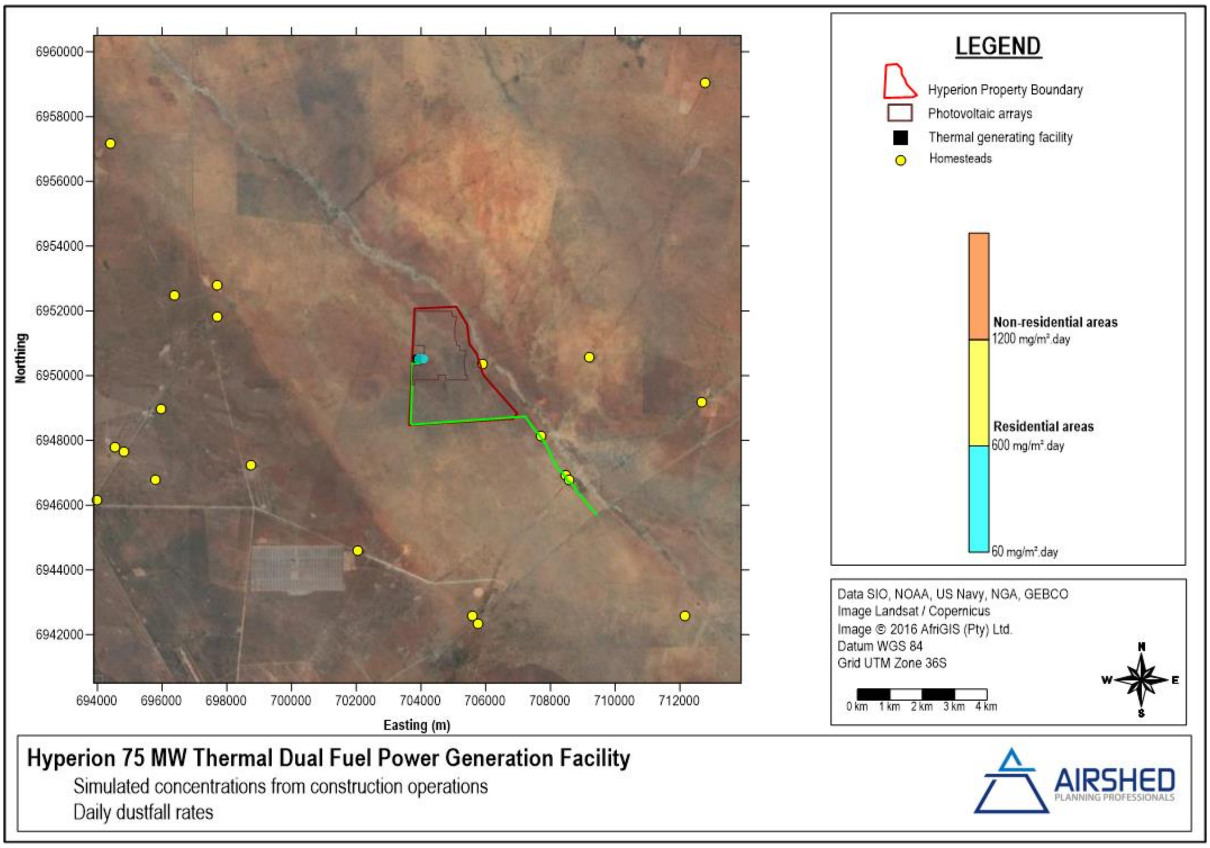

Figure 5-32: Simulated daily dustfall rates as a during the construction phase

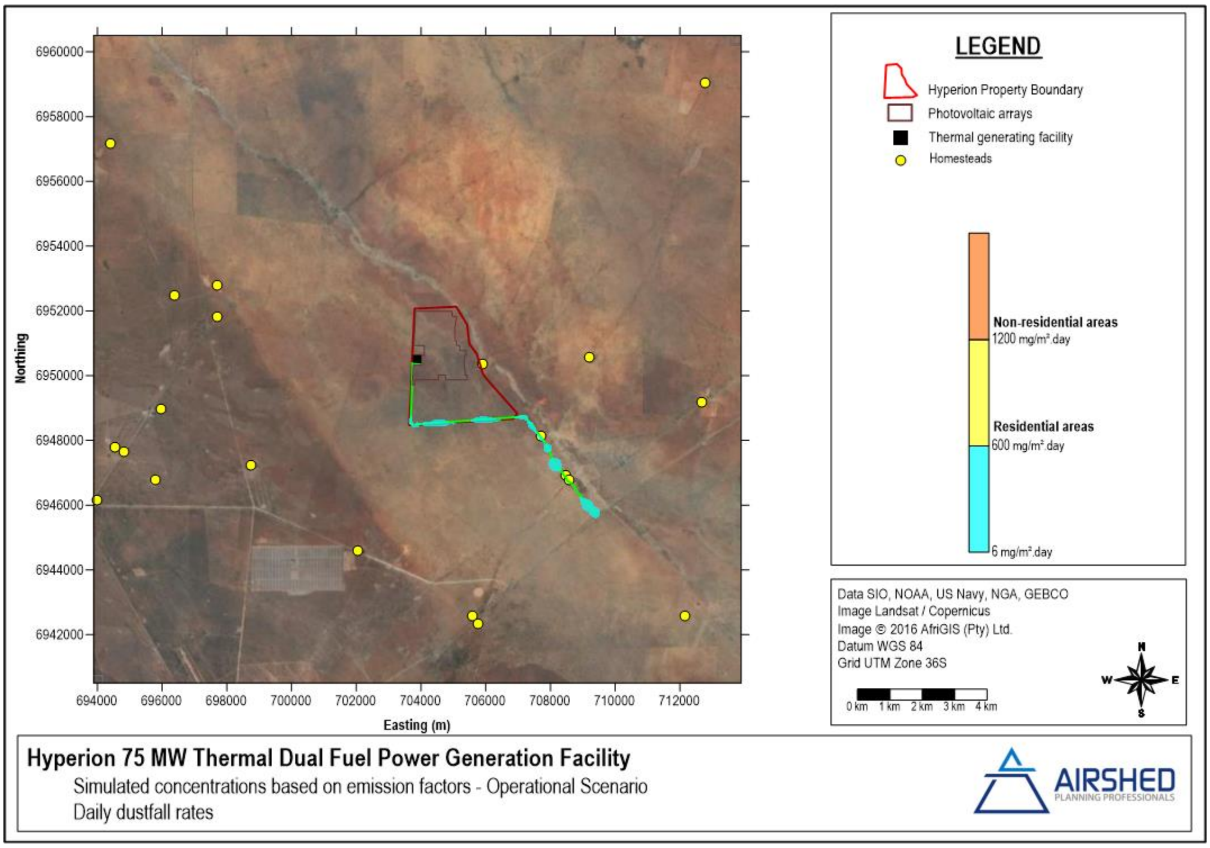

Figure 5-33: Simulated daily dustfall rates based on emission factors

5.2.4.4 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 & 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 (for example, 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 (for example, 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, 1993).

Estimated dust fallout rates due to the project are low (<100 mg/m².day) (Figure 5-33). While dust fallout can have a negative effect on both plant growth and the economic value of crops, the impact is expected to be limited due to the nature of surrounding land use being predominantly small stock farming. Impact of dustfall due to vehicle entrainment can be mitigated (more detail provided in Appendix F).

5.3 Climate Change Impact Statement

5.3.1 Introduction

5.3.1.1 The Greenhouse Effect

Greenhouse gases are "those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) are the primary greenhouse gases in the earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine and bromine containing substances, addressed under the Montreal Protocol. Beside CO_2, N_2O and CH_4, the Kyoto Protocol deals with the greenhouse gases sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) (IPCC, 2007). Human activities since the beginning of the Industrial Revolution (taken as the year 1750) have produced a 40% increase in the atmospheric concentration of carbon dioxide, from 280 ppm in 1750 to 406 ppm in early 2017 (NOAA, 2017). This increase has occurred despite the uptake of a large portion of the emissions by various natural "sinks" involved in the carbon cycle (NOAA, 2017). Anthropogenic CO_2 emissions (i.e., emissions produced by human activities) come from combustion of fossil fuels, principally coal, oil, and natural gas, along with deforestation, soil erosion and animal agriculture (IPCC, 2007).

5.3.1.2 International Agreements

In 1992, countries joined an international treaty, the United Nations Framework Convention on Climate Change, (UNFCCC) as a framework for international cooperation to combat climate change by limiting average global temperature increases and the resulting climate change, and coping with impacts that were, by then, inevitable.

By 1995, countries launched negotiations to strengthen the global response to climate change, and, two years later, adopted the Kyoto Protocol. The Kyoto Protocol legally binds developed country parties to emission reduction targets. The Protocol's first commitment period started in 2008 and ended in 2012. As agreed in Doha in 2012, the second commitment period began on 1 January 2013 and will end in 2020 (UNFCCC, 2017) but due to lack of ratification has not come into force.

The Paris Agreement (2016) builds upon the Convention and – for the first time – brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. As such, it charts a new course in the global climate effort.

The central aim of the Paris Agreement is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2.0°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C. Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives.

All signed parties to the Paris Agreement are required to put forward their best efforts through "nationally determined contributions" (NDCs) and to strengthen these efforts in the years ahead. This includes requirements that all Parties report regularly on their emissions and on their implementation efforts. There will also be a global stocktake every five years to assess the collective progress towards achieving the purpose of the Agreement and to inform further individual actions by Parties. As of January 2021, 190 Parties of the 197 Parties to the UNFCCC Convention, including South Africa, had ratified the Paris agreement. South Africa submitted its intended NDC (INDC) to the UNFCCC on 1 November 2016.

5.3.2 South Africa's Status in terms of Climate Change and Quantification of Greenhouse Gases

5.3.2.1 South African National Climate Change Response Policy 2011

South Africa ratified the UNFCCC in August 1997 and acceded to the Kyoto protocol in 2002, with effect from 2005. However, since South Africa is an Annex 1 country it implies no binding commitment to cap or reduce GHG emissions.

The National Climate Change Response White Paper stated that in responding to climate change, South Africa has two objectives: to manage the inevitable climate change impacts and to contribute to the global effort in stabilising GHG emissions at a level that avoids dangerous anthropogenic interference with the climate system. The White Paper proposes mitigation actions, especially a departure from coal-intensive electricity generation, be implemented in the short- and medium-term to match the GHG trajectory range. Peak GHG emissions are expected between 2020 and 2025 before a decade long plateau period and subsequent reductions in GHG emissions.

The White Paper also highlighted the co-benefit of reducing GHG emissions by improving air quality and reducing respiratory diseases by reducing ambient particulate matter, ozone and SO_2 concentrations to levels in compliance with NAAQS by 2020. In order to achieve these objectives, the Department of Environment, Forestry and Fisheries (DEFF), previously Department of Environmental Affairs – DEA) appointed a service provider to establish a national GHG emissions inventory, which will report through SAAQIS.

5.3.2.2 Intended Nationally Determined Contribution

The South African Intended Nationally Determined Contribution (INDC) submission was completed in 2016. This was undertaken to comply with decision 1/CP.19 and 1/CP.20 of the Conference of the Parties to the UNFCC. This document describes South Africa's INDC on adaptation, mitigation and finance and investment necessities to undertake the resolutions.

As part of the adaption portion the following goals have been assembled:

1. Goal 1: Development and implementation of a National Adaptation Strategy. The implementation of this will also result in the implementation of the National Climate Change Response Plan (NCCRP) as per the 2011 policy.
2. Goal 2: In the development of national, sub-national and sector strategy framework, climate concerns must be taken into consideration.
3. Goal 3: An official institutional function for climate change response planning and implementation needs to be assembled.
4. Goal 4: The creation of an early warning, vulnerability and adaptation monitoring system
5. Goal 5: Develop policy regarding vulnerability assessment and adaptation needs.
6. Goal 6: Disclosure of undertakings and costs with regards to past adaptation strategies.

As part of the mitigation portion the following have been, or can be, implemented at National level:

- The approval of 102 (6 400 MW) renewable energy Independent Power Producer (IPP) projects as part of a Renewable Energy Independent Power Producer Procurement Programme (REI4P), of which 2 800 MW from 53 IPPs were already in operation by October 2016.
- A "Green Climate Fund" has been created to back green economy initiatives. This fund will be increased in the future to sustain and improve successful initiatives.
- It is intended that by 2050 electricity will be decarbonised.
- Carbon Capture and Sequestration (or Carbon Capture and Storage) (CCS).
- To support the use of electric and hybrid electric vehicles.
- Reduction of emissions can be achieved through the use of energy efficient lighting; variable speed drives and efficient motors; energy efficient appliances; solar water heaters; electric and hybrid electric vehicles; solar photovoltaic (PV); wind power; CCS; and advanced bioenergy.

5.3.2.3 Greenhouse Gas Emissions

Regulations pertaining to GHG reporting using the NAEIS were published on 3 April 2017 (GN 257 in Government Gazette 40762). The South African mandatory reporting guidelines focus on the reporting of Scope 1 emissions only. The three broad scopes for estimating GHG are:

- Scope 1: All direct GHG emissions.
- Scope 2: Indirect GHG emissions from consumption of purchased electricity, heat or steam.
- Scope 3: Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities not covered in Scope 2, outsourced activities, waste disposal, etc.

The South African Greenhouse Gas Emission Reporting System (SAGERS) web-based monitoring and reporting system is used to collect GHG information in a standard format for comparison and analyses. The system forms part of the national atmospheric emission inventory component of South African Atmospheric Emission Licensing and Inventory Portal (SAAELIP).

The DEFF is working together with local sectors to develop country specific emissions factors in certain areas; however, in the interim the Intergovernmental Panel on Climate Change's (IPCC) default emission figures may be used to populate the

SAAQIS GHG emission factor database. These country specific emission factors will replace some of the default IPCC emission factors. Technical guidelines for GHG emission estimation have been issued.

Also, the Carbon Tax Act (Act 15 of 2019) includes details on the imposition of a tax on the CO_2-e of GHG emissions. Certain production processes indicated in Annexure A of the Declaration of Greenhouse Gases as Priority Pollutants (GN 710 in GG 40966, 21 July 2017) with GHG in excess of 0.1 Mt, measured as CO_2-e, are required to submit a pollution prevention plan to the Minister for approval. The proposed facility will be required to report CO_2-e emissions (calculated based on Tier 2 or 3 methodologies) annually as the operations are listed under Annexure 1 of the Declaration (Main Activity Electricity and Heat Production exceeding 10 MW-thermal) and GHG emission rates exceed 0.1 Mt per year.

5.3.2.4 South African Energy Supply

Coal provides in the order of 70% of the primary energy supply to the SA economy, with in excess of 90% of the electricity being generated from coal combustion. South Africa is thus regarded as having a carbon-intensive energy economy.

5.3.2.4.1 Planning Framework

The 1998 White Paper on the Energy Policy of the Republic of South Africa covered both supply and demand of energy for the next decade and made specific provision for independent suppliers of energy to enter the market. No additional capacity ensued during the decade 1998 to 2008, leading to the 'load shedding' of 2008 and the subsequent short-term interventions to ensure stability of supply. The 2011 Integrated Resource Plan (IRP) (DOE, 2011) provided a planning basis for the period up to 2030 and made provision for the supply of energy (including renewable energy) by independent producers, as well as 9600 MW of nuclear energy over that period. An update of the IRP was published in October 2019 (DOE, 2019); the drafts have attracted considerable criticism regarding the cost and greenhouse gas implications as part of the public participation process, including a report by the CSIR arguing for a much larger use of renewable sources (Wright, et al., 2017). The published 2019 IRP includes plans for electricity supply up to 2030 and beyond, including the decarbonisation of electricity supply after 2050. The plan includes the expansion of electricity generated through gas to power technologies such that they contribute 8.1% of the installed capacity by 2030 making use of imported gas imports until local natural gas reserves are explored (DOE, 2019).

5.3.2.4.2 Additional Energy Supply

By October 2016, 53 renewable independent power producing projects were already operational and contributing 2 800 MW to the national grid and several others are being deliberated as part of a Renewable Energy Independent Power Producer Procurement Programme (REI4P). The IPP Office has also initiated the procurement of 2 000 MW of new generation capacity under a programme entitled the Risk Mitigation Independent Power Producer Procurement Programme ("RMIPPPP"), targeting first generation and transmission of energy to the grid by 31 December 2022. The IPP Office is attempting to fast track the implementation of the 2 000 MW of new generation capacity to be procured under the RMIPPPP in order to alleviate the frequent load shedding being experienced in South Africa at present and is specifically targeting new generation capacity that can be brought onto the grid as quickly as possible.

5.3.2.5 GHG Inventories

5.3.2.5.1 National GHG Emissions Inventory

South Africa is perceived as a global climate change contributor and is undertaking steps to mitigate and adapt to the changing climate. DEFF is categorised as the lead climate change institution and is required to coordinate and manage climate related information such as development of mitigation, monitoring, adaption and evaluation strategies (DEA, nd). This includes the establishment and updating of the National GHG Inventory. The National Greenhouse Gas Improvement Programme (GHGIP) has been initiated; it includes sector specific targets to improve methodology and emission factors used for the different sectors as well as the availability of data.

The 2000 to 2015 National GHG Inventory was prepared using the 2006 IPCC Guidelines (IPCC, 2006). According to the National GHG Inventory (DEA, nd) the 2015 total GHG emissions were estimated at approximately 540.854 million metric tonnes CO_2-e (excluding Forestry and Other Land Use (FOLU)). This was a 23.1% increase from the 2000 total GHG emissions (excluding FOLU). FOLU is estimated to be a net carbon sink which reduces the 2015 GHG emissions to 512.383 million metric tonnes CO_2-e. The assessment (excluding FOLU) showed the main sectors contributing to GHG emissions in 2015 to be the energy industries (solid fuels); road transport; manufacturing industry and construction (solid fuels); and energy industries (liquid fuels). In 2015 the energy industry contributed 79.5% to the total GHG emissions (excluding FOLU), this increased by 17.9% from 2000.

The DEFF is working together with local sectors to develop country specific emissions factors in certain areas; however, in the interim the IPCC default emission figures may be used to populate the SAAQIS GHG emission factor database. The country specific emission factors, when developed, will replace some of the default IPCC emission factors.

5.3.2.5.2 GHG Emission Inventory for the Sector

The proposed facility would be categorised in the “energy” category for both the global GHG inventory and for the national GHG inventory. According to the “mitigation of climate change” document as part of the IPCC fifth Assessment Report (AR5) (IPCC, 2014) the 2010 global GHG emissions from the “energy” category were approximately 17 Gt CO_2-e; 35% of the total anthropogenic GHG emissions. The World Resources Institute Climate Watch[6] global GHG emissions from the “energy” sector were 36 Gt CO_2-e in 2016 (73% of total anthropogenic GHG emissions). The South African energy section contributed approximately 0.43 Gt CO_2-e to global emissions in 2015.

5.3.3 Physical Risks of Climate Change on the Region

In 2017 the South African Weather Service (SAWS) published an updated Climate Change Reference Atlas (CCRA) based on Global Climate Change Models (GCMs) projections (SAWS, 2017). It must be noted that as with all atmospheric models there is the possibility of inaccuracies in the results as a result of the model’s physics and accuracy of input data; for this reason, an ensemble of models’ projections is used to determine the potential change in near-surface temperatures and rainfall depicted in the CCRA. The projections are for to 30-year periods described as the near future (2036 to 2065) and the far future (2066 to 2095). Projected changes are defined relative to a historical 30-year period (1976 to 2005). The Rossby Centre regional model (RCA4) was used in the predictions for the CCRA which included the input of nine GCMs results. The RCA4

[6] http://cait.wri.org/ and https://www.climatewatchdata.org/ghg-emissions?breakBy=sector&sectors=energy%2Ctotal-excluding-lucf%2Ctotal-including-lucf

model was used to improve the spatial resolution to 0.44° x 0.44°- the finest resolution GCMs in the ensemble were run at resolutions of 1.4° x 1.4° and 1.8° x 1.2°.

Two trajectories are included based on the four Representative Concentration Pathways (RCPs) discussed in the IPCC's fifth assessment report (AR5) (IPCC, 2013). RCPs are defined by their influence on atmospheric radiative forcing in the year 2100. RCP4.5 represents an addition to the radiation budget of 4.5 W/m^2 as a result of an increase in GHGs. The two RCPs selected were RCP4.5 representing the medium-to-low pathway and RCP8.5 representing the high pathway. RCP4.5 is based on a CO_2 concentration of 560 ppm and RCP8.5 on 950 ppm by 2100. RCP4.5 is based on if current interventions to reduce GHG emissions being sustained (after 2100 the concentration is expected to stabilise or even decrease). RCP8.5 is based on if no interventions to reduce GHG emissions being implemented (after 2100 the concentration is expected to continue to increase).

5.3.3.1 RCP4.5 Trajectory

Based on the median, for the region in which the proposed facility and AQSRs are situated, the annual average near surface temperatures (2 m above ground) are expected to increase by between 1.5°C and 2.0°C for the near future and between 2.5°C and 3.0°C for the far future. The seasonal average temperatures are expected to increase for all seasons, in the same order as the annual average increases, with slightly larger temperature increases in autumn (March to May) and spring (September to November). The total annual rainfall is expected to increase by between 0 mm and 5 mm for the near future and decrease by up to 5 mm in the far future. Seasonal rainfall is expected to increase in summer (December to February) in the near- and far future, while other seasons are likely to show decreases between 5 and 10 mm.

5.3.3.2 RCP8.5 Trajectory

Based on the median, the region in which the proposed facility and AQSRs discussed are situated, the annual average near surface temperatures (2 m above ground) are expected to increase by between 2.0°C and 2.5°C for the near future and between 4.5°C and 5.0°C for the far future. The seasonal average temperatures are expected to increase for all seasons in similar ranges to the annual average temperature, with slightly higher increases in spring, summer, and autumn. The total annual rainfall change is likely to decrease by between 30 and 50 mm, while it is more uncertain for the far future with potential decrease up to 5 mm. Seasonal rainfall changes could see an increase of 5 mm in spring and summer in the near future with decreased up to 10 mm in autumn and winter. In the far future, the seasonal the rainfall changes are similar to the near future, except in summer where increased rainfall could range between 5 and 20 mm.

5.3.3.3 Water Stress and Extreme Events

South Africa is known to be a water stressed country (Kusangaya, Shekede, & Mbengo, 2017), however, the Orange River basin, including Upington and Groblershoop areas, is currently rated with a low risk with low levels of depletion, but low to medium interannual variability and medium to high seasonal variability, leading to a low to medium drought risk[7]. Climate change, through elevated temperatures, is likely to increase evaporation rates and decrease water volumes available for dryland and irrigated agriculture (Davis-Reddy & Vincent, 2017). Commercial agriculture (irrigated vineyards and stock farming) is the predominant agricultural land-use in the vicinity of Groblershoop.

[7] https://www.wri.org/applications/aqueduct/water-risk-atlas/#/?advanced=false&basemap=hydro&indicator=w_awr_def_tot_cat&lat=30&lng=-80&mapMode=view&month=1&opacity=0.5&ponderation=DEF&predefined=false&projection=absolute&scenario=optimistic&scope=baseline&timeScale=annual&year=baseline&zoom=3

Extreme weather events affecting southern Africa, including heat waves, flooding due to intensified rainfall due to large storms and drought, have been shown to increase in number since 1980 (Davis-Reddy & Vincent, 2017). Projections indicate (Davis-Reddy & Vincent, 2017):

- with high confidence, that heat wave and warm spell duration are likely to increase while cold extremes are likely to decrease, where up to 80 days above 35°C are projected by the end of the century under the RCP4.5 scenario;
- with medium confidence, that droughts are likely to intensify due to reduced rainfall and/or an increase in evapotranspiration;
- with low confidence, that heavy rainfall events (more than 20 mm per 24 hours) will increase.

5.3.4 Impact Assessment: Hyperion 75 MW Thermal Dual Fuel Power Generation Facility

5.3.4.1 Methodology

As the emission of greenhouse gases has a global impact, it is not feasible to follow the normal impact assessment methodology where the state of the physical environment after implementation of the project is compared to the condition of the physical environment prior to its implementation. Instead, this report will assess the following:

(i) the GHG emissions during operation of the gas-fired power station compared to the global and South African emission inventory;

(ii) The impact of climate change over the lifetime of the power station taking the robustness of the project into account; and,

(iii) the vulnerability of communities in the immediate vicinity of power station to climate change.

The Carbon Footprint is an indication of the greenhouse gases estimated to be emitted directly and/or indirectly by an organisation, facility or product. It can be estimated from:

$$Carbon\ emissions = Activity\ information * emission\ factor * GWP$$

where

- *Activity information* relates to the activity that causes the emissions
- *Emission factor* refers to the amount of GHG emitted per unit of activity
- *GWP* or global warming potential is the potential of an emitted gas to cause global warming relative to CO_2. This converts the emissions of all GHGs to the equivalent amount of CO_2 or CO_2-e. National GHG reporting guidelines state GWP for CH_4 emissions should have a multiplier of 23; and N_2O emissions should have a multiplier of 296

5.3.4.2 Construction

Carbon Sequestration and Carbon Sink

Accounting for the uptake of carbon by plants, soils and water is referred to as *carbon sequestration* and these sources are commonly referred to as *carbon sinks*. Quantifying the rate of carbon sequestration is however not a trivial task requiring detailed information on the geographical location, climate (specifically temperature and humidity) and species dominance (Ravin & Raine, 2007).

Photosynthesis is the main sequestration process in forests and in soils. Carbon is absorbed as fixed carbon into the roots, trunk, branches and leaves, and during the shedding of leaves and limbs, but is emitted – although at a reduced percentage

– from foliage and when biomass decays. Several factors also determine the amount of carbon absorbed by trees such as species, size and age. Mature trees, for example, will absorb more carbon than saplings (Ravin & Raine, 2007).

There will be a carbon sink loss due to the vegetation removal for the thermal power generation facility and areas needed for associated infrastructure. These are considered **Scope 1** carbon emissions.

This includes clearing of the area – Kathu Bushveld (medium to tall tree savanna, mostly consisting of *Vachellia erioloba* and *Boscia albitrunca*. The shrub layer is dominated by *Senegalia mellifera*, *Diospyros lycioides* and *Lycium hirsutum*, while the field layer is noticeably variable in cover - Mucina & Rutherford, 2006. The National Greenhouse Gas Emission Inventory (DEA, nd) makes no distinction between savanna or bushveld and grassland and assumes a carbon stock of 5.32 tonne C/ha in grasslands, savannas, and bushveld. During construction, approximately 11.57 ha will be denuded for the construction of the thermal generation terrace and the associated infrastructure required during construction (e.g. laydown areas). Assuming all carbon eventually reports to the atmosphere as CO_2, it is therefore calculated that a total of 61.55 tonnes of CO_2 would be released as a result of clearing vegetation at the site.

Fuel Combustion

GHG emissions from fuel during construction of the thermal power generation facility are also considered **Scope 1** emissions. The IPCC default emission factors for diesel combustion in both stationary (for example: backup generators) and mobile combustion (for example from heavy earth moving vehicles) were used together with country-specific density and calorific value (Table 5-14). The estimated amount of diesel used during the 18-month construction phase was provided as 800 000 litres; where the stationary combustion (in generators) to mobile combustion (in vehicles) fuel use was assumed to be a 50:50 ratio.

A summary of the estimated greenhouse gas emissions is provided in Table 5-18. The total CO_2 (equivalent) emissions due to diesel combustion is approximately 1 896.8 tonnes for the construction period (18 months).

Table 5-14: Calculation of liquid fuel related GHG emission factors for fuel combustion

Source type	Fuel type	Density kg/m^3	Calorific value kJ/kg	Emission factor kg CO_2/TJ	Emission factor kg CH_4/TJ	Emission factor kg N_2O/TJ	Use ratio	Emissions tonnes CO_2-e
Stationary combustion	Diesel	840[(a)]	43 400[(a)]	74100[(b)]	10[(c)]	0.6[(d)]	50%[(e)]	959.52
Mobile combustion	Diesel	840[(a)]	43 400[(a)]	72098[(f)]	4[(g)]	2[(h)]	50%[(e)]	937.25

Notes:

(a) From the DEA Technical Guideline TG-2016.1 Table D1 (DEA, 2017)
(b) IPCC Code 1A4a EF117938
(c) IPCC Code 1A4a EF117992
(d) IPCC Code 1A4a EF118046
(e) Assumed fuel use ratio
(f) IPCC Code 1A3biii EF19063
(g) IPCC Code 1A3biii EF19051
(h) IPCC Code 1A3biii EF19060

Electricity use

These emissions are related to purchased energy, heat or steam and can be calculated from the average South African emission factor published annually by Eskom in its integrated report. The emission factors for the last four years are given in Table 5-15. This allows the scope 2 emissions to be calculated directly from electricity consumption from the Eskom or local authority account. The average electricity usage for the 16-month construction period of the project (based on engineering estimates) is estimated to result in approximately 269.4 tonnes of indirect CO_2 emissions per year (Table 5-16).

Table 5-15: Eskom electricity emission factors

Year	Emission Factor (tonnes CO_2/MWh)	Source
2015/2016	1.00	Eskom 2016 Integrated Report
2016/2017	0.98	Eskom 2017 Integrated Report
2017/2018	0.97	Eskom 2018 Integrated Report
2018/2019	1.04	Eskom 2019 Integrated Report
Median	0.99	

Table 5-16: Scope 2 estimated greenhouse gas emissions for the construction of the Project

Phase	Annual electricity use (MWh)	Emission Factor (tonnes CO_2/MWh)	Annual Scope 2 CO_2 emissions (tonnes)
Construction	272[(a)]	0.99	3 465

Notes:
(a) Assumed maximum grid power demand during construction would be 150 kVA which equates to 120 kW multiplied by the number of construction hours per month over the construction period (see Table 5-9 for more details)

Testing and Commissioning LPG Combustion

After construction of the power plant, allowance has been made for testing of the engines and plant prior to commissioning, where full load operation of each gas turbine is planned for the performance runs using a total of 4 000 tonnes of LPG during the testing phase (all parameters, except fuel use as per the detailed description in 5.3.4.3).

Table 5-17: Summary of Scope 1 estimated greenhouse gas emissions for the thermal generation testing and commissioning

Sources	Throughput	Units	Annual Emission (tonnes / year) [(a)]			Annual Emission (tonnes / year)
			CO_2	CH_4	N_2O	CO_2-e [(c)]
LPG gas combusted[(a)]	4 000	Tonnes	14 545	0.23	0.02	11 645

Notes:
a) Emissions calculated using the DEA Technical Guideline TG-2016.1 (DEA, 2017). Emission Factors and Net Calorific Values as per Table D1.
b) Emissions calculated using the DEA Technical Guideline TG-2016.1 (DEA, 2017). The IPCC default emission factor for fugitive emissions from the transport of LPG gas (IPCC Code 1.B.2.a.iii.3; Table 45.2 – Annexure B)
c) CO_2-e = equivalent CO_2 emissions taking account of the global warming potential of CH_4 and N_2O (as per DEA, 2017).

Summary

The estimated calculated CO_2-e emissions from the construction operations contribute less than 0.00027% to the total of South African GHG emissions (0.0032% of the South African Energy sector) and approximately 10.6% of the annual operational GHG emissions (see Section 5.3.4.3). Assuming the lifetime of the thermal power generation facility is 20 years or more, this contribution is not considered to be substantial.

Table 5-18: Summary of estimated greenhouse gas emissions for the construction, testing and commissioning phase

Source Group	Total emissions as CO_2-e (tpa)
Clearing	61.6
Stationary Equipment Exhaust	1 896.8
Mobile Equipment Exhaust	937.3
Electricity	269.0
Testing and Commissioning	11 645.0
Total (Scope 1 and 2)[(a)]	**14 810.4**

5.3.4.3 Operations

For combustion processes, the emission factor is often calculated from a carbon mass balance, where the combustion of each unit mass of carbon in the fuel leads to an equivalent emission of 3.67 mass units of CO_2 (from 44/12, the ratio of molecular weight of CO_2 to that of carbon).

This report considers Scope 1 emissions, which are the emissions directly attributable to the project. Scope 2 emissions, which are the emissions associated with bought-in electricity over the lifetime of the project. Scope 3 emissions, which consider the "embedded" carbon in bought-in materials, are not considered here, in line with the guidelines provided by the IFC (IFC, 2012).

Scope 1 Emissions

The Carbon Tax Bill and its supporting technical documents provides default emission factors for Electricity and Heat Production process (specifically combustion of LPG) in kg CO_2/unit energy content, where the density and calorific values of the fuel types are defined in the same document (DEA, 2017).

A summary of the GHG emissions, based on calculated LPG daily use, is provided in Table 5-19. The total thermal power generation facility CO_2 (equivalent) emissions will be approximately 131 056 tpa. The annual South African emission rate of GHG is approximately 512.383 million metric tonnes CO_2-e (2015 national emission inventory[8]). In relation to the total electricity output of the station (assuming 75 MW are generated in 6023 operational hours per year) the CO_2 emissions per unit electricity generated is 0.18 tonnes CO_2-e/MWh. This value is approximately one-fifth of the Eskom network-wide average (Table 5-15), where coal-fired power stations contribute 83% of the total Eskom network nominal generative capacity (as reported in the 2019 Eskom Integrated report[9]).

Table 5-19: Summary of Scope 1 estimated greenhouse gas emissions for the thermal power generation facility operation

Sources	Throughput	Units	Annual Emission (tonnes / annum) [(a)]			Annual Emission (tonnes / year)
			CO_2	CH_4	N_2O	CO_2-e [(c)]
LPG gas combusted[(a)]	45 000	tonnes/annum	130 901	48	61	131 010
Fugitive emissions[(b)]	45 000	tonnes/annum	37	-	0.06	37.3
Total annual GHG emissions						131 047
Total annual GHG emissions per unit of electricity generated (tonnes CO_2-e/MWh)						0.18

[8] Most recent published inventory reported in the GHG National Inventory Report: South Africa 2000 – 2015 from https://www.environment.gov.za/sites/default/files/reports/GHG-National-Inventory-Report-SouthAfrica-2000-2015.pdf
[9] Available from http://www.eskom.co.za/IR2019/Pages/default.aspx

Notes:	
a)	Emissions calculated using the DEA Technical Guideline TG-2016.1 (DEA, 2017). Emission Factors and Net Calorific Values as per Table D1.
b)	Emissions calculated using the DEA Technical Guideline TG-2016.1 (DEA, 2017). The IPCC default emission factor for fugitive emissions from the transport of LPG gas (IPCC Code 1.B.2.a.iii.3; Table 45.2 – Annexure B)
c)	CO_2-e = equivalent CO_2 emissions taking account of the global warming potential of CH_4 and N_2O (as per DEA, 2017).

Scope 2 Emissions

All on-site electricity needs (for offices, pumps, and other equipment) will be a parasitic load to the amount of electricity produced. This loss of production capacity has been factored into the total plant generating capacity calculations. Therefore, there will be no Scope 2 GHG Emissions during normal operation of the thermal power generation facility.

5.3.4.4 The Project's GHG Impact

5.3.4.4.1 Impact on the Sector and on the National Inventory

The annual CO_2-e emissions from the power station operations contribute approximately 0.030% to the South African "energy" sector total and represent a contribution of 0.026% to the National GHG inventory total (based on the published 2015 National GHG Inventory). Assuming that the thermal power generation facility replaces generative capacity from other fossil fuel sources, the facility could lower South Africa's GHG emissions from the Energy sector since LPG facility will have a lower emission per unit electricity (0.18 tCO_2-e/MWh compared with the Eskom average 0.99 tCO_2-e/MWh, which is largely dependent on coal fired power stations).

5.3.4.4.2 Alignment with National Policy

Most of the South African GHG policy is in early phases of implementation where GHG emissions have been reported to DEFF (previously DEA) since 31 March 2018 and the Carbon Tax Bill came into effect on the 1 June 2019. The proposed facility will be required to align GHG reporting with national policy. An annual Carbon Tax environmental levy account will need to be submitted in July of each year after operations commence.

5.3.4.5 Physical Risks of Climate Change on the Project's Operations

5.3.4.5.1 Temperature

With the increase in temperature, including heat waves, there is the likelihood of an increase in discomfort, possibility of heat related illness (such as heat exhaustion, heat cramps, and heat stroke). Both these have the potential to negatively affect staff process performance and productivity.

From a process point of view, elevated ambient temperatures (up to 45°C) may slightly reduce the fuel requirements needed to meet the generating capacity required. However, water use – as a NO_X emission control measure – may increase to ensure control efficiencies.

5.3.4.5.2 Rainfall, Water Stress, and Extreme Events

The rainfall decreases in autumn, winter and spring could result in constrained water supply outside of the summer months. During drought conditions water quality, could decline to a point where in-take water quality does not meet the requirements for NO_X emission abatement requirements. Alternatives to municipal water supplies should be investigated to secure long-term supplies.

The impact of intense rainfall events on the generator sets cannot be ruled out, where the frequency of intense rainfall events could increase from the long-term baseline. These events could affect generative capacity during intense rainfall (unless fully protected from rain and wind); flooding affecting site access, safe operation of equipment and delivery of fuel; physical damage to infrastructure during high wind speed events associated with intense storms.

5.3.4.6 Transitional Risks and Opportunities of Climate Change on the Project's Operations

The Taskforce for Climate-related Financial Disclosures (TCFD) advocates the disclosure of the financial risks associated with climate change impacts on organisations (TCFD, 2020). These include physical risks resulting in large-scale financial losses caused by storms, droughts, wildfires, and other extreme events (as identified in Sections 5.3.3 and 5.3.4.5, above). The Taskforce also advocates the quantification of transitional risks associated with the adjustment to low carbon economies, such as the rapid loss in the value of assets due to policy changes or consumer preference; and financial risks to the economy through elevated credit spreads, greater precautionary saving and rapid pricing readjustment (TCFD, 2020). Along with risks, the Taskforce encourages organisations to identify possible opportunities that could build resilience in economies shifting due to climate change.

Although the full financial risk is out of the scope of the of work, potential transitional risks and opportunities applicable to the project are tabulated below (Table 5-20as summarised from TCFD, 2017).

Table 5-20: Examples of climate-related risks and opportunities and the potential financial impacts (TCFD, 2017)

Type	Climate Related Risk / Opportunity	Potential financial impact	Comments
Risks	Policy and Legal		
	- Increased pricing of GHG emissions	- Increased operating costs (for example higher compliance cost, increased insurance premiums)	Carbon tax bill proposed 2% increase in baseline carbon tax rate until 2022 and thereafter annual inflation-based increases
	- Enhanced emissions reporting obligations	- Write-offs, asset impairment, and early retirement of existing assets due to policy changes	SAGERS online GHG emissions reporting platform in early release stages
	- Mandates on and regulation of existing products and services	- Increased costs and / or reduced demand for products and services resulting from fines and judgements	Country commitment to decarbonise energy supplies by 2050 could influence product demand for gas- generated power. Exceedances of emission standards could result in fines and litigation.
	- Exposure to litigation		
	Technology		
	- Substitution of existing products and services with lower emission options	- Write-offs and early retirement of existing assets - Reduced demand for products and services	Country commitment to decarbonise energy supplies by 2050 could influence product demand for gas- generated power.
	- Costs to transition to lower emissions technology	- Capital investments in technology development - Costs to adopt / deploy new practises and processes	Country commitment to decarbonise energy supplies by 2050 could require deployment of carbon capture, utilisation and storage technology to extend the operational lifespan of the gas to power plant.
	Market		
	- Changing customer behaviour	- Reduced demand for goods and services due to shift in consumer preferences	
	- Increased cost of raw materials	- Increased production costs due to changing input prices (for example, water and fuel) and output requirements (for example, wastewater- (brine or turbine wash-water). - Abrupt and unexpected shifts in energy costs - Re-pricing of assets (for example, fossil fuel reserves)	Increased water stress could affect water cost through demand and availability drivers. Proposed LPG supply is via import and therefore could be influenced by international land and security valuations and international market signals.

Type	Climate Related Risk / Opportunity	Potential financial impact	Comments
	Reputation		
	- Shifts in consumer preferences	- Reduced revenue from decreased demand for goods and services - Reduced revenue from decreased production capacity (delayed planning approvals, supply chain interruptions)	Country commitment to decarbonise energy supplies by 2050 could influence product demand for gas- generated power, which could influence consumer choices especially close to the decarbonised target year.
	- Increased stakeholder concern or negative stakeholder feedback	- Reduction in capital availability	Gas to power provides cleaner energy options during transition to decarbonised energy supply therefore capital may be more available than for other fossil fuel technology options. However, it is still based on fossil fuels that may have limited role in energy supplies after 2050, and thus have limited long-term funding arrangements.
Opportunities	Resource efficiency		
	- Use of more efficient modes of transport	- Reduced operating costs (through efficient gains and cost reductions)	
	- Use of more efficient production and distribution processes	- Increased production capacity, resulting in increased revenue	Increased ambient temperatures could increase plant generative capacity and reduce atmospheric emission rates
	- Use of recycling	- Capital costs of alternative water supplies	Investigation of alternative water supplies could open opportunities to recycle or reuse water since water supplies may become constrained by droughts or quality
	Energy source		
	- Use of lower-emission sources of energy	- Reduced operational costs (for example, through the use of lowest cost abatement technologies) - Reduced exposure to future fossil fuel price increases - Reduced exposure to GHG emissions and therefore less sensitivity to changes in cost of carbon	Gas to power provides cleaner energy option compared with other fossil fuel options, such as coal or diesel, which is applicable during transition to decarbonised energy supply.
	- Use of new technologies	- Returns on investment in low-emission technology - Increased capital availability (as more investors favour lower emission producers)	
	- Participation in carbon market		Carbon tax incentives (through sequestration allowances)

Type	Climate Related Risk / Opportunity	Potential financial impact	Comments
	- Shift towards decentralised energy generation	- Reputational benefits resulting in increased demand for goods and services	Direct supply to customers in the region
	Products and services		
	- Shifts in consumer preferences	- Better Competitive position to reflect shifting consumer preferences, resulting in increased revenues	
	Markets		
	- Access to new markets - Use of public-sector incentives	- Increased revenue through access to new and emerging markets (for example partnerships with governments, development banks)	

5.3.4.7 Impact Assessment: Potential Effect of Climate Change on the Community

5.3.4.7.1 Temperature

With the increase in temperature, including heat waves, there is the likelihood of an increase in discomfort and possibility of heat related illness (such as heat exhaustion, heat cramps, and heat stroke). There is also the possibility of increased evaporation which in conjunction with the decrease in rainfall can result in water shortage. This does not only negatively affect the community's water supply but could affect livestock (sheep) resulting in compromised food security.

5.3.4.7.2 Rainfall, Water Stress, and Extreme Events

As discussed above the decrease in rainfall can result in the following effects:

- Reduced water supply of reduced water quality; and,
- A negative impact on food security.

The impact of intense rainfall events on the local communities cannot be ruled out, where the frequency of these event could increase from the long-term baseline. These events could affect road access within the area due to flooding; physical damage to public and private infrastructure through flooding and high wind speeds.

5.3.4.8 Project adaptation and mitigation measures

Climate change management includes both mitigation and adaptation. The main aim of mitigation is to stabilise or reduce GHG concentrations as a result of anthropogenic activities. This is achievable by lessening sources (emissions) and/or enhancing sinks through human intervention. Mitigation measures are typically the focus of the energy, transport and industry sectors (Thambiran & Naidoo, 2017). Adaptation measures focus on the minimising the impact of climate change, especially on vulnerable communities and sectors. Inclusion of the climate change adaptation in business strategic implementation plans is one of the outcomes defined in the Draft National Climate Change Adaptation Strategy (Government Gazette No.42466:644, May 2019).

General

Additional support infrastructure can reduce the climate change impact on the staff and project, for example the improving thermal and electrical efficiency of buildings to reduce electricity consumption, ensuring adequate water supply for staff and reducing on-site water usage as much as possible. A community development program could be initiated to assist communities near the plant that are vulnerable to climate change impacts, such as thermal and electrically efficient buildings (to minimise electricity needs for heating and cooling); energy efficient stoves (to minimise the use of coal and woody biomass); or small-scale renewable energy innovations suitable for use in homes.

Scope 1 (technology/sector-specific)

To minimise GHG emissions would require lower fuel use or use alternative lower-carbon fuels. Delivery of fuel to site via alternative low-carbon options (such as rail) would reduce the fuel usage by delivery vehicles. Alternative options for consideration include Carbon Capture and Storage (CCS) or Carbon offsets (for which allowances are contemplated in the Carbon Tax Bill).

CCS is a method of mitigating the contribution of fossil fuel emissions based on capturing CO_2 from large point sources such as power stations and storing it. CCS involves carbon dioxide being concentrated through various options and then permanently stored. The best researched carbon dioxide storage option is geological storage which involves injecting CO_2 directly into underground geological formations. Oil fields, gas fields, saline formations, un-mineable coal seams, and saline-filled basalt formations have been suggested as storage sites. Various physical (e.g. highly impermeable rock) and geochemical trapping mechanisms would prevent the CO_2 from escaping to the surface. The CSIR undertook a study into the potential for CO_2 storage in South Africa (2004). The study concluded that the storage of CO_2 in depleted gas fields, coal mines or gold mines is very limited. Deep saline reservoirs offer the highest potential for the geological storage of CO_2 in South Africa, especially withing the Karoo Super Group sediments of the Vryheid Formation in the north and the Katberg Formation near Burgersdorp/Molteno. However, due to a lack of information about the porosity and permeability of these of reservoirs, significant work is required before CO_2 sequestration into geological formations will be possible (Engelbrecht, Golding, Hietkamp, & Scholes, 2004). The South African CCS Atlas (Cloete, 2010) identified at a theoretical level that South Africa had about 150 Gigatons (Gt) of storage capacity. Less than 2% of this is onshore.

A significant limitation of CCS is its energy penalty. The technology is expected to use between 10 – 40% of the energy produced by a power station to capture the CO_2 (IPCC, 2005). Wide scale adoption of CCS may erase efficiency gains of the last 50 years and increase resource consumption by one third. However, even taking the fuel penalty into account, overall levels of CO_2 abatement remain high, at approximately 80 - 90% compared to a plant without CCS.

Carbon offset options could include investment in REDD+ (Reducing Emissions from Deforestation and forest Degradation) initiatives (Thambiran & Naidoo, 2017). REDD+ initiatives in developing countries incentivise communities to undertake forestry and related activities that can contribute to reducing land-based GHG emissions associated with deforestation and degradation and through sequestration of CO_2 in forests and agroforestry (Thambiran & Naidoo, 2017). REDD+ programmes are also mechanisms for socio-economic development. However, the expansion of the forestry industry in South Africa, will require quantification of the impact of expanded activities on water resources (as highlighted in the Draft National Climate Change Adaptation Strategy (Government Gazette No.42466:644, May 2019).

5.4 Impact Significance Rating

The Impact Assessment Methodology as provided by Savannah Environmental (Pty) Ltd (Appendix B) was used.

It is likely that the Construction (and decommissioning) Phase(s) may have a *medium* impact on the ambient air quality if emissions are unmitigated, and a *low* impact if mitigation measures are effectively implemented (Table 5-21).

The operational phase of the project will have a *medium* impact (based on design mitigation measures) on ambient NO_2, SO_2, PM, CO, and VOC concentrations, however, additional mitigation is still recommended along the access road especially near residences to minimise nuisance dustfall impacts reducing the impact to *low* (Table 5-22).

Cumulative impact of the facility on the ambient air quality in the area is likely to be *medium* if unmitigated (Table 5-23) but can be reduced to *low* if industry and community initiatives can minimise the combined impact on air quality.

Based on a proportional contribution to the South African National GHG Emissions Inventory published for 2015, the project is deemed to have a *medium* impact rating (Table 5-24). It is also assumed that the GHG emissions from this facility will replace, and not add to, GHG emissions from other fossil fuel sources in the Energy Sector, as older technologies are decommissioned in line with the IRP (2019) goal to decarbonise energy supplies by 2050. The annual GHG emission estimates exclude the Scope 3 upstream emissions involved in the production and transport of the LPG from international suppliers and local transport emissions. Local sources of LPG or fuel alternatives could reduce the Scope 3 emissions.

Table 5-21: Impact significance rating for the Construction (and decommissioning) Phase of the Project

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 at nearby residences and on potentially on plants.

Unmitigated particulate emissions were found to result in ambient PM10 and dustfall rates below the assessment criteria on and off-site. However, residences areas may occasionally be affected by elevated concentrations and nuisance dustfall during the road construction. Areas to the west of the project site are more likely to be affected, especially in the short-term, due to the predominant winds. The impact of gaseous pollutants is likely to minor.

	Without mitigation	With mitigation
Extent	Local (2)	Site (1)
Duration	Short duration (2)	Short duration (2)
Magnitude	Low (4)	Minor (2)
Probability	Probable (3)	Probable (3)
Significance	**24**	**15**
	Low	**Low**
Status (positive or negative)	Negative	Negative
Reversibility	Reversible	Reversible
Irreplaceable loss of resources?	Likely	Likely
Confidence in findings:	Moderate due to conservative nature of the emission calculation method, and highly variable nature of construction activities.	
Can impacts be mitigated?	Yes, with minimum control efficiency of 50%.	

Proposed mitigation measures:
- Commencement of road construction prior to thermal power generation facility construction.
- Wet, or other appropriate, dust suppression at key handling points or cleared areas.
- Berms, screens, or wet suppression along roads construction areas, especially near homesteads.
- Haul trucks to be restricted to specified haul roads and using the most direct route.
- Reduce unnecessary traffic.
- Strict on-site speed control (i.e. 40km/hr for haul trucks on access roads; 20 km/hr for all large vehicles near residences or on-site).

• 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 10 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 5-22: Impact significance rating for the Operational Phase of the Project – SO_2, NO_2, PM, CO, and VOC impacts

Nature: The normal operation of the proposed open cycle power station will result in emission of gaseous and particulate pollutants including: SO_2, NO_2, PM, CO, and VOCs. Increased ambient concentrations of these pollutants may result in negative human health impacts, and nuisance dustfall. Unmitigated emissions of these pollutants were found to comply with the assessment criteria and off-site impacts are unlikely, provided that fuel sulfur content is low (<0.1%) and recommended mitigation measures are applied to control vehicle entrainment emissions along the access road. Residential receptors, schools, and medical facilities are unlikely to be affected. Areas to the west of the project site are more likely to be affected in the long-term, due to the predominant winds.		
	Without mitigation	**With mitigation**
Extent	Near site (2)	Near site (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	Low (4)	Minor (2)
Probability	Probable (3)	Probable (3)
Significance	**30**	**24**
	Medium	**Low**
Status (positive or negative)	Negative	Negative
Reversibility	Reversible	Reversible
Irreplaceable loss of resources?	Unlikely	Unlikely
Confidence in findings:	Good.	
Can impacts be mitigated?	To some extent.	
Proposed mitigation measures: • Regular inspection and maintenance of engines, and associated equipment in accordance with manufacturer recommendations. • Optimise start-up times to minimise elevated emissions from engines. • Access roads are to be paved and particulate content minimised through sweeping or watering (or other appropriate suppressants). • Vehicle idling periods should be minimised when stationary for extended periods of time. • Strict on-site speed control (i.e. 40 km/hr for large vehicles on access road; 20 km/hr near residences or on-site). • Euro V or better emission limits from LPG delivery vehicle engines.		
Cumulative impacts:		
The Cumulative Impact of the proposed facility and the existing baseline would result in elevated ambient air pollutant concentrations. The normal operation of the proposed gas-to-power plant will result in emission of gaseous and particulate pollutants including: SO_2, NO_X, PM. Increased ambient concentrations of these pollutants may result in negative human health impacts, and nuisance dustfall. Cumulative impacts, to short- and long-term ambient concentrations, were assessed to be minor since there are few major sources of air pollution in the region. Cumulative ambient short-term PM_{10} and $PM_{2.5}$ concentrations may exceed the NAAQS within the domain but are likely to be localised near the source(s).		
Residual impacts: Expected to be low if mitigation measures are properly implemented.		

Table 5-23: Impact significance rating for the Project on the Cumulative Air Quality in the area

Nature: The Cumulative Impact of the proposed facility and the existing baseline would result in elevated ambient air pollutant concentrations. The normal operation of the proposed gas-to-power plant will result in emission of gaseous and particulate pollutants including: SO_2, NO_X, PM. Increased ambient concentrations of these pollutants may result in negative human health impacts, and nuisance dustfall. Cumulative impacts, to short- and long-term ambient concentrations, were assessed to be minor since there are few major sources of air pollution in the region. Cumulative ambient short-term PM_{10} and $PM_{2.5}$ concentrations may exceed the NAAQS within the domain but are likely to be localised near the source(s).		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Near site (2)	Local (3)

Duration	Long-term (4)	Long-term (4)
Magnitude	Low (4)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	**30** **Medium**	**33** **Medium**
Status (positive or negative)	Negative	Negative
Reversibility	Reversible	Reversible
Irreplaceable loss of resources?	Unlikely	No
Can impacts be mitigated?	Yes	To some extent
Potential mitigation measures: • Liaise with other major sources to minimise fugitive emissions especially particulates. • Use community and industry fora to discuss air pollution issues and progress towards minimising impacts.		
Residual impacts: Expected to be low if mitigation measures can be effectively implemented.		

Table 5-24: Impact significance rating for Climate Change Impacts associated with the project

Nature:

The normal operation of the gas-to-power plant will result in emission of greenhouse gases: CO_2, and to a lesser extent methane and nitrous oxide. Annual GHG emissions equate to 0.03% of South Africa's total greenhouse emissions (based on the 2015 emissions inventory) with a total of 131 047 tonnes CO_2-e per year for Scope 1 emissions for the operational phase.

The impact of the operation on global climate is considered to have a long-term impact on greenhouse gas concentrations.

	Without mitigation	With mitigation
Extent	National (5)	National (5)
Duration	Long-term (4)	Long-term (4)
Magnitude	Minor (2)	Minor (2)
Probability	Probable (3)	Probable (3)
Significance	**33** **Medium**	**33** **Medium**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes, in the long-term	Yes, in the long-term
Confidence in findings:	Moderate.	
Can impacts be mitigated?	To some extent.	

Proposed mitigation measures:
- Reduced fuel usage in delivery vehicles using Euro V or better emission standards.
- Reduced fuel usage through minimal idle time of stationary LPG delivery and fuel-efficient vehicles.
- Local sources of LPG or alternative fuels would reduce the Scope 3 emissions.
- Investigation of offset projects.

Residual impacts:
The risk of impact of climate change on the operation, due to historical global emissions, is high even if mitigation measures are effectively applied.

Cumulative Impacts:
Historical global GHG emissions will have an impact on the project and the communities in the Richards Bay area. The operation of the gas to power facility will therefore contribute to projected impacts at a local, national, and global scales (albeit at through a relatively small annual contribution). The impact of global climate change is likely to have a largely permanent impact on the global ecosystem with potential irreplaceable loss of resources.
Assuming that the thermal power generation facility replaces generative capacity from other fossil fuel sources, the facility could lower South Africa's GHG emissions from the Energy sector since LPG facility will have a lower emission per unit electricity (0.18 tCO_2e/MWh compared with the Eskom average 0.99 tCO_2e/MWh, which is largely dependent on coal fired power stations).

5.5 Main Findings and Conclusions

The findings from the air quality impact assessment are:

1. Measured ambient air quality based on data from the Karoo monitoring stations managed by the DEFF indicated compliance with hourly, daily and annual compliance with National Ambient Air Quality Standards (NAAQS) for all pollutants assessed across the period assessed.
2. The thermal power generation facility was assessed for normal operations at MES:
3. During the construction phase, compliance with NAAQS for PM_{10} and NDCR for daily dustfall rates is likely.
    a. A "**low**" rating was determined for the impact associated with the construction phase of the project.
4. Compliance with hourly, daily, and annual NAAQS under normal operations is likely across the domain and at the receptors for NO_2, particulate matter, (PM_{10} and $PM_{2.5}$), and carbon monoxide (CO).
5. The MES scenario showed simulated SO_2 concentrations above the hourly and daily NAAQ limit values up to 250 m and 180 m off-site, respectively but not at any receptors. Annual concentrations were simulated to be lower than the NAAQS across the domain.
6. It is unlikely that gas combustion will result in SO_2 emissions at the emission standard and therefore the facilities impact on SO_2 was also assessed using mass balance calculations for LPG boilers using actual sulfur content of the fuel (0.014%)
    a. Compliance the NAAQS was simulated for hourly, daily, and annual average SO_2.
7. The impact of the facility was simulated to be below the NDCR near the thermal power generation facility but exceedances of the NDCR are likely along the access road used for LPG delivery.
    a. Mitigation measures for control vehicle entrainment dust emissions are recommended along the delivery route, especially near the homesteads.
8. The United Nations Economic Commission for Europe (UNECE) Convention on Long Range Trans-boundary Air Pollution Limits) critical levels were used to assess the potential for impact of annual SO_2 and NO_2 concentrations on vegetation via various measures of productivity and reproductive success.
    a. Impacts to vegetative productivity are unlikely due to the thermal power generation facility across in the domain or at any receptors.
9. A "**medium**" rating was determined for the impact of criteria air pollutants associated with the normal operation of the project. The impact could be reduced to "**low**" with additional mitigation to along the access road.
10. Cumulative impact of the proposed thermal power generation facility and the other sources in the area are likely to be compliant with the NAAQS.
    a. A "**low**" rating was determined for the mitigated impact of the project in isolation and "**medium**" in the context of other air pollution sources in the vicinity
11. Annual greenhouse gas (GHG) emissions for the operational phases of the plant were estimated to represent 0.026% of the published South African National 2015 GHG Inventory, contributing to the Energy sector.
    a. A "**medium**" rating was determined for the GHG emissions associated with the project.

Conclusion

From an air quality perspective, it is the opinion of the specialist that the Hyperion 75 MW Thermal Power Generation Facility be authorised and licensed to operate, on condition that:

- Emissions be monitored as per standard practice for the appropriate listed activity;
- Emissions are maintained at or lower than the Minimum Emission Standards appropriate for the listed activity;
- Conformance with the other environmental management programme requirements for air quality (Appendix F) are met.

6 COMPLAINTS

The Hyperion 75 MW Thermal Dual Fuel Power Generation Facility is a new proposed operation and as such no complaints have been received. As part of the EMP, a complaints register will be in place before commencement of the operations.

7 CURRENT OR PLANNED AIR QUALITY MANAGEMENT INTERVENTIONS

The Hyperion 75 MW Thermal Dual Fuel Power Generation Facility is a new proposed operation and as such no air quality management interventions have been implemented and none except for the design mitigation measures are planned at this stage.

8 COMPLIANCE AND ENFORCEMENT HISTORY

The Hyperion 75 MW Thermal Dual Fuel Power Generation Facility is a new proposed operation and as such no compliance or enforcement actions have been implemented.

9 ADDITIONAL INFORMATION

The declaration of accuracy of information and the declaration of independence are attached in Annexure A & B respectively. The Environmental Management Programme recommendations for minimising impact on air quality are given in Appendix C.

10 ANNEXURE A

<to be added on report finalisation>

11 ANNEXURE B

<to be added on report finalisation>

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APPENDIX A: Comparison of Study Approach with the Regulations Prescribing The Format Of The Atmospheric Impact Report and the Regulations regarding Air Dispersion Modelling (Gazette No 37804 published 11 July 2014)

The Regulations prescribing the format of the Atmospheric Impact Report (AIR) (Government Gazette No 36094; published 11 October 2013) were referenced for the air dispersion modelling approach used in this study. Table A-1 compares the AIR Regulations with the approach used in Section 5.

The promulgated Regulations regarding Air Dispersion Modelling (Gazette No. 37804, vol. 589; 11 July 2014) were consulted to ensure that the dispersion modelling process used in this assessment agreed with the regulations. Table A-2 compares the Air Dispersion Modelling Regulations with the approach used in Section 5.

Table A-1: Comparison of Regulations for the AIR with study approach

Chapter	Name	AIR regulations requirement	Status in AIR
1	Enterprise details	• Enterprise Details • Location and Extent of the Plant • Atmospheric Emission Licence and other Authorisations	Enterprise details included. Location of plant included. Proposed facility
2	Nature of process	• Listed Activities • Process Description • Unit Processes	All detail included in the regulated format
3	Technical Information	• Raw Materials Used and Production Rates • Appliances and Abatement Equipment Control Technology	Section 3.1 and 3.2. Abatement technology description provided in process description.

4	Atmospheric Emissions	• Point Source Emissions
		  • Point Source Parameters
		  • Point Source Maximum Emission Rates during Normal Operating Conditions
		• Fugitive Emissions
		• Emergency Incidents
			Maximum release rates from point sources assumed to be the MES limits defined for the facility (Section 4.1).
			
			Emissions from fugitive sources was quantified (Section 4.2).
			No emergency events were included in the emissions estimations or simulations. It was assumed that operation beyond normal capacities and emissions would result in engine shutdown until normal operations can be restored.

5	Impact of enterprise on receiving environment		
5.1	Analysis of emissions impact on human health	Must conduct dispersion modelling, must be done in accordance with Regulations; must use NAAQS	Completed as set out by the Regulations.
5.2	Analysis of emissions impact on environment	Must be undertaken at discretion of Air Quality Officer.	Assessment of simulated concentrations against critical levels for vegetation, Nuisance dustfall for the construction and operational phases was quantified and assessed (Section 5.2)
6	Complaints	Details on complaints received for last two years	Not applicable. Proposed facility.
7	Current or planned air quality management interventions	Interventions currently being implemented and scheduled and approved for next 5 years.	Not applicable. Proposed facility with best available technology planned for development.
8	Compliance and enforcement history	Must set out all air quality compliance and enforcement actions undertaken against the enterprise in the last 5 years. Includes directives, compliance notices, interdicts, prosecution, fines	Not applicable. Proposed facility.
9	Additional information		None

Table A-2: Comparison of Regulations regarding the Air Dispersion Modelling with study approach

AIR Regulations	Compliance with Regulations	Comment
Levels of assessment		
• 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)	Level 2 assessment using AERMOD	This Gaussian Plume model is well suited to simulate dispersion from multiple sources at low and moderate wind speeds over domains less than 50 km X 50 km.
Model Input		
Source characterisation	Yes	Source characterisation provided in Section 4.
Emission rates: For new or modified existing sources the maximum allowed amount, volume, emission rates and concentration of pollutants that may be discharged to the atmosphere should be used	Yes	Emission rates used for each scenario are provided in Section 4.
Meteorological data		

AIR Regulations	Compliance with Regulations	Comment
Full meteorological conditions are recommended for regulatory applications.	Yes	WRF modelled meteorology (including upper air) (Section 5.1.3 and 5.1.1).
Data period	Yes	3 years (2017 to 2019)
Geographical Information		
Topography and land-use	Yes	The average slope across the study area is less than 10% and, based on the AERMOD Implementation Guide, terrain with slopes less than 10% should excluded topographic in the dispersion simulations (US EPA, 2009). Land-use classification was considered in its influence on surface roughness and albedo during the meteorological pre-processing in AERMET.
Domain and co-ordinate system	Yes	• Dispersion modelling domain: 22.5 x 22.5 km • UTM co-ordinate system (WGS84) (Section 5.1.1)
General Modelling Considerations		
Ambient Background Concentrations, including estimating background concentrations in multi-source areas	Yes	Section 5.14 and 5.15
NAAQS analyses for new or modified sources: impact of source modification in terms of ground-level concentrations should be assessed within the context of the background concentrations.	Yes	Model predicted, 99th percentile ground-level concentrations compared against NAAQS (Section 5.1.6 and 5.1.7)
Land-use classification	Yes	Rural (Section 5.1.13)
Surface roughness	Yes	Used from Land-use in the AERMET pre-processing step.
Albedo	Yes	Used from Land-use in the AERMET pre-processing step.
Temporal and spatial resolution		
Receptors and spatial resolutions	Yes	Sections 1.3
Building downwash	No	No buildings within the Good Engineering Practice guidelines (distance is less than or equal to five-times the building length or width) and point of release from stacks more than 3 m above the turbine units.
Chemical transformations	No	Chemical transformation not possible in AERMOD.
General Reporting Requirements		
Model accuracy and uncertainty	No	
Plan of study	Yes	Section 5.1.1
Air Dispersion Modelling Study Reporting Requirements	Yes	As per the Regulations Prescribing the Format of the Atmospheric Impact Report, Government Gazette No. 36904, Notice Number 747 of 2013 (11 October 2013) and as per the Regulations Regarding Air Dispersion Modelling (Government Gazette No. 37804 Notice R533, 11 July 2014).
Plotted dispersion contours	Yes	Section 5.1.6 and 5.2

APPENDIX B: 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[10].		
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).		

Assessment of Cumulative Impacts

As per DEFF's requirements, specialists are required to assess the cumulative impacts. In this regard, please refer to the methodology below that will need to be used for the assessment of 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 activities1. The role of the cumulative assessment is to test if such impacts are relevant to the proposed project in the proposed location (i.e. whether the addition of the proposed project in the area will increase the impact). This section should address whether the construction of the proposed development will result in:

- Unacceptable risk
- Unacceptable loss
- Complete or whole-scale changes to the environment or sense of place
- Unacceptable increase in impact

The specialist is required to conclude if the proposed development will result in any unacceptable loss or impact considering all the projects proposed in the area.

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

Example of a cumulative impact table:
Nature: Complete or whole-scale changes to the environment or sense of place (example)

Nature: **[Outline and describe fully the impact anticipated as per the assessment undertaken]**		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Low (1)	High (3)
Duration	Medium-term (3)	Medium-term (3)
Magnitude	Low (4)	Moderate (6)
Probability	Probable (3)	Probable (3)
Significance	**Low (24)**	**Medium (33)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Unlikely	No
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		
Residual impacts: “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).		

APPENDIX C: ENVIRONMENTAL MANAGEMENT PROGRAMME

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 Thermal Power Generation Facility components including associated infrastructure
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 residents 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
As far as practically possible, tarred road construction should precede construction activities for the thermal power generation facility, especially within 200 m of the homesteads located along the access road	EPC Contractor(s) and EO	During construction
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
Additional dust control measures (sweeping; screens; berms and/or water suppression - using non-potable water if possible) along access road near homesteads during construction of access road sections and during thermal power generation facility construction.	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

Mitigation: Action/control	Responsibility	Timeframe
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 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	Dustfall monitoring at the homesteads along the access road. Measured daily dustfall rates should not exceed the acceptable dustfall standards for residential areas.
	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	Gas engines
Potential Impact	The normal operation of the proposed thermal power generation facility will result in emission of gaseous and particulate pollutants including: SO_2, NO_2, PM, CO, and VOCs. Increased ambient concentrations of these pollutants may result in negative human health impacts, and nuisance dustfall.
	The transport of LPG in tanker trucks via road from the distribution depot will result in the emission of gaseous and particulate pollutants including: NOx, CO, PM, SO_2 and VOCs. Increased ambient concentrations of these pollutants may result in negative human health impacts and nuisance dustfall, especially along the access road.
Activity/risk source	Combustion of LPG in engines
	Combustion of diesel in LPG delivery tanker trucks
Mitigation: Target/Objective	Ensure compliance with minimum emission limits as applicable to the LPG engines
	Ensure compliance with ambient air quality standards at the property boundary and especially along LPG delivery access route.
	Ensure compliance with acceptable dustfall standards along LPG delivery access route.

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 engines 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 engine stacks.	EO, Contractor and Plant Manager	During operations
Annual emissions reporting (as per conditions of the AEL)	EO, Contractor and Plant Manager	During operations
Once per year a 7-day ambient monitoring campaign at (minimum) 4 fence-line locations using passive sampling techniques. Monitoring of SO_2, NO_2, CO, and VOCs	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, especially near homesteads along access road.	EO and Plant Manager	During operations
LPG delivery tanker trucks to be road worthy and regularly maintained. Tanker trucks to comply with Euro V emission limits or better.	LPG distribution contractor, transportation contractor(s) and EO	Duration of contract
All vehicles associated with the delivery of LPG during the operational phase must adhere to the designated speed limits on- and off-site.	LPG distribution contractor, 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. 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 tanker trucks are made available prior to construction and updated regularly. No or minimal visible exhaust fumes during normal operation.
	Compliance with emission limits applicable to turbines and boilers during normal operation.
	Compliance with national ambient air quality standards based on passive sampling campaign.
Monitoring	Dustfall monitoring at the homesteads along the access road. Measured daily dustfall rates should not exceed the acceptable dustfall standards for residential areas.
	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 engine stacks.
	Annual emissions reporting (as per conditions of the AEL)
	Once per year a 7-day ambient monitoring campaign at (minimum) 4 fence-line locations using passive sampling techniques. Monitoring of SO_2, NO_2, CO, and VOCs

APPENDIX D: CURRICULUM VITAE OF PROJECT TEAM

CURRICULUM VITAE

Name	Theresa (Terri) Leigh Bird
Date of Birth	8 November 1976
Nationality	South African
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Senior Consultant
Profession	Air Quality Specialist Consultant
Years with Firm	5 years

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- National Association for Clean Air (NACA), 2012 to present
- South African Council for Natural Science Professions (Pr.Sci.Nat.), 2016

EXPERIENCE

Projects contributing to Environmental Impact Assessments

Project type	Experience
Mining (including coal, platinum, tin, gold, and rare earth minerals)	▪ At least five proposed open-cast coal mining projects, mostly in South Africa and Botswana ▪ Air quality assessment for the expansion of an underground platinum mine to include a concentrator facility and tailings facility. ▪ Assessment of underground mining of cassiterite (the mineral ore mined for tin) in the Democratic Republic of Congo. The project included the assessment of emissions along a long-distance haul road from the mine to Mombasa for export. ▪ Assessment of open-cast and underground mining of gold-rich ore, including gold plant activities, in order to design an air quality monitoring network. ▪ Three rare earth mineral mining projects included dispersion model runs to assist the radiation specialist assessment of impact of radioactive compounds.

Projects contributing to Environmental Impact Assessments

Project type	Experience
Power Stations	▪ A project assessing the impact of Namibian coal-fired power station on urban air quality, in the context of many small industrial sources. ▪ The assessment of retrofitting improved particulate emission controls on an existing coal-fired power station on the Mpumalanga Highveld. ▪ The assessment of impact of a floating power plant, fuelled by various potential liquid fuels, docked in a port servicing an industrial development zone. ▪ Professional opinion on the impact of solar power facilities (one concentrated solar power (CSP) and one photovoltaic (PV)) on ambient air quality. ▪ The assessment of three coal-fired power stations in Botswana, including two projects where the assessment assessed the combined impact of an open-cast coal mine and the associated coal-fired power station.
Ash disposal facilities for coal-fired power stations	▪ Conducted the assessment of impact of ash disposal facilities coal-fired power stations requiring additional disposal area. Assessment included the estimation of increased life-time cancer risk as a result of exposure to carcinogenic metals in the wind-blown dust from the disposal facilities.
Tyre pyrolysis plant	▪ Assisted on an assessment of a plant that will use waste tyres as raw material to produce machine and vehicle oils.
Domestic waste landfill	▪ Assessing the health and odour impacts of a domestic waste landfill to support residential development plans for the area.
Marine Repair Facility	▪ The project quantified the impact on air quality of a marine vessel repair facility in the context of a busy port which includes an iron-ore transfer yard.

Air Quality Management Plans (AQMP)

Project type	Experience
Provincial Level AQMP	▪ Involvement included: - baseline assessment of climatic conditions and ambient air quality across the Province; - collation of questionnaires from point-source emission; - point-source emissions inventory database management ▪ Assisted with quantification of vehicle emissions and with dispersion modelling of baseline emissions. ▪ Main contributor to management plan write-up.

Air Quality Management Plans (AQMP)

Project type	Experience
	▪ The management intervention strategies proposed in the AQMP were a collaborative effort of the technical project team, which included the client and consultants.
Metropolitan city level AQMP	▪ Contributed to the emission inventory of industrial sources ▪ Collaborative project with the Council for Scientific Research (CSIR)
Platinum smelter complex	▪ Fugitive dust emissions from ground-level sources and materials handling were a concern for a platinum smelter complex. The project scope included the identification of all sources; the quantification and ranking of emissions; and proposed management strategies. A risk assessment model was used to assess where the variability of emission sources would constitute a risk if improperly managed.
Diamond mine	▪ The project scope for a Botswana-based diamond mine approaching end-of-life required the assessment of current and future impacts of operations on the ambient air quality; including the development of an air quality management plan and the proposal of an ambient air quality monitoring network, based on the findings of the impact assessment.

Atmospheric Impact Reports (AIR)

Project type	Experience
Coal-to-liquid fuel refineries	▪ Postponement application included four sites with multiple point-sources and modelling iterations for all sources emitting at four different levels for multiple pollutants. ▪ A collaborative project where responsibilities included: model simulations, post-processing and extractions; management of model extractions and management of file transfer for peer review process; graphic summaries results; mapping of results; and, graphic presentation of measured ambient air quality. My contributions to the written report included: report template sections (as per Government Gazette No. 36904: 747); summary of meteorological data used in the assessment; measured ambient air quality; results analysis, interpretation and write-up; and, a literature review of potential impacts of the operations on the environment. ▪ The assessment of impact of petroleum storage tanks storing products of the tar process on the ambient air quality, especially with respect to total volatile organic compounds (TVOCS).

Atmospheric Impact Reports (AIR)

Project type	Experience
Crude oil refinery	▪ Postponement application included emissions from multiple point-sources, and fugitive emissions from storage tanks; modelling iterations for all sources emitting at two different levels for sulfur dioxide [from point sources] and total volatile organic compounds (TVOCS) [from tanks]. ▪ A collaborative project where I focused on the point-sources, including the model simulations; post-processing and extractions; graphic results summaries; and, graphic presentation of measured ambient air quality. Contributions to the written report included: report template sections; summary of meteorological data used in the assessment; measured ambient air quality; results analysis, interpretation and write-up.
Fertilizer production	▪ Assessment report (prepared as AIR) included emissions from multiple point-sources; modelling iterations for all sources emitting at two different levels for particulate matter and ammonia emissions. ▪ A collaborative project where my responsibilities included: model simulation setup, post-processing and extractions; graphic summaries results; mapping of results; and, graphic presentation of measured ambient air quality. My contributions to the written report included: report template sections (as per Government Gazette No. 36904: 747); summary of meteorological data used in the assessment; measured ambient air quality; results analysis, interpretation and write-up.
Platinum smelter	▪ Postponement application included emissions from the smelter furnace and converter; modelling iterations for the sources emitting at two different levels where the pollutant of concern was sulfur dioxide.

* all projects listed above supported the application for postponement of stricter Minimum Emissions Standards applicable to Listed Activities

Veterinary waste incinerator	▪ New Atmospheric Emissions License (AEL) application for a State Veterinary incinerator. The assessment included calculating emission rates from the incinerator; dispersion modelling; preparation of an AIR (as per Government Gazette No. 36904: 747); and completing the technical sections of the AEL application.
Galvanizing plant	▪ The project assessed the impact of a steel galvanising plant on air quality in a developing industrial development zone. Pollutants of concern included hydrochloric acid (HCl).
Secondary Aluminium Smelter	▪ A project involving the assessment of a secondary aluminium smelter in an already developed urban industrial area

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Ambient air quality monitoring projects

Project type	Comments regarding project details and involvement
Ferrochrome smelter complex	▪ Compiled reports for the dustfall monitoring campaign for a period of 12 months. Results were compared with the relevant legislation and recommendations made for source management as required.
Platinum smelter complex	▪ Project scope required monthly reports of the ambient sulfur dioxide concentrations downwind of a platinum smelter complex, for a 12 month reporting period. Report preparation included: data cleaning and filtering; data analysis, presentation; and report write-up.
Dustfall monitoring	▪ Collate, summarise and report on dustfall rates, and metal content, after laboratory analysis. Projects include: baseline monitoring prior to active coal mining; landfill dustfall monitoring; baseline dustfall monitoring for a residential development.
Ambient air quality monitoring	▪ Using radiello™ passive samplers to assess ambient pollutant concentrations. Projects include: volatile organic compounds around industrial waste water dams; pre-development levels near a medical waste incinerator; and pre-development levels near a coal-fired power station.

SOFTWARE PROFICIENCY

- Atmospheric Dispersion Models: AERMOD, CALPUFF, ADMS (United Kingdom), CALINE, GASSIM
- Graphical Processing: Surfer, ArcGIS (basic proficiency)
- R, especially with the package "openair"
- Other: MS Word, MS Excel, MS Outlook

EDUCATION

University of the Witwatersrand

Ph.D. (School of Animal, Plant and Environmental Sciences) (2006 - 2011)	Thesis title: **Some impacts of sulfur and nitrogen deposition on the soils and surface waters of the Highveld grasslands, South Africa.**
M.Sc. (School of Animal, Plant and Environmental Sciences) (1999 – 2001).	Dissertation title: **Some effects of prescribed understory burning on tree growth and nutrient cycling, in *Pinus patula* plantations.**

B.Sc. (Hons) (Botany) (1998)	Project title: **The rate of nitrogen mineralization in plantation soils, in the presence of *Eucalyptus grandis* wood chips.** *Courses*: Wetland ecology, Ecophysiology and Environmental studies.
B.Sc. (1995 – 1997)	Botany III, Geography III, Zoology II.

COURSES COMPLETED AND CONFERENCES ATTENDED

- Paper presented at the International Union of Air Pollution Prevention and Environmental Protection Associations World Clean Air Congress, 2013 in Cape Town, South Africa,29 September - 4th October 2013
  - *Paper entitled*: Nitrogen cycling in grasslands and commercial forestry plantations: the influence of land-use change
  - *Co-authors*: T.L. Bird, M.C. Scholes, Y. Scorgie, G. Kornelius, N.-M. Snyman, J. Blight, and S. Lorentz
- Paper prepared for the National Association for Clean Air (NACA) annual conference, 2012 in Rustenburg, South Africa, 1-2 November 2012, Rustenburg. Annual Conference Proceedings ISBN 978-0-620-53886-2, Electronic Proceedings ISBN 978-0-620-53885-5
  - *Paper entitled*: Developing an Air Quality Management Plan: Lessons from Limpopo
  - *Co-authors*: T. Bird, H. Liebenberg-Enslin*, R. von Gruenewaldt, D. Modisamongwe, P. Thivhafuni, and, T. Mphahlele

COURSES PRESENTED

Training organisation	Details of involvement
National Association for Clean Air (NACA)	▪ Presenting the module regarding the Development of Air Quality Management Plans ▪ Module forms part of a 5-day course presented annually
Centre for Environmental Management (CEM), University of the North-West (Potchefstroom)	▪ Presented two modules: 1. Development of Air Quality Management Plans 2. Air Pollution Meteorology ▪ Modules forms part of a 2-day course presented annually, or at special request

COUNTRIES OF WORK EXPERIENCE

South Africa, Botswana, Mozambique, Democratic Republic of Congo, Namibia, Tanzania

Centre for Environmental Management (CEM), University of the North-West (Potchefstroom)	▪ Presented two modules: 1. Development of Air Quality Management Plans 2. Air Pollution Meteorology ▪ Modules forms part of a 2-day course presented annually, or at special request

COUNTRIES OF WORK EXPERIENCE

South Africa, Botswana, Mozambique, Democratic Republic of Congo, Namibia, Tanzania

LANGUAGES

Language	Proficiency
English	Full professional proficiency
Afrikaans	Good understanding; fair spoken and written

REFERENCES

Name	Position	Contact Number
Dr. Gerrit Kornelius	Associate of Airshed Planning Professionals	+27 (82) 925 9569 gerrit@airshed.co.za
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Dr. Hanlie Liebenberg Enslin	Managing Director at Airshed Planning Professionals	+27 (83) 416 1955 hanlie@airshed.co.za

CERTIFICATION

I, the undersigned, certify that to the best of my knowledge and belief, these data correctly describe me, my qualifications and my experience.

19 September 2019