Air Quality Specialist Report for the Proposed Siyanda FeCr Project near Northam, Limpopo Province

Project done for **SLR Consulting (South Africa) (Pty) Ltd**

Report compiled by:
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Report No: 14SLR08 Final v1.2 | **Date:** September 2016

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Report Details

Report Title	Air Quality Specialist Report for the Proposed Siyanda FeCr Project near Northam, Limpopo Province
Client	SLR Consulting (South Africa) (Pty) Ltd
Report Number	14SLR08
Report Version	Final v1.2
Date	September 2016
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Revision Record

Version	Date	Section(s) Revised	Summary Description of Revision(s)
Draft	March 2016	Original	For client review
Final v1	September 2016	All sections	Updates as per client comments and remodelling results
Final v1.1	September 2016	Section 4.1 Section 4.6	Addition of unmitigated emissions summary Addition of cumulative significance ranking table
Final v1.2	October 2016	Section 3.3.2 Annexes	Inclusion of recent monitoring data Addition of Annex C - Dust Effects on Vegetation and Animals Addition of Annex D – Comments/Issues Raised

NEMA Regulation (2014), Appendix 6

NEMA Regulations (2014) - 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.	Section 8: Annex A – Specialist's Curriculum Vitae (page 102)
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.	Section 1.1: Purpose (page 1) Section 1.2: Scope of Work (page 1)
The date and season of the site investigation and the relevance of the season to the outcome of the assessment.	A site investigation was not included in the scope of work. Ambient data representative of all seasons were available. Section 3.2 and 3.3 (page 19 and 26)
A description of the methodology adopted in preparing the report or carrying out the specialised process.	Section 1.4 (page 6)
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure.	Section 3: Description of the Receiving Environment (page 19)
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: Description of Activities from an Air Quality Perspective, Figure 1 (page 4)
A description of any assumptions made and any uncertainties or gaps in knowledge.	Section 1.5: Assumptions, Exclusions and Limitations (page 7)
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment.	Section 4: Impact Assessment (page 35)
Any mitigation measures for inclusion in the EMPr.	Section 6: Air Quality Management Measures (page 90)
Any conditions for inclusion in the environmental authorisation	Section 6: Air Quality Management Measures (page 90)
Any monitoring requirements for inclusion in the EMPr or environmental authorisation.	Section 6: Air Quality Management Measures (page 90)
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised.	Section 5: Main Findings (page 88)
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.	Section 6: Air Quality Management Measures (page 90)
A description of any consultation process that was undertaken during the course of carrying out the study.	Not applicable.
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Any other information requested by the competent authority.	Section 11: Annex D – Comments/Issues Raised (page 112)

Glossary and Abbreviations

AERMIC	AMS/EPA Regulatory Model Improvement Committee
Airshed	Airshed Planning Professionals (Pty) Ltd
AMS	American Meteorological Society
AQG(s)	Air Quality Guideline(s)
AQR(s)	Air Quality Receptor(s)
ASG	Atmospheric Studies Group
AST	Anemometer Starting Threshold
ASTM	American Society for Testing and Materials
CALEPA	California Environmental Protection Agency
CE	Control Efficiency
CPVs	Cancer Potency Values
DEA	Department of Environmental Affairs
DEAT	Department of Environmental Affairs and Tourism
DPF(s)	Diesel Particulate Filter(s)
EHS	Environmental, Health and Safety
EMS	Environmental Management Systems
GIIP	Good International Industry Practice
GLC(s)	Ground Level Concentration(s)
GLCC	Global Land Cover Characterisation
IFC	International Finance Corporation
I&APs	Interested and Affected Parties
IRIS	Integrated Risk Information System
LPG	Liquefied Petroleum Gas
mamsl	Meters above mean sea level
MEI	Maximally Exposed Individual
MM5	Fifth-Generation Penn State/NCAR Mesoscale Model
NAAQS	National Ambient Air Quality Standard(s)
NCAR	National Centre for Atmospheric Research
NDCR(s)	National Dust Control Regulation(s)
NEMAQA	National Environmental Management: Air Quality Act 2004
NPI	National Pollutant Inventory
PM	Particulate Matter
RELs	Reference Exposure Levels
RfC(s)	Reference Concentration(s)
SA	South African
SABS	South African Bureau of Standards

SCSC	Siyanda Chrome Smelting Company (Pty) Ltd
SLR	SLR Consulting (Africa) (Pty) Ltd
SRTM	Shuttle Radar Topography Mission
STCF	Short Term Climate Forcers
TCEQ	Texas Commission on Environmental Quality
t/a	Tonnes per annum
TSP	Total Suspended Particulates
URFs	Unit Risk Factors
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VKT	Vehicle Kilometres Travelled
WHO	World Health Organisation

Executive Summary

The Siyanda Chrome Smelting Company (Pty) Ltd (SCSC) proposes the construction of a new ferrochrome (FeCr) smelter on the farm Grootkuil 409 KQ, adjacent to the existing Union Section Mine approximately 5 km north-west of Northam in the Thabazimbi Local Municipality, Limpopo Province. SCSC proposes the processing of UG2 chrome concentrate from surrounding platinum mines and in broad terms, the project will comprise a railway siding, a raw materials offloading area, two 70 mega Watt (MW) direct current (DC) FeCr furnaces, crushing and screening plant, mineralized waste facility and related facilities such as material stockpiles, workshops, stores and various support infrastructure and services including powerlines, access and internal roads and pipelines.

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed SLR Consulting (Africa) (Pty) Ltd (SLR) to provide independent and competent services for the compilation of the air quality specialist study as part of a Scoping and Environmental Impact Assessment (EIA) as well as Environmental Management Programme (EMP) process. As such the report conforms to the regulated format requirements for specialist reports as per Appendix 6 of EIA Regulations (Government Gazette No. 38282, 4 December 2014). Atmospheric emissions and impacts reported here will also be used to compile an Atmospheric Impact Report (AIR) in the prescribed format as gazetted on 11 October 2013 (Gazette No. 36904). The AIR will be submitted in support of the application for an Atmospheric Emissions Licence (AEL).

The main objective of this study was to establish baseline/pre-development air quality in the study area and to quantify the extent to which ambient pollutant levels will change as a result of the project. The baseline and impact study then informed the air quality management and mitigation measures recommended as part of the Air Quality Management Plan (AQMP).

To achieve this objective, the following tasks were included in the scope of work (SoW):

1. A **review** of proposed project activities in order to identify sources of emission and associated pollutants.
2. A study of **regulatory requirements and health thresholds** for identified key pollutants against which compliance need to be assessed and health risks screened.
3. A study of the **receiving environment** in the vicinity of the project; including:
    a. The identification of potential Air Quality Receptors (AQRs);
    b. A study of the atmospheric dispersion potential of the area taking into consideration local meteorology, land-use and topography; and
    c. The analysis of all available ambient air quality information/data to determine pre-development ambient pollutant levels and dustfall rates.
4. The compilation of a comprehensive **emissions inventory** including fugitive dust, vehicle exhaust and process emissions.
5. **Atmospheric dispersion modelling** to simulate ambient air pollutant concentrations and dustfall rates.
6. A **screening** assessment to determine:
    a. Compliance of criteria pollutants with ambient air quality standards;
    b. Compliance of dustfall rates to dust control standards;
    c. Potential health risks as a result of exposure to non-carcinogenic non-criteria pollutants; and
    d. Potential increased lifetime cancer risks as a result of exposure to carcinogenic pollutants.
7. The compilation of a comprehensive air quality specialist report.
8. The completion of an AIR and AEL application form.

The main findings of the baseline/pre-development assessment are:

- The area is dominated by winds from the east-south-east. Frequent winds also occur from the south-eastern and eastern sectors. Long term air quality impacts are therefore expected to the most significant to the west-north-west of operations.
- The main sources likely to contribute to baseline PM concentrations include vehicle entrained dust from local roads, mining operations, platinum processing operations, biomass burning, household fuel burning, vehicle exhaust and windblown dust from exposed areas.
- Ambient baseline/pre-development air quality monitoring over the past six months indicated:
  - Low NO_2, SO_2 and benzene concentrations that are within NAAQS.
  - $PM_{2.5}$ and PM_{10} concentrations exceed short term NAAQS.
  - Low dustfall rates within the NDCR for residential areas.
- The nearest residences are those of the Swartklip Mine Village (located immediately adjacent to the Union Section Mine) which lies to the west approximately 500 m from the mid-point of furnaces. There are also several individual houses/farmsteads/buildings within a few kilometres of the farm Grootkuil 409. Sefikile is located approximately 5 km south and Northam approximately 8 km east-south-east of project infrastructure and not likely to be affected by project activities.

The main findings of the impact assessment are as follows:

- PM and gaseous emissions will be released during the construction, decomissioning, operational and closure phases of the project. Only the construction and operational phase air quality impacts were quantified since decommissioning phase impacts will likely be similar or less significant than the construction phase impacts.
- Construction phase:
  - If unmitigated or partially mitigated (water sprays on some sources), PM_{10} and $PM_{2.5}$ concentrations as a result of fugitive emissions released during the construction phase may exceed NAAQS off-site and at nearby AQRs.
  - The significance of construction related inhalation health impacts are considered moderate. Since fugitive dust from construction activities is easily managed the significance of its impact could be reduced to low if the management and additional mitigation measures recommended in this report are implemented effectively.
- Operational phase:
  - PM (TSP, PM_{10}, $PM_{2.5}$, Cr^{6+} and DPM) and gaseous (CO, NO_x, SO_2 and VOC) emissions and impacts were quantified.
  - Mitigation and air quality management measures incorporated into the project design were accounted for in the assessment.
  - Releases from stacks (raw materials dust extraction baghouse stack, drier baghouse stacks, clean gas stacks and secondary fume extraction baghouse stacks) were found to contribute most notably total annual emissions of all pollutants with the exception being TSP. Vehicle entrainment on paved roads was estimate to contribute most notably to TSP emissions.
  - Simulated $PM_{2.5}$ and PM_{10} concentrations were found to exceed both short-term and long-term NAAQS off-site and the significance of the impacts on AQRs are considered low. Since source group contribution analyses indicated vehicle exhaust and vehicle entrainment on paved roads as the main contributors to off-site $PM_{2.5}$ and PM_{10} impacts efforts aimed at further reducing emissions from these should be made to limit exceedances of NAAQS to on-site.
  - The potential for cumulative PM_{10} effects off-site are likely given the indications that baseline/pre-development concentrations are already close to exceeding short term NAAQS.

- There are notable uncertainties in Cr^{6+} emission estimates. To account for uncertainties a 'likely' as well as 'worst case' estimates of emissions, based on literature, were included. Similarly, a range of URFs was applied to determine likely and worst case Cr^{6+} impacts and increased lifetime cancer risks. It should furthermore be noted that simulated annual average concentrations were conservatively applied in estimates of increased *lifetime* cancer risk. Given the above, the significance of Cr^{6+} related air quality impacts were found to be low.
- DPM impacts of medium significance are as a result of vehicle exhaust emissions. Ground level DPM concentrations were found to exceed assessment criteria off-site. Ground level DPM concentrations are likely to exceed assessment criteria off-site and at AQRs should access road option 1 or option 3 be selected.
- Inhalation health NO_2 impacts was found to have low significance at AQRs with off-site exceedances of assessment criteria.
- Inhalation health CO, SO_2 and VOC impacts as well as nuisance dustfall impacts were found to have low significance with no off-site exceedances of assessment criteria.

To ensure the lowest possible impact on AQRs and environment it is recommended that the air quality management measures as set out in this report should be adopted. This includes the mitigation of sources of emission, the management of associated air quality impacts; and ambient air quality monitoring. Key aspects/recommendations are:

- Vehicles should be fitted with DPFs and SCR technologies. Regular maintenance and emission testing is recommended on all mobile diesel combustion sources. Use should also be made of low sulphur fuel (50 ppm or better).
- Regular sweeping of all paved surfaces to reduce silt loading on roads and within raw materials, ingot cooling and crusher area. Good housekeeping will ensure minimal windblown dust emissions which are often a significant source of dust at industrial facilities.
- Process emission testing and reporting:
    - Under Section 21 of the NEMAQA it is compulsory to measure and report annually, Cr^{6+} emissions from the primary fume capture systems of ferro chrome furnaces.
    - It is a further requirement that the holder of an AEL must submit an emission report in the format specified by the National Air Quality Officer or Licensing Authority on an annual basis.
    - It is therefore recommended that annual emission testing be conducted on the following:
        - Raw materials dust extraction baghouse stack, PM
        - Reductant/flux drier baghouse stack, PM, SO_2 and NO_x (Cr^{6+} to be included if furnace off gas is used as an energy source)
        - Concentrate drier baghouse stack, PM, SO_2 and NO_x (Cr^{6+} to be included if furnace off gas is used as an energy source)
        - Secondary furnace fume extraction baghouse stacks, PM, Cr^{6+}, SO_2 and NO_x
        - Pre-heater stack(s) if applicable; PM, Cr^{6+}, SO_2 and NO_x
    - It should however be noted that stack emissions testing on cleaned/raw furnace off-gas before is impractical and dangerous due to the high CO content. If flared, emissions from primary furnace off gas must rather be estimated from emission factors, limits and or mass balance methods. Since it is likely that cleaned furnace off gas will be combusted and utilised for drying and preheating emission testing at the outlet of these process can be sampled safely.
- It is recommended that an ambient monitoring campaign similar to the campaign currently under way be conducted during the construction phase as well as at least the first year of operation. Ambient monitoring during these periods should include continuous dustfall, PM_{10}, $PM_{2.5}$ sampling and a short campaign for NO_2, SO_2 and VOCs.

- A complaints register must be kept.

Based on the above findings **and provided the measures recommended are in place**, it is the specialist opinion that the project may be authorised.

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1 INTRODUCTION

The Siyanda Chrome Smelting Company (Pty) Ltd (SCSC) proposes the construction of a new ferrochrome (FeCr) smelter on the farm Grootkuil 409 KQ, adjacent to the existing Union Section Mine approximately 5 km north-west of Northam in the Thabazimbi Local Municipality, Limpopo Province. SCSC proposes the processing of UG2 chrome concentrate from surrounding platinum mines and in broad terms, the project will comprise a railway siding, a raw materials offloading area, two 70 mega Watt (MW) direct current (DC) FeCr furnaces, crushing and screening plant, mineralized waste facility and related facilities such as material stockpiles, workshops, stores and various support infrastructure and services including powerlines, access and internal roads and pipelines.

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The study was conducted for an 11 km x 11 km area so as to include all sources associated with atmospheric emissions; these being the smelter complex as well as the access roads. This study area was selected to include the entire boundary, access road option 1 which will extend almost 5.7 km from the centre point of the furnaces and access road option 3 which will extend almost 2.2 km from the centre point of the furnaces.

1.1 Purpose

The main purpose of the air quality specialist study was to determine the potential impact on the atmospheric environment and air quality receptors (AQRs) given activities proposed as part of the Project.

1.2 Scope of Work

The following tasks, typical of an air quality impact assessment, were included in the scope of work (SoW):

1. A **review** of proposed project activities in order to identify sources of emission and associated pollutants.
2. A study of **regulatory requirements and health thresholds** for identified key pollutants against which compliance need to be assessed and health risks screened.
3. A study of the **receiving environment** in the vicinity of the project; including:
    a. The identification of potential AQRs;
    b. A study of the atmospheric dispersion potential of the area taking into consideration local meteorology, land-use and topography; and
    c. The analysis of all available ambient air quality information/data to determine pre-development ambient pollutant levels and dustfall rates.
4. The compilation of a comprehensive **emissions inventory** including fugitive dust, vehicle exhaust and process emissions.
5. **Atmospheric dispersion modelling** to simulate ambient air pollutant concentrations and dustfall rates.
6. A **screening** assessment to determine:

    a. Compliance of criteria pollutants with ambient air quality standards;
    b. Compliance of dustfall rates to dust control standards;
    c. Potential health risks as a result of exposure to non-carcinogenic non-criteria pollutants; and
    d. Potential increased lifetime cancer risks as a result of exposure to carcinogenic pollutants.
7. The compilation of a comprehensive air quality specialist report.
8. The completion of an AIR and AEL application form.

1.3 Description of Activities from an Air Quality Perspective

As indicated in the introduction, SCSC is proposing to establish a smelter complex to process the UG2 chrome concentrate from chrome recovery plants of nearby operations. In broad terms, the project will comprise a railway siding, a raw materials offloading area, two 70 MW DC furnaces, crushing and screening plant, mineralised waste facility, and related facilities such as material stockpiles, workshops, stores and various support infrastructure and services including powerlines, roads and pipelines.

A short description of construction, operational, decommissioning and closure phase activities[1] are included below and likely sources of emission and associated pollutants identified.

1.3.1 Construction Phase

During the construction phase several facilities need to be established. These include; contractor's laydown areas, workshops (instrumentation, electrical, mechanical, diesel), stores for the storing and handling of fuel, lubricants, solvents, paints and construction materials, a wash bay, laboratory, construction waste collection and storage facilities, a store, a parking area for cars and equipment, mobile site offices, portable ablution facilities, temporary electricity supply (diesel generators), portable water supply (bowsers), change houses and a clinic, soil stockpiles, water management infrastructure, security and access control and the main access road. These facilities will either be removed at the end of the construction phase or incorporated into the layout of the operational phase facilities.

Access to site will be via the main project access road. It is planned that this road will be constructed at the beginning of the construction phase in order to provide site access for construction phase traffic. An already existing dirt access road traversing the Siyanda property, may be used in addition to the main access road during the construction phase

In order to establish the above facilities, the following activities are proposed:

- Site establishment of construction phase facilities;
- Clearing of vegetation;
- Stripping and stockpiling of soil resources and earthworks;
- Collection, storage and removal of construction related waste; and
- Construction of all infrastructure required for the operational phase.

Fugitive particulate matter (PM) emissions will be released to atmosphere during these activities. Fugitive emissions refer to emissions that are spatially distributed over a wide area and not confined to a specific discharge point as would be the case for process related emissions (IFC, 2007).

[1] Extracted from the *Scoping Report for the Proposed Development of the Siyanda Ferrochrome Smelter* dated February 2016 as compiled by SLR.

It should be noted that in the discussion, regulation and estimation of PM emissions and impacts a distinction is made between different particle size fractions, *viz*. TSP, PM_{10} and $PM_{2.5}$. PM_{10} is defined as particulate matter with an aerodynamic diameter of less than 10 µm and is also referred to as thoracic particulates. Inhalable particulate matter, $PM_{2.5}$, is defined as particulate matter with an aerodynamic diameter of less than 2.5 µm. Whereas PM_{10} and $PM_{2.5}$ fractions are taken into account to determine the potential for human health risks, total suspended particulate matter (TSP) is included to assess nuisance dustfall.

In addition to fugitive PM emissions, combustion related PM and gaseous emissions will also be released from construction equipment, diesel generators and construction related traffic. Key pollutants from combustion of fossil fuels include PM_{10} and $PM_{2.5}$, carbon monoxide (CO), formaldehyde, nitrogen oxides (NO_x), sulphur dioxide (SO_2) and volatile organic compounds (VOCs). PM emitted from diesel combustion will mostly be in the form of black carbon, commonly referred to as diesel particulate matter or diesel exhaust (DPM or DE). Diesel fuel storage for temporary electricity supply may result in additional but small amounts of VOCs.

It is anticipated the construction phase activities would continue for a period of 24 months, 24-hours per day, Monday to Sunday.

1.3.2 Operational Phase

The proposed Project will comprise two 70MW DC furnaces which will be used to process approximately 850 000 tonnes per annum (t/a) of UG2 chrome concentrate from nearby chrome recovery plants. Table 1 below summarises activities expected to result in atmospheric emissions and pollutants likely to be released. It should be noted that this assessment focusses on pollutants regulated under MES and NAAQS applicable to the process.

With the exception of the crusher plant, the smelter complex will be operational 24-hours a day, 7 days a week. The crusher plant will be operational 8 hours per day, 7 days per week.

1.3.3 Decommissioning and Closure Phase

The removal of infrastructure as well as sloping and revegetation of the mineralised waste facility are planned for the decommission phase. Fugitive PM emissions as well as combustion related PM and gaseous emissions will be released from mobile equipment, and traffic. No information on the duration of this phase is available. The closure phase indicates the phase when the site has been rehabilitated.

Table 1: Air emissions and pollutants associated with the Project

Activity	Description	Sources of emission	Main Pollutants	Notes/Comments
Transportation and handling and storage of raw materials	Raw materials (chrome concentrate, flux/reductant) will be transported to site by rail and road and temporarily stored in bunkers prior to use. Dust generated during handling will be captured and passed through a baghouse to reduce PM emissions. Captured dust will be returned to the raw materials system for processing.	Vehicle entrainment	PM	-
		Vehicle exhaust	PM, DPM, CO, NO_x, SO_2, VOC	-
		Materials handling	PM	-
		Raw materials baghouse stack	PM	-
		Railway related emission	PM and combustion gases if diesel powered locomotives are used.	No information. See limitations and assumptions for further details.
		Windblown dust	PM	-
Drying	In order to eliminate moisture in the raw materials concentrate and reductant/flux will move through dryers prior to being fed into proportioning bins in preparation for furnace feeding. Duel fuel burners capable of using liquid petroleum gas (LPG) or cleaned CO rich furnace off-gas will be used. Off-gas from the dryers will be passed through baghouses to reduce PM emissions before being released to the atmosphere. Captured dust will be returned to the raw materials system for processing.	Reductant/flux dryer stack	PM, DPM, NO_x and SO_2	Emissions subject to minimum emission standards (MES): Category 4: Metallurgical Industry, Subcategory 4.1: Drying and Calcining
		Concentrate dryer stack	PM, DPM, NO_x and SO_2	
Pre-heating	Gas Suspension Pre-heating (GSPH) is defined as the direct heating of material particles in a "solids in suspension" environment using pre-heated gases and cyclone gas/solids separation technology. For this application of the GSPH, CO rich cleaned furnace off-gas may be used as the energy source. Cleaned CO gas is ducted to a combustion chamber, where it is burned, together with atmospheric air, and fed into the GSPH. It is expected that combustion off-gas will be emitted through a separate, dedicated stack.	Pre-heater stack	PM, CO, NO_x and SO_2	Pre-heating of raw materials is mentioned as an option in the Project's pre-feasibility study. At the time of undertaking this assessment pre-heating was not included in the Project design and therefore not quantified. See limitations and assumptions for further information.

Activity	Description	Sources of emission	Main Pollutants	Notes/Comments
Smelting	Two 70 MW DC furnaces will be used to smelt raw materials (chrome concentrate and flux and reductant). Off-gas generated by the furnaces will be extracted through primary off-gas systems, cooled, passed through baghouses to reduce PM and used as a fuel source for various plant processes and/or flared. During emergencies, uncleaned off-gas may be directly released to the atmosphere through an emergency stack. Baghouse dust will be slurried and disposed onto the baghouse slurry dam. Slag will be disposed of onto the slag dump.	Emergency flare stack	PM, Cr^{6+}, CO, NO_x, SO_2	Only during emergency conditions
		Flare stack	PM, Cr^{6+}, CO, NO_x, SO_2	Emissions subject to MES: Category 4: Metallurgical Industry, Subcategory 4.9: Ferro-alloy Production
Tapping of metal and slag	Secondary fumes released during tapping of metal and slag will be captured and passed through the secondary off-gas cleaning system which consists of a baghouse that also serves to reduce PM emissions from the furnace feed bins. Baghouse dust will be moistened and co-disposed onto the mineralised waste facility together with the slag	Secondary fume baghouse stack	PM, Cr^{6+}	Emissions subject to MES: Category 4: Metallurgical Industry, Subcategory 4.9: Ferro-alloy Production
Crushing and screening	Cast/broken alloy ingots will be transferred to a cooling area after which they will pass through a crushing and screening plant for sizing to client specifications.	Vehicle entrainment	PM	-
		Vehicle exhaust	PM, DPM, CO, NO_x, SO_2, VOC	-
		Materials handling	PM	-
		Crushing and screening	PM	-
		Windblown dust	PM	-
Product transport	FeCr product will we loaded to rail carriages for dispatch.	Materials handling	PM	-
		Railway related emissions	PM and combustion gases if diesel powered locomotives are used.	No information. See limitations and assumptions for further details.
Slag disposal	Slag will be disposed of at a slag disposal facility.	Vehicle entrainment	PM	-
		Vehicle exhaust	PM, DPM, CO, NO_x, SO_2, VOC	-
		Materials handling	PM	-

Activity	Description	Sources of emission	Main Pollutants	Notes/Comments
		Windblown dust	PM	-
Baghouse dust disposal	Baghouse dust will be slurried and pumped to the baghouse slurry dam.	Not applicable	Not applicable	Due to the high moisture content and slurry dam design it is unlikely any emissions to the atmosphere would result from these activities.

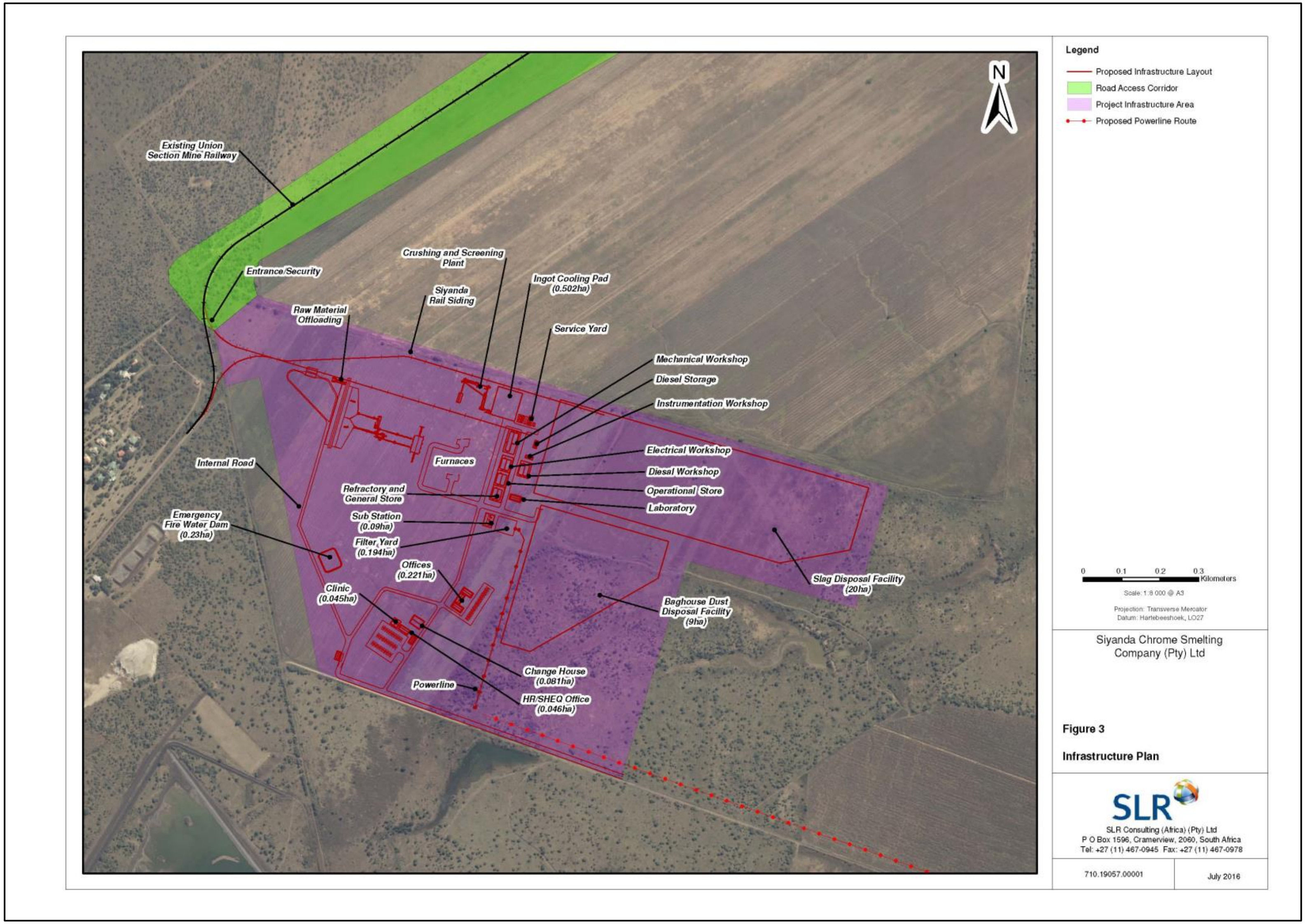

Figure 1: Proposed Project layout

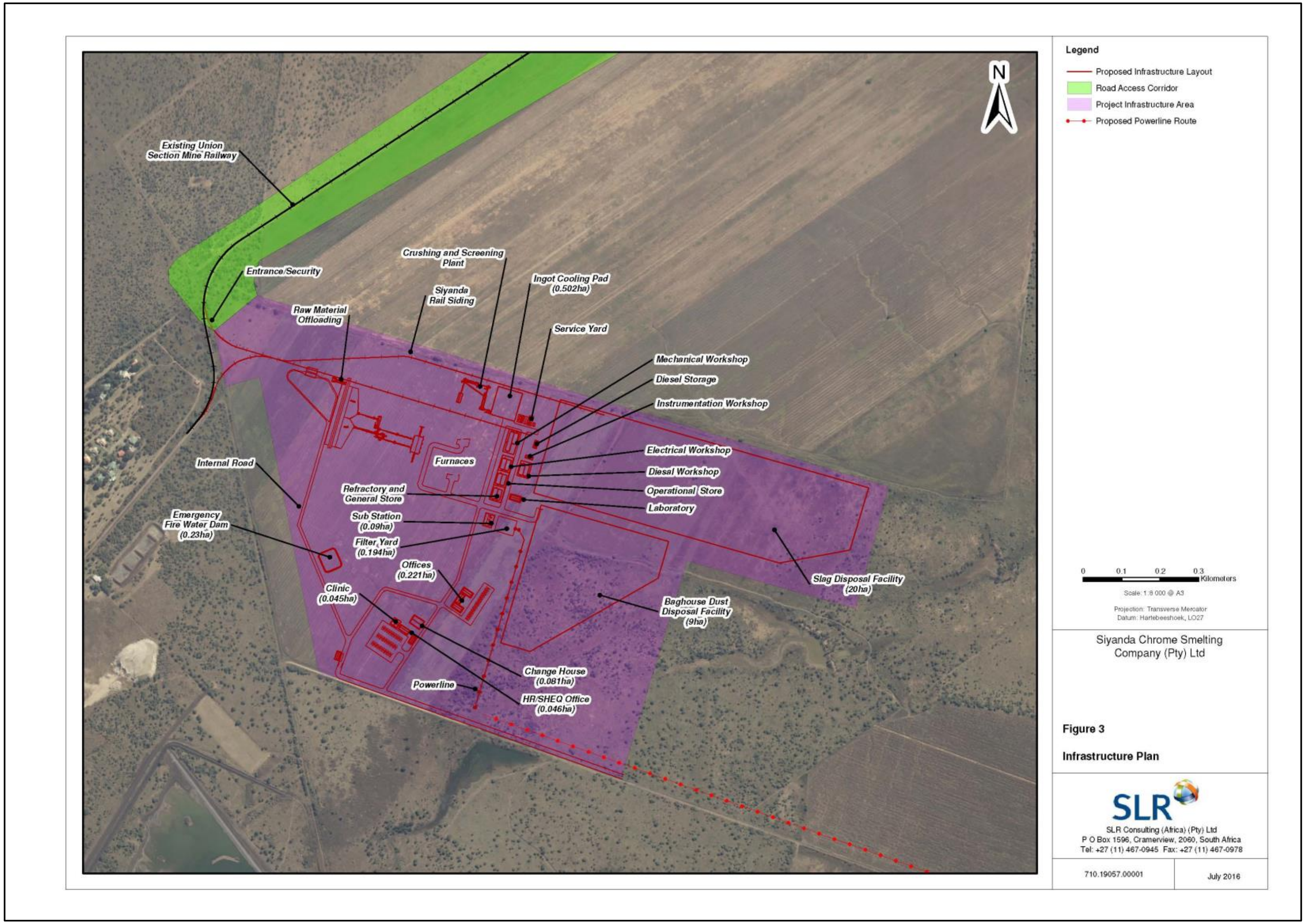

Figure 2: Proposed Project layout with infrastructure alternatives

1.4 Approach and Methodology

The approach to, and methodology followed in the completion of tasks that formed part of the SoW are discussed in this section.

1.4.1 Project Information and Activity Review

All project related information referred to in this study was provided by the technical project team. It includes responses to a detailed information requirements list submitted upon commencement of the study, the *Scoping Report for the Proposed Development of the Siyanda Ferrochrome Smelter* prepared by SLR (dated February 2016) and, the *Pre-Feasibility Study* compiled by Tenova Minerals (Pty) Ltd (dated January 2014).

1.4.2 The Identification of Regulatory Air Quality Requirements and Assessment Criteria

In the evaluation regulations pertaining to air quality, reference was made to:

- Under the National Environmental Management Air Quality Act (Act No. 39 of 2004) (NEMAQA)
    - Minimum Emission Standards (NMES);
    - National Atmospheric Emission Reporting Regulations;
    - National Ambient Air Quality Standards (NAAQS) for criteria pollutants;
    - National Dust Control Regulations (NDCR); and
    - National Code of Practice for Air Dispersion Modelling.
- Screening levels for non-criteria pollutants published by various internationally recognised organisations.

1.4.3 Study of the Receiving Environment

Physical environmental parameters that influence the dispersion of pollutants in the atmosphere include terrain, land cover and meteorology.

Readily available terrain and land cover data was obtained from the Atmospheric Studies Group (ASG) via the United States Geological Survey (USGS) web site at (ASG, 2011). Use was made of Shuttle Radar Topography Mission (SRTM) (90 m, 3 arc-sec) data and Global Land Cover Characterisation (GLCC) data for Africa.

An understanding of the atmospheric dispersion potential of the area is essential to an air quality impact assessment. In the absence of on-site meteorological data (that is required for atmospheric dispersion modelling), use was simulated (MM5) data for Northam for a period from 2012 and 2014.

Monitoring of ambient PM_{10}, $PM_{2.5}$, NO_2, SO_2 and VOC concentrations in the Project area commenced on 1 June 2015. The campaign is scheduled to continue until 31 May 2016. Data recorded up to November 2015 were used in the description of existing ambient air pollutant levels in the area. Potential AQRs were identified from Google Earth imagery.

1.4.4 Determining the Impact of the Project on the Receiving Environment

The establishment of a comprehensive emission inventory formed the basis for the assessment of the air quality impacts of the Project's emissions on the receiving environment. In the quantification of emissions, use was made of design parameters, MES as well as emission factors, which associate the quantity of a pollutant to the activity associated with the release of that pollutant. Fugitive PM emissions were calculated using a comprehensive sets of emission factors and equations as published by the United States Environmental Protection Agency (US EPA) and Australian Department of Environment (ADE) National Pollutant Inventory (NPI).

It should be noted that emissions data for the release of Cr^{6+} from FeCr smelters are limited. For the purpose of this study reference was made to content and conversion factors from two academic studies. These are:

- *Cr^{6+} Generation During Flaring of CO-Rich Off-gas from Closed Ferrochromium Submerged Arc Furnaces* (du Preez, Beukes, & van Zyl, 2015); and
- *Cr^{6+} Containing Electric Furnace Dust and Filter Cake: Characteristics, Formation, Leachability and Stabilization* (Ma, 2005)

As per the National Code of Practice for Air Dispersion Modelling use was made of the US EPA AERMOD atmospheric dispersion modelling suite for the simulation of ambient air pollutant concentrations and dustfall rates. AERMOD is a Gaussian plume model best used for near-field applications where the steady-state meteorology assumption is most likely to apply. AERMOD is a model developed with the support of the AMS/EPA Regulatory Model Improvement Committee (AERMIC), whose objective has been to include state-of the-art science in regulatory models (Hanna, Egan, Purdum, & Wagler, 1999). AERMOD is a dispersion modelling system with three components, namely: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD terrain pre-processor), and AERMET (AERMOD meteorological pre-processor).

1.4.5 Compliance Assessment and Health Risk Screening

Compliance was assessed by comparing simulated ambient criteria pollutant concentrations (PM_{10}, $PM_{2.5}$, CO, NO_2, SO_2) and dustfall rates to NAAQS and NDCR respectively. Health risk screening was done through the comparison of simulated non-criteria pollutant concentrations (Cr^{6+}, DPM and VOC) to inhalation screening levels. Increased lifetime cancer risk as a result of exposure to carcinogenic pollutants (DE) were calculated from simulated pollutant concentrations and cancer unit risk factors (URFs) and compared to international criteria.

1.4.6 Recommendation of Air Quality Management Measures

The findings of the above components informed recommendations of air quality management measures, including mitigation and monitoring.

1.5 Assumptions, Exclusions and Limitations

The following important assumptions, exclusions and limitations to the specialist study should be noted:

1. All project information required to calculate emissions for proposed operations were provided by SLR and SCSC.
2. The impact of the construction and operational phases were determined quantitatively through emissions calculation and simulation. Decommissioning phase impacts are expected to be similar or somewhat less significant that construction phase impacts. Mitigation and management measures recommended for the construction and operational phases are however also applicable to the decommissioning phase. No impacts are expected post-closure provided the rehabilitation of final land forms is successful.
3. Meteorology:
    a. In the absence of on-site or nearby South African Weather Service (SAWS) meteorological data, use was made of data simulated data (MM5). The MM5 (short for Fifth-Generation Penn State/NCAR Mesoscale Model) is a regional mesoscale model used for creating weather forecasts and climate projections. It is a community model maintained by Penn State University and the National Centre for Atmospheric Research (NCAR)

b. The National Code of Practice for Air Dispersion Modelling prescribes the use of a minimum of 1-year on-site data or at least three years of appropriate off-site data for use in Level 2 assessments. It also states that the meteorological data must be for a period no older than five years to the year of assessment. The MM5 data set applied in this study complies with the requirements of the code of practice.

4. The estimation of greenhouse gas (GHG) emissions was not included in the SoW but reference made to draft GHG emission reporting regulations for reference purposes.
5. Dustfall, $PM_{2.5}$, PM_{10}, NO_x, SO_2 and VOCs are presently sampled in the project area.
6. Emissions:
    a. The impact assessment was limited to airborne particulates (including TSP, PM_{10}, $PM_{2.5}$, Cr^{6+} and DPM) and gaseous pollutants from vehicle exhausts, including CO, NO_x, VOCs and SO_2. These pollutants are either regulated under MES, NAAQS or considered a key pollutant released by FeCr industries.
    b. The quantification of sources of emission was restricted to the proposed Project. Although other existing sources of emission within the area were identified, such sources were not quantified as part of the emissions inventory and simulations. Their impact is however considered by ambient air quality monitoring currently under way.
    c. In the absence of a detailed construction plan, construction phase fugitive dust emission had to be estimated over an area wide basis and several assumptions had to be made. The confidence rating of these emissions are therefore low in comparison with operational phase emissions. Assumptions included:
        i. 25% of the project footprint area would be under construction at any given time.
        ii. 35% of PM released would be in the 10 µm size fraction and 18% in the 2.5 µm fraction.
    d. Where site/project specific particle size, moisture and silt content data were not available, use was made of default values published as part of the US EPA or ADE emission estimation manuals.
    e. In the estimation of windblown dust emissions use was made of the ADE NPI emission factor, conservatively assuming emissions would occur continuously instead of only during high wind speed incidences.
    f. Vehicle exhaust emissions were conservatively estimated using emission factors published by the ADE. These have been found to be comparable to pre-Euro vehicle emission standards.
    g. Pre-heating of raw materials is mentioned as an option in the Project's pre-feasibility study. At the time of undertaking this assessment pre-heating was not included in the Project design and therefore not quantified. The option of pre-heating is not likely to alter the conclusions of this study. As indicated, CO rich cleaned furnace off-gas may be used as the energy source for the GSPH installation. Cleaned CO gas is ducted to a combustion chamber, where it is burned, together with atmospheric air, and fed into the GSPH. It is expected that combustion off-gas will be emitted through a separate, dedicated stack. The same pollutants are likely to be released irrespective of whether the cleaned off-gas is combusted in the clean gas flare or the combustion chamber of the pre-heater. PM and SO_2 emission rates are expected to remain similar. Whereas NO_x and Cr^{6+} emissions may differ due to different combustion temperatures, CO and VOC emissions may differ due to different combustion efficiencies.
    h. It was conservatively assumed that all NO_x emitted from stacks were assumed to be emitted as NO_2.
7. NO_2 emissions and impacts:
    a. Nitrogen monoxide (NO) emissions are rapidly converted in the atmosphere into NO_2. NO_2 impacts where calculated by AERMOD using the ozone limiting method assuming constant monthly average background ozone concentrations of 30 ppb (Zunckel, et al., 2004) and a NO_2/NO_x emission ratio of 0.2 (Howard, 1988).
8. Cr^{6+} emissions and impacts:

a. Closed DC furnaces operate under reducing conditions and chromium contained in furnace off-gas would primarily be in the trivalent state (Cr^{3+}). However, the combustion or reaction of CO rich furnace off-gas may result in the formation Cr^{6+}.
b. Data on the formation of Cr^{6+} throughout the entire FeCr production process is limited, but emissions from the flare and tapping could be estimated based on research conducted by du Preez et al (2015) and Ma (2005).
c. The calculation of Cr^{6+} emissions from the flare was based on the assumption that (a) the chrome content in the particles in the off-gas is the same as the chrome content in the ore (~30%); (b) all the chrome in contained in the off-gas before flaring is in the trivalent form i.e. Cr^{3+}; and (c) the amount of Cr^{3+} converted to Cr^{6+} is between 0.027% and 0.35% (du Preez, Beukes, & van Zyl, 2015).
d. The calculation of Cr^{6+} emissions from tapping was based on the assumption that (a) the chrome content in the particles in the off-gas is the same as the chrome content in the ore (~30%); and (b) the amount of Cr^{6+} as PM_{10} is similar to what is found in open furnace baghouse dust i.e. between 0.035% and 0.122% (Ma, 2005).
e. It was conservatively assumed that all Cr^{6+} emitted would be in the PM_{10} (thoracic) size fraction.
f. It was conservatively assumed that all forms of Cr^{6+} were carcinogenic. Known carcinogenic Cr^{6+} compounds include chromium trioxide, lead chromate, strontium chromate and zinc chromate.
g. In estimating increased lifetime cancer risk, use was made of simulated annual average Cr^{6+} concentrations. This approach is conservative since it assumes an individual will be exposed to this concentration constantly over a period of 70 years.
h. The range in cancer unit risk factors (URF) for exposure to Cr^{6+} is evidence of uncertainty related to increased lifetime cancer risk associated with this pollutant. In the presentation of increased lifetime cancer risk use was made of both the US EPA Integrated Risk Information System URF of 0.012 $(\mu g/m^3)^{-1}$ (the lower limit) and the World Health Organisation (WHO) URF of 0.04 $(\mu g/m^3)^{-1}$ (the geometric mean).

2 AIR QUALITY REGULATIONS AND ASSESSMENT CRITERIA

Prior to assessing the impact of proposed activities on human health and the environment, reference needs to be made to the air quality regulations governing the calculation and impact of such operations i.e. reporting requirements, emission standards, ambient air quality standards and dust control regulations.

Emission standards are generally provided for point sources and specify the amount of the pollutant acceptable in an emission stream and are often based on proven efficiencies of air pollution control equipment.

Air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. The ambient air quality standards and guideline values indicate safe daily exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. Air quality guidelines and standards are normally given for specific averaging or exposure periods.

2.1 National Minimum Emission Standards and AEL Application and Reporting Requirements

2.1.1 National Minimum Emission Standards

The minister must in accordance with the NEMAQA (Act No. 39 of 2004) publish a list of activities which result in atmospheric emissions and which is believed to have significant detrimental effects on the environment and human health and social welfare. All scheduled processes as previously stipulated under the Air Pollution Prevention Act (APPA) are included as listed activities with additional activities being added to the list. The most recent Listed Activities and NMES's were published on 22 November 2013 (Government Gazette No. 37054).

Both drying and ferro-alloy smelting are considered listed activities under Section 21 of the NEMAQA. MES and special arrangements for these activities are included in Table 2 and Table 3 respectively.

Table 2: MES for subcategory 4.1 listed activities, drying and calcining

Description:	Drying and calcining of mineral solids and ore		
Application:	Facilities with capacity more than 100 t/m		
Substance or mixture of substance:		**Plant status**	**mg/Nm3 under normal conditions of 273 K and 101.3 kPa**
Common name	**Chemical symbol**		
Particulate matter	n/a	New	50
Sulfur dioxide	SO_2	New	1 000
Oxides of nitrogen	NO_2	New	1 200

Table 3: MES for subcategory 4.9 listed activities, ferro-alloy production

Description:	Production of alloys of iron with chromium, manganese, silicon or vanadium, the separation of titanium slag from iron-containing minerals using heat.		
Application:	All installations		
Substance or mixture of substance:		**Plant status**	**mg/Nm3 under normal conditions of 273 K and 101.3 kPa**
Common name	**Chemical symbol**		
Particulate matter	n/a	New	50
Sulfur dioxide	SO_2	New	1 000
Oxides of nitrogen	NO_2	New	1 200
Particulate matter from primary fume capture systems of closed furnaces			
Particulate matter	n/a	New	50
Particulate matter from secondary fume capture systems of all furnaces			
Particulate matter	n/a	New	50

(a) The following special arrangements shall apply:

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

(ii) Emissions of Cr^{6+}, Mn and V from primary fume capture systems of ferrochrome, ferromanganese and ferrovanadium furnaces respectively to be measured and reported to licencing authority annually.

2.1.2 Applying for an AEL

Given the above, SCSC will be required to apply for an AEL which must include all sources of emission, not only those considered listed activities. In terms of the AEL application, the **applicant** should take into account the following sections of NEMAQA:

37. Application for atmospheric emission licences:

(1) A person must apply for an AEL by lodging with the licencing authority of the area in which the listed activity is to be carried out, an application in the form required.

(2) An application for an AEL must be accompanied by –

(a) The prescribed processing fee; and

(b) Such documentation and information as may be required by the licencing authority.

38. Procedure for licence applications:

(1) The licencing authority –

(a) May, to the extent that is reasonable to do so, require the applicant, at the applicant's expense, to obtain and provide it by a given date with other information contained in or submitted in connection with the application;

(b) May conduct its own investigation on the likely effect of the proposed licence on air quality;

(c) May invite written comments from any organ of state which has an interest in the matter; and

(d) Must afford the applicant an opportunity to make representations on any adverse statements or objections to the application.

(2) Section 24 of the NEMA and section 22 of the Environmental Conservation Act apply to all applications for atmospheric emission licences, and both an applicant and the licencing authority must comply with those sections and any applicable notice issued or regulations made in relation to those sections.

(3) –

(a) *An applicant must take appropriate steps to bring the application to the attention of relevant organs of state, interested persons and the public.*

(b) *Such steps must include the publication of a notice in at least two newspapers circulating the area in which the listed activity is applied for is or is to be carried out and must-*

(i) *Describe the nature and purpose of the licence applied for;*

(ii) *Give particulars of the listed activity, including the place where it is to be carried out;*

(iii) *State a reasonable period within which written representations on or objections to the application may be submitted and the address or place where it must be submitted; and*

(iv) *Contain such other particulars as the licencing authority may require.*

Airshed will, as part of the SoW of this assessment, prepare the AEL application form in prescribed format.

2.1.3 Reporting of Atmospheric Emissions

The National Atmospheric Emission Reporting Regulations (Government Gazette No. 38633) came into effect on 2 April 2015.

The purpose of the regulations is to regulate the reporting of data and information from an identified point, non-point and mobile sources of atmospheric emissions to an internet-based National Atmospheric Emissions Inventory System (NAEIS). The NAEIS is a component of the South African Air Quality Information System (SAAQIS). Its objective is to provide all stakeholders with relevant, up to date and accurate information on South Africa's emissions profile for informed decision making.

Emission sources and data providers are classified according to groups. The Siyanda Ferrochrome Project would be classified under Group A ("Listed activity published in terms of section 21(1) of the Act"). Emission reports from Group A must be made in the format required for NAEIS and should be in accordance with the AEL or provisional AEL.

As per the regulation, SCSC and/or their data provider must register on the NAEIS within 30 days after commencing with proposed activities. Data providers must inform the relevant authority of changes if there are any:

- Change in registration details;
- Transfer of ownership; or
- Activities being discontinued.

A data provider must submit the required information for the preceding calendar year to the NAEIS by 31 March of each year. Records of data submitted must be kept for a period of 5 years and must be made available for inspection by the relevant authority.

The relevant authority must request, in writing, a data provider to verify the information submitted if the information is incomplete or incorrect. The data provider then has 60 days to verify the information. If the verified information is incorrect or incomplete the relevant authority must instruct a data provider, in writing, to submit supporting documentation prepared by an independent person. The relevant authority cannot be held liable for cost of the verification of data. A person guilty of an offence in terms of section 13 of these regulations is liable for penalties.

2.1.4 Atmospheric Impact Report

Under section 30 of NEMAQA, an air quality officer may require any person to submit an AIR in the format prescribed if a review of provisional AEL or AEL is undertaken. The format of the AIR is stipulated in the *Regulations Prescribing the Format of the Atmospheric Impact Report*, Government Gazette No. 36904 dated 11 October 2013.

Airshed will, as part of the SoW of this assessment, prepare the AIR form in prescribed format in support of the AEL application.

2.2 National Ambient Air Quality Standards

Criteria pollutants are considered those pollutants most commonly found in the atmosphere, that have proven detrimental health effects when inhaled and are regulated by ambient air quality criteria. South African NAAQS for CO, NO_2, PM_{10} and SO_2 were published on 13 March 2009. On 24 December 2009 standards for $PM_{2.5}$ were also published. These standards are listed in Table 4.

Table 4: National Ambient Air Quality Standards for criteria pollutants

Pollutant	Averaging Period	Limit Value (µg/m³)	Limit Value (ppb)	Frequency of Exceedance	Compliance Date
Benzene	1-year	5	1.6	0	1 Jan 2015
CO	1-hour	30 000	26 000	88	Immediate
NO_2	1-hour	200	106	88	Immediate
	1-year	40	21	0	Immediate
$PM_{2.5}$	24-hour	40	-	4	1 Jan 2016 – 31 Dec 2029
	24-hour	25	-	4	1 Jan 2030
	1-year	20	-	0	1 Jan 2016 – 31 Dec 2029
	1-year	15	-	0	1 Jan 2030
PM_{10}	24-hour	75	-	4	1 Jan 2015
	1-year	40	-	0	1 Jan 2015
SO_2	10-minute	500	191	526	Immediate
	1-hour	350	134	88	Immediate
	24-hour	125	48	4	Immediate
	1-year	50	19	0	Immediate

2.3 International Finance Corporation Environmental, Health and Safety Guidelines

The technical reference documents published in the International Finance Corporation (IFC) Environmental, Health and Safety (EHS) Guidelines provide general and industry specific examples of Good International Industry Practice (GIIP). The General EHS Guidelines are designed to be used together with the relevant Industry Sector EHS Guidelines.
The EHS Guidelines' general approach to air quality (IFC, 2007) states that projects should prevent or minimize impacts by ensuring that:

- Emissions do not result in pollutant concentrations that reach or exceed the relevant national ambient air quality guidelines and standards, or in their absence, the current World Health Organisation (WHO) Air Quality Guidelines (AQG) or other internationally recognised sources;
- Emissions do not contribute a significant portion to the attainment of relevant ambient AQG or standards. The Guideline suggests 25% of the applicable ambient air quality standards to allow additional, future development in the same airshed.

The General EHS Guidelines state that at project level, impacts should be estimated through qualitative or quantitative assessments by the use of baseline air quality assessments and atmospheric dispersion models. The dispersion model should be internationally recognised and able to take into account local atmospheric, climatic and air quality data as well as the effects of downwash, wakes or eddy effects generated by structures and terrain features (IFC, 2007).
The General EHS Guidelines also provides guidance with respect to:

- projects located in degraded airsheds or ecologically sensitive areas;
- points sources and stack heights;
- emissions from small combustion facilities (3 to 50 MWth rated heat input capacity);
- fugitive sources;
- ozone depleting substances;
- land based mobile sources;
- greenhouse gases;
- monitoring; and
- air emissions prevention and control technologies

In addition to the General EHS Guidelines, the IFC also provides industry specific EHS Guidelines. The EHS Guidelines for smelting and refining is only relevant to smelting and refining of lead, zinc, copper, nickel, and aluminium.

2.4 WHO Air Quality Guidelines

Air quality guidelines (AQGs) have been published by the WHO in 1987 and were revised in 1997. Since the completion of the second edition of the Air Quality Guidelines 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 document 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.

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 between two to three interim targets 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. SA NAAQS are for instance in line with IT-3 targets for $PM_{2.5}$ and PM_{10} and IT-1 for SO_2. It should be noted that the WHO permits a frequency of exceedance of 1% per year (4 days per year) for 24 hour average $PM_{2.5}$ and PM_{10} concentrations.

2.5 Inhalation Health Criteria and Unit Risk Factors for Non-Criteria Pollutants

The potential for health impacts associated with non-criteria pollutants emitted from mobile and stationary diesel combustion sources and furnace operations are assessed according to guidelines published by the following institutions:

1. Inhalation reference concentrations (RfCs) and cancer URFs published by the US EPA IRIS.
2. Reference Exposure Levels (RELs) and Cancer Potency Values (CPV) published by the California Environmental Protection Agency (CAL EPA)
3. The RfC's by the Texas Commission on Environmental Quality (TCEQ)

Chronic inhalation criteria and URFs/CPVs for pollutants considered in the study are summarised in Table 5. Increased lifetime cancer risk is conservatively calculated by applying the unit risk factors to predicted long term (annual average) pollutant concentrations.

It should be noted that there are large variations in published cancer URF or CPV. Whereas the US EPA ISIS estimated the increased lifetime cancer risk due to exposure to Cr^{6+} to be 0.012 (US EPA, 1998). The WHO summarised several epidemiological studies and found the range in URFs to be from 0.011 to 0.13 $(\mu g/m^3)^{-1}$. They further indicate that differences in the epidemiological studies cited may suggest that the different hexavalent chromium compounds have varying degrees of carcinogenic potency (WHO, 2000). They recommend the use of 0.04 $(\mu g/m^3)^{-1}$ as the URF for exposure to Cr^{6+} through inhalation.

Given that ambient/pre-development VOC concentrations are at present being measured in the Project area, screening criteria of selected species (as included in the analysis of VOC samples) are included in Table 6.

Table 5: Chronic and acute inhalation screening criteria and cancer URFs for pollutants relevant to the Project

Pollutant	Chronic Screening Criteria ($\mu g/m^3$)	Inhalation URF $(\mu g/m^3)^{-1}$
Diesel Exhaust as DPM	5 (US EPA IRIS)	0.000 3 (CAL EPA)
VOC (*Diesel fuel* used as used as indicator)	100 (TCEQ)	Not applicable
Cr^{6+}	0.1 (US EPA IRIS)	0.012 $(\mu g/m^3)^{-1}$ (US EPA IRIS) 0.04 $(\mu g/m^3)^{-1}$ (WHO)

Table 6: Screening criteria for species included in ambient VOC monitoring

Pollutant	Chronic Inhalation Reference Concentration ($\mu g/m^3$)	Inhalation URF/CPV ($\mu g/m^3$)
Acetone	30 900 (ATSDR Final)	n/a
Pentane, n-	1 000 (PPRTV Current)	n/a
Hexane, n-	700 (US EPA IRIS)	n/a
Methylethylketone	Not applicable (n/a)	n/a
Ethyl Acetate	n/a	n/a
Benzene	5 (NAAQS)	7.8 x 10^{-06} (US EPA IRIS)
Carbon Tetrachloride	100 (US EPA IRIS)	6 x 10^{-06} (US EPA IRIS)
Cyclohexane	n/a	n/a
Isoctane	n/a	n/a

Pollutant	Chronic Inhalation Reference Concentration (µg/m³)	Inhalation URF/CPV (µg/m³)
Heptane	n/a	n/a
Thrichloroethylene	2 (US EPA IRIS)	4.1 x 10^{-06} (US EPA IRIS)
Methylisobutylketaone	3 000 (US EPA IRIS)	n/a
Toluene	5 000 (US EPA IRIS)	n/a
Isobutyl Acetate	Not Specified	n/a
Tetrachloroethylene	40 (US EPA IRIS)	2.6 x 10^{-07} (US EPA IRIS)
Butyl Acetate	n/a	n/a
Ethylbenzene	1 000 (US EPA IRIS)	2.5 x 10^{-06} (CALEPA)
Xylenes	100 (US EPA IRIS)	n/a
Styrene	1 000 (US EPA IRIS)	n/a
Nonane, n-	20 (PPRTV Current)	n/a
1,3,5-Trimethylbenzene	6 (PPRTV Archive)	n/a
1,2,4-Trimethylbenzene	7 (PPRTV Current)	n/a
Decane	n/a	n/a
Limonene	n/a	n/a
Naphtalene	3 (US EPA IRIS)	3.4 x 10^{-05} (CALEPA)
Chloroform	97.65 (ATSDR)	2.3 x 10^{-05} (US EPA IRIS)
Trichloroethane, 1,1,1-	5 000 (US EPA IRIS)	n/a
Dichloroethane,1,2-	7 (PPRTV Current)	2.6 x 10^{-05} (US EPA IRIS)
Trichloroethylene	2 (US EPA IRIS)	4.1 x 10^{-06} (US EPA IRIS)
1,4-Dibromoethane	Not Specified	n/a
Chlorbenzene	500 (PPRTV Current)	n/a
Cumene	400 (US EPA IRIS)	n/a
Propyl benzene	1000 (PPRTV Screen)	n/a
Trimethylbenzene,1,2,3-	5 (PPRTV Current)	n/a
Dichlorbenzene,1,4-	800 (US EPA IRIS)	1.1 x 10^{-05} (CALEPA)
Dibromoethane,1,2-	9 (US EPA IRIS)	6.0 x 10^{-04} (US EPA IRIS)
Propyl Acetate	Not Specified	n/a
Dioxane,1,4-	30 (US EPA IRIS)	5.0 x 10^{-06} (US EPA IRIS
Isooctane	n/a	n/a

The identification of an acceptable cancer risk level has been debated for many years and it possibly will still continue as societal norms and values change. Some people would easily accept higher risks than others, even if it were not within their own control; others prefer to take very low risks. An acceptable risk is a question of societal acceptance and will therefore vary from society to society. In spite of the difficulty to provide a definitive “acceptable risk level”, the estimation of a risk associated with an activity provides the means for a comparison of the activity to other everyday hazards, and therefore allowing risk-management policy decisions. Technical risk assessments seldom set the regulatory agenda because of the different ways in which the non-technical public perceives risks. Consequently, science does not directly provide an answer to the question.

Whilst it is perhaps inappropriate to make a judgment about how much risk should be acceptable, through reviewing acceptable risk levels selected by other well-known organizations, it would appear that the US EPA's application is the most suitable, i.e. *"If the risk to the maximally exposed individual (MEI) is no more than 1 x 10^{-6}, then no further action is required. If not, the MEI risk must be reduced to no more than 1 x 10^{-4}, regardless of feasibility and cost, while protecting as many individuals as possible in the general population against risks exceeding 1 x 10^{-6}"*. Some authorities tend to avoid the specification of a single acceptable risk level. Instead a "risk-ranking system" is preferred.
For example, the New York State Department of Health (NYSDOH) produced a qualitative ranking of cancer risk estimates, from very low to very high (Table 7). Therefore, if the qualitative descriptor was "low", then the excess lifetime cancer risk from that exposure is in the range of greater than one per million to less than one per ten thousand.

Table 7: Excess Lifetime Cancer Risk (as applied by NYSDOH)

Risk Ratio	Qualitative Descriptor
Equal to or less than one in a million	Very low
Greater than one in a million to less than one in ten thousand	Low
One in ten thousand to less than one in a thousand	Moderate
One in a thousand to less than one in ten	High
Equal to or greater than one in ten	Very high

2.6 National Dust Control Regulations

NDCR were published on the 1st of November 2013 (Government Gazette No. R. 827). Acceptable dustfall rates according to the Regulation are summarised in Table 8.

Table 8: Acceptable dustfall rates

Restriction areas	Dustfall rate (D) in mg/m^2-day over a 30 day average	Permitted frequency of exceedance
Residential areas	D < 600	Two within a year, not sequential months.
Non-residential areas	600 < D < 1 200	Two within a year, not sequential months.

The regulation also specifies that the method to be used for measuring dustfall and the guideline for locating sampling points shall be ASTM D1739 (1970), or equivalent method approved by any internationally recognized body. Dustfall is assessed for nuisance impact and not inhalation health impact.

2.7 Greenhouse Gas (GHG) Emissions

Draft regulations pertaining to GHG reporting using the NAEIS was published in May 2015 (Government Gazette 38779, Notice 411 of 11 May 2015).

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 NAEIS web-based monitoring and reporting system will also be 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 SAAQIS.

The DEA 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. It has been indicated that these factors will only be published towards the end of 2015 (Jongikhaya, 2015).

Also, a draft carbon tax bill was introduced for a further round of public consultation. The Carbon Tax Policy Paper (CTPP) (Department of National Treasury, 2013) stated consideration will be given to sectors where the potential for emissions reduction is limited. Also in draft is that GHG in excess of 0.1 Mt, measured as $CO_{2\text{-eq}}$, is required to submit a pollution prevention plan to the Minister for approval.

3 DESCRIPTION OF THE RECEIVING ENVIRONMENT

This chapter provides details of the receiving atmospheric environment which is described in terms of:

- Local AQR;
- The atmospheric dispersion potential; and
- Sampled baseline or pre-development ambient air pollutant levels.

3.1 Air Quality Receptors

AQRs generally include places of residence and areas where members of the public may be affected by atmospheric emissions generated by mining/industrial activities. The nearest residences are those of the Swartklip Mine Village (Swartklip) immediately adjacent to the existing union Section Mine and approximately 500 m west of the proposed location for the furnaces. There are also several individual houses/farmsteads/buildings within a few kilometres of the farm Grootkuil 409 (no. 1, 2, 3, 26, 27, 28, 30 and 31). The Young Farmstead on portion 9 of Kameelhoek (no. 30) lies directly adjacent access road Option 3. Tiramogo Lodge is situated 130 m from access road Option 1. Sefikile is located approximately 5 km south and Northam approximately 8 km east-south-east of project infrastructure and not likely to be affected by project activities. The AQRs are presented in Figure 3.

3.2 Atmospheric Dispersion Potential

Meteorological mechanisms govern the dispersion, transformation, and eventual removal of pollutants from the atmosphere. The analysis of land-use and topography as well as wind speed, wind direction, temperature and atmospheric stability is necessary to facilitate a comprehensive understanding of the dispersion potential of the site.

3.2.1 Topography and Land-use

Terrain in the area is gently undulating with occasional outcrops. The terrain elevation surrounding the site ranges between 963 and 1 176 meters above mean sea level (mamsl). Topographical data was included in dispersion simulations. The topography of the study area is shown in Figure 4.

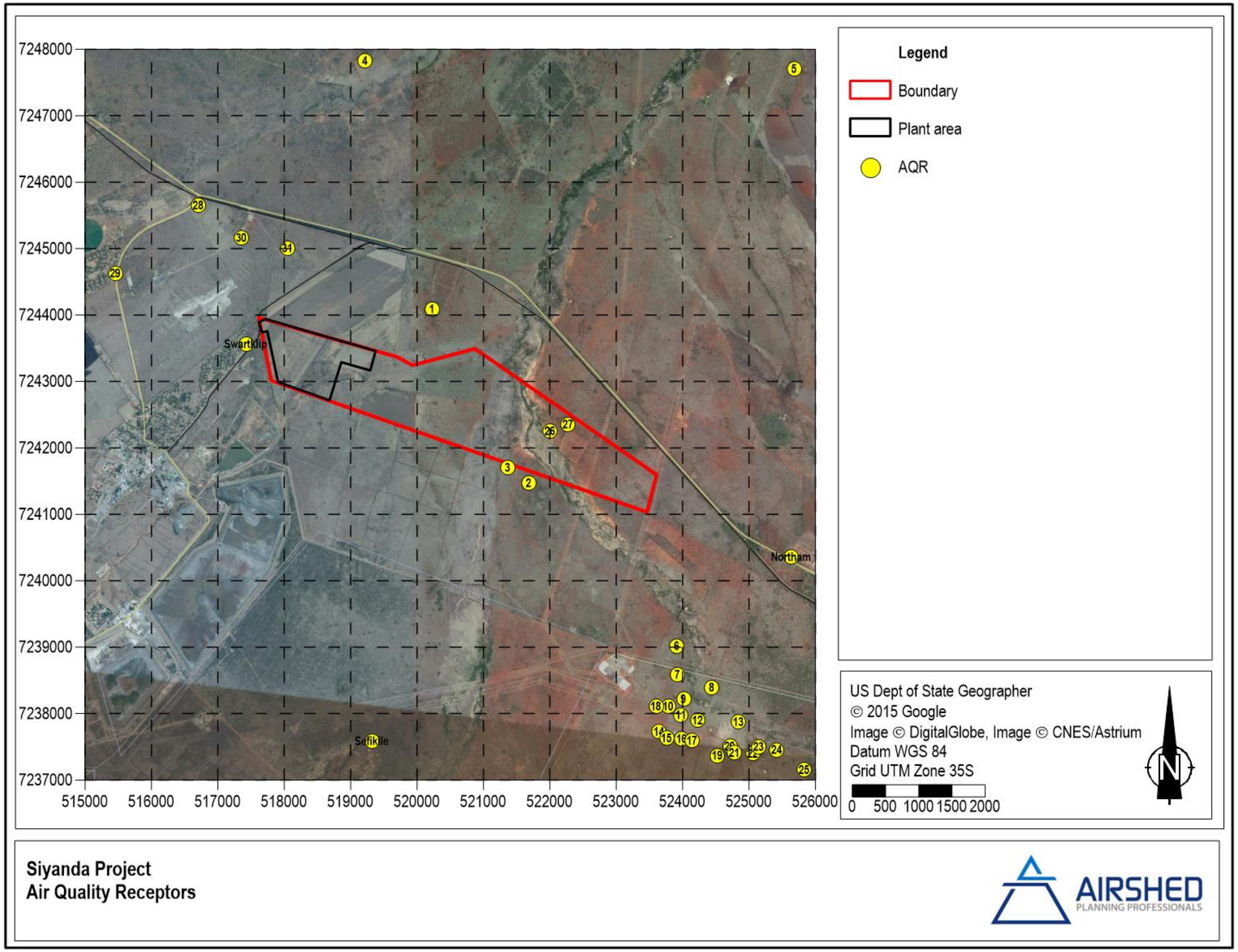

Figure 3: Topography of study area and AQRs

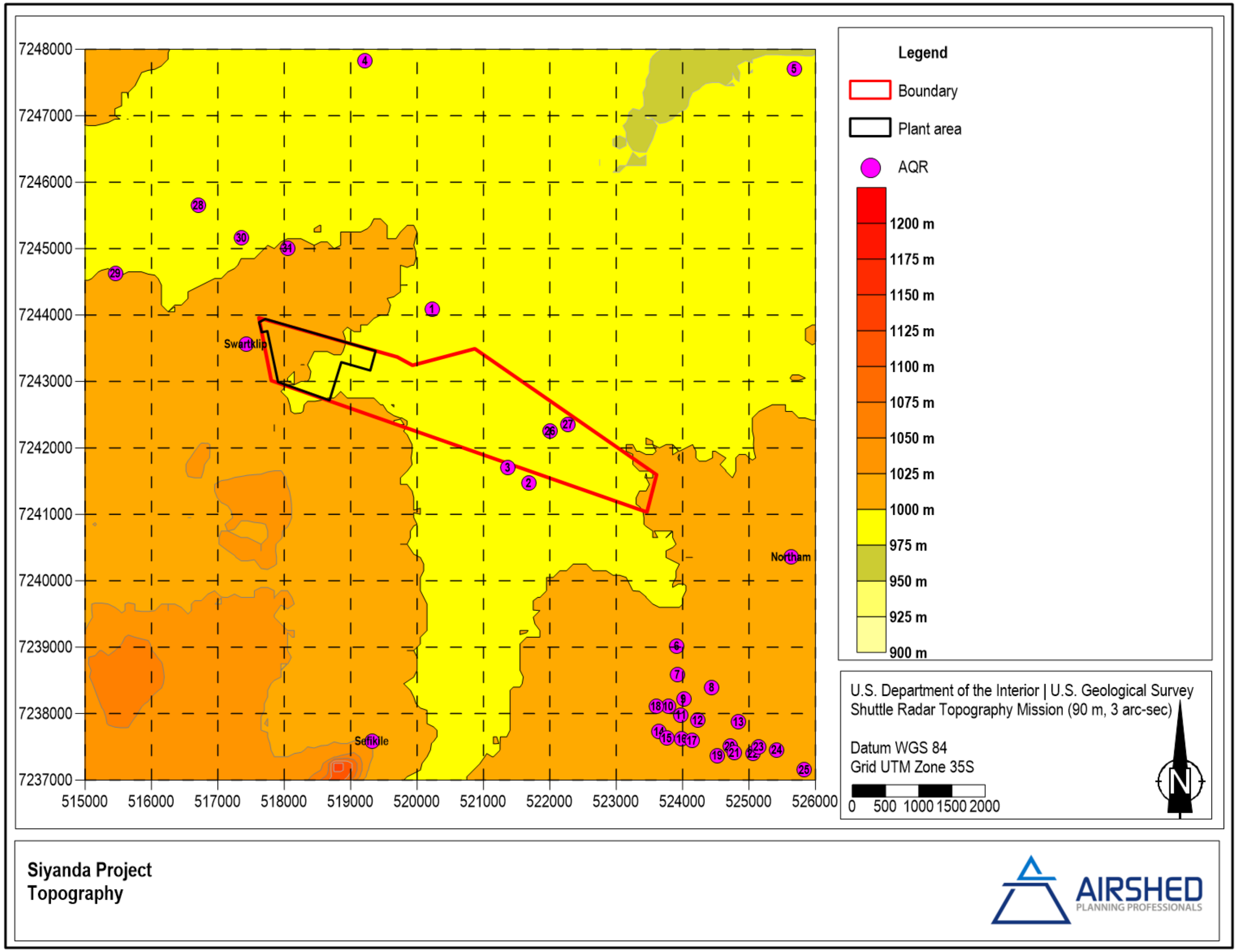

Figure 4: Topography of study area

3.2.2 Surface Wind Field

The wind field determines both the distance of downward transport and the rate of dilution of pollutants. The generation of mechanical turbulence is a function of the wind speed, in combination with the surface roughness. 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. The frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s are also indicated. The data described below is MM5 data as processed by the AERMOD suite's meteorological data pre-processor.

To avoid the overly conservative concentration estimates being made by AERMOD during calm conditions[2] the National Code of Practice for Air Dispersion Modelling suggests that all wind speeds greater than/equal to the anemometer starting threshold (AST) and less than 1 m/s be replaced with the value of 1 m/s. This approach has been adopted and 20% of the wind speeds replaced with 1 m/s.

A wind rose for the period January 2012 to December 2014 is shown in Figure 5. Day-time and night-time wind roses are included in Figure 6. Seasonal variations in the wind field are shown in Figure 7. The wind field was dominated by winds from the east-south-east. Less frequent winds also occurred from the westerly sectors. Calm conditions occurred 3% of the time. During the day, winds occurred more frequently from the east-south-easterly sector with almost 4% calm conditions. Night-time airflow had less frequent winds from the east-south-easterly sector and at lower wind speeds with winds most frequently occurring from the north-north-easterly sector. The percentage calm conditions decreased to 2%. The autumn and winter seasons reflect the prevailing wind direction as being from the east-south-east. The spring and summer seasons reflect the prevailing wind direction as from the north-north-east and an increase in winds from the easterly sector.

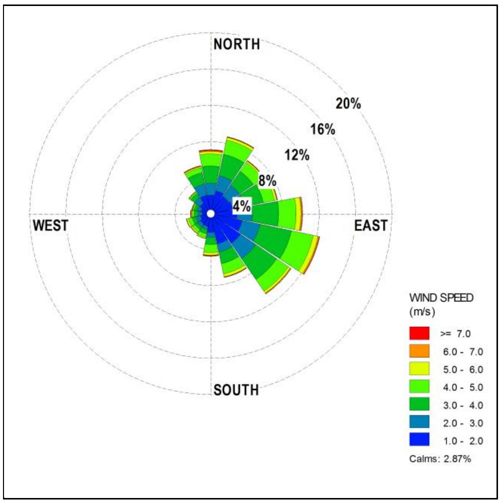

Figure 5: Period average wind rose (AERMET processed MM5 data, 2012 to 2014)

[2] The Gaussian plume equation on which AERMOD algorithms are based is inverse proportional to wind speed resulting in over estimates of concentrations at wind speeds less than 1 m/s.

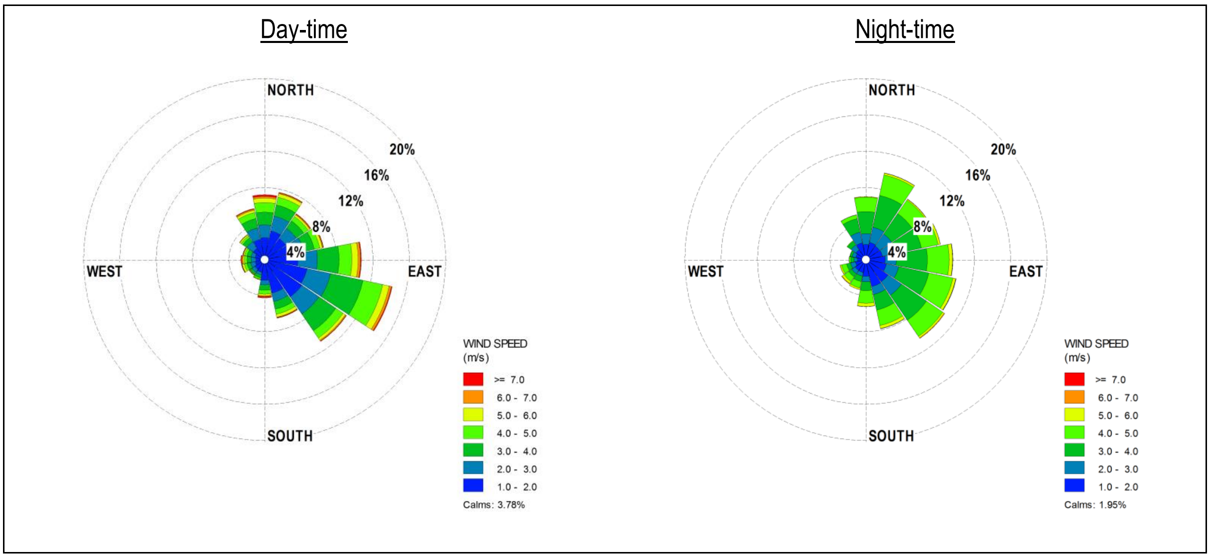

Figure 6: Day-time and night-time wind roses (AERMET processed MM5 data, 2012 to 2014)

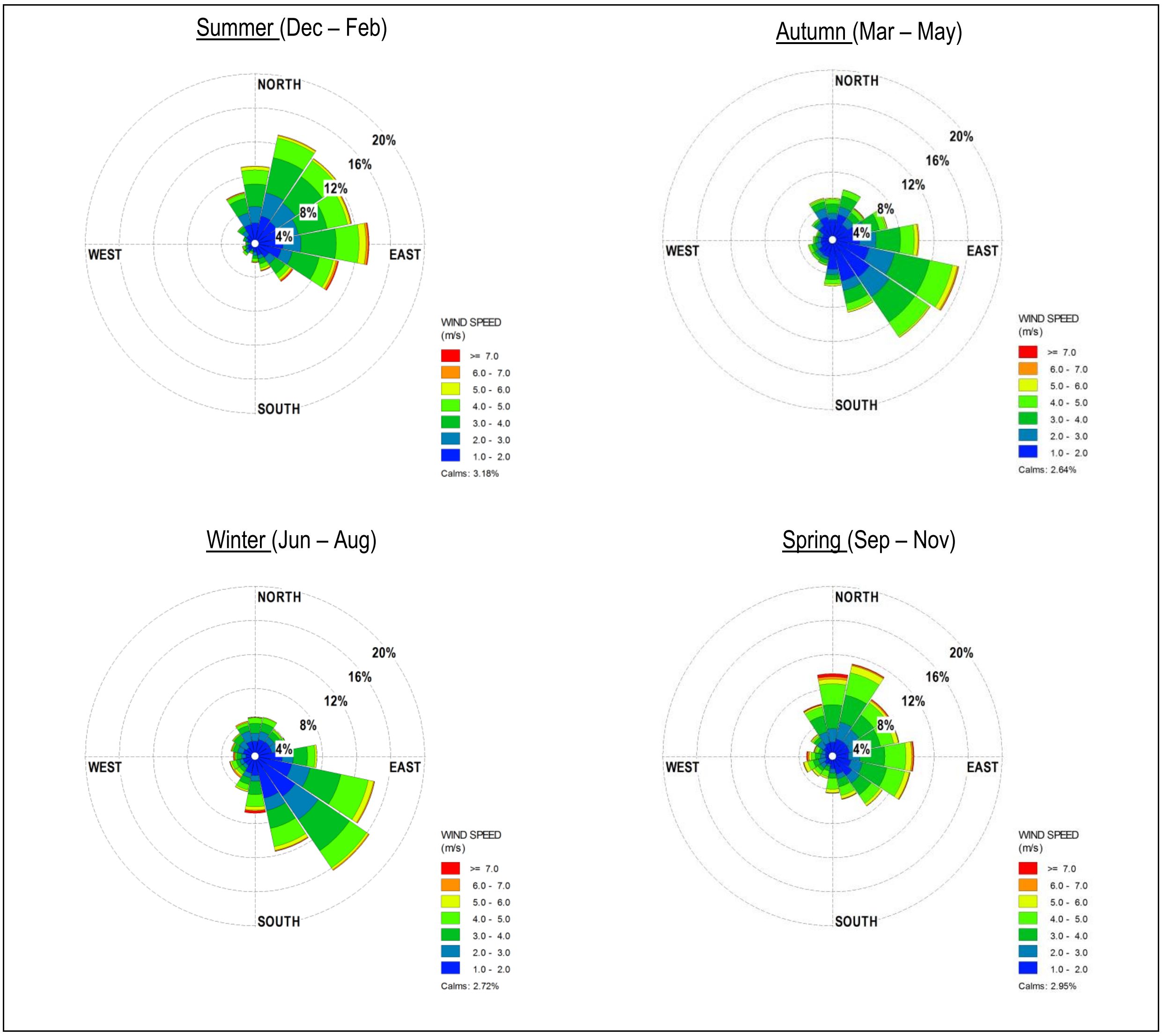

Figure 7: Seasonal wind roses (AERMET processed MM5 data, 2011 to 2013)

3.2.3 Temperature

Air temperature is important, both for determining the effect of plume buoyancy (the larger the temperature difference between the plume and the ambient air, the higher a pollution plume is able to rise), and determining the development of the mixing and inversion layers. Minimum, maximum and mean temperatures for the project area, as obtained from AERMET processed MM5 data, are shown in Table 9. Diurnal monthly average temperatures shown in Figure 8.

Average, maximum and minimum temperatures were 20°C, 34°C and 1°C, respectively. The month of June and July experienced lowest temperature of 1°C whereas the maximum temperature of 34°C occurred in November and January. Temperatures reach their minimum just before sunrise and there maximum between midday and sunset.

Table 9: Minimum, maximum and average temperatures (AERMET processed MM5 data, 2012 to 2014)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	25	25	23	19	15	12	12	15	19	21	24	25
Maximum	34	33	33	29	27	24	22	28	30	32	34	33
Minimum	16	17	15	9	5	1	1	2	4	9	12	16

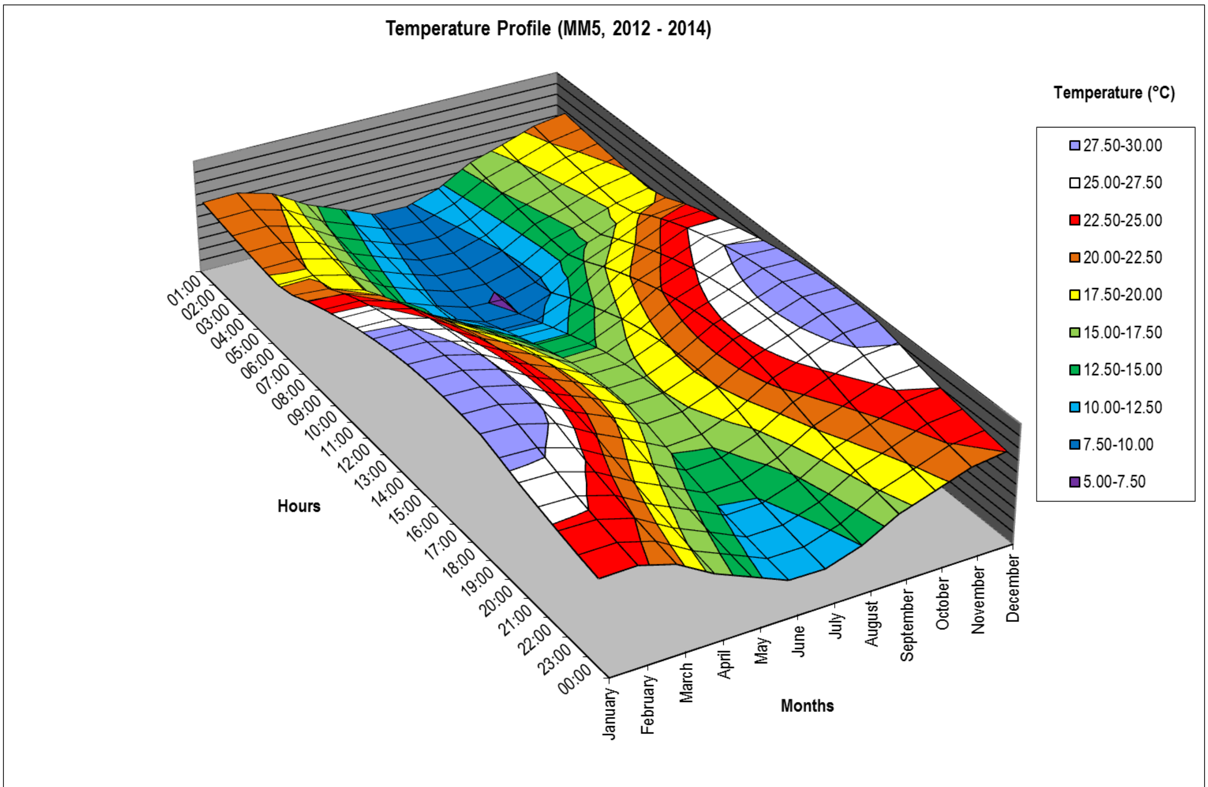

Figure 8: Diurnal monthly average temperature profile (AERMET processed MM5 data, 2012 to 2014)

3.2.4 Rainfall

Rainfall represents an effective removal mechanism of atmospheric pollutants and is therefore frequently considered during air pollution studies. Rain typically occurs primarily as storms and individual rainfall events can be intense. This creates an uneven rainfall distribution over the rainy seasons. Dust is generated by strong winds that sometimes accompany these storms. This dust generally occurs in areas with dry soils and sparse vegetation. This area generally has a rainy season starting in October and ending in March, with maximum monthly rainfalls occurring from November to January.

3.2.5 Atmospheric Stability

The new generation air dispersion models differ from the models traditionally used in a number of aspects, the most important of which are the description of atmospheric stability as a continuum rather than discrete classes. The atmospheric boundary layer properties are therefore described by two parameters; the boundary layer depth and the Monin-Obukhov length, rather than in terms of the single parameter Pasquill Class.

The Monin-Obukhov length (L_{Mo}) 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 calculated from on-site data, and described by the inverse Monin-Obukhov length and the boundary layer depth is provided in Figure 9. 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* (Figure 9 (c)) 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* (Figure 9 (b)). Stable conditions prevent the plume from mixing vertically, although it can still spread horizontally and is called *fanning* (Figure 9 (a)) (Tiwary & Colls, 2010).

For ground level releases such as fugitive dust the highest ground level concentrations will occur during stable night-time conditions.

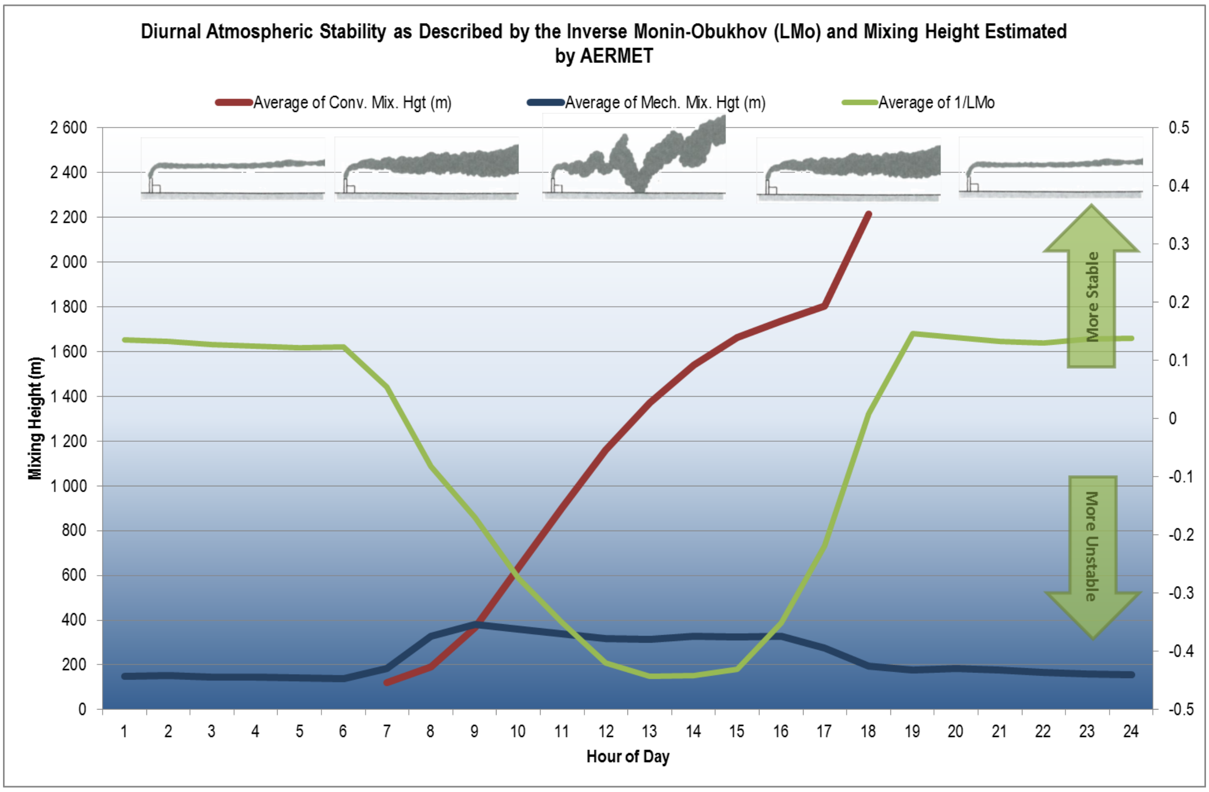

Figure 9: Diurnal atmospheric stability (AERMET processed MM5 Data, 2012 to 2014)

3.3 Status Quo Ambient Air Quality

3.3.1 Existing Sources of Air Pollution in the Area

Land use in the region includes human settlements, farming, mining, platinum processing and wilderness. Sources of atmospheric emissions include gaseous and PM emissions from:

- Platinum processing operations;
- Mining operations;
- Miscellaneous fugitive dust sources including roads and windblown dust from open areas;
- Vehicle exhaust and transport activities;
- Household fuel burning; and
- Biomass burning (e.g. wild fires).

3.3.1.1 Platinum Processing Operations

There are platinum processing operations located in the vicinity of the Project. Processing emissions and fugitive emission sources from these operations mainly comprise of smelter operations, materials handling operations (i.e. tipping, off-loading and loading, conveyor transfer points), vehicle entrainment from plant roads and windblown dust from open areas. These activities result in PM, NO_x, CO, SO_2, VOC and trace metal releases.

3.3.1.2 Mining Operations

There are numerous existing and proposed mines located in the vicinity of the Project. The closest mines located in the vicinity include Union Section Mine and Northam Mine. Fugitive emissions sources from mining operations mainly comprise of land clearing operations (i.e. scraping, dozing and excavating), materials handling operations (i.e. tipping, off-loading and loading, conveyor transfer points), vehicle entrainment from haul roads, wind erosion from open areas and drilling and blasting. These activities mainly result in fugitive PM releases with NO_x, CO, SO_2 and VOC being released during blasting operations as well as a result of diesel combustion and storage.

3.3.1.3 Miscellaneous Fugitive Dust Sources

Fugitive PM emissions are generated through entrainment from local paved and unpaved roads, and erosion of open or sparsely vegetated areas. 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. The extent, nature and duration of road-use activity and the moisture and silt content of soils are required to be known in order to quantify fugitive emissions from this source. The quantity of windblown dust is similarly a function of the wind speed, the extent of exposed areas and the moisture and silt content of such areas.

3.3.1.4 Vehicle Tailpipe Emissions

Air pollution from vehicle emissions may be grouped into primary and secondary pollutants. Primary pollutants are those emitted directly into the atmosphere, and secondary, those pollutants formed in the atmosphere as a result of chemical reactions, such as hydrolysis, oxidation, or photochemical reactions. Notable primary pollutants emitted by vehicles include CO_2, CO, hydrocarbons (HCs), SO_2, NO_x, DPM and Pb. Secondary pollutants include: NO_2, photochemical oxidants (e.g. ozone), HCs, sulphur acid, sulphates, nitric acid, nitric acid and nitrate aerosols. Hydrocarbons emitted include benzene, 1.2-butadiene, aldehydes and polycyclic aromatic hydrocarbons (PAH). Benzene represents an aromatic HC present in petrol, with 85% to 90% of benzene emissions emanating from the exhaust and the remainder from evaporative losses. Vehicle tailpipe emissions are localised sources and unlikely to impact far-field.

3.3.1.5 Household Fuel Burning

Energy use within the residential sector is given as falling within three main categories, viz.: (i) traditional - consisting of wood, dung and bagasse, (ii) transitional - consisting of coal, paraffin and liquefied petroleum gas (LPG), and (iii) modern - consisting of electricity (increasingly this includes the use of renewable energy). The typical universal trend is given as being from (i) through (ii) to (iii). Pollutants include products of combustion (CO, NO_x, SO_2 and VOC), unburned HC and PM.

3.3.1.6 Biomass Burning

Biomass burning includes the burning of evergreen and deciduous forests, woodlands, grasslands, and agricultural lands. Within the Project vicinity wild fires may therefore represent a source of combustion-related emissions.

Biomass burning is an incomplete combustion process, with CO and NO_2 gases being emitted. Approximately 40% of the nitrogen in biomass is emitted as nitrogen (N_2), 10% is left is the ashes, and it may be assumed that 20% of the nitrogen is emitted as higher molecular weight nitrogen compounds. The visibility of the smoke plumes is attributed to the aerosol (particulate matter) content. In addition to the impact of biomass burning within the vicinity of the project, long-range transported emissions from this source can further be expected to impact on the air quality. It is impossible to control this source of atmospheric pollution loading; however, it should be noted as part of the background or baseline condition before considering the impacts of other local sources.

3.3.1.7 Agriculture

Agriculture is a land-use within the area surrounding the site. PM is the main pollutant of concern from agricultural activities as particulate emissions are deriving from windblown dust, burning crop residue, and entrainment from dirt roads. In addition, pollen grains, mould spores and plant and insect parts from agricultural activities all contribute to the particulate load. Should chemicals be used for crop spraying, they would typically result in odoriferous emissions.

3.3.2 Measured Pre-Development Air Pollutant Concentrations and Dustfall Rates

Airshed commenced with baseline/pre-development ambient air quality sampling on 1 June 2015. Sampling includes:

- Dustfall, at 5 locations in accordance with ASTM D1739 (1970)
- Alternate 24-hour PM_{10} and $PM_{2.5}$ concentration sampling at one location according to the method as set out by British Standards (BS EN 12341).
- Passive diffusive sampling of SO_2, NO_2 and VOC concentrations at one location using passive diffuse samplers

Figure 10 shows the locations of samplers. Note that PM_{10} and $PM_{2.5}$ samples were combined to form monthly composite samples on which Inductively Coupled Plasma (ICP) analysis was done to determine metal content. Results of the sampling campaign available to date are summarised in Table 10.

Table 10: Summary of sampled pollutant concentrations and dustfall rates

Pollutant	Data source	Results Summary	Compliance Assessment
Dustfall	Results of sampling at five locations for the period June 2015 to June 2016. 97% data availability.	Daily dustfall rates: • Minimum, 12 mg/m²-day (Sep-15, DB1) • Maximum, 278 mg/m²-day (Oct-15, DB3) • Median, 82 mg/m²-day • Average, 97 mg/m²-day	NDCR for residential areas of 600 mg/m²-day was not exceeded at any of the sampling locations (Figure 11).
$PM_{2.5}$	Results of sampling at one location from June 2015 to June 2016, 56% data availability.	24-hour average $PM_{2.5}$ concentrations: • Minimum, 1.4 µg/m³ (Mon 14-Dec-15) • Maximum, 173.6 µg/m³ (Thu 10-Mar-16) • Median, 15.8 µg/m³ • Average, 18.5 µg/m³	Four days of exceedance of the 24-hour average NAAQS limit value of 40 µg/m³ during 2016 (Figure 12).
PM_{10}	Results of sampling at one location from June 2015 to June 2016, 66% data availability.	24-hour average PM_{10} concentrations: • Minimum, 1.3 µg/m³ (Thu 30-Jul-15) • Maximum, 205.6 µg/m³ (Mon 7-Mar-16) • Median, 23.7 µg/m³ • Average, 36.6 µg/m³	Six days of exceedance of the 24-hour average NAAQS limit value of 75 µg/m³ (Figure 12).
NO_2	Results of sampling at one location from June 2015 to May 2016, 100% data availability.	14 ±4-day average NO_2 concentrations: • Minimum, 3.4 µg/m³ (Jul-15) • Maximum, 9.6 µg/m³ (May-16) • Median, 5.0 µg/m³ • Average, 6.1 µg/m³	Compliance with annual average NAAQS are likely given the observation that 14 day averages are well below 40 µg/m³.
SO_2	Results of sampling at one location from June 2015 to May 2016, 100% data availability.	14 ±4-day average SO_2 concentrations: • Minimum, 0.6 µg/m³ (Feb-16) • Maximum, 11.8 µg/m³ (May-16) • Median, 2.8 µg/m³ • Average, 3.2 µg/m³	Compliance with annual average NAAQS are likely given the observation that 14 day averages are well below 50 µg/m³.

VOC	Results of sampling at one location from June 2015 to June 2015, 100% data availability.	Calculated 14 ±4-day averages concentrations were determined for the following VOCs: Acetone, pentane, hexane, methylethylketone, ethyl acetate, benzene, carbon tetrachloride, cyclohexane, isooctane, heptane, trichloroethylene, methylisobutylketone, toluene, isobutyl acetate, tetrachloroethylene, butyl acetate, ethylbenzene, m+ p-xylene, styrene, o-xylene, nonane, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene, decane, limonene, naphthalene, chloroform, 1,1,1-trichloroethane, 1,2-dichloroethane, trichloroethylene, 1,4-dibromoethane, chlorobenzene, cumene, propyl benzene, 1,4-dichlorbenzene, 1,2-dibromoethane, propyl acetate, 1,4-dioxane, isooctane.	Since none sampled approximately 14-day average pollutant concentrations exceed the selected evaluation criteria (Table 4 and Table 6) for chronic exposure it is unlikely that annual average pollutant concentrations will exceed this either.
Metals	ICP analysis of a composite of $PM_{2.5}$ and PM_{10} samples	ICP analysis to determine the amount of the following metals in ambient PM concentration: Silver, aluminium, arsenic, gold, barium, beryllium, bismuth, calcium, cadmium, cobalt, chromium, copper, iron, mercury, iridium, potassium, lanthanum, lithium, magnesium, manganese, molybdenum, sodium, nickel, phosphorus, lead, palladium, platinum, rhodium, ruthenium, sulfur, antimony, selenium, tin, strontium, tellurium, thorium, titanium, uranium, vanadium, tungsten, zinc, zirconium.	See Figure 14 for most prevalent metals in ambient PM. It was found that some of these metals are present in sulfate form. December 2016 data appeared spurious and has been excluded from Figure 14; see Figure 15 for December 2015 results.

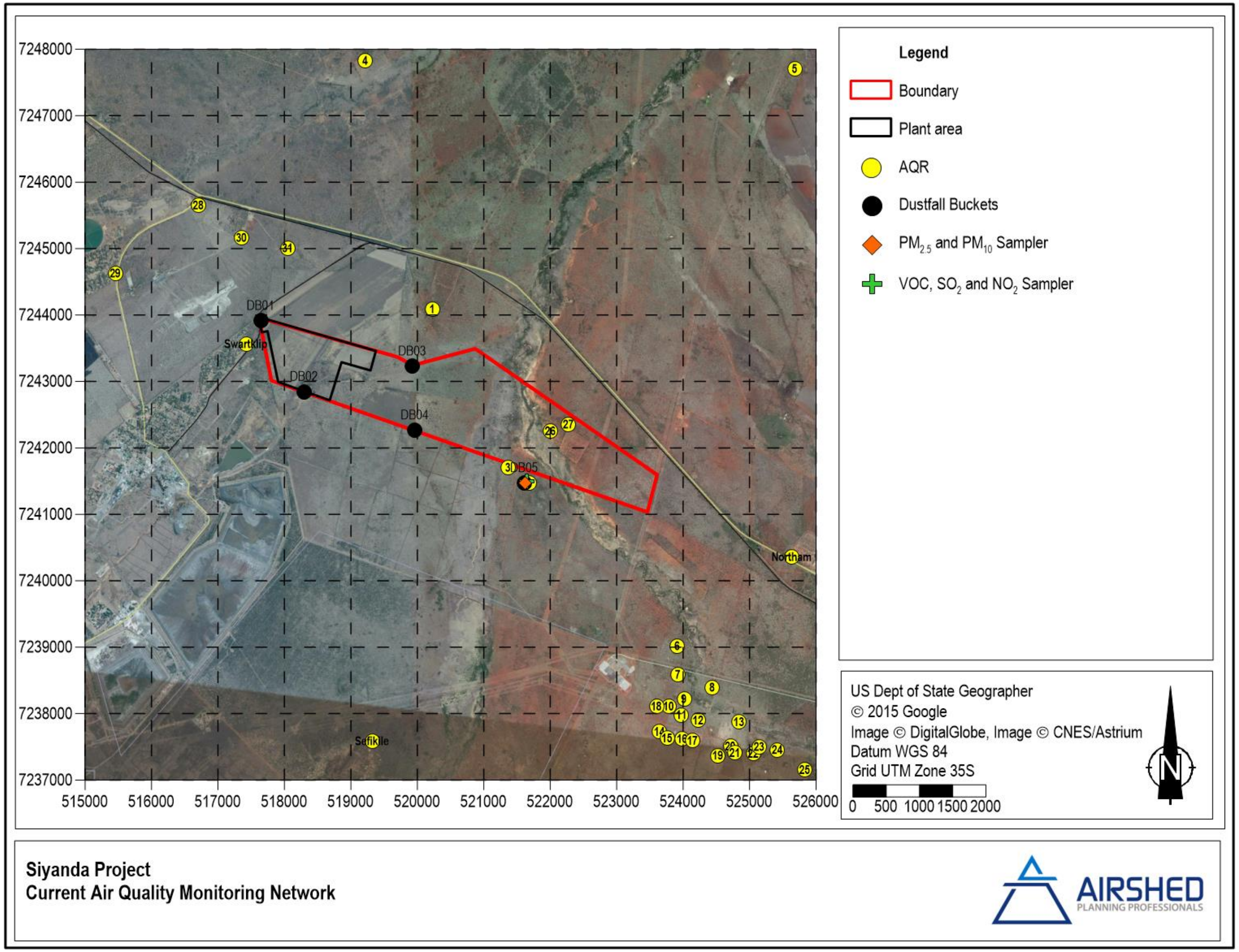

Figure 10: Baseline monitoring network

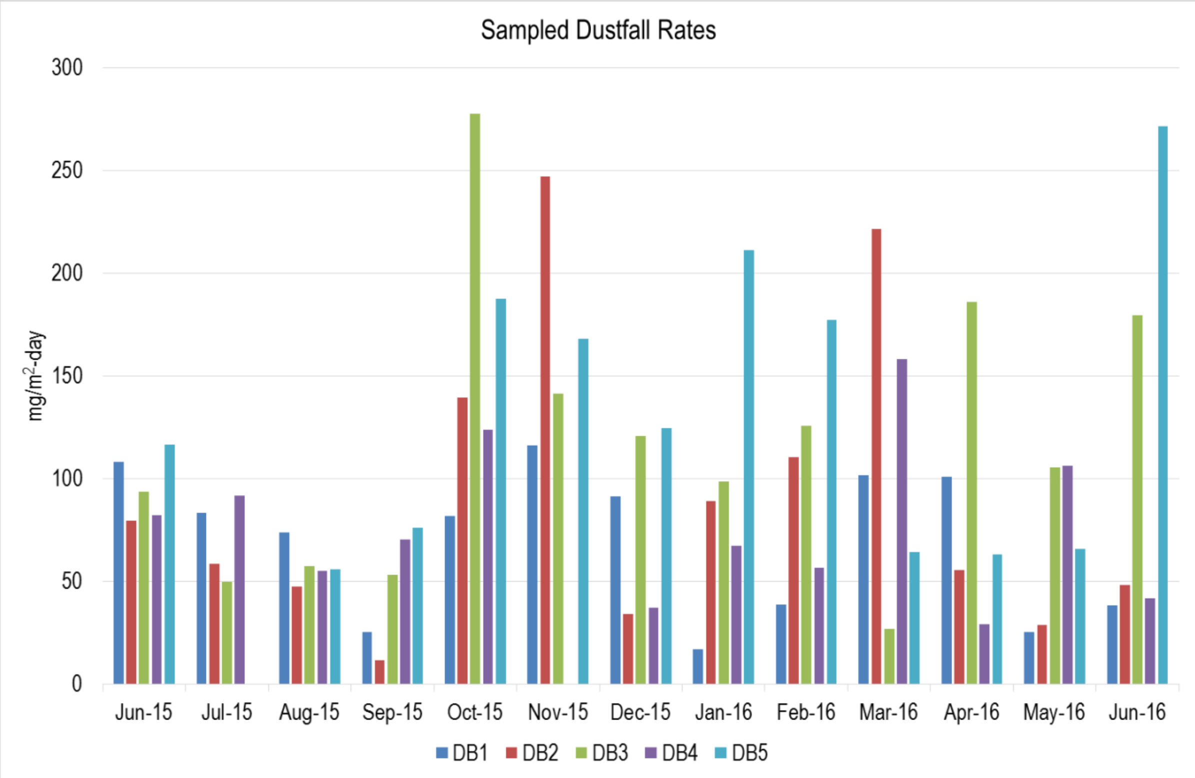

Figure 11: Siyanda baseline dustfall rates for June 2015 to June 2016

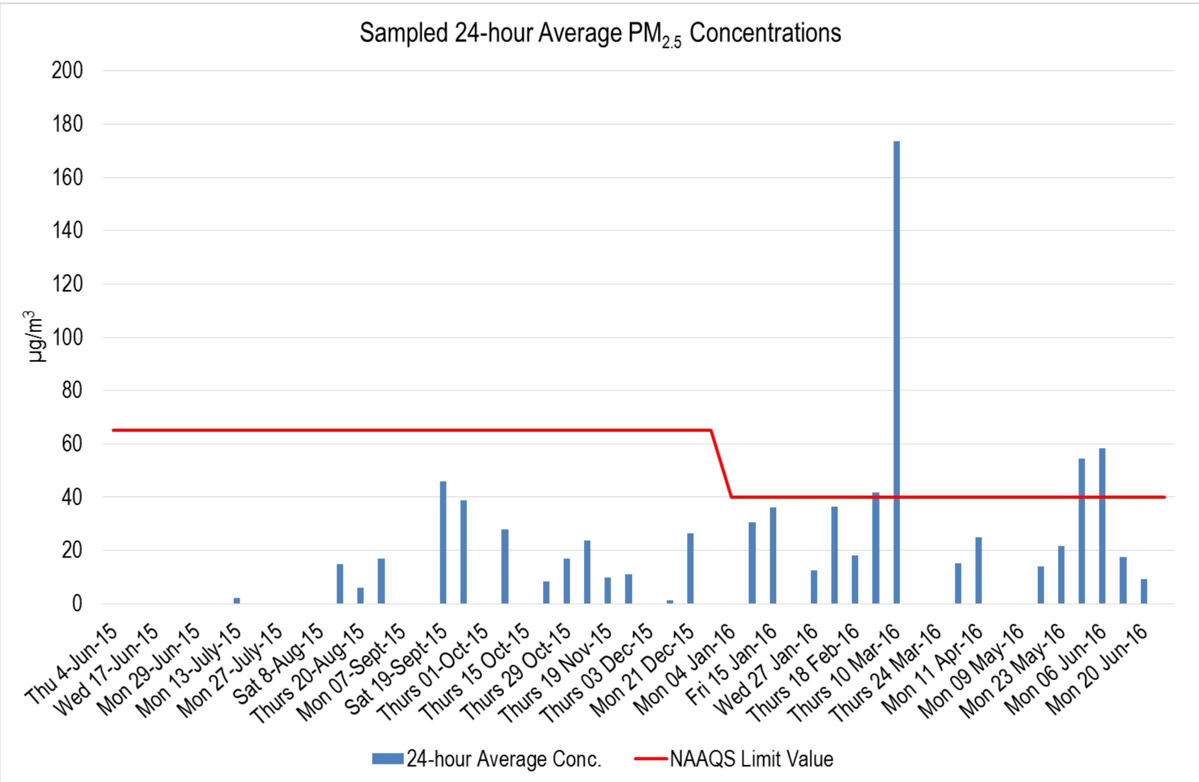

Figure 12: Siyanda baseline $PM_{2.5}$ concentrations for June 2015 to June 2016

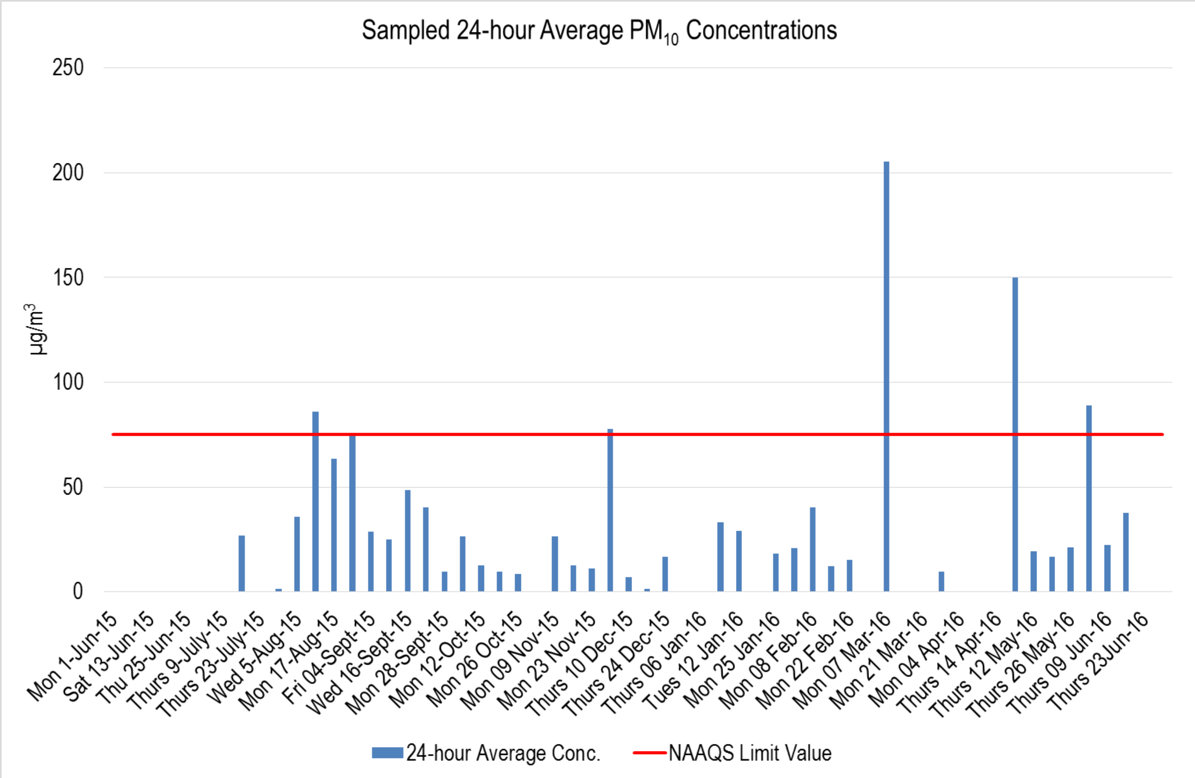

Figure 13: Siyanda baseline PM$_{10}$ concentrations for June 2015 to June 2016

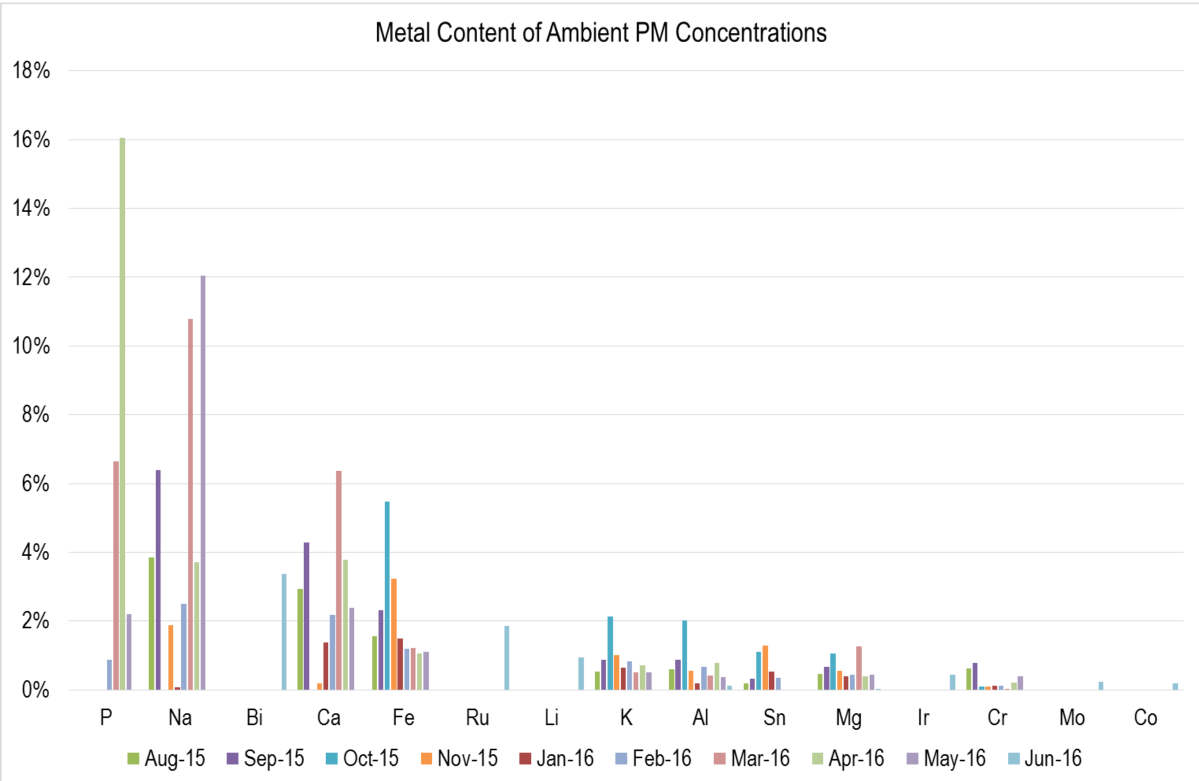

Figure 14: Metal content of ambient PM concentrations (excluding December 2015 data)

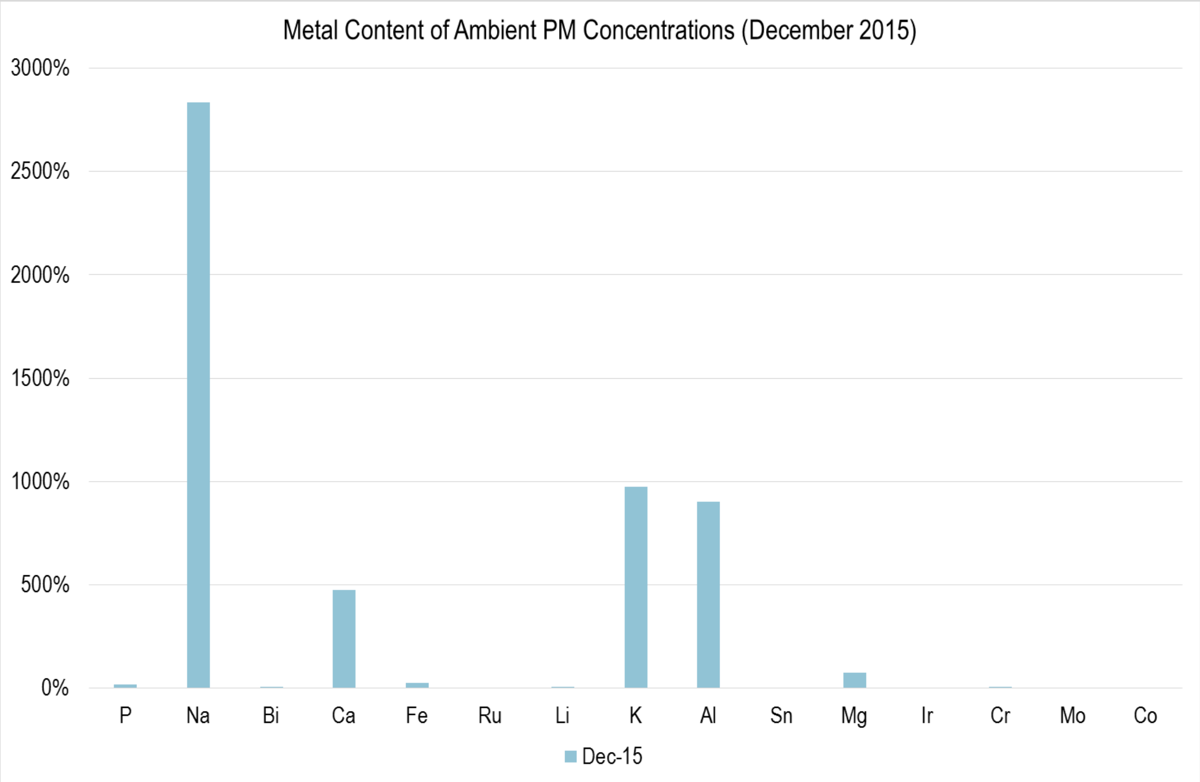

Figure 15: Metal content of ambient PM concentrations for December 2015

4 IMPACT ASSESSMENT

4.1 Atmospheric Emissions

The establishment of a comprehensive emission inventory formed the basis for the assessment of the air quality impacts of the project's activities on the receiving environment.

Sources of emission and associated pollutants considered in the emissions inventory included:

- Fugitive dust emissions (TSP, PM_{10} and $PM_{2.5}$):
  - General construction;
  - Crushing and screening;
  - Materials handling and conveyor transfer points;
  - Vehicle entrained dust as a result of raw materials and product transport on the access and internal paved roads; and
  - Windblown dust from raw materials area, mineralised waste facility and ingot cooling pad.
- Vehicle exhaust emissions – PM_{10}, $PM_{2.5}$, DPM, CO, NO_x, SO_2 and VOC
- Stack emissions:
  - Raw materials handling baghouse stack – TSP, PM_{10} and $PM_{2.5}$
  - Ore and reductant/flux dryer stacks – TSP, PM_{10}, $PM_{2.5}$, NO_x and SO_2
  - Clean gas flare stacks – TSP, PM_{10}, $PM_{2.5}$, Cr^{6+}, NO_x and SO_2
  - Raw gas stacks – TSP, PM_{10}, $PM_{2.5}$, Cr^{6+}, NO_x and SO_2
  - Secondary furnace fume baghouse stacks – TSP, PM_{10}, $PM_{2.5}$ and Cr^{6+}

A summary of sources quantified, emissions estimation techniques applied, and source input parameters are summarised in Table 11. Where dust mitigation is included in the project design, such control efficiencies were included in the estimation. As part of the management of dust emissions, the efficiencies of some additional mitigation measures were also quantified. Estimated annual average unmitigated emissions, per source group, are presented in Table 12. Estimated annual average mitigated emissions, per source group, are presented in Table 13 and Figure 16. The operational phase modelling was based on the mitigated emission.

Total annual unmitigated fugitive TSP, PM_{10} and $PM_{2.5}$ emissions from construction activities are expected to amount to 558, 195 and 97.7 t/a respectively (Table 12). It was assumed that during construction phase, the access and on-site roads will be unpaved for a large portion of the construction period. These emissions could be halved with the efficient application of dust mitigation measures such as water sprays (Table 13).

Total annual unmitigated routine TSP, PM_{10} and $PM_{2.5}$ emissions from the operational phase (including access road option 1) are estimated at 700, 255 and 174 t/a respectively. Total annual routine TSP, PM_{10} and $PM_{2.5}$ emissions from the operational phase (including access road option 2 and access road option 3) are estimated at 690, 253 and 174 t/a respectively. Access road option 1 emissions are larger mainly due to the fact that this road is the longest in length; access road option 2 and access road option 3 are similar in length. Crushing and screening will contribute most notably to the total annual unmitigated TSP emissions during the project's operational phase (more than 57%), stack releases will account for most of total annual PM_{10} and $PM_{2.5}$ emissions (more than 62%).

Total annual mitigated routine TSP, PM_{10} and $PM_{2.5}$ emissions from the operational phase (including access road option 1) are estimated at 368, 174 and 137 t/a respectively. Total annual routine TSP, PM_{10} and $PM_{2.5}$ emissions from the operational phase (including access road option 2 and access road option 3) are estimated at 357, 172 and 136 t/a respectively. Access road option 1 emissions are larger mainly due to the fact that this road is the longest in length; access road option 2 and access road option 3 are similar in length. Whereas vehicle entrainment on paved roads will contribute most notably total annual TSP emissions during the project's operational phase (more than 41%), stack releases will account for most of total annual PM_{10} and $PM_{2.5}$ emissions (more than 62%). Annual Cr^{6+} emissions from routine operations are expected to range between 0.0165 and 0.0664 t/a. During upset/emergency conditions, PM (including Cr^{6+}) emissions from the furnaces are expected to increase 5 times.

The contribution of gaseous emissions from vehicles is immaterial in comparison with emissions from furnace and drying operations.

Table 11: Emission estimation techniques and parameters

Source Group	Emission Estimation Technique	Input Parameters/Notes
General construction	US EPA emission factor (US EPA, 1995) $$EF = k \cdot 2.69$$ Where EF is the emission factor in t/ha-month k is the particle size multiplier (k_{TSP} – 1, k_{PM10} – 0.35, $k_{PM2.5}$ – 0.18)	A total infrastructure/disturbed area of ~70 ha was estimated from the site layout map. It was assumed that 25% of this area would be under construction at any given point in time. It is assumed that roads will likely be unpaved for the majority of the construction period. **Hours of operation:** 365 days per year, 24-hours per day **Design mitigation:** None **Additional mitigation:** Dust management and water sprays
Crushing and Screening	NPI single valued emission factors for low moisture ore (ADE, 2011) TSP – 0.2 kg/tonne (primary), 0.6 kg/tonne (secondary) PM_{10} – 0.02 kg/tonne (primary), 0.04 kg/tonne (secondary) $PM_{2.5}$ – *assumed* to be 0.01 kg/tonne (primary), 0.02 kg/tonne (secondary)	Crushing and screening rate ~36 t/h **Hours of operation:** 365 days per year, 24-hours per day **Design mitigation:** Water sprays and covering
Materials Handling	US EPA emission factor equation (US EPA, 2006) $$EF = k \cdot 0.0016 \cdot \left(\frac{U}{2.3}\right)^{1.3} \cdot \left(\frac{M}{2}\right)^{-1.4}$$ Where EF is the emission factor in kg/tonne material handled k is the particle size multiplier (k_{TSP} – 0.74, k_{PM10} – 0.35, $k_{PM2.5}$ – 0.053) U is the average wind speed in m/s M is the material moisture content in %	The number of handlings steps (loading, off-loading and conveyor transfer points) and material handling rates used in the estimation of emissions are: Ore concentrate, 12 handling steps, handling rate ~71 t/h Reductants/flux, 12 handling steps, handling rate ~36 t/h Slag, 1 handling step, ~41 t/h FeCr, 1 handling step, ~36 t/h An average **wind speed of 2.5 m/s** was determined from the MM5 data set A **moisture content** of 5% was given for raw materials prior to drying, 1% after drying. Slag 2% and FeCr product 1%. **Hours of operation:** 365 days per year, 24-hours per day **Design Mitigation:** Rail and road boxes as well as conveyor transfer points will be fitted with dust extraction systems. Efficiency of dust extraction with fabric filters is estimated at 83% (ADE, 2008)

Source Group	Emission Estimation Technique	Input Parameters/Notes
Vehicle Entrained Dust from Paved Roads	US EPA emission factor equation (US EPA, 2011) $$EF = k \cdot (sL)^{0.91} \cdot (W)^{1.02}$$ Where EF is the emission factor in g/vehicle kilometer travelled (VKT) k is the particle size multiplier (k_{TSP} – 3.23, k_{PM10} – 0.62, $k_{PM2.5}$ – 0.15) sL is the road surface material silt loading in g/m^2 W is the average weight vehicles in tonnes	Transport activities include the transport raw materials along the access road to the roadbox, the transport of slag to the mineralised waste facility and FeCr product from the furnace area to ingot cooling pad and rail loading facility. VKT were calculated from road lengths (limited to simulation areas), truck capacities and the number of trips required to transport materials. **Raw materials**, truck capacity 23.6 tonnes, average vehicle weight 34.8 tonnes, ~3.3 return trips/hour, ~9 VKT/h. **Slag**, slag carrier capacity 80 tonnes, average vehicle weight 96.8 tonnes, ~1.1 return trips/hour, ~0.4 VKT/h. **FeCr**, wheeled loader capacity 11.4 tonnes, average vehicle weight 13.8 tonnes, ~7.0 return trips/hour, ~4.2 VKT/h. Default road **surface silt loading of 0.6 g/m^2 and 9.7 g/m^2** (US EPA, 2011) was applied in calculations for the access road and plant roads respectively. **Hours of operation:** 365 days per year, 24-hours per day **Design Mitigation:** None
Windblown Dust	NPI single valued emission factors (ADE, 2011) TSP – 0.4 kg/ha-h PM_{10} – 0.2 kg/ha-h $PM_{2.5}$ – 0.1 kg/ha-h (assumed)	Raw materials area ~0.7 ha, ingot cooling area ~0.5 ha, slag disposal facility ~20 ha **Hours of emission:** When wind speed ≥ 5 m/s **Design Mitigation:** None
Vehicle/Equipment Exhaust Emissions	NPI single valued emission factors (ADE, 2008) CO – 1.85 x 10^{-2} kg/l NOx – 4.44 x 10^{-2} kg/l $PM_{2.5}$ (and DE) – 3.33 x 10^{-3} kg/l PM_{10} – 3.63 x 10^{-3} kg/l SO_2 – 2.40 x 10^{-5} kg/l VOC – 4.05 x 10^{-3} kg/l	Diesel consumption of ~349 l/hour was estimated from fuel consumption specifications of trucks (30.1 l/h), slag carriers (50 l/h) and wheeled loaders (52 l/h), were used in calculations. Note that sulphur content of diesel fuel was assumed to be 10 ppm. **Hours of operation:** 365 days per year, 24-hours per day **Design Mitigation:** None

Source Group	Emission Estimation Technique	Input Parameters/Notes
Stacks: **Raw materials handling and storage dust extraction baghouse stack**	All parameters supplied by SCSC: **Source parameters:** Release height 20 m, diameter at stack tip 0.75, release temperature 50 °C, volumetric flow rate 100 000 Nm^3/hour. **Design emission concentrations:** PM 30 mg/Nm^3 **MES:** not applicable	None
Stacks: **Concentrate dryer stack**	All parameters supplied/approved by SCSC: **Source parameters:** Release height 26 m, diameter at stack tip 1, release temperature 250 °C, volumetric flow rate 65 000 Nm^3/hour. **Design emission concentrations:** PM 30 mg/Nm^3 **MES:** PM 50 mg/Nm^3, NO_x as NO_2 500 mg/Nm^3, SO_2 1 000 mg/Nm^3	**Assumptions relating to Cr^{6+} emissions:** Emissions not likely given drying temperatures.
Stacks: **Reductant/flux dryer stack**	All parameters supplied/approved by SCSC: **Source parameters:** Release height 25 m, diameter at stack tip 1, release temperature 250 °C, volumetric flow rate 32 000 Nm^3/hour. **Design emission concentrations:** PM 30 mg/Nm^3 **MES:** PM 50 mg/Nm^3, NO_x as NO_2 500 mg/Nm^3, SO_2 1 000 mg/Nm^3	None
Stacks: **Clean gas flare stacks (x2)**	All parameters supplied/approved by SCSC: **Source parameters:** Release height 65 m, diameter at stack tip 0.75 m, release 350 °C, volumetric flow rate 22 000 Nm^3/hour. **Design emission concentrations:** PM 30 mg/Nm^3 **MES:** PM 50 mg/Nm^3, NO_x as NO_2 400 mg/Nm^3, SO_2 500 mg/Nm^3	**Assumptions relating to Cr^{6+} emissions:** 30% Cr in PM in cleaned furnace of gas prior to flaring. All Cr in cleaned furnace of gas prior to flaring in trivalent state i.e. Cr^{3+} Conversion from Cr^{3+} to Cr^{6+} during flaring 0.027% (likely) to 0.35% (maximum) (du Preez, Beukes, & van Zyl, 2015) **CO emissions:** Furnace off-gas 82.4% CO. 98% destruction efficiency in flare.

Source Group	Emission Estimation Technique	Input Parameters/Notes
Stacks: **Raw gas flare stacks (x2)**	All parameters supplied/approved by SCSC: **Source parameters:** Release height 55 m, diameter at stack tip 0.75 m, release 350 °C, volumetric flow rate 22 000 Nm^3/hour. **Emission concentrations:** PM 160 mg/Nm^3, NO_x as NO_2 400 mg/Nm^3, SO_2 500 mg/Nm^3 **MES:** not applicable	**Assumptions relating to Cr^{6+} emissions:** 30% Cr in PM in raw furnace of gas prior to flaring. All Cr in raw furnace of gas prior to flaring in trivalent state i.e. Cr^{3+} Conversion from Cr3+ to Cr^{6+} during flaring 0.027% (likely) to 0.35% (maximum) (du Preez, Beukes, & van Zyl, 2015) **CO emissions:** Furnace off-gas 82.4% CO. 98% destruction efficiency in flare.
Stacks: **Secondary fume baghouse stacks (x2)**	All parameters supplied/approved by SCSC: **Source parameters:** Release height 20 m, diameter at stack tip 1.23 m, release 50 °C, volumetric flow rate 84 500 Nm^3/hour. **Design emission concentrations:** PM 30 mg/Nm^3 **MES:** PM 50 mg/Nm^3	**Assumptions relating to Cr^{6+} emissions:** % Cr^{6+} in release ranges between 0.035% and 0.122%. Ma (2005) reported this range as the amount of Cr^{6+} in open ferrochrome furnace baghouse dust.

Table 12: Estimated annual unmitigated emission rates per source group

	TSP	PM_{10}	$PM_{2.5}$	Cr^{6+}	DPM	CO	NO_x	SO_2	VOC
Construction Phase									
Construction[(a)]	558	195	97.7	-	n/d[(b)]	n/d	n/d	n/d	n/d
Routine Operational Phase									
Crushing and screening[(c)]	391	90.2	45.1	-	-	-	-	-	-
Materials Handling[(d)]	28.1	13.3	2.02	-	-	-	-	-	-
Paved Roads (including AR1[(e)])	158	30.3	7.32	-	-	-	-	-	-
Paved Roads (including AR2[(f)])	148	28.3	6.85	-	-	-	-	-	-
Paved Roads (including AR3[(g)])	147	28.3	6.84	-	-	-	-	-	-
Stacks (Routine)[(h)]	108	108	108	0.0165 to 0.0664	n/d	7 940	579	1 042	n/d
Vehicle Exhaust	11.6	11.6	10.6	-	10.6	59.7	144	0.077	13.5
Windblown dust	4.05	2.02	1.01	-	-	-	-	-	-
Total (including AR1[(e)])	**700**	**255**	**174**	**0.0165 to 0.0664**	**10.6**	**7995**	**723**	**1043**	**13.5**
Total (including AR2[(f)])	**690**	**253**	**174**	**0.0165 to 0.0664**	**10.6**	**7995**	**723**	**1043**	**13.5**
Total (including AR3[(g)])	**690**	**253**	**174**	**0.0165 to 0.0664**	**10.6**	**7995**	**723**	**1043**	**13.5**
Upset/Emergency Emissions									
Raw gas flare stacks	61.7	61.7	61.7	0.00503 to 0.0653	-	7 940	154	182	n/d

Notes:

(a) No mitigation measures applied to construction activities

(b) n/d – no data

(c) No mitigation measures applied to crushers and screens
(d) No mitigation measures applied to materials handling points
(e) AR1 – access road option 1
(f) AR2 – access road option 2
(g) AR3 – access road option 3
(h) Only mitigated emissions were supplied; mitigation measures include:
    a. Inline dampers/exhaust fans/dry scrubber on clean gas stack;
    b. Water seal on raw gas stack; and
    c. Baghouses for the other stacks.

Table 13: Estimated mitigated annual emission rates per source group

	TSP	PM_{10}	$PM_{2.5}$	Cr^{6+}	DPM	CO	NO_x	SO_2	VOC
Construction Phase									
Construction	279	97.5	48.9	-	n/d[(a)]	n/d	n/d	n/d	n/d
Routine Operational Phase									
Crushing and screening	78.1	18	9.02	-	-	-	-	-	-
Materials Handling	8.29	3.92	0.594	-	-	-	-	-	-
Paved Roads (including AR1[(b)])	158	30.3	7.32	-	-	-	-	-	-
Paved Roads (including AR2[(c)])	148	28.3	6.85	-	-	-	-	-	-
Paved Roads (including AR3[(d)])	147	28.3	6.84	-	-	-	-	-	-
Stacks (Routine)	108	108	108	0.0165 to 0.0664	n/d	7 940	579	1 042	n/d
Vehicle Exhaust	11.6	11.6	10.6	-	10.6	59.7	144	0.077	13.5
Windblown dust	4.05	2.02	1.01	-	-	-	-	-	-
Total (including AR1[(b)])	**368**	**174**	**137**	**0.0165 to 0.0664**	**10.6**	**7995**	**723**	**1043**	**13.5**
Total (including AR2[(c)])	**357**	**172**	**136**	**0.0165 to 0.0664**	**10.6**	**7995**	**723**	**1043**	**13.5**
Total (including AR3[(d)])	**357**	**172**	**136**	**0.0165 to 0.0664**	**10.6**	**7995**	**723**	**1043**	**13.5**
Upset/Emergency Emissions									
Raw gas flare stacks	61.7	61.7	61.7	0.00503 to 0.0653	-	7 940	154	182	n/d

Notes:

(i) n/d – no data

(j) AR1 – access road option 1

(k) AR2 – access road option 2

(l) AR3 – access road option 3

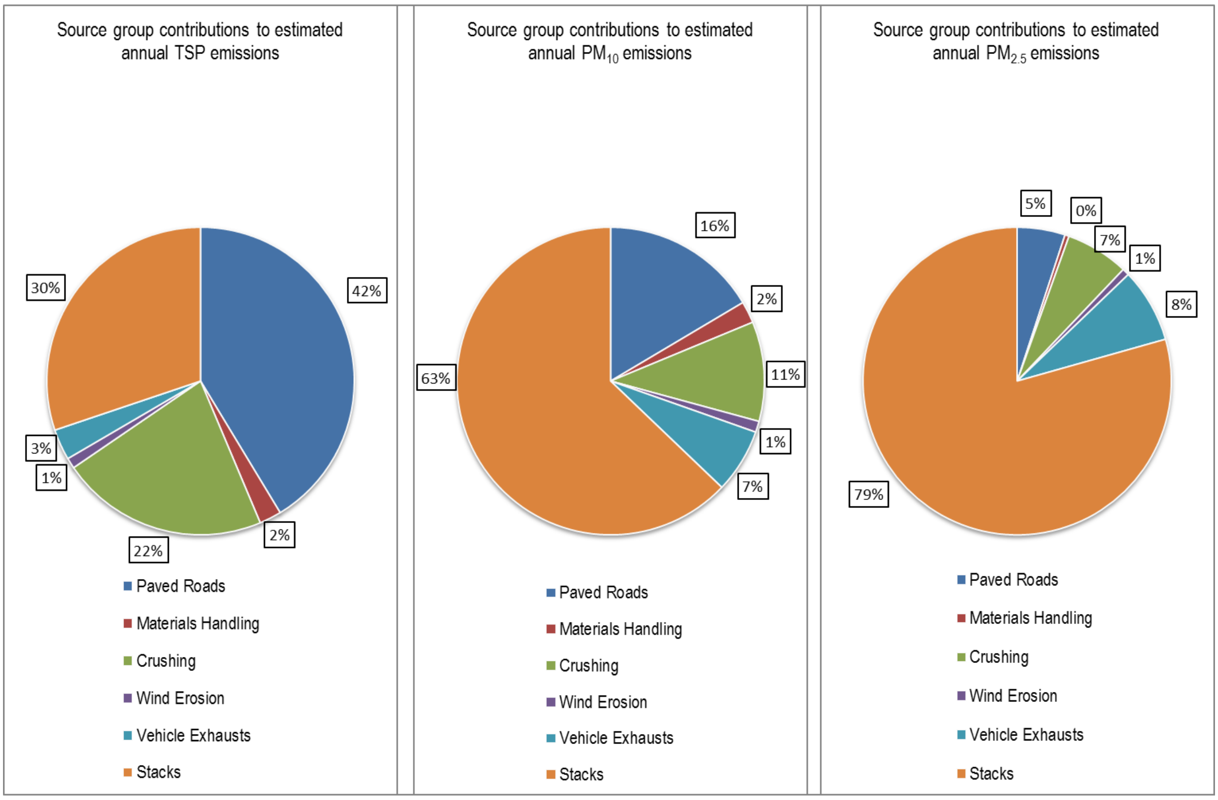

Figure 16: Source group contributions to estimated annual mitigated PM emissions from Siyanda activities including the access road option 2

4.2 Atmospheric Dispersion Modelling

The assessment of the impact of the project's operations on the environment is discussed in this Section. To assess impact on human health and the environment the following important aspects need to be considered:

- The criteria against which impacts are assessed (as discussed in Section 1);
- The location of likely AQRs (Section 3.1);
- The potential of the atmosphere to disperse and dilute pollutants emitted by the project (Section 3.2);
- Existing ambient pollutant concentrations (Section 3.3); and
- Atmospheric emissions (Section 4.1)

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

4.2.1 Dispersion Model Selection

Gaussian-plume models are best used for near-field applications where the steady-state meteorology assumption is most likely to apply. One of the most widely used Gaussian plume model is the US EPA AERMOD model (Table 14) that was used in this study. AERMOD is a model developed with the support of AERMIC, whose objective has been to include state-of the-art science in regulatory models (Hanna, Egan, Purdum, & Wagler, 1999). AERMOD is a dispersion modelling system with three components, namely: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD terrain pre-processor), and AERMET (AERMOD meteorological pre-processor).

AERMOD is an advanced new-generation model. It is designed to predict pollution concentrations from continuous point, flare, area, line, and volume sources. AERMOD offers new and potentially improved algorithms for plume rise and buoyancy, and the computation of vertical profiles of wind, turbulence and temperature however retains the single straight line trajectory limitation. AERMET is a meteorological pre-processor for AERMOD. Input data can come from hourly cloud cover observations, surface meteorological observations and twice-a-day upper air soundings. Output includes surface meteorological observations and parameters and vertical profiles of several atmospheric parameters. AERMAP is a terrain pre-processor designed to simplify and standardise the input of terrain data for AERMOD. Input data includes receptor terrain elevation data. The terrain data may be in the form of digital terrain data. The output includes, for each receptor, location and height scale, which are elevations used for the computation of air flow around hills.

A disadvantage of the model is that spatial varying wind fields, due to topography or other factors cannot be included. Input data types required for the AERMOD model include: source data, meteorological data (pre-processed by the AERMET model), terrain data and information on the nature of the receptor grid. Version (version 7.11.0.13) of AERMOD and its pre-processors were used in the study.

4.2.2 Meteorological Requirements

For the purpose of the current study use was made of simulated surface and upper air data (MM5) for Northam for the period Jan 2012 to Dec 2014 (Section 3.2).

4.2.3 Source Data Requirements

The AERMOD model is able to model point, jet, area, line and volume sources. Sources were modelled as follows:

- Crushing and screening – modelled as volume sources;
- Materials handling and conveyor transfer points – modelled as volume sources;
- Roads (including vehicle exhaust) and exposed erodible areas – modelled as area sources;
- Baghouse stacks – modelled as point sources; and
- Clean gas and raw gas stacks – modelled as flare sources.

4.2.4 Simulation Domain

The dispersion of pollutants expected to arise from current operations was simulated for an area covering 11 km (east-west) by 11 km (north-south). The area was divided into a grid matrix with a resolution of 100 m. The nearest residences and community areas were included as AQR. AERMOD calculates ground-level (1.5 m above ground level) concentrations and dustfall rates at each grid and discrete receptor point.

Table 14: Model details

Model and Version	**AERMOD 7.11.0.3**
Executable	BREEZE 15181

Table 15: Simulation domain

Simulation domain	
South-western corner of simulation domain	515 000 m; 7 237 000 m
Domain size	11 x 11 km
Projection	Grid: UTM Zone 35S, Datum: WGS 84
Resolution	100 m

Presentation of Results

Dispersion simulations was undertaken to determine highest hourly, highest daily and annual average ground level concentrations and dustfall rates for each of the pollutants considered in the study as well as the frequency at which short term criteria are exceeded. Averaging periods were selected to facilitate the comparison of simulated pollutant concentrations to relevant ambient air quality and inhalation health criteria as well as dustfall regulations.

Ground level concentration (GLC) isopleths plots presented in this section depict interpolated values from the concentrations predicted by AERMOD for each of the receptor grid points specified. Plots reflecting hourly (daily) and averaging periods contain only the 99.99th (99.73th) percentile of predicted ground level concentrations, for those averaging periods, over the entire period for which simulations were undertaken. It is therefore possible that even though a high hourly (daily) average concentration is predicted to occur at certain locations, that this may only be true for one hour (day) during the year. Results are also provided in tabular form as discrete values predicted at AQRs.

Ambient air quality criteria apply to areas where the Occupational Health and Safety regulations do not apply, which is generally outside the property or lease area. Ambient air quality criteria are therefore not occupational health indicators but applicable to areas where the general public has access. In the case of this study the ambient criteria is seen to be applicable outside the boundary and at all AQRs (inside or outside of the boundary). Section 4.3 deals with impacts on human health. Dustfall is assessed for nuisance impact on the environment (Section 4.4) and not inhalation health impact.

4.3 Screening of Simulated Concentrations for Potential Human Health Impacts

Key pollutants with the potential to result in human health impacts and included in simulations for this study are PM_{10}, $PM_{2.5}$, Cr^{6+}, DPM, CO, NO_x and SO_2. It should be noted that simulated concentrations only reflect those associated with atmospheric emissions from the project as quantified and summarised in Section 4.1.

4.3.1 Construction and Decommissioning Phases

The construction emissions were determined using emission factors and simulated impacts were determined using atmospheric dispersion modelling. It was assumed that unpaved roads will be used for the majority of the construction period. Decommissioning is likely to be similar or less than the construction impacts; therefore decommissioning emission were not quantified and atmospheric dispersion modelling not undertaken.

4.3.1.1 Simulated Ambient PM_{10} Concentrations

A summary of simulated results for PM_{10} at nearby AQRs is presented in Table 16. Simulated annual average PM_{10} concentrations exceeded the NAAQS of 40 µg/m^3 and along access road option 2 (Figure 17). The 24-hour NAAQS (4 days of exceedance of 75 µg/m^3) is also exceeded off-site and at four AQRs (Figure 18). With the implementation of water sprays at some sources (estimated control efficiency of 50%) concentrations reduce to levels that exceeded the annual average off-site but over a smaller area and the 24-hour NAAQS at only three receptors (Table 16, Figure 19 and Figure 20).

Should access road option 1 be selected the PM_{10} 24-hr NAAQS are likely to be exceeded off-site and at five AQRs (no. 2, 3, 26, 27 and Swartklip). The PM_{10} annual average NAAQS are likely to be exceeded off-site and at two AQRs (no. 2 and 3). With partial mitigation applied the area of exceedance will reduce but still exceed at the same receptors.

Should access road option 3 be selected the PM_{10} 24-hr NAAQS are likely to be exceeded off-site and at five AQRs (no. 28, 29, 30, 31 and Swartklip). The PM_{10} annual average NAAQS are likely to be exceeded off-site and at one AQR (no. 30). With partial mitigation applied the area of exceedance will reduce but still exceed at the same receptors.

Cumulative PM_{10} levels are likely to be in exceedance of NAAQS off-site; especially since baseline PM_{10} concentrations are close to being in exceedance of NAAQS (Section 3.3.2). Cumulative impacts will be most notable at Swartklip.

Table 16: Summary of simulation results of PM_{10} at AQRs during the construction phase

Pollutant	**PM_{10}**			
Aver. Period	1-year		24-hour	
Reporting Unit	Concentration in µg/m³		Frequency of exceedance in 'days per year'	
Criteria	40 µg/m³		4 days of exceedance of 75 µg/m³	
AQR/ Source	Construction (Unmitigated)	Construction (with partial mitigation)	Construction (Unmitigated)	Construction (with partial mitigation)
Swartklip	31.5	18.6	**56**	**29**
1	3.02	1.51	0	0
2	2.50	1.26	0	0
3	2.86	1.44	0	0
4	2.31	1.17	0	0
26	1.93	0.94	0	0
27	1.50	0.76	0	0
28	10.9	5.34	**5**	2
29	7.61	3.84	0	0
30	19.4	9.40	**22**	**11**
31	23.6	11.8	**33**	**16**

4.3.1.2 Simulated Ambient $PM_{2.5}$ Concentrations

A summary of simulated results for $PM_{2.5}$ at AQRs during the construction phase is presented in Table 17. Simulated annual average $PM_{2.5}$ concentrations exceeded the NAAQS of 20 µg/m³ off-site to the north-west of the proposed plant construction and along access road option 2 (Figure 21). The 24-hour NAAQS (4 days of exceedance of 40 µg/m³) is exceeded at four AQRs (Figure 22). Although areas of exceedance reduce notably with implementation of water sprays at some sources, Swartklip and nearby AQR no. 30 and 31 will still be exposed to levels in exceedance of the 24-hour NAAQS (Table 17, Figure 23 and Figure 24).

Should access road option 1 be selected the $PM_{2.5}$ 24-hr NAAQS are likely to be exceeded off-site and at five AQRs (no. 2, 3, 26, 27 and Swartklip). The $PM_{2.5}$ annual average NAAQS are likely to be exceeded off-site and at two AQRs (no. 2 and 3). With partial mitigation applied the area of exceedance will reduce but still exceed at the same receptors.

Should access road option 3 be selected the $PM_{2.5}$ 24-hr NAAQS are likely to be exceeded off-site and at five AQRs (no. 28, 29, 30, 31 and Swartklip). The $PM_{2.5}$ annual average NAAQS are likely to be exceeded off-site and at one AQR (no. 30). With partial mitigation applied the area of exceedance will reduce but still exceed at the same receptors.

The potential for cumulative off-site $PM_{2.5}$ concentrations in exceedance of NAAQS is probable even though baseline $PM_{2.5}$ concentrations are not in exceedance of NAAQS (Section 3.3.2); since the simulated unmitigated incremental concentrations off-site are elevated.

Table 17: Summary of simulation results of $PM_{2.5}$ at AQRs during the construction phase

Pollutant	**$PM_{2.5}$**			
Ave. Period	1-year		24-hour	
Reporting Unit	Concentration in µg/m³		Frequency of exceedance in 'days per year'	
Criteria	20 µg/m³		4 days of exceedance of 40 µg/m³	
AQR/ Source	Construction (Unmitigated)	Construction (Mitigated)	Construction (Unmitigated)	Construction (Mitigated)
Swartklip	20.2	10.2	**48**	**29**
1	1.49	0.73	0	0
2	1.25	0.63	0	0
3	1.43	0.72	0	0
4	1.16	0.58	0	0
26	0.95	1.00	0	0
27	0.76	1.00	0	0
28	5.37	2.67	**4**	2
29	3.79	1.90	0	0
30	9.74	4.83	**19**	**9**
31	12.0	6.03	**29**	**14**

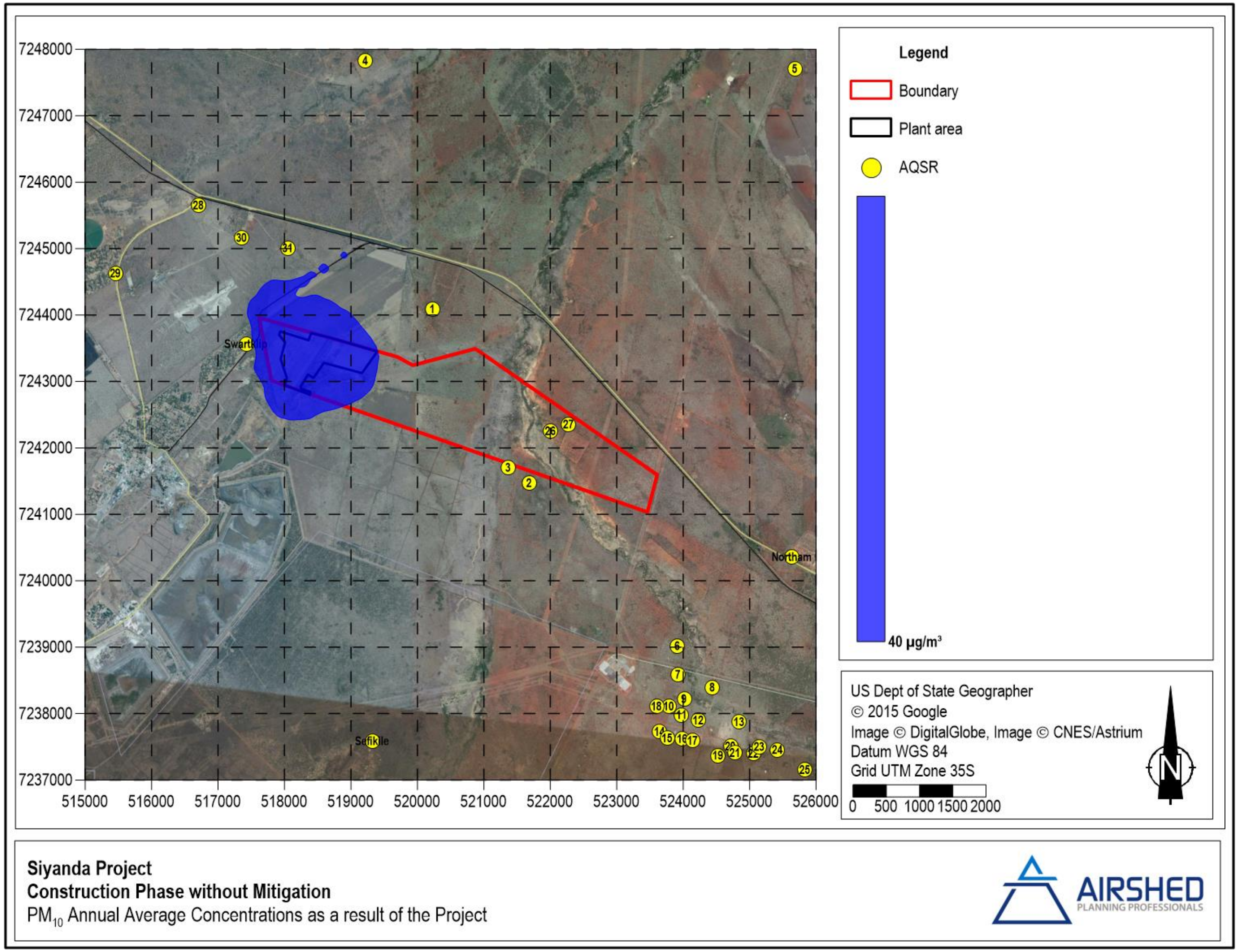

Figure 17: Unmitigated construction phase: simulated 1-year average PM_{10} concentrations

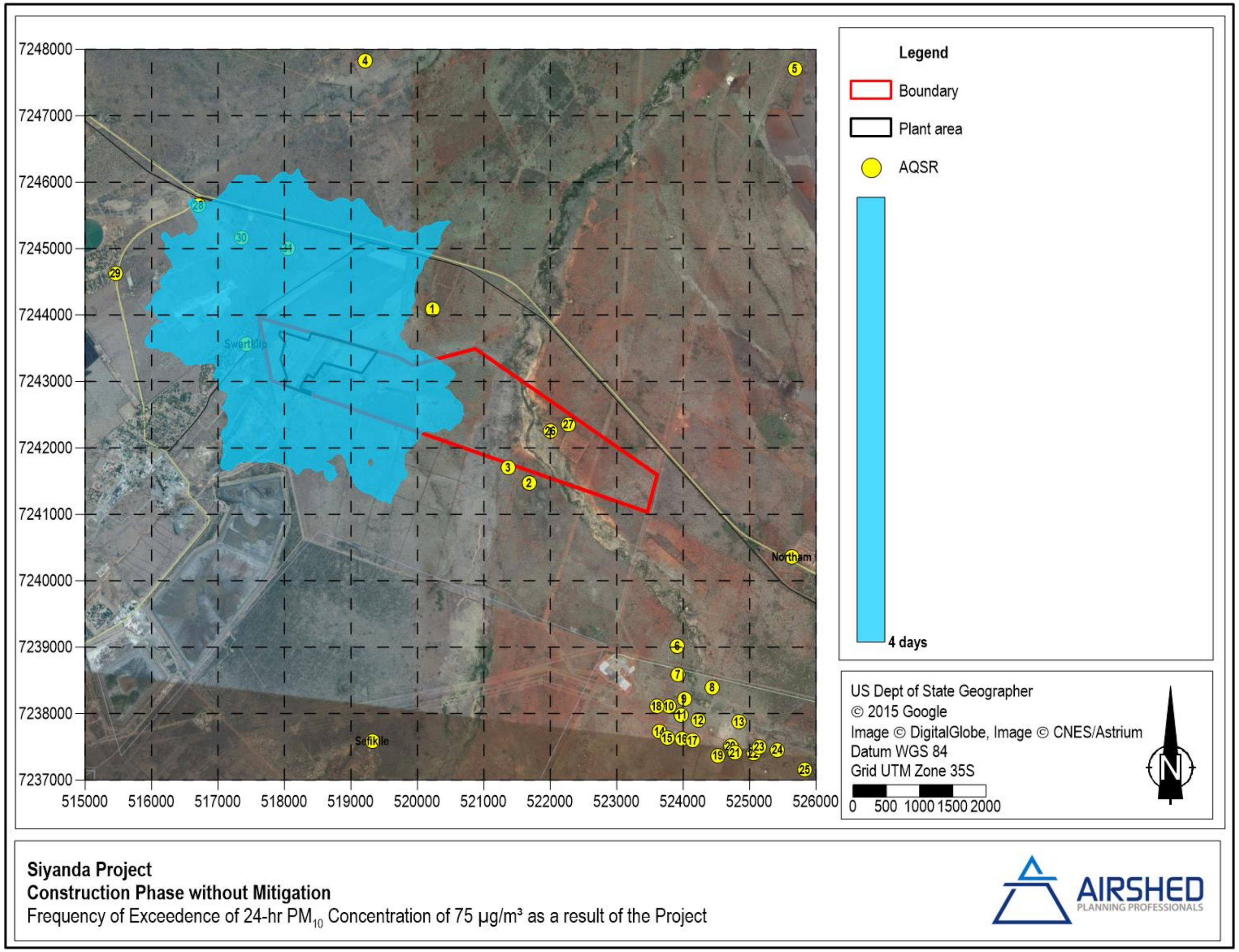

Figure 18: Unmitigated construction phase: Area of exceedance of the 24-hour average PM_{10} NAAQS

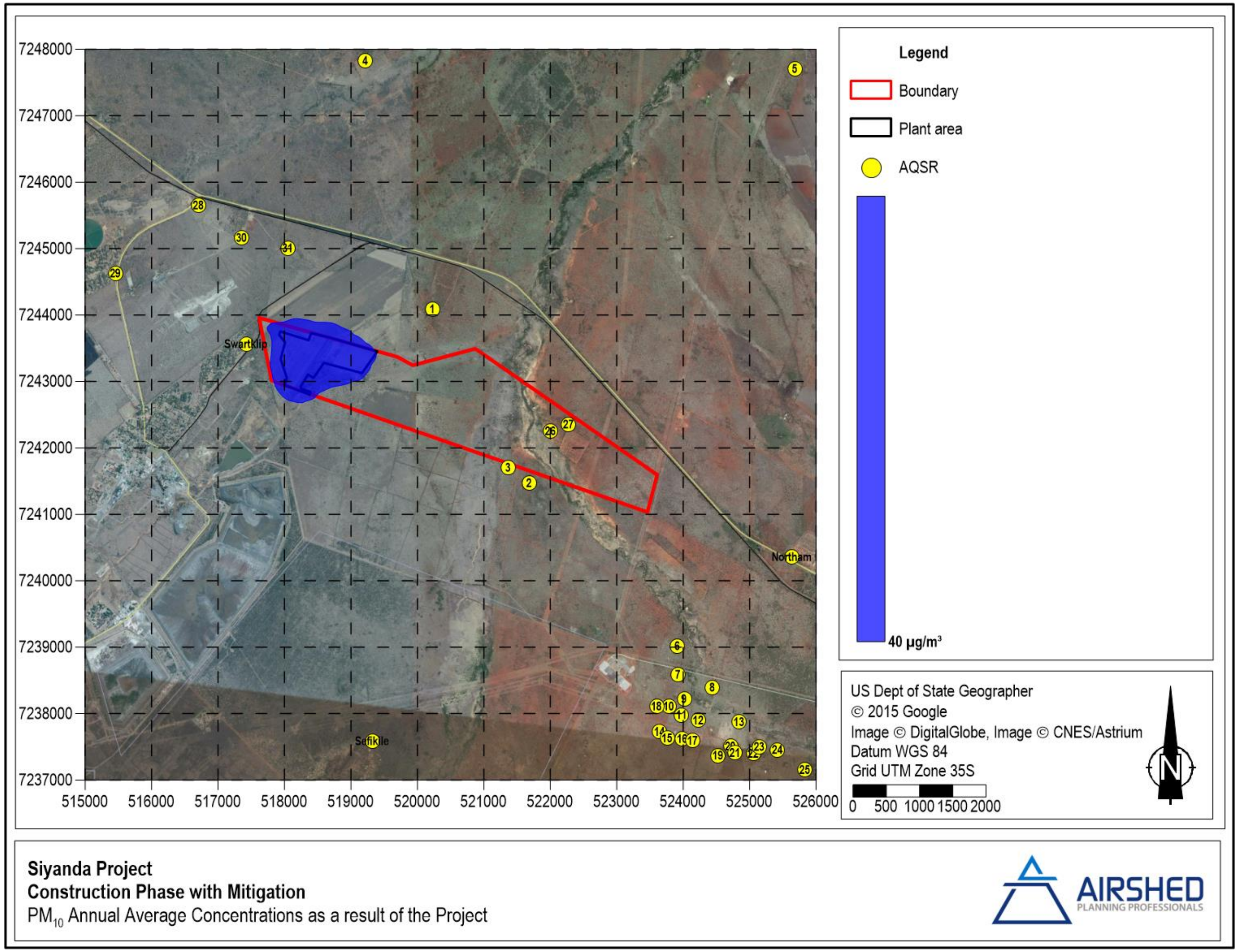

Figure 19: Mitigated construction phase: simulated 1-year average PM_{10} concentrations

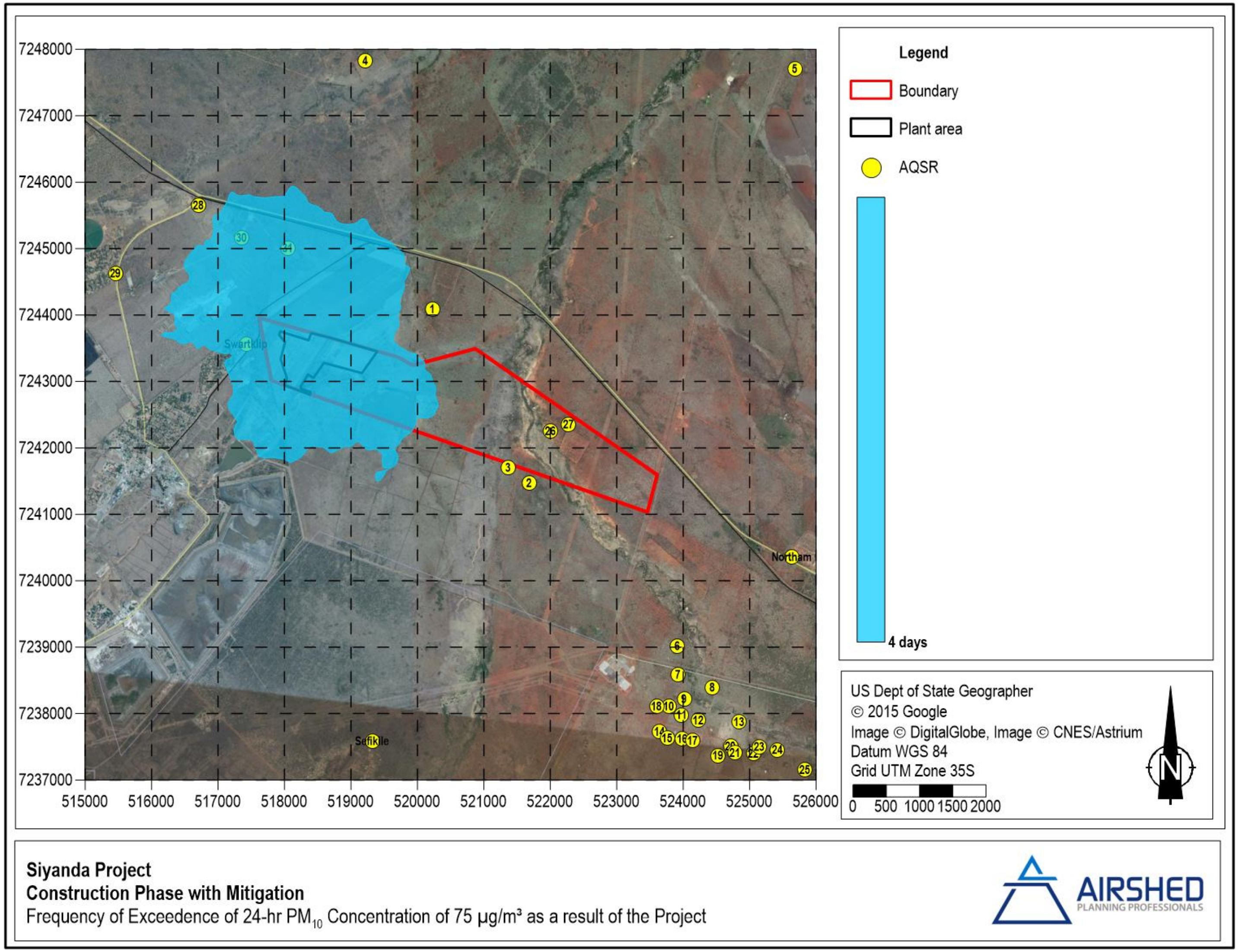

Figure 20: Mitigated construction phase: Area of exceedance of the 24-hour average PM_{10} NAAQS

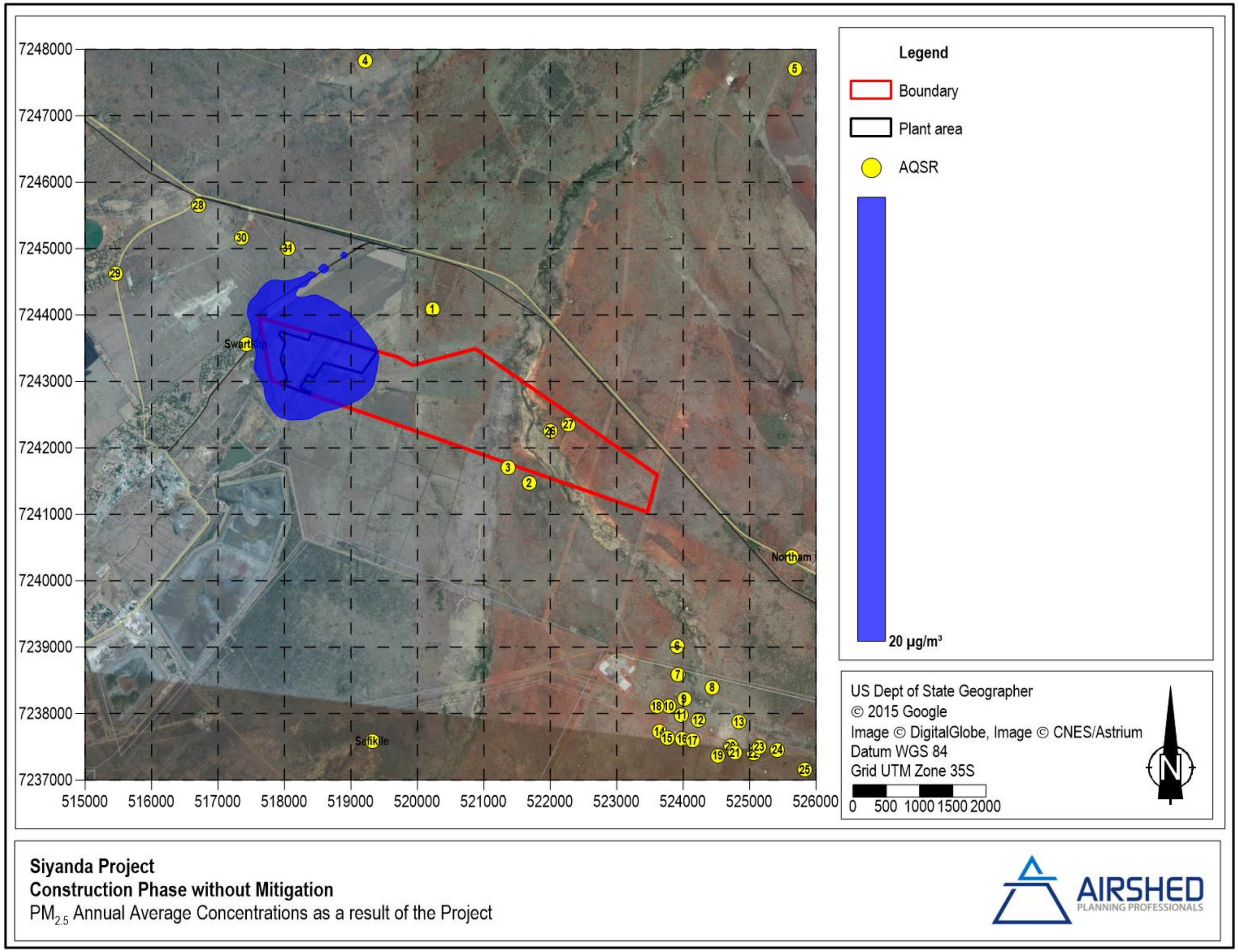

Figure 21: Unmitigated construction phase: simulated 1-year average $PM_{2.5}$ concentrations

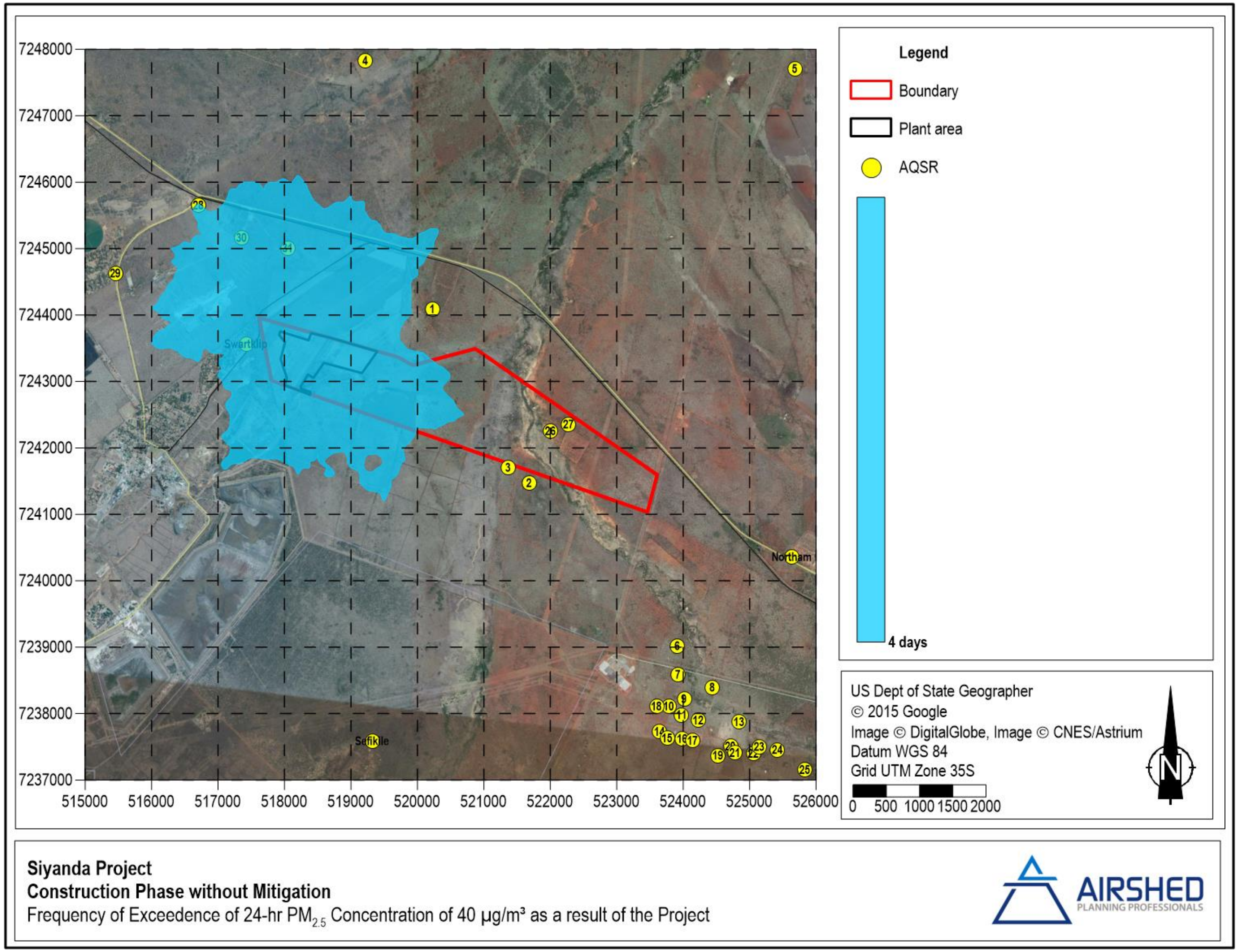

Figure 22: Unmitigated construction phase: Area of exceedance of the 24-hour average $PM_{2.5}$ NAAQS

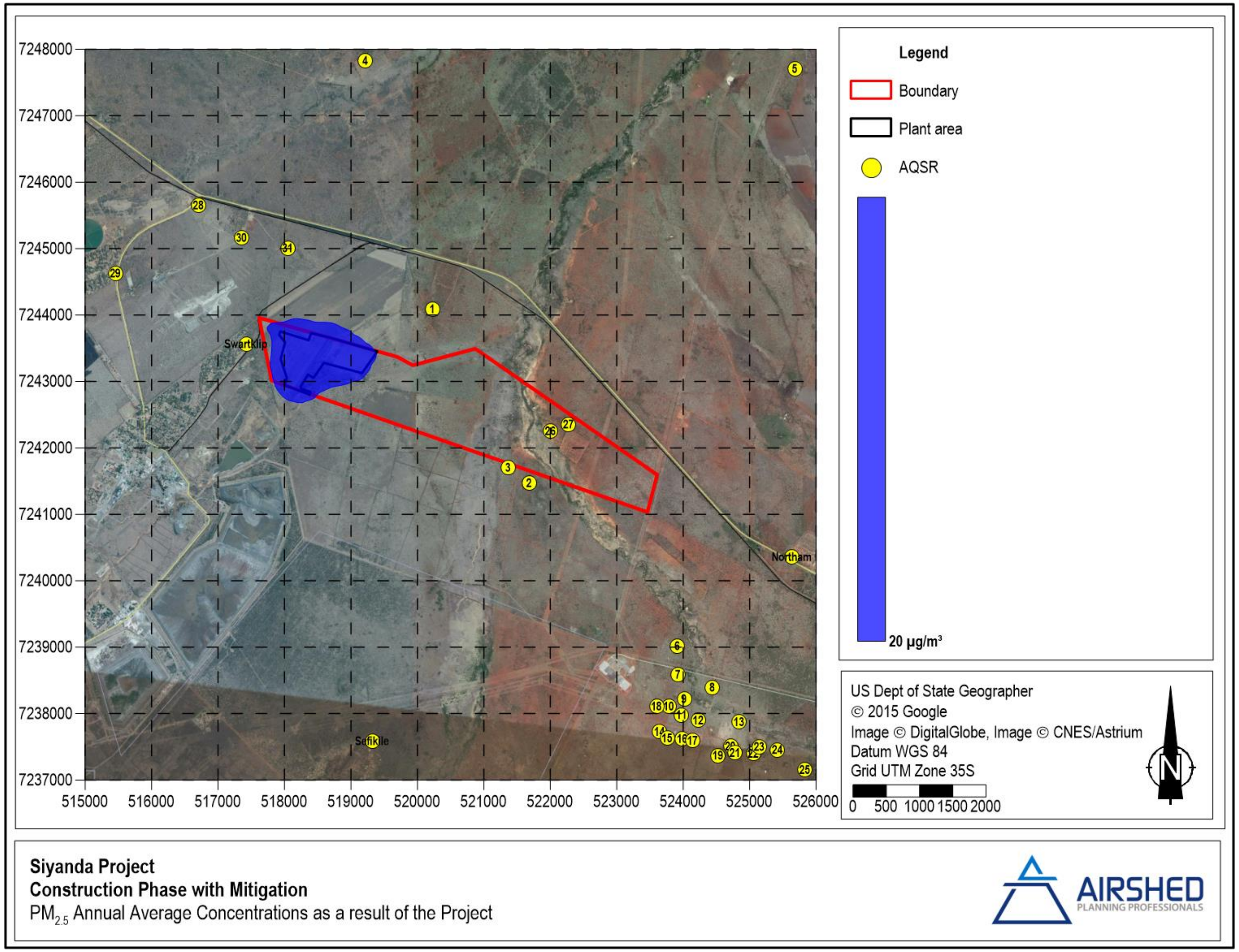

Figure 23: Mitigated construction phase: simulated 1-year average $PM_{2.5}$ concentrations

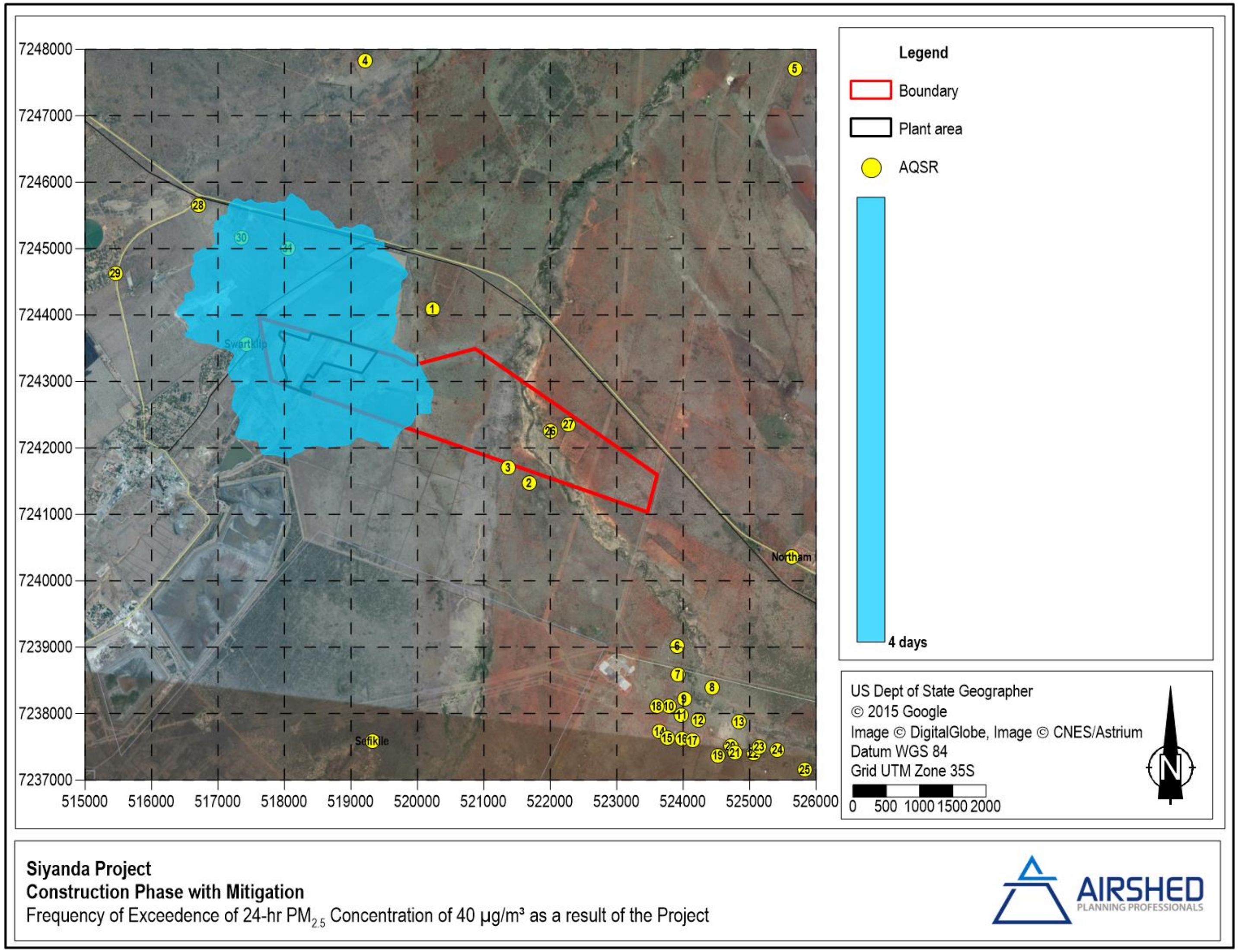

Figure 24: Mitigated construction phase: Area of exceedance of the 24-hour average $PM_{2.5}$ NAAQS

4.3.2 Operational Phase

Simulation results of “routine” emissions as per the project design are discussed in this section. Upset, emergency, start-up/shutdown conditions will occur infrequently and over short time intervals making comparison with NAAQS, especially over periods longer than 24-hours, inaccurate. Operations including the access road option 2 were simulated using dispersion modelling. It was determined that the simulated results for the access road did not exceed the NAAQS for $PM_{2.5}$, PM_{10} and NO_2. It is unlikely that there will be exceedances at the AQRs due to access road operations (vehicle entrainment along access road and vehicle exhaust) for all the access road options.

4.3.2.1 Simulated Ambient PM_{10} Concentrations

A summary of simulated results for PM_{10} at AQRs is presented in Table 18. Simulated annual average PM_{10} concentrations exceeds the NAAQS of 40 µg/m³ off-site but not at AQRs (Figure 26). The 24-hour NAAQS (4 days of exceedance of 75 µg/m³) is also exceeded off-site and at no AQRs (Figure 27).

A source group contribution analysis indicated that vehicle entrainment along (on-site) paved roads is the main contributor to simulated annual average PM_{10} concentrations (Figure 25). The potential for cumulative off-site PM_{10} concentrations in exceedance of NAAQS is likely, especially at Swartklip, since baseline/pre-development PM_{10} concentrations are almost in exceedance of NAAQS (Section 3.3.2).

Table 18: Summary of simulation results of PM_{10} at AQRs during routine operational phase activities

Pollutant	**PM_{10}**	
Averaging Period	1-year	24-hour
Reporting Unit	Concentration in µg/m³	Frequency of exceedance in ‘days per year'
Criteria	40 µg/m³	4 days of exceedance of 75 µg/m³
AQR/Source Group	All Sources	
Swartklip	8.83	1
1	0.693	0
2	0.418	0
3	0.476	0
4	0.554	0
26	0.346	0
27	0.294	0
28	2.18	0
29	1.84	0
30	4.58	0
31	5.75	1

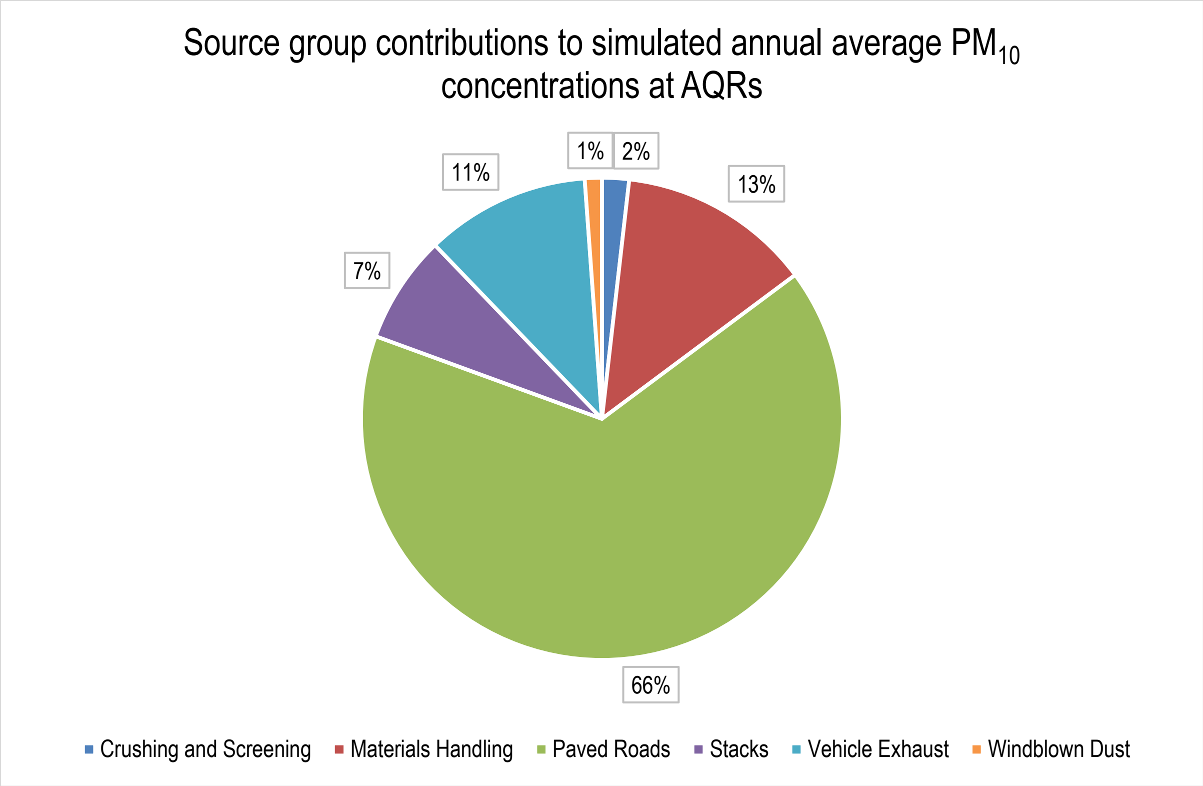

Figure 25: Source group contributions to average PM_{10} concentrations at AQRs

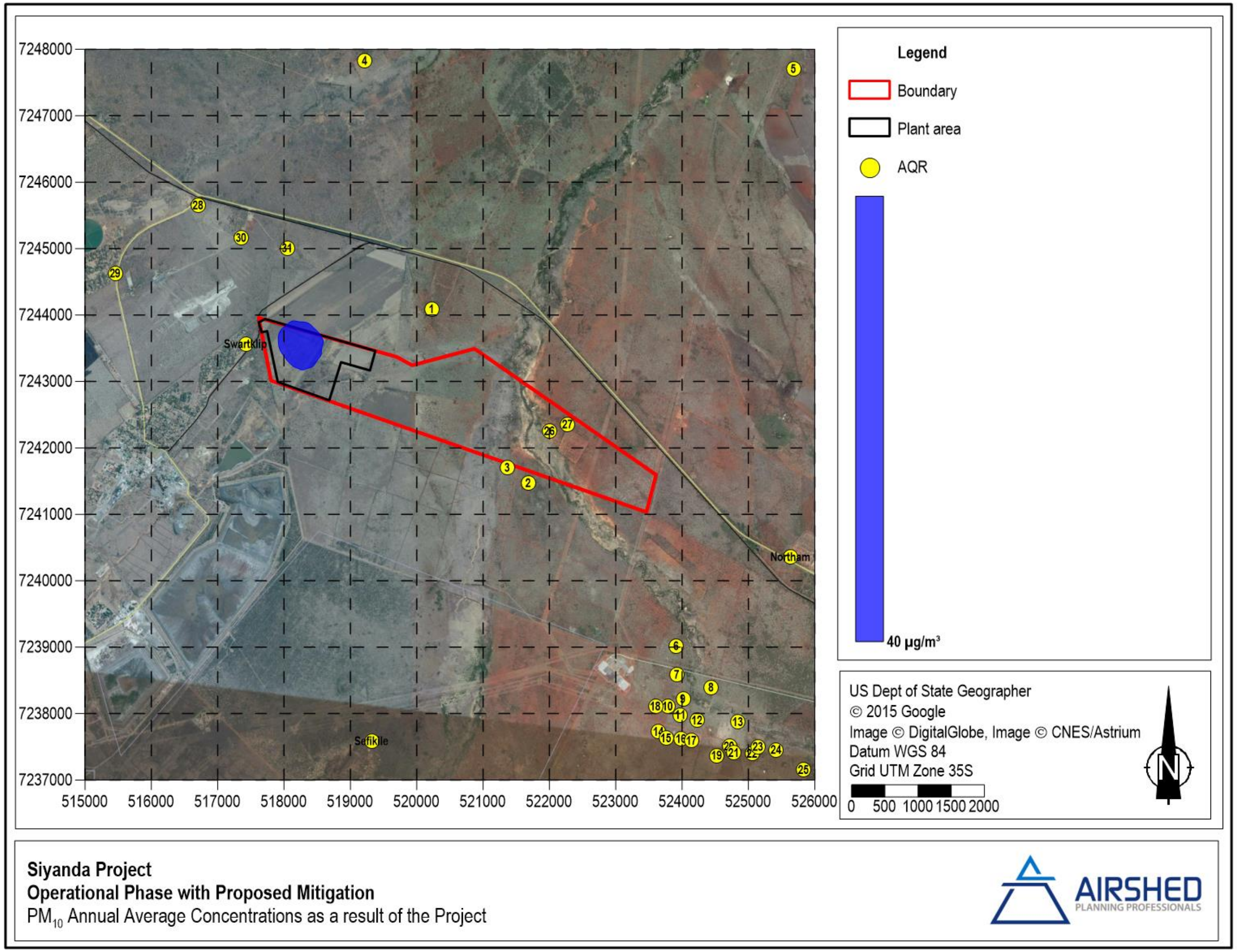

Figure 26: Operational phase: simulated 1-year average PM_{10} concentrations

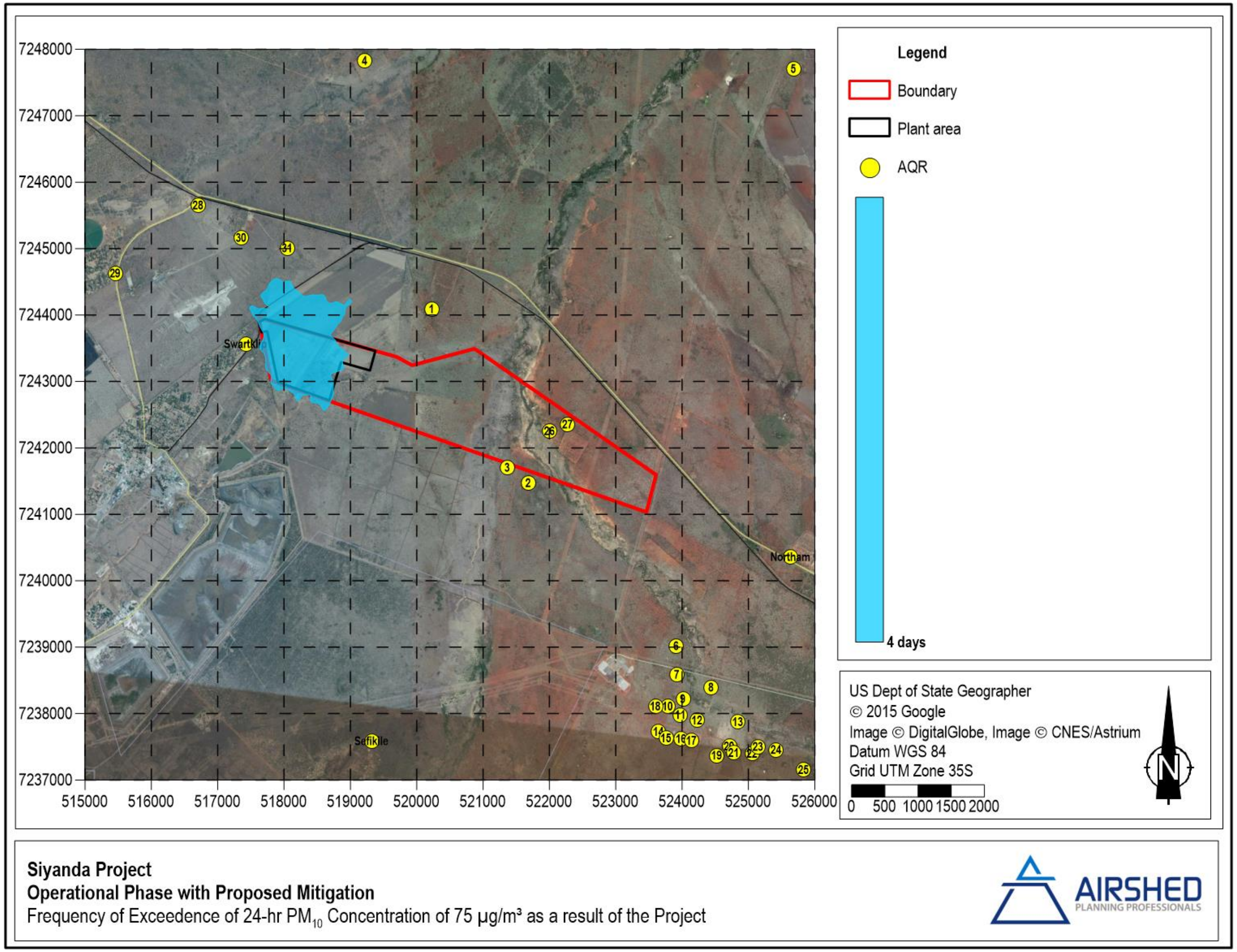

Figure 27: Operational phase: Area of exceedance of the 24-hour average PM_{10} NAAQS

4.3.2.2 *Simulated Ambient $PM_{2.5}$ Concentrations*

A summary of simulated results for $PM_{2.5}$ at AQRs is presented in Table 19. Simulated annual average $PM_{2.5}$ concentrations resulted in exceedances of the NAAQS of 20 µg/m^3 off-site to the north of the proposed plant (Figure 29). The 24-hour NAAQS (4 days of exceedance of 40 µg/m^3) was exceeded off-site but not at any AQRs (Figure 30).

A source group contribution analysis indicated vehicle exhaust as the main contributor to simulated annual average $PM_{2.5}$ concentrations (Figure 28). The potential for cumulative off-site $PM_{2.5}$ in exceedance of NAAQS is somewhat likely even considering that the baseline/pre-development is below NAAQS (Section 3.3.2) as simulated incremental ambient $PM_{2.5}$ are not within NAAQSs off-site.

Table 19: Summary of simulation results of $PM_{2.5}$ at AQRs during routine operational phase activities

Pollutant	$PM_{2.5}$	
Averaging Period	1-year	24-hour
Reporting Unit	Concentration in µg/m3	Frequency of exceedance in 'days per year'
Criteria	20 µg/m3	4 days of exceedance of 40 µg/m3
AQR/Source Group	All Sources	
Swartklip	5	0
1	0.363	0
2	0.209	0
3	0.24	0
4	0.281	0
26	0.169	0
27	0.145	0
28	1.16	0
29	0.974	0
30	2.49	0
31	3.23	0

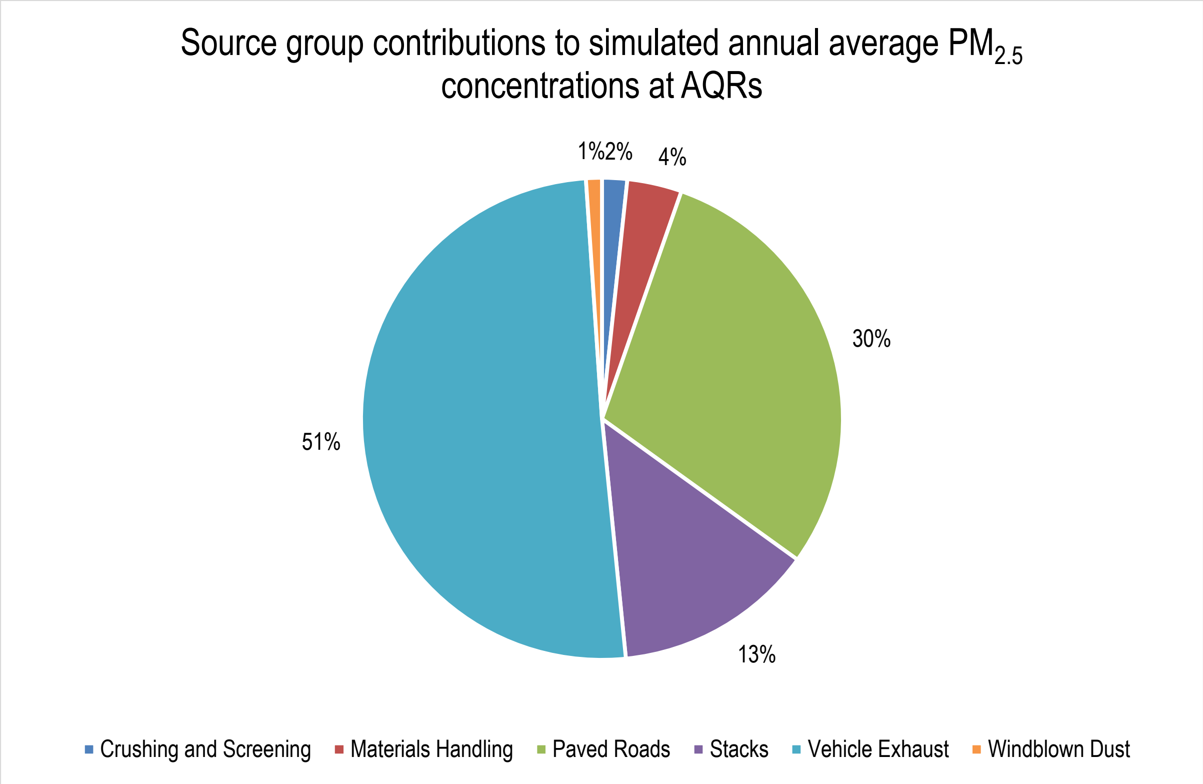

Figure 28: Source group contributions to average $PM_{2.5}$ concentrations at AQRs

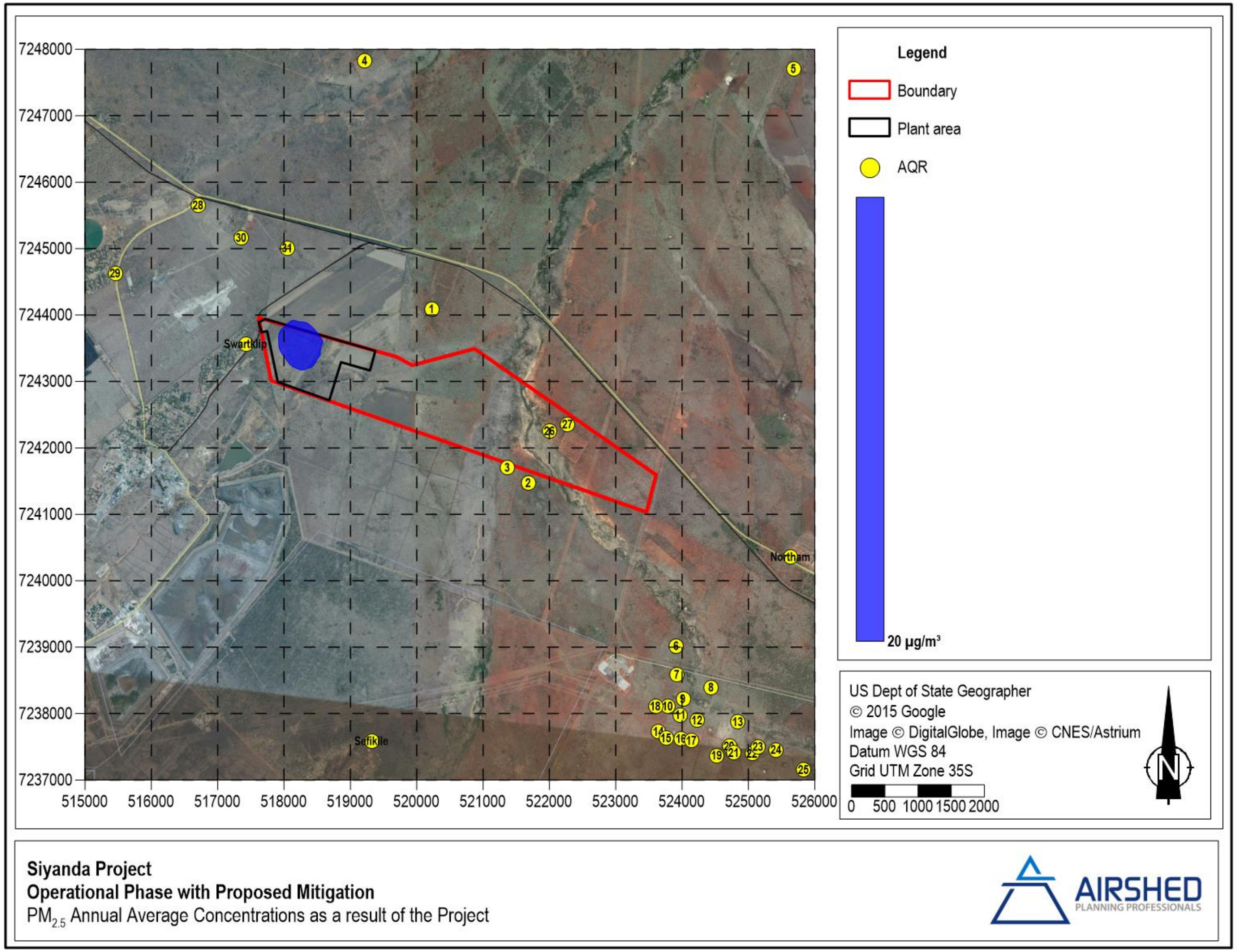

Figure 29: Operational phase: simulated 1-year average $PM_{2.5}$ concentrations

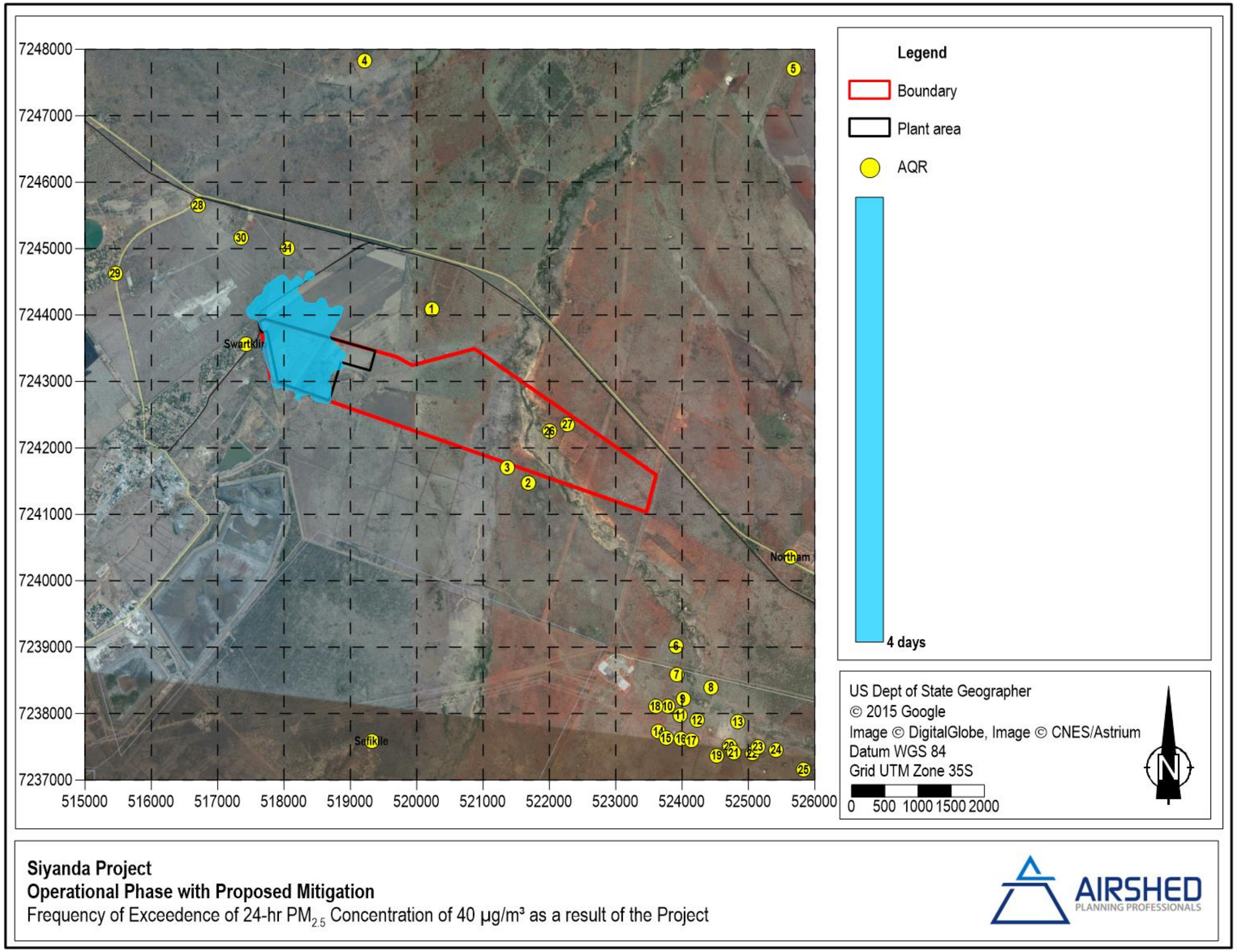

Figure 30: Operational phase: Area of exceedance of the 24-hour average $PM_{2.5}$ NAAQS

4.3.2.3 Simulated Ambient Cr^{6+} Concentrations and Associated Increased Lifetime Cancer Risk

Simulated annual average ambient Cr^{6+} concentrations are very low do not exceed the US EPA IRIS RfC of 0.1 µg/m³ on-site or off-site. The reader is reminded that due to uncertainty in Cr^{6+} emission estimates and conservative nature of simulation results, increased lifetime cancer risk is reported as a range where the lower range represents the most likely emission estimate and the least conservative URF. The upper range represents the worst case emission estimate and most stringent URF.

For the former, using US EPA IRIS cancer URF of 0.012 $(\mu g/m^3)^{-1}$, increased lifetime cancer risk at most AQRs was estimated to be less than 1 in 1 000 000 which is considered “very low risk” by the NYSDOH. “Low risk” (less than 1 in 10 000) occurs at Swartklip which is situated in close proximity to the project (Figure 31). Similarly, the WHO cancer URF of 0.04 $(\mu g/m^3)^{-1}$ was applied to determine worst case increased lifetime cancer risk (Figure 32). Increased lifetime cancer risk at most AQRs is less than 1 in 10 000 which is considered “low”.

4.3.2.4 Simulated Ambient DPM Concentrations

A summary of simulated results for DPM at AQRs during the operational phase are presented in Table 20. Simulated annual average ambient DPM concentrations exceeded the US EPA IRIS RfC of 5 µg/m³ off-site but not at any of the AQRs (Figure 33). The CAL EPA cancer URF of $3x10^{-4}$ $(\mu g/m^3)^{-1}$ was applied to simulated annual average concentrations to provide a conservative estimate of increased lifetime cancer risk (Figure 34). Excess lifetime cancer risk at AQRs range between low and moderate. Moderate risk was estimated at Swartklip and AQRs no. 28, 29, 30 and 31 which are downwind of the project. The only source of DPM is vehicle exhaust. Potential cumulative off-site DPM concentrations could not be determined.

Should access road option 1 be selected it is likely the US EPA IRIS RfC of 5 µg/m³ will be exceeded off-site and at two AQRs (no. 2 and 3). It is likely the excess lifetime cancer risk at AQRs may range between low and moderate. Moderate risk is estimated at two AQRs (no. 2 and 3).

Should access road option 2 be selected it is likely the US EPA IRIS RfC of 5 µg/m³ will be exceeded off-site and at oneo AQRs (no. 30). It is likely the excess lifetime cancer risk at AQRs may range between low and moderate. Moderate risk is estimated at one AQRs (no. 30).

Table 20: Summary of simulation results of DPM at AQRs during routine operational phase activities

Pollutant	DPM
Averaging Period	1-year
Reporting Unit	Concentration in µg/m^3
Criteria	5 µg/m^3
AQR/Source Group	Vehicle/Equipment Exhaust Emissions
Swartklip	2.41
1	0.172
2	0.097
3	0.115
4	0.141
26	0.094
27	0.09
28	0.602
29	0.435
30	1.23
31	1.77

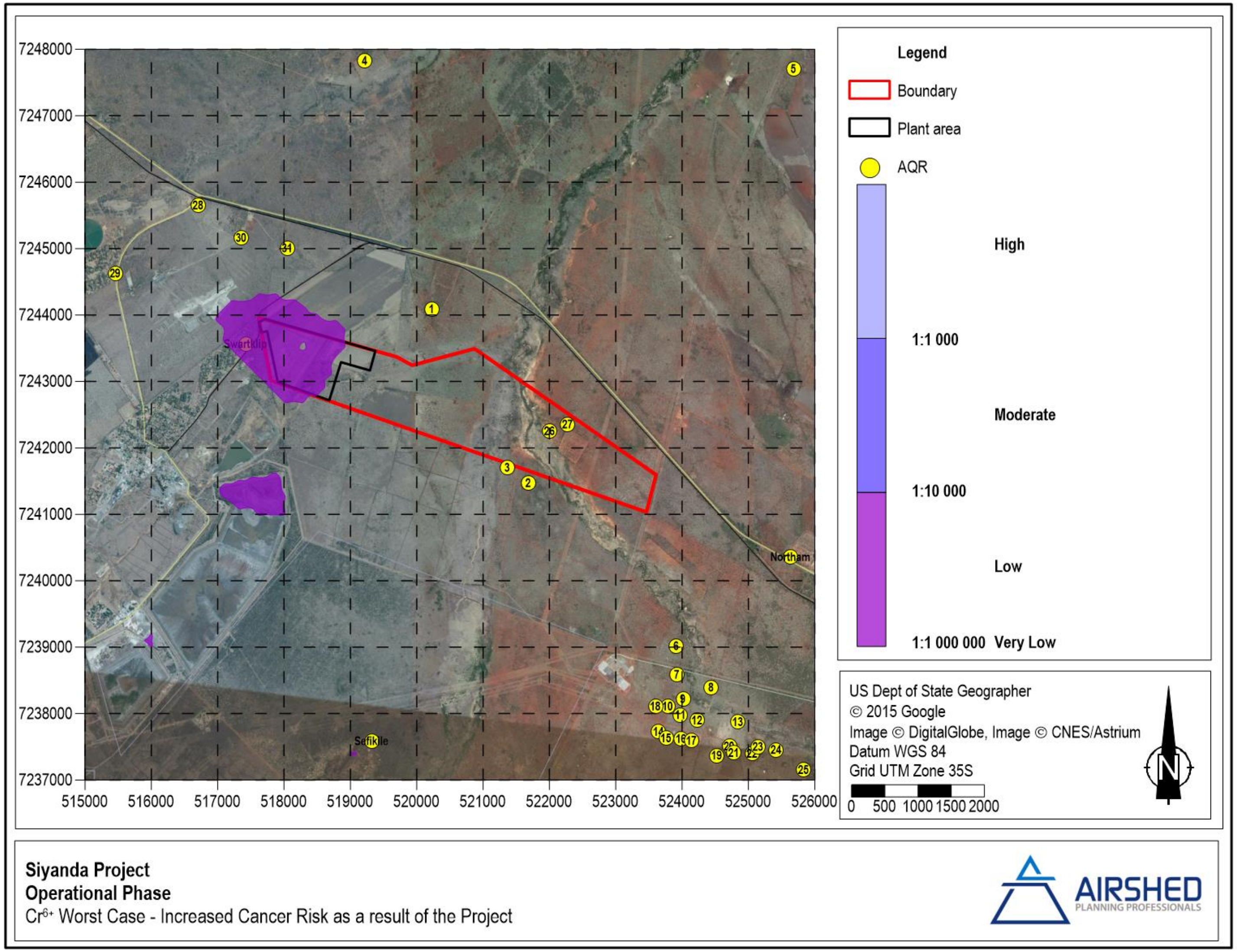

Figure 31: Operational phase: simulated excess lifetime cancer risk associated with Cr^{6+} (most likely estimate)

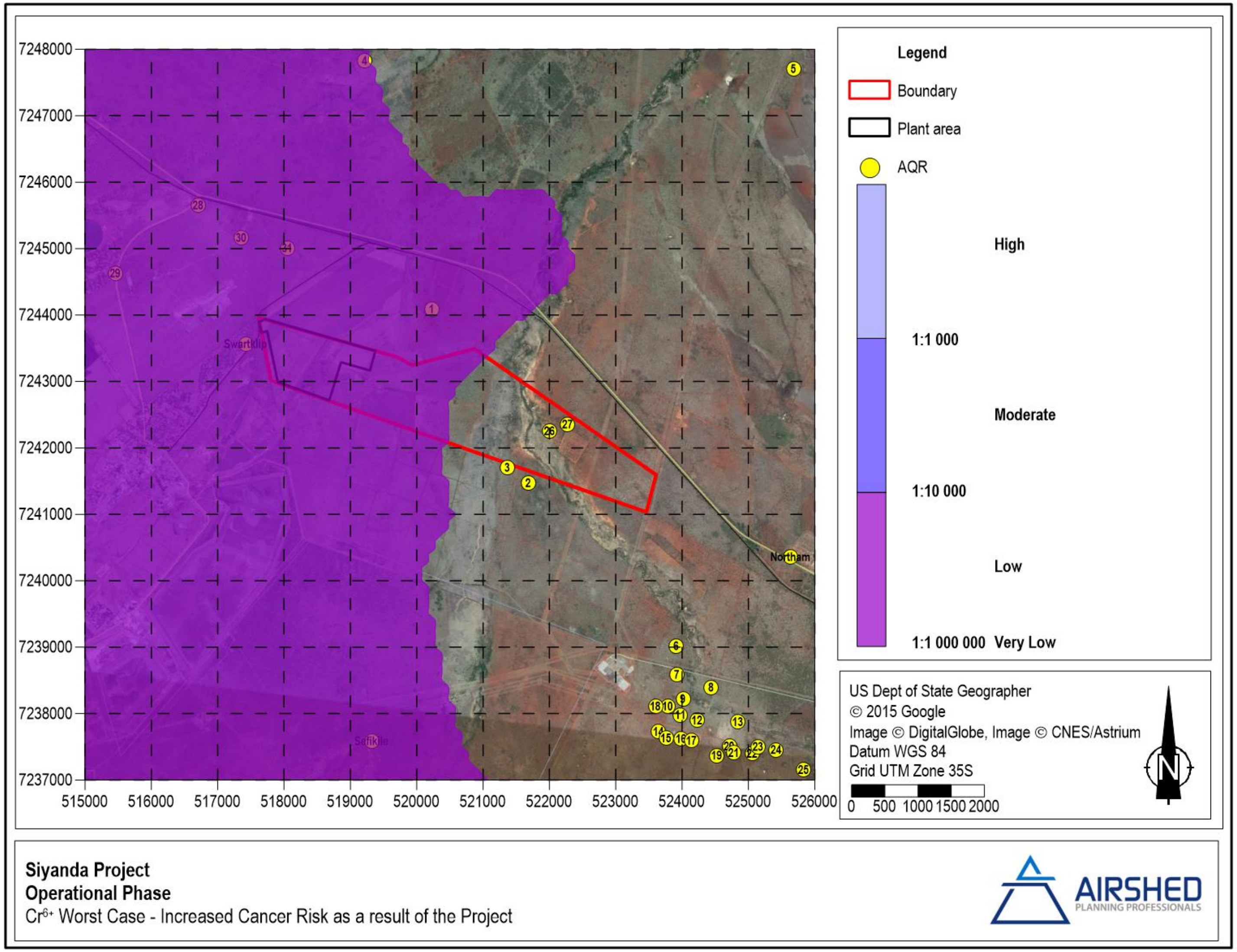

Figure 32: Operational phase: simulated excess lifetime cancer risk associated with Cr^{6+} (worst case estimate)

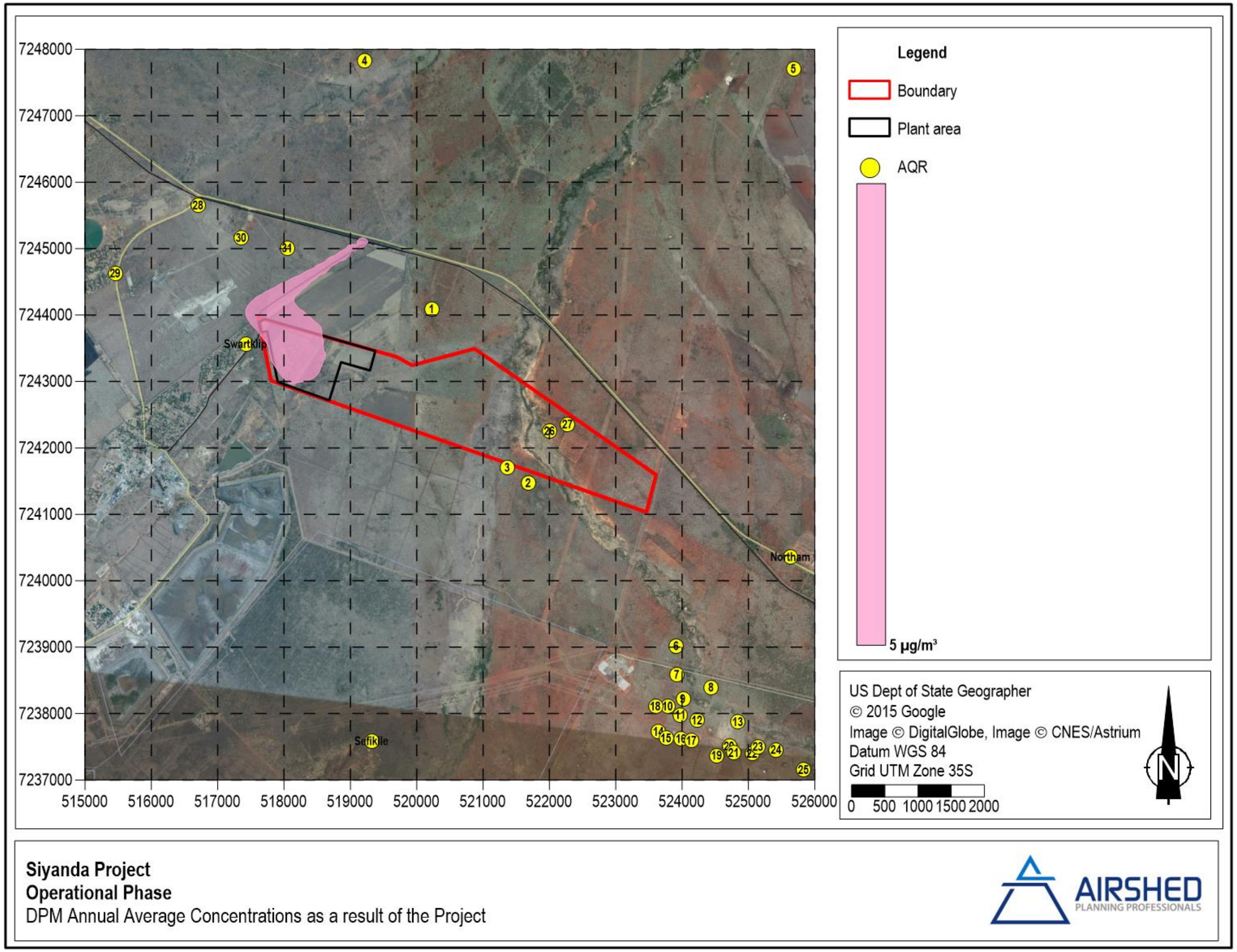

Figure 33: Operational phase: simulated 1-year average DPM concentrations

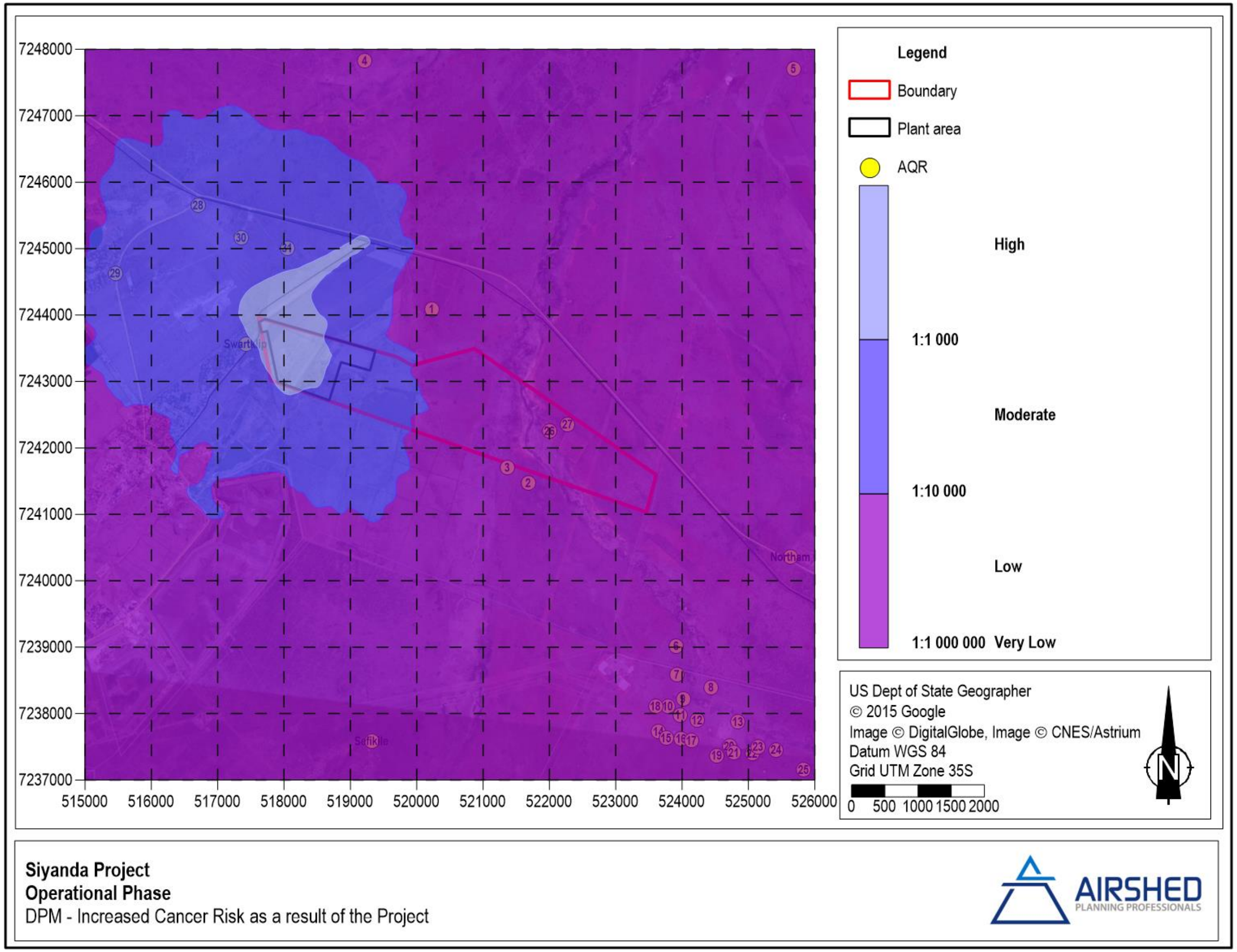

Figure 34: Operational phase: simulated excess lifetime cancer risk associated with DPM

4.3.2.5 Simulated Ambient NO_2 Concentrations

The reader is reminded that NO emissions are rapidly converted in the atmosphere into harmful NO_2 which is regulated by NAAQSs. NO_2 impacts where calculated by AERMOD using the ozone limiting method and applying an average background O_3 concentration of 30 ppb. A vehicle exhaust NO_2/NO_x emission ratio of 0.2 (Howard, 1988) was used.

A summary of simulated results for NO_2 at AQRs are presented in Table 21. Simulated annual average NO_2 concentrations are in exceedance of the NAAQS of 40 µg/m³ off-site but not at any of the AQRs (Figure 36). The 1-hour NAAQS (88 hours of exceedance of 200 µg/m³) but not at any of the AQRs (Figure 37).

There are only two contributors to the simulated incremental NO_2, these are the stacks and vehicle exhaust. A source group contribution analysis indicated that although stack emissions account for most of the NO_x emissions, vehicle exhaust is the main contributor NO_2 concentrations at AQRs (Figure 35). The contribution of background NO_2 to simulated NO_2 levels as a result of the project is likely to be immaterial given the low results of background measurements (Section 3.3.2).

Table 21: Summary of simulation results of NO_2 at AQRs during routine operational phase activities

Pollutant	**NO_2**	
Averaging Period	1-year	1-hour
Reporting Unit	Concentration in µg/m³	Frequency of exceedance in 'hours per year'
Criteria	40 µg/m³	88 hours of exceedance of 200 µg/m³
AQR/Source Groups	Vehicle/Equipment Exhaust Emissions and Stacks	
Swartklip	13.4	41
1	2.11	0
2	0.621	0
3	0.677	0
4	1.05	0
26	0.581	0
27	0.552	0
28	4.017	0
29	3.01	0
30	6.76	0
31	10.3	0

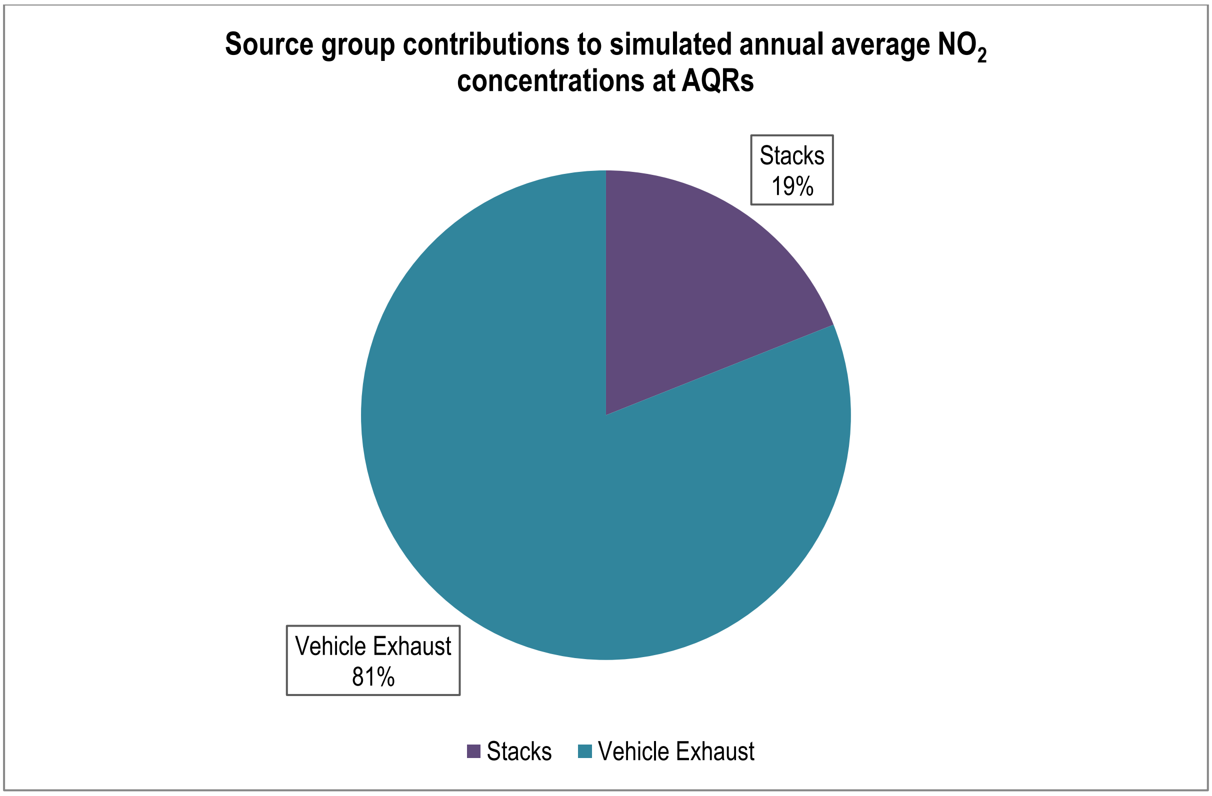

Figure 35: Source group contributions to annual average NO_2 concentrations at AQRs

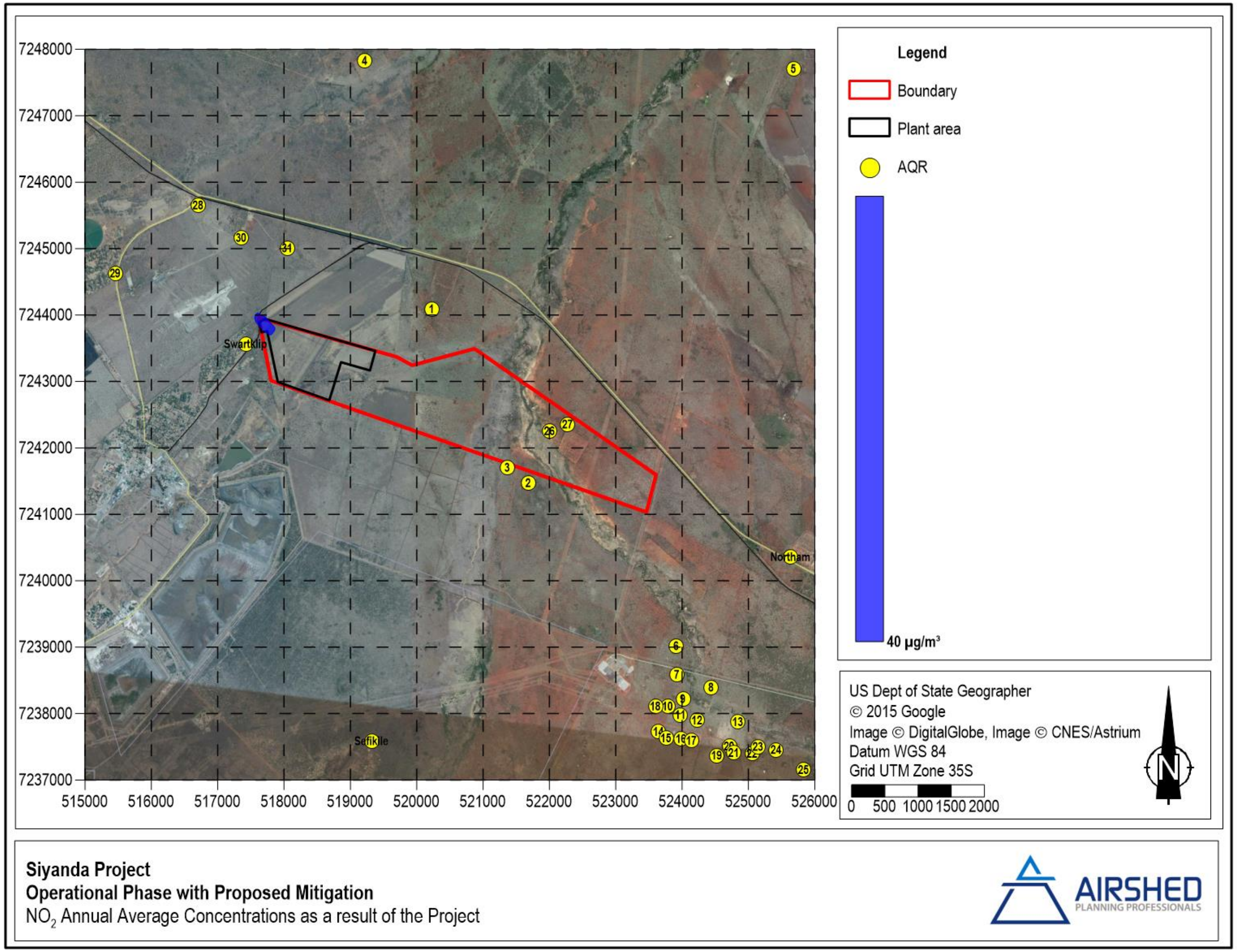

Figure 36: Operational phase: simulated 1-year average NO_2 concentrations

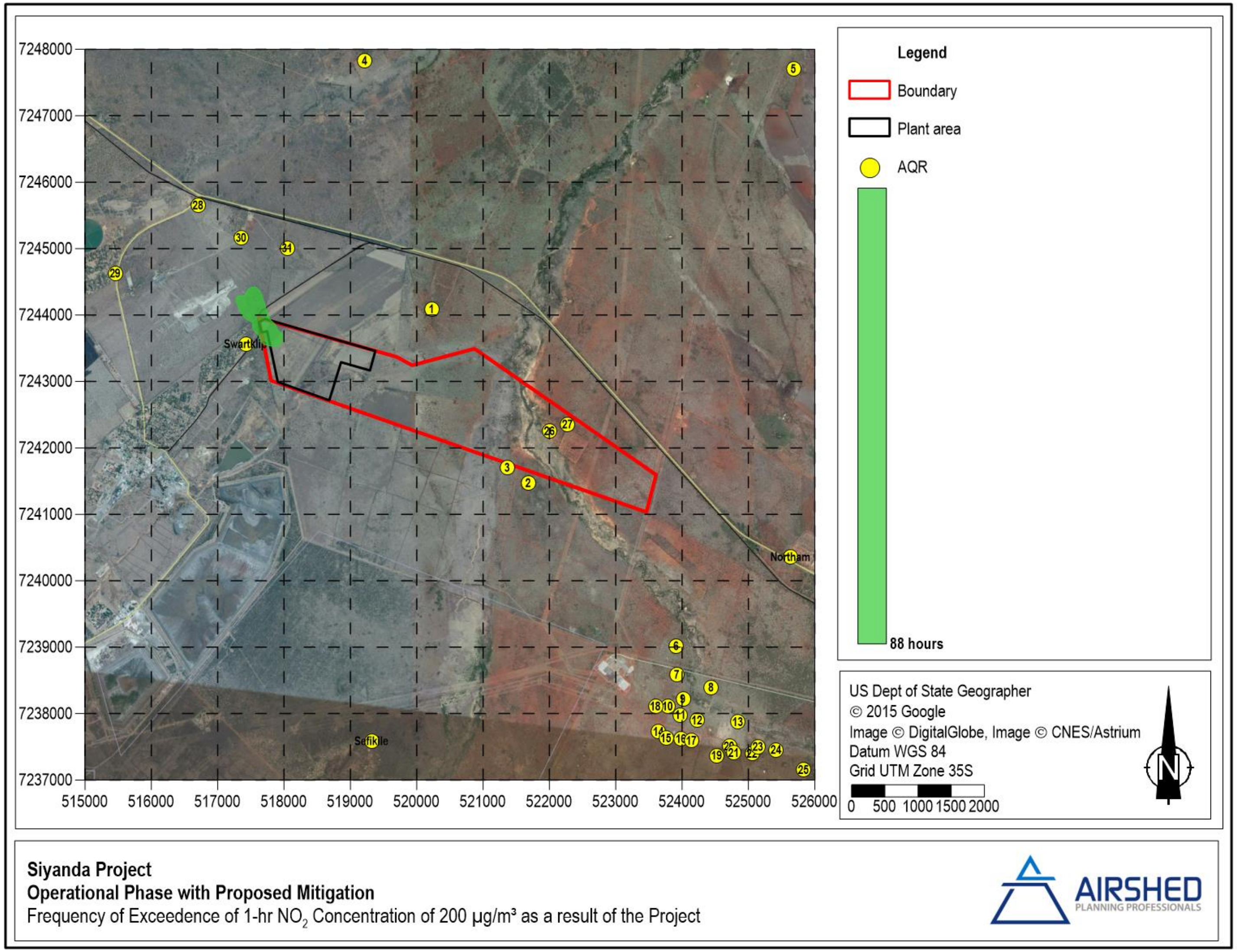

Figure 37: Operational phase: Area of exceedance of the 1-hour NO_2 NAAQS

4.3.2.6 Simulated Ambient SO_2 Concentrations

Simulated ambient SO_2 does not exceed short or long term NAAQS on-site or off-site. Given low pre-development SO_2 levels and project related impacts, cumulative effects are considered immaterial.

4.3.2.7 Simulated Ambient VOC Concentrations

Simulated annual average ambient VOC concentrations do not exceed the chronic TCEQ of 100 µg/m³ on-site or off-site. In light of low baseline VOC levels, cumulative effects are considered immaterial.

4.3.2.8 Simulated Ambient CO Concentrations

Simulated annual average ambient CO concentrations are very low and well within 1-hour and 8-hour NAAQS on-site and off. Cumulative CO impacts are considered immaterial.

4.4 Analysis of Emissions' Impact on the Environment (Dustfall)

4.4.1 Construction Phase

A summary of simulated dustfall rates (without and with partial mitigation) at AQRs during the construction phase are presented in Table 22. Construction phase activities was found to result in dustfall rates in exceedance of 600 mg/m²-day, the limit for residential areas, only in close proximity to areas of disturbance (Figure 39 and Figure 40 and not at any of the AQRs). With sampled baseline/pre-development dustfall rates, which were low, cumulative dustfall rates in exceedance of NDCR limit for residential areas is not expected.

Table 22: Summary of simulation results of dustfall at AQRs during the construction phase

Pollutant	TSP	
Averaging Period	1 month (simulation)	
Reporting Unit	Dustfall rate in mg/m²-day	
Criteria	600 mg/m²-day in residential areas	
AQR	Unmitigated	Mitigated
Swartklip	55.3	27.6
1	2.85	1.43
2	1.69	0.865
3	2.19	1.09
4	1.56	0.79
26	2.04	1.02
27	1.74	0.875
28	12.1	6.00
29	12.0	6.02
30	18.3	9.20
31	19.9	10.3

4.4.2 Operational Phase

A summary of simulated results for dustfall at AQRs is presented in Table 23. Operational phase activities were found to result in dustfall rates in exceedance of the limit for residential areas only in close proximity to the proposed operational activities (Figure 41) and not at any of the AQRs. Cumulative dustfall rates are also not expected to exceed NDCRs off-site.

A source group contribution analysis indicated that crushing & screening is the main contributors to simulated dustfall rates (Figure 38).

Table 23: Summary of simulation results of dustfall at AQRs during routine operational phase activities

Pollutant	**TSP**
Averaging Period	1 month (simulation)
Reporting Unit	Dustfall rate in mg/m^2-day
Criteria	600 mg/m^2-day in residential areas
AQR	All Sources (Routine)
Swartklip	191
1	12
2	3
3	3
4	3
26	6
27	5
28	25
29	24
30	37
31	50

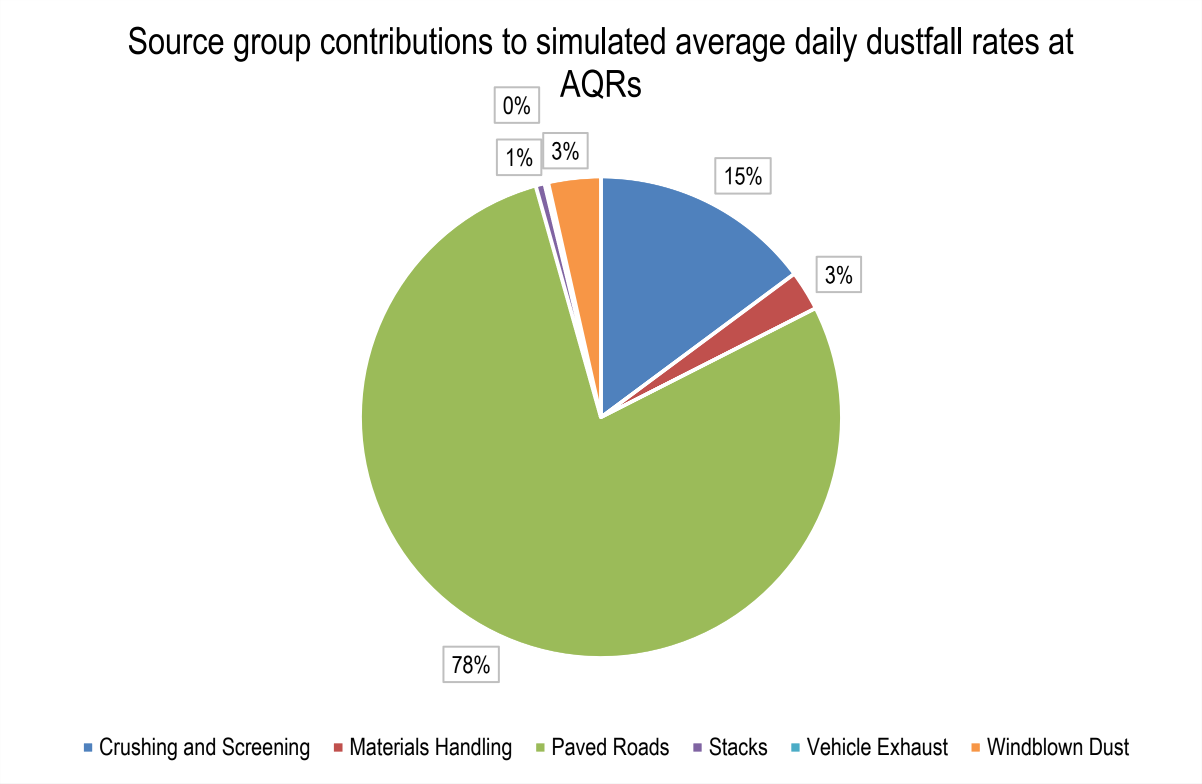

Figure 38: Source group contributions to average dustfall rates at AQRs due routine operational phase activities

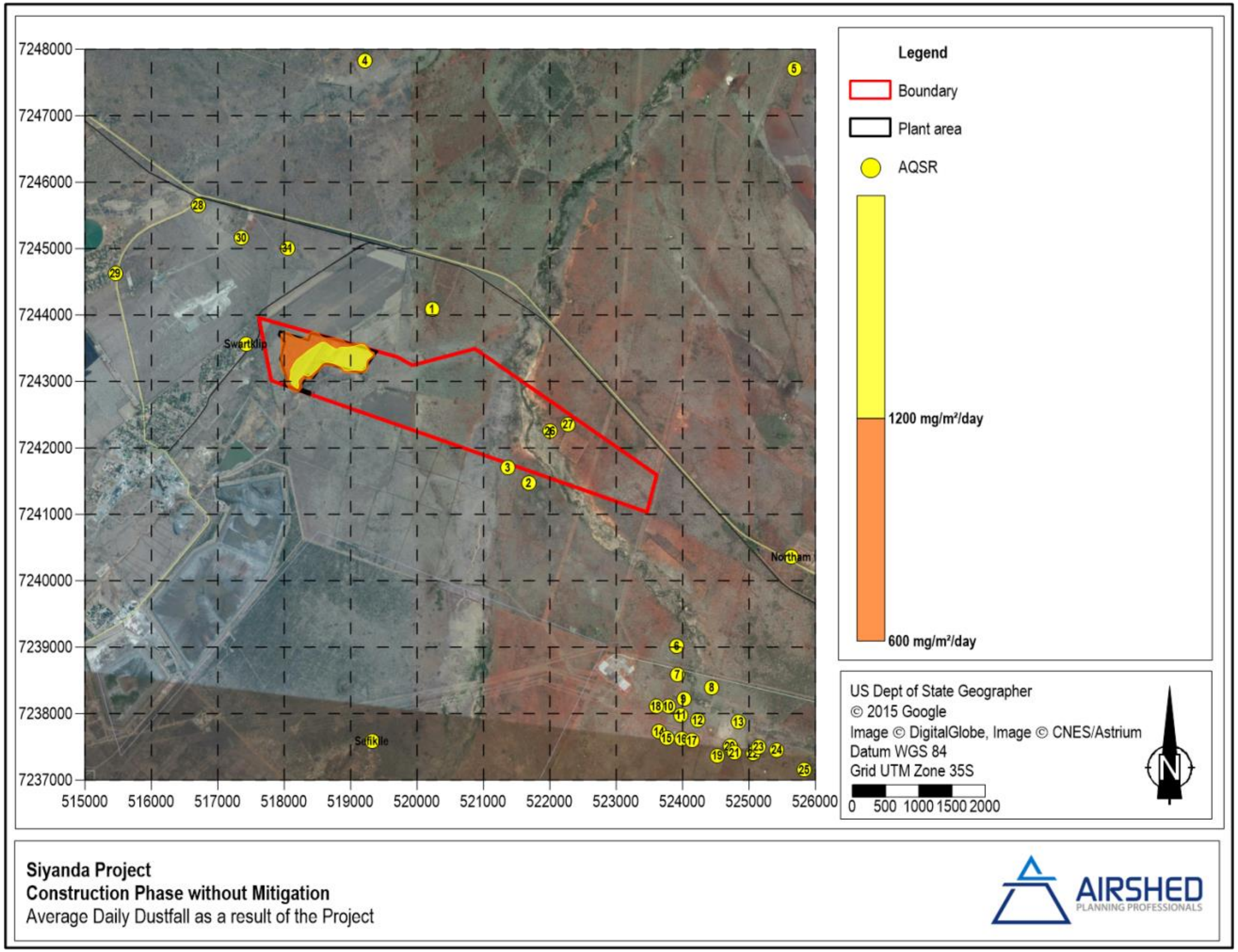

Figure 39: Unmitigated construction phase: simulated dustfall rates

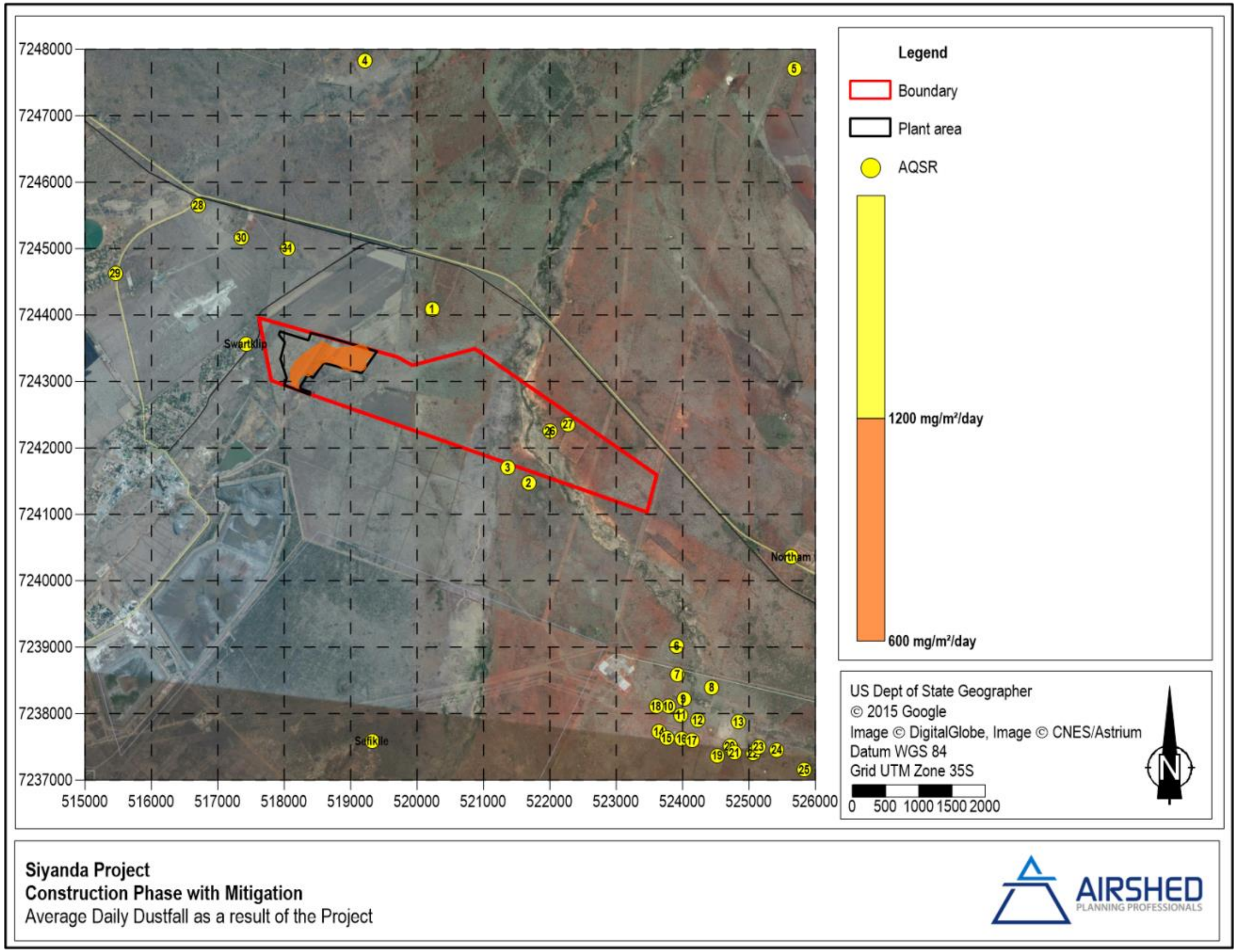

Figure 40: Mitigated construction phase: simulated dustfall rates

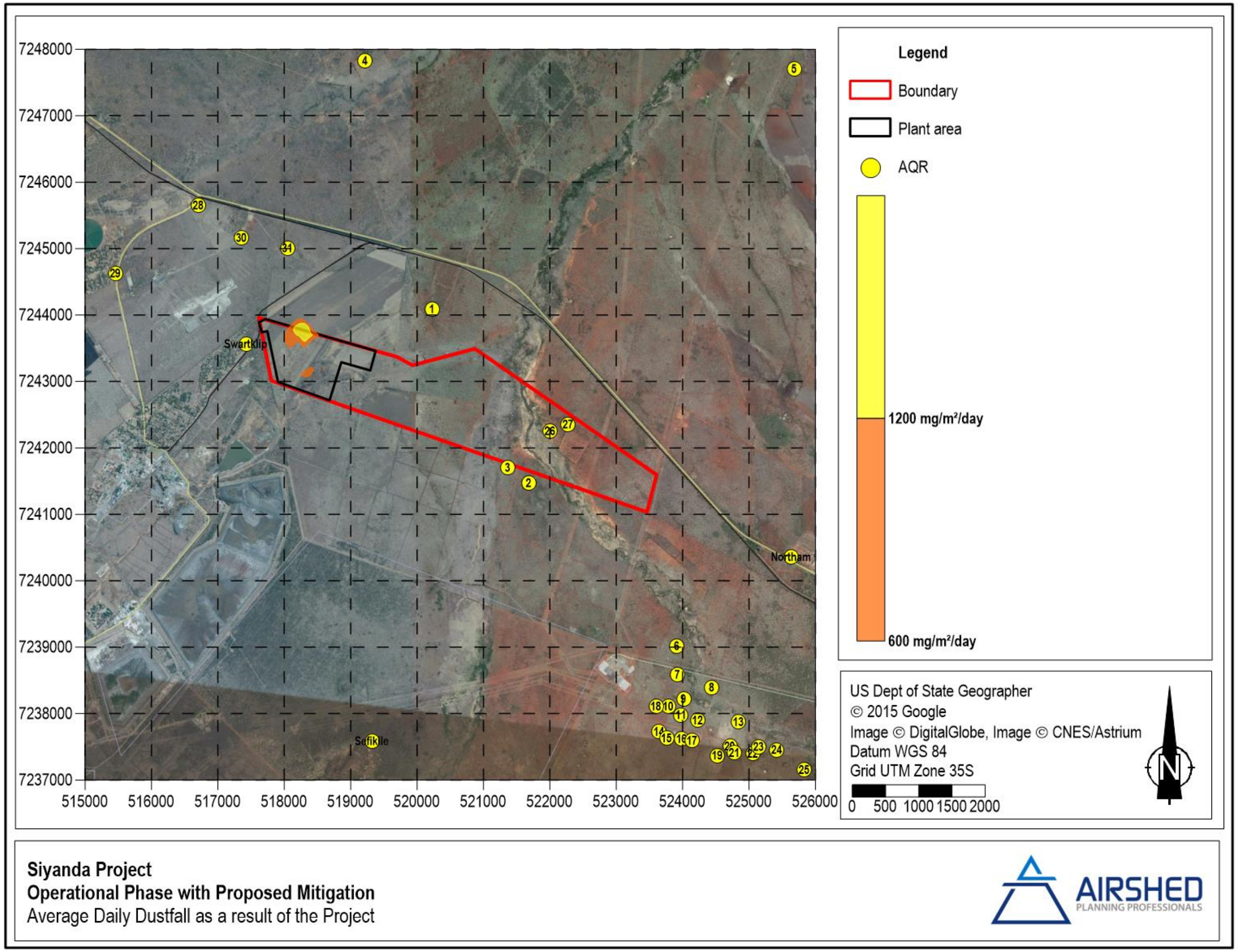

Figure 41: Operational phase: simulated dustfall rates

4.5 Assessment of Site Alternatives

All access road options were considered in this assessment.

4.6 Impact Significance

The impact assessment is summarised in the subsequent tables for the different phases. Table 24 provides the significance rating for the construction phase with the evaluation of the operational phase provided in Table 25. The significance rating for the closure phase is provided in Table 26. The impact significance rating is based on simulation results at AQRs. The SLR impact significance rating methodology is included in Annex B.

Table 24: Quantitative impact significance summary for the construction and decommissioning phases

Scenario	Impact	Severity/Nature of Impact	Duration of Impact	Spatial Scale of Impacts	Consequence	Probability	Significance
Unmitigated (incremental)	$PM_{2.5}$ (health)	H	L	M	Medium	M	Medium
	PM_{10} (health)	H	L	M	Medium	M	Medium
	Dustfall (nuisance)	L	L	L	Low	L	Low
Partially Mitigated (incremental)	$PM_{2.5}$ (health)	M	L	M	Medium	M	Medium
	PM_{10} (health)	M	L	M	Medium	M	Medium
	Dustfall (nuisance)	L	L	L	Low	L	Low
Unmitigated (cumulative)	$PM_{2.5}$ (health)	H	L	M	Medium	H	Medium
	PM_{10} (health)	H	L	M	Medium	H	Medium
	Dustfall (nuisance)	L	L	L	Low	L	Low
Partially Mitigated (cumulative)	$PM_{2.5}$ (health)	M	L	M	Medium	H	Medium
	PM_{10} (health)	M	L	M	Medium	H	Medium
	Dustfall (nuisance)	L	L	L	Low	L	Low

Notes:

(a) Severity/nature:
  i. H - Short term and long term assessment criteria exceeded at AQRs.
  ii. M - Short term assessment criteria exceeded and/or high increased lifetime cancer risk at AQRs.
  iii. L - No exceedances of assessment criteria and/or moderate or lower increased lifetime cancer risk at AQRs.

(b) Duration:
  i. L - Less than the project life. Short term.

(c) Spatial Scale
  i. L - Localised, area of exceedance of assessment criteria within the site boundary.
  ii. M - Fairly widespread, area of exceedance of assessment criteria beyond the site boundary but local.

(d) Probability of exposure:
  i. H - Probable
  ii. M - Possible/frequent
  iii. L - Unlikely/seldom.

Table 25: Quantitative impact significance summary table for the operational phase

Scenario	Impact	Severity/ Nature of Impact	Duration of Impact	Spatial Scale of Impacts	Consequence	Probability	Significance
Routine unmitigated operational phase activities (incremental)	$PM_{2.5}$ (health)	M	M	M	Medium	M	Medium
	PM_{10} (health)	M	M	M	Medium	M	Medium
	Dustfall (nuisance)	L	M	M	Low	L	Low
	Cr^{6+} (health)	L	M	L	Low	L	Low
	SO_2 (health)	L	M	L	Low	L	Low
	NO_2 (health)	M	M	M	Medium	M	Medium
	CO (health)	L	M	L	Low	L	Low
	DPM (health)	M	M	M	Medium	M	Medium
	VOC (health)	L	M	L	Low	L	Low
Routine design operational phase activities (incremental)	$PM_{2.5}$ (health)	L	M	M	Low	L	Low
	PM_{10} (health)	L	M	M	Low	L	Low
	Dustfall (nuisance)	L	M	M	Low	L	Low
	Cr^{6+} (health)	L	M	L	Low	L	Low
	SO_2 (health)	L	M	L	Low	L	Low
	NO_2 (health)	L	M	M	Low	L	Low
	CO (health)	L	M	L	Low	L	Low
	DPM (health)	M	M	M	Medium	M	Medium
	VOC (health)	L	M	L	Low	L	Low
Routine unmitigated operational phase activities	$PM_{2.5}$ (health)	H	M	M	Medium	H	Medium
	PM_{10} (health)	H	M	M	Medium	H	Medium

Scenario	Impact	Severity/ Nature of Impact	Duration of Impact	Spatial Scale of Impacts	Consequence	Probability	Significance
(cumulative)	Dustfall (nuisance)	L	M	M	Low	L	Low
	Cr^{6+} (health)	L	M	L	Low	L	Low
	SO_2 (health)	L	M	L	Low	L	Low
	NO_2 (health)	M	M	M	Medium	M	Medium
	CO (health)	L	M	L	Low	L	Low
	DPM (health)	M	M	M	Medium	M	Medium
	VOC (health)	L	M	L	Low	L	Low
Routine design operational phase activities (cumulative)	$PM_{2.5}$ (health)	M	M	M	Medium	H	Medium
	PM_{10} (health)	M	M	M	Medium	H	Medium
	Dustfall (nuisance)	L	M	M	Low	L	Low
	Cr^{6+} (health)	L	M	L	Low	L	Low
	SO_2 (health)	L	M	L	Low	L	Low
	NO_2 (health)	L	M	M	Low	L	Low
	CO (health)	L	M	L	Low	L	Low
	DPM (health)	M	M	M	Medium	M	Medium
	VOC (health)	L	M	L	Low	L	Low

Notes:

(a) Severity/nature:

i. H - Short term and long term assessment criteria exceeded at AQRs.

ii. M - Short term assessment criteria exceeded and/or high increased lifetime cancer risk at AQRs.

iii. L - No exceedances of assessment criteria and/or moderate or lower increased lifetime cancer risk at AQRs.

(b) Duration:

i. M - Life of the project

(c) Spatial Scale

i. L - Localised, area of exceedance of assessment criteria within the site boundary.

ii. M - Fairly widespread, area of exceedance of assessment criteria beyond the site boundary but local.

(d) Probability of exposure:

i. H - Probable

ii. M - Possible/frequent

iii. L - Unlikely/seldom

Table 26: Qualitative impact significance summary table for the closure phase

Scenario	Impact	Severity/ Nature of Impact	Duration of Impact	Spatial Scale of Impacts	Consequence	Probability	Significance
Unmitigated decommissioning and closure phase (incremental)	$PM_{2.5}$	M	L	L	Low	L	Low
	PM_{10}	M	L	L	Low	L	Low
	Dustfall	L	L	L	Low	L	Low
Unmitigated decommissioning and closure phase (cumulative)	$PM_{2.5}$	M	L	L	Medium	M	Medium
	PM_{10}	M	L	M	Medium	M	Medium
	Dustfall	L	L	L	Low	L	Low

Notes:

(a) Severity/nature:

a. M - Short term assessment criteria exceeded and/or high increased lifetime cancer risk at AQRs.

b. L - No exceedances of assessment criteria and/or moderate or lower increased lifetime cancer risk at AQRs.

(b) Duration:

a. L - Less than the project life. Short term

(c) Spatial Scale

a. L - Localised, area of exceedance of assessment criteria within the site boundary.

b. M - Fairly widespread, area of exceedance of assessment criteria beyond the site boundary but local.

(d) Probability of exposure:

a. M - Possible/frequent

b. L - Unlikely/seldom

5 MAIN FINDINGS

An air quality impact assessment was conducted for activities proposed as part of the Siyanda FeCr Project. The main objective of this study was to establish baseline/pre-development air quality in the study area and to quantify the extent to which ambient pollutant levels will change as a result of the proposed project. The baseline and impact study then informed the air quality management and mitigation measures recommended as part of the Air Quality Management Plan (AQMP). This section summarises the main findings of the baseline and impact assessments.

The main findings of the baseline/pre-development assessment are:

- The area is dominated by winds from the east-south-east. Frequent winds also occur from the south-eastern and eastern sectors. Long term air quality impacts are therefore expected to the most significant to the west-north-west of operations.
- The main sources likely to contribute to baseline PM concentrations include vehicle entrained dust from local roads, mining operations, platinum processing operations, biomass burning, household fuel burning, vehicle exhaust and windblown dust from exposed areas.
- Ambient baseline/pre-development air quality monitoring over the past six months indicated:
    - Low NO_2, SO_2 and benzene concentrations that are within NAAQS.
    - $PM_{2.5}$ and PM_{10} concentrations exceed short term NAAQS.
    - Low dustfall rates within the NDCR for residential areas.
- The nearest residences are those of the Swartklip Mine Village (located immediately adjacent to the Union Section Mine) which lies to the west approximately 500 m from the mid-point of furnaces. There are also several individual houses/farmsteads/buildings within a few kilometres of the farm Grootkuil 409. Sefikile is located approximately 5 km south and Northam approximately 8 km east-south-east of project infrastructure and not likely to be affected by project activities.

The main findings of the impact assessment are as follows:

- PM and gaseous emissions will be released during the construction, decomissioning, operational and closure phases of the project. Only the construction and operational phase air quality impacts were quantified since decommissioning phase impacts will likely be similar or less significant than the construction phase impacts.
- Construction phase:
    - If unmitigated or partially mitigated (water sprays on some sources), PM_{10} and $PM_{2.5}$ concentrations as a result of fugitive emissions released during the construction phase may exceed NAAQS off-site and at nearby AQRs.
    - The significance of construction related inhalation health impacts are considered moderate. Since fugitive dust from construction activities is easily managed the significance of its impact could be reduced to low if the management and additional mitigation measures recommended in this report are implemented effectively.
- Operational phase:
    - PM (TSP, PM_{10}, $PM_{2.5}$, Cr^{6+} and DPM) and gaseous (CO, NO_x, SO_2 and VOC) emissions and impacts were quantified.
    - Mitigation and air quality management measures incorporated into the project design were accounted for in the assessment.
    - Releases from stacks (raw materials dust extraction baghouse stack, drier baghouse stacks, clean gas stacks and secondary fume extraction baghouse stacks) were found to contribute most notably total

annual emissions of all pollutants with the exception being TSP. Vehicle entrainment on paved roads was estimate to contribute most notably to TSP emissions.

- Simulated $PM_{2.5}$ and PM_{10} concentrations were found to exceed both short-term and long-term NAAQS off-site and the significance of the impacts on AQRs are considered low. Since source group contribution analyses indicated vehicle exhaust and vehicle entrainment on paved roads as the main contributors to off-site $PM_{2.5}$ and PM_{10} impacts efforts aimed at further reducing emissions from these should be made to limit exceedances of NAAQS to on-site.
- The cumulative $PM_{2.5}$ significance ranking is likely to be medium.
- The potential for cumulative PM_{10} effects off-site are likely given the indications that baseline/pre-development concentrations are already close to exceeding short term NAAQS. The cumulative PM_{10} significance ranking is likely to be high.
- There are notable uncertainties in Cr^{6+} emission estimates. To account for uncertainties a 'likely' as well as 'worst case' estimates of emissions, based on literature, were included. Similarly, a range of URFs was applied to determine likely and worst case Cr^{6+} impacts and increased lifetime cancer risks. It should furthermore be noted that simulated annual average concentrations were conservatively applied in estimates of increased *lifetime* cancer risk. Given the above, the significance of Cr^{6+} related air quality impacts were found to be low.
- DPM impacts of medium significance are as a result of vehicle exhaust emissions. Ground level DPM concentrations were found to exceed assessment criteria off-site. Ground level DPM concentrations are likely to exceed assessment criteria off-site and at AQRs should access road option 1 or option 3 be selected.
- Inhalation health NO_2 impacts was found to have low significance at AQRs with off-site exceedances of assessment criteria.
- Inhalation health CO, SO_2 and VOC impacts as well as nuisance dustfall impacts were found to have low significance with no off-site exceedances of assessment criteria.

To ensure the lowest possible impact on AQRs and environment it is recommended that the air quality management plan as set out in this report should be adopted. This includes:

- The mitigation of sources of emission;
- The management of associated air quality impacts; and
- Ambient air quality monitoring.

Based on these findings and provided the measures recommended are in place, it is the specialist opinion that the project may be authorised.

6 AIR QUALITY MANAGEMENT MEASURES

Based on the findings of the baseline and impact assessment, the following mitigation, management and monitoring recommendations are made.

6.1 Air Quality Management Objectives

The main objective of the proposed air quality management measures for the project is to ensure that operations at the plant cumulatively result in ambient air concentrations that are within the relevant ambient air quality criteria off-site. In order to define site specific management objectives, the main sources of pollution needed to be identified. Sources area ranked based on source strengths (emissions) and impacts (concentrations). Once the main sources have been identified, target control efficiencies for each source can be defined to ensure acceptable cumulative ground level concentrations.

The ranking of sources serves to confirm the current understanding of the significance of specific sources, and to evaluate the emission reduction potentials required for each. Sources of emissions are ranked based on:

- Emissions; based on the comprehensive emissions inventory established for routine operations, and,
- Impacts; based on the simulated dustfall levels and PM concentrations.

6.1.1 Ranking of Sources by Emissions

Sources of **emissions** are ranked as follows from most to least significant:

1. Stacks/process emissions
2. Paved roads
3. Crushing and screening
4. Vehicle exhaust
5. Materials handling
6. Windblown dust

6.1.2 Ranking of Sources by Impact

Sources of **impacts** are ranked as follows from most to least significant:

1. Paved roads
2. Materials handling
3. Vehicle exhaust
4. Stacks/process emissions
5. Crushing and screening
6. Windblown dust

6.1.3 Conclusion with Regards to Source Ranking

From the preceding it can be concluded that the proposed management and mitigation measures (see Table 11) are effective. However, the reduction of emissions from vehicle entrainment on paved roads and vehicle exhaust must be considered to most notably reduce impacts on the environment. As these two sources do not have any proposed management and mitigation measures, the following section refers to management and mitigation measures recommended specifically for these.

6.1.4 Additional Source Specific Management and Mitigation Measures

6.1.4.1 Emissions Control for Vehicle Exhaust

Vehicle exhaust emission estimates in this study are based on emission factors released by the ADE. These factors were found to be fairly conservative when compared for instance with current European and American emission standards for heavy duty highway diesel engines (Table 27). The emission standards are defined in a series of directives staging the progressive introduction of increasingly stringent standards. NO_x and PM emission factors applied in this study are comparable to emission standards of the early nineteen nineties.

Table 27: Comparison of vehicle emission factors and international standards

Source/Directive	Date	CO (g/kWh)	NO_x (g/kWh)	PM (g/kWh)
ADE emission factors (ADE, 2008)		6.2	15	1.2
Euro emission standards for large heavy duty highway diesel engines				
Euro I	1992, <85 kW	4.5	8	0.612
	1992, >85 kW	4.5	8	0.36
Euro II	October 1996	4	7	0.25
	October 1998	4	7	0.15
Euro III	October 2000	2.1	5	0.1
Euro IV	October 2005	1.5	3.5	0.02
Euro V	October 2008	1.5	2	0.02
Euro VI	31 December 2013	1.5	0.4	0.01
US EPA Emission standards for large heavy duty highway diesel engines				
	1974 – 78	53.6	-	-
	1979 – 84	33.5	-	-
	1985 – 87	20.8	14.4	-
	1988 – 89	20.8	14.4	0.8
	1990	20.8	8	0.8
	1991 – 93	20.8	6.7	0.34
	1994 – 97	20.8	6.7	0.13
	1998 – 2003	20.8	5.3	0.13
	2004 – 2006	20.8	-	0.13
	2007 +	20.8	0.27	0.01

To meet internationally acceptable vehicle emission standards vehicle exhaust emissions can be reduced through the following methods:

- Diesel particulate filters (DPF) and selective catalytic reduction (SCR) or other similar tailpipe technologies;
- Use of better quality diesel; and
- Inspection and maintenance programs

Effective inspection and maintenance programs will ensure new vehicles remain in good condition and reduce emissions from old vehicles. For the Siyanda project, vehicles should be fitted with DPFs and SCR technologies. Regular maintenance and emission testing is recommended on all mobile diesel combustion sources. Use should also be made of low sulphur fuel (50 ppm better).

6.1.4.2 Dust Control Options for Paved Roads

Mechanical broom sweepers use large, rotating brooms to lift the material from the road onto a conveyor belt, which then discharges the debris into a collection hopper. In the early 1990s, mechanical broom sweeping was discounted as a feasible means of air pollution control on paved roads, with studies having shown that the brushes re-suspend as many particles as they remove (Chow, et al., 1990). Significant recent developments in broom sweeping technology have, however, reinstated these sweepers as a viable dust control alternative to vacuum sweeping.

Commercially available vacuum sweepers use pure vacuum suction, re-generative air suction, or blow-air suction re-circulation. Most vacuum sweepers use a gutter broom to loosen debris from the road surface and direct it to a vacuum nozzle, which sucks it into a hopper. The hopper usually consists of a chamber into which particles are collected by gravitational settling. The air is then exhausted either directly back into the environment, or through a bag-filter or precipitator, or to the collection nozzle for re-circulation (Chow, et al., 1990).

The control efficiency of vacuum and broom sweepers is dependent on: sweeper design and maintenance, the frequency of sweeping, the nature of the area being swept, and the particle size distribution of the dust on the roadway. Until recently, the control efficiency of vacuum sweepers was given as being generally in the range of 0% to 60%. The frequent use of efficiently designed and well maintained vacuum sweepers was found to provide an estimated PM_{10} control efficiency of between 30 and 60 % by studies conducted in the 1980s (Calvert, Brattin, Bhutra, & Ono, 1984) The control efficiency of daily sweeping with a regenerative-air vacuum sweeper was, however, found at this time to resulted in no detectable reductions in ambient PM_{10} concentrations (Chow, et al., 1990). One of the main reasons for the inefficiency of regenerative-air suction, and similar types of vacuum sweepers, was observed during the study to be due to the insufficient residence time of particles in the hopper collection chamber. The air was found not to be in the chamber for a long enough period to allow for the gravitational settling of particles in the PM_{10} size fraction. Instead small particles were directed back to the pickup head, and a significant portion of the particles are impacted back onto the road.

Developments in vacuum and broom sweepers over the past decade have resulted in significant increases in their PM_{10} control efficiency, with certain of the latest sweepers being shown to have efficiencies in excess of 80%. A wide variety of broom and vacuum sweepers are currently available on the market. In selecting a suitable sweeper, it is recommended that close attention be paid to the PM_{10} collection efficiency of the machine (Figure 42).

Factors in addition to PM_{10} control efficiency to be taken into account in selecting an appropriate sweeper include: the extent of the sweeping path, hopper capacity, water capacity, travel speed, drive-by noise levels and maneuverability. Large hopper, water and sweep path capacities allow for extended sweeping time and maximum productivity.

Vacuum and broom sweepers are routinely used in various South African industries in which fugitive dust emissions are a problem, including lead and asbestos industries, brickworks, cement factories, and various metallurgical smelters. Such sweepers are either purchased directly by the end user (~60% of cases) or alternatively use is made of contracting companies to supply sweeping services.

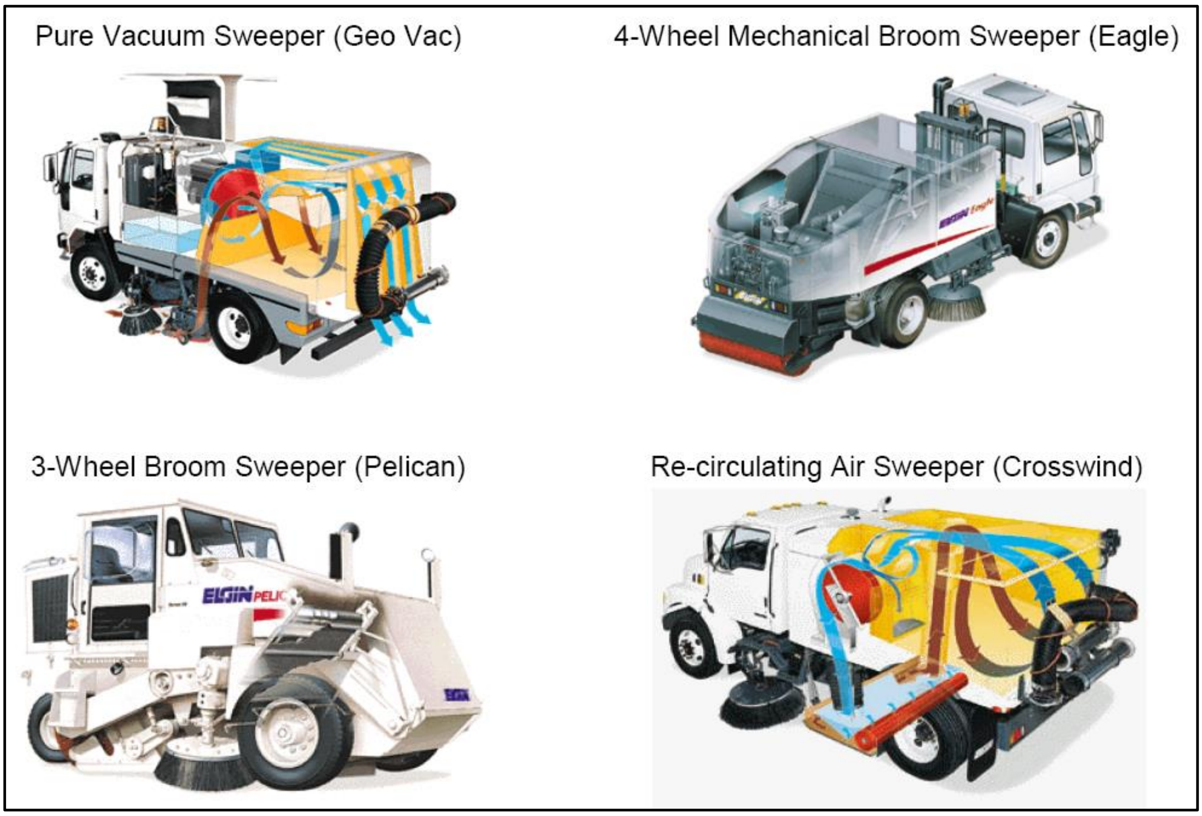

Figure 42: Examples of PM_{10} certified sweepers

6.1.5 Source Monitoring

Under Section 21 of the NEMAQA it is compulsory to measure and report annually, Cr^{6+} emissions from the primary fume capture systems of ferro chrome furnaces. It further requires the holder of an AEL to submit an emission report in the format specified by the National Air Quality Officer or Licensing Authority on an annual basis. It is therefore recommended that annual emission testing for PM, SO_2 and NO_x also be conducted on an annual basis. See Table 28 for recommended stack emissions testing.

It should however be noted that stack emissions testing on cleaned/raw furnace off-gas before is impractical and dangerous due to the high CO content. If flared, emissions from primary furnace off gas must rather be estimated from emission factors, limits and or mass balance methods. Since it is likely that cleaned furnace off gas will be combusted and utilised for drying and preheating emission testing at the outlet of these process can be sampled safely.

Table 28: Recommended stack emissions testing

Source	Annual emission testing	Pollutants
Raw materials dust extraction baghouse stack	Yes	PM
Reductant/flux drier baghouse stack	Yes	PM, SO_2 and NO_x (Cr^{6+} to be included if furnace off gas is used as an energy source)
Concentrate drier baghouse stack	Yes	PM, SO_2 and NO_x (Cr^{6+} to be included if furnace off gas is used as an energy

Source	Annual emission testing	Pollutants
		source)
Secondary furnace fume extraction baghouse stacks	Yes	PM, Cr^{6+}, SO_2 and NO_x
Pre-heater stack(s) if applicable	Yes	PM, Cr^{6+}, SO_2 and NO_x
Clean gas furnace flare stacks	No	-
Raw gas furnace flare stacks	No	-

It is further recommended that exhaust emissions testing be done on all mobile and stationary diesel combustion sources as part of equipment maintenance schedules.

Should the abovementioned source monitoring be implemented the suggested IFC General EHS guidelines (IFC, 2007) for source monitoring will also be satisfied.

6.1.6 Ambient Air Quality Monitoring

Ambient air quality monitoring can serve to meet various objectives, such as:

- Compliance monitoring;
- Validate dispersion model results;
- Use as input for health risk assessment;
- Assist in source apportionment;
- Temporal trend analysis;
- Spatial trend analysis;
- Source quantification; and,
- Tracking progress made by control measures.

It is recommended that, as a minimum continuous dustfall, PM_{10}, $PM_{2.5}$ sampling be conducted as part of the project's air quality management plan. It is also suggested that a short sampling campaign after commencement of operations for NO_2, SO_2 and VOCs be conducted to determine if the operations are compliant with the NAAQSs. Recommended sampling locations are shown in Figure 45. These locations were selected for the reasons given in Table 29.

The same methods currently employed for baseline/pre-development sampling are recommended. These include:

- For dustfall, the NDCR specifies that the method to be used for measuring dustfall and the guideline for locating sampling points shall be ASTM D1739 (1970), or equivalent method approved by any internationally recognized body.
- For PM_{10} and $PM_{2.5}$ the method as set out by British Standards (BS EN 12341).
- Radiello® passive/diffusive samplers for NO_2, SO_2 and VOC sampling.

Should the discussed ambient monitoring be implemented the suggested IFC General EHS guidelines (IFC, 2007) for ambient monitoring will mostly be satisfied. Based on the IFC General EHS guidelines for ambient monitoring, the installation of a weather station is also recommended.

Table 29: Sampling locations and parameters

No.	Description	Parameter to be Sampled	Reasoning
1	North-western corner of boundary	Dustfall, PM_{10} and $PM_{2.5}$, NO_2, SO_2 and VOCs	In the maximum impact zone between areas of operation and most affected AQR.
2	Along boundary directly south of operations	Dustfall	Existing dustfall sampling location.
3	Along boundary east of operations	Dustfall	Existing dustfall sampling location.
4	Along boundary south-east of operations	Dustfall and meteorological data	Existing dustfall sampling location. Weather station is unlikely to be blocked by surrounding objects.
5	North of crusher plant	Dustfall	To determine dustfall as a result of crushing operations.

6.1.6.1 Dustfall Sampling

The ASTM method covers the procedure of collection of dustfall and its measurement and employs a simple device consisting of a cylindrical container (not less than 150 mm in diameter) exposed for one calendar month (30 ±2 days). Even though the method provides for a dry bucket, de-ionised (distilled) water can be added to ensure the dust remains trapped in the bucket.
The bucket stand includes wind shield at the level of the rim of the bucket to provide an aerodynamic shield. The bucket holder is connected to a 2 m galvanized steel pole, which is either planted and cemented or directly attached to a fence post (Figure 43). This allows for a variety of placement options for the fallout samplers. Two buckets are usually provided for each dust bucket stand. Thus, after the first month, the buckets get exchanged with the second set.

Collected sampled are sent to an accredited laboratory for gravimetric analysis. At the laboratory, each sample will be rinsed with clean water to remove residue from the sides, and the contents filtered through a coarse (>1 mm) filter to remove insects and other course organic detritus. The sample is then filtered through a pre-weighed paper filter to remove the insoluble fraction. This residue and filter are dried, and gravimetrically analysed to determine total dustfall.

6.1.6.2 PM_{10}/$PM_{2.5}$ Sampling

Ambient PM_{10}/$PM_{2.5}$ concentrations can be determined through the use a MiniVol sampler (Figure 44). In summary, the monitoring methodology is as follows:

- The MiniVol sampler is programmed to draw air over a pre-weighed filter at a constant rate over a 24-hour period.
- At an interval of 1 in 2 days or 1 in 3 days, the used filter is removed, a new filter put in place, the battery exchanged (each MiniVol is equipped with two batteries) and the MiniVol re-programmed.
- The used filter is removed from the filter holder assembly in a clean environment and sealed in its dish.
- At each exchange, the date, location, filter number, pump run time etc. need to be noted in the data sheet that will be sent to the laboratory with the sealed samples for analysis.

6.1.6.3 Passive Diffusive Tubes

Radiello® passive diffusive tubes can be employed for the sampling of SO_2, NO_2 and VOC concentrations. Passive diffusive sampling relies on the diffusion of analytes through a diffusive surface onto an adsorbent. After sampling, the analytes are chemically desorbed by solvent extraction or thermally desorbed and analysed. Passive sampling does not involve the use of pumping systems and does not require electricity

Passive diffusive samplers should be placed at eye level in representative outdoor areas. The manufacturer approved rain shelter attached to a post in a central position to insure protection against adverse weather conditions, while insuring adequate ventilation. Supporting plates should be assembled and operated according to manufacturer instructions. Exposure time can vary from 14 to 16 days, as per the manufacture's recommendations. The analytical methods and calculations depend on the pollutant according to the manufacturer specification sheets. In Figure 44, a passive diffusive sampler is installed behind the MiniVol.

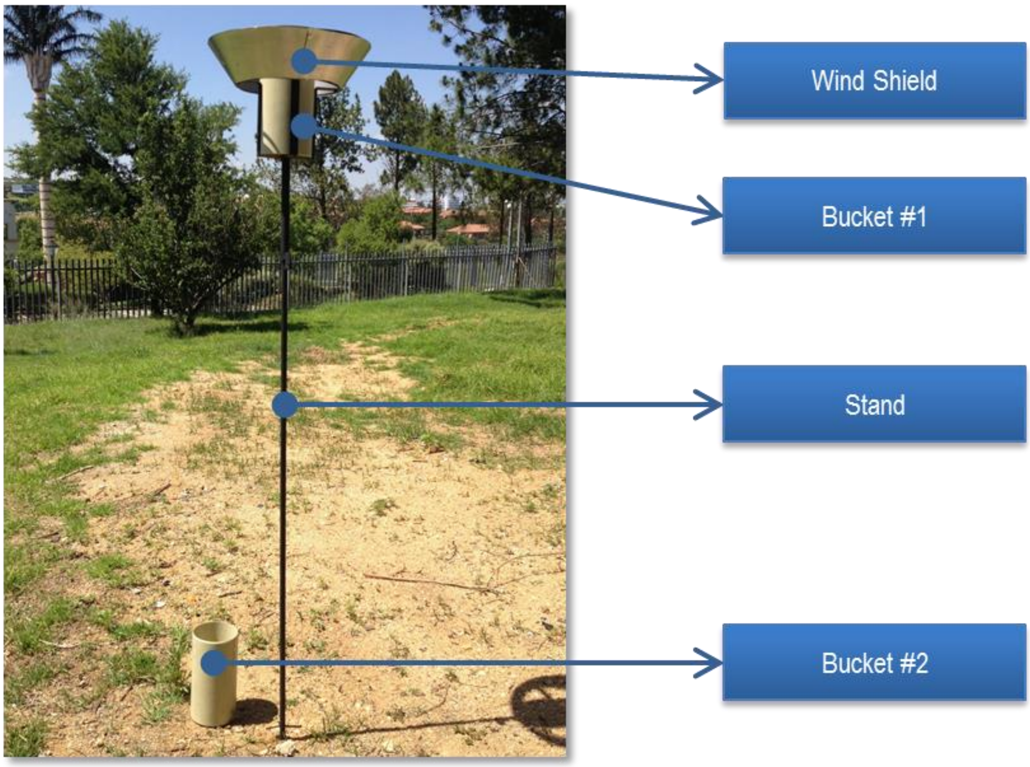

Figure 43: Dustfall collection unit example

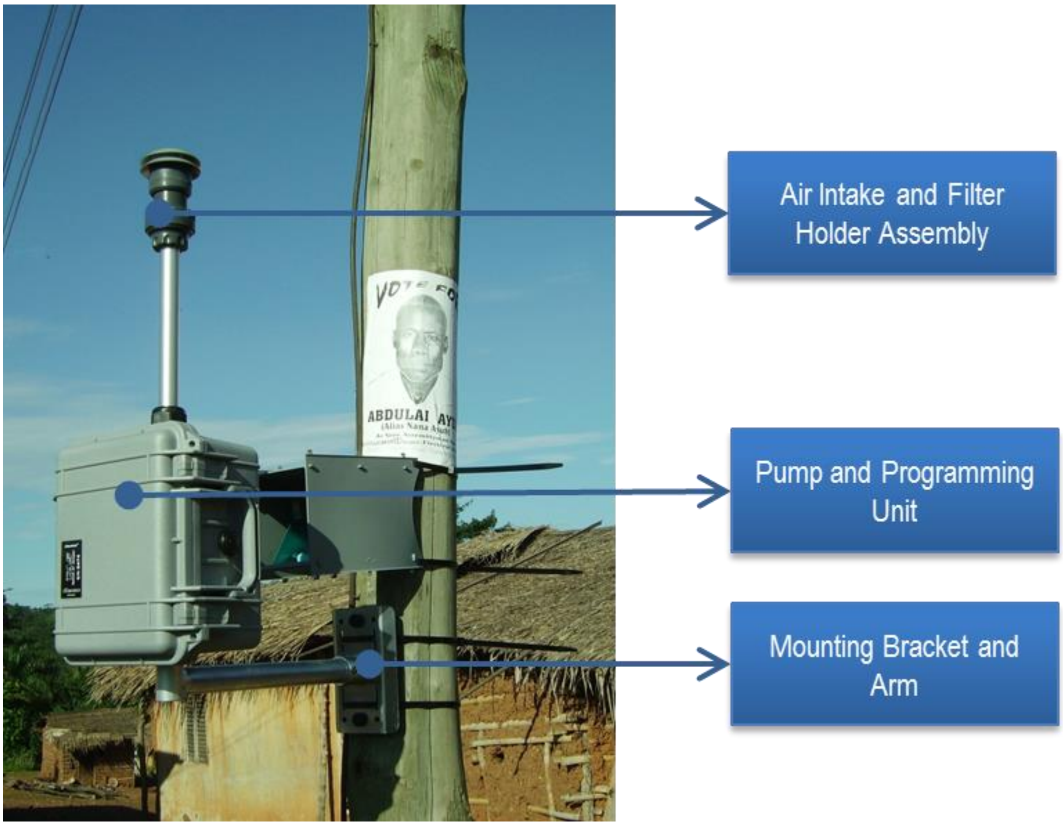

Figure 44: Example of typical PM_{10} MiniVol setup with Radiello® passive diffuse tube setup behind

Figure 45: Recommended sampling locations

6.2 Record-keeping, Environmental Reporting and Community Liaison

6.2.1 Periodic Inspections and Audits

Periodic inspections and external audits are essential for progress measurement, evaluation and reporting purposes. It is recommended that site inspections and progress reporting be undertaken at regular intervals (at least quarterly), with annual environmental audits being conducted. Annual environmental audits should be continued at least until closure. Results from site inspections and monitoring efforts should be combined to determine progress against source- and receptor-based performance indicators. Progress should be reported to all interested and affected parties, including authorities and persons affected by pollution.

The criteria to be taken into account in the inspections and audits must be made transparent by way of minimum requirement checklists included in the management plan. Corrective action or the implementation of contingency measures must be proposed to the stakeholder forum in the event that progress towards targets is indicated by the quarterly/annual reviews to be unsatisfactory.

6.2.2 Liaison Strategy for Communication with I&APs

Stakeholder forums provide possibly the most effective mechanisms for information dissemination and consultation. Management plans should stipulate specific intervals at which forums will be held, and provide information on how people will be notified of such meetings. For operations for which un-rehabilitated or party rehabilitated impoundments are located in close proximity (within 3 km) from community areas, it is recommended that such meetings be scheduled and held at least on a bi-annual basis. A complaints register must be kept at all times.

6.2.3 Financial Provision

The budget should provide a clear indication of the capital and annual maintenance costs associated with dust control measures and dust monitoring plans. It may be necessary to make assumptions about the duration of aftercare prior to obtaining closure. This assumption must be made explicit so that the financial plan can be assessed within this framework. Costs related to inspections, audits, environmental reporting and I&AP liaison should also be indicated where applicable. Provision should also be made for capital and running costs associated with dust control contingency measures and for security measures. The financial plan should be audited by an independent consultant, with reviews conducted on an annual basis.

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8 Annex A – Specialist's Curriculum Vitae

CURRICULUM VITAE

Name	Nicolette von Reiche (nee Krause)
Date of Birth	22 October 1982
Nationality	South African
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Principal Consultant and Project Manager
Profession	Mechanical Engineer employed as a Air Quality and Environmental Noise Assessment Consultant
Years with Firm	9 Years

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- South African Acoustic Institute (SAAI), 2006 to present
- National Association for Clean Air (NACA), 2006 to present
- International Institute for Acoustics and Vibration (IIAV), 2014 to present

EXPERIENCE

Nicolette has over nine years of experience in both air quality and noise impact assessment and management. She is an employee of Airshed Planning Professionals (Pty) Ltd and is involved in the compilation of emission inventories, atmospheric dispersion modelling, air pollution mitigation and management, and air pollution impact work. Airshed Planning Professionals is affiliated with Francois Malherbe Acoustic Consulting cc and in assisting with numerous projects she has gained experience in environmental noise measurement, modelling and assessment as well.

A list of projects competed in various sectors is given below:

Power Generation, Oil and Gas

eni East Africa S.p.A Rovuma Area 4 baseline for offshore gas (Mozambique), Staatsolie Power Company Suriname (Suriname), Benga Coal Fired Power Station (Mozambique), Zuma Energy Project (Nigeria), Anglo Coal Bed Methane Project, Eskom Ash Disposal Projects for Kusile Power Station, Camden Power Station and Kendal Power Station, Hwange Thermal Coal Fired Power Station Project (Zimbabwe), Eskom Ankerlig Gas Power Station.

Industrial Sector

Scantogo Cement Project (Togo), Boland Bricks, Brits Ferrochrome Smelter Project, Samancor Chrome's Ferrometals, Middelburg Ferrochrome and Tubatse Ferrochrome, BHP Billiton Metalloys Ferromanganese Projects and Mamatwan Sinter Plant Projects, Tharisa Minerals Concentrator Plant Project, Obuasi Gold Processing Plant (Ghana), Obuasi Gold Mine Pompora Treatment Plant Project (Ghana), Afrisam Saldanha Project, Scaw Metals Projects, including a Co-generation Plant and Steel Wire Rope Plant Project, Delta EMD Project, Dense Medium Separation (DMS) Powders Project, Transalloys Silica Manganese, Dundee Precious Metals Tsumeb (Namibia), Rössing Uranium Desalination Plant (Namibia), Otavi Steel Project (Namibia)

Air Quality and Environmental Noise Management

- Saldanha Industrial Development Zone (IDZ) – Part of an integrated team of specialists that developed the proposed development and management strategies for the IDZ. Air quality guidelines were developed and a method of determining emissions for potential developers. The investigation included the establishment of the current air emissions and air quality impacts (baseline) with the objective to further development in the IDZ and to allow equal opportunity for development without exceeding unacceptable air pollution levels.
- Gauteng Department of Transport air quality and noise management plan - The plan involved the identification of main traffic related sources of noise and air pollution, the identification of intervention strategies to reduce traffic related noise and emissions to air and the theoretical testing of intervention strategies through emission quantification and dispersion modelling of selected case studies.
- Erongo Strategic Environmental Impact Assessment (Namibia) and Air Quality Management Plan

Mining Sector

- **Coal mining:** Elders Colliery, Grootgeluk Colliery, Inyanda Colliery, Boschmanspoort Colliery, Benga Mine (Mozambique), Vangatfontein Colliery Dust Monitoring, T-Project Underground Coal Mine, Lusthof Colliery
- **Metalliferous mines:** Samancor Chrome's Eastern and Western Chrome Mines, Kinsenda Copper Mine (DRC), Bannerman Uranium Mine (Namibia), Sadiola Gold Mine Deep Sulphides Project (Mali), Kolomela Iron Ore Mine Noise Monitoring, Mamatwan Manganese Mine, Ntsimbintle Manganese Mine, Tharisa Minerals Chrome and Platinum Group Metals Open-pit Mine Project, Obuasi Gold Mine (Ghana), Omitiomire Copper Mine (Namibia), Perkoa Zinc Project (Burkina Faso), Tschudi Copper Mine (Namibia), Rössing Uranium Mine (Namibia), WCL Iron Ore Mines (Liberia), Fekola Gold Project (Mali), Esaase Gold Project (Ghana), Xstrata Paardekop and Amersfoort Underground Coal Mines, Mampon Gold Mine (Ghana), Husab Uranium Mine (Namibia), Mkuju River Uranium Project (Tanzania), Impala Platinum Mine, Angola Exploration Mining Resources Project (Angola), Kanyika Niobium Mine (Malawi)
- **Quarries:** Scantogo Limestone Quarry, Lion Park Quarries Dustfall Monitoring

Waste Disposal and Treatment Sector

Aloes Hazardous Waste Disposal Site, Holfontein Hazardous Waste Disposal Site, Shongweni Hazardous Waste Disposal Site, Coega General and Hazardous Waste Disposal Site, Umdloti Waste Water Treatment Works, Waltloo Medical Waste Incinerator

Transport and Logistics Sector

Saldanha Iron Ore Port Projects and Railway Line, Gautrain Environmental Noise Monitoring Project, Guinea Port and Railway Project (Guinea), Kenneth Kaunda International Airport Expansion (Zambia), Zambia Dry Port Project in Walvis Bay (Namibia)

Ambient Air Quality and Noise Sampling

- Gravimetric Particulate Matter (PM) and dustfall sampling
- Passive diffusive gaseous pollutant sampling
- Environmental noise sampling
- Source noise measurements

SOFTWARE PROFICIENCY

- Atmospheric Dispersion Models: AERMOD, ISC, CALPUFF, ADMS (United Kingdom), CALINE, GASSIM, TANKS
- Noise Propagation Modeling: Integrated Noise Model (for airport noise), CONCAWE, South African National Standards (SANS 10210) for Calculating and Predicting Road Traffic Noise
- Graphical Processing: Surfer, ArcGIS (basic proficiency)
- Other: MS Word, MS Excel, MS Outlook

EDUCATION

- BEng: (Mechanical Engineering), 2005, *University of Pretoria*
- BEng (Hons): (Mechanical Engineering) 2010, *University of Pretoria*; specializing in:
  - Advance Heat and Mass Transfer
  - Advanced Fluid Mechanics
  - Numerical Thermo-flow
  - Tribology

COURSES COMPLETED AND CONFERENCES ATTENDED

- Course: Air Quality Management. Presented by the University of Johannesburg (March 2006)
- Course: AERMET/AERMAP/AERMOD Dispersion Model. Presented by the University of Johannesburg (March 2010)
- Conference: NACA (October 2007), Attended and presented a paper
- Conference: NACA (October 2008), Attended and presented a paper
- Conference: NACA (October 2011), Attended and presented a poster
- Conference: NACA (October 2012), Attended and presented a paper
- Conference: IUAPPA (October 2013), Attended and presented a paper

COUNTRIES OF WORK EXPERIENCE

South Africa, Mozambique, Zimbabwe, Zambia, Namibia, the Democratic Republic of the Congo, Botswana, Ghana, Liberia, Togo, Mali, Burkina Faso, Tanzania, Malawi, Angola, Nigeria and Suriname

LANGUAGES

	Speak	Read	Write
English	Excellent	Excellent	Excellent
Afrikaans	Excellent	Excellent	Excellent

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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CERTIFICATION

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

28/03/2015

FULL CURRICULUM VITAE

Name of Firm	Airshed Planning Professionals (Pty) Ltd
Name of Staff	Natasha Anne Shackleton (nee Gresse)
Position	Senior Air Quality Consultant
Profession	Meteorologist employed as an Air Quality Consultant
Date of Birth	12 September 1988
Years with Firm	5 Years
Nationality	South African

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Golden Key International Honour Society, 2011 to present.

KEY QUALIFICATIONS

Natasha has 5 years of experience in air quality impact assessment and management. She is an employee of Airshed Planning Professionals (Pty) Ltd and is involved in the compilation of emission inventories, air pollution mitigation and management, and air pollution impact work. Airshed Planning Professionals is affiliated with Francois Malherbe Acoustic Consulting cc and in assisting with projects she has gained experience in environmental noise measurement, modelling and assessment.

A list of projects competed in various sectors is given below.

Mining Sector

- **Coal mining**: Argent Colliery, Commissiekraal Coal Mine, Estima Coal Project (Mozambique), Grootegeluk Coal Mine, Matla Coal Mine, Rietvlei Coal Mine, Vuurfontein Coal Mine.

- **Metalliferous mines**: Bakubung Platinum Mine, Bannerman Uranium Mine (Namibia), Gold Fields' South Deep Gold Mine, Kitumba Copper Project (Zambia), Lehating Manganese Mine, Lesego Platinum Mine, Lofdal Mining Project (Namibia), Marula Platinum Mine, Maseve Platinum Mine, Mkuju River Uranium Project (Tanzania), Namakwa Sands Quartz Rejects Disposal and Mine, Otjikoto Gold Project (Namibia), Otjikoto Gold Mine's Wolfshag Project (Namibia), Pan Palladium Project, Perkoa Zinc Project (Burkina Faso), Tete Iron Ore Project (Mozambique), Thabazimbi Iron Ore's Infinity Project, Toliara Sands Project (Madagascar), Trekkopje Uranium Mine (Namibia), Tschudi Copper Mine (Namibia), Wayland Iron Ore Project, Zulti South Project.
- **Quarries**: AfriSam Saldanha Cement Project Limestone Quarry.

Industrial Sector

AfriSam Saldanha Project; CAH Chlorine Caustic Soda and HCl Plant, Namakwa Sands Dryer, Otavi Rebar Manufacturing, Pan Palladium Project, PPC Riebeeck Cement, Rare Earth Elements Saldanha Separation Plant, Siyanda Project.

Power Generation, Oil and Gas

Hwange Thermal Power Station Project (Zimbabwe), Ibhubesi Gas Project, Expansion of Staatsolie Power Company, Suriname Operations (Suriname).

Waste Disposal and Treatment Sector

Fishwater Flats Waste Water Treatment Works, Moz Environmental Industrial Landfill (Mozambique).

Petroleum Sector

Puma South Africa's Fuel Storage Facility.

Transport and Logistics Sector

Saldanha Port Project.

EDUCATION

- BSc (2010), *University of Pretoria*. Major courses completed include:
    - meteorology,
    - remote sensing,
    - cartography,
    - GIS,
    - land surveying,
    - mathematics, and
    - physics.
- BSc(Hons) Meteorology (2011), *University of Pretoria.* Major courses completed include:
    - dynamical meteorology,
    - remote sensing,
    - cloud dynamics,
    - cloud microphysics,
    - boundary layer meteorology,
    - numerical modeling applications, and
    - tropical and mesoscale meteorology.

COUNTRIES OF WORK EXPERIENCE

South Africa, Botswana, Burkina Faso, Mozambique, Madagascar, Namibia, Suriname, Tanzania, Zambia and Zimbabwe.

LANGUAGES

	Speak	Read	Write
English	Excellent	Excellent	Excellent
Afrikaans	Good	Good	Good

CERTIFICCATION

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

01/04/2016

9 ANNEX B – SLR IMPACT SIGNIFICANCE RATING METHODOLOGY

Table 30: Criteria for assessment of impacts

PART A: DEFINITION AND CRITERIA*		
Definition of **SIGNIFICANCE**		Significance = consequence x probability
Definition of **CONSEQUENCE**		Consequence is a function of severity, spatial extent and duration
Criteria for ranking of the **SEVERITY** of environmental impacts	**H**	Substantial deterioration (death, illness or injury). Recommended level will often be violated. Vigorous community action.
	M	Moderate/ measurable deterioration (discomfort). Recommended level will occasionally be violated. Widespread complaints.
	L	Minor deterioration (nuisance or minor deterioration). Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	L+	Minor improvement. Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	M+	Moderate improvement. Will be within or better than the recommended level. No observed reaction.
	H+	Substantial improvement. Will be within or better than the recommended level. Favourable publicity.
Criteria for ranking the **DURATION** of impacts	**L**	Quickly reversible. Less than the project life. Short term
	M	Reversible over time. Life of the project. Medium term
	H	Permanent. Beyond closure. Long term.
Criteria for ranking the **SPATIAL SCALE** of impacts	**L**	Localised - Within the site boundary.
	M	Fairly widespread – Beyond the site boundary. Local
	H	Widespread – Far beyond site boundary. Regional/ national

PART B: DETERMINING CONSEQUENCE					
			SEVERITY = L		
DURATION	Long term	**H**	Medium	Medium	Medium
	Medium term	**M**	Low	Low	Medium
	Short term	**L**	Low	Low	Medium
			SEVERITY = M		
DURATION	Long term	**H**	Medium	High	High
	Medium term	**M**	Medium	Medium	High
	Short term	**L**	Low	Medium	Medium
			SEVERITY = H		
DURATION	Long term	**H**	High	High	High
	Medium term	**M**	Medium	Medium	High
	Short term	**L**	Medium	Medium	High
			Localised Within site boundary Site	Fairly widespread Beyond site boundary Local	Widespread Far beyond site boundary Regional/ national
			SPATIAL SCALE		

PART C: DETERMINING SIGNIFICANCE					
PROBABILITY (of exposure to impacts)	Definite/ Continuous	**H**	Medium	Medium	High
	Possible/ frequent	**M**	Medium	Medium	High
	Unlikely/ seldom	**L**	Low	Low	Medium
			L	**M**	**H**
			CONSEQUENCE		

PART D: INTERPRETATION OF SIGNIFICANCE	
Significance	Decision guideline
High	It would influence the decision regardless of any possible mitigation.
Medium	It should have an influence on the decision unless it is mitigated.
Low	It will not have an influence on the decision.

***H = high, M= medium and L= low and + denotes a positive impact.**

10 ANNEX C – DUST EFFECTS ON VEGETATION AND ANIMALS

10.1 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, Mills, Hayes, Williams, & De Temmerman, 2005). Heavy loads of particle can also result in reduced light transmission to the chloroplasts and the occlusion of stomata (Harmens, Mills, Hayes, Williams, & De Temmerman, 2005); (Naidoo & Chirkoot, 2004), decreasing the efficiency of gaseous exchange (Harmens, Mills, Hayes, Williams, & De Temmerman, 2005); (Naidoo & Chirkoot, 2004); (Ernst, 1981) and hence water loss (Harmens, Mills, Hayes, Williams, & De Temmerman, 2005). They may also disrupt other physiological processes such as budbreak, pollination and light absorption/reflectance (Harmens, Mills, Hayes, Williams, & De Temmerman, 2005). The chemical composition of the dust particles can also affect the plant and have indirect effects on the soil pH (Spencer, 2001).

To determine the impact of dust deposition on vegetation, two factors are of importance: (i) Does dust collect on vegetation and if it does, what are the factors influencing the rate of deposition (ii) Once the dust has deposited, what is the impact of the dust on the vegetation?

Regarding the first question, there is adequate evidence that dust does collect on all types of vegetation. Any type of vegetation causes a change in the local wind fields, with an increase in turbulence which enhances the collection efficiency. The characteristics of the vegetation influences the rate; the larger the “collecting elements” (branches and leaves), the lower the impaction efficiency per element. This would seem to indicate that, for the same volume of tree/shrub canopy, finer leaves will have a better collection efficiency. However, the roughness of the leaves themselves and particularly the presence of hairs on the leaves and stems plays a significant role, with veinous surfaces increasing deposition of 1-5 micron particles by up to seven times compared to smooth surfaces. Collection efficiency rises rapidly with particle size; for moderate wind speeds wind tunnel studies show a relationship of deposition velocity on the fourth power of particle size (Tiwary & Colls, 2010). In wind tunnel studies , windbreaks or “shelter belts” of three rows of trees has shown a decrease in 35 to 56% in the downwind mass transport of inorganic particles.

On the effect of particulate matter once it is deposited on vegetation, this depends on the composition of the dust. Internationally it is recognised that there are major differences in the chemical composition of the fine PM (the fraction between 0 and 2.5 µm in aerodynamic diameter) and coarse PM (the fraction between 2.5 µm and 10 µm in aerodynamic diameter). The former is often the result of chemical reactions in the atmosphere and may have a high proportion of black carbon, sulphate and nitrate, whereas the latter often consist of primary particles resulting from abrasion, crushing, soil disturbances and wind erosion (Grantz, Garner, & Johnson, 2003). Sulphate is however often hygroscopic and may exist in significant fractions in coarse PM. Alade, 2009. Grantz, Garner, & Johnson, 2003 (*op .cit.*) do however indicate that sulphate is much less phototoxic than gaseous sulphur dioxide and that “it is unusual for injurious levels of particular sulphate to be deposited upon vegetation”.

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, fully exposed, sun leaves 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 found not to be toxic to the leaves; neither wasit found that it occlude stomata as these particles were larger than fully open stomatal apertures (Naidoo & Chirkoot, 2004).

In general, according to the Canadian Environmental Protection Agency (CEPA), air pollution adversely affects plants in one of two ways. Either the quantity of output or yield is reduced or the quality of the product is lowered. The former (invisible) injury results from pollutant impacts on plant physiological or biochemical processes and can lead to significant loss of growth or yield in nutritional quality (e.g. protein content). The latter (visible) may take the form of discolouration of the leaf surface caused by internal cellular damage. Such injury can reduce the market value of agricultural crops for which visual appearance is important (e.g. lettuce and spinach). Visible injury tends to be associated with acute exposures at high pollutant concentrations whilst invisible injury is generally a consequence of chronic exposures to moderately elevated pollutant concentrations. However given the limited information available, specifically the lack of quantitative dose-effect information, it is not possible to define a Reference Level for vegetation and particulate matter (CEPA/FPAC Working Group, 1998).

Exposure to a given concentration of airborne PM may therefore lead to widely differing phytotoxic responses, depending on the mix of the deposited particles. The majority of documented toxic effects indicate responses to the chemical composition of the particles. Direct effects have most often been observed around heavily industrialised point sources, but even there, effects are often associated with the chemistry of the particulate rather than with the mass of particulate.

10.2 Dust Effects on Animals

Most of the literature regarding air quality impacts and animals, specifically cattle, refers to the impacts from feedlots on the surrounding environment, hence where the feedlot is seen as the source of pollution. This mainly pertains to odours and dust generation. The US EPA has recently started to focus on the control of air pollution from feed yards and dairies, primarily regulating coarse particulate matter ((Horzinek & Lutz, 2001). The National Cattle Beef Association in the USA in response has disputed this decision based on the lack of evidence on health impacts associated with coarse dust (TSP) concentrations.

A study was conducted by the State University of IOWA on the effects of air contaminants and emissions on animal health in swine facilities. Air pollutants included gases, particulates, bioaerosols, and toxic microbial by-products. The main findings were that ammonia is associated with lowered average number of pigs weaned, arthritis, porcine stress syndrome, muscle lesions, abscesses, and liver ascarid scars. Particulates are associated with the reduction in growth and turbine pathology, and bioaerosols could lower feed efficiency, decrease growth, and increase morbidity and mortality. The study concurred the lack of information on the health effects and productivity problems of air contaminants on cattle and other livestock. Ammonia and hydrogen sulphide are regarded the two most important inorganic gases affecting the respiratory system of cattle raised in confinement facilities, affecting the mucociliary transport and alveolar macrophage functions. With regard to particulates, it was found that it is the fine inhalable fraction that is mainly deriving from dried faecal dust (Holland, Carson, & Donham, 2002). Another study conducted by DSM Nutritional Products North America indicated that calves exposed to a dust-stress environment continued to have lower serum vitamin E concentrations.

Inhalation of confinement house dust and gases produces a complex set of respiratory responses. An individual’s response depends on characteristics of the inhaled components (such as composition, particle size and antigenicity) and of the individual’s susceptibility, which is tempered by extant respiratory conditions. Most of the studies concurred that the main implication of dusty environments are causing animal stress which is detrimental to their health. However, no threshold levels exist to indicate at what levels these are having a negative effect. In this light it was decided to use the same screening criteria applied to human health, i.e. international standards and SA NDCR values.

11 ANNEX D – COMMENTS/ISSUES RAISED

Table 31: I&APs' comments and applicable sections of the report

Comment	Person responsible for comment	Applicable section in report
I am concerned about air quality impacts. When the southerly wind blows, I will be breathing this air from the plant.	Comment raised by Hannes Olckers at scoping meeting, Northam Town Hall, 23 July 2015	It was determine that air quality impacts occur most significantly to the west-north-west and north-west of operations; however, simulated results showed that exceedances of the standards are not likely to occur at any of the receptors during the operational phase. See section 4.3 for more information.
We are concerned about air quality impacts	Comment by Philip Schoeman and Pier De Vries during focused scoping meeting with Union Mine, 13 May 2015	It was determine that air quality impacts occur most significantly to the west-north-west and north-west of operations. 1. Simulated results showed that exceedances of the standards are likely to occur at multiple receptors during the construction phase. This phase occurs for a short period in comparison to operational phase thus significance is likely to be medium to low. 2. Simulated results showed that exceedances of the standards are not likely to occur at any of the receptors during the operational phase. 3. See section 4 and section 5 for more information.
I am concerned about the air quality impacts and how far the pollution will travel from the proposed smelter.	Comment raised by William Segone at scoping meeting, Mmansterre, 21 July 2015	
It is common knowledge that a Ferrochrome Smelter is associated with, amongst others: air pollution.	Comment raised by Ernst Burger (on behalf of the Schoeman family, the beneficiaries of a Testamentary Trust) – draft scoping report comments, received on the 04 May 2016	It was determine that air quality impacts occur most significantly to the west-north-west and north-west of operations; however, simulated results showed that exceedances of the standards are not likely to occur at any of the receptors during the operational phase. For more information on the air pollution associated with this smelter. See section 1.3, section 4 and section 5.
We are concerned about the dust fallout and the impacts that it might have on the receiving environment.	Comments raised by Sandy McGill, Mr and Mrs Schoeman at the scoping meeting, Swartklip Rec Centre, 21 July 2015	Nuisance dustfall impacts were found to have low significance with no off-site exceedances of assessment criteria. See section 4.4, section 4.6 and section 5 for more information.
Dust from existing mines is already an issue for neighbouring farmers. There is active monitoring done by the mines however according to the regulations the mine dust is under		While there is little direct evidence of what the impact of dust fall on vegetation is under a South African context, a review of European studies has shown the potential for reduced

the exceedance limits. This does not make sense because we still experience veld deterioration due to the dust.		growth and photosynthetic activity in sunflower and cotton plants exposed to dust fall rates greater than 400 mg/m²/day (Farmer, 1993). See section 3.3, section 5 and section 10.1 for more information.
I am concerned about air quality impacts with regard to the health associated impacts.	Comment raised by Grace Goso at scoping meeting, Kwetsheza, 22 July 2015	It was determine that air quality impacts occur most significantly to the west-north-west and north-west of operations; however, simulated results showed exceedances of the standards is not likely occur at any of the receptors. See section 4.3 and section 5 for more information.
I am concerned about dust associated with using this road (alternative 3). It makes the veld un-utilisable and I am also concerned about health related impacts.	Comment by Johan Young at focused meeting, on Johan Young's property (Kameelhoek ptn 9), 26 May 2016	It is unlikely that there will be exceedances at the receptors due to access road operations (vehicle entrainment along access road and vehicle exhaust) for all the access road options. See section 4.3 Section 4.5 Section 5
You mentioned that there is currently baseline air quality monitoring done for the proposed project, would you kindly confirm the duration of the baseline monitoring.	Comment raised by Stanley Koenaite (WDM: Air Quality) at the authority site visit-meeting, Swartklip Rec Centre, 23 July 2015	Baseline/pre-development ambient air quality sampling commenced on 1 June 2015 and ended on 8 July 2016. See section 3.3.2 for more information.
What parameters are being measured as part of your baseline monitoring campaign?		Dustfall rates, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and VOC concentration are currently being sampled at the proposed site. See section 3.3.2 for more information.
We would also like some sort of specialist to come and see why our trees and grasses are dying. We think it may be "acid rain" from the present smelter - and a second smelter will probably make it worse. The trees that have died include: Maroelas, Sickle-bush, Dombeya (wild pear), "Kan-nie Dood, Jacket Plums, and Prickly Pears. A number of waterbuck and reed-buck also just died for no apparent reason.	Comment raised by Sandy McGill, via email, 29 July 2015	It is likely that sulphur from the project would not really be linked to localised acid rain due to the low SO_2 concentrations as a result of the project. It could increase the corrosion potential in the area.