

**Project Done on Behalf of
Sasol Technology (Pty) Ltd**

**Atmospheric Impact Report:
Sasol Infrachem, a division of Sasol Chemical Industries Limited**

Report Number: 13STL01SB

Report Version: 2.0

Date: September 2014

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Preface

Sasol Infrachem, a division of Sasol Chemical Industries Limited, operation in Sasolburg is required to comply with the Minimum Emissions Standards, which came into effect in terms of Section 21 of the National Environment Management: Air Quality Act (Act No 39 of 2004) on 1 April 2010. The Minimum Emission Standards were subsequently amended and the amendments were promulgated on 22 November 2013 (Government Gazette No. 37054), replacing the 2010 regulations. These standards require the operations to comply with standards for “existing plant” by 1 April 2015, and for “new plant” by 1 April 2020. Sasol intends submitting an application for postponement from the compliance timeframes. In support of the submissions and to fulfil the requirements for these applications stipulated in the Air Quality Act and the Minimum Emissions Standards, an Atmospheric Impact Report (AIR) is required to substantiate the motivations for the postponement.

At the Sasolburg facility, Sasol Infrachem is responsible to supply utilities as well as reformed and synthesis gas to the other Sasol Business Units operating on the site. Apart from coal-fired steam stations supplying steam and electricity, natural gas is reformed in two auto thermal reformers (ATRs) with oxygen at high temperature to produce synthesis gas (syngas). This syngas is distributed to Sasol Wax, to produce a range of waxes and paraffins, and to Sasol Solvents, to produce methanol, butanol and acrylates. Tail gases from various gas units are used in the ammonia plant to produce ammonia which in turn is used to produce nitric acid, ammonium nitrate and ammonium nitrate-based explosives and fertilisers.

The main air pollutants from Sasol Infrachem are sulfur dioxide (SO₂) and nitric oxide (NO) and nitrogen dioxide (NO₂) – collectively known as NO_x, and particulates. Other minor pollutants considered included ammonia (NH₃), hydrochloric acid (HCl), hydrogen fluoride (HF), dioxins/furans and metals.

Airshed Planning Professionals (Pty) Ltd (hereafter referred to as Airshed) was appointed by Sasol to provide independent and competent services for the compilation of an Atmospheric Impact Report as set out in the Draft Regulations and detailing the results of the dispersion model runs. The tasks to be undertaken consisted of:

- 1) Review of emissions inventory for the identified point sources and identification of any gaps in the emissions inventory. It is preferable that gaps be estimated using an agreed emission estimation technique.
- 2) Prepare meteorological input files for use in one or more dispersion models to cover the applicable Sasol sites. Sasol will provide surface meteorological data and ambient air quality data from the Sasol ambient air quality monitoring stations. Surface meteorological data for three years, as required by the draft Dispersion Modelling Guidelines for Level 3 Assessments (Government Gazette No 35981, published 14 December 2012), is available for ambient air quality monitoring stations situated in both Sasolburg and Secunda.
- 3) Preparation of one or more dispersion models set up with Sasol’s emissions inventory capable of running various scenarios for each of the point sources as specified by Sasol, in conjunction with Sasol Technology’s Research and Development department. The intent is to model delta impacts of the various emission scenarios against an acceptable measured airshed baseline.
- 4) Airshed will validate the dispersion model based on a fractional bias approach.
- 5) It is anticipated that each point source identified above will require three scenarios per component per point source to be modelled, in order to establish the delta impacts against the DEA-approved baselines. i.e.:
 - a. Baseline – modelling is conducted based on the current inventory and impacts
 - b. Compliance scenarios – modelling must be conducted based on compliance to the legislative requirement as stipulated within the Listed Activities and Minimum Emissions Standards (for both existing plant and new plant standards).

- c. Alternative Emission Limits – the emission reductions as proposed by Sasol, where applicable and different from the baseline and / or compliance emission scenarios.
- 6) Comparison of dispersion modelling results with the National Ambient Air Quality Standards (NAAQS).
- 7) A report detailing the methodology used and model setup was compiled for purposes of a peer review. This report, together with the peer review report and comments from Airshed on the findings, is included as an annexure to this AIR.
- 8) Interactions with the Environmental Assessment Practitioner (EAP) to provide all necessary inputs into the EAP's compilation of documentation in support of Sasol's applications. Airshed will attend all Public Participation meetings scheduled by the EAP to address any queries pertaining to the dispersion model.

The Atmospheric Impact Report (AIR) was prepared in alignment the Regulations Regarding Air Dispersion Modelling following a 'fit for purpose' code of practice (Section 1.2; Government Gazette No. 37804 vol. 589; 11 July 2014). This approach aimed to present sufficient and pertinent information to assist stakeholders to assess the impacts associated with Sasol's applications for postponement of MES compliance timeframes.

Updates made to the AIR following conclusion of the public comment period

The following types of updates have been made to this document following the conclusion of the public comment period:

- updates that address stakeholder comments or queries or provide expanded explanations of key concepts;
- references to changes in regulations, for example the Regulations regarding Air Dispersion Modelling which were promulgated in July 2014; and,
- update cross-references; for example between the AIR and the motivation report.

A detailed list of changes is provided in Table B-1.

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List of Abbreviations

AQA	Air quality act
APCS	Air pollution control systems
ARM	Ambient Ratio Method
As	Arsenic
ASG	Atmospheric Studies Group
Cd	Cadmium
Co	Cobalt
CO	Carbon monoxide
CO₂	Carbon dioxide
Cr	Chromium
Cu	Copper
DEA	Department of Environmental Affairs
ESP	Electro static precipitator
FDG	Flue-gas desulfurisation
g	Gram
g/s	Gram per second
HCl	Hydrogen chloride
Hg	Mercury
HNO₃	Nitric acid
HF	Hydrogen fluoride
IP	Intellectual property
IPCC	Intergovernmental Panel on Climate Change
LMo	Monin-Obukhov length
m	Meter
m²	Meter squared
m³	Meter cubed
MIBK	Methyl isobutyl ketone
m/s	Meters per second
Mn	Manganese
NAAQ Limit	National Ambient Air Quality Limit concentration
NAAQS	National Ambient Air Quality Standards (as a combination of the NAAQ Limit and the allowable frequency of exceedance)
NEMAQA	National Environmental Management Air Quality Act
NH₃	Ammonia
Ni	Nickel
NO	Nitrogen oxide
NO₂	Nitrogen dioxide
NO_x	Oxides of nitrogen
O₃	Ozone
OLM	Ozone Limiting Method
PBL	Planetary boundary layer
Pb	Lead
PM	Particulate matter

PM₁₀	Particulate matter with diameter of less than 10 µm
PM_{2.5}	Particulate matter with diameter of less than 2.5 µm
Sb	Antimony
SO₂	Sulfur dioxide
SO₃	Sulfur trioxide
SS1	Steam station 1
SS2	Steam station 2
Tl	Thalium
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
V	Vanadium
VOC	Volatile organic compound
µ	micro
°C	Degrees celcius

Glossary

Advection	Transport of pollutants by the wind
Airshed	An area, bounded by topographical features, within which airborne contaminants can be retained for an extended period
Algorithm	A mathematical process or set of rules used for calculation or problem-solving, which is usually undertaken by a computer
Alternative Emission Limit	Ceiling or maximum emission limit requested by Sasol, with which it commits to comply
Assessment of environmental effects	A piece of expert advice submitted to regulators to support a claim that adverse effects will or will not occur as a result of an action, and usually developed in accordance with section 88 of the Resource Management Act 1991
Atmospheric chemistry	The chemical changes that gases and particulates undergo after they are discharged from a source
Atmospheric dispersion model	A mathematical representation of the physics governing the dispersion of pollutants in the atmosphere
Atmospheric stability	A measure of the propensity for vertical motion in the atmosphere
Building wakes	Strong turbulence and downward mixing caused by a negative pressure zone on the lee side of a building
Calm / stagnation	A period when wind speeds of less than 0.5 m/s persist
Cartesian grid	A co-ordinate system whose axes are straight lines intersecting at right angles
Causality	The relationship between cause and effect
Complex terrain	Terrain that contains features that cause deviations in direction and turbulence from larger-scale wind flows
Configuring a model	Setting the parameters within a model to perform the desired task
Convection	Vertical movement of air generated by surface heating
Convective boundary layer	The layer of the atmosphere containing convective air movements
Data assimilation	The use of observations to improve model results – commonly carried out in meteorological modelling
Default setting	The standard (sometimes recommended) operating value of a model parameter
Diagnostic wind model (DWM)	A model that extrapolates a limited amount of current wind data to a 3-D grid for the current time. It is the ‘now’ aspect, and makes the model ‘diagnostic’.
Diffusion	Clean air mixing with contaminated air through the process of molecular motion. Diffusion is a very slow process compared to turbulent mixing.
Dispersion	The lowering of the concentration of pollutants by the combined processes of advection and diffusion
Dispersion coefficients	Variables that describe the lateral and vertical spread of a plume or a puff
Dry deposition	Removal of pollutants by deposition on the surface. Many different processes (including gravity) cause this effect.
Sasol Infrachem	Sasol Chemical Industries (Pty) Limited operating through its Sasolburg Operations, formerly Sasol Infrachem, a division of Sasol Chemical Industries (Pty) Limited. To avoid unnecessary confusion, the name “Sasol Infrachem” has been retained in this report.

Atmospheric Impact Report

1 ENTERPRISE DETAILS

1.1 Enterprise Details

The details of Sasol Infrachem's operations are summarised in Table 1-1. The contact details of the responsible person, the emission control officer, are provided in Table 1-2.

Table 1-1: Enterprise details

Company Name:	Sasol Infrachem
Trading as:	Sasol Chemiese Nywerhede (Pty) Ltd
Company/Close Corporation/Trust Registration Number (Registration Numbers if Joint Venture):	1968/013914/07
Company Registered Address:	Sasol 1 Site 1 Klasie Havenga Street Sasolburg 1947
Company Postal Address:	PO Box 1 Sasolburg 1947
Telephone Number (General):	016 960 1111
Fax Number (General):	016 920 2338
Company Website:	www.sasol.com
Industry Type/Nature of Trade:	Petrochemical industry
Name of the Landowner/s or Landlord/s:	Sasol Chemises Nywerhede (Pty) Ltd
Name of Mortgage Bondholder/s (if any):	n/a
Deeds Office Registration Number of Mortgage Bond:	n/a
Land Use Zoning as per Town Planning Scheme:	Industrial
Land Use Rights if outside Town Planning Scheme:	N/A

Table 1-2: Contact details of responsible person

Responsible Person Name:	Ristoff van Zyl / Herman vd Walt
Responsible Person Post:	Air Quality Specialist / Environmental Services Manager
Telephone Number:	016 920 4913 / 016 920 2921
Cell Phone Number:	083 632 5975 / 083 630 4619
Fax Number:	011 219 2438
E-mail Address:	ristoff.vanzyl@sasol.com / herman.vanderwalt@sasol.com
After Hours Contact Details:	083 632 5975
Name of Safety, Health and Environmental Official:	Trevor Dubber

1.2 Location and Extent of the Plant

Table 1-3: Location and extent of the plant

Physical Address of the Plant	Sasol 1 Site 1 Klasie Havenga Street Sasolburg 1947
Description of Site (Where no Street Address)	Subdivision 6 of 2 of Driefontein No- 2 and certain subdivisions of the farm Saltberry Plain, Roseberry Plain Flerewarde and Antrim and subdivision 5 of 4 of Montrose, District of Sasolburg, Free State.
Coordinates of Approximate Centre of Operations	Sasol 1 Site: Latitude: S 26.82678 Longitude: E 27.84206
Extent	15.51 km ²
Elevation Above Sea Level	1 498 m
Province	Free State
Metropolitan/District Municipality	Fezile Dabi District Municipality
Local Municipality	Metsimaholo
Designated Priority Area	Vaal Triangle Priority Area

1.3 Atmospheric Emission Licence and other Authorisations

The following authorisations, permits and licences related to air quality management are applicable:

- Atmospheric Emission License:
 - FDDM-MET-2011-01
 - FDDM-MET-2013-18
 - FDDM-MET-2013-19
 - FDDM-MET-2013-21
 - FDDM-MET-2013-22
 - FDDM-MET-2013-23
 - FDDM-MET-2013-24
- Other: None

2 NATURE OF THE PROCESS

2.1 Listed Activities

A summary of listed activities seeking postponement at Sasol Infracem is provided in Table 2-1 below.

Table 2-1: Listed activities seeking postponement of MES

Name of the Unit	Unit process function	Batch or Continuous process
Water and waste – Thermal oxidation		
B6993 Spent Caustic Incinerator	The incineration of spent caustic solution and off specification solvent products including MIBK by-products in a down fired incinerator.	Continuous
B6930 High Sulfur Pitch Incinerator	The incineration of High Sulfur Pitch, Organic solvents and High Organic waters in a limestone fluidized bed unit.	Continuous
B6990 Heavy ends B Incinerator	The incineration of heavy oils, off-specification waxes, Sasol spent catalyst, Funda filter cake, slop solvents and high organic waste.	Continuous
Steam Stations		
Boilers 4 - 15	Steam and electricity production	Continuous

For completeness, all listed activities undertaken at Sasol's Sasolburg Operations are provided in Table 2-2.

Table 2-2: All listed activities currently operating at Sasol's Sasolburg Operations

Category of Listed Activity	Subcategory of listed activity	Listed activity name	Description of the Listed Activity
1	1.1	Solid Fuel Combustion installations	Solid fuels (excluding biomass) combustion installations used primarily for steam raising or electricity generation
2	2.1	Petroleum Industry	Petroleum industry, the production of gaseous and liquid fuels as well as petrochemicals from crude oil, coal, gas or biomass
	2.4	Petroleum Industry (Storage and handling of petroleum products)	All permanent immobile liquid storage facility on a single site with a combined storage capacity of greater than 1000 m ³
3	3.1	Carbonization and Coal Gasification	Combustion installations not primarily used for steam raising or electricity generation.
4	4.1	Metallurgical industry	Drying of minerals including ore.
6	6.1	Organic Chemical Industry	The production, or use in production of organic chemicals not specified elsewhere including acetylene, ecetic, maleic or phthalic anhydride or their acids, carbon disulphide, pyridine, formaldehyde, acetaldehyde, acrolein and its derivatives, acrylonitrile, amines and synthetic rubber. The production of organometallic compounds, organic dyes and pigments, surface-active agents.

Category of Listed Activity	Subcategory of listed activity	Listed activity name	Description of the Listed Activity
			<p>The polymerisation or co-polymerisation of any unsaturated hydrocarbons, substituted hydrocarbon (including Vinyl chloride).</p> <p>The manufacture, recovery or purification of acrylic acid or any ester of acrylic acid.</p> <p>The use of toluene di-isocyanate or other di-isocyanate of comparable volatility; or recovery of pyridine.</p> <p>All permanent immobile liquid storage facilities at a single site with a combined storage capacity of greater than 1 000 m³.</p>
7	7.1	Inorganic chemicals industry	The use of ammonia in the manufacturing of ammonia
	7.2		The primary production of nitric acid in concentrations exceeding 10%
	7.3		The manufacturing of ammonium nitrate and its processing into fertilisers
	7.4		Manufacturing activity involving the production, use or recovery of antimony, beryllium, cadmium, chromium, cobalt, lead, mercury, selenium, thalium and their salts
8	8.1	Thermal treatment of hazardous and general waste	Facilities where general and hazardous waste are treated by the application of heat (Applicable : Capacity of Incinerator > 10 kg/hour)

2.2 Process Description

Steam Stations

Sasol Infrachem operates two steam/power stations in Sasolburg. Pulverised coal is fired in boilers which are used for steam and power generation. All the steam and the majority of the power generated at these stations are used for Sasol's purposes, however Sasol do supply Eskom with electricity directly into the national grid to alleviate the pressure on the national grid, for which Steam Station 1 is critical. Emissions include combustion gases (SO₂), nitrogen oxide (NO), nitrogen dioxide (NO₂), particulate matter (PM), carbon dioxide (CO₂) and carbon monoxide (CO).

Auto Thermal Reformers

Sasol Infrachem operates two Auto Thermal Reformers (ATRs) on the Sasol One facility. Natural gas is reformed in the ATRs to form the building blocks of the Fischer Tropsch process. The heat required in the ATRs is obtained from the Fired Heaters which is fired with process tail gas, except during startup when they are fired with natural gas. Emissions from the two Fired Heaters are combustion gas products, such as NO, NO₂, CO and CO₂. No sulfur compounds are present.

Rectisol

Sasol operates a Rectisol plant on the Sasol One Site. The purpose of the Rectisol plant is “dew point correction” and “CO₂” removal. Due to the high concentration of methane and other hydrocarbons, the gas from the first two stages are sent to the flare and those from the last three stages are sent to atmosphere through the Steam Station 1 Stacks. Emissions include hydrocarbons specifically with high concentrations of CO₂ emitted from the Steam Station 1 stacks.

Thermal Oxidation

Sasol operates a thermal oxidation unit where various waste streams from various business units are thermally oxidized. The thermal oxidation facility consists of three incinerators, namely: the caustic; old HSO; and, new HSP incinerators. As part of the oxidation process, heat is recovered by means of steam, which supplements the steam supply to the plants from the Steam Stations. The B6930 incinerator has a bag house for particulate emission control, whilst the caustic incinerator has a caustic scrubber for both SO₂ and particulate matter emission control.

Benfield

Sasol operates a Benfield unit as part of the ammonia plant on the Sasol One Site. The Benfield unit consists of a CO₂ absorber column where CO₂ is removed from the process gas stream using the benfield solution. The benfield solution is regenerated in the desorber column where the CO₂ is desorbed to the atmosphere.

Nitric acid plant (NAP)

A nitric acid plant is operational at the Sasol Bunsen Street site. Ammonia is piped from the cold storage area to the nitric acid plant where it is reacted with oxygen to produce NO_x, as an intermediate product, which is fed to a catalyst to selectively convert NO to NO₂. The NO₂ is fed to a series of absorption columns where nitric acid is formed. The exhaust vent from the second tower, which contains NO₂, and N₂O is sent to the de-NO_x reactor, where the gas is reduced over a catalyst to nitrogen and oxygen, which is released to atmosphere.

Ammonium Nitrate solution

Sasol operates an ammonium nitrate solution plant. This plant is integrated into the NAP plant. The nitric acid from the NAP plant is reacted with ammonia in a reactor to form the ammonium nitrate solution.

Ammonium Nitrate Prill

Sasol also operates an ammonium nitrate prill unit on the Sasol One Site. Aqueous ammonium nitrate is combined with off spec prill in a dissolving tank and then concentrated by means of parallel evaporators. The concentrated liquor is then fed to the top of the prill tower where after it is sprayed through the prill nozzles to obtain a desired diameter. The spheres fall inside the prill tower through counter current air flow which cools the droplet and forming the prill. The upward air flow is passed through three scrubbers at the top of the prill plant before it is vented to atmosphere. The prill is fed to drying, cooling and screening units where off spec prill is recycled to the dissolving tank whilst the on spec prill is packaged as the final product. The air used for drying is passed through a scrubber before being vented to atmosphere. Emissions are particulates coming from the scrubbers on top of the Prill tower as well as from the drying scrubbers.

Ammonia

Nitrogen from the Air Products plant on site is combined with hydrogen from the Rectisol stream to form ammonia in the ammonia plant. Inert gasses and hydrogen are vented to ammonia flare and combustion gasses (CO₂, CO, NO₂ and NO) are vented to atmosphere from the super heater.

SCCM

Step 1: Support Modification

Aluminium oxide powder is unloaded from bags and fed to the support modification reactor. The reactor also receives metered streams of tetraethyl orthosilicate (TEOS) and organic solvent (ethanol). In the reactor, the ethanol evaporates and leaves an ethoxysilicate coating on the alumina particles. This coating will promote adhesion of the active components of the catalyst during subsequent process stages.

The reactor has a nitrogen blanket, a screw agitator and is heated by a hot oil jacket. During the process volatile organic compounds (VOC) (mainly ethanol) are removed from the reactor under vacuum through a cooling tower condenses. After passing through a gas liquid separator and a knock out vessel, vapours are incinerated in the VOC incinerator while all liquid residues are collected in the spent ethanol tank.

At the exit the main product, modified support powder, proceeds directly to the next process stage (calcination) or is collected on tote bins if required.

Step 2: Calcination

A hopper receives modified support powder from the support modification reactor. The powder is fed into a calciner, which is heated by a gas burner. Ethanol groups from TEOS are removed under air at elevated temperatures from the calciner. At the calciner exit the product (roasted modified support powder) passes through a water cooler and can be stored for use or collected in a tote bin. Vapours from the hoppers and the calciner are fed to the VOC incinerator.

Step 3: Impregnation

In the first impregnation reactor the calcinated modified support powder (from bins) is treated with impregnation liquid. This liquid is prepared in a mixing tank by diluting a cobalt nitrate solution with demineralised water and adding a metal promoter solution (platinum). The process objective is to absorb cobalt and platinum (the active catalyst components) onto the silica coated alumina particles that make up the modified support powder (and ultimately the catalyst). The final product from impregnation reactor is a moist impregnated powder.

The impregnation reactor is heated by a hot oil jacket and has a screw agitator. Aqueous vapours are removed from the reactor under vacuum through a cooling water condenser. The condensate is routed to the chemical sewer while clean vapours are released to the atmosphere.

Step 4: Calcination

Moist impregnated powder feeds directly from the impregnated reactor into a fluidised bed calciner. The nitrate salts in the powder are converted into oxides under release of NO_x. Preheated air acts as the fluidising medium which carries the nitrous vapours to the DeNO_x unit. This unit is also fed with an anhydrous ammonia solution and is equipped with a gas burner. It facilitates a two-step catalytic reduction of NO_x with NH₃ to nitrogen and water. Calcinated impregnated powder is fed catalytic reduction fed to a sieve where it is separated according to particle size. On specification, product is collected into a tote bin.

Step 5 and 6: Impregnation and Calcination

The next two steps are a second impregnation and calcination. Both the impregnation and calcination steps are repeated in a separate process section which is identical to steps 3 and 4. Key differences are the composition of impregnation liquid and this impregnation process is also known as adsorption. Most process equipment is duplicated.

Step 7: Reduction

Following the two-step adsorption and calcinations process, the cobalt and platinum oxides are reduced to active metals under release of water and ammonia. Initially the product is fed from bins into a purge hopper where all oxygen is removed. The powder then enters a fluidised bed reduction reactor, which represents the final step in converting the powder into a catalyst. Hydrogen is used as a reduction medium and nitrogen is used for purging. The hydrogen flow is compressed and heated prior to injection into the reactor.

After passing through the fluidised bed the gas stream is cooled in two steps. The coolers utilise water and a water/glycol mixture respectively. After removal of water and ammonia in an adsorption dryer, the regenerated reduction gas is fed into the compressor suction and recirculated. A regenerated gas bleed-off is located between the water cooler and water glycol chiller. Water and ammonia removed from the gas is routed to the chemical sewer.

Step 8: Coating

Having passed the reduction step the product can be considered as an active catalyst which needs to be protected against oxidative degradation (it would auto-ignite under atmospheric conditions) to accomplish this protection the catalyst feeds directly from the reduction reactor into the coating tank where it is suspended in molten wax. Wax consists of synthetic paraffins and is melted in the wax melt tank.

Wax volatiles from the wax melt tank and coating tank are routed to a separate dedicated wax scrubber where they stripped with water. Stripper water from the wax melt tank scrubber is routed to the storm water drain, while stripper water from the coating tank scrubber is routed to the chemical sewer as it may contain metals. Clean gas from both scrubbers is released to atmosphere. Both tanks and transfer lines have jackets with hot oil for heating.

Step 9: Packaging

Finished product (active catalyst suspended in wax) runs through to the drum filling station using a nitrogen purge, to package the product for distribution and use.

Merisol

Merisol extracts and purifies a range of phenolic products from tar acid containing feed streams sourced from Sasol Synfuels. Various process chemicals are used to extract the tar acids and to remove impurities where-after phenol, cresols and xlenols are recovered via distillation. Merisol also operates a o-Cresol Novolac plant where OCN pellets of different grades are produced. Waste generated by the processes are either incinerated or treated at the Sasol Bio-works. All relieve valves and vents are connected to the plant's flare system and normal combustion products are emitted (CO₂, CO, NO, NO₂ and H₂O). The fuel gas furnace emits combustion gas products and SO₂ and SO₃ are emitted from the SO_x scrubber. Aldehydes and semi-VOCs are emitted from the OCN scrubbing system.

Solvents

All vents and hydrocarbon emissions from Solvents are sent to the flare with the exception of a few units which vent hydrocarbons to atmosphere which has been quantified.

Methanol High Purity

Gas and hydrogen is reacted in a synthesis reactor at Sasol Waxes where crude methanol is produced. The distillation of the crude methanol into high purity methanol takes place at Sasol Solvents, through atmospheric distillation. The purification is accomplished through degassing and the removal of low and high boiling point by-products.

Methanol Technical Grade

The methanol extracted from the reaction water (Chemical water treatment plant) is purified to methanol technical grade through a process of atmospheric distillation. The purification is accomplished through the removal of low and high boiling point by-products.

Chemical Water Treatment

Chemicals are recovered from the reaction water from the Sasol Waxes synthesis processes, as well as purge streams from Butanol and by-products from HP methanol, TG methanol, MIBK and FTDU. Recovery of chemicals takes place through a process of atmospheric distillation and degassing.

Methyl Iso Butyl Ketone (MIBK 1 and 2)

DMK (acetone) is converted over a palladium impregnated ion-exchange catalyst in the presence of hydrogen to MIBK via a single stage process. The reactor product is worked up and purified through a series of distillation columns. All impurities and co-products are removed through the distillation processes.

Solvents Blending Plant

Raw material from Secunda, Sasolburg and outside suppliers, transported via road tankers to the blending plant, are stored in on-site storage tanks. The raw products, mixed according to customers specifications, are supplied to the customer via road tankers or drums.

Heavy Alcohol Plant

Raw material from Secunda (Sabutol bottoms) is distilled through a single step distillation column into 2 final products, i.e. pentylol and hexylol. No by-products are removed in the process.

Solvents Mining Chemicals Plant

Raw material from Secunda, Sasolburg and outside suppliers, transported via road tankers to the blending plant, are stored in on-site storage tanks. The raw products, mixed according to customers specifications, are supplied to the customer via road tankers or drums.

AAA/Butanol

Sasol operates an Acrylic Acid and Acrylate (AAA) as well as a Butanol plant on the Sasol Midland Site.

Butanol:

Synthesis gas is fed to a cold box separation phase where impurities are removed from the syngas. The impurities are recycled back into the gas loop and vented into an elevated flare. The purified syngas as well as propylene are fed into a series of reactive distillation units to produce n-butanol and i-butanol as the final product. All columns are vented to the flare.

AAA:

Acrylic acid is manufactured by reacting propylene with air through a series of reactors and a distillation / purification process. The crude Acrylic Acid is fed to three processes. It can be purified to form Glacial Acrylic Acid, it can be reacted

with n-Butanol to produce Butyl Acrylate or it can be reacted with Ethanol to produce Ethyl Acrylate. All vents from the AAA plant goes through high temperature incinerator to eliminate any Acrylates entering the atmosphere, especially due to the odorous nature of Ethyl Acrylate. Off gasses from the catalytic destruction unit and the vapour combustion unit contains CO₂, CO, NO and NO₂.

LOC

Liquid bulk storage contains/stores the various products produced on site. It is coupled to the loading bay which is covered to the vapour combustion. Drum, road and rail loading takes place. The fugitive organic vapour emitted during loading of road bulk haul trucks are extracted from the tanker hoods and incinerated at the vapour combustion unit. Emissions are normal combustion gasses such as CO₂, CO and H₂O. No sulfur components are present.

Polymers

Ethylene

Sasol operates a monomers production unit where ethylene is produced to be used within the polyethylene and polyvinylchloride manufacturing plants. Ethane is piped to Sasolburg from Secunda where it enters the cracker units where the ethane is cracked to ethylene. Once cracked the ethylene/ethane gas mixture goes through a quenching, scrubbing and drying phase where after the gas is hydrogenated to convert acetylene to ethylene. After this the gas is purified by means of distillation process where light and heavy components as well as unreacted ethane are removed. The ethylene is then stored in the ethylene tank to be distributed to the polythene and vinyl chloride monomer plants. Hydrocarbon off-gasses are sent to the plant's main flare where it is converted to CO₂, CO and H₂O. The cracking unit emits traces of H₂S from the caustic scrubber.

Polyethylene

Sasol operates two polyethylene plants on the Sasol Midland Site, namely the Poly 2 and Poly 3 plants.

Poly 2: The Poly 2 process involves the manufacture of linear low density polyethylene in a fluidized bed gas phase reactor. The materials used for the manufacture comprise ethylene which is the main component, hexene/butene as a density modifier, hydrogen as a melt index modifier, isopentane for temperature control, a silica based Ziegler Natta catalyst (manufacture in house in the catalyst plant, a catalyst activator and nitrogen for reactor pressure control. The feeds enter the reactor where the reaction process takes place and polymer together with some unreacted gas is transferred to the degassing bin for separation of hydrocarbons from the polymer. The liquid hydrocarbons (hexene, isopentane) is recovered in the monomer recovery section of the plant and recycled back to the reactor for re-use. The polymer pneumatically transferred from the degassing bin and is stored in intermediate storage silos and thereafter pelletised at the extruder. At the extruder, virgin polymer is mixed with additives, is melted and is thereafter cut it into pellets in an underwater cutter. This polymer pellets are thereafter dried and cooled before being pneumatically conveyed to the Pack Silos from which it is bagged at the packline and stored in the warehouse. Emergency venting occurs through the plant flare system where ethylene is converted to CO₂, CO and H₂O.

Poly 3: The Poly 3 plant produces medium and low density polyethylene. The ethylene is fed to a reactor where initiator and modifier depending on which grade (LDPE or MDPE) is added and the polymerization reaction take place. The excess ethylene is recycled and the polyethylene is separated, extruded, dried and transferred to degassing silos where the access ethylene is purged out with air. After degassing the product is transferred for packaging. Emergency venting occurs through the plant flare system where ethylene is converted to CO₂, CO and H₂O.

Chlorine

Sasol also operates a chlorine, hydrochloric acid, sodium hydroxide and sodium hypochlorite production facility on the Sasol Midlands Site. Salt is conveyed to a dissolving tank where the salt is dissolved up to a specific brine concentration. After several purification steps, the brine solution is fed to the chloro-caustic cells where chlorine, hydrogen and aqueous sodium hydroxide is manufactured. The chlorine manufactured is stored, reacted with sodium hydroxide to create sodium hypochlorite or reacted with hydrogen to create hydrochloric acid in the HCl burners. The hydrogen is either used at the HCl burners to manufacture HCl or sent to the VCM plant as a fuel gas. The hydrochloric acid produced in the HCl burners is stored and sold as a final product. Scrubbers and outlets might contain traces of HCl and Cl₂.

Vinyl Chloride Monomer

Sasol operates a Vinyl Chloride Monomer (VCM) production facility on the Sasol Midland Site. The facility uses two different reactions for the manufacturing of the intermediate 1,2-dichloroethane (EDC). The first is the direct chlorination of ethylene to produce EDC. The second is the oxychlorination step where ethylene, oxygen, hydrogen and HCl react to produce crude EDC and water. The water is separated after the oxychlorination reactor and the crude EDC is sent to the EDC purification unit. The water stream is fed to the water recovery unit for purification before being exported to the Sasol Polymers Chlorine Plant for brine make up. EDC from the purification step is fed to the EDC cracker together with EDC from the direct chlorination step. In the EDC cracking unit EDC is cracked to VCM and HCl after which the cracked stream is fed to the VCM purification unit. Here the VCM and HCl are separated and HCl is recycled to the oxychlorination unit. The VCM is sent to storage in two spheres at the PVC Plant. By products from the EDC Purification Unit and plant vent gasses are incinerated and the recovered dilute hydrochloric acid exported to the Sasol Polymers Hydrochloric Acid Plant.

Polyvinyl Chloride

Sasol operates a Polyvinyl chloride plant on the Sasol Midland Site. VCM from the VCM plant storage spheres is suspended in water whilst the reaction is brought up to the desired temperature. The polymerization reaction takes place and the polyvinyl chloride (PVC) is formed. The reactor is discharged into a blow down vessel which feeds into the stripper, where unreacted VCM is recovered from the slurry and recycled. The PVC/water mixture is then fed to the slurry stock tank and then to the centrifuge where the PVC is separated. Once the PVC is separated, it is dried, screened and pneumatically fed to the storage area for packaging. The unreacted VCM is recovered by liquefaction and stored for reuse. The incompressible tail gas from the latter unit is fed to the incinerator at the VCM Plant.

Cyanide

Sasol, furthermore, operates a Cyanide manufacturing plant on the Sasol Midland Site. Methane (CH₄) rich natural gas reacts with ammonia (NH₃) in a fluidized coke bed reactor to form a hydrogen cyanide (HCN) rich synthesis gas. The energy required for the endothermic reactor is supplied by a set of six graphite electrodes connected to a 6.6kV electrical supply. The synthesis gas and large coke particles leaving the reactor are transferred through a cyclone where the particles are separated from the gas. After the cyclone, the gas is cooled and fed to fabric filters where any carbon soot entrained in the synthesis gas is removed. The "polished" gas is then fed to a pair of sodium hydroxide (NaOH) absorbers installed in series. Here the HCN reacts with the NaOH to form sodium cyanide (NaCN), which is the final product. The exhaust gasses from the second NaOH absorber is fed into a NaOH vent scrubber after which it is emitted to atmosphere via an elevated stack. Emissions contain mainly hydrogen, particulates from the bag houses and are measured for traces of HCN.

Wax

Sasol Wax operates a catalyst manufacturing plant as well as two wax production units namely the Sasol Slurry Bed Reactor (SSBR) and the Arge Reactors. In the catalyst preparation plant metals are dissolved in nitric acid and then precipitated after which the catalyst is dried and activated, where after it is ready for use. NO_x is emitted from one and particulates are emitted from three stacks at the Catalyst plant.

The SSBR and Arge reactors are fed with the active catalyst and synthesis gas to produce hydrocarbons. The hydrocarbons are worked up via hydrogenation, distillation and oxidation to liquid final products. The products are blended, solidified and packed. Organics and combustion gasses (CO₂, CO, H₂O, NO and NO₂) are emitted from various furnaces within the process. Hydrocarbons could be sent to the factory main flare system where the organics are converted to CO₂, CO and H₂O before being emitted to atmosphere.

2.3 Unit Processes

Unit process, seeking postponement, considered to be listed activities under the National Environmental Management Air Quality Act (NEMAQA) are summarised in Table 2-3.

Table 2-3: List of unit processes at Sasol's Sasolburg Operations seeking postponement of MES

Name of the Unit Process	Unit Process Function	Batch or Continuous Process	Listed Activity Sub-category
B6993 Spent Caustic Incinerator	The incineration of spent caustic solution and off specification solvent products in a down fired incinerator.	Continuous	8
B6930 High Sulfur Pitch Incinerator	The incineration of High Sulfur Pitch, Organic solvents and High Organic waters in a limestone fluidized bed unit.	Continuous	8
B6990 Heavy ends B Incinerator	The incineration of various organic streams, including: High Sulfur Pitch when the new HSP oven is down for maintenance.	Continuous	8
Boilers 4 - 15	Steam and electricity production	Continuous	1.1

Sasol Chemical Industries in Sasolburg also operates various activities including water treatment facilities, fine ash dams, research activities and various distillation and processing units that are not included in the Listed Activities and Minimum Emissions Standards. The site is a gas plant and as such continuous emissions are limited to predominantly combustion gases where flares have been installed as safety mechanisms. For completeness, all unit processes for the Sasol Infrachem complex are listed in Table 2-4.

Table 2-4: Unit processes at Sasol Sasolburg

Unit Process	Function of Unit Process	Batch or Continuous Process
Infracchem		
<i>ATR</i>		
Auto Thermal reformers	Convert natural gas to reform gas	Continuous
Membrane separators	Purification of reformed gas	Continuous
Flares	Destruction of gas	Batch
Rectisol		
Rectisol	CO ₂ removal and dew point correction	Continuous
<i>Water and waste – Thermal oxidation</i>		
B6993 Spent Caustic Incinerator	The incineration of spent caustic solution and off specification solvent products including MIBK by-products in a down fired incinerator.	Continuous
Spent Caustic Storage - F6903	Intermediate storage	Batch
Hydrocarbon Solvents - F6963 A/B F6927 B	Intermediate storage	Batch
Sodium Carbonate - F6954	Intermediate storage	Batch
Caustic - F6959 / F6975	Intermediate storage	Batch
B6930 High Sulfur Pitch Incinerator	The incineration of High Sulfur Pitch, Organic solvents and High Organic waters in a limestone fluidized bed unit.	Continuous
HSP Storage tanks - F6926 / F6990	Intermediate storage	Batch
HOW tank - F6938	Intermediate storage	Batch
BFW tank - F6939	Intermediate storage	Batch
B6990 Chemical Incinerator	The incineration of heavy oils, off-specification waxes, Sasol spent catalyst, funda filter cake, slop solvents and high organic waste.	Continuous
Product tank	Intermediate storage	Batch
<i>Steam Stations</i>		
Fuel oil tanks	Holding fuel	Continuous
Coal bunkers/silos	Holding coal	Continuous
15 Boilers	Steam production	Continuous
Feed water tanks	Holding water	Continuous
Resins (HCL, caustic)	Holding chemicals	Continuous
NH ₃ tank	Holding ammonia	Continuous
Blow down tank		Continuous
<i>Nitric Acid (NAP)</i>		
NO reactor	Reaction of NH ₃ and air to form NO	Continuous
Absorber columns	Absorbtion of NO ₂ to HNO ₃	Continuous
De-NOx reactor	Reduction of NOx to O ₂ and N ₂	Continuous
<i>Ammonium Nitrate</i>		
AN reactor	Reaction to form ammonium nitrate	Continuous
Neutralizer	pH correction	Continuous
AN solution tank	Storage of AN solution	Continuous

Unit Process	Function of Unit Process	Batch or Continuous Process
<i>Prillan</i>		
Wet section	Concentration of ammonium NH ₄ OH solution	Continuous
Dry section	Drying of prilled NH ₄ OH	Continuous
Storage	Storage of prilled NH ₄ OH	Continuous
<i>Ammonia</i>		
CO ₂ capture	Remove moisture from the CO ₂ stream	Continuous
CO-shift	Reacts CO + steam to form H ₂	Continuous
Benfield	Removal of CO ₂ from the process stream	Continuous
PSA	Production of LPH ₂	Continuous
Deoxo	N ₂ purification	Continuous
Ammonia synthesis	Production of NH ₃	Continuous
BFW	Demineralized water	Continuous
SCCM		
<u>Step 1</u>		
Storage tanks/Bags	Containing raw materials for the support modification step	Continuous
Reactor	Allow chemical reactions	Batch
VOC destruction unit	Destroying VOC vapours	Continuous
<u>Step 2</u>		
Hoppers	Temporally storage of the support powder	Continuous
Calciner	Calcinations of the raw materials	Continuous
Water cooler	Cooling the roasted the roasted support powder for storage	Continuous
<u>Step 3</u>		
Mixing tank	Mixing cobalt nitrate, water and metal promoter	Batch
Heated reactor	Impregnating support powder with the metals and subsequent partial drying	Batch
<u>Step 4</u>		
Fluidised bed calciner	Oxidising of the impregnated support powder	Batch
DeNO _x unit	Catalytic destruction of NO _x fumes	Continuous
Sieve	Sizing of the particles	Continuous
Reverse pulse jet cartridge filters	Removing of dust particulates	Continuous
<u>Step 5</u>		
Mixing tank	Mixing cobalt nitrate, water and metal promoter	Batch
Heated reactor	Impregnating support powder with the metals and subsequent partial drying	Batch
<u>Step 6</u>		
Fluidised bed calciner	Oxidising of the impregnated support powder	Batch
DeNO _x unit	Catalytic destruction of NO _x fumes	Continuous
Sieve	Sizing of the particles	Continuous
Reverse pulse jet cartridge filters	Removing of dust particulates	Continuous

Unit Process	Function of Unit Process	Batch or Continuous Process
<u>Step 7</u>		
Purge Hopper	Remove oxygen	Batch
Reduction Reactor	Activation step on the catalyst	Batch
Coolers	Cooling activated catalyst	Batch
<u>Step 8</u>		
Tank	Wax coating of the activated analyst	Continuous
Scrubber	Removal of wax vapours emanating from the coating tank	Continuous
<u>Step 9</u>		
Packaging unit	Package of the activated catalyst for distribution	Continuous
<u>Vent System</u>		
Vent system	Removing dust particles from step 1,4,6, and 7 hoppers off hoppers gas	Continuous
Merisol		
Phenol producing column	Process NBF DTA material for phenol production	Continuous
Feedstock storage	Hold feed material	Batch
Rundown tanks	Hold product phenol	Batch
Final product tanks	Hold final product phenol	Batch
Product Stabiliser tanks	Hold chemicals	Batch
Tempered water system	Hold and provide condensate to phenol unit	Continuous
Relief system	Relief system in high pressure cases	Batch
HP steam	Provide heat to phenol unit reboilers/heater	Continuous
HOW Storage tanks	Holding high organic effluent materials	Batch
Sand Filtration	Filter solids from HOW water	Continuous
Extraction	Extract phenolics from the high organic wastewater	Continuous
C stream distillation	Recover butyl acetate (solvent)	Continuous
Stripping section	Strip out butyl acetate from final effluent	Continuous
Crude tar acids storage	Hold tar acids extracted from high organic effluent	Batch
Separators	Remove tar and oil from high organic stream	Continuous
Storage tanks	Holding raw materials – Formalin, Caustic Soda, O-cresol, Water	Batch
OCN Reactor	Orthocresol novolac reaction using o-cresol and formalin using Para toluene sulphonic acid as a catalyst	Batch
Atmospheric and Vacuum Dehydration	Removal of water from crude resin by heating	Batch
	Stripping of unreacted o-cresol from crude resin by direct steam injection under vacuum conditions	
Pastillising	Pastillising of resin to form final product	Batch
Buffer storage	Intermediate storage of resin before pastillsing	Batch
Feed storage tanks	Holding raw materials as buffer between Secunda and Sasolburg	Batch
Drying and N-base removal	Removing excess water from the feed followed by a process step to remove unwanted nitrogen base compounds from the feed	Continuous
Phenol production	Phenol produced from cleaned-up cresol feed	Continuous

Unit Process	Function of Unit Process	Batch or Continuous Process
Phenol removal	Remaining phenol in bottom product from above unit has to be removed	Continuous
Product Splitter	Separates cresol products from feed based on boiling points differences	Continuous
Intermediate feed product storage	Between units products are temporarily stored to minimize the whole production train to be affected if one unit experiences problems	Batch / Continuous
Final product tanks	Bulk storage before shipment to customer	Batch / Continuous
Loading facility	Road tanker loading of intermediate or final products	Batch
Loading facility	Road tanker loading of pitch type material for transport to incineration plant	Batch
Incineration	Heavy product from the above nitrogen base removal is incinerated	Continuous
Solvents		
<i>Solvents – All plants</i>		
Off-loading facility	Off-loading raw material to holding tank	Batch
Loading Facilities	Loading final product	Batch
Final product tanks	Holding product	Batch
<i>Solvents – AAA/Butanol</i>		
Oxidation	Raw material to crude product	Continuous
Distillation	Purification of crude product	Continuous
Esterification	Reaction of crude product with specific alcohol	Continuous
Refrigeration unit - NH ₃	Cooling in process	Continuous
Cryogenic separation	Conditioning of synthesis gas	Continuous
Chemical Dosing	In-process requirement	Continuous
Flare system	Process gas	Continuous
Off gas incineration	Incineration of process and tank waste gas	Continuous
Catalytic combustion	VOC combustion	Continuous
<i>Solvents – MIBK 1 and 2</i>		
Raw material tank	Holding raw materials	Continuous
Compression	Preparation of raw material	Continuous
High pressure Reaction	Production of raw product	Continuous
Refrigeration Unit	Preparation of vapour (H ₂) emissions to flare	Continuous
Distillation	Fractionation of product to desired spec.	Continuous
Prover tanks	Stores MIBK while being analysed before being pumped to final storage tank	Batch
Catalyst Loading Facilities	Loading and washing of catalyst for D551 A&B	Batch
<i>Solvents – Methanol</i>		
Synthesis	Converting gas and hydrogen to crude methanol	Continuous
Raw crude methanol tank	Holding raw materials	Continuous
Prover product tanks	Holding product	Batch
Atmospheric distillation	Distill methanol from crude	Continuous
Caustic dosing	Corrosion control and neutralization of acids	Continuous

Unit Process	Function of Unit Process	Batch or Continuous Process
<u>Solvents – Methanol TG</u>		
Atmospheric distillation	Distill methanol in reaction water to Technical grade purity	Continuous
Prover tanks	Storage of Methanol TG	Continuous
<u>Solvents – E1204</u>		
Prover tanks	Holding product	Continuous
Atmospheric distillation	Distill Pentylol and Hexylol from Sabutol Bottoms	Continuous
<u>Solvents – Chemical Recovery (S500) Alcohol distillation</u>		
Degassing	Dissolved gases are removed from chemical water	Continuous
Feed storage	Reaction water Storage to E501	Continuous
Atmospheric distillation	Removal of water and other light components from chemical water	Continuous
Scrubbing	Vapours are scrubbed of acids	Continuous
<u>Solvents – Blending plant</u>		
Raw material	Feed for blends	Batch
Blending tanks	To blend formulations according to customer requirements	Batch
Storage	Final Products	Batch
<u>Solvents – Mining Chemicals plant</u>		
Raw material	Feed for blends	Batch
Blending tanks	To blend formulations according to customer requirements	Batch
Storage	Final Products	Batch
LOC		
Vapour combustion unit	Destruction of organic vapours from the loading racks	Batch
Various storage tanks	Storage of liquid products	Continuous
Polymers		
<u>Poly 2</u>		
<u>Feed Streams:</u>		
Knock-out drum	Knock out oil entrainment in supply ethylene	Continuous
Ethylene Compression	Compression of supply ethylene from supply pressure to reaction pressure	Continuous
Hydrogen Storage	Acceptance of supply high pressure hydrogen from air products line	Continuous
Raw material offloading	Offloading of rail cars / isocontainers into storage tanks before use in catalyst and LLDPE manufacturing	Batch
<u>Catalyst Plant:</u>		
Dehydration	Preparation of silica for use in the manufacture of catalyst	Batch
Catalyst Preparation	Manufacture of Ziegler Natta, silica based catalyst for the polyethylene manufacture process	Batch
Catalyst Storage	Storage of catalyst manufactured and transfer to reactor catalyst feeders	Batch
Catalyst Deactivation	Deactivation of out of specification catalyst	Batch
<u>Purification</u>	Purification of feed streams to remove trace poisons before use in the Catalyst and LLDPE manufacturing processes	Continuous and batch
<u>Reaction</u>	Produce polyethylene in the fluidized bed reactor	Continuous

Unit Process	Function of Unit Process	Batch or Continuous Process
<u>Degassing:</u>		
Degassing Bin	Degassing of reactor polymer to remove hydrocarbons from polymer and screen polymer to prevent conveying line blockages	Continuous
Monomer recovery	Knock out hydrocarbons from degassing bin vent via a compressor and fridge system – recycle liquid hydrocarbons to the reactor	Continuous
<u>Flare</u>	Flaring of hydrocarbons not recovered at the monomer recovery unit	Continuous
	Flaring of reactor inventory during reactor shutdown / purging	- Batch
<u>Blending:</u>		
Intermediate storage	Intermediate storage and feed of reactor polymer to the extruder	Batch
Extruder	Mixing of reactor polymer with additives and pelletising	Batch
<u>Packline</u>	Bagging of polymer into 25kg bags and 1.25ton semi bulk bags	Batch
<u>Warehouse</u>	Storage of polymer before being transported to customers	Batch
<u>Poly 3</u>		
<u>Ethylene Feed</u>		
Knock-out drum	Knock-out oils and wax formation in feed line	Continuous
<u>Compressors</u>	Compress Ethylene to required reaction pressure	Continuous
<u>Reactor</u>	Produce Polyethylene	Continuous
<u>Separators</u>	Separate Ethylene from Polyethylene	Continuous
<u>Recycle unit</u>		
Knock-out drums	Knock-out oils and wax formation	Continuous
Heat exchangers	Cool down ethylene	Continuous
<u>Off-loading Area</u>		
Buffer Tank	Isododecane used as flushing agent	Batch
Buffer Tank	Compressor Lubrication Oil (Polybutene & Polyglycol)	Batch
Storage tank (iso-tanker)	Contain Propionaldehyde used as modifier solvent	Batch
<u>Extrusion</u>	Pelletise polymer	Continuous
<u>Pellet transfer and degassing</u>	Transfer pellets and degas product	Continuous
<u>Waste oil and initiator</u>	Disposal of waste oil and initiator	Batch
<u>Flare system</u>	Flaring ethylene or propylene	Batch
<u>VCM and PVC</u>		
Reactor	VCM Plant Unit 1100 – manufacture of 1,2-dichloroethane (EDC) from ethylene and chlorine.	Continuous
Cracker	VCM Plant Unit 1400 – cracking of EDC to form vinyl chloride monomer (VCM) and hydrogen chloride (HCl)	Continuous
Reactor	VCM Plant Unit 1200 – manufacture of EDC by oxyhydrochlorination of ethylene	Continuous
Incinerator	VCM Plant Unit 1600 – by-product hydrochloric acid recovery from mixed gaseous and liquid plant streams from both the VCM and PVC Plants.	Continuous
Scrubber	VCM Plant Unit 1500 Safety Scrubber – removal of HCl from gaseous vent streams during incinerator off-line time.	Batch
Cold flare	VCM Plant Unit 1500 Cold Flare – vent gaseous streams of VCM and HCl diluted with steam and nitrogen during emergencies and gas clearing in preparation for maintenance shutdown.	Batch

Unit Process	Function of Unit Process	Batch or Continuous Process
Tanks – spheres	PVC Plant Storage Spheres – storage of VCM	Continuous / Batch
Reactors	PVC Plant Reaction Unit – manufacture of poly (vinyl chloride) (PVC) from VCM	Batch
Separation - recovery	PVC Plant Vinyl Chloride Recovery Unit – recovery of unreacted VCM from the manufacture of PVC	Continuous
Drying	PVC Plant Drying Unit – remove moisture from raw PVC polymer	Continuous
Separation - recovery	PVC Plant Multigrade Recovery Unit – recovers PVC polymer from effluent water streams	Batch
<u>Monomers</u>		
Ethylene unit 4600	Cracking of ethane and propane Separation of ethylene & ethane from C2 rich gas	Continuous
Ethylene storage tank	Storage of final product	Continuous
Ethane storage sphere	Storage of furnace feed material	Continuous
Propylene storage sphere and bullets	Storage of final product	Continuous
Cracker system	Cracking of ethane or propane to ethylene (This unit operation include boiler feed water, dilution steam, crack gas quench, MEA, Caustic and fuelgas)	Continuous
Cooling water system	Used as cooling medium	Continuous
Loading bay facility	Loading of ethylene road tanker	Batch
Feed gas preparation	Ethane saturator	Continuous
Compression	Crack gas compression as well as ethylene and propylene compression	Continuous
Flare system	Flaring of off-spec product during upset conditions as well as over-pressure protection (3 flares: Ground flare; elevated flare and tank flare)	Continuous
Cold separation	This unit operation include de-ethaniser, C3-recovery, secondary feed gas drying, cold separation, de-methaniser, ethylene cycle, C2-splitter and ethane system	Continuous
Liquefaction	This unit operation include propylene refrigeration, ethylene distribution and storage	Batch
Pre-cooling and drying	Propylene system, pre-cooling, acetylene removal, primary feed gas drying	Continuous
Utilities	Plant air, instrument air, LP nitrogen, de-oxo nitrogen, fire steam, 38bar HP steam, 4.5bar MP steam & 1.5bar LP steam, drinking water, condensate & fire water system	Continuous / Batch
DCS system	Digital Control System for plant operation	Continuous
<u>Cyanide</u>		
Water	Process make up water	Batch
Nitrogen	Plant purging, bag house pulsing and coke feed	Continuous
Caustic	Diluted caustic for the production of sodium cyanide	Batch
Ammonia	For the production of hydrogen cyanide gas	Continuous
Sodium cyanide	Primary and secondary absorption	Batch
Sodium cyanide	Crude Tanks	Batch
Sodium cyanide	Final storage	Batch
Natural gas	Piped in for the production of hydrogen cyanide gas	Continuous
Bag house	Filtering of hydrogen cyanide gas	Continuous
Absorbers	Absorbing HCN gas into caustic	Continuous

Unit Process	Function of Unit Process	Batch or Continuous Process
Back up scrubbers	Final separation of HCN gas from waste gas stream	Continuous
Stack and seal pot	Exhausting waste gas mainly hydrogen into atmosphere	Continuous
Press filter	Filtration of crude sodium cyanide	Batch
Nash compressors	Recycle hydrogen system into process	When required
Loading facility	Dispatch of final product	Continuous
<u>Chlorine</u>		
Chlorine production	To produce chlorine , hydrogen, sodium hydroxide	Continuous
Calcium Chloride	Produce calcium chloride	Batch
Hydrochloric Acid	Hydrochloric acid	Continuous
Tank farm	Storage and dispatch of caustic soda, hydrochloric acid and sulfuric acid.	Continuous
Wax		
<u>Sasol Wax – Production</u>		
Reactors	Production of hydrocarbons	Continuous
Distillation column	Separation of hydrocarbons	Continuous
Packaging	Solidification of wax to get required products	Continuous
Bagging	Packaging of products	Continuous
Mixing and blending	Production of catalyst	Batch
Hoppers	Storage of sodium carbonate	Batch
<u>Sasol Wax – Catalyst preparation</u>		
Dissolving reactors	To produce an metal solution	Batch
Precipitation reactors	To precipitate the catalyst slurry from precursor solutions	Batch
Calcination	To strengthen the catalyst particles	Continuous
Driers	To dry the catalyst to the correct moisture content	Continuous
Evaporators	To concentrate the by-product solution from the precipitation area	Continuous
Crystallisers	To crystallise a salt slurry solution	Continuous
Drier	To dry the salt crystals	Continuous
Storage tanks	Storage for nitric acid, potassium silicate, and caustic soda.	Batch

3 TECHNICAL INFORMATION

Raw material consumption for the listed activities applying for MES postponement at Sasol Sasolburg is tabulated in Table 3-1. For completeness, the raw materials used by all process are included in Appendix C1 (Table C1-1), unless the information is intellectual property (IP) or otherwise sensitive due to competition law. Pollution abatement technologies employed at Infrachem for the listed activities applying for MES postponement are provided in Table 3-2 (all appliance and abatement equipment in use at Sasol Secunda provided in Appendix C; Table C1-2).

3.1 Raw Materials Used and Production Rates

Table 3-1: Raw materials used in the listed activities seeking MES postponement

Raw Material Type	Design Consumption Rate (Volume)	Units (quantity/period)
Thermal oxidation		
Spent Caustic	3.5	tonnes/h
Organic Solvents	1.5	tonnes/h
High Sulfur Pitch	2.5	tonnes/h
Organic Solvents	1	tonnes/h
Limestone	3	tonnes/h
Organic waste water	2	tonnes/h
Off- specification waxes	60	tonnes/month
Sasol spent catalyst	204	tonnes/month
High sulfur pitch	730	tonnes/month
Funda filter cake	220	tonnes/month
Polyethylene wax	80	tonnes/month
Other solid waste	150	tonnes/month
High organic waste	400	tonnes/month
Fuel Gas	1000	Nm ³ /h
Steam Stations		
Water (Steam station 1)	1 304	tonnes/h
Water (Steam station 2)	1 467	tonnes/h
Coal (Steam station 1)	245.2	tonnes/h
Coal (Steam station 2)	228.2	tonnes/h

3.2 Appliances and Abatement Equipment Control Technology

Table 3-2: Appliances and abatement equipment control technology

Appliance name	Appliance type/description	Appliance function/purpose
Spent Caustic Incinerator B6993		
Scrubber	Venturi scrubber	Scrubbing of flue gasses to remove particulates and SO ₂
New High Sulfur Pitch (HSP) Incinerator B6930		
Fluidized bed	Limestone fluidized bed	Removal of SO ₂
Bag house	Bag house	Particulate removal
Boilers 4 - 15		
ESPs	Electrostatic precipitators	Particulate removal

4 ATMOSPHERIC EMISSIONS

The establishment of a comprehensive emission inventory for the listed activities seeking postponement formed the basis for the assessment of the air quality impacts from the Infrachem operations on the receiving environment.

Point source parameters for those units applying for MES postponement are provided in Table 4-1. A locality map indicating is included as Figure 4-1. For completeness, the details for all point sources at Sasol's Sasolburg Operations are provided in Appendix C1; Table C2-3 and Table C2-4.

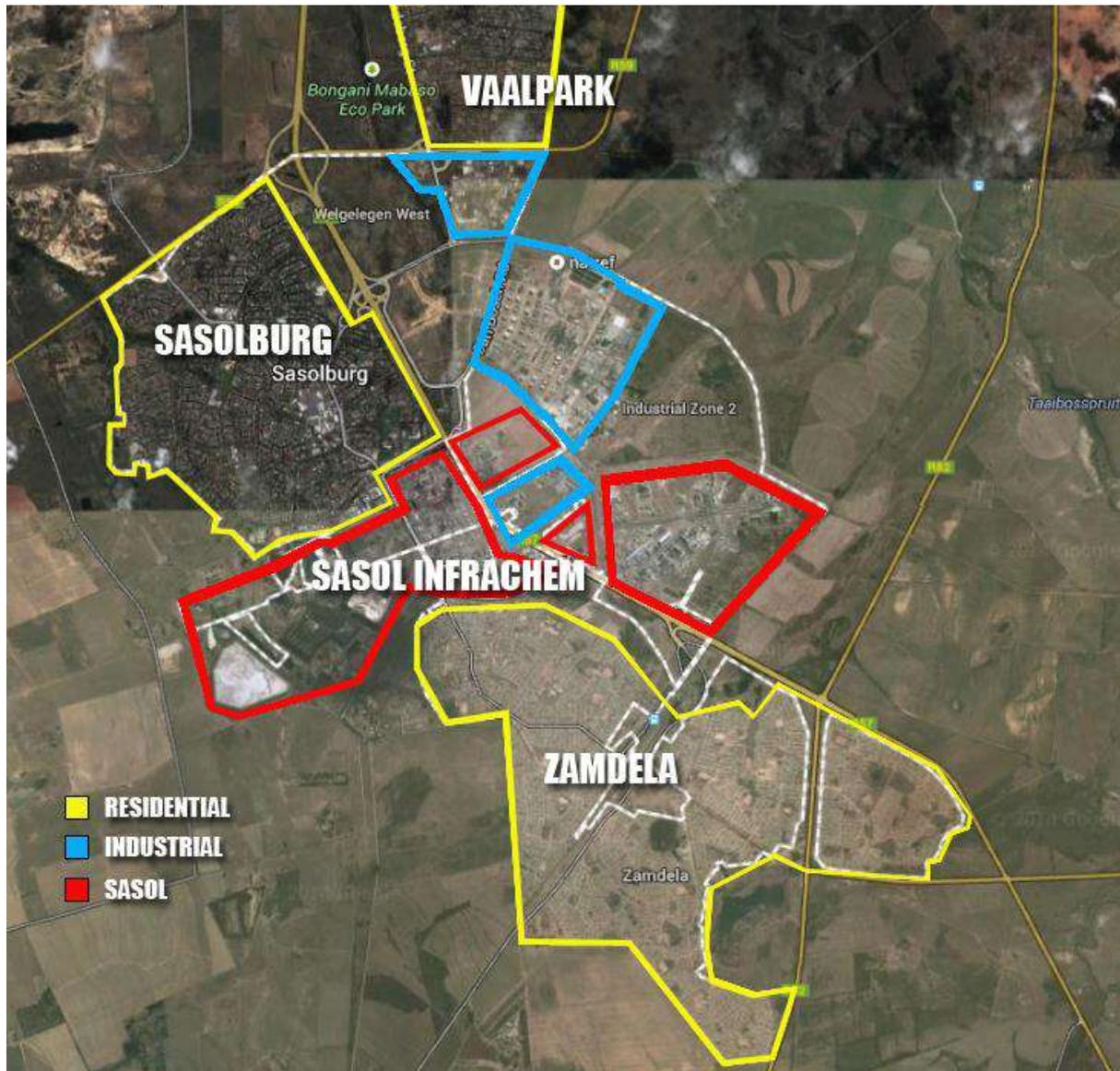


Figure 4-1: Locality map of Sasol Infrachem in relation to surrounding residential and industrial areas (Infrachem boundary indicated by red line).

4.1 Point Source Parameters

Table 4-1: Point source parameters

Point Source number	Source name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Height Above Nearby Building (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m ³ /hr)	Actual Gas Exit Velocity (m/s)	Continuous or batch
Thermal Oxidation										
B6990	Heavy ends B incinerator	26.82556	27.84044	40	n/a	1.53	171	173 411	26.2	Continuous
B6930	High Sulfur Pitch incinerator	26.82544	27.84022	40	n/a	1.5	570	24 811	3.9	Continuous
B6993	Spent Caustic incinerator	26.82544	27.84086	40	n/a	1.2	83	52 522	12.9	Continuous
Steam Stations										
1	Steam Station 1	26.82272	27.84008	75	n/a	2.5	160	490 489	6.939	Continuous
2		26.82272	27.84006	75	n/a	2.5	160	505 969	7.158	Continuous
3		26.82272	27.84004	75	n/a	2.5	160	252 985	3.579	Continuous
4	Steam Station 2	26.82247	27.84853	145	n/a	7.8	160	1 737 413	10.1	Continuous

4.2 Point Source Maximum Emission Rates during Normal Operating Conditions

In cases where periodic compliance measurements are conducted, these are measured in accordance with the methods prescribed in Schedule A of the MES, and aligned with what is prescribed in the Atmospheric Emission Licence. These reflect the average of measurements conducted over a 3-hour period during normal operating conditions.

Table 4-2: Point source emission rates during normal operating conditions

Point Source Code	Point Source Name	Pollutant Name	Average Emission Rate	
			(mg/Nm ³)	Averaging Period
B6990	Old Heavy ends B incinerator	Particulates	Not possible*	
		SO ₂	15	Hourly ^(b)
		NO	90	Hourly
		NO ₂	1	Hourly
		Sum of Pb, As, Sb, Cr, Co, Cu, Mn, Ni, V	Not possible*	Hourly
		Hg	Not possible ^(a)	Hourly
		Cd+Tl	Not possible ^(a)	Hourly
		HF	0.73	Hourly
		NH ₃	0.4	Hourly
		HCl	0.73	Hourly
		TOCs	20	Hourly
		Dioxins/Furans	Not possible*	Hourly
B6930	New High Sulfur Pitch incinerator	Particulates	25	Hourly
		SO ₂	1 358	Hourly
		NO	326	Hourly
		NO ₂	5	Hourly
		Sum of Pb, As, Sb, Cr, Co, Cu, Mn, Ni, V	0.63	Hourly
		Hg	0.004	Hourly
		Cd+Tl	0.0007	Hourly
		HF	0.88	Hourly
		NH ₃	0.8	Hourly
		HCl	1.06	Hourly
		TOCs	46	Hourly
		Dioxins/Furans (ng TEQ/Nm ³)	<0.01	Hourly
B6993	Spent Caustic incinerator	Particulates	160	Hourly
		SO ₂	14	Hourly

Point Source Code	Point Source Name	Pollutant Name	Average Emission Rate	
			(mg/Nm ³)	Averaging Period
		NO	247	Hourly
		NO ₂	4	Hourly
		Sum of Pb, As, Sb, Cr, Co, Cu, Mn, Ni, V	20	Hourly
		Hg	0.0013	Hourly
		Cd+Tl	0.05	Hourly
		HF	0.007	Hourly
		NH ₃	48	Hourly
		HCl	13	Hourly
		TOCs	9	Hourly
		Dioxins/Furans (ng TEQ/Nm ³)	<0.01	Hourly
1	Steam Station1 – stack 1	Particulates	126	Daily
		SO ₂	908	Hourly ^(c)
		NO	807	Hourly ^(c)
		NO ₂	5	Hourly ^(c)
2	Steam Station1 – stack 2	Particulates	126	Daily
		SO ₂	908	Hourly ^(c)
		NO	807	Hourly ^(c)
		NO ₂	5	Hourly ^(c)
3	Steam Station1 – stack 3	Particulates	126	Daily
		SO ₂	908	Hourly ^(c)
		NO	807	Hourly ^(c)
		NO ₂	5	Hourly ^(c)
4	Steam Station 2	Particulates	103	Daily
		SO ₂	865	Hourly ^(c)
		NO	702	Hourly ^(c)
		NO ₂	4	Hourly ^(c)
<p>(a) Due to the high temperature in the stack it is not possible to conduct isokinetic sampling. Two third-party contractors attempted and failed. Emission factors are also not possible as this incinerator is in excess of 50 years old and its application is unique, and therefore no accurate emission factor can be allocated. It should however be noted that the incinerator operates at a plume visibility below Ringelman 2 and no halogenated components are incinerated.</p> <p>(b) All Hourly averages, unless otherwise marked, indicate ad hoc sampling based on 3 hourly average samples</p> <p>(c) Sampling conducted on a monthly basis by Sasol employees and verified with independent annual ad hoc measurements</p>				

4.3 Point Source Maximum Emission Rates during Start-up, Maintenance and/or Shut-down

Unplanned downtime events such as upset conditions are undesirable from a production perspective as well as an environmental perspective and Sasol endeavours to minimise unplanned downtime by conducting regular and pro-active maintenance and ensuring control of the process within their designed operating parameters. While unplanned downtime cannot be completely eliminated, it is minimised as far as practicably possible, and rectified with high priority.

The MES prescribes that start-up, shut-down, upset and maintenance events should not exceed 48-hours – and if they do, a Section 30 NEMA incident is incurred (as also indicated in the AEL). Sasol's Infrachem operations can confirm that, in the preceding two years, its facility has not exceeded the 48-hour window during start up, maintenance, upset and shutdown conditions, which has ensured that ambient impacts are limited in duration.

Sasol owns and operates accredited ambient air quality monitoring stations in the vicinity of its Sasolburg plant. The real-time ambient air quality monitoring data is closely followed during upset conditions at the plant, to ensure that air quality does not exceed the national ambient air quality standards as a consequence of Sasol's activities.

The Sasolburg operations have an annual phase shut down on both the Sasol One and Midland sites with a total shut-down once every four years for statutory maintenance and inspections. These shut-downs are planned well in advance. Significant emissions are normally associated with cold start-up from the Nitric acid plant and boilers as well as the reformers, which results in the flaring of gas.

The Atmospheric Impact Report Regulations require that the maximum emissions during start-up, shut down and upset conditions must be included within the AIR for the processes. This information is unfortunately not available for two practical reasons, explained below.

1. Since Sasol operates predominantly gaseous plants, operating the plant under start-up, shut down and upset condition is a period of high instability and for safety reasons, as few people as possible are allowed on the plant. Therefore ad hoc sampling under these conditions is a safety risk and therefore the sampling cannot be conducted. It should further be emphasised that the aim of the plant personnel is to get the plant back into operation as soon as possible and therefore the support required by sampling teams cannot be provided as the focus is on returning the plant to stable operation.

Another practical limitation is identification of the precise process conditions that will result in a maximum emission concentration. Since these conditions are unstable, large variations in plant conditions occur dynamically and pin pointing the exact combination of conditions at which to take the sample indicative of a maximum concentration is virtually impossible. Additional to the last mentioned, a maximum concentration may hypothetically exist for only a couple of minutes, however the prescribed legislation requires certain sampling techniques to be done over a period of at least an hour and then to be repeated for two times. Doing this under start-up, shut down and upset conditions are almost impossible due to the dynamics of a plant.

2. In the event where online monitoring is available, Sasol can attempt to make concentrations available for start-up, shut down and upset conditions; however, in investigating this Sasol has realised that the maximum concentrations are higher than the calibration range of the instrument, meaning that the online instrument is yielding only its maximum value. Since the actual true maximum concentration is higher than the instrument maximum, the true actual concentration cannot be provided and therefore an accurate maximum concentration under start-up, shut-down and upset conditions cannot be included.

In mentioning the above, cognisance should be taken that Sasol's ambient air quality monitoring stations monitor ambient air quality over a 24-hour period and any upset, start-up or shut down events will reflect in the ambient air quality measurements and results. Therefore, maximum measured concentrations, although not quantified on site, is included in measured values for ambient air quality.

4.4 Fugitive Emissions

Fugitive emissions on the Sasolburg sites are managed and quantified through two fugitive emissions monitoring programs.

4.4.1 *Fallout dust*

Fallout dust is governed by the National Dust Control Regulations (NDCR) (Government Gazette No. 36974, No. R. 827; 1 November 2013). Sasolburg Operations has 12 dustfall monitoring stations measuring the dust fallout on and around the site. The dust fallout buckets are placed in locations where the likely fallout of dust from coal stockpiles, fine ash dams and construction activities will occur, to ensure adequate control of most probable dust sources is in place. The Safety, Health and Environment function at the Sasolburg site is responsible for the measurement and management of dust in accordance with the NDCR and an accredited third party is responsible for replacing and analysing the buckets on a monthly basis.

The results for an annual sampling campaign for fallout dust are included in Appendix C3 (Figure C3-1 to Figure C3-12). These figures indicate that the fallout dust is predominantly within the lower range considered acceptable for residential areas, despite being an industrial site. Sasol inherently does not operate a process with large quantities of dust or large stock piles of possible fugitive dust emissions, with the exception of some coal stock piles and fine ash dams. The operational fine ash dam is wet and therefore wind-blown dust is limited. Non-operational fine ash dams are vegetated as soon as possible to reduce windblown dust.

The monitoring plan philosophy is that Sasol conduct monitoring and investigate spikes in the monitoring results. In the event that a spike is due to possible long-term effect, the problem will be addressed to ensure low levels of fugitive fallout dust.

4.4.2 *Fugitive VOCs*

The second monitoring program is associated with fugitive VOC emissions. These emissions originate from various basins and ponds, as well as from process equipment such as storage tanks. The on-site monitoring of fugitive process emissions is associated with Leak Detection and Repair. A third party contractor is contracted to conduct leak detection, with the help of a sniffer, to identify and quantify the leaks associated with various process emissions. The report results are then included in the maintenance plan and the leaking process units are repaired per schedule. This process has been in operation for a period exceeding five years. Subsequent to the changeover from coal to gas in 2004, the presence of harmful VOCs such as Benzene, Toluene and Xylene is limited to vehicle emissions.

4.5 Emergency Incidents

There were no reportable emergency incidents, relating to air quality, in the relevant two year period (2012/2013).

Emergency incidents on the site are handled through standard operating procedures governing the actions that need to take place as well as defining the responsibilities of the parties involved in managing the incident. Part of any environmental incident/emergency response, the environmental respondent will evaluate the incident and then classify it according to an internal ranking as well as against relevant legislative requirements which will then trigger the necessary reporting requirements.

5 IMPACT OF ENTERPRISE ON THE RECEIVING ENVIRONMENT

The report includes the results for three emission scenarios per pollutant (per point source where necessary), in order to establish the delta impacts against air quality limit values. The scenarios are as follows:

- *Baseline emissions* – modelling conducted based on the current inventory and impacts
- *Minimum Emissions Standards* - modelling conducted based on plants theoretically complying with:
 - Existing Plant Standards, and;
 - New Plant Standards
- *Alternative Emission Limits* – the emission scenario as proposed by Sasol, where applicable and different from the other three emission scenarios

5.1 Analysis of Emissions' Impact on Human Health

5.1.1 Study Methodology

5.1.1.1 Study Plan

The study methodology may conveniently be divided into a “preparatory phase” and an “execution phase”. The basic methodology followed in this assessment is provided in Figure 5-1.

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

1. Understand Scope of Work
2. Assign Appropriate Specialists (See Appendix A)
3. Review of legal requirements (e.g. dispersion modelling guideline) (see Section 5.1.2)
4. Prepare a Plan of Study for Peer Review
5. Decide on Dispersion Model (see Section 5.1.1.2)

The Regulations regarding Air Dispersion Modelling (Gazette No 37804, vol. 589; published 11 July 2014) was referenced for the dispersion model selection (Appendix B).

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

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

- when assessing contaminants resulting from non-linear processes (e.g. deposition, ground-level ozone (O₃), particulate formation, visibility)

The models recommended for Level 3 assessments are CALPUFF or SCIPUFF. In this study, CALPUFF was selected for the following reasons (as referenced in Figure 5-1 - *Model Aspects to Consider and Dispersion Models*):

- This Lagrangian Gaussian Puff model is well suited to simulate low or calm wind speed conditions. Alternative regulatory models such as the US EPA AERMOD model treats all plumes as straight-line trajectories, which under calm wind conditions grossly over-estimates the plume travel distance.
- CALPUFF is able to perform chemical transformations. In this study the conversion of NO to NO₂ and the secondary formation of particulate matter were concerns.

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

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

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

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

- Decide on meteorological data input (Figure 5-1- CALMET). A summary of the model control options for CALMET is provided in Appendix D. Refer to Section 5.1.4.6.1.
- Prepare all meteorological model input files (Figure 5-1- CALMET)
 - Surface meteorological files
 - MM5 meteorological files
 - Topography
 - Land Use
- Select control options in meteorological model (Figure 5-1- CALMET)
 - Dispersion coefficients
 - Vertical levels
 - Receptor grid
- *Feedback to Project Team and revise where necessary*
- Review emissions inventory and ambient measurements
- *Feedback to Project Team and revise where necessary*
- Decide on dispersion model controls and module options (Figure 5-1- CALPUFF). A summary of the model control options for CALPUFF is provided in Appendix E. Refer to Section 5.1.4.6.3.
- Decide on dispersion module options (Figure 5-1- CALPUFF).
 - Sulfate and nitrate formation module (MESOPUFF or RIVAD)
 - NO₂ formation (MESOPUFF or RIVAD)

- Model resolution
- *Feedback to Project Team and revise where necessary*
- Decide on modelling domain and receptor locations (Figure 5-1– CALPUFF and Simulations)
- *Feedback to Project Team and revise where necessary*
- Prepare all dispersion model input files (Figure 5-1- CALPUFF)
 - Control options
 - Measured ambient O₃ and NH₃ for chemical transformation module
 - Meteorology
 - Source data
 - Receptor grid and discrete receptors
- Review all modelling input data files and fix where necessary
- Simulate source groups per pollutant and calculate air concentration levels for regular and discrete grid locations for the following scenarios (Figure 5-1–Simulations):
 - Baseline (current) air emissions
 - Change Baseline sources to reflect compliance with “Existing Plant” standards
 - Change Baseline sources to reflect compliance with “New Plant” standards
 - Change Baseline sources to reflect “Alternative Emission Limits”, where applicable
- Compare against National Ambient Air Quality Standards (NAAQS)
- *Present Results to Project Team*
- Preparation of draft AIR
- *Present AIR to Project Team*
- Preparation of final AIR
- Updates to AIR in order to address stakeholder comments.

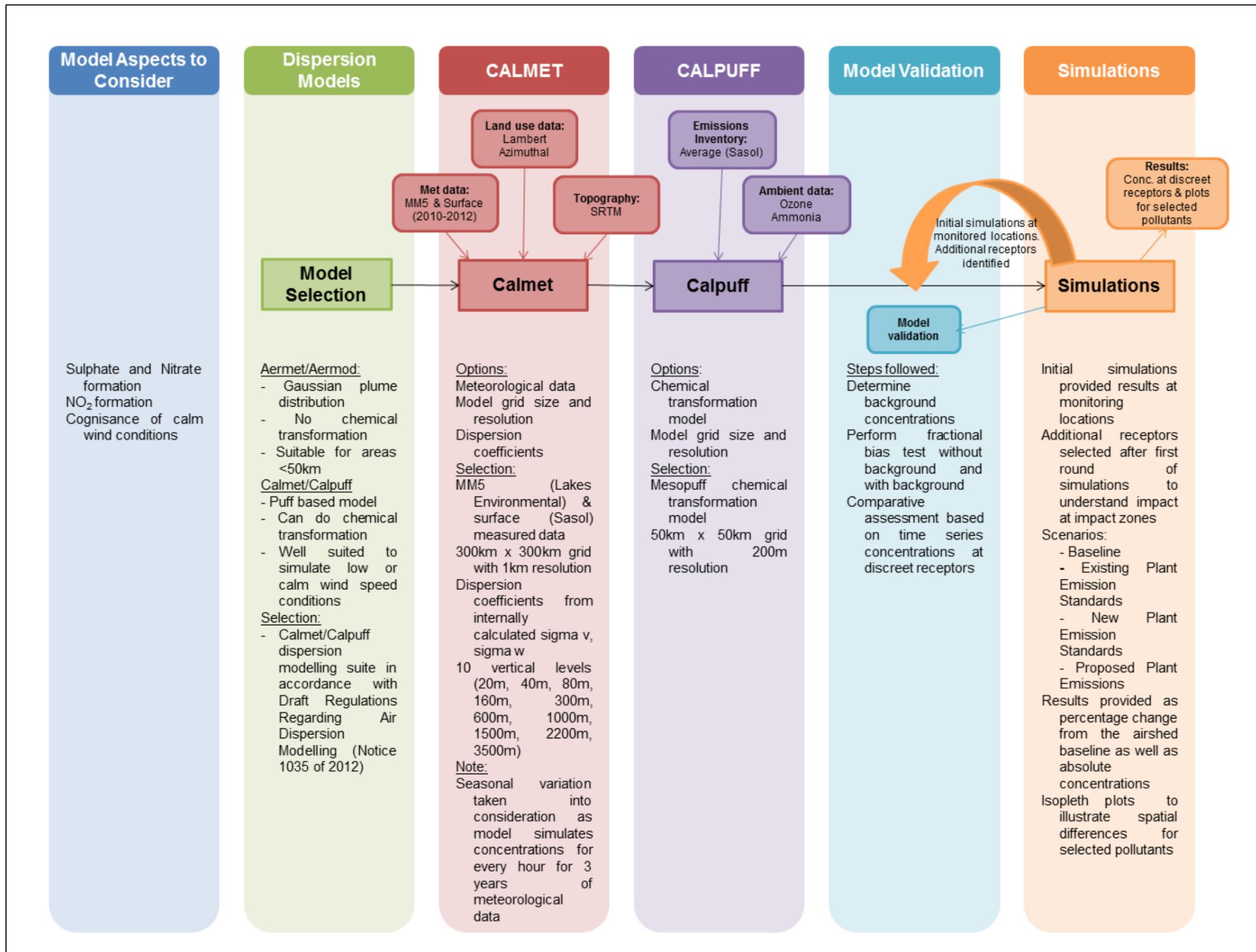


Figure 5-1: The basic study methodology followed for the assessment

In order to assess the impact of each of the postponements for which Sasol has applied, four emissions scenarios were modelled, with the results throughout the AIR presented as illustrated in Figure 5-2.

1. **Current baseline emissions**, reflective of the impacts of present operations, which are modelled as averages of measurements taken from continuous emission monitoring (where available) or periodic emission monitoring. This scenario is then represented by the first column in the presentation of all AIR graphs (shown in blue in Figure 5-2). Baseline emissions were derived from approved 3rd parties and accredited (ISO/IEC17025) laboratories. Emissions measurements follow the requirements prescribed in Schedule A of GN 893. The reason baseline emissions were modelled as averages of measured point source emissions was to obtain a picture of long-term average impacts of Sasol's emissions on ambient air concentrations, which could be reasonably compared with monitored ambient concentrations, as a means of assessing the representativeness of the dispersion model's predictions. Modelling baseline emissions at a ceiling level, which is seldom reflective of actual emissions, would over-predict ambient impacts, and therefore not allow for reasonable assessment of the model's representativeness.

The following three scenarios are modelled to reflect the administrative basis of the MES, being ceiling emission levels. These scenarios are therefore theoretical cases where the point source is constantly emitting at the highest expected emission level possible under normal operating conditions, for the given scenario (i.e. the 100th percentile emission concentration).

2. **Compliance with the 2015 existing plant standards**. This is modelled as a ceiling emissions limit (i.e. maximum emission concentration) aligned with the prescribed standard, and reflects a scenario where abatement equipment is introduced to theoretically reduce emissions to conform to the standards. This scenario is then represented by the second column in the presentation of all AIR graphs (shown in red in Figure 5-2). For example, this considers the renewal of ESPs and the implementation of low NO_x burners to meet Steam plant boiler existing plant standards.
3. **Compliance with the 2020 new plant standards**. This is modelled as a ceiling emissions limit (i.e. maximum emission concentration) aligned with the prescribed standard, and reflects a scenario where abatement equipment is introduced to theoretically reduce emissions to conform to the standards. This scenario is the represented by the third column in the presentation of all AIR graphs (shown in green in Figure 5-2). For example, this considers the implementation of flue-gas desulfurisation (FGD) at the Steam plant's boilers, which would result in lowered flue gas temperatures from the boilers with a resulting detrimental effect on the co-dispersion of other pollutants including NO_x and PM; and,
4. **A worst-case scenario of operating constantly at the requested alternative emissions limits**, which have been specified as ceiling emissions limits (i.e. maximum emission concentrations). This scenario is then represented by the fourth column in the presentation of all AIR graphs (shown in purple in Figure 5-2). It is re-emphasised that Sasol will not physically increase its current baseline emissions (expressed as an average). In some instances the scenario appears higher than the baseline, only because it portrays the worst case outcome where the 100th percentile emission rate occurs under the 99th percentile worst meteorological conditions – and this is modelled assuming these conditions prevail for the entire duration of the modelling period. Sasol seeks alternative emissions limits which are aligned with the manner in which the MES are stated and which accommodate the natural variability inherent in emissions under different operating conditions, and hence must request a ceiling emissions limit rather than an average emissions limit. The alternative emission limit is hence simply a different way of expressing current baseline emissions (in cases where further abatement is not possible), or may even reflect a reduction in average baseline

emissions (in cases where further abatement is possible, but not to a level which achieves compliance with the MES ceiling emissions limits).

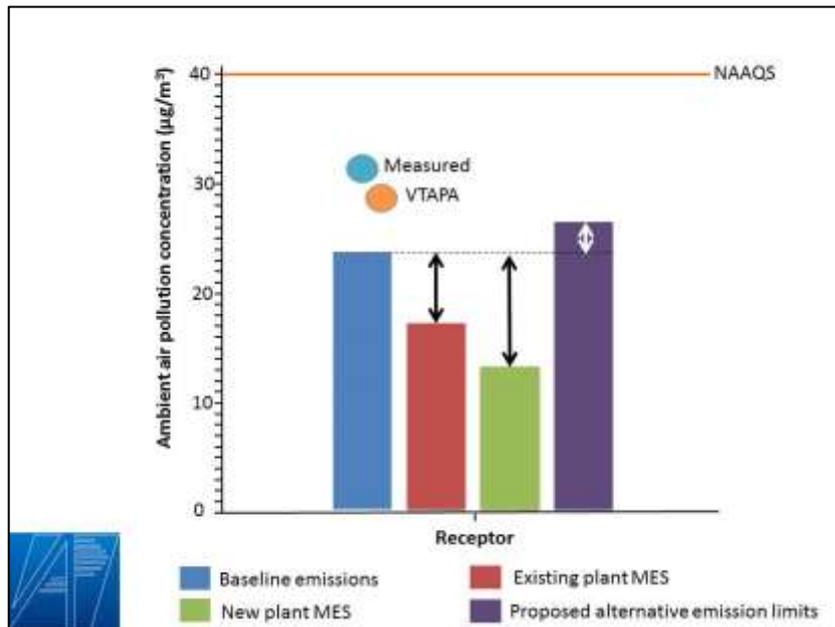


Figure 5-2: Schematic displaying how the dispersion modelling scenarios are presented, for each receptor in the modelling domain

In Figure 5-2, the black arrows above the red and green bars reflect the predicted delta (change) in ambient impacts of Sasol Sasolburg Operations baseline emissions versus the given compliance scenario. At a practical level, the white arrow on the purple bar represents the theoretical delta increase in short-term ambient impacts, where 100th percentile emissions occur, compared with the predicted impact of average current baseline emissions. The blue dot in Figure 5-2 represents physically measured ambient air quality, reflective of the total impact of all sources in the vicinity, as the 99th percentile recorded value over the averaging period. On a given day, there is a 99% chance that the actual measured ambient air quality would be lower than this value, but this value is reflected for the purpose of aligning with modelling requirements. The orange line represents the applicable National Ambient Air Quality Standard (NAAQS) or, where not available, relevant international health-effect screening level, used for interpretation of the dispersion modelling results, as described in Section 5.1.8.2.

5.1.1.3 CALPUFF/CALMET Modelling Suite

As discussed in the previous section, the CALPUFF model was selected for use in the current investigation to predict maximum short-term (1 and 24-hour) and annual average ground-level concentrations at various receptor locations within the computational domain. CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion model that can simulate the effects of time- and space-varying meteorological conditions on pollutant transport, transformation, and removal (Scire *et al.*, 2000a). It can accommodate arbitrarily varying point source, area source, volume source, and line source emissions. The CALPUFF code includes algorithms for near-source effects such as building downwash, transitional plume rise, partial plume penetration, sub grid scale terrain interactions as well as longer range effects such as pollutant removal due to wet scavenging and dry deposition, chemical transformation, vertical wind shear, overwater transport and coastal interaction effects.

The model is intended for use on scales from tens of metres to hundreds of kilometres from a source (US EPA 1998). The CALPUFF model allows the user to select from a number of calculation options, including a choice of dispersion coefficient and chemical transformation formulations. The different dispersion coefficient approaches accommodated in the CALPUFF model include:

- stability-based empirical relationships such as the Pasquill-Gifford or McElroy-Pooler dispersion coefficients;
- turbulence-based dispersion coefficients (based on measured standard deviations of the vertical and crosswind horizontal components of the wind); and
- similarity theory to estimate the turbulent quantities using the micrometeorological variables calculated by CALMET

The most desirable approach is to use turbulence-based dispersion coefficients using measured turbulent velocity variances or intensity components, if such data are readily available and they are of good quality. However, since reliable turbulent measurements are generally not available, the next best recommendation is to use the similarity approach.

CALPUFF includes parameterized chemistry modules for the formation of secondary sulfate and nitrate from the oxidation of the emitted primary pollutants, SO₂ and NO_x. The conversion processes are assumed to be linearly dependent (first-order) on the relevant primary species concentrations. Two options are included, namely the MESOPUFF II and RIVAD/ARM3 chemistry options. In both options, a fairly simple stoichiometric thermodynamic model is used to estimate the partitioning of total inorganic nitrate between gas-phase nitric acid and particle-phase ammonium nitrate. Ammonia and O₃ concentrations are required as background values to the model.

CALPUFF uses dry deposition velocities to calculate the dry deposition of gaseous and particulate pollutants to the surface. These dry deposition velocities can either be user-specified or calculated internally in CALPUFF. A resistance-based model is used for the latter option. For gaseous pollutants, the resistances that are considered are the atmospheric resistance, the deposition layer resistance, and the canopy resistance. For particles, a gravitational settling term is included and the canopy resistance is assumed to be negligible. CALPUFF uses the scavenging coefficient approach to parameterize wet deposition of gases and particles. The scavenging coefficient depends on pollutant characteristics (e.g., solubility and reactivity), as well as the precipitation rate and type of precipitation. The model provides default values for the scavenging coefficient for various species and two types of precipitation (liquid and frozen). These values may be overridden by the user.

CALPUFF also has the capability to model the effects of vertical wind shear by explicitly allowing different puffs to be independently advected by their local average wind speed and direction, as well as by optionally allowing well-mixed puffs to split into two or more puffs when across-puff shear becomes important. Another refinement is an option to use a probability density function (pdf) model to simulate vertical dispersion during convective conditions.

The CALPUFF modelling system consists of a number of software components, as summarised in Table 5-1, however only CALMET and CALPUFF contain the simulation engines to calculate the three-dimensional atmospheric boundary layer conditions and the dispersion and removal mechanisms of pollutants released into this boundary layer. The other components are mainly used to assist with the preparation of input and output data. Table 5-1 also includes the development versions of each of the codes used in this investigation.

Table 5-1: Summary description of CALPUFF/CALMET model suite with versions used in the investigation

Module	Version	Description
CALMET	v6.334	Three-dimensional, diagnostic meteorological model

Module	Version	Description
CALPUFF	v6.42	Non-steady-state Gaussian puff dispersion model with chemical removal, wet and dry deposition, complex terrain algorithms, building downwash, plume fumigation and other effects.
CALPOST	V6.292	A post-processing program for the output fields of meteorological data, concentrations and deposition fluxes.
CALSUM	v1.4 ⁽¹⁾	Sums and scales concentrations or wet/dry fluxes from two or more source groups from different CALPUFF runs
PRTMET	v 4.495 ⁽¹⁾	Lists selected meteorological data from CALMET and creates plot files
POSTUTIL	v1.641 ⁽¹⁾	Processes CALPUFF concentration and wet/dry flux files. Creates new species as weighted combinations of modelled species; merges species from different runs into a single output file; sums and scales results from different runs; repartitions nitric acid/nitrate based on total available sulfate and ammonia.
TERREL	v3.69 ⁽¹⁾	Combines and grids terrain data
CTGPROC	v3.5 ⁽¹⁾	Processes and grids land use data
MAKEGEO	v3.2 ⁽¹⁾	Merges land use and terrain data to produce the geophysical data file for CALMET

Note ⁽¹⁾: These modules indicate version number as listed on http://www.src.com/calpuff/download/mod6_codes.htm (for CALPro Plus v6) [version number not given in graphical interface or 'About' information].

A summary of the main CALMET and CALPUFF control options are given in Appendices D and E, respectively.

5.1.2 Legal Requirements

5.1.2.1 Atmospheric Impact Report

In the event where an application for postponement is being made, Section 21 of NEM: Air Quality Act (AQA), Regulations 11 and 12 state:

1. An application for postponement may be made to the National Air Quality Officer
2. The application contemplated in Regulation 11 must include, amongst others, an Atmospheric Impact Report.

The format of the Atmospheric Impact Report is stipulated in the Regulations Prescribing the Format of the Atmospheric Impact Report, Government Gazette No. 36904, Notice Number 747 of 2013 (11 October 2013) (Appendix B; Table B-1).

Sasol appointed Airshed to compile this AIR to meet the requirements of Regulation 12 (Postponement of compliance time frames) of the Listed Activities and Associated Minimum Emissions Standards (Government Gazette No. 37054, 22 November 2013) (Appendix B; Table B-1).

5.1.2.2 National Ambient Air Quality Standards

Modelled concentrations will be assessed against NAAQS (Table 5-2), where they are prescribed by South African legislation. Where no NAAQS exists for a relevant non-criteria pollutant, health screening effect levels based on international guidelines are used. These are discussed with the results of dispersion modelling in Section 5.1.8.2.

Table 5-2: National Ambient Air Quality Standards

Pollutant	Averaging Period	Concentration ($\mu\text{g}/\text{m}^3$)	Frequency of Exceedance	Compliance Date
Benzene (C_6H_6)	1 year	10	0	Immediate until 31 December 2014
	1 year	5	0	1 January 2015
Carbon Monoxide (CO)	1 hour	30000	88	Immediate
	8 hour ^(a)	10000	11	Immediate
Lead (Pb)	1 year	0.5	0	Immediate
Nitrogen Dioxide (NO_2)	1 hour	200	88	Immediate
	1 year	40	0	Immediate
Ozone (O_3)	8 hour ^(b)	120	11	Immediate
$\text{PM}_{2.5}$	24 hour	65	4	Immediate until 31 December 2015
	24 hour	40	4	1 January 2016 until 31 December 2029
	24 hour	25	4	1 January 2030
	1 year	25	0	Immediate until 31 December 2015
	1 year	20	0	1 January 2016 until 31 December 2029
	1 year	15	0	1 January 2030
PM_{10}	24 hour	120	4	Immediate until 31 December 2014
	24 hour	75	4	1 January 2015
	1 year	50	0	Immediate until 31 December 2014
	1 year	40	0	1 January 2015
Sulfur Dioxide (SO_2)	10 minutes	500	526	Immediate
	1 hour	350	88	Immediate
	24 hour	125	4	Immediate
	1 year	50	0	Immediate

Notes:

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

5.1.3 Regulations regarding Air Dispersion Modelling

Air dispersion modelling provides a cost-effective means for assessing the impact of air emission sources, the major focus of which is to determine compliance with the relevant ambient air quality standards. Regulations regarding Air Dispersion Modelling were promulgated in Government Gazette No. 37804 vol. 589; 11 July 2014, and recommend a suite of

dispersion models to be applied for regulatory practices as well as guidance on modelling input requirements, protocols and procedures to be followed. The Regulations Regarding Air Dispersion Modelling are applicable:

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

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

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

Dispersion modelling can typically be used in the:

- Apportionment of individual sources for installations with multiple sources. In this way, the individual contribution of each source to the maximum ambient predicted concentration can be determined. This may be extended to the study of cumulative impact assessments where modelling can be used to model numerous installations and to investigate the impact of individual installations and sources on the maximum ambient pollutant concentrations.
- Analysis of ground level concentration changes as a result of different release conditions (e.g. by changing stack heights, diameters and operating conditions such as exit gas velocity and temperatures).
- Assessment of variable emissions as a result of process variations, start-up, shut-down or abnormal operations.
- Specification and planning of ambient air monitoring programmes which, in addition to the location of sensitive receptors, are often based on the prediction of air quality hotspots.

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

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

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

New generation dispersion models, including models such as AERMOD and CALPUFF¹, simulate the dispersion process using planetary boundary layer (PBL) scaling theory. PBL depth and the dispersion of pollutants within this layer are influenced by specific surface characteristics such as surface roughness, albedo and the availability of surface moisture:

- Roughness length (z_0) is a measure of the aerodynamic roughness of a surface and is related to the height, shape and density of the surface as well as the wind speed.
- Albedo is a measure of the reflectivity of the Earth's surface. This parameter provides a measure of the amount of incident solar radiation that is absorbed by the Earth/atmosphere system. It is an important parameter since absorbed solar radiation is one of the driving forces for local, regional, and global atmospheric dynamics.
- The Bowen ratio provides measures of the availability of surface moisture injected into the atmosphere and is defined as the ratio of the vertical flux of sensible heat to latent heat, where sensible heat is the transfer of heat from the surface to the atmosphere via convection and latent heat is the transfer of heat required to evaporate liquid water from the surface to the atmosphere.

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

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

Chapter 5 provides general guidance on geophysical data, model domain and coordinates system required in dispersion modelling, whereas Chapter 6 elaborates more on these parameters as well as the inclusion of background air concentration data. The chapter also provides guidance on the treatment of NO₂ formation from NO_x emissions, chemical transformation of sulfur dioxide into sulfates and deposition processes.

Chapter 7 of the Regulations outline how the plan of study and modelling assessment reports are to be presented to authorities. A comparison of how this study met the requirements of the Regulations is provided in Appendix B.

5.1.4 Atmospheric Dispersion Processes

CALPUFF initiates the simulation of point source plumes with a calculation of buoyant plume rise as discussed below in Section 5.1.3.1. Transport winds are extracted from the meteorological data file at the location of the stack and at the effective plume height (stack height plus plume rise). For near-field effects, the height of the plume in transition to the final

¹ The CALMET modelling system require further geophysical parameters including surface heat flux, anthropogenic heat flux and leaf area index (LAI).

plume height is taken into account. The puff release rate is calculated internally, based on the transport speed and the distance to the closest receptor.

As the puff is transported downwind, it grows due to dispersion and wind shear, and the trajectory is determined by advection winds at the puff location and height at each time step. The pollutant mass within each puff is initially a function of the emission rate from the original source. The pollutant mass is also subject to chemical transformation, washout by rain and dry deposition, when these options are selected, as is the case in this application. Chemical transformation and removal are calculated based on a one-hour time step.

Both wet and dry deposition fluxes are calculated by CALPUFF, based on a full resistance model for dry deposition and the use of precipitation rate-dependent scavenging coefficients for wet deposition. Pollutant mass is removed from the puff due to deposition at each time step. For the present modelling analyses, most options were set at "default" values, including the MESOPUFF II transformation scheme² and the treatment of terrain.

5.1.4.1 *Plume Buoyancy*

Gases leaving a stack mix with ambient air and undergo three phases namely the initial phase, the transition phase and the diffusion phase (Figure 5-3). The initial phase is greatly determined by the physical properties of the emitted gases. These gases may have momentum as they enter the atmosphere and are often heated and therefore warmer than the ambient air. Warmer gases are less dense than the ambient air and are therefore buoyant. A combination of the gases' momentum and buoyancy causes the gases to rise (vertical jet section, in Figure 5-3). In the Bent-Over Jet Section, entrainment of the cross flow is rapid because, by this time, appreciable growth of vortices has taken place. The self-generated turbulence causes mixing and determines the growth of plume in the thermal section. This is referred to as plume rise and allows air pollutants emitted in this gas stream to be lifted higher in the atmosphere. Since the plume is higher in the atmosphere and at a further distance from the ground, the plume will disperse more before it reaches ground level. With greater volumetric flow and increased exit gas temperatures, the plume centreline would be higher than if either the volumetric flow or the exit gas temperature is reduced. The subsequent ground level concentrations would therefore be lower.

This is particularly important in understanding some of the dispersion model results in Section 5.1.7. As an example, consider the emissions from a boiler. With the introduction of retrofitted emission controls (e.g. wet scrubber or bag filters), the exit gas temperature and perhaps the volumetric flow would be lower than the original values. Thus it is quite possible that the resultant decrease in plume momentum and buoyancy may actually result in higher ground level concentrations despite the reduction in point source emission concentrations, due to the lower plume centreline.

² A sensitivity study was carried out with the RIVAD II transformation scheme to examine the performance of the different approaches to calculating the SO₂ to SO₄ and NO_x to NO₃ transformation rates. The concentrations from the RIVAD II and the MESOPUFF II transformation schemes showed no real bias with the secondary particulate formation varying by -41% to 31% for the two schemes.

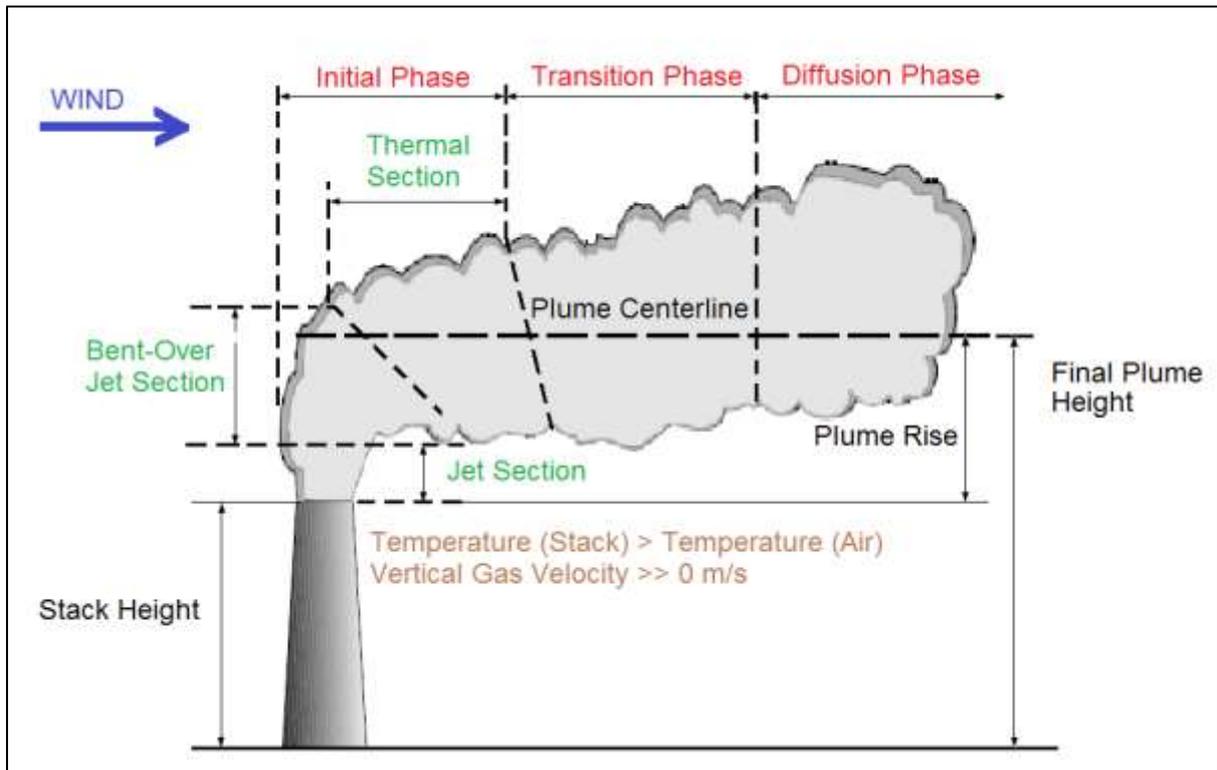


Figure 5-3: Plume buoyancy

5.1.4.2 Urban & Rural Conditions

Land use information is important to air dispersion modelling, firstly to ensure that the appropriate dispersion coefficients and wind profiles (specified as surface roughness) are used, and secondly, that the most appropriate chemical transformation models are employed. Urban conditions result in different dispersion conditions than in rural areas, as well as changing the vertical wind profiles. Urban conditions are also generally associated with increased levels of volatile organic compounds (VOCs), thereby influencing chemical equilibriums between the photochemical reactions of NO_x , CO and O_3 .

It can be appreciated that the definition of urban and rural conditions for the dispersion coefficients and wind profiles, on the one hand, and chemical reactions on the other, may not be the same. Nonetheless, it was decided to use the US Environmental Protection Agency's (US EPA's) guideline on air dispersion models (US EPA 2005), to classify the surrounding land-use as rural or urban based on the Auer method, which is strictly recommended for selecting dispersion coefficients.

The classification scheme is based on the activities within a 3 km radius of the emitting stack. Areas typically defined as rural include residences with grass lawns and trees, large estates, metropolitan parks and golf courses, agricultural areas, undeveloped land and water surfaces. An area is defined as urban if it has less than 35% vegetation coverage or the area falls into one of the use types in Table 5-3.

Table 5-3: Definition of vegetation cover for different developments (US EPA 2005)

Urban Land-Use		
Type	Development Type	Vegetation Cover
I1	Heavy industrial	Less than 5%
I2	Light/moderate industrial	Less than 10%
C1	Commercial	Less than 15%
R2	Dense/multi-family	Less than 30%
R3	Multi-family, two storey	Less than 35%

According to this classification scheme, the Infracem facility is classified as urban.

5.1.4.3 Nitrogen Dioxide Formation

Of the several species of nitrogen oxides, only NO₂ is specified in the NAAQS. Since most sources emit uncertain ratios of these species and these ratios change further in the atmosphere due to chemical reactions, a method for determining the amount of NO₂ in the plume must be selected.

Estimation of this conversion normally follows a tiered approach, as discussed in the draft Regulations Regarding Air Dispersion Modelling (Government Gazette No. 35981, published 14 December 2012), which presents a scheme for annual averages:

Tier 1: Total Conversion Method

Use any of the appropriate models recommended to estimate the maximum annual average NO₂ concentrations by assuming a total conversion of NO to NO₂. If the maximum NO_x concentrations are less than the NAAQS for NO₂, then no further refinement of the conversion factor is required. If the maximum NO_x concentrations are greater than the NAAQS for NO₂, or if a more "realistic" estimate of NO₂ is desired, proceed to the second tier level.

Tier 2: Ambient Ratio Method (ARM) - Multiply NO_x by a national ratio of NO₂/NO_x = 0.80

Assume a wide area quasi-equilibrium state and multiply the Tier 1 empirical estimate NO_x by a ratio of NO₂/NO_x = 0.80. The ratio is recommended for South Africa as the conservative ratio based on a review of ambient air quality monitoring data from the country. If representative ambient NO and NO₂ monitoring data is available (for at least one year of monitoring), and the data is considered to represent a quasi-equilibrium condition where further significant changes of the NO/NO₂ ratio is not expected, then the NO/NO₂ ratio based on the monitoring data can be applied to derive NO₂ as an alternative to the national ratio of 0.80.

In the Total Conversion Method, the emission rate of all NO_x species is used in the dispersion model to predict ground-level concentrations of total NO_x. These levels of NO_x are assumed to exist as 100% NO₂, and are directly compared to the NAAQS for NO₂. If the NAAQS are met, the Tier 2 methods are not necessary.

Although not provided in the Regulations (Section 5.1.3), the conversion of NO to NO₂ may also be based on the amount of ozone available within the volume of the plume. The NO₂/NO_x conversion ratio is therefore coupled with the dispersion of the plume. This is known as the Ozone Limiting Method (OLM). Use of onsite ozone data is always preferred for the OLM method.

Ideally, the NO₂ formation should be dealt with in the dispersion model. CALPUFF has one such a module, known as the RIVAD / ARM3 chemical formulations. The RIVAD / ARM3 chemical formulations option in the CALPUFF model can be

used to calculate NO₂ concentrations directly in rural (non-urban) areas (Morris et al., 1988). The RIVAD / ARM3 option incorporates the effect of chemical and photochemical reactions on the formation of nitrates and other deposition chemicals. However, since the Infracem study area could be classified as urban (Section 5.1.4.2), the RIVAD / ARM3 chemical formulations should not be used.

Whilst the MESOPUFF II chemical transformation scheme, which is also included in the CALPUFF model accommodates NO_x reactions, these are only considering the formation of nitrates and not the NO /NO₂ reactions.

Given all of the above limitations, it was decided to employ the Ambient Ratio Method (ARM), i.e. the second version of the DEA Tier 2 option. The ARM ambient ratio method is based upon the premise that the NO₂/NO_x ratio in a plume changes as it is transported but attains an equilibrium value some distance away from the source (Scire and Borissova, 2011). In their study, Scire and Borissova analysed hourly monitored NO₂ and NO_x data for 2006 at 325 monitoring sites throughout USA, which amounted to approximately 2.8 million data points for each species. These observations were grouped into a number of concentration ranges (bins), and the binned data were used to compute bin maximums and bin average curves. Short-term (1-hr) NO₂/NO_x ratios were subsequently developed based on bin-maximum data. Similarly, long-term (annual average) NO₂/NO_x ratios were based on bin-averaged data. The method was tested using the NO₂/NO_x ratios applied to the observed NO_x at selected stations to predict NO₂, and then compared to observed NO₂ concentrations at that station. The comparison of NO₂ derived from observed NO_x using these empirical curves was shown to be a conservative estimate of observed NO₂, whilst at the same time arriving at a more realistic approximation than if simply assuming a 100% conversion rate. More details of the adopted conversion factors are given in Appendix F.

5.1.4.4 Particulate Formation

CALPUFF includes two chemical transformation schemes for the calculation of sulfate and nitrate formation from SO₂ and NO_x emissions. These are the MESOPUFF II and the RIVAD / ARM3 chemical formulations. Whilst the former scheme is not specifically restricted to urban or rural conditions; the latter was developed for use in rural conditions. Since the Infracem study area could be classified as urban (Section 5.1.5), the RIVAD / ARM3 chemical formulations should not be used. The chemical transformation scheme chosen for this analysis was therefore the MESOPUFF II scheme. As described in the CALPUFF User Guide it is a "pseudo first-order chemical reaction mechanism" and involves five pollutant species namely SO₂, sulfates (SO₄), NO_x, nitric acid (HNO₃) and particulate nitrate. CALPUFF calculates the rate of transformation of SO₂ to SO₄, and the rate of transformation of NO_x to NO₃, based on environmental conditions including the ozone concentration, atmospheric stability, solar radiation, relative humidity, and the plume NO_x concentration. The daytime reaction formulation depends on solar radiation and the transformation increases non-linearly with the solar radiation (see the SO₂ to SO₄ transformation rate equation (equation 2-253 in the CALPUFF User Guide). At night, the transformation rate defaults to a constant value of 0.2% per hour. Calculations based on these formulas show that the transformation rate can reach about 3 per cent per hour at noon on a cloudless day with 100 ppb of ozone.

With the MESOPUFF-II mechanism, NO_x transformation rates depend on the concentration levels of NO_x and O₃ (equations 2-254 and 2-255 in the CALPUFF User Guide) and both organic nitrates (RNO₃) and HNO₃ are formed. According to the scheme, the formation of RNO₃ is irreversible and is not subject to wet or dry deposition. The formation of HNO₃, however, is reversible and is a function of temperature and relative humidity. The formation of particulate nitrate is further determined through the reaction of HNO₃ and NH₃. Background NH₃ concentrations are therefore required as input to calculate the equilibrium between HNO₃ and particulate nitrate. At night, the NO_x transformation rate defaults to a constant value of 2.0% per hour. Hourly average ozone and ammonia concentrations were included as input in the CALPUFF model to facilitate these sulfate and nitrate formation calculations.

The limitation of the CALPUFF model is that each puff is treated in isolation, i.e. any interaction between puffs from the same or different points of emission is not accounted for in these transformation schemes. CALPUFF first assumes that ammonia reacts preferentially with sulfate, and that there is always sufficient ammonia to react with the entire sulfate present within a single puff. The CALPUFF model performs a calculation to determine how much NH_3 remains after the particulate sulfate has been formed and the balance would then be available for reaction with NO_3 within the puff. The formation of particulate nitrate is subsequently limited by the amount of available NH_3 . Although this may be regarded a limitation, in this application the particulate formation is considered as a group and not necessarily per species.

5.1.4.5 Ozone Formation

Similar to sulphate, nitrate and nitrogen dioxide, ozone (O_3) can also be formed through chemical reactions between pollutants released into the atmosphere. As a secondary pollutant, O_3 is formed in the lower part of the atmosphere, from complex photochemical reactions following emissions of precursor gases such as NO_x and VOCs (Seinfeld and Pandis, 1998). O_3 is produced during the oxidation of CO and hydrocarbons by hydroxyls (OH) in the presence of NO_x and sunlight (Seinfeld and Pandis, 1998). The rate of ozone production can therefore be limited by CO, VOCs or NO_x . In densely populated regions with high emissions of NO_x and hydrocarbons, rapid O_3 production can take place and result in a surface air pollution problem. In these urban areas O_3 formation is often VOC-limited. O_3 is generally NO_x -limited in rural areas and downwind suburban areas.

O_3 concentration levels have the potential to become particularly high in areas where considerable O_3 precursor emissions combine with stagnant wind conditions during the summer, when high insolation and temperatures occur (Seinfeld and Pandis, 1998). The effects of sunlight on O_3 formation depend on its intensity and its spectral distribution.

The main sectors that emit ozone precursors are road transport, power and heat generation plants, household (heating), industry, and petrol storage and distribution. In many urban areas, O_3 nonattainment is not caused by emissions from the local area alone. Due to atmospheric transport, contributions of precursors from the surrounding region can also be important. The transport of O_3 is determined by meteorological and chemical processes which typically extend over spatial scales of several hundred kilometres. Thus, in an attempt to study O_3 concentrations in a local area, it is necessary to include regional emissions and transport. This requires a significantly larger study domain with the inclusion of a significantly more comprehensive emissions inventory of NO_x and VOCs sources (e.g. vehicle emissions in Gauteng). Such a collaborative study was not within the scope of this report.

5.1.4.6 Model Input

5.1.4.6.1 Meteorological Input Data

The option of Partial Observations was selected for the CALMET wind field model which used both measured and observed meteorological data (refer to Appendix D for all CALMET Control Options).. For measured data, use was made of PSU/NCAR mesoscale model (known as MM5). MM5 is an acronym for the Fifth-Generation NCAR/Penn State Mesoscale Model, which is a limited-area, nonhydrostatic, terrain-following sigma-coordinate model designed to simulate or predict mesoscale and regional-scale atmospheric circulation. Terrestrial and isobaric meteorological data are horizontally interpolated with observations from the standard network of surface and rawinsonde stations. MM5 data for the period 2010 to 2012 on a 12 km horizontal resolution for a 300 km by 300 km was used. MM5 data was supplemented with surface field observations from the monitoring stations operated by Sasol. For CALMET, the surface data was consolidated into one source file, taking the most representative data set into account. Meteorological parameters provided for the Sasol monitoring stations are provided in Table 5-4.

Table 5-4: Meteorological parameters provided for the Sasol monitoring stations in the Sasolburg vicinity

Monitoring Station	Latitude	Longitude	Closest Residential Area	Meteorology						
				WD	WS	Temp	Rel Hum	Press	Sol rad	Rain
Sasol 1 Fence Line*	-26.834722	27.848611	Sasolburg	✓	✓	✓	✓	✓	✓	✓
AJ Jacobs	-26.822778	27.826111	Sasolburg	✓	✓					
Leitrim	-26.850278	27.874167	Sasolburg	✓	✓	✓	✓	✓		

* Sasol 1 Fence Line used only as a meteorological station and for measured ammonia (NH₃) used to estimate secondary particulate formation in CALPUFF but not for ambient concentration comparison, due to potential bias to industry as the station is located on-site.

5.1.4.6.2 Land Use and Topographical Data

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

5.1.4.6.3 Dispersion Coefficients

The option of dispersion coefficients from internally calculated sigma v, sigma w using micrometeorological variables (u*, w*, L, etc.) was selected (refer to Appendix E for all CALPUFF control options).

5.1.4.6.4 Grid Resolution and Model Domain

The CALMET modelling domain included an area of 300 km by 300 km with a horizontal grid resolution of 1 km. The vertical profile included ten vertical levels up to a height of 3 500 m. The CALPUFF model domain selected for the point sources at the Infrachem complex included an area of 50 km by 50 km with a grid resolution of 200 m. This area was selected based on the assessment undertaken for the Vaal Triangle Air-shed Priority Area and the predicted area of impact around Sasolburg.

5.1.5 Atmospheric Dispersion Potential

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

Sasol currently operate four meteorological stations in the Sasolbug area (viz. AJ Jacobs, Leitrim, Fence Line and Ecopark). For this assessment, data was provided for AJ Jacobs, Leitrim and Fence Line monitoring stations for the period 2010 to 2012. Parameters useful in describing the dispersion and dilution potential of the site i.e. wind speed, wind direction, temperature and atmospheric stability, are subsequently discussed.

5.1.5.1 Surface Wind Field

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

The period wind field and diurnal variability for Leitrim and AJ Jacobs are provided in Figure 5-4 and Figure 5-5 respectively. The predominant wind direction at Leitrim for the period 2010-2012 is from the east-northeast with little variation of day- and night-time wind fields.

The predominant wind direction from AJ Jacobs is from north to northeast. It should be noted that relatively low wind speeds are observed with very little wind from the south eastern sector. This is due to high trees to the southeast of the monitoring station that blocks the wind flow. The CALMET flow field (taking surface and MM5 data into account), provides higher wind speeds for the AJ Jacobs location with more frequent wind from the south eastern quadrant (Figure 5-6).

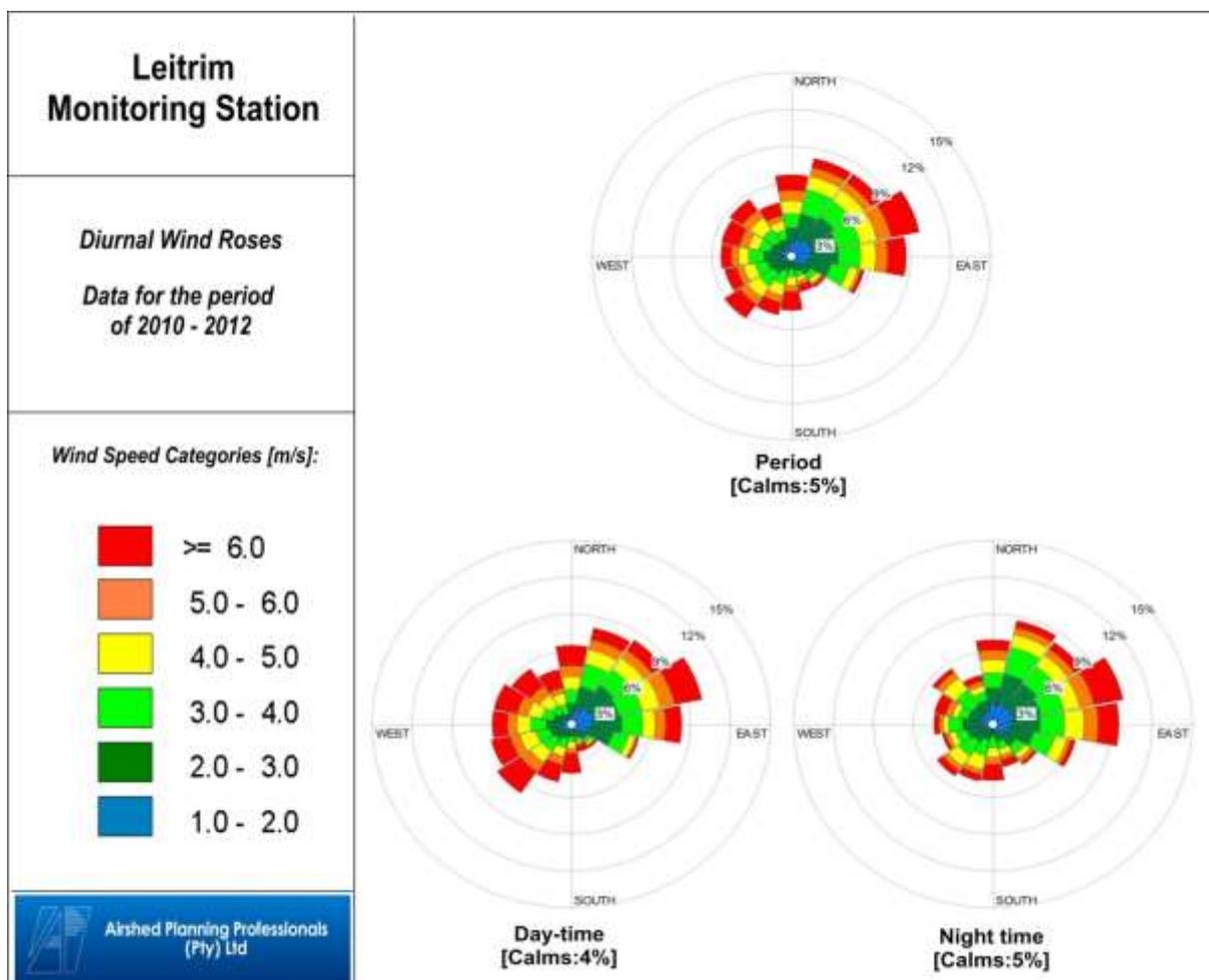


Figure 5-4: Period, day- and night-time wind rose for Leitrim for the period 2010 - 2012

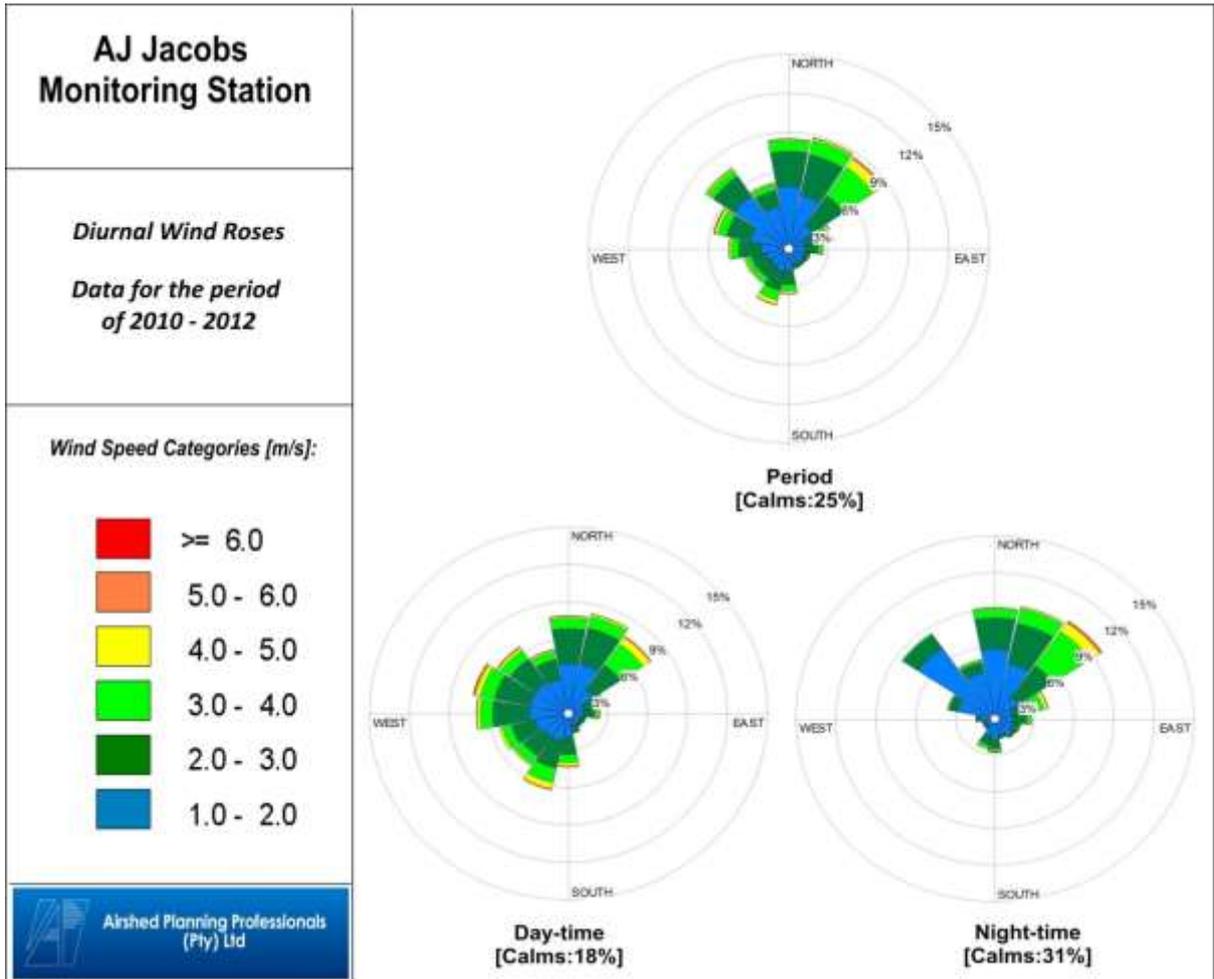


Figure 5-5: Period, day- and night-time wind rose for AJ Jacobs for the period 2010 - 2012

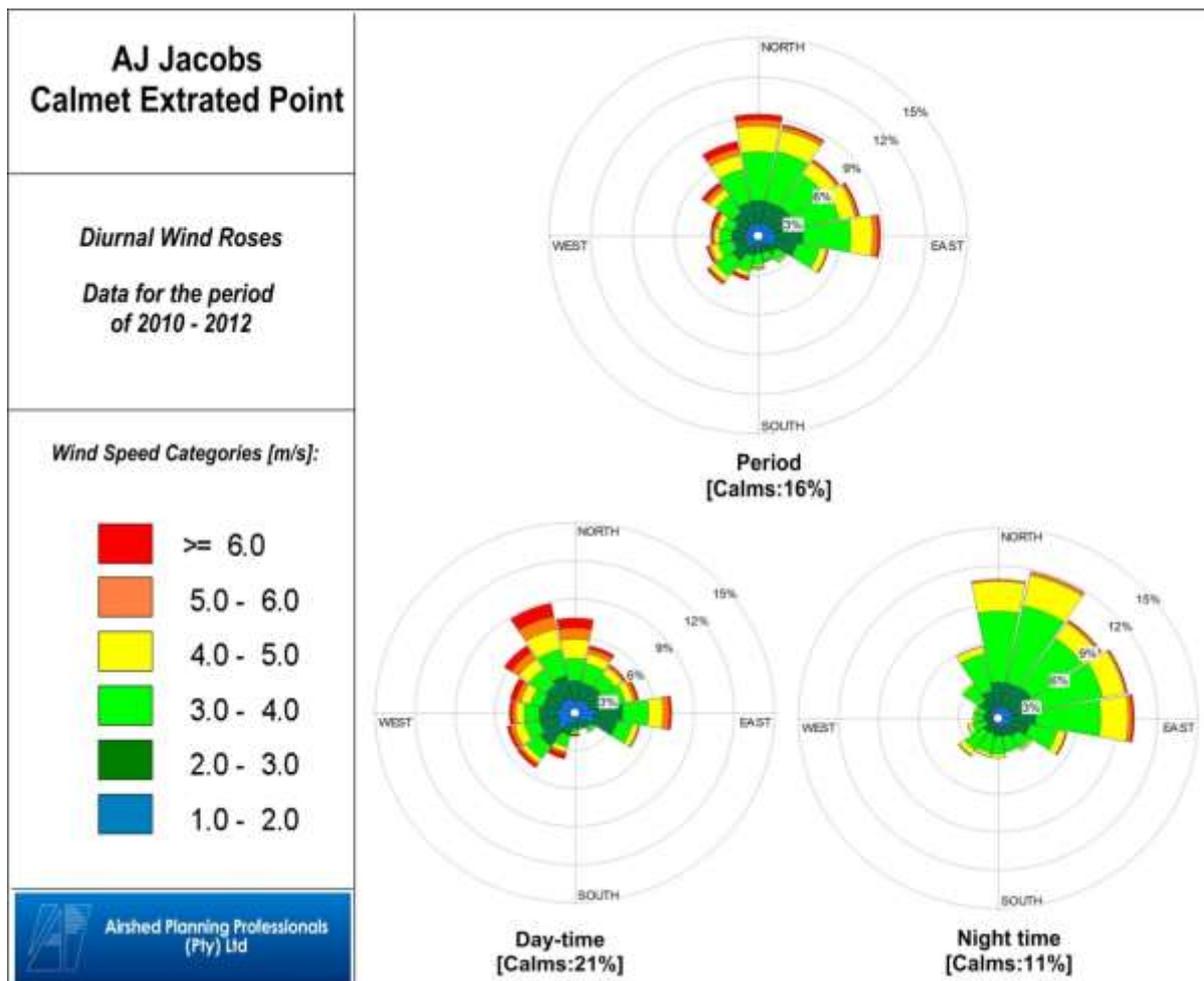


Figure 5-6: Period, day- and night-time wind rose for an extracted CALMET point at AJ Jacobs for the period 2010 - 2012

5.1.5.2 Temperature

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

The average monthly temperature trends are presented in Figure 5-7 and Figure 5-8 for Leitrim and Fence Line respectively. Monthly mean and hourly maximum and minimum temperatures are given in Table 5-5. Average temperatures ranged between 6.9 °C and 21.1 °C. The highest temperatures occurred in February and the lowest in July. During the day, temperatures increase to reach maximum at around 15:00 in the afternoon. Ambient air temperature decreases to reach a minimum at around 07:00 i.e. just before sunrise.

Table 5-5: Monthly temperature summary (2010 - 2012)

Hourly Minimum, Hourly Maximum and Monthly Average Temperatures (°C) (2010 - 2012)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Leitrim												
Minimum	16.2	15.1	13.9	10.5	6.7	1.7	1.8	4.1	9.0	12.1	14.2	15.7
Maximum	25.9	27.0	27.1	23.0	22.4	19.2	18.8	22.4	25.8	27.2	27.3	26.7
Average	20.8	21.1	20.2	16.2	13.8	9.7	9.6	12.9	17.1	19.6	20.5	20.8
Fence Line												
Minimum	13.8	13.9	12.5	7.5	4.3	-0.1	-0.6	3.1	7.9	10.5	11.2	13.6
Maximum	24.1	25.0	24.9	19.3	19.1	14.8	15.1	19.1	22.6	24.2	22.5	24.1
Average	18.9	19.3	18.8	13.2	11.4	7.0	6.9	11.3	15.3	17.6	17.1	18.7

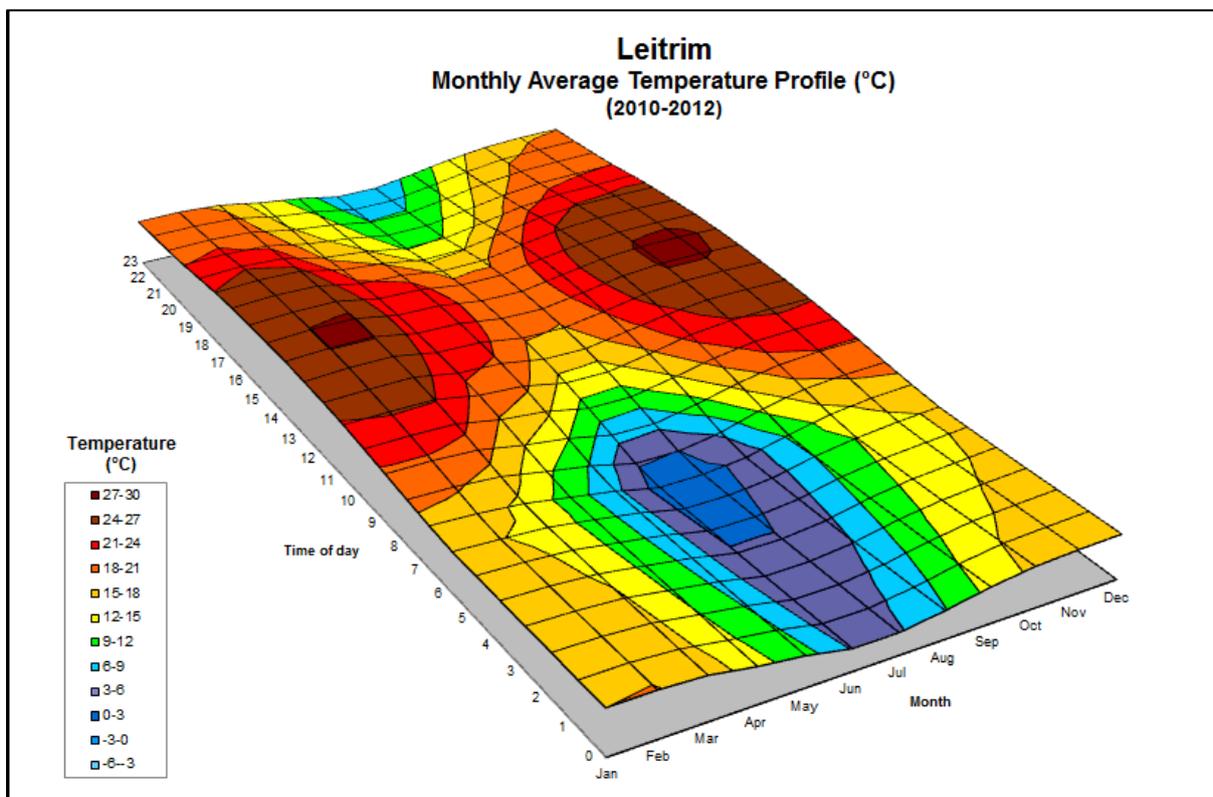


Figure 5-7: Monthly average temperature profile for Leitrim (2010 – 2012)

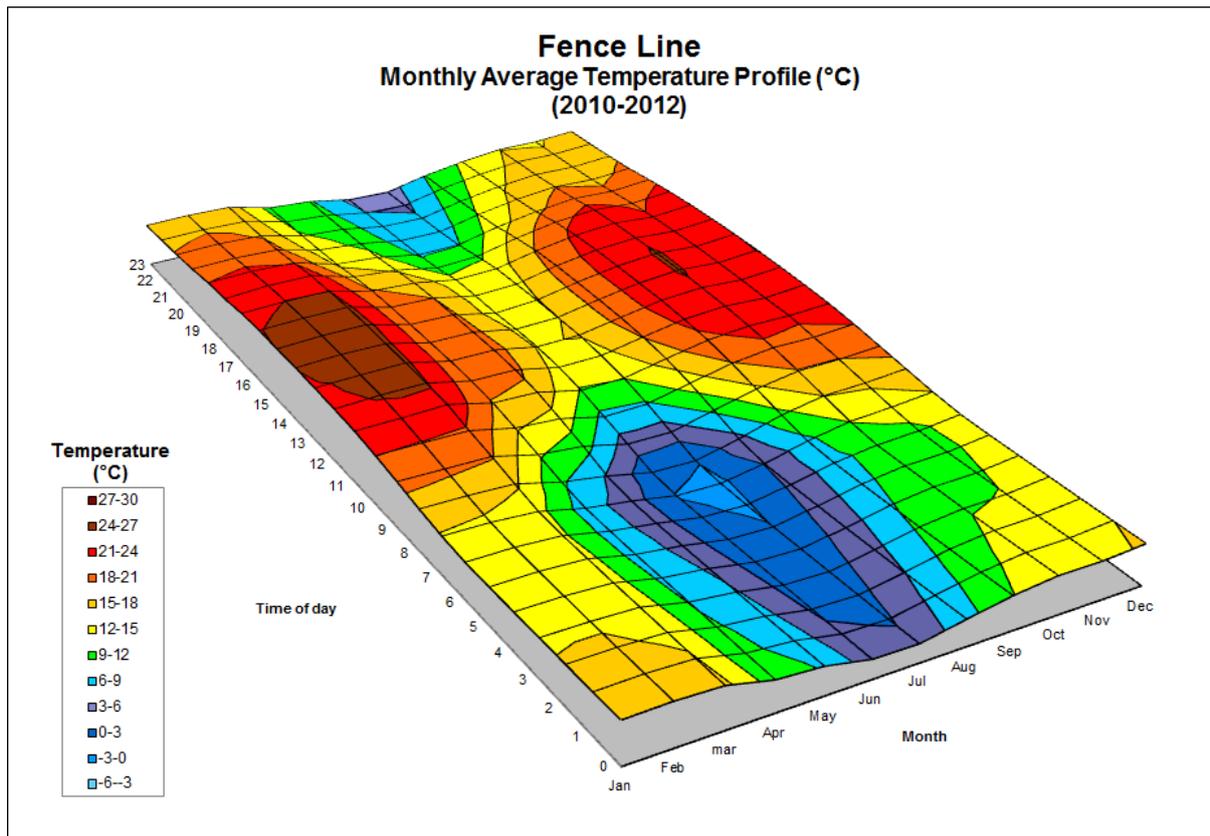


Figure 5-8: Monthly average temperature profile for Fence Line (2010 – 2012)

5.1.5.3 Atmospheric Stability

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

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 5-9. 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 5-9 (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 5-9 (b)). Stable

conditions prevent the plume from mixing vertically, although it can still spread horizontally and is called fanning (Figure 5-9 (a)) (Tiwary & Colls, 2010).

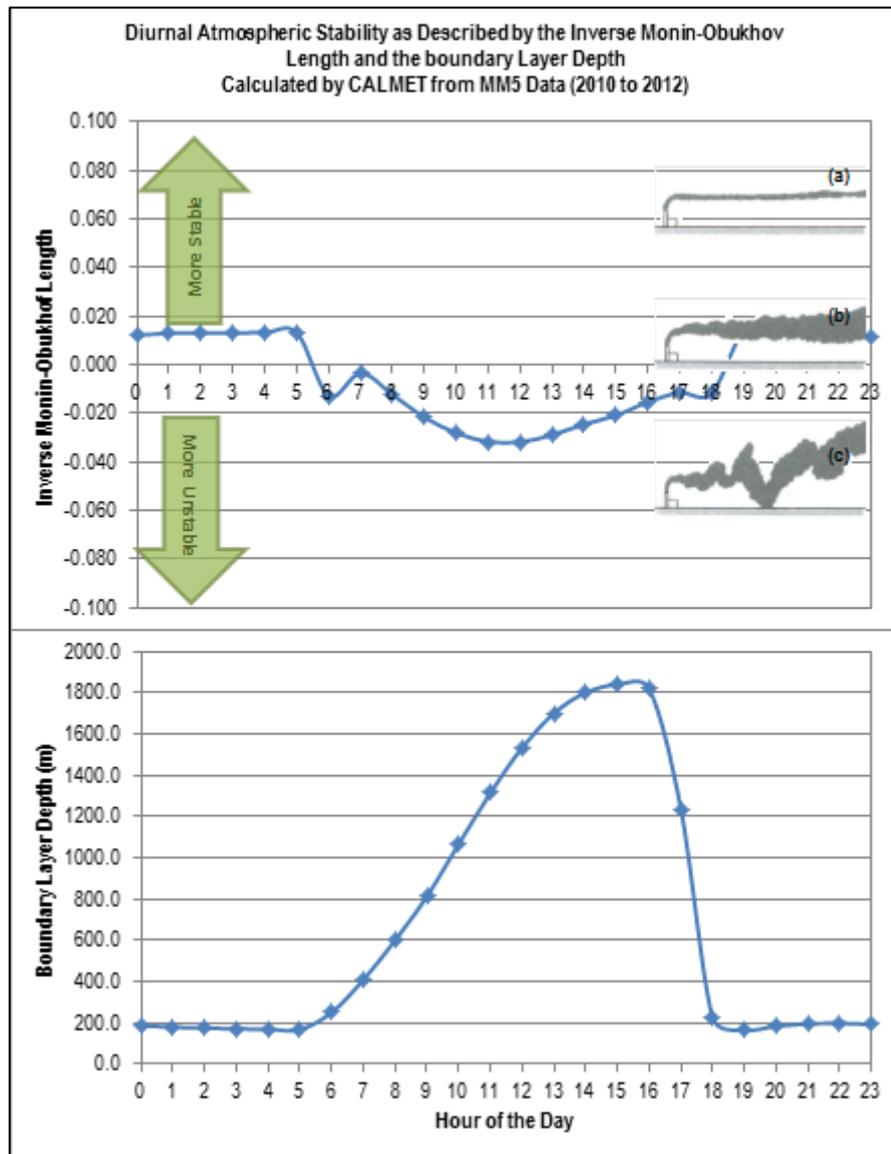


Figure 5-9: Diurnal atmospheric stability (extracted from CALMET at the AJ Jacobs monitoring point)

5.1.5.4 Air Quality Monitoring data

Time series of the measured ambient air quality data is provided in Appendix G. A summary of ambient data measured at Fence Line, AJ Jacobs and Leitrim for the period 2010 – 2012 is provided in Table 5-7, Table 5-8 and Table 5-9 respectively.

Table 5-6: Summary of the ambient measurements at Fence Line for the period 2010-2012 (units: $\mu\text{g}/\text{m}^3$)

Period	Hourly				Annual Average
	Max	99 th Percentile	90 th Percentile	50 th Percentile	
NH₃					
2010	231.34	65.19	6.59	0.59	4.74
2011	270.11	82.68	15.98	1.10	6.60
2012	236.77	88.22	23.29	5.18	10.11
<i>Period Average</i>	<i>246.07</i>	<i>78.69</i>	<i>15.28</i>	<i>2.29</i>	<i>7.15</i>

Table 5-7: Summary of the ambient measurements at AJ Jacobs for the period 2010-2012 (units: $\mu\text{g}/\text{m}^3$)

Period	Hourly				Annual Average	No of hourly exceedances
	Max	99 th Percentile	90 th Percentile	50 th Percentile		
SO₂						
2010	495.5	255.9	78.3	18.7	34.8	23.0
2011	678.9	265.6	92.8	24.9	42.6	28.0
2012	542.7	259.6	88.2	31.3	46.1	28.0
<i>Period Average</i>	<i>572.4</i>	<i>260.4</i>	<i>86.4</i>	<i>25.0</i>	<i>41.2</i>	<i>26.3</i>
NO₂						
2010	241.8	75.8	44.4	15.5	20.2	2.0
2011	156.5	81.8	45.5	14.9	20.2	0.0
2012	106.0	66.2	37.8	13.0	17.0	0.0
<i>Period Average</i>	<i>168.1</i>	<i>74.6</i>	<i>42.6</i>	<i>14.5</i>	<i>19.1</i>	<i>0.7</i>
Period	Daily				Annual Average	No of daily exceedances
	Max	99 th Percentile	90 th Percentile	50 th Percentile		
PM₁₀						
2010	166.2	117.0	80.3	37.4	54.1	43
2011	154.0	122.2	73.4	35.1	48.0	36
2012	146.3	107.1	73.6	32.8	51.0	28
<i>Period Average</i>	<i>155.5</i>	<i>115.4</i>	<i>75.7</i>	<i>35.1</i>	<i>51.0</i>	<i>36</i>

Table 5-8: Summary of the ambient measurements at Leitrim for the period 2010-2012

Period	Hourly				Annual Average	No of hourly exceedances
	Max	99 th Percentile	90 th Percentile	50 th Percentile		
SO₂						
2010	473.4	171.6	50.2	10.4	21.9	7.0
2011	458.4	155.9	47.7	8.7	19.8	7.0
2012	455.5	156.3	57.1	10.3	22.4	7.0

Period	Hourly				Annual Average	No of hourly exceedances
	Max	99 th Percentile	90 th Percentile	50 th Percentile		
<i>Period Average</i>	462.4	161.3	51.7	9.8	21.4	7.0
NO₂						
2010	140.3	83.1	46.9	15.8	20.9	0.0
2011	355.9	79.3	44.1	14.6	19.6	1.0
2012	118.8	86.2	50.2	16.8	22.2	0.0
<i>Period Average</i>	205.0	82.9	47.1	15.7	20.9	0.3
O₃						
2010	161.5	108.3	74.5	37.3	40.6	
2011	150.6	101.5	73.9	35.6	39.6	
2012	185.6	106.6	79.9	44.9	47.6	
<i>Period Average</i>	165.9	105.5	76.1	39.3	42.6	
Period	Daily				Annual Average	No of daily exceedances
	Max	99 th Percentile	90 th Percentile	50 th Percentile		
PM₁₀						
2010	252.9	168.4	109.8	43.2	54.4	89
2011	186.3	164.4	95.3	38.0	48.0	64
2012	171.4	160.5	99.7	41.8	50.7	77
<i>Period Average</i>	203.5	164.5	101.6	41.0	51.0	77

The following graphs summarise the observed concentrations of SO₂, NO₂ and PM₁₀ at AJ Jacobs and Leitrim monitoring stations for the years 2010, 2011 and 2012. The NAAQS have been included in the graphs for:

- SO₂ hourly (permitted 88 hourly exceedances of 350 µg/m³) and daily average (permitted 4 daily exceedances of 125 µg/m³)
- NO₂ hourly average (permitted 88 hourly exceedances of 200 µg/m³); and,
- PM₁₀ daily average (permitted 4 daily exceedances of 75 µg/m³; 2015 standards).

The hourly 99th percentiles for SO₂ were below the limit value of 350 µg/m³ at both stations for all three years (Figure 5-10 and Figure 5-11). The daily 99th percentiles for SO₂ were below the limit value (125 µg/m³) at the Leitrim station for all three years (Figure 5-13), but were exceeded at AJ Jacobs for 2011 and 2012 (Figure 5-12).

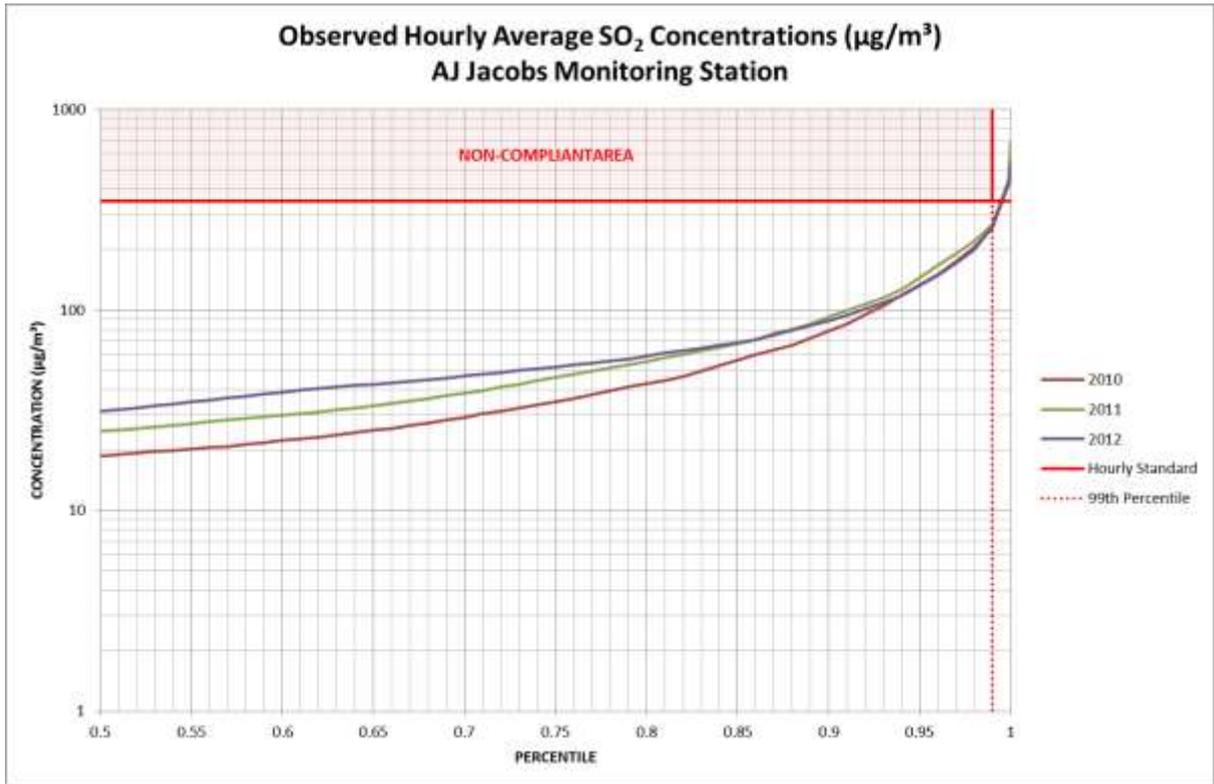


Figure 5-10: Observed hourly average SO₂ concentrations at AJ Jacobs

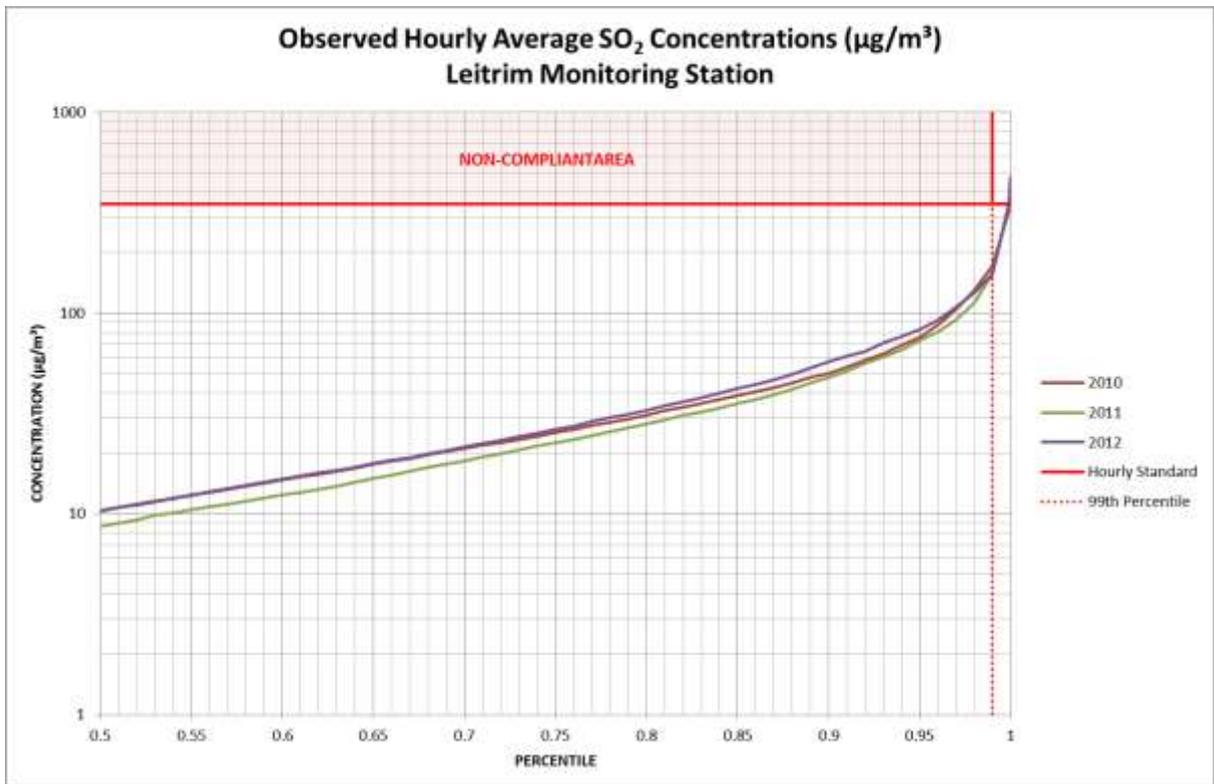


Figure 5-11: Observed hourly average SO₂ concentrations at Leitrim

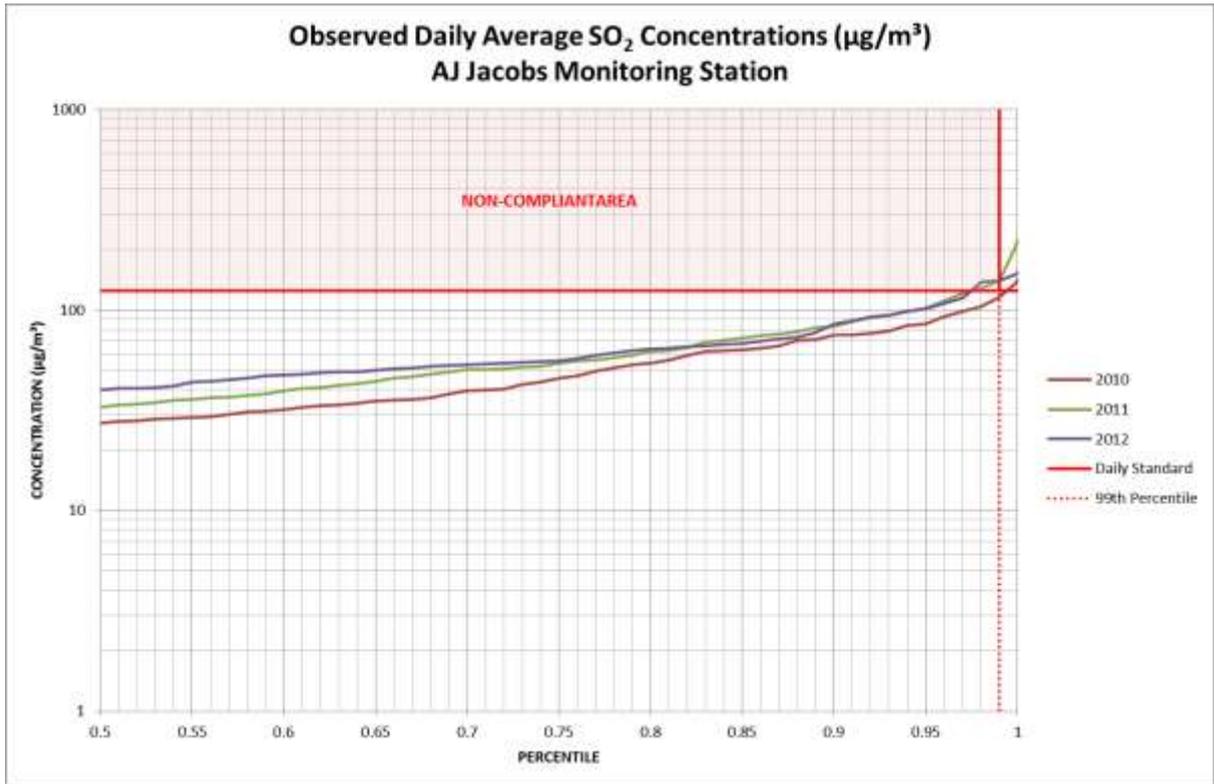


Figure 5-12: Observed daily average SO₂ concentrations at AJ Jacobs

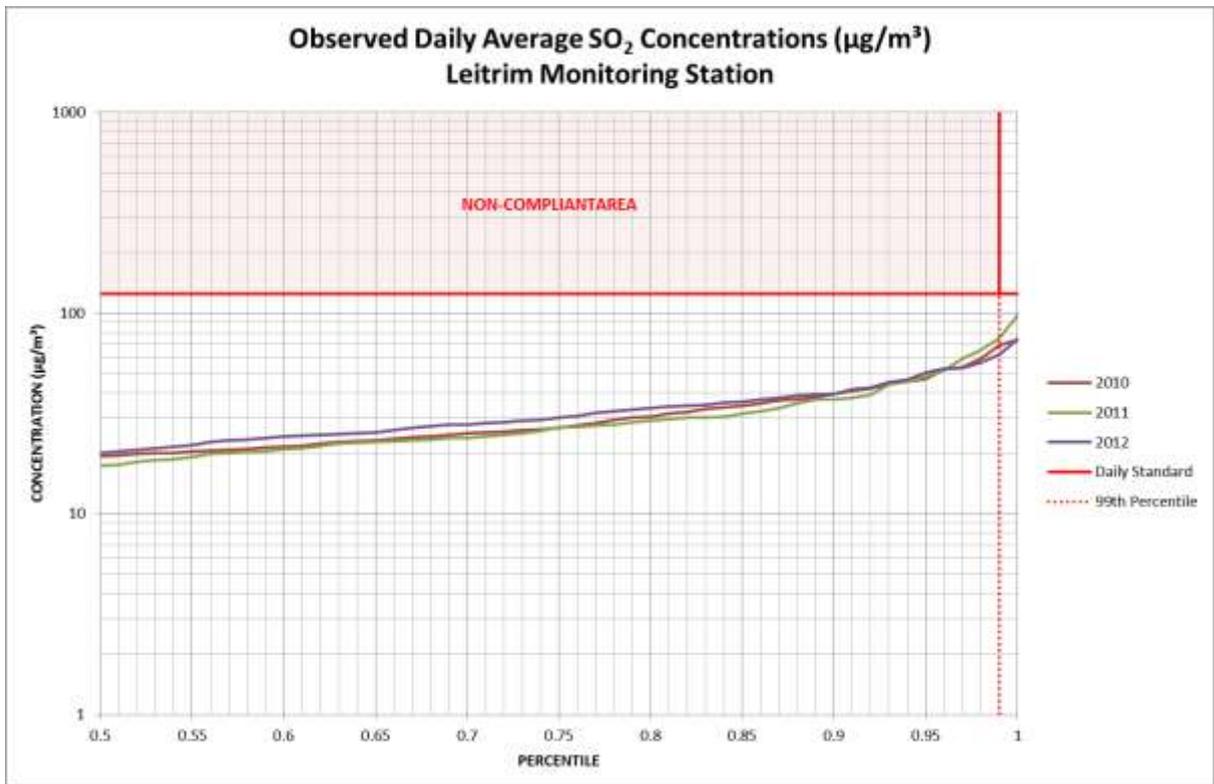


Figure 5-13: Observed daily average SO₂ concentrations at Leitrim

The hourly 99th percentiles for NO₂ were below the limit value (200 µg/m³) at both stations and for all three years (Figure 5-14 and Figure 5-15).

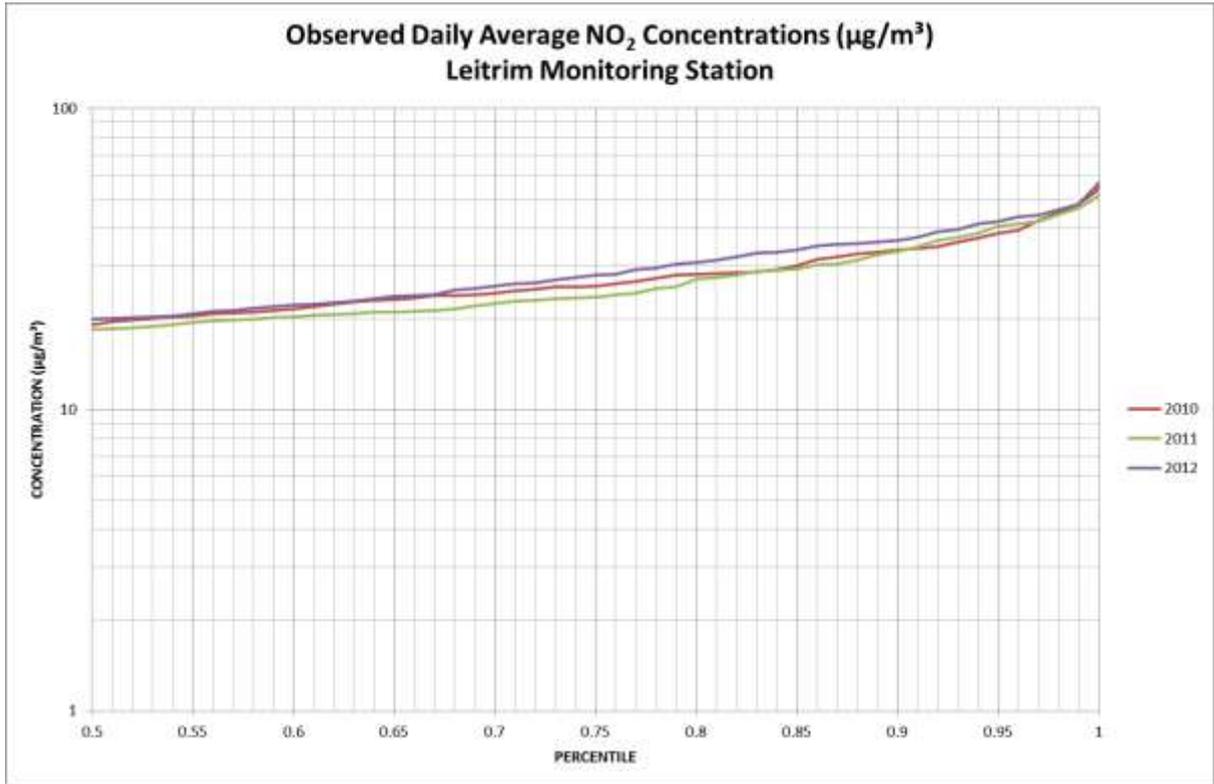


Figure 5-14: Observed hourly average NO₂ concentrations at AJ Jacobs (no standard for daily average)

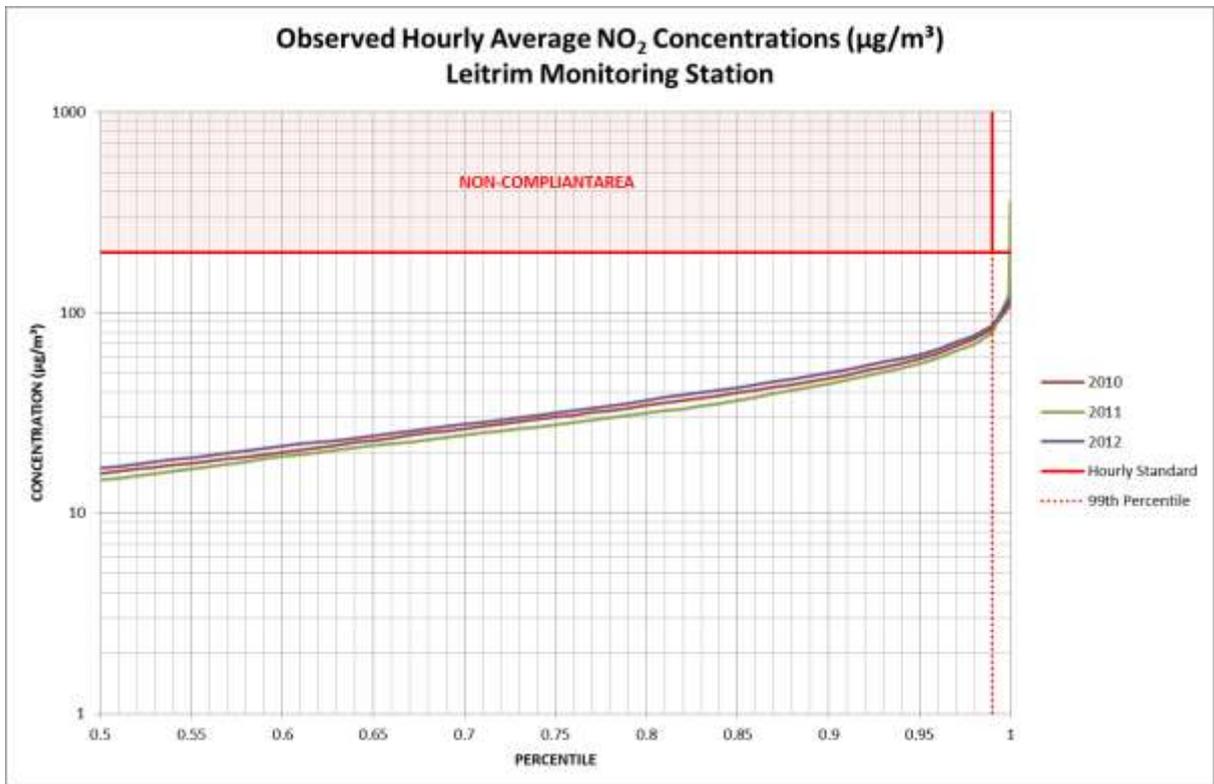


Figure 5-15: Observed hourly average NO₂ concentrations at Leitrim

The daily 99th percentiles for PM₁₀ exceeded the limit value (75 µg/m³; 2015 standard) at both stations and for all three years (Figure 5-16 and Figure 5-17). While the SO₂ and NO₂ annual averages were below the NAAQS, the PM₁₀ annual averages exceeded the 2015 limit value of 40 µg/m³ for all three years at Leitrim. The PM₁₀ annual averages were just below the limit value for 2010 and 2012, but exceeded the value in 2011.

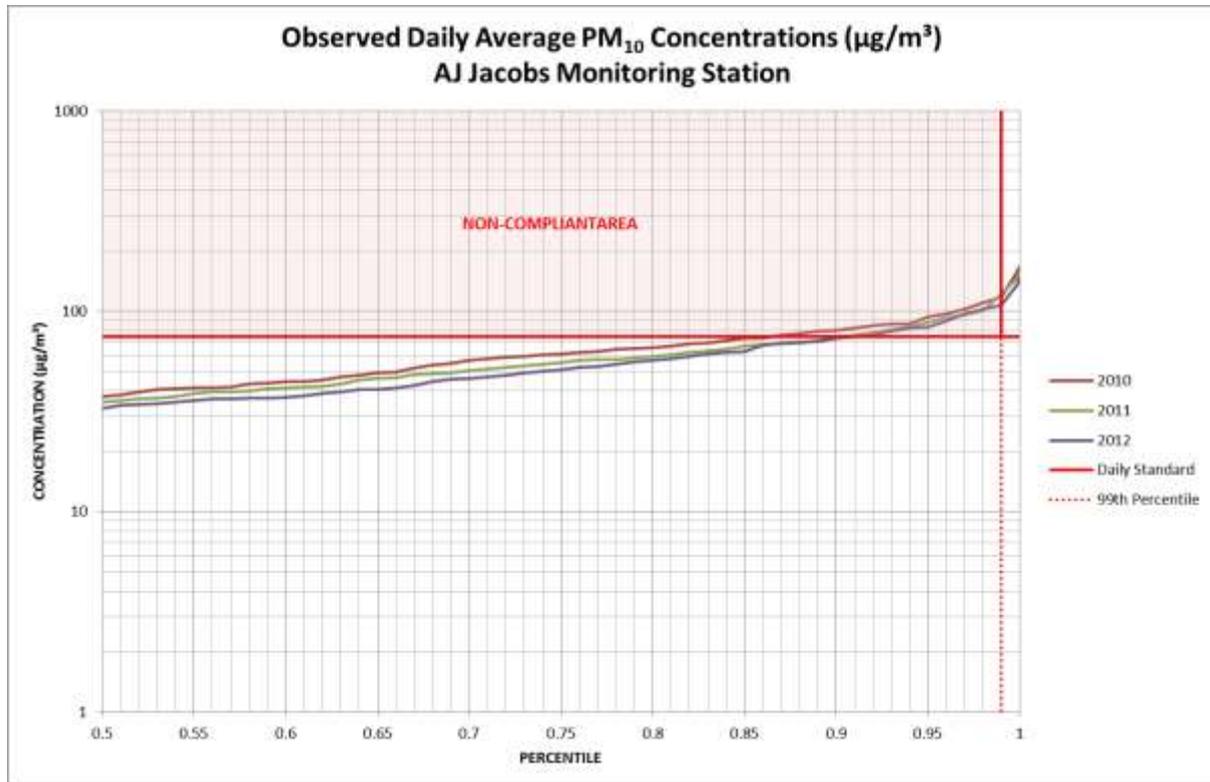


Figure 5-16: Observed daily average PM₁₀ concentrations at AJ Jacobs

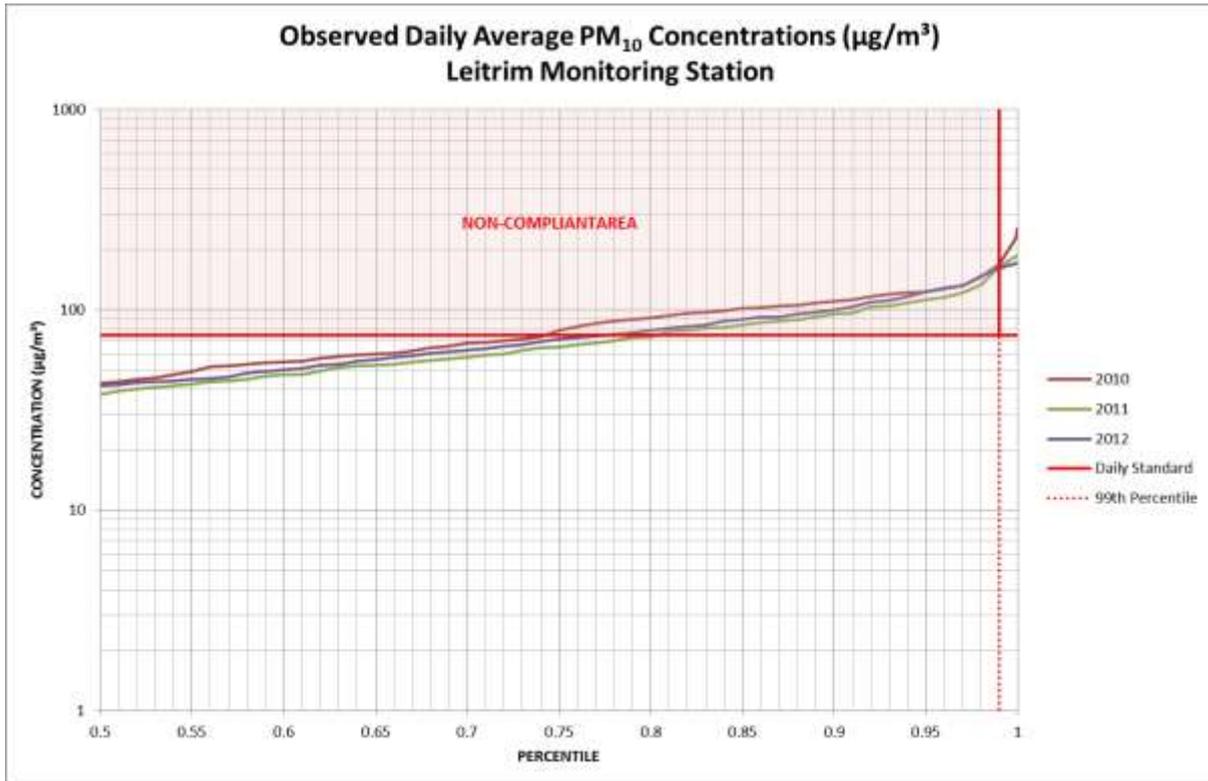


Figure 5-17: Observed daily average PM₁₀ concentrations at Leitrim

Time series plots (mean with 95% confidence interval) of ambient SO₂ and NO₂ concentrations measured at AJ Jacobs (Figure 5-18) and Leitrim (Figure 5-19) show the variation of these pollutants over daily, weekly and annual cycles. The daily SO₂ show a typically industrial signature with increased SO₂ concentrations as just before midday due to the break-up of an elevated inversion layer, in addition to the development of daytime convective conditions causing the plume to be brought down to ground level relatively close to the point of release from tall stacks. Increased NO₂ concentrations during peak traffic times (07:00 to 08:00 and 16:00 to 18:00) illustrate the contribution of vehicle emissions to the ambient NO₂ concentrations. The winter (June, July and August) elevation of SO₂ and NO₂ shows the contribution of residential fuel burning to the ambient SO₂ and NO₂ concentrations.

Monthly variation of PM₁₀ shows elevated concentrations during winter months due to the larger contribution from domestic fuel burning, dust from uncovered soil and the lack of the settling influence of rainfall (Figure 5-20 and Figure 5-21).

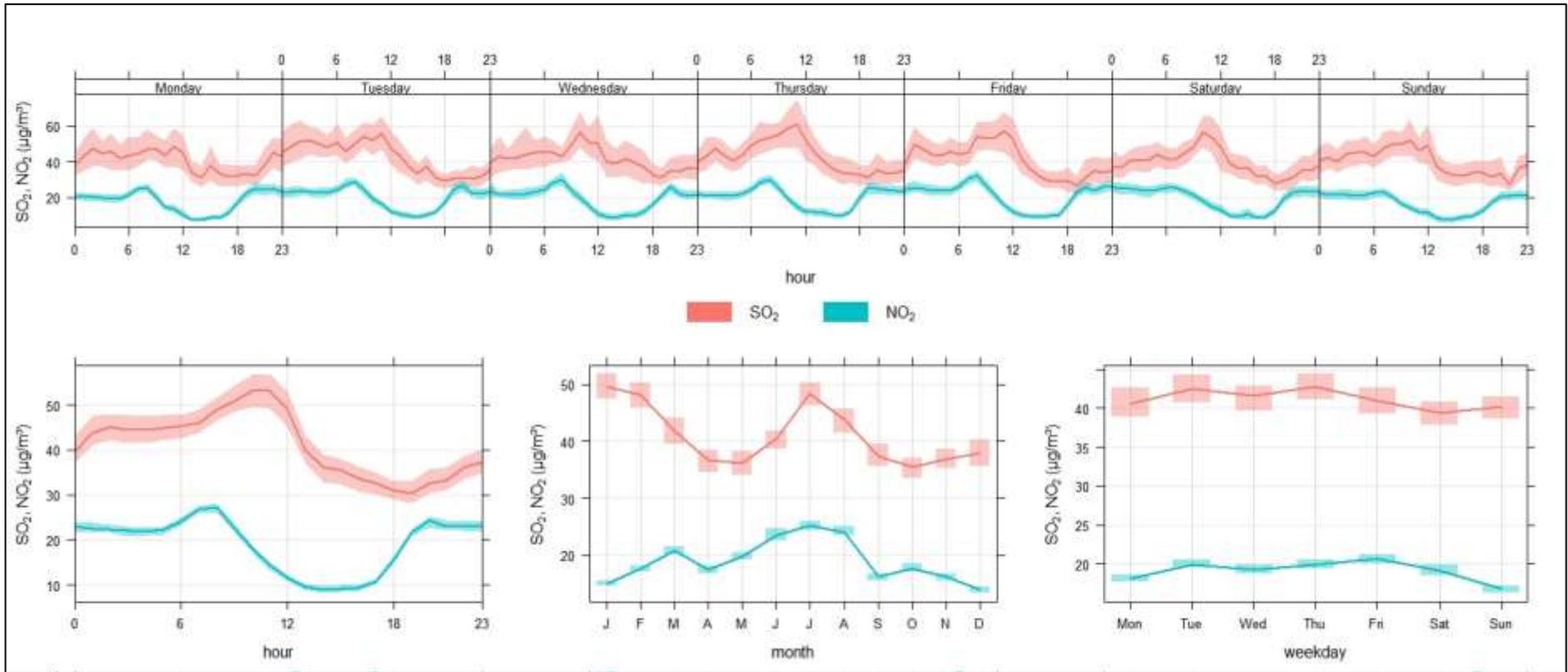


Figure 5-18: Time series plot of observed SO₂ and NO₂ concentrations at AJ Jacobs

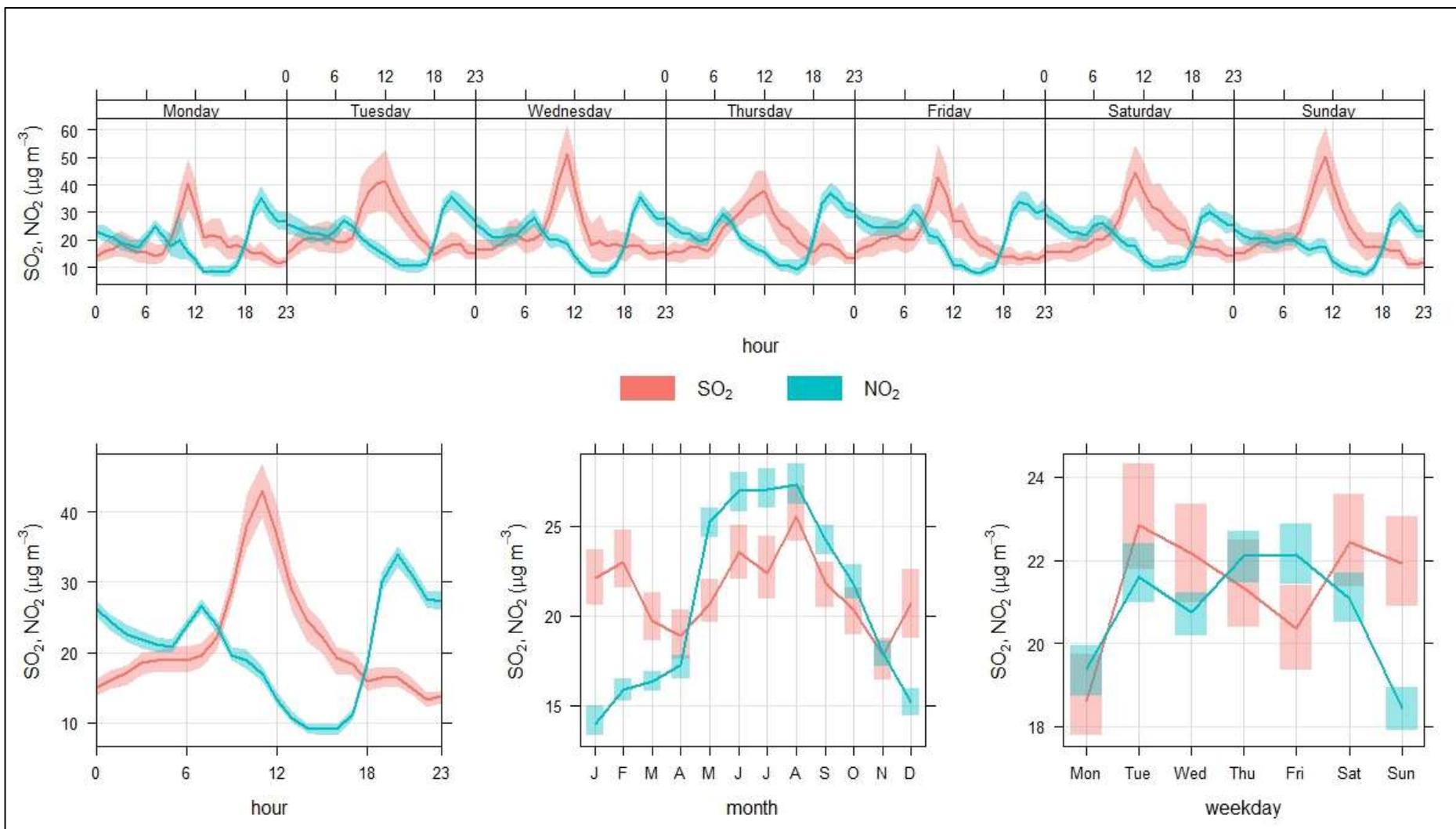


Figure 5-19: Time series plot of observed SO₂ and NO₂ concentrations at Leitrim

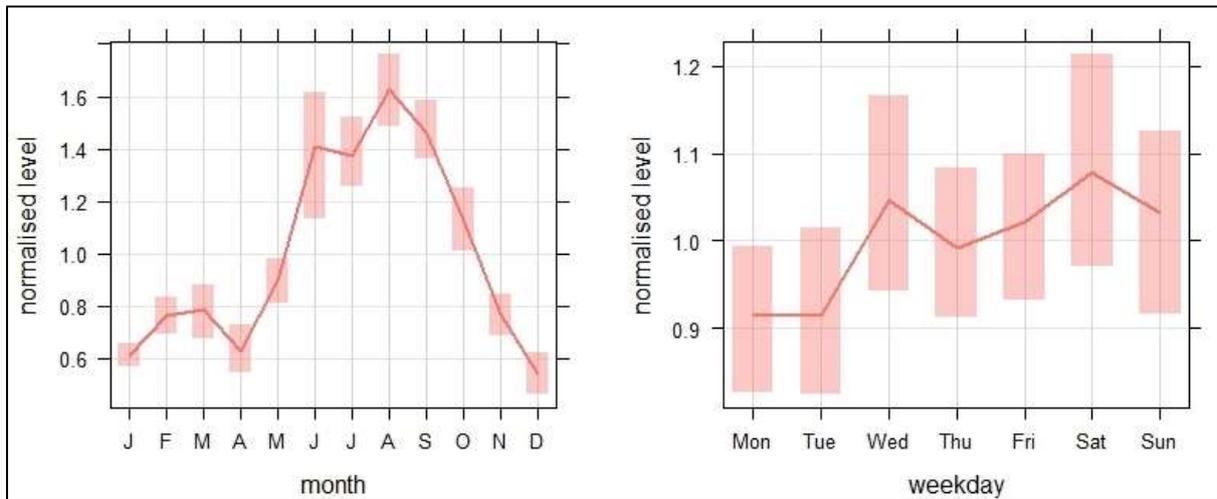


Figure 5-20: Time series plot of observed PM₁₀ concentrations (µg/m³) at AJ Jacobs

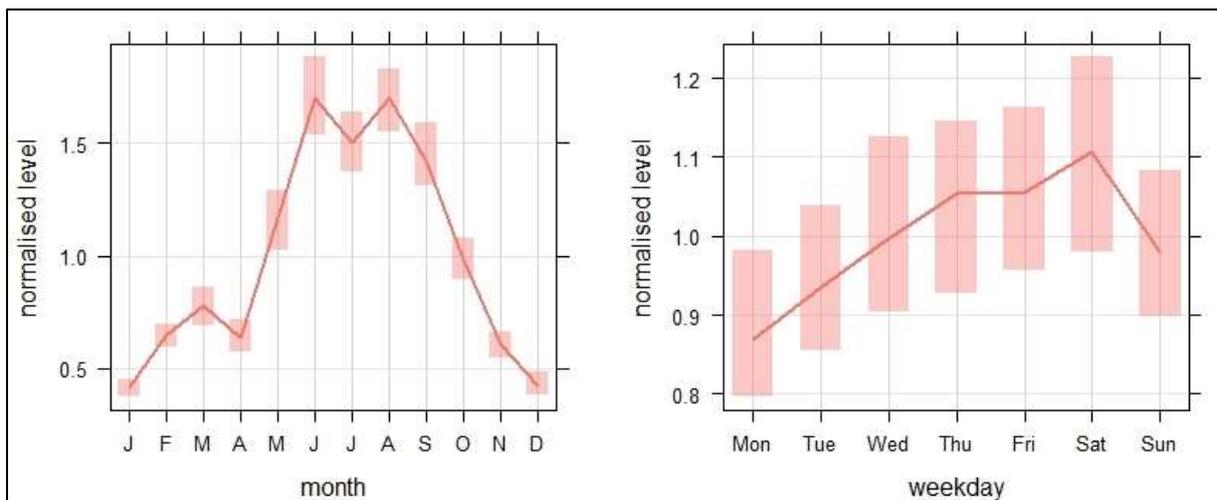


Figure 5-21: Time series plot of observed PM₁₀ concentrations (µg/m³) at Leitrim

5.1.6 Model Performance

5.1.6.1 Understanding of Observed Concentrations

An analysis of the observed SO₂ and NO₂ concentrations at AJ Jacobs and Leitrim monitoring stations was completed, in which the concentration values have been categorised into wind speed and direction bins for different concentrations. This information is most easily visualised as median concentrations for each wind speed and direction bin presented in polar plots, where the centre of the polar plot refers to the location of the monitoring station, as shown in Figure 5-22 for AJ Jacobs and Figure 5-23 for Leitrim for SO₂ observations. The corresponding NO₂ analyses are summarised in Figure 5-24 for AJ Jacobs and Figure 5-25 for Leitrim, respectively. Polar plots for PM analyses are presented in Figure 5-26 for AJ Jacobs and Figure 5-27 for Leitrim, respectively.

These polar plots (Carslaw and Ropkins, 2012; Carslaw, 2013) provide an indication of the directional contribution as well as the dependence of concentrations on wind speed, by providing a graphical impression of the potential sources of a pollutant at a specific location. Whereas the directional display is fairly obvious, i.e. when higher concentrations are shown to occur

in a certain sector, e.g. north-east for SO₂ at AJ Jacobs (Figure 5-22), it is understood that most of the high concentrations occur when winds blow from that sector (i.e. north-east). When the high concentration pattern is more symmetrical around the centre of the plot, it is an indication that the contributions are near-equally distributed, as is displayed for NO₂ in Figure 5-24 and Figure 5-25.

Furthermore, since the observed concentrations have also been categorised according to wind speed categories, it provides an indication of the plume height. As explained in Section 5.1.4.1 (plume buoyancy), stronger winds reduce the amount of plume rise, and may effectively increase ground level concentrations. However, since an increased wind speed also enhances plume dispersion, a concentration maximum would be reached for a wind speed where the plume rise and dilution effects cancel each other. These conditions would be different for day- and night-time atmospheric stabilities. It is expected that high ground level concentrations from elevated stacks would be more prevalent during stronger wind speeds during stable conditions than daytime, convective conditions, when the plume buoyancy is often not as effective in lifting the plume centreline. Low-level emissions behave differently, and higher concentrations would normally be observed during weak-wind conditions.

The SO₂ concentrations observed at AJ Jacobs (Figure 5-22) indicate that most of the high concentrations (i.e. above 350 µg/m³) occur with north-easterly winds of between 6 m/s and 7 m/s. Albeit not as high as the concentrations from the north-easterly sector (i.e. less than 300 µg/m³), the observations also show elevated concentrations from an easterly direction, i.e. from Infrachem.

The SO₂ concentrations observed at Leitrim (Figure 5-23) show elevated concentrations occurring with north-easterly winds of between 5 m/s and 10 m/s. Infrachem operations are located towards the north-west and the increased concentrations due to emissions from this direction are likely. A significant contribution of concentrations above 50 µg/m³ also occurred from the west and north-east during strong wind conditions.

The NO₂ concentrations observed at AJ Jacobs (Figure 5-24) indicate that most of the elevated concentrations occur with north-easterly winds of between 4 m/s and 6 m/s, east-north-easterly winds of between 6 m/s and 8 m/s, and a northerly sector contribution during low wind conditions (i.e. less than 2 m/s). Since vehicular exhaust emissions are significant NO₂ contributors, the observations from the northern sector most likely indicates this source. The north-easterly and east-north-easterly contributions are most likely from Natref and Sasol, respectively.

The NO₂ concentrations observed at Leitrim (Figure 5-25) similarly show elevated concentrations occurring during relatively weak winds of about 2.5 m/s and less, primarily from the northern sector. These observations are most likely due to vehicle exhaust emissions. A second set of high concentrations were recorded during strong wind conditions from the north-east and west. The westerly contribution is not too clear and is most likely from community activities and smaller industries towards the west. Contribution of mean concentrations below 30 µg/m³ occurred from the north-west (Infrachem).

Elevated particulate matter concentrations at AJ Jacobs are shown to originate from the north-west at high wind speeds where the source of particulates is not clear (Figure 5-26). Other sources of particulate matter contribute to concentrations of approximately 50 µg/m³ from the north-east and south-west at wind speeds varying between 2 and 4 m/s.

Elevated particulate concentrations at Leitrim show contributions from the north-east and the west-south-west at higher (between 8 and 10 m/s) wind speeds (Figure 5-27). At low wind speeds (2 m/s or less) the almost symmetrical plot shows a local contribution, most likely a result of community activities. Sources to the north and west at wind speeds around 8 m/s also contribute to elevated PM concentrations at Leitrim.

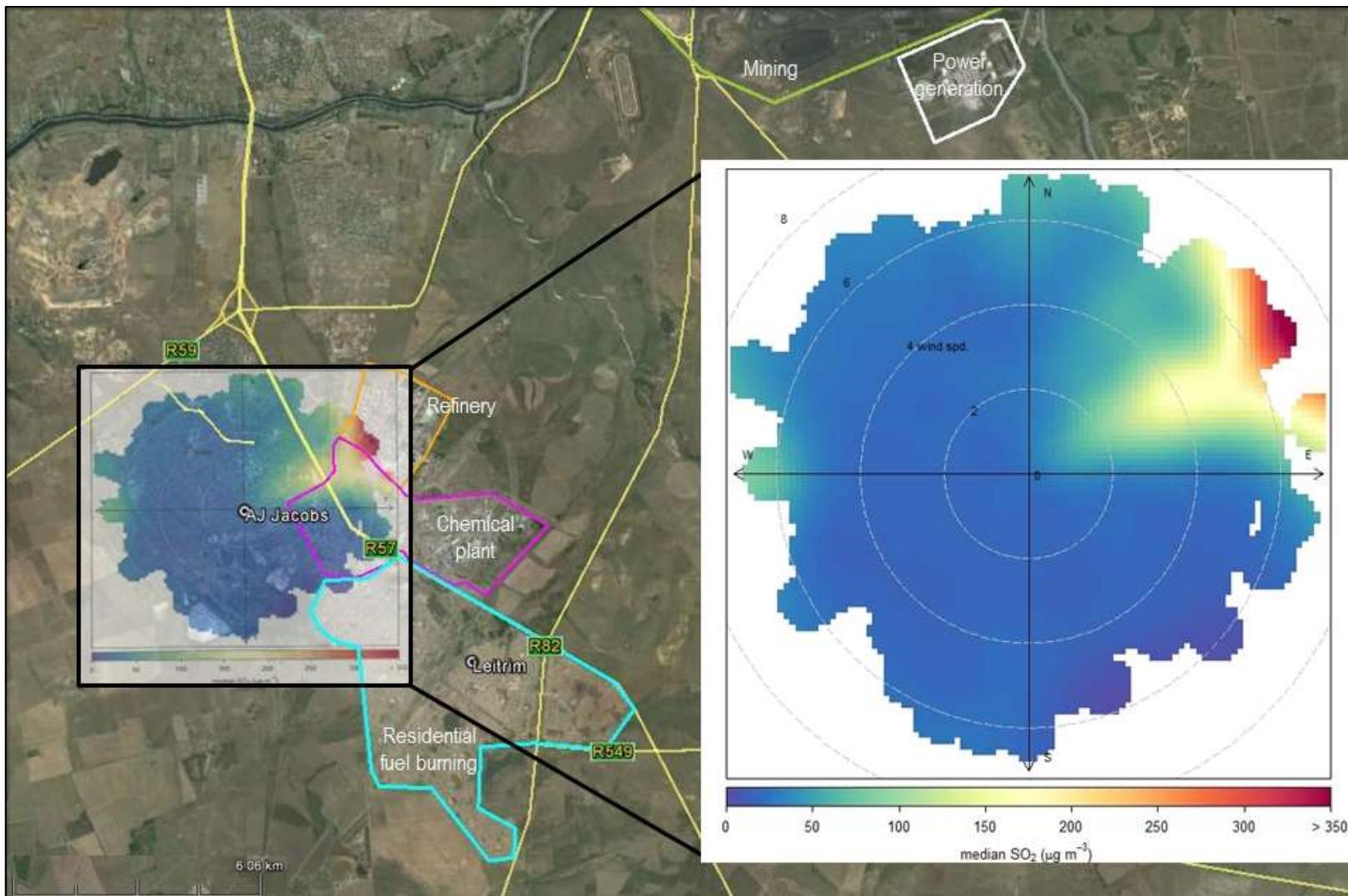


Figure 5-22: Polar plot of hourly median SO₂ concentration observations at AJ Jacobs for 2011 to 2012

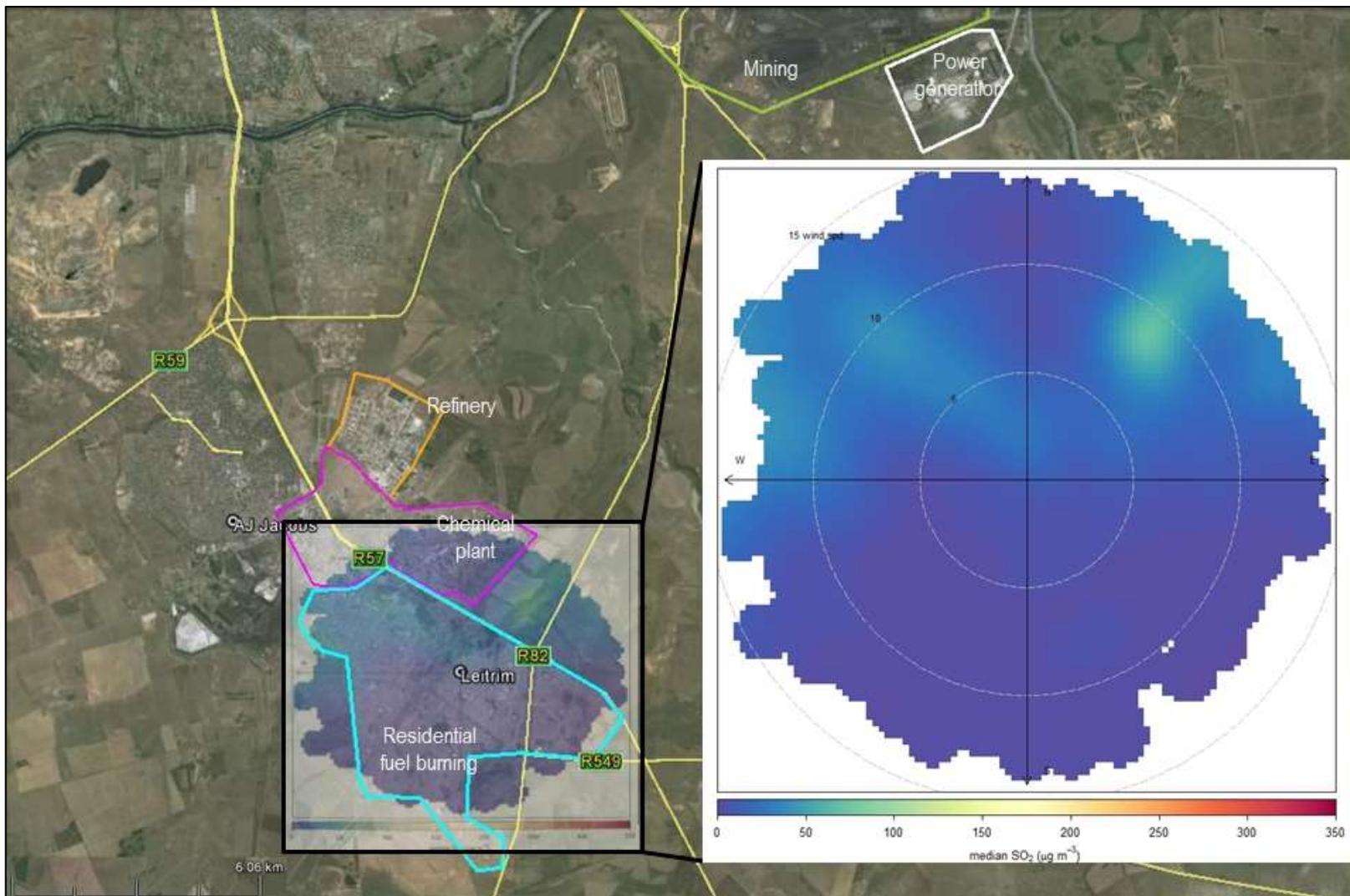


Figure 5-23: Polar plot of hourly median SO₂ concentration observations at Leitrim for 2010 to 2012

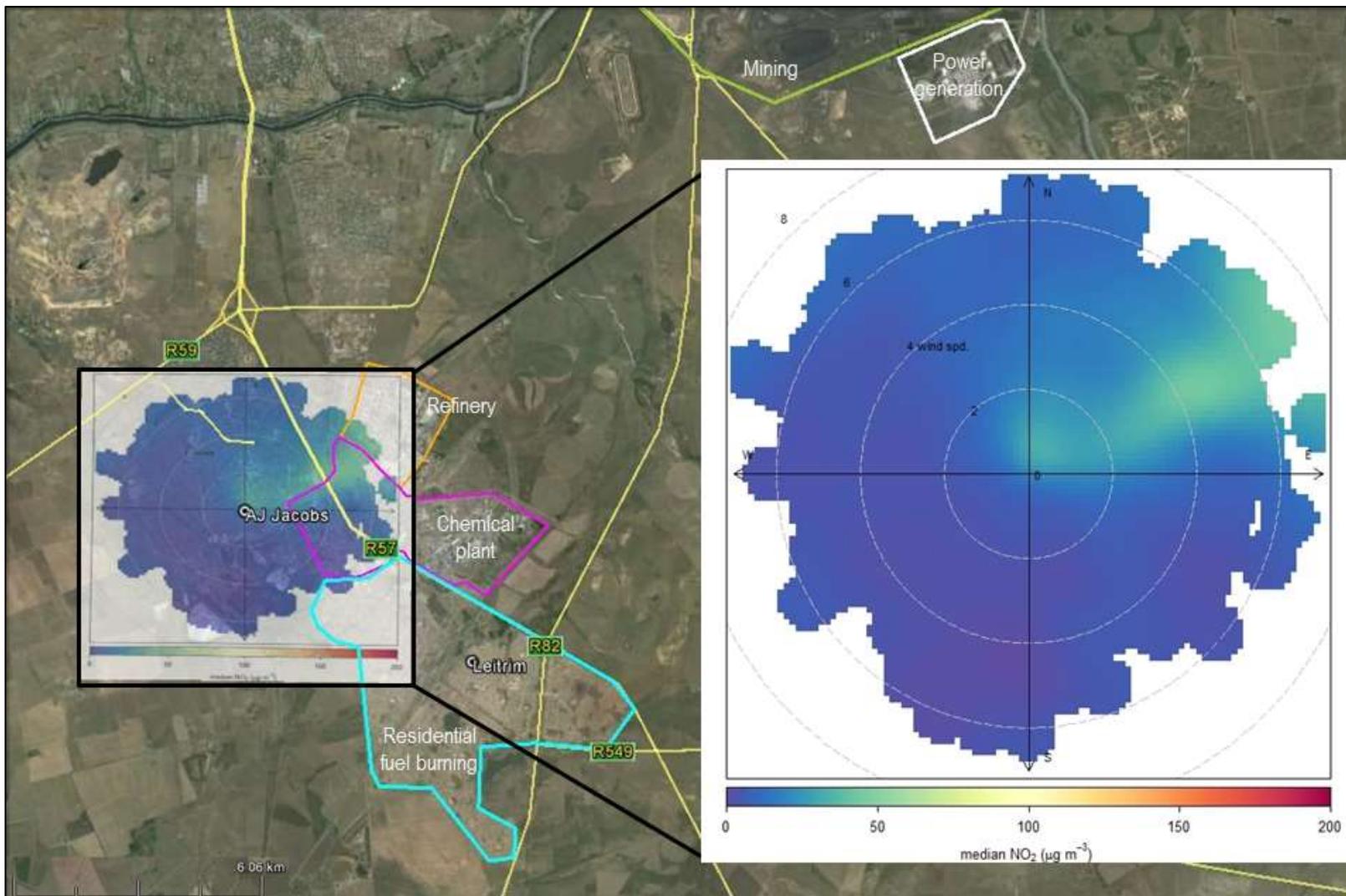


Figure 5-24: Polar plot of hourly median NO₂ concentration observations at AJ Jacobs for 2010 to 2012

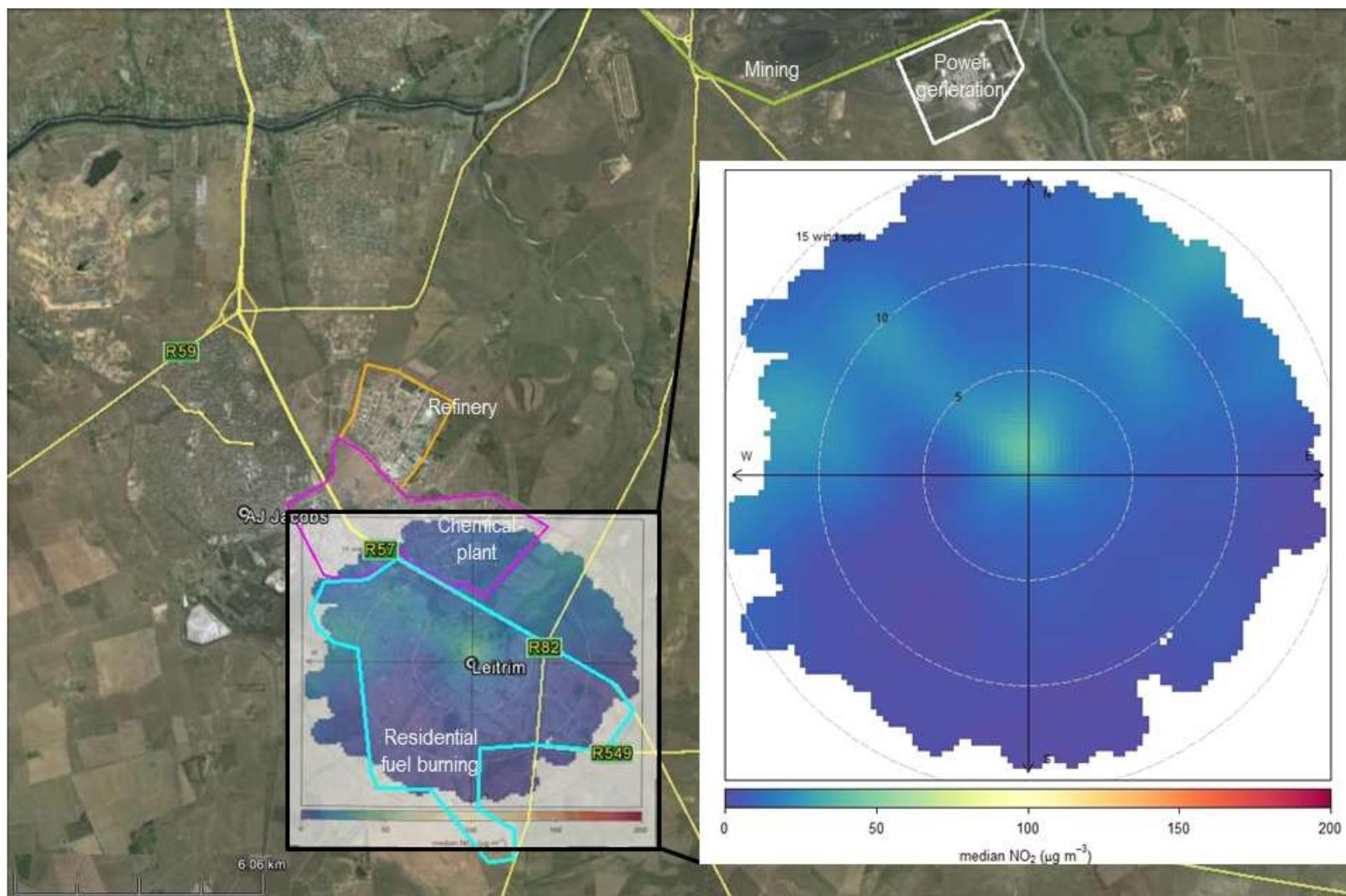


Figure 5-25: Polar plot of hourly median NO₂ concentration observations at Leitrim for 2010 to 2012

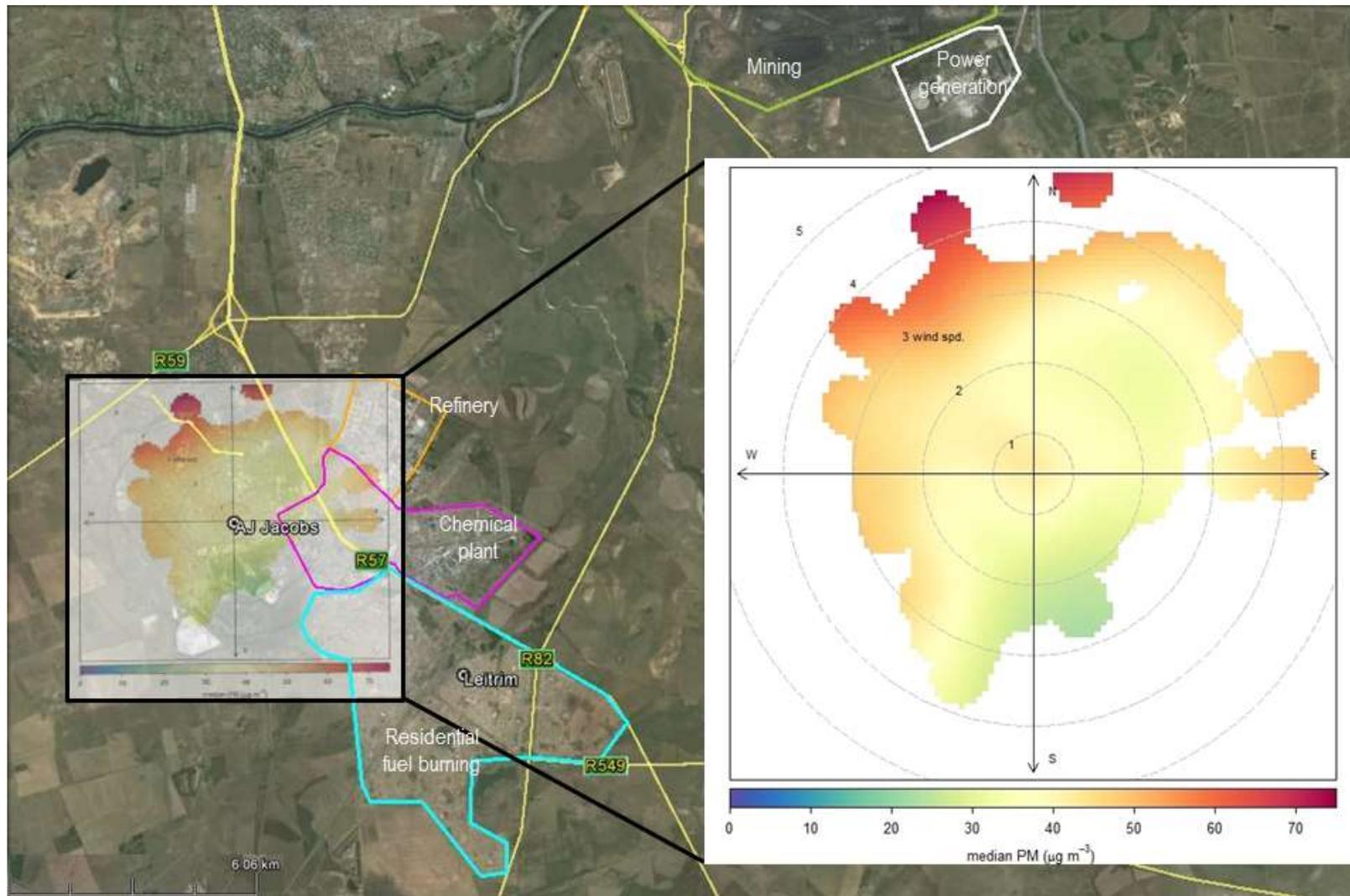


Figure 5-26: Polar plot of daily median PM concentration observations at AJ Jacobs for 2010 to 2012

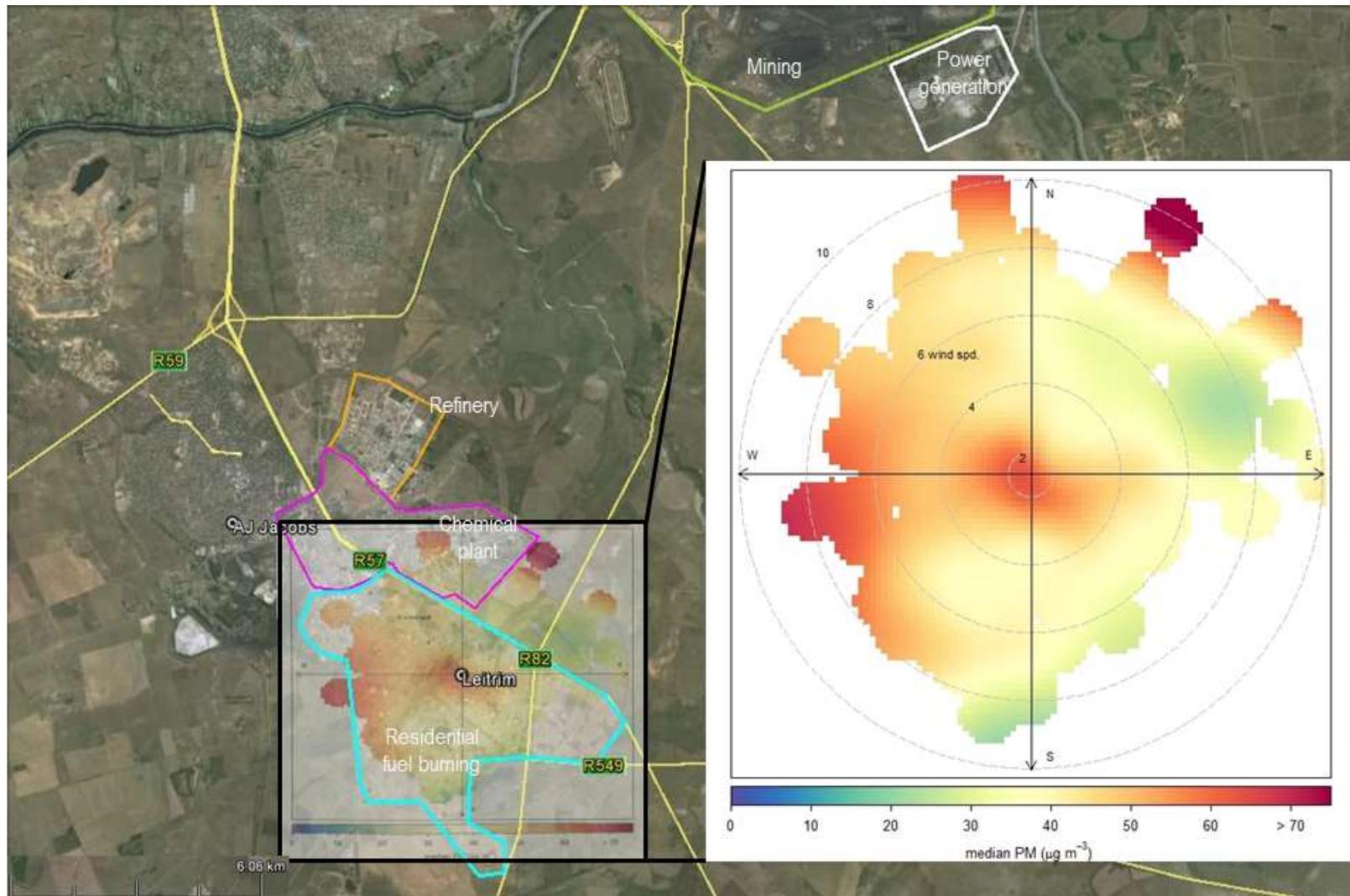


Figure 5-27: Polar plot of daily median PM concentration observations at Leitrim for 2010 to 2012

5.1.6.2 Model validation

Ambient concentrations of NO₂, SO₂ and PM₁₀ measured by Sasol in Sasolburg help provide an understanding of existing ambient air concentrations as well as providing a means of verifying the dispersion modelling. Since the aim of the investigation is to illustrate the change in ground level concentrations from the current levels (i.e. baseline emission scenario) to those levels resulting from the introduction of the required emission limits (i.e. existing and new plant emission standards), the intention was not to comprehensively include all air emissions from the Sasol operations in Sasolburg or those associated with activities other than Sasol operations. Unaccounted emissions include those from unintended leaks within the plant (fugitive emissions) and small vents, as well as air emissions from other industries, emissions from activities occurring within the communities, and biomass burning (especially during winter season), as well as long-range transport into the modelling domain. However, information about community activities, such as the amount of traffic within the community and the amount of fuel used for heating is often difficult to estimate.

These emissions, when combined, may potentially add up to be a significant portion of the observed concentrations in the modelling domain. In terms of the current investigation, the portion of air quality due to air emission sources that is not included in the model emissions inventory constitutes the background concentration.

Discrepancies between predicted and observed concentrations may also be as a result of process emission variations, and may include upset emissions and shutdowns. These conditions could result in significant under-estimating or over-estimating the air concentrations.

A summary of the predicted concentrations and their comparison with observations are given in Appendix H. In order to establish model performance under average emission conditions, it is not uncommon to use a certain percentile of predicted and observed concentrations for comparison. Although these may range from a 90th to 99.9th percentile, it was decided to use the DEA NAAQS for guidance. For criteria pollutants SO₂, NO₂ and PM₁₀, the NAAQS requires compliance with the 99th percentile. As hourly averages, this allows exceedances of the limit value of 88 hours (SO₂ and NO₂) or 4 days (PM₁₀) per year. To estimate the background concentrations not associated with the emission included in the simulations, the methodology below was therefore adopted.

- For short-term (1-hour and 24-hour) predicted averaging periods, the 99th percentile value from the cumulative frequency distribution of the monitoring data (per year) were used.
- For the annual predicted averaging period (long-term), the observed concentration is used at the percentile where the modelled concentration becomes zero, but not less than the 50th percentile of the cumulative frequency distribution of the monitoring data (per year) were used.

The monitoring station at AJ Jacobs is closer to the Infrachem operations than the Leitrim monitoring station. It is therefore not unexpected that the former station may observe more pollution from the Infrachem operations than the latter station. Furthermore, since the AJ Jacobs station is relatively close to the Infrachem operations, it is also not unexpected if observations of higher concentrations are closer to predicted values when compared to the lower concentrations which may have been due to other sources further away and reported when the wind was blowing in the opposite direction from the Infrachem operations. Table 5-9 is a summary of comparisons between predicted and observed SO₂ concentrations at AJ Jacobs. As shown in the table of the observed peak concentration only 17% could not be accounted for in the predicted peak. The difference between prediction and observation increases significantly when considering long-term comparisons (i.e. 50th percentile and annual average), clearly illustrating the contribution of emission sources not included in the

dispersion model's emissions inventory. Not shown in the table is the observed concentration at the percentile where the prediction was zero; namely, 39.9 µg/m³ (average of 2010, 2011 and 2012).

Table 5-9: Comparison of predicted and observed SO₂ concentrations at AJ Jacobs monitoring station in Sasolburg

	AJ Jacobs			
	SO ₂ concentration (µg/m ³)			Unaccounted Fraction*
	Predicted	Observed	Unaccounted	
Peak	473.8	572.4	98.5	17%
99th Percentile	174.9	260.4	85.5	33%
90th Percentile	10.9	86.4	75.5	87%
50th Percentile	0.0	25.0	25.0	100%
Annual Average	8.6	41.2	32.5	79%

* unaccounted fraction as a percentage of observed concentration

Table 5-10 is a summary of comparisons between predicted and observed SO₂ concentrations at Leitrim. In contrast to AJ Jacobs, where most of the peak concentration was shown to be from Infrachem or Natref, only about half of the observed concentration was predicted. Although this may still have resulted from the Infrachem and Natref operations, there is also a strong likelihood that a more localised source may have added to the observed peak. This is also illustrated by the 99th percentile that indicates a similar fraction of unaccounted for emissions. As with AJ Jacobs, the difference between prediction and observation increases significantly when considering long-term comparisons (i.e. 50th percentile and annual average). The observed concentration at the zero prediction percentiles was determined to be 17.4 µg/m³ (average of 2010, 2011 and 2012).

Table 5-10: Comparison of predicted and observed SO₂ concentrations at Leitrim monitoring station in Sasolburg

	Leitrim			
	SO ₂ concentration (µg/m ³)			Unaccounted Fraction*
	Predicted	Observed	Unaccounted	
Peak	223.7	462.4	238.7	52%
99th Percentile	55.1	161.3	106.2	66%
90th Percentile	14.7	51.6	37.0	72%
50th Percentile	0.0	9.8	9.8	100%
Annual Average	4.1	21.3	17.2	81%

* unaccounted fraction as a percentage of observed concentration

The performance evaluation was completed using the fractional bias method. Fractional bias is one of the evaluation methods recommended by the U.S. EPA for determining dispersion model performance (U.S. EPA 1992). Fractional bias provides a comparison of the means and standard deviation of both modelled and monitored concentrations for any given number of locations.

In this assessment, both short- and long-term fractional biases were computed. In this regards, the short- and long-term background concentrations were added to the predicted hourly and annual average concentrations prior to the calculation of the fractional bias. With the short-term fractional bias the 99th percentile (with background concentration for each year, as shown in Table 5-11) was compared to the same ranked monitored concentrations. The long-term fractional bias was based on the annual predicted mean and standard deviations (with estimated background concentration for each year) and observed concentrations.

Table 5-11: Estimated SO₂ background concentrations for Leitrim and AJ Jacobs

Year	SO ₂ background concentration (µg/m ³)			
	Leitrim		AJ Jacobs	
	Short-Term	Long-Term	Short-Term	Long-Term
2010	115.1	18.3	81.3	31.3
2011	101.1	16.3	87.4	39.7
2012	102.4	17.8	87.7	48.8

In Figure 5-28, the fractional bias is plotted with the means on the X-axis and the standard deviations on the Y-axis. The box on the plot encloses the area of the graph where the model predictions are within a factor of two (corresponding to a fractional bias of between -0.67 and +0.67). The U.S. EPA states that predictions within a factor of two are a reasonable performance target for a model before it is used for refined regulatory analysis (U.S. EPA 1992). Data points appearing on the left half of the plot indicate an over-prediction and those on the right half of the plot represent under-predictions.

The fractional bias of the means for both short- and long-term predictions were less than 0.67, clearly showing good model performance (i.e. within a factor of two). Using the individual fractional biases, the model's prediction is shown to be well within a factor of two, with fractional biases of the mean ranging from 0.01 (Leitrim, long-term) to 0.19 (Leitrim, short-term) and 0.06 (AJ Jacobs, short-term) to 0.16 (AJ Jacobs, long-term). The fractional bias of the standard deviation for Leitrim fell outside the factor-of-two box, and is an indication of the model not depicting the wide range of concentrations observed at this location. This is also a good indicator of the contribution of other sources in the vicinity of the monitor that would contribute to this deviation from the mean.

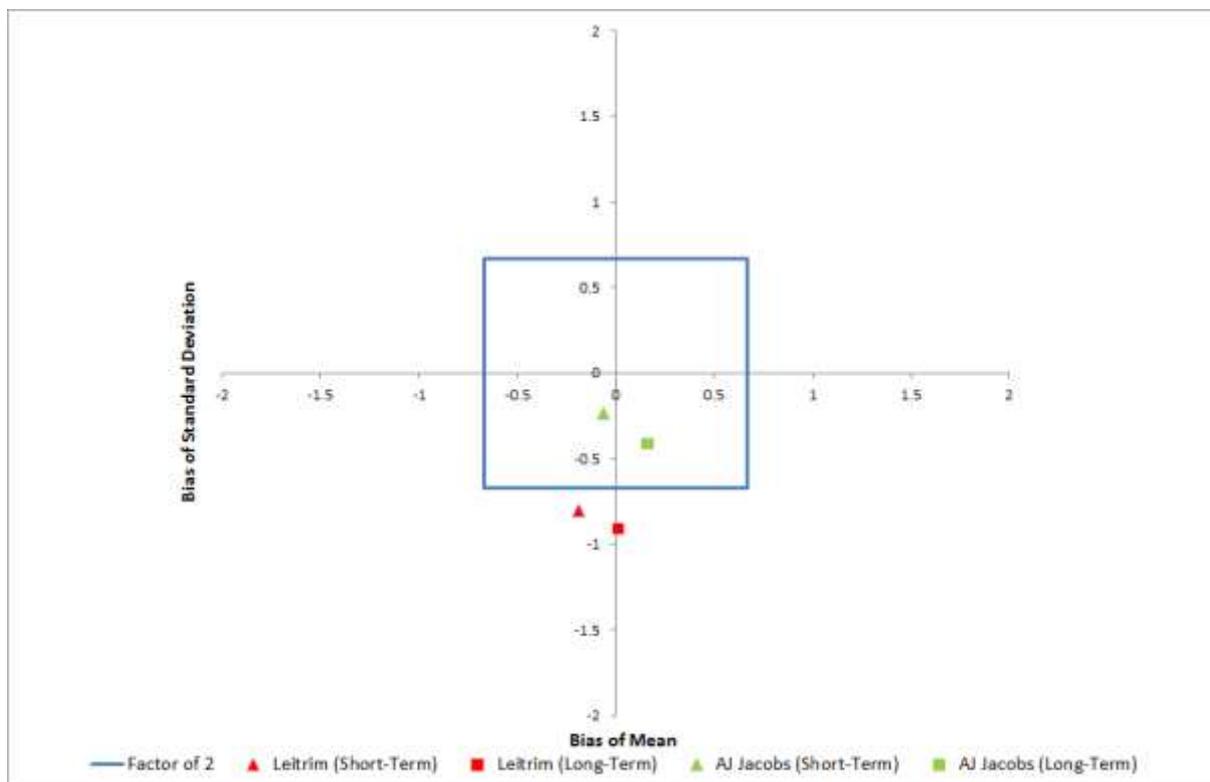


Figure 5-28: Fractional bias of means and standard deviation for SO₂

The same calculations and comparisons were repeated for NO₂ predictions and observations. The CALPUFF predictions were specifically for NO_x and the formation on HNO₃ and other nitrates using the MESOPUFF II chemical transformation mechanism, as discussed in Section 5.1.3.3.

Table 5-12 is a summary of comparisons between predicted and observed NO₂ concentrations at AJ Jacobs. As shown in the table, higher concentrations were predicted than the observed peak concentrations. This may be due to the rather simplistic methodology of applying a constant conversion rate from NO_x to NO₂ (Section 5.1.3.3). As shown in Appendix F, the conversion ratio at high concentration levels (i.e. closer to the point of emission) generally varies between 14% and 27% for NO_x concentrations above 188 µg/m³. In this investigation, a NO₂ conservative ratio of not less than 40% was adopted for high concentrations of NO_x. Concentrations similar to the observed peak would be predicted if the lower conversions of 27% were used instead.

As for SO₂, the difference between prediction and observation increases significantly when considering long-term comparisons (i.e. 50th percentile and annual average), clearly illustrating the contribution of emission sources not included in the dispersion model's emissions inventory. Not shown in the table is the observed concentration at the percentile where the prediction was zero; namely, 22.0 µg/m³ (average of 2010, 2011 and 2012).

Table 5-12: Comparison of predicted and observed NO₂ concentrations at AJ Jacobs monitoring station in Sasolburg

	AJ Jacobs			
	NO ₂ concentration (µg/m ³)			Unaccounted Fraction*
	Predicted	Observed	Unaccounted	
Peak	263.2	168.1	0.0	0%
99th Percentile	109.9	74.6	0.0	0%
90th Percentile	7.2	42.6	35.3	83%
50th Percentile	0.0	14.5	14.5	100%
Annual Average	6.5	19.1	12.6	66%

* unaccounted fraction as a percentage of observed concentration

Table 5-13 is a summary of comparisons between predicted and observed NO₂ concentrations at Leirim. In contrast to AJ Jacobs, where the peak concentration was definitely shown to be from Sasol operations, only about two-thirds of the observed concentration was predicted. Although this may still have resulted from the Sasol operations, there is also a strong likelihood that more localised sources, typically vehicle exhaust gases, may have added to the observed peak. This is also illustrated by the 99th percentile that indicates a similar fraction of unaccounted for emissions. As with AJ Jacobs, the difference between prediction and observation increases significantly when considering long-term comparisons (i.e. 50th percentile and annual average). The observed concentration at the zero prediction percentiles was determined to be 21.3 µg/m³ (average of 2010, 2011 and 2012).

Table 5-13: Comparison of predicted and observed NO₂ concentrations at Leitrim monitoring station in Sasolburg

	Leitrim			
	NO ₂ concentration (µg/m ³)			Unaccounted Fraction*
	Predicted	Observed	Unaccounted	
Peak	135.3	205.0	69.7	34%
99th Percentile	55.7	82.9	27.1	33%
90th Percentile	7.4	47.1	39.7	84%
50th Percentile	0.0	15.7	15.7	100%
Annual Average	3.3	20.9	17.6	84%

* unaccounted fraction as a percentage of observed concentration

Background concentrations were estimated for short- and long-term concentrations for each of the three years of simulations, as summarised in Table 5-14.

Subsequently, short-term fractional biases (i.e. using the 99th percentile with background concentration for each year) as well as long-term fractional biases (i.e. annual concentrations with estimated background concentration for each year) were calculated for the two monitoring stations. The results are summarised in Figure 5-29. The fractional bias of the means and standard deviations for both short- and long-term predictions were less than 0.67, clearly showing good model performance (i.e. within a factor of two). Using the individual fractional biases, the model's prediction is shown to be well within a factor of two, with fractional biases of the mean ranging from 0.04 (Leitrim, short-term) to 0.39 (AJ Jacobs, long-term).

Table 5-14: Estimated NO₂ background concentrations for Leitrim and AJ Jacobs

Year	NO ₂ background Concentration (µg/m ³)			
	Leitrim		AJ Jacobs	
	Short-Term	Long-Term	Short-Term	Long-Term
2010	23.9	21.3	0.0	24.2
2011	26.4	20.6	0.0	22.2
2012	31.0	22.1	0.0	19.5

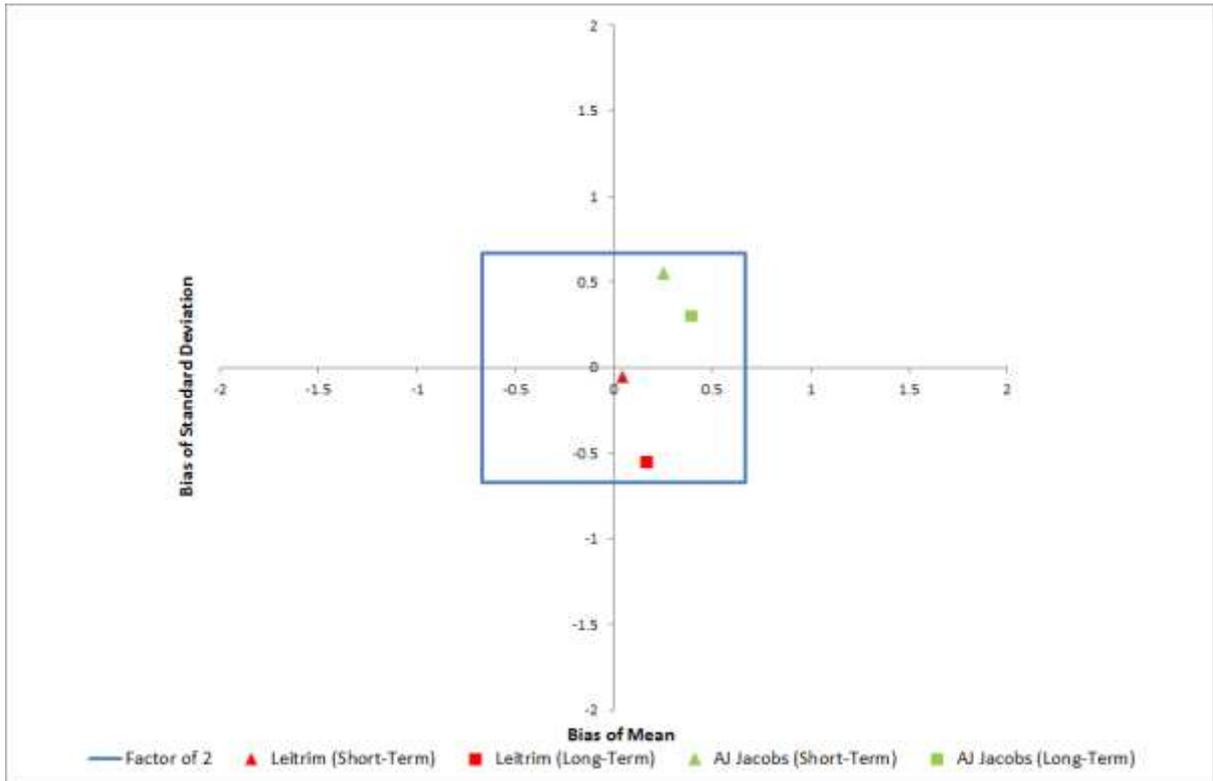


Figure 5-29: Fractional bias of means and standard deviation for NO₂

5.1.7 Scenario Emission Inventory

The source parameters and emissions per scenario were provided by Sasol for the assessment and are given in Table 5-15 and Table 5-16 respectively.

Table 5-15: Source parameters per scenario provided for Infracchem

Source Group	Source name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)
Baseline								
Steam Stations	Steam Station 1 (stacks 1,2 and 3)	-26.82272	27.84008	75	2.5	160	490489	6.9
		-26.82272	27.84006	75	2.5	160	505969	7.2
		-26.82272	27.84004	75	2.5	160	252985	3.6
	Steam Station 2	-26.82247	27.84853	145	7.8	160	1737413	10.1
Incinerators	B6930	-26.82556	27.84044	40	1.5	171	24811	3.9
	B6990	-26.82544	27.84022	40	1.53	570	173411	26.2
	B6993	-26.82544	27.84086	40	1.2	83	52522	12.9
At Existing Plant Emission Standards								
Steam Stations	Steam Station 1 (stacks 1,2 and 3)	-26.82272	27.84008	75	2.5	160	490489	6.9
		-26.82272	27.84006	75	2.5	160	505969	7.2
		-26.82272	27.84004	75	2.5	160	252985	3.6
	Steam Station 2	-26.82247	27.84853	145	7.8	160	1737413	10.1
Incinerators	B6930	-26.82556	27.84044	40	1.5	171	24811	3.9
	B6990	-26.82544	27.84022	40	1.53	570	173411	26.2
	B6993	-26.82544	27.84086	40	1.2	83	52522	12.9
At New Plant Emission Standards								
Steam Stations	Steam Station 1 (stacks 1,2 and 3)	-26.82272	27.84008	75	2.5	75	490489	6.9
		-26.82272	27.84006	75	2.5	75	505969	7.2
		-26.82272	27.84004	75	2.5	75	252985	3.6
	Steam Station 2	-26.82247	27.84853	145	7.8	75	1737413	8.12
Incinerators	B6930	-26.82556	27.84044	40	1.5	171	24811	3.9
	B6990	-26.82544	27.84022	40	1.53	570	173411	26.2
	B6993	-26.82544	27.84086	40	1.2	83	52522	12.9
At Alternative Emission Standards								
Steam Stations	Steam Station 1 (stacks 1, 2 and 3)	-26.82272	27.84008	75	2.5	160	490489	6.9
		-26.82272	27.84006	75	2.5	160	505969	7.2
		-26.82272	27.84004	75	2.5	160	252985	3.6
	Steam Station 2	-26.82247	27.84853	145	7.8	160	981548	5.7
Incinerators	B6930	-26.82556	27.84044	40	1.5	171	24811	3.9
	B6990	-26.82544	27.84022	40	1.53	570	173411	26.2
	B6993	-26.82544	27.84086	40	1.2	83	52522	12.9

Table 5-16: Source emissions per scenario provided for Infrachem (ND – emission rates could not be determined)

Source Group	Source name	Particulates (g/s)	SO ₂ (g/s)	NO _x (g/s)	Sum of Pb, As, Sb, Cr, Co, Cu, Mn, Ni, V (g/s)	Hg (g/s)	Cd+Tl (g/s)	HF (g/s)	NH ₃ (g/s)	HCl (g/s)	TOCs (g/s)	Dioxins/Furans (g/s)
Baseline												
Steam Stations	Steam Station 1 (stacks 1,2 and 3)	9.187	66.202	91.137								
		9.477	68.291	94.013								
		4.738	34.146	47.007								
	Steam Station 2	26.601	223.395	280.987								
Incinerators	B6930	0.090	4.884	0.965	0.004	0.000	0.000	0.005	0.005	0.006	0.277	0.000
	B6990	ND	0.203	3.503	ND	ND	ND	0.021	0.012	0.021	0.588	ND
	B6993	1.519	0.133	3.627	0.137	0.000	0.000	0.007	0.325	0.087	0.064	0.000
At Existing Plant Emission Standards												
Steam Stations	Steam Station 1 (stacks 1,2 and 3)	7.291	255.183	80.200								
		7.521	263.236	82.731								
		3.761	131.618	41.366								
	Steam Station 2	25.826	903.910	280.987								
Incinerators	B6930	0.047	0.095	0.957	0.002	0.000	0.000	0.003	0.003	0.003	0.146	0.000
	B6990	ND	0.385	3.519	ND	ND	ND	0.041	0.022	0.041	1.117	ND
	B6993	1.519	0.133	3.627	0.137	0.000	0.000	0.0007	0.325	0.0087	0.064	0.000
At New Plant Emission Standards												
Steam Stations	Steam Station 1 (stacks 1,2 and 3)	3.645	36.455	54.682								
		3.761	37.605	56.408								
		1.880	18.803	28.204								
	Steam Station 2	12.913	129.130	193.695								
Incinerators	B6930	0.019	0.095	0.379	0.002	0.000	0.000	0.003	0.003	0.003	0.032	0.000
	B6990	ND	0.385	3.519	ND	ND	ND	0.041	0.022	0.041	0.559	ND
	B6993	0.095	0.133	1.899	0.003	0.000	0.000	0.007	0.068	0.068	0.064	0.000
At Alternative Emission Limits												
Steam Stations	Steam Station 1 (stacks 1,2 and 3)	12.030	145.819	163.155								
		12.410	150.421	168.305								

Source Group	Source name	Particulates (g/s)	SO ₂ (g/s)	NO _x (g/s)	Sum of Pb, As, Sb, Cr, Co, Cu, Mn, Ni, V (g/s)	Hg (g/s)	Cd+Tl (g/s)	HF (g/s)	NH ₃ (g/s)	HCl (g/s)	TOCs (g/s)	Dioxins/Furans (g/s)
		6.205	75.210	84.152								
	Steam Station 2	29.912	256.513	330.660								
Incinerators	B6930	0.097	3.532	1.470	0.002	0.000	0.000	0.003	0.003	0.003	0.097	0.000
	B6990	ND	3.151	5.412	ND	ND	ND	0.021	0.012	0.021	0.291	ND
	B6993	0.484	0.133	1.162	0.033	0.000	0.000	0.007	0.325	0.053	0.064	0.000

5.1.8 Model Results

Air quality standards are fundamental tools to assist in air quality management. The National Ambient Air Quality Standards (NAAQS) (Section 5.1.2.2) are intended to reduce harmful effects on health of the majority of the population, including the very young and the elderly. In this section, predicted ambient concentrations of criteria (Table 5-2) and non-criteria pollutants at specific sensitive receptors are compared against NAAQS and international health effect screening levels, respectively.

Prior to dispersion modelling, twelve receptors were identified in the vicinity of the Sasolburg operations (within the 50-by-50 km modelling domain). Sensitive receptors included residential areas and points of maximum predicted pollutant concentrations (Figure 5-30 and Table 5-17). Ambient air quality monitoring stations were the first receptors identified because comparison of the predicted concentrations could be compared with measured concentrations for model validation. Residential areas, both close to the point sources and further away, were then selected. After an initial model screening process, predicted points of maximum concentrations of criteria pollutants were included as sensitive receptors in all dispersion modelling. Grid intercept points corresponding with the identified receptors were given code names such as GR1 (Grid Receptor 1). Receptor code names have been included in figures and tables for the sake of brevity. Receptors are presented in the figures and tables in increasing distance from the main source of pollutants – the Steam Stations. In response to stakeholder comments, schools and clinics within the domain were identified and are now included in the sensitive receptor map (Figure 5-30) and in the isopleth plots in Section 5.1.8.

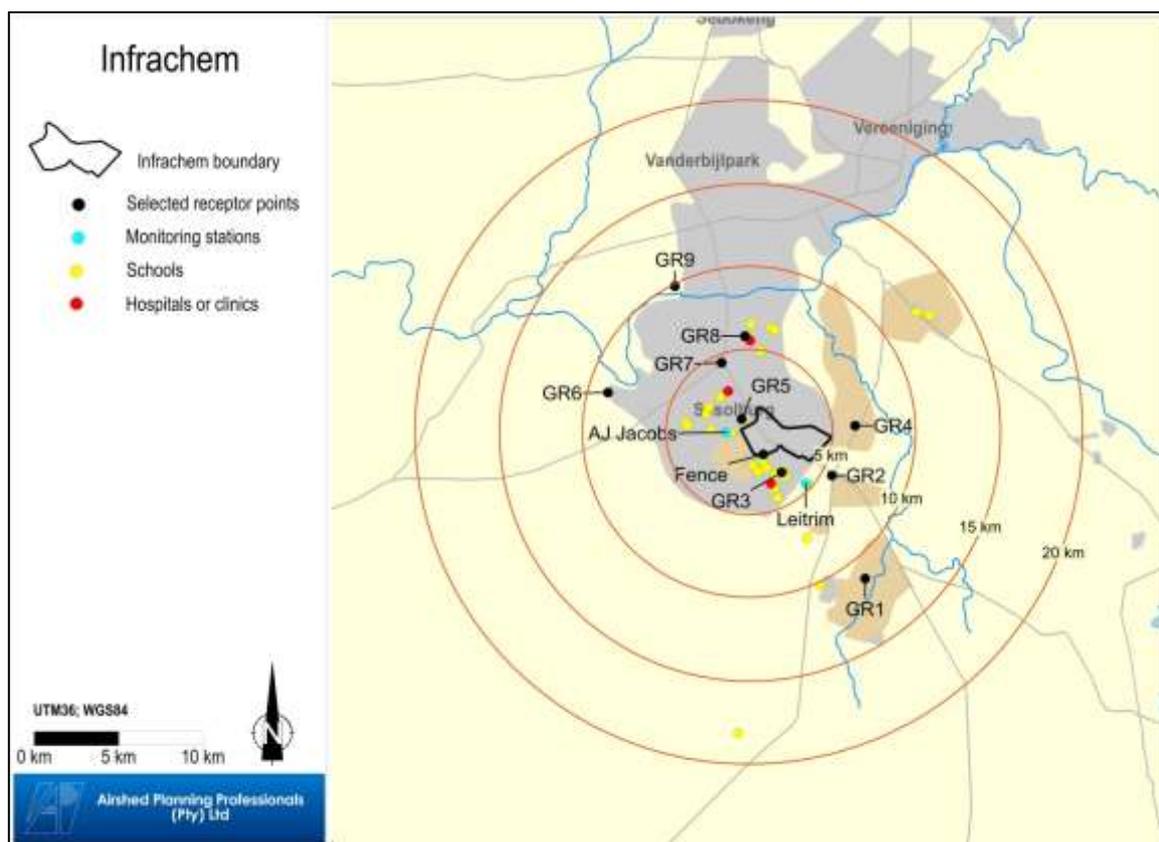


Figure 5-30: Sensitive receptors identified for assessment of impact as a result of Infrachem operations

Table 5-17: Receptors identified for assessment of impact as a result of Infrachem operations

Receptor code	Receptor details	Distance from source
---------------	------------------	----------------------

name ^(a)		(metres) ^(b)
GR5	Sasolburg - point of maximum	1 176
AJ Jacobs	SASOL AJ Jacobs monitoring station	1 391
Fenceline	SASOL One Fence-line monitoring station	1 410
GR3	Zamdela - point of maximum	2 858
Leitrim	SASOL Leitrim monitoring station	4 268
GR7	SASOL Eco-Park monitoring station	4 668
GR2	Zamdela (boundary)	5 224
GR8	Vaalpark	5 817
GR4	Edge of industrial zone (East of plant)	5 930
GR6	Marlbank river estate AH	9 195
GR9	Vanwaarshof AH	10 044
GR1	Edge of impact plume (South East of plant)	10 968

(a) Code names used in Figures and Tables for brevity

(b) Figures and tables present findings for receptors in increasing distance from a mid-point between the Steam Stations

Since the focus of the study is to illustrate the relative changes with the introduction of different emission conditions, the predicted concentration differences from scenario to scenario were provided as percentages increase or decrease over the modelled baseline scenario ($C_{Baseline\ Scenario}$). However, these percentages need to also include concentrations attributable to other sources not accommodated in the model ($C_{Background}$). The change in concentration from any of the future source or source group scenario ($C_{s, Future\ Scenario}$) compared to the baseline source or source group scenario ($C_{s, Baseline\ Scenario}$) was therefore expressed as follows:

$$\frac{C_{s, Future\ Scenario} - C_{s, Baseline\ Scenario}}{C_{Baseline\ Scenario} + C_{Background}}$$

Equation 1

The average long-term background concentrations, as given in Table 5-18, were used in this expression rather than the short-term value. If the short-term background concentrations were to be used instead (i.e. a higher value), the comparison would be less optimistic since the denominator would be larger and the fraction therefore smaller. This offers a more conservative approach.

It should be noted that the changes in ground-level concentrations, at the receptors, between the scenarios shown in the results: (1) are theoretical changes and may not necessarily be technically possible, and; (2) represent the maximum achievable improvements and are, therefore, not indicative of the day-to-day average reduction at every receptor point cumulatively.

Table 5-18: Estimated background concentrations of SO₂ and NO₂ for use in predicted concentration changes between scenarios

Monitoring Station	Background Concentration (µg/m ³)	
	SO ₂	NO ₂
AJ Jacobs	39.9	22.0
Leitrim	17.4	21.3
<i>Average</i>	<i>28.7</i>	<i>21.7</i>

5.1.8.1 Criteria pollutants

The findings for each of the criteria pollutants (SO₂, NO₂ and PM) are presented for each of the sources or source groups identified in two figures. The first figure presents the predicted pollutant concentration (99th percentile) at the identified receptors (Table 5-20) for each of the emission scenarios (baseline operating conditions, emissions in theoretical compliance with Existing Plant Standards [2015], and with New Plant Standards [2020]; and the Alternative Emission Limits) relative to the appropriate NAAQ limit. At the selected receptor points, the 99th percentile predicted baseline concentrations as obtained from the Vaal Priority Area was included. The second figure presents the theoretical change in ground-level concentrations between the emission scenarios and the baseline. The predicted frequency of exceedance of NAAQ limits is provided in a table for all source groups comparing the impact as a result of the three emission scenarios.

For the Infrachem operations, the source groups are:

- The combined sources seeking postponement (Steam Station 1, Steam Station 2 and the Incinerators)
- Steam Station 1 (as a combination of emissions from the three stacks associated with Steam Station 1)
- Steam Station 2 (as an individual source)
- Incinerators (as the combined impact of Incinerator units: B6930, B6990 and B6993)

The following sections focus on predicted short-term impacts, because if there is compliance with short-term standards then medium (daily) and long-term (annual) impacts will be in compliance with relevant standards. Impacts on daily and annual average ambient concentrations are presented in Appendix I.

Isopleth plots have been included for the Baseline Emissions (or Alternative Emission Limit) scenario for the Steam Station emissions of SO₂, NO₂, and, PM.

5.1.8.1.1 Sulfur dioxide (SO₂)

Ambient concentrations of SO₂ as a result of Infrachem baseline operations (Figure 5-31) were predicted to fall below the hourly NAAQS, where impact on nearby receptors is mainly a result of emissions from the Steam Stations, especially Steam Station 1 (Figure 5-32). Reductions in ambient SO₂ concentrations are evident as the distance from source increases and with theoretical compliance with New Plant Emission standards (for example as in Figure 5-31). Alternative Emission Limits for the combined sources aims to meet the VTAPA commitment to reduce short-term ground-level concentrations by 7% from the 2009 Vaal Triangle Airshed Priority Area (VTAPA) baseline (Figure 5-31).

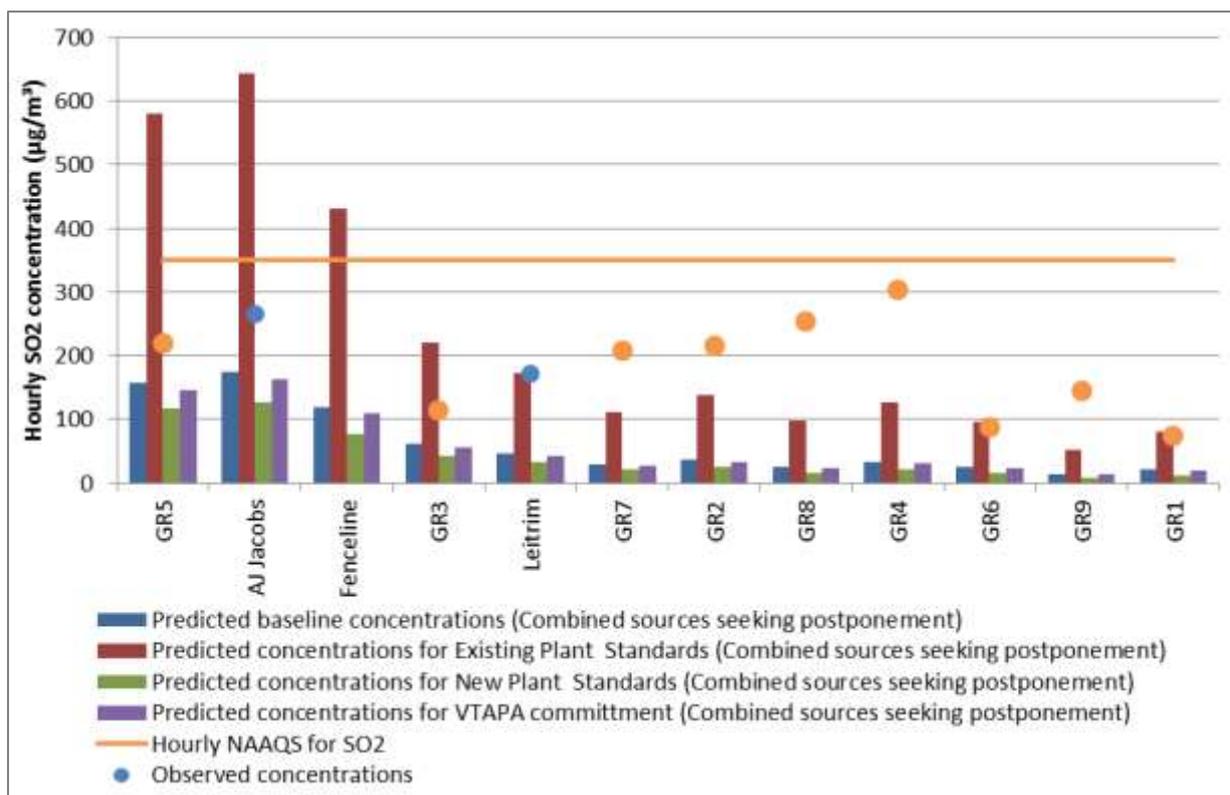


Figure 5-31: Predicted 99th percentile hourly SO₂ concentration at identified receptors for combined Infracchem sources seeking postponement (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

Theoretical compliance with New Plant Emissions Standards is predicted to result in reductions in ambient SO₂ concentrations at all 12 receptors; where the largest reductions are expected at AJ Jacobs and the Fenceline monitoring stations (~25% reduction) mostly as a result of theoretical changes at Steam Station 1 (Figure 5-33). Increases in ambient SO₂ concentrations at nearby receptors (GR5, AJ Jacobs and Fenceline) are likely as a result of Steam Station 2 theoretically complying with New Plant Standards (Figure 5-36), due to decreased stack exit temperatures resulting in reduced buoyancy of the emissions. Ambient SO₂ concentrations at receptors would increase, by between 23% and 93%, as a result of Alternative Emission Limits for the Steam Station 1 (Figure 5-33), and between 8% and 23% for Steam Station 2 (Figure 5-36). Although Infracchem aims to meet the VTAPA commitment to reduce the short-term ambient SO₂ concentrations by 7% (indicated by the error bars in Figure 5-32 and Figure 5-35).

The Infracchem incinerators result in very low ambient SO₂ concentrations under all scenarios (Figure 5-38) and theoretical compliance with Existing and New Plant Standards will result in less than 5% reductions in ambient SO₂ concentrations (Figure 5-39).

Isopleth plots are presented for the predicted 99th percentile hourly ground-level SO₂ concentrations as a result of the Baseline from the Steam Stations (Steam Station 1: Figure 5-34 and Steam Station 2: Figure 5-37). Although exceedances of the SO₂ NAAQ hourly limit were predicted, for Steam Station 1, the number of exceedances is fewer than the 88 hours permitted by the NAAQS standard. At Steam Station 2, the maximum predicted 99th percentile ground-level concentrations were below the NAAQ limit concentration and as such the level presented in both figures represents 29% of the hourly limit (100 µg/m³).

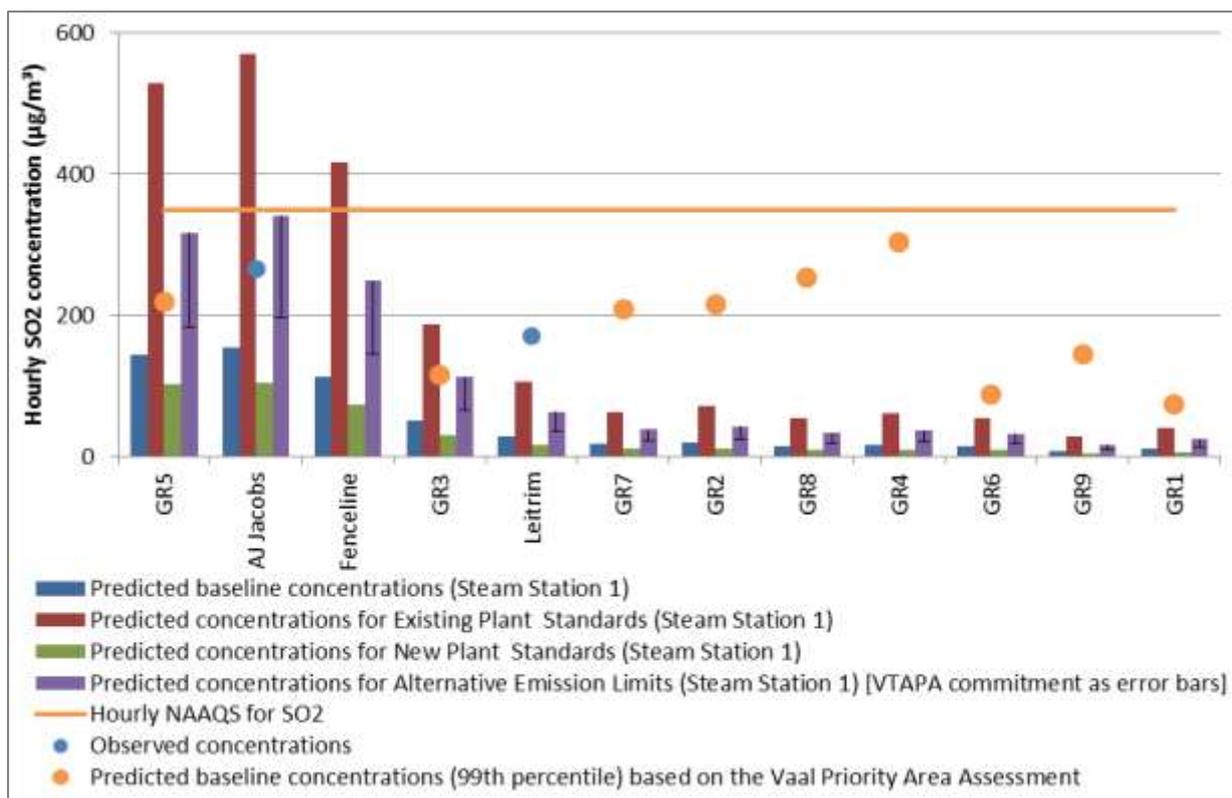


Figure 5-32: Predicted 99th percentile hourly SO₂ concentration at identified receptors for Infracchem Steam Station 1 (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

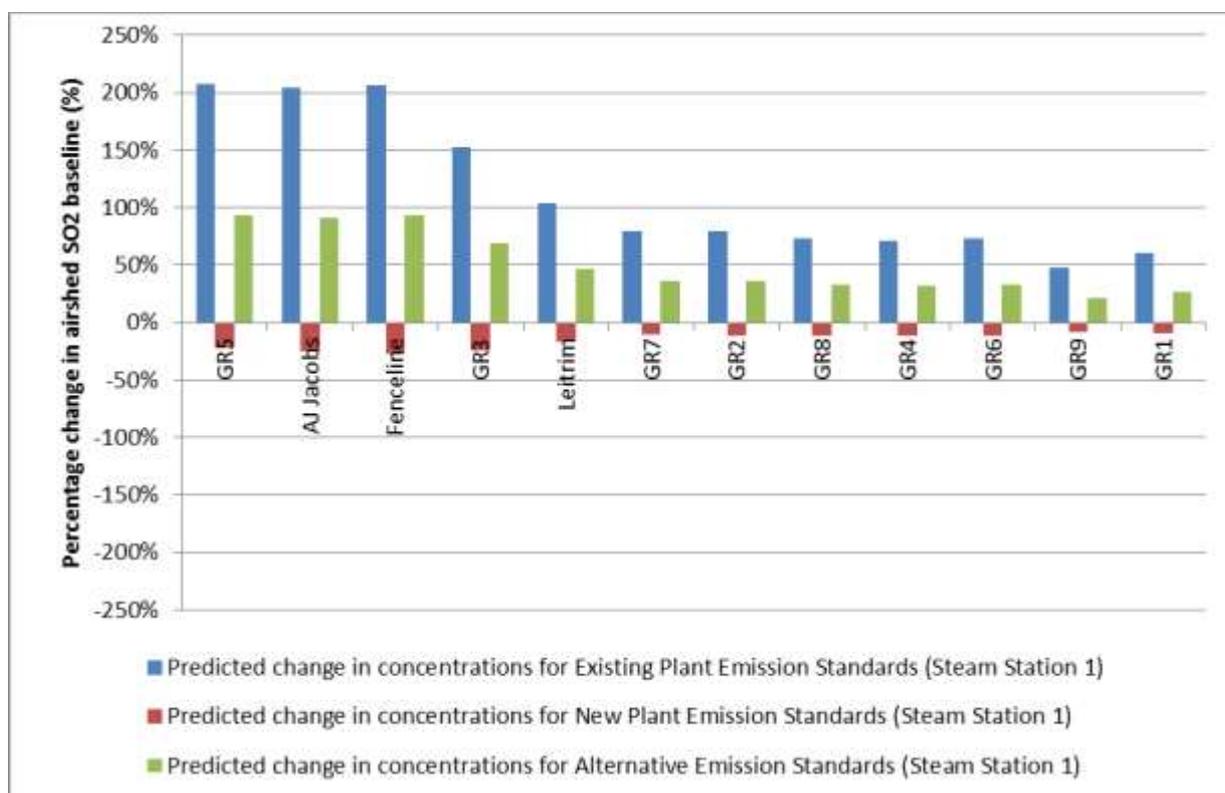


Figure 5-33: Theoretical change in hourly ambient SO₂ concentrations and the airshed baseline at the identified receptors for Infracchem Steam Station 1 (change calculated using Equation 1)

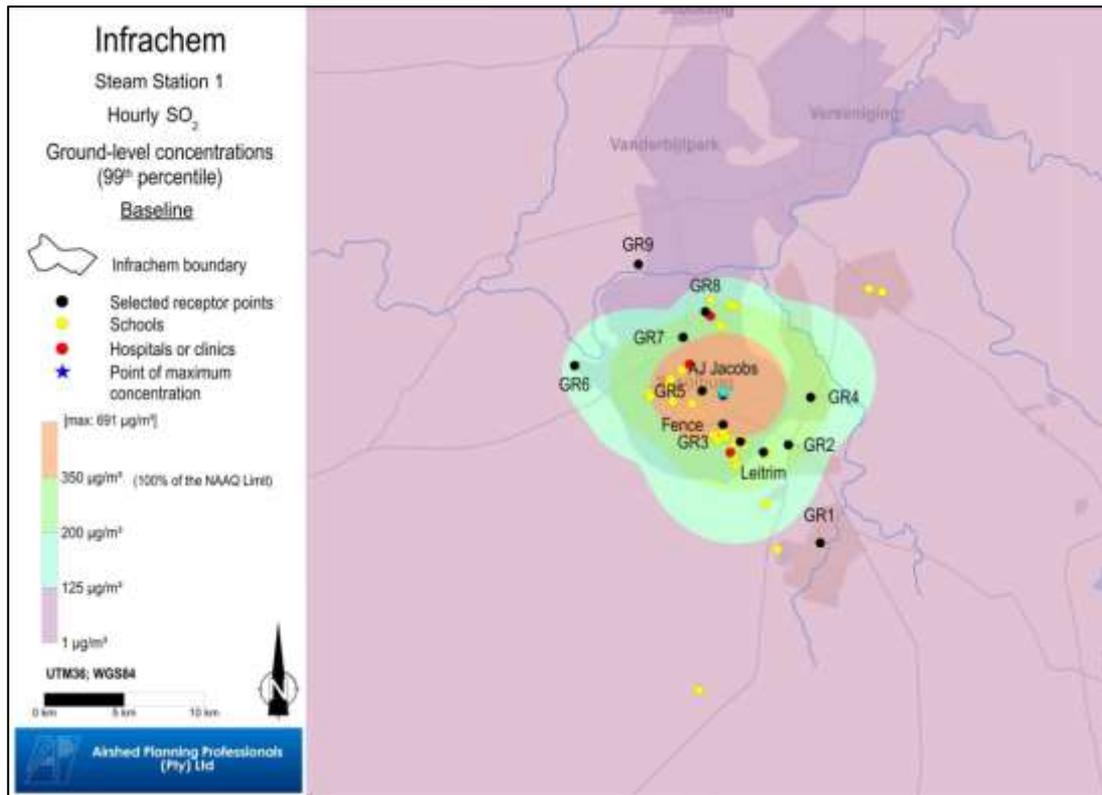


Figure 5-34: Predicted 99th percentile SO₂ concentrations as a result of Baseline emissions from Steam Station 1

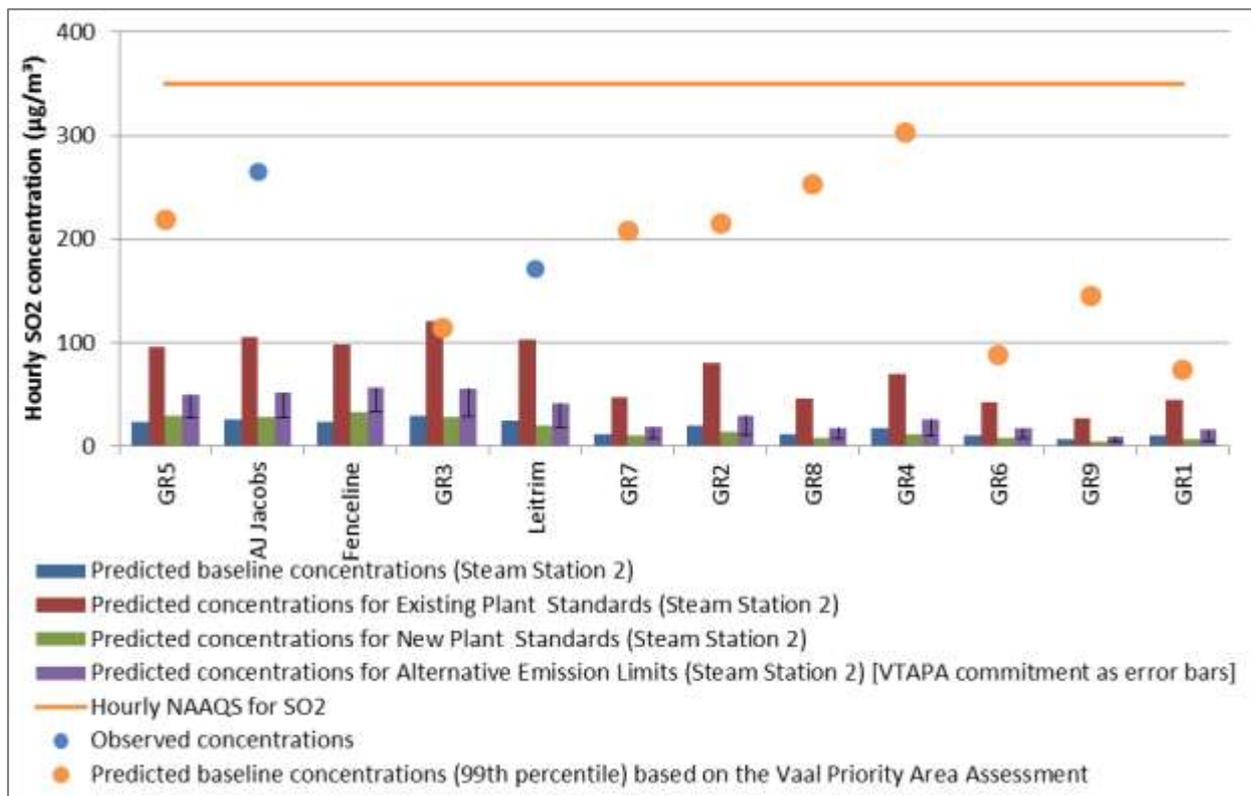


Figure 5-35: Predicted 99th percentile hourly SO₂ concentration at identified receptors for Infracchem Steam Station 2 (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

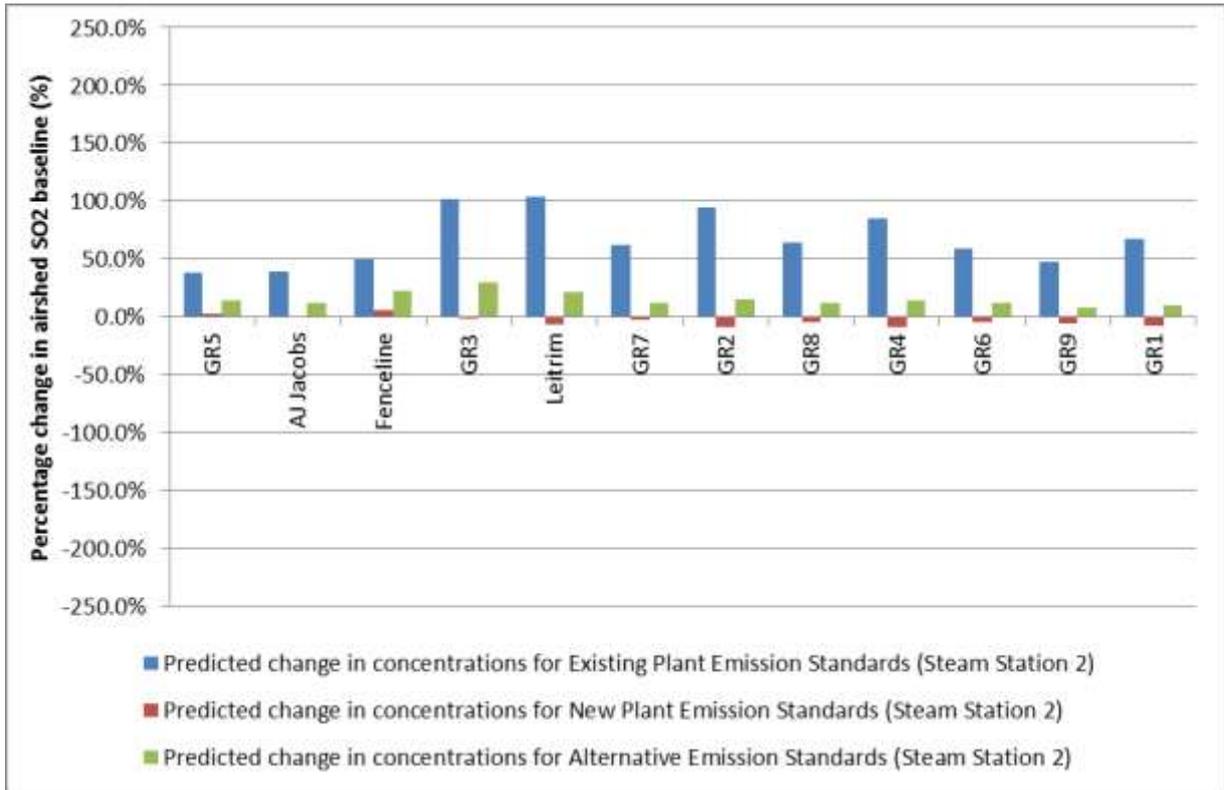


Figure 5-36: Theoretical change in hourly ambient SO₂ concentrations and the airshed baseline at the identified receptors for Infrachem Steam Station 2 (change calculated using Equation 1)

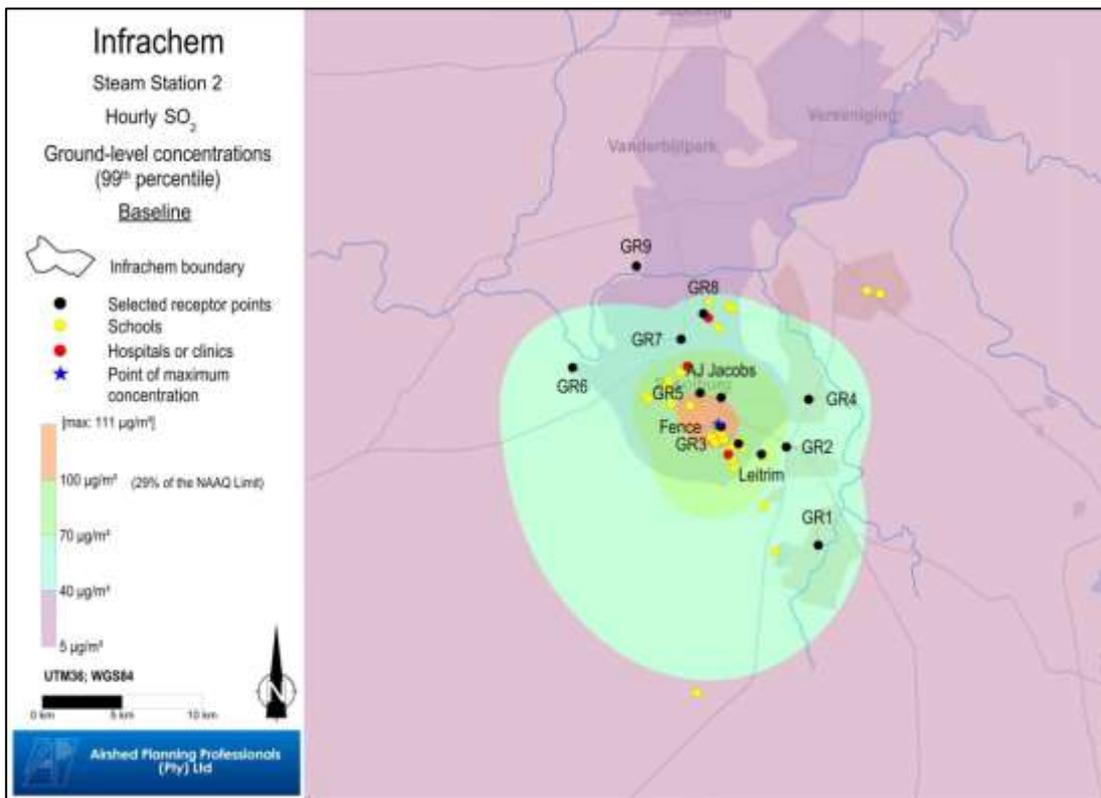


Figure 5-37: Predicted 99th percentile SO₂ concentrations as a result of Baseline emissions from Steam Station 2

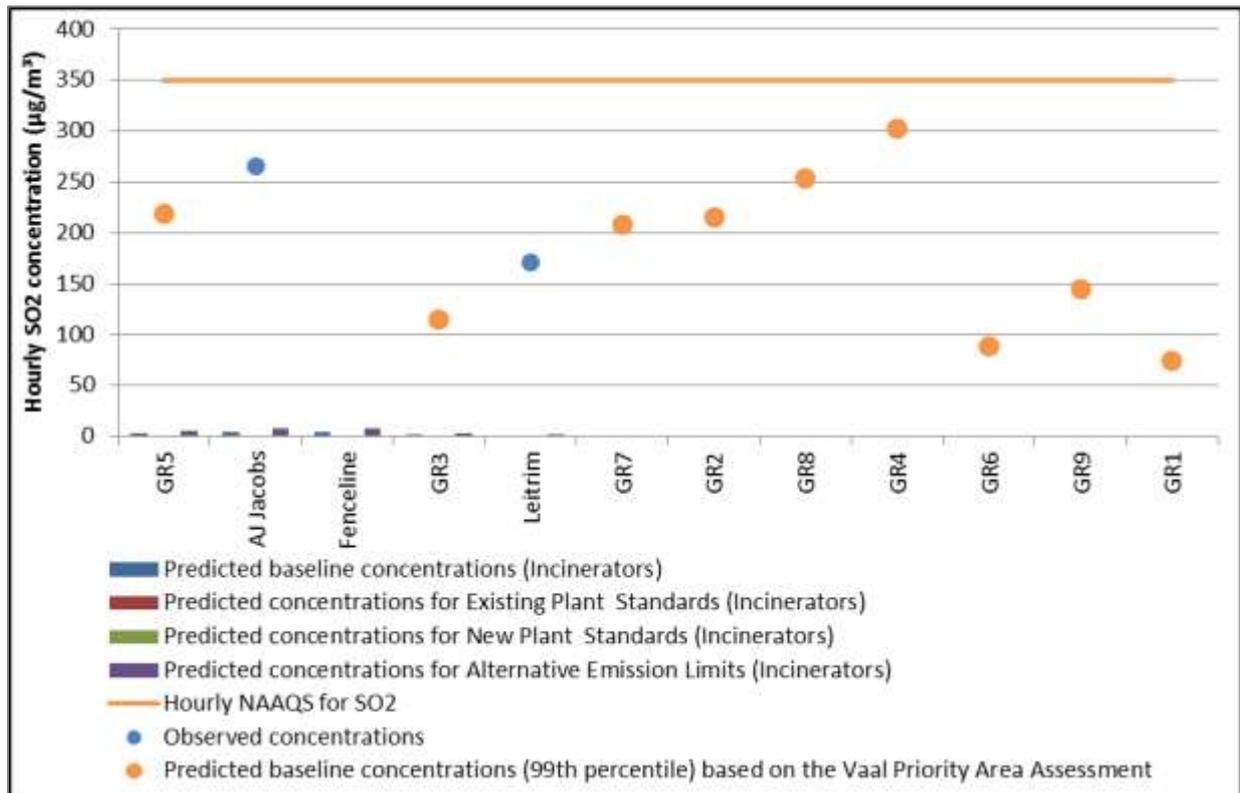


Figure 5-38: Predicted 99th percentile hourly SO₂ concentration at identified receptors for Infracem Incinerators (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

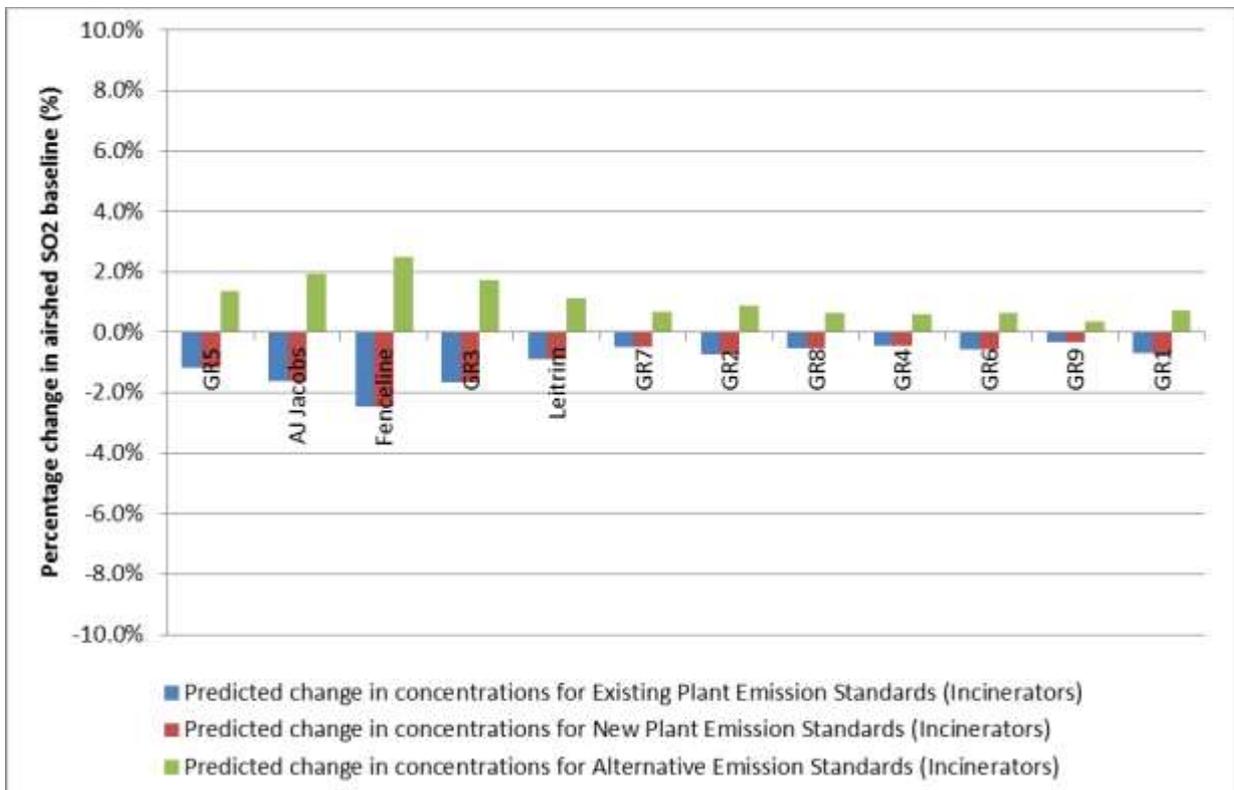


Figure 5-39: Predicted change, from the baseline, in ambient SO₂ concentrations for emission scenarios at identified receptors for Infracem Incinerators (calculated using Equation 1)

5.1.8.1.2 Nitrogen dioxide (NO₂)

Theoretical compliance with Existing Plant standards was predicted to result in reduced ambient NO₂ concentrations at most of the receptors (Figure 5-40) mostly as a result of theoretically reduced emissions from Steam Station 1 (Figure 5-41 and Figure 5-42). Ambient NO₂ concentrations are expected to increase at AJ Jacobs with theoretical compliance with New Plant Standards, due to exit temperature reductions resulting in reduced buoyancy of the emissions from the Steam Station 2 stack (Figure 5-45). Ambient NO₂ concentrations were predicted to be increase relative to the airshed baseline under Alternative Emission Limits, mostly as a result of changes proposed for Steam Station 1 (Figure 5-42). Infracchem will meet the VTAPA commitment to reduce short-term ambient NO₂ concentrations, as a result of its operations, by 18% (indicated by the error bars in Figure 5-41 and Figure 5-44).

Isopleth plots are presented for the predicted 99th percentile hourly ground-level SO₂ concentrations as a result of the Baseline from the Steam Stations (Steam Station 1: Figure 5-43 and Steam Station 2: Figure 5-46). Although exceedances of the SO₂ NAAQ hourly limit were predicted, for Steam Station 1, the number of exceedances is fewer than the 88 hours permitted by the NAAQS standard. At Steam Station 2, the maximum predicted 99th percentile ground-level concentrations were below the NAAQ limit concentration and as such the level presented in the figure represents 27.5% of the hourly limit (55 µg/m³).

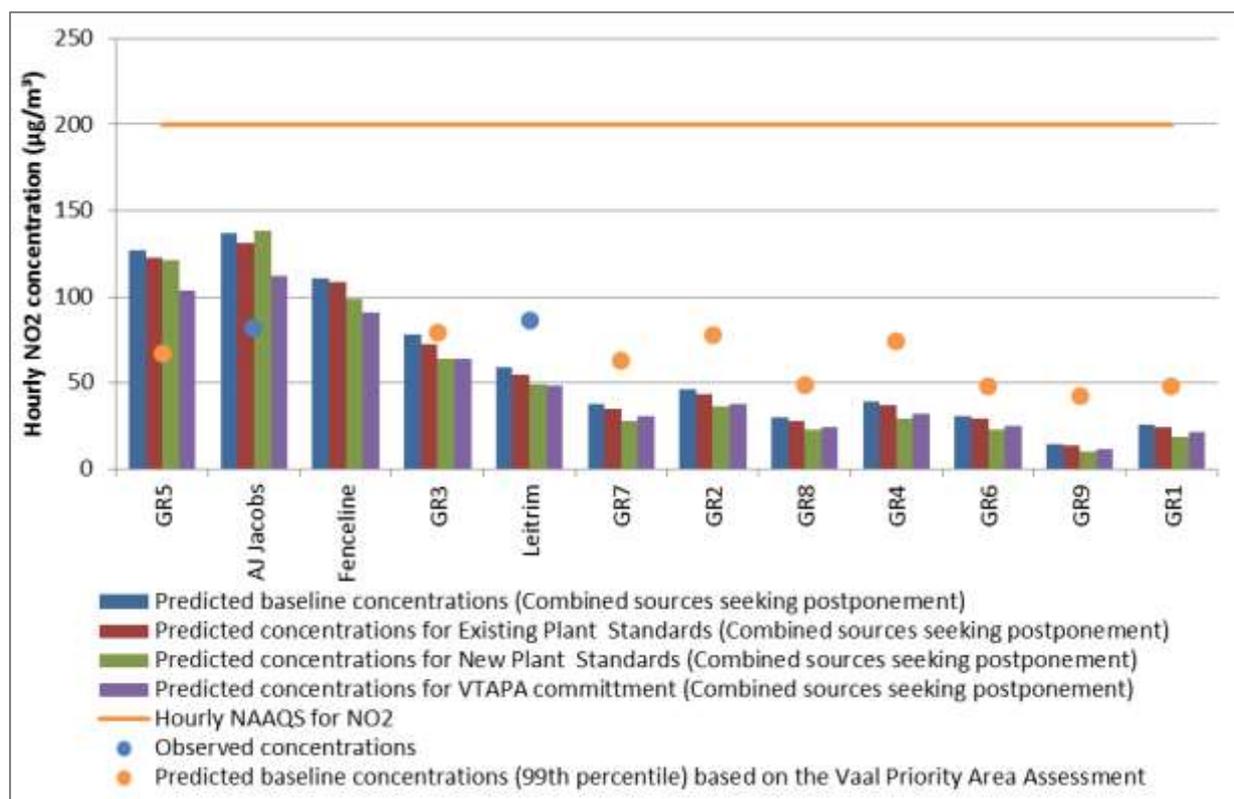


Figure 5-40: Predicted 99th percentile hourly NO₂ concentration at identified receptors for combined Infracchem sources seeking postponement (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

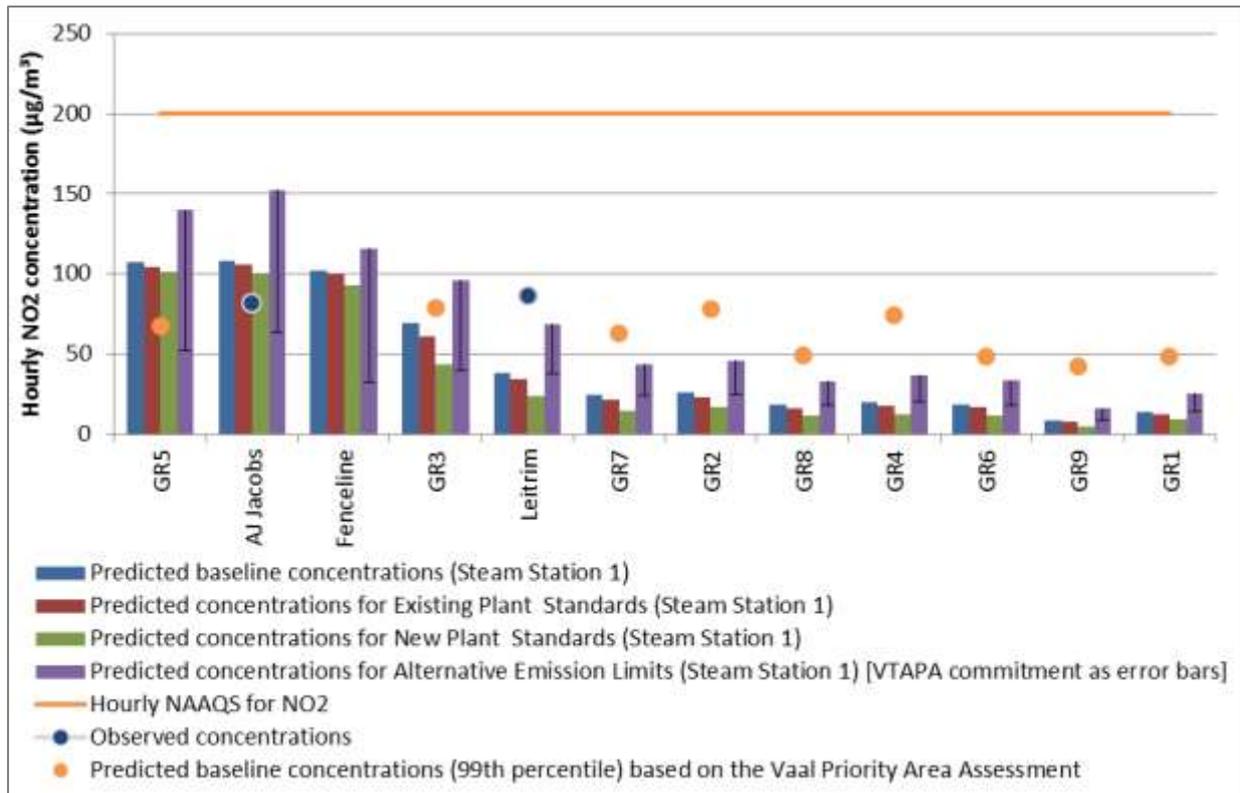


Figure 5-41: Predicted 99th percentile hourly NO₂ concentration at identified receptors for Infracchem Steam Station 1 (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

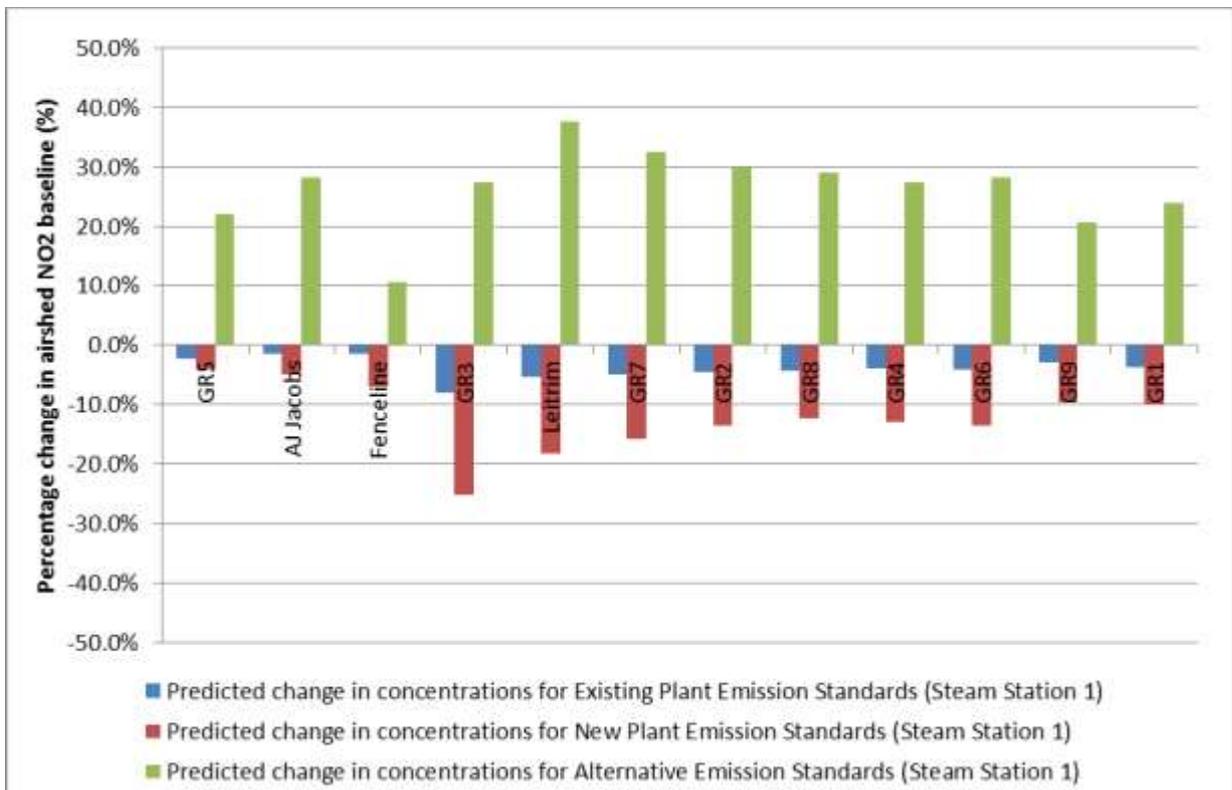


Figure 5-42: Theoretical change in hourly ambient NO₂ concentrations and the airshed baseline at the identified receptors for Infracchem Steam Station 1 (change calculated using Equation 1)

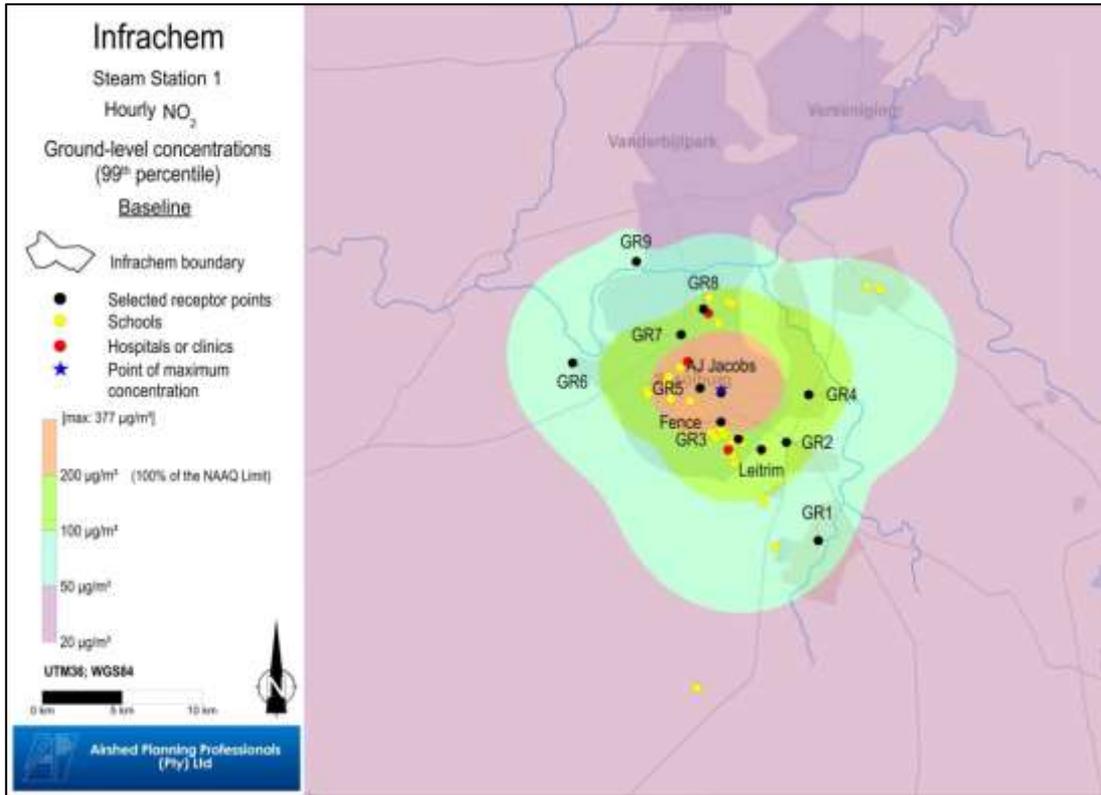


Figure 5-43: Predicted 99th percentile NO₂ concentrations as a result of Baseline emissions from Steam Station 1

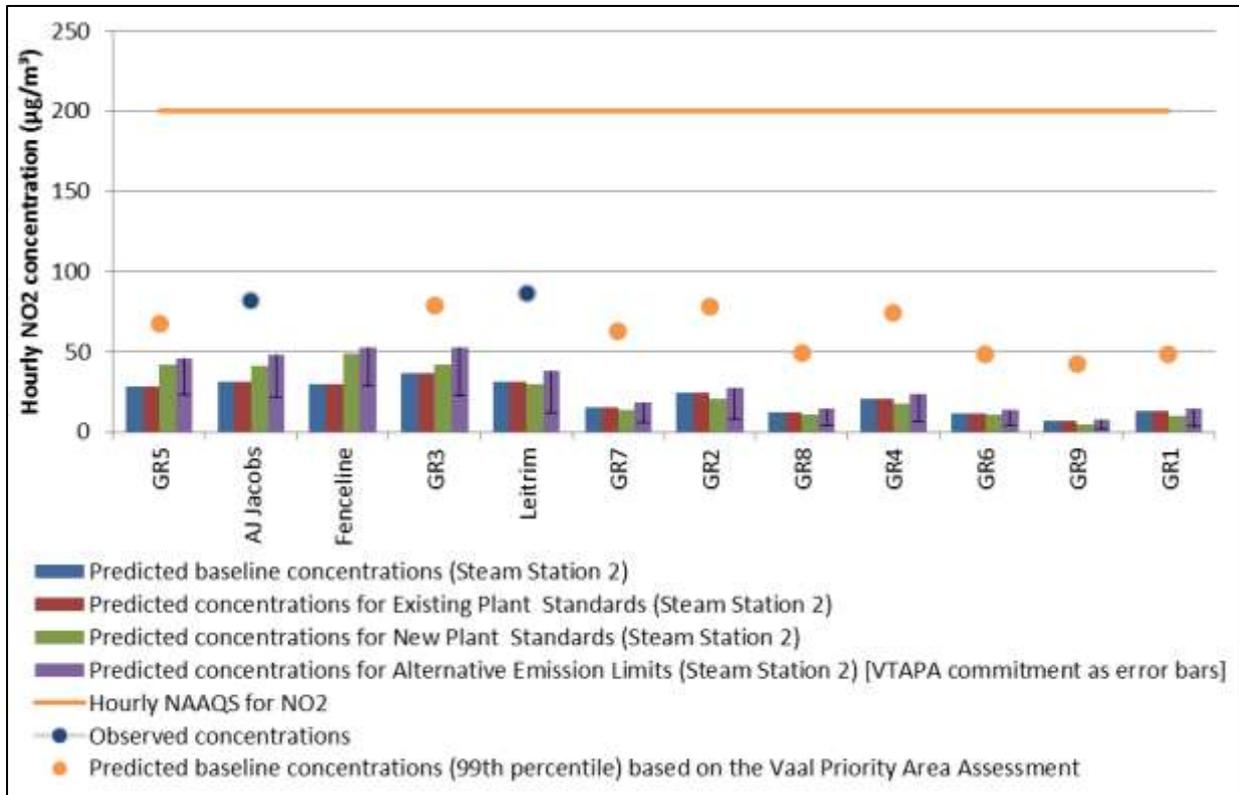


Figure 5-44: Predicted 99th percentile hourly NO₂ concentration at identified receptors for Infracchem Steam Station 2

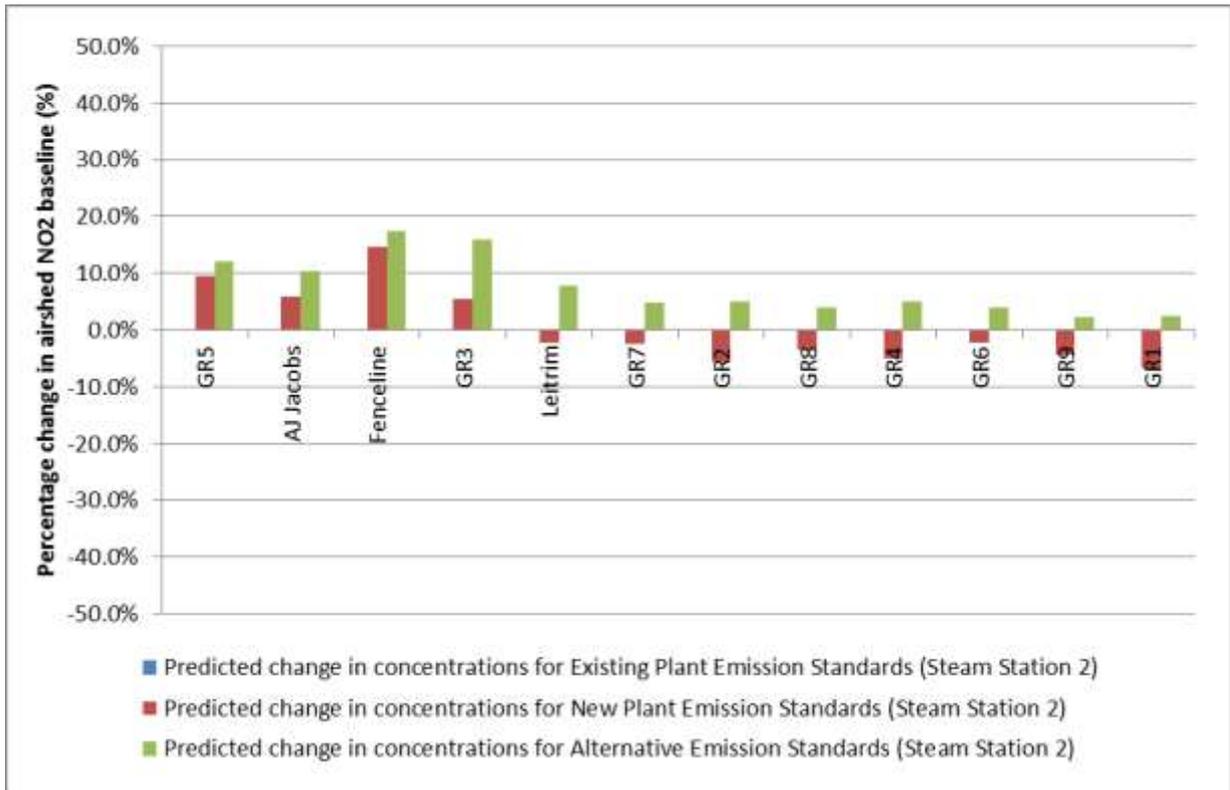


Figure 5-45: Theoretical change in hourly ambient NO₂ concentrations and the airshed baseline at the identified receptors for Infracchem Steam Station 2 (change calculated using Equation 1)

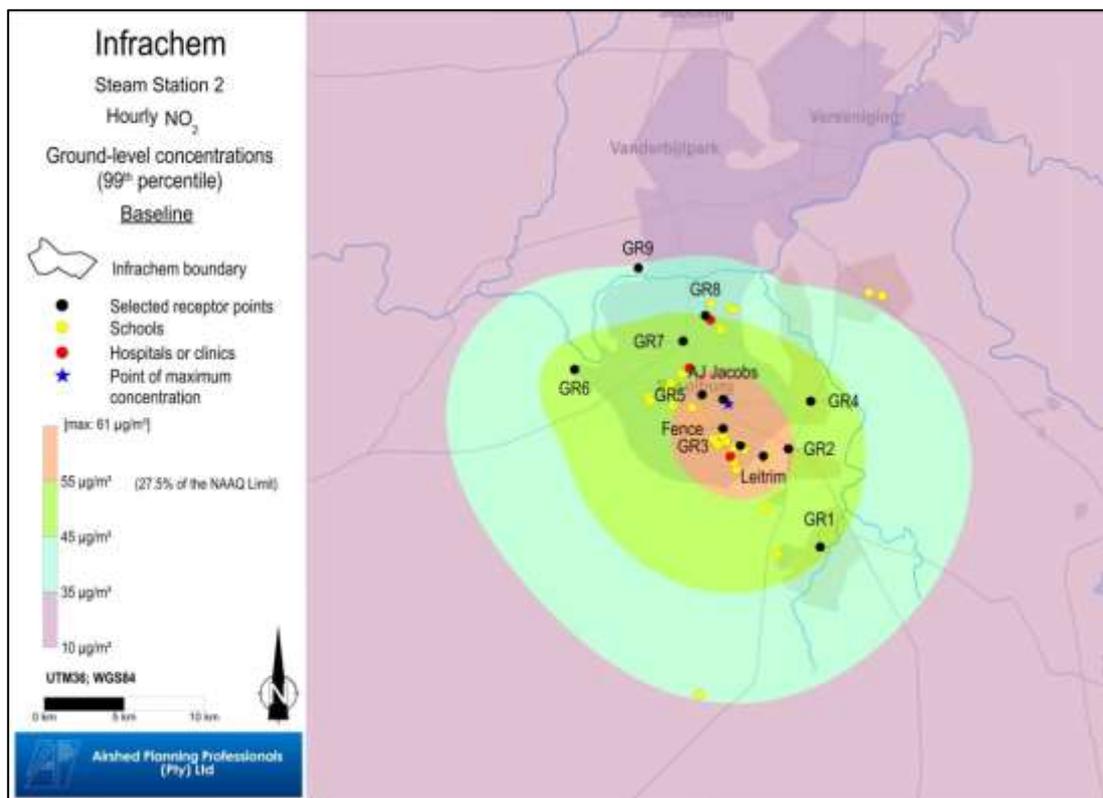


Figure 5-46: Predicted 99th percentile NO₂ concentrations as a result of Baseline emissions from Steam Station 2

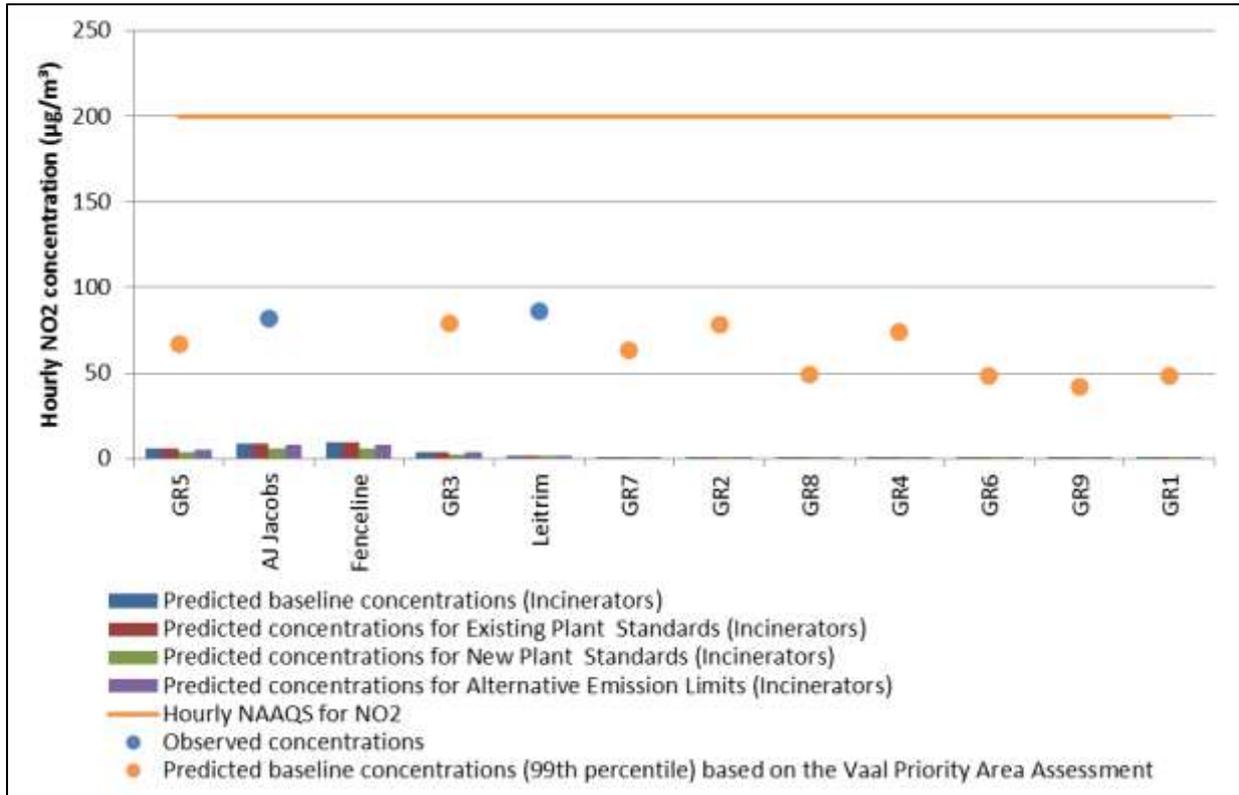


Figure 5-47: Predicted 99th percentile hourly NO₂ concentration at identified receptors for Infracchem Incinerators

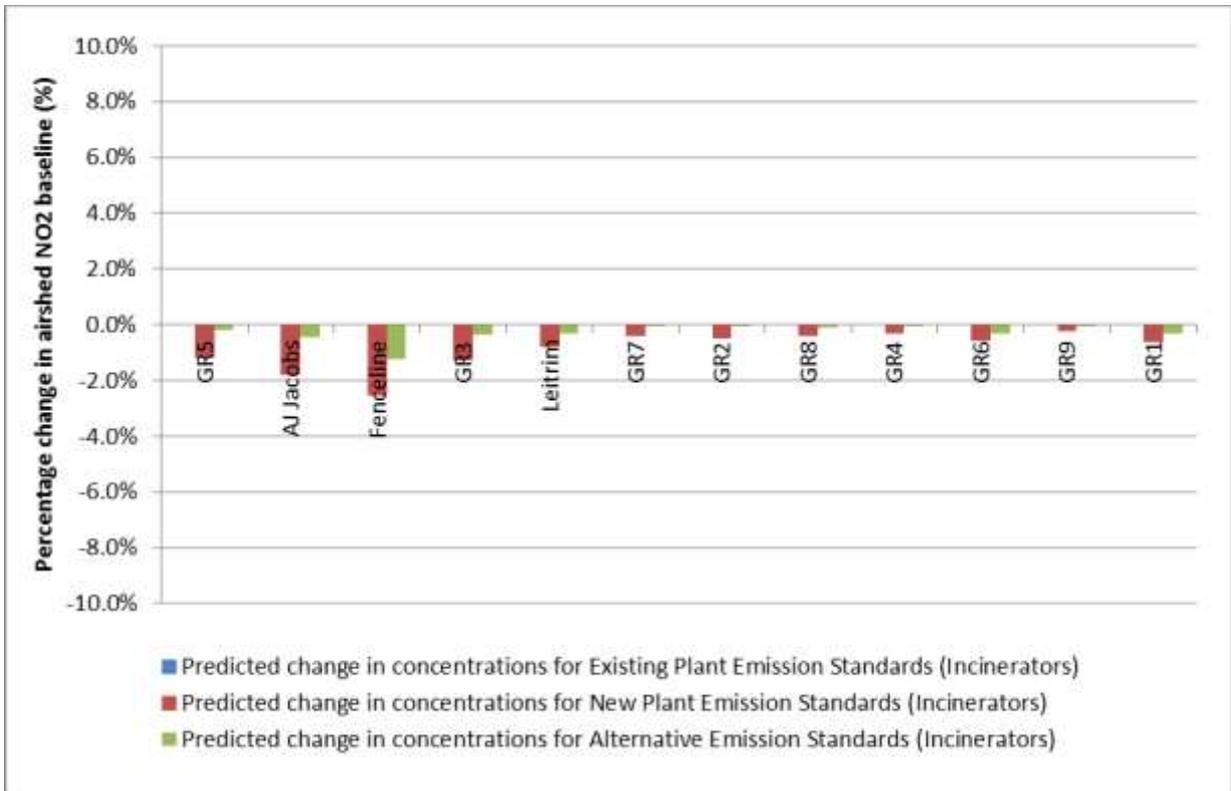


Figure 5-48: Theoretical change in hourly ambient NO₂ concentrations and the airshed baseline at the identified receptors for Infracchem Incinerators (change calculated using Equation 1)

5.1.8.1.3 Particulate Matter (PM_{2.5} and PM₁₀)

For particulate matter, NAAQS are available for PM₁₀ and PM_{2.5}. Ambient air quality impacts for both particulate fractions (i.e. PM₁₀ and PM_{2.5}) thus need to be considered.

Predicted concentrations of particulate matter (PM) were conservatively assumed to be PM_{2.5} since it was not possible to establish the PM_{2.5}/PM₁₀ split. Furthermore, the monitoring of PM at the AJ Jacobs and Leitrim monitoring stations only include PM₁₀ and therefore figures present predicted PM concentrations relative to the daily PM₁₀ NAAQS.

The source groups at Infrachem operations result in low ground-level concentrations of PM; less than 10 µg/m³ for all sources (Figure 5-49, Figure 5-50, Figure 5-53, and Figure 5-56). No exceedances of either the PM₁₀ or the PM_{2.5} NAAQ daily limit were predicted. Isoleth plots are presented for the predicted 99th percentile daily ground-level PM concentrations as a result of the Baseline from the Steam Stations (Steam Station 1: Figure 5-52 and Steam Station 2: Figure 5-56). The maximum predicted 99th percentile ground-level concentrations were below the NAAQ limit concentration as a result of both Steam Stations and as such the level presented in the figures represents 13% of the daily limit (10 µg/m³) for Steam Station 1; and 1.3% of the daily limit (1 µg/m³) for Steam Station 2.

Ground-level PM concentrations could be reduced by up to 3% compared with the baseline operations with theoretical compliance with Existing and New Plant Emission Standards (Figure 5-49, Figure 5-51, Figure 5-54, and Figure 5-57). Although the Alternative Emission Limits were predicted to result in increased ambient PM concentrations, especially as a result of emissions from Steam Station 1 (Figure 5-51), Infrachem will meet the VTAPA commitment to reduce daily ambient PM concentrations as a result of its operations by 1%.

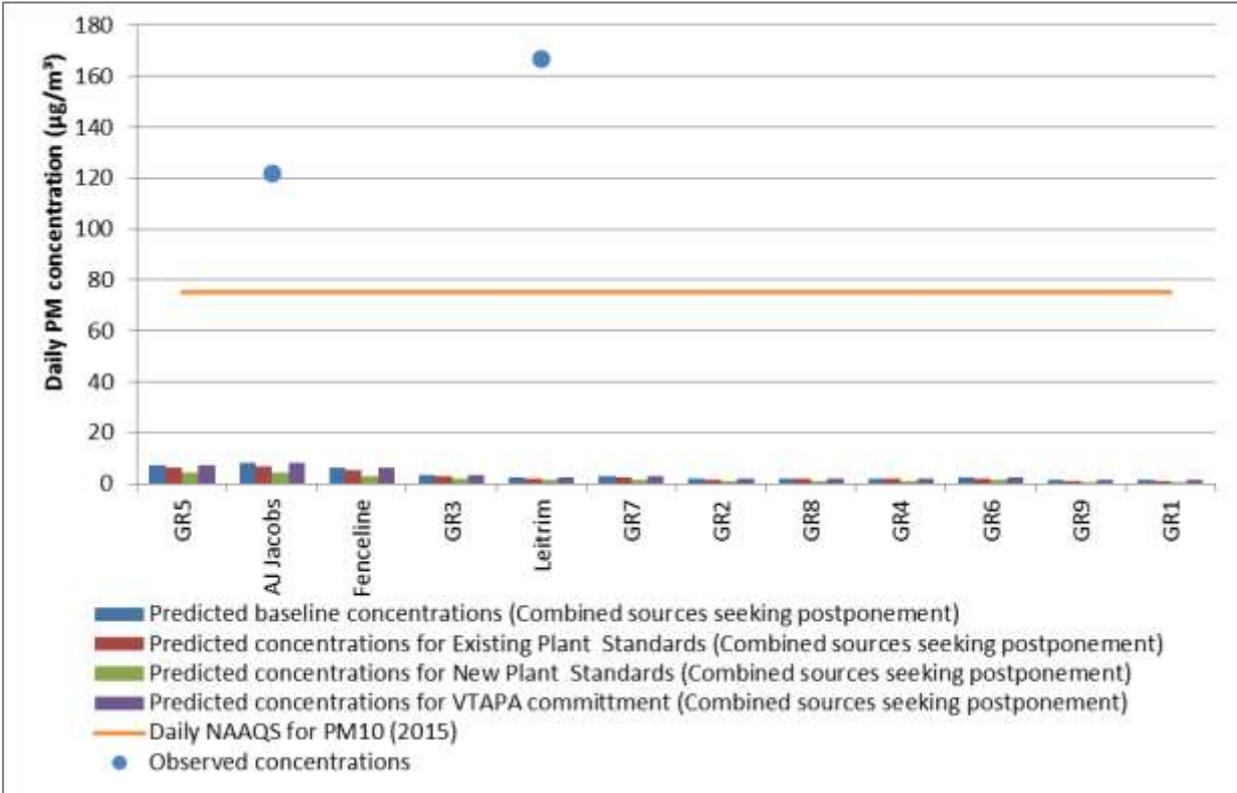


Figure 5-49: Predicted 99th percentile daily PM concentration at identified receptors for combined Infracchem seeking postponement (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

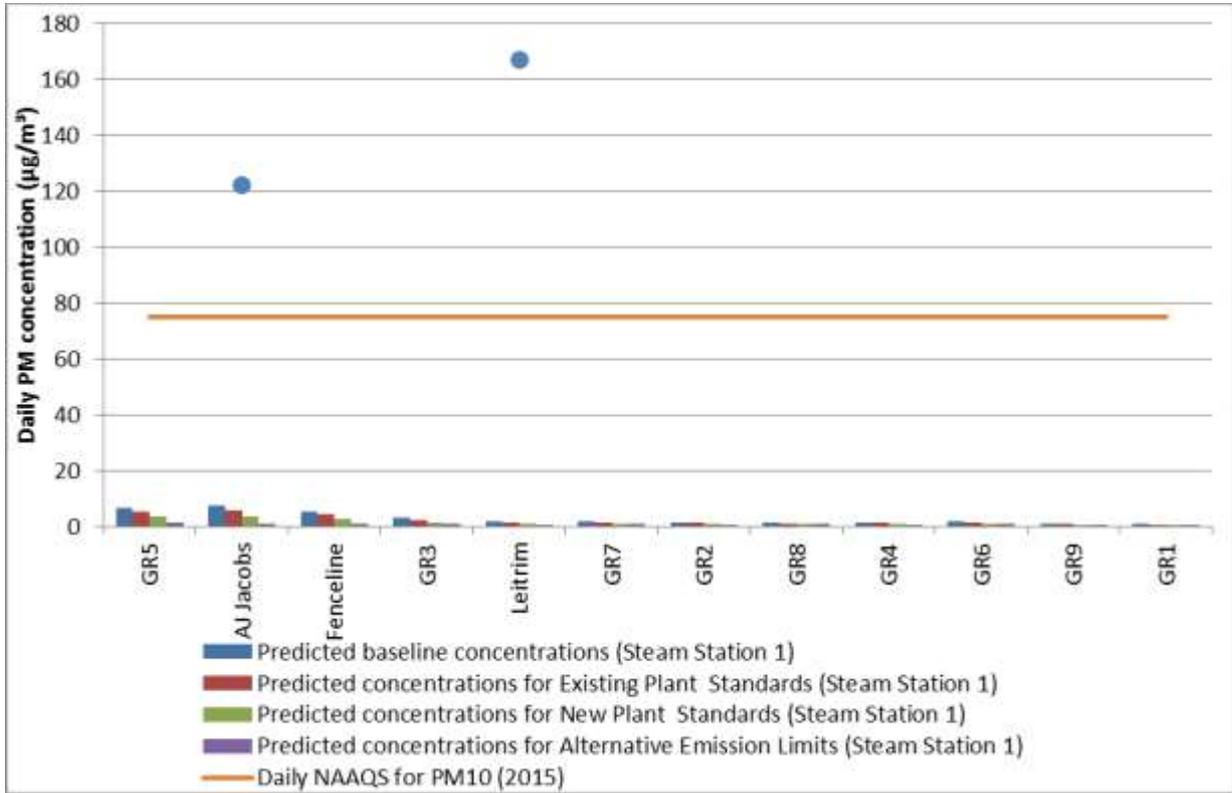


Figure 5-50: Predicted 99th percentile daily PM concentration at identified receptors for Infracchem Steam Station 1 (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

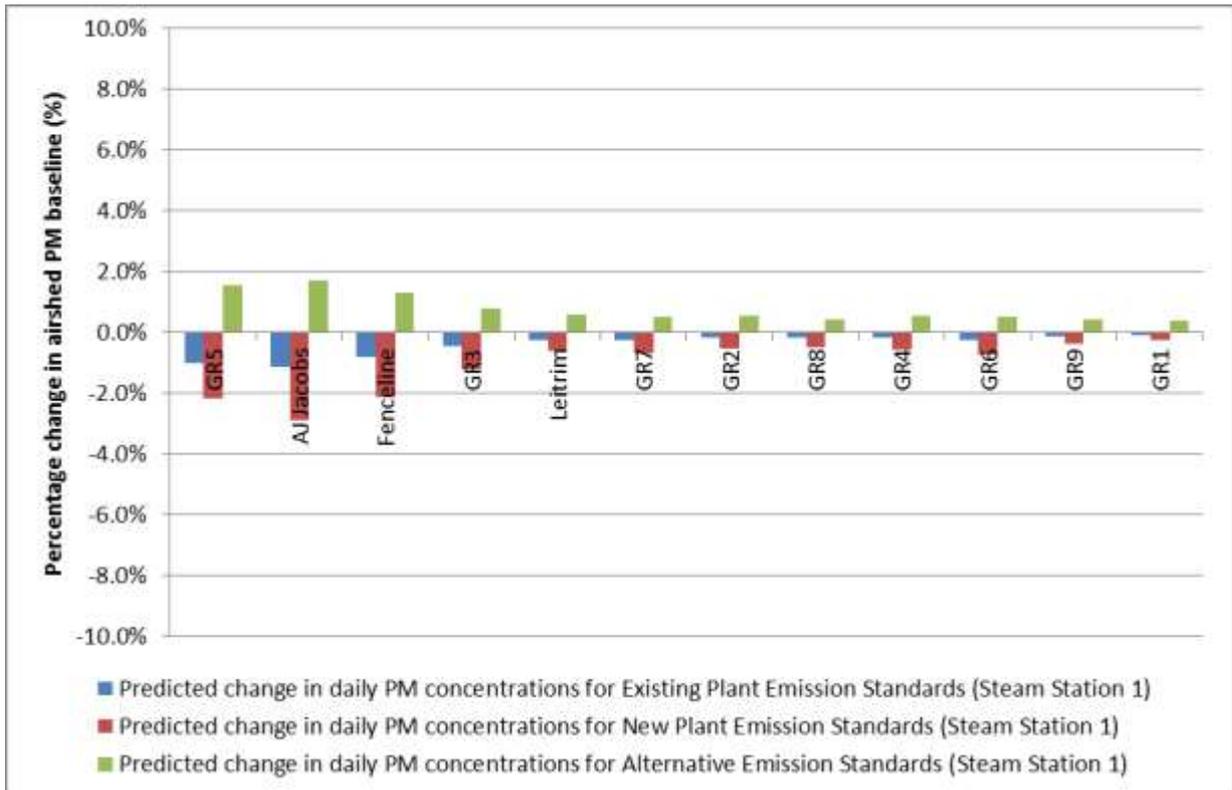


Figure 5-51: Theoretical change in daily ambient PM concentrations and the airshed baseline at the identified receptors for Infracchem Steam Station 1 (change calculated using Equation 1)

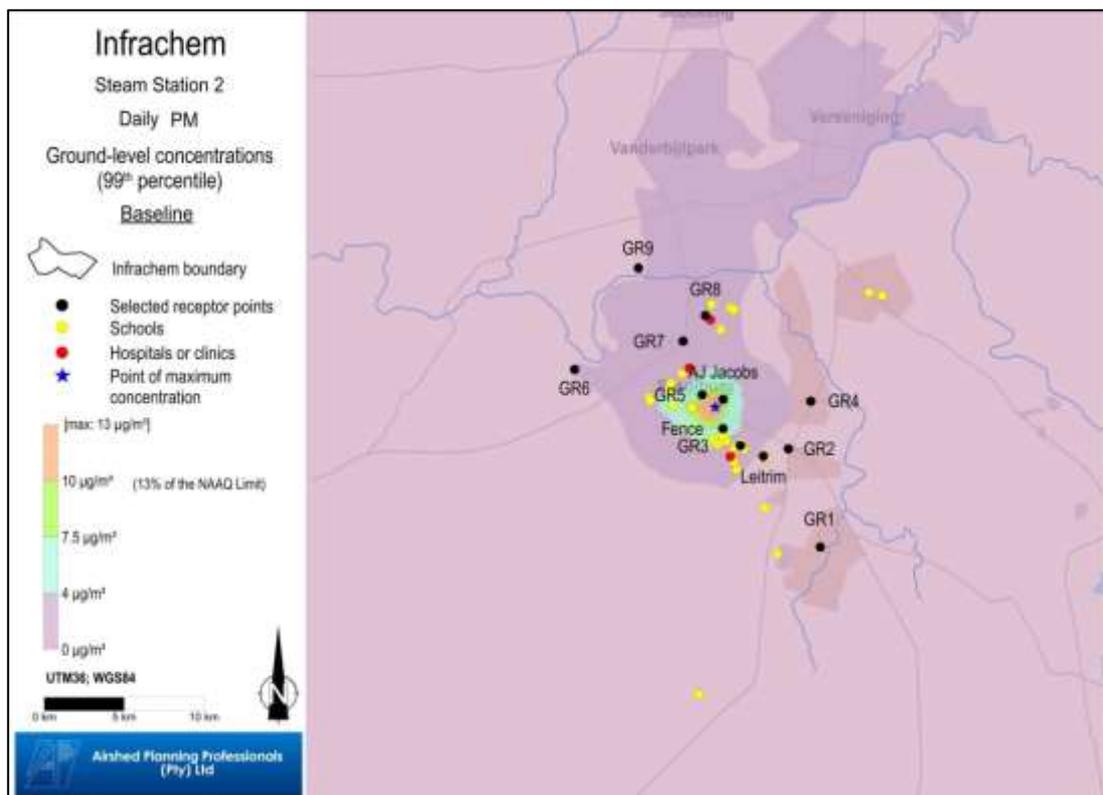


Figure 5-52: Predicted 99th percentile PM concentrations as a result of Baseline emissions from Steam Station 1

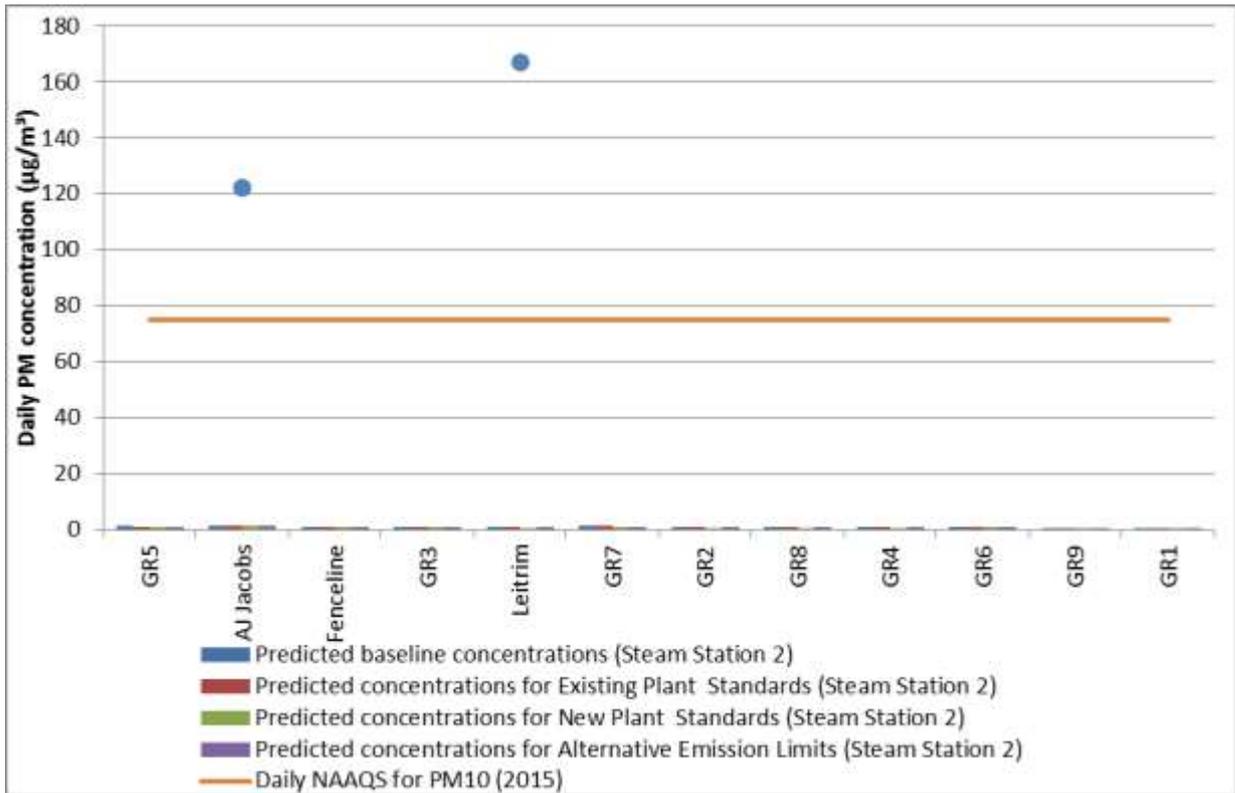


Figure 5-53: Predicted 99th percentile daily PM concentration at identified receptors for Infracchem Steam Station 2 (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

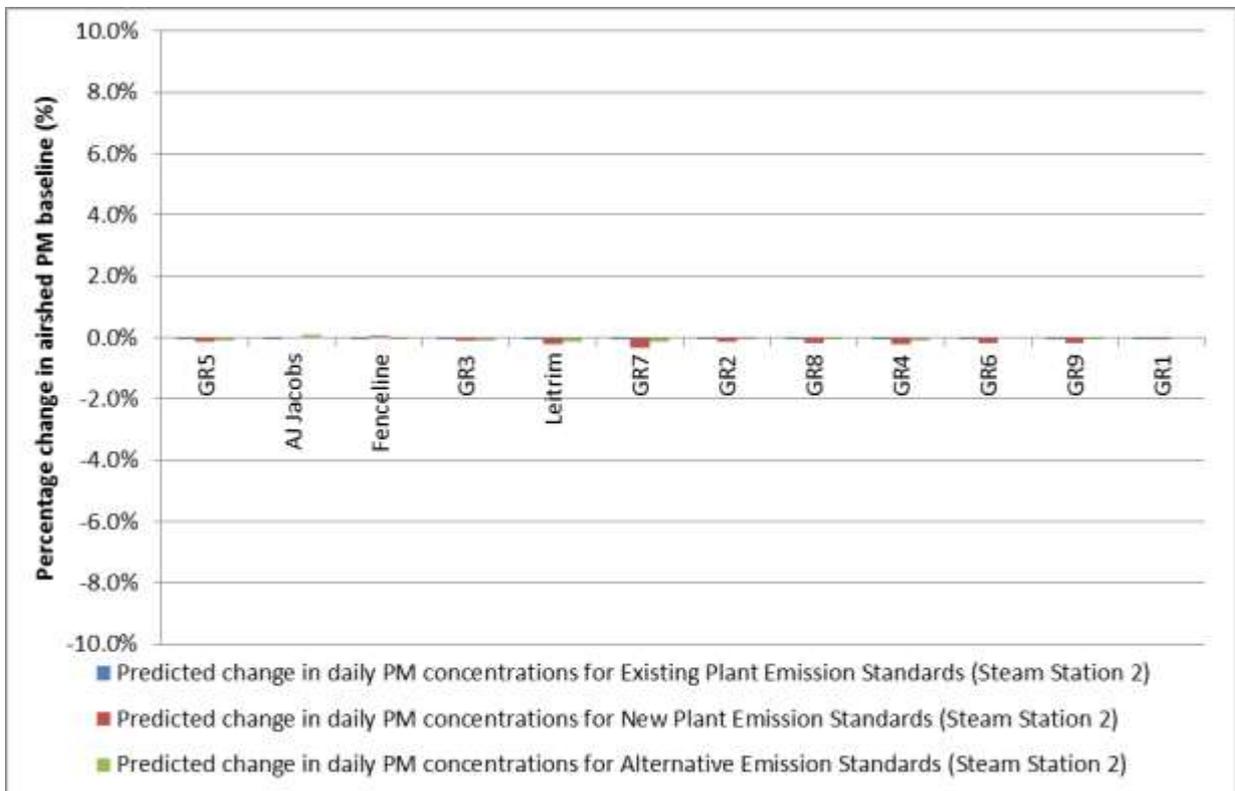


Figure 5-54: Theoretical change in daily ambient PM concentrations and the airshed baseline at the identified receptors for Infracchem Steam Station 2 (change calculated using Equation 1)

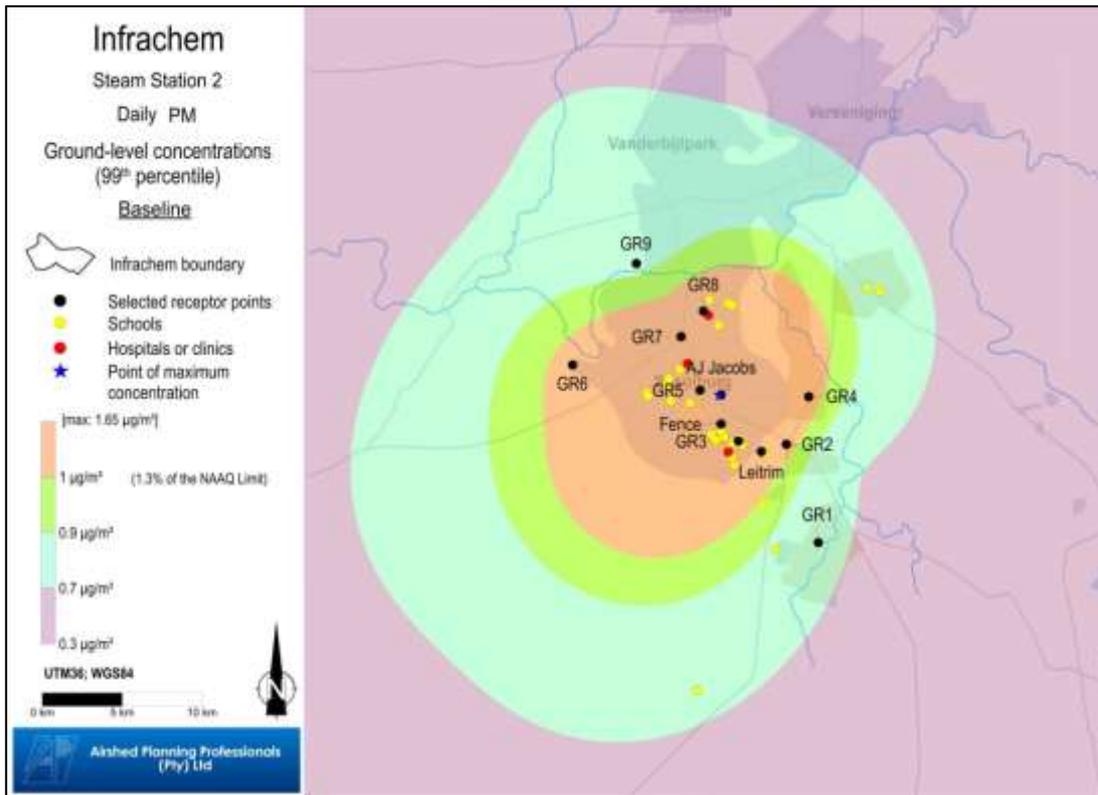


Figure 5-55: Predicted 99th percentile PM concentrations as a result of Baseline emissions from Steam Station 2

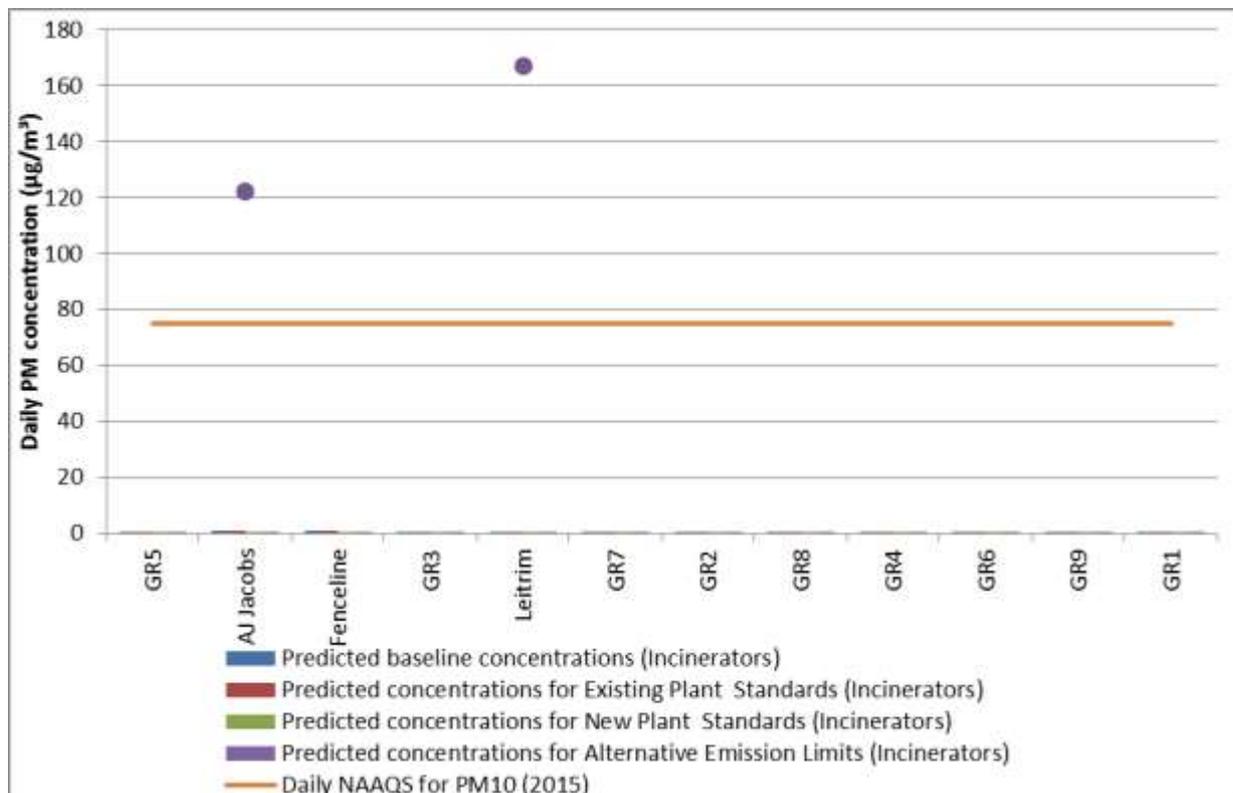


Figure 5-56: Predicted 99th percentile daily PM concentration at identified receptors for Infracchem Incinerators (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

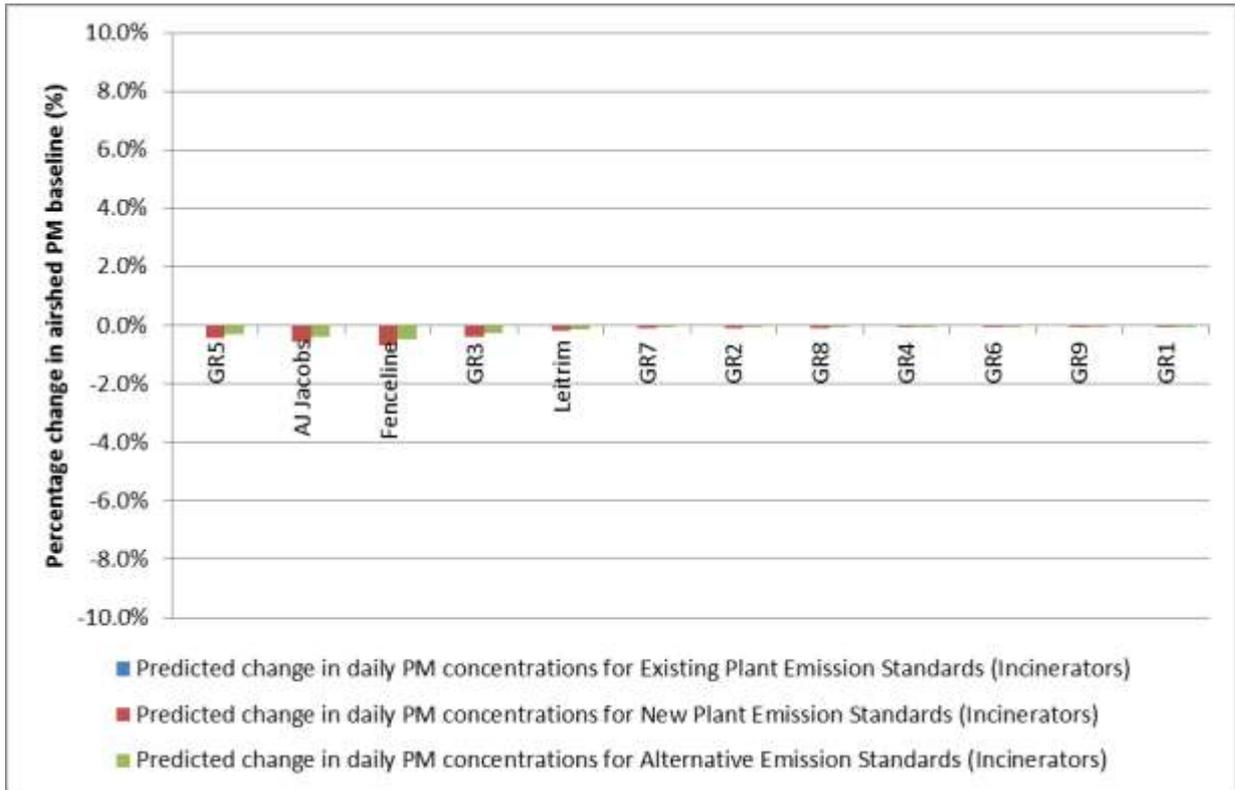


Figure 5-57: Theoretical change in daily ambient PM concentrations and the airshed baseline at the identified receptors for Infracchem Incinerators (change calculated using Equation 1)

5.1.8.2 Non-criteria pollutants

Ambient pollutant concentrations, either from the dispersion modelling or from direct physical measurements, are typically compared to defined standards or other thresholds to assess the health and/or environmental risk implications of the predicted or measured air quality. In South Africa, NAAQS have been set for criteria pollutants at limits deemed to uphold a permissible level of health risk and the assessment has accordingly been based on a comparison between the predicted concentrations and the NAAQS. The measured concentrations have been used to ascertain the representativeness of the modelling and to assess compliance with the NAAQS as a function of all sources of emissions.

Where NAAQS have not been set health-effect screening levels, appropriate for assessing the non-criteria pollutants emitted by Sasol, were identified from literature reviews and internationally recognised databases. These non-criteria pollutants for which screening levels were identified include, various emissions from incinerators, namely lead, arsenic, antimony, chromium, cobalt, copper, manganese, nickel and vanadium. The health-effect screening levels used are listed in Table 5-19..

Table 5-19: Most stringent health-effect screening level identified for all non-criteria pollutants assessed

Compound	Acute exposure ^(a) [units: µg/m ³]	Chronic exposure ^(b) [units: µg/m ³]
Lead (Pb)	(c)	(d)
Arsenic (As)	0.2 (g)	0.015 (g)
Antimony (Sb)	(c)	(d)
Chromium (Cr)	(c)	0.1 (e)
Cobalt (Co)	(c)	0.1 (f)
Copper (Cu)	100 (g)	(d)
Manganese (Mn)	(c)	0.05 (e)
Nickel (Ni)	0.2 (g)	0.014 (g)
Vanadium (V)	0.8 (f)	0.1 (f)

(a) Hourly concentrations compared with short-term / acute exposure health effect screening level
 (b) Annual concentrations compared with long-term / chronic exposure health effect screening level
 (c) No hourly health screening level
 (d) No annual health screening level
 (e) US-EPA IRIS Inhalation Reference Concentrations (µg/m³) – chronic
 (f) US ATSDR Maximum Risk Levels (MRLs) (µg/m³) - acute
 (g) Californian OEHHA (µg/m³) – acute

A screening exercise of non-criteria, pollutants emitted from Sasol’s Incinerators - including all non-criteria pollutants listed in Table 5-16 - was undertaken to identify pollutants that would be likely to exceed the most stringent health-effect screening levels identified (Table 5-19). The non-criteria pollutants that would possibly exceed the screening level concentrations included: manganese (Mn), ammonia (NH₃), volatile organic compounds as benzene, hydrogen chloride (HCl), hydrogen fluoride (HF). Further analysis showed that predicted ground-level concentrations of these pollutants comply (Table 5-20) with the strictest health effect screening level concentrations.

Table 5-20: Screening of non-criteria pollutants against health risk guidelines

Compound	Acute exposure ^(a) [units: µg/m ³]			Chronic exposure ^(b) [units: µg/m ³]		
	Minimum concentration ^(c)	Maximum concentration ^(d)	Strictest health effect screening level	Minimum concentration ^(c)	Maximum concentration ^(d)	Strictest health effect screening level
<i>Baseline emissions and Existing Plant Standards</i>						
Mn				0.0002	0.0109	0.05 (e)
NH ₃	0.016	0.550	1184 (f)			
Benzene				0.0022	0.0788	5 (g)
HCl	0.006	0.174	2100 (h)			
HF	0.002	0.050	240 (h)			
<i>New Plant Standards</i>						
Mn				0.0000	0.0001	0.05 (e)
NH ₃	0.004	0.480	1184 (f)			
Benzene				0.0011	0.0389	5 (g)
HCl	0.005	0.147	2100 (h)			
HF	No change from baseline					
<i>Alternative Emission Limits</i>						

Compound	Acute exposure ^(a) [units: µg/m ³]			Chronic exposure ^(b) [units: µg/m ³]		
	Minimum concentration ^(c)	Maximum concentration ^(d)	Strictest health effect screening level	Minimum concentration ^(c)	Maximum concentration ^(d)	Strictest health effect screening level
Mn				0.0000	0.0016	0.05 ^(e)
NH ₃	0.016	0.542	1184 ^(f)			
Benzene				0.0008	0.0300	5 ^(g)
HCl	0.003	0.105	2100 ^(h)			
HF	No change from baseline					

(a) hourly concentrations compared with short-term / acute exposure health effect screening level

(b) annual concentrations compared with long-term / chronic exposure health effect screening level

(c) minimum concentration predicted across the 12 receptors (Table 5-17)

(d) maximum concentration predicted across the 12 receptors (Table 5-17)

(e) US-EPA IRIS Inhalation Reference Concentrations (µg/m³) – chronic

(f) US ATSDR Maximum Risk Levels (MRLs) (µg/m³) - acute

(g) South African NAAQS annual standard

(h) Californian OEHHA (µg/m³) – acute

5.1.8.2.1 Sum of lead, arsenic, antimony, chromium, cobalt, copper, manganese, nickel and vanadium

Baseline emissions of the 'Sum of lead, arsenic, antimony, chromium, cobalt, copper, manganese, nickel and vanadium' from the Infrachem Incinerators will exceed the New Plant Standards (applicable 2020). The ambient impact of these emissions were modelled (at emission rates provide in Table 5-16) for the Baseline Emissions, theoretical compliance with New Plant Standards and the Alternative Emission Limits. After accounting for the proportional contribution of each pollutant, predicted concentrations (99th percentile hourly and annual average) were compared with the appropriate strictest health effect screening levels. No exceedances of hourly / acute (Table 5-21) or annual / chronic (Table 5-22) screening levels were found.

Table 5-21: Predicted hourly ambient concentrations ($\mu\text{g}/\text{m}^3$) of metal pollutants emitted from the Infracem Incinerators (a)

Receptor	Lead (Pb) (b)	Arsenic (As) (c)	Antimony (Sb) (b)	Chromium (Cr) (b)	Cobalt (Co) (b)	Copper (Cu) (d)	Manganese (Mn) (b)	Nickel (Ni) (c)	Vanadium (V) (e)
Scenario 1 – Baseline emissions and Scenario 2a – Theoretical compliance with Existing Plant Standards									
GR5	0.0004	0.0000	0.0000	0.0009	0.0005	0.0142	0.0131	0.0012	0.0001
AJ Jacobs	0.0002	0.0000	0.0000	0.0005	0.0003	0.0069	0.0063	0.0006	0.0001
Fenceline	0.0054	0.0001	0.0002	0.0122	0.0069	0.1830	0.1685	0.0148	0.0014
GR3	0.0023	0.0000	0.0001	0.0052	0.0030	0.0783	0.0720	0.0063	0.0006
Leitrim	0.0010	0.0000	0.0000	0.0023	0.0013	0.0342	0.0315	0.0028	0.0003
GR7	0.0005	0.0000	0.0000	0.0010	0.0006	0.0155	0.0143	0.0013	0.0001
GR2	0.0007	0.0000	0.0000	0.0016	0.0009	0.0244	0.0225	0.0020	0.0002
GR8	0.0005	0.0000	0.0000	0.0012	0.0007	0.0177	0.0163	0.0014	0.0001
GR4	0.0049	0.0001	0.0001	0.0110	0.0062	0.1657	0.1525	0.0134	0.0013
GR6	0.0033	0.0001	0.0001	0.0074	0.0042	0.1108	0.1020	0.0090	0.0009
GR9	0.0004	0.0000	0.0000	0.0010	0.0005	0.0144	0.0132	0.0012	0.0001
GR1	0.0005	0.0000	0.0000	0.0012	0.0007	0.0176	0.0162	0.0014	0.0001
Scenario 2a – Theoretical compliance with New Plant Emission Standards									
GR5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0005	0.0000	0.0000
AJ Jacobs	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002	0.0000	0.0000
Fenceline	0.0002	0.0000	0.0000	0.0005	0.0003	0.0070	0.0064	0.0006	0.0001
GR3	0.0001	0.0000	0.0000	0.0002	0.0001	0.0028	0.0026	0.0002	0.0000
Leitrim	0.0000	0.0000	0.0000	0.0001	0.0000	0.0013	0.0012	0.0001	0.0000
GR7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0006	0.0000	0.0000
GR2	0.0000	0.0000	0.0000	0.0001	0.0000	0.0008	0.0008	0.0001	0.0000
GR8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0006	0.0001	0.0000
GR4	0.0002	0.0000	0.0000	0.0004	0.0002	0.0061	0.0057	0.0005	0.0000
GR6	0.0001	0.0000	0.0000	0.0003	0.0001	0.0040	0.0036	0.0003	0.0000
GR9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0005	0.0000	0.0000
GR1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0007	0.0006	0.0001	0.0000
Scenario 3 - Alternative Emission Limits									
GR5	0.0085	0.0002	0.0003	0.0190	0.0108	0.2858	0.2630	0.0231	0.0022
AJ Jacobs	0.0136	0.0003	0.0004	0.0305	0.0173	0.4589	0.4224	0.0372	0.0036

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Receptor	Lead (Pb) (b)	Arsenic (As) (c)	Antimony (Sb) (b)	Chromium (Cr) (b)	Cobalt (Co) (b)	Copper (Cu) (d)	Manganese (Mn) (b)	Nickel (Ni) (c)	Vanadium (V) (e)
Fenceline	0.0158	0.0003	0.0005	0.0353	0.0200	0.5310	0.4887	0.0430	0.0041
GR3	0.0057	0.0001	0.0002	0.0128	0.0073	0.1929	0.1775	0.0156	0.0015
Leitrim	0.0027	0.0001	0.0001	0.0061	0.0034	0.0911	0.0838	0.0074	0.0007
GR7	0.0013	0.0000	0.0000	0.0029	0.0017	0.0442	0.0407	0.0036	0.0003
GR2	0.0017	0.0000	0.0001	0.0038	0.0022	0.0579	0.0533	0.0047	0.0004
GR8	0.0012	0.0000	0.0000	0.0026	0.0015	0.0390	0.0359	0.0032	0.0003
GR4	0.0011	0.0000	0.0000	0.0025	0.0014	0.0381	0.0350	0.0031	0.0003
GR6	0.0012	0.0000	0.0000	0.0027	0.0015	0.0405	0.0373	0.0033	0.0003
GR9	0.0005	0.0000	0.0000	0.0012	0.0007	0.0179	0.0164	0.0014	0.0001
GR1	0.0013	0.0000	0.0000	0.0030	0.0017	0.0447	0.0411	0.0036	0.0003

(a) exceedances of strictest health screening level highlighted
(b) no hourly health screening level
(c) Californian OEHHA ($\mu\text{g}/\text{m}^3$) – acute screening level of $0.2 \mu\text{g}/\text{m}^3$
(d) Californian OEHHA ($\mu\text{g}/\text{m}^3$) – acute screening level of $100 \mu\text{g}/\text{m}^3$ over 1 hour
(e) US ATSDR Maximum Risk Levels (MRLs) ($\mu\text{g}/\text{m}^3$) – acute MRL of $0.8 \mu\text{g}/\text{m}^3$

Table 5-22: Predicted annual ambient concentrations ($\mu\text{g}/\text{m}^3$) of metal pollutants emitted from the Infracem Incinerators (a)

Receptor	Lead (Pb) (b)	Arsenic (As) (c)	Antimony (Sb) (b)	Chromium (Cr) (d)	Cobalt (Co) (e)	Copper (Cu) (b)	Manganese (Mn) (f)	Nickel (Ni) (g)	Vanadium (V) (e)
Scenario 1 – Baseline emissions and Scenario 2a – Theoretical compliance with Existing Plant Standards									
GR5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0007	0.0000	0.0000	0.0000
AJ Jacobs	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000
Fenceline	0.0003	0.0000	0.0000	0.0002	0.0000	0.0107	0.0005	0.0000	0.0001
GR3	0.0001	0.0000	0.0000	0.0001	0.0000	0.0035	0.0002	0.0000	0.0000
Leitrim	0.0001	0.0000	0.0000	0.0000	0.0000	0.0018	0.0001	0.0000	0.0000
GR7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000	0.0000
GR2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0012	0.0001	0.0000	0.0000
GR8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000	0.0000
GR4	0.0002	0.0000	0.0000	0.0001	0.0000	0.0069	0.0003	0.0000	0.0001
GR6	0.0001	0.0000	0.0000	0.0001	0.0000	0.0032	0.0002	0.0000	0.0000

Receptor	Lead (Pb) (b)	Arsenic (As) (c)	Antimony (Sb) (b)	Chromium (Cr) (d)	Cobalt (Co) (e)	Copper (Cu) (b)	Manganese (Mn) (f)	Nickel (Ni) (g)	Vanadium (V) (e)
GR9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000
GR1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0007	0.0000	0.0000	0.0000
Scenario 2a – Theoretical compliance with New Plant Emission Standards									
GR5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
AJ Jacobs	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fenceline	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000	0.0000	0.0000
GR3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
Leitrim	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
GR7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
GR2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
GR8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
GR4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000
GR6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
GR9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
GR1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Scenario 3 - Alternative Emission Limits									
GR5	0.0004	0.0000	0.0000	0.0009	0.0005	0.0139	0.0128	0.0011	0.0001
AJ Jacobs	0.0006	0.0000	0.0000	0.0014	0.0008	0.0205	0.0189	0.0017	0.0002
Fenceline	0.0009	0.0000	0.0000	0.0021	0.0012	0.0316	0.0290	0.0026	0.0002
GR3	0.0003	0.0000	0.0000	0.0008	0.0004	0.0114	0.0105	0.0009	0.0001
Leitrim	0.0002	0.0000	0.0000	0.0004	0.0002	0.0053	0.0049	0.0004	0.0000
GR7	0.0001	0.0000	0.0000	0.0002	0.0001	0.0023	0.0021	0.0002	0.0000
GR2	0.0001	0.0000	0.0000	0.0003	0.0001	0.0039	0.0036	0.0003	0.0000
GR8	0.0001	0.0000	0.0000	0.0001	0.0001	0.0019	0.0017	0.0002	0.0000
GR4	0.0001	0.0000	0.0000	0.0002	0.0001	0.0023	0.0021	0.0002	0.0000
GR6	0.0001	0.0000	0.0000	0.0001	0.0001	0.0021	0.0019	0.0002	0.0000
GR9	0.0000	0.0000	0.0000	0.0001	0.0000	0.0008	0.0008	0.0001	0.0000
GR1	0.0001	0.0000	0.0000	0.0002	0.0001	0.0023	0.0021	0.0002	0.0000
(a) exceedances of strictest health screening level highlighted									
(b) no annual health screening level									

Receptor	Lead (Pb) (b)	Arsenic (As) (c)	Antimony (Sb) (b)	Chromium (Cr) (d)	Cobalt (Co) (e)	Copper (Cu) (b)	Manganese (Mn) (f)	Nickel (Ni) (g)	Vanadium (V) (e)
		(c) Californian OEHHA ($\mu\text{g}/\text{m}^3$) – chronic screening level of $0.015 \mu\text{g}/\text{m}^3$		(d) US-EPA IRIS inhalation reference concentration – chronic ($0.1 \mu\text{g}/\text{m}^3$)					
				(e) US ATSDR Maximum Risk Levels (MRLs) ($\mu\text{g}/\text{m}^3$) – chronic MRL of $0.1 \mu\text{g}/\text{m}^3$					
				(f) US-EPA IRIS inhalation reference concentration – chronic ($0.05 \mu\text{g}/\text{m}^3$)					
				(g) Californian OEHHA ($\mu\text{g}/\text{m}^3$) – chronic screening level of $0.014 \mu\text{g}/\text{m}^3$					

5.1.9 Uncertainty of Modelled Results

The main steps of uncertainty management are to:

- identify and understand uncertainties;
- understand whether uncertainties matter for decisions being made at the time;
- if they do matter, decide what to do about them; and,
- recommend a way forward.

Managing uncertainties attempts to eliminate the source of technical disagreements and failure to understand them often leads to a conclusion that all uncertainties need to be eliminated before project decisions can be made. The first decision about how to manage uncertainties relates to their significance given the decision being addressed. In the current context, the different parts of the investigation were grouped into similar uncertainty regimes, namely:

- dispersion model uncertainties;
- input data uncertainties;
- the methodology of validating model results; and,
- the methodology of expressing the modelled scenarios.

A comprehensive discussion on uncertainties is provided in Appendix J.

As discussed in Section 5.1.5, the baseline predictions with the inclusion of estimated background concentrations performed well within the generally accepted (U.S. EPA 2005) “factor of two” accuracy of dispersion models. Unless greater general experience is gained or some further formal validation studies are conducted, it is not possible to say how much more confidence can be given to well-executed plume and puff models.

However, with the incremental differences between scenarios expressed as a ratio of the baseline concentration, the impact of model inaccuracies are essentially eliminated. As discussed in Appendix J, it is estimated that the ambient monitoring has an uncertainty of 5% with a 95% confidence interval and the emissions monitoring an uncertainty of 10% with a 95% confidence interval. Based on these uncertainties, it is estimated that the concentration ratios of the different emission scenarios have an uncertainty of -36% and +58%, i.e. potential under-prediction of 36% and over-prediction of 58%.

The Intergovernmental Panel on Climate Change (IPCC) produced a qualitative method for consistent communication of uncertainties in the IPCC Fifth Assessment Report. This Guidance Note has been summarised in Appendix K. On application of this guide, the results from this investigation is considered to be of “high confidence” based on a “high agreement” of the baseline predictions with observations, albeit based only on two monitoring sites, i.e. “medium evidence”.

5.2 Analysis of Emissions’ Impact on the Environment

Understanding the impact of deposition of atmospheric sulfur (S) and nitrogen (N) on South African ecosystems has been on-going since the late 1980’s (Tyson *et al.* 1988), with much of the earlier work focussing on the circulation over the sub-continent (Tyson *et al.* 1996). More recent research has focussed on quantifying S and N deposition (Galpin and Turner 1999, Zunckel *et al.* 1996, Scorgie and Kornelius 2009, Josipovic *et al.* 2010) and the subsequent impacts on ecosystems (Fey and Guy 1993, Van Tienhoven *et al.* 1995, Reid 2007, Bird 2011, Josipovic *et al.* 2011).

These studies estimating deposition of S and or N compounds to ecosystems present ranges of deposition rates where the differences are related to the distance from major industrial sources; the method of estimation (field work and/or calculation based on deposition velocities or dispersion modelling). As an indication, total S deposition over the industrialised Highveld of South Africa was modelled to range between 8 and 35 kg/ha/year with background levels of approximately 1 kg/ha/year (Scorgie and Kornelius 2009). In contrast, using ambient SO₂ concentrations and an inferential deposition model to calculate S deposition, Zunckel *et al.*(1996) estimated total S deposition of 13.9 kg/ha/year as maximum deposition rate on the Highveld. Estimates of nitrogen deposition range between 6.7 kg/ha/year (Collett *et al.* 2010) and 15 kg/ha/year (Scorgie and Kornelius 2009). Considering total acidic input from atmospheric sources, Josipovic and colleagues (2011) calculated a range of deposition rates between 15.8 and 23.2 kg/ha/year. All estimates are within the range of deposition rates for S and N as for some of the industrialised regions of Europe and North America (compared in Scorgie and Kornelius 2009, and Bird 2011) raising concern that the acidic loading of sulfur and nitrogen on the ecosystems of the Highveld – South Africa's most heavily industrialised region – could have implications for ecosystem functioning.

Establishing clear cause-effect relationships in complex ecosystem studies can be difficult, especially where the extent of visible damage is large and local emissions are low (Matzner and Murach 1995). Reasons include: time lags between stressor (high concentration of atmospheric pollutants) and visible symptomatic response of biota; interaction of natural factors (e.g. climate, soil and pests) and human activities (such as management, site history and air pollution); local ecosystem uniqueness and difficulty of extrapolating to larger scales; or, symptomatic responses that are not unique to the cause (e.g. defoliation) (Matzner and Murach 1995). The synergistic effect of pollutant cocktails can also add complexity to identifying causative pollutants (Emberson 2003).

Mobilisation of active forms of S and N into the atmosphere, and later as deposition onto ecosystems, can result in acidification of soils and freshwater systems, soil nutrient depletion, fertilization of naturally (usually nitrogen) limited systems and increased availability of metal ions (e.g. Al) disrupting ecosystem functioning (Rodhe *et al.* 1995) and changing plant and/or freshwater species diversity (Stevens *et al.* 2004). Although investigating the impact of atmospheric pollution from Sasol operations was beyond the scope of this study, some research findings suggest that grassland ecosystems of the Highveld are not yet affected by sulfur and nitrogen deposition (Reid 2007, Bird 2011); however, some areas may be approaching critical loads (Bird 2011, Josipovic *et al.* 2011).

6 COMPLAINTS

Year	Nature of complaints	Actions taken to investigate complaints	Causes of complaints identified	Measures taken to avoid reoccurrences in instances where the plant's operations were found to be the cause
2013	<p>A total of 7 external Sasol Infrachem related complaints were received during 2013. The mentioned incidents varied from minor to moderate incidents.</p> <p>The following Sasol Infrachem related incidents occurred and was handled during the past financial year:</p> <p>6 visible emission complaints were received, mostly related to visible black smoke or dust</p> <p>1 Noise complaint was received during this period</p> <p>The non-Sasol related complaints were investigated and handed over to the relevant party or industry.</p>	<p>Sasol operates a complaint line where any environmental complaint can be registered. The environmental standby will investigate the complaint and ensure that the necessary steps are taken to reduce and manage the impact and to reduce the time of the incident.</p>	<p>Process start-ups, upsets, plant trips and equipment failure</p>	<p>An investigation form is sent to the relevant BU's SHERQ manager who launches a full investigation. Measures implemented to prevent a similar incident from reoccurring need to be specified and implemented. This is tracked from the Environmental Centre</p>
2012	<p>A total of 3 external Sasol Infrachem related complaints were received during 2012. The mentioned incidents varied from minor to serious incidents.</p> <p>The following Sasol Infrachem related incidents occurred and was handled during the past financial year:</p> <p>2 Noise complaints were received during this period</p> <p>1 odour complaint was received related to ammonia odours</p> <p>The non-Sasol related complaints were investigated and handed over to the relevant party or industry.</p>	<p>Sasol operates a complaint line where any environmental complaint can be registered. The environmental standby will investigate the complaint and ensure that the necessary steps are taken to reduce and manage the impact and to reduce the time of the incident.</p>	<p>Process start-ups, upsets, plant trips and equipment failure</p>	<p>An investigation form is sent to the relevant BU's SHERQ manager who launches a full investigation. Measures implemented to prevent a similar incident from reoccurring need to be specified and implemented. This is tracked from the Environmental Centre</p>

7 RECOMMENDED AIR QUALITY MANAGEMENT INTERVENTIONS

An overview of approved air quality management improvement interventions, currently implemented and scheduled over the next 5 to 10 years, is detailed in the accompanying Motivation Report (Chapter 7).

8 COMPLIANCE AND ENFORCEMENT ACTIONS

No directives or compliance notices have been issued to Sasol Infrachem, a division of Sasol Chemical Industries (Pty) Ltd in the last five years.

9 ADDITIONAL INFORMATION

Beyond the requirements stipulated in the AIR Regulations and Dispersion Modelling Regulations, the following additional information is considered useful for better understanding the impacts of Sasol's activities and the implications of the requested postponements on ambient air quality. A brief description of each of these analyses is provided below, and referenced to where in the applications the information may be found.

a) Polar plots

Polar plots have been provided in Section 5.1.6.1 to visually demonstrate directional contribution as well as the dependence of concentrations on wind speed, in much the same way as a pollution rose does. The polar plots identify major contributing emissions sources impacting on a monitoring station and the direction of the impact. These polar plots do not replace isopleth plots, but rather provide additional information on the measured air quality in the region of the facility.

b) Peer review of dispersion model

To provide increased certainty to both the DEA and the public that the dispersion modelling approach of Airshed is accurate, valid and representative, Sasol decided to take an additional step to appoint an independent international expert to peer review the modelling methodology, Exponent Incorporated. The peer reviewer report is included in the application material. Furthermore, the peer reviewer's findings were addressed in the manner described by Airshed Planning Professionals in their written response, included as an appendix to the peer reviewer's report. Exponent Inc. is a world-renowned expert assisting the US-EPA with compliance modelling in similar instances in the United States

c) Delta approach to assessing implications of postponements for ambient air quality

In assessing the impacts of Sasol's postponement applications on ambient air quality, a fit-for-purpose approach, as requested for by the Dispersion modelling Regulations, was taken to assess the results from the dispersion modelling, which we have referred to as the "delta approach". The delta approach is premised on recognising that the difference between the current or "before additional compliance is implemented" emission scenario (i.e. the baseline scenario) and "after additional compliance is implemented" scenario (i.e. the 2020 MES compliance scenario) relates to the change in emissions from the point sources in question.

Therefore, the delta approach focuses on demonstrating the change in predicted ambient impacts of the various compliance scenarios, to guide decision makers toward better understanding the implications of the approval of postponements on air quality, and how compliance with the existing and new plant standards would impact on prevailing ambient air quality.

A detailed explanation of the scenarios modelled to highlight the delta changes in ambient air quality arising from retrofit of abatement technology is provided in Section 5.1.1.2. In summary, the four scenarios modelled include:

- Baseline Emissions – modelling conducted based on the current inventory and impacts
- Minimum Emissions Standards – modelling conducted based on plants theoretically complying with:
 - Existing Plant Standards, and
 - New Plant Standards

- Alternative Emission Limits – the proposed maximum emission concentrations, where applicable and different from the other three emission scenarios.

d) Estimating background ambient air pollutant concentrations

A background air concentration is normally defined as that concentration which would result from air emission sources outside the chosen modelling domain. This concentration can, for instance, be estimated by analysing observed air concentrations for those wind directions when it is blowing towards the sources included in the modelling domain. In other words, the observation point would be upwind from the sources being simulated by the dispersion modelling.

However, as used in the current investigation, background concentrations could also incorporate the contributions from air emission sources present in the modelling domain, but which were not included in the dispersion simulations. For example, air emissions from vehicle tailpipes can significantly contribute to the local ambient NO₂ concentrations. Although most of the sources of air emissions within the Sasol operations were included in the simulations, there remains some that were excluded, for instance fugitive emissions, but would add to the background concentration level.

Since these sources are not neatly located for easy analysis of upwind contributions, the procedure normally adopted to estimate background air concentrations could not be followed. Instead, the “background” concentration was established by comparing the predicted air concentrations with the observed air concentrations. The background concentration as used in this application therefore corresponds to the observed concentration value at a monitoring site when the simulated value at this site reached a near zero value. In other words, the observed residual air concentration was assumed to arise from other sources in the modelling domain.

With this method, the assumption is made that the model performs realistically and that the residual concentration determined this way is a good reflection of the emissions not included in the simulations. In an attempt to illustrate the model accuracy, the fractional bias was calculated for each monitoring station as described in Section 5.1.6.2 of the AIRs. This methodology has been prescribed by the US EPA (U.S. EPA 1992) as an acceptable manner to illustrate the validity of atmospheric dispersion model. Given the good model performance, as measure by the fractional bias, it is assumed that the background concentration obtained using this methodology is reasonable estimates.

e) Ambient impacts of secondary particulates arising from Sasol emissions

As detailed in Section 5.1.4.4, one of the reasons for selection of the CALPUFF modelling suite is the fact this this enabled inclusion of the impact of the chemical conversion of sulfur dioxide and nitrogen oxides to secondary particulates within the dispersion model results. Thus, the predicted PM₁₀ concentrations reflected in Section 5.1.8.1.3 include direct emissions of PM₁₀ plus secondary particulates formed from Sasol's emissions.

10 ANNEXURE A(i)

DECLARATION OF ACCURACY OF INFORMATION – APPLICANT

Name of Enterprise: Sasol Infrachem a division of Sasol Chemical Industries (PTY) LTD. Reg.nr: 1968/013914/07

Declaration of accuracy of information provided:

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

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

Signed at Sasolburg on this 14th day of April 2014


SIGNATURE

Regional Manager, Environmental Services: Infrachem
CAPACITY OF SIGNATORY

11 ANNEXURE A(ii)

DECLARATION OF ACCURACY OF INFORMATION – APPLICANT

Name of Enterprise: Sasol Chemical Industries (Pty) Ltd through its Sasolburg Operations

Declaration of accuracy of information provided:

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

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

Signed at Sasolburg on this 22 day of September 2014.


SIGNATURE

Senior Manager: Environment, Sasolburg Operations
CAPACITY OF SIGNATORY

12 ANNEXURE B(i)

DECLARATION OF INDEPENDENCE - PRACTITIONER

Name of Practitioner: _Reneé von Gruenewaldt

Name of Registration Body: South African Council for Natural Scientific Professions

Professional Registration No.: 400304/07

Declaration of independence and accuracy of information provided:

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

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

Signed at Midrand on this 31st day of March 2014



SIGNATURE

Principal Air Quality Scientist

CAPACITY OF SIGNATORY

13 ANNEXURE B(ii)

DECLARATION OF INDEPENDENCE - PRACTITIONER

Name of Practitioner: _Reneé von Gruenewaldt

Name of Registration Body: South African Council for Natural Scientific Professions

Professional Registration No.: 400304/07

Declaration of independence and accuracy of information provided:

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

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

Signed at Midrand on this 22nd day of September 2014



SIGNATURE

Principal Air Quality Scientist

CAPACITY OF SIGNATORY

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APPENDIX A: COMPETENCIES FOR PERFORMING AIR DISPERSION MODELLING

All modelling tasks were performed by competent personnel. Table A-1 is a summary of competency requirements. Apart from the necessary technical skills required for the calculations, personnel competency also include the correct attitude, behaviour, motive and other personal characteristic that are essential to perform the assigned job on time and with the required diligence as deemed necessary for the successful completion of the project.

The project team included two principal engineers, both with relevant experience of more than 25 years each and one principal scientist with 12 years relevant experience. One of the principal scientists managed and directed the project.

Verification of modelling results was also conducted by one of the principal engineers. The latter function requires a thorough knowledge of the

- meteorological parameters that influence the atmospheric dispersion processes and
- atmospheric chemical transformations that some pollutants may undergo during the dispersion process.

In addition, the project team included one senior and one junior staff member.

Table A-1: Competencies for Performing Air Dispersion Modelling

Competency	Task, Knowledge and Experience
Context	Communication with field workers, technicians, laboratories, engineers and scientists and project managers during the process is important to the success of the model
	Familiar with terminology, principles and interactions
	Record keeping is important to support the accountability of the model - Understanding of data collection methods and technologies
Knowledge	Meteorology: <ul style="list-style-type: none"> • Obtain, review and interpret meteorological data • Understanding of meteorological impacts on pollutants • Ability to identify and describe soil, water, drainage and terrain conditions <ul style="list-style-type: none"> ○ Understanding of their interaction ○ Familiarity with surface roughness` • Ability to identify good and bad data points/sets • Understanding of how to deal with incomplete/missing meteorological data
	Atmospheric Dispersion models <ul style="list-style-type: none"> • Select appropriate dispersion model • Prepare and execute dispersion model • Understanding of model input parameters • Interpret results of model
	Chemical and physical interactions of atmospheric pollutants <ul style="list-style-type: none"> • Familiarity with fate and transport of pollutants in air • Interaction of primary pollutants with other substances (natural or industrial) to form secondary pollutants
	Information relevant to the model <ul style="list-style-type: none"> • Identify potential pollution (emission) sources and rates • Gather physical information on sources such as location, stack height and diameter • Gather operating information on sources such as mass flow rates, stack top temperature, velocity or volumetric flow rate • Calculate emission rates based on collected information • Identify land use (urban/rural) • Identify land cover/terrain characteristics • Identify the receptor grid/site
	Legislation, regulations and guidelines in regards to National Environment Management: Air Quality Act (Act No 39 of 2004), including <ul style="list-style-type: none"> • Minimum Emissions Standards (Section 21 of Act) • National Ambient Air Quality Standards • Regulations regarding Air Dispersion Modelling

Competency	Task, Knowledge and Experience
	<ul style="list-style-type: none"> • Atmospheric Impact Report (AIR)
Abilities	Ability to read and understand map information
	Ability to prepare reports and documents as necessary
	Ability to review reports to ensure accuracy, clarity and completeness
	Communication skills
	Team skills

APPENDIX B: COMPARISON OF STUDY APPROACH WITH THE REGULATIONS PRESCRIBING THE FORMAT OF THE ATMOSPHERIC IMPACT REPORT AND THE REGULATIONS REGARDING AIR DISPERSION MODELLING (GAZETTE NO 37804 PUBLISHED 11 JULY 2014)

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

The draft regulations regarding Air Dispersion Modelling (Gazette No 35981 published 14 December 2012) were referenced for the air dispersion modelling approach used in this study. The promulgated Regulations regarding Air Dispersion Modelling (Gazette No. 37804, vol. 589; 11 July 2014) were consulted to ensure that the dispersion modelling process used in this assessment was in agreement with the updated regulations. Table B-2 compares the draft Air Dispersion Modelling Regulations with the approach used in Section 5. The only updates applied, following stakeholder comment, was to the receptors to include schools and clinics, as indicated on the isopleth plots in Section 5.1.8.

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

Chapter	Name	AIR regulations requirement	Status in AIRs (April 2014)	Status in AIR (updated to address stakehold comments)
1	Enterprise details	<ul style="list-style-type: none"> Enterprise Details Location and Extent of the Plant Atmospheric Emission Licence and other Authorisations 	Enterprise details included. Location of plant included. APPA permit numbers included.	(unchanged)
2	Nature of process	<ul style="list-style-type: none"> Listed Activities Process Description Unit Processes 	All detail included in the regulated format	Updated to include more information for the Sasolburg Operations (Section 2.2).
3	Technical Information	<ul style="list-style-type: none"> Raw Materials Used and Production Rates Appliances and Abatement Equipment Control Technology 	All raw material information included. Information on abatement equipment is confined to the listed activities seeking postponement.	Updated to include all raw materials information that is not confidential and proprietary information. Sensitive information will be made available to the Licensing Authorities upon request (Section 3.1 and 3.2).
4	Atmospheric Emissions	<ul style="list-style-type: none"> Point Source Emissions <ul style="list-style-type: none"> Point Source Parameters Point Source Maximum Emission Rates during Normal Operating Conditions Point Source Maximum Emission Rates during Start-up, Maintenance and/or Shut-down Fugitive Emissions Emergency Incidents 	There is no information available regarding the maximum rates available, because these are not measured, and are impractical to measure; therefore only emissions rates during normal operating conditions are available. Information regarding fugitive sources has not been included, as the modelling only considers the sources for which Sasol are requesting postponements. Information regarding emergency incidents was not included as the applications deal with normal operating conditions.	<ul style="list-style-type: none"> Point Source Parameters and Emissions for MES compliant point sources have been included (Appendix C-1; C2: Point Source Emissions) Table C2-3 and Table C2-4). Emissions released during start-up, maintenance and/or Shut-down have been discussed (Section 4.3). Management of fugitive emissions across the Sasol Sasolburg complex has been described (Section 4.4 and Appendix C2; Figure C3-1). The history of Emergency

Chapter	Name	AIR regulations requirement	Status in AIRs (April 2014)	Status in AIR (updated to address stakehold comments)
				Incidents during the period of assessment and planned management of future Emergency Incidents has been described (Section 4.5).
5	Impact of enterprise on receiving environment			
5.1	Analysis of emissions impact on human health	Must conduct dispersion modelling, must be done in accordance with Regulations; must use NAAQS	Completed as set out by the Regulations. For VOC's the total measured values were used in the analysis and not the modelling of only sources applying for postponement.	<ul style="list-style-type: none"> • Section 5.1.1.1 updated to include revision of AIR in response to stakeholder comments • Section 5.1.1.2 updated to clarify the emission scenario modelled and how to interpret the bar chart figures in the results • Section 5.1.2 updated to include appropriate cross-references. • Section 5.1.3 updated to reflect the promulgated Regulations regarding Air Dispersion Modelling (also applicable throughout document) • Section 5.1.8 receptor map to include schools and clinics as well as indicate distance away from the major point sources • The description of the process to identify sensitive receptors (Section 5.1.8) has been updated for clarity. • Section 5.1.8 updated with isopleth plots that show: schools and clinics in the modelling domain; multiple predicted pollutant concentration levels; the point of maximum predicted concentration; and, a more detailed legend to assist interpretation of the plots. • Section 5.1.8.2 updated to include a table of the most stringent health-effect screening levels against which predicted non-criteria pollutant concentrations were assessed.
5.2	Analysis of emissions impact on environment	Must be undertaken at discretion of Air Quality Officer.	Literature review included in AIR, further information also provided in the motivation reports	(unchanged)
6	Complaints	Details on complaints received for last two years	Included	(unchanged)
7	Current or planned air	Interventions currently being implemented and scheduled and	Information on air quality interventions are included in	Update to correct the chapter reference in the, supporting,

Chapter	Name	AIR regulations requirement	Status in AIRs (April 2014)	Status in AIR (updated to address stakehold comments)
	quality management interventions	approved for next 5 years.	detail in the motivation reports	Motivation report and the time period for planned interventions.
8	Compliance and enforcement history	Must set out all air quality compliance and enforcement actions undertaken against the enterprise in the last 5 years. Includes directives, compliance notices, interdicts, prosecution, fines	Included	(unchanged)
9	Additional information		Included polar plots as an additional visualisation means of ambient air quality as monitored. Independent peer review of dispersion modelling methodology by international expert consultant.	Updated with list and explanation of information included in, or annexed to, the AIR beyond the requirements, in order to support the decision-making process.

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

AIR Regulations	Compliance with Regulations	Comment
<p>Levels of assessment</p> <ul style="list-style-type: none"> Level 1: where worst-case air quality impacts are assessed using simpler screening models Level 2: for assessment of air quality impacts as part of license application or amendment processes, where impacts are the greatest within a few kilometers downwind (less than 50km) Level 3: requires more sophisticated dispersion models (and corresponding input data, resources and model operator expertise) in situations: <ul style="list-style-type: none"> where a detailed understanding of air quality impacts, in time and space, is required; where it is important to account for causality effects, calms, non-linear plume trajectories, spatial variations in turbulent mixing, multiple source types, and chemical transformations; when conducting permitting and/or environmental assessment process for large industrial developments that have considerable social, economic and environmental consequences; when evaluating air quality management approaches involving multi-source, multi-sector contributions from permitted and non-permitted sources in an airshed; or, when assessing contaminants resulting from non-linear processes (e.g. deposition, ground-level ozone (O₃), particulate formation, visibility) 	Level 3 assessment using CALPUFF	<p>This Lagrangian Gaussian Puff model is well suited to simulate low or calm wind speed conditions. Alternative regulatory models such as the US EPA AERMOD model treats all plumes as straight-line trajectories, which under calm wind conditions grossly over-estimates the plume travel distance.</p> <p>CALPUFF is able to perform chemical transformations. In this study the conversion of NO to NO₂ and the secondary formation of particulate matter were concerns.</p>
<p>Model Input</p> <p>Source characterisation</p>	Yes	Only Point sources, characterised as per the Draft Regulations in Table 5-15

AIR Regulations	Compliance with Regulations	Comment
<p>Emission rates: For new or modified existing sources the maximum allowed amount, volume, emission rates and concentration of pollutants that may be discharged to the atmosphere should be used</p> <p>Meteorological data</p> <p>Full meteorological conditions are recommended for regulatory applications.</p> <p>Data period</p> <p>Geographical Information</p> <p>Topography and land-use</p>	<p>Yes</p> <p>Yes</p> <p>Yes</p>	<p>Baseline emission rates used in this investigation were based on an hourly average mass flow and concentration. The maximum allowable emission rates were used in the scenarios for 2015 and 2020 standards.</p> <p>The emission rates for the Alternative Emission Standards (i.e. the emission reductions as proposed by Sasol), used maximum emission rates</p> <p>Emission rates used for each scenario are provided in Table 5-16.</p> <p>MM5 modelled meteorology (including upper air) corrected with on-site observed meteorology (surface meteorology) (Sections 5.1.4.6 and 5.1.5).</p> <p>3 years (2010 to 2012)</p> <p>Required for CALMET 3D meteorological file preparation (Section 5.1.4.6.2)</p>
<p>Domain and co-ordinate system</p>	<p>Yes</p>	<ul style="list-style-type: none"> • Dispersion modelling domain: 50 x 50 km centered around Steam Station stacks • Flat terrain • UTM co-ordinate system (WGS84) (Section 5.1.4.6.4)
<p>General Modelling Considerations</p> <p>Ambient Background Concentrations, including estimating background concentrations in multi-source areas</p> <p>NAAQS analyses for new or modified sources: impact of source modification in terms of ground-level concentrations should be assessed within the context of the background concentrations and the</p> <p>Land-use classification</p> <p>Surface roughness</p> <p>Albedo</p> <p>Temporal and spatial resolution</p> <p>Receptors and spatial resolutions</p> <p>Building downwash</p> <p>Chemical transformations</p>	<p>Yes</p> <p>Yes</p> <p>Yes</p> <p>Yes</p> <p>Yes</p> <p>Yes</p> <p>No</p> <p>Yes</p>	<p>Section 5.1.5.4, Section 5.1.6, and Appendix G</p> <p>Model predicted, 99th percentile ground-level concentrations compared against current observed concentrations and assessed for contribution to ambient concentrations. Used as an indication of how modifications to the plant will impact ambient concentrations.</p> <p>Section 5.1.4.2</p> <p>Computed from Land-use categories in the CALMET pre-processing step (Section 5.1.4.6.2).</p> <p>Computed from Land-use categories in the CALMET pre-processing step (Section 5.1.4.6.2).</p> <p>Sections 5.1.8 and 5.1.4.6.4</p> <p>Based on screening of nearby buildings and due to the height of release from the largest pollutant emitting sources (Steam Stations), it is unlikely that building downwash would significantly influence the plume.</p> <p>Sections 5.1.4.3, Section 5.1.4.4 and</p>

AIR Regulations	Compliance with Regulations	Comment
		Appendix F.
General Reporting Requirements Model accuracy and uncertainty Plan of study Air Dispersion Modelling Study Reporting Requirements Plotted dispersion contours	Yes Yes Yes No	Section 5.1.6, Section 5.1.8, and Appendix J Section 5.1.1.1 As per the Regulations Prescribing the Format of the Atmospheric Impact Report, Government Gazette No. 36904, Notice Number 747 of 2013 (11 October 2013) and as per the Draft Regulations Regarding Air Dispersion Modelling (Government Gazette No. 35981 Notice 1035 of 2012, 14 December 2012). In first draft of AIR, predicted off-site ground-level concentrations were below NAAQS and were therefore not provided as contour plots.

APPENDIX C: RAW MATERIALS, ABATEMENT EQUIPMENT AND ATMOSPHERIC EMISSIONS AT SASOL SASOLBURG COMPLEX

C1: Raw Materials

Table C1-1: Raw materials used at Sasol Sasolburg

Raw Material Type	Maximum Permitted Consumption Rate (Quantity)	Units (quantity/period)
Infrachem		
<i>ATR</i>		
Natural Gas	147800	Nm ³ /h
<i>Rectisol</i>		
Gas mixture (CO, H ₂ , CO ₂ , CH ₄)	150000	Nm ³ /h
<i>Water and waste – Thermal oxidation</i>		
Spent Caustic	3.5	tonnes/year
Organic Solvents		tonnes/hour
High Sulphur Pitch	2.5	tonnes/hour
Limestone	3	tonnes/hour
Organic waste water	2	tonnes/hour
Off- specification waxes	60	tonnes/month
Sasol spent catalyst	204	tonnes/month
Funda filter cake	220	tonnes/month
Polyethylene wax	80	tonnes/month
Other solid waste	150	tonnes/month
High organic waste	400	tonnes/month
Pitch/ tar waste	150	tonnes/month
Slop oils		
<i>Steam Stations</i>		
Water (Steam station 1)	1304	tonnes/hour
Water (Steam station 2)	1467	tonnes/hour
Water (Steam station 3)	255	tonnes/hour
Coal (Steam station 1)	245.2	tonnes/hour
Coal (Steam station 2)	228.2	tonnes/hour
Coal (Steam Station 3)	35.5	tonnes/hour
<i>Ammonia</i>		
Gas mixture (CO, H ₂ , CO ₂ , CH ₄)		Nm ³ /h
Nitrogen		Nm ³ /h
Steam		tonnes/hour
<i>Prillian</i>		
Ammonia nitrate solution (88%)		tonnes/day
<i>Nitric Acid/Ammonium Nitrate</i>		
Ammonia		tonnes/day
SCCM		
Alumina		tonnes/year
Tetra Ethyl Ortho Silicate		tonnes/year
Wax		tonnes/year
Hydrogen		kNm ³ /year
Ethanol		tonnes/year
Ammonia		tonnes/year
Fuel Gas		tonnes/year
Electrical Power		MVA
Nitrogen		kNm ³ /year
Cobalt Solution		tonnes/year
Platinum		tonnes/year
Merisol		
IP sensitive information		
Solvents		
<i>Solvents – All plants</i>		

Atmospheric Impact Report: Infrachem

Raw Material Type	Maximum Permitted Consumption Rate (Quantity)	Units (quantity/period)
Hydrogen	1046	Nm ³ /h
Acetone	18	m ³ /h
Catalyst	15000	l/a
<i>Solvents – MIBK 1 and 2</i>		
Crude methanol		m ³ /h
Make – up water		l/h
<i>Solvents – Methanol</i>		
Crude methanol		m ³ /h
Make – up water		l/h
<i>Solvents – Methanol TG</i>		
Crude methanol E1102		m ³ /h
<i>Solvents – E1204</i>		
Sabutol feed		m ³ /h
<i>Solvents - Butanol</i>		
Propylene		tonnes/hour
Synthesis gas		Nm ³ /h
99 mol% Hydrogen		Nm ³ /h
<i>Solvents - AAA</i>		
Propylene		tonnes/year
Butanol		tonnes/year
Ethanol		tonnes/year
LOC		
Storage of various raw materials and products on site		
Polymers		
<i>Poly 2</i>		
Ethylene	Information protected. Licensing Authority can view information on site	
Additives		
1-Hexene		
Hydrogen		
<i>Poly 3</i>		
Ethylene		tonnes/year
Propylene		tonnes/year
Isododecain		
Organic peroxide initiators		tonnes/year
Additives (depending on market requirements)		tonnes/year
<i>VCM and PVC</i>		
<i>VCM Plant</i>		
Ethylene		tonnes/day
Chlorine		tonnes/day
Oxygen		tonnes/day
Hydrogen		tonnes/day
<i>PVC Plant</i>		
Vinyl Chloride monomer (VCM)		tonnes/day
Ethyl chloroformate		tonnes/day
<i>Monomers</i>		
C2-feed from Secunda	Information IP sensitive	
Ethane from Secunda		
Depropaniser off gas from Natref (propane + ethane)		
PPU4 bottoms from Natref (mainly propane)		
<i>Cyanide 1</i>		
Ammonia		tonnes/month
		Nm ³ /h (instantaneous)
Natural gas		GJ/month
		Nm ³ /h (instantaneous)
Electricity		MW/month
		kW instantaneous
Caustic		tonnes/month
		kg/h (instantaneous)
Graphite		tonnes/month

Raw Material Type	Maximum Permitted Consumption Rate (Quantity)	Units (quantity/period)
Nitrogen		kNm ³ /month
		Nm ³ /h (instantaneous)
<i>Cyanide 2</i>		
Ammonia		tonnes/month
		Nm ³ /h (instantaneous)
Natural gas		GJ/month
		Nm ³ /h (instantaneous)
Electricity		MW/month
		kW instantaneous
Caustic		tonnes/month
		kg/h (instantaneous)
Graphite		tonnes/month
Nitrogen		kNm ³ /month
		Nm ³ /h (instantaneous)
<i>Chlorine</i>		
Sodium Chloride		tonnes/year
Wax		
Sasol Wax – Production		Information IP sensitive
Sasol Wax – Catalyst preparation		

* Raw materials not provided are due to IP or competition law sensitivities

Table C1-2: All appliances and abatement equipment used on unit processes at the Sasol Sasolburg complex

Appliance name	Appliance type/description	Appliance function/purpose
Precips	Electrostatic precipitators	Reduce particulate emissions
Bag filters	Bag house	Reduce particulate emissions
Venturi Scrubber	Venturi Scrubber	Reduce particulate and SO ₂ emissions
SCR	Selective catalytic reduction unit	Reduce NO _x emissions
Flares	Flare	Convert organic gasses into CO ₂ and H ₂ O
Scrubbers	Wet scrubbers	Reduce particulate emissions
Filters	Reverse pulse cartridge filters	Reduce particulate emissions
VCU	Vapour combustion units	Converting fugitive emissions from columns, tanks and loading operations into CO ₂ and H ₂ O
Cyclones	Cyclones	Reduce particulate emissions

C2: Point Source Emissions

Table C2-3: Point source parameters

Point Source Code	Source Name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Height Above Nearby Building (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)	Emissions Hours	Type of Emissions (Continuous / Batch)
Infrachem											
<u>ATR</u>											
1	Fired Heaters ATR A	26.82653	27.84331	65	-	3.32	190	794710	25.5	24 Hours	Continuous
2	Fired Heaters ATR B	26.82689	27.84069	65	-	3.32	190	769778	24.7	24 Hours	Continuous
<u>Steam Stations</u>											
3	SS1 Boiler 4	26.82272	27.84008	75	n/a	5	160	490489	6.939	24 Hours	Continuous
4	SS1 Boiler 5&6	?			n/a					24 Hours	Continuous
5	SS1 Boiler 7&8	26.82272	27.84006	75	n/a	5	160	505969	7.158	24 Hours	Continuous
6	SS2 Boiler 1 to 7	26.82247	27.84853	145	n/a	7.8	160	1737413	10.1	24 Hours	Continuous
<u>Thermal Oxidation</u>											
7	Old HSP incinerator	26.82556	27.84044	40	n/a	1.5	570	24811	3.9	24 Hours	Continuous
8	New HSP incinerator	26.82544	27.84022	40	n/a	1.53	171	173411	26.2	24 Hours	Continuous
9	Caustic incinerator	26.82544	27.84086	40	n/a	1.2	83	52522	12.9	24 Hours	Continuous
<u>Rectisol</u>											
10	Rectisol E stream off gas	26.82272	27.84006	75	n/a	5	Combined with Steam Station 1			24 Hours	Continuous
<u>PRILLIAN / Ammonium nitrate</u>											
11	Prill Tower	26.82881	27.84078	85	n/a	1.5	23.9	180037	28.3	24 Hours	Batch
	Scrubber stack 1	26.82881	27.84078	22	n/a	1	32	80000	28	24 Hours	Batch
	Scrubber stack 2	26.82881	27.84078	22	n/a	1	32	80000	28	24 Hours	Batch

Point Source Code	Source Name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Height Above Nearby Building (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m ³ /hr)	Actual Gas Exit Velocity (m/s)	Emissions Hours	Type of Emissions (Continuous / Batch)
<i>Nitric Acid Plant</i>											
12	Effluent stack	26.82542	27.86047	75	n/a	1.5	215	150000	24	24 Hours	Continuous
Cobalt Catalyst Manufacturing Plant											
1	VOC Destruction unit	26.8255	27.8387	29.5	5.5	0.562	850	8950	10	24 Hours	Continuous
2	DeNox unit	26.8255	27.8387	29.5	5.5	0.6	450	12000	12	24 Hours	Continuous
3	DeNox unit	26.8255	27.8387	29.5	5.5	0.6	450	12000	12	24 Hours	Continuous
4	Wax Scrubber 1	26.82585	27.83854	27	3	0.8	130	1302	1	24 Hours	Continuous
5	Wax Scrubber 2	26.82585	27.83854	27	3	0.8	130	1302	1	24 Hours	Continuous
6	Purolox powder vent system	26.82563	27.83834	27	3	0.2	20	57	1	24 Hours	Continuous
7	Step 4 burner flue gas	26.82581	27.83848	29.7	5.7	0.15	330	550	10	24 Hours	Continuous
8	Step 6 burner flue gas	26.82585	27.83854	29.7	5.7	0.15	330	600	10	24 Hours	Continuous
9	Hot oil system fuel gas burner	26.82566	27.83852	27	3	0.3	330	1120	1.1	24 Hours	Continuous
10	Step 2 burner flue gas	26.82543	27.8382	29	5	0.3	630	3500	3.4	24 Hours	Continuous
11	Step 2 burner flue gas	26.82858	27.83854	29.2	5.2	0.3	550	600	10	24 Hours	Continuous
Merisol											
1	Fuel gas furnace	26.83031	27.84717	40	None in vicinity	0.11	98.5	164	4.8	24h/d	Continues
2	SOx scrubber on N-base units	26.83017	27.84686	12	None in vicinity	0.11	124	1998	58.4	24h/d	Continues
3	OCN Scrubber vent line	26.83069	27.84761	35	± 3m	0.11	19	140	4.1	24h/d	Continues
4	Phenol plant	26.82392 7	27.839275	30	None in vicinity	n/a	n/a	n/a	n/a	24h/d	Continues
5	Merisol Flare	26.83170 6	27.845865	67	None in vicinity	1.2	Not available	2000m ³ /hr	4.8	adhoc	adhoc

Atmospheric Impact Report: Infracem

Point Source Code	Source Name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Height Above Nearby Building (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)	Emissions Hours	Type of Emissions (Continuous / Batch)
Sasol Technology											
1	Pilot Plant Flare	-26.8221	27.8447	39	3.5	0.15-0.2	200	2160	~70	24 Hours	Intermittently related to start-up, shut down and upset conditions
Solvents											
<u>AAA</u>											
1	ST6010	26.82331	27.86686	20	n/a	0.95	852	16586	6.5	24 hours	Continuous
2	ST1040	26.82297	27.86811	25	n/a	1.5	125.6	70615	11.1	24 hours	Continuous
<u>Solvents</u>											
3	E 501 Bottoms knockout	26.776	27.84419	Ties in to B 1102 – 10 m	Ties in to B 1102	Ties in to B 1102	Ties in to B 1102	Ties in to B 1102	Ties in to B 1102	24 hours	Continuous
4	F501 + F 502 vent	26.77617	27.84472	15	None in vicinity	0.16	35	50.7	0.7	24 hours	Continuous
5	F 505 vent	26.77618	27.84471	15	None in vicinity	0.1	176	57.1	2.02	24 hours	Continuous
6	E1204	26.77589	27.84469	15	None in vicinity	0.1	24	12.4	0.44	24 hours	Continuous
7	B 1102	26.7759	27.8447	10	None in vicinity	0.4	59	452.4	1	24 hours	Continuous
8	F1133 A+B	26.77588	27.84468	15	None in vicinity	0.1	27	36.8	1.3	24 hours	Continuous
LOC											
1	VCU UNIT	26.82794	27.84175	12		2.4	152	68401	4.2	24 hours	Intermittently when loading occurs
Polymers											
<u>Poly 2 (LLDPE) and Poly 3 (LDPE) plant</u>											
9	Poly 2 Flare	26.83327	27.87093	±52	None in the vicinity	TBM	Flame	7173	Above flashback velocity	24 hours	Continuous
10	Poly 3 Flare	26.83271	27.87146	52	None in the	0.6	Flame	Designed for max	Above flashback	24 hours	Continuous

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Point Source Code	Source Name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Height Above Nearby Building (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)	Emissions Hours	Type of Emissions (Continuous / Batch)	
					vicinity			relief load of 120t/h	velocity			
11	Poly 3 Emergency Vent Separator (EVS)			8	None in the vicinity	0.8	Used only during emergency situations			24 hours	Continuous	
<i>Monomers</i>												
1	Steam cracker furnaces, B002A/B	26.832	27.84386	20	None in the vicinity	1.8	417	26 978 x 2	5.9	24 hours	Continuous	
1b	Steam cracker furnaces, B003	26.832	27.84386	26.275	None in the vicinity	1.2 x 2	200	69 183 (both stacks)	8.5	24 hours	Continuous	
1c	Elevated Flare (B101)	26.83351	27.84492	65	None in the vicinity	0.914	176 (op)	Non continuous Flow		24 hours	Continuous	
1d	Tank Flare (B180)	26.83408	27.84626	30	None in the vicinity			Non continuous Flow		24 hours	Continuous	
1e	Ground Flare (B009)	26.83342	27.84558	24.39	None in the vicinity	19.278	100 (20 – 200)	12.1	0.0065	24 hours	Continuous	
1f	Mea Regen Off Gas	26.832	27.84386	35	None in the vicinity	0.1016	40	0.098	0.003	24 hours	Continuous	
<i>Vinyl Chloride Monomer (VCM) Plant</i>												
2	VCM incinerator	26.82989	27.87317	30	None in the vicinity	0.36	41	9527	26	24 hours	Continuous	
3	VCM Cracker	26.82969	27.87272	40	None in the vicinity	1.71	390	26457	3.2	24 hours	Continuous	
3a**	VCM Safety Scrubber – not continuous flow	26.82833	27.87253	26.6	None in the vicinity	0.7	96	18500	13.5	24 hours	Continuous	
3b**	VCM Cold Flare – not continuous flow	26.82858	27.87306	50	None in the vicinity	0.81	136	77200	42	24 hours	Continuous	
<i>Poly Vinyl Chloride (PVC) Plant</i>												
3c**	PVC Autoclave H Vent	Sources 3c to 3n, venting only occurs under emergency conditions – typical values are given below										
3d**	PVC Autoclave J Vent			20		0.3	56	5400	500			

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Point Source Code	Source Name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Height Above Nearby Building (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)	Emissions Hours	Type of Emissions (Continuous / Batch)
3e**	PVC Autoclave K Vent										
3f**	PVC Autoclave L Vent										
3g**	PVC Autoclave M Vent										
3h**	PVC Autoclave N Vent										
3i**	PVC Autoclave P Vent										
3j**	PVC Autoclave Q Vent										
3k**	PVC Autoclave R Vent										
3l**	PVC Autoclave S Vent										
3m**	PVC Autoclave T Vent										
3n**	PVC Autoclave U Vent										
3o	PVC Reaction Stack North	26.82758	27.87408	24	n/a	0.6	30	7700	7.6	24 hours	Continuous
3p	PVC Reaction Stack South	26.82717	27.87353	24	n/a	0.6	30	7700	7.6	24 hours	Continuous
3q	PVC Slurry Stock Tank Stack	26.82717	27.87442	35	n/a	1.2	45	60000	15	24 hours	Continuous
3r	PVC VCM Recovery Stack	26.828	27.87408	24	n/a	0.05	-40	19	3	24 hours	Continuous
3s	PVC Multigrade Vent Stack	26.82758	27.87408	6	n/a	0.05	100	89	12.6	24 hours	Continuous
4	PVC Drier Stack North	26.83	27.87	35	n/a	1.8	60-70	130000	15	24 hours	Continuous
5	PVC Dryer Stack	26.83	27.87	35	n/a	1.8	60-70	130000	15	24 hours	Continuous

Point Source Code	Source Name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Height Above Nearby Building (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)	Emissions Hours	Type of Emissions (Continuous / Batch)
	South										
<u>Chlorine plant</u>											
6	HCl burner stacks	26.82419	27.88142	15	n/a	0.16	31	120	1.6	24 hours	Continuous
7	Chlorine hypo stacks	26.82361	27.87406	40	n/a	0.25	23	60	2.2	24 hours	Continuous
<u>Cyanide plant</u>											
8	Cyanide stacks	26.82361	27.86672			0.2	35	Cannot be quantified due to hydrogen and the associated fire risk		24 hours	Continuous
Sasol Wax											
<u>Sasol Wax</u>											
1	Oven B 4701	26.83058	27.84625	26	None in the vicinity	1	409	18378	6.5	24 hours	Continuous
2	Oven B 4702	26.83058	27.84625	26	None in the vicinity	1	320	18661	6.6	24 hours	Continuous
3	Oven B 4801	26.83069	27.84644	26	None in the vicinity	1.25	165	23856	5.4	24 hours	Continuous
4	Oven B 4802	26.83069	27.84644	26	None in the vicinity	1.25	285	30925	7	24 hours	Continuous
5	Oven L 4234 Catalyst washout	26.83122	27.84267	45	None in the vicinity	0.5	61	9613	13.6	24 hours	Continuous
6	Oven B 2801	26.82617	27.84292	20	None in the vicinity	0.7	188	3930	2.8	24 hours	Continuous
7	Oven B 1521	26.82578	27.84256	20	None in the vicinity	0.77	285	4670	2.8	24 hours	Continuous
<u>Wax catalyst preparation</u>											
8	Catalyst preparation Salt plant	26.83214	27.84139	15	None in the vicinity	0.2	36	1242	14.9	24 hours	Continuous

Atmospheric Impact Report: Infracem

Point Source Code	Source Name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Height Above Nearby Building (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)	Emissions Hours	Type of Emissions (Continuous / Batch)
9	Catalyst preparation SBR	26.8315	27.841	15	More or less midway between the ground and the roof	0.5	60	4415	9.1	24 hours	Continuous
10	Catalyst preparation FBR	26.83247	27.84158	15	On top of the roof	0.61	53	13968	13.3	24 hours	Continuous
11	Nitric acid plant / Calciner stack	26.831254	27.842644	40m	± 3 m	1	40	4000	5.7	24 hours	Continuous
12	Oven L4201	26.832	27.84131	15	None in the vicinity	0.31	190	720	2.7	24 hours	Continuous
13	Oven L4203	26.832	27.84131	15	None in the vicinity	0.46	201	3060	4.92	24 hours	Continuous

Table C2-4: Point source emission rates during normal operating conditions

Point Source Code	Pollutant Name	Maximum Release Rate (mg/Nm ³) ^(a)	Average Period	Duration of Emissions
Infracem				
ATR A	Particulates	120	Hourly	Continuous
	NO _x	1700	Hourly	Continuous
	SO ₂	1700	Hourly	Continuous
ATR B	Particulates	120	Hourly	Continuous
	NO _x	1700	Hourly	Continuous
	SO ₂	1700	Hourly	Continuous
Boiler 4	Particulates	165	Daily	Continuous
	SO ₂	2000	Hourly	Continuous
	NO _x	1450	Hourly	Continuous
Boiler 5&6	Particulates	165	Daily	Continuous
	SO ₂	2000	Hourly	Continuous
	NO _x	1450	Hourly	Continuous
Boiler 7&8	Particulates	165	Daily	Continuous
	SO ₂	2000	Hourly	Continuous
	NO _x	1450	Hourly	Continuous
SS2 Boiler 1-7	Particulates	100	Daily	Continuous
	SO ₂	2000	Hourly	Continuous
	NO _x	1250	Hourly	Continuous
Thermal Oxidation (90 Furnace)	Particulates	Cannot be measured due to high temperature		
	CO	50	Hourly	Continuous
	NO _x expressed as NO ₂	360	Hourly	Continuous
	SO ₂	50	Hourly	Continuous
	HCl	10	Hourly	Continuous
	HF	1.5	Hourly	Continuous
	Pb+As+Sb+Cr+Co+Cu+Mn+Ni+V	Cannot be measured due to high temperature		
	Hg	Cannot be measured due to high temperature		
	Cd+Tl	Cannot be measured due to high temperature		
	TOC	25	Hourly	Continuous
	NH ₃	10	Hourly	Continuous
	Dioxins and furans	Cannot be measured due to high temperature		
Thermal Oxidation (30 Furnace)	Particulates	50	Hourly	Continuous
	CO	75	Hourly	Continuous
	NO _x expressed as NO ₂	750	Hourly	Continuous
	SO ₂	1800	Hourly	Continuous
	HCl	10	Hourly	Continuous
	HF	1	Hourly	Continuous
	Pb+As+Sb+Cr+Co+Cu+Mn+Ni+V	1	Hourly	Continuous
	Hg	0.05	Hourly	Continuous
	Cd+Tl	0.05	Hourly	Continuous
	TOC	50	Hourly	Continuous
	NH ₃	10	Hourly	Continuous
	Dioxins and furans	0.1 ng TEQ/Nm ³	Hourly	Continuous

Point Source Code	Pollutant Name	Maximum Release Rate (mg/Nm ³) ^(a)	Average Period	Duration of Emissions
Thermal Oxidation (93 Furnace)	Particulates	180	Hourly	Continuous
	CO	1050	Hourly	Continuous
	NO _x expressed as NO ₂	420	Hourly	Continuous
	SO ₂	50	Hourly	Continuous
	HCl	15	Hourly	Continuous
	HF	1.2	Hourly	Continuous
	Pb+As+Sb+Cr+Co+Cu+Mn+Ni+V	22	Hourly	Continuous
	Hg	0.05	Hourly	Continuous
	Cd+Tl	0.05	Hourly	Continuous
	TOC	10	Hourly	Continuous
	NH ₃	10	Hourly	Continuous
	Dioxins and furans	0.1 ng TEQ/Nm ³	Hourly	Continuous
10	Particulates	50	Hourly	Batch
	NH ₃	100	Hourly	Batch
11	Particulates	50	Hourly	Batch
	NH ₃	100	Hourly	Batch
12	Particulates	50	Hourly	Batch
	NH ₃	100	Hourly	Batch
13	NO _x	500	Hourly	Continuous
Cobalt Catalyst plant				
1	VOCs	40	Hourly	Continuous
2	NO _x	700	Hourly	Continuous
3	NO _x	700	Hourly	Continuous
4	VOCs	40	Hourly	Batch
5	VOCs	40	Hourly	Batch
6	Particulates	50	Hourly	Continuous
7	NO _x	700	Hourly	Continuous
	VOCs	40	Hourly	Continuous
8	NO _x	700	Hourly	Continuous
9	NO _x	700	Hourly	Continuous
	VOCs	40	Hourly	Continuous
10	NO _x	700	Hourly	Continuous
	VOCs	40	Hourly	Continuous
11	NO _x	700	Hourly	Continuous
	VOCs	40	Hourly	Continuous
Merisol				
1	Particulates	120	Hourly	Continuous
	NO _x expressed as NO ₂	1700	Hourly	Continuous
	SO ₂	1700	Hourly	Continuous
2	SO ₃	100	Hourly	Continuous
	VOCs	40000	Hourly	Continuous
3	SO ₃	100	Hourly	Continuous
	VOCs	40000	Hourly	Continuous
4	VOCs	40000	Hourly	Continuous
Sastech				

Point Source Code	Pollutant Name	Maximum Release Rate (mg/Nm ³) ^(a)	Average Period	Duration of Emissions
1	Not applicable as the point source is associated with emergency flaring.			
Solvents				
1	VOCs	150	Hourly	Continuous
2	VOCs	150	Hourly	Continuous
3	VOCs	150	Hourly	Continuous
4	VOCs	150	Hourly	Continuous
5	VOCs	150	Hourly	Continuous
6	VOCs	150	Hourly	Continuous
7	VOCs	150	Hourly	Continuous
8	VOCs	150	Hourly	Continuous
LOC				
98	VOCs	150	Hourly	Intermittent
Polymers				
1	Particulates	120	Hourly	Continuous
	SO ₂	1700	Hourly	Continuous
	NO _x expressed as NO ₂	1700	Hourly	Continuous
1b	Particulates	120	Hourly	Continuous
	SO ₂	1700	Hourly	Continuous
	NO _x expressed as NO ₂	1700	Hourly	Continuous
1c	Methyl amine	10	Hourly	Continuous
2	Particulates	25	Hourly	Continuous
	SO ₂	50	Hourly	Continuous
	NO expressed as NO ₂	200	Hourly	Continuous
	HF	1	Hourly	Continuous
	CO	75	Hourly	Continuous
	HCl	30	Hourly	Continuous
	Pb+As+Sb+Cr+Co+Cu+Mn+Ni+V	0.5	Hourly	Continuous
	Hg	0.05	Hourly	Continuous
	Cd+Tl	0.5	Hourly	Continuous
	TOC	10	Hourly	Continuous
	NH ₃	10	Hourly	Continuous
	Dioxins	0.2ngTEQ/Nm ³	Hourly	Continuous
3	Particulates	120	Hourly	Continuous
	SO ₂	1700	Hourly	Continuous
	NO _x	200 ppm	Hourly	Continuous
3a	VOCs	40000	Hourly	Continuous
3b	Bursting discs – emissions will only occur during over pressure incidents			Only during emergencies
3c				Only during emergencies
3d				Only during emergencies
3e				Only during emergencies
3f				Only during emergencies

Point Source Code	Pollutant Name	Maximum Release Rate (mg/Nm ³) ^(a)	Average Period	Duration of Emissions
3g				Only during emergencies
3h				Only during emergencies
3i				Only during emergencies
3j				Only during emergencies
3k				Only during emergencies
3l	VCM	150 ppm (m/m)	Daily	Continuous
3m	VCM	150 ppm (m/m)	Daily	Continuous
3n	VCM	25 ppm (m/m)	Daily	Continuous
3o	VOCs	40000	Hourly	Continuous
3p	VOCs	40000	Hourly	Continuous
4	Particulates	21 mg/Am ³	Hourly	Continuous
5	Particulates	21 mg/Am ³	Hourly	Continuous
6	Cl ₂	5	Hourly	Continuous
	HCl	10	Hourly	Continuous
7	Cl ₂	50	Hourly	Continuous
8	HCN	50 ppm	Hourly	Continuous
Wax				
1, 2, 3, 4, 5, 6, 7, 12, 13	Particulates	120	Hourly	Continuous
	NO _x	1700	Hourly	Continuous
	SO ₂	1700	Hourly	Continuous
8, 9, 10	Particulate Matter	50	Hourly	Continuous
	NO _x	2000	Hourly	Continuous
	SO ₂	1700	Hourly	Continuous
11	NO _x	3.5 t/month	Daily	Continuous

(a) units mg/Nm³ unless otherwise stated

C3: Fugitive emissions – dustfall monitoring

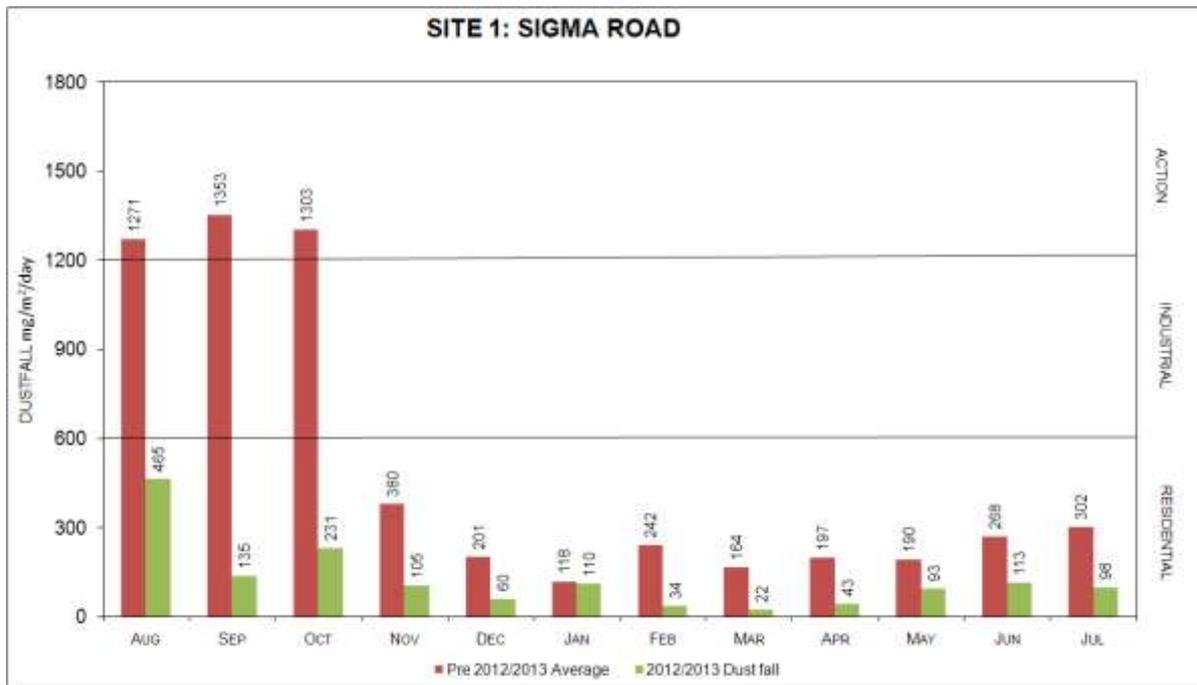


Figure C3-1: Dustfall rates at Site 1 (Sigma road) between August 2012 and July 2013

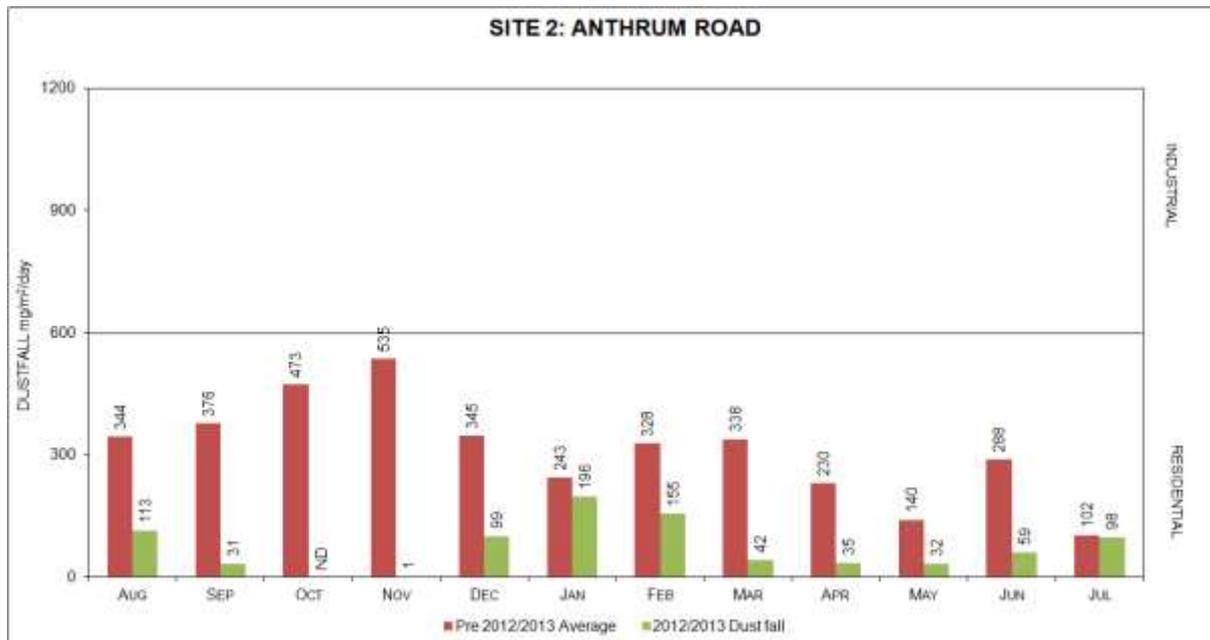


Figure C3-2: Dustfall rates at Site 2 (Anthrum road) between August 2012 and July 2013

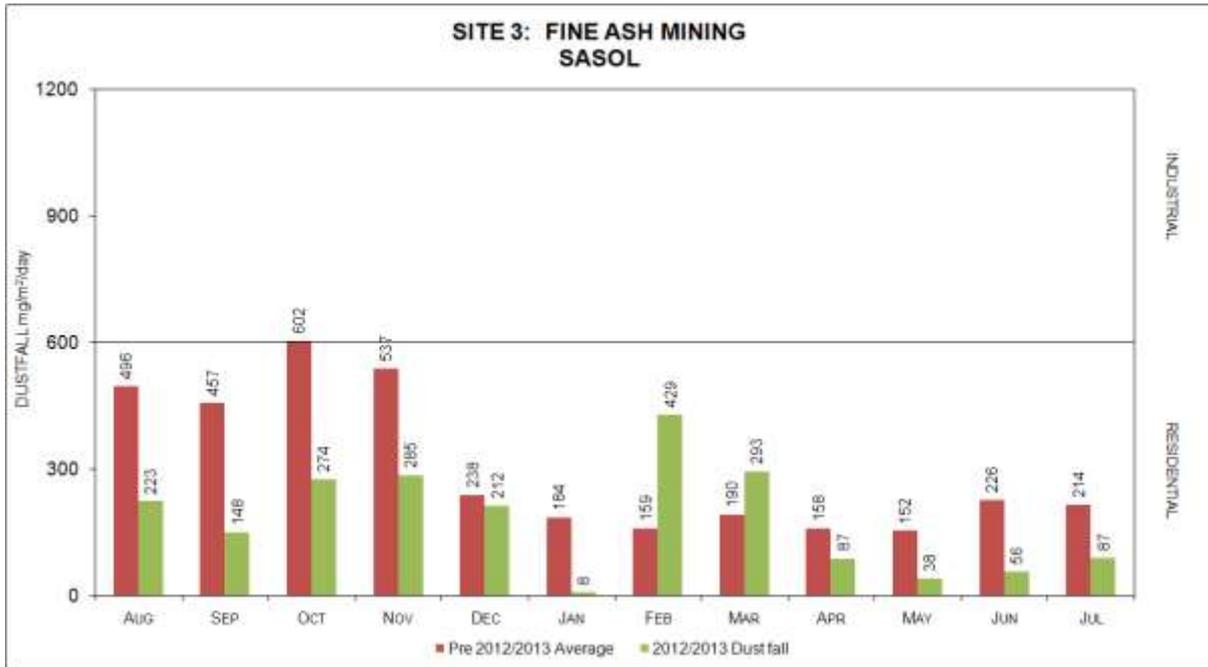


Figure C3-3: Dustfall rates at Site 3 (Fine Ash Mining) between August 2012 and July 2013

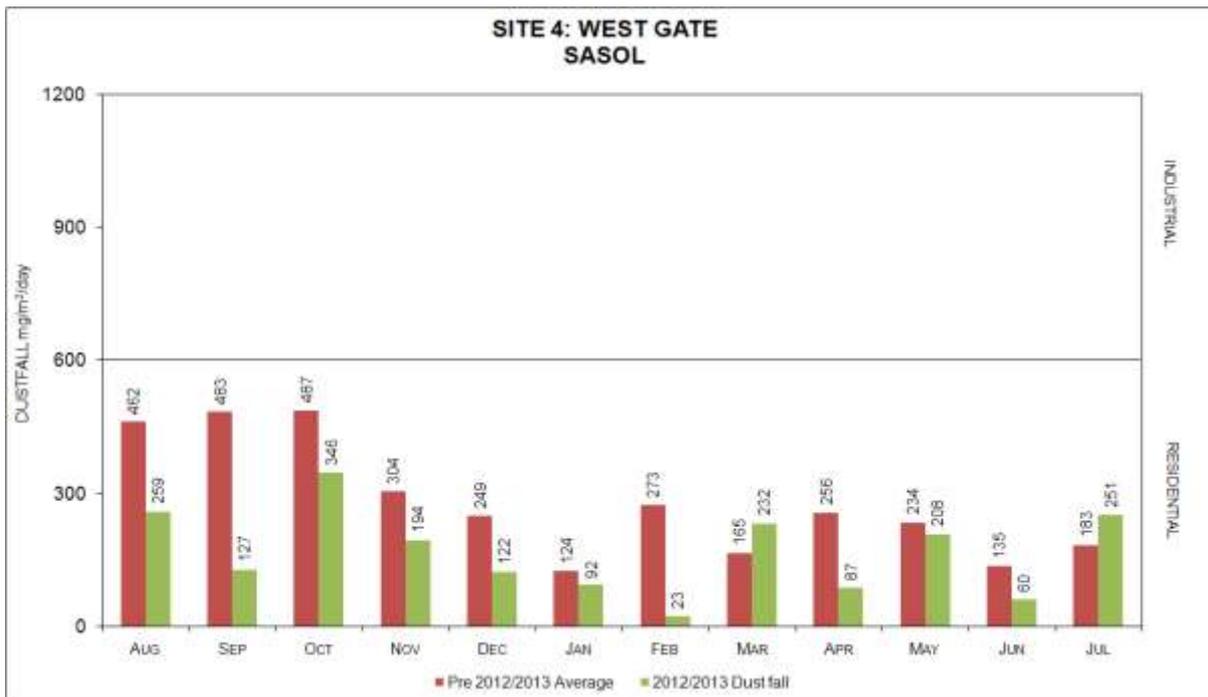


Figure C3-4: Dustfall rates at Site 4 (West Gate) between August 2012 and July 2013

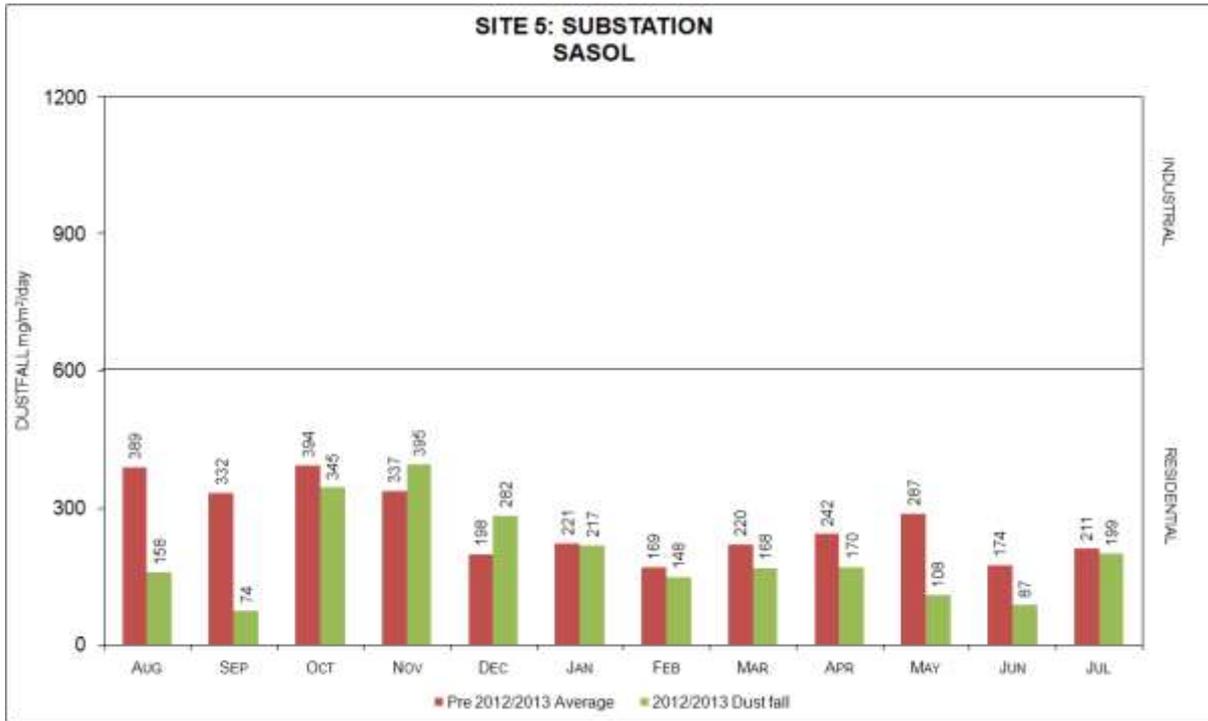


Figure C3-5: Dustfall rates at Site 5 (Substation) between August 2012 and July 2013

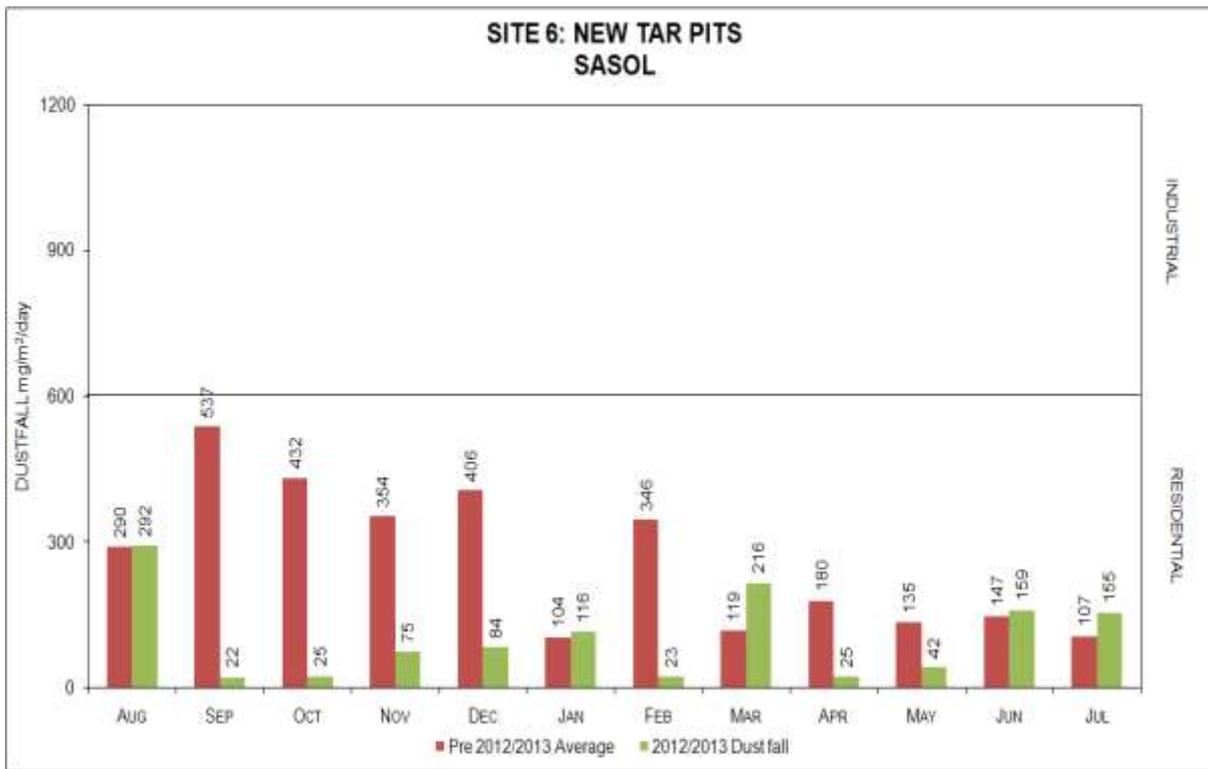


Figure C3-6: Dustfall rates at Site 6 (New Tar Pits) between August 2012 and July 2013

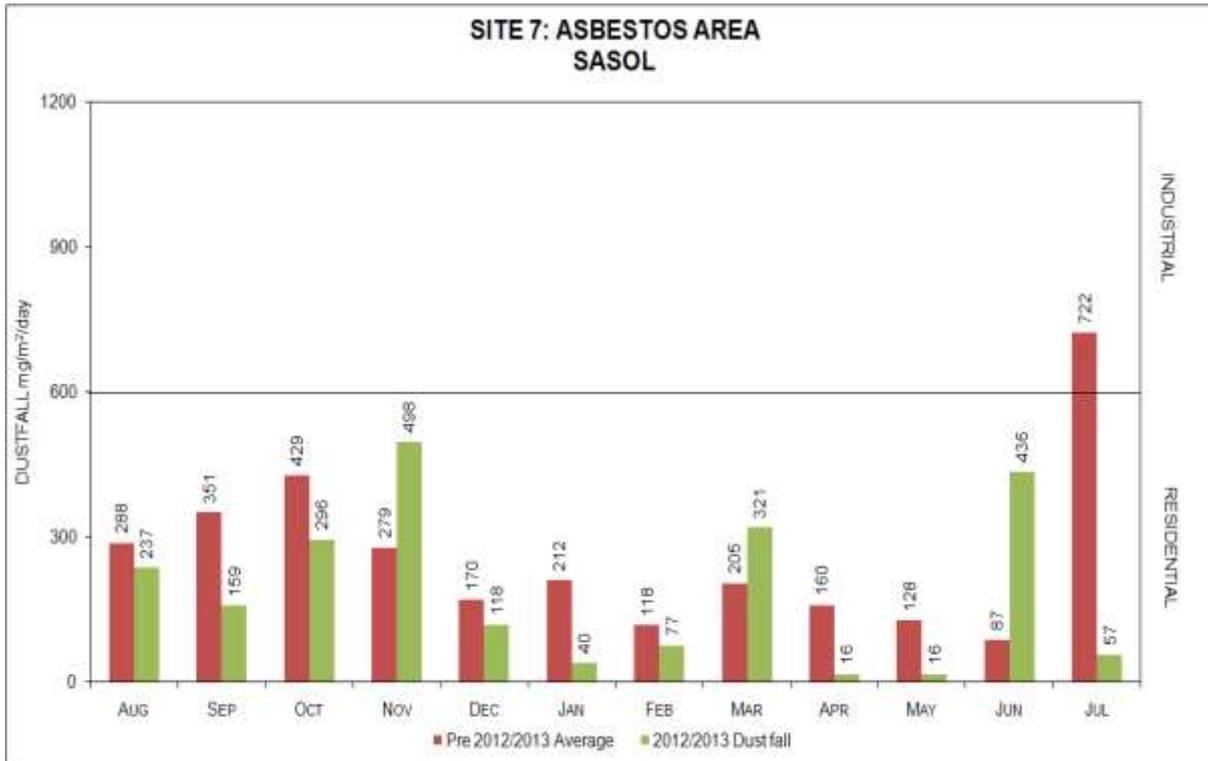


Figure C3-0-7: Dustfall rates at Site 7 (Asbestos area) between August 2012 and July 2013

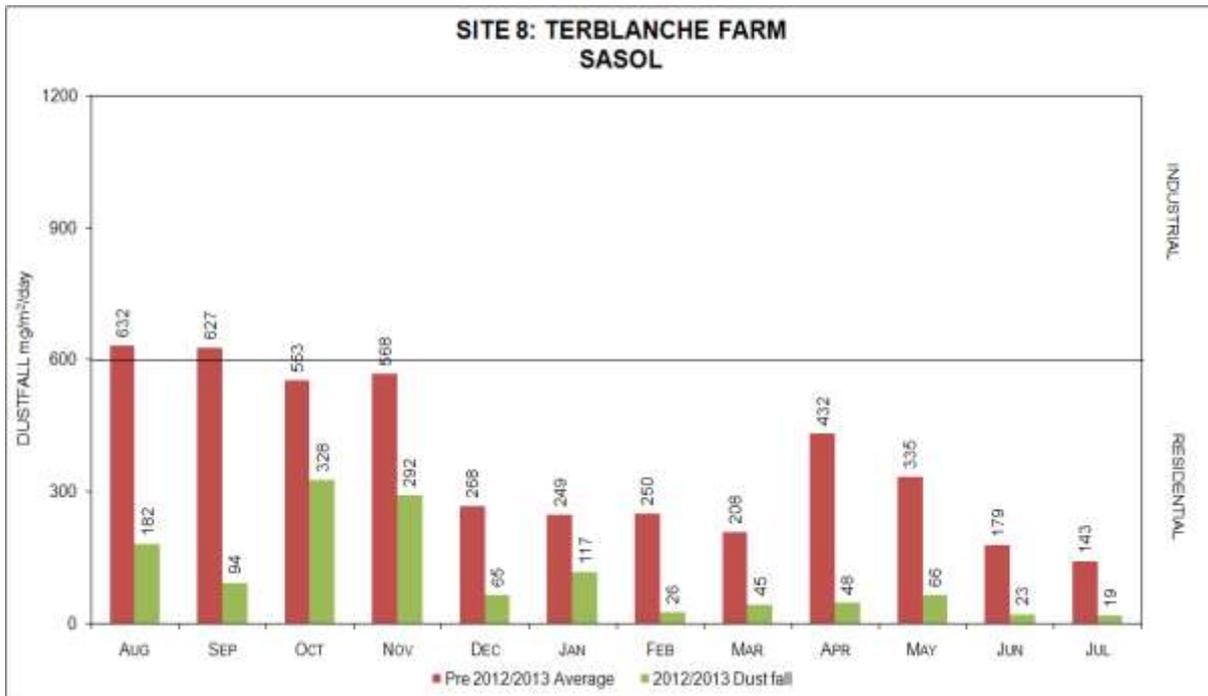


Figure C3-8: Dustfall rates at Site 8 (Terblanche farm) between August 2012 and July 2013

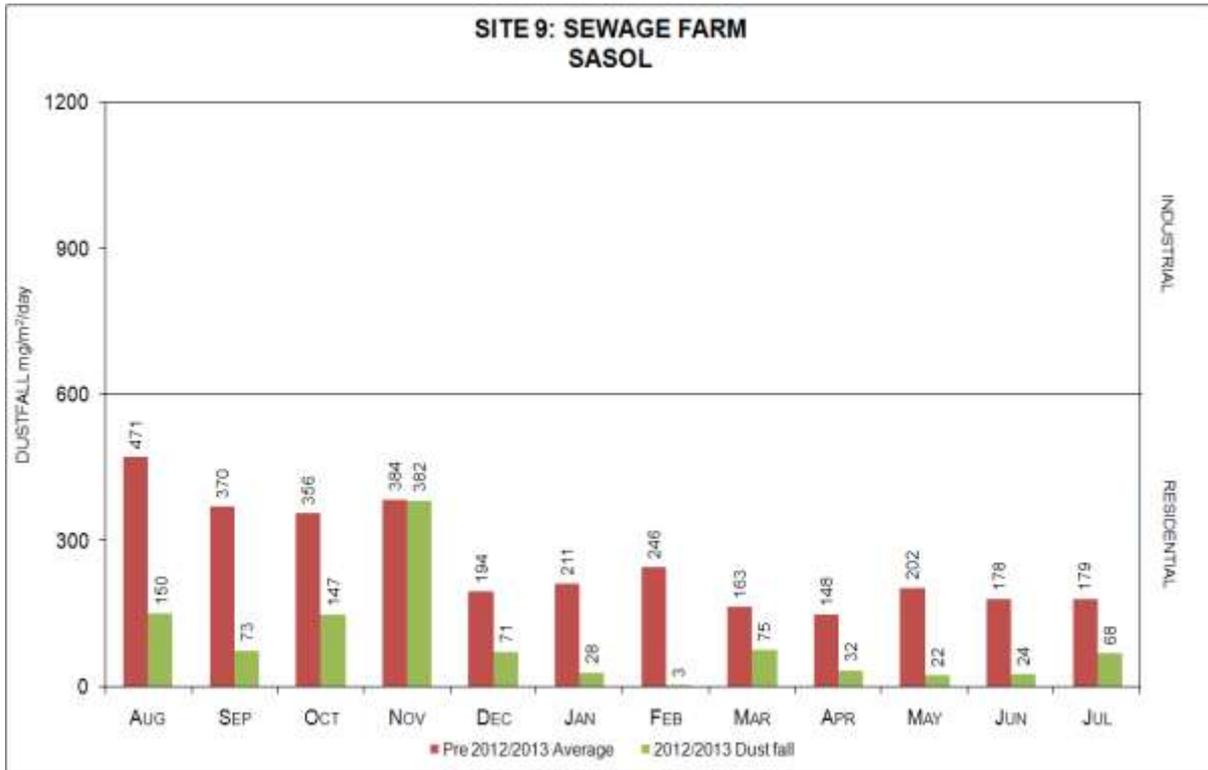


Figure C3-9: Dustfall rates at Site 9 (Sewage farm) between August 2012 and July 2013

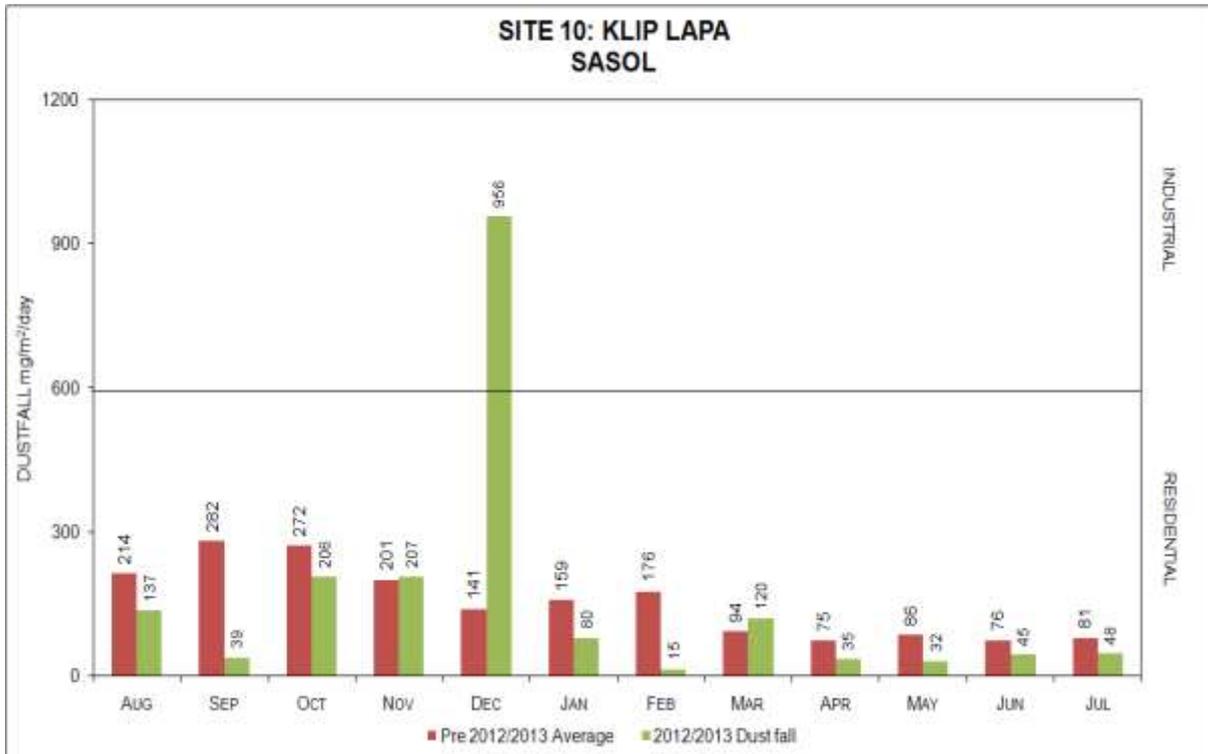


Figure C3-10: Dustfall rates at Site 10 (Klip Lapa) between August 2012 and July 2013

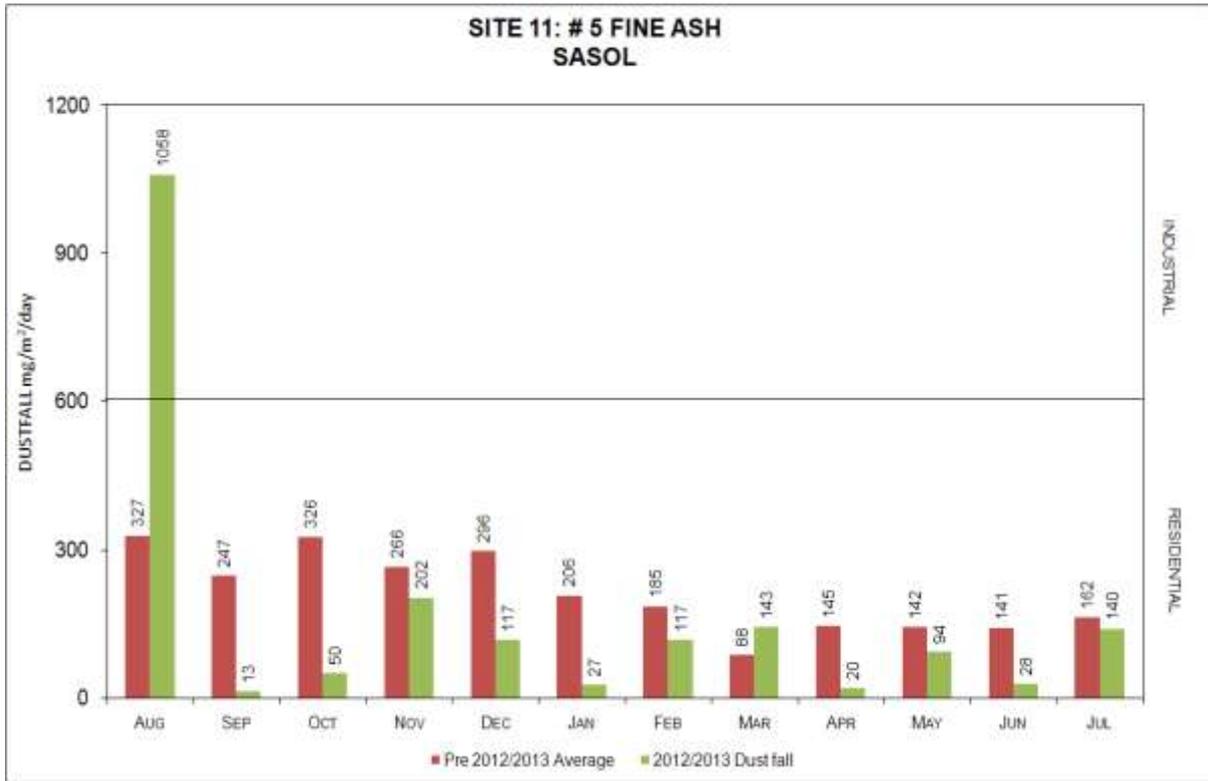


Figure C3-11: Dustfall rates at Site 11 (#5 Fine Ash) between August 2012 and July 2013

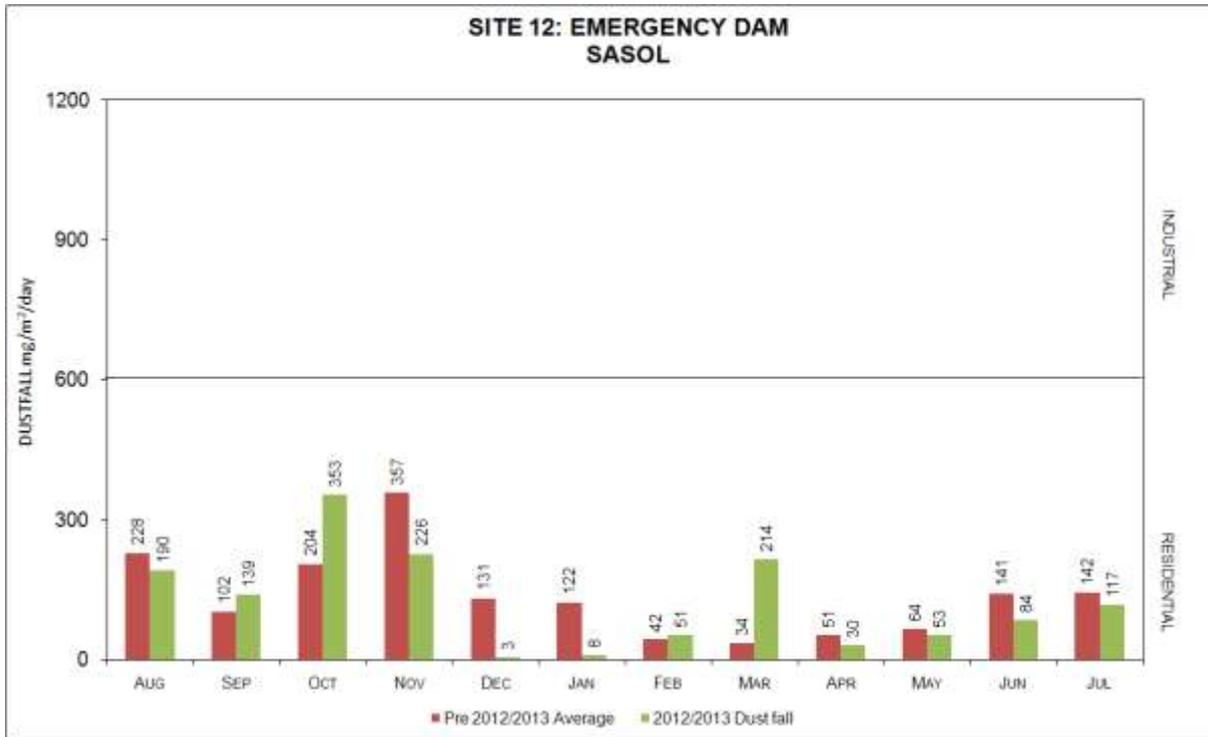


Figure C3-12: Dustfall rates at Site 12 (Emergency dam) between August 2012 and July 2013

APPENDIX D: CALMET MODEL CONTROL OPTIONS

Table D-1: CALMET model control options

Run Type	Description of Run Type	Ease of Use and Representativeness	Data availability	Advantages	Disadvantages
No Observations	<ul style="list-style-type: none"> •Prognostic model data, such as MM5 to drive CALMET. •No surface or upper air observations input at all. 	<ul style="list-style-type: none"> •Relatively simple to implement in model •Representative of regional meteorological conditions 	MM5 data (Lakes Environmental) for 2010, 2011 and 2012 at 12km resolution for 300km by 300km study area (Secunda + Sasolburg)	<ul style="list-style-type: none"> •Simple to implement •Full spatial and temporal variability •No overwater data required •Cloud cover has spatial distribution •Eliminates need for complicated 7 user-input site-specific variables •Ideal as screening run as gives very good estimate 	Resolution of prognostic data may potentially be too coarse to be representative of local conditions
Partial Observations	<ul style="list-style-type: none"> •Prognostic model data, such as MM5 to drive CALMET <p>PLUS</p> <ul style="list-style-type: none"> •One or more surface stations 	<ul style="list-style-type: none"> •More difficult to implement than only prognostic (MM5) data. •Require 7 site-specific model parameters to be specified. •Difficulty in dealing with missing data. •Potential disagreement between prognostic and surface observations. •Very representative and considered 'refined modelling' 	<ul style="list-style-type: none"> •MM5 data (Lakes Environmental) for 2010, 2011 and 2012 at 12km resolution for 300km by 300km study area (Secunda + Sasolburg) •Sasol operated surface meteorological weather stations (3 Sasolburg³ and 3 Secunda⁴) 	<ul style="list-style-type: none"> •Full spatial and temporal variability •No overwater data required •Refined model run as using combined approach of numerical model and observations. •Ability to incorporate surface representative observation data when MM5 data is too coarse to fully pick up local effects. 	<ul style="list-style-type: none"> •Surface data, especially winds may be different to that in the MM5 data file •User must include 7 site-specific variables •Data preparation and missing data
Observations Only	CALMET driven solely by surface, upper air and optional overwater and precipitation stations	<ul style="list-style-type: none"> •Require 7 site-specific model parameters to be specified. <p>Difficulty in dealing with missing data.</p> <ul style="list-style-type: none"> •Considered representative if sufficient observation stations and site specific choice of parameters by the modeller. 	<ul style="list-style-type: none"> •Sasol operated surface meteorological weather stations (3 Sasolburg and 3 Secunda) •Closest upper air monitoring station is at OR Tambo International Airport (twice-daily soundings only) 	Very good if upper air and surface stations are located close to the facility and if upper air data are recorded at sunrise and sunset.	<ul style="list-style-type: none"> •Upper air data typically 12 hourly, poor spatial and temporal resolution •Model has to interpolate between 12 hour soundings •Soundings at incorrect time of the day. •User has to deal with missing surface and upper air data

³ Steam Station 1 (WS, WD, TEMP, RH, AMB PRESS, SOL RAD, RAIN); AJ Jacobs (WS, WD, SO₂, NO₂, PM₁₀) and Leirim (WS, WD, SO₂, NO₂, PM₁₀)

⁴ Club House (WS, WD, TEMP, RH, AMB PRESS, NO_x, NO₂, SO₂, PM₁₀); Bosjespruit (WS, WD, TEMP, SOL RAD, NO₂, SO₂) and Langverwagt (WS, WD, TEMP, RH, SOL RAD, NO_x, NO₂, SO₂, PM₁₀)

APPENDIX E: CALPUFF MODEL CONTROL OPTIONS

Table E-1: CALPUFF model control options

Run Type	Description of Run Type	Ease of Use and Representativeness	Data availability	Advantages	Disadvantages
Sampling Function Puff	This sampling scheme employs radically symmetric Gaussian puffs and is suitable for far field.				
Sampling Function Slug	This sampling scheme uses a non-circular puff (a "slug"), elongated in the direction of the wind during release, to eliminate the need for frequent releases of puffs. Used for near field during rapidly-varying meteorological conditions.				Takes a very long time to run.
Dispersion coefficients MDISP = 1	<ul style="list-style-type: none"> Dispersion coefficients are computed from measured values of turbulence, sigma-v and sigma-w. 	<ul style="list-style-type: none"> The user must provide an external PROFILE.DAT file containing these parameters, and select a backup method out of options 2, 3 and 4 below in case of missing data. 	<ul style="list-style-type: none"> This measured data is not available in South Africa 	<ul style="list-style-type: none"> Very good if data is available. 	<ul style="list-style-type: none"> These measured parameters are not readily available in South Africa.
Dispersion coefficients MDISP = 2	<ul style="list-style-type: none"> Dispersion coefficients are computed from internally-calculated sigma-v, sigma-w using micrometeorological variables (u^*, w^*, L, etc.). 	<ul style="list-style-type: none"> This option can simulate AERMOD-type dispersion when the user also selects the use of PDF method for dispersion in the convective boundary layer (MPDF = 1). Note that when simulating AERMOD-type dispersion, the input meteorological data must be from CALMET and cannot be ISC-type ASCII format data. The user should also be aware that under this option the CALPUFF model will be more sensitive to the appropriateness of the land use 	<ul style="list-style-type: none"> The data is obtained from MM5 input information. 	<ul style="list-style-type: none"> Based on improved theoretical work and is an improvement over Pasquill-Gifford. 	<ul style="list-style-type: none"> The coefficients are derived from other parameters.

Run Type	Description of Run Type	Ease of Use and Representativeness	Data availability	Advantages	Disadvantages
		characterization.			
Dispersion coefficients MDISP = 3	<ul style="list-style-type: none"> Pasquill-Gifford (PG) dispersion coefficients for rural areas (computed using the ISCST3 multi-segment approximation) and McElroy-Pooler (MP) coefficients in urban areas. 	<ul style="list-style-type: none"> The current default selection is MDISP = 3, which is ISC-type dispersion. Given the demonstrated improved characterization of dispersion provided by AERMOD, and EPA's intention to replace ISC with AERMOD, use of AERMOD-like dispersion (MDISP = 2, and MPDF = 1) is also acceptable, but likely will be of most benefit for short-range complex flow applications. 		<ul style="list-style-type: none"> Simple to use if you don't have detailed meteorological information. This option can be run using fairly basic meteorological data. 	<ul style="list-style-type: none"> Based on discreet classification scheme (not continuous function). Based on field experiments done elsewhere, may or may not be representative of Highveld area. Previous projects done using this scheme however have provided good correlation over this area.
Dispersion coefficients MDISP = 4	<ul style="list-style-type: none"> Same as MDISP = 3, except PG coefficients are computed using the MESOPUFF II equations 				
Dispersion coefficients MDISP = 5	<ul style="list-style-type: none"> CTDM sigmas are used for stable and neutral conditions. For unstable conditions, sigmas are computed as in MDISP=3 described above. 	<ul style="list-style-type: none"> When selecting this option, the user must provide an external PROFILE.DAT file, and select a backup method out of options 2, 3 and 4 above in case of missing data. 			
Chemical transformation RIVAD	<ul style="list-style-type: none"> Pseudo-first-order chemical mechanism for SO₂, SO₄²⁻, NO, NO₂, HNO₃, and NO₃ - (RIVAD/ARM3 method) 	<ul style="list-style-type: none"> RIVAD is a 6-species scheme wherein NO and NO₂ are treated separately. In the RIVAD scheme the conversion of SO₂ to sulfates is not RH-dependent. The conversion of NO_x to nitrates is RH-dependent. 	<ul style="list-style-type: none"> In order to use the RIVAD scheme, the user must divide the NO_x emissions into NO and NO₂ for each source. Two options are specified for the ozone concentrations: (1) hourly ozone concentrations from a network of stations, or (2) a 	<ul style="list-style-type: none"> In several tests conducted to date, the results have shown no significant differences between the RIVAD and MESOPUFF II options. 	<ul style="list-style-type: none"> User has to input the NO and NO₂ emissions which are not always known for all sources. User has to input the ozone concentrations which are not always known. The model is restricted to rural conditions.

Run Type	Description of Run Type	Ease of Use and Representativeness	Data availability	Advantages	Disadvantages
			single user defined ozone value. • The background ammonia concentrations required for the HNO ₃ /NH ₄ NO ₃ equilibrium calculation can be user-specified or a default value will be used.		
Chemical transformation MESOPUFF II	• Pseudo-first-order chemical mechanism for SO ₂ , SO ₄ ²⁻ , NO _x , HNO ₃ , and NO ₃ - (MESOPUFF II method)	• MESOPUFF II is a 5-species scheme in which all emissions of nitrogen oxides are simply input as NO _x . • In the MESOPUFF II scheme, the conversion of SO ₂ to sulfates is dependent on relative humidity (RH), with an enhanced conversion rate at high RH. • The conversion of NO _x to nitrates is RH-dependent.	• The MESOPUFF II scheme assumes an immediate conversion of all NO to NO ₂ . • Two options are specified for the ozone concentrations: (1) hourly ozone concentrations from a network of stations, or (2) a single user defined ozone value. • The background ammonia concentrations required for the HNO ₃ /NH ₄ NO ₃ equilibrium calculation can be user-specified or a default value will be used.	• In several tests conducted to date, the results have shown no significant differences between the RIVAD and MESOPUFF II options for sulfate and nitrate formation. • The model is applicable to both urban and rural conditions.	• User has to input the ozone concentrations which are not always known. • NO to NO ₂ conversion is not included. In model.
User-specified diurnal cycles of transformation rates					
No chemical conversion					

APPENDIX F: THE NO₂/NO_x CONVERSION RATIOS FOR NO₂ FORMATION

Scire and Borissova (2011) analysed hourly monitored NO₂ and NO_x data for 2006 at 325 monitoring sites throughout USA (approximately 2.8 million data points for each species). These observations were grouped into a number of concentration bins and were used to compute bin maximums and bin average curves. Short-term (1-hr) NO₂/NO_x ratios were developed on bin-maximum data, whereas the long-term (annual average) NO₂/NO_x ratios were based on bin-averaged data. The method was subsequently tested using the NO₂/NO_x ratios applied to the observed NO_x at selected stations to predict NO₂, and then compared to observed NO₂ concentrations at that station. As illustrated in the examples, Figure F-1 and Figure F-2, using these empirical curves provide a reasonable estimate of the observed NO₂ can be obtained, albeit mostly more conservative. In Figure F-3, the method is compared to the assumption of 100% conversion over the short-term, which clearly illustrates the extreme conservatism, especially at elevated concentrations.

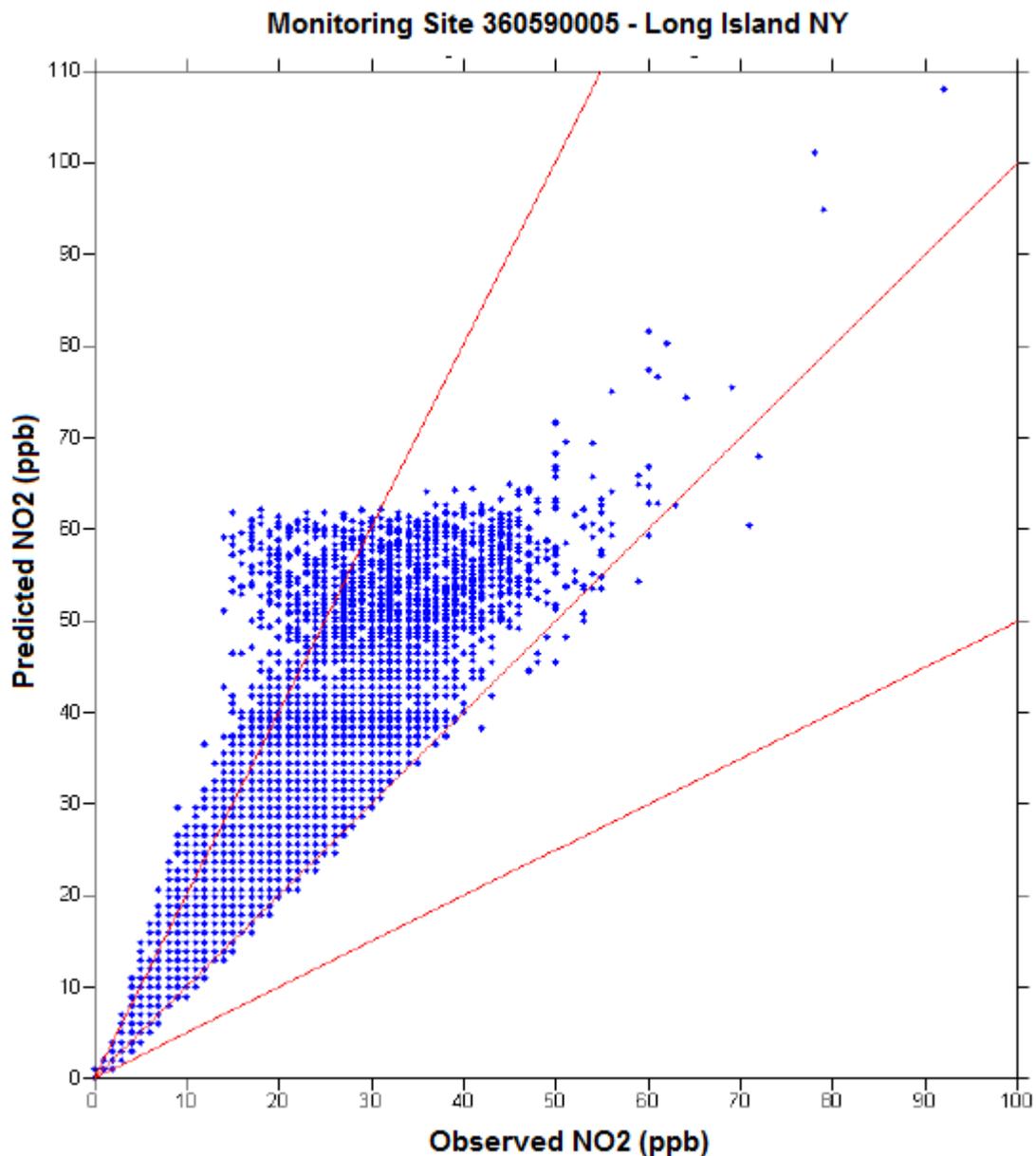


Figure F-1: Comparison of observed with predicted NO₂ concentrations (Long Island, NY) using the derived short-term NO₂/NO_x ratios (Scire and Borissova, 2011)

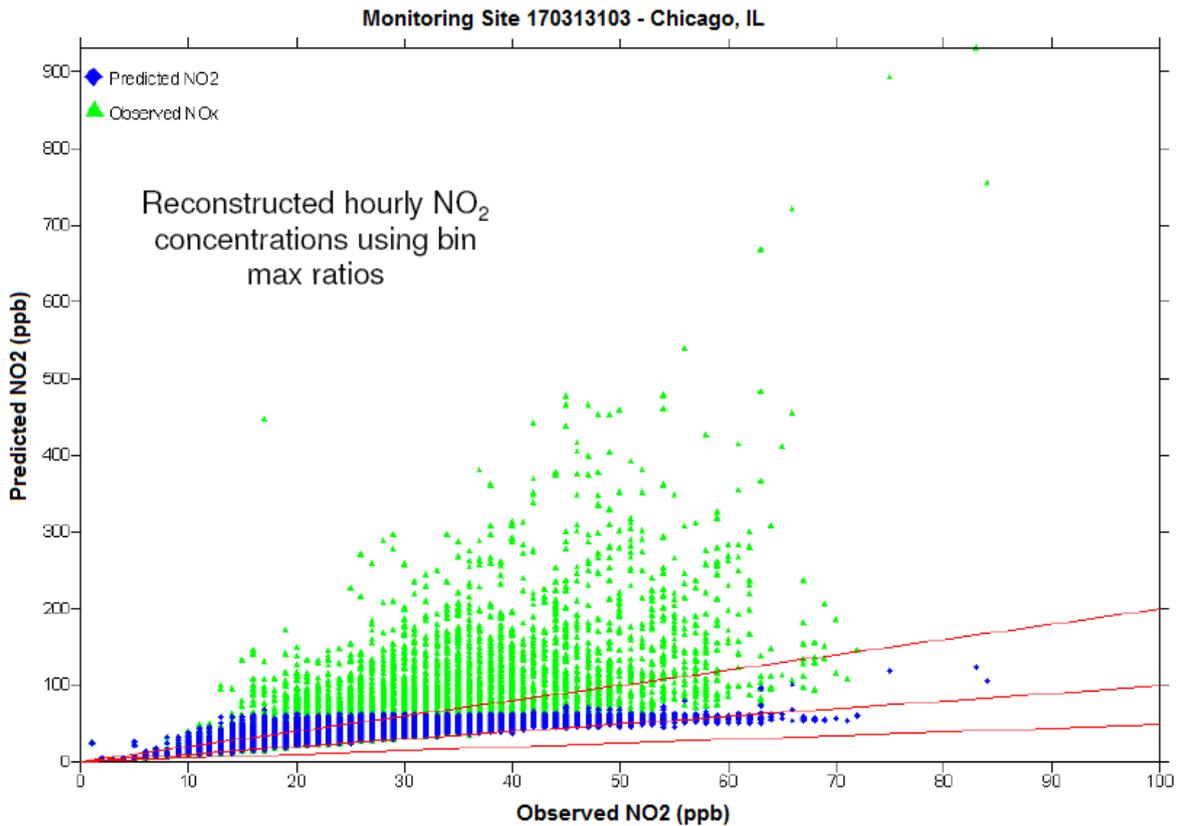


Figure F-2: Comparison of observed with predicted NO₂ concentrations (Chicago, IL) using the derived short-term NO₂/NO_x ratios (Scire and Borissova, 2011)

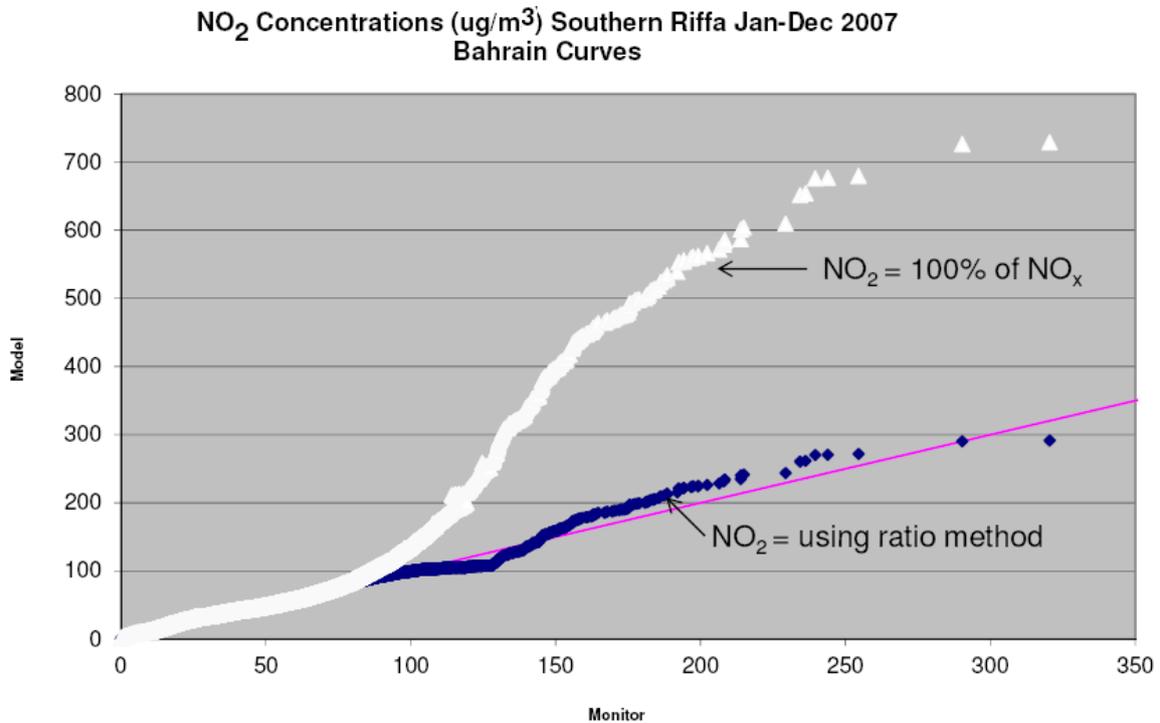


Figure F-3: Observed versus predicted NO₂ concentrations (Bahrain) using the derived short-term NO₂/NO_x ratios (Scire and Borissova, 2011)

It was decided that the NO₂/NO_x conversion factors described by Scire and Borissova (2011) and as given in Table F-1, will be employed in this study. Observed NO₂/NO_x ratios at the Sasolburg monitoring stations were also analysed and compared to the factors in the table (Figure F-1). It is shown in the table and Figure F-4, that the Scire and Borissova ratios would also be applicable in the current study since it would produce estimates similar or more conservative than if the actual NO₂/NO_x ratios at the site would have been used instead.

Table F-1: NO₂/NO_x conversion ratios for NO₂ formation

Bin	Concentration (µg/m ³)			NO ₂ /NO _x Ratios			
				Sasolburg		Scire and Borissova 2011	
	Min	Max	Centre	AJ Jacobs 2010-2012	Ecopark 2012	Bin Average	1-Hour Max
1	0	19	9	0.658	0.521	0.7980	0.9938
2	19	38	28	0.714	0.605	0.8130	0.9922
3	38	75	56	0.657	0.501	0.7306	0.9844
4	75	113	94	0.506	0.428	0.5544	0.9094
5	113	150	132	0.380	0.305	0.4370	0.7477
6	150	188	169	0.309	0.117	0.3553	0.6085
7	188	235	212	0.265	0.311	0.3013	0.4976
8	235	282	259	0.222	0.019	0.2559	0.4173
9	282	329	306	0.208	0.114	0.2276	0.3543
10	329	376	353	0.184	0.105	0.2081	0.3056
11	376	423	400	0.216	0.164	0.1852	0.2684
12	423	470	447	0.161	0.114	0.1809	0.2404
13	470	517	494	0.135	0.101	0.1767	0.2194
14	517	564	541		0.153	0.1546	0.2035
15	564	611	588		0.119	0.1524	0.1912
16	611	658	635		0.071	0.1476	0.1813
17	658	705	682		0.169	0.1402	0.1726
18	705	752	729		0.157	0.1363	0.1645
19	752	846	799		0.133	0.1422	0.1527
20	846	940	893		0.164	0.1223	0.1506
21	940	1128	1034		0.164	0.1087	0.1474
22	1128	1316	1222			0.1110	0.1432
23	1316	1504	1410			0.1112	0.139
24	1504	1786	1645			0.1165	0.1337

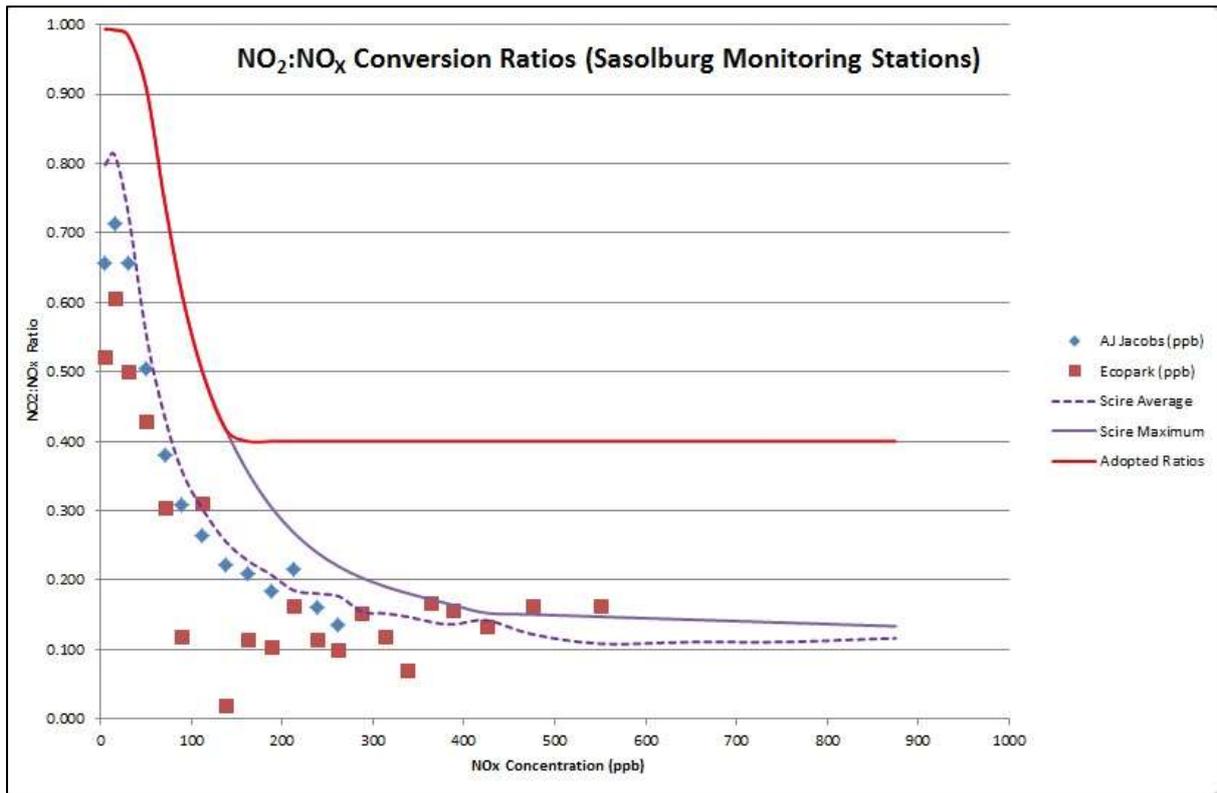


Figure F-4: NO₂/NO_x conversion ratios for Sasolburg monitoring stations

APPENDIX G: TIME SERIES PLOTS FOR THE OBSERVED AMBIENT DATA

A summary of the time series plots for the measured data as provided by Sasol is given in the following section.

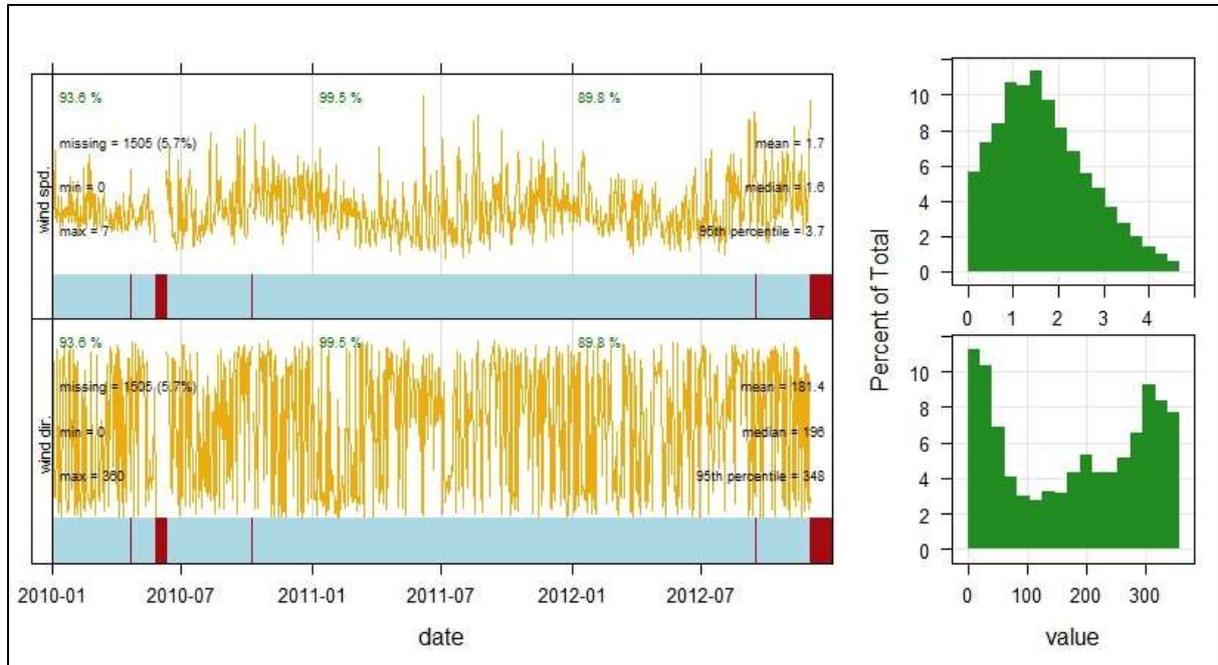


Figure G-1: Summary of meteorological data received for AJ Jacobs (2010-2012)

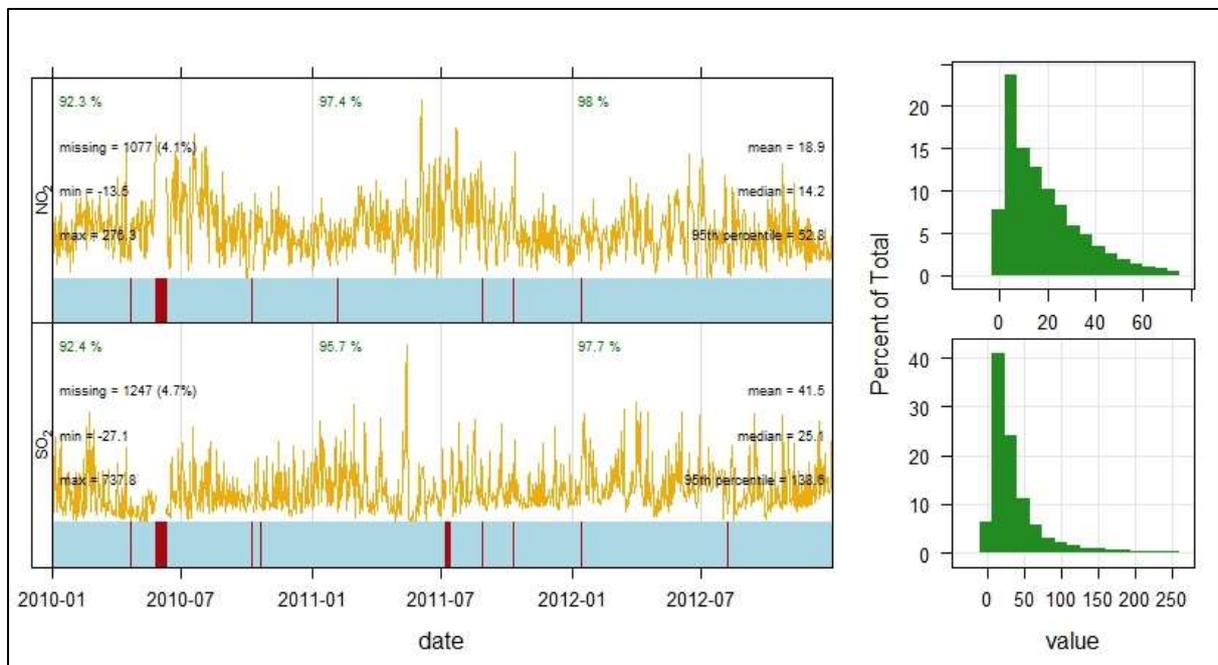


Figure G-2: Summary of ambient data received for AJ Jacobs (2010-2012)

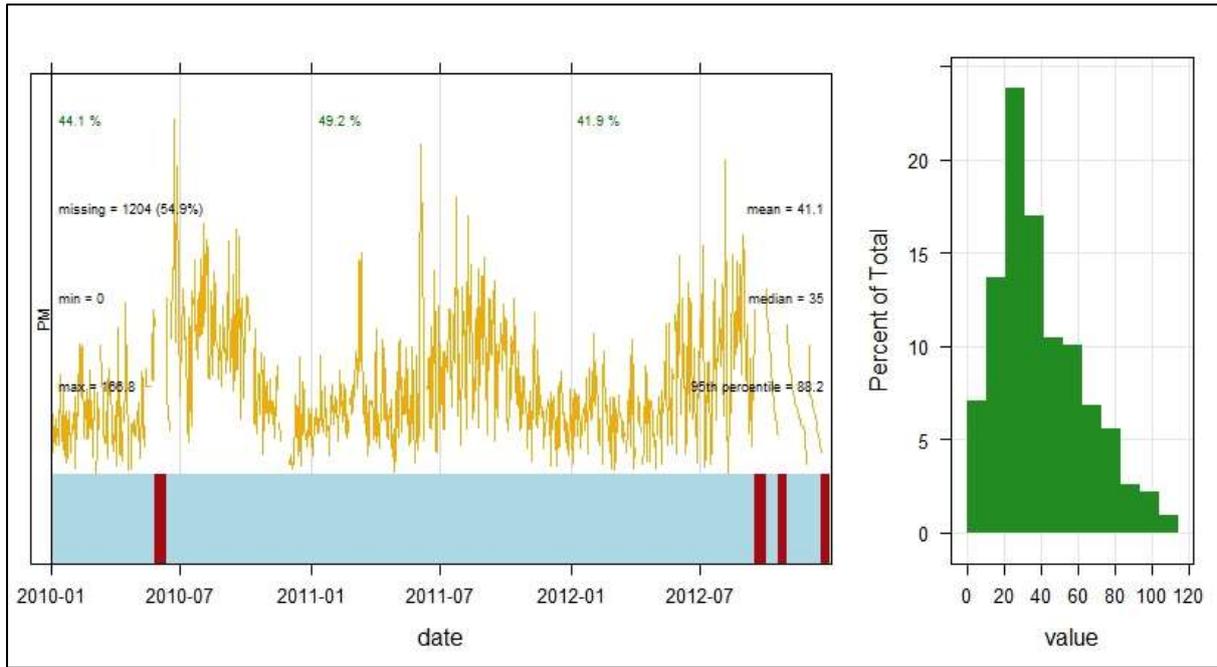


Figure G-3: Summary of daily PM data received for AJ Jacobs (2010-2012)

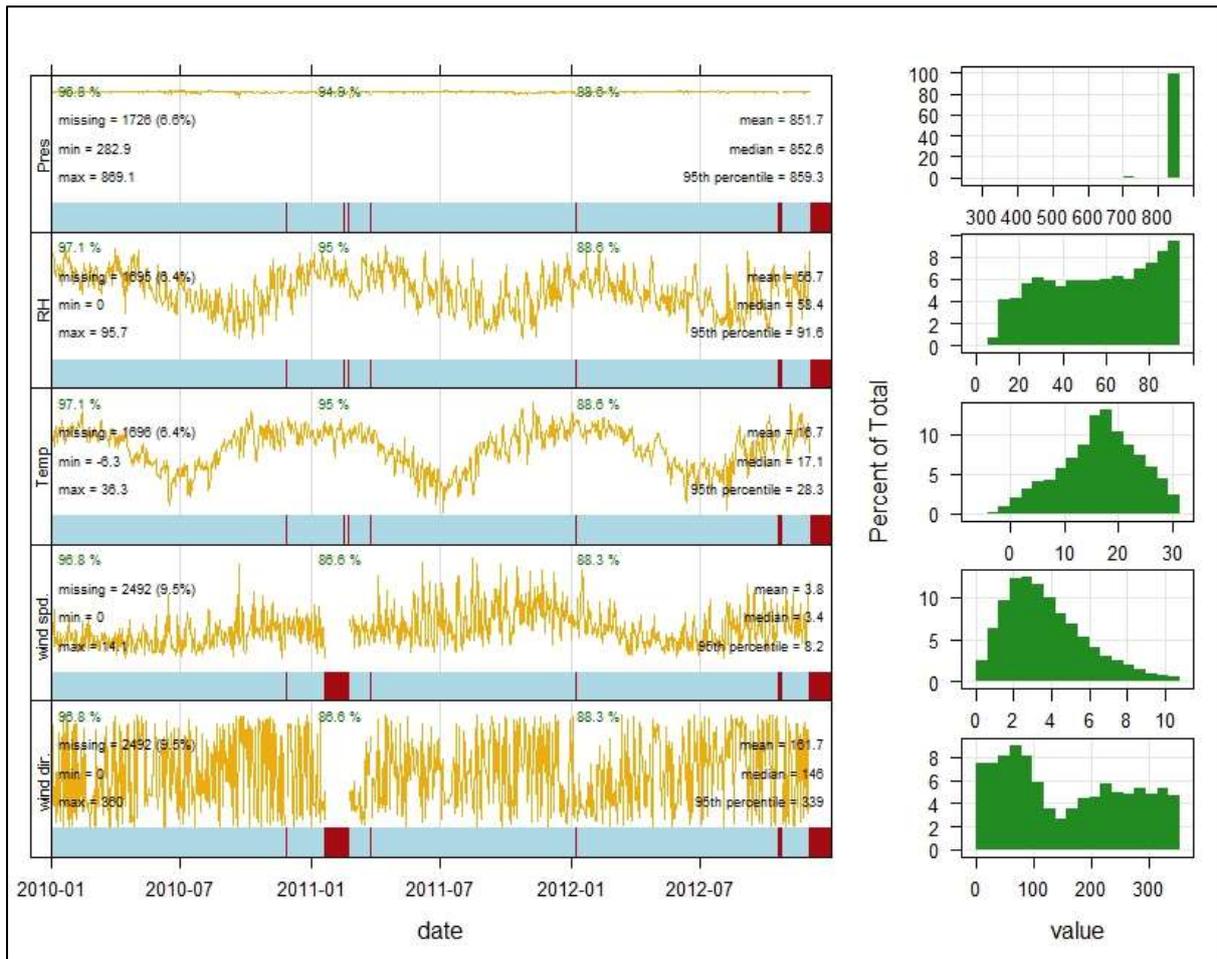


Figure G-4: Summary of meteorological data received for Leitrim (2010-2012)

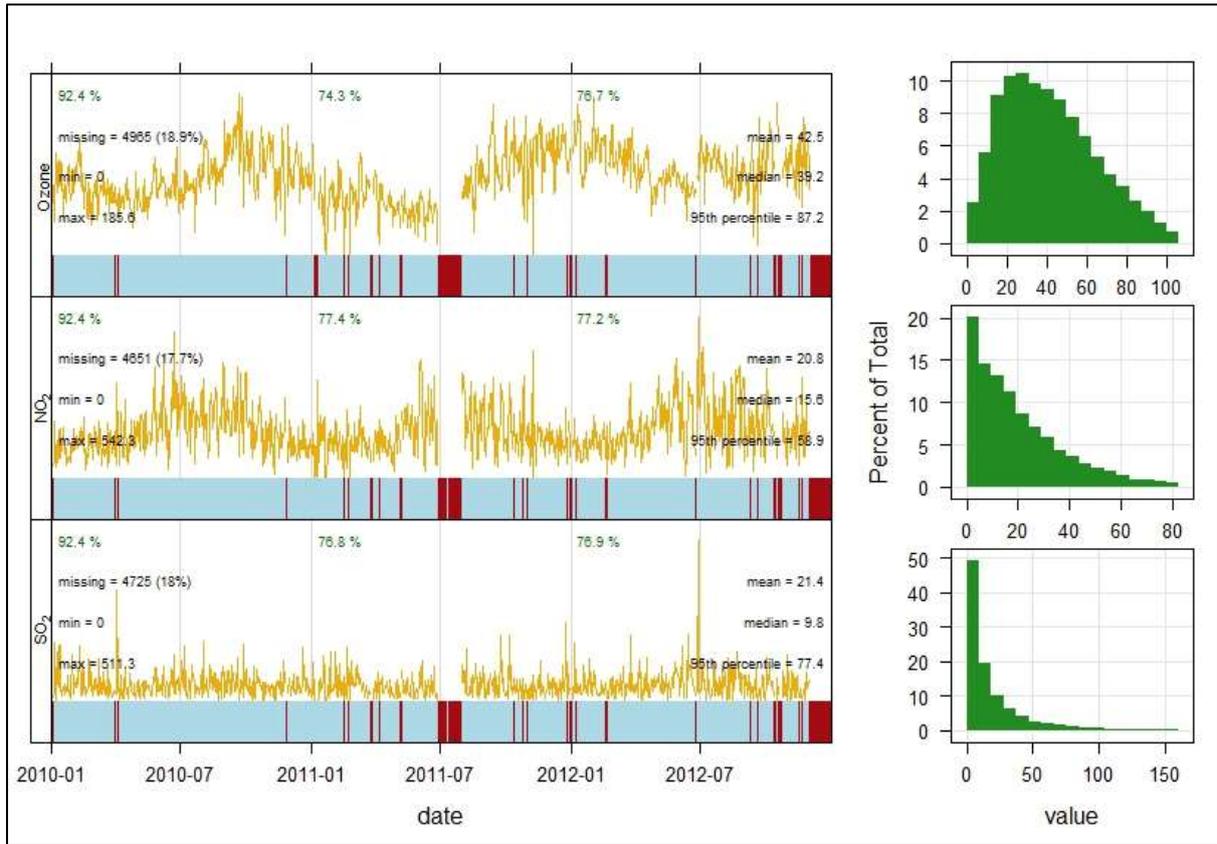


Figure G-5: Summary of ambient data received for Leitrim (2010-2012)

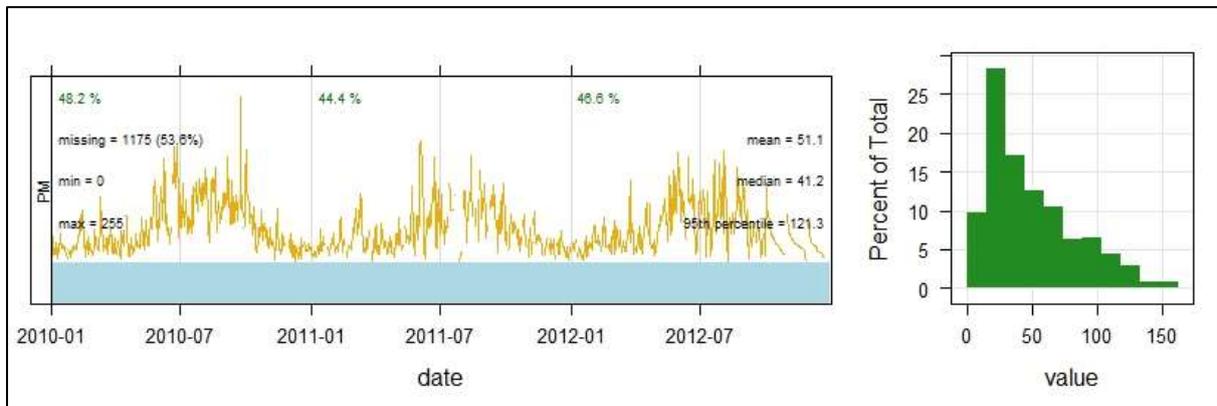


Figure G-6: Summary of daily PM data received for Leitrim (2010-2012)

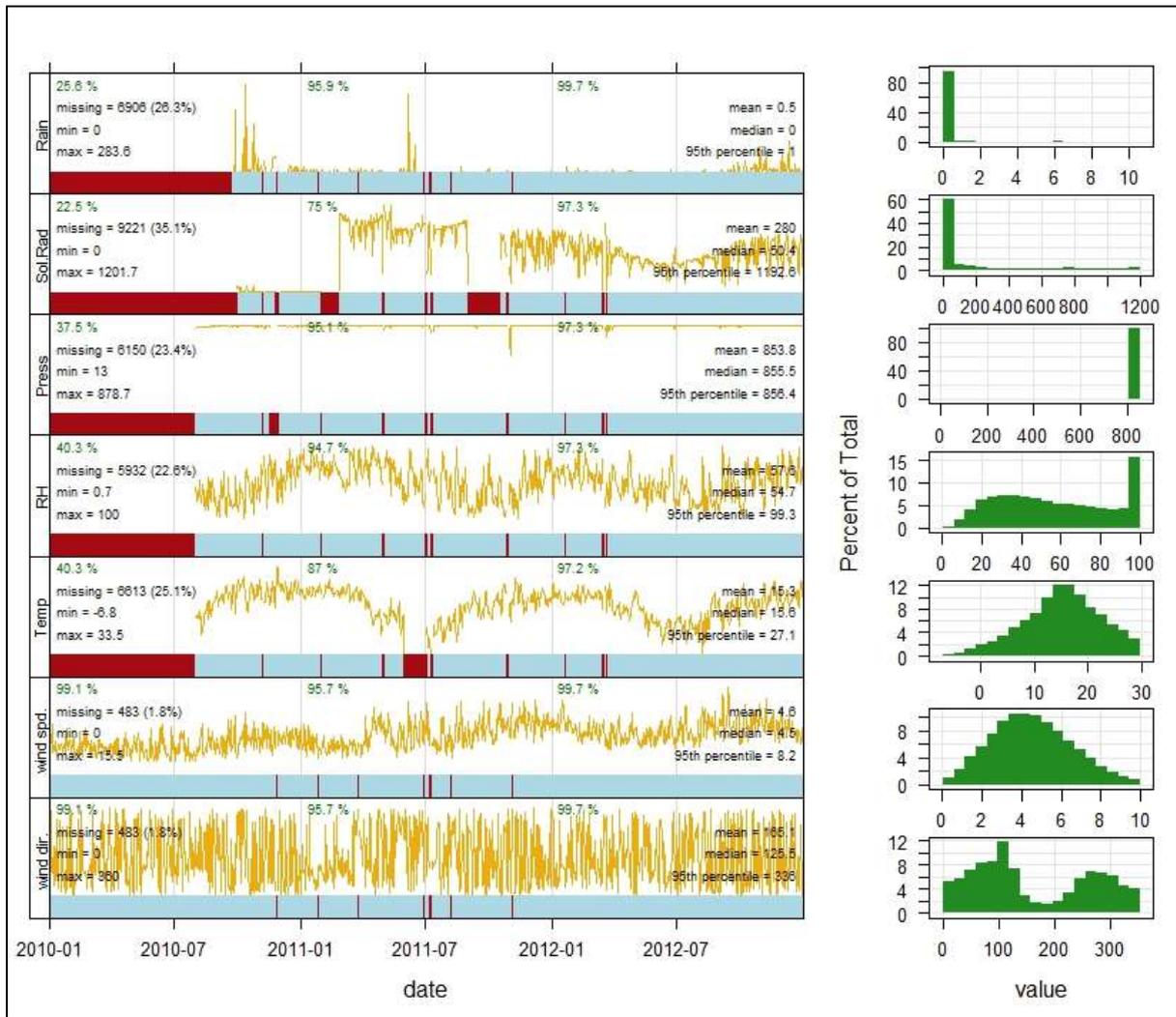


Figure G-7: Summary of meteorological data received for Steam Station (2010-2012)

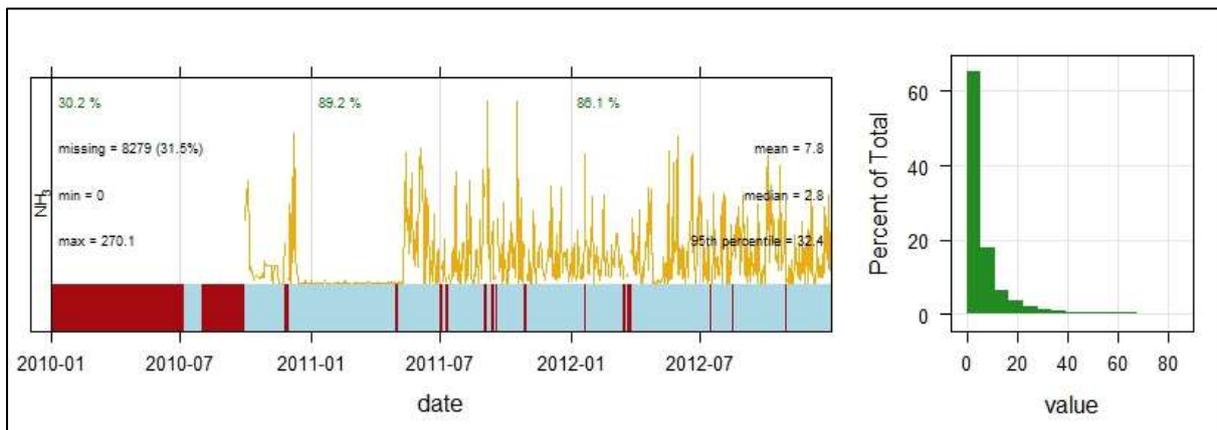


Figure G-8: Summary of ambient data received for Steam Station (2010-2012)

APPENDIX H: PREDICTED BASELINE AND OBSERVED AIR CONCENTRATIONS

The following tables summarise the predicted baseline SO₂ and NO₂ concentrations at the AJ Jacobs and Leitrim monitoring site locations, respectively. The peak (maximum), 99th, 90th, 50th and annual average values are given for each of the simulated years, 2010, 2011 and 2012. The corresponding observed concentration values are also summarised in the tables for comparison. Estimates of long-term background concentrations were obtained from the observed values at the ranked position when no contributions from the simulated sources were predicted.

Table H-1: Predicted and observed SO₂ concentration statistics

	Year	SO ₂ Concentration (µg/m ³)			
		Leitrim		AJ Jacobs	
		Predicted	Observed	Predicted	Observed
Maximum	2010	185.1	473.4	371.6	495.5
	2011	158.8	458.4	456.3	678.9
	2012	327.3	455.5	593.6	542.7
	<i>Average</i>	223.7	462.4	473.8	572.4
99 th Percentile	2010	56.5	171.6	174.6	255.9
	2011	54.8	155.9	178.2	265.6
	2012	54.0	156.3	171.8	259.6
	<i>Average</i>	55.1	161.3	174.9	260.4
90 th Percentile	2010	17.3	50.2	8.7	78.3
	2011	11.8	47.7	13.4	92.8
	2012	14.9	57.1	10.6	88.2
	<i>Average</i>	14.7	51.6	10.9	86.4
50 th Percentile	2010	0.0	10.4	0.0	18.7
	2011	0.0	8.7	0.0	24.9
	2012	0.0	10.3	0.0	31.3
	<i>Average</i>	0.0	9.8	0.0	25.0
Annual Average	2010	4.5	21.9	8.4	34.8
	2011	3.7	19.8	8.9	42.6
	2012	4.2	22.4	8.6	46.1
	<i>Average</i>	4.1	21.3	8.6	41.2
Background (observed value when prediction indicated no contribution)	2010		18.3		31.3
	2011		16.3		39.7
	2012		17.8		48.8
	<i>Average</i>		17.4		39.9

Table H-2: Predicted and observed NO₂ concentration statistics

	Year	NO ₂ Concentration (µg/m ³)			
		Leitrim		AJ Jacobs	
		Predicted	Observed	Predicted	Observed
Maximum	2010	118.8	140.3	205.5	241.8
	2011	105.3	355.9	254.6	156.5
	2012	181.8	118.8	329.7	106.0
	Average	135.3	205.0	263.2	168.1
99 th Percentile	2010	59.2	83.1	109.9	75.8
	2011	52.9	79.3	110.6	81.8
	2012	55.1	86.2	109.1	66.2
	Average	55.7	82.9	109.9	74.6
90 th Percentile	2010	8.7	46.9	5.9	44.4
	2011	6.3	44.1	8.7	45.5
	2012	7.0	50.2	7.1	37.8
	Average	7.4	47.1	7.2	42.6
50 th Percentile	2010	0.0	15.8	0.0	15.5
	2011	0.0	14.6	0.0	14.9
	2012	0.0	16.8	0.0	13.0
	Average	0.0	15.7	0.0	14.5
Annual Average	2010	3.6	20.9	6.3	20.2
	2011	3.0	19.6	6.7	20.2
	2012	3.2	22.2	6.6	17.0
	Average	3.3	20.9	6.5	19.1
Background (observed value when prediction indicated no contribution)	2010		21.3		24.2
	2011		20.6		22.2
	2012		22.1		19.5
	Average		21.3		22.0

APPENDIX I: DAILY AND ANNUAL AMBIENT CONCENTRATIONS

Sulfur dioxide (SO₂)

Daily

Daily SO₂ concentrations (99th percentile) were predicted to exceed the daily NAAQS at the closest three receptors if Infrachem were to theoretically comply with Existing Plant standards (Figure I-1); these exceedances would be a result of emissions from Steam Station 1 (Figure I-2), where Steam Station 2 (Figure I-5) and the Incinerators (Figure I-7) would make smaller contributions to the daily SO₂ concentrations. Daily average SO₂ concentrations were predicted to decrease with theoretical compliance with New Plant Standards, except at near-by receptors as a result of changes at Steam Station 2 (due to changes in plume buoyancy - Figure I-6). The Alternative Emission Limits scenario was predicted to result in increased daily SO₂, relative to the airshed baseline, by a maximum of 80% at the AJ Jacobs monitoring station (Figure I-1) as a result of higher peak emissions at both Steam Station 1 and Steam Station 2.

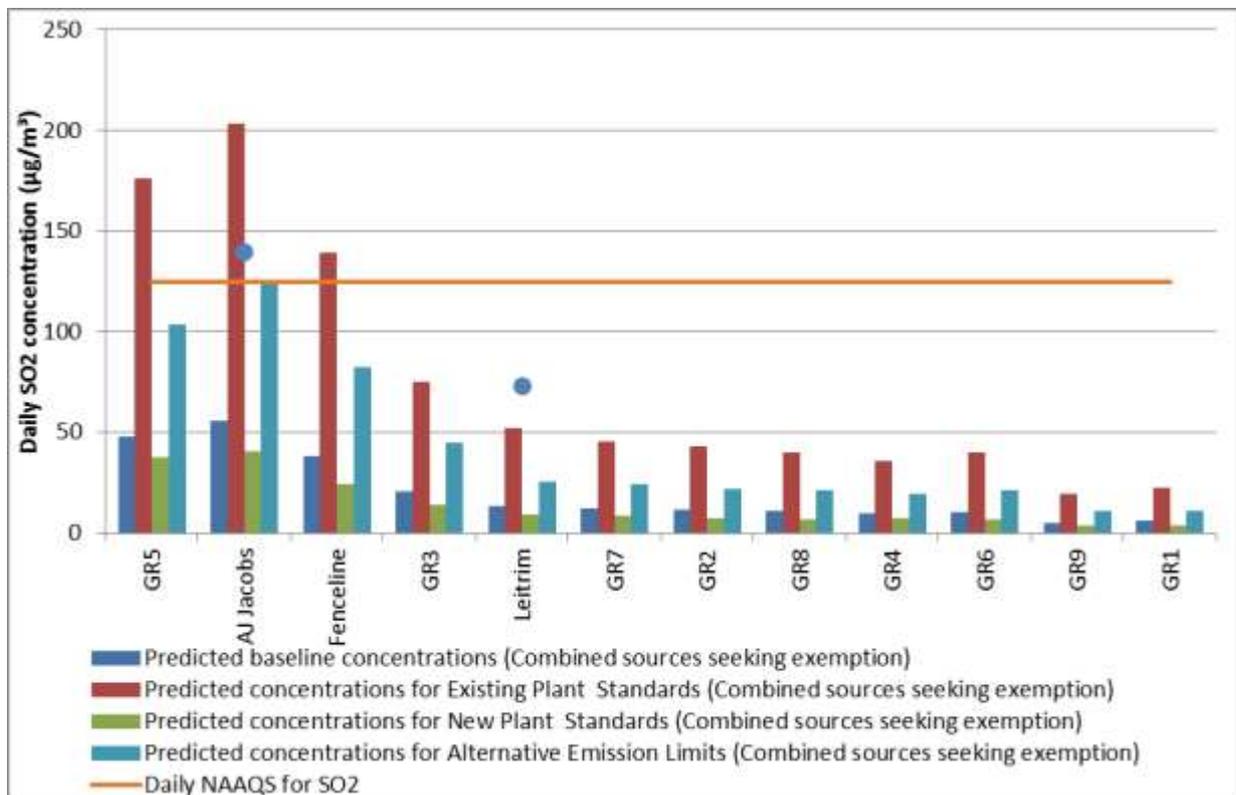


Figure I-1: Predicted 99th percentile daily SO₂ concentration at identified receptors for combined Infrachem sources seeking postponement (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

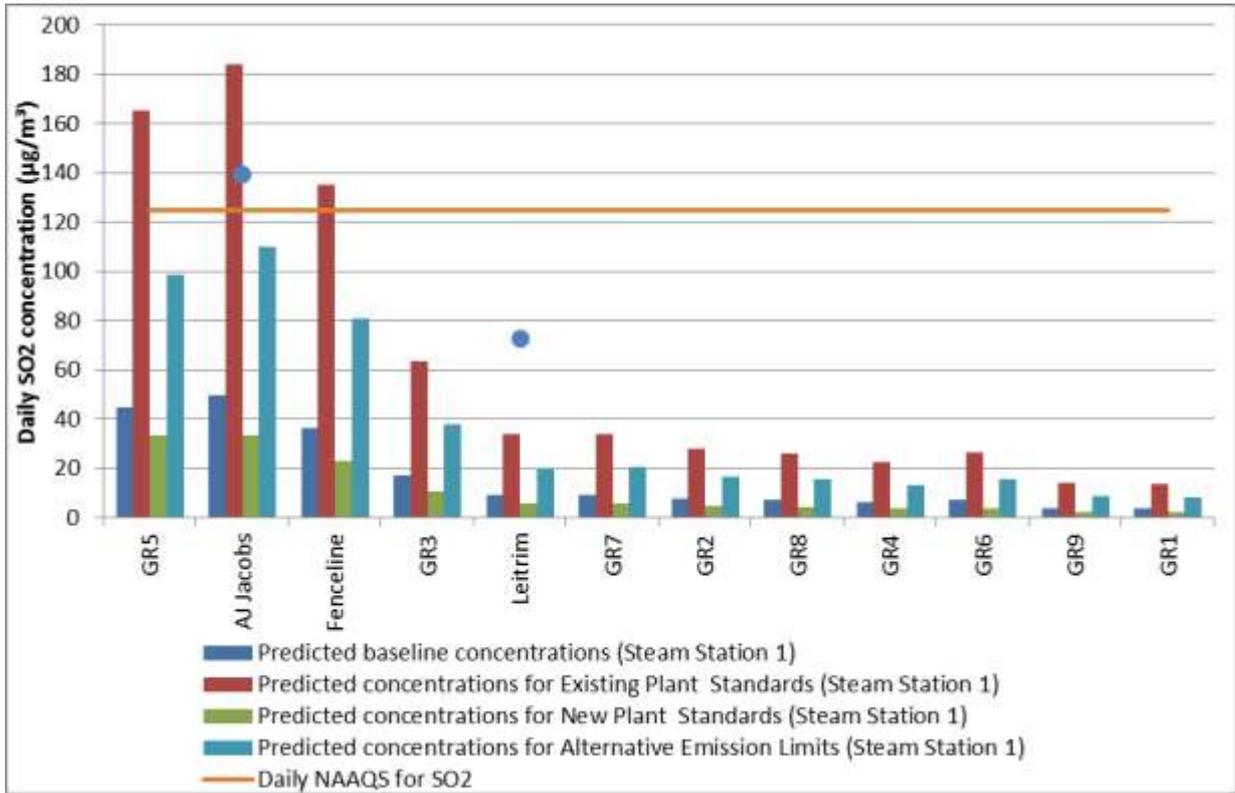


Figure I-2: Predicted 99th percentile daily SO₂ concentration at identified receptors for Infracchem Steam Station 2 (receptor code names as detailed in Table 5 20, where locations are shown in Figure 5 15)

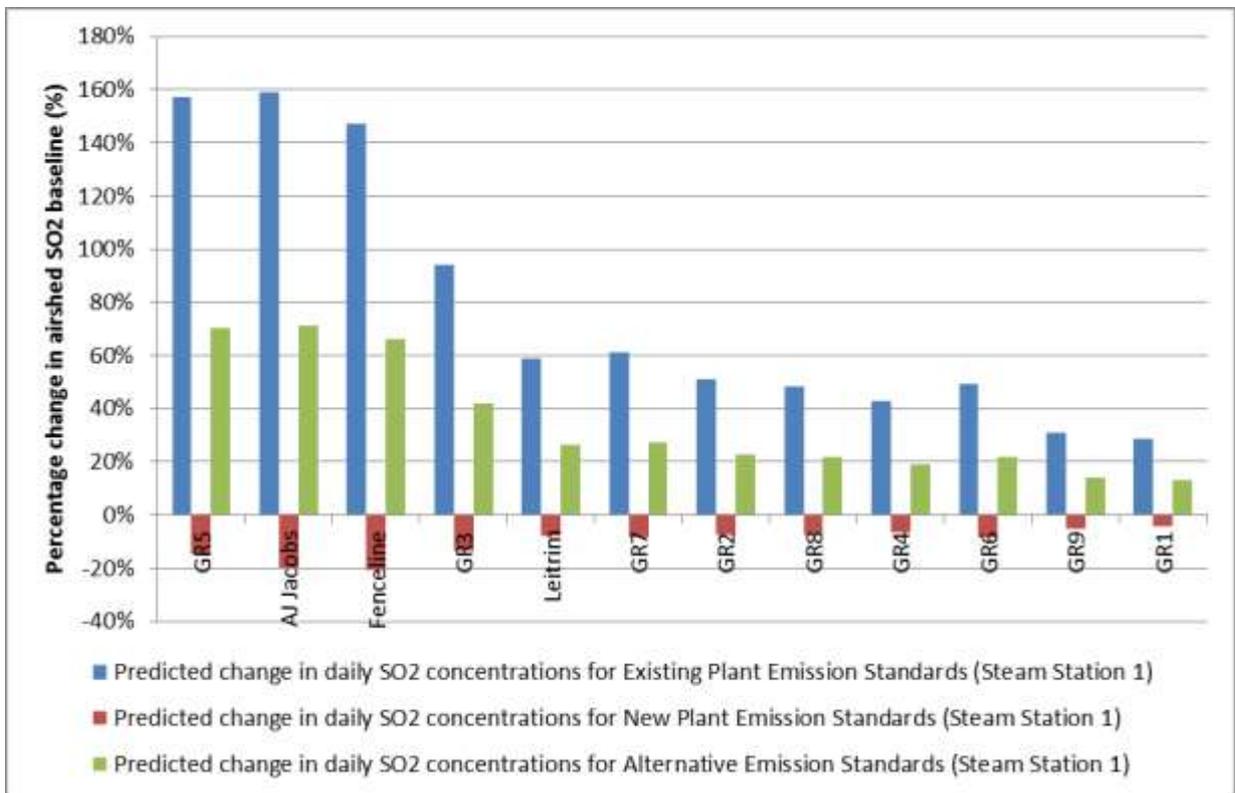


Figure I-3: Theoretical change in daily ambient SO₂ concentrations and the airshed baseline at the identified receptors for Infracchem Steam Station 1 (change calculated using Equation 1)

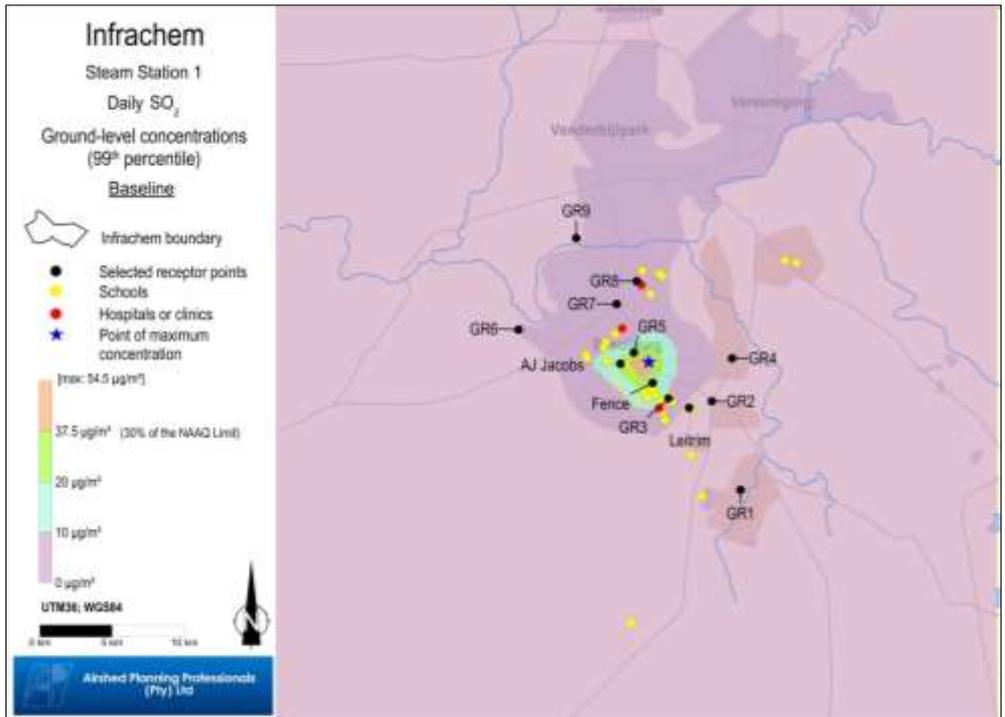


Figure I-4: Predicted 99th percentile daily SO₂ concentrations as a result of Baseline emissions from Steam Station 1

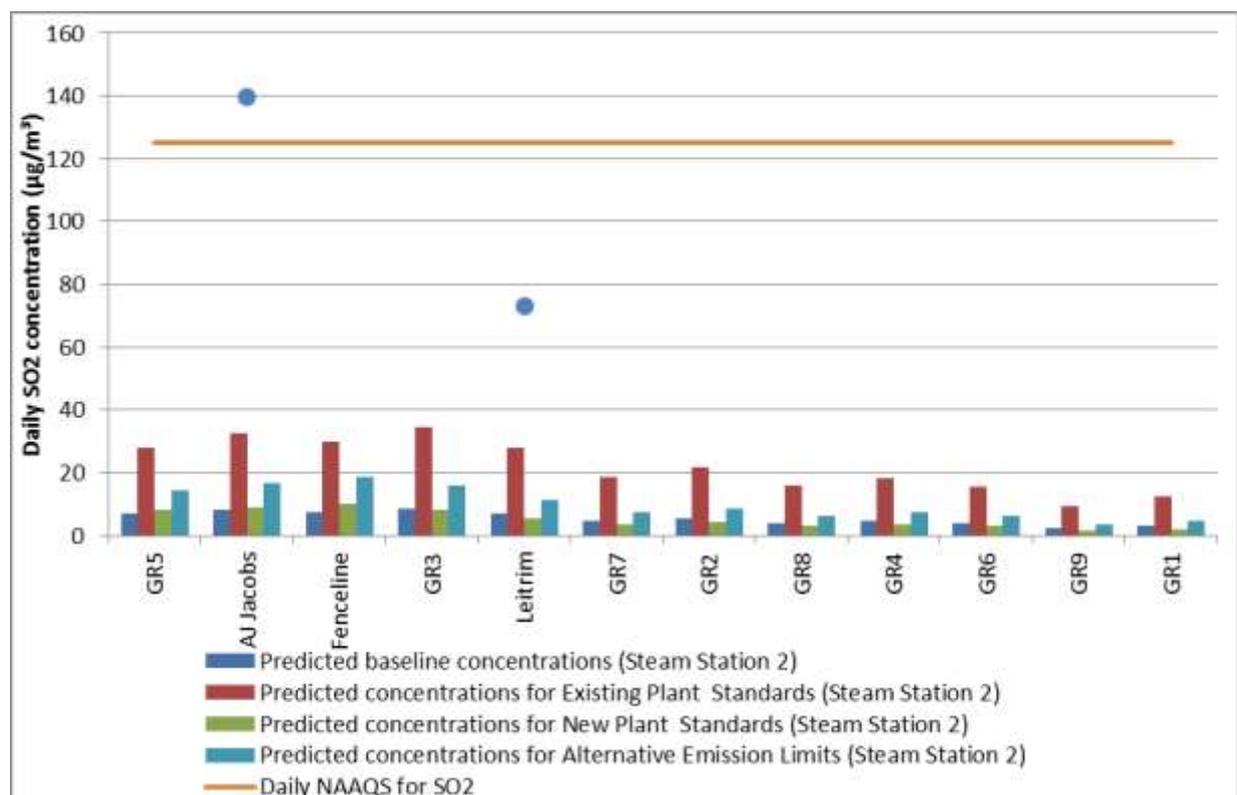


Figure I-5: Predicted 99th percentile daily SO₂ concentration at identified receptors for Infrachem Steam Station 2 (receptor code names as detailed in Table 5 20, where locations are shown in Figure 5 15)

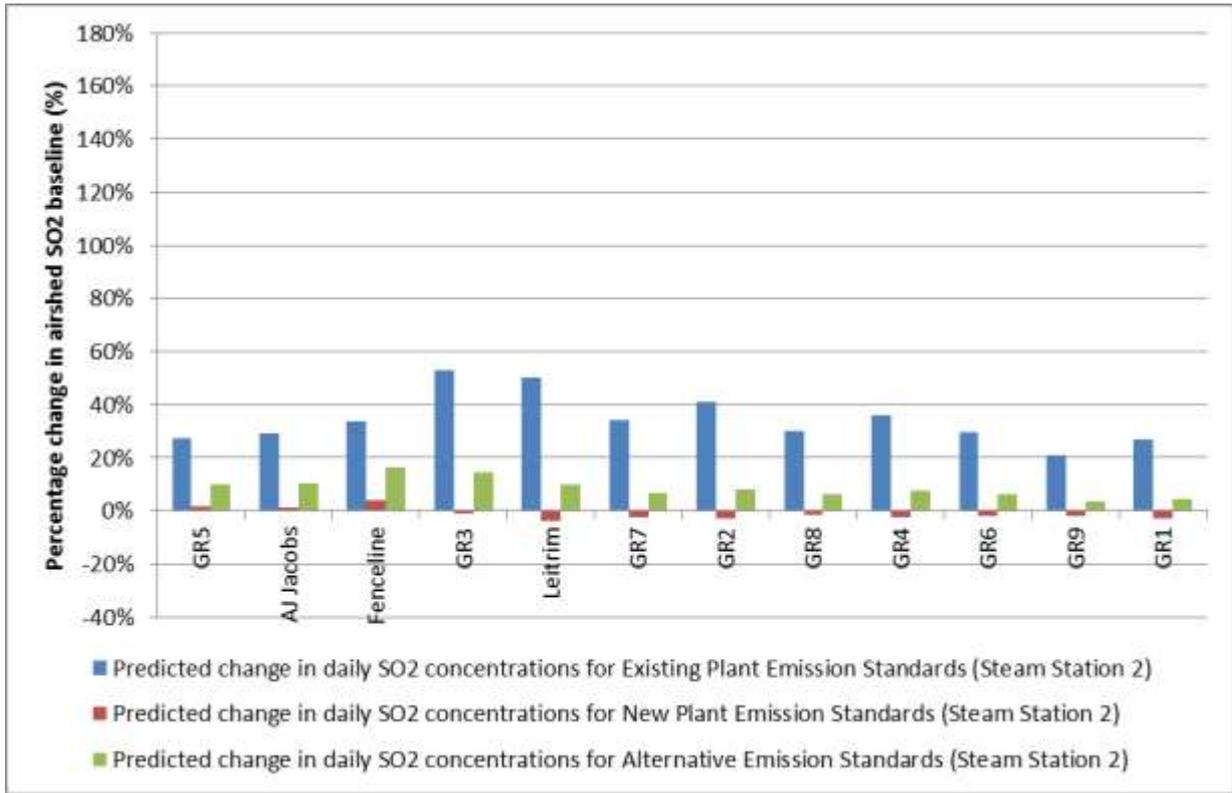


Figure I-6: Theoretical change in daily ambient SO₂ concentrations and the airshed baseline at the identified receptors for Infrachem Steam Station 2 (change calculated using Equation 1)

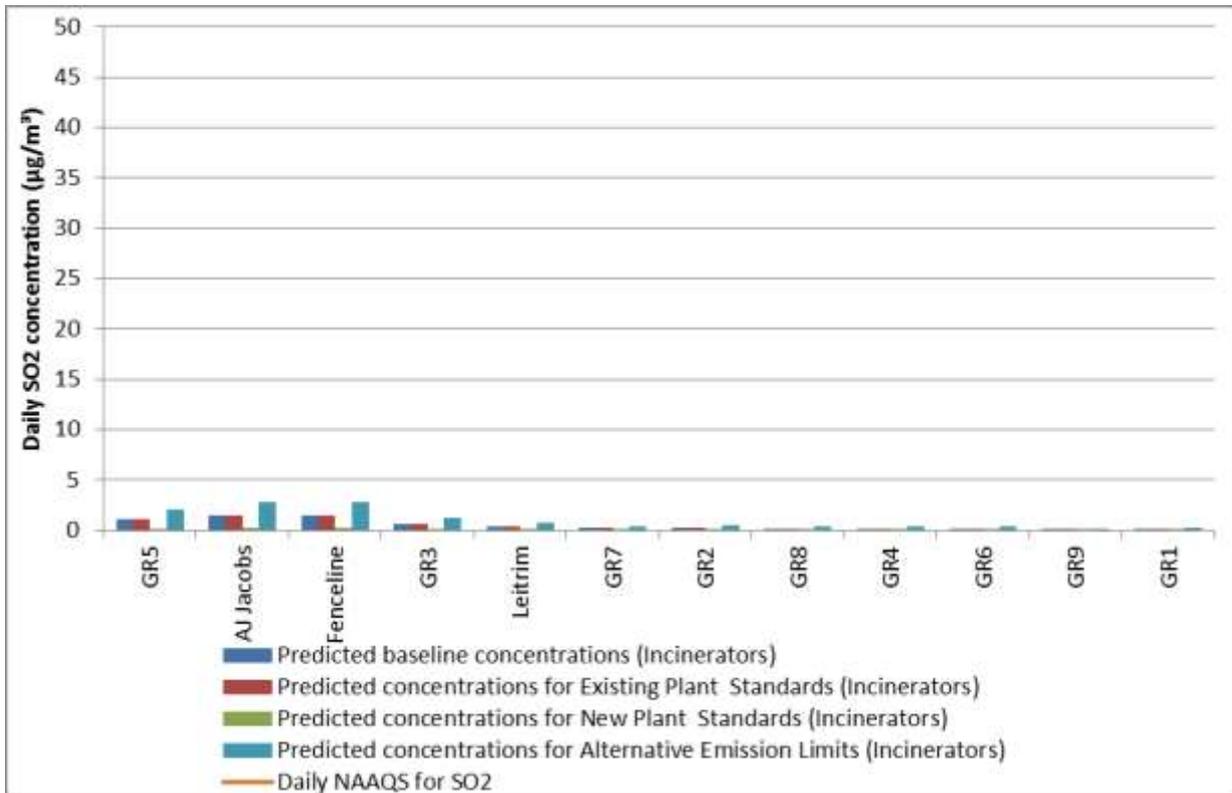


Figure I-7: Predicted 99th percentile daily SO₂ concentration at identified receptors for Infrachem Steam Stations (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

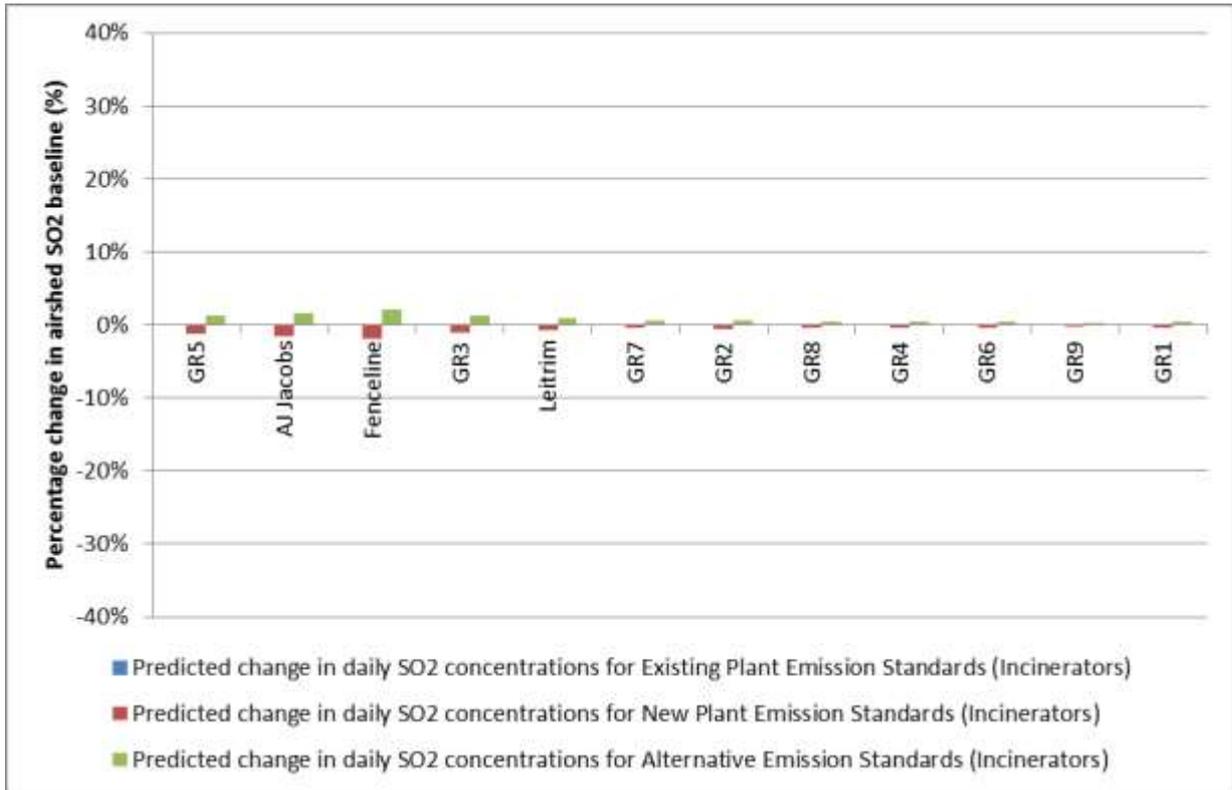


Figure I-8: Theoretical change in daily ambient SO₂ concentrations and the airshed baseline at the identified receptors for Infracchem Incinerators (change calculated using Equation 1)

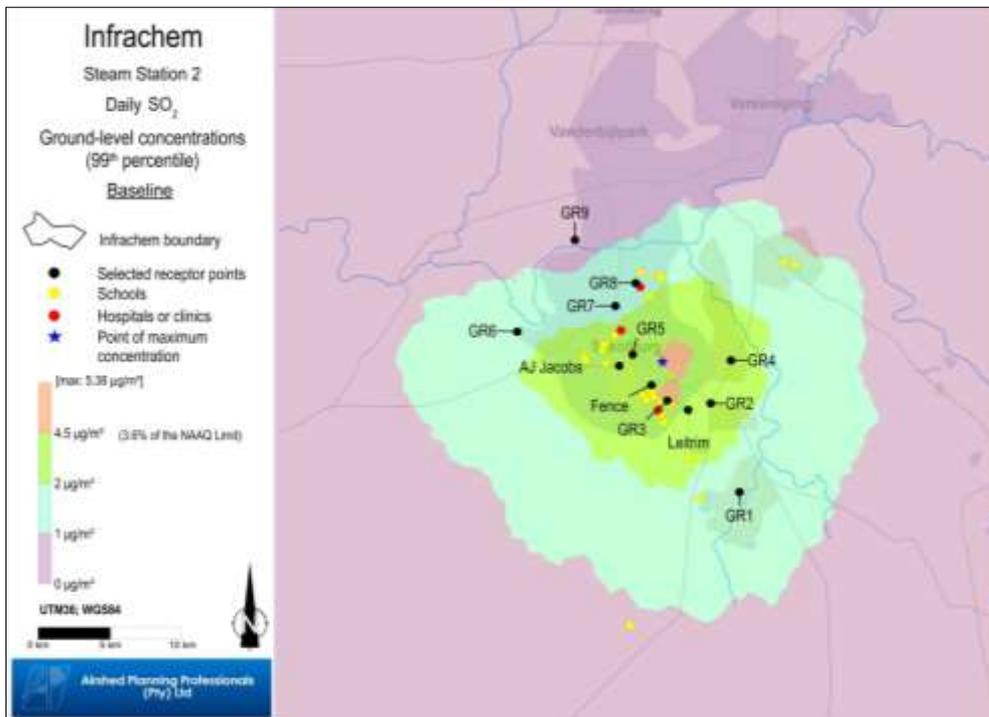


Figure I-9: Predicted 99th percentile daily SO₂ concentrations as a result of Baseline emissions from Steam Station 2

Annual

Predicted annual ambient SO₂ concentrations show similar trends as for hourly (Section 5.1.8.1.1) and daily average concentrations (above). The source with the largest impact is Steam Station 1 (Figure I-10). Improvements in annual ambient SO₂ concentrations reach a maximum of 6.9% at Fenceline as a result of Steam Station 1 theoretically meeting New Plant Standards (Figure I-12). Annual SO₂ concentrations were predicted to increase by a maximum of 25% (at the Fenceline monitoring station) under the peak emission rates of the Alternative Emission Limit scenario (Figure I-12 and Figure I-15).

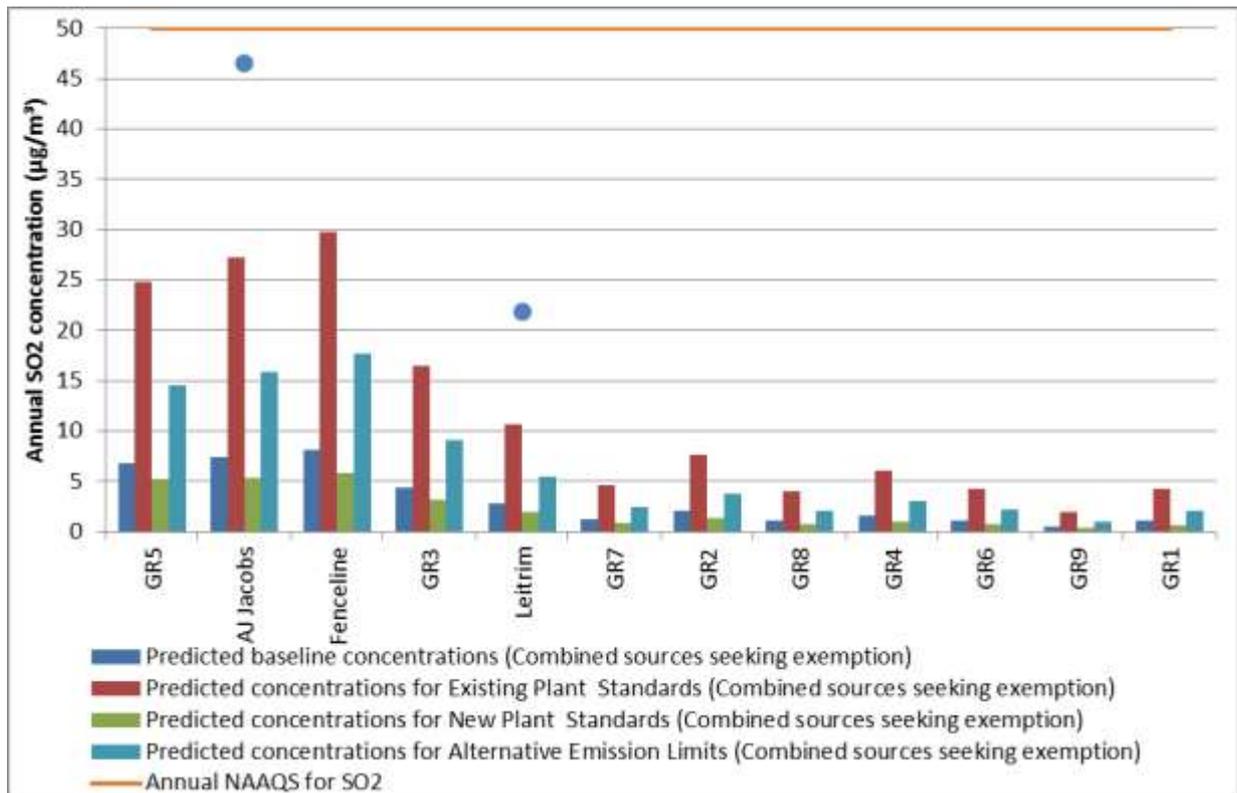


Figure I-10: Predicted annual SO₂ concentration at identified receptors for combined Infrachem sources seeking postponement (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

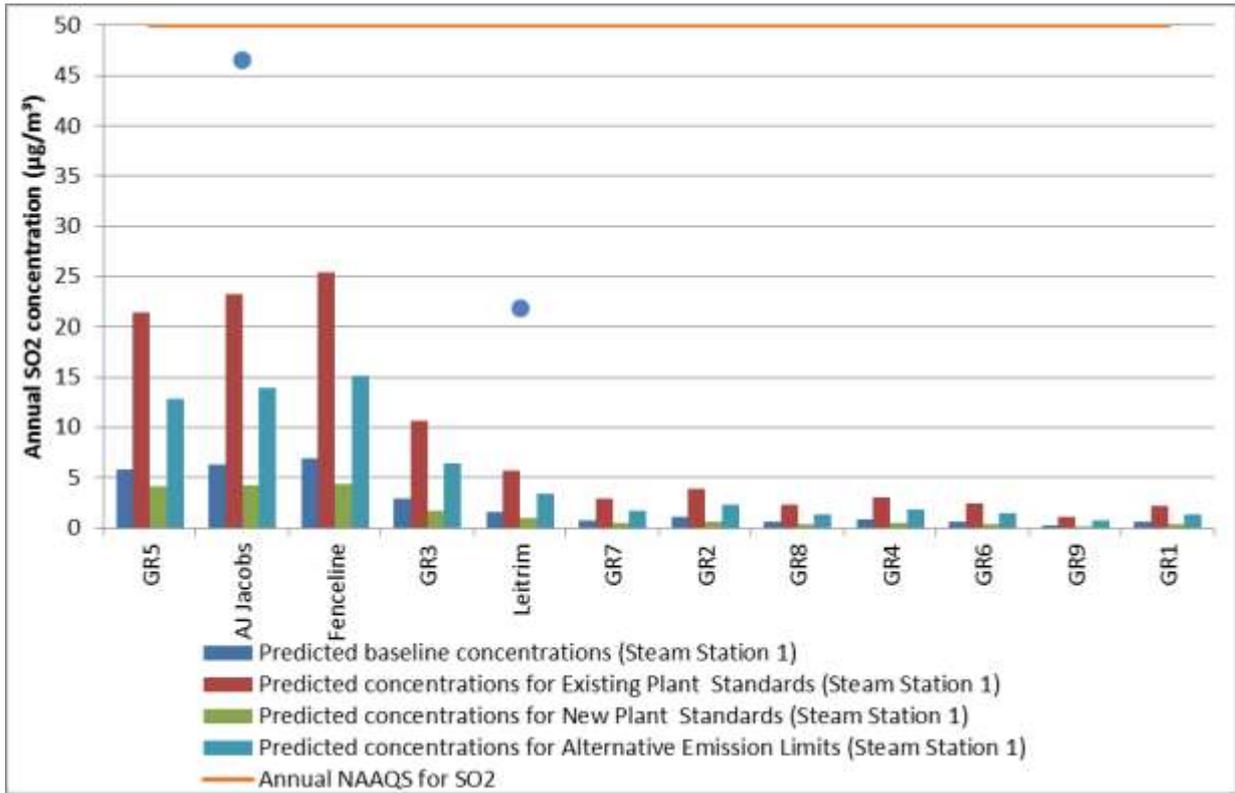


Figure I-11: Predicted annual SO₂ concentration at identified receptors for Infracchem Steam Station 1 (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

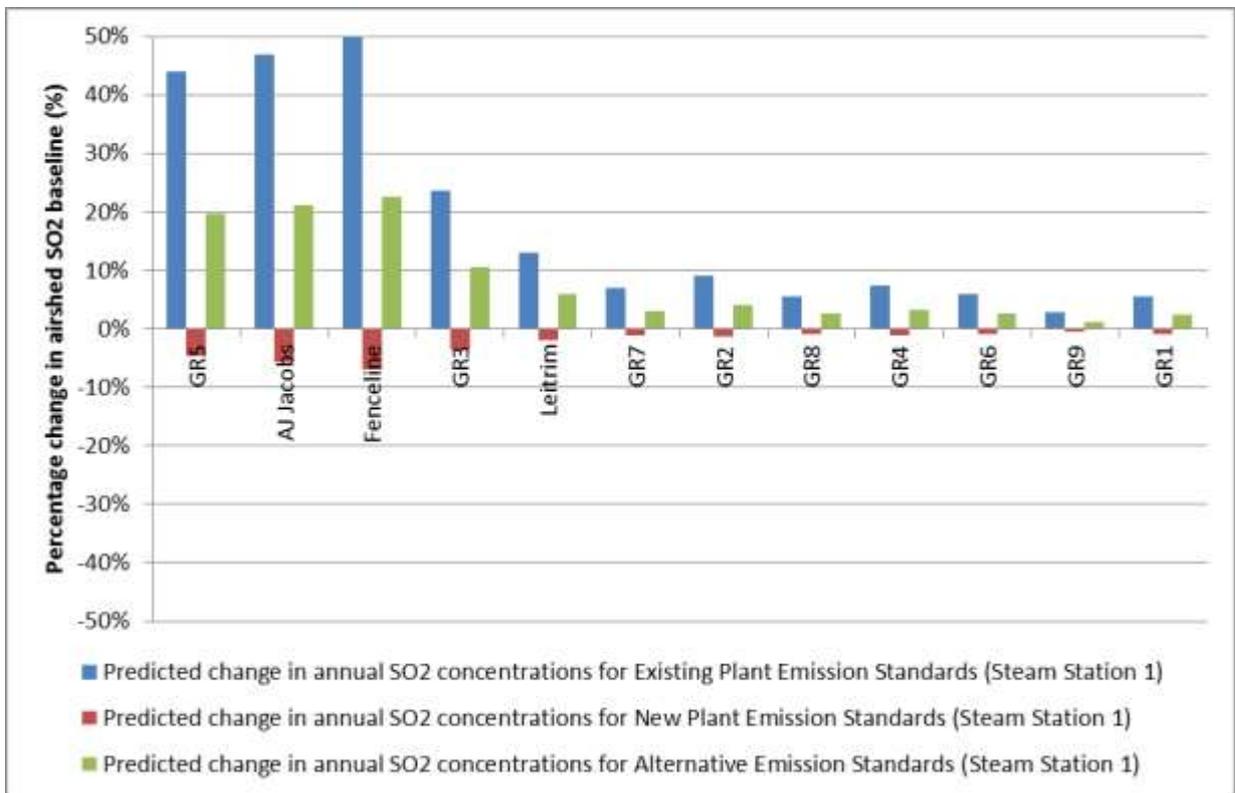


Figure I-12: Theoretical change in annual ambient SO₂ concentrations and the airshed baseline at the identified receptors for Infracchem Steam Station 1 (change calculated using Equation 1)

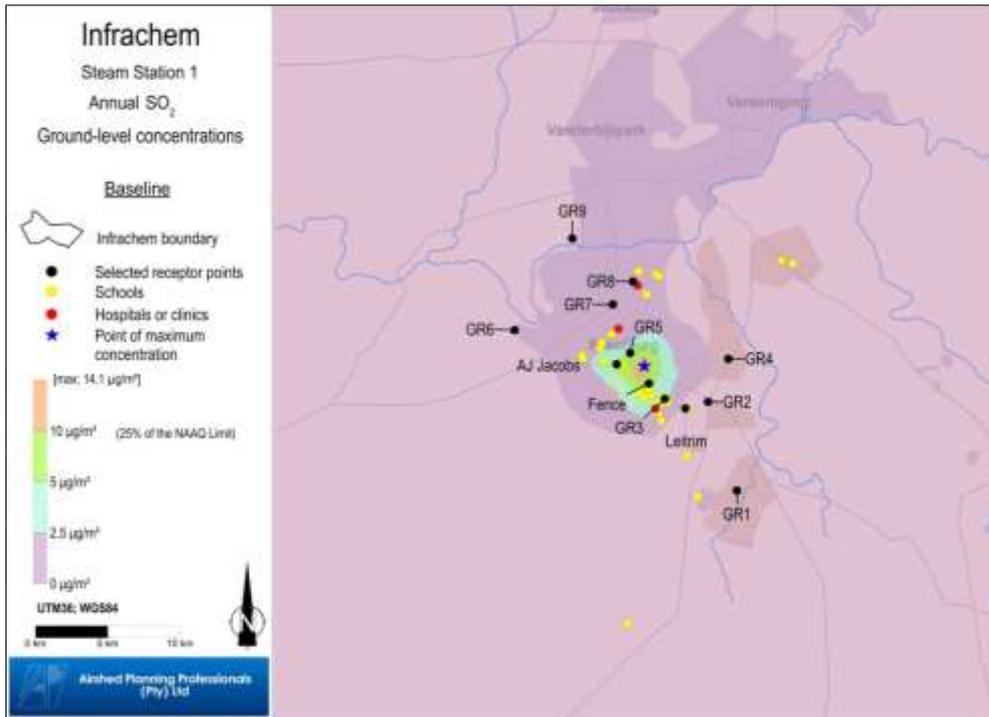


Figure I-13: Predicted annual SO₂ concentrations as a result of Baseline emissions from Steam Station 1

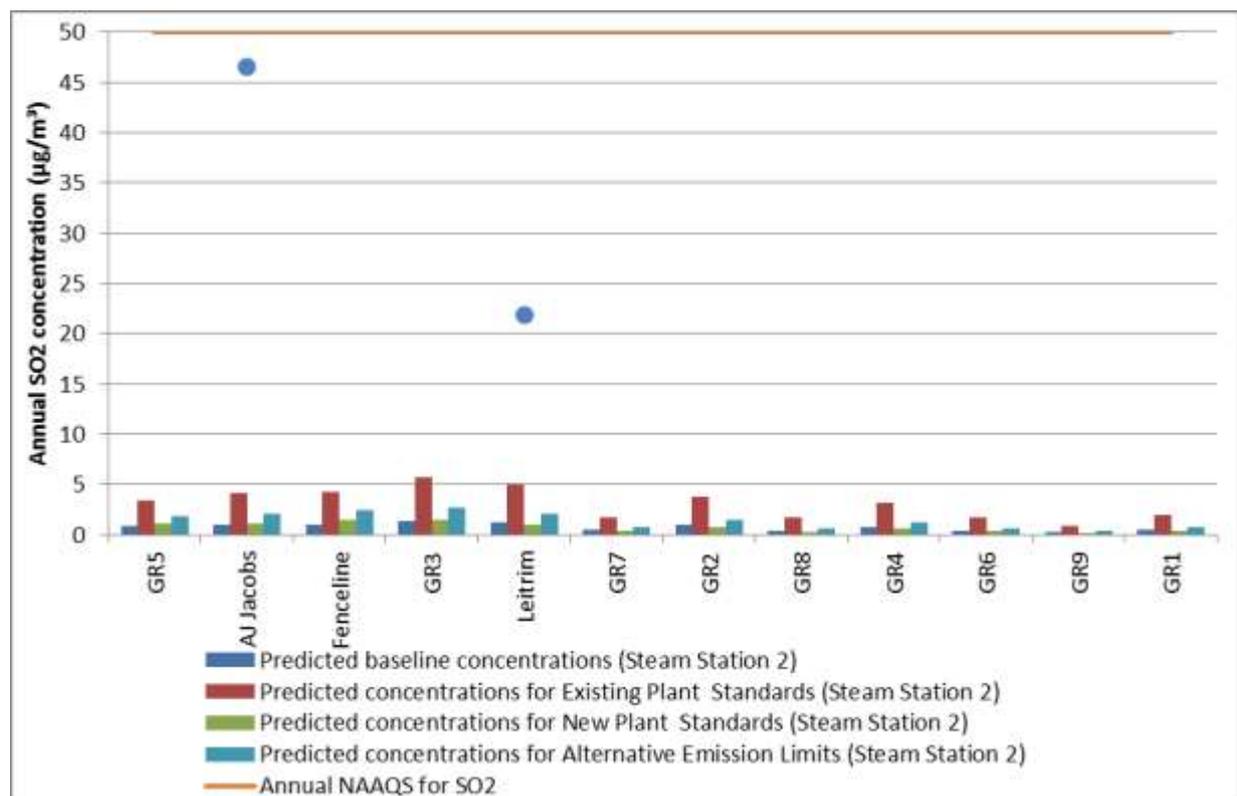


Figure I-14: Predicted annual SO₂ concentration at identified receptors for Infrachem Steam Station 2 (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

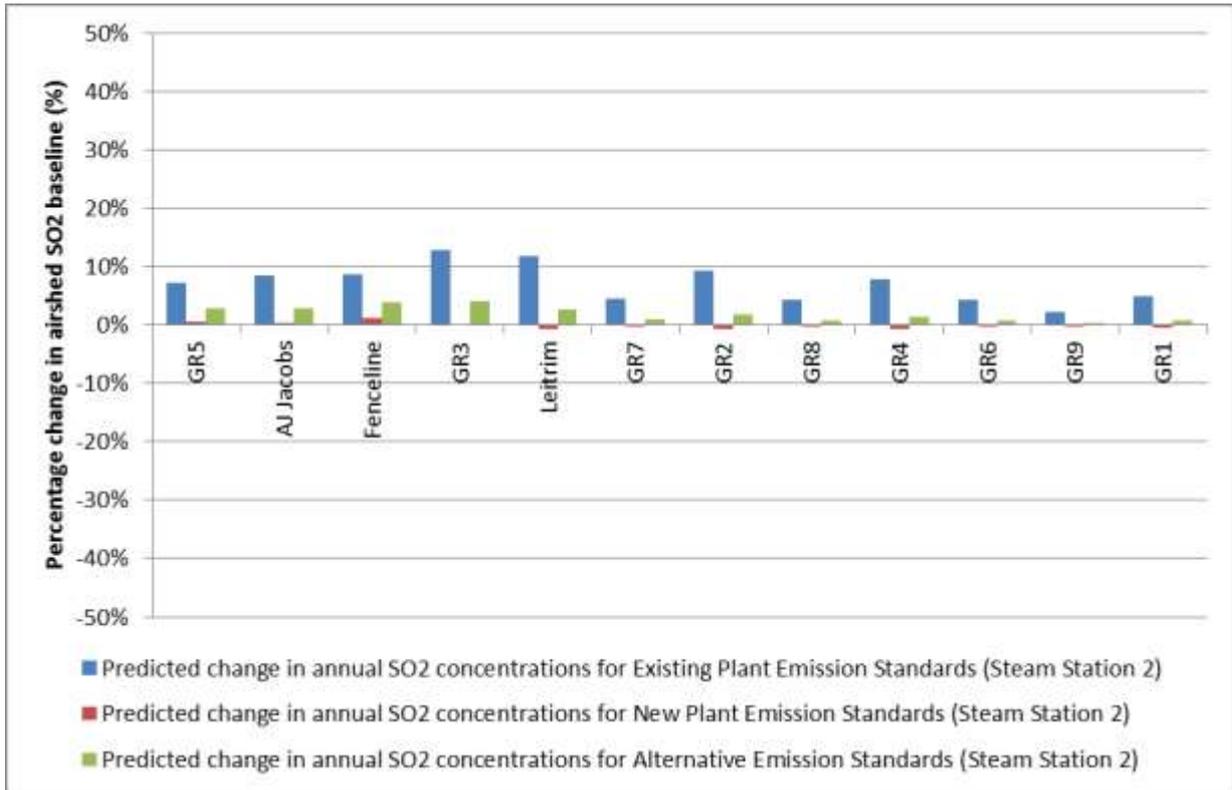


Figure I-15: Theoretical change in annual ambient SO₂ concentrations and the airshed baseline at the identified receptors for Infracchem Steam Station 2 (change calculated using Equation 1)

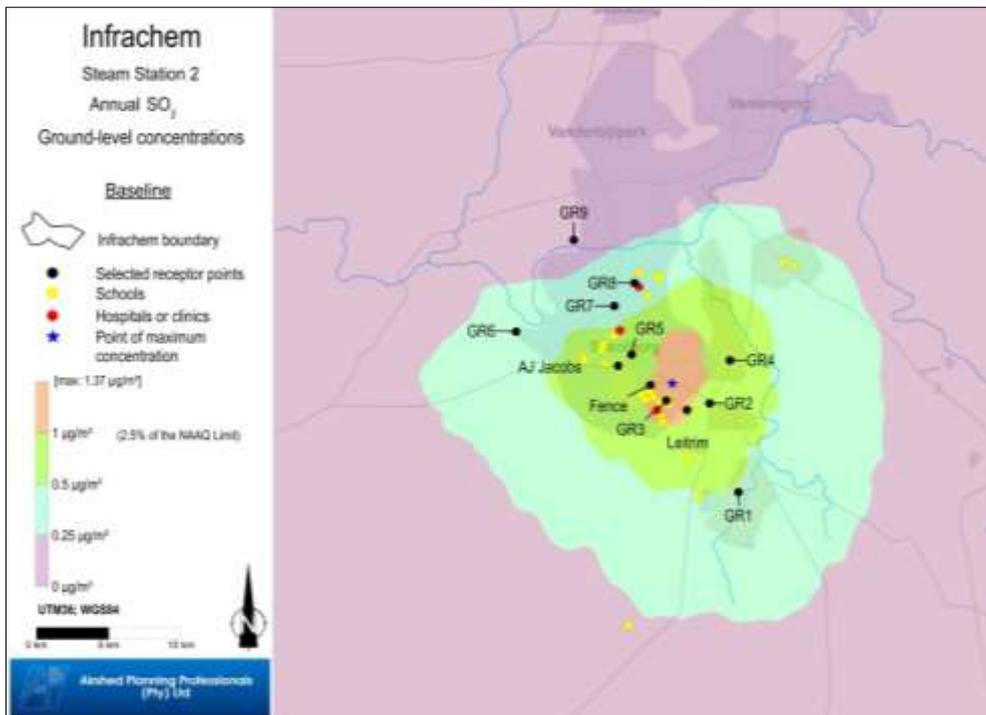


Figure I-16: Predicted annual SO₂ concentrations as a result of Baseline emissions from Steam Station 2

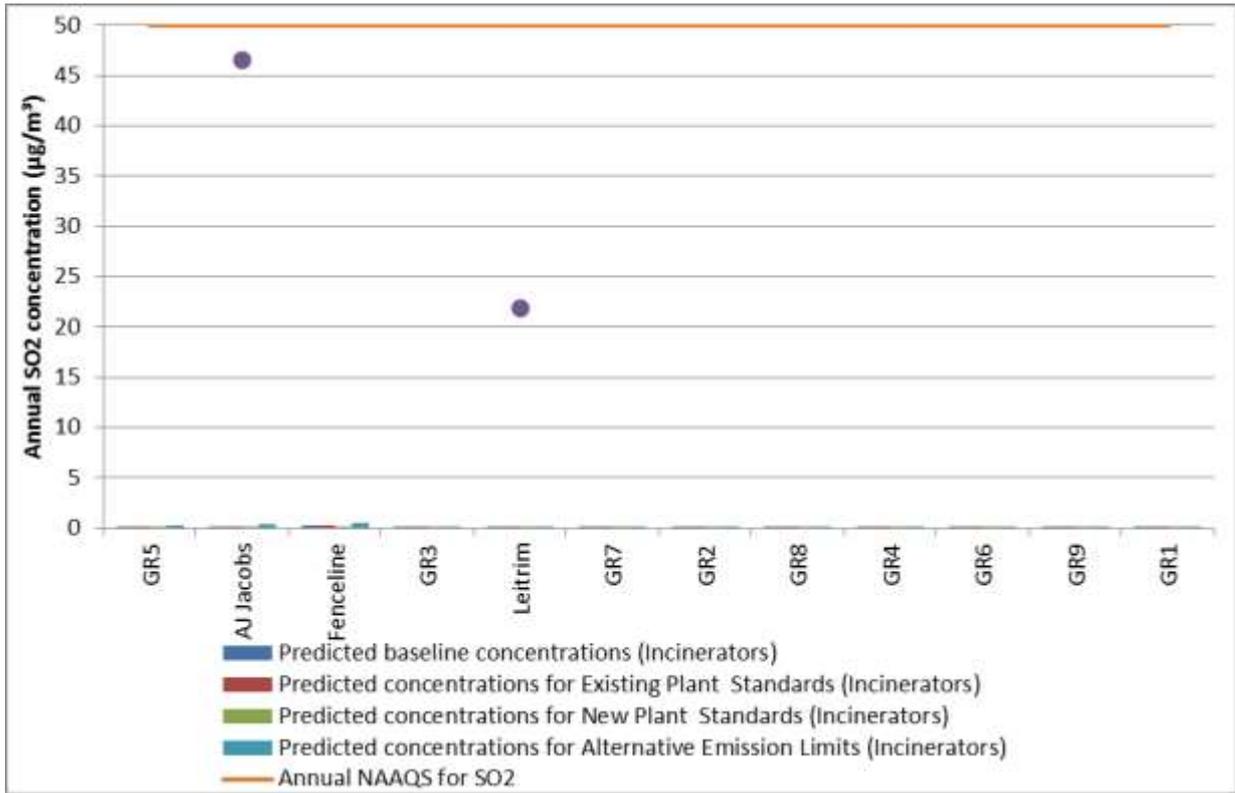


Figure I-17: Predicted annual SO₂ concentration at identified receptors for Infracchem Incinerators (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

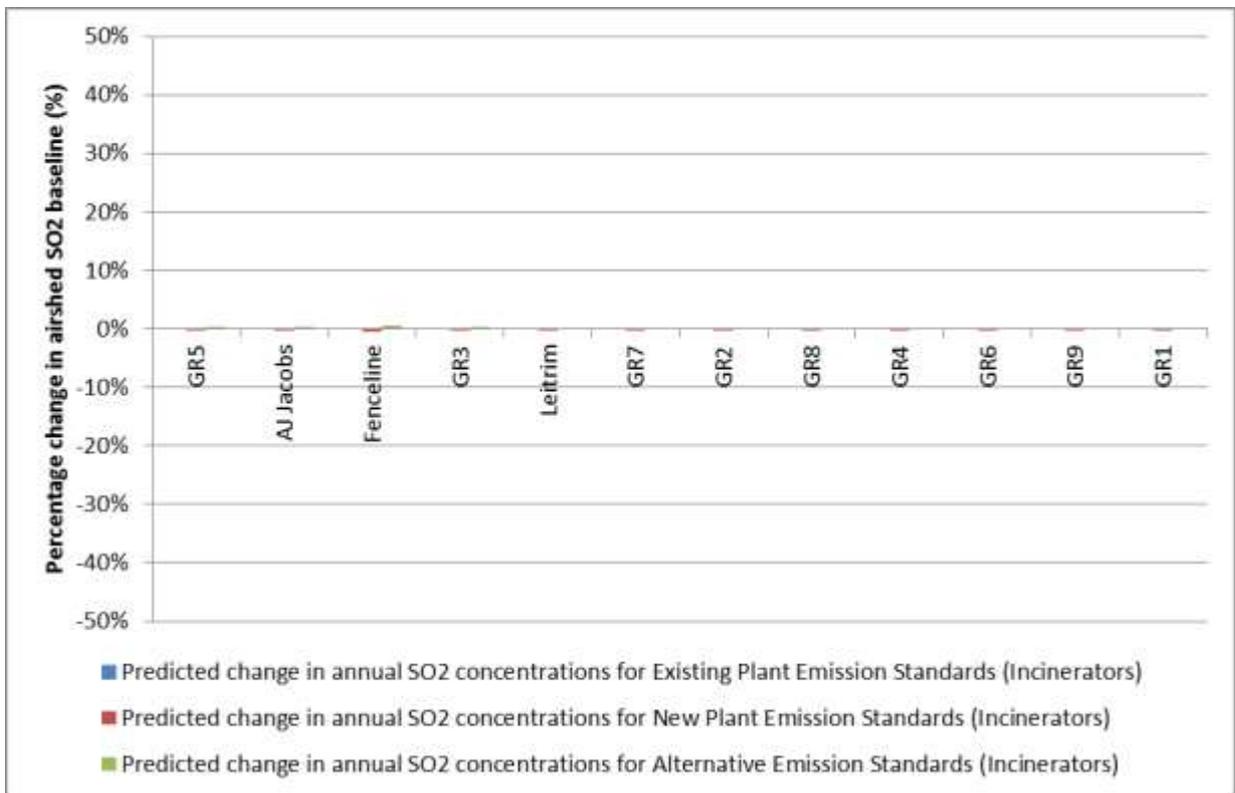


Figure I-18: Theoretical change in annual ambient SO₂ concentrations and the airshed baseline at the identified receptors for Infracchem Incinerators (change calculated using Equation 1)

Nitrogen dioxide (NO₂)

Annual

Annual average ambient NO₂ concentrations were predicted to fall below the annual NAAQS for all sources assessed, for all scenarios. As for the hourly predicted NO₂ concentrations, some increases are expected at receptors under the Alternative Emission Limit scenario (Figure I-19). Theoretical compliance with New Plant Standards was also predicted to increase annual NO₂ concentrations at the closest four receptors, as a result of changes in plume buoyancy from the taller stack of Steam Station 2 (Figure I-24).

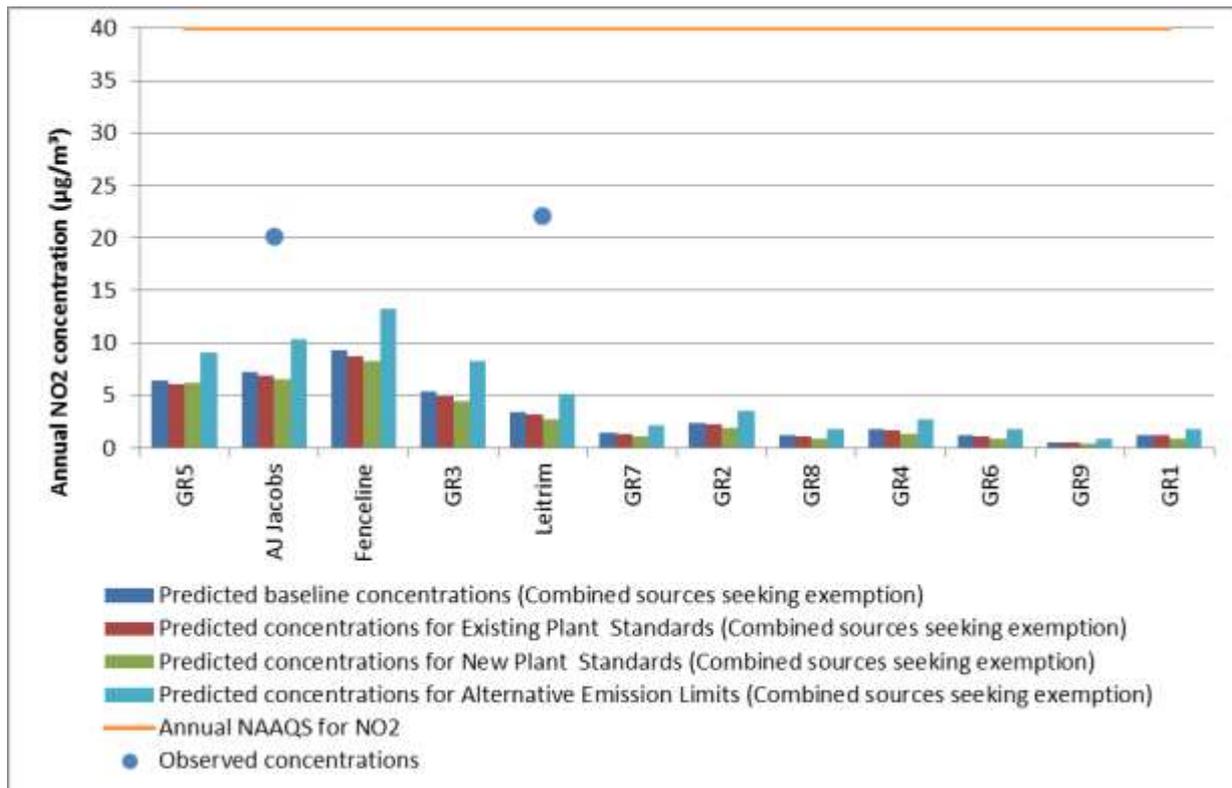


Figure I-19: Predicted annual NO₂ concentration at identified receptors for combined Infrachem sources seeking postponement (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

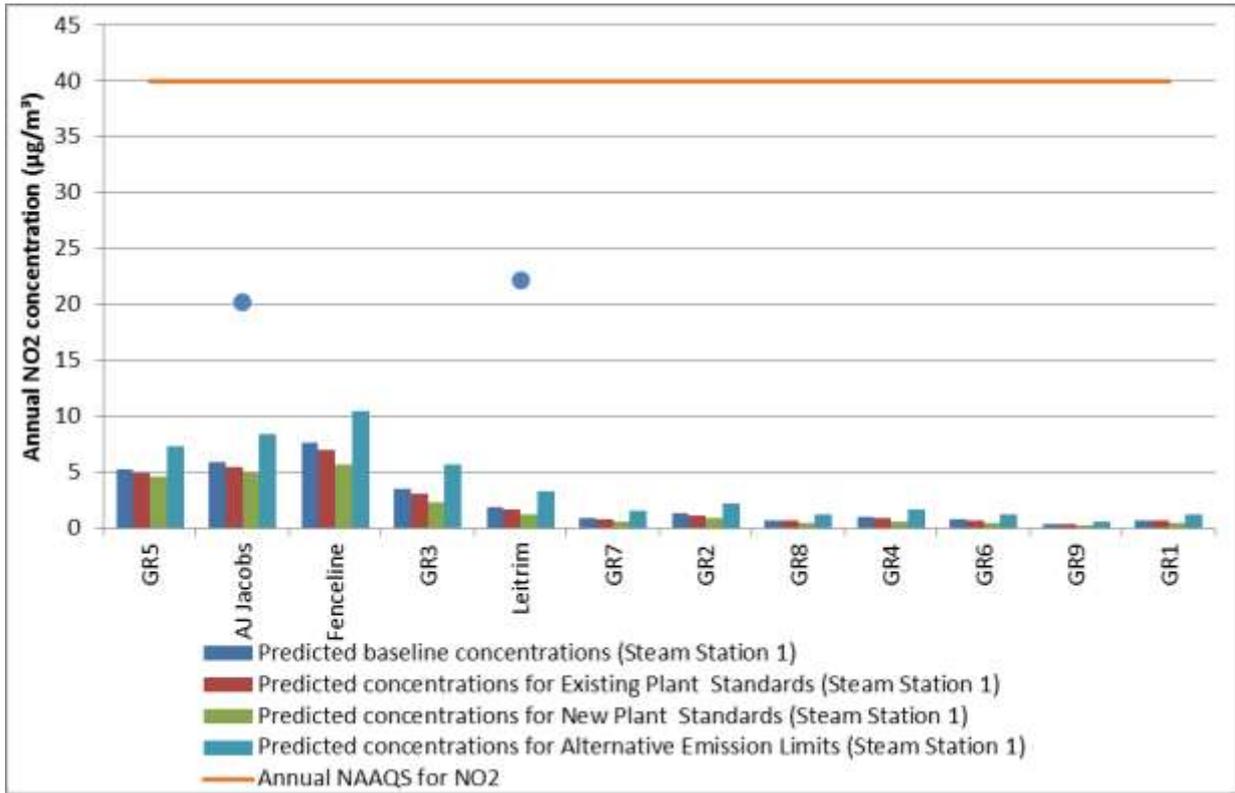


Figure I-20: Predicted annual NO₂ concentration at identified receptors for Infracchem Steam Station 1 (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

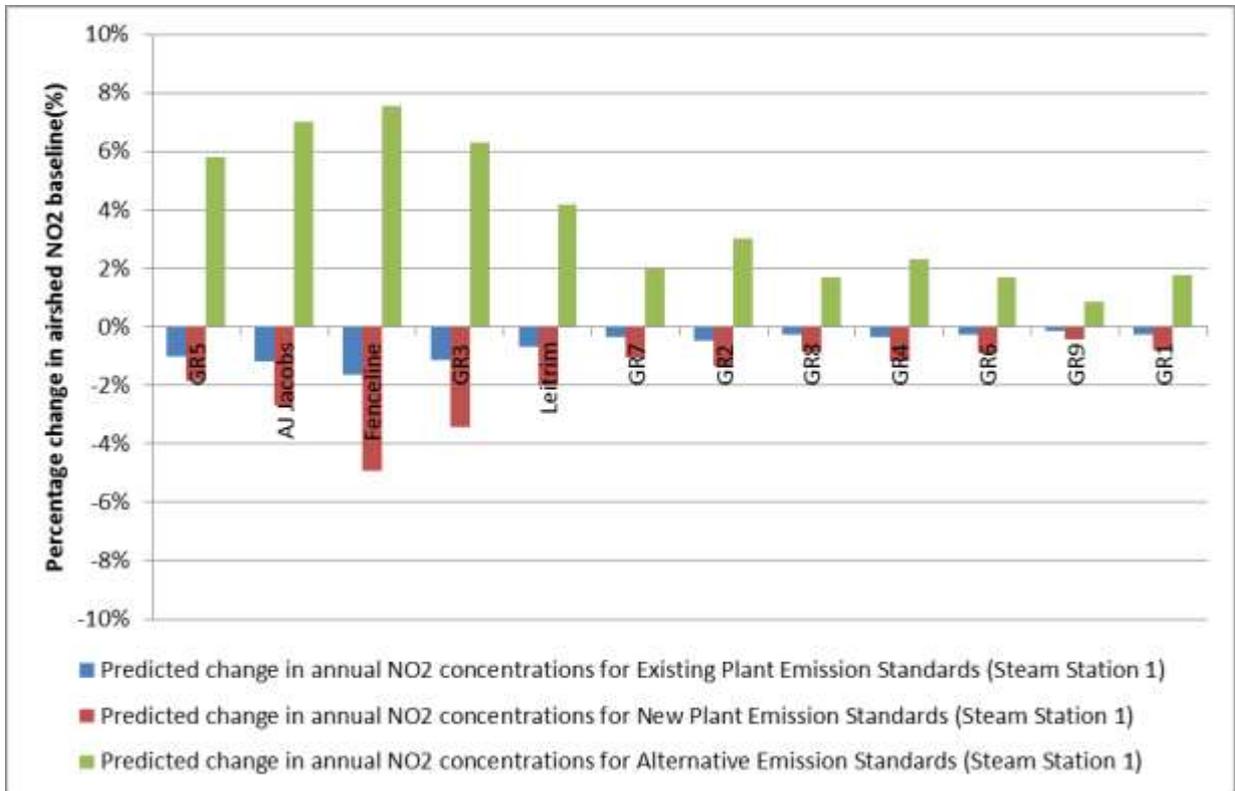


Figure I-21: Theoretical change in annual ambient NO₂ concentrations and the airshed baseline at the identified receptors for Infracchem Steam Station 1 (change calculated using Equation 1)

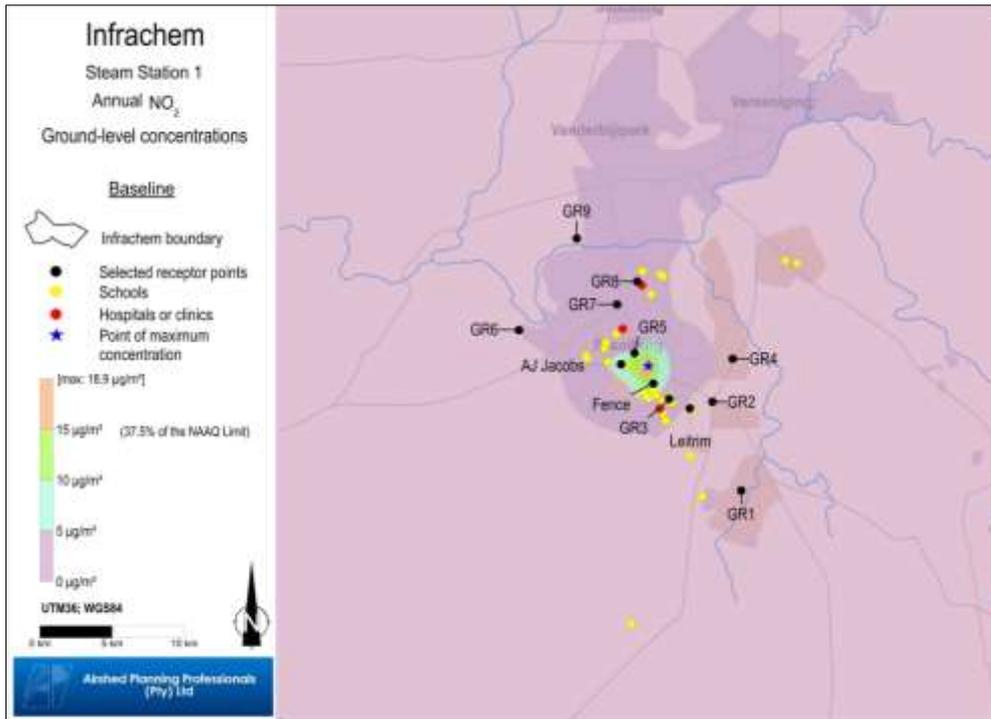


Figure I-22: Predicted annual NO₂ concentrations as a result of Baseline emissions from Steam Station 1

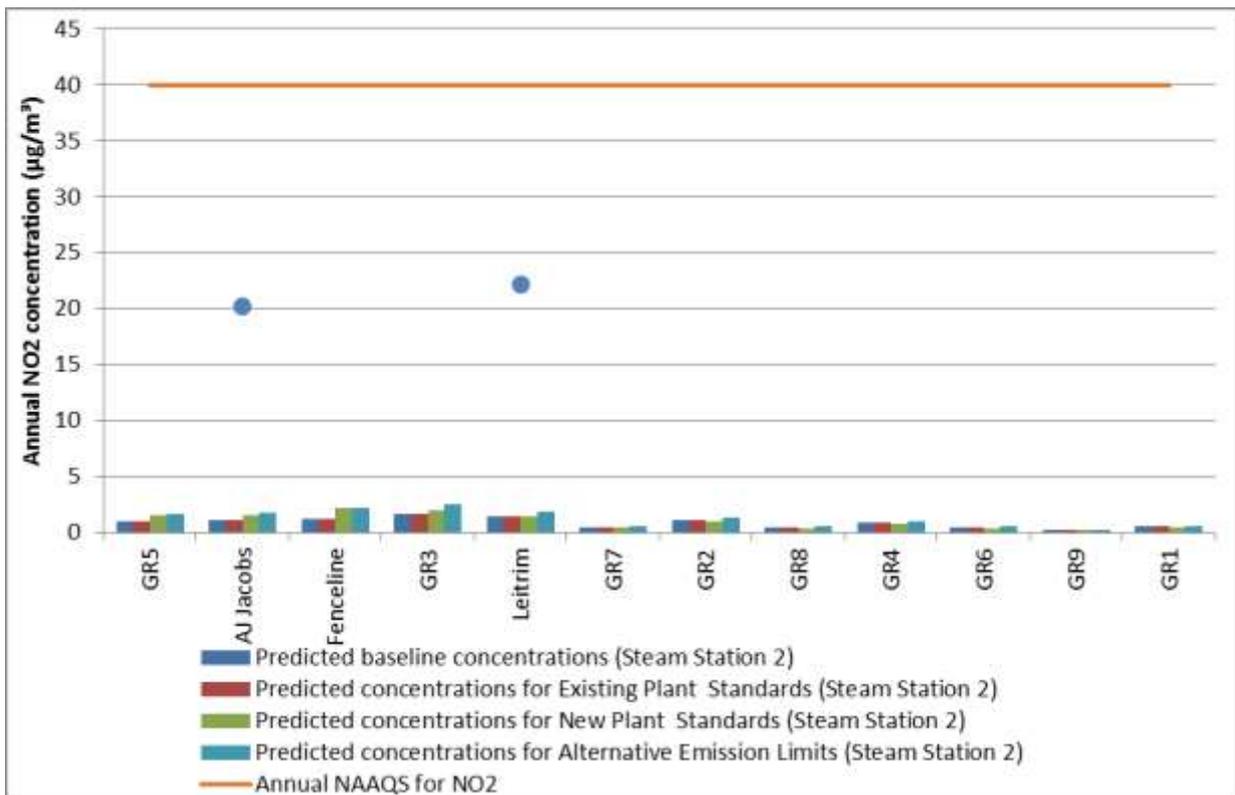


Figure I-23: Predicted annual NO₂ concentration at identified receptors for Infracchem Steam Station 2 (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

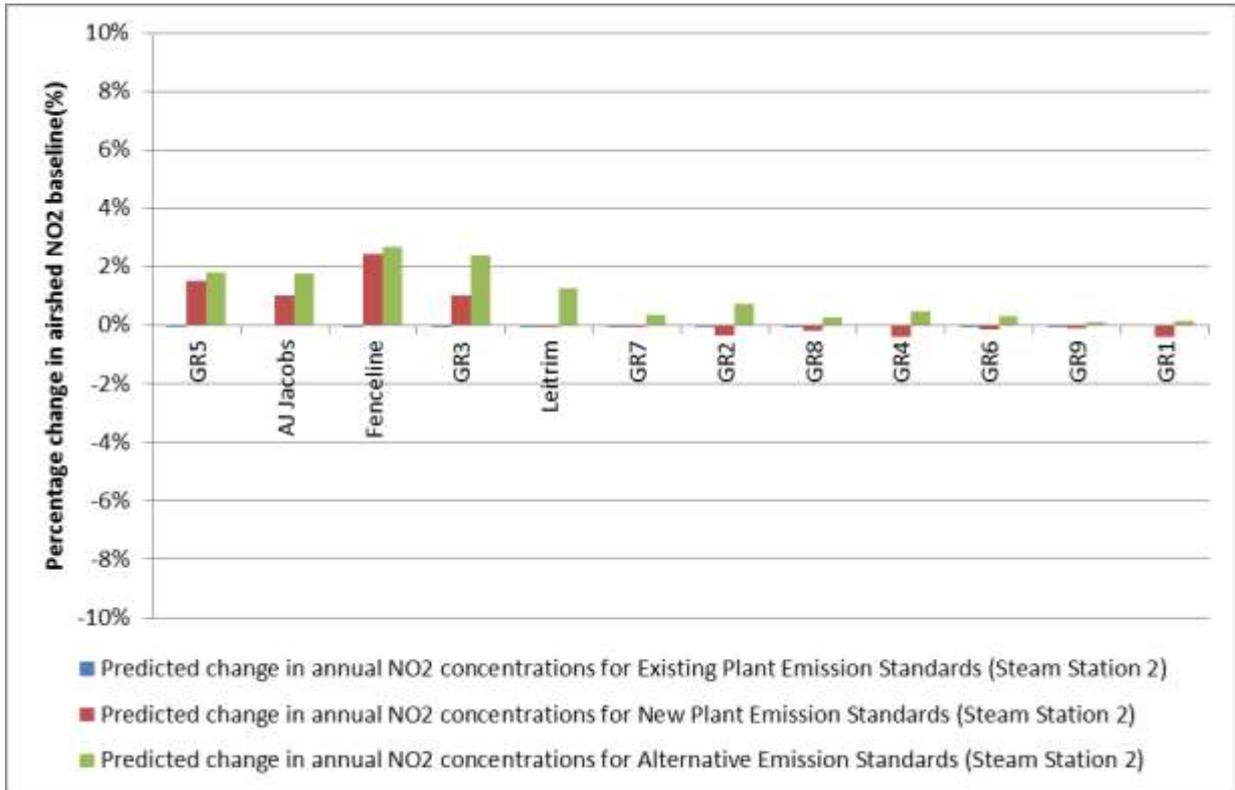


Figure I-24: Theoretical change in annual ambient NO₂ concentrations and the airshed baseline at the identified receptors for Infracchem Steam Station 2 (change calculated using Equation 1)

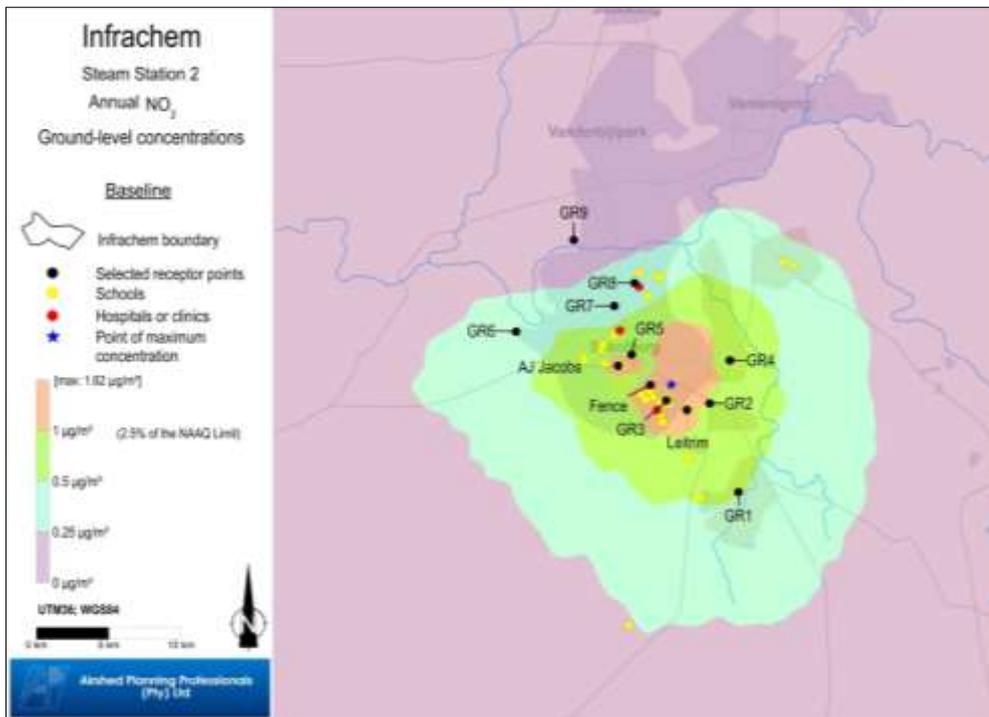


Figure I-25: Predicted annual NO₂ concentrations as a result of Baseline emissions from Steam Station 2

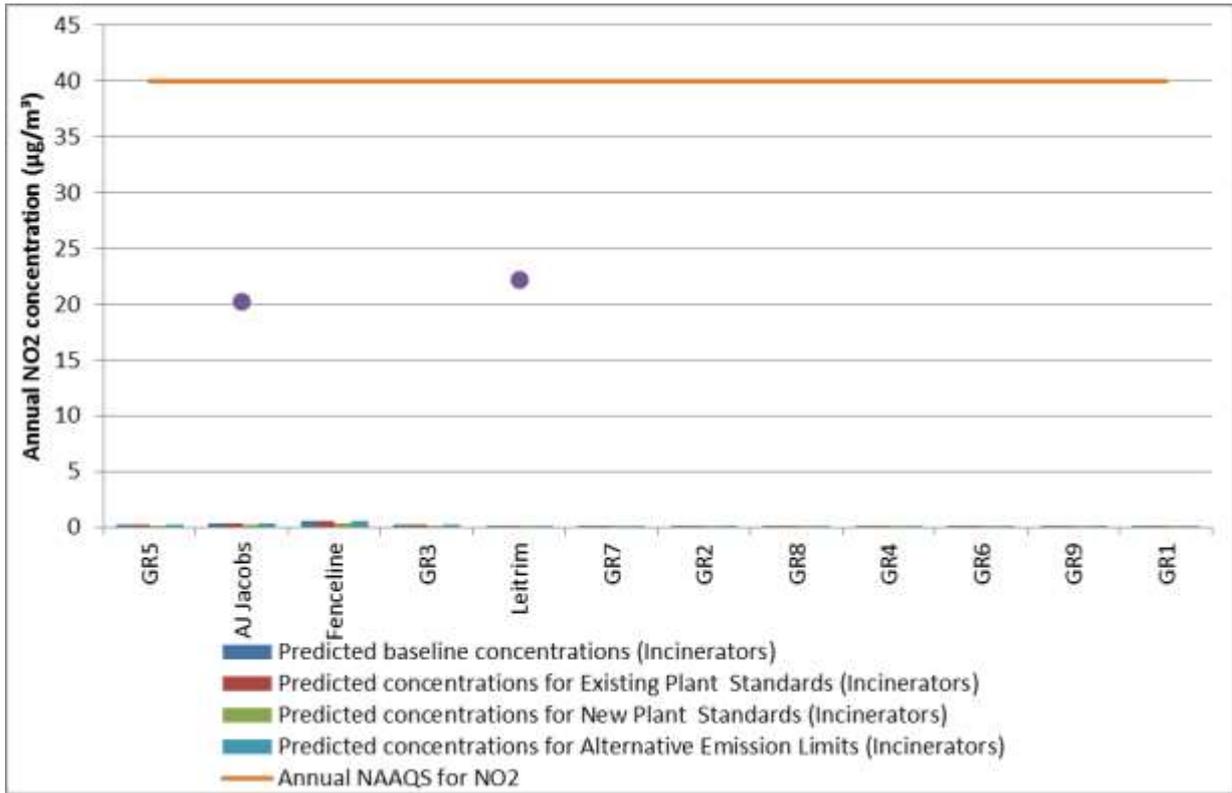


Figure I-26: Predicted annual NO₂ concentration at identified receptors for Infracchem Incinerators (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

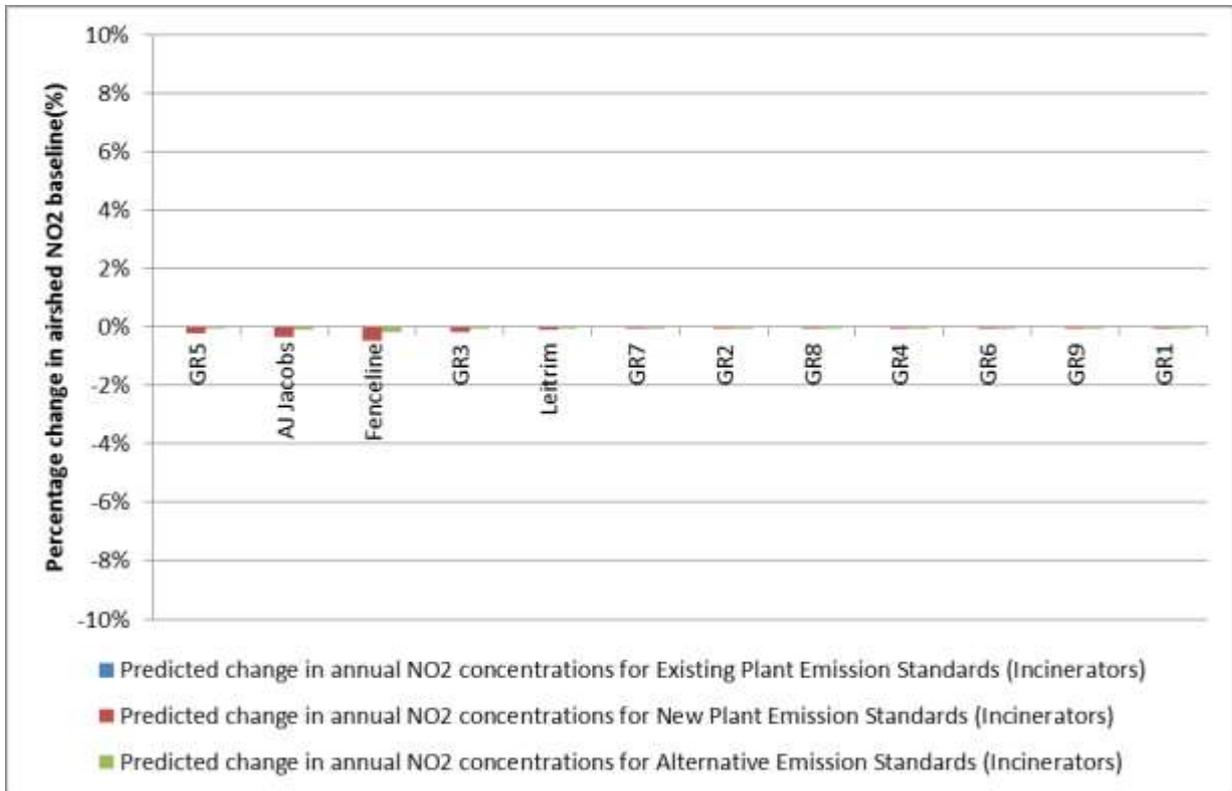


Figure I-27: Theoretical change in annual ambient NO₂ concentrations and the airshed baseline at the identified receptors for Infracchem Incinerators (change calculated using Equation 1)

Particulate matter (PM)

Annual

Annual ambient PM concentrations were predicted to be less than 10 $\mu\text{g}/\text{m}^3$ at all receptors for all sources and scenarios assessed (Figure I-28); below the annual NAAQS concentration for PM. Improvements in ambient PM concentrations as a result of theoretical compliance with New Plant Standards is less than 1% in all cases.

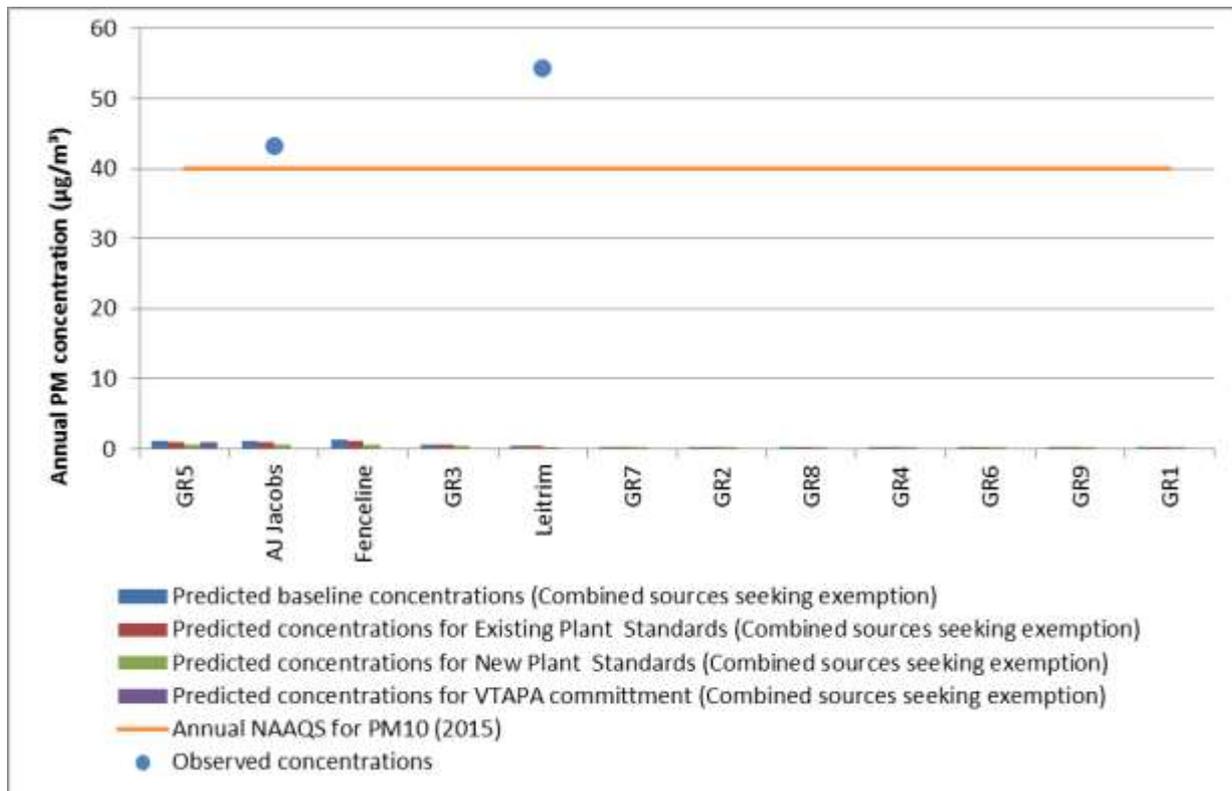


Figure I-28: Predicted annual PM concentration at identified receptors for combined Infracchem seeking postponement (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

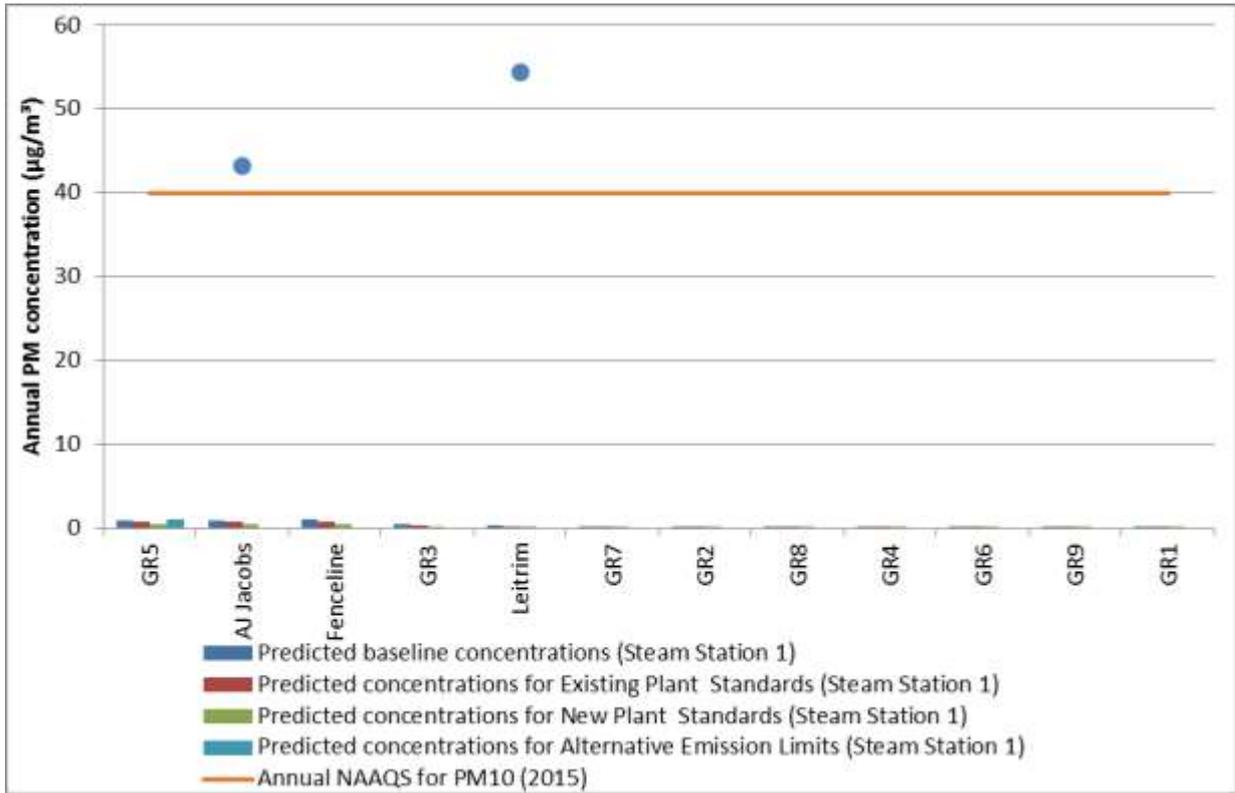


Figure I-29: Predicted annual PM concentration at identified receptors for Infracchem Steam Station 1 (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

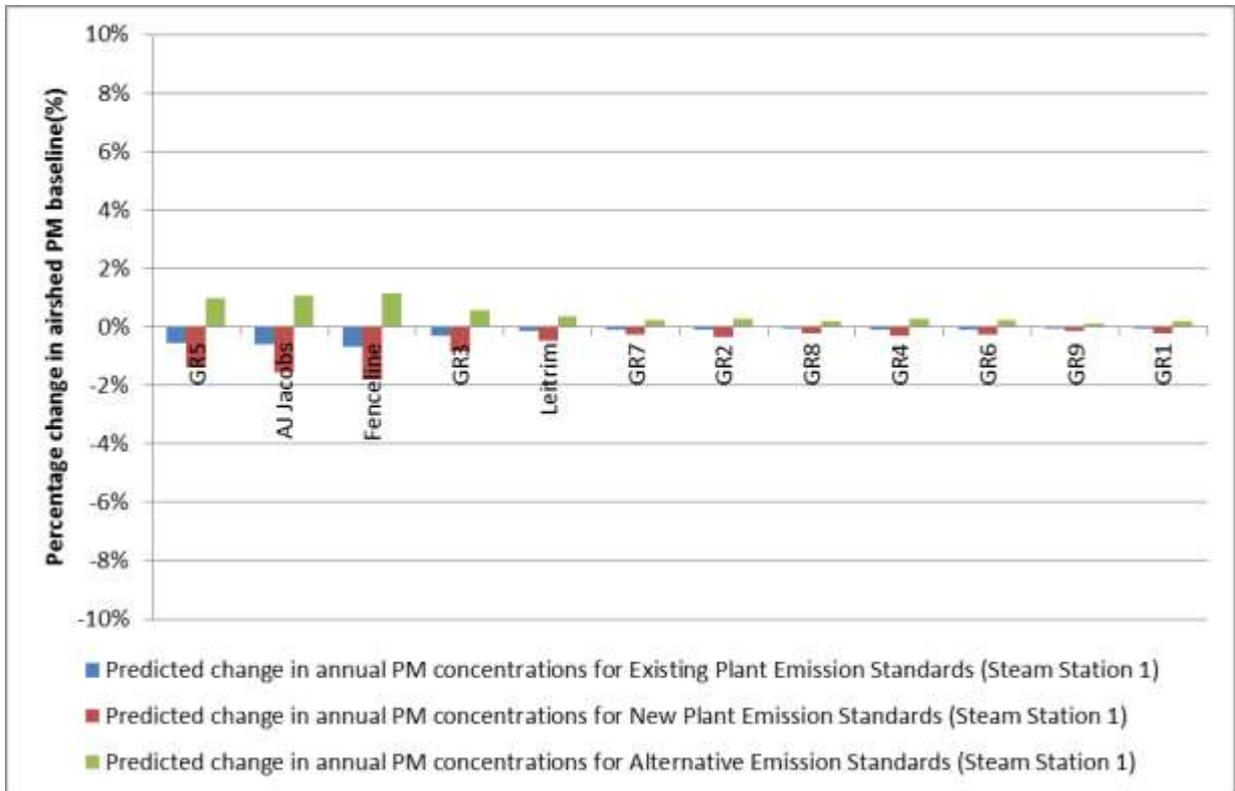


Figure I-30: Theoretical change in annual ambient PM concentrations and the airshed baseline at the identified receptors for Infracchem Steam Station 1 (change calculated using Equation 1)

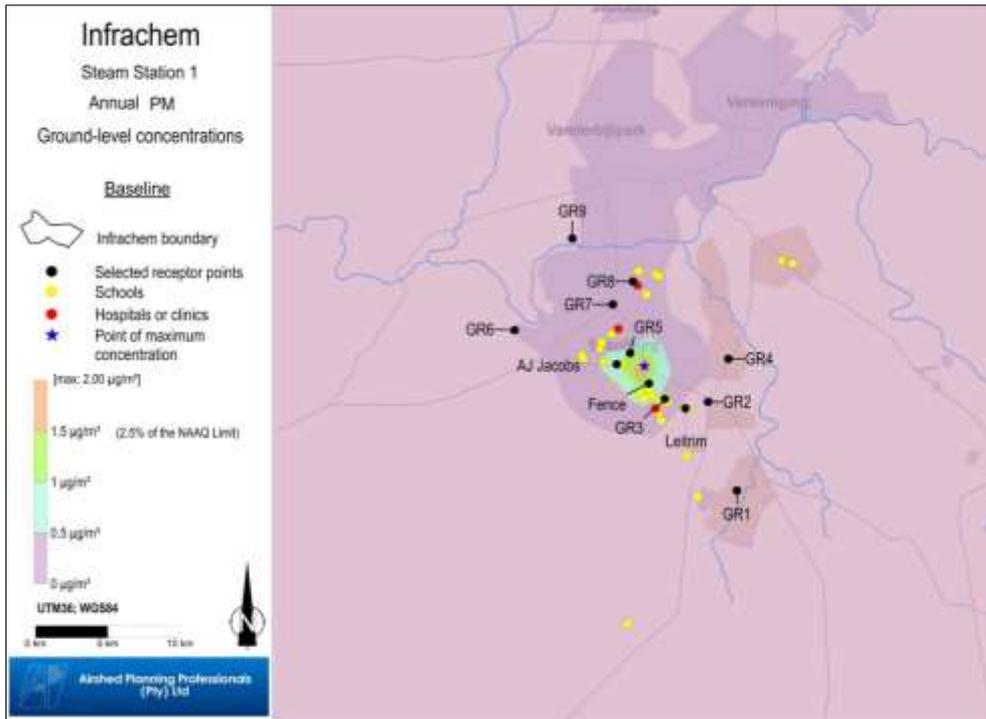


Figure I-31: Predicted annual PM concentrations as a result of Baseline emissions from Steam Station 1

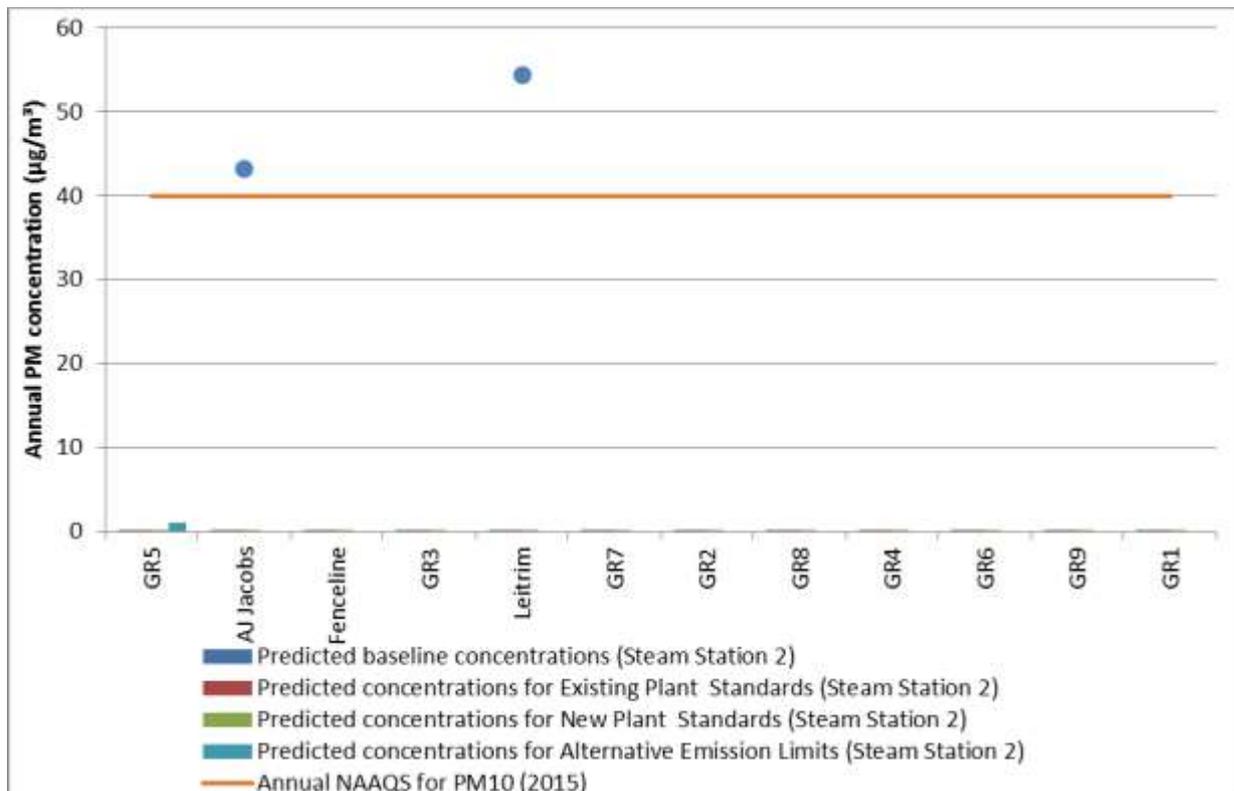


Figure I-32: Predicted annual PM concentration at identified receptors for Infracchem Steam Station 2 (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

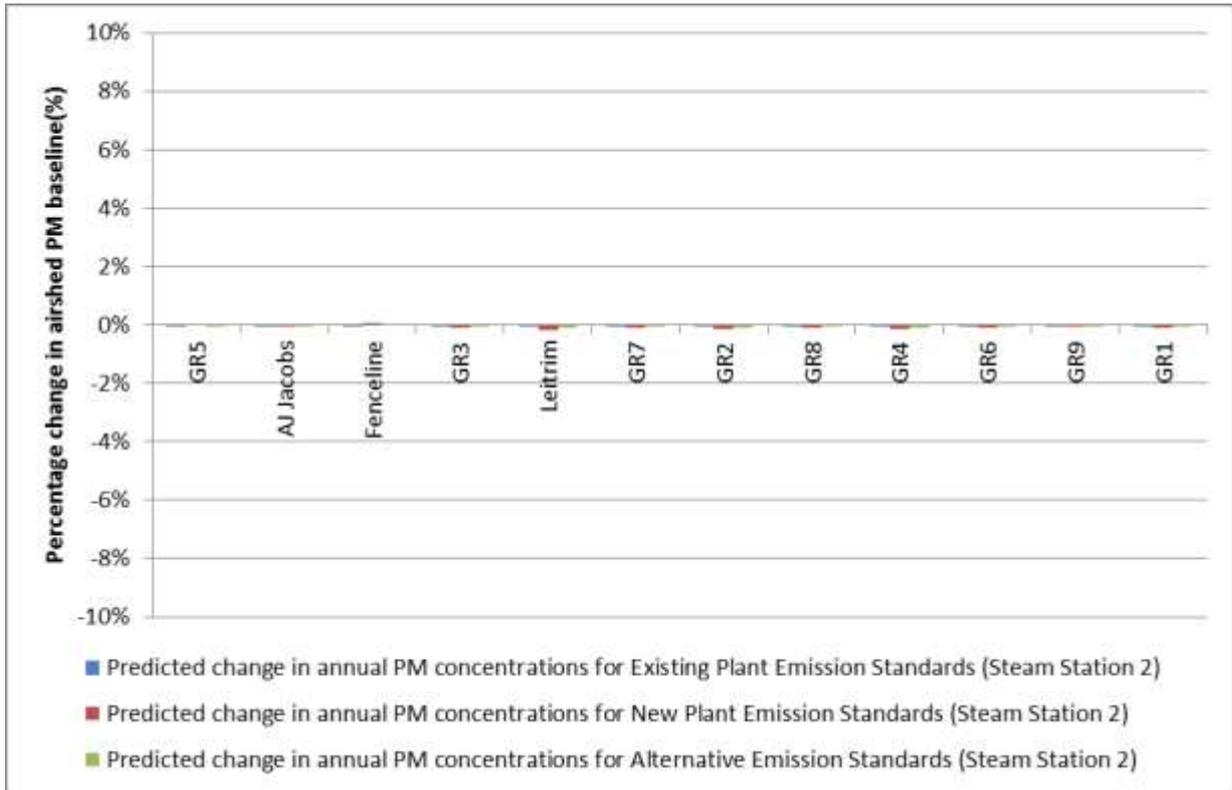


Figure I-33: Theoretical change in annual ambient PM concentrations and the airshed baseline at the identified receptors for Infracchem Steam Station 2 (change calculated using Equation 1)

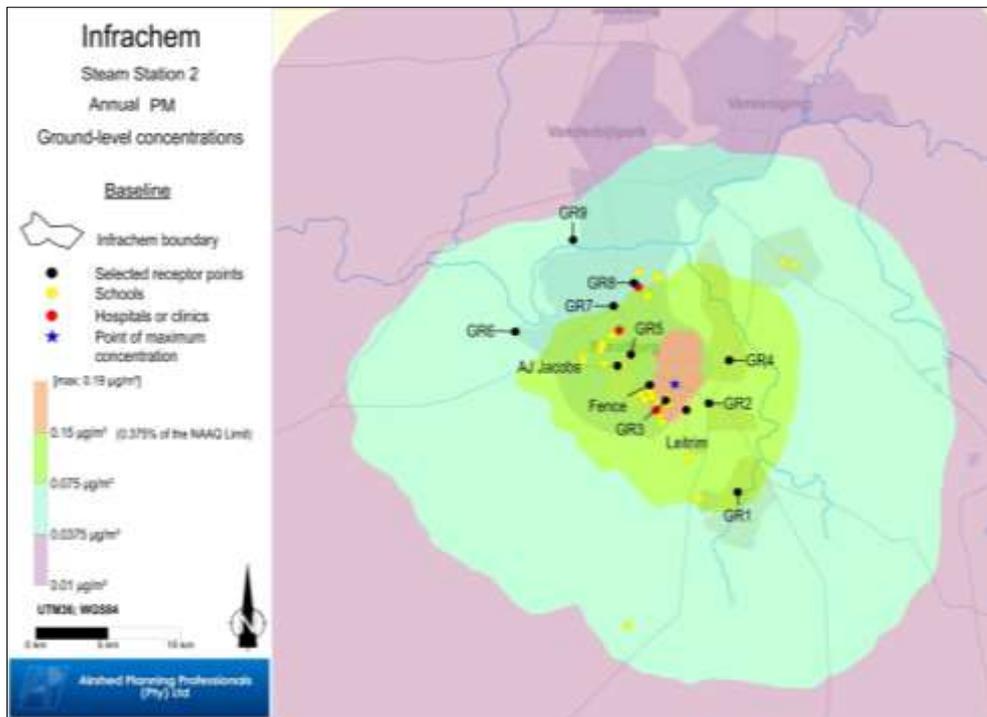


Figure I-34: Predicted annual PM concentrations as a result of Baseline emissions from Steam Station 2

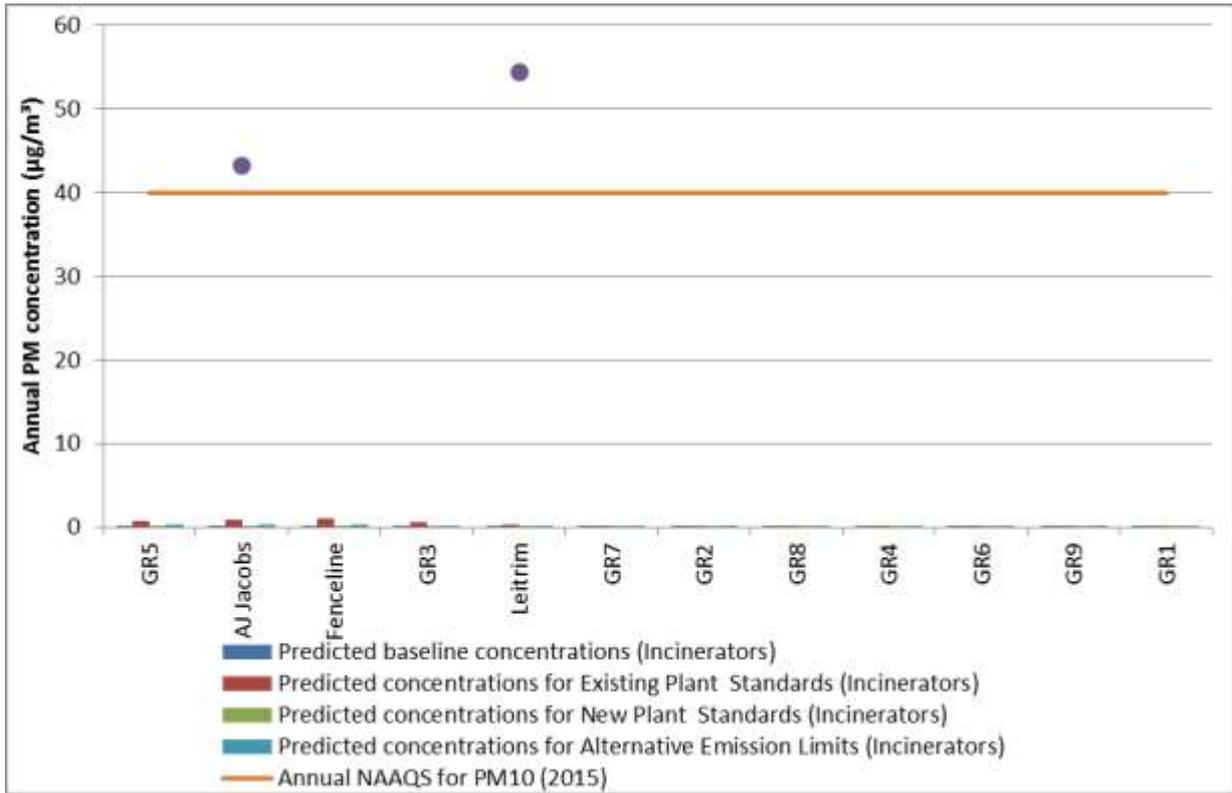


Figure I-35: Predicted annual PM concentration at identified receptors for Infracchem Incinerators (receptor code names as detailed in Table 5-17, where locations are shown in Figure 5-30)

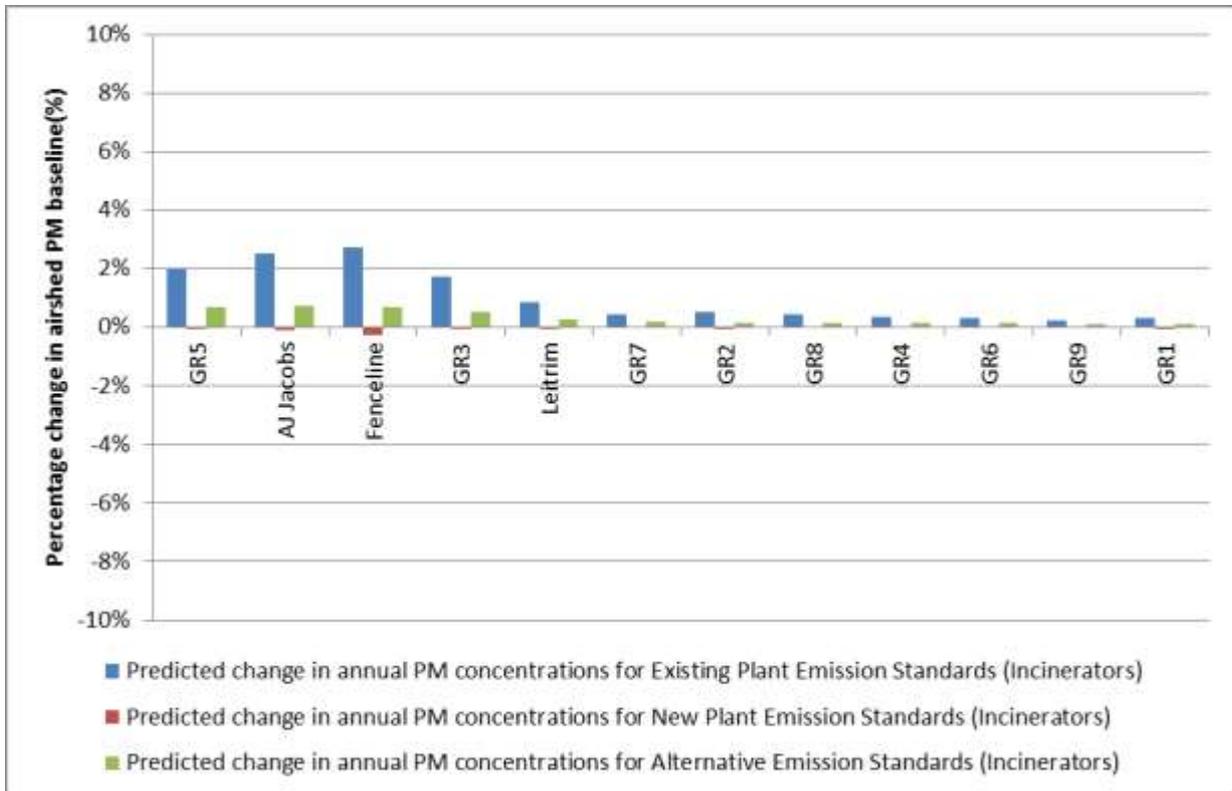


Figure I-36: Theoretical change in annual ambient PM concentrations and the airshed baseline at the identified receptors for Infracchem Incinerators (change calculated using Equation 1)

APPENDIX J: MANAGEMENT OF UNCERTAINTIES

Dispersion Model Uncertainties

In the US EPA Guideline on Air Quality Models (U.S. EPA, 2005), the need to address the uncertainties associated with dispersion modelling is acknowledged as an important issue that should be considered. The US Guideline divides the uncertainty associated with dispersion model predictions into two main types (U.S. EPA, 2005), as follows:

- Reducible uncertainty, which results from uncertainties associated with the input values and with the limitations of the model physics and formulations. Reducible uncertainty can be minimized by improved (i.e., more accurate and representative) measurements and improved model physics.
- Inherent uncertainty is associated with the stochastic (turbulent) nature of the atmosphere and its representation (approximation) by numerical models. Models predict concentrations that represent an ensemble average of numerous repetitions for the same nominal event. An individual observed value can deviate significantly from the ensemble value. This uncertainty may be responsible for a $\pm 50\%$ deviation from the measured value.

Atmospheric dispersion models are often criticised for being inadequate since "...it is only a model approximating reality", and therefore include inherent uncertainty. Both reducible and inherent uncertainties mean that dispersion modelling results may over- or under-estimate measured ground-level concentrations at any specific time or place. However, the US EPA Guideline on Air Quality Models (U.S. EPA, 2005) also states that:

"Models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area. For example, errors in highest estimated concentrations of +/- 10 to 40 per cent are found to be typical, i.e., certainly well within the often-quoted factor of two accuracy that has long been recognized for these models. However, estimates of concentrations that occur at a specific time and site are poorly correlated with actually observed concentrations and are much less reliable."

To minimise the overall uncertainty, but specifically the "reducible uncertainty", the following simple principles were followed in the investigation:

- Understanding the objectives of the investigation;
- Demonstrating that the model inputs are as correct as possible;
- Understanding and stating the model performance limitations;
- Demonstrating that the modelling process has been conducted appropriately and in line with both local DEA requirements and international practice;
- Including any validating information from monitoring that might be available; and
- To be conservative in cases where there is greater uncertainty (e.g. conversion of NO to NO₂).

Although the existence of model uncertainty is well-accepted, it does not exclude the use of dispersion modelling results in making important air quality impact decisions. The uncertainties should simply be acknowledged and understood that, given their inherent uncertainty, current dispersion models are a "best-case" approximation of what are otherwise very complex physical processes in the atmosphere. An accepted dispersion model (i.e., CALPUFF) was selected for the analysis to minimize some of these uncertainties. The US EPA states that when dispersion models such as CALPUFF are used to assess ground-level concentration and when a sufficiently large number of meteorological conditions are considered, the

modelling results should ideally fall well within the often quoted "factor of two" accuracy for these modelled (U.S. EPA, 2005).

Validation of Predictions

Model verification and validation (V&V) are the primary processes for quantifying and building credibility in numerical models. There are distinct differences between the two processes, as described below:

- Verification is the process of determining that a model implementation accurately represents the developer's conceptual description of the model and its solution.
- Validation is the process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended uses of the model.

Whilst V&V cannot prove that a model is correct and accurate for all possible scenarios, it can provide evidence that the model is sufficiently accurate for its intended use.

A rigorous V&V programme was not completed as part of the study; however, regular sanity checks on model results and comparisons with observations were done, as discussed in Section 5.1.5. An attempt was also made to quantify the level of agreement between observed data and model prediction, as well as the predictive accuracy of the model once the necessary adjustments have been made (such as including the estimated background concentrations). In this regard, the CALPUFF model's performance was evaluated by comparing the modelling results for the years 2010, 2011 and 2012 to the Sasol monitoring data collected over the same time period. In particular, the predicted SO₂ and NO₂ concentrations arising from both the Sasol operations and Natref plant were included in the comparison.

The performance evaluation was completed using the fractional bias method, since this statistical technique is one of the evaluation methods recommended by the U.S. EPA for determining dispersion model performance (U.S. EPA 1992). Both short- and long-term fractional biases were computed for SO₂ and NO₂ as predicted and observed at Leitrim and AJ Jacobs monitoring stations. The fractional biases of the means were shown to be well within a factor of two, which the U.S. EPA consider to be a reasonable performance target for a dispersion model before it is used for refined regulatory analysis (U.S. EPA 1992).

Scenario Simulations

Since the focus of the study has been to illustrate the relative changes with the introduction of different emission conditions (i.e. emission rates, exit gas temperatures and velocities), whilst maintaining the same stack heights and diameters, it is expected that the model errors would mostly be carried between the different modelling scenarios. Therefore, expressing the changes as incremental and relative to the baseline scenario, it is expected that these errors would be mostly cancel each other out.

It should also be noted that the average long-term background concentrations (Table 5-18) were used in this expression rather than the short-term value, which offers a more conservative approach.

Ambient Monitoring Uncertainty

Sasol operates a total of 4 ambient air quality monitoring stations in and around Sasolburg, namely at AJ Jacobs, Leitrim and Ecopark. Data for 2010, 2011 and 2012 from AJ Jacobs and Leitrim were included in this investigation since operation

of the Ecopark station only commenced in 2012. NO₂, NO and NO_x observations made at Ecopark monitoring station for 2012 was, however included in the analysis of NO₂/NO_x ratios as reported in Appendix F.

All of the abovementioned monitoring stations are ISO/IEC17025 accredited, to ensure data integrity and data quality as well as to ensure that the data obtained from the monitoring stations are representative of the ambient air when measured. Data availability and credibility is maximised through:

- Regular (at least on a weekly basis) visits of the monitoring stations to ensure the stations are functioning properly.
- Dynamic calibrations are conducted on at a quarterly basis, however where possible more frequent calibrations have been done.
- Certified calibration gas is used and obtained from reputable vendors
- Inter-laboratory comparisons are done between Sasol's Sasolburg and Secunda monitoring stations as well as between Sasolburg, Secunda and a third party calibration laboratory.
- Participation in the National Metrological Laboratory's national inter-laboratory comparisons to ensure that the system is in line with the rest of the accredited laboratories in South Africa.

Although the ISO/IEC 17025 System requires a quarterly data availability of 80%, Sasol's internal data availability, tracked on a monthly Scorecard, is a monthly data availability of 90%.

Based on the uncertainty calculations completed as per the ISO/IEC17025 requirements, Sasol's uncertainty in measurements on its ambient air quality monitoring stations is between 3% and 5% with a level of confidence of 95%. This has been confirmed through inter-laboratory comparisons and is confirmed on a regular basis.

Upper Air Meteorological Data

Although meteorological data from the monitoring stations described in the previous section are available for input into the CALPUFF dispersion model, there is a lack of upper air meteorology. Furthermore, it is anticipated that the wind observations at AJ Jacobs may be compromised due to nearby trees and building structures (see Section 5.1.5.1). The lack of appropriate meteorological information is often the single most important limiting factor in modelling accuracy. It is also the most subjective in deciding just how many data are needed, from which location and how accurate they must be.

The CALMET wind field model requires, as a minimum, meteorological data from at least one surface and an upper air station. This information is then used to "seed" the three-dimensional wind field with an initial solution of a relatively simple mass conservation model. CALMET does not include momentum, energy, or moisture conservation equations, and is therefore classified as a diagnostic model.

It is expected, that a wind field developed using all the parameters that could influence the flow, thermal and turbulence mechanisms should improve the accuracy of the dispersion predictions. MM5 is a three-dimensional, non-hydrostatic prognostic mesoscale models. MM5 is the fifth generation NCAR/Penn State Mesoscale model. The model includes a multiple-nesting capability, non-hydrostatic dynamics and four-dimensional data assimilation (Dudhia et al., 1999). The MM5 model uses all the conservation equations and has more refined parameterisations for processes that cannot be simulated directly. The main advantages and disadvantages of these models are detailed below.

Advantages of MM5:

- has the ability to assimilate local meteorological data;

- has realistic dynamical and physical formulations, suitable for simulations in South Africa's environment;
- can produce realistic meteorological fields in data-sparse regions; and
- is flexible enough to couple output meteorological fields to dispersion model runs at any resolution.

Disadvantages of MM5:

- has relatively high computational demands;
- requires a large amount of user knowledge and expertise to produce reliable and convincing results; and
- do not themselves include dispersion models, and the associated dispersion models do not necessarily comprise all of the features required for regulatory assessments (e.g. building effects).

MM5 data for the study domain was purchased from Lake Environmental that has proven record of generating MM5 data ready for use in the US EPA's AERMOD and CALPUFF dispersion modelling suites. The dataset included the years 2010, 2011 and 2012 at 12km resolution for a 300km by 300km study area.

The MM5 prognostic model together with the meteorological observations provide a 'first-guess field', which is then modified by the CALMET diagnostic model to take account of terrain and land-use features that are at a smaller spatial scale than the terrain used by the prognostic model. The main purpose of this approach is to increase the horizontal resolution of the meteorological fields.

Emission Inventory Uncertainty

In addition to meteorological input data, the uncertainty associated with the emissions inventory needs to be accommodated in the results. All emissions used in the simulations of the baseline scenario were based on either iso-kinetic measurement campaigns or continuous emissions monitoring (CEM).

Sasol makes use of reputable sampling companies for its third party measurement campaign and also operates CEM devices in certain of its plants. Although there is currently no quality accredited system for online monitoring devices within a stack, Sasol is using the same principles as for its ambient air quality monitoring stations, i.e. the ISO/IEC17025 principles to manage the quality of the data received from its online monitoring network.

All third party (and *ad hoc*) sampling requests (or requirements) within the Sasol Group has to comply with AQA Section 21, Schedule 2 of the Listed Activities and Minimum Emission Standard. Furthermore, Sasol has, as far as possible, standardised on US EPA sampling methodologies. Analyses of the samples are also done by an ISO/IEC17025 accredited laboratory to further control the quality of the results.

Where ad hoc sampling is done, Sasol's philosophy is aligned with the requirements of the AQA Section 21, namely that all point sources must be sampled at least once a year.

Continuous Emission Monitoring

Due to the lack of a National Accreditation system for CEM, uncertainty in measurements cannot be confirmed at this stage, however based on the uncertainty associated with sampling, Sasol has

- a 10% uncertainty factor associated with its online particulate measurements; and
- an uncertainty below 10% for gases, the based on the accuracy of the completed calibrations, as well as the accuracy of the calibration gases (this uncertainty ranges between 5% and 10%).

These uncertainties are with a level of confidence of 95%.

Third-Party Emission Monitoring

The uncertainty associated with third-party emission's measurements is considered to be up to 10% with a level of confidence of 95%. This uncertainty is based on the isokineticity of the isokinetic sampling, as well as the uncertainty associated with the sample taking and chemical analysis of gaseous components.

According to the Sasol quality control system, all third-party contractors for isokinetic sampling need to comply with the following control criteria:

- Their entire sampling staffs undergo the training associated with the UK-based Monitoring Certification Scheme (MCERTS): Manual Stack emissions monitoring program (MCERTS 2011);
- An electronic automated sampler is used for all isokinetic sampling;
- The pitot tubes used for sampling is calibrated at least on a quarterly basis;
- The pneumatic pressure sensors on the sampler is also calibrated on at least a quarterly basis; and
- The dry gas meters are checked on a regular basis and replaced every 6 months.

The CEM data is logged per second, and then averaged. In this way, all process upsets are captured within the database. The CEM data used in this investigation were based on an hourly average mass flow and concentration.

Had-Hoc Emissions Sampling

SANAS is compiling an accreditation system for *ad hoc* sampling and as soon as this system is in place, the uncertainty of the measurements will be confirmed; however it is not expected to be higher than 10%.

Sasol is also in the process of conducting an international peer review on its third party contractors to determine whether there is a potential higher uncertainty in its measurements.

The Minimum Emissions Standards requires that sampling be conducted at normal operating conditions; therefore the emissions information included in the dispersion model is aligned with normal operating conditions on site. The sampling schedule is communicated to the plant managers with the aim of having process conditions as representative as possible to normal operations. Sampling upset conditions often poses a challenge from both a logistical and safety point of view, since safety requirements require as few people as possible on the plant during severe upset conditions and therefore sampling cannot be done during such conditions.

PM_{2.5} and PM₁₀ Air Emissions

All particulate matter was assumed to be PM_{2.5} since it was not possible to establish the PM_{2.5}/PM₁₀ split.

Non-Sasol Air Emissions

No attempt was made to estimate the emissions from non-industrial activities within regional communities. Instead, the community contribution (and other sources) of a particular compound was discussed in Section 5.1.5.1.

APPENDIX K: GUIDANCE NOTE ON TREATMENT OF UNCERTAINTIES

The Intergovernmental Panel on Climate Change (IPCC) produced a Guidance Note for lead authors of the IPCC Fifth Assessment Report on consistent treatment of uncertainties. These notes define a common approach and calibrated language that can be used broadly for developing expert judgments and for evaluating and communicating the degree of certainty in findings of the assessment process. Communicating the degree of certainty in key findings relies on expressing the:

- Confidence in the validity of a finding, based on the type, amount, quality, and consistency of evidence (e.g., mechanistic understanding, theory, data, models, expert judgment) and the degree of agreement. Confidence is expressed qualitatively.
- Quantified measures of uncertainty in a finding expressed probabilistically (based on statistical analysis of observations or model results, or expert judgment).

The Guidance Note proposes the use of the following dimensions to evaluate the validity of a finding: the type, amount, quality, and consistency of evidence (summary terms: “limited,” “medium,” or “robust”), and the degree of agreement (summary terms: “low,” “medium,” or “high”), as summarised in the figure below.

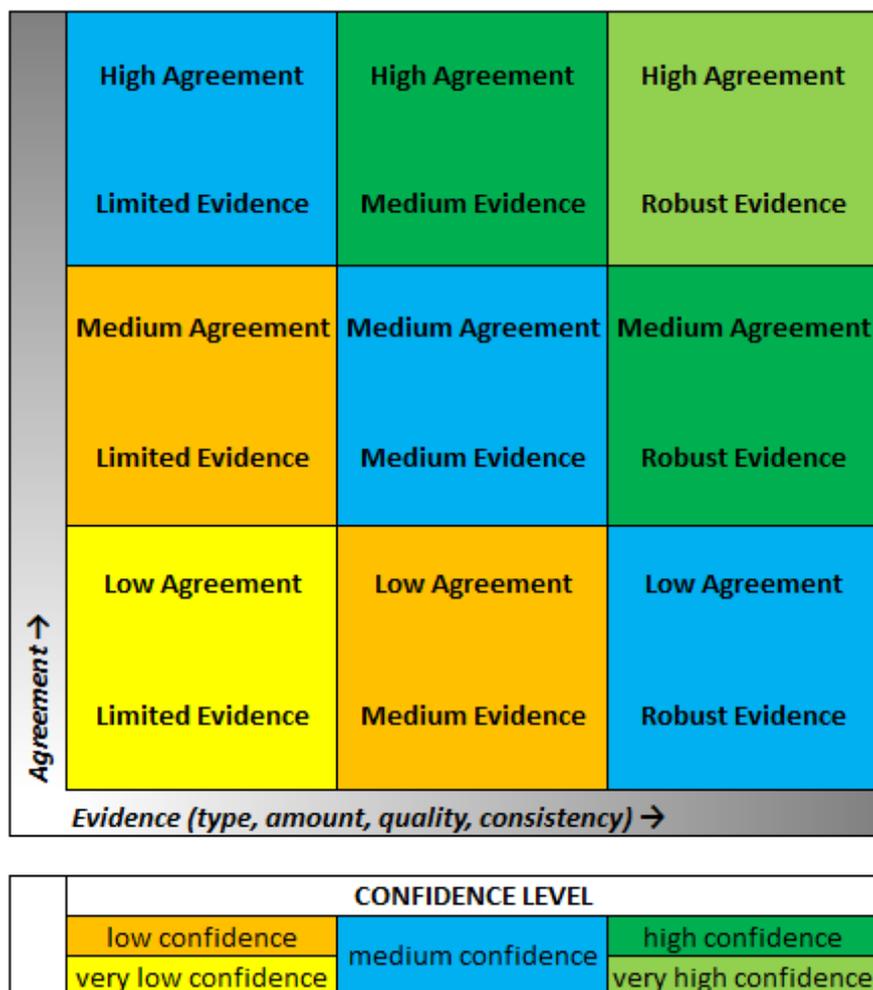


Figure K-1: A depiction of evidence and agreement statements and their relationship to confidence. Confidence increases towards the top-right corner as suggested by the increasing strength of shading. Generally, evidence is most robust when there are multiple, consistent independent lines of high-quality evidence.

Generally, evidence is most robust when there are multiple, consistent independent lines of high-quality evidence. The guide further provides advice for a traceable account describing the evaluation of evidence and agreement, as follows:

- For findings with high agreement and robust evidence, present a level of confidence or a quantified measure of uncertainty.
- For findings with high agreement or robust evidence, but not both, assign confidence or quantify uncertainty when possible. Otherwise, assign the appropriate combination of summary terms for your evaluation of evidence and agreement (e.g., robust evidence, medium agreement).
- For findings with low agreement and limited evidence, assign summary terms for your evaluation of evidence and agreement.
- In any of these cases, the degree of certainty in findings that are conditional on other findings should be evaluated and reported separately.

A level of confidence is expressed using five qualifiers: “very low,” “low,” “medium,” “high,” and “very high.” It synthesizes the author teams’ judgments about the validity of findings as determined through evaluation of evidence and agreement. Figure J-1 depicts summary statements for evidence and agreement and their relationship to confidence. There is flexibility in this relationship; for a given evidence and agreement statement, different confidence levels could be assigned, but increasing levels of evidence and degrees of agreement are correlated with increasing confidence. Confidence cannot necessarily be assigned for all combinations of evidence and agreement in Figure J-1. Presentation of findings with “low” and “very low” confidence should be reserved for areas of major concern, and the reasons for their presentation should be carefully explained. Confidence should not be interpreted probabilistically, and it is distinct from “statistical confidence.” Additionally, a finding that includes a probabilistic measure of uncertainty does not require explicit mention of the level of confidence associated with that finding if the level of confidence is “high” or “very high.”

Likelihood, as defined in Table J-1, provides calibrated language for describing quantified uncertainty. It can be used to express a probabilistic estimate of the occurrence of a single event or of an outcome (e.g., a climate parameter, observed trend, or projected change lying in a given range). Likelihood may be based on statistical or modelling analyses, elicitation of expert views, or other quantitative analyses.

Table K-1: Likelihood scale

Term	Likelihood of the Outcome
Virtually certain	99-100% probability
Very likely	90-100% probability
Likely	66-100% probability
About as likely as not	33 to 66% probability
Unlikely	0-33% probability
Very unlikely	0-10% probability
Exceptionally unlikely	0-1% probability

The categories defined in this table can be considered to have “fuzzy” boundaries. A statement that an outcome is “likely” means that the probability of this outcome can range from $\geq 66\%$ (fuzzy boundaries implied) to 100% probability. This implies that all alternative outcomes are “unlikely” (0-33% probability). When there is sufficient information, it is preferable to specify the full probability distribution or a probability range (e.g., 90-95%) without using the terms in Table J-1. “About as likely as not” should not be used to express a lack of knowledge.

APPENDIX L: COMBINED INFRACHEM – NATREF SCENARIO

Sulfur dioxide (SO₂)

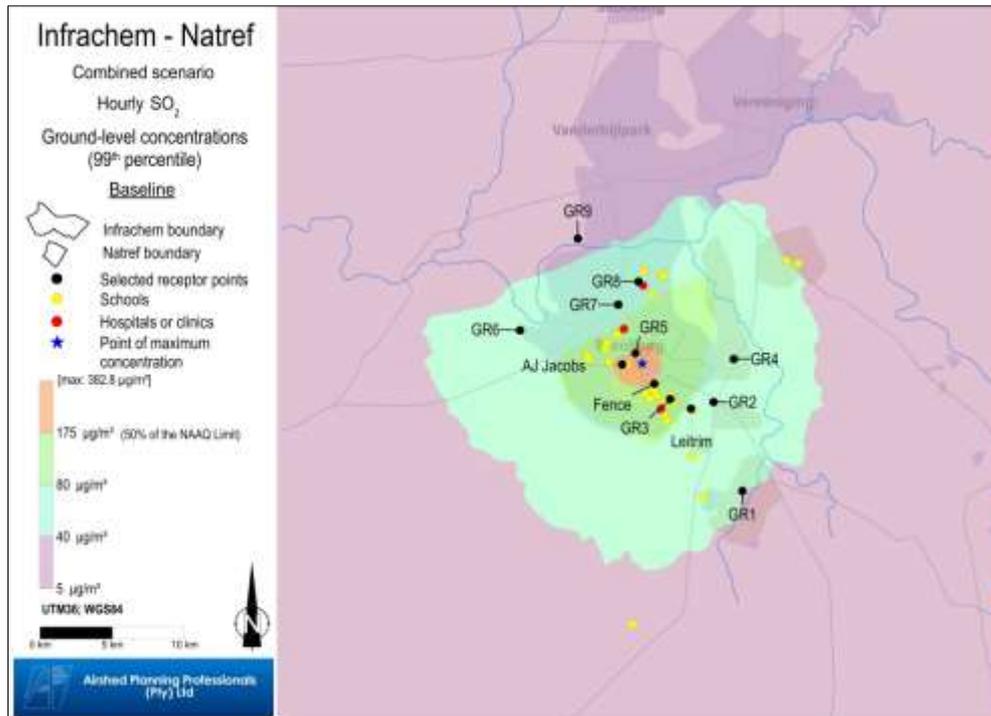


Figure L-1: Predicted hourly SO₂ concentrations as a result of the combined impact of Infracchem and Natref baseline emissions

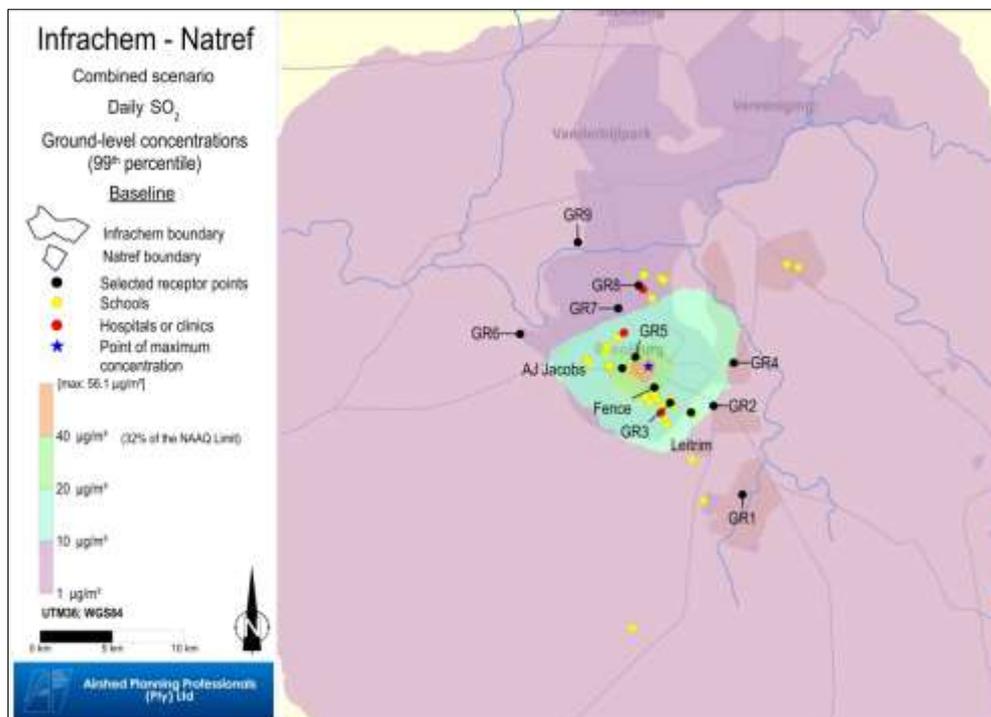


Figure L-2: Predicted daily SO₂ concentrations as a result of the combined impact of Infracchem and Natref baseline emissions

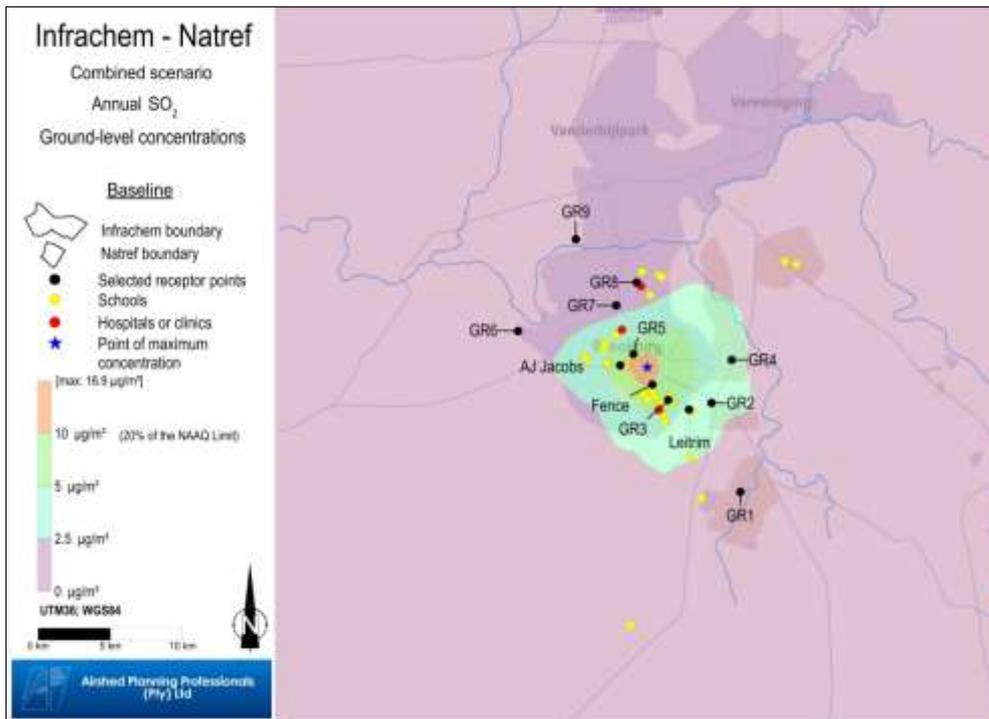


Figure L-3: Predicted annual SO₂ concentrations as a result of the combined impact of Infracchem and Natref baseline emissions

Nitrogen dioxide (NO₂)

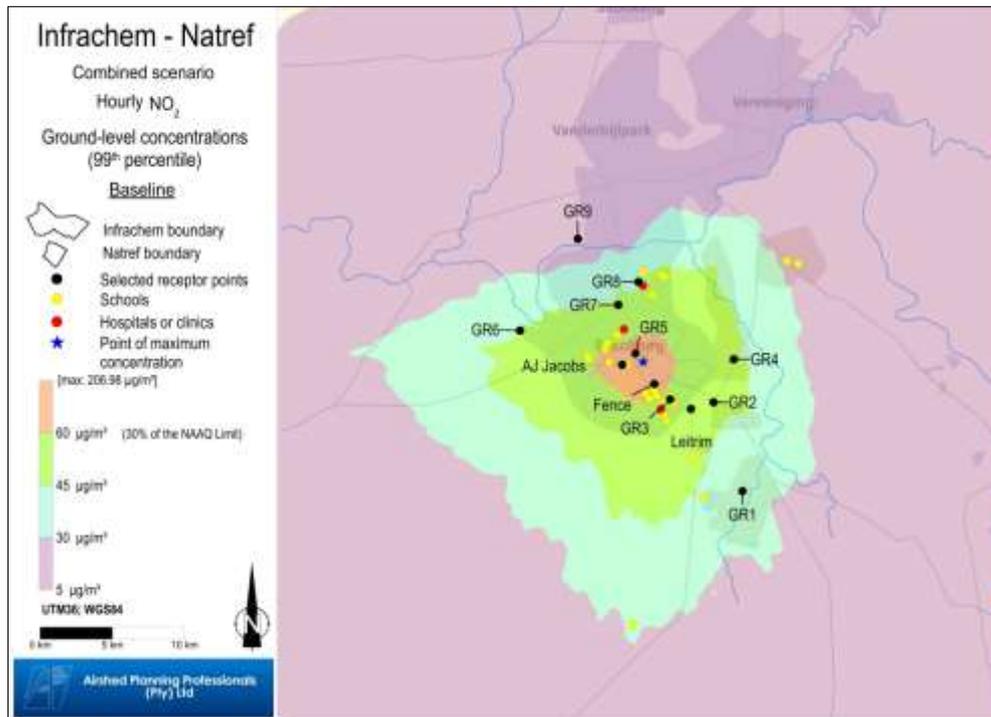


Figure L-4: Predicted hourly NO₂ concentrations as a result of the combined impact of Infracchem and Natref baseline emissions

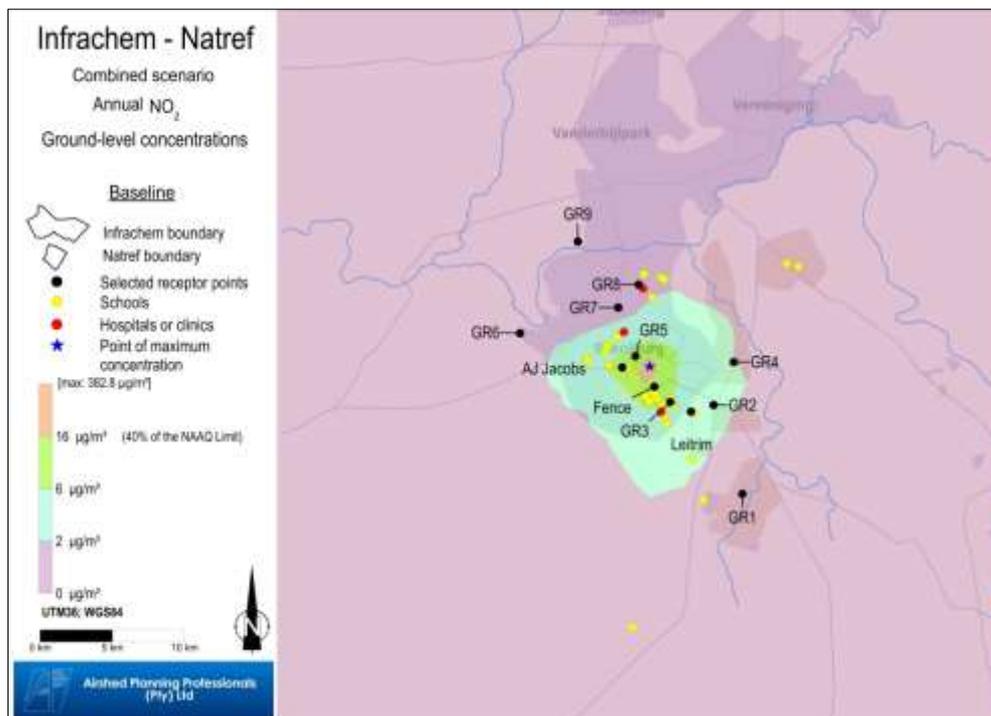


Figure L-5: Predicted annual NO₂ concentrations as a result of the combined impact of Infracchem and Natref baseline emissions

Particulate matter (PM)

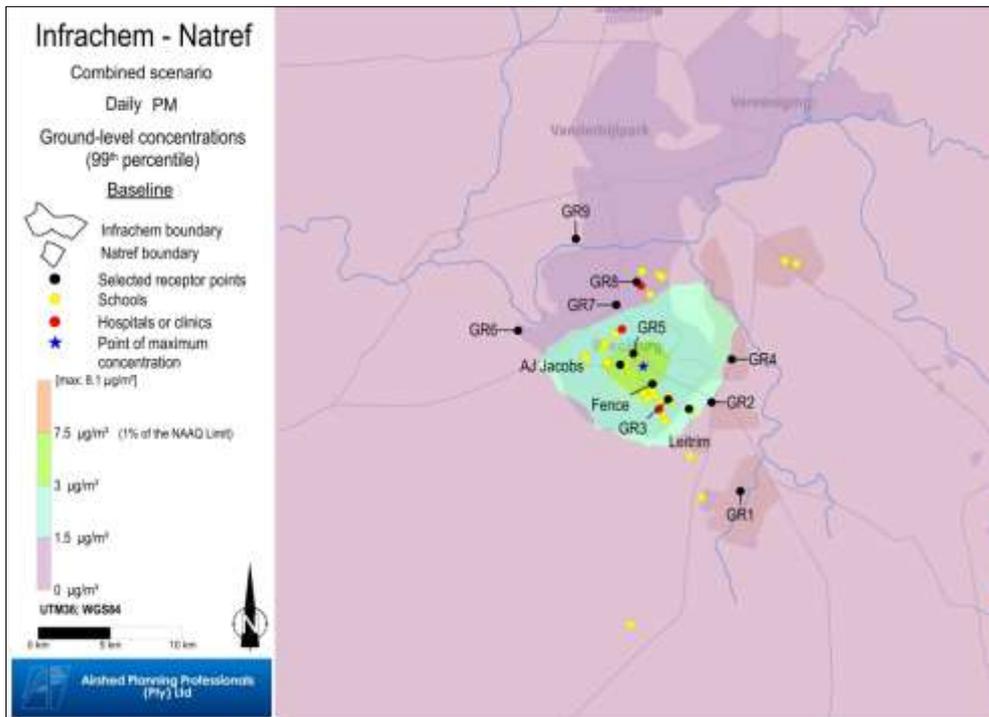


Figure L-6: Predicted annual PM concentrations as a result of the combined impact of Infracchem and Natref baseline emissions

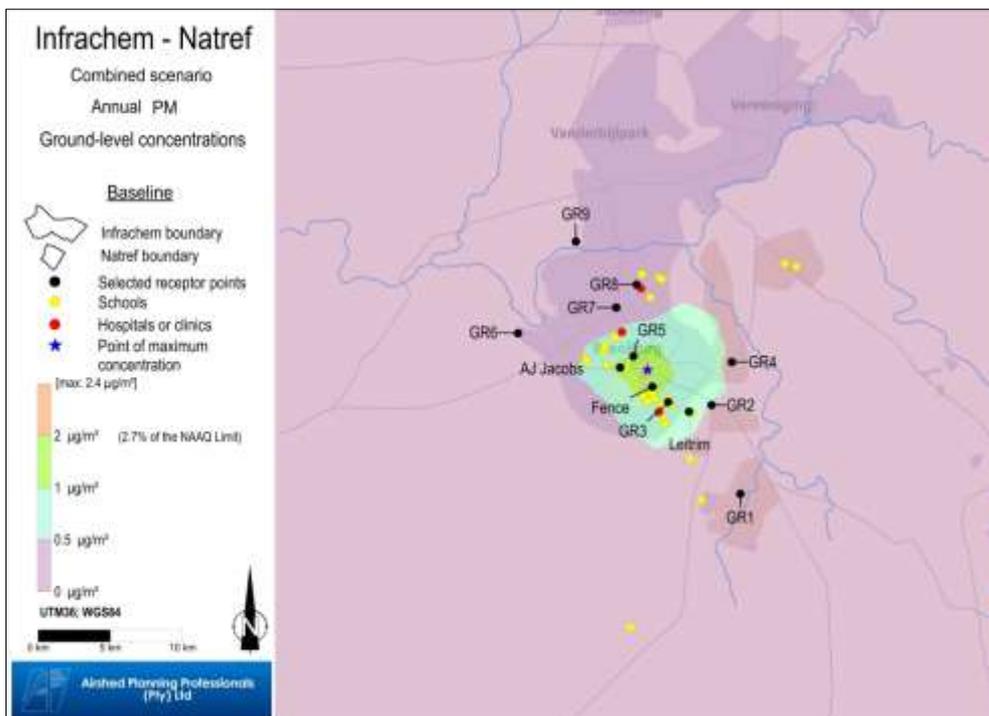


Figure L-7: Predicted annual PM concentrations as a result of the combined impact of Infracchem and Natref baseline emissions