Silver Springs Gas Storage Facility - Air Quality Impact Assessment

Prepared for

RPS

KE1009971

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Final

Prepared by

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Glossary

Term	Definition
Units of measurement	
°C	degrees Celsius
g/s	grams per second
kg/yr	Kilograms per year
km	kilometre
m	metre
mE	metres East
mN	metres North
m/s	metres per second
Nm^3/s	normal cubic metres per second (at 0^oC and 1 atmosphere)
$\mu g/m^3$	micrograms per cubic metre

Air pollutants and chemical nomenclature

CO	carbon monoxide
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen

Other abbreviations

BoM	Bureau of Meteorology
DERM	Qld Department of Environment and Resource Management
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EP Act	Environmental Protection Act 1994
EPP(Air) 2008	Environmental Protection (Air) Policy
CSG	Coal seam gas
NPI	National Pollutant Inventory
TAPM	The Air Pollution Model
DEM	Digital Elevation Model

Executive Summary

Katestone Environmental has been commissioned by RPS, on behalf of AGL Energy Limited (AGL), to undertake an air quality impact assessment of the proposed Silver Springs Gas Storage Facility (the Project). The Project proposes to construct and operate a coal seam gas (CSG) storage facility at the existing Silver Springs Processing Plant.

The findings of the assessment are:

- *The predicted ground-level concentrations of nitrogen dioxide and carbon monoxide for all modelled scenarios at all locations are below the EPP (Air) objectives.*

- *The predicted air quality impact of the Project on the surrounding atmospheric environment is low.*

1. Introduction

Katestone Environmental has been commissioned by RPS, on behalf of AGL Energy Limited (AGL), to undertake an air quality impact assessment of emissions associated with the operation of the proposed Silver Springs Gas Storage Facility (the Project).

AGL propose to construct and operate a coal seam gas (CSG) storage facility at the existing Silver Springs Processing Plant. The facility will allow for the storage of CSG in the depleted Silver Springs and Renlim gas reservoirs. Development of the Project is a key element in the AGL and Queensland Gas Company (QGC) strategy to capture ramp-up gas for preservation and use at a later date. Under a contractual arrangement with QGC, AGL will assist QGC to manage its ramp-up gas in the lead up to the commissioning of the Gladstone Queensland Curtis Liquefied Natural Gas (QCLNG) Processing Facility.

The construction of the gas storage facility will involve the commissioning of a new compressor unit, in addition to the four existing compressor units on-site. All compressors will burn natural gas and will emit oxides of nitrogen (NO_x) and carbon monoxide (CO) as the main air pollutants.

This assessment examines the potential air quality impacts of the Project on the local atmospheric environment by:

- Describing the existing air quality in the region
- Estimating the emissions to air associated with the construction and operation of the proposed compressor unit in isolation and including existing Silver Springs infrastructure
- Quantify meteorological parameters, land-uses and terrain features in the region that may impact the dispersion of air pollutants released from the Project
- Predicting ground-level air pollutant concentrations using the air dispersion model CALPUFF
- Assessing and comparing predicted impacts against the relevant air quality objectives used in Queensland

2. Development Proposal

2.1 Silver Springs Gas Storage Facility

AGL Energy Limited (AGL) are proposing to construct a new facility, the Silver Springs Gas Storage Facility and associated infrastructure (‘the Project’), at the existing Silver Springs Processing Plant on Petroleum License (PL 16), situated approximately 44 km south of Surat. Whilst PL 16 is located in both the Maranoa Regional Council and Balonne Regional Council areas, the Project area itself is located entirely within the Maranoa Regional Council area.

The proposed storage facility will allow the storage of coal seam gas (CSG) in the depleted Silver Springs and Renlim gas reservoirs.

The nature of the gas developments currently being undertaken by QGC requires a significant number of gas wells to be producing gas prior to the start up of the QCLNG Processing Facility in Gladstone. Due to the scale of the QCLNG project and the amount of gas required to be produced during the ramp-up phase there is limited potential for this gas to be utilised in conventional ways. Storing the ramp-up gas is a practical and environmentally sensible option to ensure that this gas resource is preserved for use at a later date when it can be supplied for use in the QCLNG Processing Facility.

The storage of gas underground requires the gas to be compressed before being pumped down a well. The process is driven by a gas fired engine that drives a compressor unit. In terms of air quality impacts associated with compressor units the main emissions are associated with the exhaust emissions from the combustion of fuel in the engine.

The existing Silver Spring Processing Plant currently has 4 compressor units in the form of one Stage 1 compressor and three Stage 2 compressors. The Stage 1 compressor operates continuously, baring maintenance and technical problems, and any two of the three Stage 2 compressors operate in tandem with Stage 1. The new Silver Springs Gas Storage Facility will comprise a single compressor unit that will operate continuously.

2.2 Air Quality Impact Assessment Scenarios

The emissions to air from the Project considered in this assessment are from the combustion of fuel (gas) in the compressor engines. To assess the impact of the Project three scenarios have been assessed.

2.2.1 Scenario 1

Scenario 1 represents the existing Silver Springs Processing Plant and includes constant emissions from the following sources:

- Stage 1 Compressor - CM200C
- Stage 2 Compressor x2 - CM200A and CM200B

The on-site generator has not been considered in this assessment because the size of the generator engine is very small compared to the Stage 1 and Stage 2 compressor engines and therefore the emissions will be insignificant.

2.2.2 Scenario 2

Scenario 2 represents the proposed Silver Springs Gas Processing Facility and includes constant emissions from the following source:

- Proposed Compressor - CAT G3612 compressor engine

2.2.3 Scenario 3

Scenario 3 represents a cumulative worst-case assessment of emissions for the Project and includes both the proposed source and the existing CM200C and CM200A compressors. Compressor CM200B has not been included as an existing source in the cumulative assessment as it will become redundant if the proposed CAT G3612 compressor is approved.

3. Overview of Assessment Methodology

The air quality impact assessment for the Project is based upon a dispersion modelling study that couples air pollutant emission rates and source characteristics with meteorology representative of conditions experienced at the site. This section outlines the methodology adopted for this review.

The site location has been described in terms of:

- Land-use
- Terrain features
- Sensitive receptor locations

The existing air quality in the region has been described by:

- Search of National Pollution Inventory (NPI) database for other air pollutant emitting facilities in the region

Emissions to air for the Project have been sourced from:

- Existing and proposed compressor engine stack characteristics provided by RPS
- Emissions from the Stage 1 compressor (existing source) measured during emission testing conducted by EML
- CAT G3612 (proposed) emissions calculated from information provided by RPS

Dispersion modelling was conducted as follows:

- The prognostic model TAPM (developed by CSIRO, version 4 and the diagnostic meteorological model CALMET (developed by EarthTec, version 6) were used in conjunction with nearby Bureau of Meteorology station data to develop a 3-dimensional windfield representing wind flows in the region. Refer to Appendix A for model details.
- The three dimensional wind field produced by TAPM/CALMET was then used to create a meteorological file suitable for use with the CALPUFF dispersion model. Source characteristics and emissions rates were then used as input to the dispersion model, and ground-level concentrations were predicted.

The air quality objectives presented in the *Environmental Protection (Air) Policy 2008 (EPP Air)* were adopted for the assessment for comparison with predicted ground-level concentrations for each assessment scenario.

The main pollutant associated with the combustion of natural gas is nitrogen dioxide (NO_2). This study focuses on predictions of ground-level concentrations of NO_2 and carbon monoxide (CO) as specified in Schedule F of the Department of Environment and Resources Management (DERM) (2010) Guideline "*Model conditions for level 1 environmental authorities for coal seam gas activities".* Predictions have been made at identified local houses and across a Cartesian grid.

4. Air Quality Criteria

4.1 Queensland Environmental Protection Policies

The *Environmental Protection Act 1994* (EP Act) provides for the management of the air environment in Queensland. The legislation applies to government, industry and individuals and provides a mechanism for the delegation of responsibility to other government departments and local government. It also provides all government departments with a mechanism to incorporate environmental factors into decision-making.

The EP Act gives the Minister of the Department of Environment and Resource Management (DERM) the power to create Environmental Protection Policies that identify, and aim to protect, environmental values of the atmosphere that are conducive to the health and well-being of humans and biological integrity. The Environmental Protection (Air) Policy (EPP(Air)) was revised and reissued in 2008. The administering authority must consider the requirements of the EPP(Air) when it decides an application for an environmental authority, amendment of a licence or approval of a draft environmental management plan. Schedule 1 of the EPP(Air) specifies air quality indicators and objectives for Queensland. Indicators and objectives from the EPP(Air) that are relevant for this study are reproduced in Table 1.

Table 1 EPP(Air) ambient air quality objectives relevant to the study

Indicator	Environmental value	Averaging period	Air quality objective[1] (µg/m³)	Number of days of exceedance allowed per year
Nitrogen dioxide	Health and wellbeing	1-hour	250	1
		1-year	62	N/A
	Health and biodiversity of ecosystems	1-year	33	N/A
Carbon monoxide	Health and wellbeing	8-hour	11,000	1

Table note:
[1] Air quality objective at 0°C
N/A: Not applicable

4.2 Model Conditions

Schedule F of the Department of Environment and Resources Management (DERM) (2010) Guideline "*Model conditions for level 1 environmental authorities for coal seam gas activities"* prescribes a number of model conditions in relation to 'Air' for the assessment and operation of coal seam gas activities and projects including:

- *"Contaminants emitted from fuel burning or combustion equipment point sources must be directed vertically upwards.*
- *The calculated ground level concentration of contaminants discharged to the atmosphere under maximum operating conditions must not exceed the criteria in Schedule F - Table 1 for each air contaminant* (reproduced here in Table 1).

- *The holder of this environmental authority must maintain a Register of Fuel Burning or Combustion Equipment that must include, as a minimum, the following information for each of the equipment:*
    - *Fuel Burning or Combustion Equipment Name and Location*
    - *Stack emission height (metres)*
    - *Minimum efflux velocity (metres /sec)*
    - *Mass emission rates (g/s)*
    - *Contaminant concentrations (mg/Nm^3 @ x %O_2 dry gas at 0°Celsius and 1 atmosphere)"*

5. Site and Surrounds

The Project site is to be located at the existing Silver Springs Gas Plant located 44km south of Surat and 70km northeast of St George in south central Queensland. The site is approximately 390km west of Brisbane located within the heart of the Surat Basin.

5.1 Local terrain and land-use

The Project site is located approximately 270 metres above sea level. The local terrain surrounding the site is characterised by the relatively flat terrain of the Surat Basin to the north, south and west. A small range rises to approximately 350 metres above sea level 20km east of the Project site and the terrain slowly rises in this direction. The land-use surrounding the Project site is a mix of sparse pasture and grassland.

5.2 Sensitive receptors

This study has predicted ground-level concentrations of air pollutants at the location of sensitive receptors provided by RPS and detailed in Table 2 and Figure 1.

Table 2 Sensitive receptor locations

Receptor ID	Location		Type	Distance / direction from Project site
	X (mE)	Y(mN)		
R1	708158	6942544	Property	3 km / S
R2	708006	6949890	Property	4 km / N
R3	710083	6946015	Property	1.8km / NE

6. Existing Air Quality

Nitrogen dioxide and carbon monoxide have been identified as the most important air quality pollutants for the study. There is currently no monitoring of the ambient levels of NO_2 or CO in the region. Aside from the existing Silver Springs Processing Plant there are no other large combustion sources within a 40km radius of the site. Therefore, a background concentration for NO_2 and CO has not been included as the existing gas plant will be included as part of the air dispersion modelling assessment.

7. Project Emissions

Emissions of air pollutants considered in this assessment are associated with the combustion of fuel (natural gas) in the compressor engines. Fugitive emissions, on-site vehicle emissions and construction dust emissions will have a negligible impact compared to combustion impacts therefore, have not been considered further.

The source characteristics and emission rates used as input for CALPUFF dispersion modelling are shown in Table 3.

Table 3 Stack characteristics and emission rates for the Project

Parameter	Units	Silver Springs Processing Plant (Existing)[1,2]			Silver Springs Gas Processing Facility (Proposed)[3]
Compressor		CM200A	CM200B	CM200C	CAT G3612
Location	mE, mN	708250 , 6945435	708240 , 6945435	708230 , 6945435	708235 , 6945380
Stack height	m	6.6	6.7	7.3	7
Stack diameter	m	0.35	0.35	0.4	0.5
Temperature	°C	248.85	248.85	267.85	459.3
Exit velocity	m/s	12.9	12.9	15.4	27.6
NOx emission rate	g/s	0.91	0.91	1.37	0.69
NO_x concentration	mg/Nm^3	1400	1400	1400	N/A[4]
CO emission rate	g/s	0.07	0.07	0.11	1.4
CO concentration	mg/Nm^3	110	110	110	N/A[4]
Oxygen content	%	16.2	16.2	16.2	N/A[4]

Note:
n/a – not applicable
[1]Stack characteristics have been based on information provided by RPS and AGL
[2]Emission rates have been calculated from the stack concentrations provided in EML stack testing report (Appendix B)
[3]Stack characteristics and emission rates sourced from technical specifications provided by RPS
[4] Requires testing once operational

Trace amounts of other pollutants may also be emitted from the existing and proposed sources but in much smaller quantities than NO_2. Emissions of volatile organic compounds (VOC's), and particulate matter (PM_{10} and $PM_{2.5}$) are much lower than NO_2 and Sulfur dioxide (SO_2) may also be emitted if there is sulfur present in the fuel. The ground-level concentrations of these trace air pollutants are expected to be very low and well below EPP(Air) objectives and have not been considered further.

8. Assessment Methodology

8.1 Meteorology

The site-specific meteorological data for this study was generated by coupling TAPM, a prognostic mesoscale model to CALMET, a diagnostic dispersion model. The coupled TAPM/CALMET modelling system was developed by Katestone Environmental to enable high resolution modelling capabilities for regulatory and environmental assessments. The modelling system incorporates synoptic, mesoscale and local atmospheric conditions, detailed topography and land use categorisation schemes to simulate synoptic and regional scale meteorology for input into pollutant dispersion models, such as CALPUFF.

A summary of on-site dispersion meteorology is provided in Section 9 and details of the meteorological model configuration are supplied in Appendix A.

8.2 Dispersion Modelling

Atmospheric dispersion modelling was carried out using the CALPUFF Version 6.267 dispersion model (EarthTec). CALPUFF is a non-steady-state puff dispersion model and is accepted for use by DERM.

The modelling was conducted assuming constant operations of each source over twelve months of modelled meteorological data. This encompasses all weather conditions likely to be experienced at the site during a typical year, including worst case dispersion conditions.

Key features of CALPUFF used to simulate dispersion:

- Domain area of 101 by 101 grid points at 100 m spacing
- 365 days (1 January 2008 to 31 December 2008)
- CALPUFF run in AUPLUME mode (uses AUSPLUME metrological file)
- Compressors CM200A and CM200B have been modelled with a rain hat to simulate horizontal stacks
- No terrain impacts
- No building wakes
- Surface roughness of 0.1 m to account for surrounding land use (flat terrain and minimal vegetation apart from low lying shrubs and grassland)
- Default temperature gradients
- Irwin rural wind profile exponents

All other options set to default.

8.3 Method for the Conversion of Oxides of Nitrogen to Nitrogen Dioxide

The prediction of ground-level concentrations of NO_2 has been conducted by modelling the total emission rate in grams per second for NO_X from each source, with the results scaled by an empirical nitric oxide/nitrogen dioxide conversion ratio. Measurements around power stations in Central Queensland show that under worst case conditions a conversion ratio of 25 - 40% of nitric oxide to nitrogen dioxide occurs within the first ten kilometres of plume travel. During days with elevated background levels of hydrocarbons (generally originating from bush-fires, hazard reduction burning or other similar activities), the resulting conversion is usually below 50% in the first thirty kilometres of plume travel (Bofinger *et al*., 1986).

For this assessment a conservative ratio of 30% conversion of the NO_X to NO_2 has been applied.

9. Dispersion Model Meteorology

9.1 Wind speed and wind direction

Wind speed and wind direction are important parameters that can determine the rate of dispersion of stack emissions. A summary of wind frequencies on annual, seasonal and diurnal basis are shown as wind roses for the Project site at a height of 10 metres above ground level in Figure 2, Figure 3 and Figure 4, respectively.

The wind rose for all hours of the year (Figure 2) shows that winds are predominantly light (< 4 m/s) and from the east. Moderate winds (2 – 6 m/s) occur from the south-southwest to north but to a lesser extent.

The seasonal wind roses (Figure 3) show summer and autumn are dominated by light winds from the east, while stronger winds from the southwest dominate during winter and spring winds are predominantly stronger from the north.

The diurnal wind rose (Figure 4) shows that lighter winds occur between 6pm and 6am (nighttime) and stronger winds occur between 6am and 6pm (daytime).

A summary of the annual, seasonal and diurnal frequency distribution of wind speeds predicted at the Project site is shown in Table 4. The data show that winds are predicted to be light to moderate (< 4 m/s) for 82% of the year and strong winds (> 6 m/s) for only 2% of the year.

Table 4 Summary of wind speeds at the Project site (m/s)

Period	Wind speed			
	< 2 m/s	2 – 4 m/s	4 – 6 m/s	> 6 m/s
Annual	35%	48%	15%	2%
Diurnal distribution				
Midnight to 6am	42%	52%	6%	0%
6am to midday	25%	47%	24%	4%
Midday to 6pm	20%	48%	27%	5%
6pm to midnight	52%	44%	4%	0%
Seasonal distribution				
Spring	30%	49%	18%	3%
Summer	39%	49%	11%	1%
Autumn	41%	47%	10%	1%
Winter	27%	46%	23%	5%

9.2 Atmospheric stability and mixing height

Stability classification is a measure of the stability of the atmosphere and can be determined from wind measurements and other atmospheric observations. The stability classes range from A class which represents very unstable atmospheric conditions that may typically occur on a sunny day to F class stability which represents very stable atmospheric conditions that typically occur during light wind conditions at night. Unstable conditions (Classes A to C) are characterised by strong solar heating of the ground that induces turbulent mixing in the atmosphere close to the ground. This turbulent mixing is the main driver of dispersion during unstable conditions. During the night, the atmospheric conditions are generally stable (often classes E and F).

Table 5 shows the percentage of stability classes at the Project site for the 2008 meteorological data used in the dispersion modelling, where A Class represents the most unstable conditions. There is a higher frequency of F class stability that can be attributed to the calm winds during the nighttime.

Table 5 Frequency of occurrence (%) of surface atmospheric stability at the Project site under Pasquil-Gifford stability classification scheme

Pasquil-Gifford stability class	Classification	Frequency (%)
A	Extremely unstable	2
B	Unstable	16
C	Slightly unstable	21
D	Neutral	11
E	Slightly stable	6
F	Stable	44

The mixing height refers to the height above ground within which pollutants released at or near ground can mix with ambient air. During stable atmospheric conditions, the mixing height is often quite low and pollutant dispersion is limited to within this layer. During the day, solar radiation heats the air at the ground level and causes the mixing height to rise. The air above the mixing height during the day is generally cooler. The growth of the mixing height is dependent on how well the air can mix with the cooler upper level air and therefore depends on meteorological factors such as the intensity of solar radiation and wind speed. During strong wind speed conditions the air will be well mixed, resulting in a high mixing height.

Mixing height information at the Project site is presented in Figure 5. The data shows that the mixing height develops around 6 to 7 am, increases to a peak at 2 to 4 pm before descending rapidly.

10. Analysis of Dispersion Modelling

This section presents the results of the air quality impact assessment.

Predicted maximum 1-hour average and annual average ground-level concentrations of NO_2 and maximum 8-hour average ground-level concentrations of CO, at identified receptor locations and the model domain maximum, for each model scenario are presented in Table 6. Contour plots of predicted maximum 1-hour average and annual average ground-level concentrations of NO_2 across the model domain for each model scenario are shown in Figure 6 to Figure 11. Contour plots of predicted maximum 8-hour ground-level concentrations of CO across the model domain for each model scenario are shown in Figure 12 to Figure 14.

Table 6 Predicted maximum ground-level concentrations of pollutants assessed for the Project (µg/m³)

Pollutant	Averaging Period	EPP(Air) objective	Maximum on grid	Receptor 1	Receptor 2	Receptor 3**
Scenario 1 (Existing)						
Nitrogen dioxide	1-hour	250	195.1	33.6	28.9	46.5
	Annual	62 (33*)	4.6	0.2	0.1	0.4
Carbon monoxide	8-hour	11,000	33.2	3.6	2.6	5.8
Scenario 2 (Proposed)						
Nitrogen dioxide	1-hour	250	7.2	1.6	1.8	4.8
	Annual	62 (33*)	0.1	0.02	0.01	0.03
Carbon monoxide	8-hour	11,000	36.0	8.6	7.3	11.9
Scenario 3 (combined)						
Nitrogen dioxide	1-hour	250	138.5	24.4	21.3	32.0
	Annual	62 (33*)	3.0	0.2	0.1	0.3
Carbon monoxide	8-hour	11,000	48.0	9.7	9.1	15.5

Note:
* EPP(Air) objective for the protection of ecosystems
** Location of receptor 3 was provided after dispersion modelling was completed and as a result the predicted ground-level concentrations are only indicative and have not been explicitly modelled

The results of the dispersion modelling show the following:

- The predicted ground-level concentrations of 1-hour average and annual average NO_2 for all model scenarios are below the EPP(Air) objectives at all receptor locations and at the maximum on the model domain.
- The predicted worst maximum 1-hour average ground-level concentration of NO_2 is from Scenario 1, existing sources, which is 195.1 µg/m³ or 78 % of the 1-hour average NO_2 EPP(Air) objective of 250 µg/m³.
- The predicted ground-level concentrations of 8-hour average CO for all model scenarios are significantly below the EPP(Air) objective at all receptor locations and at the maximum on the model domain.

11. Conclusion

An air quality impact assessment of emissions associated with the proposed development of a gas processing facility to be located at the existing Silver Springs Processing Plant has been undertaken. The assessment has been done in accordance with industry standard models, analysis techniques and DERM model conditions. A cumulative assessment of the proposed facility operating in conjunction with the existing gas plant has been undertaken. The findings of the assessment are:

- The predicted ground-level concentrations of nitrogen dioxide and carbon monoxide for all modelled scenarios at all locations are below the EPP (Air) objectives.
- The predicted air quality impact of the Project on the surrounding atmospheric environment is low.

12. References

Bofinger, N.D., Best P.R., Cliff D.I., Stumer, L.J., 1986, "*The oxidation of nitric oxide to nitrogen dioxide in power station plumes*", Proceedings of the Seventh World Clean Air Congress, Sydney, 384-392.

Department of Environment and Resources Management, 2010, Guideline - "*Model conditions for level 1 environmental authority for coal seam gas activities"*

National Pollutant Inventory (NPI), 2010, Internet: www.npi.gov.au, accessed December 2010.

Figure 1 Location of Silver Springs Processing Facility and sensitive receptors

Location: Silver Springs, Queensland	**Data source:** Google Earth 2010	**Units:** Projection MGA94 Zone 55S
Type: Aerial map	**Prepared by:** A. Vernon	**Date:** December 2010

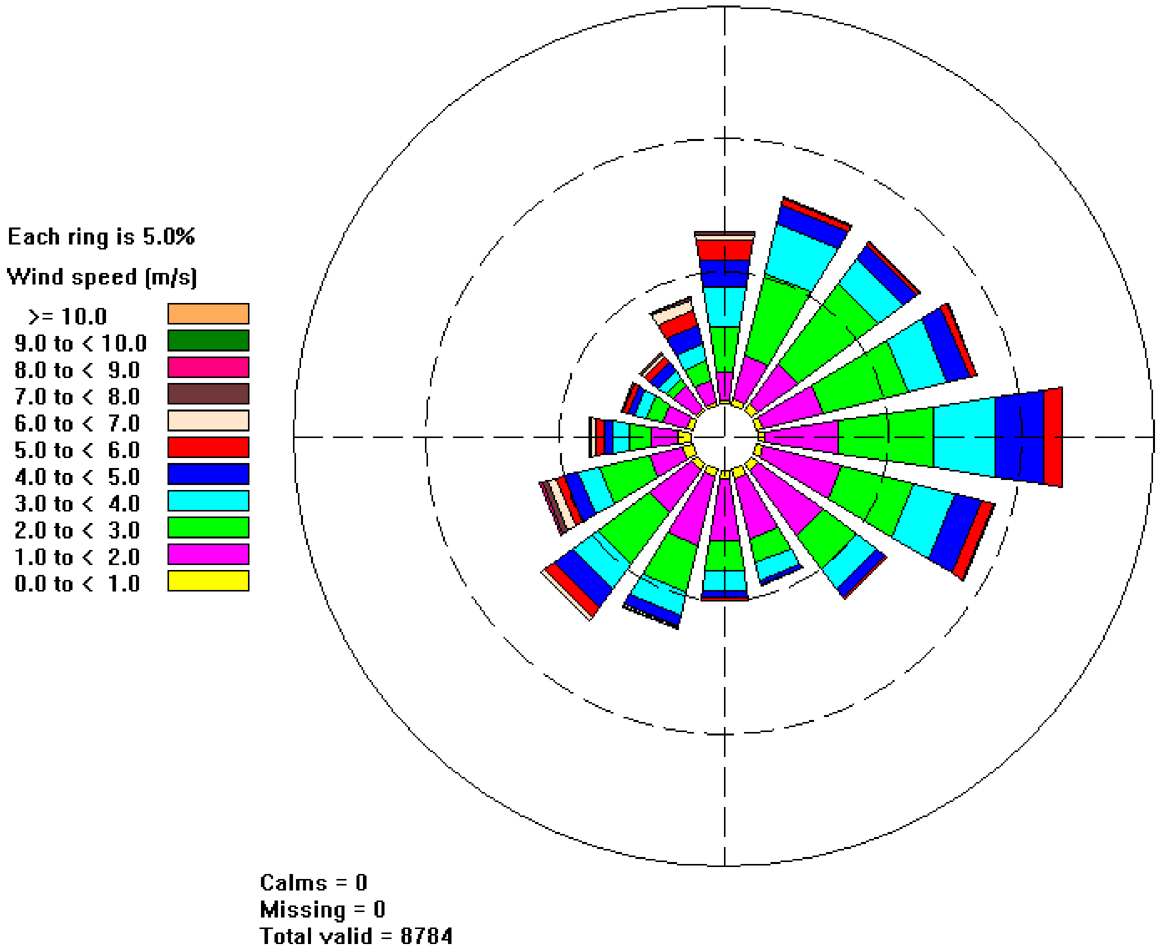


Figure 2 Annual distribution of winds at Silver Springs

Location: Silver Springs, Queensland	**Period:** 2008	**Data source:** TAPM/CALMET	**Units:** metres per second for wind speed and degrees for wind direction
Type: Annual wind rose	8760 hourly average records	**Prepared by:** A. Vernon	**Date:** December 2010

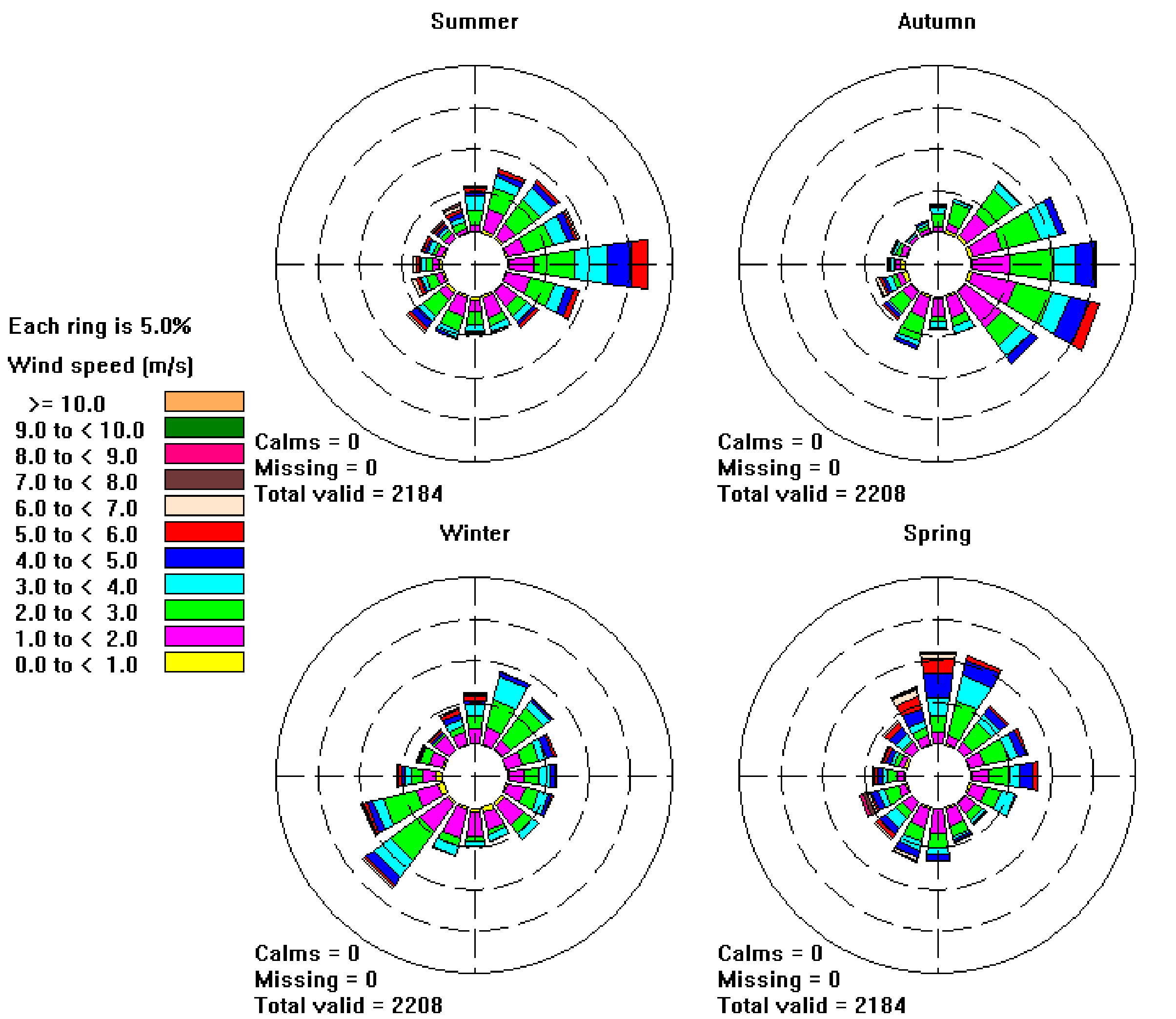


Figure 3 Seasonal distribution of winds at Silver Springs

Location: Silver Springs, Queensland	**Period:** 2008	**Data source:** TAPM/ CALMET	**Units:** metres per second for wind speed and degrees for wind direction
Type: Seasonal wind rose	8760 hourly average records	**Prepared by:** A. Vernon	**Date:** December 2010

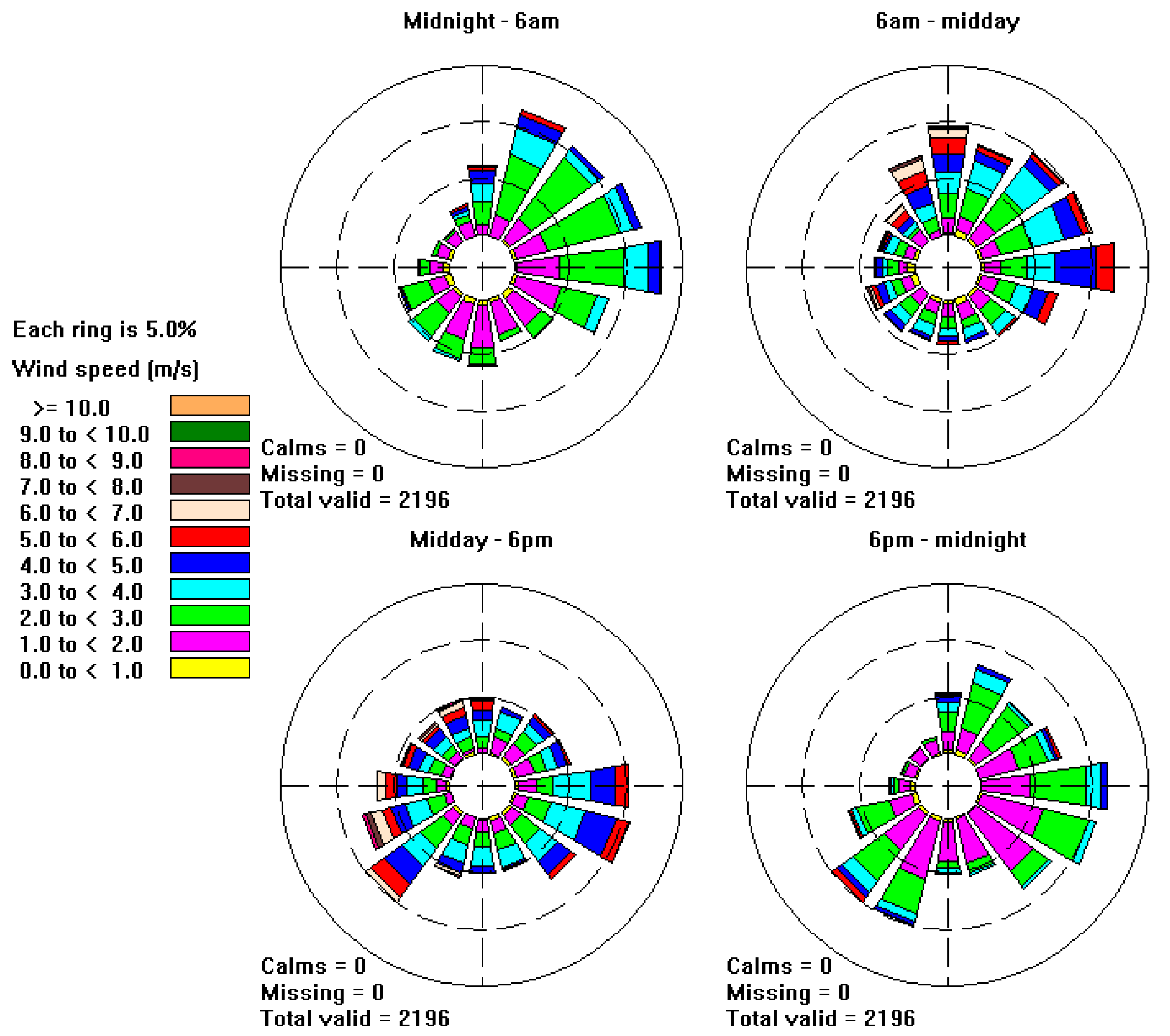


Figure 4 Diurnal distribution of winds at Silver Springs

Location: Silver Springs, Queensland	**Period:** 2008	**Data source:** TAPM / CALMET	**Units:** metres per second for wind speed and degrees for wind direction
Type: Diurnal wind rose	8760 hourly average records	**Prepared by:** A. Vernon	**Date:** December 2010

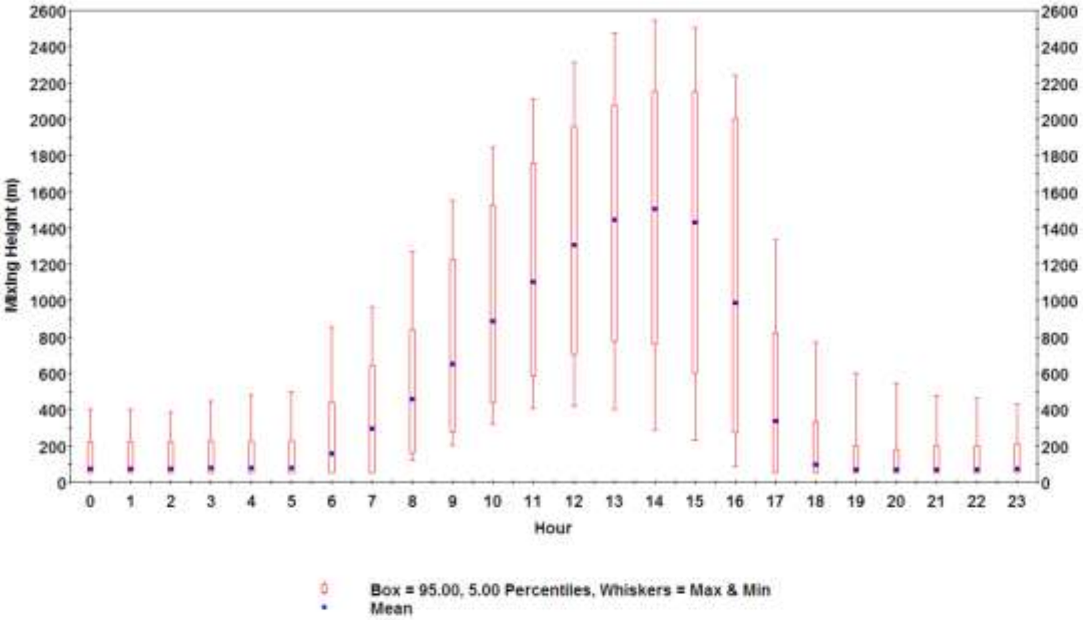


Figure 5 Diurnal profile of mixing height at Silver Springs

Location: Silver Springs, Queensland	**Period:** 2008	**Data source:** TAPM / CALMET	**Units:** metres
Type: Box and whisker	8760 hourly average records	**Prepared by:** A. Vernon	**Date:** December 2010

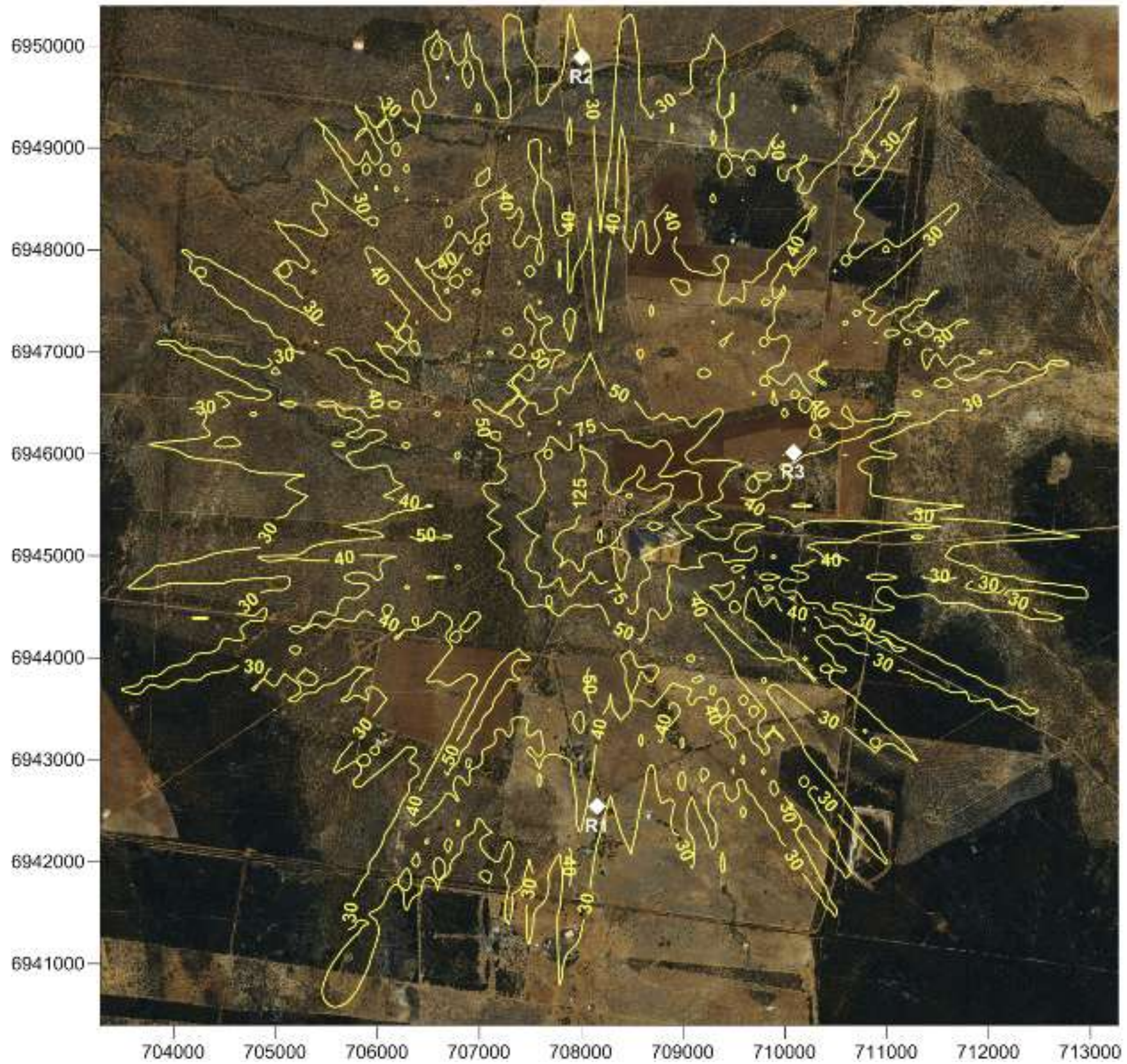


Figure 6 Predicted maximum 1-hour average ground level concentration of nitrogen dioxide from Scenario 1

Location: Silver Springs, Queensland	**Averaging period:** 1-hour	**Data source:** CALPUFF	**Units:** µg/m³
Type: Maximum contour plot	**EPP(Air)Objective:** 250 µg/m³	**Prepared by:** A. Vernon	**Date:** December 2010

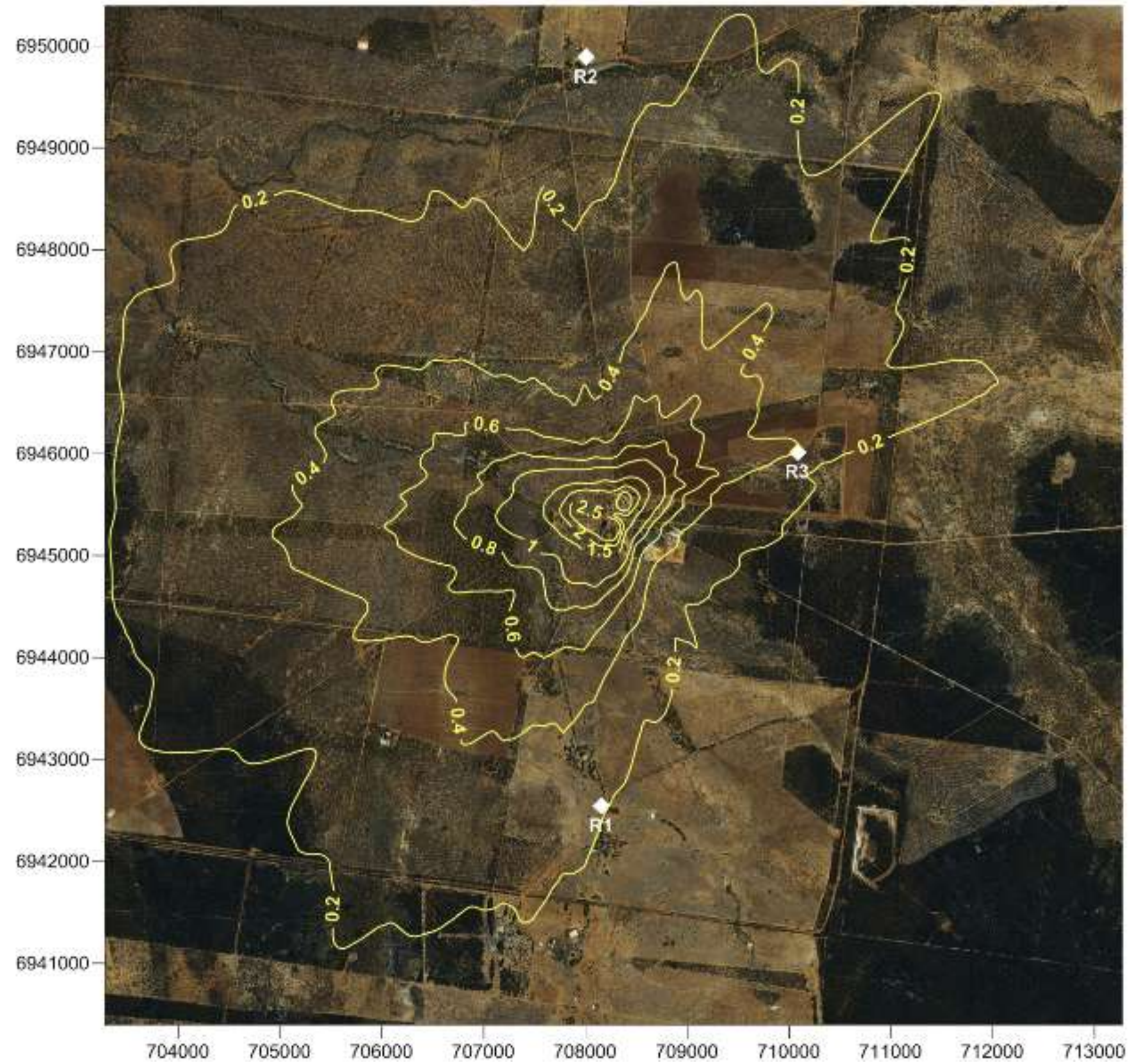


Figure 7	**Predicted annual average ground level concentration of nitrogen dioxide from Scenario 1**		
Location: Silver Springs, Queensland	**Averaging period:** Annual	**Data source:** CALPUFF	**Units:** µg/m³
Type: Contour plot	**EPP(Air)Objective:** 62 µg/m³ & 33 µg/m³	**Prepared by:** A. Vernon	**Date:** December 2010

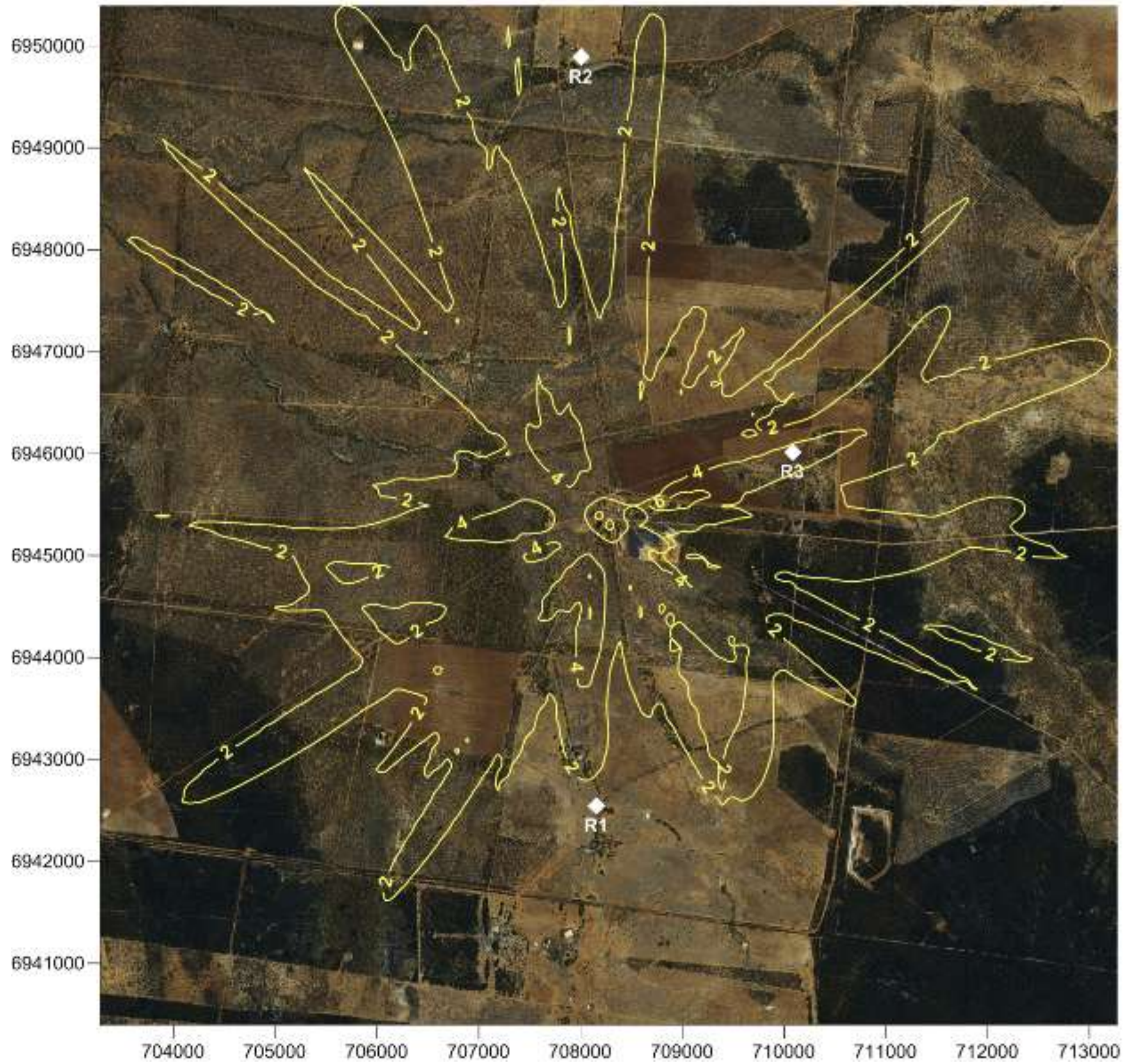


Figure 8	**Predicted maximum 1-hour average ground level concentration of nitrogen dioxide from Scenario 2**		
Location: Silver Springs, Queensland	**Averaging period:** 1-hour	**Data source:** CALPUFF	**Units:** µg/m³
Type: Maximum contour plot	**EPP(Air)Objective:** 250 µg/m³	**Prepared by:** A. Vernon	**Date:** December 2010

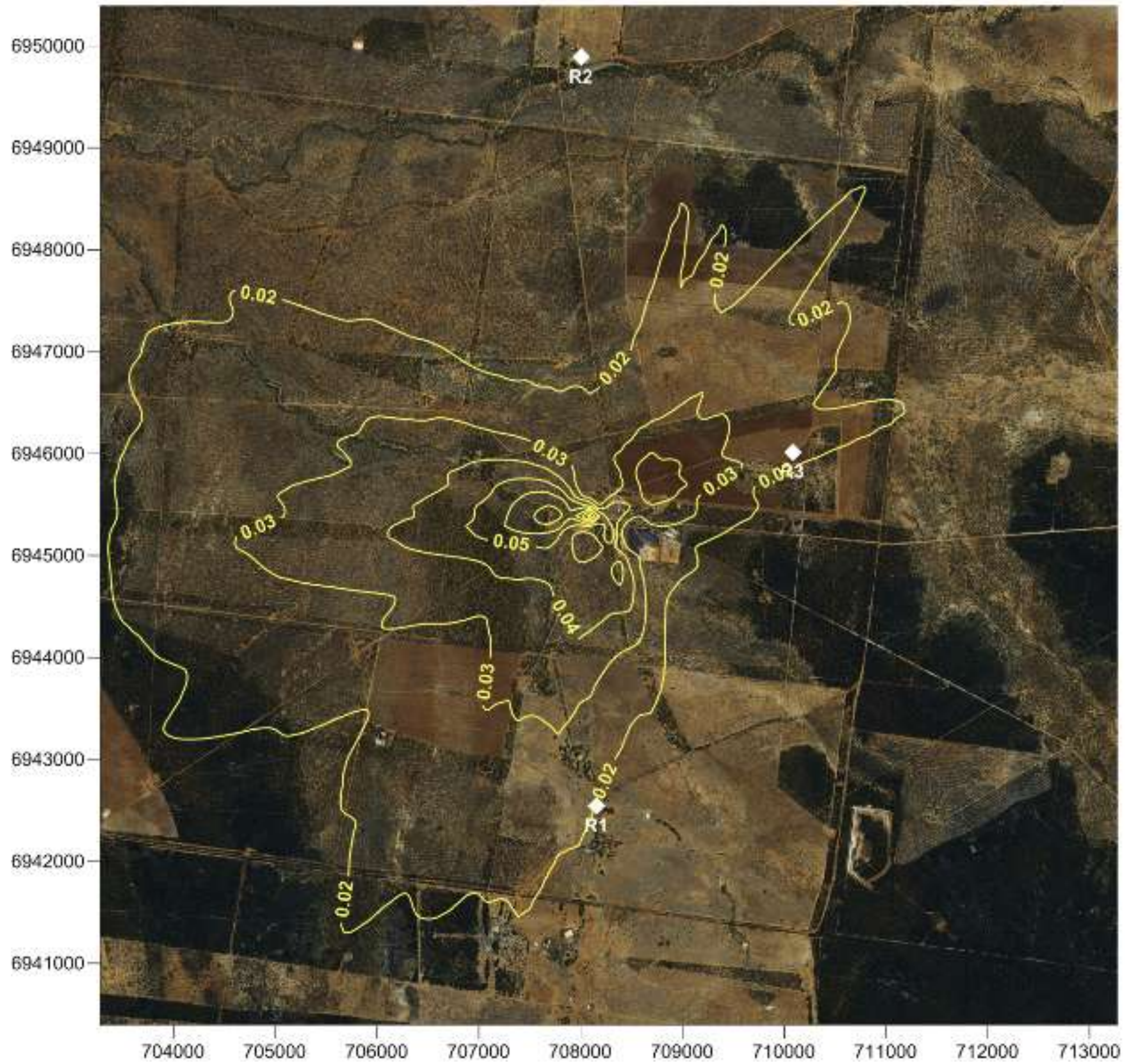


Figure 9 Predicted annual average ground level concentration of nitrogen dioxide from Scenario 2

Location: Silver Springs, Queensland	**Averaging period:** Annual	**Data source:** CALPUFF	**Units:** µg/m³
Type: Contour plot	**EPP(Air)Objective:** 62 µg/m³ & 33 µg/m³	**Prepared by:** A. Vernon	**Date:** December 2010

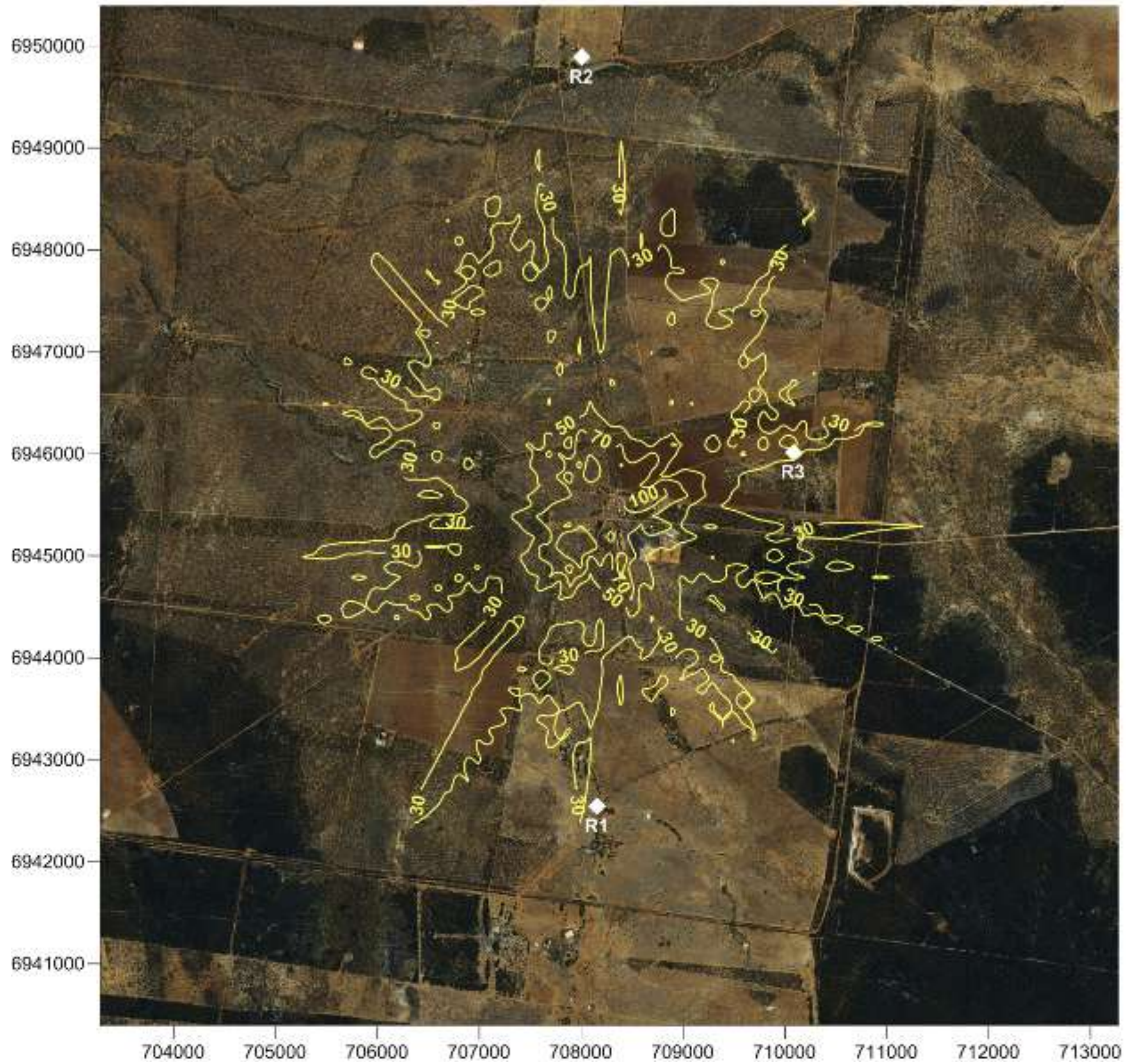


Figure 10 Predicted maximum 1-hour average ground level concentration of nitrogen dioxide from Scenario 3

Location: Silver Springs, Queensland	**Averaging period:** 1-hour	**Data source:** CALPUFF	**Units:** µg/m³
Type: Maximum contour plot	**EPP(Air)Objective:** 250 µg/m³	**Prepared by:** A. Vernon	**Date:** December 2010

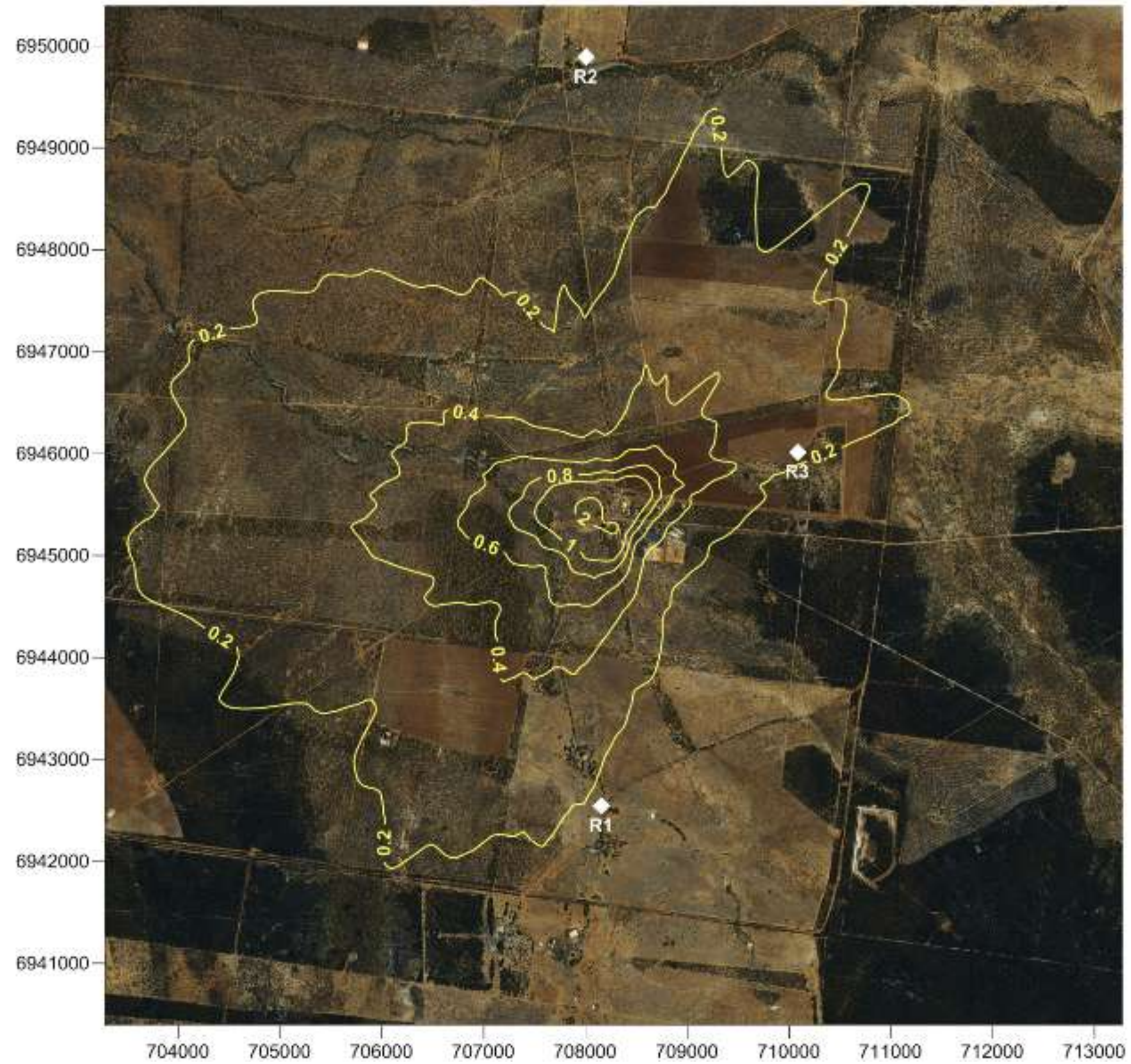


Figure 11 Predicted annual average ground level concentration of nitrogen dioxide from Scenario 3

Location: Silver Springs, Queensland	**Averaging period:** Annual	**Data source:** CALPUFF	**Units:** µg/m³
Type: Contour plot	**EPP(Air)Objective:** 62 µg/m³ & 33 µg/m³	**Prepared by:** A. Vernon	**Date:** December 2010

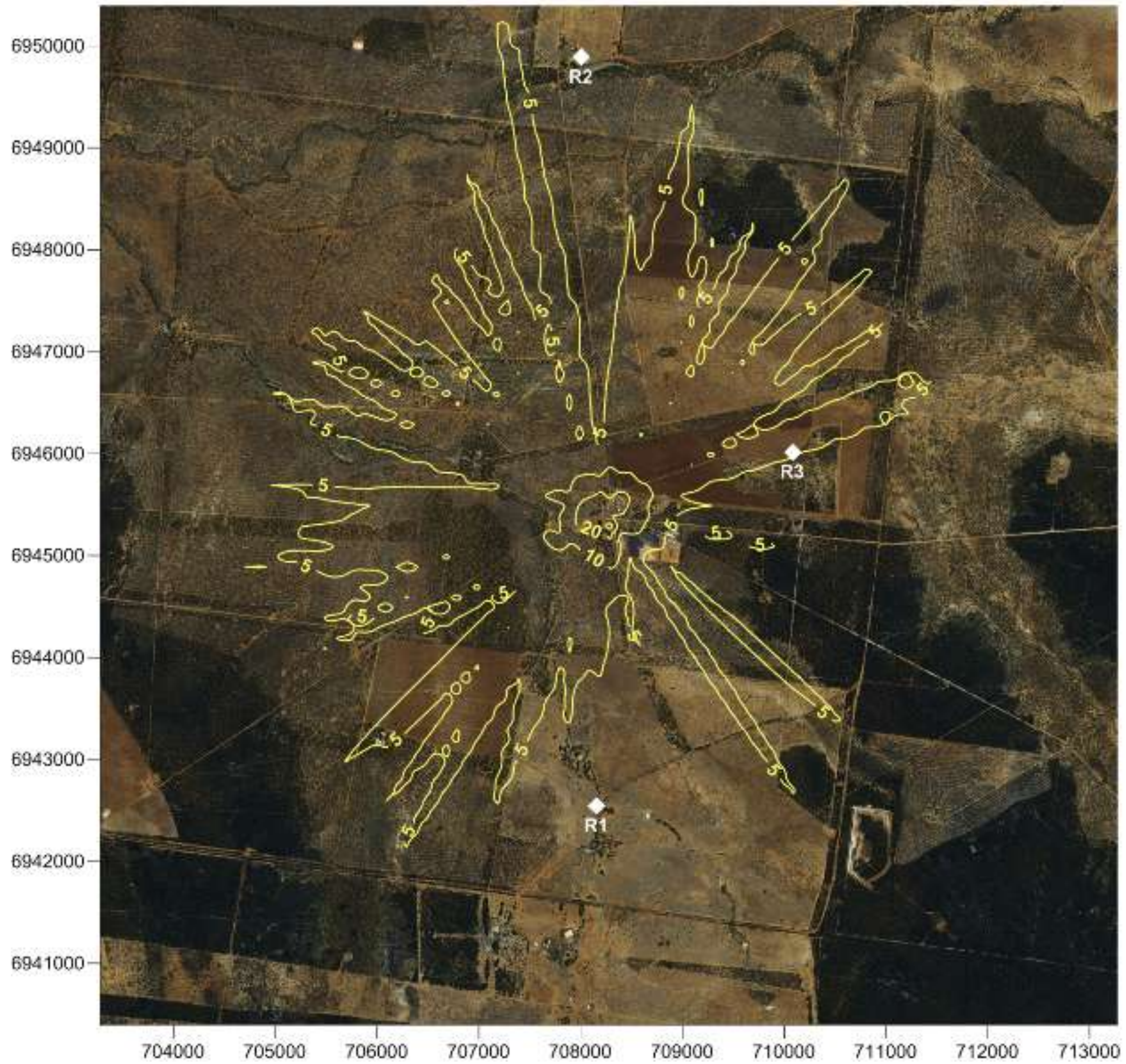


Figure 12 Predicted maximum 8-hour average ground level concentration of carbon monoxide from Scenario 1

Location: Silver Springs, Queensland	**Averaging period:** 8-hour	**Data source:** CALPUFF	**Units:** µg/m³
Type: Maximum contour plot	**EPP(Air)Objective:** 11,000 µg/m³	**Prepared by:** A. Vernon	**Date:** December 2010

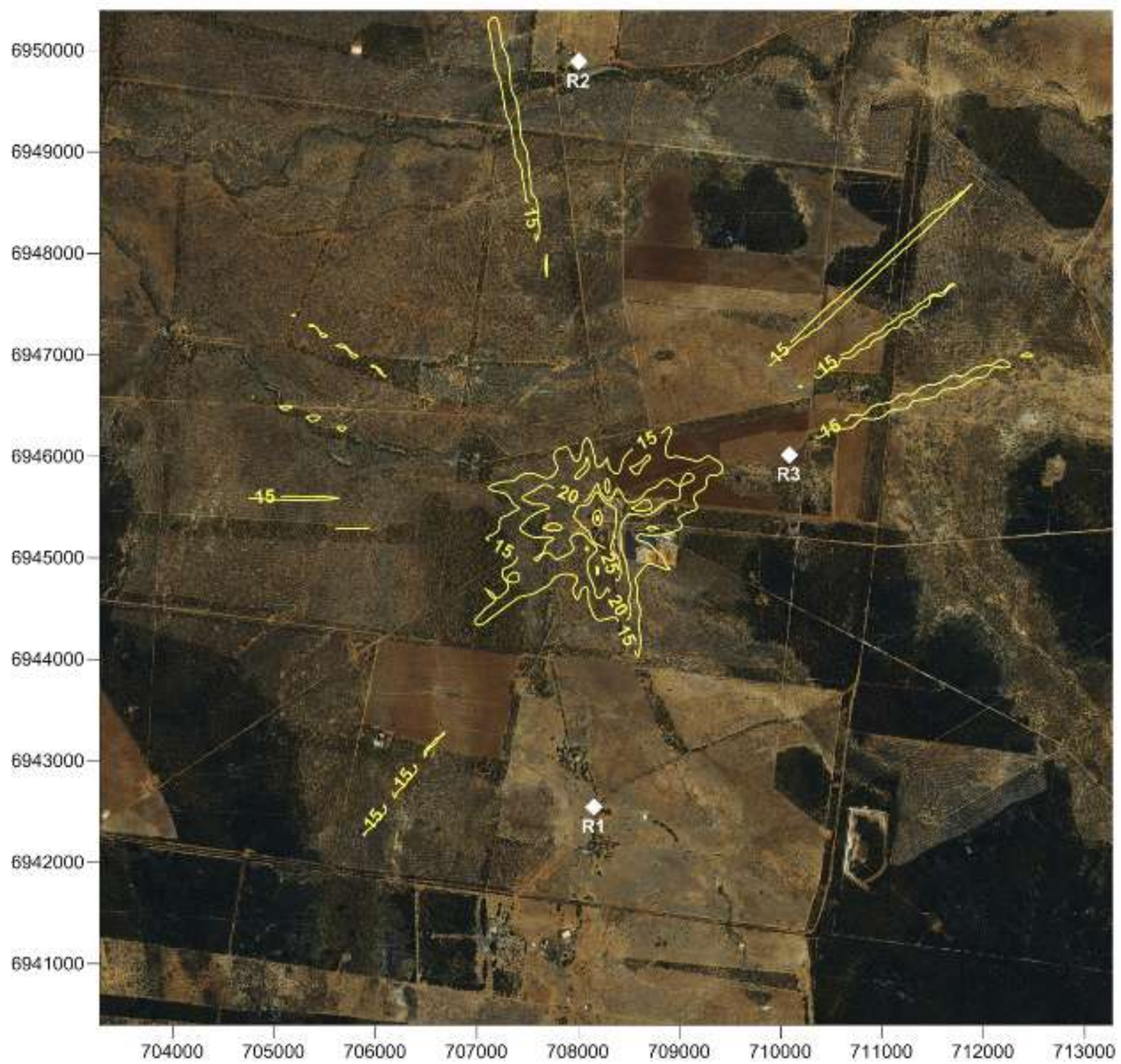


Figure 13 Predicted maximum 8-hour average ground level concentration of carbon monoxide from Scenario 2

Location: Silver Springs, Queensland	**Averaging period:** 8-hour	**Data source:** CALPUFF	**Units:** µg/m³
Type: Maximum contour plot	**EPP(Air)Objective:** 11,000 µg/m³	**Prepared by:** A. Vernon	**Date:** December 2010

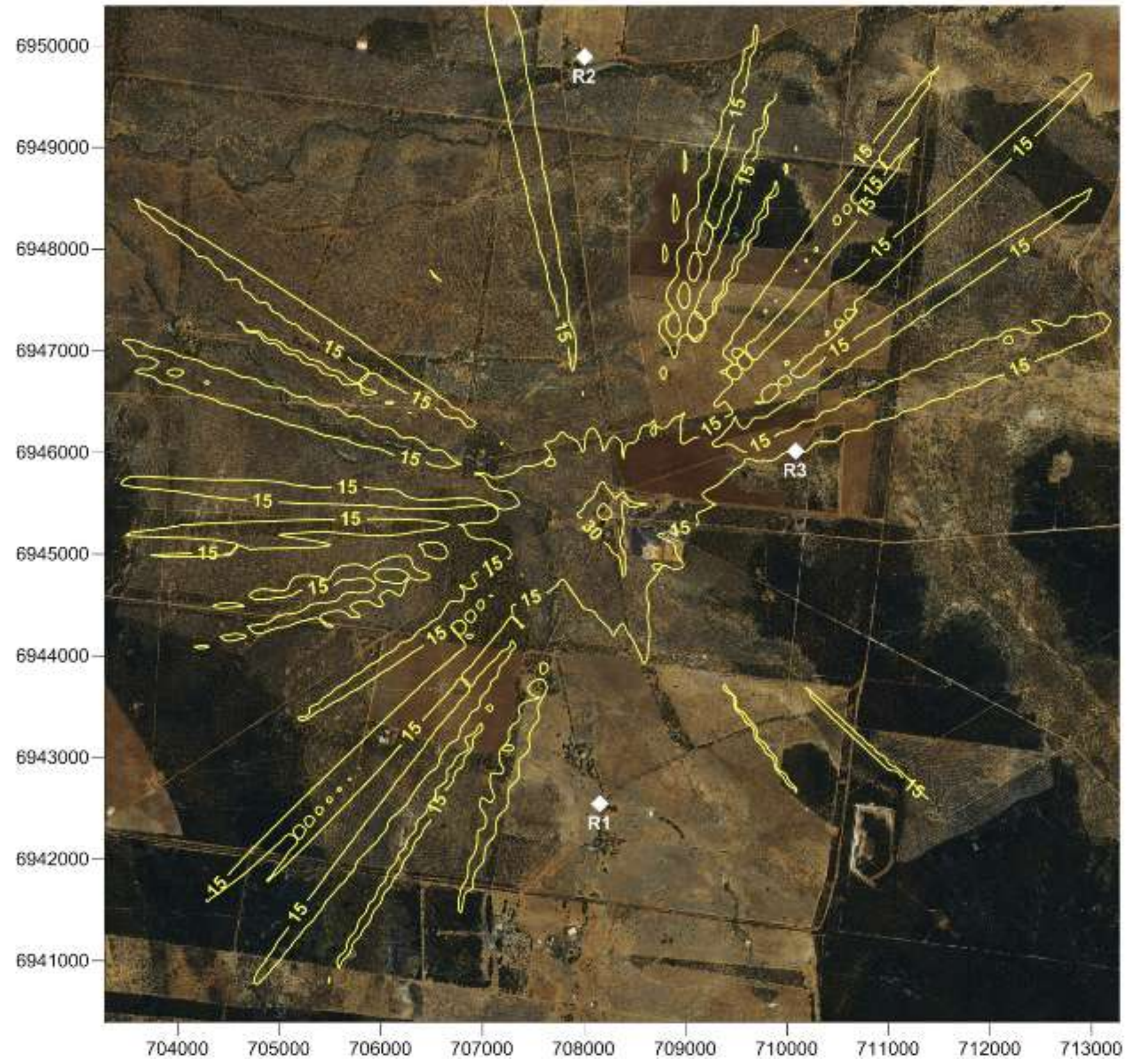


Figure 14 Predicted maximum 8-hour average ground level concentration of carbon monoxide from Scenario 3

Location: Silver Springs, Queensland	**Averaging period:** 8-hour	**Data source:** CALPUFF	**Units:** µg/m³
Type: Maximum contour plot	**EPP(Air)Objective:** 11,000 µg/m³	**Prepared by:** A. Vernon	**Date:** December 2010

Appendix A

Meteorology for Air Dispersion Modelling

A1 Meteorology for Air Dispersion Modelling

The meteorological data for this study was generated by coupling TAPM, a prognostic mesoscale model to CALMET, a diagnostic meteorological model. The coupled TAPM/CALMET modelling system was developed by Katestone Environmental to enable high resolution modelling capabilities for regulatory and environmental assessments. The modelling system incorporates synoptic, mesoscale and local atmospheric conditions, detailed topography and land use categorisation schemes to simulate synoptic and regional scale meteorology for input into pollutant dispersion models, such as AUSPLUME. Details of the model configuration and evaluation are supplied in the following sections.

A1.1 TAPM

The meteorological model, TAPM (The Air Pollution Model) Version 4.0.2, was developed by the CSIRO and has been validated by the CSIRO, Katestone Environmental and others for many locations in Australia, in southeast Asia and in North America (see www.cmar.csiro.au/research/tapm for more details on the model and validation results from the CSIRO). Katestone Environmental has used TAPM throughout Australia as well as in parts of New Caledonia, Bangladesh, America and Vietnam. This model has performed well for simulating regional meteorological conditions. TAPM has proven to be a useful model for simulating meteorology in locations where monitoring data is unavailable.

TAPM is a prognostic meteorological model which predicts the flows important to regional and local scale meteorology, such as sea breezes and terrain-induced flows from the larger-scale meteorology provided by the synoptic analyses. TAPM solves the fundamental fluid dynamics equations to predict meteorology at a mesoscale (20 km to 200 km) and at a local scale (down to a few hundred metres). TAPM includes parameterisations for cloud/rain micro-physical processes, urban/vegetation canopy and soil, and radiative fluxes.

TAPM requires synoptic meteorological information for the study region. This information is generated by a global model similar to the large-scale models used to forecast the weather. The data are supplied on a grid resolution of approximately 75 km, and at elevations of 100 m to 5 km above the ground. TAPM uses this synoptic information, along with specific details of the location such as surrounding terrain, land-use, soil moisture content and soil type to simulate the meteorology of a region as well as at a specific location.

TAPM was configured with the following parameters:

- Mother domain with a horizontal grid resolution of 27 km
- Nested domain with a horizontal grid resolution of 9 km
- 55 x 55 grid points for both modelling domains
- Grid centred on latitude -26.86°S, longitude 150.27°E
- 25 vertical levels, from the surface up to an altitude of 8000 metres above ground level
- Geoscience Australia 9 second DEM terrain data
- The TAPM defaults for sea surface temperature
- Default options selected for advanced meteorological inputs
- Default TAPM landuse data
- The synoptic data used in the simulation is for the year 2008 as provided by the CSIRO
- Local data assimilation using observations from the three regionally representative sites (Applethorpe, Miles and Dalby)

A1.2 CALMET

CALMET is an advanced non-steady-state diagnostic three-dimensional meteorological model with micro-meteorological modules for overwater and overland boundary layers. The model is the meteorological pre-processor for the CALPUFF Modelling system. CALMET is capable of reading hourly meteorological data from multiple sites within the modelling domain; it can also be initialised with the gridded three-dimensional prognostic output from other meteorological models such as TAPM. This can improve dispersion model output, particularly over complex terrain as the near surface meteorological conditions are calculated for each grid point.

CALMET (version 6.327) was used to simulate meteorological conditions in the study region. The CALMET simulation was initialised with the gridded TAPM three dimensional wind field data from the 9 km grid. CALMET treats the prognostic model output as the initial guess field for the CALMET diagnostic model wind fields. CALMET then adjusts the initial guess field for the kinematic effects of terrain, slope flows, blocking effects and 3-dimensional divergence minimisation. The geophysical data (land use and terrain heights) were generated consistent with the geophysical dataset for TAPM.

Key features of CALMET used to generate the wind fields are as follows:

- Grid domain area of 360 km by 360 km
- Horizontal grid cell resolution of 3 km by 3 km
- 12 vertical levels with heights at 20m, 60m, 100m, 150m, 200m, 250m, 350m, 500m, 800m, 1600m, 2600m and 4600m
- 1-year time scale (1 January – 31 December 2008)
- The terrain and land use were refined from those used in the TAPM model to account for the increased resolution, with the terrain generated from the Geosciences Australia 9-second arc DEM dataset at a resolution of 3 km
- Prognostic wind fields input as MM5/2D.dat “initial guess” field only (as generated from TAPM)
- All default options and factors were selected with the exception of the following:
    - Step 1 wind field options include kinematic effects, divergence minimisation, Froude adjustment to a critical Froude number of 1, and slope flows
    - Terrain radius of influence set at 2 km
    - Cloud cover calculated from prognostic relative humidity

Appendix B

EML Air Pty Ltd

Report N86450

EML AIR PTY LTD ABN 98 006 878 342
PO Box 466, Canterbury, Victoria 3126
Telephone(03) 9836 1999 • Facsimile(03) 9830 0670
Email Address: emlair@eml.com.au
Web Address: www.eml.com.au

Our reference: **N86450**

8 November 2010

Katestone Environmental
PO Box 2217
MILTON QLD 4064

Attention Ms Ella Castillo

AGL SILVER SPRINGS PLANT

Emission Testing Report - OCTOBER 2010

Tests were performed at the request of Katestone Environmental to determine emissions to air as detailed below;

Test Summary		
Location	Test Date	Test Parameters*
200C Exhaust	21 October 2010	Nitrogen oxides, sulfur dioxide, carbon monoxide, carbon dioxide, oxygen, speciated volatile organic compounds, C_1-C_4 hydrocarbons

* Flow rate, velocity, temperature and moisture were determined unless otherwise stated.

Please refer to the following pages for results, plant operating conditions, test methods, quality assurance / quality control information and definitions.

David Corbett
NATA Signatory
cs doc:n86450.doc

Melissa Reddan BAppSc
NATA Signatory

RESULTS

Date	21/10/2010	**Client**	Katestone Environmental		
Report	N86450	**Stack ID**	200C Exhaust		
Licence No.	-	**Location**	AGL, Silver Springs	**State**	QLD
EML Staff	EC/DC				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested testing to determine emissions to air				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	400	0.126 m²
Sampling port size, number & depth	Sampled at exit	
Access & height of ports	No Access	6 m
Duct orientation & shape	Vertical	Circular
Downstream disturbance	Exit	0 D
Upstream disturbance	Change in diameter	3 D
Traverse method & compliance	AS4323.1	Non-compliant

Comments

No access to stack. Sample taken via stainless steel tubing from stack exit to ground level. Concentrations only.
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	5.2	
Gas molecular weight, g/g mole	28.7 (wet)	29.3 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.31 (dry)

Gases	Average	Minimum	Maximum
Sampling time	1234-1303	1234-1303	1234-1303
	Concentration mg/m³	Concentration mg/m³	Concentration mg/m³
Nitrogen oxides (as NO_2)	1400	1100	1700
Sulfur dioxide	140	63	200
Carbon monoxide	110	84	130
	Concentration %	Concentration %	Concentration %
Carbon dioxide	3	2.3	3.1
Oxygen	16.2	15.7	17.1

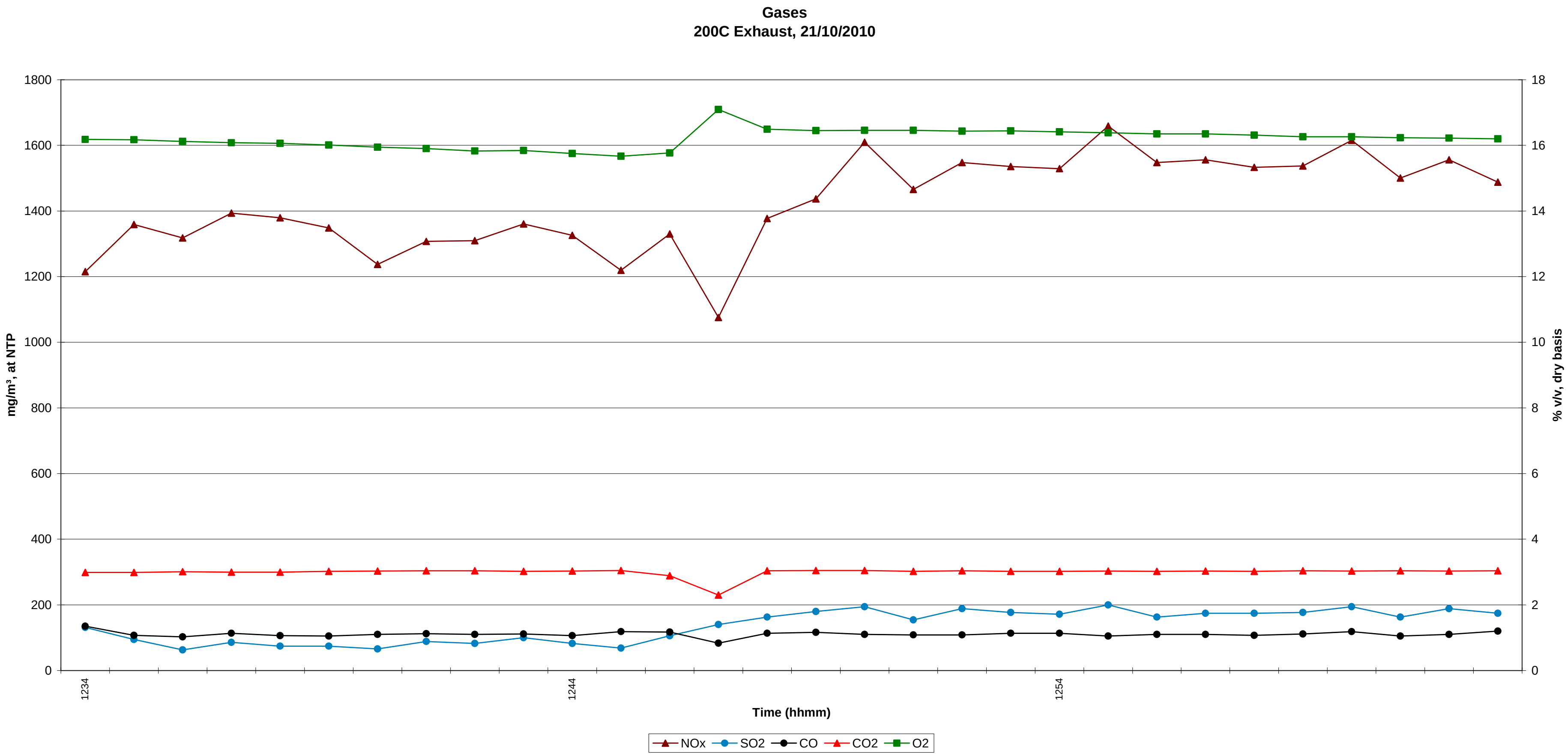
VOC's C_1-C_4	Average	Test 1	Test 2
Sampling time		1305-1310	1310-1315
	Concentration mg/m³	Concentration mg/m³	Concentration mg/m³
Ethane	820	780	870
Ethylene	140	130	140
Propane	610	580	640
Cyclopropane	<1.9	<1.9	<1.9
Propylene	<1.9	<1.9	<1.9
Isobutane	<2.6	<2.6	<2.6
Butane	<2.6	<2.6	<2.6
Propadiene	<1.8	<1.8	<1.8
Acetylene	<1.2	<1.2	<1.2
trans-2-Butene	<2.5	<2.5	<2.5
1-Butene	<2.5	<2.5	<2.5
cis-2-Butene	<2.5	<2.5	<2.5
1,3-Butadiene	<2.4	<2.4	<2.4
Propyne	<1.8	<1.8	<1.8

Date	21/10/2010	**Client**	Katestone Environmental		
Report	N86450	**Stack ID**	200C Exhaust		
Licence No.	-	**Location**	AGL, Silver Springs	**State**	QLD
EML Staff	EC/DC				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested testing to determine emissions to air				

Methane	Average	Test 1	Test 2
Sampling time		1305-1310	1310-1315
	Concentration %	Concentration %	Concentration %
Methane	3.6	3.5	3.6

VOC's (speciated)	Average	Test 1	Test 2
Sampling time		1215-1230	1315-1330
	Concentration mg/m³	Concentration mg/m³	Concentration mg/m³
Detection limit(1)	<0.26	<0.22	<0.3
Toluene	0.69	0.64	0.75
Pentane	41	42	39
Hexane	8.2	8.1	8.4
Cyclohexane	6.6	6.5	6.8
2-Methylhexane	2	1.7	2.2
2,3-Dimethylpentane	0.91	0.84	0.98
Heptane	5.2	4.5	5.9
Methylcyclohexane	11	9.8	12
Octane	1.2	0.97	1.4
Residual as Methylcyclohexane	150	140	150

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene


Gases
200C Exhaust, 21/10/2010
mg/m³, at NTP
% v/v, dry basis
1800
1600
1400
1200
1000
800
600
400
200
0
18
16
14
12
10
8
6
4
2
0
1234
1244
1254
Time (hhmm)
NOx
SO2
CO
CO2
O2

PLANT OPERATING CONDITIONS

Unless otherwise stated, the plant operating conditions were normal at the time of testing. See Katestone Environmental's records for complete process conditions.

TEST METHODS

Unless otherwise stated, the following methods meet the requirements of the Queensland Department of Environment & Resource Management (as specified in the *Queensland Air Quality Sampling Manual, November 1997).* All sampling and analysis was performed by EML Air unless otherwise specified.

Parameter	EML Air Method	Reference Method	Uncertainty	NATA Accredited	
				Sampling	Analysis
Sample Plane Criteria	-	AS 4323.1	-	✓	NA
Flow rate, temperature and velocity	100	USEPA 2	not specified	✓	NA
Moisture	-	USEPA Alt-008	not specified	✓	✓
Carbon monoxide and carbon dioxide	200	USEPA 10 and 3A	not specified	✓	✓
Oxygen	-	USEPA 3A	not specified	✓	✓
Sulfur dioxide	228	USEPA 6C	not specified	✓	✓
Nitrogen oxides	230	USEPA 7E	not specified	✓	✓
C_1-C_4 Hydrocarbons	340	USEPA 18	not specified	✓	✓
Speciated volatile organic compounds	344	USEPA 18	not specified	✓	✓

AS – Australian Standard
USEPA – United States Environmental Protection Agency

QUALITY ASSURANCE / QUALITY CONTROL INFORMATION

EML Air Pty Ltd is accredited by the National Association of Testing Authorities (NATA) for the sampling and analysis of air pollutants from industrial sources (Accreditation number 2732). Unless otherwise stated test methods used are accredited with the National Association of Testing Authorities. For full details, search for EML Air at NATA's website www.nata.asn.au.

EML Air is accredited to Australian Standard 17025 – General Requirements for the Competence of Testing and Calibration Laboratories. Australian Standard 17025 requires that a laboratory have a quality system similar to ISO 9002. More importantly it also requires that a laboratory have adequate equipment to perform the testing, as well as laboratory personnel with the competence to perform the testing. This quality assurance system is administered and maintained by the Quality Assurance Manager.

A formal Quality Control program is in place at EML Air to monitor analyses performed in the laboratory and sampling conducted in the field. The program is designed to check where appropriate; the sampling reproducibility, analytical method, accuracy, precision and the performance of the analyst. The Laboratory Manager is responsible for the administration and maintenance of this program.

DEFINITIONS

The following symbols and abbreviations may be used in this test report:

NTP	Normal temperature and pressure. Gas volumes and concentrations are expressed on a dry basis at 0°C, at discharge oxygen concentration and an absolute pressure of 101.325 kPa, unless otherwise specified.
Disturbance	A flow obstruction or instability in the direction of the flow which may impede accurate flow determination. This includes centrifugal fans, axial fans, partially closed or closed dampers, louvres, bends, connections, junctions, direction changes or changes in pipe diameter.
VOC	Any chemical compound based on carbon with a vapour pressure of at least 0.010 kPa at 25°C or having a corresponding volatility under the particular conditions of use. These compounds may contain oxygen, nitrogen and other elements, but specifically excluded are carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonate salts.
BSP	British standard pipe.
NA	Not applicable
D	Duct diameter or equivalent duct diameter for rectangular ducts.
<	Less than.