Proposed LPG Depot, Kooragang, NSW
Odour Impact and Greenhouse Gas Emission Study

For Elgas Ltd

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Summary

This study summarises the greenhouse gas emission estimation and odorant (ethyl mercaptan) emission associated with potential LPG releases, during normal operation of Elgas' proposed Kooragang LPG Depot.

The proposed depot will receive LPG in bulk road tankers, store in bulk tank (80 kL) and distribute the LPG to customers through filled cylinders and through small bulk tankers known as Bobtails (9 tonne capacity maximum).

The sources of emissions identified were:

- LPG tanker unloading (vapour)
- LPG tanker loading (liquid and vapour)
- Fugitive emissions (tank and cylinder filling)

The first two items were calculated from piping dimensions and lengths. The last item was estimated using an emission factor for the equipment, provided by Elgas. These emission factors are currently used by Elgas in reporting greenhouse gas emissions to EPA NSW.

The summary of emissions is shown in Table 1.

Table 1: Summary of Estimated LPG emissions

Operation	Estimated Pollutant Load, kg/year
Bulk Storage	12.80
Cylinder Filling	0.220
Tanker unloading	1.98
Tanker loading	46.64
Total	**61.64**

LPG is odourised with ethyl mercaptan with 25 grams of odorant per tonne (1000 kg) of LPG. This is a statutory requirement for leak detection as a safety measure.

Based on LPG emissions and the concentration of odorant, odorant emissions were calculated. A summary is given in Table 2.

Table 2: Summary of Estimated Odorant emissions

Operation	Estimated Load, mg/s	Duration of release, s
Bulk Storage	4.06E-04	Intermittent
Cylinder Filling	3.8.4E-05	7 am-5pm, 5 days a week
Tanker unloading	5.80E-03	90, twice a day
Tanker loading	2.94E-01	90, 3 times a day

The odour threshold for ethyl mercaptan is 1.4x 10^{-3} ppm or 0.37 µg/m^3. This is one odour unit (OU). The mercaptan emissions dispersion were modelled using the NSW EPA approved software AUSPLUME 6.0, using the meteorological data for Willamtown RAFF Base met station, provided by the Bureau of Meteorology.

The dispersion analysis is conservative as the short duration infrequent emissions were modelled as continuous releases during Depot operating hours. This is due to software limitation.

It was found that a target exposure level of 2 OU for urban residential areas was reached in approximately 80m from the source and contained entirely within the Kooragang industrial precinct.

The maximum exposure was less than 4 OU, indicating that there will be no adverse impact on the local industrial facilities.

Elgas adopts the following measures to minimise odour emissions in all its LPG Depots in Australia:

- No storage and injection of odorant on site
- Hose end valve on the loading hose that minimises the trapped inventory between the hose end valve and the tanker liquid or vapour line
- Vapour return line for loading/ unloading to keep the LPG (and hence odorant) within a closed circuit.
- Tanker unloading procedures using site compressor to displace all the liquid into the storage tank until the trapped inventory between tanker liquid line and hose end valve would only contain vapour.
- Tanker loading/ unloading procedures and driver training to ensure all the valves at the tanker end and hose end (liquid and vapour – 4 valves in total) are isolated before the bleed valve can be opened.
- Closing the bleed valve once the small section is depressurised.
- Integrity inspections on site conducted at scheduled intervals that covers pump seals, valve stem and other fittings to minimise fugitive emissions.

It was concluded that the odour impact from the proposed Depot operations is not significant and satisfies the NSW EPA targets.

There are no recommendations from the study.

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NOTATION

Abbreviation	Description
µg/m^3	Micrograms per cubic metre
AS/NZS	Australian Standard/ New Zealand Standard
DA	Development Application
DPE NSW	NSW Department of Planning & Environment
EF	Emission Factor
EIS	Environmental Impact Statement
EPA NSW	Environment Protection Authority, NSW
g	Grams
Kg	Kilograms
kL	Kilo-Litres
kPag	kilo-Pascals gauge
LPG	Liquefied Petroleum Gas
LSH	Level Switch High
m	Metres
m^2	Square metres
m^3	Cubic metres
mg/m^3	Milligrams per cubic metre
mm	millimetres
OHS	Occupational Health and Safety
OU	Odour Units
PHA	Preliminary Hazard Analysis
ppb	Parts per billion (v/v)
ppm	Parts per million (v/v)
s	Seconds
S ‘n’ G	Swap and Go
SEARS	Secretary’s Environmental Assessment Requirements (NSW)
US EPA	United States Environmental Protection Agency
v/v	Volume basis
VOC	Volatile Organic Carbon

1 INTRODUCTION

1.1 Background

Elgas Ltd proposes to build and operate a Liquefied Petroleum Gas (LPG) storage and cylinder filling loading facility at Part of 130 Cormorant Road (Corner of Egret Street), Kooragang, NSW. The facility will be developed by Sovechles Nominees Pty Ltd.

The proposed site falls within the leased land in Kooragang, managed by the Port of Newcastle.

A development application (DA) accompanied by an Environmental Impact Statement (EIS) a Preliminary Hazard Analysis (PHA) were submitted to the Department of Planning and Environment NSW (DPE) by Sovechles Developments Pty Ltd.

As part of the DA determination process, Newcastle City Council has asked for an Odour Study of the development, in accordance with SEARS requirements, which states:

- *A quantitative assessment of the potential air quality, dust and odour impacts of the development in accordance with relevant Environmental Protection Authority Guidelines.*
- *A greenhouse gas assessment, and*
- *Details of proposed mitigation, management and monitoring measures.*

Elgas Ltd, on behalf of Sovecheles Nominees Pty Ltd, has commissioned Arriscar Pty Ltd to undertake an odour impact and greenhouse gas assessment study for the proposed development.

1.2 Study Scope

The scope of the study covers the following:

1. Identify LPG release sources during routine operations
2. Estimate LPG emissions from operations and fugitive emissions from equipment, fittings and pipework
3. Estimate total greenhouse gas emissions from the Kooragang Depot
4. Conduct gas dispersion study using AUSPLUME 6.0 for mercaptan dispersion in terms of odour units at target locations
5. Assess odour impact from routine operations against NSW EPA odour impact criteria
6. Identify proposed mitigation measures to minimise emissions and odour impacts.

2 SITE LOCATION AND SURROUNDING LAND USES

2.1 Site Location

The proposed Elgas LPG depot is located on part of 130, Cormorant Road, Kooragang, NSW. The site covers approximately 7500 m^2 (55 metres x 138 metres).

There is an existing service station (gasoline and diesel) retail outlet and a car wash facility on Part of 130 Cormorant Road. The proposed site is on the northern part of 130, Cormorant Road, with vehicle access and exit to be located on Egret Street.

A location map is shown in Figure 1.

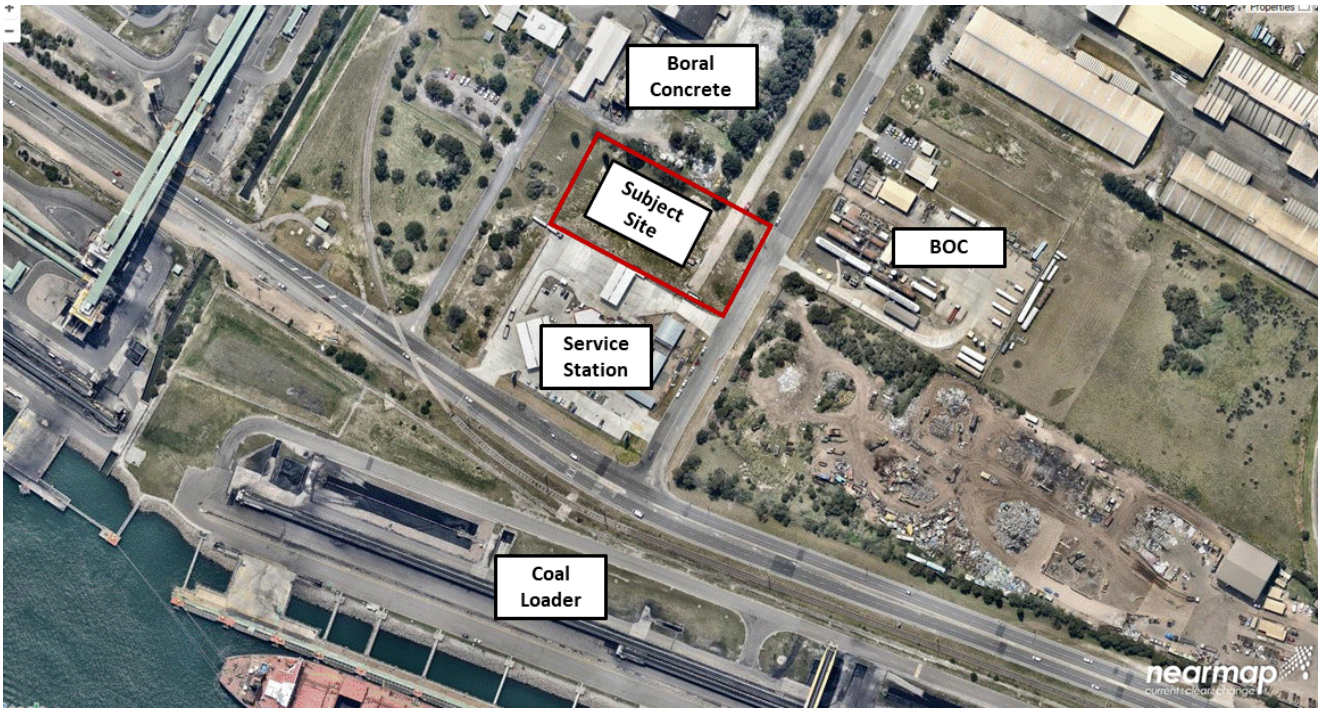

Figure 1: Elgas Kooragang LPG Depot Location Map

2.2 Surrounding Land Uses

The subject site is to the North of Cormorant Road with vehicle entry and exit from Egret Street (on the East).

The land is zoned SP1 - Special Activities (pub. 2014-05-31), where the proposed development is permissible with consent. The determining authority is the Department of Planning & Environment NSW (DPE).

The site and surrounds are in an industrial area and the nearest residential area is located at Stockton, 1400m away from Egret Street.

Surrounding facilities are:

North:

- Boral concrete. A substation belonging to Boral is on the border between the Elgas site and the Boral site.

South:

- Shell service station and truck wash facility (operated by Sovechles Developments, the leaseholder for Lot 1, DP 1195449 on 130 Cormorant Road). The facility services the vehicles involved in port related activities.
- South of the service station across Cormorant Road is the south channel of the Hunter River and the Port Waratah Coal loading terminal.

East:

- Across Egret Street the BOC facility for industrial gases.

West:

- Vacant land leased by Boral Concrete

The people exposed to any potential odour impact are the LPG depot employees, LPG truck drivers and public using the neighbouring service station facility.

3 SITE OPERATIONS AND LPG EMISSION SOURCES

3.1 Overview of Depot Operations

The following operations are proposed to be performed at the LPG Depot:

- LPG (propane) is delivered by single or B-double road tankers from the Elgas Cavern facility in Port Botany to Kooragang Depot. The average temperature of propane is 18°C (generally slightly below ambient).
- The product is unloaded from an unloading bay into the storage tank using a gas compressor.
- LPG from the storage tank is loaded onto 6-9 tonne road tankers (Bobtails), using the Depot pump.
- Cylinder filling occurs for delivery to customers (8.5, 15, 18, 45 kg cylinders).
- 5 x B Double Linehaul loads of S'n'G Cylinders for distribution

3.2 Odour Sources

There is very little source of odour generation in the facility due to the following reasons:

- No manufacturing on site;
- No heat, naked flames, or stack emissions from processing/ combustion products on site;
- No loading, movement or storage of any bulk waste material on site;
- No dust generation as all operating areas and vehicle movement areas are paved with concrete.

The only material stored and handled at the facility is LPG (propane). LPG in its natural state is colourless and odourless. An odorant is added to the gas to enable detection by smell. The dosage required in Australia to achieve this level of safety is 25 grams of Ethyl Mercaptan per tonne of LPG (1000kg). This level of dosing is consistent with international Occupational Health and Safety (OHS) guidelines as safe and adequate to provide detection of LPG presence by the public.

The LPG received at the Depot is already odourised at loading facility. No odorant is stored or injected at the Depot.

3.3 LPG Emission Sources

3.3.1 Tanker Unloading

When a tanker arrives at the depot, the following sequence of actions are conducted by the diver:

- Remove the cap on tanker liquid line. The section of line between the isolation valve and the cap is empty at this time and there is no discharge of LPG.
- Connect the liquid transfer hose to the tanker liquid connection. Liquid valve on tanker as well as the hose end valve on the hose are still closed.
- Remove the cap on the vapour return line to the tanker. The section of line between the isolation valve and the cap is empty at this time and there is no discharge of LPG.

- Connect the vapour return hose to the vapour line of tanker. Vapour valve on tanker as well as the hose end valve on the hose are still closed.
- Open the liquid valves and vapour valves on the tanker side and tank side.
- Start the compressor, which takes suction from the vapour side of the tank and displaces liquid in the tanker through the liquid line to the tank.
- When transfer is complete, all he liquid is displaced into the tank until the inlet vapour is returned to the tank. The tanker is full of vapour without liquid.
- Stop the compressor and close all the four valves (liquid valve and vapour valve on the tanker and at the hose end. At this stage, the small length of pipe between the tanker valve and hose connection threaded end is full of vapour at tank pressure.
- Open the small bleed valve between the tanker valve and hose end valve and let the gas out to atmosphere until the section is depressurised.
- Disconnect the hoses, place caps on the two lines on the tanker. The unloading is complete.

The only emission during this stage is through the bleed lines on the liquid and vapour lines through which the vapour escapes, to enable disconnection.

3.3.2 Tanker Loading

Tanker loading is carried out using the Depot pump. The sequence of actions by the driver are:

- Remove the cap on tanker liquid line. The section of line between the isolation valve and the cap is empty at this time (having been depressurised at discharge locations) and there is no discharge of LPG at the Depot.
- Connect the liquid transfer hose to the tanker liquid connection. Liquid valve on tanker as well as the hose end valve on the hose are still closed.
- Remove the cap on the vapour return line to the tanker. The section of line between the isolation valve and the cap is empty at this time and there is no discharge of LPG.
- Connect the vapour return hose to the vapour line of tanker. Vapour valve on tanker as well as the hose end valve on the hose are still closed.
- Open the liquid valves and vapour valves on the tanker side and tank side.
- Start the LPG pump (a switch is provided at the loading bay), which takes liquid from the tank and fills the tanker. The displaced vapour is returned to the tank by the vapour return line.
- When required level in the tanker is reached, stop the pump. Close all the four valves (liquid valve and vapour valve on the tanker and at the hose end). At this stage, and the liquid hose is full of liquid, and the vapour return hose is full of vapour.
- Open the small bleed valve on the vapour line between the tanker valve and hose end valve and let the gas out to atmosphere until the section is depressurised.
- Open the small bleed valve on the liquid line between the tanker valve and hose end valve and let the liquid out to atmosphere until the section is depressurised. The liquid would be released as a two-phase flashing spray.
- Disconnect the hoses, place caps on the two lines on the tanker. The loading is complete.

The only emission during this stage is through the bleed lines on the liquid and vapour lines through which the trapped liquid and vapour escape, to enable disconnection.

3.3.3 Cylinder filling

Individual cylinder filling is one of the main operations conducted on site. The cylinders required to be filled are connected to a filling system. Smaller cylinders are filled 2 at a time, with each cylinder on its own weigh scale. Larger cylinders are filled one at a time.

During onsite cylinder filling the process that will be employed will comply with the "Filling by Mass (Electronic Scales) as per AS/NZS 1596:2014 "The Storage and Handling of LPG Gas".

During this filling process, the cylinder does not "vent" during filling and there is no emission.

When the required weight is reached on the electronic scale, it automatically shuts off the filling valve and the pump will return the reticulated LPG back to the tank via the bypass line.

There is a check valve on the cylinder filling hose that stops back flow of liquid when the cylinder is disconnected.

During the cylinder disconnection there may be vapour emission for 1-2 seconds only for each disconnection, and it can hardly be smelled locally by the operator. These are covered under fugitive emissions.

3.3.4 LPG Tanker Movements

The taker movements in and out of the Depot are listed in Table 3.

Table 3: LPG Bulk Tanker Product Movements

Truck Type	Function	No. of movements
B-Double Tanker	Bulk Delivery	5 per week
Bobtails (6 and 9 tonnes)	Bulk Distribution	3 per day (Mon-Fri)

3.4 Emission Factor

In the greenhouse gas assessment methodology, each hydrocarbon released has been assigned an 'emissions factor', based on pollutant generation potential.

The emission factor (EF) is a measure of the average amount of a specific pollutant or material discharged into the atmosphere by a specific process, fuel, equipment, or source. It is expressed as number or kilograms of pollutant per tonne (or kL) of the material or fuel.

EF can be expressed in terms of pollutant carbon dioxide, methane or nitrous oxide. In this study, the emission factor for propane expressed in terms of equivalent CO2 (e-CO2) is used (Ref.3).

3.5 Quantification of LPG and Odorant emissions

3.5.1 Tanker unloading

LPG emission per tanker unloading =

LPG vapour release from vapour line connection screw and vapour valve on tanker (38mm connection) +

LPG vapour release from liquid line connection screw and liquid valve on tanker (50mm connection)

Length of section of line between tanker valve and threaded hose connection = 60mm

Volume of vapour released from vapour line (38mm diameter) = 0.068 Litre

Volume of vapour released from liquid line (50mm diameter) = 0.118 Litre

Density of LPG vapour (at tanker pressure of 900 kPag at 25^{O}C)= 20.6 kg/m3

Quantity of LPG released to atmosphere = (0.068+0.118) x 20.6 = 3.83 grams/ tanker unload

Odorant concentration in LPG = 25 grams/ 1 tonne = 25 ppm by weight

Odorant emission = 0.096 mg (milligrams) per tanker unload

Number of tankers received per week = 5 B-double tanker trucks (10 individual tankers) / week

Total LPG emissions per year are:

LPG emission = 3.83 x 10 x 52 x 10^{-3} = 1.992 kg/ year

Total LPG received/ year = 36 tonnes per B-double = 36 x 5 x 52 = 9360 tonnes /year

= 18909 kL/year

Thus, LPG emission ratio to LPG received = 1.992 x 1000/18909 = 0.105 grams/ kL of LPG

Bleed line depressuring duration = 1 -2 minutes (on average) per tanker unload

Odourant emission rate during tanker unloading = 0.096 mg/ 90 sec= 1.07 µg/ s (micrograms/ second) for 1-2 minutes a day 5 days a week.

3.5.2 Tanker Loading

The calculations are similar to tanker loading:

LPG emission per tanker loading =

LPG vapour release from vapour line connection screw and vapour valve on tanker (38mm connection) +

LPG liquid release from liquid line connection screw and liquid valve on tanker (50mm connection)

Length of section of line between tanker valve and threaded hose connection = 60mm

Volume of vapour released from vapour line (38mm diameter) = 0.068 Litre

Volume of liquid released from liquid line (50mm diameter) = 0.118 Litre

Density of LPG vapour (at tanker pressure of 900 kPag at 25^{O}C) = 20.6 kg/m^3

Density of LPG liquid (at 25^{O}C) = 495 kg/m^3

Quantity of LPG released to atmosphere = (0.068 x 20.6+0.118 x 495) = 59.8 grams/ tanker load

Odorant concentration in LPG = 25 grams/ 1 tonne = 25 ppm by weight

Odorant emission = 1.5 mg (milligrams) per tanker load

Number of Bobtails loaded per week (8-tonne Bobtail assumed) = 15 tanker trucks / week

Total LPG emissions per year are:

LPG emission = $59.8 \times 15 \times 52 \times 10^{-3} = 46.65$ kg/ year

Total LPG loaded/ year = 8 tonnes per Bobtail = 8 x 15 x 52 = 6240 tonnes /year

= 12606 kL/ year

Thus, LPG emission ratio to LPG loaded = 46.65 x 1000/12606 = 3.7 grams/ kL of LPG

Bleed line depressuring duration = 1 -2 minutes (on average) per tanker load

Odourant emission rate during tanker unloading = 1.5 mg/ 90 sec= 16.67 µg/ s (micrograms/ second) for 1-2 minutes 3 times a day, 5 days a week.

3.6 Fugitive Emissions

Fugitive emissions in the oil and gas sector can be largely classified as being either a vent, leak or a flare. A flare involves the combustion of a gas or liquid for a non-energy purpose. The fugitive emissions from leaks are estimated by using the emissions factors provided by Elgas (Ref. 5) and total storage/ throiughput of LPG through the facility. Details are given in Section 3.5.3.

3.6.1 Flare

There is no flare on the site.

3.6.2 Vent

There is no routine venting as part of normal operation due to the following safeguards:

1. Vapour return to tank or tanker during LPG loading or unloading respectively.
2. An external fire would not cause a pressure safety valve (PSV) discharge on the tank as the tank is coated with fendolite, a passive fire protection material.
3. The following safeguards are in place to minimise the likelihood of an overfill of the Bobtail:
    - Tanker loading procedure.
    - The Bobtails are equipped with a digital level gauge. Once the set level is reached (about 85%), this level switch will shut off the air supply from the truck and consequently close the SDV. This will also trip the transfer pump and stop the transfer.
    - Before commencing transfer operation, the driver will open the fixed liquid ullage valve on the Bobtail. If the digital level gauge has not stopped loading automatically as stated above, a small amount of liquid will leak out of this valve. The driver is required to observe this throughout the filling operation and manually stop the transfer if required.
    - If the above measures do not stop the transfer, excess LPG will flow back to the storage tank via the 32 mm vapour return line. There would be no release to atmosphere.
4. The following safeguards are in place to minimise the likelihood of an overfill of the main LPG tank:
    - Independent high high-level switch on the tank that would shut the fill valve.

- If the high-level protection were to fail, LPG would flow out of the tank through the vapour line feeding the compressor that drives the product transfer from the bulk tanker. A level switch high (LSH) is installed on the compressor suction pot which automatically trips the compressor and stop the transfer.

5. Discharge from cylinder overfilling is prevented the electronic weigh scale automatically shutting off the fill line valve once the set weight is reached. Even if the shutdown mechanism were to fail, the LPG is returned to the vessel by the bypass line and hence cylinder overfilling is prevented.
6. There would be some venting from the tank as the tank is purged preparatory to internal inspections. This occurs once in 10 years. The following safeguards are present to minimise the emissions:
   - The tank is completely cleared of liquid by pump out
   - The vapour compressor is used to remove residual vapour from the tank into a temporary vessel until the tank pressure is less than 50 kPag.
   - The remaining vapour quantity is small and is purged out through a vent by nitrogen.
7. LPG recovery from returned cylinders. The returned cylinders containing LPG vapour or small quantities of liquid are not vented. The liquid is recovered by connecting inverted cylinders to a manifold and a small manifold pump transferring the recovered LPG back to the sorage tank.

3.6.3 Leaks

Leaks are considered to be emissions from unintentional equipment leaks from valves, flanges, pump seals, compressor seals, relief valves etc.

Leaks are assesed using ‘Emission Factors (EF)’. An emissions factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant.

The emission factor for propane is defined for storage and for process (i.e. cylinder filling).

- EF storage = 0.12 kg VOC (volatile organic carbon)/kL of LPG storage
- EF cylinder filling = 4.0E-05 kg VOC/ kL of LPG throughput

On a similar basis, an EF is defined here for tanker operations:

- EF tanker operations – kg LPG released /kL of tanker transfers

Using a density of 495 kg/m^3 of LPG liquid, 1 kg of LPG liquid = 2.02 Litres of LPG.

3.7 LPG Emissions Summary

The emissions calculate in Sections 3.4.1, 3.4.2 and 3.5.3 are summarised in Table 4.

Table 4: VOC Emissions Summary

Operation	EF, kg/kL	Maximum Tank Capacity/ Throughput	Estimated Pollutant Load, kg/year
Bulk Storage (Note 1)	0.16 kg/kL storage	80 kL	12.80
Cylinder Filling (Note 1,2)	4.0E-05 kg/ kL throughput	5503 kL throughput/ year	0.220
Tanker unloading	0.105 g/ kL (actual)	18109 kL/ year	1.98
Tanker loading	3.7 g/ kL (actual)	12606 kL/ year	46.64
		Total emissions	**61.64**

Note 1: Values provided by Elgas as those being used for reporting to EPA NSW, on Greenhouse Gas emissions in NSW from Elgas LPG Depots.

Note 2: this value is also quoted in Ref.6 for LPG in Service Stations.

4 ODOUR STUDY

4.1 Odour Sources

The odour source is the mercaptan odorant added to the LPG to meet statutory requirements, as a safeguard to detect any leaks by smell. For every tonne of LPG, 25 grams of mercaptan is added to the LPG tanker.

No odorant is stored or inject at the Kooragang Depot. The LPG arrives by bulk tanker to the Depot, already odourised. Therefore, the source of odour is the presence of odorant in the LPG, when an LPG release or emission occurs.

Thus, the sources of odour are the mercaptan associated with:

- LPG vapour release during disconnections during bulk tanker unloading
- LPG vapour/liquid release from disconnections during tanker (Bobtail) loading
- Fugitive emissions of LPG from valves/ fittings

The LPG emission rates are discussed in Section 3.

4.2 Odour Emissions

Using the data in Section 3 and LPG emissions summary in Table 2 the odour emissions are summarised in Table 5.

Table 5: Mercaptan Emissions Summary

Operation	Estimated Load, mg/s	Duration of release, s	Frequency of release
Bulk Storage	4.06E-04	Intermittent until detected and fixed during routine plant surveillance	Intermittent
Cylinder Filling	3.8.4E-05	20	Frequent during working hours
Tanker unloading	5.80E-03	90/ unload of tanker	10 per week (5 B-Double supplies per week x 2 tankers per B=double)
Tanker loading	2.94E-01	90/ tanker load	15 per week

It is seen that none of the above emissions are significant. Continuous emissions are very low in quantity, of the order of micrograms, and larger missions are intermittent, 2-3 times a day (Mon-Fri).

4.3 Gas Dispersion Study

4.3.1 Odour Units

In odour studies, the dispersion of odorant in the atmosphere is estimated in terms of ‘odour units’.

The detection threshold concentration of the odorant by 50% of an exposed population is defined as 1 odour unit (1 OU). The number of dilutions required for a sample to reach the detection threshold is the number of odour units of that sample.

For instance, if a sample of odorant has a concentration where it has to be diluted 100 times in air to reach the detection threshold, then the sample is said to have 100 OU.

4.3.2 Odour threshold for ethyl mercaptan

The odour threshold for ethyl mercaptan covers a threefold range. This report has relied on the work of ACGIH who has stated that "The level of distinct odour awareness (LOA) for ethyl mercaptan is 1.4×10^{-4} ppm or 0.14 ppb (v/v).

Using the molecular weight of mercaptan (62.13), the threshold value can be expressed as a concentration in air of 0.37 µg/m^3. This is also the value for 1 OU.

4.3.3 Odour Exposure Criteria

The odour exposure criteria are based on ground level concentration (GLC) at nominated receptor locations.

The NSW Department of Conservation and Environment has specified OU exposure levels as shown in Table 6. The criteria are based on continuous exposure.

Table 6: Odour Exposure Criteria Summary

Population of affected community	Odour assessment criteria (OU)
Rural single residence (≤ 2)	7
~10	6
~ 30	5
~ 125	4
~ 500	3
Urban area (≥ 2000) and/or schools and hospitals	2

The above criteria are based on continuous exposure. Therefore, it is inappropriate to apply the above criteria strictly for intermittent emissions described in Section 3 above.

The EPA NSW stares (Ref.4) states:

> *"It is also necessary to consider whether a facility will be likely to emit an odour continuously or whether the intensity, frequency, duration or character of the odour may fluctuate.*
>
> *Diffuse odours are often emitted intermittently because of the nature of their sources. A risk assessment should be taken to identify the materials, plant, equipment or activities likely to generate intermittent odour, as well as the likely timing, frequency, duration, intensity and character of the emissions. When dealing with intermittent odour, the focus should be on*

ensuring that appropriate design, management and maintenance practices are used to prevent, or minimise, the level of unreasonable interference it causes.

Quantitatively predicting the impact of odour puffs is very difficult but identifying them and their area of impact can be carried out using a Level 3 assessment."

Level 3 is a refined-level dispersion modelling technique that uses site-specific input data.

In this study, gas dispersion modelling has been carried out using site emissions and local meteorological data.

4.3.4 Dispersion Software

The NSW Department of Conservation and Environment (Ref.4) has specified that the air quality modelling software AUSPLUME is the approved software for air quality modelling, using local meteorological data. However, there are some limitations of the model that would make use of AUSPLUME highly conservative.

- AUSPLUME models continuous emissions and not short duration emissions ('puff' emissions)
- Even if AUSPLUME is used assuming that steady state conditions are established in a very short time, hourly meteorological data round the year is inappropriate for infrequent emissions.

It was decided to model the emissions using AUSPLUME, using the Williamtown airbase meteorological data for the years 2010 to 2014 and calculate contours at various OU levels. The predicted values are conservative in that the exposure to that level of OUs are only intermittent and of short duration.

The releases were limited to the hours between 6:00am and 5:00pm, corresponding to times when tankers would be loaded at the site.

4.3.5 Meteorological Data

The meteorological data for the study was based on the data for Williamtown Weather Station, this being one of the closest to the Kooragang site. The meteorological data for the study obtained from the Bureau of Meteorology. Hourly wind speeds, wind directions and associated data file for the years 2010 to 2014 was imported into the AUSPLUME software.

4.3.6 Dispersion Results

Dispersion cases were carried out for tanker loading, averaging time of 10 minutes (total release duration is only 90 seconds). This represents the largest release.

Fugitive emission from tank (continuous release) were not modelled as the release rate itself was below the odour threshold limit of ethyl mercaptan.

The software calculated the maximum concentration of odorant on a polar grid around the release source.

The maximum concentrations against distance in terms of odour units are plotted in Figure 2.

It is seen that the odour criteria for residential areas (urban) of 2 OU (0.74 µg/m^3) is reached at a distance of approximately 80m from the source and falls entirely within the local industrial area.

No odour will be sensed at residential areas which are 1400m away.

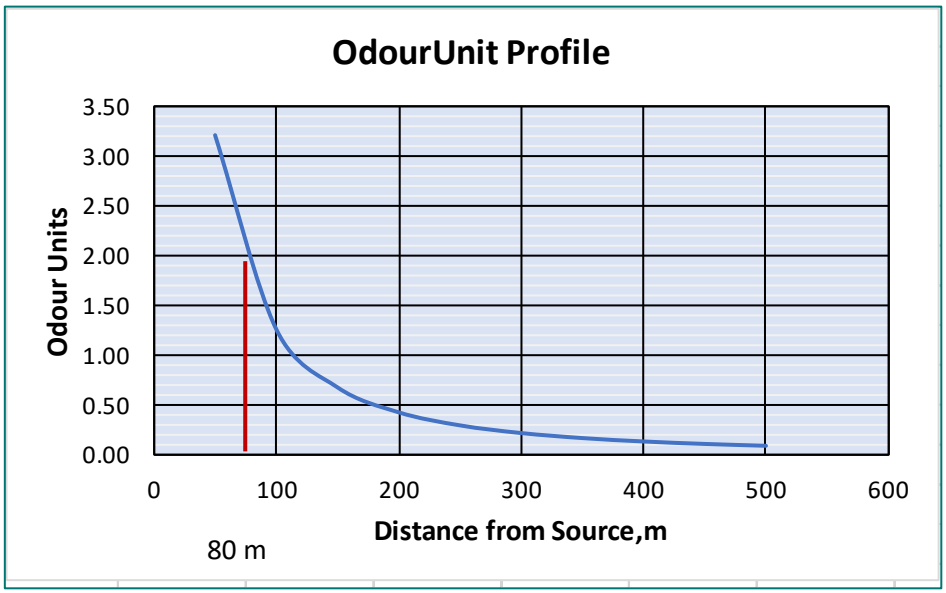

Figure 2: Odour dispersion profile

4.4 Safeguards to minimise odour emissions

Elgas adopts the following measures to minimise odour emissions in all its LPG Depots in Australia:

- No storage and injection of odorant on site
- Hose end valve on the loading hose that minimises the trapped inventory between the hose end valve and the tanker liquid or vapour line
- Vapour return line for loading/ unloading to keep the LPG (and hence odorant) within a closed circuit.
- Tanker unloading procedures using site compressor to displace all the liquid into the storage tank until the trapped inventory between tanker liquid line and hose end valve would only contain vapour.
- Tanker loading/ unloading procedures and driver training to ensure all the valves at the tanker end and hose end (liquid and vapour – 4 valves in total) are isolated before the bleed valve can be opened.
- Closing the bleed valve once the small section is depressurised.
- Integrity inspections on site conducted at scheduled intervals that covers pump seals, valve stem and other fittings to minimise fugitive emissions.

5 REFERENCES

1 Environment Protection Authority NSW, "Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales", 2016.

2 Emission Factors for Greenhouse Gas Inventories, US Environment Protection Agency, https://www.epa.gov/ghgreporting, 2014.

3 Arriscar Pty Ltd, "Preliminary Hazard Analysis of Proposed Elgas LP Gas Depot, Kooragang, NSW", Report J-000250-ELG-PHA, Revision 0, July 2017.

4 NSW Department of Conservation and Environment, "Technical framework - Assessment and management of odour from stationary sources in NSW", November 2006.

5 Elgas Ltd, "Emission Factors for fugitive emissions for bulk storage and cylinder filling in LPG depots", provided to Arriscar Pty Ltd.

6 Emissions Estimation Technique Manual for Aggregated Emissions from Service Stations, Commonwealth Department of Environment, November 1999

Appendix A Ausplume Output

Elgas Kooroogang

Concentration or deposition	Concentration
Emission rate units	grams/second
Concentration units	microgram/m3
Units conversion factor	1.00E+06
Constant background concentration	0.00E+00
Terrain effects	None
Smooth stability class changes?	No
Other stability class adjustments ("urban modes")	None
Ignore building wake effects?	No
Decay coefficient (unless overridden by met. file)	0.000
Anemometer height	10 m
Roughness height at the wind vane site	0.300 m

DISPERSION CURVES

Horizontal dispersion curves for sources <100m high	Pasquill-Gifford
Vertical dispersion curves for sources <100m high	Pasquill-Gifford
Horizontal dispersion curves for sources >100m high	Briggs Rural
Vertical dispersion curves for sources >100m high	Briggs Rural
Enhance horizontal plume spreads for buoyancy?	Yes
Enhance vertical plume spreads for buoyancy?	Yes
Adjust horizontal P-G formulae for roughness height?	Yes
Adjust vertical P-G formulae for roughness height?	Yes
Roughness height	0.100m
Adjustment for wind directional shear	None

PLUME RISE OPTIONS

Gradual plume rise?	Yes
Stack-tip downwash included?	Yes
Building downwash algorithm:	PRIME method.
Entrainment coeff. for neutral & stable lapse rates	0.60,0.60
Partial penetration of elevated inversions?	No
Disregard temp. gradients in the hourly met. file?	No

and in the absence of boundary-layer potential temperature gradients given by the hourly met. file, a value from the following table (in K/m) is used:

Wind Speed Category	Stability Class A	B	C	D	E	F
1	0.000	0.000	0.000	0.000	0.020	0.035
2	0.000	0.000	0.000	0.000	0.020	0.035
3	0.000	0.000	0.000	0.000	0.020	0.035
4	0.000	0.000	0.000	0.000	0.020	0.035
5	0.000	0.000	0.000	0.000	0.020	0.035
6	0.000	0.000	0.000	0.000	0.020	0.035

WIND SPEED CATEGORIES
Boundaries between categories (in m/s) are: 1.54, 3.09, 5.14, 8.23, 10.80

WIND PROFILE EXPONENTS: "Irwin Urban" values (unless overridden by met. file)

AVERAGING TIME: 10 minutes.

1

Elgas Kooroogang

SOURCE CHARACTERISTICS

AREA SOURCE: HOSE

X(m)	Y(m)	Ground Elevation	Height	Side length
0	0	0m	1m	1m

Emission rates by hour of day in grams/second per square metre:

1	0.00E+00	2	0.00E+00	3	0.00E+00	4	0.00E+00
5	0.00E+00	6	1.67E-05	7	1.67E-05	8	1.67E-05
9	1.67E-05	10	1.67E-05	11	1.67E-05	12	1.67E-05
13	1.67E-05	14	1.67E-05	15	1.67E-05	16	1.67E-05
17	1.67E-05	18	0.00E+00	19	0.00E+00	20	0.00E+00
21	0.00E+00	22	0.00E+00	23	0.00E+00	24	0.00E+00

No gravitational settling or scavenging.

1

Elgas Kooroogang

RECEPTOR LOCATIONS

The polar receptor grid has the following radii:

50.m	100.m	150.m	200.m	250.m	300.m	350.m	400.m
450.m	500.m	550.m	600.m	650.m	700.m	750.m	800.m
850.m	900.m	950.m	1000.m	1050.m	1100.m	1150.m	1200.m
1250.m	1300.m	1350.m	1400.m	1450.m	1500.m		

and these bearings (in degrees):

15.0	45.0	75.0	105.0	135.0	165.0	195.0	225.0
255.0	285.0	315.0	345.0				

at a height above ground level of 1.5 metres

METEOROLOGICAL DATA : Header row

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1 HIGHEST RECORDINGS FOR EACH RECEPTOR (in microgram/m3)
AVERAGING TIME = 10 MINUTES

R (km):	0.050	0.100
Bearing		
15.0	1.04E+00 06,28/03/10	4.04E-01 06,28/03/10
45.0	1.18E+00 06,12/10/13	4.65E-01 06,12/10/13
75.0	1.18E+00 07,16/05/13	4.65E-01 07,16/05/13
105.0	1.18E+00 07,04/08/11	4.65E-01 07,04/08/11
135.0	1.18E+00 07,01/09/11	4.65E-01 07,01/09/11
165.0	1.18E+00 06,17/01/12	4.65E-01 06,17/01/12
195.0	1.18E+00 06,17/10/11	4.65E-01 06,17/10/11
225.0	1.14E+00 07,13/06/14	4.49E-01 06,16/08/11
255.0	1.14E+00 06,16/09/12	4.49E-01 06,16/09/12
285.0	1.18E+00 07,23/08/11	4.65E-01 07,23/08/11
315.0	1.18E+00 06,09/04/11	4.65E-01 06,09/04/11

345.0	1.14E+00 07,15/05/14	4.49E-01 07,15/05/14

R (km):	0.150	0.200
Bearing		
15.0	2.16E-01 06,28/03/10	1.36E-01 06,28/03/10
45.0	2.51E-01 06,12/10/13	1.59E-01 06,12/10/13
75.0	2.51E-01 07,16/05/13	1.59E-01 07,16/05/13
105.0	2.51E-01 07,04/08/11	1.59E-01 07,04/08/11
135.0	2.51E-01 07,01/09/11	1.59E-01 07,01/09/11
165.0	2.51E-01 06,17/01/12	1.59E-01 06,17/01/12
195.0	2.51E-01 06,17/10/11	1.59E-01 06,17/10/11
225.0	2.42E-01 07,13/06/14	1.53E-01 07,13/06/14
255.0	2.42E-01 06,16/09/12	1.53E-01 06,16/09/12
285.0	2.51E-01 07,23/08/11	1.59E-01 07,23/08/11
315.0	2.51E-01 06,09/04/11	1.59E-01 06,09/04/11
345.0	2.42E-01 07,15/05/14	1.53E-01 07,15/05/14

R (km):	0.250	0.300
Bearing		
15.0	9.46E-02 06,28/03/10	7.01E-02 06,28/03/10
45.0	1.11E-01 06,12/10/13	8.27E-02 06,12/10/13
75.0	1.11E-01 07,16/05/13	8.27E-02 07,16/05/13
105.0	1.11E-01 07,04/08/11	8.27E-02 07,04/08/11
135.0	1.11E-01 07,01/09/11	8.27E-02 07,01/09/11
165.0	1.11E-01 06,17/01/12	8.27E-02 06,17/01/12
195.0	1.11E-01 06,17/10/11	8.27E-02 06,17/10/11
225.0	1.07E-01 07,13/06/14	7.94E-02 07,13/06/14
255.0	1.07E-01 06,16/09/12	7.94E-02 06,16/09/12
285.0	1.11E-01 07,23/08/11	8.27E-02 07,23/08/11
315.0	1.11E-01 06,09/04/11	8.27E-02 06,09/04/11
345.0	1.07E-01 07,15/05/14	7.94E-02 07,15/05/14

R (km):	0.350	0.400
Bearing		
15.0	5.43E-02 06,28/03/10	4.35E-02 06,28/03/10
45.0	6.43E-02 06,12/10/13	5.17E-02 06,12/10/13
75.0	6.43E-02 07,16/05/13	5.17E-02 07,16/05/13
105.0	6.43E-02 07,04/08/11	5.17E-02 07,04/08/11
135.0	6.43E-02 07,01/09/11	5.17E-02 07,01/09/11
165.0	6.43E-02 06,17/01/12	5.17E-02 06,17/01/12
195.0	6.43E-02 06,17/10/11	5.17E-02 06,17/10/11
225.0	6.16E-02 07,13/06/14	4.95E-02 07,13/06/14
255.0	6.16E-02 06,16/09/12	4.95E-02 06,16/09/12
285.0	6.43E-02 07,23/08/11	5.17E-02 07,23/08/11
315.0	6.43E-02 06,09/04/11	5.17E-02 06,09/04/11
345.0	6.16E-02 07,15/05/14	4.95E-02 07,15/05/14

R (km):	0.450	0.500
Bearing		
15.0	3.57E-02 06,28/03/10	2.99E-02 06,28/03/10
45.0	4.26E-02 06,12/10/13	3.58E-02 06,12/10/13
75.0	4.26E-02 07,16/05/13	3.58E-02 07,16/05/13
105.0	4.26E-02 07,04/08/11	3.58E-02 07,04/08/11
135.0	4.26E-02 07,01/09/11	3.58E-02 07,01/09/11
165.0	4.26E-02 06,17/01/12	3.58E-02 06,17/01/12
195.0	4.26E-02 06,17/10/11	3.58E-02 06,17/10/11
225.0	4.07E-02 07,13/06/14	3.42E-02 07,13/06/14
255.0	4.07E-02 06,16/09/12	3.42E-02 06,16/09/12

285.0	4.26E-02 07,23/08/11	3.58E-02 07,23/08/11
315.0	4.26E-02 06,09/04/11	3.58E-02 06,09/04/11
345.0	4.07E-02 07,15/05/14	3.42E-02 07,15/05/14

R (km): 0.550 0.600

Bearing		
15.0	2.55E-02 06,28/03/10	2.20E-02 06,28/03/10
45.0	3.06E-02 06,12/10/13	2.65E-02 06,12/10/13
75.0	3.06E-02 07,16/05/13	2.65E-02 07,16/05/13
105.0	3.06E-02 07,04/08/11	2.65E-02 07,04/08/11
135.0	3.06E-02 07,01/09/11	2.65E-02 07,01/09/11
165.0	3.06E-02 06,17/01/12	2.65E-02 06,17/01/12
195.0	3.06E-02 06,17/10/11	2.65E-02 06,17/10/11
225.0	2.92E-02 07,13/06/14	2.53E-02 07,13/06/14
255.0	2.92E-02 06,16/09/12	2.53E-02 06,16/09/12
285.0	3.06E-02 07,23/08/11	2.65E-02 07,23/08/11
315.0	3.06E-02 06,09/04/11	2.65E-02 06,09/04/11
345.0	2.92E-02 07,15/05/14	2.53E-02 07,15/05/14

R (km): 0.650 0.700

Bearing		
15.0	1.92E-02 06,28/03/10	1.70E-02 06,28/03/10
45.0	2.32E-02 06,12/10/13	2.05E-02 06,12/10/13
75.0	2.32E-02 07,16/05/13	2.05E-02 07,16/05/13
105.0	2.32E-02 07,04/08/11	2.05E-02 07,04/08/11
135.0	2.32E-02 07,01/09/11	2.05E-02 07,01/09/11
165.0	2.32E-02 06,17/01/12	2.05E-02 06,17/01/12
195.0	2.32E-02 06,17/10/11	2.05E-02 06,17/10/11
225.0	2.21E-02 07,13/06/14	1.96E-02 07,13/06/14
255.0	2.21E-02 06,16/09/12	1.96E-02 06,16/09/12
285.0	2.32E-02 07,23/08/11	2.05E-02 07,23/08/11
315.0	2.32E-02 06,09/04/11	2.05E-02 06,09/04/11
345.0	2.21E-02 07,15/05/14	1.96E-02 07,15/05/14

R (km): 0.750 0.800

Bearing		
15.0	1.52E-02 06,28/03/10	1.37E-02 06,28/03/10
45.0	1.84E-02 06,12/10/13	1.67E-02 06,12/10/13
75.0	1.84E-02 07,16/05/13	1.67E-02 07,16/05/13
105.0	1.84E-02 07,04/08/11	1.67E-02 07,04/08/11
135.0	1.84E-02 07,01/09/11	1.67E-02 07,01/09/11
165.0	1.84E-02 06,17/01/12	1.67E-02 06,17/01/12
195.0	1.84E-02 06,17/10/11	1.67E-02 06,17/10/11
225.0	1.76E-02 07,13/06/14	1.59E-02 07,13/06/14
255.0	1.76E-02 06,16/09/12	1.59E-02 06,16/09/12
285.0	1.84E-02 07,23/08/11	1.67E-02 07,23/08/11
315.0	1.84E-02 06,09/04/11	1.67E-02 06,09/04/11
345.0	1.76E-02 07,15/05/14	1.59E-02 07,15/05/14

R (km): 0.850 0.900

Bearing		
15.0	1.25E-02 06,28/03/10	1.14E-02 06,28/03/10
45.0	1.52E-02 06,12/10/13	1.39E-02 06,12/10/13
75.0	1.52E-02 07,16/05/13	1.39E-02 07,16/05/13
105.0	1.52E-02 07,04/08/11	1.39E-02 07,04/08/11
135.0	1.52E-02 07,01/09/11	1.39E-02 07,01/09/11
165.0	1.52E-02 06,17/01/12	1.39E-02 06,17/01/12
195.0	1.52E-02 06,17/10/11	1.39E-02 06,17/10/11

225.0	1.44E-02 07,13/06/14	1.32E-02 07,13/06/14
255.0	1.44E-02 06,16/09/12	1.32E-02 06,16/09/12
285.0	1.52E-02 07,23/08/11	1.39E-02 07,23/08/11
315.0	1.52E-02 06,09/04/11	1.39E-02 06,09/04/11
345.0	1.44E-02 07,15/05/14	1.32E-02 07,15/05/14

R (km): 0.950 1.000

Bearing		
15.0	1.04E-02 06,28/03/10	9.61E-03 06,28/03/10
45.0	1.27E-02 06,12/10/13	1.18E-02 06,12/10/13
75.0	1.27E-02 07,16/05/13	1.18E-02 07,16/05/13
105.0	1.27E-02 07,04/08/11	1.18E-02 07,04/08/11
135.0	1.27E-02 07,01/09/11	1.18E-02 07,01/09/11
165.0	1.27E-02 06,17/01/12	1.18E-02 06,17/01/12
195.0	1.27E-02 06,17/10/11	1.18E-02 06,17/10/11
225.0	1.21E-02 07,13/06/14	1.12E-02 07,13/06/14
255.0	1.21E-02 06,16/09/12	1.12E-02 06,16/09/12
285.0	1.27E-02 07,23/08/11	1.18E-02 07,23/08/11
315.0	1.27E-02 06,09/04/11	1.18E-02 06,09/04/11
345.0	1.21E-02 07,15/05/14	1.12E-02 07,15/05/14

R (km): 1.050 1.100

Bearing		
15.0	8.91E-03 06,28/03/10	8.29E-03 06,28/03/10
45.0	1.09E-02 06,12/10/13	1.02E-02 06,12/10/13
75.0	1.09E-02 07,16/05/13	1.02E-02 07,16/05/13
105.0	1.09E-02 07,04/08/11	1.02E-02 07,04/08/11
135.0	1.09E-02 07,01/09/11	1.02E-02 07,01/09/11
165.0	1.09E-02 06,17/01/12	1.02E-02 06,17/01/12
195.0	1.09E-02 06,17/10/11	1.02E-02 06,17/10/11
225.0	1.04E-02 07,13/06/14	9.67E-03 07,13/06/14
255.0	1.04E-02 06,16/09/12	9.67E-03 06,16/09/12
285.0	1.09E-02 07,23/08/11	1.02E-02 07,23/08/11
315.0	1.09E-02 06,09/04/11	1.02E-02 06,09/04/11
345.0	1.04E-02 07,15/05/14	9.67E-03 07,15/05/14

R (km): 1.150 1.200

Bearing		
15.0	7.74E-03 06,28/03/10	7.25E-03 06,28/03/10
45.0	9.52E-03 06,12/10/13	8.93E-03 06,12/10/13
75.0	9.52E-03 07,16/05/13	8.93E-03 07,16/05/13
105.0	9.52E-03 07,04/08/11	8.93E-03 07,04/08/11
135.0	9.52E-03 07,01/09/11	8.93E-03 07,01/09/11
165.0	9.52E-03 06,17/01/12	8.93E-03 06,17/01/12
195.0	9.52E-03 06,17/10/11	8.93E-03 06,17/10/11
225.0	9.04E-03 07,13/06/14	8.47E-03 07,13/06/14
255.0	9.04E-03 06,16/09/12	8.47E-03 06,16/09/12
285.0	9.52E-03 07,23/08/11	8.93E-03 07,23/08/11
315.0	9.52E-03 06,09/04/11	8.93E-03 06,09/04/11
345.0	9.04E-03 07,15/05/14	8.47E-03 07,15/05/14

R (km): 1.250 1.300

Bearing		
15.0	6.80E-03 06,28/03/10	6.40E-03 06,28/03/10
45.0	8.39E-03 06,12/10/13	7.91E-03 06,12/10/13
75.0	8.39E-03 07,16/05/13	7.91E-03 07,16/05/13
105.0	8.39E-03 07,04/08/11	7.91E-03 07,04/08/11
135.0	8.39E-03 07,01/09/11	7.91E-03 07,01/09/11

165.0	8.39E-03 06,17/01/12	7.91E-03 06,17/01/12
195.0	8.39E-03 06,17/10/11	7.91E-03 06,17/10/11
225.0	7.96E-03 07,13/06/14	7.50E-03 07,13/06/14
255.0	7.96E-03 06,16/09/12	7.50E-03 06,16/09/12
285.0	8.39E-03 07,23/08/11	7.91E-03 07,23/08/11
315.0	8.39E-03 06,09/04/11	7.91E-03 06,09/04/11
345.0	7.96E-03 07,15/05/14	7.50E-03 07,15/05/14

R (km):	1.350	1.400
Bearing		
15.0	6.04E-03 06,28/03/10	5.71E-03 06,28/03/10
45.0	7.47E-03 06,12/10/13	7.07E-03 06,12/10/13
75.0	7.47E-03 07,16/05/13	7.07E-03 07,16/05/13
105.0	7.47E-03 07,04/08/11	7.07E-03 07,04/08/11
135.0	7.47E-03 07,01/09/11	7.07E-03 07,01/09/11
165.0	7.47E-03 06,17/01/12	7.07E-03 06,17/01/12
195.0	7.47E-03 06,17/10/11	7.07E-03 06,17/10/11
225.0	7.08E-03 07,13/06/14	6.70E-03 07,13/06/14
255.0	7.08E-03 06,16/09/12	6.70E-03 06,16/09/12
285.0	7.47E-03 07,23/08/11	7.07E-03 07,23/08/11
315.0	7.47E-03 06,09/04/11	7.07E-03 06,09/04/11
345.0	7.08E-03 07,15/05/14	6.70E-03 07,15/05/14

R (km):	1.450	1.500
Bearing		
15.0	5.41E-03 06,28/03/10	5.13E-03 06,28/03/10
45.0	6.71E-03 06,12/10/13	6.37E-03 06,12/10/13
75.0	6.71E-03 07,16/05/13	6.37E-03 07,16/05/13
105.0	6.71E-03 07,04/08/11	6.37E-03 07,04/08/11
135.0	6.71E-03 07,01/09/11	6.37E-03 07,01/09/11
165.0	6.71E-03 06,17/01/12	6.37E-03 06,17/01/12
195.0	6.71E-03 06,17/10/11	6.37E-03 06,17/10/11
225.0	6.36E-03 07,13/06/14	6.04E-03 07,13/06/14
255.0	6.36E-03 06,16/09/12	6.04E-03 06,16/09/12
285.0	6.71E-03 07,23/08/11	6.37E-03 07,23/08/11
315.0	6.71E-03 06,09/04/11	6.37E-03 06,09/04/11
345.0	6.36E-03 07,15/05/14	6.04E-03 07,15/05/14

1 SECOND-HIGHEST RECORDINGS FOR EACH RECEPTOR (in microgram/m3)
AVERAGING TIME = 10 MINUTES

R (km):	0.050	0.100
Bearing		
15.0	1.04E+00 07,09/08/10	4.04E-01 07,09/08/10
45.0	1.18E+00 06,08/03/14	4.65E-01 06,08/03/14
75.0	1.18E+00 07,31/05/14	4.65E-01 07,31/05/14
105.0	1.18E+00 06,24/10/11	4.65E-01 06,24/10/11
135.0	1.18E+00 06,11/06/13	4.65E-01 06,11/06/13
165.0	1.14E+00 06,31/05/13	4.49E-01 06,01/04/14
195.0	1.04E+00 07,27/03/13	4.04E-01 07,27/03/13
225.0	1.14E+00 06,16/08/11	4.49E-01 07,11/04/13
255.0	1.14E+00 06,18/03/14	4.49E-01 06,18/03/14
285.0	1.18E+00 06,24/08/11	4.65E-01 06,24/08/11
315.0	1.18E+00 07,19/07/13	4.65E-01 07,19/07/13
345.0	1.04E+00 06,09/04/14	4.04E-01 06,09/04/14

R (km):	0.150	0.200

Bearing		
15.0	2.16E-01 07,09/08/10	1.36E-01 07,09/08/10
45.0	2.51E-01 06,08/03/14	1.59E-01 06,08/03/14
75.0	2.51E-01 07,31/05/14	1.59E-01 07,31/05/14
105.0	2.51E-01 06,24/10/11	1.59E-01 06,24/10/11
135.0	2.51E-01 06,11/06/13	1.59E-01 06,11/06/13
165.0	2.42E-01 06,31/05/13	1.53E-01 06,31/05/13
195.0	2.16E-01 07,27/03/13	1.36E-01 07,27/03/13
225.0	2.42E-01 06,16/08/11	1.53E-01 06,16/08/11
255.0	2.42E-01 06,18/03/14	1.53E-01 06,18/03/14
285.0	2.51E-01 06,24/08/11	1.59E-01 06,24/08/11
315.0	2.51E-01 07,19/07/13	1.59E-01 07,19/07/13
345.0	2.16E-01 06,09/04/14	1.36E-01 06,09/04/14

R (km): 0.250 0.300

Bearing		
15.0	9.46E-02 07,09/08/10	7.01E-02 07,09/08/10
45.0	1.11E-01 06,08/03/14	8.27E-02 06,08/03/14
75.0	1.11E-01 07,31/05/14	8.27E-02 07,31/05/14
105.0	1.11E-01 06,24/10/11	8.27E-02 06,24/10/11
135.0	1.11E-01 06,11/06/13	8.27E-02 06,11/06/13
165.0	1.07E-01 06,31/05/13	7.94E-02 06,31/05/13
195.0	9.46E-02 07,27/03/13	7.01E-02 07,27/03/13
225.0	1.07E-01 06,16/08/11	7.94E-02 06,16/08/11
255.0	1.07E-01 06,18/03/14	7.94E-02 06,18/03/14
285.0	1.11E-01 06,24/08/11	8.27E-02 06,24/08/11
315.0	1.11E-01 07,19/07/13	8.27E-02 07,19/07/13
345.0	9.46E-02 06,09/04/14	7.01E-02 06,09/04/14

R (km): 0.350 0.400

Bearing		
15.0	5.43E-02 07,09/08/10	4.35E-02 07,09/08/10
45.0	6.43E-02 06,08/03/14	5.17E-02 06,08/03/14
75.0	6.43E-02 07,31/05/14	5.17E-02 07,31/05/14
105.0	6.43E-02 06,24/10/11	5.17E-02 06,24/10/11
135.0	6.43E-02 06,11/06/13	5.17E-02 06,11/06/13
165.0	6.16E-02 06,31/05/13	4.95E-02 06,31/05/13
195.0	5.43E-02 07,27/03/13	4.35E-02 07,27/03/13
225.0	6.16E-02 06,16/08/11	4.95E-02 06,16/08/11
255.0	6.16E-02 06,18/03/14	4.95E-02 06,18/03/14
285.0	6.43E-02 06,24/08/11	5.17E-02 06,24/08/11
315.0	6.43E-02 07,19/07/13	5.17E-02 07,19/07/13
345.0	5.43E-02 06,09/04/14	4.35E-02 06,09/04/14

R (km): 0.450 0.500

Bearing		
15.0	3.57E-02 07,09/08/10	2.99E-02 07,09/08/10
45.0	4.26E-02 06,08/03/14	3.58E-02 06,08/03/14
75.0	4.26E-02 07,31/05/14	3.58E-02 07,31/05/14
105.0	4.26E-02 06,24/10/11	3.58E-02 06,24/10/11
135.0	4.26E-02 06,11/06/13	3.58E-02 06,11/06/13
165.0	4.07E-02 06,31/05/13	3.42E-02 06,31/05/13
195.0	3.57E-02 07,27/03/13	2.99E-02 07,27/03/13
225.0	4.07E-02 06,16/08/11	3.42E-02 06,16/08/11
255.0	4.07E-02 06,18/03/14	3.42E-02 06,18/03/14
285.0	4.26E-02 06,24/08/11	3.58E-02 06,24/08/11
315.0	4.26E-02 07,19/07/13	3.58E-02 07,19/07/13
345.0	3.57E-02 06,09/04/14	2.99E-02 06,09/04/14

R (km):	0.550	0.600
Bearing		
15.0	2.55E-02 07,09/08/10	2.20E-02 07,09/08/10
45.0	3.06E-02 06,08/03/14	2.65E-02 06,08/03/14
75.0	3.06E-02 07,31/05/14	2.65E-02 07,31/05/14
105.0	3.06E-02 06,24/10/11	2.65E-02 06,24/10/11
135.0	3.06E-02 06,11/06/13	2.65E-02 06,11/06/13
165.0	2.92E-02 06,31/05/13	2.53E-02 06,31/05/13
195.0	2.55E-02 07,27/03/13	2.20E-02 07,27/03/13
225.0	2.92E-02 06,16/08/11	2.53E-02 06,16/08/11
255.0	2.92E-02 06,18/03/14	2.53E-02 06,18/03/14
285.0	3.06E-02 06,24/08/11	2.65E-02 06,24/08/11
315.0	3.06E-02 07,19/07/13	2.65E-02 07,19/07/13
345.0	2.55E-02 06,09/04/14	2.20E-02 06,09/04/14

R (km):	0.650	0.700
Bearing		
15.0	1.92E-02 07,09/08/10	1.70E-02 07,09/08/10
45.0	2.32E-02 06,08/03/14	2.05E-02 06,08/03/14
75.0	2.32E-02 07,31/05/14	2.05E-02 07,31/05/14
105.0	2.32E-02 06,24/10/11	2.05E-02 06,24/10/11
135.0	2.32E-02 06,11/06/13	2.05E-02 06,11/06/13
165.0	2.21E-02 06,31/05/13	1.96E-02 06,31/05/13
195.0	1.92E-02 07,27/03/13	1.70E-02 07,27/03/13
225.0	2.21E-02 06,16/08/11	1.96E-02 06,16/08/11
255.0	2.21E-02 06,18/03/14	1.96E-02 06,18/03/14
285.0	2.32E-02 06,24/08/11	2.05E-02 06,24/08/11
315.0	2.32E-02 07,19/07/13	2.05E-02 07,19/07/13
345.0	1.92E-02 06,09/04/14	1.70E-02 06,09/04/14

R (km):	0.750	0.800
Bearing		
15.0	1.52E-02 07,09/08/10	1.37E-02 07,09/08/10
45.0	1.84E-02 06,08/03/14	1.67E-02 06,08/03/14
75.0	1.84E-02 07,31/05/14	1.67E-02 07,31/05/14
105.0	1.84E-02 06,24/10/11	1.67E-02 06,24/10/11
135.0	1.84E-02 06,11/06/13	1.67E-02 06,11/06/13
165.0	1.76E-02 06,31/05/13	1.59E-02 06,31/05/13
195.0	1.52E-02 07,27/03/13	1.37E-02 07,27/03/13
225.0	1.76E-02 06,16/08/11	1.59E-02 06,16/08/11
255.0	1.76E-02 06,18/03/14	1.59E-02 06,18/03/14
285.0	1.84E-02 06,24/08/11	1.67E-02 06,24/08/11
315.0	1.84E-02 07,19/07/13	1.67E-02 07,19/07/13
345.0	1.52E-02 06,09/04/14	1.37E-02 06,09/04/14

R (km):	0.850	0.900
Bearing		
15.0	1.25E-02 07,09/08/10	1.14E-02 07,09/08/10
45.0	1.52E-02 06,08/03/14	1.39E-02 06,08/03/14
75.0	1.52E-02 07,31/05/14	1.39E-02 07,31/05/14
105.0	1.52E-02 06,24/10/11	1.39E-02 06,24/10/11
135.0	1.52E-02 06,11/06/13	1.39E-02 06,11/06/13
165.0	1.44E-02 06,31/05/13	1.32E-02 06,31/05/13
195.0	1.25E-02 07,27/03/13	1.14E-02 07,27/03/13
225.0	1.44E-02 06,16/08/11	1.32E-02 06,16/08/11
255.0	1.44E-02 06,18/03/14	1.32E-02 06,18/03/14
285.0	1.52E-02 06,24/08/11	1.39E-02 06,24/08/11
315.0	1.52E-02 07,19/07/13	1.39E-02 07,19/07/13

345.0	1.25E-02 06,09/04/14	1.14E-02 06,09/04/14

R (km):	0.950	1.000
Bearing		
15.0	1.04E-02 07,09/08/10	9.61E-03 07,09/08/10
45.0	1.27E-02 06,08/03/14	1.18E-02 06,08/03/14
75.0	1.27E-02 07,31/05/14	1.18E-02 07,31/05/14
105.0	1.27E-02 06,24/10/11	1.18E-02 06,24/10/11
135.0	1.27E-02 06,11/06/13	1.18E-02 06,11/06/13
165.0	1.21E-02 06,31/05/13	1.12E-02 06,31/05/13
195.0	1.04E-02 07,27/03/13	9.61E-03 07,27/03/13
225.0	1.21E-02 06,16/08/11	1.12E-02 06,16/08/11
255.0	1.21E-02 06,18/03/14	1.12E-02 06,18/03/14
285.0	1.27E-02 06,24/08/11	1.18E-02 06,24/08/11
315.0	1.27E-02 07,19/07/13	1.18E-02 07,19/07/13
345.0	1.04E-02 06,09/04/14	9.61E-03 06,09/04/14

R (km):	1.050	1.100
Bearing		
15.0	8.91E-03 07,09/08/10	8.29E-03 07,09/08/10
45.0	1.09E-02 06,08/03/14	1.02E-02 06,08/03/14
75.0	1.09E-02 07,31/05/14	1.02E-02 07,31/05/14
105.0	1.09E-02 06,24/10/11	1.02E-02 06,24/10/11
135.0	1.09E-02 06,11/06/13	1.02E-02 06,11/06/13
165.0	1.04E-02 06,31/05/13	9.67E-03 06,31/05/13
195.0	8.91E-03 07,27/03/13	8.29E-03 07,27/03/13
225.0	1.04E-02 06,16/08/11	9.67E-03 06,16/08/11
255.0	1.04E-02 06,18/03/14	9.67E-03 06,18/03/14
285.0	1.09E-02 06,24/08/11	1.02E-02 06,24/08/11
315.0	1.09E-02 07,19/07/13	1.02E-02 07,19/07/13
345.0	8.91E-03 06,09/04/14	8.29E-03 06,09/04/14

R (km):	1.150	1.200
Bearing		
15.0	7.74E-03 07,09/08/10	7.25E-03 07,09/08/10
45.0	9.52E-03 06,08/03/14	8.93E-03 06,08/03/14
75.0	9.52E-03 07,31/05/14	8.93E-03 07,31/05/14
105.0	9.52E-03 06,24/10/11	8.93E-03 06,24/10/11
135.0	9.52E-03 06,11/06/13	8.93E-03 06,11/06/13
165.0	9.04E-03 06,31/05/13	8.47E-03 06,31/05/13
195.0	7.74E-03 07,27/03/13	7.25E-03 07,27/03/13
225.0	9.04E-03 06,16/08/11	8.47E-03 06,16/08/11
255.0	9.04E-03 06,18/03/14	8.47E-03 06,18/03/14
285.0	9.52E-03 06,24/08/11	8.93E-03 06,24/08/11
315.0	9.52E-03 07,19/07/13	8.93E-03 07,19/07/13
345.0	7.74E-03 06,09/04/14	7.25E-03 06,09/04/14

R (km):	1.250	1.300
Bearing		
15.0	6.80E-03 07,09/08/10	6.40E-03 07,09/08/10
45.0	8.39E-03 06,08/03/14	7.91E-03 06,08/03/14
75.0	8.39E-03 07,31/05/14	7.91E-03 07,31/05/14
105.0	8.39E-03 06,24/10/11	7.91E-03 06,24/10/11
135.0	8.39E-03 06,11/06/13	7.91E-03 06,11/06/13
165.0	7.96E-03 06,31/05/13	7.50E-03 06,31/05/13
195.0	6.80E-03 07,27/03/13	6.40E-03 07,27/03/13
225.0	7.96E-03 06,16/08/11	7.50E-03 06,16/08/11
255.0	7.96E-03 06,18/03/14	7.50E-03 06,18/03/14

285.0	8.39E-03 06,24/08/11	7.91E-03 06,24/08/11
315.0	8.39E-03 07,19/07/13	7.91E-03 07,19/07/13
345.0	6.80E-03 06,09/04/14	6.40E-03 06,09/04/14

R (km):	1.350	1.400
Bearing		
15.0	6.04E-03 07,09/08/10	5.71E-03 07,09/08/10
45.0	7.47E-03 06,08/03/14	7.07E-03 06,08/03/14
75.0	7.47E-03 07,31/05/14	7.07E-03 07,31/05/14
105.0	7.47E-03 06,24/10/11	7.07E-03 06,24/10/11
135.0	7.47E-03 06,11/06/13	7.07E-03 06,11/06/13
165.0	7.08E-03 06,31/05/13	6.70E-03 06,31/05/13
195.0	6.04E-03 07,27/03/13	5.71E-03 07,27/03/13
225.0	7.08E-03 06,16/08/11	6.70E-03 06,16/08/11
255.0	7.08E-03 06,18/03/14	6.70E-03 06,18/03/14
285.0	7.47E-03 06,24/08/11	7.07E-03 06,24/08/11
315.0	7.47E-03 07,19/07/13	7.07E-03 07,19/07/13
345.0	6.04E-03 06,09/04/14	5.71E-03 06,09/04/14

R (km):	1.450	1.500
Bearing		
15.0	5.41E-03 07,09/08/10	5.13E-03 07,09/08/10
45.0	6.71E-03 06,08/03/14	6.37E-03 06,08/03/14
75.0	6.71E-03 07,31/05/14	6.37E-03 07,31/05/14
105.0	6.71E-03 06,24/10/11	6.37E-03 06,24/10/11
135.0	6.71E-03 06,11/06/13	6.37E-03 06,11/06/13
165.0	6.36E-03 06,31/05/13	6.04E-03 06,31/05/13
195.0	5.41E-03 07,27/03/13	5.13E-03 07,27/03/13
225.0	6.36E-03 06,16/08/11	6.04E-03 06,16/08/11
255.0	6.36E-03 06,18/03/14	6.04E-03 06,18/03/14
285.0	6.71E-03 06,24/08/11	6.37E-03 06,24/08/11
315.0	6.71E-03 07,19/07/13	6.37E-03 07,19/07/13
345.0	5.41E-03 06,09/04/14	5.13E-03 06,09/04/14