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AGL Leafs Gully Power Project Environmental Assessment

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Appendix D

Local Air Quality Assessment

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Local Air Quality Assessment for Proposed Gas Turbine Power Station, Appin NSW

Prepared for

AGL POWER GENERATION (NSW) P/L

72 Christie St, St Leonards, NSW 2065

30 October 2008

43177401

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1.1 Background

The proposed Leafs Gully power station involves the construction of two new turbines each in the 125-180 MW range which would run on natural gas. The units would operate as a peaking plant in open cycle configuration, with a total installed capacity of nominally 300 MW. This report provides an assessment of the potential impacts on local air quality as a result of the proposed development.

The impact on ambient air quality with respect to regulatory emission limits and ground level concentration criteria of the primary gaseous emissions has been assessed by URS, however, CSIRO has been engaged by AGL to perform photochemical smog modelling. Two studies were performed by CSIRO, namely a detailed assessment of the affect of a 600MW plant on six peak ozone events between 2000 and 2004 (*Photochemical Smog Assessment for a Proposed Power Plant in Appin NSW, Report ET/IR874*, (CSIRO, August 2006)) and an annual assessment of a 300MW plant for the year 2002 (*Preliminary Assessment of the Impact of NOx Emissions from a proposed Appin Gas Fired Power Station On Photochemical Smog in the Sydney Region*, (CSIRO, June 2004). The CSIRO reports are provided as a separate Appendix to the Environmental Assessment.

An aviation safety assessment has also been conducted for the project, to determine compliance with the Civil Aviation Safety Authority (CASA) guidelines. This assessment is provided as **Appendix B** of this report.

A comprehensive greenhouse gas assessment including quantitative modelling has been conducted and is presented in **Appendix C** of this report.

1.2 Project Description

The proposed gas turbines are each in the 125-180 MW size range. Emission rates have been provided by Alstom to AGL, for the GT13E2 turbine (13E2). The 13E2 has a rating of approximately 180MW and its emissions have been used in the dispersion modelling. The final selection of turbines would be made prior to the commencement of construction on the basis of several factors.

1.3 Gas Turbine Operation

In each gas turbine generator, air is drawn in through filters to remove particulate matter and passed into the compressor section of the gas turbine. In each compressor, multiple rows of rotating blades raise the temperature and pressure of the air. Following compression of the air to pressures of 15 - 30 atmospheres (depending on the gas turbine model selected), the air flows into combustion chambers (combustors) arranged around each gas turbine. In these combustors, natural gas is injected and burnt, increasing the temperature to approximately 1,100 - 1,200 °C. The combustors feature dry low-NO_X (DLN) technology to minimise levels of NO_X emissions.

The combustion products from the combustion chambers enter the turbine section of the gas turbines and expand to atmospheric pressure, reducing in temperature to around 550 °C. As the gas expands, the gases drive the turbine, which in turn drives the compressor and an electrical generator. From the turbine, the hot exhaust gases are discharged through a stack. For the purposes of the modelling scenarios considered in this assessment this sequence is referred to herein as *Operation*.

During the start sequence, the gas turbine generators use an electric starter motor to establish a flow of air through the turbine and purge any flammable vapour from the system. After purging, gas is introduced into the combustors and ignited with spark plugs. The generator is then run up to 3,000 rpm on its own power. When the unit reaches 3,000 rpm, it is synchronised to the grid allowing the export of power. Gas flow is further increased and the export of power increased until the unit is at full load. For the purposes of the modelling scenarios considered in this assessment this sequence is referred to herein as *Start Up*. This sequence takes up to 30 minutes for the modelled Alstom turbine.

The primary atmospheric emissions from the turbines would be the same as those from most combustion sources, namely: nitrogen (N_2), oxygen (O_2), carbon dioxide (CO_2), water vapour, oxides of nitrogen (NO_x) and carbon monoxide (CO). Other gaseous emissions are likely to include low concentrations of sulphur dioxide (SO_2), particulates less than 10 microns in diameter (PM_{10}) and hydrocarbons.

1.4 Overview of Approach to Air Quality Impact Assessment

The Environmental Assessment Requirements require the air quality assessment to be prepared in accordance with the DEC (2005) *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW* (the *Approved Methods*). The *Approved Methods* identify a number of stages in an air quality impact assessment:

1. Input data collection.
2. Dispersion modelling.
3. Processing dispersion model output data.
4. Interpretation of dispersion modelling results.
5. Preparation of an impact assessment report.

The first step in the impact assessment is the collection of information required to complete the dispersion modelling. This includes development of an air emissions inventory, compilation of meteorological data, background air quality data and terrain data. This step is addressed in detail in **Sections 3, 4, 5** and **6**.

For Step 2 of the assessment it is noted that three dispersion models are generally endorsed by DECC for development approvals, namely AUSPLUME, TAPM and CALPUFF. The TAPM and CALPUFF models both incorporate site-specific factors such as terrain influences, regional-scale winds and inversions to predict ground-level concentrations. Given the significance of this assessment, it was considered that the use of two models provided greater reliability in the prediction of the potential impacts. **Section 7** presents the results from the TAPM modelling. A discussion of the validation using AUSPLUME modelling of two of the most significant pollutants modelled, namely NO_2 and PM_{10} is presented in **Appendix F**.

Step 4 of the impact assessment is the interpretation of dispersion modelling results. The outputs of the dispersion modelling are added to existing maximum background concentrations of pollutants to determine the predicted ground level concentrations. These ground level concentrations are compared with the relevant impact assessment criteria. DEC (2005) states in the *Approved Methods* that *"…compliance indicates the proposal is unlikely to result in adverse air quality impacts"*. (DEC, 2005 p-3)

1.5 Definitions

Approved Methods - DEC (2005) *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW*
AUSPLUME – a regulatory approved atmospheric (gaussian plume) dispersion model developed by the Victorian EPA.
AWS – Automatic Weather Station.
BoM – Bureau of Meteorology.
CO_2-e – Carbon dioxide equivalent. Relates to the greenhouse warming potential (GWP) of a certain gas compared to that of carbon dioxide, where carbon dioxide has a GWP of 1. For example, methane (CH_4) has a GWP of 21, meaning that a release of 100 tonnes of CH_4 would be the equivalent to releasing 2100 tonnes of CO_2, in terms of global warming.
CSIRO – Commonwealth Scientific and Industrial Research Organisation
DEC - Department of Environment and Conservation incorporating NSW EPA. The DEC was superseded by the DECC.
DECC – Department of Environment and Climate Change incorporating NSW EPA
Greenhouse Gas Protocol – a globally accepted procedure for companies to quantify, report and reduce their greenhouse gas emissions.
Greenhouse Challenge Plus - The programme integrates the Generator Efficiency Standards and the Greenhouse Friendly™ initiative into a single industry programme, focused on reducing greenhouse gas, promoting energy efficiency, integrating greenhouse issues into decision making and allowing for a consistent manner for reporting greenhouse gas emissions.
GGAS - The Greenhouse Gas Reduction Scheme (GGAS) commenced on 1 January 2003. It is one of the first mandatory GHG emissions trading schemes in the world and is specifically associated with the electricity generation sector. GGAS aims to reduce GHG emissions in NSW by 5% per capita below 1989/90 levels by 2007, by encouraging project based activities to offset the production of GHG emissions.
GWP – Global Warming Potential – compares the heat absorbing ability of a greenhouse gas to that of the same mass of carbon dioxide over a given timeframe.
OCGT – Open Cycle Gas Turbine**.**
Operation – The gas turbine running during normal operation i.e. after Start Up. For the purposes of this assessment, normal operation was considered to be 100% load.
Start Up – The Start Up period for the gas turbine. The duration of Start Up is turbine specific, however, for gas turbines being considered, Start Up would generally take less than 30 minutes.
TAPM – **T**he **A**ir **P**ollution **M**odel. An air quality dispersion model developed by CSIRO.

2.1 Air Quality Criteria

There are three main types of air quality criteria relevant to industrial developments such as the AGL Leafs Gully Power Project:

Emission Standards – which are maximum allowable pollutant emission concentrations (stack concentrations) specified for particular types of equipment;

Air Impact Assessment Criteria – which are designed for use in air dispersion modelling studies and air quality impact assessments for new or modified emission sources; and

Ambient Air Quality Standards – which set standards against which ambient air quality monitoring results may be assessed.

In general, Emission Standards and Air Impact Assessment Criteria are used to evaluate the expected impact of air emissions on air quality and the effectiveness of plant design and any associated mitigation measures. The main objective of these criteria is to ensure that the resulting local and regional ambient air quality meets the relevant Ambient Air Quality Standards.

2.2 Emission Standards

The *Protection of the Environment Operations (Clean Air) Regulation 2002* sets emission limits for air impurities from stationary plant and equipment. The current standards, taken from Schedule 3 (Electricity Generation) of the Regulation, relevant to the AGL plant are presented in **Table 2-1** for oxides of nitrogen. The plant is classified as a Group 6 source, as it will commence operation after 1 September 2005.

Table 2.1: Emission Standards for Electricity Generation (from Schedule 3, Protection of the Environment Operation (Clean Air) Regulation 2002)

Pollutant	Applicability [A]	Limit [B]
NO_2 or NO or both as NO_2 equivalent	Any turbine operating on gas, being a turbine used in connection with an electricity generating system with a capacity of 30 MW or more	70 mg/m^3 as NO_2

Note:

[A]: An activity is designated to "Group 6" if it commenced to be carried on, or to operate, on or after 1 September 2005, as a result of an environment protection licence granted under the Protection of the Environment Operations Act 1997 pursuant to an application made on or after 1 September 2005.

[B]: Concentrations expressed at reference conditions (273K, dry, 1atm, 15% O_2).

2.3 Air Impact Assessment Criteria

In August 2005, the New South Wales Environment Protection Authority (NSW EPA now incorporated into the Department of Environment and Climate Change (DECC) released the *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW* (the *Approved Methods)*. This document specifies a range of impact assessment criteria for toxic and odorous air pollutants. The impact assessment criteria for those pollutants associated with the proposed plant are shown in **Tables 2-2** and **2-3**.

Table 2-2 DEC Impact Assessment Criteria for Criteria Pollutants[A]

Pollutant	Concentration		Averaging Period
	(ppm)	($\mu g/m^3$)	
SO_2	0.25 0.20 0.08 0.02	712 570 228 60	10 minutes 1 hour 24 hours Annual
NO_2	0.12 0.03	246 62	1 hour Annual
Ozone	0.10 0.08	214 171	1 hour 4 hour
PM_{10}	- -	50 30	24 hour Annual
CO	87 25 9	100,000 30,000 10,000	15 minutes 1 hour 8 hours

Note:

[A]: Criteria pollutants are regional pollutants identified by the DEC (2005) as pollutants that are known to adversely impact human health and the atmosphere.

Table 2-3 DEC Impact Assessment Criteria for Air Toxics [A]

Pollutant [B]	Concentration ($\mu g/m^3$)	Averaging Period
Benzene	29	1 hour
Ethylbenzene	8,000	1 hour
Formaldehyde	20	1 hour
Total PAHs [C]	0.4	1 hour
Toluene	360	1 hour
Xylenes	190	1 hour

Note:

[A] Air Toxics are pollutants identified by the DECC as pollutants that have the potential in the long term to adversely impact human health and the atmosphere. These pollutants are generally found at much lower concentrations compared with criteria pollutants.

[B] The air toxics relevant to this type of combustion emission have been sourced from US EPA (2000).

[C] PAH = Polycyclic Aromatic Hydrocarbons.

2.4 Ambient Air Quality Criteria

In August 2006 the DEC updated and re-issued 'Action for Air' (DEC 2006) - the NSW Government's 25-year Air Quality Management Plan, which was originally published in 1998. In this plan the DEC adopted a number of regional ambient air quality goals for a range of air pollutants. The ambient air quality goals adopted were taken from the National Environment Protection Measure (NEPM) for Ambient Air Quality, published by the National Environment Protection Council (NEPC). The NEPM for Ambient Air Quality, sets out national standards and goals for six common ambient air pollutants (NEPC, 1998), namely nitrogen dioxide (NO_2), carbon monoxide (CO), photochemical oxidants (as ozone), sulfur dioxide (SO_2), lead and particulates as PM_{10}.

When reviewing the standards and goals set out in the NEPM for Ambient Air Quality, it should be noted that they are designed for use in assessing regional air quality and are not intended for use as site boundary or atmospheric dispersion modelling criteria. It should also be noted that the DEC impact assessment criteria shown in **Table 2-2** are essentially identical to the NEPM Ambient Air Quality Standards. Thus for the purposes of this report, the Air Impact Assessment Criteria and Ambient Air Quality Standards are in effect, the same criteria.

3.1 Meteorology

As site specific meteorology was not available, the meteorological data used in the dispersion modelling was generated using the CSIRO model, The Air Pollution Model (TAPM) dispersion model (Hurley, 2005). To augment the meteorological data, meteorological data from the DECC Automatic Weather Station (AWS), located at Macarthur (11km north west of the proposed site), was also incorporated into the TAPM. This method for developing site specific meteorological data is provided in **Appendix D** of this report.

Local Wind

The DECC Macarthur monitoring station measures meteorological data, from which annual and seasonal wind roses have been generated, as displayed in **Figure 3-1**. As shown in **Figure 3-1**, the predicted wind on site primarily blows from the south west. The summer winds tend to blow primarily from the south west, however, have significant north east and south east components. Winter, Autumn and Spring appear similar with winds blowing primarily from the south west quadrant.

Interregional Winds

Interregional transport associated with this development is primarily concerned with photochemical smog impacts on surrounding regions, namely the Sydney Basin and Illawarra regions. Due to the dominant transport and industrial emissions in the Sydney Basin, the impact of Sydney air moving into the Illawarra is more pronounced than the reverse. Air emissions injected into these regional winds have different impacts depending on the time of day and the height of the emissions.

Surface emissions from Sydney can move into the Illawarra during morning drainage events, whilst emissions that are emitted from elevated points in the atmosphere in Sydney can also be transported southwards. The elevated emissions generally move further out to sea due to the higher release point and associated higher wind speeds, then get pushed back by on shore winds to the Illawarra region (NSW EPA, 1997).

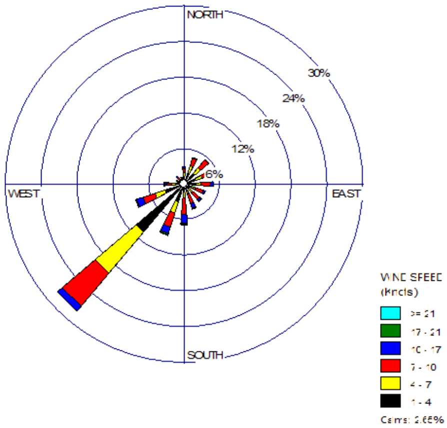
Hurley *et al.* (1996) also suggests surface and elevated emissions emanating from Sydney could be carried out to sea by westerly winds during the night and early morning and be transported back to the Illawarra region during the morning and afternoon periods. Conversely, surface and elevated emissions from the Illawarra region can also travel northwards, transported from the Illawarra to Sydney under night time conditions when southerly synoptic winds occur.

Ibid also suggests that overnight southerly drainage flows in western Sydney, when combined with northerly synoptic winds at height, can promote a north south vertical circulation. Sydney emissions injected into this circulation have the potential to reach the ground sooner under this scenario.

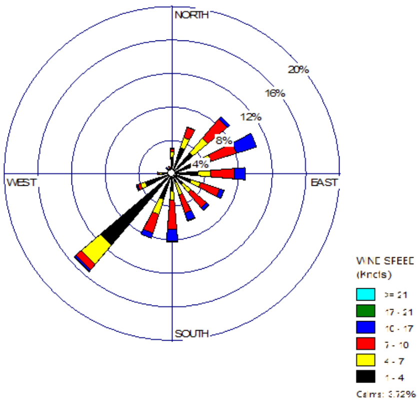
As this development is a peaking plant and emissions are likely to be transient, emphasis has been on local air quality which focuses on near field impacts. The photochemical smog assessment is more pertinent to interregional transport which has been undertaken by CSIRO and is provided as an Appendix to the Environmental Assessment for Leafs Gully Power Project.

3.2 Climate

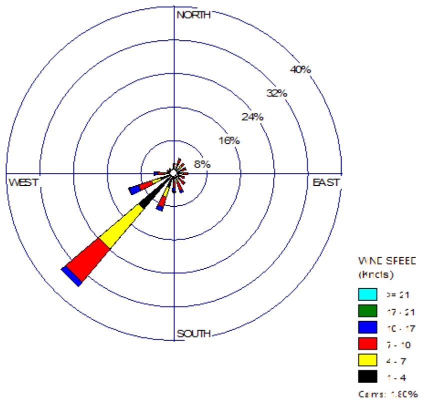
A summary of climatological data collected at the Camden Airport by the Bureau of Meteorology (BoM) is provided in **Table 3-1**. Whilst Picton Council Depot is the closest known meteorological station to the site, the data currently being collected is limited. As the Camden site has been recording all major atmospheric parameters for several decades, and is in close proximity to the site, it was considered appropriate to use this station to discuss climate of the area. The Camden Airport Meteorological Station is located approximately 15km to the north west of the site. **Table 3-1** indicates the region experiences hot summers and mild winters. The records indicate that average daily temperatures for summer are approximately 28-29°C and can exceed 40°C in January and February. The area has a moderate rainfall, with a mean annual rainfall of 828 mm reported over an average of 109 rain days per year.



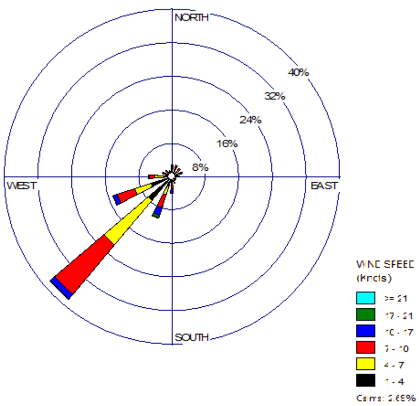
Annual Windrose



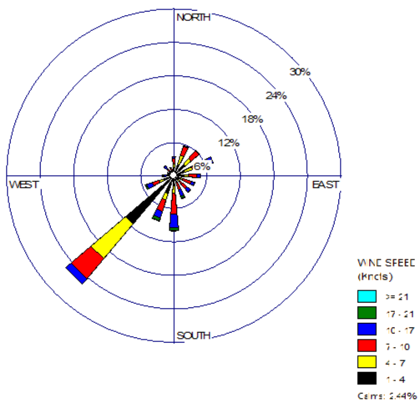
Summer



Autumn



Winter



Spring

Figure 3-1: Windroses for Macarthur AWS (2006)

Table 3-1: Climate averages for Station: Camden Airport (Bureau of Meteorology, 2006)

Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Number of years	Percentage complete
Mean daily maximum temperature - deg C	29.2	28.5	26.7	23.8	20.4	17.7	17.2	18.9	21.7	23.9	25.9	28.5	23.6	27.1	84
Mean no. of days where Max Temp >= 40.0 deg	0.9	0.5	0.1	0	0	0	0	0	0	0	0.3	0.4	2.2	27.5	85
Mean no. of days where Max Temp >= 35.0 deg	4.2	2.9	0.9	0	0	0	0	0	0.1	0.5	1.4	3.6	13.5	27.5	85
Mean no. of days where Max Temp >= 30.0 deg	12.6	10.4	6	0.9	0	0	0	0	1	3.5	5.9	10.5	50.7	27.5	85
Highest daily Max Temp - deg C	45	43.2	41	38.5	27.4	24.9	25.3	30.2	36	40.5	42.6	42	45	27.5	85
Mean daily minimum temperature - deg C	16.7	16.7	14.7	11.1	7.3	4.4	2.9	3.9	6.6	9.8	12.6	15.1	10.2	27.4	85
Mean no. of days where Min Temp <= 2.0 deg C	0	0	0	0.1	3.6	10.5	15	12.2	4.1	0.2	0	0	45.8	27.5	85
Mean no. of days where Min Temp <= 0.0 deg C	0	0	0	0	0.8	4.6	8.1	4.6	0.5	0	0	0	18.5	27.5	85
Lowest daily Min Temp - deg C	7.9	7.2	6	0.6	-2.2	-5.4	-6	-4	-1	1.3	3.8	6	-6	27.5	83
Mean 9am air temp - deg C	21.6	21	19.9	17	13	9.6	8.5	10.6	14.5	17.6	18.6	20.9	16	30.3	49
Mean 9am wet bulb temp - deg C	18.5	18.5	17.4	14.7	11.4	8.1	7.1	8.5	11.4	13.9	15.4	17.2	13.5	28.3	47
Mean 9am dew point - deg C	16.2	16.8	15.3	12.7	9.7	6.4	5.2	5.8	7.9	10.2	12.6	14.3	11.1	29.8	48
Mean 9am relative humidity - %	73	78	77	78	83	82	82	75	67	64	70	68	75	28.3	47
Mean 9am wind speed - km/h	6.5	5.4	6.1	6.3	5.3	6	5.7	8	8.9	9.4	7.7	7.6	6.9	29.5	48
Mean 3pm air temp - deg C	27.6	27.1	25.3	22.4	19.2	16.5	16	17.5	20.3	22	24	26.8	22.1	27.1	44
Mean 3pm wet bulb temp - deg C	20	19.9	18.6	16.4	14	11.6	10.8	11.4	13.5	15.4	17.2	18.6	15.6	24.9	41
Mean 3pm dew point - deg C	14.7	15.1	13.7	11.2	8.7	6.3	4.6	4.3	6.4	9	11.6	12.4	9.9	26.7	43
Mean 3pm relative humidity - %	50	51	53	53	54	53	49	45	45	48	50	45	50	24.9	41
Mean 3pm wind speed - km/h	16.7	15.6	15.2	13.6	12.3	14	14.5	16.6	18	17.4	17.3	18.4	15.8	27.4	45
Mean monthly rainfall - mm	94.3	99.3	93.9	77.5	68.7	60.5	38.9	46	43.4	70.3	78.6	56.6	828.2	23.3	46
Median (5th decile) monthly rainfall - mm	63.4	76.5	72.2	43	44.8	31	29	18.6	25.7	47.6	67.9	36.9	818.8	26	-
9th decile of monthly rainfall – mm	217.4	256.5	209.6	177.2	151.3	154.8	114.2	163.9	100.3	165.1	129.7	129.7	1171.4	26	-
1st decile of monthly rainfall – mm	21.4	19	17.2	12.6	6.9	6.3	4.6	4.6	5.3	8.1	11	13	472.1	26	-
Mean no. of raindays	10.9	11	9.7	8.8	9.3	7.4	7.1	7.7	8.1	10.5	10.2	8.5	109.2	23.3	46
Highest monthly rainfall - mm	263.6	421.8	343.6	338.2	309.3	304.4	143.1	276.4	148.2	242.8	165.6	162.7	-	23.3	46
Lowest monthly rainfall - mm	10.4	12.8	0	2.3	1.6	4	0.2	0.6	1.6	0.3	8.8	0	-	23.3	46
Highest recorded daily rainfall - mm	88.9	156	99.4	108	89.4	135	83	142.6	61.4	109.2	57.6	48	156	23.4	46
Mean no. of clear days	6.6	5.4	7.3	8.8	9.1	10.2	11.4	12.7	10.4	7.7	6.8	6.7	103.2	23.7	46
Mean no. of cloudy days	11.1	10.5	9.8	8.8	9.1	7.2	6.6	5.3	6.8	9	9.8	8.6	102.4	23.7	46
Highest recorded wind gust - km/h	68.4	76	53.6	53.6	66.6	70.2	55.4	87.1	83.2	72.4	101.9	64.8	101.9	1.3	100

4.1 Introduction

Background air quality in the vicinity of the proposed site is expected to be moderate to good, given that the development is situated away from significant urban development. The surrounding land is predominantly used for farming and forest reserves and there are no major industrial sources known to exist within a 5 km radius of the site. The nearest residence to the site is located approximately 1.5 km to the northeast and the nearest town is Appin, which is located approximately 4.5 km to the southeast and has a population of approximately 1600 people.

Background concentrations of air pollutants in this area may be derived from a range of sources. Short-term elevated concentrations of PM_{10}, NO_x, CO and other products of combustion may occur in the event of bush-fires or fuel reduction burns, and elevated levels of suspended particulate may occur at times due to agricultural activities. In general, however, ambient air pollutant concentrations would be expected to be minimal from activities in the area.

Background concentrations of pollutants for modelling purposes were considered from three DECC monitoring sites in the vicinity of the proposed development site. These are Macarthur (11km north-west), Bargo (32km south-west) and Oakdale (34km west).

As background concentrations of pollutants change over time, it is considered prudent to use the most recent full set of data. The most recent 12 months of data available from the DECC monitoring stations were obtained from the Macarthur station, which is the closest monitoring station to the proposed development site, however, is situated within close proximity to a heavily trafficked area.

The *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005) suggest the use of the maximum measured ambient concentration, measured over at least a 12 month period, to be used as the background concentration within the modelling assessment. The 12 month period allows for seasonal variations in background concentrations to be represented. This method is considered conservative.

It should be noted that the data measured at each station is generally averaged over one hour periods. These one hour averaged values then form the basis for calculated 4 hour, 8 hour, 24 hour, monthly and annual averages.

4.2 Macarthur Monitoring Data

The Macarthur monitor is located on the University of Western Sydney Campus in Campbelltown, 11km northwest of the proposed site. The Campbelltown campus is located adjacent to the Hume Highway, between the heavily trafficked Narellan and Menangle Roads. As a result, concentrations of traffic related pollutants such as NO_2, PM_{10} and CO are likely to be higher than concentrations at the proposed site.

Monitoring has been undertaken at the Macarthur site since January 2003, however details of the results were not published in the Quarterly Air Quality Monitoring reports published by the

DECC until the final quarter of 2004. **Table 4-1** presents a summary of the measured pollutants monitored at the station during 2006, namely NO_2, CO, SO_2 and particulate matter (PM_{10}).

Table 4.1: Background air pollutants measured at Macarthur, 2006.

Species	Averaging Time	Background Concentration (µg/m³)	Air Quality Critiera (µg/m³)
NO_2	1 hour maximum	134.7	246
	Annual average	23.1	62
CO	15 minute maximum	-	100,000
	1 hour maximum	2500	30,000
	8 hour maximum	2300	10,000
SO_2	10 minute maximum	-	712
	1 hour maximum	27.5	570
	24 hour maximum	9.7	228
	Annual average	1.5	60
PM_{10}	24 hour maximum	43.7	50
	Annual average	17.2	30

4.3 Hazardous Air Pollutants

In addition to the criteria air pollutants which are the primary air pollutants emitted from natural gas combustion, other air toxics, otherwise known as Hazardous Air Pollutants (HAP) may be produced and can include (US EPA, 2000):

- Benzene;
- Ethylbenzene;
- Formaldehyde;
- Toluene;
- Total Polycyclic Aromatic Hydrocarbons (PAH); and
- Xylenes.

Whilst the listed HAP's are likely to be present in the airshed, DEC (2005) specify that only the incremental impact of HAP be assessed. Hence this assessment has not included background concentrations of these compounds.

4.4 Background concentrations used for modelling

As discussed, the choice of the background concentrations for use within the modelling should be representative, or more conservative, of the area in which it is utilised, and for this purpose, criteria pollutants were taken from the DECC Monitoring Station at Macarthur.

The *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005) suggest the use of the maximum measured ambient concentration, measured over at least a 12 month period, to be used as the background concentration within the modelling assessment. The 12 month period allows for seasonal variations in background concentrations to be represented. This method is considered conservative.

A summary of the background concentrations used in the dispersion modelling is shown in **Table 4-2**.

Table 4-2 Summary of Background data used in Modelling

Species	Averaging Time	DEC Monitoring Station Data used in this assessment	Background Concentration (µg/m³)	Air Quality Critiera (µg/m³)
NO_2	1 hour maximum	Macarthur	134.7	246
	Annual average	Macarthur	23.1	62
CO	15 minute maximum	Macarthur	-	100,000
	1 hour maximum	Macarthur	2,500	30,000
	8 hour maximum	Macarthur	2,300	10,000
SO_2	10 minute maximum	Macarthur	-	712
	1 hour maximum	Macarthur	27.5	570
	24 hour maximum	Macarthur	9.7	228
	Annual average	Macarthur	1.5	60
PM_{10}	24 hour maximum	Macarthur	43.7	50
	Annual average	Macarthur	17.2	30

4.4.1 Particulate matter (PM_{10})

Particulate matter (PM_{10}) concentrations measured at Macarthur in 2006 showed four instances where, on a 24 hour average, the DEC recommended guideline of 50 ug/m^3 were exceeded. These instances are further discussed in the following paragraph.

The four high PM_{10} events occurred on 24th September (91 ug/m^3), 21 November (51 ug/m^3), 22 November (64 ug/m^3) and 1 December (91.1 ug/m^3). The Bureau of Meteorology (BoM, 2007a) notes that there were numerous large fires in and around Sydney on the 24th September, 2006, thus accounting for the peak PM_{10} measurement. The Bureau of Meteorology (BoM, 2007b) notes that more than 30 fires were reported in the last two weeks of the November 2006, thus accounting for the high PM_{10} concentrations in late November and early December 2006. The 24 hour averaged elevated PM_{10} levels that exceed the DEC criteria of 50 ug/m^3 are associated with periods of bushfire activity, consequently, have been excluded from the assessment. Whilst these exceedance values were excluded from the assessment of 24 hour averaging periods, the elevated measurements of PM_{10}, during the bushfire events have been included in the annual average concentration of PM_{10}, as a conservative measure.

5.1 Potential Discharges to Air During Construction

The construction phase is anticipated to take approximately 18 months and will involve the construction of concrete footings for the generator units, the formation of site roads, installation of the units, construction of a switchyard and transmission connection, installation of the gas lateral and gas receiving station, fencing, commissioning and other minor works.

During the construction phase, there is the potential for dust to be generated due to the excavation and handling of soils, site grading activities and vehicles movements. Given the undeveloped nature of the site, there is considered to be no significant potential for any dust emissions from construction activities to contain contaminants, or for the works to give rise to odorous emissions, consequently emissions during construction have not been quantified. The distance to the nearest residential dwellings (approximately 1.5 km) provides a sufficient buffer zone between the main work area and neighbouring land uses to prevent nuisance dust impacts.

5.2 Potential Discharges to Air During Operation

Estimated pollutant emission rates for the Leafs Gully Power Project turbines are shown in **Table 5-1**. Emission data for NOx and CO, for normal Operation and Start Up conditions were supplied by AGL, with Start Up information supplied in **Appendix E**.

Where AGL or supplier emission data did not exist, namely for PM_{10} and SO_2 emission data, values were primarily adopted from Table 11.5 of Parsons Brinckerhoff (2005), which assessed a similar Open Cycle Gas Turbine (OCGT) facility having 4 turbines and a combined output of 600MW.

As supplier data suggested SO_2 emissions to be zero, a more conservative approach was taken and SO_2 emission data has been sourced from Table 11.5 of Parsons Brinckerhoff (2005), which showed an emission rate of 2.2 and 4.9 g/s for Start Up and Operational Scenarios respectively. It should be noted that sulfur does exist in natural gas, however, it exists only in small concentrations and the SO_2 emissions are considered conservative.

As supplier data was not available for PM_{10}, emission data has been sourced from Table 11.5 of Parsons Brinckerhoff (2005), which showed an emission rate of 4.4 g/s for both Start Up and Operational Scenarios respectively. Particulate matter is generally not considered a significant issue with gas turbines, given the high efficiency of the process and the gaseous fuel, which generally does not give rise to high concentrations of particulates.

The method used to calculate HAP emissions during Operation was based on the relationship between fuel consumption and HAP provided in the US EPA (2000), commonly known as the AP-42 Emission Factors. The ratio of HAP to fuel consumption was applied to the fuel consumption for each turbine under normal Operation conditions in order to estimate the individual HAP concentrations.

Due to the different operating conditions during Start Up, fuel consumption was not deemed to be an appropriate factor to estimate HAP emissions. The method used to calculate HAP emissions during Start Up was based on the relationship between VOC[1] produced during Start Up and normal Operation for a similar E Class turbine operating on natural gas, as documented in El Segundo Power (ESP II LLC, 2007). Table A.1.6 of El Segundo Power (2007) states that Start Up emissions of VOC to be 13.0 lbs per 12 minute event, equating to a rate of 65.0 lbs/hr. The normal operation VOC emission rate was stated to be 5.4 lbs/hr, thus giving a surrogate VOC scaling factor of 12.04. This scaling factor of 12.04 was applied to the HAP emission rates calculated for the normal operation scenario to generate HAP emission rates during Start Up.

The HAP emission calculations for both normal Operation and Start Up are shown in **Appendix E**. The Leafs Gully Power Project would be available to operate 24 hours a day, 7 days a week. However, in practice, the plant would only run during periods of high electricity price and/or demand. AGL's experience with its peaking power stations in Victoria and South Australia suggest that the Leafs Gully Power Station is likely to operate between 2 and 15% of the year. The actual operating times of the power station would be largely dependent on supply and demand conditions in the electricity market. Based on historic experience in the electricity market, it is expected that the plant would be required to operate for less than 15% of the year.

5.2.1 Dispersion Modelling Scenarios

The following dispersion modelling scenarios were undertaken:

1. **Alstom Start Up**;

   - **Start Up Scenario for averaging times of less than 1 hour**. For the assessment of SO_2 and CO, where the averaging times are 10 minutes and 15 minutes respectively, the Start Up Scenario was modelled based two turbines operating under Start Up conditions for the full hour. The SO_2 and CO concentrations were then estimated using the power law relationship (Refer to **Section 6.2.3**);

   - **Start Up Scenario for averaging times of 1 hour or longer**. For the assessment of NO_2 PM_{10} and HAP where averaging times are 1 hour or longer, the Start Up Scenario was modelled based on one turbine operating under Start Up conditions for the full hour, whilst the other turbine ran on Operational conditions for the hour. This approach has been adopted in order to reflect the Start Up duration, whereby the proposed turbines are able to reach full load in less than 30 minutes from the commencement of combustion.

2. **Alstom Full Operation**;

   - **Full Operation**. Assessment of the Full Operation Scenario assumed the two turbines were operating at full load.

Other operating scenarios which were considered but not modelled included ***Part Load*** and ***Shut Down*** conditions. The worst emissions occur when the turbines are not running in full operation

[1] For the purpose of this assessment VOC and HAP are considered to refer to a similar group of compounds.

mode and would generally occur during Start Up, which requires approximately 30 minutes for the Alstom. **Appendix E** presents emissions during ***Start Up*** (49 kg NO_X per event) next to emission during ***Shut Down*** (44 kg NO_X per event). The emission rates show ***Shut Down*** emissions to be lower, consequently ***Part Load*** and ***Shut Down*** scenarios were not modelled, as the ***Start Up*** Scenario was considered to represent worst case plant conditions.

5.2.2 Source Characteristics and Emission Data

The emissions modelling was performed using the emission estimates shown in **Table 5-1**, presenting the in-stack emission concentration and the mass emission rate of each pollutant. The emissions were entered into the model as point sources and all turbines were assumed to emit continuously, 24 hours per day. This is a highly conservative approach as the station operates as a peaking station and is only expected to operate intermittently and for less than 15% of the year. This approach is appropriate for the estimation of short-term concentrations of pollutants from the power station. Annual average concentrations of pollutants due to operation of the power station will be overestimated due to the intermittent operation associated with its role as a peaking plant.

Table 5-1 Stack Parameters and Modelling Scenarios

Stack Parameter	Units	Alstom GT13E2 Operational	Alstom GT13E2 Start Up
Stack Height (above ground level)	(m)	35	35
Stack Diameter	(m)	6	6
Nominal Capacity	(MW)	160	160
Exit Temperature	(°C)	532	398 [B]
Exit Velocity	(m/s)	40	27 [B]
Mass Flow Rate	(kg/s)	532	NA
Stack Emissions			
NO_X (as NO_2)	(g/s)	19.3	27.2 [A]
CO	(g/s)	4.6	366.1 [A]
SO_2 [B]	(g/s)	4.9	2.2
PM_{10} [B]	(g/s)	4.4	4.4
Benzene[C]	(g/s)	0.003	0.030
Toluene[C]	(g/s)	0.027	0.328
Ethylbenzene[C]	(g/s)	0.007	0.081
Xylene[C]	(g/s)	0.013	0.162
Formaldehyde[C]	(g/s)	0.149	1.793
Total PAH[C]	(g/s)	0.0005	0.006

[A]: NOx and CO emissions during Start Up events are provided in **Appendix E.**

[B]: Stack emissions for SO_2 and PM_{10} and stack temperature and velocity for data during Start Up have been estimated based on proportional data taken from Table 11-5, Parsons Brinckerhoff (2005).

[C]: Calculation of HAPs (benzene, toluene, ethylbenzene, xylenes, formaldehyde and Total PAH are provided in **Appendix E**;

NA : Not Applicable

6.1 Background

In order to assess the likely impact of the plant on local and regional air quality, atmospheric dispersion modelling was performed. The study consisted of three primary components, namely:

1. Assessment of impact on photochemical smog in Sydney's Regional Airshed;
2. Assessment of local impact from stack emissions; and
3. Assessment of stack emission on aviation.

CSIRO was commissioned to perform the first component using CIT – LCC[2] and URS performed the latter two studies using TAPM. The full report of the photochemical smog study is provided separately in the Environmental Assessment. The following sections discuss the second component, namely the local air quality study. The third component relating to aviation safety is provided as **Appendix B** to this report.

6.2 Modelling methodology

6.2.1 Choice of Model

Models to predict ground level concentrations at local scales (< 5-10 km) can be generally classed as either steady-state models e.g., AUSPLUME or non-steady-state models such as TAPM. Steady-state models do not capture the effects of time-varying meteorological conditions over short time periods and may not accurately model maximum ground level concentrations resulting from stack emissions. More realistic predictions are generally made with the non-steady-state models, which incorporate more sophisticated treatment of dispersion in convective and complex flow conditions.

For the assessment of the impacts from the proposed development, the TAPM model was chosen. TAPM encompasses site-specific factors such as terrain influences, regional-scale winds and inversions to predict ground-level concentrations. The main advantages of the proposed modelling system over simpler tools such as AUSPLUME are that:

- The effects of convective turbulence on plume grounding are better represented in TAPM; and
- Any complex three-dimensional behaviour affecting plume dispersion cannot be handled by AUSPLUME.

Within the TAPM model, default parameters were generally chosen. It should, however, be noted that TAPM was run without the influence of stack tip downwash for all scenarios excluding the sub-one hourly Start Up Scenario.

[2] CIT – LCC stands for the California Institute of Technology – Luhrman Carter Coyner. The CIT model can be used in conjunction with other applications and in this instance, the LCC photochemical mechanism was incorporated into the CIT model.

6.2.2 Meteorological modelling

The meteorological assessment and meteorological modelling using TAPM is discussed in **Appendix D**.

6.2.3 Estimation of pollutant concentrations for averaging periods less than 1 hour

Where pollutant concentrations were required to be assessed for averaging times less than one hour, namely for sulfur dioxide and carbon monoxide, Equation 1 was used (Victoria EPA, 2005).

$$C_t = C_{60}\left[\frac{60}{t}\right]^{0.2} \qquad \text{…[Equation 1]}$$

Where:
C_t = concentration of pollutant at time t
C_{60} = concentration of pollutant based on averaging time of 60 minutes;
t = time (in minutes)

For the Start Up scenarios, given the possibility that two turbines could be starting up at any one time, the hourly averaged emission scenarios, as used in the modelling, could provide an underestimation of the peak concentrations for 10 or 15 minute averaging periods. Consequently, the concentrations to which **Equation 1** was applied were the hourly concentrations based on two turbines operating in Start Up mode for the full hour.

6.2.4 AUSPLUME Screening Assessment

To assure the quality of this assessment, it was considered that an additional model be used to validate and therefore provide greater reliability of the predictions using TAPM. Thus additional modelling was undertaken using AUSPLUME, for the principal species of concern, namely, NO_2 (1 hour average) and PM_{10} (24 hour average). A discussion of the validation of these results using AUSPLUME is presented in **Appendix F**, and substantiates the TAPM modelling results.

7.1 Summary of Potential Air Quality Impacts

A summary of the potential worst case air quality impacts within the modelling domain is provided in **Table 7-1**. Under these conditions, the modelled species do not show exceedances of criteria.

Selected dispersion model contour plots for NO_2, CO, SO_2 and PM_{10} are provided in **Appendix A**. The results generally show the worst case impact area for the operating scenario to be approximately 10 km to the north east of the plant. **Figure A1** shows the location of sensitive receptors within close proximity to the proposed development. As discussed in the following sections, the maximum impact is shown to occur beyond these receptors, consequently they have not been specifically identified in the dispersion modelling figures.

Table 7-1: Summary of Potential Worst Case Air Quality Impacts – Alstom GT 13E2

Species	Averaging Period	Background Concentration [A] ug/m^3	Predicted Impact ug/m^3	Cumulative Impact ug/m^3	Air Quality Criteria ug/m^3
Start Up					
NO_2	1 hour maximum	134.7	33.2	167.9	246
	Annual average	23.1	0.3	23.4	62
CO	15 minute maximum [C]	3,404	1469	4,873	100,000
	1 hour maximum	2,580	439.2	3,019	30,000
	8 hour maximum	2,280	158.6	2,439	10,000
SO_2	10 minute maximum [C]	39.4	9.6	48.9	712
	1 hour maximum	27.5	6.8	34.3	570
	24 hour maximum	9.7	1.3	11.0	228
	Annual average	1.5	0.06	1.6	60
PM_{10}	24 hour maximum	43.7	1.12	44.8	50
	Annual average	17.2	0.053	17.3	30
Benzene	1 hour average	-	0.021	0.021	290
Toluene	1 hour average	-	0.188	0.188	360
Ethylbenzene	1 hour average	-	0.049	0.049	8,000
Xylenes	1 hour average	-	0.090	0.090	190
Formaldehyde	1 hour average	-	1.035	1.035	20
Total (PAH) [B]	1 hour average	-	0.0035	0.0035	0.4
Operating					
NO_2	1 hour maximum	134.7	29.6	164.3	246
	Annual average	23.1	0.2	23.3	62
CO	15 minute maximum [C]	3,404	9.3	3,414	100,000
	1 hour maximum	2,580	7.1	2,587	30,000
	8 hour maximum	2,280	2.1	2,282	10,000
SO_2	10 minute maximum [C]	39.4	10.8	50.1	712
	1 hour maximum	27.5	7.5	35.0	570
	24 hour maximum	9.7	1.2	10.9	228
	Annual average	1.5	0.04	1.54	60
PM_{10}	24 hour maximum	43.7	1.09	44.8	50
	Annual average	17.2	0.04	17.24	30
Benzene	1 hour average	-	0.002	0.002	290
Toluene	1 hour average	-	0.018	0.018	360
Ethylbenzene	1 hour average	-	0.005	0.005	8,000
Xylenes	1 hour average	-	0.009	0.009	190
Formaldehyde	1 hour average	-	0.101	0.101	20
Total (PAH) [B]	1 hour average	-	0.0003	0.0003	0.4

Note:

[A]: As shown in **Table 4-2**.

[B]: Total PAH reported as benzo[a]pyrene

[C]: The sub-hour concentrations were based on both stacks operating at peak Start Up emissions for the whole hour.

Ground level concentrations of NO_2, CO, SO_2 and PM_{10} are presented as 100% frequency (worst case), while HAP show 99.9% frequency, as required in DEC (2005).

7.2 Nitrogen Dioxide

The ground level guidelines for oxides of nitrogen are limited to NO_2, the principal species of concern in terms of health effects. For this assessment, it has been assumed that all emitted NO_x exists in the form of NO_2. Given that emissions of oxides of nitrogen exist in the atmosphere as both NO_2 and NO this assumption is considered conservative.

The Alstom Operating Scenario showed a peak impact approximately 8 km north east of the plant. For the Operating Scenario, both the 1 hour and annual averages were shown to have cumulative concentrations of NO_2 below regulatory guidelines.

The Alstom Start Up Scenario showed a peak impact approximately 12 km south east of the plant, with the secondary impact area approximately 10 km to the north east of the plant. For the Start Up Scenario, the 1 hour averages were shown to have cumulative concentrations of NO_2 below regulatory guidelines.

It should again be further noted that the plant is expected to operate for less than 15% of the year, and that the modelling results shown in **Table 7-1** represent the worst case short-term (1 hour) predictions based on the plant operating for every hour of the year with all emitted NO_x is present as NO_2, consequently the impacts are likely to be significantly less than modelled.

In addition, the annual average NO_2 concentrations, when modelled under the Operating conditions were shown to be below criteria of 62 $\mu g/m^3$. Given the background concentration of 23.1 $\mu g/m^3$, and the predicted cumulative impact from operation of the site showed concentrations at or less than 0.3 $\mu g/m^3$, long term impacts are negligible.

7.3 Carbon Monoxide

The maximum cumulative impact on CO was shown to be during the Start Up Scenario at a 15 minute averaging period, with a predicted concentration of 4873 ug/m^3, which is below the criteria of 100,000 ug/m^3. Similarly, the 1 hour and 8 hour concentrations of CO are well below their respective guidelines. Consequently, no adverse impacts on local air quality are expected as a result of the intermittent discharge of CO from the proposed power plant.

7.4 Sulphur Dioxide

For the proposed development, the maximum cumulative predicted ground level concentration of SO_2 is 50.1 $\mu g/m^3$ as a 10 minute average and occurs under Operating conditions. This is well below the 10 minute criteria for SO_2 of 712 $\mu g/m^3$. Likewise, the 1 hour, 24 hour and annual concentrations of SO_2 are well below their respective guidelines.

7.5 Particulate Matter (as PM_{10})

Particulate matter background data was assessed using a 2006 data set and four events were shown to have high background PM_{10} concentrations approaching the criteria of 50 µg/m³ (24 hour averaging). These peak concentrations were associated with bushfires, and consequently were dismissed as extraordinary events. The maximum measured 24 hour average background concentration of PM_{10} was shown to be 43.7 µg/m³, which is below the regulatory limit of 50 µg/m³.

Based on the conservative assumption of continuous emission throughout each 24 hour averaging period, the maximum predicted increase in ground level concentration of PM_{10} from the two scenarios modelled was from the Start Up conditions, predicted to have a maximum concentration of 1.12 µg/m³, and a maximum cumulative impact of 44.8 µg/m³, which is below the regulatory guideline of 50 µg/m³. Given the low predicted impact of PM_{10}, as expected from gas fired turbines, it is considered that PM_{10} impacts on local air quality will be minor.

7.6 Hazardous Air Pollutants

Hazardous air pollutants from gas fired turbines are generally not considered to be a pollutant of concern, and this has been illustrated in the results. Even under worst case operating conditions, the species assessed were all significantly below the air quality criteria. The highest HAP, in terms of percentage of guideline, formaldehyde, with a maximum predicted concentration of 1.035 µg/m³ (Start Up Scenario), representing 5.2% of the DEC guidelines of 20 µg/m³.

7.7 Emissions Limits

The *Protection of the Environment Operations (Clean Air) Regulation 2002* sets emission limits for air impurities from stationary plant and equipment, during normal operational conditions, excluding Start Up. The proposed stack emissions for oxides of nitrogen meet the current standards, taken from Schedule 3 (Electricity Generation) of the Regulation as presented in **Table 7-2**.

Table 7.2: Comparison of Turbine Emissions to POEO (Clear Air) Regulatory Limits

Stack Emissions	Units	Alstom GT13E2	POEO (Clean Air) Regulatory Limit
NO_X (all NO_x as NO_2)	(mg/m^3)	51	70

Note: Concentration expressed at reference conditions (273K, dry, 1atm, 15% O_2).

7.8 Summary of Model Predictions

A review of the air emissions from the proposed Leafs Gully Power Project and their potential impact has been undertaken using dispersion modelling. This assessment has drawn the following conclusions:

- There are no predicted exceedances of the NO_2 ground level guidelines when accounting for emissions from operation of the turbines, combined with background sources considering a conservative assumption that all emitted NO_x is present as NO_2 ;
- Operation of the plant is not predicted to result in PM_{10}, CO, nor SO_2 ground-level concentrations in excess of relevant ambient air quality guidelines;
- Stack emission concentrations are below relevant emission criteria;
- Concentrations of pollutants for longer averaging times (24 hour and annual averages) are overestimated, as:
  - The operating scenario has been run on the basis that the plant is operating full time. This is an unlikely scenario as it is expected that the plant will be operating for up to 15% of the year; and
  - The Start Up scenario has been run on the basis that two turbines are started per hour, for every hour of the year. This is an exceedingly unlikely scenario as it is expected that the plant will be operating for up to 15% of the year, and Start Up events will comprise approximately 1% of the total plant operating time.

7.9 Mitigation Measures

7.9.1 During the Design Phase

The atmospheric dispersion modelling study undertaken as part of this assessment has been based on preliminary design information. As part of the detailed design of the development, the assumptions and emission estimates used in this assessment will be reviewed. Should the updated emission parameters indicate that the values used in this assessment are unsuitable, this assessment will be revised to ensure that DEC air quality standards and goals will be met.

In addition, throughout the design process, opportunities to minimise emissions to air will be investigated and implemented wherever possible to ensure that off-site impacts are kept to a minimum.

7.9.2 During Construction

Environmental safeguards that would be implemented during the construction phases of the expansion are listed below. Any emissions of particulates (dust) would be specifically controlled through the implementation of these mitigation measures, which would be incorporated into a Construction Environment Management Plan (CEMP) for the works.

- Before works begin, a CEMP will be prepared which addresses air monitoring and management issues;
- In dry, windy conditions, water sprays would be used to dampen down soils prior to excavation and handling. Exposed surfaces and stockpiles would also be watered, sprayed or covered where required;
- Where practical, demolition activities or particularly dusty works would be scheduled under favourable meteorological conditions only. Earth-moving activities would be stopped when wind speeds exceed 30 km/hr;

- Vehicles would only be loaded to less than the height of the side and tailboards and loads of fill would be covered during transport. Any soil adhering to the undercarriage and wheels of trucks would be removed prior to departure from the site;
- Any long-term stockpiles would be stabilised using fast-seeding grass or synthetic cover spray; and
- All major access roads would be sealed and vehicle speeds on unsealed areas would be controlled to minimise dust.

7.10 Load Based Licensing

Load Based Licensing (LBL) is a NSW licensing scheme and involves the setting of annual load limits for pollutant emissions in licences. The licence fees are to be used to provide financial incentives for licensees to achieve discharges below the required minimum performance specified by the POEO regulation.

The fee based activities are outlined in the Environmental Protection Licence (EPL), which is issued upon operation of the facility. At this stage, it is understood that air related fee based activities at the proposed site are limited to the turbine emissions and the assessable air pollutants for the identified fee based activities are limited to nitrogen oxides.

Emission Estimates and Calculation of Assessable Load

As outlined previously in this report, emissions for this proposed facility have been based on data from similar turbines, and data provided by Alstom. The amount of nitrogen oxides released from the turbines cannot be accurately estimated at this stage. However, based on the emission rates listed in this report (**Table 5-1**), it is possible to provide an estimate of nitrogen oxide emissions. **Table 7.3** shows the daily NO_x emissions for a range of operating times. It should be noted that the operating emissions are derived from supplier guaranteed emission data, and that actual emissions are likely to be lower.

AGL propose that the actual nitrogen oxide emissions would be measured throughout operation, using a Constant Emissions Monitoring System (CEMS). For the purposes of load based licensing, this would allow a more accurate assessment of the nitrogen oxide emissions to be performed.

Table 7-3: Daily NO_x emissions of the plant under different operating periods [A]

Hours of Operation per day	NO_x emitted at full capacity (2 turbines) (kg NO_x per day)
1	168
2	306
3.6 [B]	529
4	584
8	1140
12	1696
24	3364

Notes:

[A]: Emissions are based on two turbines operating at full load, and assume one Start Up per day.

[B]: 3.6 hours of operation per day is approximately equivalent to plant operation 15% of the year.

7.11 Aviation Safety

Due to the plume rise from the stack emissions, an aviation hazard analysis based on the predicted impacts of the proposed facility has been performed and is included in **Appendix B**. The statistics have been compiled in accordance with the Civil Aviation Safety Authority's (CASA) Advisory Circular *"Guidelines for Conducting Plume Rise Assessments"* (June, 2004). Where there is potential for an exhaust plume with a vertical velocity greater than 4.3m/s at the Obstacle Limitation Surface (OLS) of 110m, a hazard analysis is required.

This assessment involved the use of the TAPM model which was used to create site-specific meteorological data, including meteorology for the upper atmosphere. TAPM was also used to calculate plume rise trajectories for the turbine emissions.

The modelling results show that as expected for an open cycle gas turbine facility, the plant would produce exhaust plumes with vertical velocities that exceed 4.3m/s above the OLS for a significant proportion of the year (when modelling the plant running at full load all hours of the year). The maximum, minimum and average heights at which the plume velocity is greater than 4.3 m/s are provided in **Table 7-4**.

Table 7.4 Maximum, Minimum and Average Critical Plume Extents

	Critical Vertical Plume Extent (m)	Critical Horizontal Plume Extent (m)
Maximum	962	316
Minimum	60	59
Average	172	125

Based on the TAPM assessment for 2006, the OLS is exceeded during approximately 80% of the year, with an average vertical velocity of 4.3 m/s at 172m above ground level. Whilst this assessment is considered extremely conservative with respect to the modelled operating times and operating conditions, consideration should be given for the plant to be designated a hazard to aircraft operators in the area.

7.12 Greenhouse Gas Assessment

A comprehensive greenhouse gas assessment including quantitative modelling has been conducted and is presented in **Appendix C**. The greenhouse gas emissions of the Leafs Gully Power Project are estimated to be 0.29 million tonnes of CO_2-e per year based on the plant operating for 15% of the year. In comparison to the 2006 greenhouse gas inventory, this would represent 0.37% of greenhouse gas emissions from stationary energy generation in NSW or 0.10% of all stationary energy generation in Australia. The emissions intensity of the Leafs Gully Power Project will be in the range of 0.6t CO_2-e/MWh; significantly less than the 2008 average for NSW generation of 0.954t/MWh. Under the proposed ETS, AGL will procure permits for the emissions for the plant as part of Australia's overall emissions cap.

The proposed Leafs Gully Power Project at Appin and its predicted impact on local air quality has been assessed using a dispersion model known as TAPM and the results were substantiated with another dispersion model, AUSPLUME. The emissions assessed included oxides of nitrogen (NO_X), carbon monoxide (CO), sulphur dioxide (SO_2), PM_{10} and Hazardous Air Pollutants (HAPs).

In order to assess the cumulative impact of the plant emissions on the local air quality, background concentrations of the primary pollutants were obtained from the DECC monitoring station at Macarthur, which is the closest monitoring station to the site.

The assessment of background data showed that NO_2, CO, and SO_2 were not in exceedance of regulatory criteria. Background PM_{10} (averaged over 24 hours) was noted to exceed regulatory criteria on four occasions, however, these occasions were associated with bushfire events, and were excluded from the assessment.

The dispersion modelling predicted the impact of the plant emissions on local air quality based on the plant operating all hours of the year. Whilst plants of this type are likely to operate less than 15% of the year, this conservative approach was taken to assess the impacts under worst case operating and atmospheric conditions.

The results of the worst case dispersion modelling showed the following:

- Ground level concentrations of NO_2, PM_{10}, CO and SO_2 were shown to be below the DEC regulatory criteria;
- HAP including benzene, toluene, ethylbenzene, xylenes, formaldehyde and Total PAHs were found to below the DEC regulatory criteria.

In conclusion, no exceedances of DEC regulatory criteria were observed and it is considered that the impacts on local air quality from this development would be minor and adverse impacts are unlikely.

Notwithstanding this, it is noted that nitrogen oxide emissions would be measured throughout operation, using a Constant Emissions Monitoring System (CEMS).

A plume rise assessment was undertaken on the basis that the plant was operating at full load for the entire year. The analysis estimated that the OLS would be exceeded during operation for approximately 80% of the assessment period, with an average vertical velocity of 4.3 m/s at 172 m above ground level. Whilst this assessment is considered conservative with respect to the modelled operating times and operating conditions, consideration should be given for the plant to be designated a hazard to aircraft operators in the area.

The greenhouse gas emissions of the Leafs Gully Power Project are estimated to be 0.29 million tonnes of CO_2-e per year based on the plant operating 15% of the year. In comparison to the 2006 greenhouse gas inventory, this would represent 0.37% of greenhouse gas emissions from power generation in NSW or 0.10% of all power generation in Australia.

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US EPA 2000 *AP-42, 5th Ed, Volume 1: Chapter 3 Stationary Internal Combustion Sources*. US Government.

Victoria EPA 2005 *AUSPLUME Dispersion Model, Version 6.0*.

Appendix A
Dispersion Model Contour Plots

Legend

Site Boundary

Sensitive Receptors

Source: Google Earth 2008

Client	Project	Title
AGL Limited	**LEAFS GULLY POWER STATION**	**LOCATION OF SENSITIVE RECEPTORS LOCATED CLOSE TO PROPOSED PLANT**
URS	Drawn: AJW · Approved: FINAL · Date: August 2006	Figure: **A1**
	Job No: **43177401** · File No: 43177401-030.wor	

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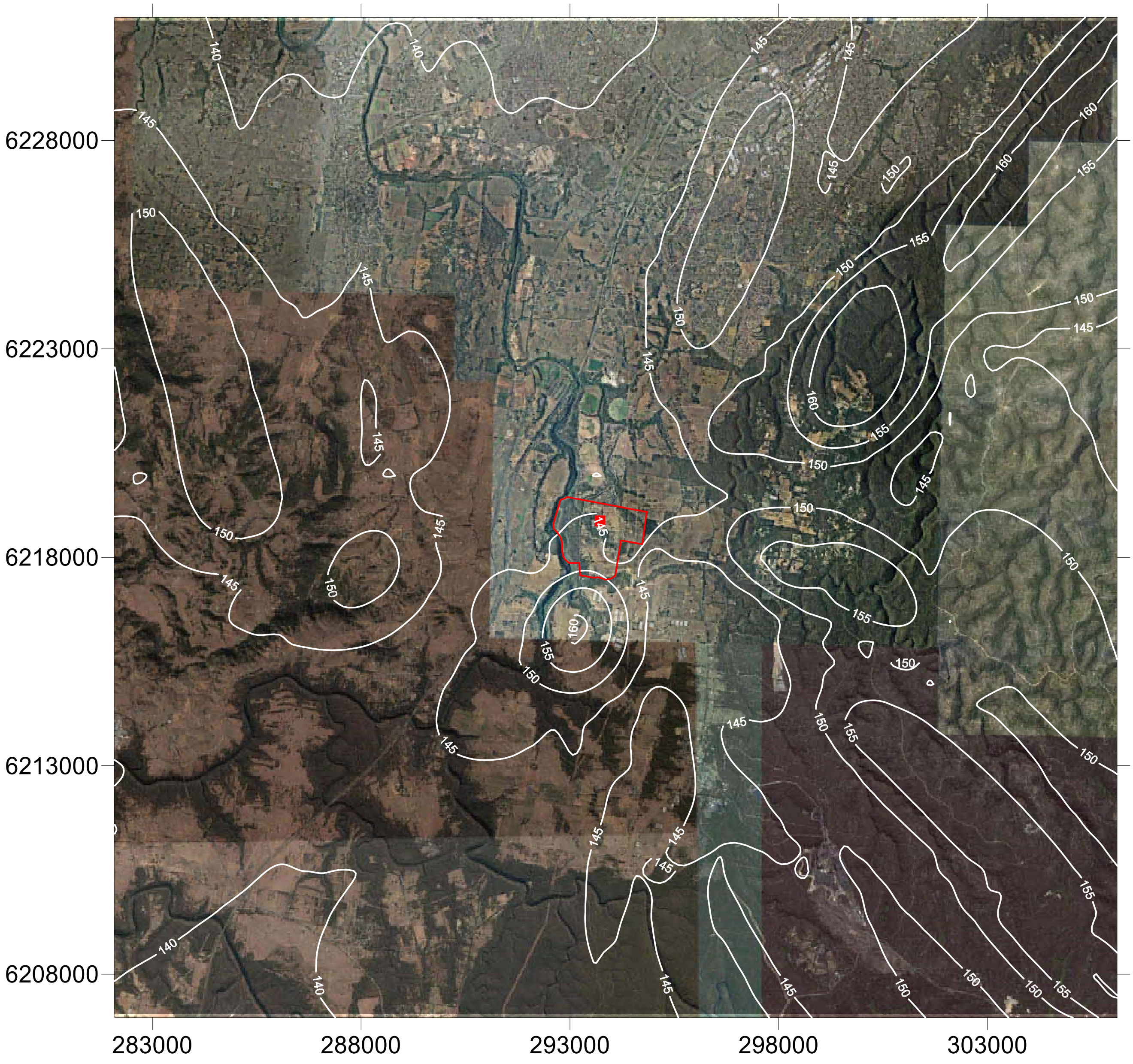

1 Hour maximum
Contours in µg/m3
Background Level of 134.7 µg/m3

Site Boundary

Source: Google Earth 2008

Client: AGL LTD	Project: LEAFS GULLY - PROPOSED GAS TURBINE PLANT	Title: Operating, Nitrogen Oxides as NO_2 1 Hour Maximum
URS	Drawn: RW / Approved: DRAFT / Date: June 2008 / Job No: 43177401 / File: 43177401 Figure A2.srf	Figure: A2 / Rev: A / A4

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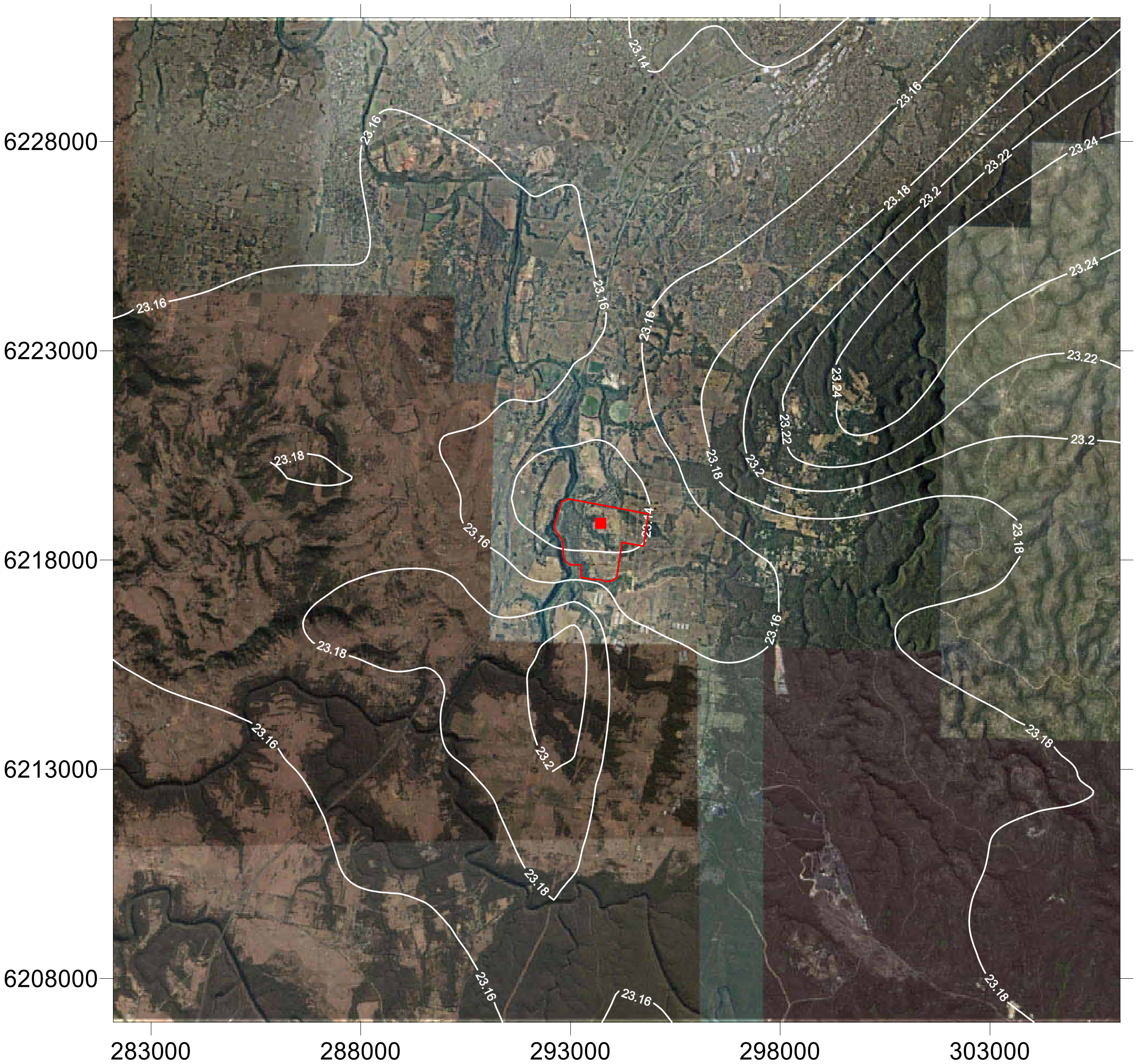

Annual Average
Contours in µg/m3
Background Level of 23.1 µg/m3

Site Boundary

Source: Google Earth 2008

Client: AGL LTD	Project: LEAFS GULLY - PROPOSED GAS TURBINE PLANT	Title: Operating, Nitrogen Oxides as NO_2 Annual Average
URS	Drawn: RW; Approved: DRAFT; Date: June 2008; Job No: 43177401; File: 43177401 Figure A3.srf	Figure: A3; Rev: A; A4

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15 Minute Maximum
Contours in µg/m3
Background Level of 3400 µg/m3

Site Boundary

Source: Google Earth 2008

Client: AGL LTD	Project: LEAFS GULLY - PROPOSED GAS TURBINE PLANT	Title: Operating, Carbon Monoxide CO 15 Minute Maximum
URS	Drawn: RW / Approved: DRAFT / Date: June 2008 / Job No: 43177401 / File: 43177401 Figure A4.srf	Figure: A4 / Rev: A / A4

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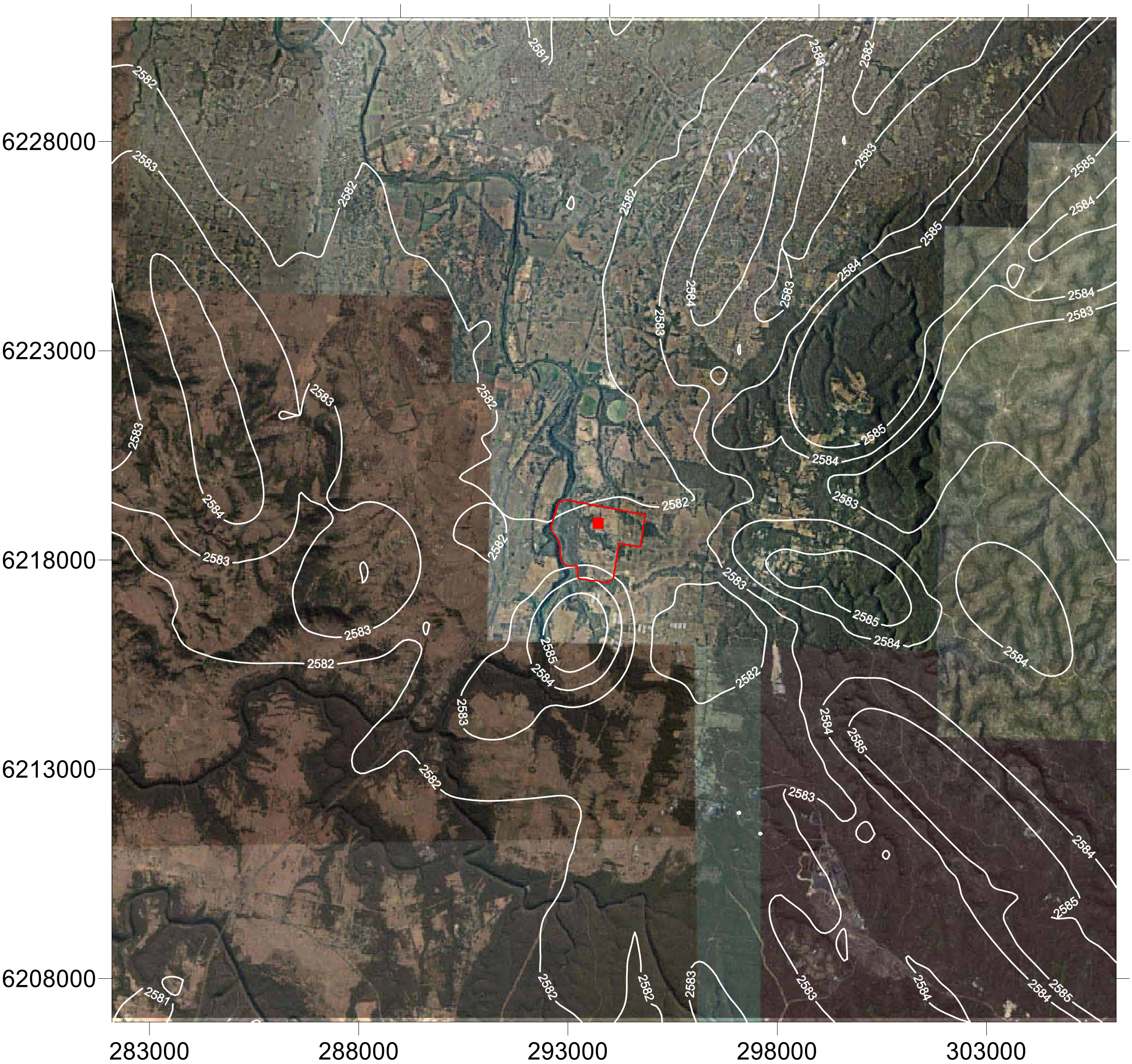

1 Hour Maximum
Contours in µg/m3
Background Level of 2580 µg/m3

Site Boundary

Source: Google Earth 2008

Client: AGL LTD	Project: LEAFS GULLY - PROPOSED GAS TURBINE PLANT	Title: Operating, Carbon Monoxide CO 1 Hour Maximum
URS	Drawn: RW; Approved: DRAFT; Date: June 2008; Job No: 43177401; File: 43177401 Figure A5.srf	Figure: A5; Rev: A; A4

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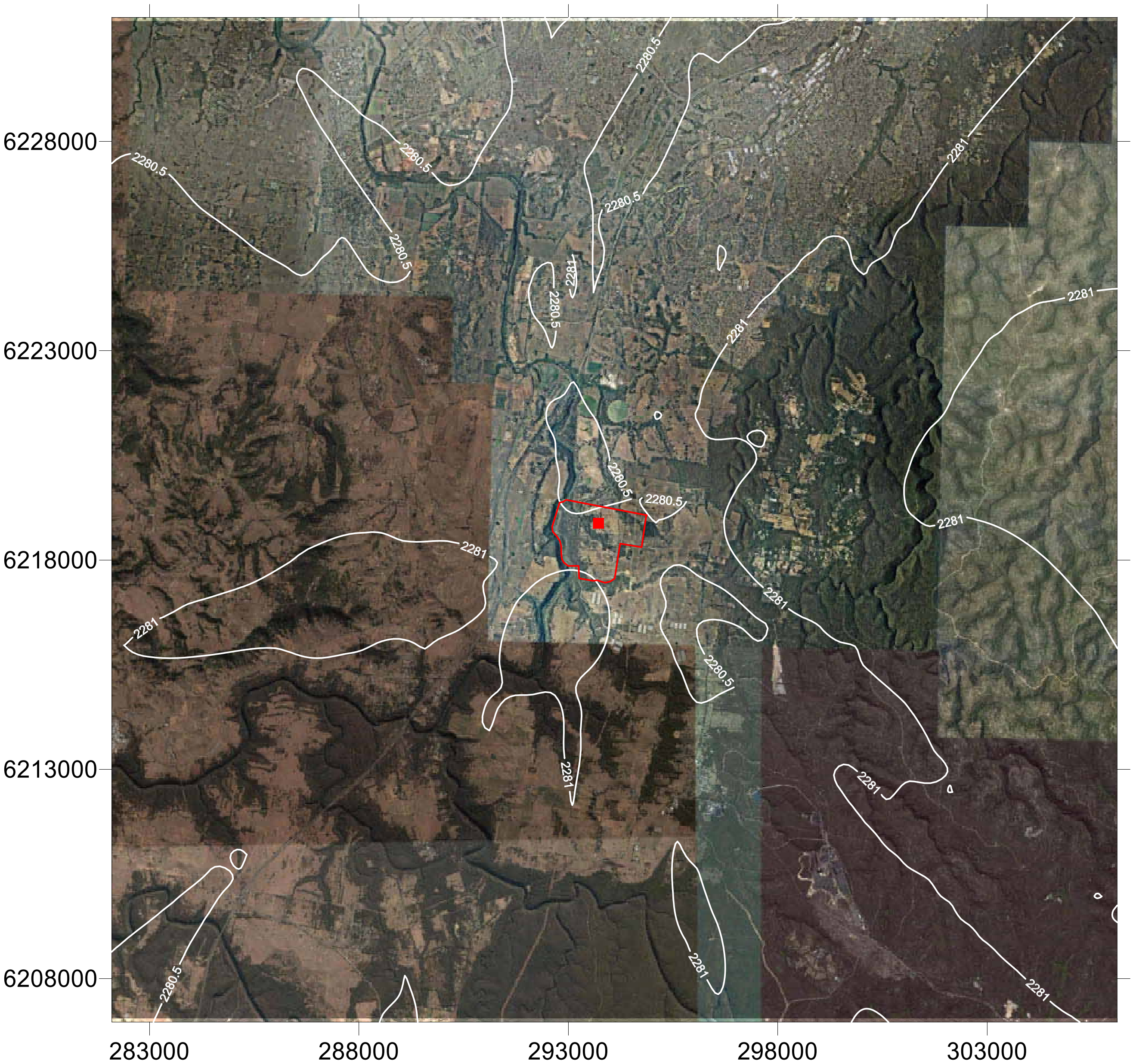

8 Hour Maximum
Contours in µg/m3
Background Level of 2280 µg/m3

Site Boundary

Source: Google Earth 2008

Client: AGL LTD	Project: LEAFS GULLY - PROPOSED GAS TURBINE PLANT	Title: Operating, Carbon Monoxide CO 8 Hour Maximum
URS	Drawn: RW; Approved: DRAFT; Date: June 2008; Job No: 43177401; File: 43177401 Figure A6.srf	Figure: A6; Rev: A; A4

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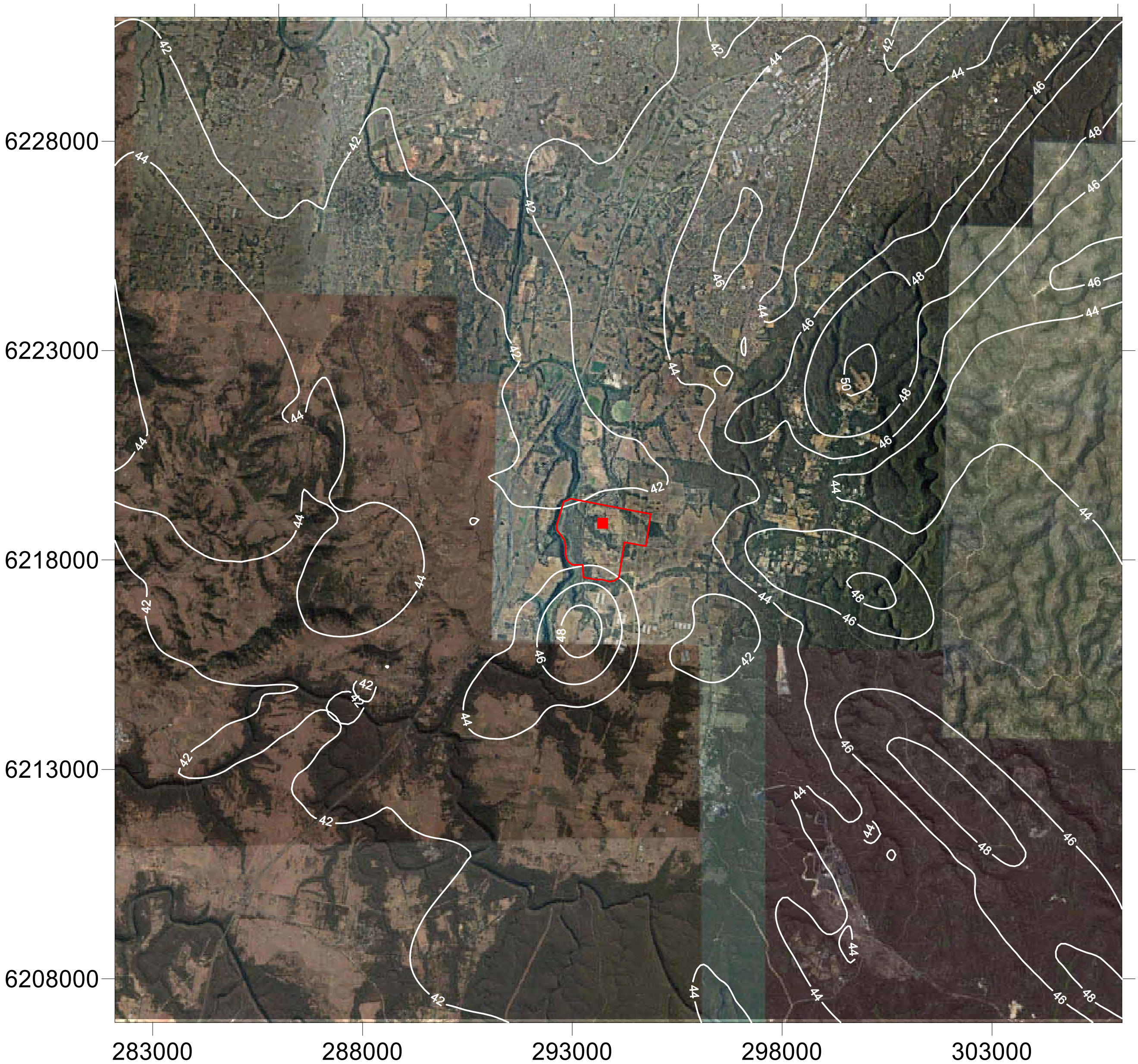

10 Minute Maximum
Contours in µg/m3
Background Level of 39.4 µg/m3

Site Boundary

Source: Google Earth 2008

Client: AGL LTD	Project: LEAFS GULLY - PROPOSED GAS TURBINE PLANT	Title: Operating, Sulphur Dioxide SO_2 10 Minute Maximum
URS	Drawn: RW; Approved: DRAFT; Date: June 2008; Job No: 43177401; File: 43177401 Figure A7.srf	Figure: A7; Rev: A; A4

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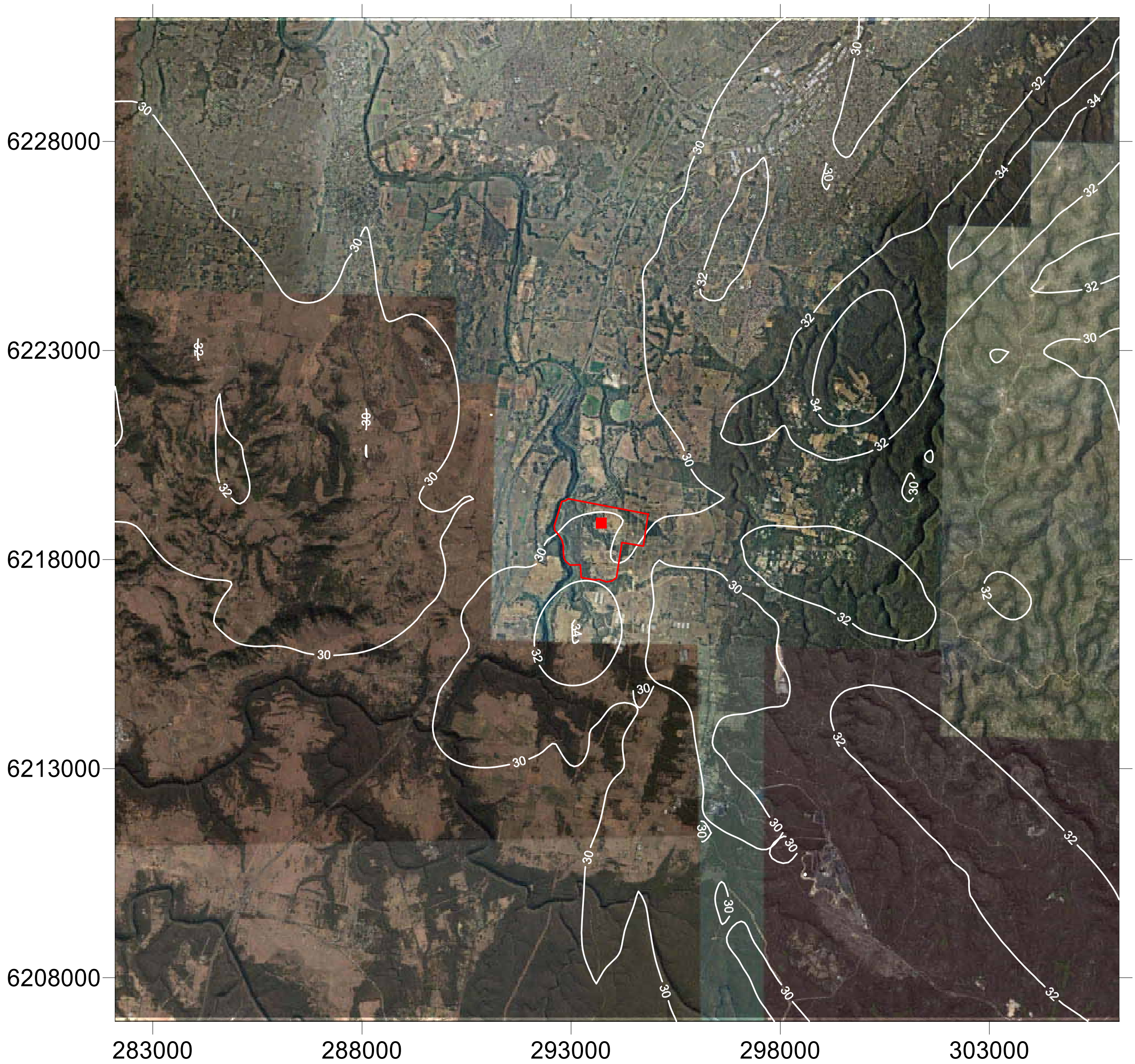

1 Hour Maximum
Contours in µg/m3
Background Level of 27.5 µg/m3

Site Boundary

Source: Google Earth 2008

Client: **AGL LTD**	Project: **LEAFS GULLY - PROPOSED GAS TURBINE PLANT**	Title **Operating, Sulphur Dioxide SO_2 1 Hour Maximum**
URS	Drawn: RW; Approved: DRAFT; Date: June 2008; Job No: **43177401**; File: 43177401 Figure A8.srf	Figure: A8; Rev: A; A4

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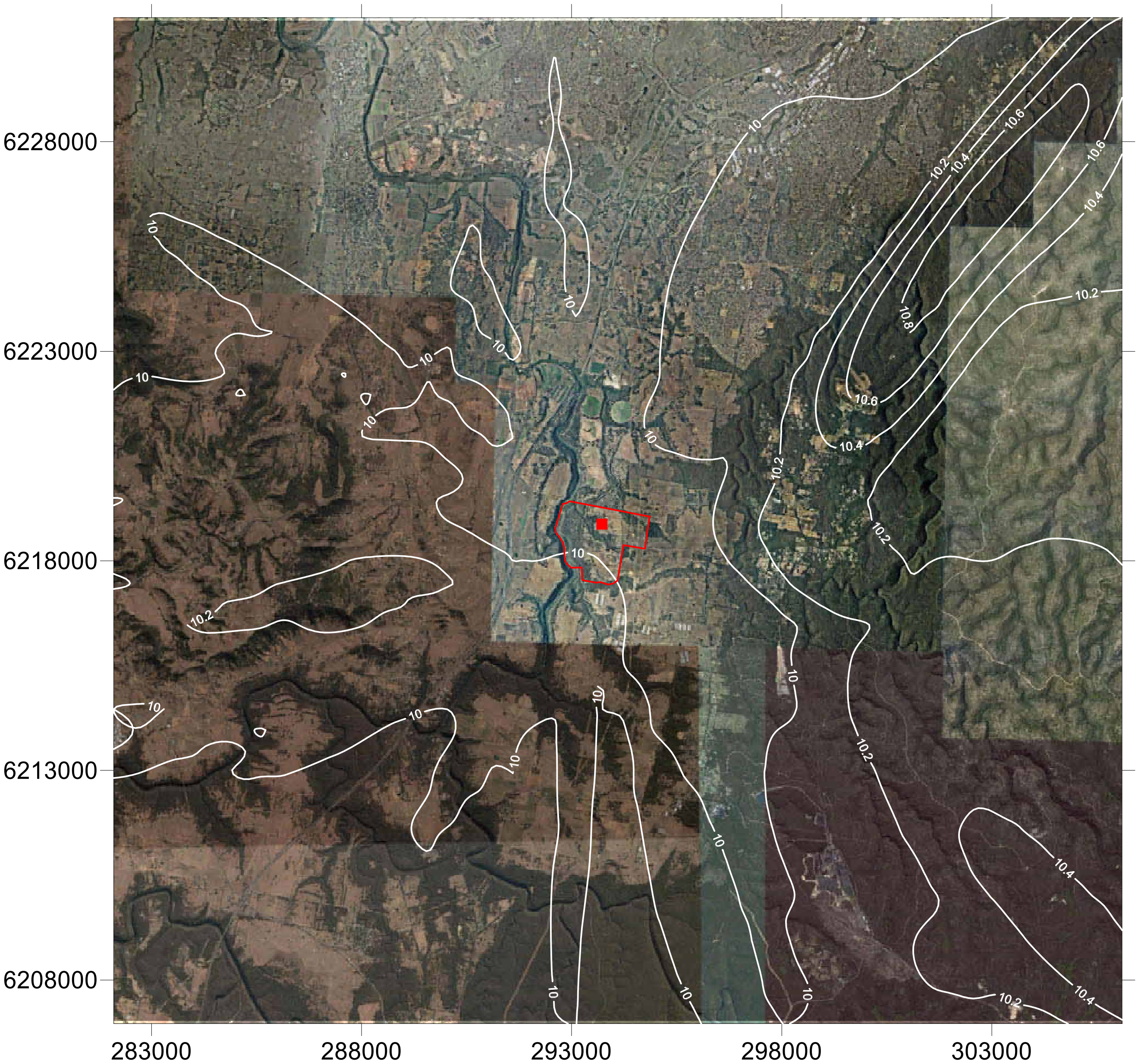

24 Hour Maximum
Contours in µg/m3
Background Level of 9.7 µg/m3

Site Boundary

Source: Google Earth 2008

Client: AGL LTD	Project: LEAFS GULLY - PROPOSED GAS TURBINE PLANT	Title: Operating, Sulphur Dioxide SO_2 24 Hour Maximum
URS	Drawn: RW / Approved: DRAFT / Date: June 2008 / Job No: 43177401 / File: 43177401 Figure A9.srf	Figure: A9 / Rev: A / A4

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Annual Average
Contours in µg/m3
Background Level of 1.5 µg/m3

Site Boundary

Source: Google Earth 2008

Client: AGL LTD	Project: LEAFS GULLY - PROPOSED GAS TURBINE PLANT	Title: Operating, Sulphur Dioxide SO_2 Annual Average
URS	Drawn: RW; Approved: DRAFT; Date: June 2008; Job No: 43177401; File: 43177401 Figure A10.srf	Figure: A10; Rev: A; A4

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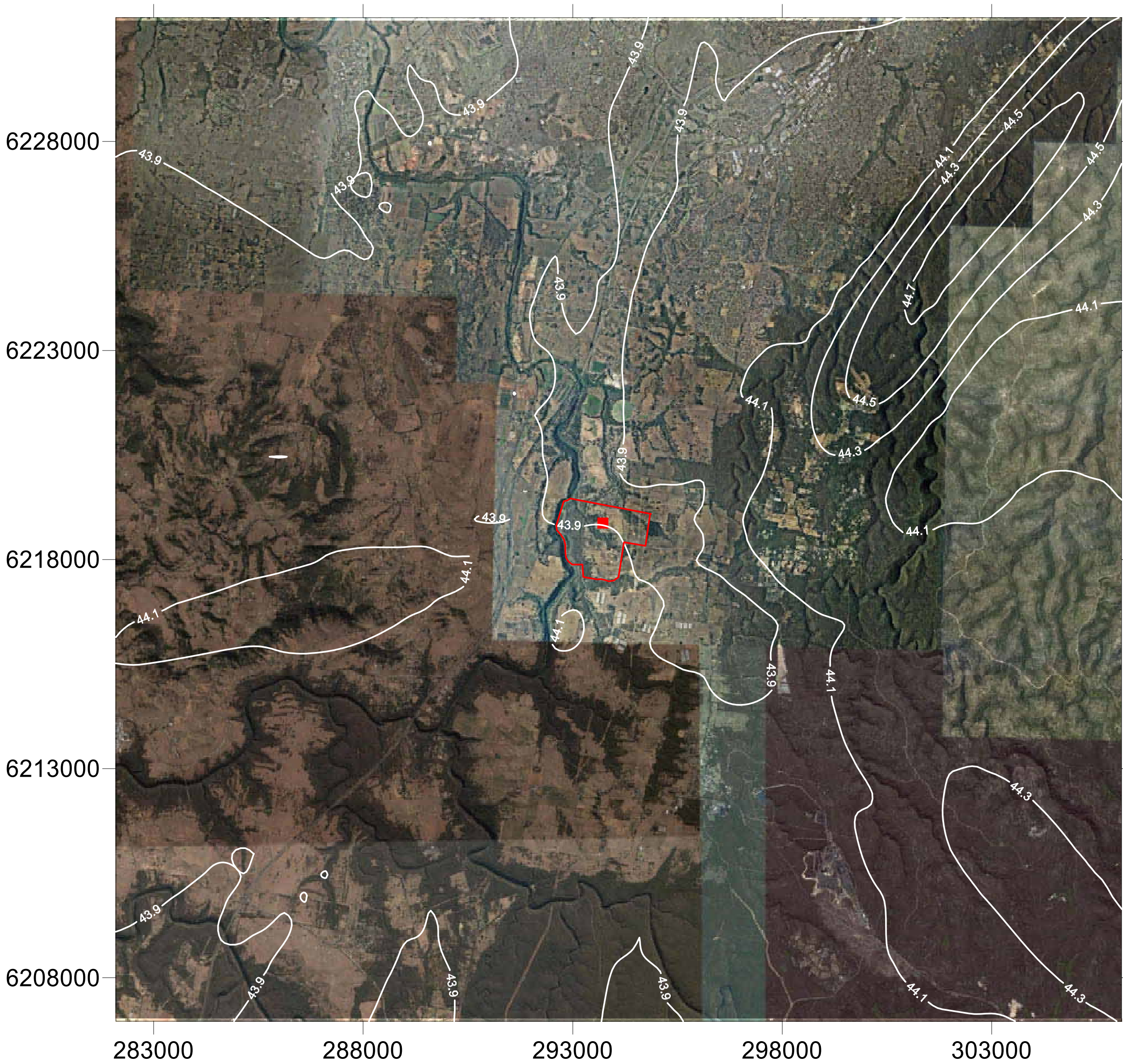

24 Hour Maximum
Contours in µg/m3
Background Level of 43.7 µg/m3

Site Boundary

Source: Google Earth 2008

Client: AGL LTD	Project: LEAFS GULLY - PROPOSED GAS TURBINE PLANT	Title: Operating, Particulate Matter PM_{10} 24 Hour Maximum
URS	Drawn: RW; Approved: DRAFT; Date: June 2008; Job No: 43177401; File: 43177401 Figure A11.srf	Figure: A11; Rev: A; A4

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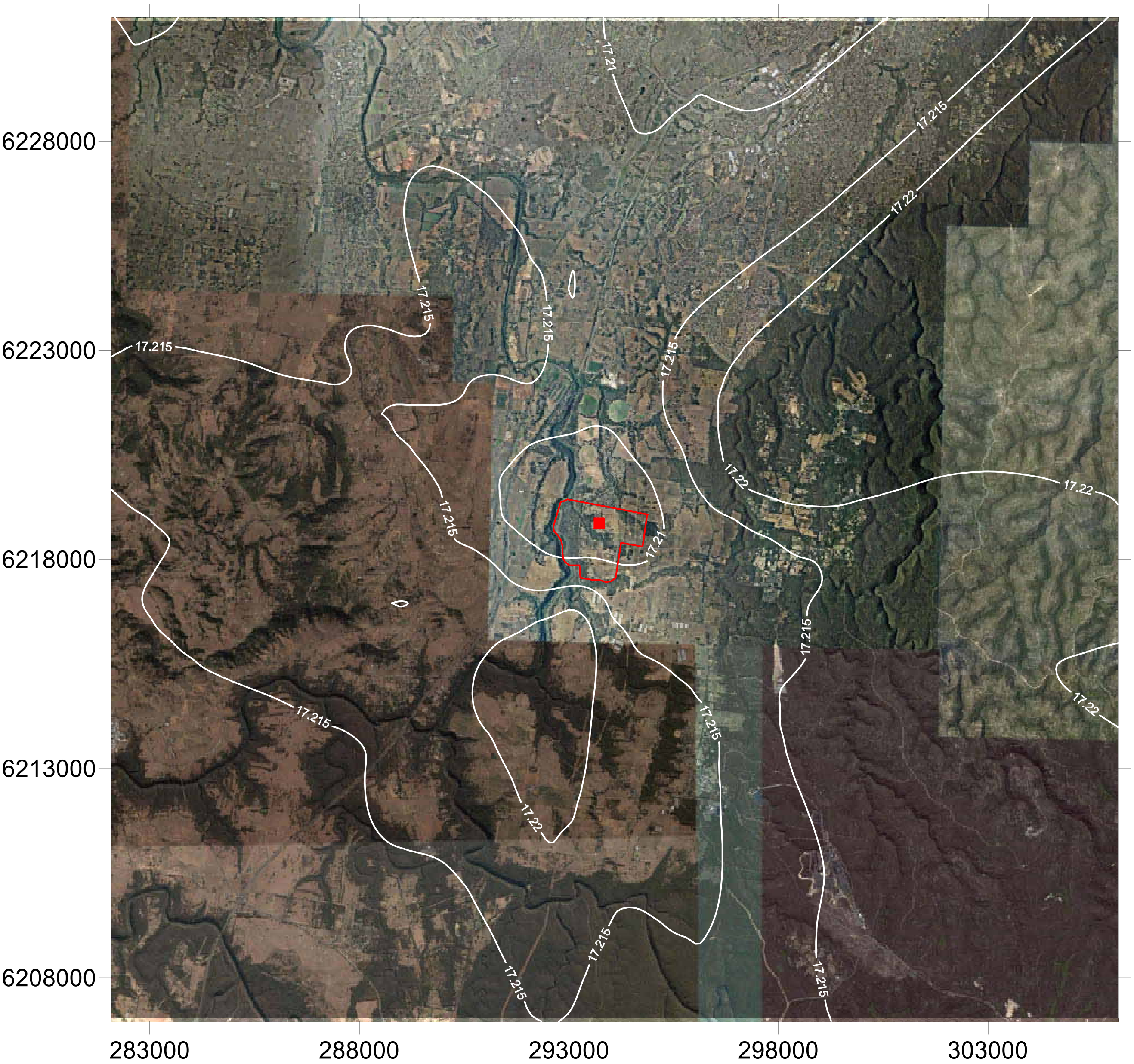

Annual Average
Contours in µg/m3
Background Level of 17.2 µg/m3

Site Boundary

Source: Google Earth 2008

Client: AGL LTD	Project: LEAFS GULLY - PROPOSED GAS TURBINE PLANT	Title: Operating, Particulate Matter PM_{10} Annual Average
URS	Drawn: RW; Approved: DRAFT; Date: June 2008; Job No: 43177401; File: 43177401 Figure 12.srf	Figure: A12; Rev: A; A4

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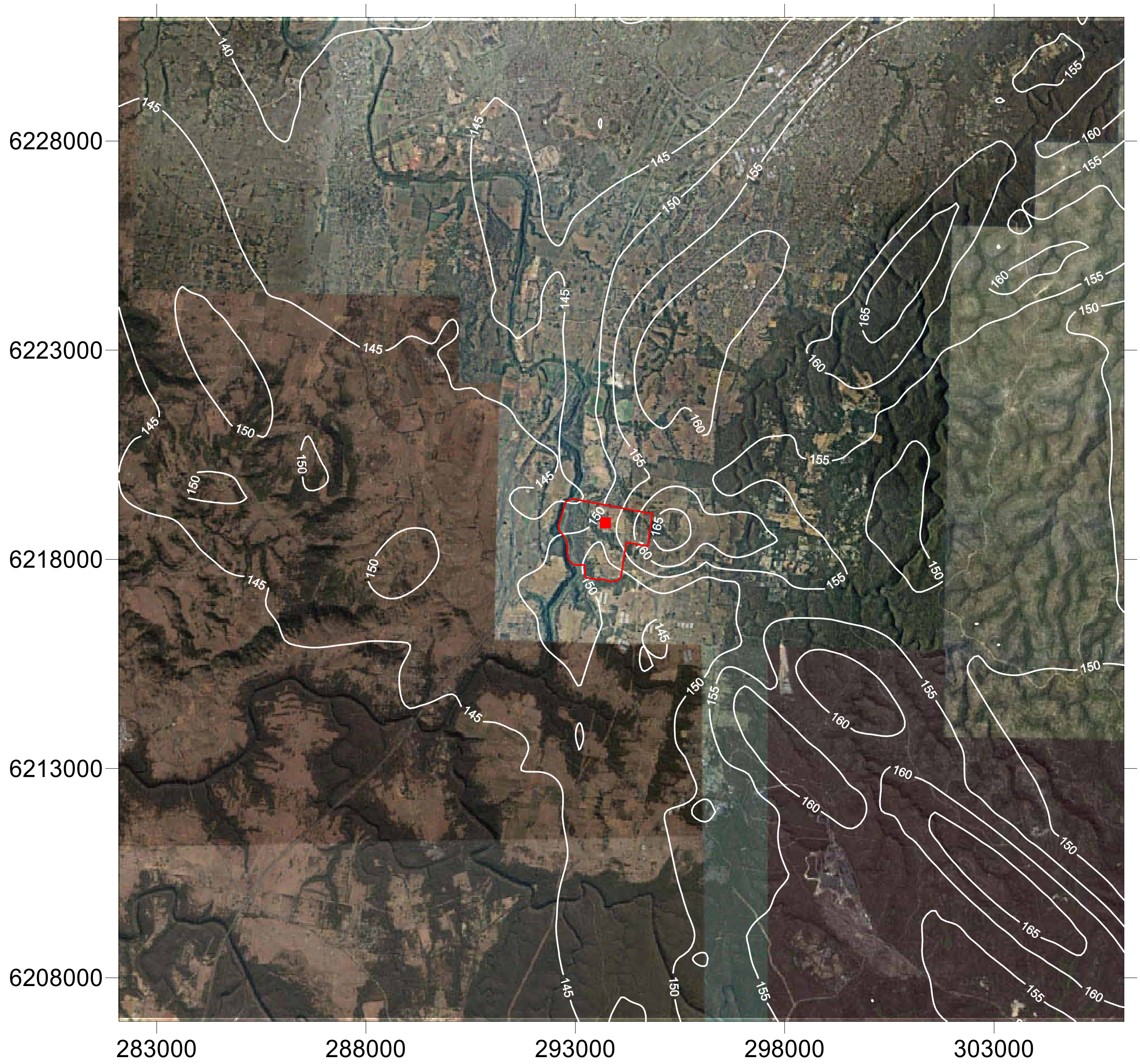

1 Hour maximum
Contours in µg/m3
Background Level of 134.7 µg/m3

Site Boundary

Source: Google Earth 2008

Client: AGL LTD	Project: LEAFS GULLY - PROPOSED GAS TURBINE PLANT	Title: Start Up, Nitrogen Oxides as NO_2 1 Hour Maximum
URS	Drawn: RW · Approved: DRAFT · Date: June 2008 · Job No: 43177401 · File: 43177401 Figure A13.srf	Figure: A13 · Rev: A · A4

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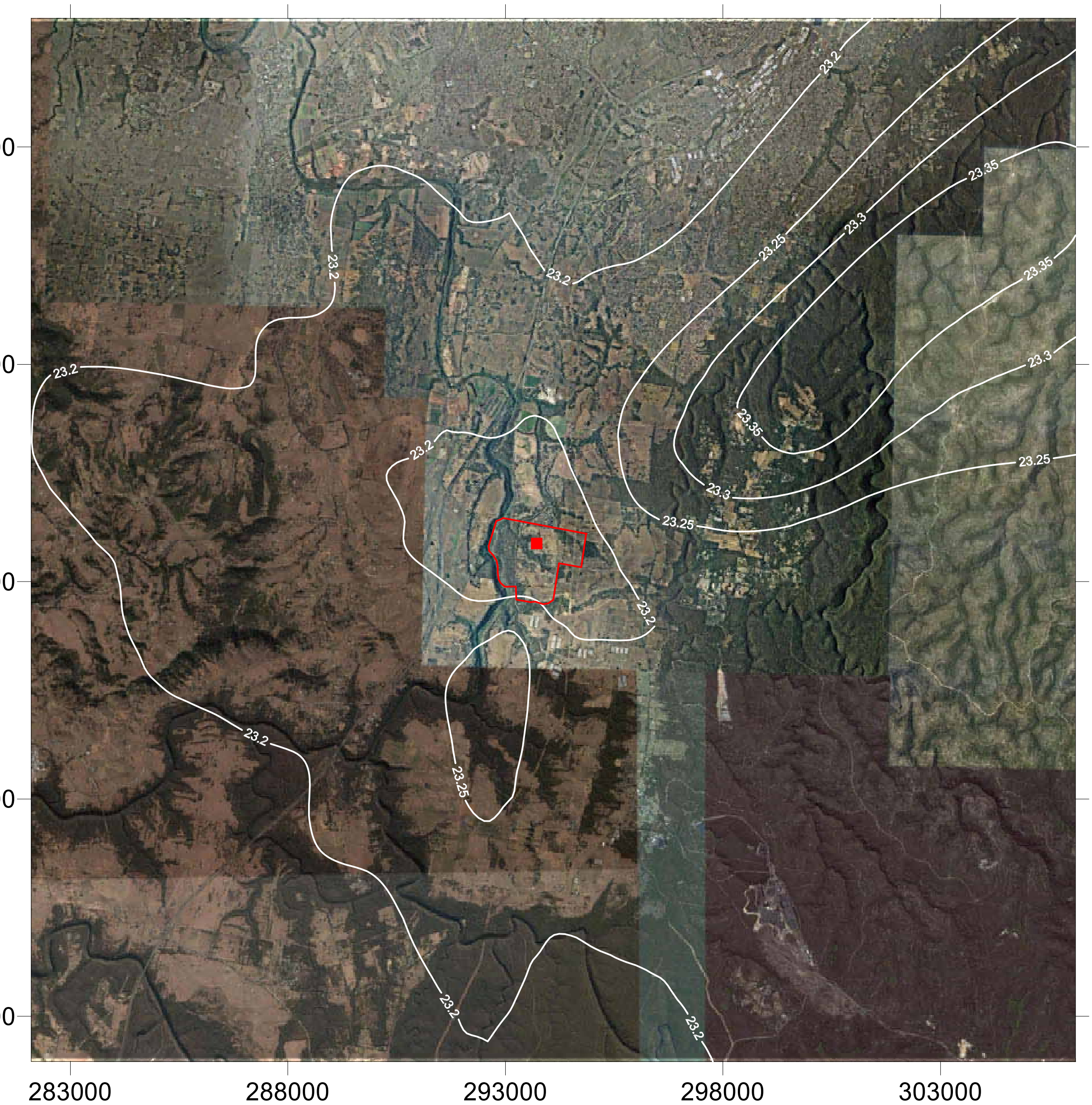

Annual Average
Contours in µg/m3
Background Level of 23.1 µg/m3

Site Boundary

Source: Google Earth 2008

Client: AGL LTD	Project: LEAFS GULLY - PROPOSED GAS TURBINE PLANT			Title: Start Up, Nitrogen Oxides as NO_2 Annual Average	
URS	Drawn: RW	Approved: DRAFT	Date: June 2008	Figure: A14	Rev: A
	Job No: 43177401	File: 43177401 Figure A14.srf			A4

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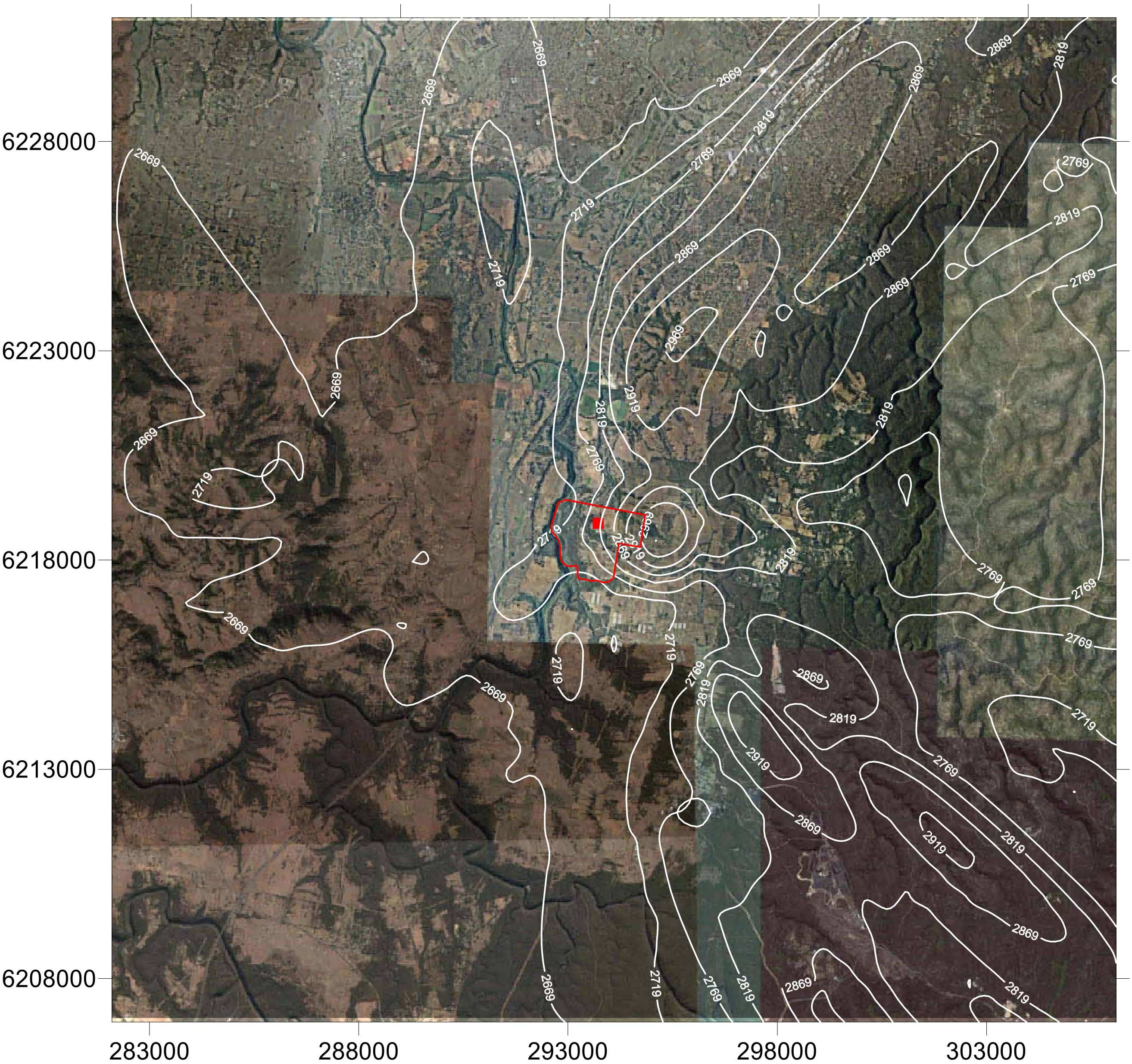

1 Hour Maximum
Contours in µg/m3
Background Level of 2580 µg/m3

Site Boundary

Source: Google Earth 2008

Client: AGL LTD	Project: LEAFS GULLY - PROPOSED GAS TURBINE PLANT	Title: Start Up, Carbon Monoxide CO 1 Hour Maximum
URS	Drawn: RW / Approved: DRAFT / Date: June 2008	Figure: A15 / Rev: A
	Job No: 43177401 / File: 43177401 Figure A15.srf	A4

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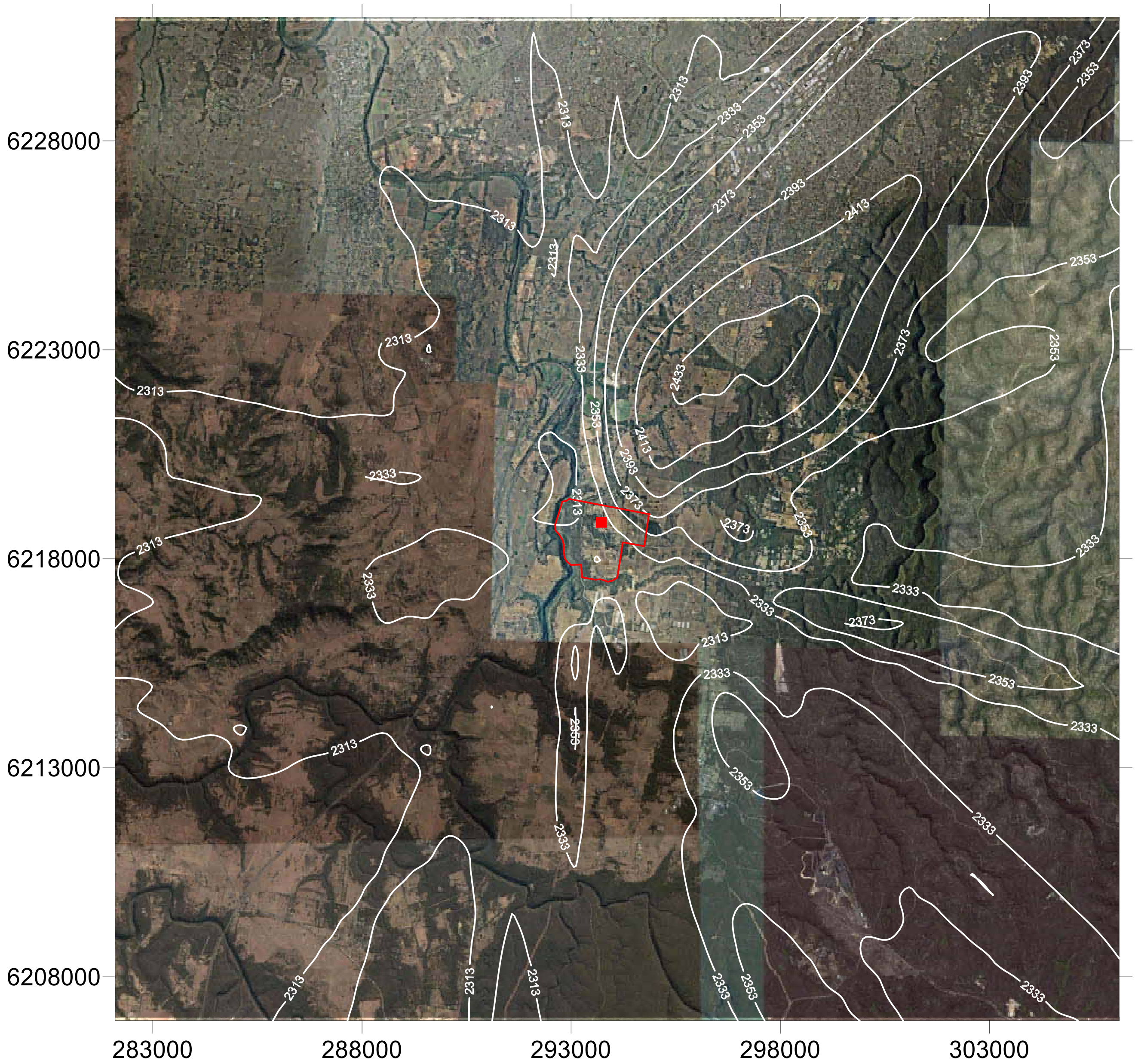

8 Hour Maximum
Contours in µg/m3
Background Level of 2280 µg/m3

Site Boundary

Source: Google Earth 2008

Client: **AGL LTD**	Project: **LEAFS GULLY - PROPOSED GAS TURBINE PLANT**	Title **Start Up, Carbon Monoxide CO 8 Hour Maximum**
URS	Drawn: RW / Approved: DRAFT / Date: June 2008 / Job No: **43177401** / File: 43177401 Figure A16.srf	Figure: A16 / Rev: A / A4

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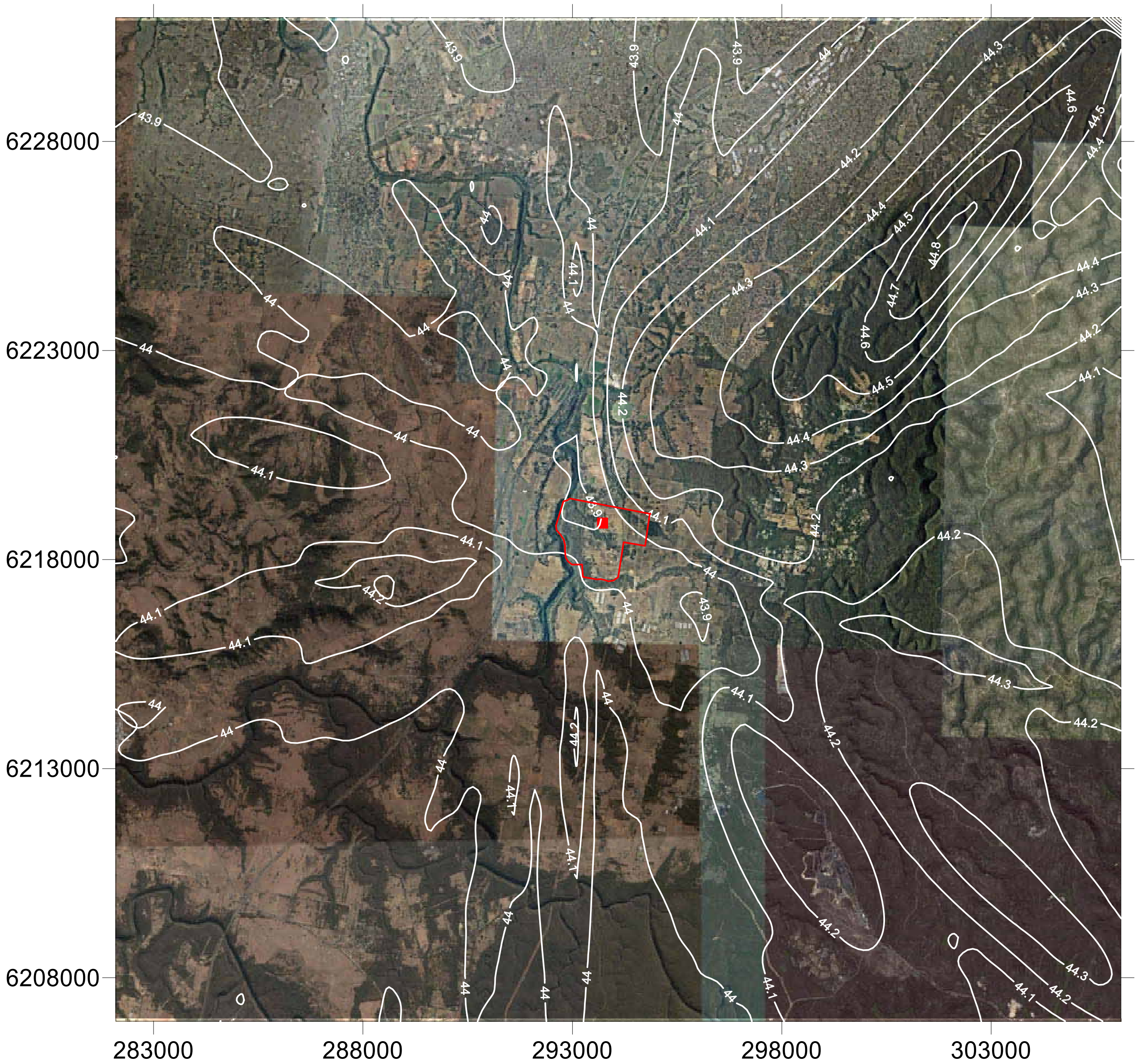

24 Hour Maximum
Contours in µg/m3
Background Level of 43.7 µg/m3

Site Boundary

Source: Google Earth 2008

Client: **AGL LTD**	Project: **LEAFS GULLY - PROPOSED GAS TURBINE PLANT**	Title **Start Up, Particulate Matter PM_{10} 24 Hour Maximum**
URS	Drawn: RW · Approved: DRAFT · Date: June 2008 · Job No: **43177401** · File: 43177401 Figure A17.srf	Figure: A17 · Rev: A · A4

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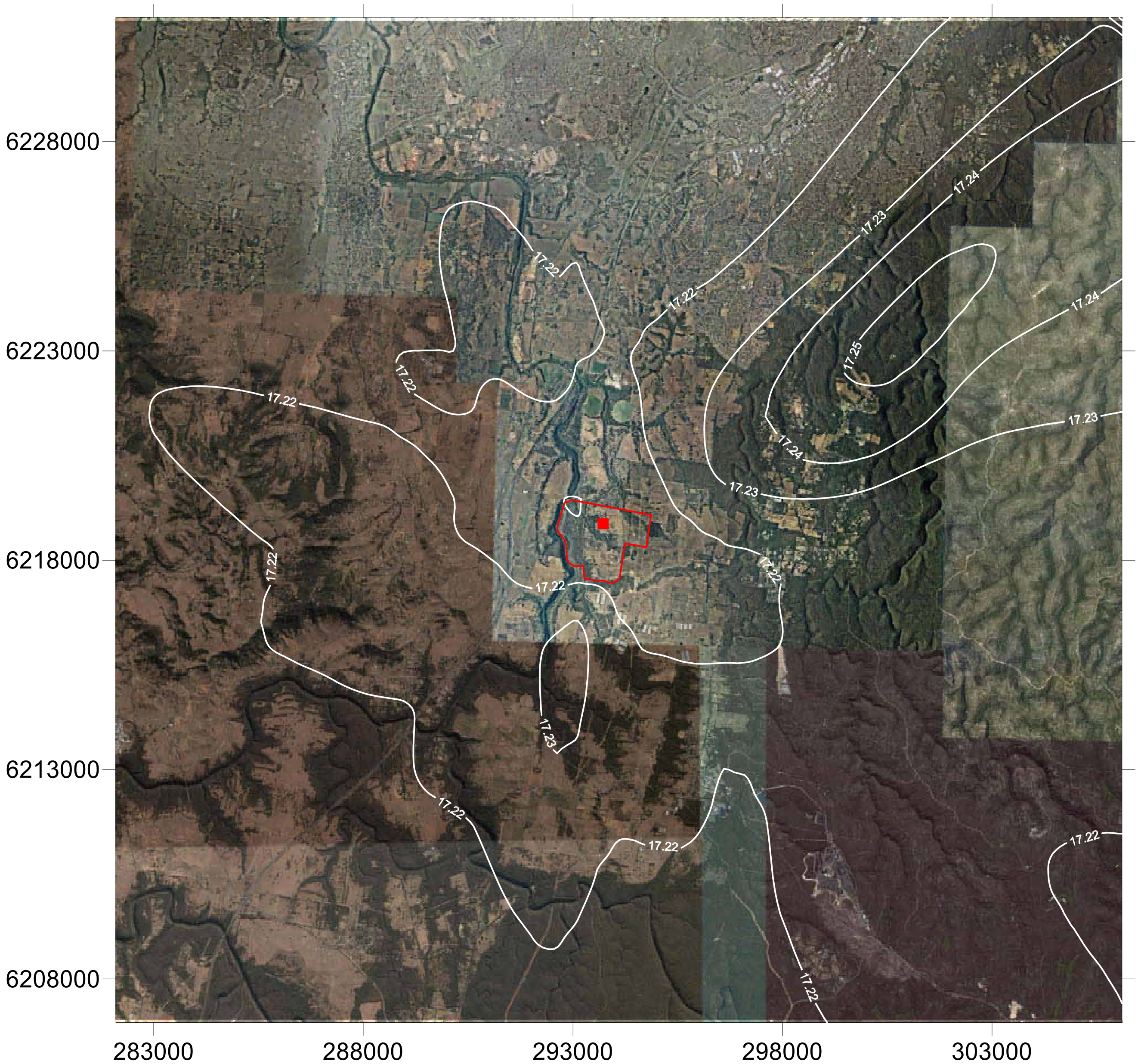

Annual Average
Contours in µg/m3
Background Level of 17.2 µg/m3

Site Boundary

Source: Google Earth 2008

Client: AGL LTD	Project: LEAFS GULLY - PROPOSED GAS TURBINE PLANT	Title: Start Up, Particulate Matter PM_{10} Annual Average
URS	Drawn: RW; Approved: DRAFT; Date: June 2008; Job No: 43177401; File: 43177401 Figure A18.srf	Figure: A18; Rev: A; A4

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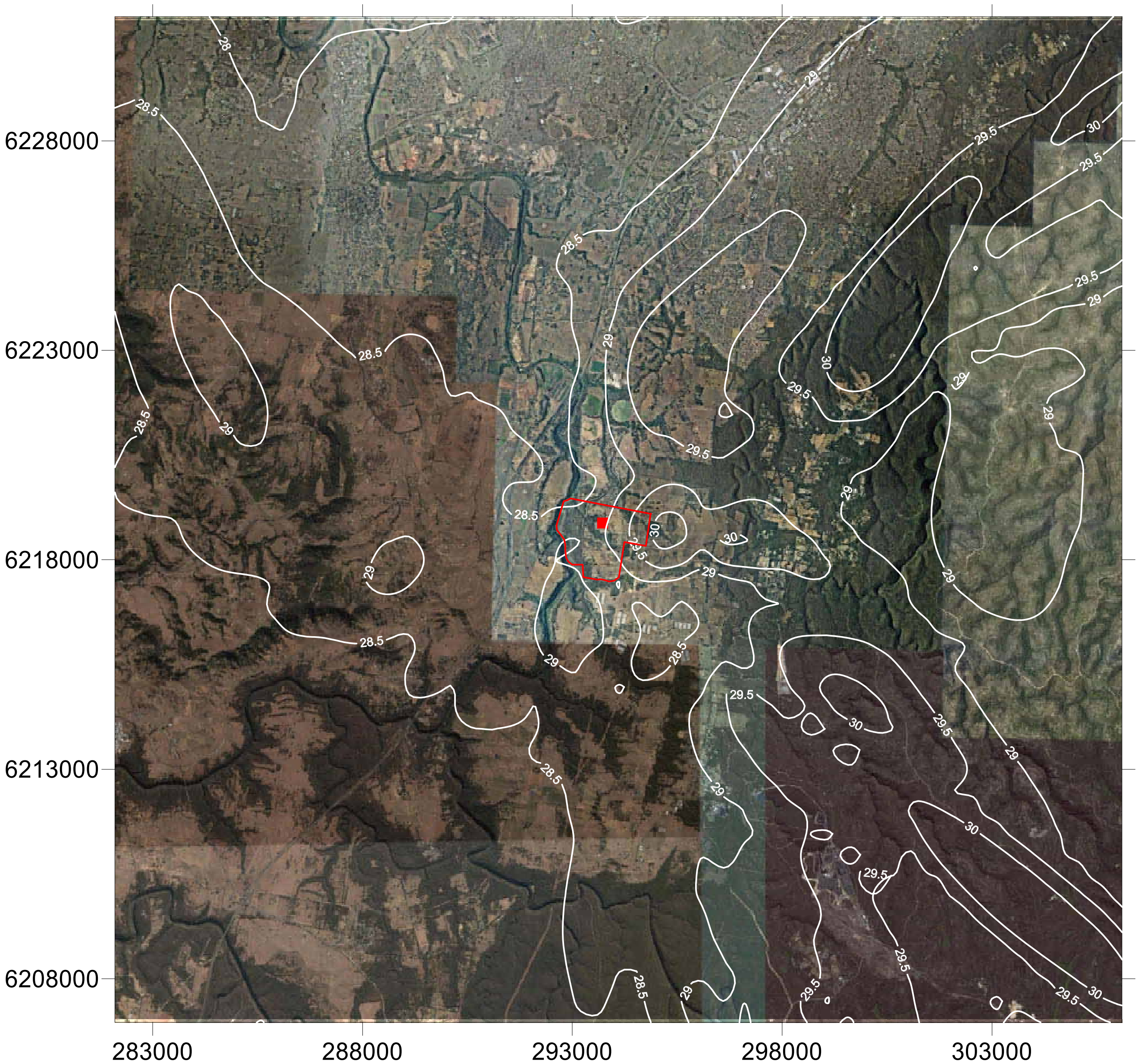

1 Hour Maximum
Contours in µg/m3
Background Level of 27.5 µg/m3

Site Boundary

Source: Google Earth 2008

Client: AGL LTD	Project: LEAFS GULLY - PROPOSED GAS TURBINE PLANT	Title: Start Up, Sulphur Dioxide SO_2 1 Hour Maximum
URS	Drawn: RW / Approved: DRAFT / Date: June 2008	Figure: A19
	Job No: 43177401 / File: 43177401 Figure A19.srf	Rev: A / A4

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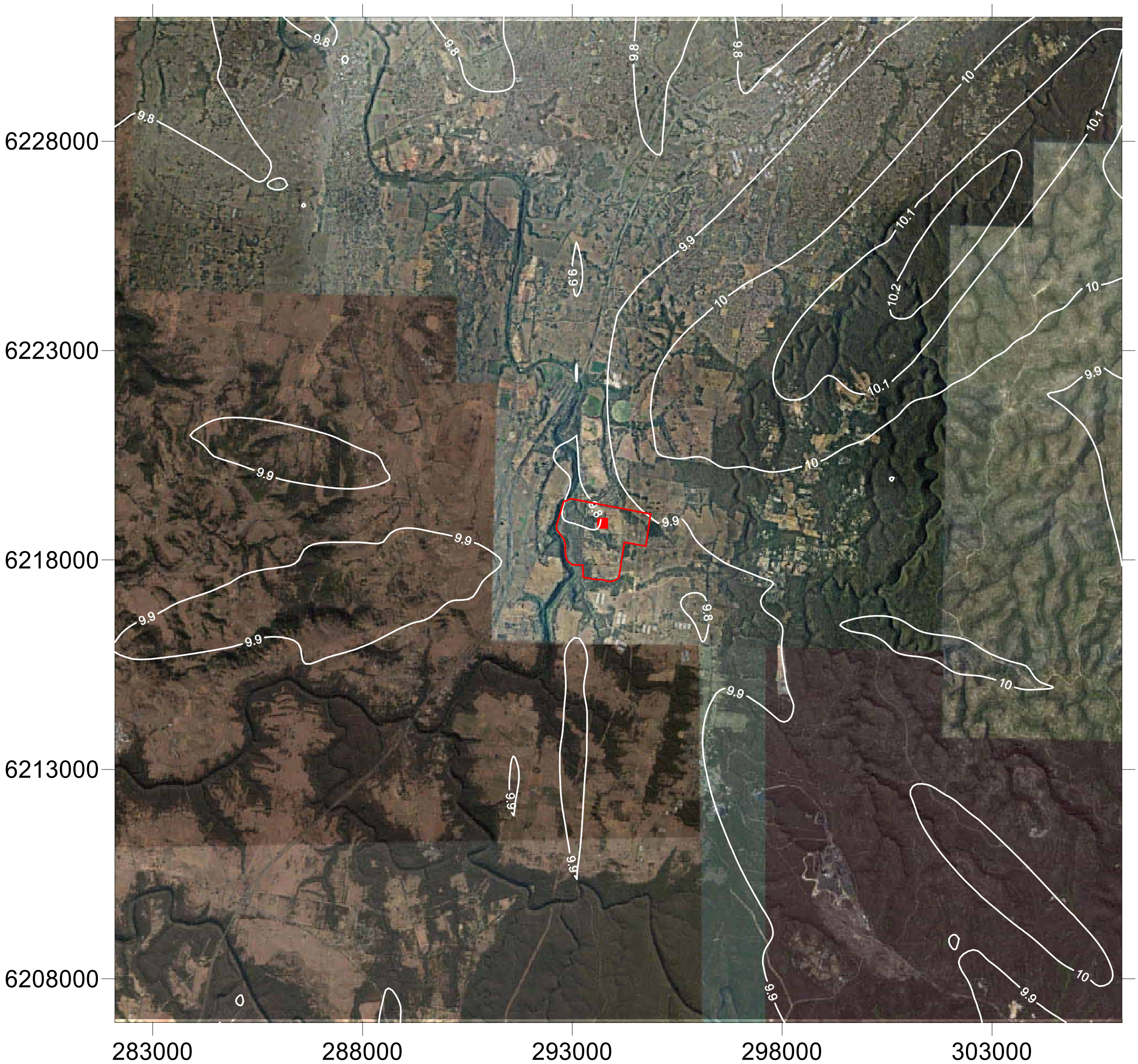

24 Hour Maximum
Contours in µg/m3
Background Level of 9.7 µg/m3

Site Boundary

Source: Google Earth 2008

Client: AGL LTD	Project: LEAFS GULLY - PROPOSED GAS TURBINE PLANT			Title: Start Up, Sulphur Dioxide SO_2 24 Hour Maximum	
URS	Drawn: RW	Approved: DRAFT	Date: June 2008	Figure: A20	Rev: A
	Job No: 43177401	File: 43177401 Figure A20.srf			A4

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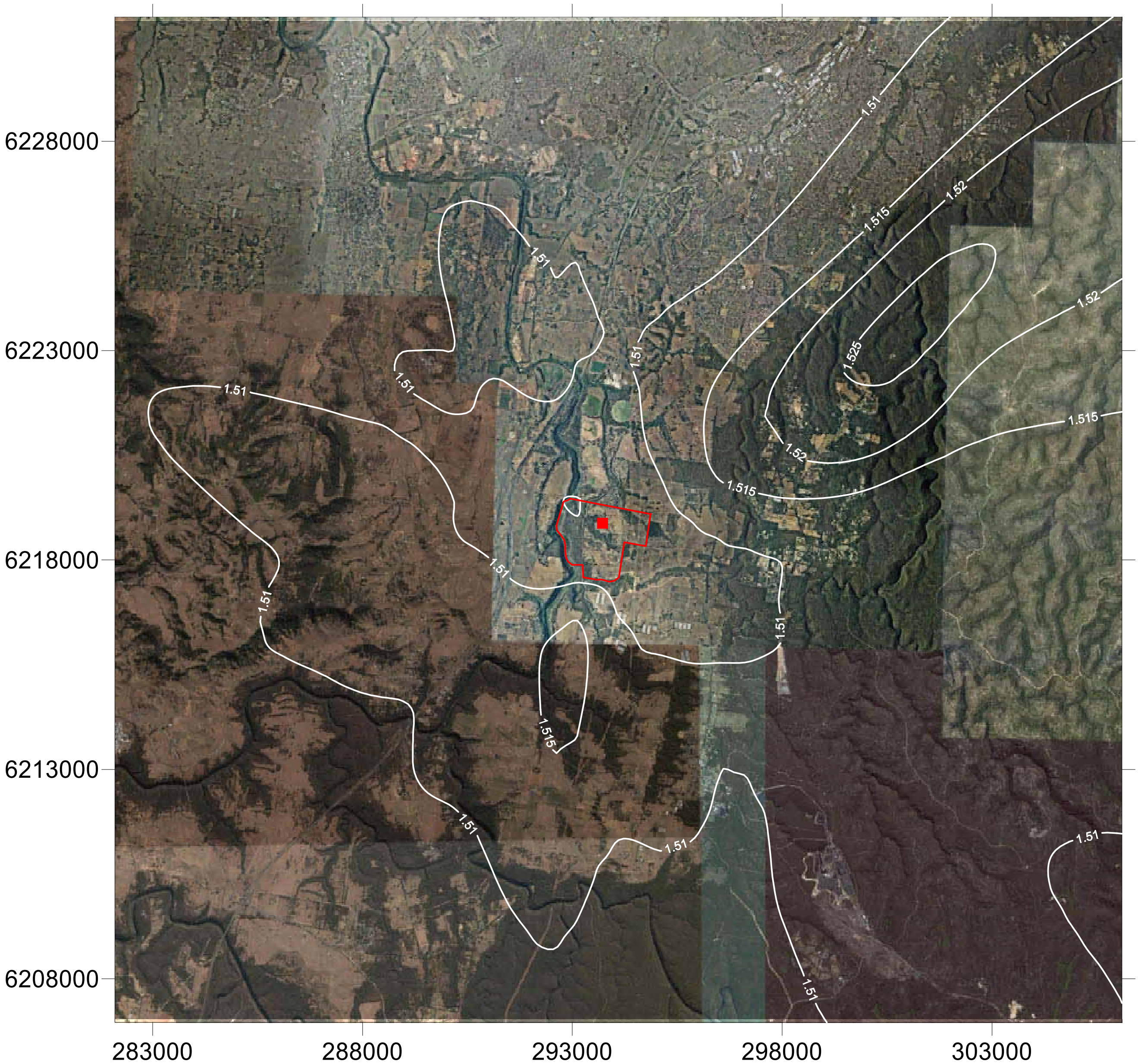


Annual Average
Contours in µg/m3
Background Level of 1.5 µg/m3

Site Boundary

Source: Google Earth 2008

Client: AGL LTD	Project: LEAFS GULLY - PROPOSED GAS TURBINE PLANT			Title: Start Up, Sulphur Dioxide SO_2 Annual Average	
URS	Drawn: RW	Approved: DRAFT	Date: June 2008	Figure: A21	Rev: A
	Job No: 43177401	File: 43177401 Figure A21.srf			A4

Appendix B
Aviation Safety - Plume Rise Assessment

F I N A L R E P O R T

Leafs Gully Power Station Plume Rise Assessment

Prepared for

AGL POWER GENERATION (NSW) P/L

72 Christie St, St Leonards, NSW 2065

28th October 2008

43177607

Project Manager:	Nicole Brewer Associate Environmental Engineer	URS Australia Pty Ltd Level 3, 116 Miller Street North Sydney, NSW 2060 Australia Tel: 61 2 8925 5500 Fax: 61 2 8925 5555
Project Director:	Ian McCardle Principal Environmental Scientist	
Author:	James Grieve Air Quality Engineer	Date: 28th October 2008 Reference: 43177607/Air Quality Status: Final

Contents

1.1 Background

URS Australia Pty Ltd was commissioned by AGL Power Generation P/L (AGL) to conduct a Plume Rise Assessment for their proposed Power Station at Leafs Gully, located approximately 10km south of Campbelltown, south-west of Sydney. It is proposed to build an open cycle gas turbine facility in the order of 300MW capacity, consisting of two turbine units. The facility is considered to be a peaking plant, in that it will typically operate for short periods in response to peak electricity demand.

Given the quantity, velocity and temperature of the exhaust gases emitted from the stacks, open cycle gas turbine plumes can travel at high velocities through the atmosphere.

The purpose of this report is to present the information required to perform an aviation hazard analysis based on the predicted impacts of the proposed facility. The statistics have been compiled in coordination with the Civil Aviation Safety Authority's (CASA) Advisory Circular *"Guidelines for Conducting Plume Rise Assessments"* (June, 2004). This involved use of the CSIRO's The Air Pollution Model (TAPM) model which was used to create site-specific meteorological data, including meteorology for the upper atmosphere. TAPM was also used to calculate plume rise trajectories for the turbine emissions.

1.2 Aviation Safety

CASA consider an exhaust plume with a vertical velocity component of greater than 4.3m/s to be a potential hazard to aircraft stability during approach, landing, take-off and for low level manoeuvring in general. At these stages of flight the stability of the aircraft is critical, especially in situations where visibility is extremely poor, such that potentially hazardous areas cannot be identified visually, and pilots are reliant on instruments for navigation.

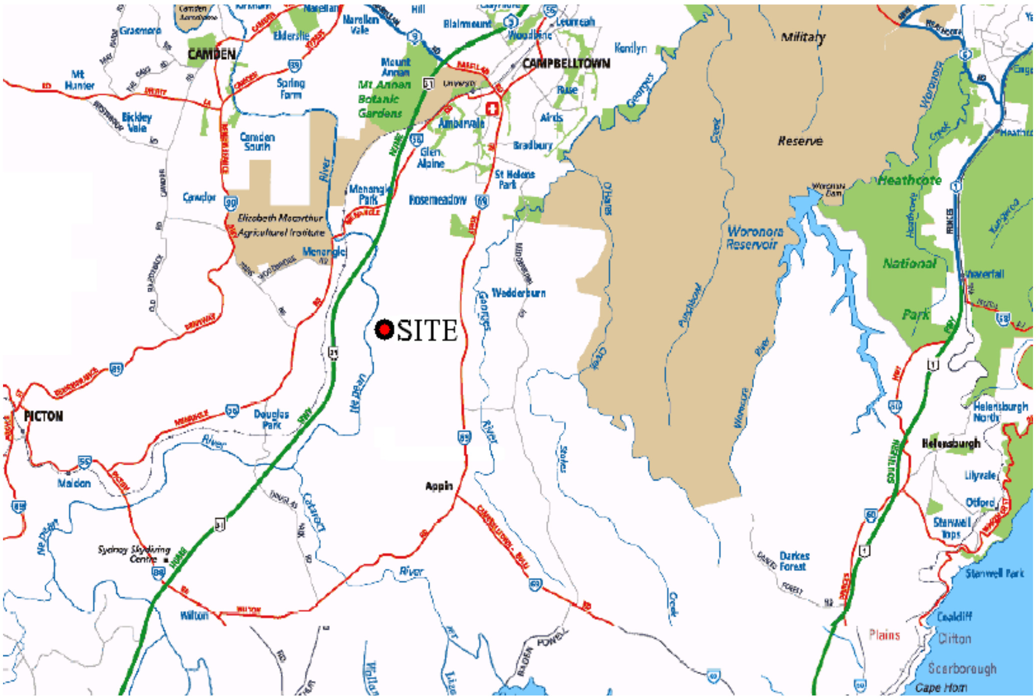
Such plumes also potentially create risks to the structure of the aircraft, where the transient nature of the plume velocity may have the potential to overstress the frame.

Therefore, industrial sources that may release exhaust plumes with a vertical velocity greater than 4.3m/s at the Obstacle Limitation Surface (OLS) of 110m, must undergo a hazard analysis, such that suitable measures can be taken to prevent the hazards described above.

2.1 Proposed Plant Location

The proposed site for the plant is at Leafs Gully as illustrated in **Figure 2.1**. The two stacks are located in a single line in a north-south direction with 40m spacing. **Table 2.1** presents the locations of the stacks.

Figure 2.1: Plant location



Map taken from Leafs Gully Power Station, Project Application (AGL, April, 2006)

Table 2.1: Stack locations

Stack	Latitude	Longitude	MGA 94 Coordinates	
1	150.762	-34.1505	293717 mE	6218896 mN
2	150.763	-34.1509	293719 mE	6218856 mN

2.2 Operating Scenarios

AGL are currently proposing the use of open cycle gas turbine power plant such as the Alstom GT13E2 (Alstom), GE Frame 9E type or similar gas turbine units for the Leafs Gully Power Project. The operating scenario in this assessment considers the two turbines running for every hour of the year at full operating temperature and at full load. Given the expected operating times of the plant (approximately 400 hours per annum in a normal year and likely to be operating at less than full load conditions), this represents a highly conservative scenario, whilst still remaining relevant to the needs of the aviation safety assessment, recognising that the plant may operated for extended periods during electricity supply shortages.

2.3 Stack Exit Parameters

In this report, analysis is conducted for the Alstom power plant with the turbines configured in an open cycle arrangement as proposed. This arrangement means exhaust gases exit the turbines with considerable amounts of energy, relative to the ambient air. Stack parameters are shown in **Table 2-2**. Flow rates are for a single turbine.

Table 2.2: Stack Exit Parameters

Parameter	(units)	Alstom GT13E2
Stack Height (above ground level)	(m)	35
Stack Diameter	(m)	6
Exit Temperature	(°C)	532
Exit Velocity	(m/s)	40
Mass Flow Rate (at full load)	(kg/s)	537

3.1 Modelling Methodology

The analysis performed in this report was conducted using TAPM. TAPM was used to generate site specific meteorology for the proposed plant. The model was also set to produce an output of the plume rise trajectory from the stacks. This output consists of vertical velocity, plume centreline elevation and radius of the plume. The plume elevation and radius are calculated from the plume's point of release, until it is vertically stable in the atmosphere. TAPM produces this output in intervals ranging from 1 to 5 seconds, for each source (stack), for every hour of the modelling period. This allows the elevation of the plume at the point at which it reaches 4.3m/s to be interpolated.

3.2 Model Setup

The configuration of TAPM used in this assessment was based on the guidelines included in Attachment A of the Advisory Circular *"Guidelines for Conducting Plume Rise Assessments"* (CASA –AC139-05(0) – June 2004). This is with the exception of the specified modelling period of 5 years. The year 2006 was used in this assessment.

- Grid centre coordinates 34^0-09 min latitude, 150^0 46 min longitude (294100mE, 6218959mN);
- Four nested grid domains (25 x 25): 30 km, 10 km, 3 km and 1 km;
- Assimilation of hourly meteorological data from the (DECC) Macarthur Ambient Monitoring Station
- Twenty-five vertical grid levels from 10 to 8000 m;
- AUSLIG 9 second DEM database;
- Eulerian Grid Dispersion was used for 10km and 3km nests, whilst Lagrangian Particle Mode was used for the inner most (1km) grid, with the 'gradual plume rise' option selected;
- Buoyancy enhancement from multiple stacks was calculated according to the method described in Manins *et al.* 1992.

3.3 Meteorological Data Assimilation

The TAPM generated wind fields were influenced by the DECC Macarthur Automatic Weather Station (AWS). The Macarthur data was used on a radius of influence of 15km, and configured to affect the lowest two levels of TAPM generated wind fields (9.8 and 24.8m). The Macarthur station is located 9km north of the Leafs Gully site (295405mE, 6227890mN).

3.4 Plume Merging

TAPM does not account for interaction between sources with regards to plume dynamics. Every source is treated separately, with its trajectory defined by its individual exit parameters and the surrounding meteorology. This is an inadequate representation for cases where, due to the presence of multiple stacks, the plumes merge and experience enhanced plume rise. Contact between plumes results in a reduction of the rate of entrainment of cooler static air, thus increasing the extent and rate of plume rise.

In this assessment, the 'Buoyancy Enhancement Factor' parameter in TAPM has been used in accordance with the methodology of Manins (1992) and Hurley (2005) to account for the additional plume rise due to the merging of the plumes. This methodology takes into account the number of stacks present, their separation, as well as the exit parameters of the exhaust gas, thus arriving at a parameter known as the Number of Effective Stacks for use as the Buoyancy Enhancement Factor in TAPM. In TAPM this factor is used to scale the initial condition for buoyancy flux of a single plume, thus increasing the magnitude of the plume velocity throughout its rise.

For two of the open cycle stacks considered in this assessment, under meteorological conditions favourable to plume rise, the rise of a single plume is such that the difference between Number of Effective Stacks and the number of stacks is considered negligible. This implies that under conditions favourable to plume rise the emitted buoyancy from the two stacks is wholly combined into the merged plume.

Hence a Buoyancy Enhancement Factor equal to the number of stacks (2) was used in this assessment. This is considered conservative under the majority of meteorological conditions, and appropriate for the conditions under which the greatest plume rise occurs.

3.5 Statistical Analysis

Plume rise statistics were developed using the TAPM gradual plume rise output in accompaniment with the upper air data derived from TAPM (at heights of 9.8 to1468 m above ground level). This data was processed to give the statistical representation of the plume's vertical and horizontal plume extent required for the assessment.

The height at which the plume velocity decreases to 4.3m/s was calculated through linear interpolation of the TAPM gradual plume rise output. This gives the critical vertical extent of the plume for each hour of the modelling period (i.e. the height at which the vertical velocity reaches 4.3m/s).

The critical horizontal plume extent was calculated using the TAPM gradual plume rise output, in conjunction with the TAPM generated upper air data. The plume is assumed to adopt the ambient horizontal wind velocity immediately (Hurley, 2005).

i.e. $$\frac{dx_p}{dt} = u$$

where x_p = horizontal plume velocity;
t = time
u = horizontal component of wind speed.

For each time step of the gradual plume rise file that is output from TAPM, the upper air data was linearly interpolated to give the horizontal wind speed at that point. The horizontal translation of the plume during this time step was calculated as a product of the interpolated wind speed, and the length of the time step. These were summed for each time step until the critical vertical velocity of 4.3m/s was reached. The plume radius (R_y) at this height was then added to the total to give the horizontal distance from the source to the extremity of the plume boundary, at the point at which a vertical velocity of 4.3 m/s was reached (i.e. critical horizontal extent).

Statistics for wind speed at specific elevations were calculated through linear interpolation of the upper air data, which was given at 15 heights (between 9.8, 24.5, 48.9, 97.9, 146.8, 195.8, 244.7, 293.6, 391.5, 489.4, 587.3, 734.1, 978.8, 1223.5 and 1468.2 m). These results were then manipulated to give the various statistical representations required for the hazard assessment.

4.1 Local Meteorology

As displayed in **Figures 4.1** through **4.3**, TAPM analysis of the local meteorology shows winds in the south to west-south-west direction to be dominant, with calm winds (<0.5m/s) occurring for 1.54% of the year. This is consistent with observations in the area, with the Jacks Gully (9km North of the site) and Macarthur weather stations both featuring dominant southerly winds, whilst recording 1.53% and 2.65% calms for the year 2006 respectively.

The greater the wind speed, the greater the rate at which the vertical plume velocity depreciates. Thus directionality of wind is not considered to be of importance in this assessment, where for higher wind speeds (during which translation of the plume centreline occurs more rapidly), the diminished vertical extent of the plume reduces the critical vertical extent significantly compared to that predicted under light or calm winds.

Figure 4.1 – TAPM generated Wind Rose for Leafs Gully 2006, all hours, 10 m elevation

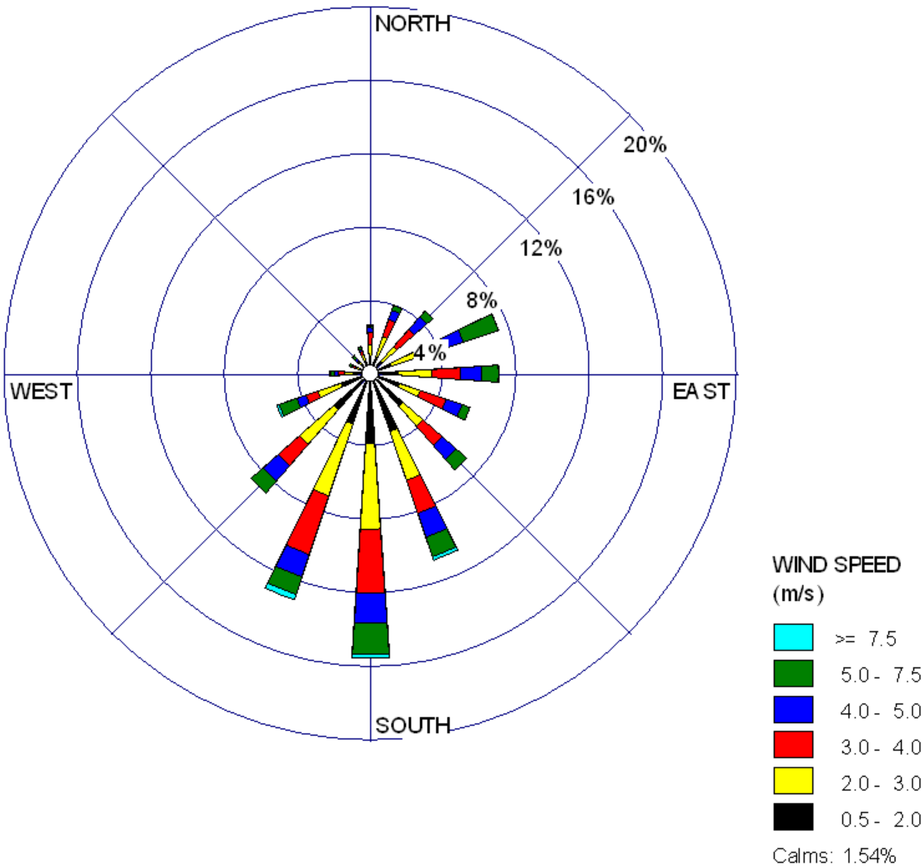


Figure 4.2: TAPM generated Probability Density and Cumulative Probability for Wind Speed at 10m at Leafs Gully 2006

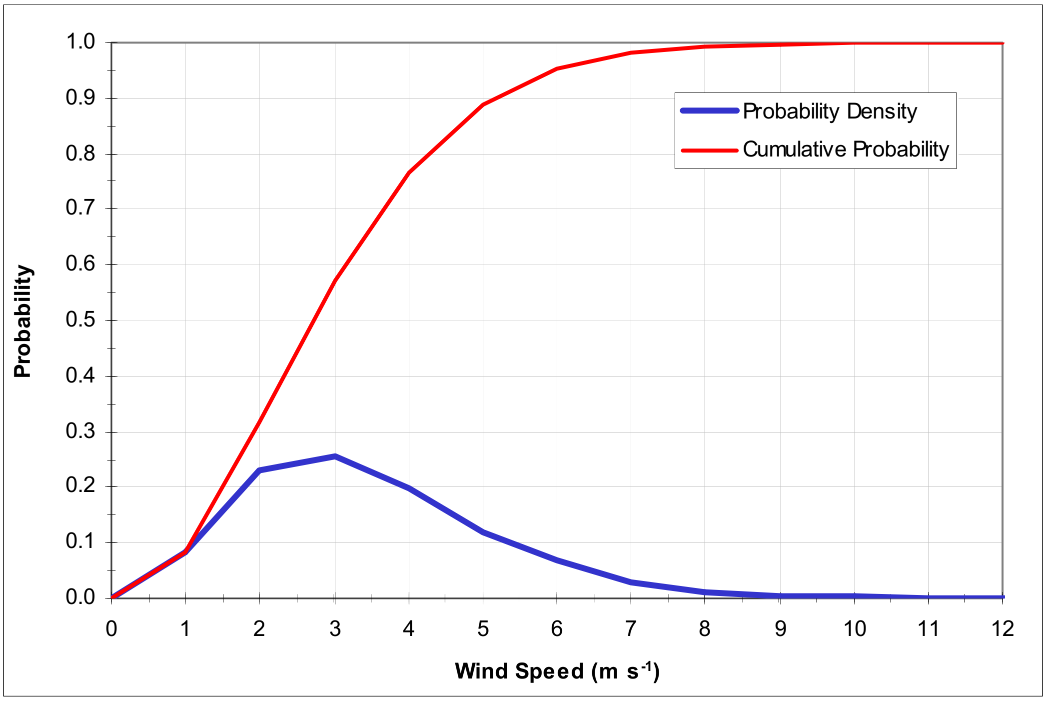


Figure 4.3: TAPM generated probability density function for Wind Direction at 10m at Leafs Gully 2006

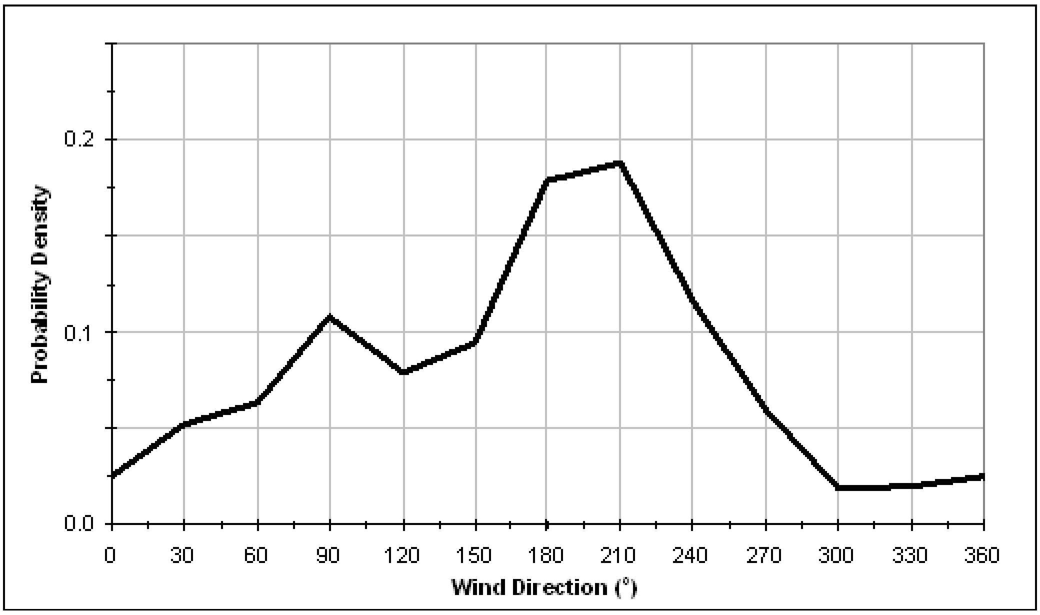


Figure 4.4: TAPM Upper Air Wind Speed Relative Cumulative Frequency

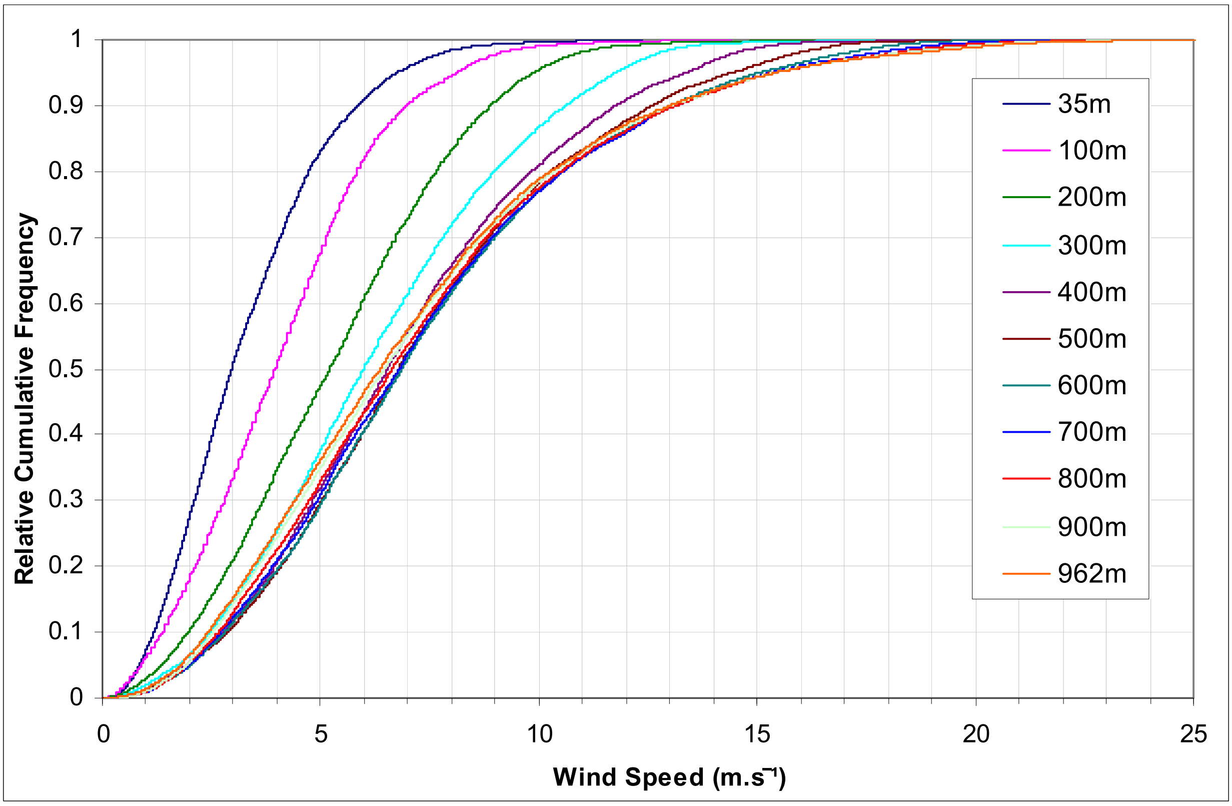


Figure 4.4 shows the relative cumulative frequency for wind speeds at various elevations. This represents the probability (at various elevations) of experiencing a wind speed less than or equal to a given value, based on the TAPM results for 2006. For example, at 200m elevation, there is approximately 60% probability that the wind speed for a given hour is less than or equal to 6m/s. The decreasing probability of low wind speeds with increasing elevation is indicated by rightward trend for increasing elevations.

Table 4.1: TAPM Upper Air Wind Speeds by percentage

Elevation	35m	100m	200m	300m	400m	500m	600m	700m	800m	900m	962m
Wind Speed	Upper Air Wind Speeds (%)										
<=0.1m/s	0.02	0.02	0.01	0.01	0.01	0.02	0.01	0.00	0.00	0.00	0.02
<=0.2m/s	0.16	0.22	0.13	0.07	0.05	0.05	0.03	0.02	0.00	0.01	0.03
<=0.3m/s	0.29	0.48	0.33	0.17	0.13	0.09	0.07	0.06	0.02	0.01	0.08
<=0.4m/s	0.72	1.06	0.48	0.24	0.19	0.16	0.16	0.08	0.07	0.05	0.19
<=0.5m/s	1.30	1.61	0.70	0.42	0.29	0.26	0.26	0.14	0.11	0.07	0.32
<=1.0m/s	7.19	6.04	2.93	1.93	1.38	1.13	0.98	0.94	0.98	1.08	1.35
<=1.5m/s	16.15	11.45	5.97	4.04	3.33	2.76	2.77	2.85	2.76	2.92	3.54
<=3.0m/s	50.79	33.40	20.81	14.70	11.72	10.86	11.45	12.23	12.99	14.30	15.22
<=5.0m/s	83.01	67.30	47.25	37.44	31.79	29.51	29.26	30.79	32.92	34.93	36.24

4.2 Plume Rise Statistics

The modelling results show that as expected for a large open cycle gas turbine facility, the Alstom plant will produce exhaust plumes with vertical velocities that exceed 4.3m/s above the OLS for a significant proportion of the year (based on the plant running at full load all hours of the year).

Table 4.2 displays the maximum, minimum and average critical plume extent for the turbine type considered. The critical vertical plume extent is the height (for a given hour modelled) at and below which, the vertical velocity (*w*) of the plume exceeds 4.3m/s. The maximum critical vertical plume extent was 962m, which occurred during calm conditions, with a neutral atmospheric profile, where low wind speeds resulted in minimal entrainment of cooler ambient air into the plume. These conditions allowed the plumes to conserve their buoyancy to a greater degree, causing them to rise at a greater velocity, and to a greater extent.

The critical horizontal plume extent is the total downwind translation of the outer plume boundary at the point at which the vertical velocity decreases to 4.3m/s. The maximum critical horizontal plume extent of 316m occurs at a height of approximately 760m (see outermost contour of **Figure 4.6** for detail of variation of maximum critical horizontal plume extent with altitude).

Table 4.2: Alstom GT13E2 Maximum, Minimum and Average Critical Plume Extents

Alstom GT13E2	Critical Vertical Plume Extent (m)	Critical Horizontal Plume Extent (m)
Maximum	962	316
Minimum	60	59
Average	172	125

Table 4.3 shows the critical vertical plume extent by percentage of time, for the year 2006. The result of 864m for 0.05% indicates that for 1 in every 2000 hours, the plume velocity exceeds 4.3m/s at a height greater than or equal to 864m. The OLS of 110 m is achieved for approximately 80% of the year, assuming that the power station operates full time and under all possible meteorological conditions.

Table 4.3: Heights at which the vertical velocity exceeds 4.3m/s by percentage of time

Percentage of time, 2006 (%)	Height below which *w* >4.3m/s (m)
100	60
90	92
80	106
70	117
60	129
50	143
40	162
30	188
20	226
10	283
9	290
8	299
7	309
6	322
5	335
4	357
3	393
2	437
1	550
0.5	635
0.3	691
0.2	718
0.1	776
0.05	864

Figure 4.5 is another representation of the data contained in **Table 4.4** and provides the critical vertical plume extent by percentile. For example, this figure indicates that for approximately 70% of the time, the vertical velocity of the plume decreases to 4.3m/s at or below 200m elevation.

Figure 4.5: Critical vertical plume extent by percentile

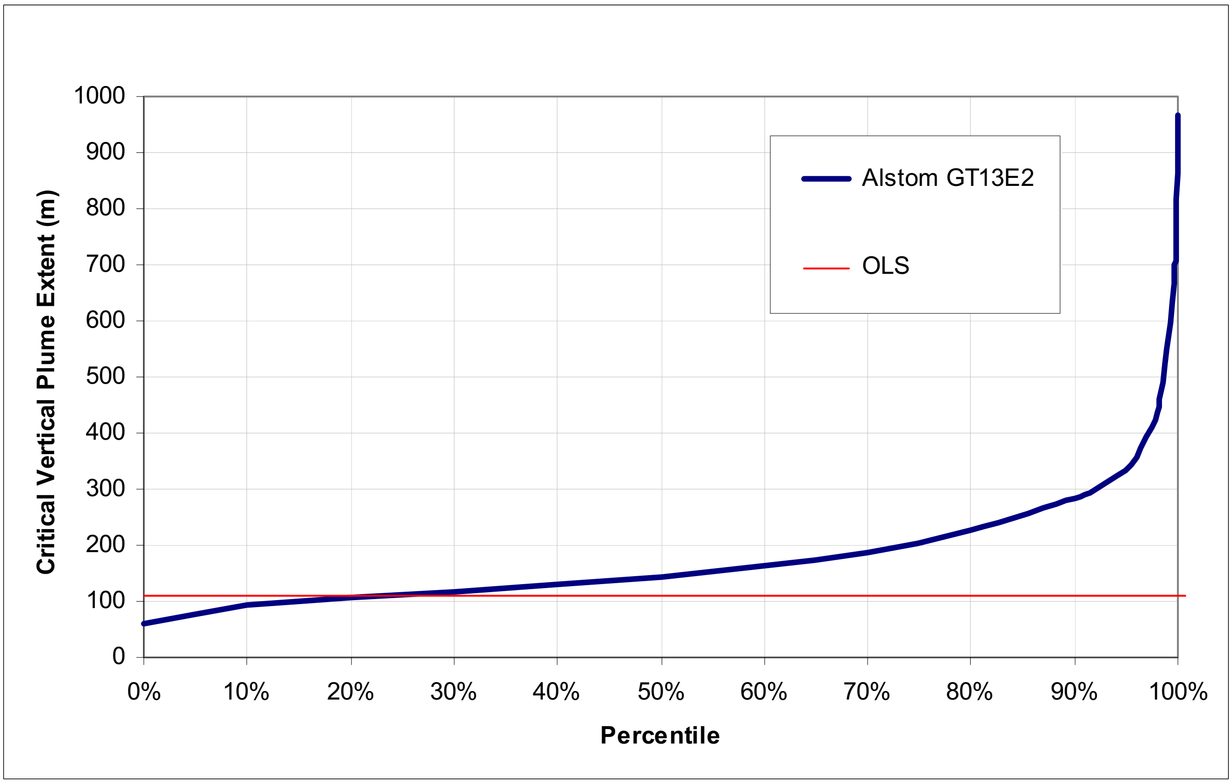
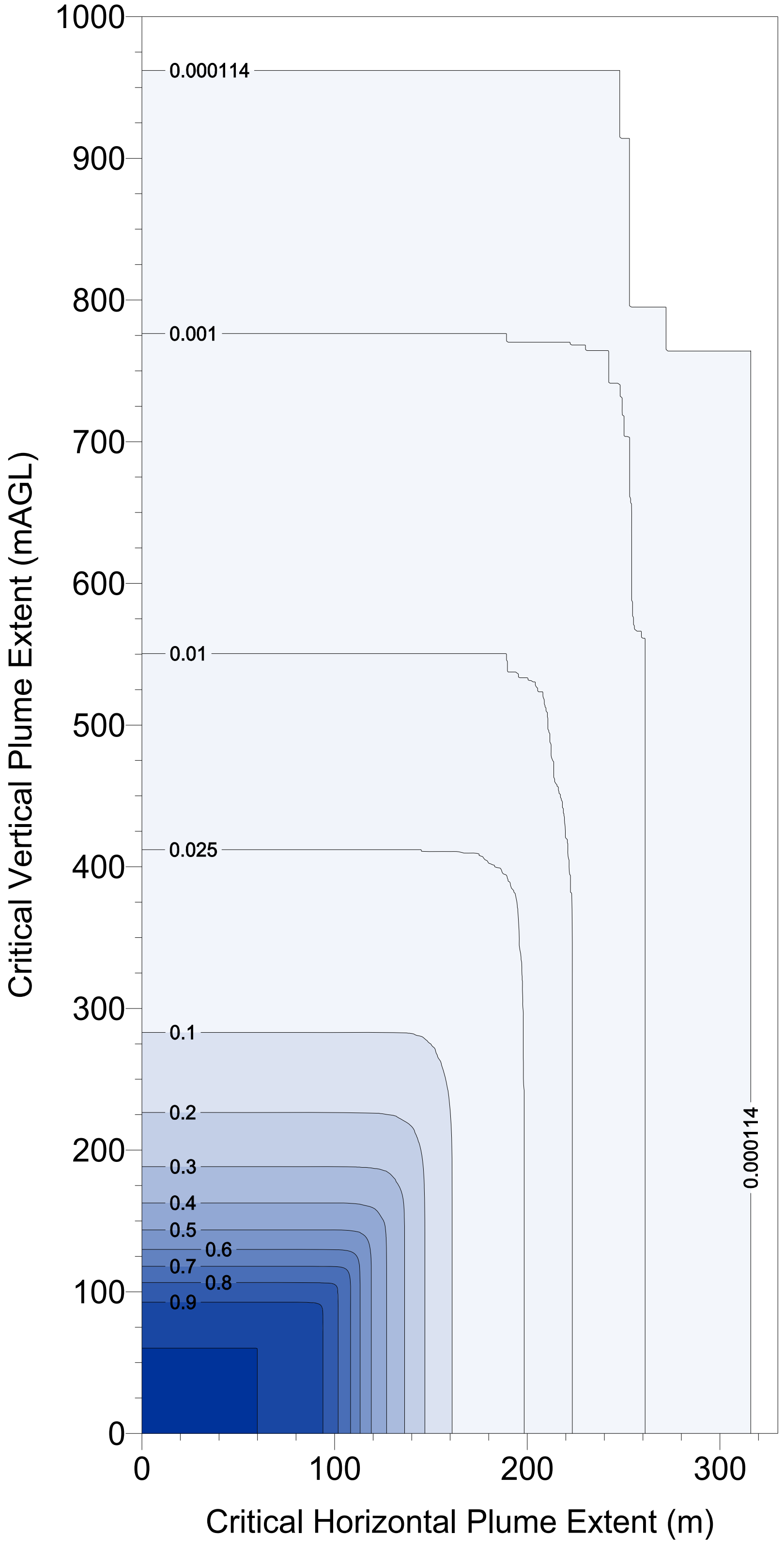


Figure 4.6 contains contour plots of the probability density of the horizontal and vertical plume extents, thus illustrating the regions of space for which the plume velocity exceeds 4.3m/s by fraction of the year 2006. For example, for the contour level 0.01 (1% of the time, or 87 hours per year), the maximum critical vertical plume extent is 550m and the corresponding total horizontal extent is around 220 m. It should be noted that the contour of 0.00011384 is representative of the worst hour (1/8784 = 0.00011384) and thus indicates entire region of space at which the vertical velocity was greater than 4.3m/s for any instance during the year of 2006. The contour level of 0.8 indicates that the critical vertical velocity is achieved at the OLS of 110m for around 80% of the year.

Figure 4.6: Alstom GT13E2 - Probability density plot representing the region of space for which the plume velocity exceeds the critical velocity of 4.3m/s.



The proposed Leafs Gully Station has been assessed for its impact on aviation safety. As operational times for peaking plants cannot be predicted, the assessment was performed on the basis that the plant would be operating continuously at full load (i.e. 2 turbines operating at full capacity). The actual operation of the plant is expected to occur for approximately 400 hours per annum.

Based on the TAPM predictions for the year 2006, the OLS is exceeded during approximately 80% of the year, with an average vertical velocity of 4.3 m/s at 172m above ground level for the modelling scenario considered. Whilst this assessment is considered conservative with respect to the modelled operating times and operating conditions, consideration should be given for the plant to be designated a hazard to aircraft operators in the area.

Hurley, Peter J, *The Air Pollution Model (TAPM) Version 3: Technical Description*, CSIRO 2005

Manins, P C, *Plume Rise from Multiple stacks*, Clean Air (Australia) May 1992 Vol 26 Part2 pp 65-68

CASA 2004 *Advisory Circular AC 139-05(0) Guidelines for conducting Plume Rise Assessments*, June 2004,

Website document: *Leafs Gully Power Station Project Application (AGL, April,2006)*

http://www.planning.nsw.gov.au/asp/pdf/06_0117_leafs_gully_preliminary_env_assessment.pdf (accessed 20/06/06)

Appendix C
Greenhouse Gas Assessment

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Greenhouse gases are naturally occurring gases in the earth's atmosphere that absorb and radiate infrared radiation (heat) reflected from the earth's surface. The most abundant of these gases are carbon dioxide (CO_2) and water (H_2O). Other naturally occurring greenhouse gases such as methane (CH_4) and nitrous oxide (N_2O) are present in much smaller amounts in the atmosphere. Naturally occurring greenhouse gases raise the Earth's global average temperature to approximately 15°C, approximately 33°C higher than without their presence.

The less abundant greenhouse gases (eg CH_4 and N_2O) are much more efficient in trapping infrared radiation than CO_2. The measure of how "efficient" a greenhouse gas in trapping infrared radiation is called the Global Warming Potential, defined as the ratio of infrared radiation trapped by one kilogram of non-CO_2 greenhouse gas compared to one kilogram of CO_2, over a defined time frame. For example, over a 100 year time-frame, methane traps approximately 21 times as much infrared radiation from the earth as CO_2 and nitrous oxide approximately 310 times as much infrared radiation as CO_2[1]. When compiling greenhouse gas inventories, this difference in Global Warming Potential is accounted for by converting one tonne of non-CO_2 greenhouse gas into a CO_2 equivalent (CO_2-e) amount using the Global Warming Potential for that particular non-CO_2 gas.

Since greenhouse gases efficiently trap infrared radiation, scientists have suggested that there is a causal link between the rapid increases in the concentrations of greenhouse gases and the possibility of increased global temperatures. The best available scientific evidence suggests that the global average temperature has increased by approximately 0.76±0.19°C in the period 1850-1899 to 2001-2005[2]. Because of this apparent link to climate change, the accounting and management of greenhouse gases is seen as an important issue by some governments and industrial companies. Furthermore, efficiencies in greenhouse gas emissions are often related to efficiencies in energy consumption.

This assessment has included a quantitative model of the tonnages of each greenhouse gas produced expressed as a percentage of the total national greenhouse gases produced per year over the life of the project.

C1.1 AGL and Greenhouse Gas Emissions

AGL has an extensive greenhouse gas policy and company-wide commitment to reduction of greenhouse gas emissions from its operations. AGL believes that it is their responsibility to:

- set clear policies on environmental issues;

[1] Department of Climate Change, *National Greenhouse Accounts Factors*, , January 2008, Australian Government

[2] IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

- ensure AGL’s business operations are environmentally efficient;
- support government initiatives to reduce greenhouse gas emissions;
- comply with greenhouse gas emission legislation;
- provide customers with products and services choice that contribute to greenhouse gas reduction; and
- support and develop projects that directly reduce greenhouse gas emissions.

The main sources of greenhouse gas emissions along AGL’s energy supply chain to customers are from electricity generation, natural gas production or the combustion of natural gas by customers. Most of the emissions that result directly from AGL operations come from natural gas leakage from low-pressure distribution networks (about 0.4 Mt CO_2-e per annum).

AGL’s Greenhouse Gas Policy outlines AGL's commitment to sustainability, AGL will[3]:

- at a minimum, meet all statutory requirements relating to reducing greenhouse gas emissions;
- quantify and publish the greenhouse gas impacts of AGL’s investments, operations and supply chain;
- seek to reduce the greenhouse gas intensity of energy across the supply chain by:
  - expanding investments in low emission and renewable generation, and through the development and commercialisation of technologies that assist in reducing greenhouse gas emissions;
  - helping customers to reduce greenhouse gas emissions by providing practical and accurate information on energy use and offering and promoting green energy;
- encourage employees to develop a fuller understanding of climate change and ways to reduce greenhouse gas emissions, by providing training opportunities;
- improve the greenhouse gas efficiency of AGL’s operations, and those in which AGL have an influence; and
- work with customers, shareholders, governments and the community to progress policy options and initiatives to reduce greenhouse gas emissions.

These objectives are supported by actions that are currently being undertaken by AGL. Further discussion of these is covered in **Section C1.4**.

[3] AGL Greenhouse Gas Policy
http://www.agl.com.au/AGLNew/About+AGL/Environment/Greenhouse+gases/default.htm

Appendix C
Greenhouse Gas Assessment

C1.1.1 Greenhouse Gas Policy Issues

Global and national greenhouse gas policy is complex and despite the Kyoto protocol coming into force in 2005, remains uncertain. This section briefly summarises the policy issues.

International Policy

The Kyoto Protocol to the United Nations Framework Convention on Climate Change was signed in 1997 and entered into force in 2005. Its aim is to limit greenhouse gas emissions by countries by setting mandatory greenhouse gas emission targets relative to a country's 1990 greenhouse gas emissions. It sets out three "flexibility mechanisms" to allow greenhouse gas targets to be met:

1. The Clean Development Mechanism.
2. Joint Implementation.
3. International emissions trading.

The definitions of the three mechanisms above are complex but effectively they allow greenhouse gas reductions to be made at the point where the marginal cost of that reduction is lowest. Essentially, an industrialised country sponsoring a greenhouse gas reduction project in a developing country can claim that reduction towards its Kyoto Protocol target and those greenhouse gas reductions can be traded.

Australian Policy

The Australian climate change program is managed by the Commonwealth Department of Environment and Heritage. Key features of the Australian climate change policy are:

- compiling and validating the National Greenhouse Gas Inventory;
- delivery of the voluntary based Greenhouse Challenge Plus program, a vehicle for companies to report their greenhouse gas emissions annually; and
- guiding a range of energy efficiency initiatives.

More recently the introduction of the National Greenhouse and Energy Reporting Act 2007, to take effect 1st July 2008, and associated regulations, means that specific industries will require reporting their greenhouse gas emissions based on methods published by the Department of Climate Change (and utilised within this report). The reporting inventories are then anticipated to be used for the introduction of a carbon trading system. AGL will fall under this reporting requirement, and thus greenhouse estimations provided within this report may formulate AGL's initial reporting.

C1.2 Greenhouse Gas Assessment Methodology

The greenhouse gas emission inventory for the AGL Leafs Gully Power Project is based on the methodology detailed in the relevant emission factors in the Department of Climate Change "*National*

Greenhouse Accounts (NGA) Factors, 2008", which updates and replaces the "*AGO Factors and Methods Workbook*", 2006. These emission factors are utilised in the reporting of greenhouse gas emission under the National Greenhouse and Energy Reporting Act 2007.

The Greenhouse Gas Protocol is based on the concept of emission "scopes".

- **Scope 1: Direct greenhouse gas emissions**. Direct greenhouse gas emissions occur from sources that are owned or controlled by the company, for example:
  - Emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.;
  - Emissions from chemical production in owned or controlled process equipment.
- **Scope 2: Electricity indirect greenhouse gas emissions**. This accounts for greenhouse gas emissions from the generation of purchased electricity consumed by the company. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organizational boundary of the company. Scope 2 emissions physically occur at the facility where electricity is generated.
- **Scope 3: Other Indirect greenhouse gas emissions**. This is an optional reporting class that accounts for all other indirect greenhouse gas emissions resulting from a company's activities, but occurring from sources not owned or controlled by the company. Examples include extraction and production of purchased materials; transportation of purchased fuels; and use of sold products and services.

The Director-General's Environmental Assessment Requirements specify that both direct and indirect emissions from the project should be assessed. This has been conducted using the Australian Department of Climate Change's quantitative methodology. Individual contributions to the total site emissions were estimated from the use of natural gas for stationary energy generation, diesel fuel in vehicles and diesel fuel for stationary energy generation. These were compared to the estimated annual power output from the Power Project to assess the greenhouse gas intensity of the project (total kilograms of CO_2-equivalent per MWh of power sent out).

C1.3 Greenhouse Gas Inventory

The greenhouse gas inventory for the AGL Leafs Gully Power Project reports Scope 1 and Scope 3 emissions, to account for the direct (Scope 1) and indirect (Scope 3) emissions from the project. For the purpose of this inventory, the operational boundary is defined as the boundary of the power station site. Scope 3 emissions are limited to:

- Upstream emissions from the production of natural gas used for electricity generation; and
- Upstream emissions from the production of diesel consumed by on-site vehicles and for auxiliary power generation.

The projected usage of natural gas for power generation, kilometres for diesel truck movements on site as well as diesel usage for auxiliary power generation are presented in **Table C-1**. These data were used to estimate the annual greenhouse gas emissions (represented as CO_{2-e}) from operation of the Leafs Gully Power Project.

Emissions from purchased electricity were not included in the assessment as these were estimated by AGL to be negligible. As the site would not have on-site landfills or purchase steam from elsewhere, these parameters have not been included. Greenhouse gas emissions from clearing of vegetation on site have not been included, as the footprint of the Leafs Gully Power Project is largely cleared and used for grazing, with only a few isolated paddock trees remaining.

Table C-1 - Estimated gas consumption, diesel usage and power production per year

Parameter	Value	Units
Amount of gas combusted per year	84,800	tonnes
	4.36	PJ
Distance travelled in on-site diesel vehicles	730	km
Diesel used in on-site generators, auxiliaries etc	1	kL
Electricity delivered to grid (annually)	412.4	GWh

Table C-2 shows the greenhouse gas emission inventory for the Leafs Gully Power Project, conducted using the quantitative assessment methodology that is outlined above. Based on these estimates greenhouse gas emissions from combustion of natural gas account for approximately 99.999% of the total site greenhouse gas emissions. The emission factors used in this study report greenhouse gas emissions in kg CO_2-e, hence individual greenhouse gases (including methane and nitrous oxide) have not been itemised in the assessment.

Table C-2- Greenhouse Gas Inventory for Leafs Gully Power Project

Scope	Emission Type	Parameter	Value	Emission Factor	t CO_2-e	% of total CO_2-e	Notes
1	Direct stationary combustion emissions	Amount Natural Gas combusted	4.36 PJ/yr	51.3 kg CO_2-e/GJ	223,668	78.3	1, 2
3	Indirect stationary combustion emissions			14.2 kg CO_2-e/GJ	61,912	21.7	1, 2
1	Direct mobile emissions	Diesel used in on-site vehicles	730 km (i.e. 89L or 3.44GJ)	69.8 kg CO_2-e/GJ	0.24	0.00008%	3, 4
3	Indirect mobile emissions			5.3 kg CO_2-e/GJ	0.02	0.00001%	3, 4
1	Direct other fuel consumption	Onsite diesel generators for auxiliary power	1kL	69.8 kg CO_2-e/GJ	2.76	0.001%	5, 6
3	Indirect other fuel consumption			5.3 kg CO_2-e/GJ	0.21	0.00007%	5, 6
Total Greenhouse Gas Emissions				**t CO_2-e per year**	285,583	**100**	
				Mt CO_2-e per year	0.286	**-**	
Greenhouse gas intensity – total emissions				**kg CO_2-e per MWh**	692	-	7
Greenhouse gas intensity – direct emissions only				**kg CO_2-e per MWh**	542	-	

Table Notes:
1. Amount of natural gas combusted based on projected annual usage for the site (84,800 tonnes). Natural gas higher heating value of 51.4 MJ/kg (AGL Natural Gas Technical Data Handbook -1995).
2. Emission factors from Table 2 of "National Greenhouse Accounts (NGA) Factors", Department of Climate Change, 2008
3. The distance travelled has been estimated by AGL based on 1 site utility vehicle travelling approximately 2 km on site per day.
4. Emission factors from Table 3 of "National Greenhouse Accounts (NGA) Factors", Department of Climate Change, 2008. A diesel fuel efficiency of 0.122 L/km has been assumed.
5. Fuel consumption estimated by AGL for backup auxiliary power generation, using diesel fuel.
6. Emission factors from Table 3 of "National Greenhouse Accounts (NGA) Factors", Department of Climate Change, 2008. Energy content of diesel of 38.6 GJ/kL assumed.
7. Annual sent out generation of 412.4 GWh provided by AGL.

C1.4 Project Lifetime Emissions

Table C-3 provides greenhouse gas emissions for the proposed plant based on an assumed project lifetime of 30 years. Given the uncertainty in operating duty, estimates have been provided for both typical operation (3% of a given year) and maximum proposed operation (15% of a given year). Long term market trends define the operating duty, and ultimately the commercial life of the plant, hence there exist large uncertainties in potential emissions over the project lifetime.

Table C-1 Estimated Greenhouse Gas Emissions - Project Lifetime Basis

		Project Lifetime Emissions (Mt CO2-e)		
Operating Duty	**%**	**Direct**	**Indirect**	**Total**
Typical	3	1.3	0.4	1.7
Upper Limit	15	6.7	1.9	8.6

C1.5 Management of Greenhouse Gases

Generation of electricity by gas power stations currently represents the most efficient fossil-fuel based method of generating base load electricity. The relative emissions of greenhouse gases per unit of electricity generated from power stations is called the greenhouse gas intensity, reported in kg CO_2-e per MWh of power sent out. Base-load gas-fired electricity generation has approximately two-thirds the greenhouse gas intensity of coal-fired power stations, reducing to half of the greenhouse gas intensity for combined cycle gas power stations.

The Leafs Gully Power Project will be operated as a peaking plant, and is likely to operate for less than 15% of the year. Greenhouse gas intensities for peaking plants are generally higher than the equivalent base-load gas fired power station. However, quantitative data on typical greenhouse gas intensity data for peaking plants is not readily available.

A comparison of the emissions intensity from the Leafs Gully Power Project to other electricity generators in NSW is provided in **Table C-4**, with the comparisons taken from the NSW Energy Directions Green Paper 2004 (NSW Government, 2004). The Project is expected to be well below the current NSW pool average and coal-fired power generation. The emission intensity from the Leafs Gully Power Project is comparable to typical natural gas open-cycle plants that operate as base-load stations.

Table C-4 - Comparison of Greenhouse Gas Intensity for power generation

Electricity generator	Basis of emission calculations	Greenhouse gas emission intensity	Total GHG emissions for 412.4 GWh electricity (1)
NSW generator pool for 2008, comprising a composite of all forms of electricity generation in NSW	See Fact Sheet, the NSW Pool Coefficient (www.greenhousegas.nsw.gov.au)	954 kg CO_2-e/MWh	393,430 tonnes CO_2-e
Example of existing coal fired generation	Direct and indirect	970 kg CO_2-e/MWh	400,028 tonnes CO_2-e
Natural gas open-cycle plant	Direct and indirect	700 kg CO_2-e/MWh	288,680 tonnes CO_2-e
Example of Australian natural gas combined cycle plant (2)	Direct and indirect	480 kg CO_2-e/MWh	197,952 tonnes CO_2-e
Leafs Gully Power Project	Direct and indirect	692 kg CO_2-e/MWh	285,583, tonnes CO_2-e

1. This column shows the equivalent GHG emissions from each of type of generator if 412.4 GWh of electricity were generated. This electricity production is what Leafs Gully will send to the NSW electricity grid annually.

2. This is for a base load power station, designed to operate continuously at high efficiency. Leafs Gully will operate as a peaking plant and will be switched on and off intermittently to meet peak electricity demands across NSW. Plants operating in peaking mode do not provide the same efficiencies as base load operation.

Total greenhouse gas emissions in Australia for 2006[5] were estimated to be 576.0 million tonnes of CO_2-e, while NSW was estimated to emit 160 million tonnes CO_2-e from all sources (28% of emissions from all states). Most of the greenhouse gas emissions in NSW come from stationary energy sources (49% of NSW emissions). The Leafs Gully Power Project is estimated to release 0.29 million tonnes of CO_2-e per year, representing 0.37% of the stationary energy emissions in NSW, or 0.18% of all sources of greenhouse gas in NSW in 2006. The greenhouse gas production from the Leafs Gully Power Project represents 0.10% of the stationary energy emissions in Australia, and 0.05% of all sources of greenhouse gas in Australia, based on the 2006 inventory. When comparing production of the same GWh of electricity between different fuels, the Leafs Gully Power Project provides (approximately) 108,000 tonnes CO_2-e less (or 27% less) than that of a coal fired power plant operating for the same electricity production.

Australia's future greenhouse gas inventory data are not possible to forecast with certainty. The 2006 inventory data shows that national emissions across all sectors rose by 4.2% from 1990 to 2006. The largest sector increase was the stationary energy sector, followed by transport, showing a rise due to population growth and electricity demand for resources. The land use sector showed a decrease in emissions over this period, largely due to a reduction in vegetation clearing. Since the future trends are unknown, the greenhouse gas emissions from the Project cannot be meaningfully compared to future emissions from other sources of greenhouse gases in Australia over the life of the project.

[5] Department of Climate Change 2008 *National Greenhouse Gas Inventory*.

Appendix C
Greenhouse Gas Assessment

AGL is committed to complying with all mandatory government programs, and is a voluntary participant in Federal and State government greenhouse gas reduction programs (AGL Greenhouse Gas Reduction Program):

- Federal Government's Mandatory Renewable Energy Target (MRET)
- The NSW Greenhouse Gas Abatement Scheme
- The Greenhouse Challenge
- SEDA Energy Smart Business Program

AGL's greenhouse gas reduction projects have covered:

- purchase and generation of electricity from renewable energy sources;
- installing cogeneration technology to recover waste heat from electricity generation;
- extraction of landfill gas and use for electricity generation;
- use of compressed natural gas for transport;
- leak reduction for gas distribution systems; and
- recovery of useful hydrocarbons from refinery off-gases.

These projects contribute to AGL’s overall strategy to reduce the greenhouse gas intensity and impact of their operations.

AGL is a participant in the NSW Greenhouse Gas Abatement Scheme (GGAS) as an energy retailer. AGL also has significant investment in renewable energy generation capacity, including investment in hydro, landfill gas-fired power stations, wastewater treatment gas-fired power stations and interests in wind farms. Although AGL is not proposing to implement any additional greenhouse gas offsets for this project, AGL is committed to reducing greenhouse gas emissions and it is further noted that 43% of operations within AGL’s portfolio do not produce greenhouse gas emissions. AGL will be a participant in the National Greenhouse and Energy Reporting System which takes effect 1 July 2008.

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Meteorological Data Assessment

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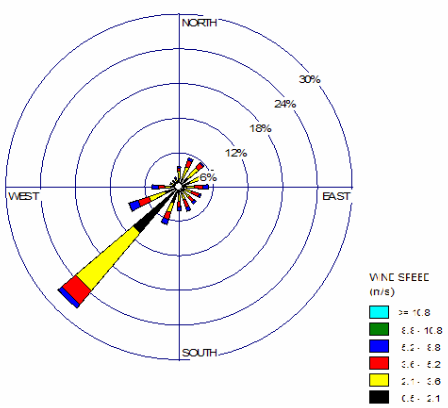
D1.1 Assessment of Meteorological Data

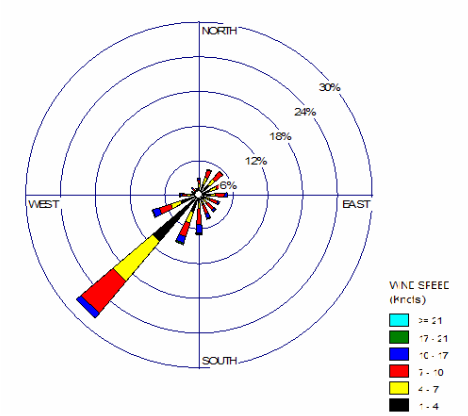
The meteorological data needed for dispersion modelling is required to be site representative. In order to obtain site representative meteorological data, URS located the closest known weather stations to the site, adhering to relevant Australian Standards. The closest weather station was found to be the NSW EPA Macarthur Automatic Weather Station[A] (AWS) and is understood to conform to relevant Australian Standards. The Macarthur weather station is located approximately 10km NNE of the Leafs Gully site.

As the Macarthur AWS became operational in 2004, the representativeness of the meteorological data collected in 2006 could not be compared to at least five previous years. The comparison to at least five previous years is recommended in DEC (2005) *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*.

As the most recent background air pollution data is preferred to be used is dispersion modelling, it follows that the meteorological data for the same period should also be used. Whilst the representativeness of meteorological collected at Macarthur for 2006 could not be compared to several previous years, 2006 was compared to the only previous full year, namely 2005, which is illustrated in Figure D.1. Figure D.1 shows the windroses for 2005 and 2006 have a very similar pattern and percentage of calms, thus 2006 is considered suitable for use in this assessment. Additionally, Figure D.2 shows the seasonal windroses for 2006. The wind roses for the individual seasons appear to be relatively consistent, showing a dominant south-westerly component, with a low proportion of the winds from the south east and north east quadrants.



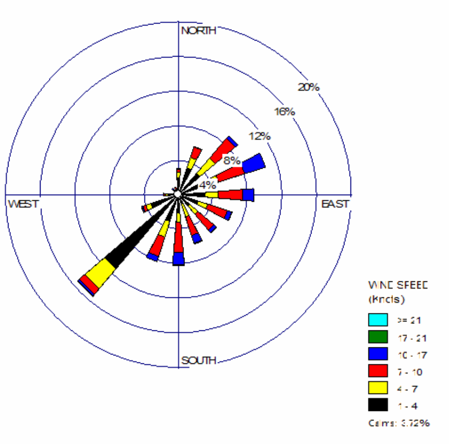
2005 (Calms 3.09%)



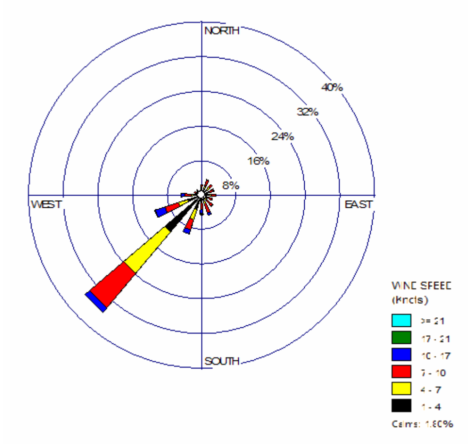
2006 (Calms 2.65%)

Figure D.1: Windroses for Macarthur (2005 and 2006)

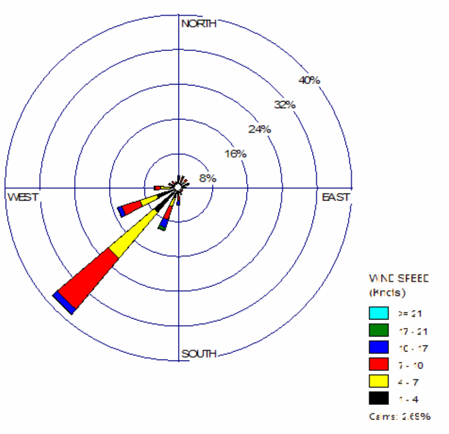
[A] The Macarthur AWS is situated at Australian Map Grid (AMG) coordinates* (km): 6227.7 northing, 295.3 easting and zone 56



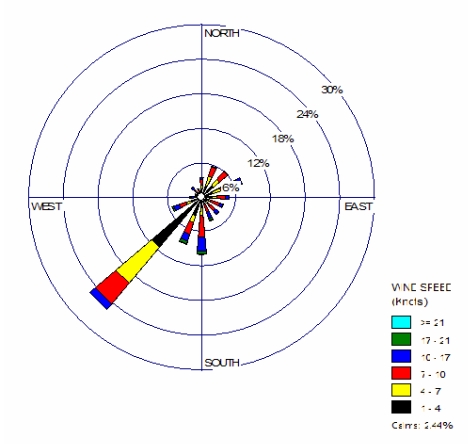
Summer



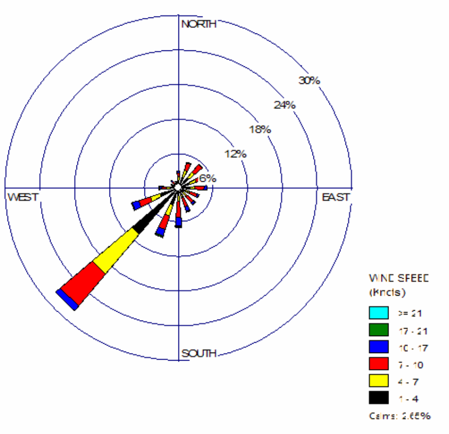
Autumn



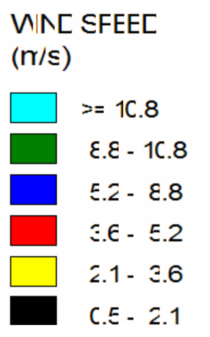
Winter



Spring



Annual Windrose



Legend

Figure D.2: Seasonal Windroses for Macarthur (2006)

Appendix D
Meteorological Data Discussion

Whilst Macarthur was located close to the proposed development site, in order to ensure local conditions were represented within the meteorology used in the dispersion modelling, The Air Pollution Model (TAPM) was used to generate local wind fields. Macarthur meteorological data for 2006 was assimilated into TAPM with a radius of influence of 20 km. Assimilation "nudges" the solution of the TAPM differential equations so that the TAPM-generated wind fields at Macarthur exactly equal those measured by the meteorological station. The meteorological modelling, using TAPM is discussed in the following section.

D1.1.1 Meteorological modelling

TAPM was run to calculate meteorological fields for the modelling domain. Through a number of verification studies (e.g. CSIRO 2005), TAPM has been identified as a suitable model of choice to simulate meteorological fields in a number of situations[B].

TAPM is an incompressible, non-hydrostatic, primitive equation model with a terrain-following vertical co-ordinate for three-dimensional simulations. It includes parameterisations for cloud/rain micro-physical processes, turbulence closure, urban/vegetative canopy and soil, and radiative fluxes.

TAPM, with the use of the input databases provided by CSIRO, was used to generate a meteorological dataset for the year 2006 based on actual synoptic data. The following TAPM settings and input files were used to generate the meteorological file for the Leafs Gully site for the year 2006:

- Grid centre coordinates 34^0-9 min latitude, 150^0 46 min longitude (294100mE, 6218959mN);
- Four nested grid domains (25 x 25): 30 km, 10 km, 3 km and 1 km;
- Assimilation of hourly meteorological data from the (NSWEPA) Macarthur Ambient Monitoring Station with a radius of influence of 15km;
- Twenty-five vertical grid levels from 10 to 8000 m;
- AUSLIG 9 second DEM database;
- Eulerian Grid Dispersion was used for 10km and 3km nests, whilst Lagrangian Particle Mode was used for the inner most (1km) grid, with the 'gradual plume rise' option selected;
- Building downwash affects were considered to be negligible as the turbines are the only significant structures proposed for the development; and
- Except where noted otherwise below, default options were selected in the model.

[B] CSIRO, 2005. *The Air Pollution Model (TAPM) Version 3. Part 2: Summary of Some Verification Studies.* CSIRO Atmospheric Research Technical Paper 72, 2005.

D1.2 Assessment of Meteorological data 2006

D1.2.1 Wind Speed and Direction

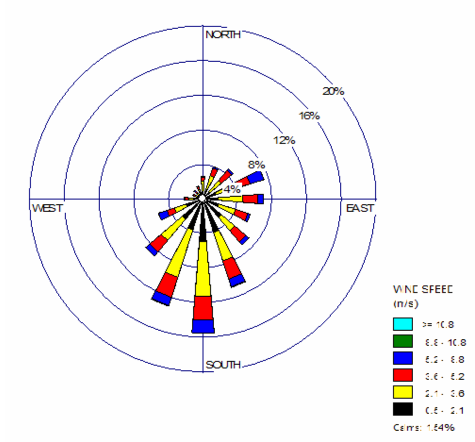
Communications with NSW EPA in August and September 2006 resulted in further assessment of the TAPM generated meteorological data to ensure the data was not under or over estimating calm periods. In order to further understand the calm conditions in the locality, URS obtained meteorological data from the AWS at Jacks Gully landfill, currently operated by WSN Environmental (formerly Waste Services, NSW).

The Jacks Gully landfill is located approximately 9km north of the Leafs Gully site, hence, the proximity suggests the meteorology at Jacks Gully is similar to that at Leafs Gully. Two AWS are situated at Jacks Gully, with one being located on top of a ridge (AWS 2), the other located at the entrance of the site, which is sheltered by surrounding topography (AWS 1). Being in a sheltered location, AWS 1 data was not considered to be representative of the local meteorology, thus was excluded from this assessment. Figure D.3 shows the windroses during 2006 for the following locations:

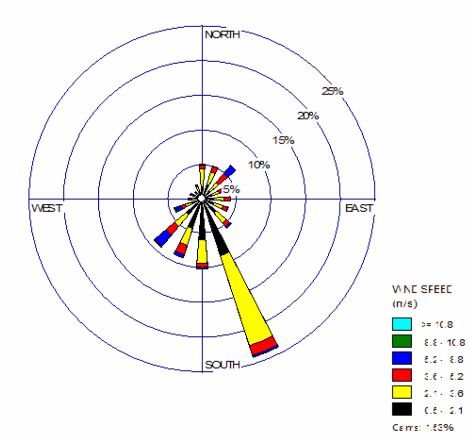
1. the Leaf's Gully site, as generated by TAPM;
2. Macarthur (as supplied by NSW EPA);
3. Jacks Gully AWS 2.

When comparing the wind roses for these four stations, as shown in Figure D.3, all four show a tendency for winds from the south western quadrant to dominate with low proportion of winds from the north west.

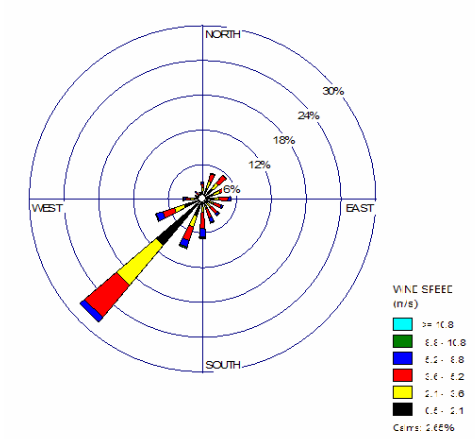
Appendix D
Meteorological Data Discussion



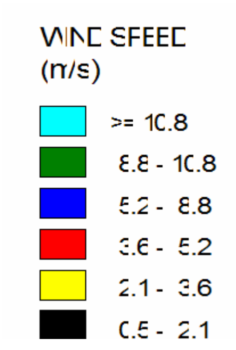
TAPM generated Leaf's Gully data



Jacks Gully AWS 2



Macarthur AWS (NSW EPA)



Legend

Figure D.3: Comparison of TAPM generated windroses to Macarthur AWS and Jacks Gully (2006)

D1.2.2 Calms

The primary reason for the comparison was to assess the percentage of calm periods (where wind speeds are less than 0.5 m/s) and assess whether the calm periods predicted by TAPM are similar to surrounding areas, or whether the TAPM predictions have under or over estimated the calm periods. The comparison of the calm periods is provided in **Table D.1**.

As shown in **Table D.1**, the TAPM generated data (1.54% calms) estimates a similar proportion of calms to the Macarthur AWS (2.65%) and Jacks Gully AWS 2 (1.53%). Given that the Macarthur AWS and Jacks Gully AWS 2, which are both located in relatively open areas, are situated within close proximity to the site and have a similar proportion of calms to the TAPM generated data for the site, it is considered that TAPM has not under or over estimated the calm periods at the site.

Table D.1 Comparison of calm periods

Site	Calms (% of year)
TAPM generated	1.54
Macarthur AWS	2.65
Jacks Gully AWS 2	1.53

D1.2.3 Mixing Height – Leaf's Gully site

Figure D.4 shows the Mixing Height (m) vs Time of Day (Hour) generated from TAPM data at the Leaf's Gully site for 2006. The figure shows that the TAPM predicted mixing height increases with increasing solar radiation as a function of time of day. This is consistent with general atmospheric processes that show increased vertical mixing during the daytime associated with the increasing thermal radiation. Nightime conditions are cooler, more stable and, as expected, winds are generally lighter thus vertical mixing is reduced leading to a lower mixing height.

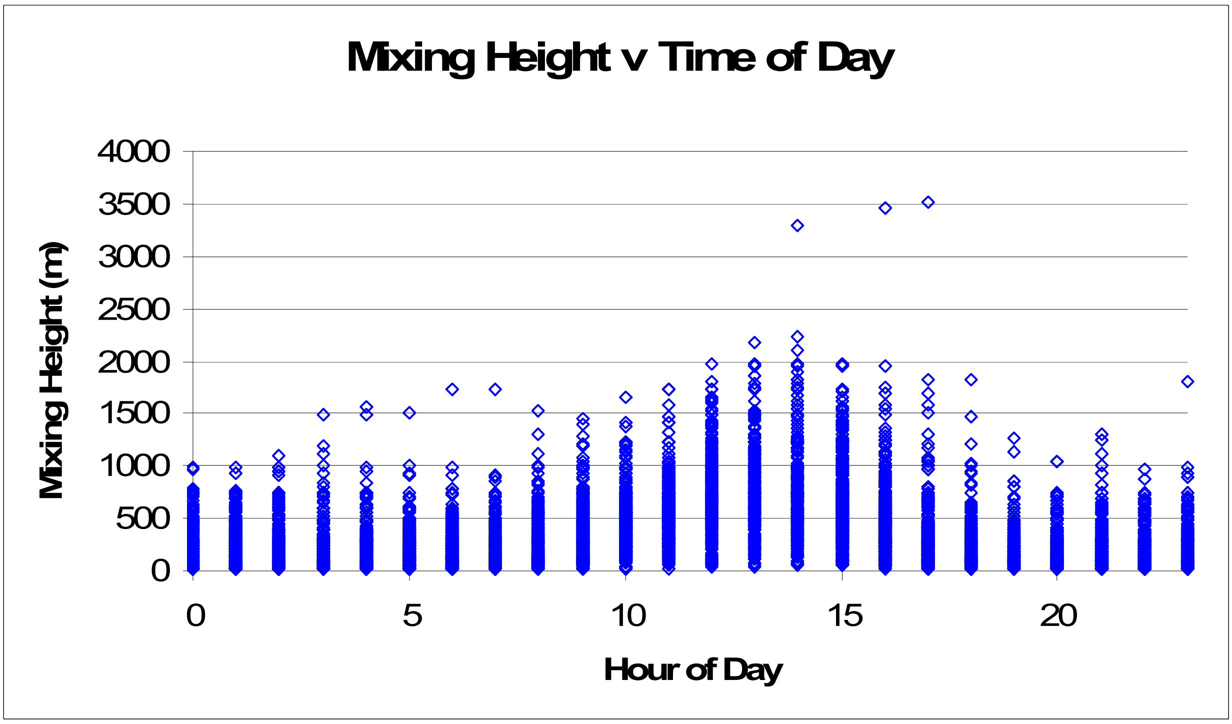


Figure D.4 Mixing Height (m) vs Time of Day (Hour of Day) – TAPM predicted, Leaf's Gully 2006

D1.2.4 Atmospheric Stability

Stability class is used as an indicator of atmospheric turbulence for use in meteorological models. The class of atmospheric stability generally used in these types of assessments is based on the Pasquill-Gifford-Turner scheme where six categories are used (A to F) which represent atmospheric stability from extremely unstable to moderately stable conditions. The stability class of the atmosphere is based on three main characteristics, these being:

- Static stability (vertical temperature profile/structure);
- Convective turbulence (caused by radiative heating of the ground);and
- Mechanical turbulence (caused by surface roughness).

The Pasquill Gifford Stability classes are provided in **Table D.2**. The stability classes for the site have been extracted from a TAPM generated meteorological file and are shown in **Table D.3**.

Table D.2: Modified Pasquill-Gifford Stability Classes (adapted from Turner, 1994[C])

Surface Wind Speed at 10m (m/s)	Insolation			Night-time cloud (Oktas)	
	Strong	Moderate	Slight	Thinly overcast of > 4/8 low cloud	< 3/8 Cloud
≤ 2	A	A-B	B	-	-
2 - 3	A-B	B	C	E	F
3 - 5	B	B-C	C	D	E
5 - 6	C	C-D	D	D	D
> 6	C	D	D	D	D

The Pasquill Gifford Stability Classes, shown in **Table D.3** shows neutral atmospheric conditions (Stability Class D) is the most prevalent Stability Class of the area, with Extremely Unstable conditions (Stability Class A) being the least prevalent.

Table D.3: Site Representative Pasquill-Gifford Stability Classes

Stability Class	% of year
A	0.3%
B	7.4%
C	15.6%
D	38.0%
E	16.0%
F	22.6%

[C] Turner B 1994 *Workbook of Atmospheric Dispersion Estimates: An Introduction to Dispersion Modeling*. 2nd Edition. CRC Press Inc.

In addition to their composition, Stability Classes were also predicted by TAPM for the site as a function of time of day, as shown in **Figure D.4**. The Stability Classes in **Figure D.4** are labelled 1 through 6 and refer to Stability Classes A (Extremely Unstable) through F (Very Stable) respectively. As expected, the Stability Classes show a tendency for the unstable classes (Stability Classes A, B and C) to occur during daytime, whilst the more stable conditions (Stability Classes D,E and F) are shown to occur primarily during night time. This is consistent with the values contained in **Table D.2**.

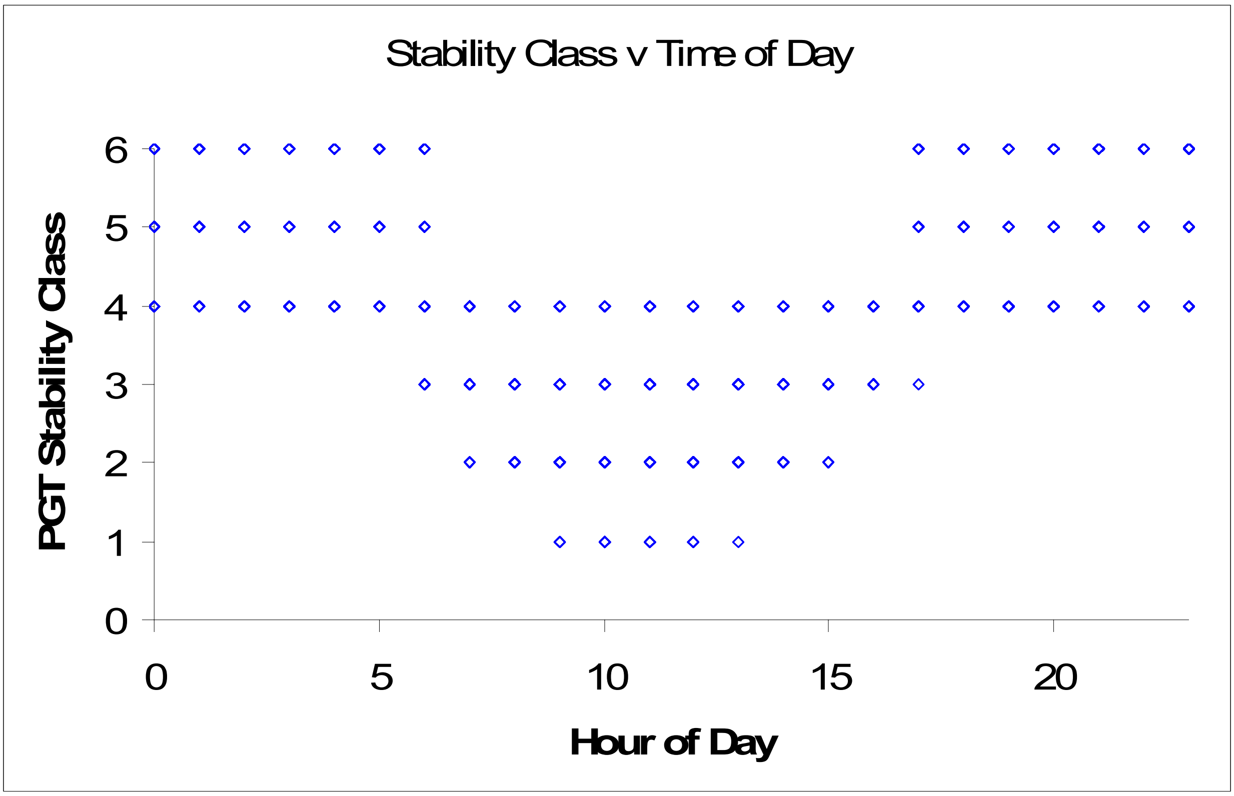


Figure D.4: Stability Class vs Time of Day – TAPM predicted, Leaf's Gully 2006

Stability Classes were also measured against wind speed, as shown in **Figure D.5**. The Stability Classes in **Figure D.5** are labelled 1 through 6 and refer to Stability Classes A through F respectively. As expected, the highest wind speeds are associated with stable or neutral stability classes (Stability Classes C and D). The more unstable conditions (Stability Classes A and B) have lower wind speeds due to vertical mixing, and the more stable conditions (Stability Classes E and F) also have low wind speeds as a result of stable night time atmospheric conditions. These data are consistent with the values contained in **Table D.2.**

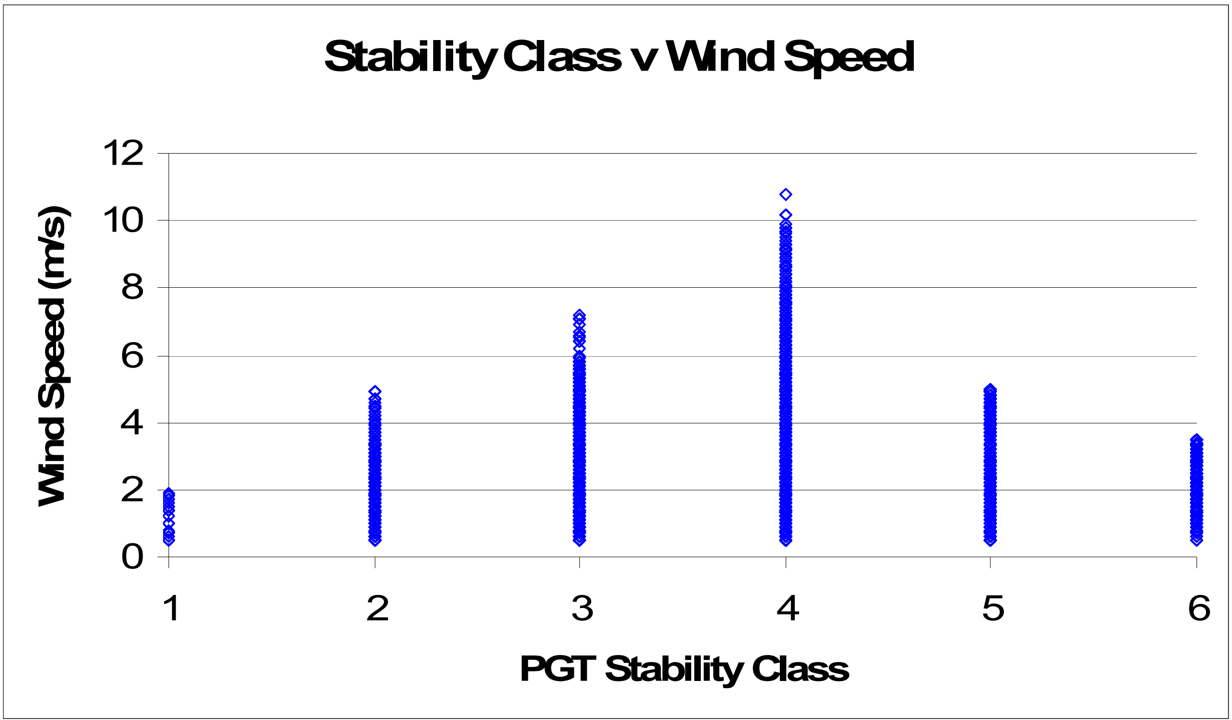


Figure D.5: Stability Class vs Wind Speed – TAPM predicted, Leaf's Gully 2006

D1.3 Conclusion

Where site specific meteorological data does not exist, as is the case for the Leafs Gully site, the predicted meteorological data used in the dispersion modelling is required to be representative of the surrounding area. It is an accepted standard Australian practice, that in situations where adequate site-specific meteorological data does not exist, TAPM is used to synthetically generate meteorological data. TAPM is a sophisticated, 3D meteorological model that has been extensively validated. In order to better represent the meteorology of the Leaf's Gully site, Macarthur AWS data was incorporated into the predicted TAPM meteorology.

In relation to the assessment of calm periods, there is no peer-reviewed study, that URS is aware of, that shows TAPM consistently underestimates calm conditions. This is supported by data provided in Table D.1 above, showing that TAPM does not appreciably underestimate calms in the vicinity of the proposed development.

The assessment of the predicted meteorology at the Leafs Gully site was discussed and was shown to be consistent with general atmospheric parameters. It is therefore considered that the meteorological data used in dispersion modelling is appropriate.

Appendix E
Stack Emission Data

Appendix E
Stack Emission Data

Table E-1 Emission Rates of Hazardous Air Pollutants

Fuel Consumption		Alstom - Operation	Alstom - Start Up
GJ/hr		1756	-
MMBtu/hr		1665	-
HAP Scaling Factor Relative to Normal Operation (from ESP II LLC, 2007)		1.00	12.04
	Emissions Factor (AP-42)	HAP Emission Rate	HAP Emission Rate
HAP Emissions	lb/MMBtu	g/s	g/s
Benzene	1.20E-05	0.003	0.030
Toluene	1.30E-04	0.027	0.328
Ethylbenzene	3.20E-05	0.007	0.081
Xylene	6.40E-05	0.013	0.162
Formaldehyde	7.10E-04	0.149	1.793
Total PAH	2.20E-06	0.0005	0.006

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29 April 2008

Mr Steven Jackson
AGL Energy Ltd
72 Christie St
St LEONARDS NSW 2065

Dear ~~Mr Jackson~~ Steve

LEAFS GULLY POWER STATION DEVELOPMENT
GT13E2 – START UP AND SHUT DOWN EMISSIONS

Further to our discussion of last week, please find listed below information about emissions values for Alstom's GT13E2 gas turbine under natural gas fuel operation (ie typical gas configuration) during plant start-up and shut down; and under steady state as a reference.

GT13E2 emission information during engine start-up and shutdown:

	Start up						Shut down	
	Ignition to idle		Idle to Base Load		Total Start up		Base load to extinction	
	[kg]	[lb]	[kg]	[lb]	[kg]	[lb]	[kg]	[lb]
NOx	3	6	46	101	49	107	44	97
CO	148	326	512	1128	659	1454	433	955

ALSTOM

For your reference, GT13E2 emissions information at steady state operation, ISO conditions, is as follows:

NOX:	75.1 kg/h
CO:	9.2 kg/h

(Note: These emissions values have been provided to AGL for information purposes only. Alstom makes no representations and gives no warranties in relation to the information provided).

I trust that this information satisfies your current requirements. However, if you would need any further information or clarification, please let me know.

Yours Faithfully
ALSTOM Ltd

Bernard Hayes
Country Sales Director
Australia and New Zealand

Appendix F
AUSPLUME Screening Assessment

Contents

Appendix F Ausplume Screening Assessment

Appendix F
Ausplume Screening Assessment

F.1 Evaluation of Worst Case Impacts using Ausplume

A screening study of potential air quality impacts from the proposed plant has been performed using the Victorian EPA's (EPAV) regulatory dispersion model Ausplume. This screening validation has been performed in order to evaluate the scale of the TAPM predictions against Ausplume predictions when running both worst case synthetic meteorology, and TAPM generated meteorology. In performing this analysis, both the dispersion and meteorological components of TAPM have been evaluated against Ausplume.

Given that ground level concentrations associated with emissions of oxides of nitrogen (NO_X) and particulate matter constitute the highest proportions of regulatory criteria, the assessment looked at peak impacts for these species. The assessment has considered emissions under startup conditions, as detailed in the main report.

The following scenarios were modelled and the modelling parameters are further discussed in the subsequent sections:

- 1 hour NO_X using Ausplume with TAPM meteorology;
- 1 hour NO_X using Ausplume with standard Metsamp[1];
- 1 hour NOx using Ausplume with refined Metsamp[1]; and
- 24 hour PM10 using Ausplume with TAPM meteorology.

Both the Ausplume and TAPM assessments have assumed that pollutants are conserved in the atmosphere. Therefore the predicted impacts of two different pollutants for a particular averaging time are directly proportional to their relative emission rates.

Hence, this appendix also validates the Air Quality Assessment, (which used TAPM), for all other chemical species with 1 hour and 24 hour regulatory criteria. 10 and 15 minute impacts are also validated by this study, as they are linearly scaled from the 1 hour impacts.

F.2 The Metsamp Meteorological Data File

For analysis of NO_X, Ausplume was run using the Metsamp screening meteorological data file. This file contains a range of permutations of meteorological parameters. With reference to Metsamp, the Victorian EPA Ausplume guidance material states:

"License applications may only require that predicted pollution levels be less than some threshold under all conceivable meteorological conditions. Because of the conservative assumptions involved, the use of an artificial screening file is often sufficient to ensure that regulatory requirements are met."

(EPAV,2004[2] p.10)

In this case however, the Ausplume screening procedure has been used to augment the comprehensive TAPM study included in the main report. It should be noted that Metsamp consists of synthetic hourly meteorological parameters, and is not suitable for the calculation of impacts for periods greater than one hour. Hence in this appendix, TAPM generated meteorology has been used in Ausplume to assess the peak impact for particulate matter, which requires a 24 hour averaging period.

The standard Metsamp screening file contains meteorological data for a single wind direction, hence the file was configured to contain the standard Metsamp data at 5° increments in wind direction. This in turn allows terrain effects to be incorporated into the model, resulting in over 19,000 hour cases of synthetic meteorology.

[1] Synthetic meteorological file supplied with AUSPLUME.
[2] EPA Victoria, June 2004, *AUSPLUME Gaussian Dispersion Model – Technical User Manual*

Appendix F
Ausplume Screening Assessment

Once worst case parameters were identified using Metsamp, the file was further refined to investigate sensitivity to other parameters, beyond the range and resolution of the standard Metsamp file. The parameters investigated were wind speed, ambient temperature and wind direction.

F.3 Model Configuration

Ausplume was run using the following settings. Default parameters were used elsewhere:

- 81 x 81 gridded receptors, at 250m resolution
- Terrain Effects were incorporated using the 'Egan Half Height' option with terrain data sourced from the TAPM 9 arc-second terrain database;
- Pasquill Gifford dispersion coefficients were used for both horizontal and vertical dispersion;
- Irwin Rural wind profile exponents were used;
- The 'Adjust PG curves for roughness' option was selected;
- A roughness height of 0.6m was used;
- The 'Enhance Plume for Buoyancy' option was selected;
- Both the 'Gradual Plume Rise' and 'Partial Penetration of Elevated inversions' options were trialled;
- Stack parameters, emission rates and locations were input as detailed in the main report, with the exception of neglecting buoyancy enhancement due to plume merging.

These details are also contained in the Ausplume output file which is included in Attachment A.

F.4 Comparison of Results

Table 1 shows the results of the scenarios modelled. As presented, Ausplume using worst-case refined synthetic meteorological data has produced a higher peak impact than that predicted by TAPM.

Table 1 – Worst Case Impacts

Modelling Scenario	Predicted Worst Case Impact (µg/m³)	Percent of Maximum Prediction
Peak 1 hour Oxides of Nitrogen Impact (All NO_x as NO_2)		
TAPM (as presented in main report)	33.2	48
Ausplume using TAPM Meteorology	43.3	62
Ausplume using standard Metsamp (at 325°)	61.1	88
Ausplume using refined Metsamp	69.3	100
Peak 24 hour PM_{10} Impact		
TAPM (as presented in main report)	1.12	80
Ausplume (using TAPM Meteorology)	1.40	100

F.5 Compliance with Regulatory Criteria

Despite the more conservative predictions of Ausplume, the methodology still indicates that regulatory criteria would not be breached by the proposal. Details of the cumulative impact (peak impact / peak background) are included in Table 2 below.

Table 2 – Comparison of Ausplume Predicted Impacts against Regulatory Criteria

Modelling Scenario	Averaging Period	Background Concentration ug/m³	Predicted Impact ug/m³	Cumulative Impact ug/m³	Air Quality Criteria ug/m³
NO_2	1 hour maximum	134.7	69.3	204	246
PM_{10}	24 hour maximum	43.7	1.4	45.1	50

F.6 Worst Case Model Meteorology

This section details the influence of various meteorological parameters in producing the worst case impact.

Table 3 – Worst Case Model Meteorology

Parameter	Value
Temperature	-6°C
Wind Speed	0.5m/s
Wind Direction	323°
Stability Class	F
Mixing Height	-

Temperature

The worst case impact was largely insensitive to changes in ambient temperature. The model was run using Metsamp at 10°C increments across the temperature range experienced for the region. An increase from 66.5 µg/m³ to 69.3µg/m³ was predicted, over the 45°C to -6°C temperature range recorded in the area, with the peak being recorded at an ambient temperature of -6°C.

Wind Direction

The peak impact occurred for a wind direction of 323°. For this wind direction, the plume is in line with the most elevated point of terrain in the modelling grid. Ausplume incorporates a terrain correction scheme whereby a correction is made to the plume height, based on elevation. For the predicted peak impact, which is 9km from the plant, this scheme is considered simplistic, and conservative.

Wind Speed

Metsamp was configured at 0.1m/s increments which showed a peak maximum concentration for a wind speed of 0.5m/s. This is the lowest wind speed that Ausplume will accept, as the Gaussian methodology is considered inappropriate for lower wind speeds (as conservation of mass assumptions imply that concentration is inversely proportional to wind speed).

Stability Class

The worst case impacts occurred under the Pasquill Gifford stability class F, which is representative of “extremely stable” conditions. This is represented in Ausplume as an endless ground based inversion with a uniform lapse rate of 3.5K per 100m increase in altitude. In this condition, the ability of the plume to continue rising is restricted, as the plume buoyancy decreases through both the entrainment of ambient air, and continuously increasing ambient air temperature as the plume rises.

Mixing Height

The worst case impact occurs irrespective of mixing height. This is due to the assumptions Ausplume makes for stability classes E and F, in which the inversion is ground based and continues endlessly up throughout the atmosphere.

Plume Rise Option

The worst case impact occurs irrespective of whether or not the ‘Partial Penetration of Elevated Inversions option’ is selected, due to the assumptions Ausplume makes for stability classes E and F (listed above).

F.7 Conclusion

The results of this screening study indicate that despite the more conservative nature of the Ausplume predictions, the cumulative impacts are within regulatory criteria.

The conservative nature of this assessment implies with a high level of confidence that air impact assessment criteria will not be breached by the proposed plant.

Appendix F
Ausplume Screening Assessment

Attachment A: Ausplume Output File

```
1
                        ALSTOM GT13E2 STARTUP

 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                                    Egan method
 Smooth stability class changes?                    No
 Other stability class adjustments ("urban modes")  None
 Ignore building wake effects?                      Yes
 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                                   0.600m
 Adjustment for wind directional shear              None

                    PLUME RISE OPTIONS
 Gradual plume rise?                                No
 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              Stability Class
     Category       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 Rural" values (unless overridden by met. file)

 AVERAGING TIMES
  1 hour
 24 hours
 _____________________________________________________________________________

                        ALSTOM GT13E2 STARTUP

                            SOURCE GROUPS

             Group No.    Members
```



```
                    1      NOXS1  NOXS2
                    2      PM10S1 PM10S2
 _____________________________________________________________________________
1
                        ALSTOM GT13E2 STARTUP

                        SOURCE CHARACTERISTICS

                    STACK SOURCE: NOXS1

   X(m)     Y(m)    Ground Elev.  Stack Height  Diameter Temperature  Speed
  293717  6218896       142m           35m        6.00m      369C    26.0m/s

                           No building wake effects.
                (Constant) emission rate = 2.72E+01 grams/second
                    No gravitational settling or scavenging.

                    STACK SOURCE: NOXS2

   X(m)     Y(m)    Ground Elev.  Stack Height  Diameter Temperature  Speed
  293719  6218856       142m           35m        6.00m      532C    40.0m/s

                           No building wake effects.
                (Constant) emission rate = 1.93E+01 grams/second
                    No gravitational settling or scavenging.

                    STACK SOURCE: PM10S1

   X(m)     Y(m)    Ground Elev.  Stack Height  Diameter Temperature  Speed
  293717  6218896       142m           35m        6.00m      369C    26.0m/s

                           No building wake effects.
                (Constant) emission rate = 4.40E+00 grams/second
                    No gravitational settling or scavenging.

                    STACK SOURCE: PM10S2

   X(m)     Y(m)    Ground Elev.  Stack Height  Diameter Temperature  Speed
  293719  6218856       142m           35m        6.00m      532C    40.0m/s

                           No building wake effects.
                (Constant) emission rate = 4.40E+00 grams/second
                    No gravitational settling or scavenging.
 _____________________________________________________________________________
1
                        ALSTOM GT13E2 STARTUP

                          RECEPTOR LOCATIONS

 The Cartesian receptor grid has the following x-values (or eastings):
 286100.m  286300.m  286500.m  286700.m  286900.m  287100.m  287300.m
 287500.m  287700.m  287900.m  288100.m  288300.m  288500.m  288700.m
 288900.m  289100.m  289300.m  289500.m  289700.m  289900.m  290100.m
 290300.m  290500.m  290700.m  290900.m  291100.m  291300.m  291500.m
 291700.m  291900.m  292100.m  292300.m  292500.m  292700.m  292900.m
 293100.m  293300.m  293500.m  293700.m  293900.m  294100.m  294300.m
 294500.m  294700.m  294900.m  295100.m  295300.m  295500.m  295700.m
 295900.m  296100.m  296300.m  296500.m  296700.m  296900.m  297100.m
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 297300.m  297500.m  297700.m  297900.m  298100.m  298300.m  298500.m
 298700.m  298900.m  299100.m  299300.m  299500.m  299700.m  299900.m
 300100.m  300300.m  300500.m  300700.m  300900.m  301100.m  301300.m
 301500.m  301700.m  301900.m  302100.m

 and these y-values (or northings):
6210959.m 6211159.m 6211359.m 6211559.m 6211759.m 6211959.m 6212159.m
6212359.m 6212559.m 6212759.m 6212959.m 6213159.m 6213359.m 6213559.m
6213759.m 6213959.m 6214159.m 6214359.m 6214559.m 6214759.m 6214959.m
6215159.m 6215359.m 6215559.m 6215759.m 6215959.m 6216159.m 6216359.m
6216559.m 6216759.m 6216959.m 6217159.m 6217359.m 6217559.m 6217759.m
6217959.m 6218159.m 6218359.m 6218559.m 6218759.m 6218959.m 6219159.m
6219359.m 6219559.m 6219759.m 6219959.m 6220159.m 6220359.m 6220559.m
6220759.m 6220959.m 6221159.m 6221359.m 6221559.m 6221759.m 6221959.m
6222159.m 6222359.m 6222559.m 6222759.m 6222959.m 6223159.m 6223359.m
6223559.m 6223759.m 6223959.m 6224159.m 6224359.m 6224559.m 6224759.m
6224959.m 6225159.m 6225359.m 6225559.m 6225759.m 6225959.m 6226159.m
6226359.m 6226559.m 6226759.m 6226959.m
```

METEOROLOGICAL DATA : "METSAMP" test meteorological file

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1           Peak values for the 100 worst cases  (in microgram/m3)
                  Averaging time = 1 hour;  Source group No. 1

  Rank     Value   Time Recorded         Coordinates
                    hour,date        (* denotes polar)

     1   6.93E+01   19,02/01/00   (299300, 6211559,    0.0)
     2   6.78E+01   21,02/01/00   (299300, 6211559,    0.0)
     3   6.66E+01   22,02/01/00   (299300, 6211559,    0.0)
     4   6.65E+01   20,02/01/00   (299300, 6211559,    0.0)
     5   6.52E+01   23,02/01/00   (299300, 6211559,    0.0)
     6   6.20E+01   24,02/01/00   (299300, 6211559,    0.0)
     7   5.89E+01   01,03/01/00   (299300, 6211559,    0.0)
     8   5.62E+01   02,03/01/00   (299300, 6211559,    0.0)
     9   5.38E+01   03,03/01/00   (299300, 6211559,    0.0)
    10   5.16E+01   04,03/01/00   (299300, 6211559,    0.0)
    11   4.97E+01   05,03/01/00   (299300, 6211559,    0.0)
    12   3.26E+01   11,02/01/00   (299300, 6211559,    0.0)
    13   2.97E+01   12,02/01/00   (299300, 6211559,    0.0)
    14   2.62E+01   13,02/01/00   (299300, 6211559,    0.0)
    15   2.32E+01   14,02/01/00   (299300, 6211559,    0.0)
    16   2.01E+01   15,02/01/00   (299300, 6211559,    0.0)
    17   1.77E+01   16,02/01/00   (299300, 6211559,    0.0)
    18   1.42E+01   17,02/01/00   (299300, 6211559,    0.0)
    19   1.20E+01   18,02/01/00   (299100, 6211959,    0.0)
    20   4.57E+00   06,07/01/00   (295100, 6216959,    0.0)
    21   4.57E+00   16,08/01/00   (295100, 6216959,    0.0)
    22   4.57E+00   02,10/01/00   (295100, 6216959,    0.0)
    23   4.57E+00   12,11/01/00   (295100, 6216959,    0.0)
    24   4.57E+00   24,11/01/00   (295100, 6216959,    0.0)
    25   3.89E+00   08,10/01/00   (294300, 6217959,    0.0)
    26   3.73E+00   05,07/01/00   (295100, 6216959,    0.0)
    27   3.72E+00   15,08/01/00   (295100, 6216959,    0.0)
    28   3.72E+00   01,10/01/00   (295100, 6216959,    0.0)
    29   3.72E+00   11,11/01/00   (295100, 6216959,    0.0)
    30   3.72E+00   23,11/01/00   (295100, 6216959,    0.0)
    31   3.51E+00   20,05/01/00   (295100, 6217159,    0.0)
    32   3.03E+00   19,05/01/00   (295100, 6216959,    0.0)
    33   2.87E+00   04,07/01/00   (295500, 6216559,    0.0)
    34   2.83E+00   14,08/01/00   (295500, 6216559,    0.0)
    35   2.83E+00   24,09/01/00   (295500, 6216559,    0.0)
    36   2.83E+00   10,11/01/00   (295500, 6216559,    0.0)
    37   2.83E+00   22,11/01/00   (295500, 6216559,    0.0)
    38   2.39E+00   13,08/01/00   (299300, 6211559,    0.0)
    39   2.39E+00   23,09/01/00   (299300, 6211559,    0.0)
    40   2.39E+00   09,11/01/00   (299300, 6211559,    0.0)
    41   2.39E+00   21,11/01/00   (299300, 6211559,    0.0)
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    42   2.31E+00   12,08/01/00   (299300, 6211559,    0.0)
    43   2.31E+00   22,09/01/00   (299300, 6211559,    0.0)
    44   2.31E+00   08,11/01/00   (299300, 6211559,    0.0)
    45   2.31E+00   20,11/01/00   (299300, 6211559,    0.0)
    46   2.22E+00   11,09/01/00   (295500, 6216559,    0.0)
    47   2.21E+00   21,10/01/00   (295500, 6216559,    0.0)
    48   2.21E+00   14,10/01/00   (295700, 6216159,    0.0)
    49   2.14E+00   15,10/01/00   (295100, 6216959,    0.0)
    50   2.08E+00   04,09/01/00   (295500, 6216559,    0.0)
    51   2.06E+00   24,07/01/00   (296100, 6215759,    0.0)
    52   1.98E+00   11,08/01/00   (299300, 6211559,    0.0)
    53   1.97E+00   10,09/01/00   (296100, 6215759,    0.0)
    54   1.97E+00   21,09/01/00   (299300, 6211559,    0.0)
    55   1.97E+00   07,11/01/00   (299300, 6211559,    0.0)
    56   1.97E+00   19,11/01/00   (299300, 6211559,    0.0)
    57   1.89E+00   20,10/01/00   (296100, 6215759,    0.0)
    58   1.89E+00   01,08/01/00   (295900, 6216159,    0.0)
    59   1.79E+00   03,07/01/00   (296100, 6215759,    0.0)
    60   1.78E+00   05,09/01/00   (295100, 6216959,    0.0)
    61   1.75E+00   02,07/01/00   (299300, 6211559,    0.0)
    62   1.70E+00   20,09/01/00   (299300, 6211559,    0.0)
    63   1.70E+00   06,11/01/00   (299300, 6211559,    0.0)
    64   1.70E+00   18,11/01/00   (299300, 6211559,    0.0)
    65   1.63E+00   13,10/01/00   (295900, 6215959,    0.0)
    66   1.56E+00   19,10/01/00   (296100, 6215759,    0.0)
    67   1.45E+00   18,10/01/00   (298300, 6212959,    0.0)
    68   1.36E+00   19,09/01/00   (299300, 6211559,    0.0)
    69   1.36E+00   05,11/01/00   (299300, 6211559,    0.0)
    70   1.36E+00   17,11/01/00   (299300, 6211559,    0.0)
    71   1.34E+00   08,09/01/00   (297700, 6213759,    0.0)
    72   1.31E+00   10,08/01/00   (299300, 6211559,    0.0)
    73   1.24E+00   09,09/01/00   (296100, 6215759,    0.0)
    74   1.08E+00   09,08/01/00   (299300, 6211559,    0.0)
    75   1.03E+00   17,10/01/00   (299300, 6211559,    0.0)
    76   9.93E-01   18,09/01/00   (299300, 6211559,    0.0)
    77   9.85E-01   04,11/01/00   (299300, 6211559,    0.0)
    78   9.85E-01   16,11/01/00   (299300, 6211559,    0.0)
    79   6.29E-01   03,11/01/00   (299300, 6211559,    0.0)
    80   6.28E-01   15,11/01/00   (299300, 6211559,    0.0)
    81   5.06E-01   17,09/01/00   (299300, 6211559,    0.0)
    82   3.47E-01   14,11/01/00   (299300, 6211559,    0.0)
    83   2.75E-01   02,11/01/00   (299300, 6211559,    0.0)
    84   1.30E-01   13,11/01/00   (299300, 6211559,    0.0)
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1           Peak values for the 100 worst cases  (in microgram/m3)
                  Averaging time = 1 hour;  Source group No. 2

  Rank     Value   Time Recorded         Coordinates
                    hour,date        (* denotes polar)

     1   1.25E+01   19,02/01/00   (299300, 6211559,    0.0)
     2   1.23E+01   21,02/01/00   (299300, 6211559,    0.0)
     3   1.21E+01   22,02/01/00   (299300, 6211559,    0.0)
     4   1.20E+01   20,02/01/00   (299300, 6211559,    0.0)
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