AIR QUALITY ASSESSMENT REPORT
COLEAMBALLY ETHANOL PLANT AND INTENSIVE DAIRY

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Prepared for

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by

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1 INTRODUCTION

This report has been prepared by Holmes Air Sciences on behalf of Booth Associates, who in turn are acting for Four Arrows Rural Group. The purpose of the report is to quantitatively assess the air quality impacts of a proposed ethanol plant and intensive dairy at Coleambally in New South Wales. The report assesses the impact of air emissions including odour from the proposed ethanol plant, and odour emissions from the proposed intensive dairy.

The report presents the results of computer dispersion modelling for the proposed facility. The impacts of emissions have been assessed by comparing estimated odour and criteria pollutant concentrations with relevant air quality criteria. Modelling was undertaken in accordance with the Department of Environment and Conservation (DEC, formerly NSW EPA) "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" (**NSW DEC, 2005**) using CALPUFF and a wind field prepared using CALMET.

2 PROJECT DESCRIPTION

The proposed development is located approximately 7 km to the northeast of Coleambally, and 14 km to the south of Darlington Point. The location of the project is shown in **Figure 1**. The project site is situated in an irrigated area, and the surrounding landuse is rural. The terrain in the surrounding area is flat and open with sparse vegetation. The site layout and nearest receptors are shown in **Figure 2**. The residence closest to the proposed facility is owned by the proponent. The industrial site to the north of the project site is used for grain storage. The site will be planted with native trees and shrubs on all non-project lands and will be drained.

The proposed ethanol plant will produce ethanol in the order of 300 ML per annum. The plant will employ vacuum extraction technology and the carbon dioxide (CO_2) produced during the fermentation process will be captured and sold. A by-product of the ethanol production process, wet distillers grain (WDG), will be supplied as feed to the on-site dairy and surplus WDG will be supplied to regional feedlots. The required moisture content of the distillers grain may vary and will be controlled in the centrifuge and belt press dewatering stages.

The proposed dairy will house 7200 head of cattle in aerated freestall sheds and 10,800 head of cattle in dry pens. The freestall sheds will be flood-washed daily using 7 ML of water from aerobic storage on-site, while the manure in the dry pens will be removed weekly. Manure will be collected from sediment basins daily. The manure will drain in a bunded area for 24 to 48 hours before being removed from the site to the nearby Tubbo station. Dead animals will also be taken to Tubbo station for burial as required. Dry grain will be held on site in bunkers and added to the WDG from the ethanol plant. Silage will be brought in to the dairy by truck daily, and other materials such as dry cotton seed, molasses and additives will be brought in as needed on a daily or weekly basis. The feed will be mixed daily in a commodity shed.

3 METEOROLOGY AND CLIMATE

The rate at which pollutants are dispersed is dependent on wind speed, wind direction, atmospheric stability class[1] and mixed-layer height[2]. This section describes the dispersion meteorology and climate of the study area. It provides information on prevailing wind patterns and historical data on temperature, humidity and rainfall. The data base used and the way in which it has been used to derive the parameters required for dispersion modelling are discussed below.

A meteorological station was installed on the project site on 16th February 2006. The station measures wind speed and direction, temperature, pressure, humidity, solar radiation and rainfall. The station will continue to measure atmospheric conditions while the proposed facility is operating. As less than a year of data have been collected to date, weather data from nearby Bureau of Meteorology stations have been presented below.

The Bureau of Meteorology weather stations that are nearest to the project site are shown in **Figure 1**. The closest stations with hourly meteorological data are Yanco Agricultural Institute, approximately 45 km to the northeast of the study area; and Griffith Airport, approximately 60 km to the north of the project area. The data at these sites are not quality controlled by the Bureau of Meteorology.

3.1 Yanco Agricultural Institute wind data

Figure 3 shows annual and seasonal windroses of wind data from Yanco Agricultural Institute for 2005. On an annual basis the most frequent winds are from the north, east and southwestern quadrant. The windroses for autumn and spring also show this pattern. In summer the wind is most commonly from the southwestern quadrant, whereas in winter the wind is predominantly from the north. The annual average wind speed is 4.1 m/s.

3.2 Griffith Airport wind data

Figure 4 shows the annual and seasonal windroses compiled from the Griffith Airport data for 2005. The data show a high frequency of winds from the east, north and southwestern quadrant on an annual basis. In summer the wind is predominantly from the southwestern quadrant, while in winter the wind is most commonly from the north, the northwestern quadrant and the east. In autumn the wind is mainly from the east and the southern sector, while in spring the wind is fairly evenly distributed, with easterly winds the most frequent. The annual average wind speed is 4.4 m/s.

3.3 TAPM meteorological data

In dispersion modelling it is often the case that there are no on-site data available and as with this assessment the closest Bureau of Meteorology data are not site-specific. Due to limitations in the data collection (for example, the wind direction data are collected in 10^{o} increments) they may not represent all the features of wind flow in the local area.

[1] In dispersion modelling stability class is used to categorise the rate at which a plume will disperse. In the Pasquill-Gifford stability class assignment scheme (as used in this study) there are six stability classes, A through to F. Class A relates to unstable conditions, such as might be found on a sunny day with light winds. In such conditions plumes will spread rapidly. Class F relates to stable conditions, such as occur when the sky is clear, the winds are light and an inversion is present. Plume spreading is slow in these circumstances. The intermediate classes B, C, D and E relate to intermediate dispersion conditions.

[2] The term mixed-layer height, refers to the height above the ground through which ground-based emissions will eventually be dispersed once a plume has been thoroughly mixed. An elevated plume, initially above the mixed-layer height will remain isolated from the ground until such time as the mixed-layer height reaches the height of the plume. In general the mixed-layer height will increase during the day as the sun causes convection to deepen the turbulent layer of the atmosphere close to the ground. Mixed-layer height will also increase if the wind speed increases because higher wind speeds will increase turbulence as the wind blows over the rough ground.

To aid in the assessment of projects where meteorological data are lacking, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) has developed a prognostic model – The Air Pollution Model (TAPM) – which predicts flows important to local scale meteorology, such as sea breezes and terrain induced flows. It uses data from the Bureau of Meteorology Global AnalysiS and Prediction (GASP) model. This feeds into the Limited Area Prediction System (LAPS) (**Puri *et al.,* 1997)** which is used to provide meteorological predictions over 37 km grids. TAPM uses information such as terrain and sea breezes to fine tune these data to provide meteorological data on a smaller scale. The model is discussed further in the user manual (**Hurley, 2002)**.

A synthetic, site-specific meteorological data set for the site was created using TAPM Version 2.0. The model used 2005 data and was centred on the proposed project site at 34^{o}45.5' S and 145^{o}56.5' E.

Figure 5 shows the annual and seasonal windroses compiled from the data generated using TAPM. The winds are predominantly from the north northeast and south southwest on an annual basis. Summer winds are predominantly from the south southwest, while in autumn there is also a high frequency of winds from the northeast. In winter the winds are predominantly from the north northeast and the northwestern sector. In spring the winds are most commonly from the northeast and north northeast with frequent winds from the southwestern quadrant. The annual average wind speed is 4.1 m/s. These patterns are similar to those observed in the airport data.

The windroses in **Figure 3** to **Figure 5** show that there is a higher percentage of calm periods in the Yanco Agricultural Institute and Griffith Airport data than in the TAPM file. However, assessment of the Yanco Agricultural Institute and Griffith Airport show the higher percentage of calm periods in the airport data are more than likely due to the anemometer stalling rather than extended periods with no wind as the majority of the calm periods are seen to be due to consecutive hours with the same wind speed and direction.

Stability is usually assigned according to six classes, A to F (see Footnote 1). The frequency of occurrence of the different stability categories expected at Coleambally, based on the TAPM meteorological data, are shown in **Table 1** and displayed graphically in **Figure 6**. The high frequency of D class stabilities (30.2%) indicates that emissions will disperse quickly for a significant proportion of the time. Joint wind speed, wind direction and stability class frequency tables for the data set are presented in **Appendix A**.

Table 1 – Frequency of occurrence of stability classes at Coleambally

Stability class	Percentage frequency of occurrence
A	5.7
B	10.4
C	15.8
D	30.2
E	19.9
F	18.0
Total	**100.0**

3.4 Climate

Climate averages including 9 am and 3 pm data are available from Leeton Caravan Park, Griffith CSIRO and Griffith Airport. **Figure 7** presents the average monthly temperature and rainfall data from these three stations. The figure shows that there is little variation between the long term average climate data at the three weather stations. The following description of climate in the study area is based on the Leeton climate averages. The Leeton data represent the longest period of data collection, including 89 years of rainfall data.

Table 2 presents the temperature, humidity and rainfall data for Leeton (**Bureau of Meteorology, 2006**). Temperature and humidity data consist of monthly averages of 9 am and 3 pm readings. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consist of mean and median monthly rainfall and the average number of raindays per month.

Table 2 – Temperature, humidity and rainfall data for Leeton

(Station number 075041; Commenced: 1960, Last record: 2004; Latitude (°S): -34.2487; Longitude (°E): 146.0695)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
9 am Mean Dry-bulb and Wet-bulb Temperatures (°C) and Relative Humidity (%)													
Dry-bulb	24.2	23.4	20.6	16.2	11.6	8.3	7.4	9.3	13.1	16.9	20.4	23.1	16.2
Wet-bulb	17.1	17.2	15.5	12.6	9.5	7.0	6.1	7.4	9.9	12.4	14.3	16.4	12.1
Humidity	46	51	56	65	75	82	82	76	64	57	48	47	62
3 pm Mean Dry-bulb and Wet-bulb Temperatures (°C) and Relative Humidity (%)													
Dry-bulb	30.5	29.8	27.3	22.5	17.2	14.6	13.3	14.9	18.1	21.5	25.4	28.3	21.8
Wet-bulb	18.9	19.3	18	15.3	12.3	10.6	9.5	10.2	12.2	14.3	15.9	17.5	14.4
Humidity	29	34	37	43	53	59	61	53	47	43	33	31	44
Daily Maximum Temperature (°C)													
Mean	31.9	31.2	28.2	22.9	18.1	14.7	13.9	15.8	19.3	23.0	27	30.2	23.0
Daily Minimum Temperature (°C)													
Mean	17.3	17.2	14.6	10.4	7.0	4.6	3.7	4.6	6.6	9.7	12.7	15.6	10.3
Rainfall (mm)													
Mean	32.0	30.6	33.5	35.0	39.5	39.5	37.3	40.7	37.3	44.5	30.7	30.8	431.3
Median	18.8	20.0	20.4	24.6	31.4	37.3	36.9	40.0	32.8	34.4	24.3	22.1	441.4
Raindays (Number)													
Mean	4.0	3.7	4.1	5.2	7.4	8.6	9.6	9.7	7.7	7.4	4.9	4.7	77

Source: Bureau of Meteorology (2006)

The annual average maximum and minimum temperatures experienced at Leeton are 23.0°C and 10.3°C respectively. On average January is the hottest month with an average maximum temperature of 31.9°C. July is the coldest month, with average minimum temperature of 3.7°C.

The annual average humidity reading collected at 9 am from the Leeton site is 62 percent, and at 3 pm the annual average is 44 percent. The highest humidity on average is in June and July with a 9 am average of 82 percent, and the lowest is January with a 3 pm average of 29 percent.

Rainfall data collected at Leeton shows that October is the wettest month, with an average rainfall of 44.5 mm over 7.4 days. The average annual rainfall is 431.3 mm with an average of 77 raindays. On average there are a higher number of raindays in the winter months, however the rainfall is not significantly higher.

4 AIR QUALITY ISSUES

Air emissions from ethanol plants include the criteria pollutants carbon monoxide (CO), particulate matter, nitrogen dioxide (NO_2), and sulfur dioxide (SO_2), as well as minor emissions of hazardous air pollutants, irritants and odorous chemicals including acrolein, acetic acid, butyric acid, lactic acid, furfural, glycerol, carbonyl sulfide, dimethyl sulfide, carbon disulfide, and hydrogen sulfide. The minor emissions do not constitute a health effect but combine to form an odorous emission which has been assessed separately.

4.1 Gaseous and particulate emissions

4.1.1 Assessment criteria

The DEC has historically noted air quality goals for nitrogen dioxide, carbon monoxide and particulate matter determined by the World Health Organisation (WHO), the United States Environmental Protection Agency (US EPA) and the National Health and Medical Research Council of Australia (NHMRC).

The National Environment Protection Council of Australia (NEPC) has determined a set of air quality goals for adoption at a national level, which are part of the National Environment Protection Measures (NEPM). In its publication "Action for Air" (**NSW EPA, 1998**), the NSW EPA adopted new air quality goals for particulate matter and nitrogen dioxide. These make the NSW standards for these pollutants consistent with the NEPM standards. The DEC set assessment criteria for assessing the effects of air pollution from a specific project in their 'Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales' (**NSW DEC, 2005**).

Table 3 lists the DEC's air quality goals and impact assessment criteria for New South Wales for emissions from the proposed ethanol plant.

Table 3 – NSW Air Quality Goals and Impact Assessment Criteria

Pollutant	Goal	Averaging Period
Carbon monoxide	30 mg/m^3 10 mg/m^3	1-hour maximum 8-hour maximum
Nitrogen dioxide	246 $\mu g/m^3$ 62 $\mu g/m^3$	1-hour maximum Annual Mean
Total Suspended Particulates	90 $\mu g/m^3$	Annual average
Particulate matter < 10 μm (PM_{10})	50 $\mu g/m^3$ 30 $\mu g/m^3$	24-hour maximum Annual mean
Sulfur dioxide	570 $\mu g/m^3$ 228 $\mu g/m^3$ 60 $\mu g/m^3$	1-hour maximum 1 day Annual average

$\mu g/m^3$ – micrograms per cubic metre
mg/m^3 – milligrams per cubic metre

4.1.2 Carbon monoxide

Carbon monoxide can be harmful to humans because its affinity for haemoglobin is more than 200 times greater than that of oxygen. When it is inhaled it is taken up by the blood and therefore reduces the capacity of the blood to transport oxygen. This process is reversible and reducing the exposure will lead to the establishment of a new equilibrium with a period of three hours being the approximate time required to reach fifty percent of the equilibrium value.

Symptoms of carbon monoxide intoxication are lassitude and headaches, however these are generally not reported until the concentrations of carboxyhaemoglobin in the blood are in excess of ten percent of saturation. This is approximately the equilibrium value achieved with an ambient atmospheric concentration of 70 mg/m^3 for a person engaged in light activity. However, there is evidence that there is a risk for individuals with cardiovascular disease when the carboxyhaemoglobin concentration reaches four percent and the WHO recommends that ambient concentrations be kept to values which would protect individuals from exceeding the four percent level.

The 15-minute, 1-hour and 8-hour goals noted by the DEC provide a significant margin for safety, however this is appropriate for this type of guideline, which is designed to protect a wide range of people in the community including the very young and elderly. The 1-hour and 8-hour goals are 30 mg/m^3 and 10 mg/m^3 respectively.

4.1.3 Oxides of nitrogen

Nitrogen oxides (NO_x) are comprised mainly of nitric oxide (NO) and nitrogen dioxide (NO_2). Nitric oxide is much less harmful to humans than nitrogen dioxide and is not generally considered a pollutant with health impacts at the concentrations normally found in urban environments. Concern with nitric oxide relates to its transformation to nitrogen dioxide and its role in the formation of photochemical smog. Nitrogen dioxide has been reported to have an effect on respiratory function although the evidence concerning effects has been mixed and conflicting. The DEC has not set any air quality goals for nitric oxide, however it has set 1-hour and annual average goals for nitrogen dioxide. It has adopted the NEPM standard of 246 μg/m^3. The annual average goal for nitrogen dioxide is 30 μg/m^3. The DEC has also adopted the WHO 1-hour goal of 200 μg/m^3 as a long term reporting goal.

4.1.4 Particulate matter

The presence of particulate matter in the atmosphere can have an adverse effect on health and amenity. The health effects of particles are largely related to the extent to which they can penetrate the respiratory tract. Larger particles, that is those greater than 10 μm, generally adhere to the mucus in the nose, mouth, pharynx and larger bronchi and from there are removed by either swallowing or expectorating. Finer particles can enter bronchial and pulmonary regions of the respiratory tract, with increased deposition during mouth breathing which increases during exercise. The very fine particles can be deposited in the pulmonary region and it is these which are of particular concern.

The health effects of particulate matter are further complicated by the chemical nature of the particles and by the possibility of synergistic effects with other air pollutants such as sulfur dioxide.

Much of the recent concern over the health effects of fine particulate matter is based on investigations carried out in the United States, with the view to quantifying the health risks associated with both long-term and short-term exposure to airborne particulate matter. The study is colloquially referred to as "The Six Cities Study" from the original work by **Dockery et al. (1993)**, which determined a relationship between fine particulate matter (defined as particles smaller than 2.5 μm in diameter) in the air and mortality in six United States cities.

The basic findings of the Six Cities Study is that there is an increase in mortality with increasing concentrations of fine particulate matter. The conclusions appear to be robust and have been supported by subsequent studies and, as far as can be determined, are not confounded by other known variables. It is important to note that the observed association between fine particles and mortality is statistical. The particles are not the primary cause of death, but are one of many environmental and other risk factors. More recently the statistical associations have been revised downwards based on a review of the statistical methods used, but the association remains (**HEI, 2003**). However the current Australian air quality goals for particulate matter are still based on the more conservative associations.

In October 2002, NEPC released a draft variation to the NEPM and an Impact Statement for $PM_{2.5}$ for public consultation (**NEPC, 2002** and **2003**). The standards proposed are a 24-hour average of 25 $\mu g/m^3$ and an annual average of 8 $\mu g/m^3$. These standards proposed are 'advisory reporting standards' which do not set a time line for compliance. The goal is to gather sufficient data nationally to facilitate the review of the Air Quality NEPM scheduled to commence in 2005. The draft includes a protocol setting out monitoring and reporting requirements for particles as $PM_{2.5}$.

The DEC continues to note the NHMRC's 90 $\mu g/m^3$ annual average goal for total suspended particulate matter (TSP). This level is recommended as the maximum permissible level in urban environments.

4.1.5 Sulfur dioxide

Sulfur dioxide (SO_2) is a colourless pungent irritating and reactive gas which is soluble in water. It can have harmful effects on the respiratory system as well as on vegetation and building materials.

The main sources of SO_2 are power generation from the combustion of fossil fuels containing significant amounts of sulfur, the roasting or smelting of mineral ores containing sulfur, oil refining and industrial plants which burn large quantities of fuel with significant sulfur contents. Motor vehicles are also a source of SO_2 although this is relatively minor.

The DEC ambient air quality standards for sulfur dioxide are:

- 570 $\mu g/m^3$ (1-hour)
- 228 $\mu g/m^3$ (24-hours)
- 60 $\mu g/m^3$ (1-year).

Exposures to concentrations of sulfur dioxide at or below these values would be expected to protect the health of the community including the most sensitive groups.

4.2 Odour emissions

Odour is measured using panels of people who are presented with samples of odorous gas diluted with decreasing quantities of clean odour-free air. The panellists then note when the smell becomes detectable. Odour in the air is then quantified in terms of odour units which is the number of dilutions required to bring the odour to a level at which 50% of the panellists can just detect the odour, defined as one odour unit. This process is known as olfactometry.

The determination of air quality goals for odour and their use in the assessment of odour impacts is recognised as a difficult topic in air pollution science. The topic has received considerable attention in the past five years and the procedures for assessing odour impacts have been refined considerably.

Odour impacts are determined by several factors, the most important of which are:

- the **F**requency of the exposure
- the **I**ntensity of the odour
- the **D**uration of the odour episodes
- the **O**ffensiveness of the odour and
- the **L**ocation of the source (the so-called FIDOL factor)

In determining the offensiveness of an odour it needs to be recognised that for most odours the context in which an odour is perceived is also relevant. Some odours, for example the smell of sewage, hydrogen sulphide, butyric acid, landfill gas etc., are likely to be judged offensive regardless of the context in which they occur. Other odours such as the smell of jet fuel may be acceptable at an airport, but not in a house, and diesel exhaust may be acceptable near a busy road, but not in a restaurant.

Whether or not an individual considers an odour to be a nuisance will depend on the FIDOL factors outlined above and although it is possible to derive formulae for assessing odour annoyance in a community, the response of any individual to an odour is still unpredictable. Odour goals need to take account of these factors.

The NSW DEC have developed a Draft Odour Policy (**NSW EPA, 2001**) which includes some recommendations for odour criteria. They have been refined by the DEC to take account of population density in the area. **Table 4** lists the odour certainty[3] thresholds, to be exceeded not more than 1% of the time, for different population densities.

Table 4 – Odour performance criteria for the assessment of odour

Population of affected community	Odour performance criteria (nose response odour certainty units at the 99th percentile)
Single residence (≤ ~2)	7
~10	6
~ 30	5
~ 125	4
~ 500	3
Urban (~ 2000)	2

The difference between odour goals is based on considerations of risk of odour impact rather than differences in odour acceptability between urban and rural areas. For a given odour level there will be a wide range of responses in the population exposed to the odour. In a densely populated area there will therefore be a greater risk that some individuals within the community will find the odour unacceptable than in a sparsely populated area. The goals assume that 7 odour units at the 99th percentile would be acceptable to the average person, but as the number of exposed people increases there is a chance that sensitive individuals would be exposed. The goal of 2 odour units at the 99th percentile is considered to be acceptable for the whole population.

[3] In the process of odour measurement, the odour certainty threshold is, by definition, the minimum concentration at which the panellist is <u>certain</u> they can detect the odour.

There are three residences in the immediate vicinity of the project area (within 2 km of the Project boundary), therefore the population density in the area around the Coleambally site would be equivalent to a single residence. On this basis the odour criterion of 7 ou has been applied at these residences. While the population of Coleambally is well under 2000, the most stringent goal of 2 ou has been used to assess the impacts at receptors further from the site.

It is common practice to use dispersion models to determine compliance with odour goals. This introduces a complication because Gaussian dispersion models are only able to directly predict concentrations over an averaging period of three-minutes or greater. The human nose, however, responds to odours over periods of the order of a second or so. During a three-minute period, odour levels can fluctuate significantly above and below the mean depending on the nature of the source.

To determine more rigorously the ratio between the one-second peak concentrations and three-minute and longer period average concentrations (referred to as the peak to mean ratio) that might be predicted by a Gaussian dispersion model, the NSW DEC commissioned a study by **Katestone Scientific Pty Ltd (1995, 1998)**. This study recommended peak to mean ratios for a range of source types. The ratio is also dependent on atmospheric stability and the distance from the source. A summary table of these ratios is presented in **Appendix B.** In this case the peak to mean factors for the area sources in the near field are relevant for residences close to the dairy. For residences more than 1 km from the dairy far field factors have been used. For the stack emissions, far field factors for surface point sources have been used.

The NSW DEC Draft Odour Policy (**NSW EPA, 2001**) takes account of this peaking factor and the goals shown in **Table 4** are based on nose-response time.

5 EXISTING AIR QUALITY

The project site is located in a rural agricultural area where background levels of pollution are typically low. The main source of CO and NO_x emissions will be motor vehicles on the adjacent Kidman Highway, however the amount of traffic on the road is unlikely to significantly increase background concentrations of these pollutants. The main source of SO_2 is from industry, however there are no industrial sources of SO_2 in the local area. Particulate matter comes from a multitude of sources and the concentration of particulates in the air is highly variable. Bushfires and wind-blown dust are often the cause of 24-hour average PM_{10} exceedances.

6 EMISSION ESTIMATES

Emissions from the proposed ethanol plant and intensive dairy will comprise gaseous and particulate emissions from the ethanol plant, and odour and dust from the intensive dairy. The following sections provide some background information on the way gaseous and particulate emissions and odour will be generated and controlled on the project site. Emissions from the ethanol plant will comprise a complex mix of organic components which on an individual basis may have health effects, however they will be present at levels where they will not cause toxic health impacts. The components have been considered as a group within the odour assessment.

6.1 Criteria pollutant emissions

Emission rates for the proposed ethanol plant have been derived from emissions data from an ethanol plant in Dalby, Queensland (**PAE, 2004**). The Dalby plant was designed to produce 60 ML/y of ethanol, compared with the 300 ML/y production rate of the proposed Coleambally plant. Equivalent emission rates and stack dimensions have been calculated by scaling up the Dalby emission rates by a factor of five. **Table 5** shows the assumed emission rates of CO, NO_x, SO_2, TSP and PM_{10} from the proposed ethanol plant. It has been assumed that the emissions will be proportional to the throughput of the plant.

Table 5 – Ethanol plant assumed criteria pollutant emission rates (g/s)

Emission source	Source type	Criteria pollutants				
		TSP	PM_{10}	SO_2	NO_x	CO
Steam generation (boilers)	Point	0.602	0.602	-	8.400	6.665
Emergency generation	Point	0.0666	0.0666	0.0920	2.2007	0.1332
Grain hammer milling	Volume	0.206	0.206	-	-	-
Grain receival building, cleaning/separator, and handling	Volume	0.279	0.106	-	-	-

Table 6 shows the point and volume source parameters used in the model. Projected building heights and widths associated with building wake effects were calculated using the US Building Profile Input Program (BPIP).

Table 6 – Point and volume source parameters

Point source	Stack height (m)	Diameter (m)	Exit velocity (m/s)	Exit temperature (K)	Easting (m)	Northing (m)
Boiler	15	2.24	15	450	404296	6154514
Emergency generation	5	0.67	10	298	404136	6154684
Volume source	**Effective height (m)**	**Base elevation (m)**	**Initial sigma y (m)**	**Initial sigma z (m)**	**Easting (m)**	**Northing (m)**
Grain hammer milling	3	120	2.5	1.5	404133	6154591
Grain receival building, cleaning/separator, and handling	4.2	120	8	2.1	404136	6154579

6.2 Odour emissions

Odour emissions from the proposed facility will comprise point source emissions from the ethanol plant and area source emissions from the dairy.

There are a number of possible sources of odorous emissions from the ethanol plant. The sources are as follows:

<u>Fermentation</u>: Emissions from the grain fermentation process that could cause odours are ethanol and a variety of trace volatile organic compounds (VOC) that are produced as the grain ferments. The CO_2 that is produced can act as a carrier for the organic compounds. The fermentation equipment vents to a water scrubber which removes VOC (including ethanol) from the exhaust CO_2.

<u>Distillation</u>: The distillation equipment vents to a thermal oxidiser unit where residual VOC are destroyed. Odours could be emitted from ethanol and residual VOC that are inherent with grain fermentation, vacuum distillation, and molecular sieve dehydration.

WDG/wet cake: The wet cake from centrifuging and belt pressing processes will be used directly on the site as a part of the feed mix for the dairy. Excess WDG will be moved to a covered storage pad for truck loading. WDG is not significantly odorous, but is a fertile medium for bacterial growth if exposed to warm ambient temperatures for an extended period of time. Daily plant cleaning in the storage area will prevent off-site odours.

Storage and ethanol loading: Ethanol and VOC odours could come from the storage and ethanol loading facilities, however these emissions would be minimal and are unlikely to have significant odour impacts.

Aqueous ammonia: Aqueous ammonia used to control the process fluid pH is contained within a closed system and is unlikely to be released to the atmosphere. The ammonia is readily consumed in the process stream.

Other sources: Other possible odour emission sources in the ethanol plant include grain loading and milling, maintenance, warehousing and transport engines, fire control equipment, office activities, heating, fuel storage, water for boilers, and sewer plumbing. These sources are unlikely to have a significant odour potential.

Odour emission rates for the proposed ethanol plant were derived from values used for the Dalby plant (**PAE, 2004**), which were estimated from a report by **McGinley Associates** (**2002**) detailing odour concentration of various sources from an ethanol plant in the United States using grain as a feedstock. The proposed ethanol plant will emit odours from the carbon dioxide scrubber. **Table 7** shows the point source emission parameters for the emission point that has been used in the model. As in the case of the pollutants it has been assumed that the odour emission rate is proportional to the plant throughput. Although the feedstock at Coleambally would not be identical to that used in the plant in the United States, both plants use grain and it has been assumed that the odour emissions would be similar.

Table 7 – Ethanol plant odour point source parameters

Odour source	**CO_2 scrubber**
Odour concentration (ou)	4700
Odour emission rate (ou.m^3/s)	92,285
Peak to Mean ratio (Stability classes A, B, C)	4
Peak to Mean ratio (Stability classes D, E, F)	7
Stack height (m)	15
Diameter (m)	2.24
Exit velocity (m/s)	5
Exit temperature (K)	306
Easting (km)	404.14
Northing (km)	6154.65
Base elevation (m)	120.1

Odour emission rates from area sources (for example, aerobic ponds, feed sheds) are probably the most difficult to measure for a variety of reasons. Firstly, the source is often heterogeneous. For example, in the case of an anaerobic pond there will be different odour emission rates from different parts of the pond. Secondly, unlike stack emissions, area emission rates are dependent upon atmospheric conditions including wind speed, degree of turbulence, temperature, etc. This adds another level of complexity to odour assessments.

There is no publicly available industry database in Australia for odour emission rates from dairy operations. The results from samples taken from a dairy operation in Gooloogong, NSW, have been used in this assessment. Gooloogong is a well run dairy and the odour sampling results sit within values that have been measured at other similar sites. The odour monitoring results have been used previously to assess the impacts of dairy operations at Bowthorne Dairy in Hinton, NSW (**Holmes Air Sciences, 2000**) and Wirong Dairy in Cowra, NSW (**Holmes Air Sciences, 2004**).

The Gooloogong samples were collected by Australian Water Technologies (AWT) using an isolation flux hood and analysed for odour using dynamic olfactometry in compliance with the European Standards that were current at the time of the odour measurements. This standard is consistent with the Australian Standards AS/N2S. The odour measurement reports for Gooloogong are shown in **Appendix C**.

The assumptions were as follows:

- measurements from the wet weather pond at Gooloogong were used to represent odour generated from the aerobic pond;
- measurements from the recycling pond at Gooloogong were used to represent odour generated from the anaerobic pond at Coleambally;
- measurements from the effluent pump at Gooloogong were used to represent odour from the manure storage area and sediment ponds at Coleambally; and
- measurements from bedding pile, free stall sheds, and flush channel at Gooloogong were used to represent odour generated from the cow sheds at Coleambally;

The most significant factor affecting odour emissions from the dry pens will be the state of the manure pad. Conditions which are conducive to the growth of anaerobic bacteria will give rise to the highest odour emission rates. These bacteria proliferate in warm moist conditions in the absence of oxygen. If the manure pad is deep through infrequent cleaning and there is an episode of high rainfall and warm weather, high odour emission rates are likely to occur. Odours are therefore a function of the factors connected with the state of the feedlot pad and include stocking density, moisture content, temperature of the pad and a function of the number of days since rainfall and the time to peak after rain. **Lunney & Smith (1994)** used these parameters to develop an odour emissions model. The model has the form shown below.

$$E_1 = \alpha \delta^{1.8} \theta^{0.77 T_P^{0.13}} F(\theta, T_a)$$ ***Equation 1***

where:

E_1 = emission rate (ou.m^3/m^2/s)
α = a constant
δ = weight in kg per m^2 of beast
θ = a measure of moisture content of the pad in percent
T_P = pad temperature
F = function based on time after a rainfall event
T_a = ambient average daily temperature

This equation can be applied to continuous meteorological data to estimate hourly varying odour emissions from a specific feedlot pad. An important factor which the model does not explicitly take account of is the management of the feedlot. Well managed feedlots which have relatively short pen cleaning intervals can have significantly lower odour emissions than those which have longer pen cleaning intervals.

Odour emission estimates from the dry pens have been derived from Moira feedlot values (**Holmes Air Sciences, 2005**). The average odour emission rate from the feed pen surface at Moira with an assumed maximum manure depth of 50 mm and a pen slope of 3% (as will be the case in the dry pens) was 2.0 ou.$m^3/m^2/s$. The average emission rate for the dry pens can be calculated from the Moira average emission rate by taking account of the weight in kg per m^2 of beast. For the Moira feedlot this value was 33.6 kg per m^2 of beast. The average weight of the cattle in the proposed dry pens at Coleambally will be 310 kg with a stocking density of approximately 21.3 m^2/beast. This gives a value of 14.6 kg per m^2 of beast. The adjusted emission rate for the dry pens is then 0.44 ou.$m^3/m^2/s$.

Odour emission rates were estimated per square metre and the total emissions from the site relate to the size of the sources. To correct for the nose response time of one second, peak-to-mean (P/M) factors were applied to emission rates to predict the odour impact at both near field and far field receptors. For the near field, a P/M factor of 2.5 was applied for neutral conditions (stability classes A to D) and a factor of 2.3 was applied for stable conditions (stability classes E and F). The near field emission rates that were calculated and used in the dispersion modelling are summarised in **Table 8**.

Table 8 – Near field estimated odour emissions from dairy operations

Source	Specific odour emission rate (ou.$m^3/s/m^2$)			Area (m^2)	Total emission rate (ou.m^3/s)	
	"Actual"	"Nose Response" (near field) P/M Neutral (2.5)	"Nose Response" (near field) P/M Stable (2.3)		P/M Neutral (2.5)	P/M Stable (2.3)
Aerobic Pond	0.12	0.30	0.28	260051	78015	71774
Anaerobic Pond	0.38	0.95	0.87	90000	85500	78660
Cow sheds	0.58	1.45	1.33	228000	330600	304152
Manure Stockpiles	1.48	3.70	3.40	16768	62041	57078
Sediment basins	1.48	3.70	3.40	22980	85,026	78,224
Dry pens	0.44	1.08	0.99	230111	247370	227580

For the far field, a P/M factor of 2.3 was applied for neutral conditions and 1.9 for stable conditions. The far field emission rates that were calculated and used in the dispersion modelling are summarised in **Table 9**.

Table 9 – Far field estimated odour emissions from dairy operations

Source	Specific odour emission rate (ou.$m^3/s/m^2$)			Area (m^2)	Total emission rate (ou.m^3/s) (Far field)	
	"Actual"	"Nose Response" (far field) P/M Neutral (2.3)	"Nose Response" (far field) P/M Stable (1.9)		P/M Neutral (2.3)	P/M Stable (1.9)
Aerobic Pond	0.12	0.28	0.23	260051	71774	59292
Anaerobic Pond	0.38	0.87	0.72	90000	78660	64980
Cow sheds	0.58	1.33	1.10	228000	304152	251256
Manure Stockpiles	1.48	3.40	2.81	16768	57078	47151
Sediment basins	1.48	3.40	2.81	22980	78,224	64,620
Dry pens	0.44	0.99	0.82	230111	227580	188001

7 APPROACH TO ASSESSMENT

The impacts of the criteria pollutant and odour emissions from the proposed facility have been assessed with CALPUFF using the emissions data presented in **Table 5** to **Table 9** to predict concentrations in the vicinity of the site.

Predictions have been made at a set of receptors arranged in a 15 km by 15 km square grid, with the ethanol plant and dairy near the centre of the grid. A grid spacing of 200 m was used to cover the modelling area. Discrete receptors were located to represent residences within 500 metres of the Project boundary. The near field emission rates from the dairy were used to predict odour concentrations over a smaller 5 km square grid centred on the project, including the nearest residential receptors. The averaging time used in the model was 1-hour. Modelling results were processed using CALPOST and gridded to produce contour plots of concentrations.

8 ASSESSMENT OF IMPACTS

Contour plots of the criteria pollutant and odour emissions from the ethanol plant and dairy using CALPUFF are presented in **Figure 8** to **Figure 22**, while **Table 10** presents the maximum predicted concentrations at receptors within 500 m of the Project boundary. It should be noted that receptor 7 is a grain storage area, not a residential receptor.

Table 10 – Maximum predicted concentrations at receptors within 5 km of Project boundary

Receptor	Easting (km)	Northing (km)	CO		NO_2		SO_2			PM_{10}		TSP	Odour 99th percentile (ou)	
			1-hour (mg/m^3)	8-hour (mg/m^3)	1-hour (μg/m^3)	Annual (μg/m^3)	1-hour (μg/m^3)	24-hour (μg/m^3)	Annual (μg/m^3)	24-hour (μg/m^3)	Annual (μg/m^3)	Annual (μg/m^3)	Near field	Far field
1	403.513	6152.531	0.031	0.013	76.6	1.07	3.1	0.39	0.023	2.59	0.18	0.24	8.88	-
2	404.432	6152.062	**0.050**	0.019	76.4	0.88	2.6	0.48	0.015	1.43	0.12	0.15	4.54	-
3	404.254	6151.655	0.031	0.017	57.8	0.72	2.3	0.40	0.013	2.03	0.10	0.13	3.96	-
4	406.241	6152.353	0.045	0.009	63.9	0.51	1.8	0.19	0.009	1.69	0.07	0.10	-	1.56
5	406.242	6151.718	0.035	0.008	59.4	0.45	2.5	0.25	0.008	1.25	0.06	0.08	-	1.3
6	405.885	6151.224	0.046	**0.020**	58.2	0.48	1.4	0.12	0.006	1.07	0.06	0.08	-	1.49
7	404.488	6155.170	0.046	0.009	**148**	**2.70**	**6.2**	**1.06**	**0.102**	**19.4**	**1.29**	**1.95**	10.7	-
8	407.354	6157.196	0.017	0.009	33.3	0.48	1.3	0.13	0.010	1.05	0.07	0.09	-	1.37
9	408.490	6150.838	0.035	0.009	44.5	0.24	0.8	0.10	0.004	0.59	0.03	0.04	-	0.675
10	407.173	6148.301	0.033	0.015	42.0	0.23	0.8	0.06	0.003	0.56	0.03	0.03	-	0.705
11	406.186	6147.990	0.028	0.010	34.6	0.22	0.7	0.09	0.003	0.79	0.03	0.033	-	0.757
12	405.680	6147.764	0.030	0.009	37.2	0.25	0.9	0.12	0.003	0.64	0.03	0.03	-	0.756
13	404.977	6148.434	0.024	0.007	32.7	0.30	0.9	0.14	0.004	0.46	0.03	0.04	-	0.878
14	403.971	6148.859	0.016	0.005	24.3	0.30	0.8	0.10	0.004	0.66	0.04	0.05	-	1.2
15	403.114	6148.314	0.017	0.007	22.9	0.31	0.8	0.06	0.004	0.38	0.03	0.05	-	1.08
16	402.980	6148.056	0.015	0.008	21.2	0.30	0.7	0.05	0.004	0.39	0.03	0.04	-	1.06
17	403.234	6147.879	0.015	0.008	20.7	0.28	0.6	0.05	0.003	0.34	0.03	0.04	-	0.917
18	401.488	6147.839	0.025	0.011	39.4	0.34	0.8	0.08	0.004	0.76	0.04	0.05	-	1.17
19	400.075	6148.087	0.016	0.005	29.5	0.28	0.8	0.14	0.005	0.52	0.04	0.05	-	1.29
20	399.727	6149.111	0.016	0.006	40.8	0.31	1.7	0.09	0.006	0.72	0.04	0.06	-	1.97
21	399.281	6149.392	0.015	0.004	27.7	0.28	1.1	0.13	0.006	0.69	0.04	0.05	-	1.79
22	398.928	6150.241	0.032	0.010	42.8	0.29	0.9	0.15	0.005	1.12	0.04	0.05	-	1.73
23	398.573	6150.856	0.018	0.007	26.0	0.25	1.1	0.08	0.005	0.69	0.03	0.05	-	1.74
24	399.067	6151.415	0.028	0.006	35.6	0.29	1.3	0.10	0.006	0.84	0.04	0.06	-	2.07
25	400.551	6156.257	0.024	0.006	39.5	0.26	1.5	0.17	0.007	1.14	0.04	0.07	-	3.29
26	400.434	6156.342	0.023	0.006	36.1	0.25	1.4	0.16	0.006	1.16	0.04	0.06	-	3.1
		DEC Goal	*30*	*10*	*246*	*62*	*570*	*228*	*60*	*50*	*30*	*90*	7	2

Bold type *indicates the highest predicted concentration*

8.1 Criteria pollutants

8.1.1 Carbon monoxide

Figure 8 and **Figure 9** present the predicted 1-hour and 8-hour average CO concentrations from the project, respectively. The predicted concentrations are within the DEC 1-hour criterion of 30 mg/m^3 and 8-hour criterion of 10 mg/m^3. The highest 1-hour average CO concentration at a discrete receptor was 0.050 mg/m^3, predicted at Receptor 2, and represents 0.2% of the DEC goal. The highest 8-hour average CO concentration at a discrete receptor was 0.020 mg/m^3 predicted at Receptor 6. This value represents 0.2% of the DEC goal.

The main source of CO emissions will be from motor vehicles, particularly on the adjacent Kidman Highway. However, even in busy suburban areas such as Blacktown in Sydney, 1-hour average CO concentrations in the past 10 years did not exceed 8.8 mg/m^3 (**NSW DEC, 1995 - 2005**). It is therefore extremely unlikely that the total CO emissions, including the predicted incremental concentration plus the background concentration, will exceed the DEC criteria.

8.1.2 Nitrogen oxides

As discussed in **Section 4.1.3**, NO_x is comprised mainly of NO and NO_2. In this assessment it has been conservatively assumed that all of the NO_x is emitted as NO_2. In reality only about 20% of NO would be converted to NO_2 at the location of the maximum predictions.

Figure 10 and **Figure 11** present the predicted 1-hour and annual average NO_x concentrations from the project, respectively. All off-site receptors were within the DEC 1-hour NO_2 criterion of 246 μg/m^3 and annual average NO_2 criterion of 62 μg/m^3. The highest 1-hour average NO_x concentration at a discrete receptor was 148 μg/m^3, predicted at Receptor 7, and represents 60% of the DEC goal. The highest annual average NO_x concentration at a discrete receptor was 2.70 μg/m^3, predicted at Receptor 7. This value represents 4% of the DEC goal.

As with CO, the main source of NO_2 will be from motor vehicles in the local area. Even in suburban areas, NO_2 concentrations rarely consume more than half of the 1-hour NO_2 goal. The background concentration of NO_2 will be lower than this in a rural area such as Coleambally. It is therefore unlikely that the DEC goals for NO_2 will be exceeded as a result of the proposed facility.

8.1.3 Sulfur dioxide

Figure 12 and **Figure 13** present the predicted 1-hour and 24-hour average SO_2 concentrations from the project, respectively. The DEC 1-hour criterion of 570 μg/m^3 and 24-hour criterion of 228 μg/m^3 were met at all receptors. The highest 1-hour average SO_2 concentration at a discrete receptor was 6.2 μg/m^3, predicted at Receptor 7, and represents 1% of the DEC goal. The highest 24-hour average SO_2 concentration at a discrete receptor was 1.06 μg/m^3, predicted at Receptor 7, and represents 0.5% of the DEC goal.

Figure 14 presents the predicted annual average SO_2 concentrations from the proposed ethanol plant. The DEC criterion of 60 μg/m^3 was met at all receptors. The highest annual average SO_2 concentration of 0.102 μg/m^3 was predicted at Receptor 7 and represents 0.2% of the DEC goal.

As there are no industrial sources of SO_2 in the local area, it has been assumed that the background concentration of SO_2 is extremely low. Therefore it is predicted that the SO_2 emitted from the proposed facility will not cause exceedances of the DEC goals.

8.1.4 Particulate matter

Figure 15 shows predicted annual average TSP concentrations from the proposed ethanol plant. The DEC annual criterion of 90 $\mu g/m^3$ was met at all off-site receptors. The highest annual average TSP concentration of 1.95 $\mu g/m^3$ was predicted at Receptor 7 and represents 2% of the DEC goal.

Figure 16 and **Figure 17** present the predicted 24-hour and annual average PM_{10} concentrations from the proposed ethanol plant, respectively. The DEC 24-hour criterion of 50 $\mu g/m^3$ and annual criterion of 30 $\mu g/m^3$ was met at all off-site receptors. The highest 24-hour average PM_{10} concentration of 19.4 $\mu g/m^3$ was predicted at Receptor 7 and represents 39% of the DEC goal. The highest 24-hour average PM_{10} concentration at a residential receptor was 2.59 $\mu g/m^3$ at Receptor 1, which represents 5% of the DEC goal. The highest annual average PM_{10} concentration of 1.29 $\mu g/m^3$ was predicted at Receptor 7 and represents 4% of the DEC goal.

Background levels of particulates in the local environment will come from a multitude of sources, and will be predominantly comprised of wind-blown dust. The predicted TSP and PM_{10} concentrations represent a small percentage of the DEC goals and are unlikely to cause any additional exceedances.

The particulate emissions were found to be dominated by the fugitive emissions from the grain handling buildings from grain receival and milling. Of these sources, steam generation has the highest emission rates as shown in **Table 5**. It will therefore be important to minimise the fugitive particulate emissions from these buildings and in particular the boilers by using dust control systems.

8.2 Odour

The contribution of 99th percentile odour levels from the ethanol plant are shown in **Figure 18**, while the contribution from the dairy is shown for near field receptors in **Figure 19** and far field receptors in **Figure 20**. It can be seen from these figures that the dairy is the dominant source of odour from the project. The predicted 99th percentile compliance odour levels from the dairy and the ethanol plant combined are presented for near field receptors in **Figure 21** and far field receptors in **Figure 22**. The near field predicted odour level at Receptor 1 was 8.8 ou. This value is above the peak 1-hour average compliance level of 7 ou. However, the property is owned by the proponent and may be discontinued as a residence. The predicted odour levels at the other two receptors near the facility comply with the DEC Draft Odour Policy guidelines outlined in **Table 4**. It is estimated that there will be occasions when odour levels will be higher than 7 ou, but these occurrences are predicted to occur for less than 1% of the time. The predicted odour levels were lower than the most stringent 2 ou goal at the far field receptors near the town of Colleambally.

Odour emissions should be controlled in the ethanol plant through the following methods:

- Using a well maintained, high efficiency wet CO_2 scrubber;
- Using a thermal oxidiser/heat recovery boiler to control emissions from the distillation system;
- Minimising VOC emissions from the storage tanks using internal floating roofs; and
- Utilise WDG on-site and truck excess WDG from the site as quickly as possible.

9 CONCLUSIONS

Emissions of odour and criteria pollutants from the proposed Coleambally ethanol plant and intensive dairy were modelled using the CALPUFF dispersion model. In the absence of a complete set of site-specific meteorological data, the TAPM prognostic model was used to provide meteorological predictions for the project site.

On the basis of predictions of odour and gaseous concentrations from the dispersion model, it is concluded that the proposed ethanol plant and dairy will comply with the DEC impact assessment criteria for the predicted gaseous and odour emissions. Further modelling will be required if the proposed facility plans are modified in the design phase. It is recommended that performance monitoring of air emissions is carried out during operation to monitor compliance with the DEC criteria.

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APPENDIX A

JOINT WIND SPEED, WIND DIRECTION AND STABILITY CLASS FREQUENCY TABLES

PASQUILL STABILITY CLASS 'A'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.001256	0.001484	0.000913	0.000000	0.000000	0.000000	0.000000	0.000000	0.003653
NE	0.000457	0.000913	0.000913	0.000000	0.000000	0.000000	0.000000	0.000000	0.002283
ENE	0.001027	0.001027	0.000342	0.000000	0.000000	0.000000	0.000000	0.000000	0.002397
E	0.000913	0.001370	0.000342	0.000000	0.000000	0.000000	0.000000	0.000000	0.002626
ESE	0.001370	0.001712	0.000457	0.000000	0.000000	0.000000	0.000000	0.000000	0.003539
SE	0.000457	0.002968	0.001142	0.000000	0.000000	0.000000	0.000000	0.000000	0.004566
SSE	0.000685	0.002055	0.000913	0.000000	0.000000	0.000000	0.000000	0.000000	0.003653
S	0.001142	0.001712	0.000799	0.000000	0.000000	0.000000	0.000000	0.000000	0.003653
SSW	0.001027	0.001712	0.000685	0.000000	0.000000	0.000000	0.000000	0.000000	0.003425
SW	0.000913	0.002169	0.000799	0.000000	0.000000	0.000000	0.000000	0.000000	0.003881
WSW	0.000799	0.001370	0.000457	0.000000	0.000000	0.000000	0.000000	0.000000	0.002626
W	0.000571	0.001484	0.001027	0.000000	0.000000	0.000000	0.000000	0.000000	0.003082
WNW	0.000799	0.002169	0.000799	0.000000	0.000000	0.000000	0.000000	0.000000	0.003767
NW	0.001142	0.003082	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004224
NNW	0.000913	0.002626	0.000342	0.000000	0.000000	0.000000	0.000000	0.000000	0.003881
N	0.000685	0.003311	0.000457	0.000000	0.000000	0.000000	0.000000	0.000000	0.004452
CALM									0.001370
TOTAL	0.014155	0.031164	0.010388	0.000000	0.000000	0.000000	0.000000	0.000000	0.057078

MEAN WIND SPEED (m/s) = 2.14
NUMBER OF OBSERVATIONS = 500

PASQUILL STABILITY CLASS 'B'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000457	0.002740	0.003995	0.001826	0.000000	0.000000	0.000000	0.000000	0.009018
NE	0.000228	0.001598	0.001826	0.000571	0.000000	0.000000	0.000000	0.000000	0.004224
ENE	0.000000	0.001370	0.001826	0.000571	0.000000	0.000000	0.000000	0.000000	0.003767
E	0.000571	0.001598	0.001826	0.000228	0.000000	0.000000	0.000000	0.000000	0.004224
ESE	0.000685	0.000913	0.000571	0.000457	0.000000	0.000000	0.000000	0.000000	0.002626
SE	0.000457	0.002740	0.002854	0.000000	0.000000	0.000000	0.000000	0.000000	0.006050
SSE	0.000228	0.002169	0.002511	0.000228	0.000000	0.000000	0.000000	0.000000	0.005137
S	0.000114	0.001826	0.004110	0.001027	0.000000	0.000000	0.000000	0.000000	0.007078
SSW	0.000342	0.001712	0.005936	0.002283	0.000000	0.000000	0.000000	0.000000	0.010274
SW	0.000228	0.001598	0.004566	0.004224	0.000000	0.000000	0.000000	0.000000	0.010616
WSW	0.000457	0.000799	0.005365	0.002283	0.000000	0.000000	0.000000	0.000000	0.008904
W	0.000228	0.001712	0.005137	0.001256	0.000000	0.000000	0.000000	0.000000	0.008333
WNW	0.000228	0.001370	0.001598	0.000799	0.000000	0.000000	0.000000	0.000000	0.003995
NW	0.000457	0.001598	0.004224	0.000342	0.000000	0.000000	0.000000	0.000000	0.006621
NNW	0.000114	0.001712	0.003653	0.000571	0.000000	0.000000	0.000000	0.000000	0.006050
N	0.000342	0.001256	0.004110	0.001256	0.000000	0.000000	0.000000	0.000000	0.006963
CALM									0.000799
TOTAL	0.005137	0.026712	0.054110	0.017922	0.000000	0.000000	0.000000	0.000000	0.104680

MEAN WIND SPEED (m/s) = 3.51
NUMBER OF OBSERVATIONS = 917

PASQUILL STABILITY CLASS 'C'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000571	0.001712	0.002968	0.005365	0.001598	0.000342	0.000000	0.000000	0.012557
NE	0.000114	0.002169	0.001826	0.003425	0.003082	0.000000	0.000000	0.000000	0.010616
ENE	0.000114	0.000685	0.001142	0.001941	0.000913	0.000000	0.000000	0.000000	0.004795
E	0.000342	0.001256	0.000799	0.001142	0.000000	0.000000	0.000000	0.000000	0.003539
ESE	0.000571	0.000342	0.001370	0.000342	0.000000	0.000000	0.000000	0.000000	0.002626
SE	0.000571	0.001256	0.000913	0.000685	0.000457	0.000000	0.000000	0.000000	0.003881
SSE	0.000228	0.001598	0.001370	0.000799	0.000457	0.000228	0.000000	0.000000	0.004680
S	0.000342	0.000799	0.002740	0.004110	0.001598	0.000114	0.000000	0.000000	0.009703
SSW	0.000342	0.001484	0.002626	0.004566	0.003881	0.000228	0.000000	0.000000	0.013128
SW	0.000571	0.001027	0.002626	0.007763	0.003881	0.000457	0.000000	0.000000	0.016324
WSW	0.000342	0.001370	0.002397	0.005251	0.005936	0.001142	0.000000	0.000000	0.016438
W	0.000228	0.001370	0.003196	0.004110	0.005023	0.000228	0.000000	0.000000	0.014155
WNW	0.000000	0.001370	0.002854	0.002968	0.002169	0.000571	0.000000	0.000000	0.009932
NW	0.000228	0.000685	0.003311	0.002740	0.002055	0.000114	0.000000	0.000000	0.009132
NNW	0.000342	0.001142	0.001142	0.006279	0.002283	0.000571	0.000000	0.000000	0.011758
N	0.000228	0.000913	0.002397	0.006849	0.002626	0.000457	0.000000	0.000000	0.013470
CALM									0.001027
TOTAL	0.005137	0.019178	0.033676	0.058333	0.035959	0.004452	0.000000	0.000000	0.157763

MEAN WIND SPEED (m/s) = 4.86
NUMBER OF OBSERVATIONS = 1382

PASQUILL STABILITY CLASS 'D'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000685	0.002968	0.005479	0.011073	0.004680	0.002968	0.000000	0.000000	0.027854
NE	0.000457	0.004338	0.005479	0.010731	0.001941	0.002397	0.000000	0.000000	0.025342
ENE	0.000342	0.001941	0.001941	0.004566	0.001142	0.000000	0.000000	0.000000	0.009932
E	0.000685	0.001826	0.002283	0.000571	0.002397	0.000000	0.000000	0.000000	0.007763
ESE	0.001027	0.002055	0.000799	0.000913	0.000571	0.000000	0.000000	0.000000	0.005365
SE	0.001027	0.003653	0.001027	0.000571	0.000000	0.000000	0.000000	0.000000	0.006279
SSE	0.000342	0.004795	0.002169	0.001370	0.000685	0.000685	0.000114	0.000000	0.010160
S	0.000342	0.002283	0.003767	0.002854	0.001256	0.000571	0.000457	0.000000	0.011530
SSW	0.000685	0.002854	0.004680	0.010845	0.002854	0.000457	0.000000	0.000000	0.022374
SW	0.000913	0.002511	0.005365	0.006507	0.004338	0.001598	0.000000	0.000000	0.021233
WSW	0.000799	0.003425	0.003881	0.009589	0.007648	0.002169	0.000000	0.000000	0.027511
W	0.000457	0.003539	0.004224	0.006621	0.006621	0.004680	0.001826	0.000000	0.027968
WNW	0.000342	0.002283	0.003196	0.005365	0.003995	0.002511	0.003082	0.000342	0.021119
NW	0.000342	0.004110	0.002854	0.007306	0.004110	0.002854	0.001484	0.000342	0.023402
NNW	0.000342	0.003767	0.001826	0.009475	0.003995	0.000799	0.001256	0.000571	0.022032
N	0.000000	0.002854	0.004680	0.009361	0.008562	0.002169	0.001484	0.001712	0.030822
CALM									0.001027
TOTAL	0.008790	0.049201	0.053653	0.097717	0.054795	0.023858	0.009703	0.002968	0.301712

MEAN WIND SPEED (m/s) = 5.13
NUMBER OF OBSERVATIONS = 2643

PASQUILL STABILITY CLASS 'E'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000685	0.000228	0.017123	0.007877	0.000000	0.000000	0.000000	0.000000	0.025913
NE	0.000114	0.000228	0.012100	0.005023	0.000000	0.000000	0.000000	0.000000	0.017466
ENE	0.000457	0.000114	0.006164	0.001941	0.000000	0.000000	0.000000	0.000000	0.008676
E	0.000228	0.000114	0.004795	0.000799	0.000000	0.000000	0.000000	0.000000	0.005936
ESE	0.000685	0.000685	0.002397	0.000571	0.000000	0.000000	0.000000	0.000000	0.004338
SE	0.000571	0.000799	0.003539	0.000342	0.000000	0.000000	0.000000	0.000000	0.005251
SSE	0.000114	0.000571	0.006735	0.000913	0.000000	0.000000	0.000000	0.000000	0.008333
S	0.000913	0.000114	0.014155	0.005023	0.000000	0.000000	0.000000	0.000000	0.020205
SSW	0.000228	0.000114	0.017808	0.006621	0.000000	0.000000	0.000000	0.000000	0.024772
SW	0.000000	0.000571	0.009817	0.003196	0.000000	0.000000	0.000000	0.000000	0.013584
WSW	0.000114	0.000342	0.010502	0.002740	0.000000	0.000000	0.000000	0.000000	0.013699
W	0.000114	0.000342	0.009247	0.002740	0.000000	0.000000	0.000000	0.000000	0.012443
WNW	0.000114	0.000571	0.007648	0.000913	0.000000	0.000000	0.000000	0.000000	0.009247
NW	0.000228	0.000457	0.004680	0.001370	0.000000	0.000000	0.000000	0.000000	0.006735
NNW	0.000228	0.000228	0.005023	0.004795	0.000000	0.000000	0.000000	0.000000	0.010274
N	0.000114	0.000114	0.007078	0.003082	0.000000	0.000000	0.000000	0.000000	0.010388
CALM									0.001256
TOTAL	0.004909	0.005594	0.138813	0.047945	0.000000	0.000000	0.000000	0.000000	0.198516

MEAN WIND SPEED (m/s) = 4.06
NUMBER OF OBSERVATIONS = 1739

PASQUILL STABILITY CLASS 'F'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000342	0.005594	0.003311	0.000000	0.000000	0.000000	0.000000	0.000000	0.009247
NE	0.000913	0.013584	0.006849	0.000000	0.000000	0.000000	0.000000	0.000000	0.021347
ENE	0.001598	0.010845	0.003881	0.000000	0.000000	0.000000	0.000000	0.000000	0.016324
E	0.001484	0.007534	0.002397	0.000000	0.000000	0.000000	0.000000	0.000000	0.011416
ESE	0.001826	0.006393	0.000913	0.000000	0.000000	0.000000	0.000000	0.000000	0.009132
SE	0.002397	0.007648	0.001826	0.000000	0.000000	0.000000	0.000000	0.000000	0.011872
SSE	0.001142	0.009475	0.003767	0.000000	0.000000	0.000000	0.000000	0.000000	0.014384
S	0.001027	0.011073	0.004110	0.000000	0.000000	0.000000	0.000000	0.000000	0.016210
SSW	0.000913	0.011073	0.005479	0.000000	0.000000	0.000000	0.000000	0.000000	0.017466
SW	0.000342	0.007877	0.004110	0.000000	0.000000	0.000000	0.000000	0.000000	0.012329
WSW	0.001027	0.007078	0.004566	0.000000	0.000000	0.000000	0.000000	0.000000	0.012671
W	0.000571	0.003881	0.002169	0.000000	0.000000	0.000000	0.000000	0.000000	0.006621
WNW	0.000457	0.002055	0.000913	0.000000	0.000000	0.000000	0.000000	0.000000	0.003425
NW	0.000228	0.002968	0.001256	0.000000	0.000000	0.000000	0.000000	0.000000	0.004452
NNW	0.000342	0.003653	0.000913	0.000000	0.000000	0.000000	0.000000	0.000000	0.004909
N	0.000228	0.005137	0.002055	0.000000	0.000000	0.000000	0.000000	0.000000	0.007420
CALM									0.001027
TOTAL	0.014840	0.115868	0.048516	0.000000	0.000000	0.000000	0.000000	0.000000	0.180251

MEAN WIND SPEED (m/s) = 2.52
NUMBER OF OBSERVATIONS = 1579

ALL PASQUILL STABILITY CLASSES

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.003995	0.014726	0.033790	0.026142	0.006279	0.003311	0.000000	0.000000	0.088242
NE	0.002283	0.022831	0.028995	0.019749	0.005023	0.002397	0.000000	0.000000	0.081279
ENE	0.003539	0.015982	0.015297	0.009018	0.002055	0.000000	0.000000	0.000000	0.045890
E	0.004224	0.013699	0.012443	0.002740	0.002397	0.000000	0.000000	0.000000	0.035502
ESE	0.006164	0.012100	0.006507	0.002283	0.000571	0.000000	0.000000	0.000000	0.027626
SE	0.005479	0.019064	0.011301	0.001598	0.000457	0.000000	0.000000	0.000000	0.037900
SSE	0.002740	0.020662	0.017466	0.003311	0.001142	0.000913	0.000114	0.000000	0.046347
S	0.003881	0.017808	0.029680	0.013014	0.002854	0.000685	0.000457	0.000000	0.068379
SSW	0.003539	0.018950	0.037215	0.024315	0.006735	0.000685	0.000000	0.000000	0.091438
SW	0.002968	0.015753	0.027283	0.021689	0.008219	0.002055	0.000000	0.000000	0.077968
WSW	0.003539	0.014384	0.027169	0.019863	0.013584	0.003311	0.000000	0.000000	0.081849
W	0.002169	0.012329	0.025000	0.014726	0.011644	0.004909	0.001826	0.000000	0.072603
WNW	0.001941	0.009817	0.017009	0.010046	0.006164	0.003082	0.003082	0.000342	0.051484
NW	0.002626	0.012900	0.016324	0.011758	0.006164	0.002968	0.001484	0.000342	0.054566
NNW	0.002283	0.013128	0.012900	0.021119	0.006279	0.001370	0.001256	0.000571	0.058904
N	0.001598	0.013584	0.020776	0.020548	0.011187	0.002626	0.001484	0.001712	0.073516
CALM									0.006507
TOTAL	0.052968	0.247717	0.339155	0.221918	0.090753	0.028311	0.009703	0.002968	1.000000

MEAN WIND SPEED (m/s) = 4.06
NUMBER OF OBSERVATIONS = 8760

APPENDIX B

PEAK TO MEAN TABLES

Table A1 – Recommended factors for estimating peak concentrations for different source types, distances and stabilities

		Near field				Far field			
Source type	**Stability**	**i_{max}**	**x_{max}**	**P/M 60**	**P/M 3**	**i**	**P/M 60**	**P/M 3**	**p**
Area	Neutral, Convective	0.5	500 – 1000	2.5	1.9	0.4	2.3	1.7	0.15
	Stable	0.5	300 – 800	2.3	1.7	0.3	1.9	1.4	0.10
Line	Neutral, Convective	1.0	350	6	2.8	0.75	6	2.8	0.25
	Stable	1.0	250	6	2.8	0.65	6	2.8	0.25
Surface point	Neutral	2.5	200	25	10	1.2	5 - 7	3	0.2
	Stable	2.5	200	25	10	1.2	5 - 7	3	0.2
	Convective	2	1000	12	7	0.6	3 - 4	2.5	0.15
Tall point	Neutral, Stable	4.5	5 h	35	8	1.0	6	1.3	0.5
	Convective	2.3	2.5 h	17	4	0.5	3	1.1	0.5
Wake affected point	Neutral, Convective	0.4	-	2.3	1.4	-	2.3	1.4	0.1
Volume	Neutral, Convective	0.4	-	2.3	1.4	-	2.3	1.4	0.1

Source: Katestone Scientific (1998)

i_{max} is maximum centreline intensity of concentration
x_{max} is the approximation location of i_{max} in metres
P/M 60 is the peak-to-mean ratio for long averaging times (typically 1 hour), at a probability of 10^{-3}
P/M 3 is the best estimates of the peak-to-mean ratio for 3 minute averages, at probability 10^{-3}
p is the averaging time power law exponent
h is stack height

APPENDIX C

ODOUR TESTING BY AWT AT GOOLOOGONG DAIRY

AWT
AUSTRALIAN WATER TECHNOLOGIES

Date: 3 May 2000

To: Kerry Holmes
Holmes Air Science

From: Rod MacKenzie
Engineering

RESULTS1.DOC

Subject: Odour testing of samples from Gooloogong Dairy

AWT, Air Quality analysed the odour samples collected at the Gooloogong Dairy by AWT and Holmes Air Science on 1 & 2 March 2000 for odour concentration using dynamic olfactometry in compliance with the current European Standards. All odour samples were analysed in accordance with the European draft standard titled "Air Quality - Determination of Odour Concentration by Dynamic Olfactometry" (release TC264/WG2/N222/E, 97-05-29 12:01). The sample analysis was performed at the AWT Olfactometry Laboratory at Crown Street, Surry Hills on the morning of 2 & 3 March 2000.

Sample	Sampling Time	Odour Concentration OU	Hedonic Tone
Corn Silage Pile⊕	9:30am, 1 Mar 2000	>50,000	+1
Sump	10:20am, 1 Mar 2000	4340	-1
Recycling Pond	11:10am, 1 Mar 2000	1120	0
Bedding Pile	11:45am, 1 Mar 2000	1550	-1
Free Stall Pen	12:20pm, 1 Mar 2000	1010	-4
Wet Weather Pond	1:00pm, 1 Mar 2000	120	-1
Corn Silage Pile	8:30am, 2 Mar 2000	23100	0
Sump	9:15am, 2 Mar 2000	2460	-4
Recycling Pond	10:00am, 2 Mar 2000	730	-3
Bedding Pile	10:35am, 2 Mar 2000	1110	-2
Flush Channel	11:15am, 2 Mar 2000	1700	-2
Wet Weather Pond	12:00pm, 2 Mar 2000	350	-2

⊕ This result is based upon the responses of five panellists. As this sample was presented without any predilution three panel members failed to provide three responses to the presented odour sample. As a consequence, this result does not conform to the requirements of the above quoted standard and is supplied for information.

Rod MacKenzie

Rod MacKenzie
Project Manager
AWT Air Quality

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Australian Water Technologies Pty Ltd ACN 003 848 860

FIGURES

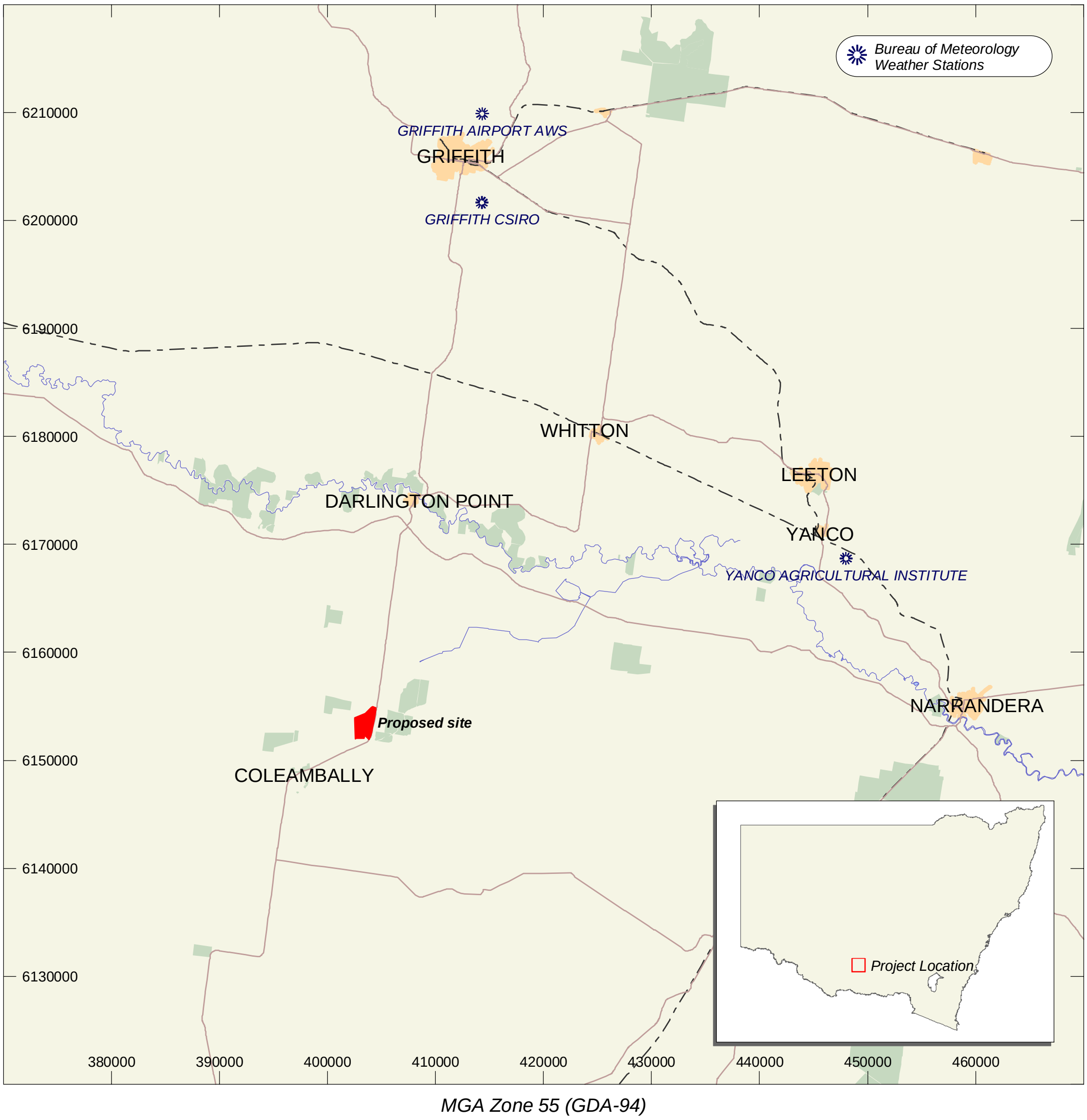


Figure 1 – Location of proposed site and nearby weather stations

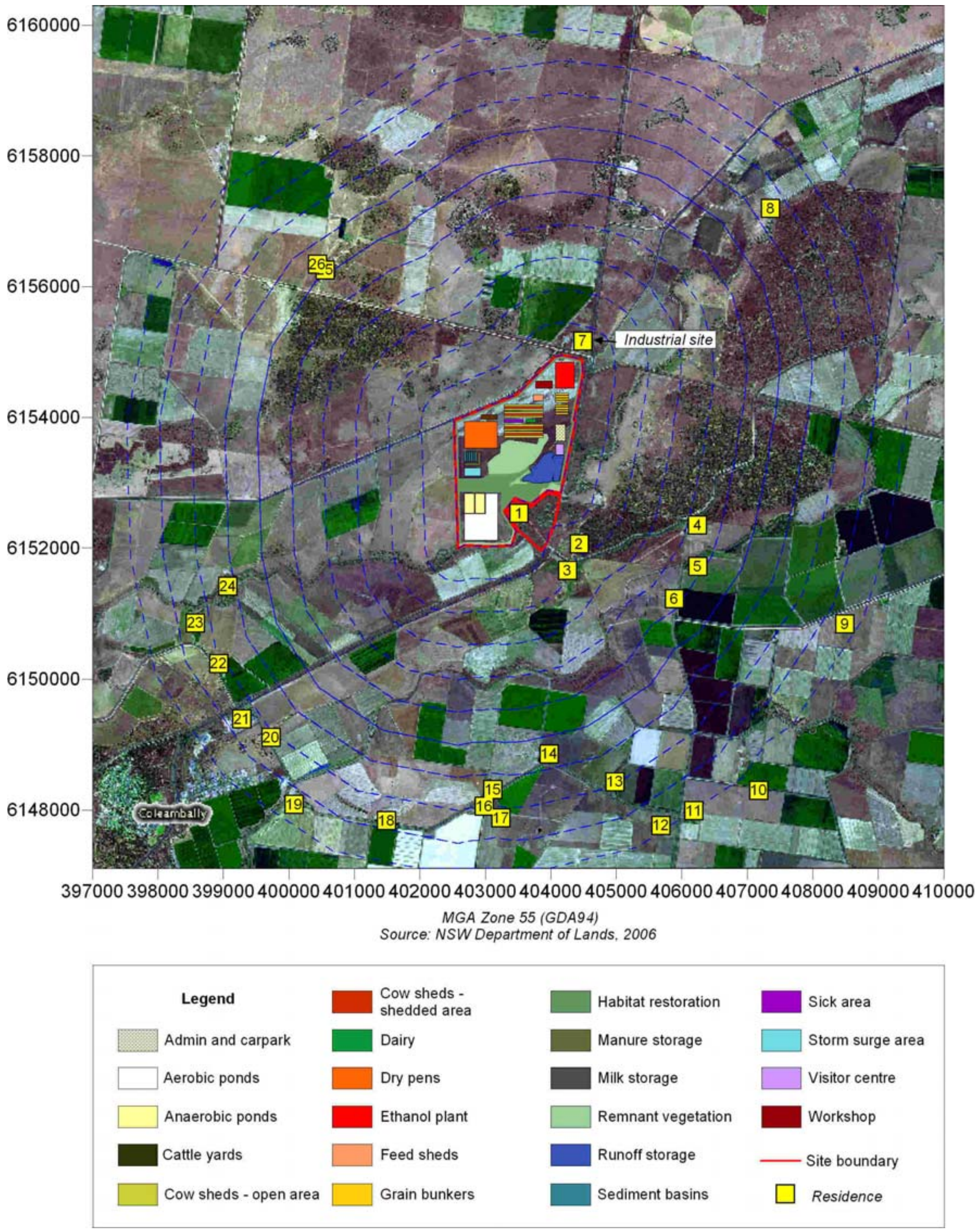


Figure 2 – Proposed site layout and nearby receptors

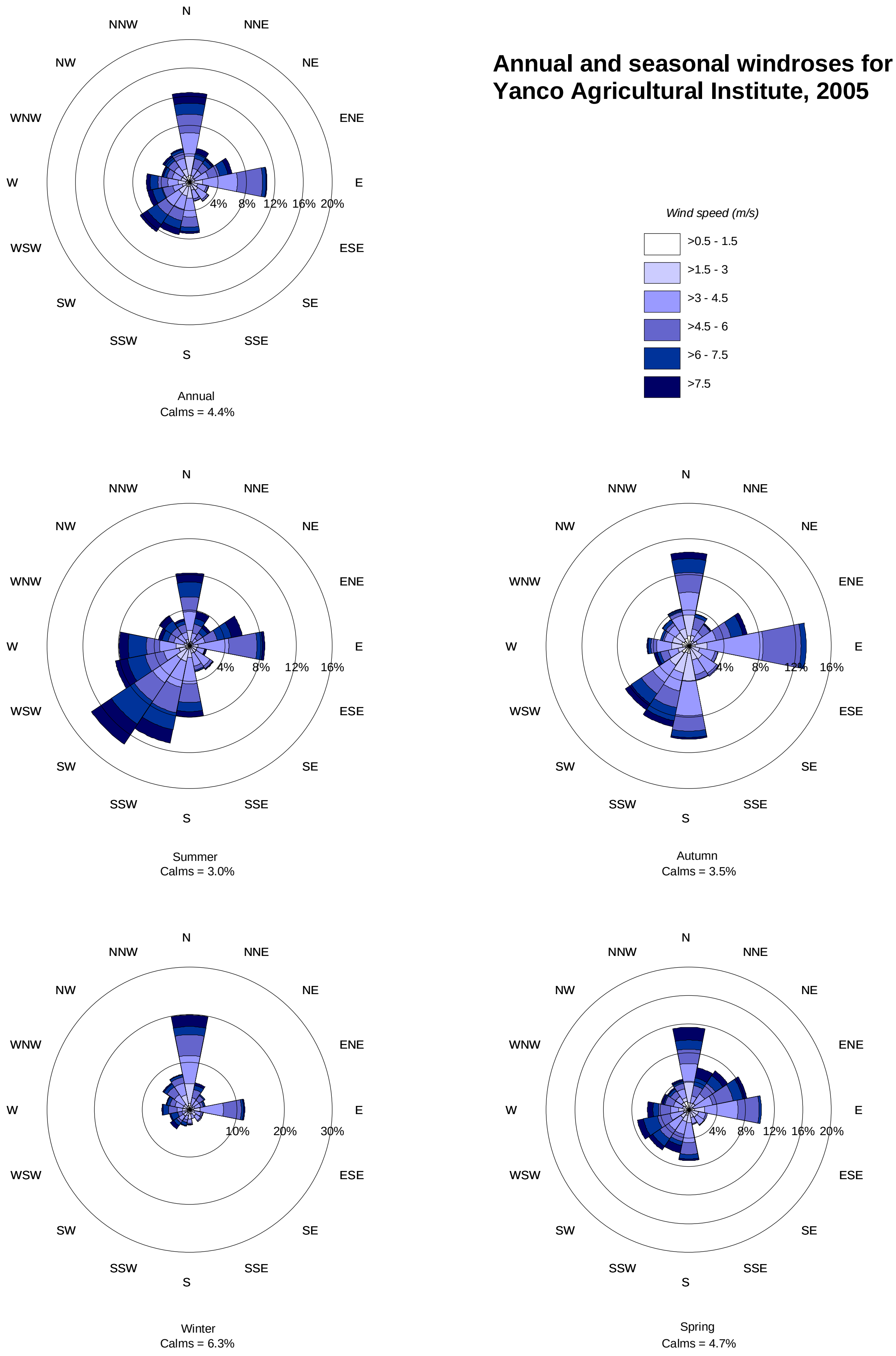


Figure 3 – Annual and seasonal windroses for Yanco Agricultural Institute, 2005

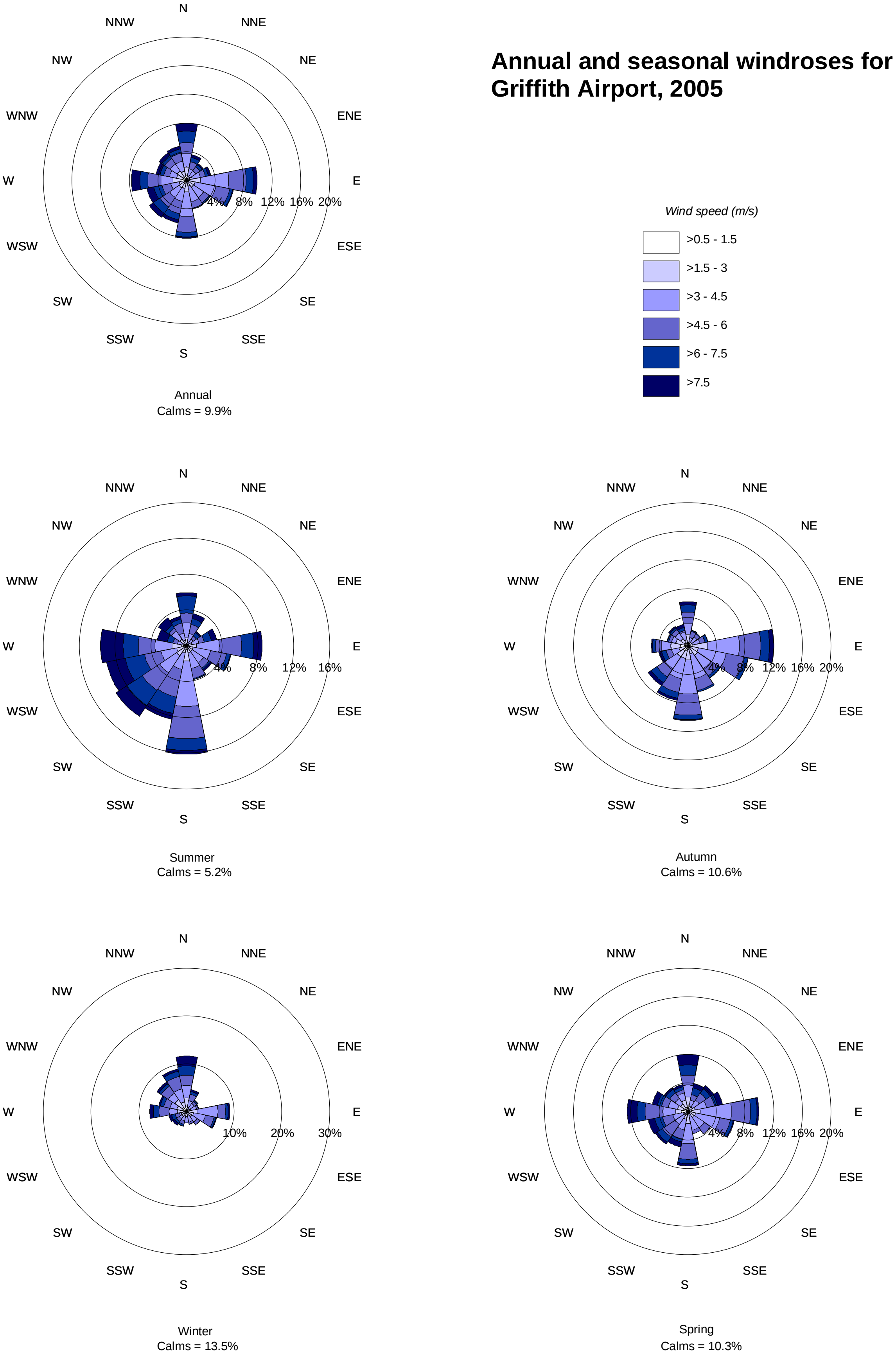


Figure 4 – Annual and seasonal windroses for Griffith Airport, 2005

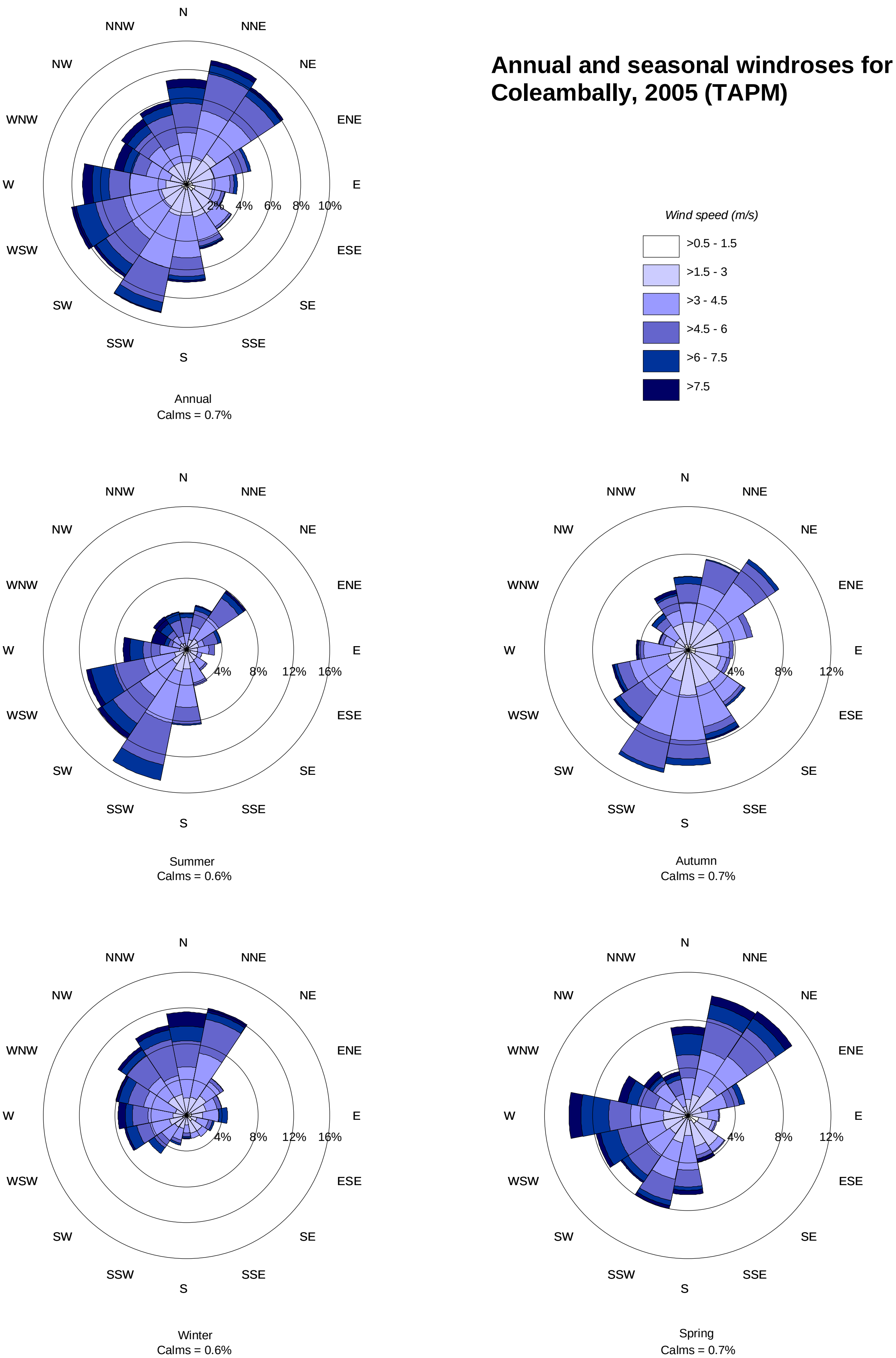


Figure 5 – Annual and seasonal windroses for Coleambally from 2005 TAPM data

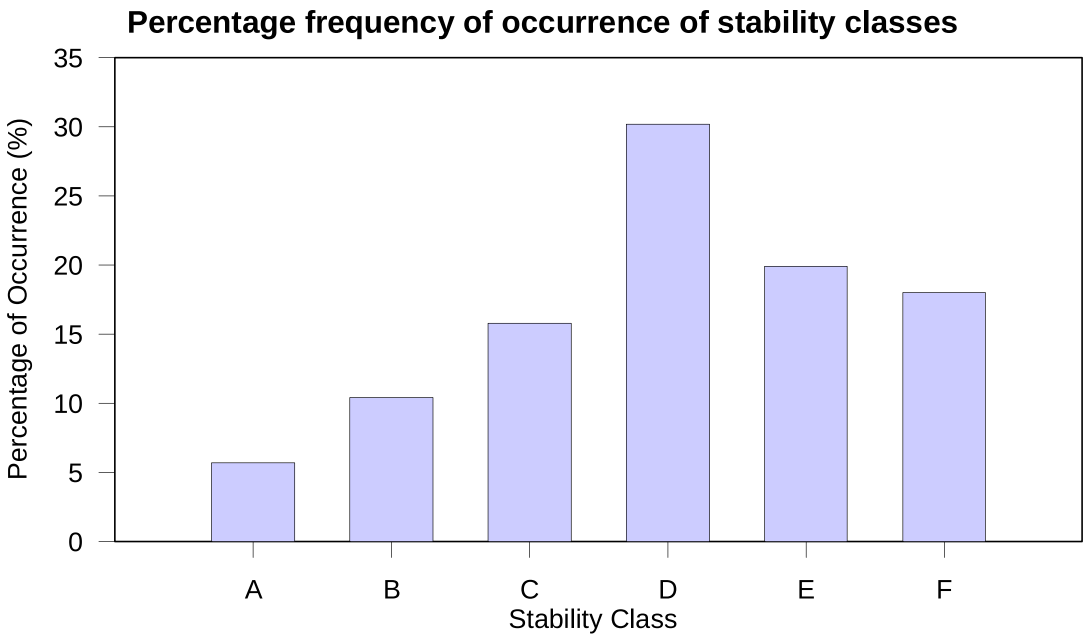


Figure 6 – Percentage frequency of occurrence of stability classes

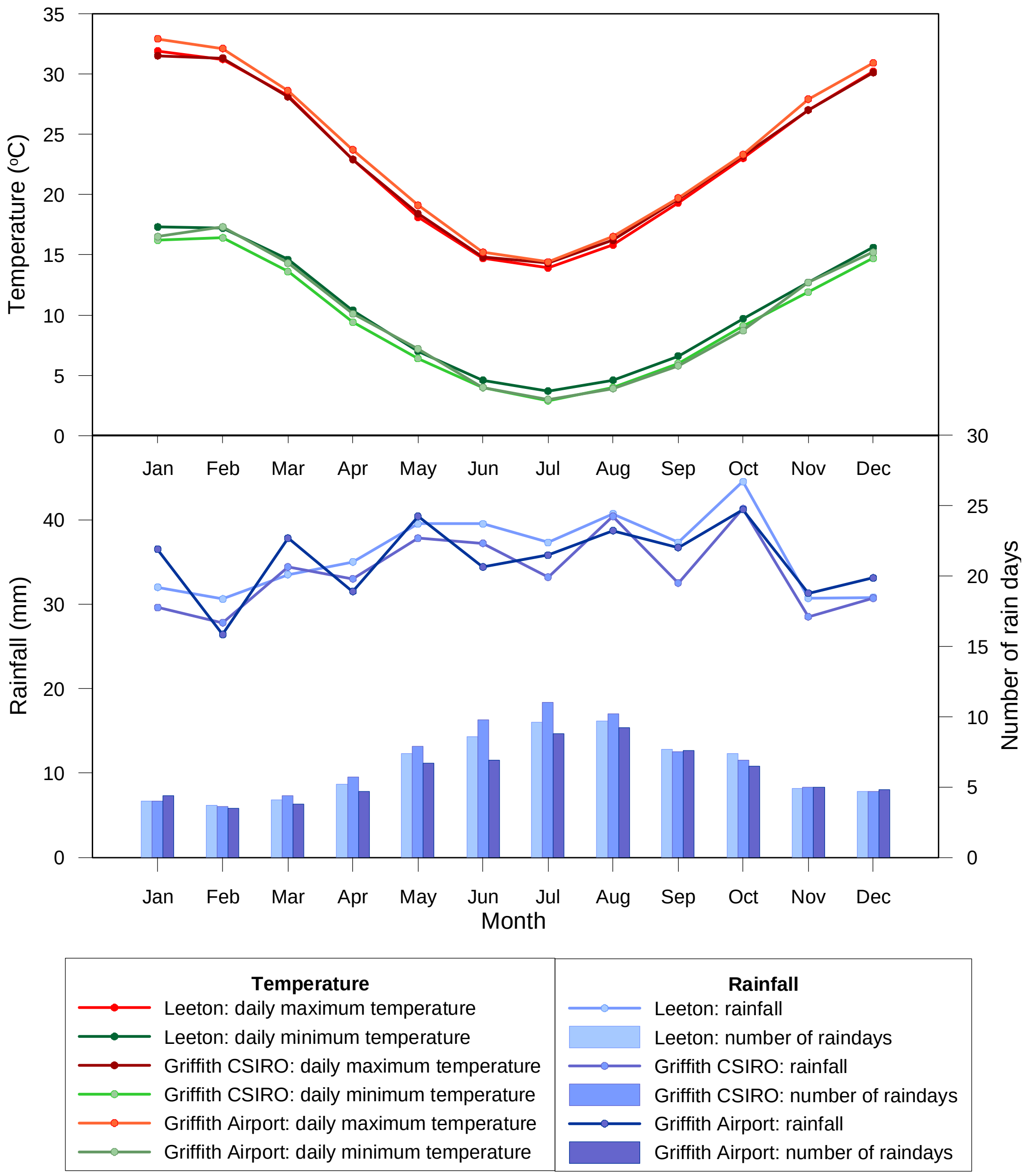


Figure 7 – Temperature and rainfall data from weather stations near the project site

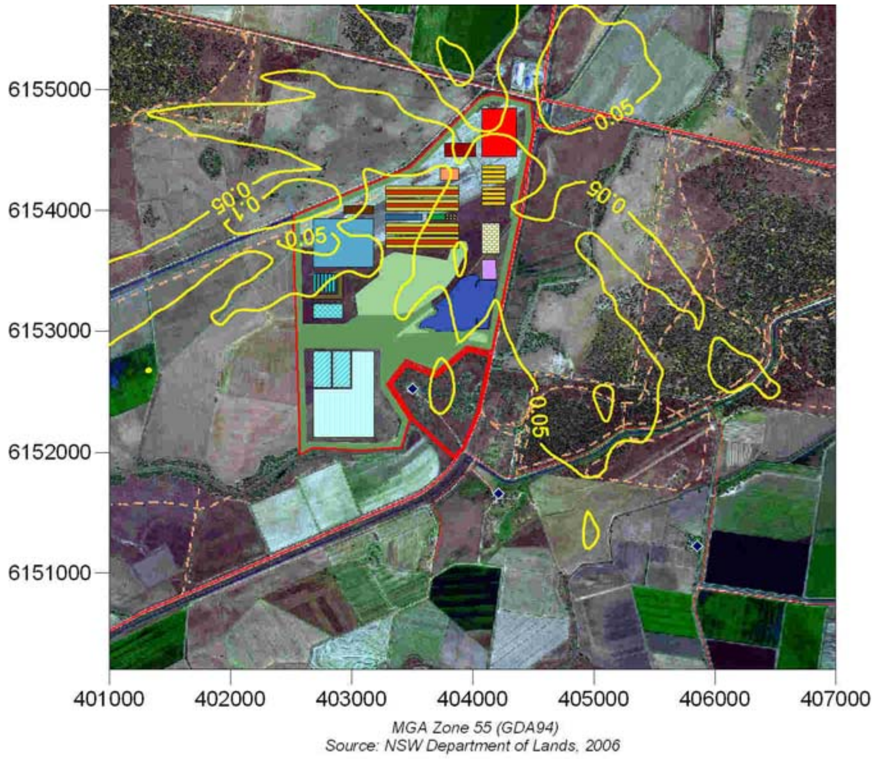


Figure 8 – Predicted 1-hour average CO concentrations (mg/m^3)

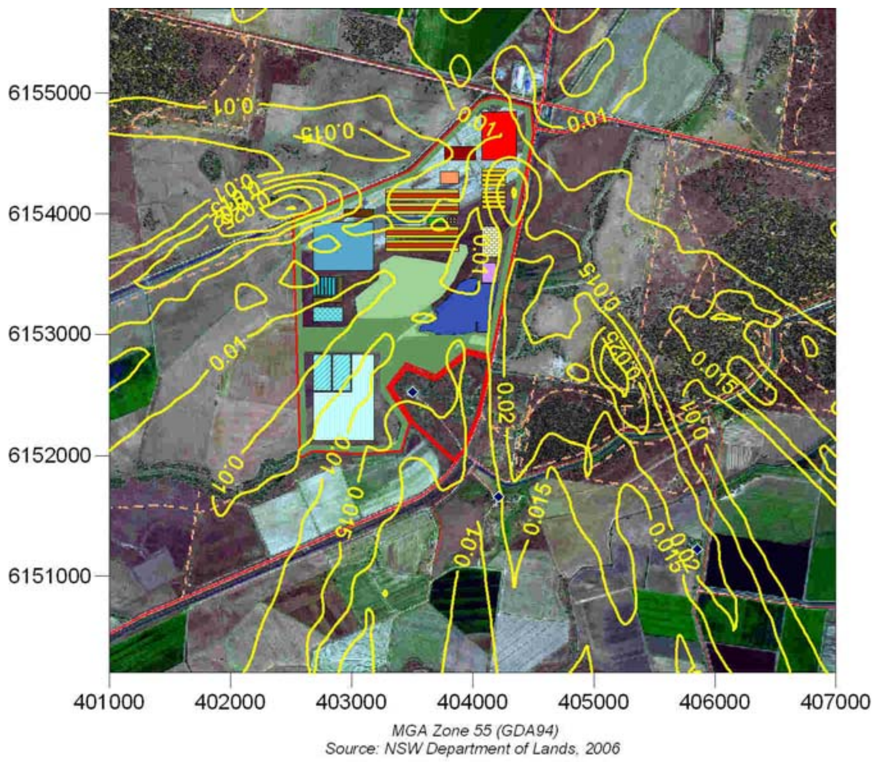


Figure 9 – Predicted 8-hour average CO concentrations (mg/m^3)

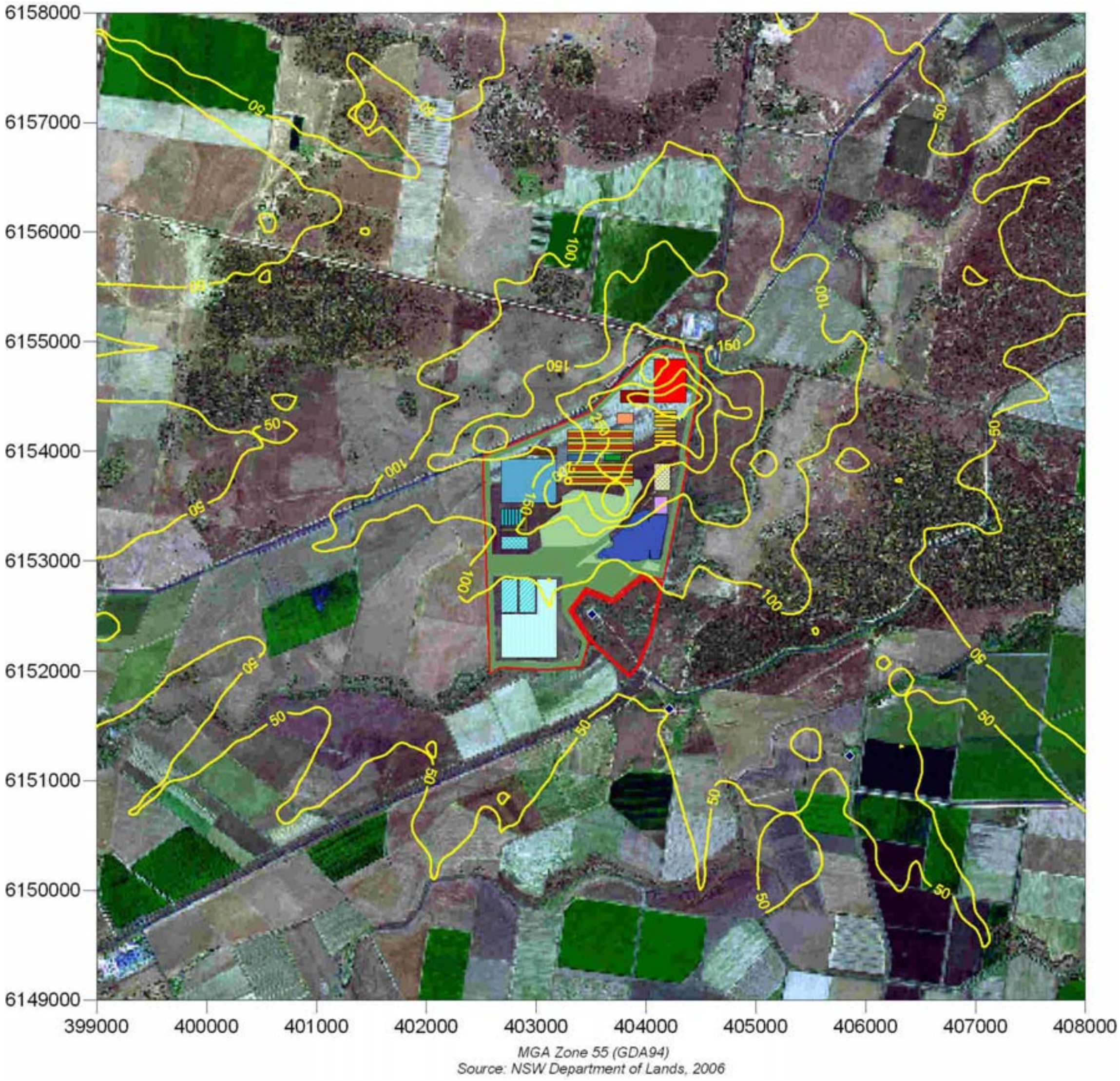


Figure 10 – Predicted 1-hour average NO_x concentrations ($\mu g/m^3$)

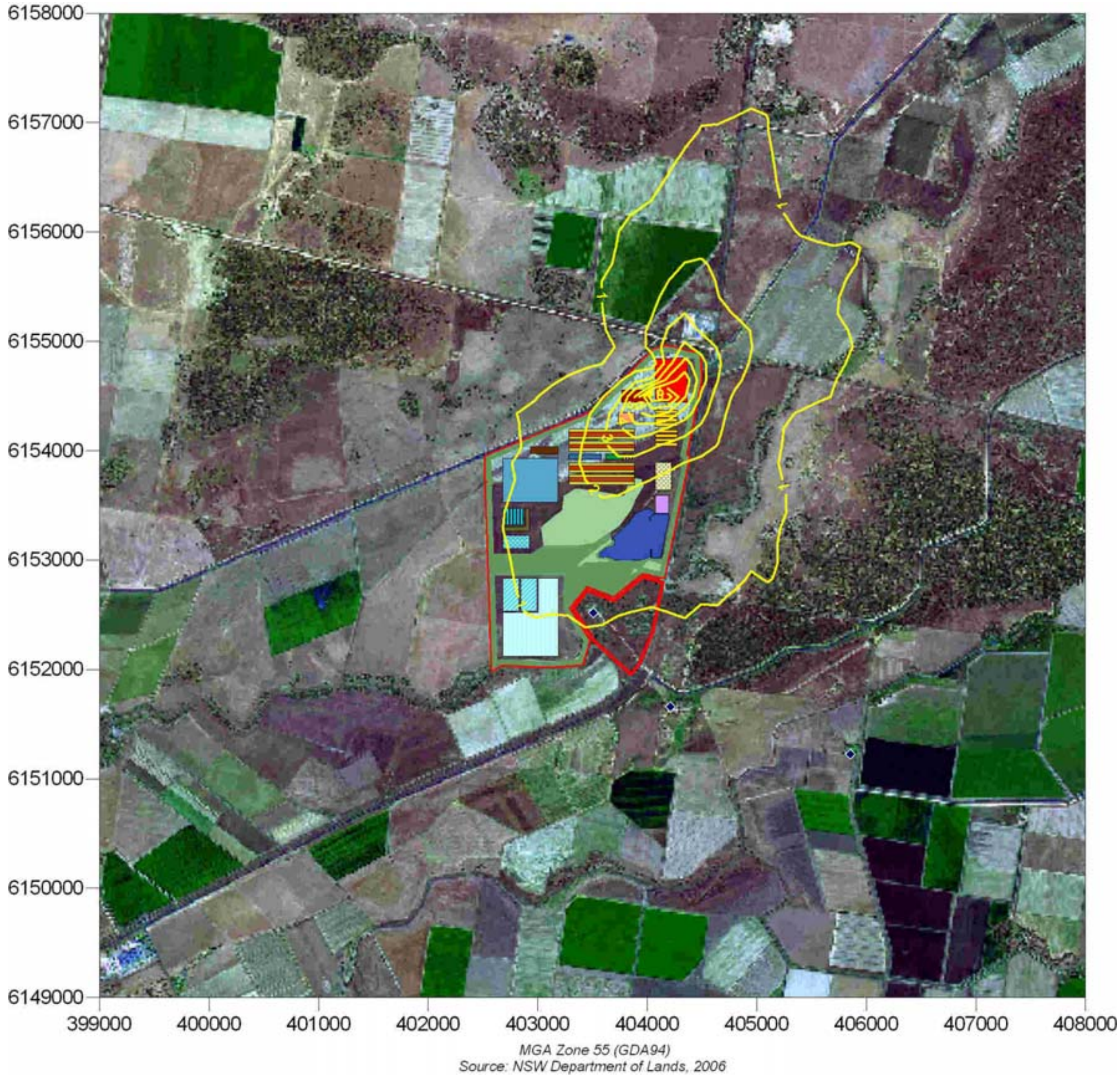


Figure 11 – Predicted annual average NO_x concentrations ($\mu g/m^3$)

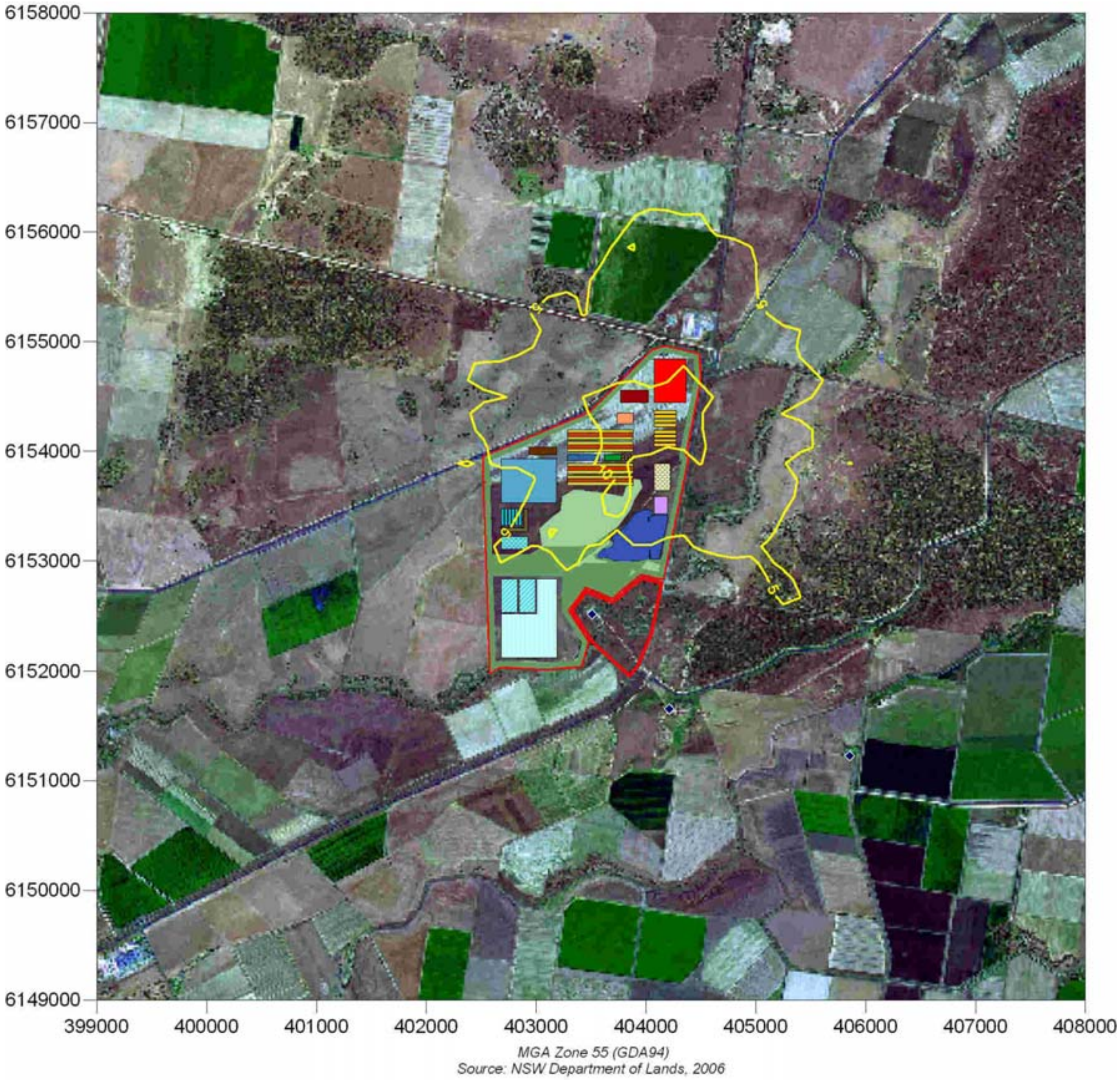


Figure 12 – Predicted 1-hour average SO_2 concentrations ($\mu g/m^3$)

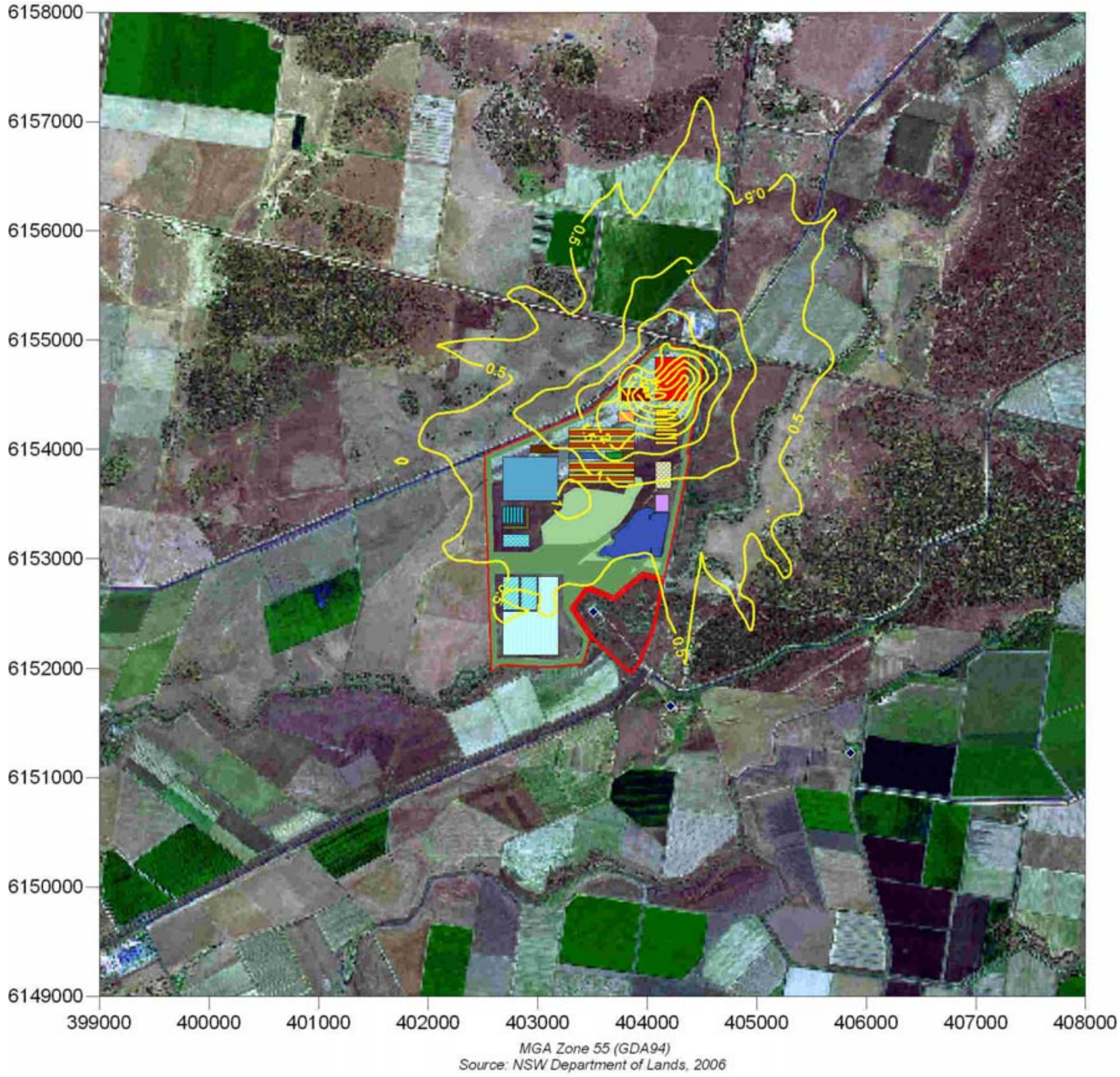


Figure 13 – Predicted 24-hour average SO_2 concentrations ($\mu g/m^3$)

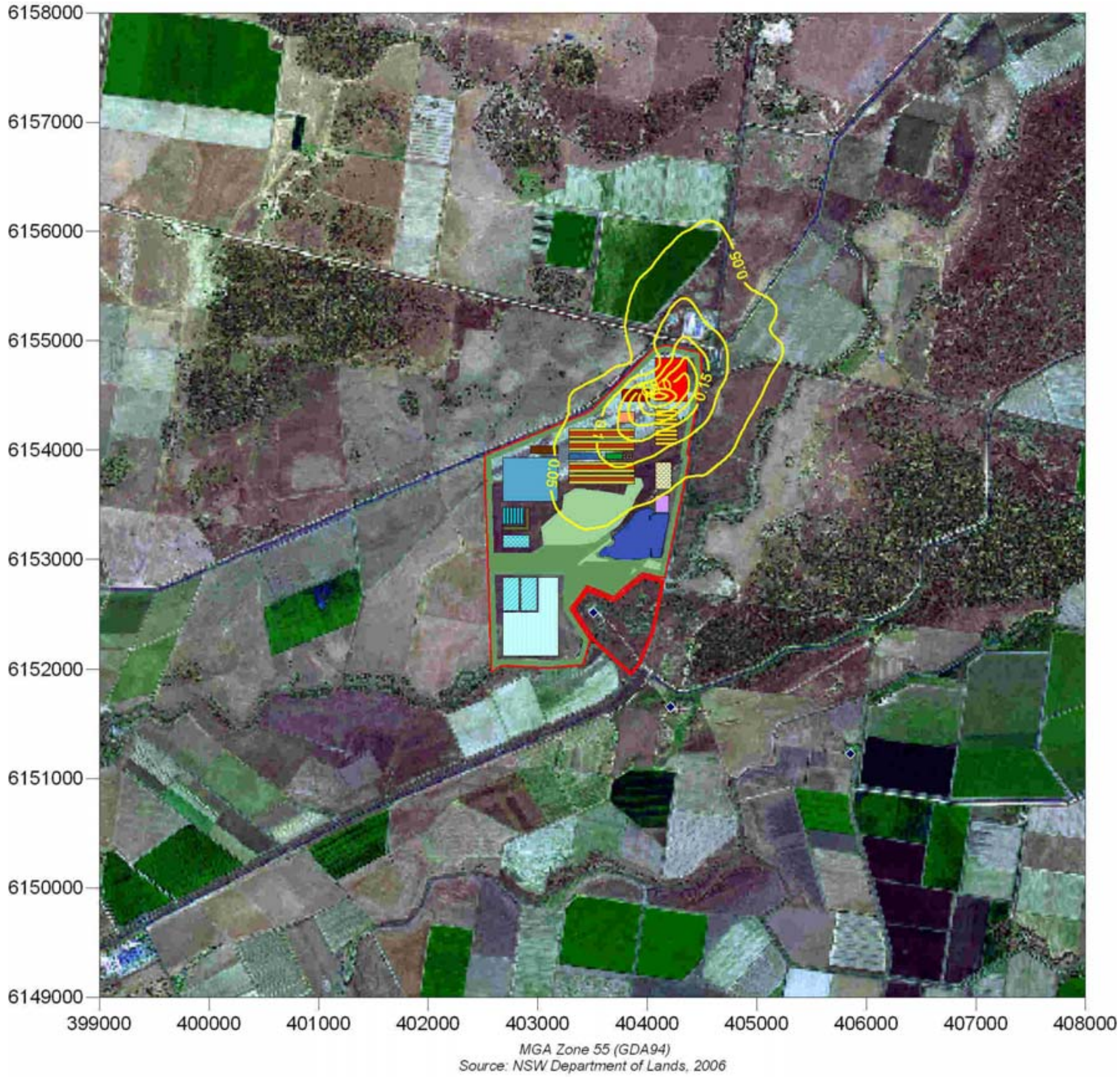


Figure 14 – Predicted annual average SO_2 concentrations ($\mu g/m^3$)

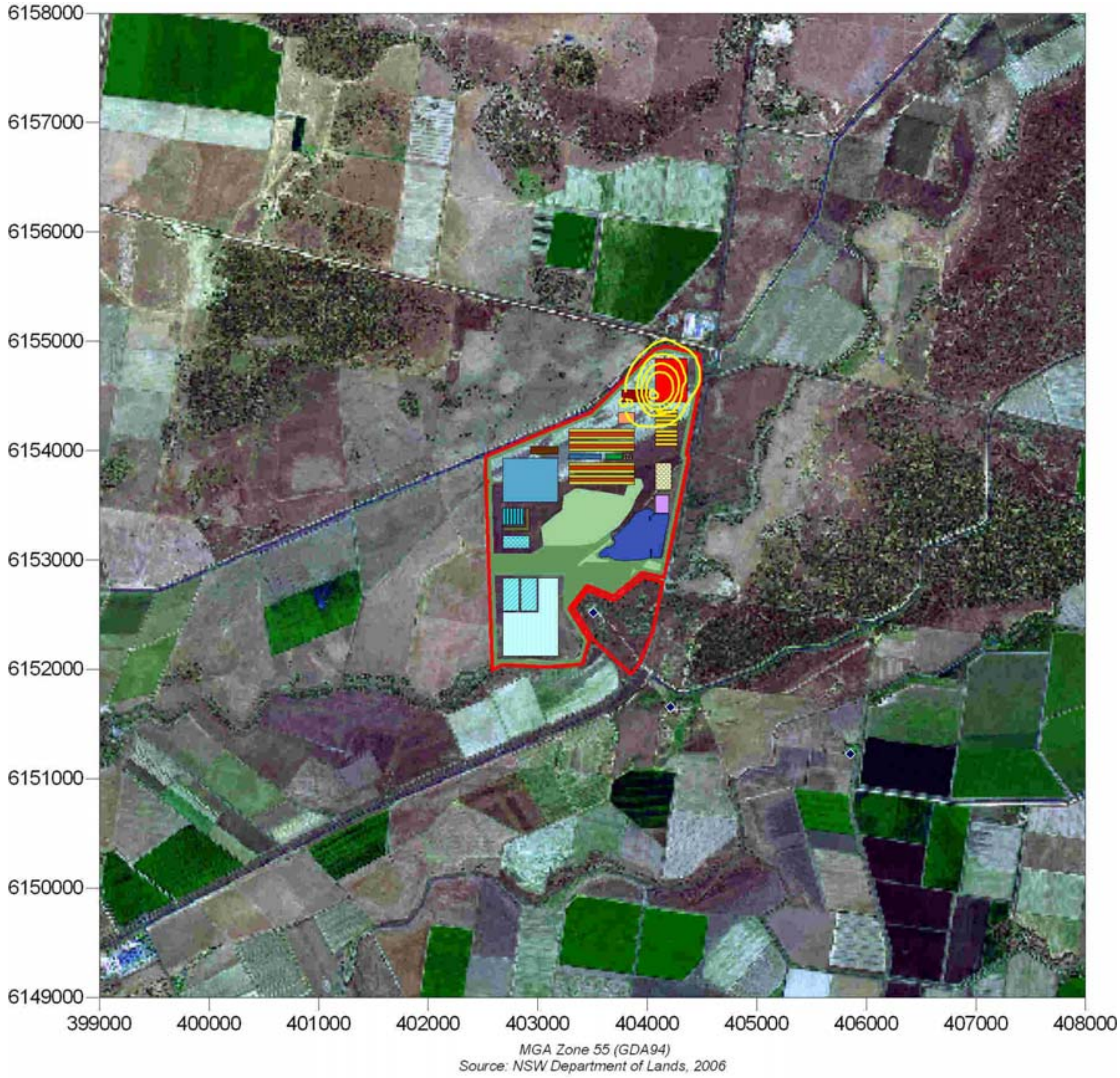


Figure 15 – Predicted annual average TSP concentrations ($\mu g/m^3$)

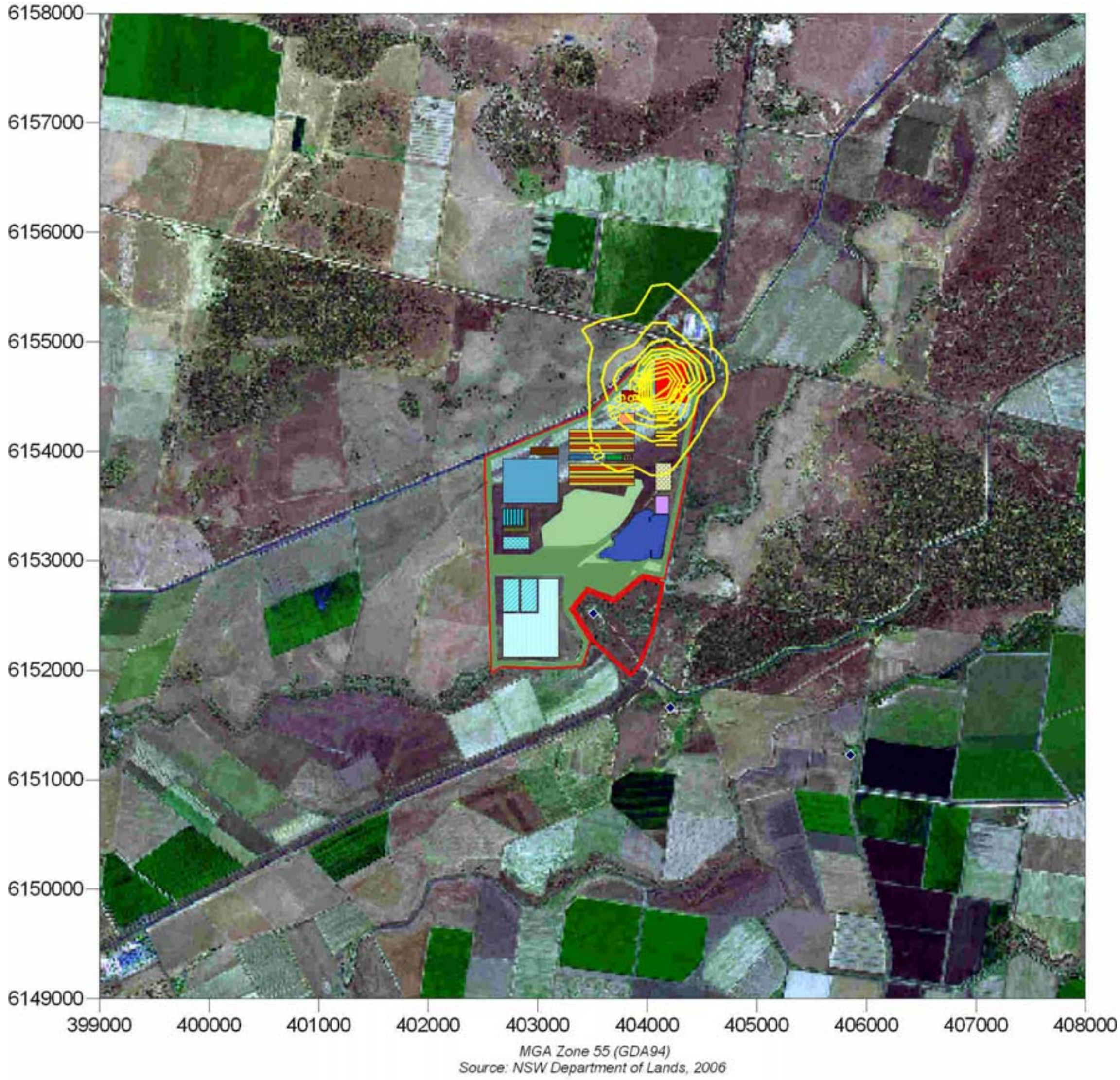


Figure 16 – Predicted 24-hour average PM_{10} concentrations ($\mu g/m^3$)

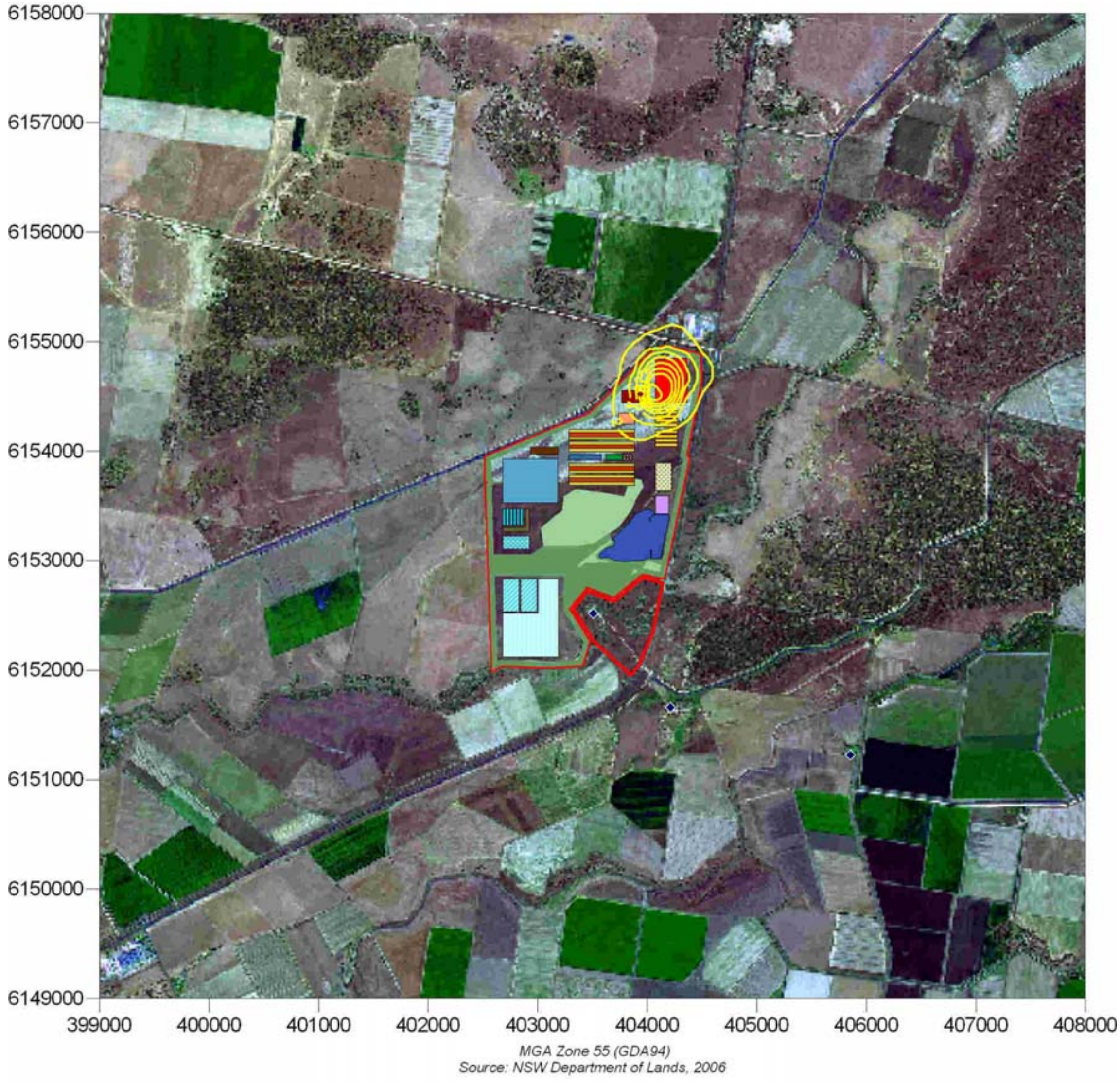


Figure 17 – Predicted annual average PM_{10} concentrations ($\mu g/m^3$)

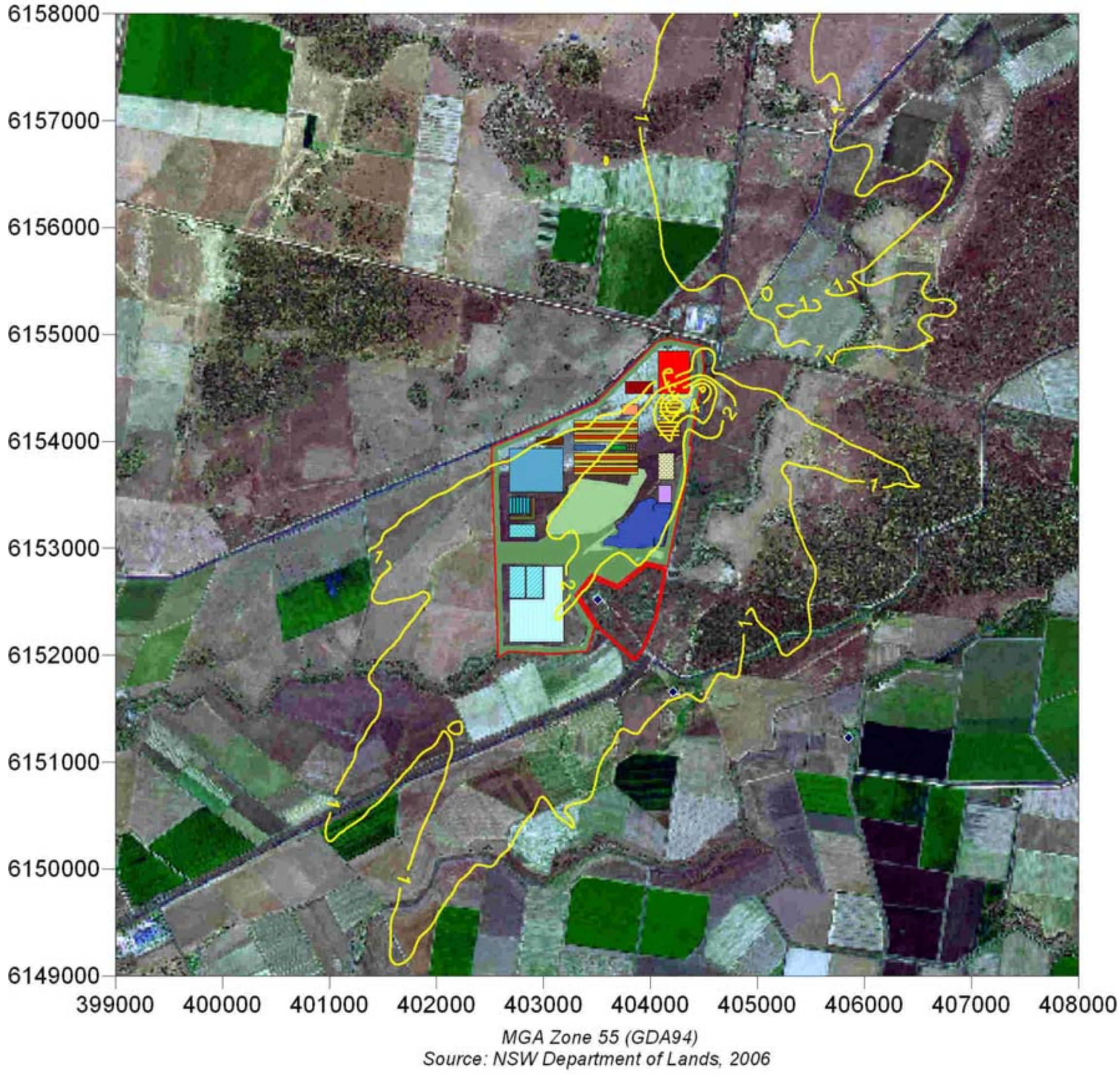
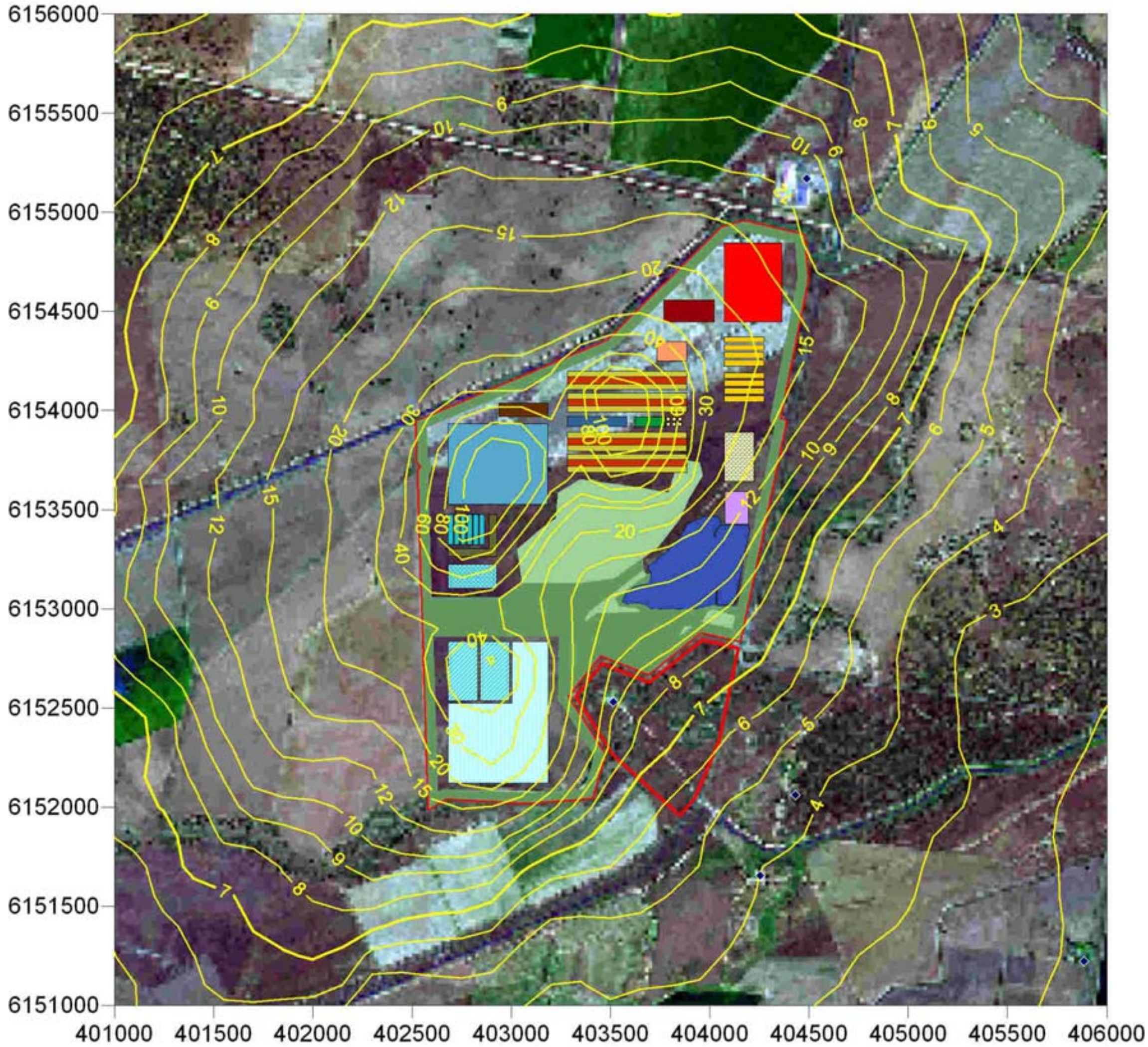


Figure 18 – Predicted 99th percentile compliance odour levels due to emissions from the ethanol plant



MGA Zone 55 (GDA94)
Source: NSW Department of Lands, 2006

Figure 19 – Predicted 99th percentile compliance odour levels at near field receptors due to emissions from the intensive dairy

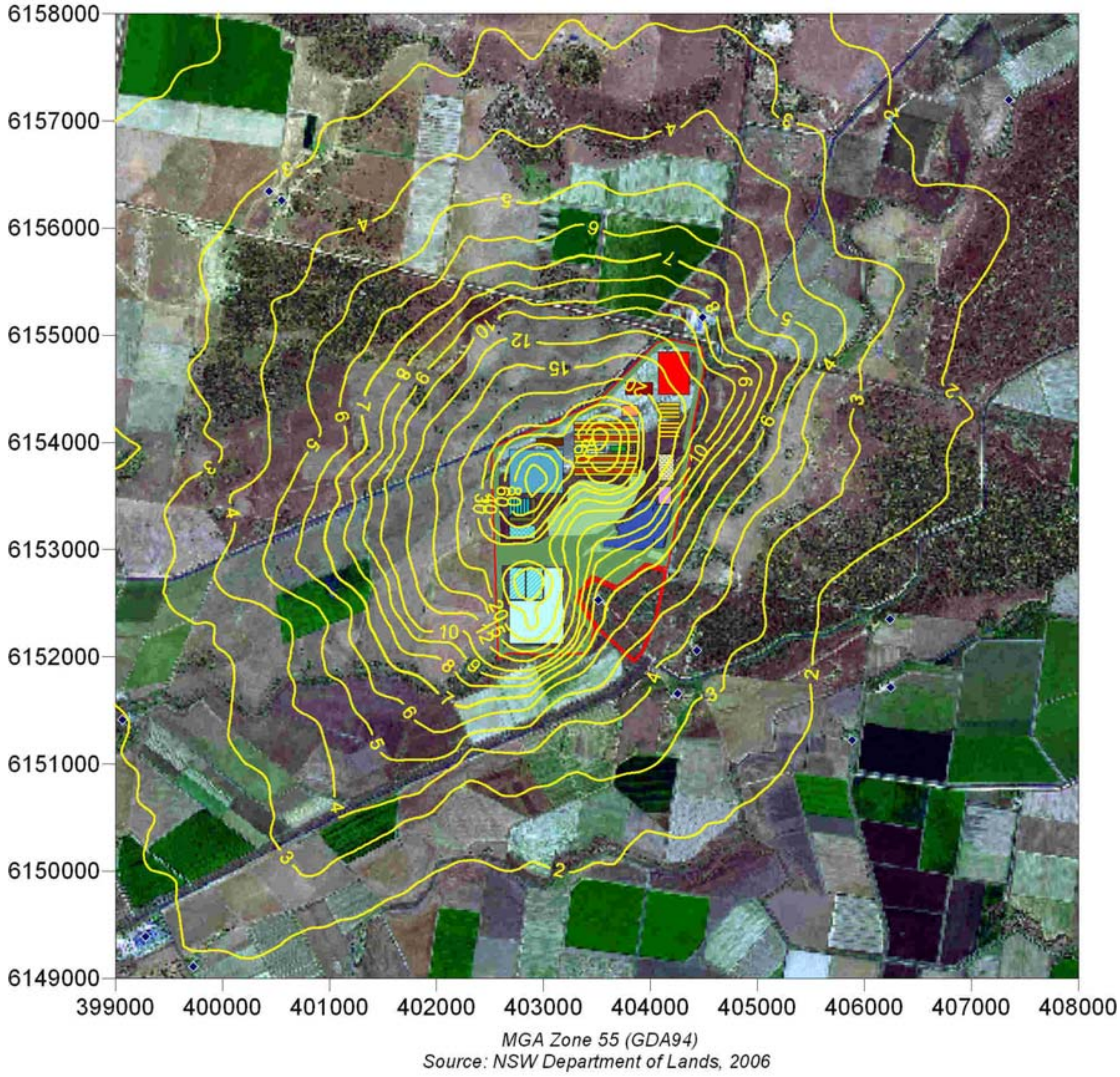


Figure 20 – Predicted 99th percentile compliance odour levels at far field receptors due to emissions from the intensive dairy

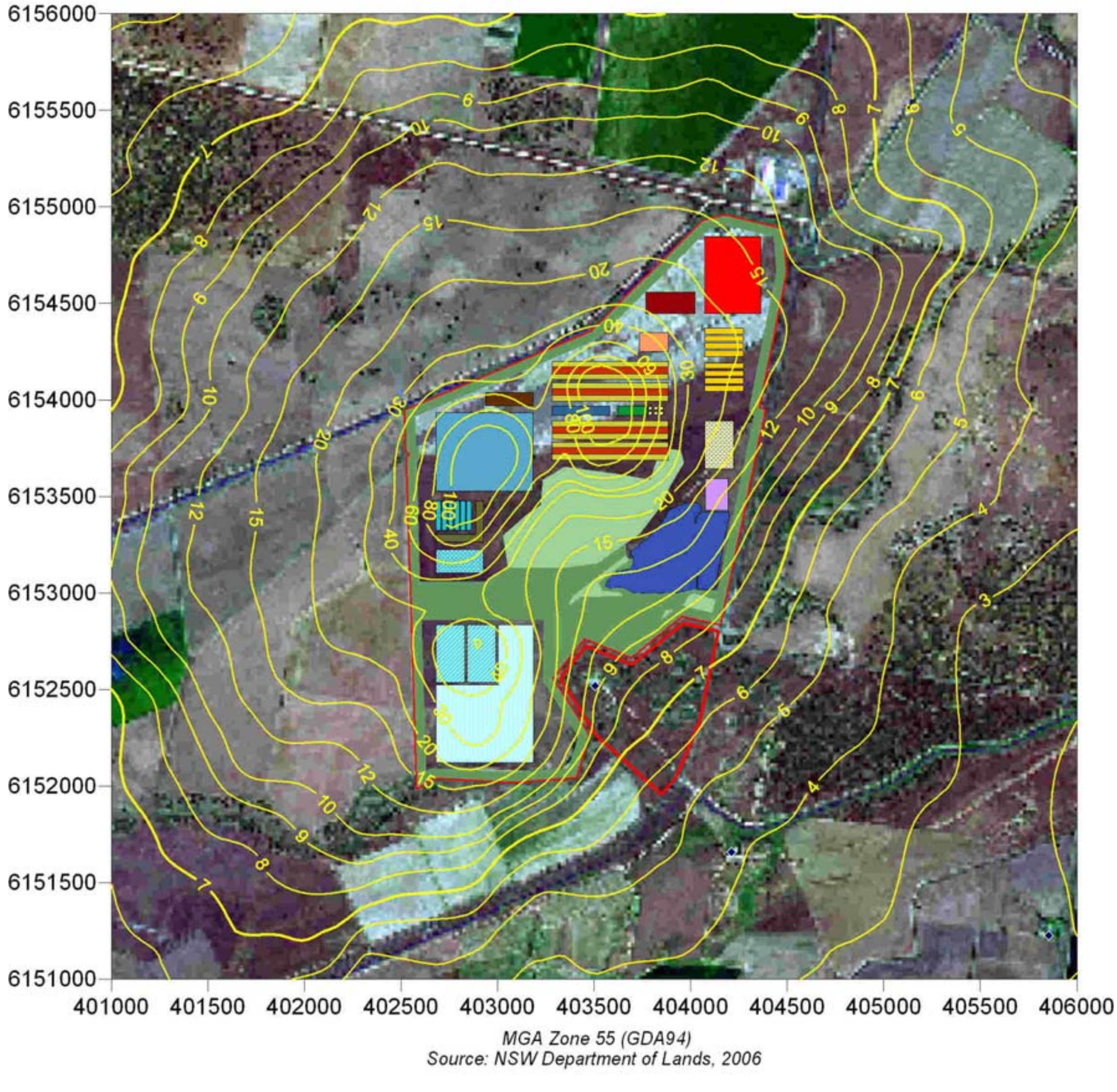


Figure 21 – Predicted 99th percentile compliance odour levels at near field receptors due to emissions from the ethanol plant and intensive dairy

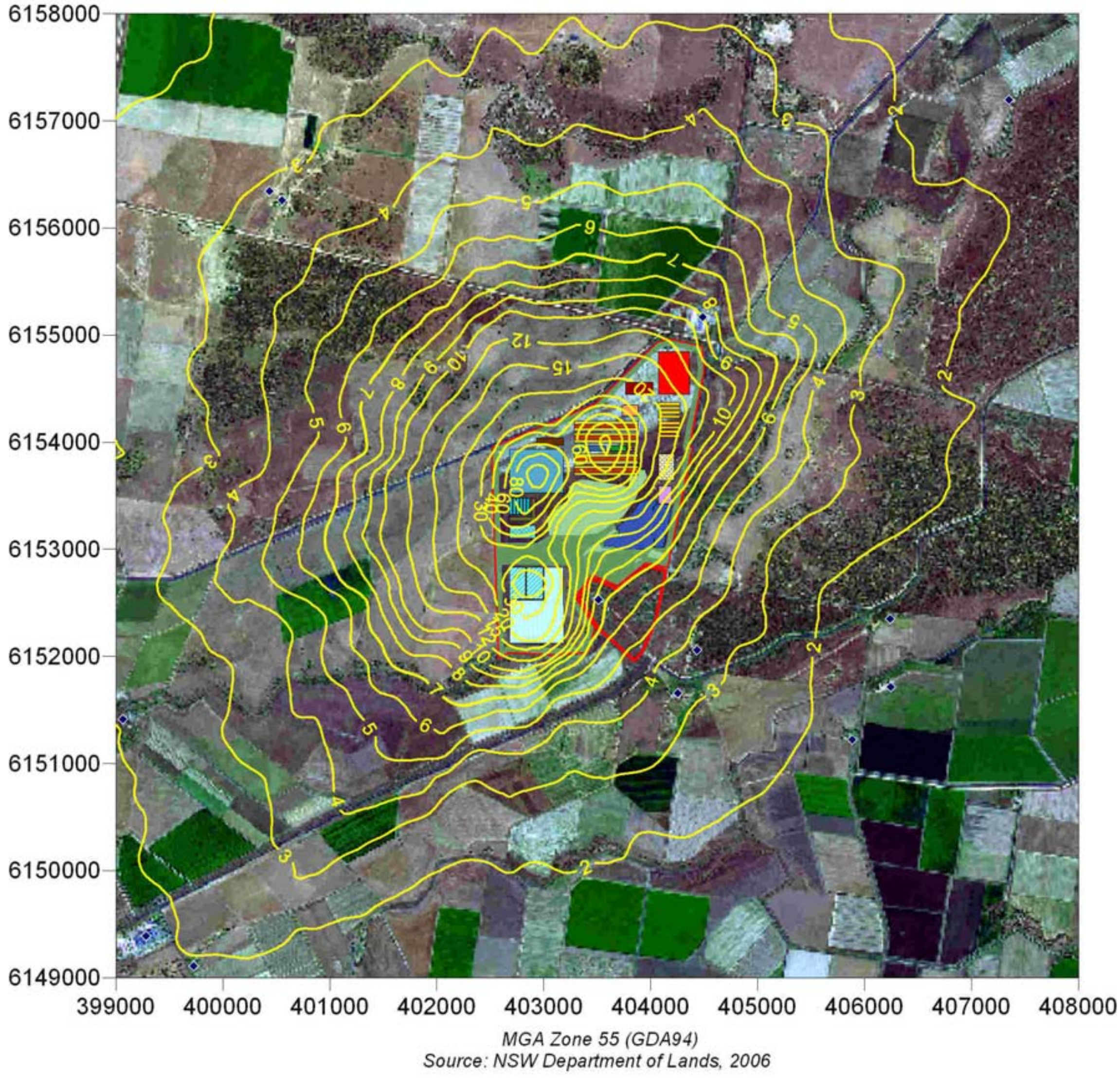


Figure 22 – Predicted 99th percentile compliance odour levels at far field receptors due to emissions from the ethanol plant and intensive dairy