Final Report

LONDONDERRY MUSHROOM FARM MODIFICATION - ODOUR ASSESSMENT

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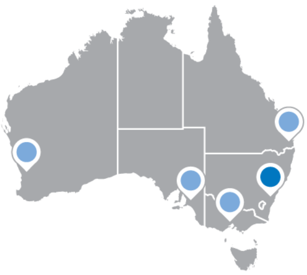

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GLOSSARY OF TERMS

Term	Definition
Air dispersion modelling	Mathematical simulation of how air quality parameters, including odour, disperse in the atmosphere.
CALPUFF	A multi-layer, multi-species, non-steady state puff dispersion model that can simulate the effects of time- and space-varying meteorological conditions on pollutant transport, transformation and removal.
Emissions	Release of air quality parameters to air.
Gaussian	The assumption that air dispersion model predictions have a Gaussian distribution, meaning that the pollutant distribution has a normal probability distribution
Mixing height	The depth of the atmospheric mixed layer, the height to which the air is mixed.
OU	Odour unit
Percentile	A value on a scale that indicates the percent of a distribution that is equal to it. For example, the 99^{th} percentile indicates that there are one percent of all predicted values that are greater than this value, and 99 percent that are lower
Sensitive receptor	A location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area. An air quality impact assessment should also consider the location of known or likely future sensitive receptors
Stability class	A measure of the ability of the atmosphere to mix or disperse a plume. One method of classifying varying stability classes is the Pasquill-Gifford scheme where A-B-C refer to unstable (well mixed) atmospheric conditions, D refers to neutral and E-F refer to stable (unmixed).
Wind rose	A graphical representation showing the frequency of occurrence of winds by direction and strength

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1. INTRODUCTION

Development Application (DA) 08_0255 was granted approval in January 2012 for additions to the existing mushroom substrate plant at Mulgrave and the establishment of a new mushroom farm at 521 The Northern Road, Londonderry.

The operator of the approved growing facility at Londonderry farm wishes to implement new state of the art picking and packing machinery. The amended facility will involve larger buildings than those approved.

The proposed amendment involves implementation of the new picking and packing machines as well as a different way in which mushrooms are grown. Traditionally mushrooms are grown in boxes that are stacked vertically on top of each other and then picked by hand from each box once they reach the required size.

The new machinery automatically packs the mushrooms once picked. The machine works on a flat plane which alters the way the mushrooms are traditionally grown stacked on top of each other. This new method of packing requires a large floor area as it is no longer possible to stack the growing boxes on top of each other.

Whilst the proposed development will increase the approved floor space in order to accommodate the machine there is no increase in the capacity and quantity of mushrooms to be grown.

Pacific Environment (previously PAEHolmes) completed an air quality and greenhouse gas assessment for the initial DA with the final report (dated 11 November 2010) attached as Appendix K to the Environmental Assessment (EA) submitted to the Department of Planning and Environment in support of DA 08_0255 (PAEHolmes, Air Quality Assessment - Proposed Mushroom Farm, Londonderry, 2010). Due to the proposed modification to the layout, a revised odour assessment is required to support the application.

This report documents the process and outcomes of a Level 3 Odour Assessment, completed in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW developed by the (NSW EPA, 2005) (herein referred to as the “Approved Methods”).

2. PROJECT DESCRIPTION

A mushroom farm is proposed to be developed at 521 The Northern Rd, Londonderry NSW 2753. This site will operate in conjunction with the Mulgrave substrate plant operated by Elf Farm Supplies. Mushroom substrate produced at Mulgrave will be used at the Londonderry site. Spent compost will be further processed on site and used as soil conditioner.

The mushroom farm site is located approximately 10 km south west of Windsor and is directly adjacent to the Castlereagh Nature Reserve (**Figure 2-1**). The site has some residential properties to the northeast and south, and directly to the east of the site is the Castlereagh Nature Reserve. The nearest sensitive receptor is approximately 200 m to the northeast.

The terrain surrounding the mushroom farm site is relatively flat and the maximum elevations are less than 100 m above sea level (**Figure 2-2**).

Figure 2-3 presents the proposed updated site layout for the mushroom farm at Londonderry. The site is located on a 25 hectare rural site on The Northern Road. The farm would have a weekly production of 220 tonnes per week of fresh mushrooms, employing 113 workers in total.

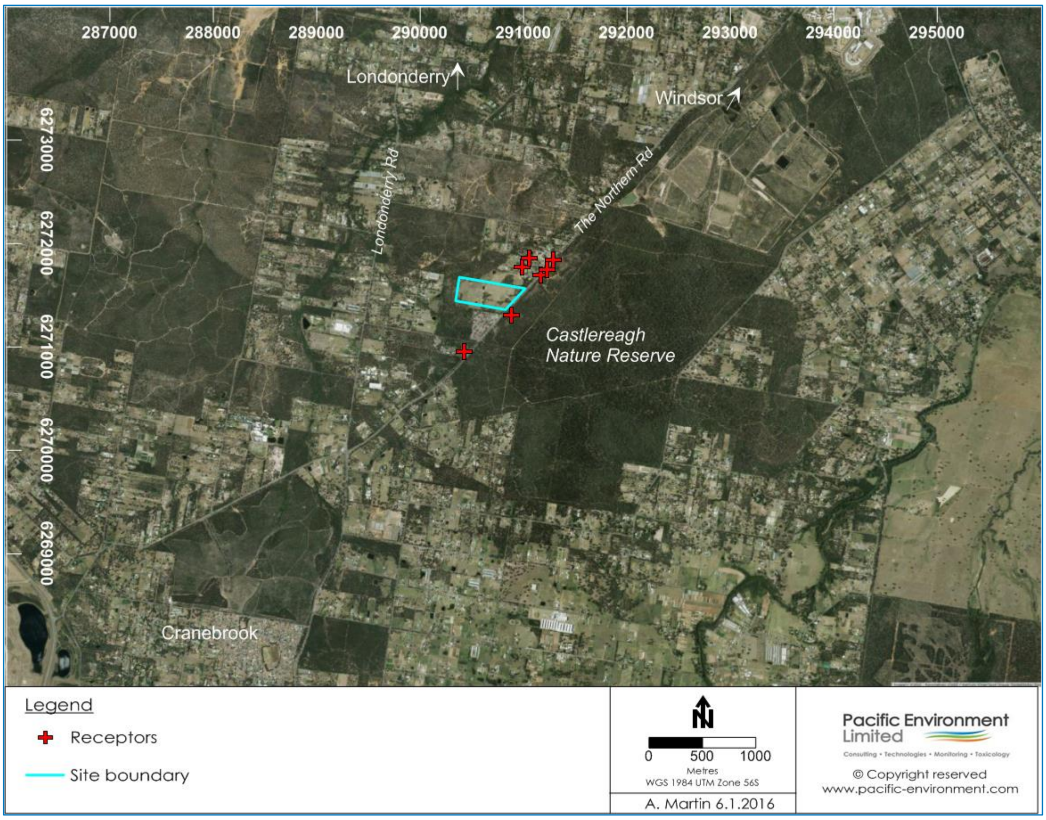


Figure 2-1: Site locality

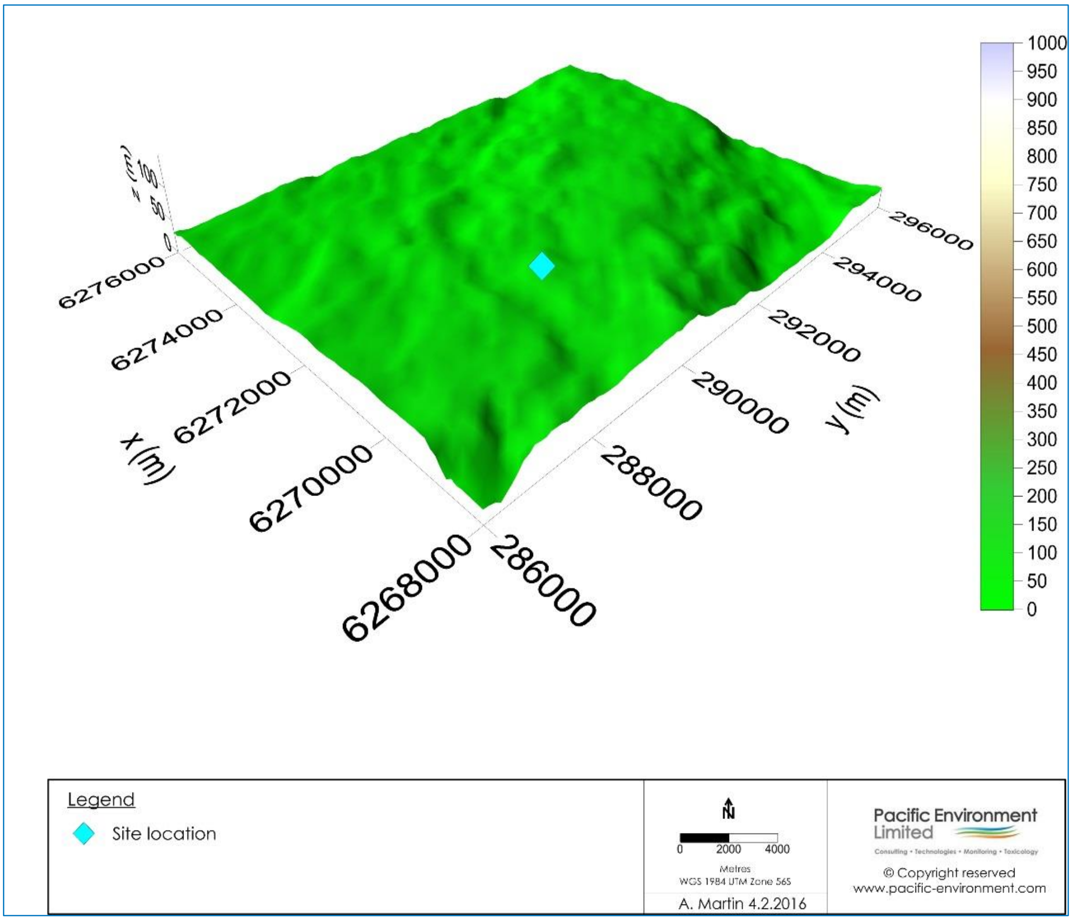


Figure 2-2: Terrain map

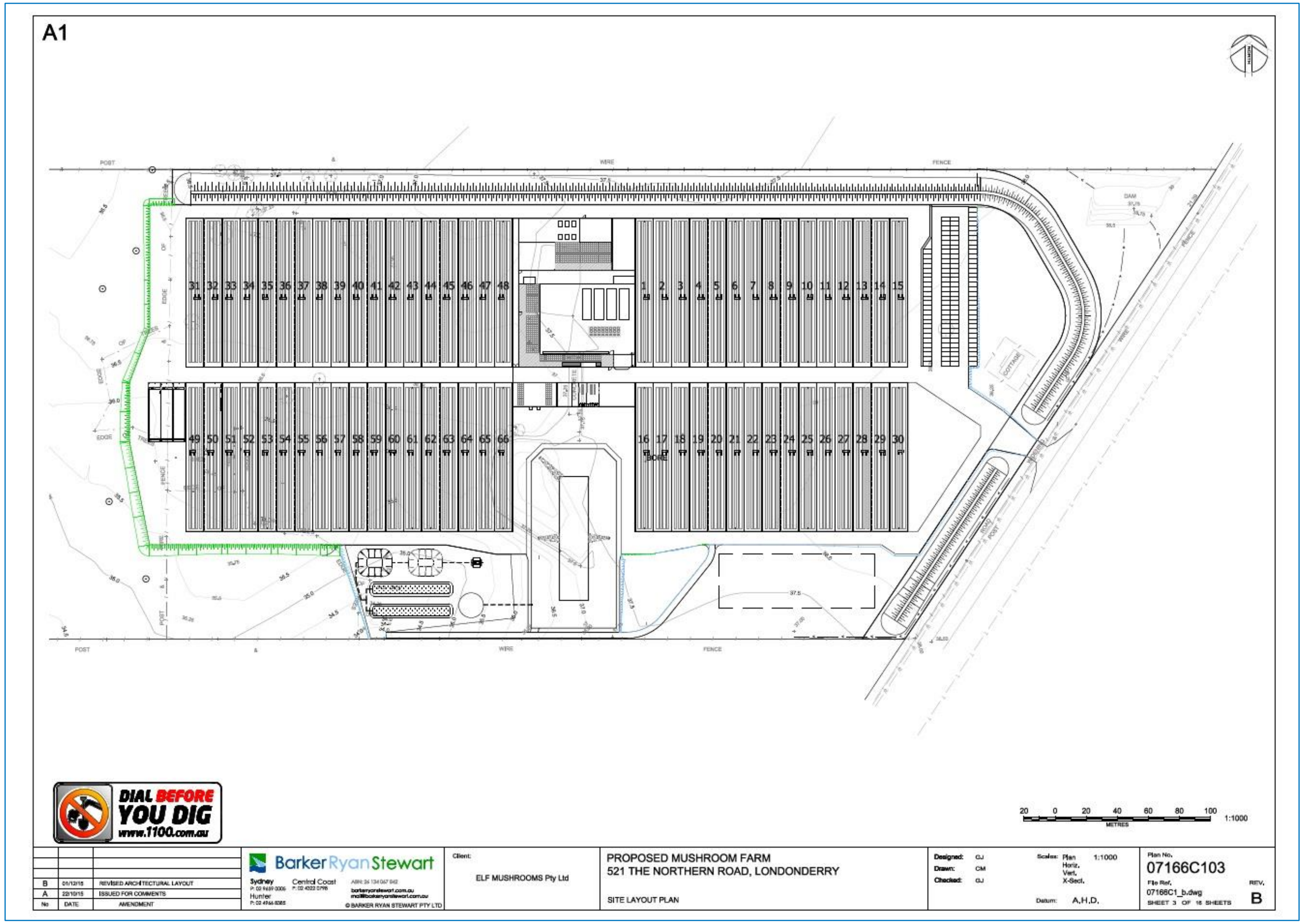


Figure 2-3: Proposed updated site layout

2.1 Receptors

Seven discrete receptors were chosen to assess predicted odour impacts at nearby residences (**Table 2-1**), and these are also shown in **Figure 2-1**.

Gridded receptors were chosen to assess predicted odour impacts across the entire modelling domain at a resolution of 0.1 x 0.1 km.

Table 2-1: Discrete receptors

Sensitive receptor ID	Easting (m)	Northing (m)
1	290879	6271308
2	291168	6271699
3	291231	6271743
4	290989	6271771
5	291053	6271857
6	291285	6271843
7	290425	6270950

3. ODOUR LEGISLATION AND GUIDELINES

3.1 Legislation

The three most important pieces of legislation for preventing and controlling odour in NSW are:

- Environmental Planning and Assessment Act 1979 (EP&A Act);
- Protection of the Environment Operations Act 1997 (POEO Act); and
- Local Government Act 1993 (LG Act).

The EP&A Act deals with land-use planning, development, assessment and approvals. The POEO Act requires that no occupier of any premises causes air pollution (including odour) through a failure to maintain or operate equipment or deal with materials in a proper and efficient manner. The operator must also take all practicable means to minimise and prevent air pollution (sections 124, 125, 126 and 128 of the POEO Act).

The POEO Act includes the concept of "offensive odour" (section 129) and states it is an offence for scheduled activities to emit "offensive odour".

The LG Act gives local councils the power to deal with public nuisance, including odour emissions.

3.2 Guidelines

Odour is probably the most widespread and complex local air quality issue in Australia. It often accounts for the majority of complaints received by regulatory authorities and can be a major source of annoyance and stress in affected communities.

In November 2006, the NSW EPA released two guidance documents: Technical framework for the Assessment and Management of Odour from Stationary Sources in NSW and its associated Technical notes for the Assessment and Management of Odour from Stationary Sources in NSW. These documents require the user to follow the dispersion modelling requirements in the Approved Methods (NSW EPA, 2005).

The discussion in this report draws extensively from those documents, which outline the NSW EPA's proposed approach for the assessment of odour emissions, using a three-level system of odour impact assessment of increasing complexity and detail. Depending on the individual characteristics of a new development and its proposed location, a varying degree of investigation into the potential for odour impacts may be required.

- Level 1 is a screening-level technique based on generic parameters for the type of activity and site. It requires minimal data and uses simple equations to provide a broad estimate of the extent of any odour impact. It may be used to identify the potentially affected zone and site suitability for a proposed facility or new neighbouring development or expansion of an existing facility.
- Level 2 is a screening-level dispersion modelling technique, using worst-case input data (rather than site-specific data). It is more rigorous and more realistic than a Level 1 assessment. It may be used to assess site suitability and odour mitigation measures for new, modified or existing activities. This approach has been taken in this assessment.
- Level 3 is a refined-level dispersion modelling technique using site-specific input data. This is the most comprehensive and most realistic level of assessment available. It may be used to assess site suitability and odour mitigation measures for new, modified or existing activities.

3.2.1 Odour performance criteria

Odour impacts are determined by several factors. The most important factors (the so-called **FIDOL** factors) 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.

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 sulfide, 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.

In summary, 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.

The Approved Methods and NSW EPA framework documents include some recommendations for odour criteria. The criteria have been refined by NSW EPA to take account of population density in the area.

The difference between odour criteria 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 criteria assumes that 7 odour units (OU) at the 99th percentile would be acceptable to the average person, but as the number of exposed people increases there is a risk that sensitive individuals would be exposed. The criterion of 2 OU at the 99th percentile is considered to be acceptable for a large population group with a variety of sensitivities to odours.

Table 3-1: Odour assessment performance criteria

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

Sources: *NSW EPA, 2005, p.38,* (NSW EPA, 2006a)*, p.21*

Based on the number of residential dwellings proposed for the development, the number of people potentially affected by odour is likely to be approximately 30 residents or less in the surrounds. The appropriate odour criterion for the assessment of odour impacts upon the development is therefore 3 OU. However, for conservatism, an odour impact criterion of 2 OU has been used in this assessment.

3.2.2 Peak-to-mean ratios

It is common practice to use dispersion models to determine compliance with odour criteria. This introduces a complication because conventional dispersion models are only able to directly predict concentrations over an averaging period of 3 minutes or greater. The human nose, however, responds to odours over periods of the order of a second or so. During a 3-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 dispersion model, the NSW EPA commissioned a study by Katestone Scientific Pty Ltd ((Katestone Scientific Pty Ltd, 1995), (Katestone Scientific Pty Ltd, 1998)). This study recommended peak-to-mean ratios for a range of circumstances. The ratio is also dependent on atmospheric stability and the distance from the source. For this assessment peak-to-mean ratios have been applied to each source type accordingly.

The Approved Methods take account of this peaking factor and the criteria shown in **Table 3-1** are based on nose-response time. **Table 3-2** shows the NSW EPA Approved Methods peak-to-mean factors to be used for odour impact assessments.

In our modelling, a peak-to-mean factor of 2.3 was applied to wake-affected point sources and for area sources, peak-to-mean factors of 2.5 and 2.3 were applied to Pasquill-Gifford stability classes A-D and E-F, respectively.

Table 3-2: Factors for estimating peak concentrations on flat terrain

Source Type	Pasquill-Gifford stability class	Near field P/M60*	Far field P/M60
Area	A, B, C, D	2.5	2.3
	E, F	2.3	1.9
Line	A – F	6	6
Surface point	A, B, C	12	4
	D, E, F	25	7
Tall wake-free point	A, B, C	17	3
	D, E, F	35	6
Wake-affected point	A – F	2.3	2.3
Volume	A – F	2.3	2.3

** Ratio of peak 1-second average concentrations to mean 1-hour average concentrations*

4. ODOUR MODEL SET-UP

The air dispersion modelling conducted for this assessment has been based on an advanced modelling system using the models TAPM and CALMET/CALPUFF. This system substantially overcomes the basic limitations of the steady-state Gaussian plume models such as AUSPLUME. These limitations are most severe in very light winds, in coastal environments, and where terrain affects atmospheric flow.

The modelling system works as follows:

- TAPM is a prognostic meteorological model that generates gridded three-dimensional meteorological data for each hour of the model run period.
- CALMET, the meteorological pre-processor for the dispersion model CALPUFF, calculates fine resolution three-dimensional meteorological data based upon observed ground and upper level meteorological data, as well as observed or modelled upper air data generated for example by TAPM.
- CALPUFF then calculates the dispersion of plumes within this three-dimensional meteorological field.

4.1 TAPM

The Air Pollution Model, or TAPM, is a three dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research. Detailed descriptions of the TAPM model and its performance can be found in (Hurley P, 2008)and (Hurley P. M. Edwards, et al, 2009).

TAPM utilises fundamental fluid dynamics and scalar transport equations to predict meteorology and (optionally) pollutant concentrations. It consists of coupled prognostic meteorological and air pollution concentration components. The model predicts airflows important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analyses.

Observed surface meteorological data collected from the on-site weather station at Elf Farm Supplies was merged into TAPM. Surface meteorological data and 3-D prognostic data were generated over the study region using TAPM. The TAPM-generated data and observed surface meteorological data were then entered into the CALMET diagnostic meteorological model, which is discussed below.

4.2 CALMET

CALMET is a meteorological pre-processor that includes a wind field generator containing objective analysis and parameterised treatments of slope flows, terrain effects and terrain blocking effects. The pre-processor produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables to produce the three-dimensional meteorological fields that are used in the CALPUFF dispersion model.

The hourly observed data supplemented with TAPM-generated data for the period of analysis were used as input to the CALMET pre-processor to create a fine resolution, three-dimensional meteorological field for input into the dispersion model. CALMET uses the meteorological inputs in combination with land use and geophysical information for the modelling domain to predict girded meteorological fields for the region.

Terrain data has been sourced from the Shuttle Terrain Mission dataset. The spatial resolution of these data is 90 m.

Meteorological information collected on-site at the Elf Farm Supplies facility in Mulgrave, Sydney Airport AMO, Richmond RAAF and TAPM-generated surface information were used as input into the CALMET model. TAPM surface information was only included when no observed data from the other meteorological stations was available. This data comprised of 0.15% of the total data points input, therefore should not influence the model output.

The 3-D prognostic data derived from TAPM simulations were used in the CALMET modelling as no measured upper air data is available for the site.

A summary of the data and parameters used for the meteorological component of this study are shown in **Table 4-1**.

Table 4-1: Meteorological parameters used for CALMET

TAPM (v 4.0)	
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grid points	25 x 25 x 25
Year of analysis	April 2008 – March 2009
Centre of analysis	“Elf Farm Supplies”, Mulgrave (30^{0}37’ S, 150^{0}49’ E)
CALMET (v. 6.326)	
Meteorological gird domain	20 km x 20 km
Meteorological grid resolution	0.2 km
TERRAD	10 km
IEXTRP	-4
BIAS (NZ)	-1,-0.5,-0.25,0,0,0,0
R1	5 km
R2	5 km
RMAX1	10 km
RMAX2	10 km
Surface meteorological stations	“Elf Farm Supplies” on-site station ▪ Wind speed ▪ Wind direction ▪ Temperature Sydney Airport AMO (Bureau of Meteorology, Station Number 066037) ▪ Cloud cover ▪ Cloud height Richmond RAAF (Bureau of Meteorology, Station Number 067105) ▪ Wind speed ▪ Wind direction ▪ Temperature ▪ Relative Humidity ▪ Pressure TAPM ▪ Wind speed ▪ Wind direction ▪ Relative humidity ▪ Pressure

The CALMET generated meteorological data was analysed in detail to confirm local meteorology and has been presented in the following sections.

Figure 4-1 presents the wind vectors from CALMET output for an hour of the modelling period. The figure shows the distribution of winds and influence of land use and terrain within the modelling domain. For example, winds from the northwest shows katabatic winds flow from the mountain range towards the site in an easterly direction. The flows are then directed southwards along the shallow floodplain region directly adjacent to the site.

Winds from other directions and hours have also been analysed and can be provided upon request.

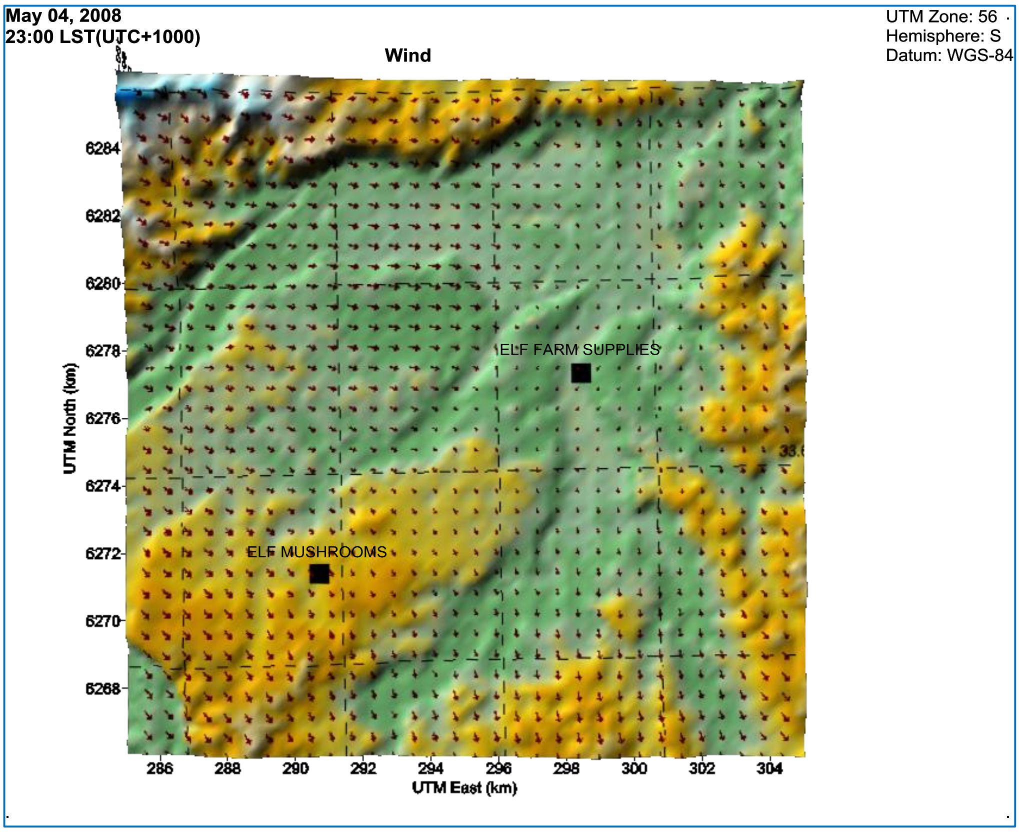


Figure 4-1: CALMET Wind Vectors – 4th May 2008, 23:00

The method used in the CALMET modelling was a 'Hybrid mode' approach that incorporated measured hourly surface data in combination with a TAPM generated 3-D input field. This method was used in light of recent guidance notes provided by TRC Atmospheric Studies Group (TRC, 2011) on the preferred methodologies for running CALMET.

When this method is compared with previous methodologies using an 'Observations only' approach that inputs TAPM derived upper air data from a discrete location within the modelling domain as opposed to using the 3-D input, it was found that there were little to no difference between the data extracted at the site. This may be attributed to the absence of significant terrain features within the CALMET modelling domain that may have affected the predictions between the modelling methodologies.

4.3 CALPUFF

The dispersion model chosen for this odour impact assessment was *CALPUFF* – a multi-layer, multi species, non-steady-state puff dispersion model[1] that can simulate the effects of time-varying and space-varying meteorological conditions on pollutant transport, transformation and removal. The model contains algorithms for near-source effects such as building downwash, partial plume penetration, sub-grid scale interactions as well as longer range effects such as pollutant removal, chemical transformation, vertical wind shear and coastal interaction effects. The model employs dispersion equations based on a Gaussian distribution of pollutants across released puffs and takes into account the complex arrangement of emissions from point, area, volume and line sources (Scire, J.S., Strimaitis, D.G. & Yamartino, R.J., 2000)

A modelling domain of 5 km by 5 km was chosen to incorporate the proposed mushroom farm development and nearby receptors. Odour sources and emission rates are described in more detail in **Section 6**. Model predictions were made across the domain at gridded receptors at a spacing of 100 m x 100 m.

The model requires meteorological data (e.g. wind speed, wind direction, atmospheric stability and mixing height) together with odour emission rates from the sources on the mushroom farm.

[1] Gaussian plume models are considered steady-state because the plume equation is independent of time, that is, dispersion from the source to receptor is instantaneous for each hour of meteorological data. CALPUFF however, 'remembers' the plume from the previous hour taking into account residual concentrations at each grid point from the hours before and is therefore non-steady-state.

5. METEOROLOGICAL DATA USED IN ASSESSMENT

5.1 Wind

Wind roses show the frequency of occurrence of winds by direction and strength. The bars correspond to the 16 compass points – N, NNE, NE, etc. The bar at the top of each wind rose diagram represents winds blowing from the north i.e. northerly winds. The length of the bar represents the frequency of occurrence of winds from that direction, and the colour of the bar sections correspond to wind speed categories, the lighter colour representing the lightest winds.

The diurnal wind roses based on a CALMET extract are shown in **Figure 5-1**.

On an annual basis winds from the north-northeast are most predominant with a good proportion of winds from the northeast. In autumn, winds blow predominantly from north-northeast and are similar to the annual wind rose. In summer winds from the north-northeast, northeast, south and south-southwest are most significant. Winter winds predominantly occur from the north-northeast. In spring, the dominant wind directions are from the north-northeast and northeast.

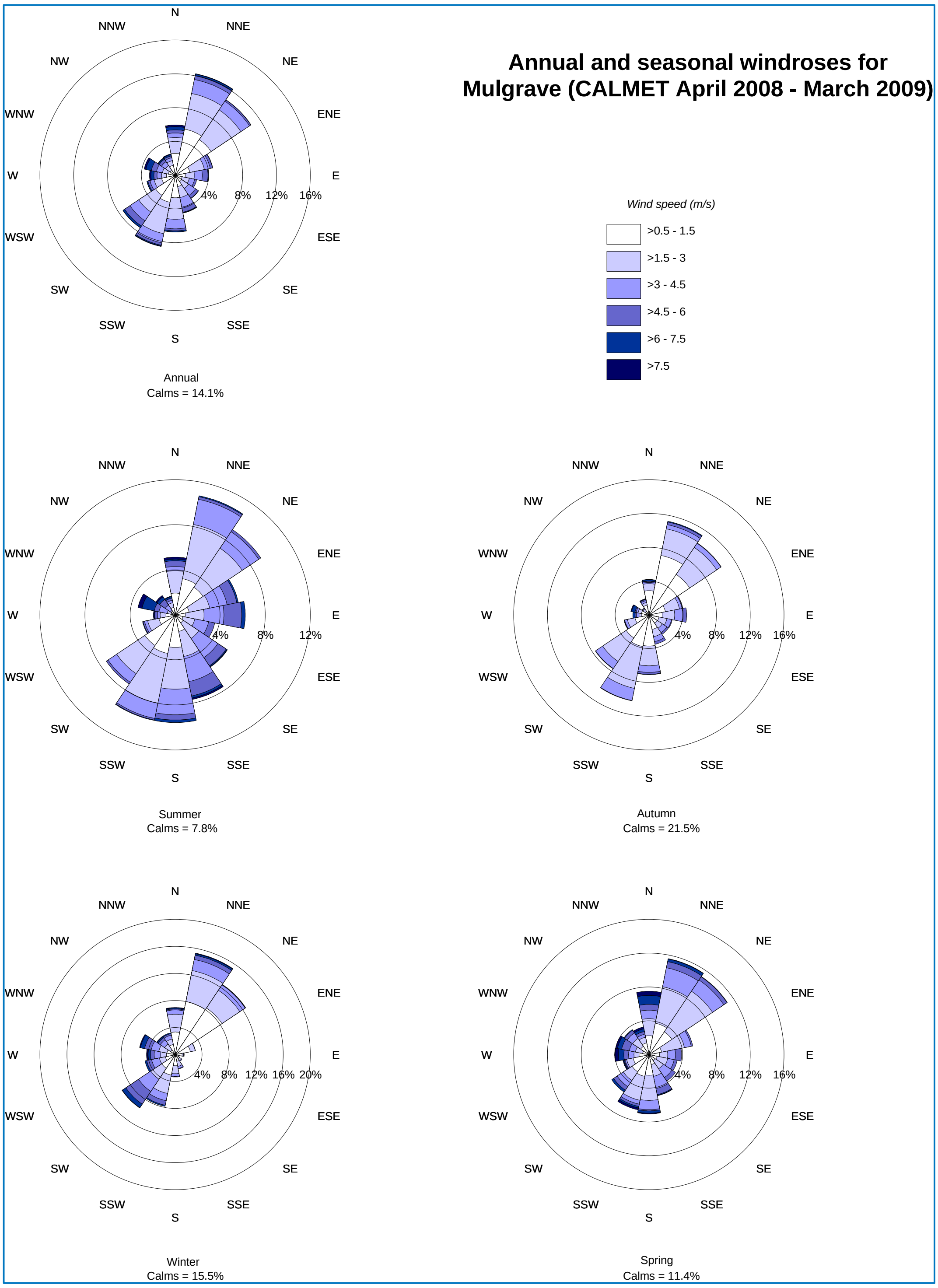


Figure 5-1: Annual and seasonal wind roses

The frequency distribution of hourly averaged wind speed values is shown in **Figure 5-2**. Light wind speeds (up to 2 m/s) are relatively frequent and occur approximately 58.1% of the time. Strong winds (greater than 6 m/s) occur approximately 14% of the time.

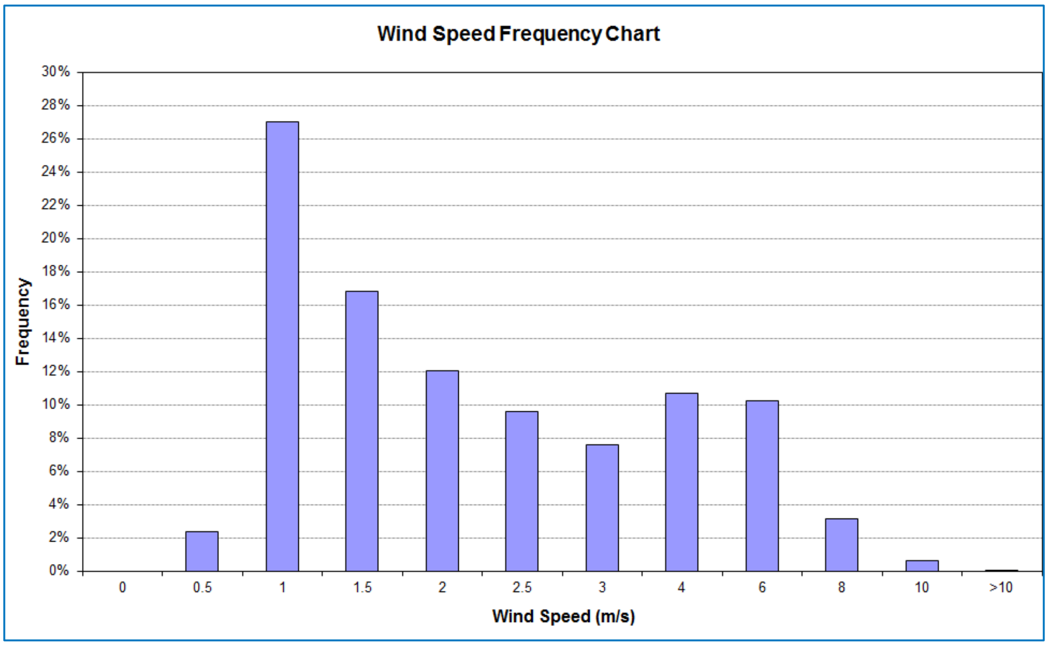


Figure 5-2: Wind Speed Distribution for April 2008 to March 2009

5.2 Stability

Atmospheric turbulence is an important factor in plume dispersion. Turbulence acts to increase the cross-sectional area of the plume due to random motions, thus diluting or diffusing a plume. As turbulence increases, the rate of plume dilution or diffusion increases. Weak turbulence limits plume diffusion and is a critical factor in causing high plume concentrations downwind of a source, particularly when combined with very low wind speeds.

Turbulence is related to the vertical temperature gradient, the condition of which determines what is known as stability, or thermal stability. For traditional dispersion modelling using Gaussian plume models, categories of atmospheric stability are used in conjunction with other meteorological data to describe atmospheric conditions and thus dispersion.

The most well-known stability classification is the Pasquill-Gifford scheme[2], which denotes stability classes from A to F. Class A is described as highly unstable and occurs in association with strong surface heating and light winds, leading to intense convective turbulence and much enhanced plume dilution.

[2] A more accurate turbulence scheme within CALPUFF, based on micrometeorological parameters, was used for modelling.

At the other extreme, class F denotes very stable conditions associated with strong temperature inversions and light winds, which commonly occur under clear skies at night and in the early morning. Under these conditions plumes can remain relatively undiluted for considerable distances downwind.

Intermediate stability classes grade from moderately unstable (B), through neutral (D) to slightly stable (E). Whilst classes A and F are strongly associated with clear skies, class D is linked to windy and/or cloudy weather, and short periods around sunset and sunrise when surface heating or cooling is small.

As a general rule, unstable (or convective) conditions dominate during the daytime and stable flows are dominant at night. This diurnal pattern is most pronounced when there is relatively little cloud cover and light to moderate winds.

The frequency distribution of estimated stability classes in the meteorological file is presented in **Figure 5-3**. The data show a total of 48.4% of hours with either E or F stability class.

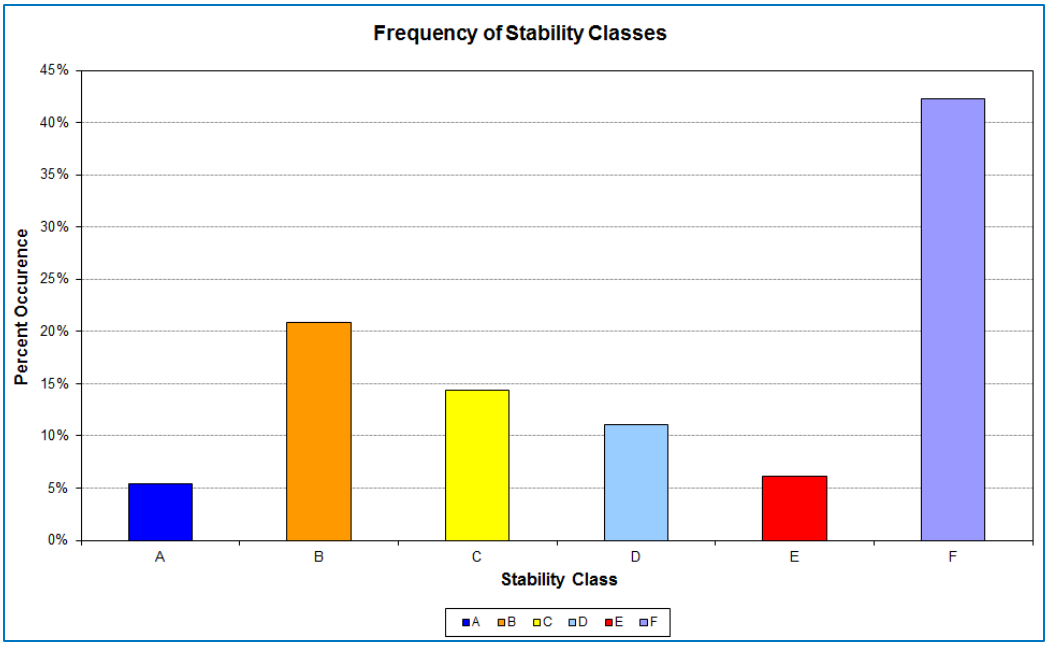


Figure 5-3: Frequency Distribution of Estimated Stability Classes

5.3 Local Climate

This section describes the general climate in the study area to give a more complete picture of the local meteorology.

Table 5 1 presents the temperature, humidity and rainfall data for the closest Bureau of Meteorology site which is located at Richmond RAAF (067105); approximately 9 km north-west of the site. Also presented are monthly averages of maximum and minimum temperatures, 9am and 3pm temperatures and humidity. Rainfall data consist of mean monthly rainfall and the average number of rain days per month.

The annual average maximum and minimum temperatures experienced are 24.1°C and 11.0°C. July is the coldest month, with an average minimum temperature of 3.5°C. January is the hottest month, with an average maximum temperature of 30.1oC.

Rainfall data show that February is on average the wettest month, with a mean rainfall reading of 128.7 mm, over 8.3 rain days. July is the driest month with an average rainfall of 31.7 mm, over an average of 4.1 rain days. The average annual rainfall is 726.7 mm and the average number of rain days annually is 72.6.

Table 5-1: Temperature, humidity and rainfall data for Richmond RAAF

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
9 am Mean Temperatures (°C) and Relative Humidity (%)													
Dry-bulb	22.1	21.3	19.1	17.0	13.1	10.1	8.9	11.4	15.4	18.3	19.2	20.9	16.4
Humidity	72	78	80	76	81	82	80	70	63	58	68	68	73
3 pm Mean Temperatures (°C) and Relative Humidity (%)													
Dry-bulb	28.5	27.4	25.8	23.0	19.6	17.0	16.6	18.7	21.5	23.5	25.2	27.5	22.9
Humidity	47	52	52	49	53	53	47	39	38	40	46	44	47
Daily Maximum Temperature (°C)													
Mean	30.1	29.1	26.8	24.0	20.6	18.0	17.5	19.8	22.7	25.1	26.6	28.7	24.1
Daily Minimum Temperature (°C)													
Mean	17.5	17.7	15.5	11.4	7.9	4.9	3.5	4.4	8.1	11.0	13.9	15.9	11.0
Rainfall (mm)													
Mean	70.7	128.7	67.5	43.8	56.2	46.0	31.7	33.3	50.0	55.3	83.3	62.1	726.7
Rain days (Number)													
Mean	7.6	8.3	7.8	5.5	5.9	5.1	4.1	3.6	4.8	5.8	7.9	6.2	72.6

Station Number 067105, Latitude: -33.60 South, Longitude: 150.78 East, Elevation: 19 m

Source: *Bureau of Meteorology,* (BOM, 2015)

6. ODOUR EMISSIONS

The main source of odorous emissions from the proposed mushroom farm will be the stockpile of spent mushroom compost, as originally identified by (PAEHolmes, Air Quality Assessment - Proposed Mushroom Farm, Londonderry, 2010). However, the revised plans state that mushroom compost will be dried in a closed room with odour emissions emitted via a stack. Additional potential sources of odour have also been identified as the on-site sewerage treatment facility and the waste water treatment areas.

Odour emissions from area sources are difficult to measure as the odour source is often heterogeneous. For compost, there will be different odour emission rates from different sections of the compost heap. Furthermore, unlike stack emissions, it is difficult to measure the volumetric flow of the odour.

Based on information provided by the proponent, the dispersion modelling assumes that there will be no outdoor activities with compost.

6.1 Spent Compost

Odour testing was conducted by Stephenson Environmental Management Australia (SEMA) on spent compost at the existing Elf Mushrooms farm at Vineyard (**Table 6-1**).

Table 6-1: Odour testing results for spent compost

Spent Compost	Odour concentration (ou)	Specific Odour Emission Rate (ou.m/s)
Fresh	1,020	0.655
One day	236	0.152
Six weeks	731	0.469

The original plans for the proposed mushroom farm included a stockpile area with an area of 13,176 m2 for drying spent compost for six weeks. The original air quality impact assessment modelled this source considering the entire stockpile area and the maximum emission rate of 0.655 ou.m/s.

In the revised plans, spent compost will be dried in a closed area with a stack. This was therefore considered as a point source. As per the original air quality impact assessment, this source was modelled using the maximum odour emission rate of 0.655 ou.m/s. A summary of stack parameters is provided later in Section 6.4.

Table 6-2: Point sources

Source	X (m)	Y (m)	Height [m]	Stack diameter (m)	Exit velocity (K)	Exit velocity (m/s)	Odour (ou.m3/s)[a]
Dry-bulb	22.1	21.3	19.1	17.0	13.1	10.1	8.9

[a]*Peak to mean ratio of 2.3* (NSW EPA, 2005)

6.2 Sewage Treatment Facility

The proposed on-site sewage treatment facility will be designed to service sewerage generated from the on-site toilet facilities for approximately 113 employees.

As the design of this facility has not yet been finalised it is difficult to provide an estimate of the potential impact likely to be generated from this facility. As a conservative approach we have taken measured odour emissions from a sewerage recycling facility that utilises raw sewerage from the trunk mains. This information was obtained from a previous odour assessment by (PAEHolmes, 2009). Odour sampling was collected by The Odour Unit Pty Ltd from an existing recycled water facility located at Pennant Hills Golf Course.

The source of odour from this facility would be from the screens used to remove inorganic material larger than 3 mm in size from the flow prior to treatment of the liquid flow. The screens are entirely enclosed; however, there are three pump locations where fugitive odour emissions can escape.

The design of the facility was assumed to be similar to the design of the facility assessed in the PAEHolmes report. The odour emissions from the proposed on-site sewerage treatment facility is expected to be much less than modelled as the amount of sewerage processed will be significantly less. A summary of the modelling parameters for this facility is presented below in **Table 6-3**.

Table 6-3: Sewage Treatment facility modelling inputs

Source	Odour Concentration (ou)	Stack height (m)	Exit Velocity (m/s)	Diameter (m)	Area (m^2)	Odour emission rate[(a)] ($ou.m^3/s$)
Point 1	856	4.5	0.5	0.11	0.010	4.1
Point 2	856	4.5	0.5	0.08	0.005	2.2
Point 3	856	4.5	0.5	0.08	0.005	2.2
Total odour emissions						8.5

*(a)Odour emission rate = odour concentration (ou) * exit velocity (m/s) * area (m^2)*

Table 6-4: Sewage treatment plant modelling inputs

Source	X (m)	Y (m)	Height [m]	Stack diameter (m)	Exit velocity (K)	Exit velocity (m/s)	Odour (ou.m3/s)[a]
Sewage treatment plant 1	290805	6271373	4.5	0.11	293	0.5	9.43
Sewage treatment plant 2	290835	6271367	4.5	0.08	293	0.5	5.06
Sewage treatment plant 3	290867	6271361	4.5	0.08	293	0.5	5.06

[a]*Peak to mean ratio of 2.3* (NSW EPA, 2005)

6.3 Waste Water Treatment Facility

Waste water generated from activities taking place on-site will be recycled through the natural filtration functions in wetlands. This design will remove any sediment and pollutants in the water, all water passing through will be completely reused in the cooling towers, stream generator and for toilet flushing. All the treated water will be reused within the property and not allowed to enter downstream ecosystems.

There was no readily available odour data to use to represent the potential odour generated from this activity. To estimate the potential odour emissions from this source we have conservatively assumed emission rates for tertiary treatment at a sewerage treatment facility.

A report on the Woodford Island Sewerage Treatment Plant (SKM, 2009) estimated a specific odour emission rate of 0.44 ou.m^2/s for the tertiary treatment based on the average odour emissions from the Sydney Water Corporation odour database. This odour emission rate is likely to be an overestimation of the actual odour generated from this source.

The wetlands will are proposed to cover a total area of approximately 1650 m^2, for the purposes of this assessment we have modelled the entire area emitting at a rate of 0.44 ou.m^2/s.

Table 6-5: Area sources

Source	X (m)	Y (m)	Area (m^2)	Specific Odour Emission Rate (ou.m/s)
Washdown water recycling pond 1	290584	6271422	365	0.44
Washdown water recycling pond 2	290614	6271416	343	
Wetland area 1	290604	6271401	471	
Wetland area 2	290600	6271389	471	

6.4 Odour sources summary

Area sources and point sources are shown in **Figure 6-1** onto a georeferenced basemap.

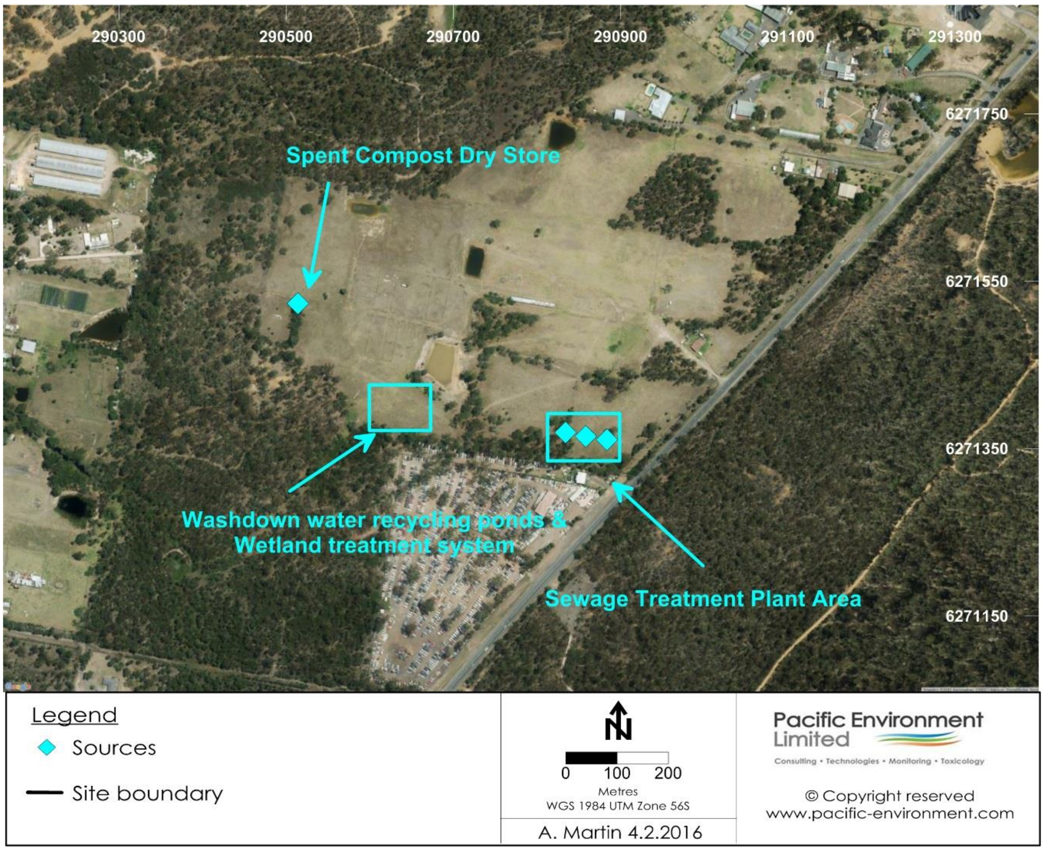


Figure 6-1: Odour sources for the proposed development

7. ASSESSMENT OF IMPACTS

The predicted 99th percentile odour contours for the proposed mushroom farm at Londonderry are presented in **Figure 7-1** and the predicted 99th percentile 1-hour average odour concentrations at nearby sensitive receptors are shown in **Figure 7-1** below.

Predicted odour concentrations were all less than 1 ou, including locations within the site boundary and at all sensitive receptors. Thus predicted odour concentrations were well below the NSW EPA criteria of 2 ou. This suggests that adverse odour impacts would not be expected to result from operations at the proposed development.

Note that odour concentrations were reported to one decimal place in (PAEHolmes, Air Quality Assessment - Proposed Mushroom Farm, Londonderry, 2010), but here they are reported as whole numbers due to the nature of odour. A level of 1 ou is the theoretical level of detection (i.e. the point at which an odour can be detected but is not distinguishable from other odours) and we have previously been advised by EPA to only present results as whole numbers as odour is not measureable below this. However, here we present numbers to more decimal places as predicted odour concentrations are so low.

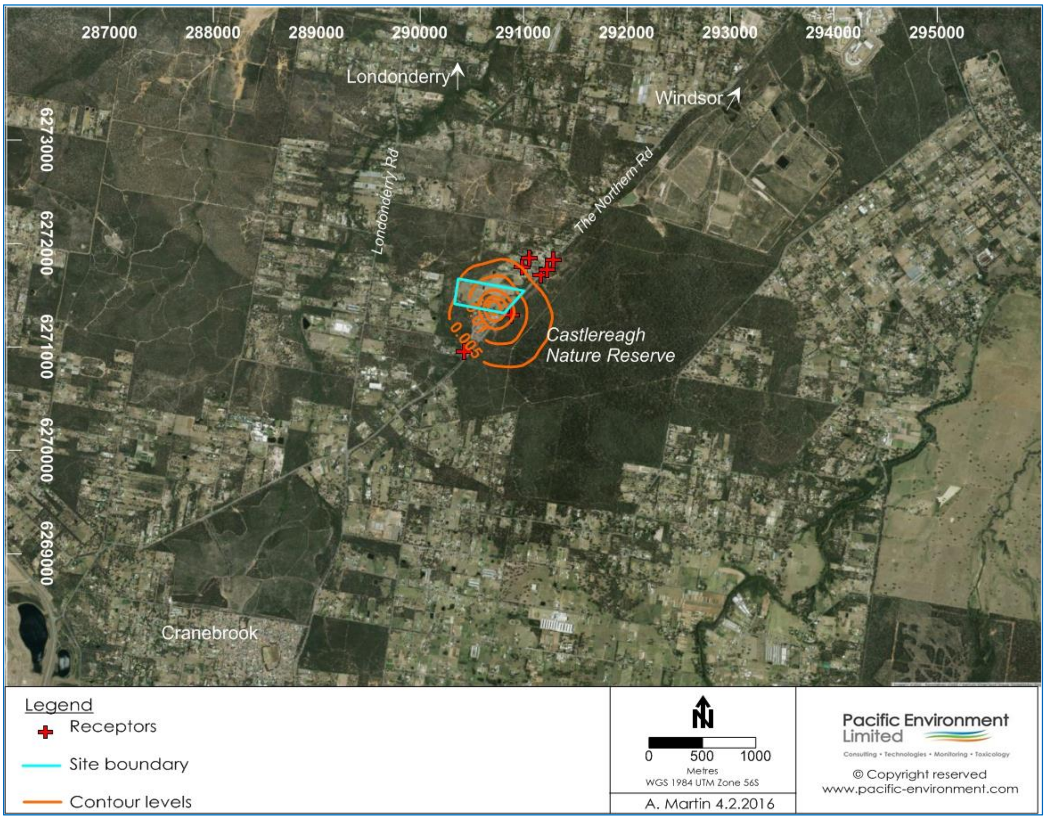


Figure 7-1: Predicted 99th percentile 1-hour average odour concentration contours (ou) associated with operation of the mushroom farm

Table 7-1: Predicted 99th percentile 1-hour average odour concentration for sensitive receptors

Sensitive receptor ID	Easting (m)	Northing (m)	Predicted 99th percentile (ou)		
			Original Assessment		Revised Assessment
			Stages 1-3	Stages 4-5	Stage 6
1	290879	6271308	0.6	1.1	0.021
2	291168	6271699	0.2	0.4	0.004
3	291231	6271743	0.2	0.4	0.003
4	290989	6271771	0.3	0.5	0.005
5	291053	6271857	0.2	0.4	0.004
6	291285	6271843	0.2	0.3	0.002
7	290425	6270950	0.4	0.7	0.004

8. GREENHOUSE GAS ASSESSMENT

GHG emissions have been estimated based on the methods outlined in the following documents:

- The World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD) Greenhouse Gas Protocol The Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard Revised Edition (WRI/WBCSD, 2004)
- National Greenhouse and Energy Reporting (Measurement) Amendment Determination 2014 (No. 1).
- The Australian Government Department of the Environment (DoE) National Greenhouse Accounts (NGA) Factors 2014 (DoE, 2015a)

The GHG Protocol establishes an international standard for accounting and reporting of GHG emissions. The GHG Protocol has been adopted by the International Standard Organisation, endorsed by GHG initiatives (such as the Carbon Disclosure Project) and is compatible with existing GHG trading schemes. Three ‘scopes’ of emissions (scope 1, scope 2 and scope 3) are defined for GHG accounting and reporting purposes, as described below and in **Figure 8-1**. This terminology has been adopted in Australian GHG reporting and measurement methods and has been employed in this assessment. The ‘scope’ of an emission is relative to the reporting entity. Indirect scope 2 and scope 3 emissions would be reportable as direct scope 1 emissions from another facility.

Scope 1: Direct Greenhouse Gas Emissions

Direct GHG emissions are defined as those emissions that occur from sources that are owned or controlled by the reporting entity. Direct GHG emissions are those emissions that are principally the result of the following types of activities undertaken by an entity:

- Generation of electricity, heat or steam. These emissions result from combustion of fuels in stationary sources. For the current assessment, this will include the use of reciprocating gas powered plant for electricity generation.
- Physical or chemical processing. Most of these emissions result from manufacture or processing of chemicals and materials (e.g. the manufacture of cement, aluminium, etc.).
- Transportation of materials, products, waste and employees. These emissions result from the combustion of fuels in entity owned/controlled mobile combustion sources (e.g. trucks, trains, ships, aeroplanes, buses and cars).
- Fugitive emissions. These emissions result from intentional or unintentional releases (e.g. equipment leaks from joints, seals, packing and gaskets; CH4 emissions from coal mines and venting); hydrofluorocarbon emissions during the use of refrigeration and air conditioning equipment; and CH4 leakages from gas transport. For the current assessment this would include fugitive CH4 emissions associated with mine ventilation and gas management activities.

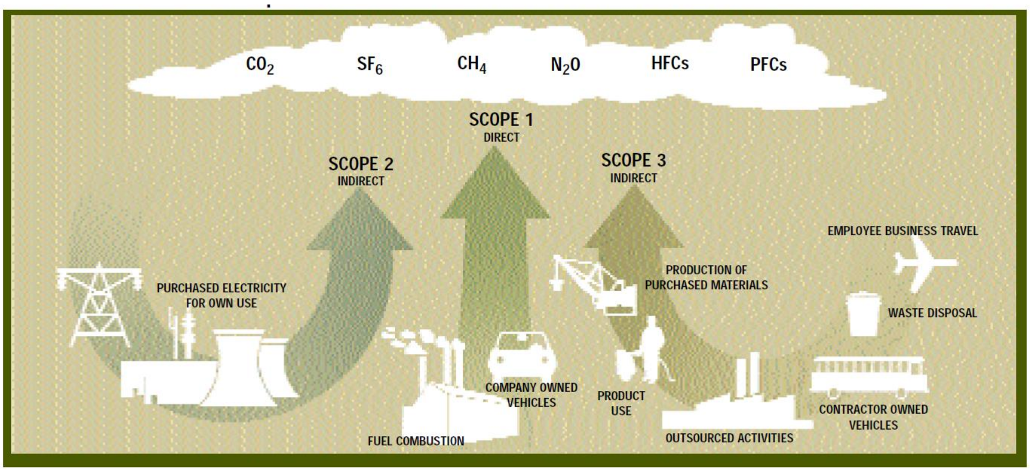
Scope 2: Energy Product Use Indirect Greenhouse Gas Emissions

Scope 2 emissions are a category of indirect emissions that account for GHG emissions from the generation of purchased energy products (principally, electricity, steam/heat and reduction materials used for smelting) by the entity. Scope 2 in relation to coal mines typically covers purchased electricity, defined as electricity that is purchased or otherwise brought into the organisational boundary of the entity.

Scope 3: Other Indirect Greenhouse Gas Emissions

Scope 3 emissions are defined as those emissions that are a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity. Some examples of scope 3 activities provided in the GHG Protocol are extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services.

In the case of the Project, scope 3 emissions would include emissions associated with the transportation of goods. The GHG Protocol provides that reporting scope 3 emissions is optional. If an organisation believes that scope 3 emissions are a significant component of the total emissions inventory, these can be reported along with scope 1 and scope 2. However, the GHG Protocol notes that reporting scope 3 emissions can result in double counting of emissions and can also make comparisons between organisations and/or products difficult because reporting is voluntary. Double counting needs to be avoided when compiling national (country) inventories under the Kyoto Protocol. The GHG Protocol also recognises that compliance regimes are more likely to focus on the "point of release" of emissions (i.e. direct emissions) and/or indirect emissions from the purchase of electricity.



Source: *Figure 3, WRI/WBCSD, 2004*

Figure 8-1: Overview of scopes and emissions across a reporting entity

8.1 Greenhouse emission calculation methodology

8.1.1 Introduction

The following equation (DoE, 2015a) was used to estimate the greenhouse gas emissions from fuel usage:

$$GHG\ Emissions\ (tCO_2 - e) = \frac{Q \times EC \times EF}{1000} \qquad \text{Equation 1}$$

Where:

Q = quantity of fuel in tonnes or thousands of litres

EC = energy content of the fuel in GJ/tonne or GJ/kL

EF = relevant emission factor in kg CO_2-e/GJ

To calculate emissions from electricity usage, the following equation was used:

$$GHG\ Emissions\ (tCO_2 - e) = Q \times \frac{EF}{1000} \qquad \text{Equation 2}$$

Where:

Q = electricity consumed in kWh

EF = relevant emission factor in kg CO_2-e/kWh

To calculate emissions from Natural gas usage, the following equation was used:

$$GHG\ Emissions\ (tCO_2 - e) = \frac{Q \times EC \times EF}{1000} \quad \text{Equation 3}$$

Where:

Q = natural gas consumed in GJ

EC = energy content factor in GJ/m^3

EF = relevant emission factor in kg CO_2-e/GJ

To calculate emissions from fuel used for transport purposes, the following equation was used:

$$GHG\ Emissions\ (tCO_2 - e) = \frac{Q \times EC \times EF}{1000} \quad \text{Equation 4}$$

Where:

Q = the quantity of fuel used in kilolitres

EC = energy content factor in GJ/m^3

EF = relevant emission factor in kg CO_2-e/GJ

8.1.2 Emission factors

Data provided in the National Greenhouse Accounts (NGA) Factors, published by the Department of the Environment (DoE, 2015a) were used. DoE defines three ‘scopes’ (or emission categories):

- Scope 1 covers direct emissions from sources within the project boundary such as fuel combustion and manufacturing processes;
- Scope 2 covers indirect emissions from the consumption of purchased electricity, steam or heat produced by another organisation; and
- Scope 3 includes all other indirect emissions that are a consequence of the organisations activities but are not from sources owned or controlled by the organisations, for example, delivery of diesel fuel and electrical energy, etc.

For the purposes of this assessment, a full fuel cycle emission factor (that is the sum of scope 1, scope 2 and 3 emission factors, where applicable) has been used.

It should also be noted that some Scope 3 emissions have not been considered in this assessment as the information is not available.

Table 8-1 provides a summary of the emission factors used.

Table 8-1: Summary of emission factors for greenhouse gas assessment

Type of Fuels and Electricity	Emission factor		Scope	Source
Diesel - Non-transport activities	69.9	kg CO_2-e/GJ	1	Table 3 (DoE, 2015a)
	3.6	kg CO_2-e/GJ	3	Table 39 (DoE, 2015a)
Diesel – Energy content factor	38.6	GJ/kL	-	Table 3 (DoE, 2015a)
Diesel – Transport activities	69.9	kg CO_2-e/GJ	1	Table 4 (DoE, 2015a)
	3.6	kg CO_2-e/GJ	3	Table 39 (DoE, 2015a)
Diesel – Energy content factor	38.6	GJ/kL	-	Table 3 (DoE, 2015a)
Electricity	0.84	kg CO_2-e/kWh	2	Table 41 (DoE, 2015a)
	0.12	kg CO_2-e/kWh	3	Table 41 (DoE, 2015a)
Natural Gas	51.4	kg CO_2-e/GJ	1	Table 2 (DoE, 2015a)
	12.8	kg CO_2-e/GJ	3	Table 37 (DoE, 2015a)
Natural Gas – Energy content factor	25.3	GJ/kL	-	Table 2 (DoE, 2015a)

8.1.3 Diesel, electricity and natural gas usage

Based on information provided by the proponent **Table 8-2** presents a summary of annual diesel, electricity and natural gas usage for the stationary site operating at full capacity.

Table 8-2: Summary of annual diesel, electricity and natural gas usage

Fuel Type	Annual Usage
Diesel (kl)	30
Electricity (kWh)	4,500,000
Natural Gas (GJ)	21,500

Source: *Elf Mushrooms*

There will also be diesel consumed from the transport of the product mushrooms and spent substrate to customers. The numbers of deliveries per year for the site operating at full capacity have been provided by the proponent and summarised in **Table 8-3** below.

It should be noted that product mushrooms are sold on-site to White Prince Mushrooms before transport off-site. The emissions generated from this activity have been included in the Scope 3 emissions for this site.

Table 8-3: Summary of outgoing product deliveries per year

	Annual deliveries
Outgoing Mushrooms	1,456
Outgoing Spent substrate	624

Source: *Elf Mushrooms*

The annual diesel usage has been calculated using the assumption that an average return distance of 100 km per load and an average fuel consumption of articulated trucks being 52 litres per 100 kilometres for spent substrate and 41 litres per 100 kilometres for delivery of mushrooms. The annual fuel usage to transport the product is calculated from following equation ((No. of deliveries) * 100 [km/trip] * fuel consumption [L/km]) and presented below in **Table 8-4**.

Table 8-4: Summary of annual diesel usage for transport

	Annual fuel usage (kl)
Outgoing Mushrooms	60
Outgoing Spent substrate	32

8.2 Greenhouse gas emissions results

Based on the fuel, electricity and natural gas usage, the annual CO2-e emissions for the site when operating at full capacity are summarised in **Table 8-5**.

Table 8-5: Summary of estimated CO2-e emissions (t CO2-e/y)

Source	Scope 1	Scope 2	Scope 3	TOTAL (t CO2-e)
Diesel (Transport and Stationary)	332	-	17	349
Electricity	-	3,780	540	4,320
Natural Gas	1,105	-	275	1,380
Total	**1,437**	**3,780**	**832**	**6,049**

Note: *some figures not exact due to rounding*

When the Project is operating at full capacity, it has been estimated that the development would release approximately 0.005 Mt/y CO2-e. The annual greenhouse emissions in NSW for 2013 were 141.8 Mt (DoE, 2015b). Therefore, the proposed development represents approximately 0.004% of the total NSW greenhouse gas emissions.

In 2013, Australia's total greenhouse gas emissions were estimated at 548.6 Mt CO2-e (DoE, 2015b). When comparing emissions for the Project operating at full capacity, the predicted increase is 0.001% of total 2013 Australian emissions.

8.3 Energy Efficiency and GHG Emission Reduction Measures

The facility will implement an energy efficiency program to look at ways to reduce the overall impact of greenhouse gas emissions from its operation. This will be achieved by focusing on each of the processes that take place at the facility and review how these can be improved. Aspects of this energy efficiency program can include:

- Improving energy use and efficiency;
- Looking at carbon capture technologies as viable means to capture greenhouse emissions;
- Implementing carbon-offset schemes; and
- Raising awareness amongst stakeholders, employees and clients.
- This program will be revised as required to respond to new information, technologies and policies as they evolve.

9. CONSTRUCTION IMPACTS

The construction process for the proposed development at the new mushroom farm in Londonderry will temporarily generate dust.

Development will involve construction of a number of buildings and related infrastructure. The impact due to these activities is difficult to accurately quantify due to the time frame over which they will occur. However the total amount of dust generated from such activities is predicted to be minor.

To ensure dust generation is controlled, the site has dust management plans which will be utilised to help reduce any off-site impacts from these activities.

The major dust emissions likely to occur are identified as vehicles travelling on-site and from wind erosion of exposed areas. Mitigation measures to control dust from these sources include:

- Maintaining active road surfaces;
- Limit vehicle speeds;

- Rehabilitate completed sections of the site.

10. CONCLUSIONS

An investigation has been conducted to identify and predict potential odour impacts that may affect sensitive receptors nearby the proposed mushroom farm development in Londonderry, NSW.

A Level 3 Odour Assessment has been undertaken, consistent with the requirements outlined in Approved Methods (NSW EPA, 2005), Technical framework: assessment and management of odour from stationary sources in NSW (NSW EPA, 2006a) and the associated Technical Notes (NSW EPA, 2006b).

The results of the odour assessment indicate that, under the conservative assumptions adopted, the predicted odour concentrations are anticipated to be below the adopted odour performance goal for the assessment of 2 OU.

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