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Revision 1

Marsden Park Industrial Precinct
Level 3 Odour Assessment

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Marsden Park Industrial Precinct

Level 3 Odour Assessment

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EXECUTIVE SUMMARY

The Department of Planning has appointed a consultant to project manage the rezoning process and preparation of Environmental and Urban Landform assessments for the proposed Marsden Park Industrial Precinct (MPIP). The area of the proposed development is situated on Richmond Road, Marsden Park, within the North West Growth Area and will comprise primarily of employment land.

Heggies Pty Ltd has been commissioned to identify and assess the potential for odour impacts from the surrounding area in accordance with NSW Department of Climate Change (DECC) odour policy. Five operational poultry farms, located within a radius of 4 km from the proposed development, represent the most likely source of odour impacts to the industrial precinct.

The study has been divided into two separate stages, Stage One and Stage Two, with the necessity for progression to Stage Two to be largely dictated by the outcomes of Stage One. This report constitutes Stage Two of the study. The findings of Stage One indicated that odour criteria would be exceeded between 1.4 km and 3.4 km from the poultry farms to the immediate north of the MPIP, on South Street. This buffer zone extends across a large portion of the MPIP.

Stage Two of the study therefore requires the completion of a Level 3 odour impact assessment of the poultry farms, as defined by DECC document's *"Technical Framework: Assessment and Management of Odour from Stationary Sources in NSW"* and "*Technical Notes: Assessment and Management of Odour from Stationary Sources in NSW"*. A Level 3 odour impact assessment is a more detailed examination of odour impacts surrounding odour sources. Odour concentrations are predicted around the emission sources using a dispersion model and a full year of hourly meteorological data. Specific odour criteria can be identified and areas of potential impact assessed.

The results for Stage Two of the study indicate that odour levels of 2 OU to 3 OU are predicted to occur over the western and northern parts of the Project Site, based on *average* OERs for poultry operations. Given applicable odour impact assessment criteria, it is concluded that odour impact potentials are likely to be in an acceptable range in approximately 50% of the MPIP area, specifically within the south eastern corner.

Staging of the master plan should consider short and long term odour issues, taking into account zoning for areas surrounding the MPIP.

In the short term, the northern and western parts of the MPIP are less suitable for sensitive land uses such as residential development, as development may coincide with existing odour sources. These potential odour issues are identified and will be presented within the Development Control Plan. It is expected that where potential odour impacts may impact on specific development outcomes, additional odour assessment may be triggered as part of the DA process.

Consideration should be given to amelioration and mitigation strategies which focus on both reducing odour emissions from the poultry farms and reducing the impacts of these emissions upon any proposed future population.

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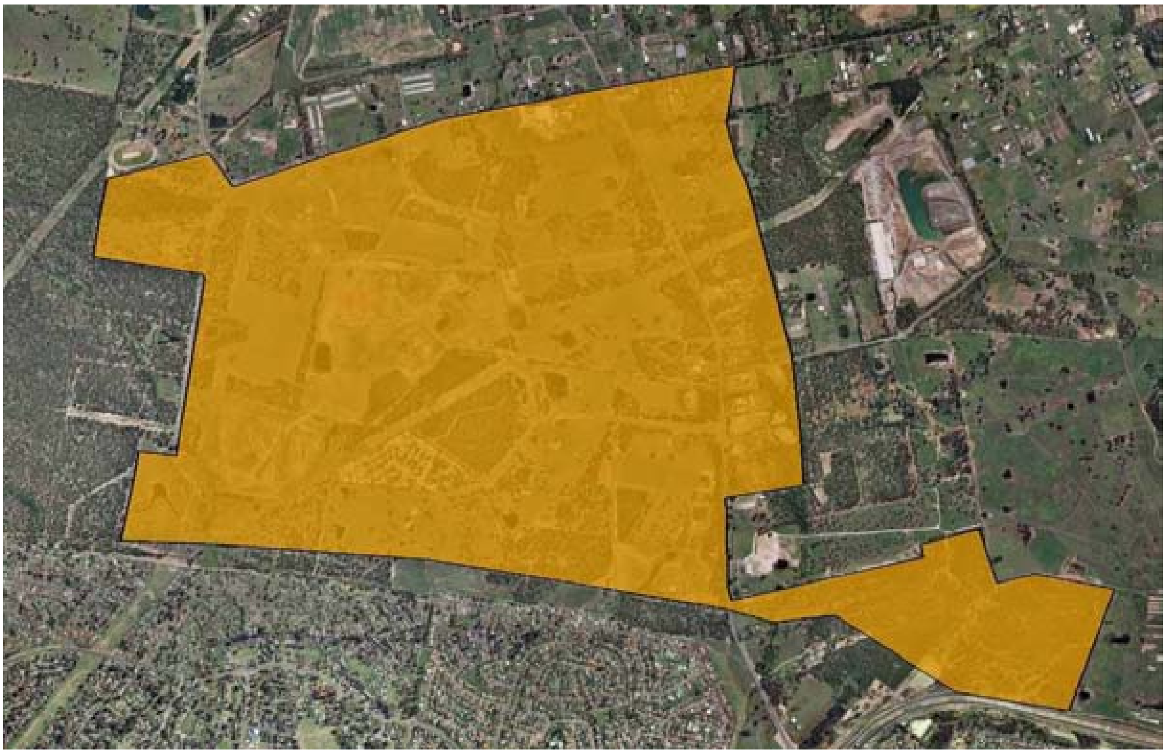
1 INTRODUCTION

The Department of Planning (DoP) seeks to carry out property development within an area of approximately 550 hectares (ha), in the southwest corner of the defined North West Growth Centre of Sydney. The development area, known as the Marsden Park Industrial Precinct (MPIP) will comprise primarily of employment land. The boundaries of the MPIP are shown in **Figure 1**.

Figure 1 Marsden Park Industrial Precinct (MPIP) Boundaries



DoP has appointed a principal consultant to project manage the rezoning process and prepare Environmental and Urban Landform assessments. Heggies Pty Ltd (Heggies) has been commissioned by the principal consultant on behalf of DoP to quantify and assess potential for odour impact across the MPIP, in accordance with NSW Department of Environment and Climate Change (DECC) odour policy.

1.1 Study Area

The MPIP is located on Richmond Road, near the Westlink M7, approximately 36 km northwest of Sydney CBD. Around 238 ha of the study area is currently controlled by DoP. Surrounding land use is primarily rural and comprises rural residential holdings and agricultural activities, specifically poultry operations, to the north and west of the site.

1.2 Study Objectives

The objectives of the study are to:

- investigate and identify any sources of odour on or in the vicinity of the subject land;
- investigate the implications of any existing odours for the staging of the development of the proposed industrial development; and

- recommend management strategies to maximise development opportunities both under the existing odour situation, and into the future.

1.3 Study Scope

The odour assessment has been divided into two stages with the necessity for the second stage being largely dictated by the outcomes of the first. The stages are identified as Stage One and Stage Two respectively. This report constitutes the Stage Two portion of the works.

1.3.1 Stage One

As part of Stage One, Heggies carried out the following tasks:

- Site visit and investigation of the area surrounding the proposed industrial development to identify potential odour sources.
- Completion of a Level 1 odour impact assessment as described in the DECC Policy: "*Assessment and Management of Odour from Stationary Sources in NSW"* (hereafter, "The Odour Policy") (DECC, 2006) and *Technical Notes: "Assessment and Management of Odour from Stationary Sources in NSW"* (hereafter, "The Odour Technical Notes") (DECC, 2006).
- Identification of the separation distance which would nominally be required between the poultry farms and the MPIP.

The results for Stage One of the study have indicated that a minimum separation distance of between 1.4 km and 3.4 km would be required between the existing poultry farms and the MPIP to ensure odour impacts are not experienced. The shortest distance from the poultry farms to the northern boundary is less than 400 m which falls well within the screening buffer established within the Level 1 odour impact assessment.

1.3.2 Stage Two

The results of Stage One indicate that odour emissions from activities at the poultry farms may adversely impact on the MPIP and therefore, further more detailed assessment is required.

As part of the Stage Two assessment, the following tasks have been undertaken:

- Quantification of the odour emissions from all sources in the vicinity of the MPIP using published odour emissions data.
- Undertake a Level 3 Odour Impact Assessment in accordance with the Odour Policy and the Odour Technical Notes – i.e. atmospheric dispersion modelling to determine the resultant impact of the odour emissions.

The current report represents Stage Two of the assessment process, and provides a more detailed assessment of the potential odour impact of poultry farm operations on the MPIP.

2 ODOUR ASSESSMENT CRITERIA

Impacts from odorous air contaminants are often nuisance-related rather than health-related. Odour performance goals guide decisions on odour management, but are generally not intended to achieve "no odour".

The detectability of an odour is a sensory property that refers to the theoretical minimum concentration that produces an olfactory response or sensation. This point is called the *odour threshold* and defines one odour unit (OU). An odour goal of less than 1 OU would theoretically result in no odour impact being experienced.

In practice, the character of a particular odour can only be judged by the receiver's reaction to it, and preferably only compared to another odour under similar social and regional conditions. Based on the literature available, the level at which an odour is perceived to be a nuisance can range from 2 OU to 10 OU depending on a combination of the following factors:

- *Odour Quality*: whether an odour results from a pure compound or from a mixture of compounds. Pure compounds tend to have a higher threshold (lower offensiveness) than a mixture of compounds.
- *Population sensitivity:* any given population contains individuals with a range of sensitivities to odour. The larger a population, the greater the number of sensitive individuals it contains.
- *Background level:* whether a given odour source, because of its location, is likely to contribute to a cumulative odour impact. In areas with more closely-located sources it may be necessary to apply a lower threshold to prevent offensive odour.
- *Public expectation:* whether a given community is tolerant of a particular type of odour and does not find it offensive, even at relatively high concentrations. For example, background agricultural odours may not be considered offensive until a higher threshold is reached than for odours from a landfill facility.
- *Source characteristics:* whether the odour is emitted from a stack (point source) or from an area (diffuse source). Generally, the components of point source emissions can be identified and treated more easily than diffuse sources. Emissions from point sources can be more easily controlled using control equipment. Point sources tend to be located in urban areas, while diffuse sources are more often located in rural locations.
- *Health Effects:* whether a particular odour is likely to be associated with adverse health effects. In general, odours from agricultural activities are less likely to present a health risk than emissions from industrial facilities.

Experience gained through odour assessments from proposed and existing facilities in NSW indicates that an odour performance goal of 7 OU is likely to represent the level below which "offensive" odours should not occur (for an individual with a 'standard sensitivity' to odours). Therefore, the Odour Framework recommends that, as design goal, no individual be exposed to ambient odour levels of greater than 7 OU. This is expressed as the 99th percentile value, as a nose response time average (approximately one second).

The proposed odour performance goals allow for population density, cumulative impacts, anticipated odour levels during adverse meteorological conditions and community expectations of amenity.

Where a number of the factors above simultaneously contribute to making an odour "offensive", an odour goal of 2 OU at the nearest residence (existing or any likely future residences) is appropriate, which generally occurs for affected populations equal or above 2000 people.

A summary of odour performance goals for various population densities, as referenced in the Odour Technical Notes is shown in is given in **Table 1**.

Table 1 NSW DECC Impact Assessment Criteria for Complex Mixtures of Odorous Air Pollutants

Population of Affected Community	Impact Assessment Criteria for Complex Mixtures of Odours (OU)
Urban area (≥ 2000)	2.0
500 – 2000	3.0
125 – 500	4.0
30 – 125	5.0
10-30	6.0
Single residence (≤ 2)	7.0

Source: The Odour Technical Notes, DECC 2006

2.1.1 Project-specific Odour Criteria

The selection of a suitable Odour Impact Assessment Criteria for application in the current study is challenging due to such criteria being made contingent upon the future population of the affected MPIP. Although the existing population within the study area can be established, uncertainties are introduced in the projection of future population numbers in areas earmarked for development.

Considering future developments, including the development of the Project Site and establishment of low and medium density housing in part of the area, an odour impact assessment criterion of 2 to 3 OU would likely be applicable.

The DECC Air Policy Unit takes the general view that the Sydney Metropolitan region is a contiguous urban area for the purposes of odour assessment, thus recommending the implementation of an odour impact criterion of 2 OU for this region. Although it is not known for certain whether this criterion would be recommended by the DECC for the study location, it is evident that such a criterion would be appropriate given the earmarking of the broader region for development as residential and employment lands.

3 ODOUR SOURCES

The Stage One odour assessment identified two poultry farms located on the northern boundary of the MPIP. These were located at Lot 6, 306 South St and Lot 7, 264A South St. During the Stage One assessment, a screening (Level 1) odour assessment was undertaken according to the Odour Policy. Based on this assessment, a separation distance between these poultry operations and any residences was recommended.

This Stage Two (Level 3) odour assessment seeks to refine the predictions of the Stage One assessment by undertaking a more detailed dispersion modelling exercise (detailed in **Section 5**). An examination of the wider area surrounding the MPIP was carried out to identify any further odour sources. Three further poultry farm operations have been identified at 1132 and 1148 Richmond Road, and 51 Argowan Rd, Schofields. These sources have been included in the current modelling assessment. Odour emission rates have been calculated and applied as outlined in **Section 5.1**).

3.1.1 Poultry Operations

The biodegradation of accumulated faecal matter within the poultry sheds is a significant source of odour. Gaseous odorous compounds which are absorbed into litter or chicken bodies are transferred into the shed air at varying rates depending on the air velocity in the shed. Water is believed to act as a catalyst in the processes of odour generation, transfer and transport.

Poultry shed odour emissions typically comprise a complex mixture of odorous molecules. The types of compounds generated are dependent on whether aerobic or anaerobic conditions exist. The presence of oxygen at or near the litter surface creates aerobic conditions under which uric acid, proteins and animal fats biodegrade to produce nitrogen-containing odorants such as ammonia, amines, indole, skatole and volatile fatty acids. Under such aerobic conditions, sulphide containing compounds are also oxidised microbially into sulphur containing odorants such as hydrogen sulphide, dimethyl disulphide and dimethyl trisulphide (Jiang and Sands, 2000). Odour qualities of typical gases and vapours released are as follows: ammonia (pungent, irritating), hydrogen sulphide (rotten eggs), dimethyl sulphide (rotting vegetables), butyric acid (rancid butter), valeric acid (putrid, faecal smell), isovaleric acid (mouldy sneakers, old shoe character), skatole (faecal, nauseating) and indole (intense faecal).

When the supply of oxygen at or near the litter surface is limited and anaerobic conditions prevail, sulphur containing compounds are biodegraded into thiols, volatile organic sulphides and mercaptans (Jiang and Sands, 2000). Limited oxygen supply is associated with poorly managed farms where caked manure occurs. Such conditions can be limited by reducing the ingress of water into the litter, increasing the exposure of the litter to air by providing more space for bird movement, and by feeding balanced complete rations with sulphur compounds of high biological availability particularly early in the growth cycle of a batch (Jiang and Sands, 2000). Based on the measurement of several natural and tunnel ventilated broiler sheds (Jiang and Sands, 2000) concluded that ammonia and dimethyl sulphide are, by volume, the major odorous constituents inside the broiler sheds investigated.

4 CLIMATE AND DISPERSION METEOROLOGY

Meteorological mechanisms govern the dispersion, transformation and eventual removal of pollutants from the atmosphere. The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer. Dispersion comprises vertical and horizontal components of motion. The stability of the atmosphere and the depth of the surface-mixing layer define the vertical component. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume 'stretching'. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. The wind direction, and the variability in wind direction, determines the general path pollutants will follow, and the extent of crosswind spreading.

Pollution concentration levels therefore fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth, and to shifts in the wind field (Oke, 2004).

To adequately characterise the dispersion meteorology of the study site information is needed on the prevailing wind regime, mixing depth and atmospheric stability and other parameters such as ambient temperature, rainfall and relative humidity.

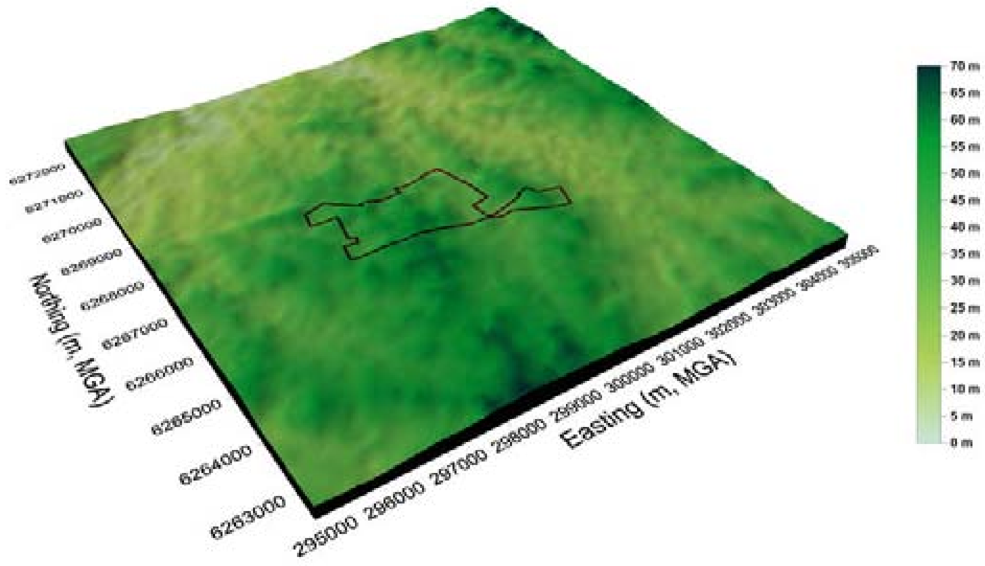
4.1 Meteorological Modelling

A diagnostic 3-dimensional wind field has been created for the western Sydney region including the area surrounding the MPIP site for a previous Heggies odour assessment. This diagnostic wind field incorporated surface observations from several Bureau of Meteorology meteorological monitoring stations in the region and included upper air data to accurately represent the 3-dimensional nature of the hourly wind field during 2006. From this file, a single point meteorological file was extracted for a grid cell located directly above the odour sources (poultry farms) to the north of the MPIP.

In areas with flat and uncomplicated terrain, the assumption of steady state meteorological conditions, particularly for use in a screening level dispersion modelling assessment, may be considered appropriate. Based on the terrain features presented in **Figure 2**, it could be argued that relatively uniform dispersion conditions would be expected across the modelling domain, between the odour sources and the MPIP, and the use of a single point file is therefore deemed appropriate.

Further information on the dispersion modelling undertaken as part of this assessment is provided in **Section 5**.

Figure 2 Local Topographical Features - MPIP (vertical exaggeration of 4)

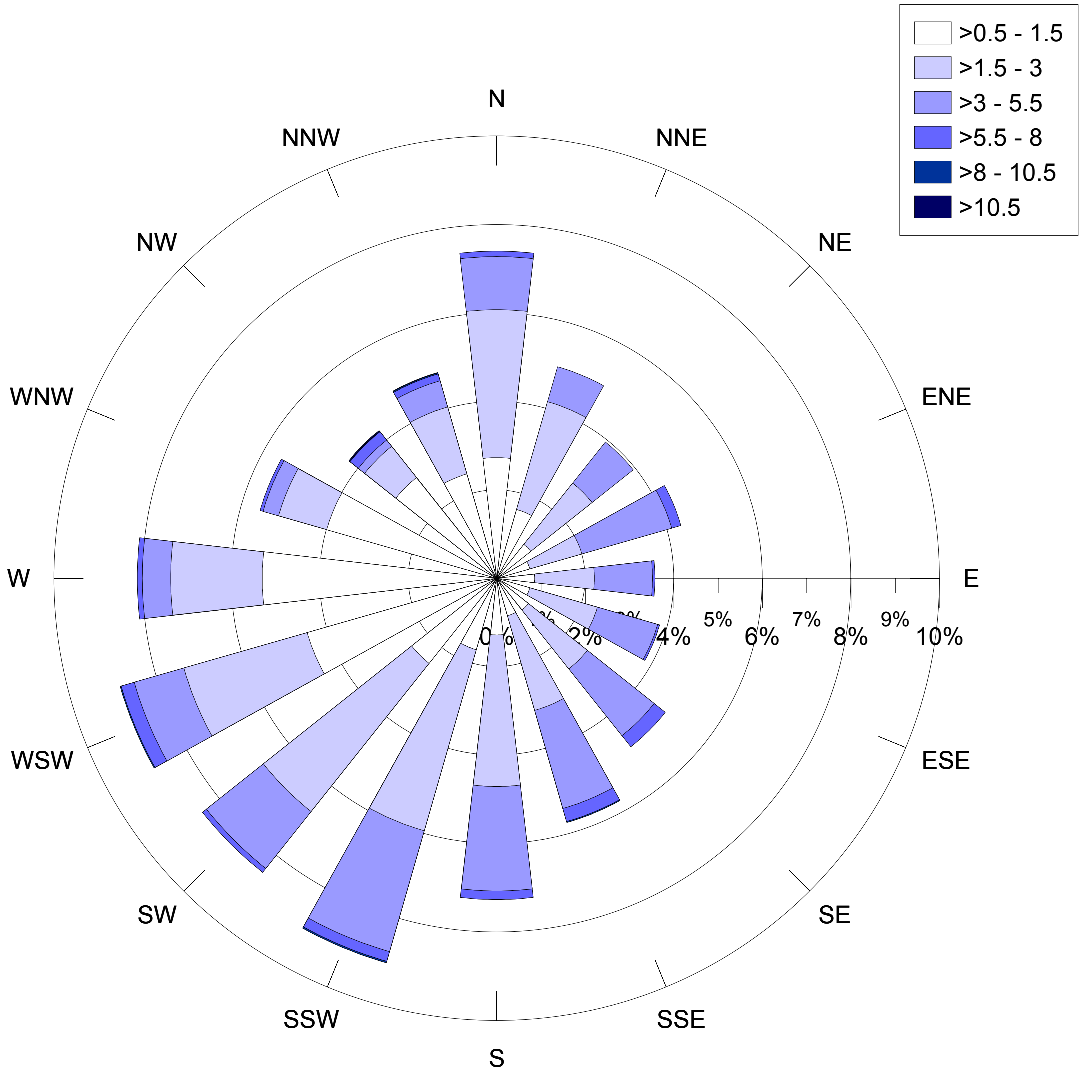


4.2 Wind Regime

A summary of the annual wind behaviour predicted for the Project Site (2006) is presented as a wind rose in **Figure 3.** This wind rose displays occurrences of winds from all quadrants.

Figure 3 indicates that winds experienced at the site are predominately light to moderate winds (between 0.5 m/s and 5.5 m/s) from the southwest. Calm wind conditions (wind speed less than 0.5 m/s) are predicted to occur infrequently (4.9 %) of the time.

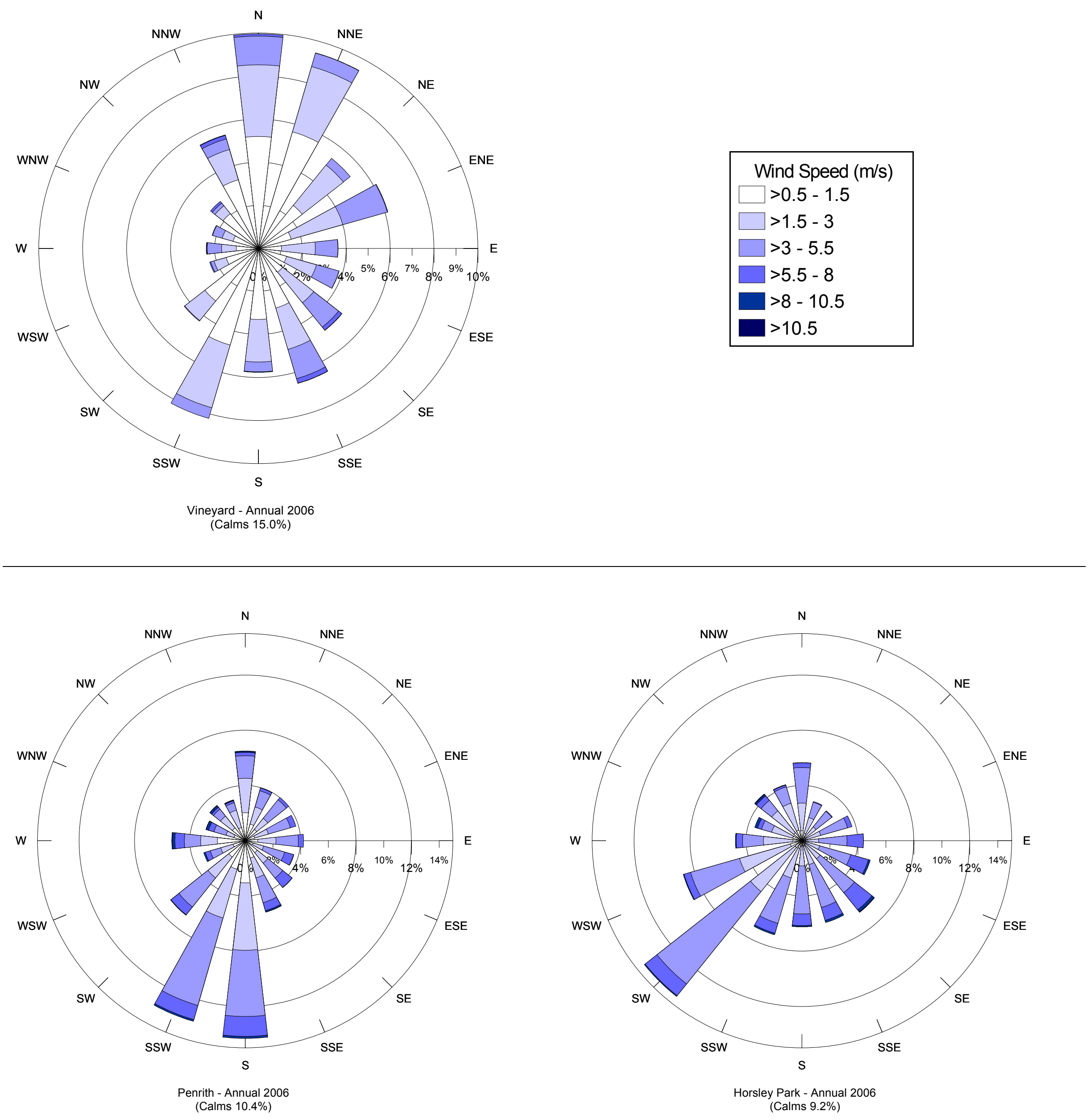
Figure 3 Annual Wind Rose – Project Site (Diagnostic Meteorological Data 2006)



Project Site - Annual 2006
(Calms 4.9%)

The annual wind roses for the surrounding Richmond (13 km NNW of Project Site), Vineyard (8 km N of Project Site) and Penrith (13 km WSW of Project Site) meteorological monitoring sites for 2006 are presented in **Figure 4**. Although the wind roses for the wider area show differences to that predicted for the Project Site during 2006, the major features such as dominant wind directions are well captured and can be considered to be representative of the region.

Figure 4 Annual Wind Roses – Vineyard, Penrith and Horsley Park, 2006



The seasonal variation in wind behaviour at the site is presented in **Appendix A**. The seasonal wind roses indicate that:

- In spring, light to moderate winds (between 1.5 m/s and 8 m/s) are experienced predominantly from the north.
- In summer, light to moderate winds are experienced predominantly from the east nort-east and southeast.
- In autumn, light to moderate winds are experienced predominantly from the west-southwest.
- In winter, light to moderate winds are experienced predominantly from the west-southwest.

4.3 Atmospheric Stability and Mixing Depth

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Gifford assignment scheme identifies six Stability Classes, "A" to "F", to categorise the degree of atmospheric stability. These classes indicate the characteristics of the prevailing meteorological conditions and are used as input into various air dispersion models (**Table 2**).

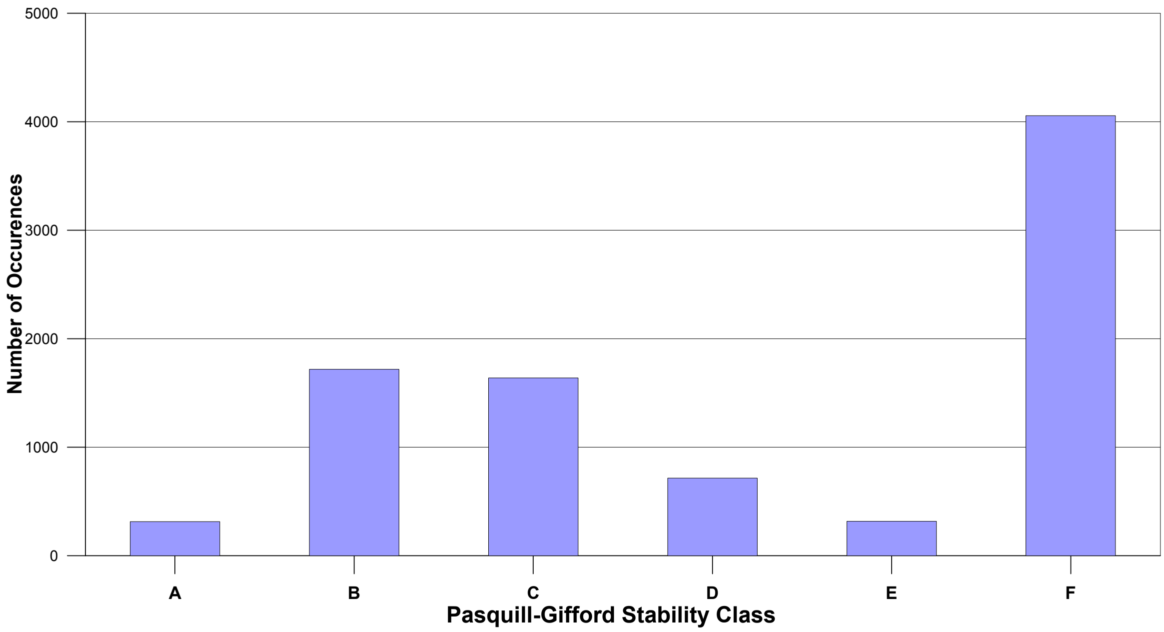
Table 2 Description of atmospheric stability classes

Atmospheric Stability Class	Category	Description
A	Very unstable	Low wind, clear skies, hot daytime conditions
B	Unstable	Clear skies, daytime conditions
C	Moderately unstable	Moderate wind, slightly overcast daytime conditions
D	Neutral	High winds or cloudy days and nights
E	Stable	Moderate wind, slightly overcast night-time conditions
F	Very stable	Low winds, clear skies, cold night-time conditions

The frequency of each stability class predicted at the Project Site is presented in **Figure 5**. The seasonal stability class distributions are included in **Appendix B**.

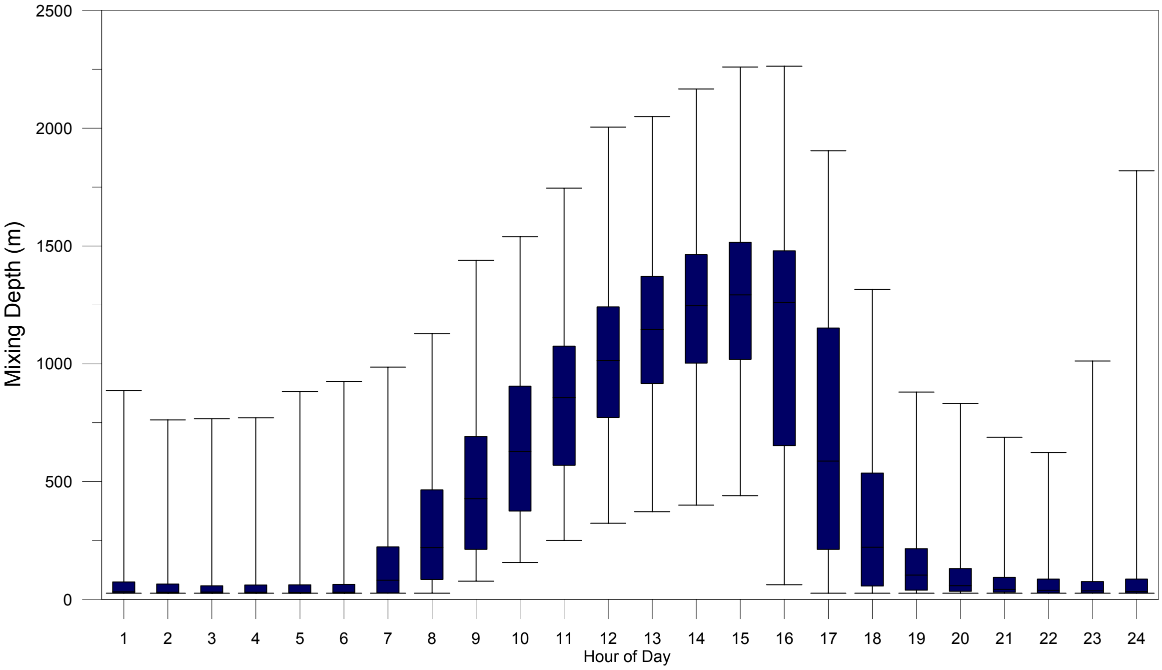
The results indicate a high frequency of conditions typical to Stability Class "F". Stability Class "F" is indicative of very stable conditions, providing little potential for atmospheric dispersion of pollutants due to a low level of mechanical mixing.

Figure 5 Predicted Annual Stability Class Distributions for the Project Site, 2006



Predicted diurnal variations in maximum and average mixing depths at the Project Site during 2006 are illustrated in **Figure 6**.

Figure 6 Predicted Diurnal Variation in Mixing Depth for the Project Site, 2006



It can be seen that an increase in the mixing depth during the morning, arising due to the onset of vertical mixing following sunrise, is apparent with maximum mixing heights occurring in the mid to late afternoon, due to the dissipation of ground-based temperature inversions and the growth of convective mixing layer.

5 DISPERSION MODELLING

CALPUFF, a puff dispersion model suitable for use in complex atmospheric dispersion situations, can be configured in screening mode, using a single meteorological input file such as an Ausplume meteorological input file. Using CALPUFF in screening mode assumes steady state conditions with a single one dimensional wind field applied across the entire modelling domain.

This approach is not considered appropriate for non-steady state conditions, such as in coastal locations or areas of complicated terrain where non-uniform wind conditions can be expected. However, as discussed in **Section 4.1**, the assumption of steady state meteorological conditions in this assessment is considered appropriate.

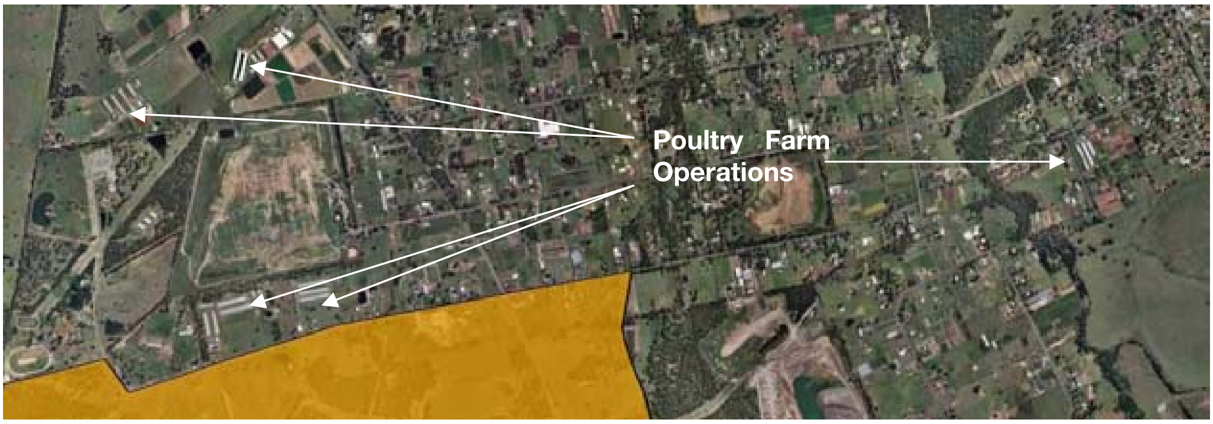
The current assessment utilises the CALPUFF (Version 6.1) modelling system run in screening mode using the single point meteorological input file. The advantages of using CALPUFF in screening mode (rather than using a steady state Gaussian dispersion model such as Ausplume) is its ability to handle calm (wind speeds less than 0.5 m/s) wind conditions. Ausplume cannot handle calm conditions because of the inverse wind speed dependence within the Gaussian plume equation. Under calm conditions, Ausplume will assume a minimum wind speed which shoots the plume to the edge of the modelling grid, even though the plume may not have moved at all under actual dispersion conditions (DECC 2005).

CALPUFF can handle these low wind speed conditions and will grow a plume by diffusion alone under zero wind speed conditions. It is often these conditions that are critical in odour assessment.

5.1 Calculated Odour Emission Rates

As discussed in **Section 3**, five poultry farm operations have been identified in the vicinity of the MPIP. The locations of these sources are shown in **Figure 7**.

Figure 7 Locations of Poultry Farm Operations surrounding the MPIP



No detailed information regarding the nature and scale of the poultry operations situated in the area could be obtained from the various local councils on which to estimate emissions. The extent of odour emissions from such operations had therefore to be calculated based on the observed number and size of sheds on each farm, with assumptions made regarding the number of birds likely to be housed in each shed based on experience gained for this sector. Based on the nature of farms and field observations for other poultry operations it was concluded that such operations were likely to comprise primarily broiler operations.

Information on the location and dimensions of poultry sheds were obtained from geo-referenced aerial photography and topographical maps for the area. The five shed groupings were simulated as volume sources within the dispersion model, the dimensions of which are given in **Table 3**.

A poultry shed which is approximately 100 m long and 15 m wide typically houses about 22,000 birds (Scorgie *et al*., 2007). The number of birds assumed to be housed in the various sheds identified were therefore scaled relative to their size. The estimated number of birds which can be housed in each of the poultry shed groupings is given in **Table 3**.

Jiang and Sands (2000) estimated *maximum* odour emission rates (OERs) to be in the range of 311 to 579 OUV/s/1000 birds across all broiler farm shed designs including natural, tunnel and cross ventilation sheds (housing between 19,500 and ~43,000 birds). Odour emission rates for naturally ventilated shed designs were in the range 311 to 405 OUV/s/1000 birds. *Average* odour emission rates were published by Jiang and Sand (1998) to be 195 OUV/s/1000 birds.

Table 3 Location and Size of Poultry Sheds in the Study Area, and Estimated Odour Emissions

Farm	Shed	Location and Dimensions of Volume Sources Simulated for each Shed Grouping						Estimated Number of Birds	*Average* Emission Rate (OUV/s)
		Easting	Northing	Shed Width (m)	Shed Length (m)	Horizontal Spread (m)	Vertical Spread (m)		
306 South St, Marsden Park	1	298493	6268099	15	90	3.75	0.75	19800	3861
	2	298530	6268107	15	90	3.75	0.75	19800	3861
	3	298616	6268160	20	140	5	0.75	41067	8008
	4	298595	6268193	15	120	3.75	0.75	26400	5148
	5	298489	6268175	15	62	3.75	0.75	13640	2659.8
264A South St, Marsden Park	1	298946	6268217	13	125	3.25	0.75	23833	4647.5
	2	298938	6268242	13	125	3.25	0.75	23833	4647.5
	3	298933	6268274	15	125	3.75	0.75	27500	5362.5
1148 Richmond Rd, Marsden Park	1	298154	6269076	15	62	3.75	0.75	13640	2659.8
	2	298133	6269037	15	95	3.75	0.75	20900	4075.5
	3	298100	6269014	15	95	3.75	0.75	20900	4075.5
	4	298058	6269005	15	62	3.75	0.75	13640	2659.8
	5	298122	6268915	15	55	3.75	0.75	12100	2359.5
	6	298162	6268930	15	67	3.75	0.75	14740	2874.3
	7	298212	6268951	50	60	12.5	0.75	44000	8580
1132 Richmond Rd, Marsden Park	1	298599	6269191	15	120	3.75	0.75	26400	5148
	2	298627	6269187	15	120	3.75	0.75	26400	5148
51 Argowan Rd, Schofields	1	302187	6268870	13	110	3.25	0.75	20973	4089.8
	2	302204	6268891	15	105	3.75	0.75	23100	4504.5
	3	302220	6268915	17	62	4.25	0.75	15459	3014.44

The difference between average and maximum OERs for poultry operations is due to such rates being highly variable throughout the year due to two main factors:

- Batch cycle. The emission rate is considered to peak just prior to the first harvest of birds (normally at weeks 5 to 6) when the bird mass in the shed is at a maximum.
- Ventilation rate. This rate is both directly and indirectly dependent on temperature and wind field.

Although factors are available to account for temporal variations in broiler shed emissions due to batch cycles, it is not possible to know how the batch cycles of the various poultry farms are likely to coincide in relation to each other. It is considered that the application of maximum emission rates for each shed is overly conservative and to better represent reality and to better guide concept plan options for the MPIP, average OERs have been applied to all sheds.

Average odour emission rates calculated for each poultry shed grouping based on the estimated number of birds and the emission factor (195 OUV/s/1000 birds) are summarised in **Table 3**.

An hourly emission rate file was generated for input in the dispersion modelling to take into account reductions in emissions during cool night-time hours when the flaps of naturally ventilated sheds are likely to be closed. Jiang and Sands (2000) observed that flaps are generally closed when the temperature drops below 15°C and that emissions reduce by 90% when flaps are closed.

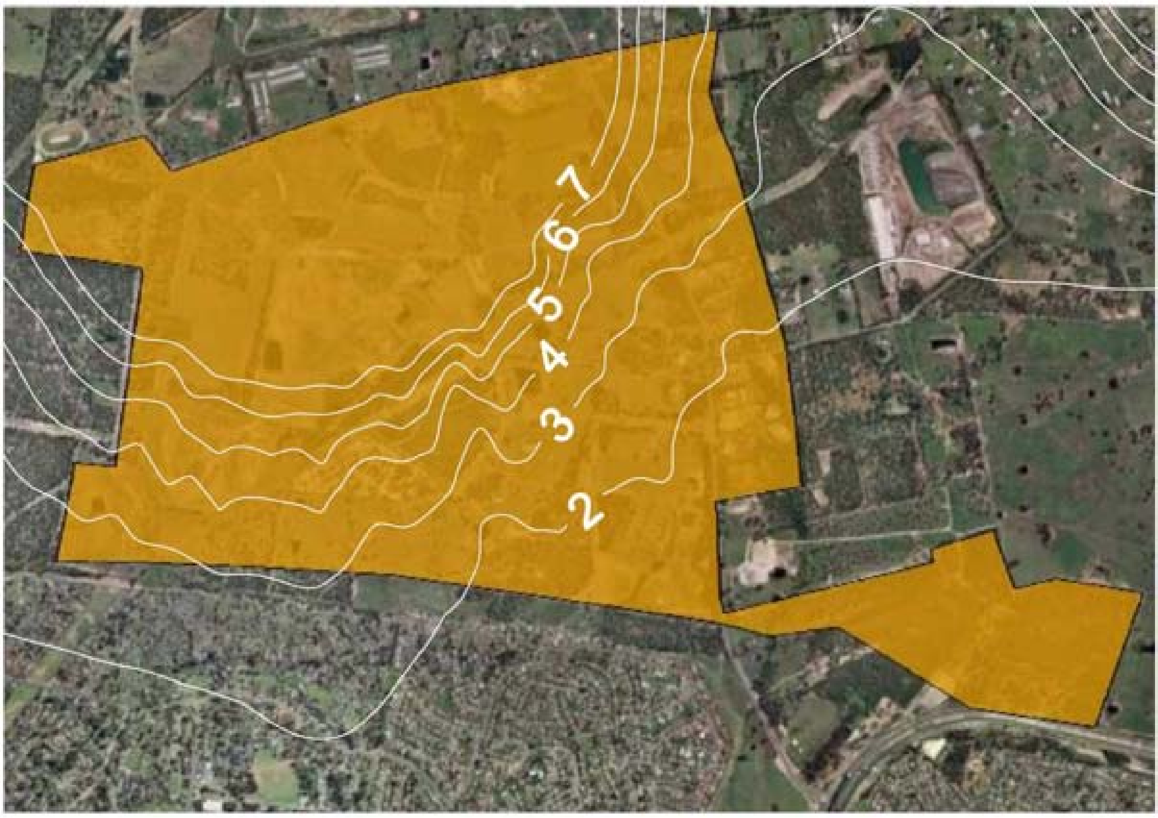
To estimate the effects of plume meandering and concentration fluctuations perceived by the human nose, a peak-to-mean ratio of 2.3 was applied to the emission rate as recommended by the DECC (2005) for volume sources. 99^{th} percentile odour concentrations (for nose-response times) were predicted across the MPIP and surrounding area.

6 DISPERSION MODEL RESULTS

Predicted 99th percentile odour units (for nose-response times) output by CALPUFF for the emission scenario outlined in **Section 5.1** are presented in **Figure 8**.

The odour contour plots for do not reflect odour concentrations occurring at any particular instant time, but rather illustrate the predicted frequency that odour concentrations are exceeded at the 99th percentile level. The plot therefore represents the concentrations that can possibly be reached under a combination of all meteorological conditions modelled.

Figure 8 Predicted 99th Percentile Odour Concentration Isopleths within the MPIP due to Poultry Farm Operations



As discussed in **Section 2.1.1**, Project specific odour criteria have been identified as being between 2 and 3 OU based on the likely numbers of residences (low to medium density housing) to be located in the MPIP. **Figure 8** demonstrates that the 3 OU criterion is exceeded across approximately 50% of the MPIP area with the west and north of the MPIP predicted to experience exceedances of this goal. The Project specific odour criteria are shown to be met in the south and east of the MPIP.

Higher odour concentrations are experienced closer to the northern boundary of the MPIP due to the proximity of the poultry farm operations on South Street. The impact of odour on the MPIP resulting from the poultry farm operations on Argowan Road, Schofields is shown to be low.

7 CONCLUSIONS AND RECOMMENDATIONS

An odour assessment was undertaken to provide clear guidance on whether odour criteria across the Marsden Park Industrial Precinct (MPIP) are expected to be within acceptable limits as a result of poultry farm operations to the north and north east of the MPIP. The main findings arising from the assessment and recommendations made in respect of such findings are presented below.

7.1 Key Findings

Odour levels of 2 OU to 3 OU are predicted to occur over the western and northern parts of the Project Site, based on *average* OERs for poultry operations, under certain meteorological conditions.

Given applicable odour impact assessment criteria, it is concluded that odour impact potentials are likely to be in an acceptable range in approximately 50% of the MPIP area, specifically within the south eastern corner.

Odour qualities of typical gases and vapours released by poultry operations include ammonia (pungent, irritating), hydrogen sulphide (rotten eggs), dimethyl sulphide (rotting vegetables), butyric acid (rancid butter), valeric acid (putrid, faecal smell), isovaleric acid (mouldy sneakers, old shoe character), skatole (faecal, nauseating) and indole (intense faecal).

7.2 Recommendations

7.2.1 Land Use Zoning

The NSW Department of Planning (DoP), through the Growth Centres Commission, has developed a long term, 20 year, Development Control Plan (DCP) for the area including the MPIP. It is assumed that within this timeframe, many of the odour sources considered in this report will not remain. This is in consideration of future rezoning planning for much of the North West Growth Centre.

In the short term, however, development within MPIP may coincide with the existing odour sources. The results of this odour assessment will be included within the DCP so that potential odour issues are presented at the master planning phase, and identified for further assessment during the development application (DA) phase. It would be expected that in cases where potential odour impacts would impact on specific development outcomes, additional odour assessment may be triggered as part of the DA process.

7.2.2 Odour Management and Mitigation

In the event that sensitive land uses are proposed for development in the northern and western areas of the Project Site, consideration should be given to odour management and mitigation measures which may aid in the reduction of odour concentrations within the MPIP.

It is suggested that DoP undertake a review of odour mitigation measures currently in operation in all poultry sheds to the north of the MPIP. During this review, additional measures could be identified for implementation. The funding of such works should be negotiated between poultry farm owners and DoP. A range of potential management and mitigation measures are presented in **Appendix C** for information. A detailed analysis of the potential odour reductions due to each measure or range of measures implemented could be undertaken to assess cost-effectiveness.

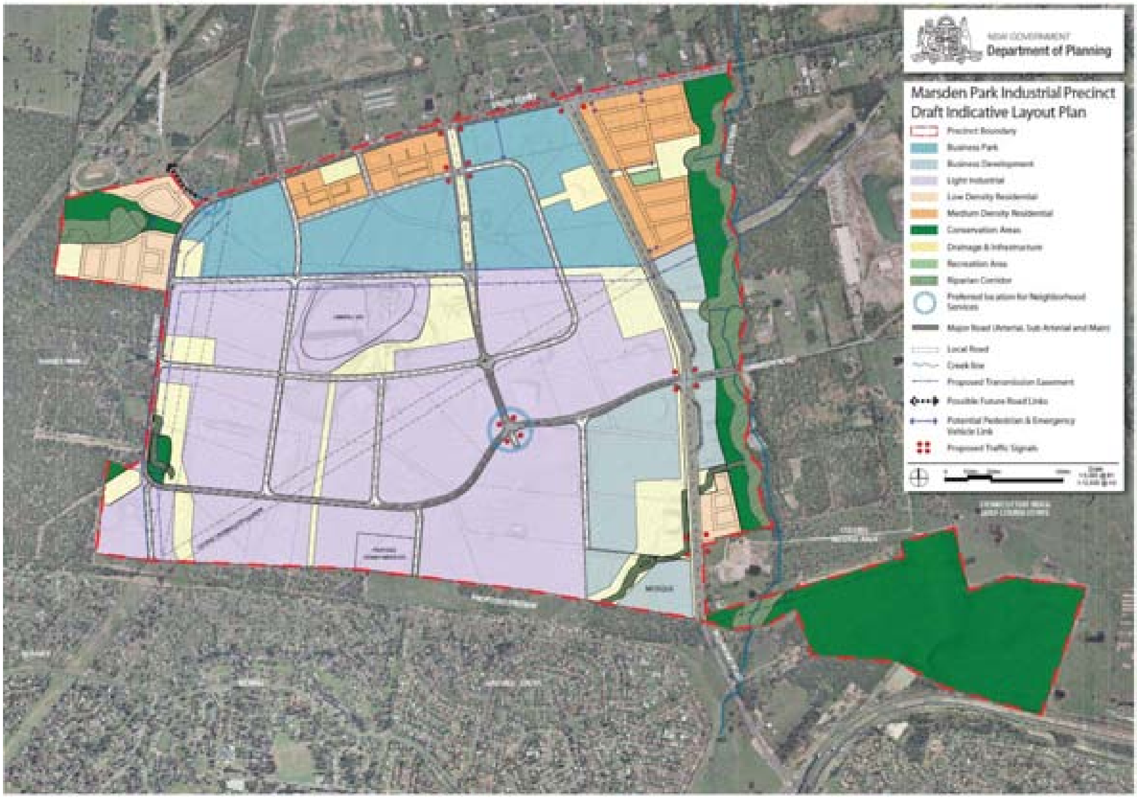
Prior to any construction works being undertaken on the MPIP, validation of odour modelling studies should be undertaken (e.g. odour intensity surveys) to confirm whether the conservative nature of the modelling undertaken is valid.

Mitigation measures could be applied within the MPIP, the aim of which would be to reduce exposure to odour; the options here are limited with installation of buffers (vegetated or concrete) between residences and poultry operations the most suitable measure.

7.3 Indicative Layout Plan Assessment

The Marsden Park Industrial Precinct – Indicative Layout Plan – dated 2 January 2009 is presented in **Figure 9**.

Figure 9 Marsden Park Industrial Precinct - Indicative Layout Plan



Given the predicted odour levels presented within this report, the following comment is provided on the master plan:

- The northern and western parts of the MPIP are less suitable for sensitive land uses such as residential development, in the short term.
- The most suitable areas for residential land uses are predicted to be in the south eastern area of the MPIP, in the short term.
- Staging of the master plan should take into account short and long term odour issues, taking into account zoning for areas surrounding the MPIP.
- Where potential odour impacts arise, further investigations may be triggered as part of the DA process for specific development outcomes.

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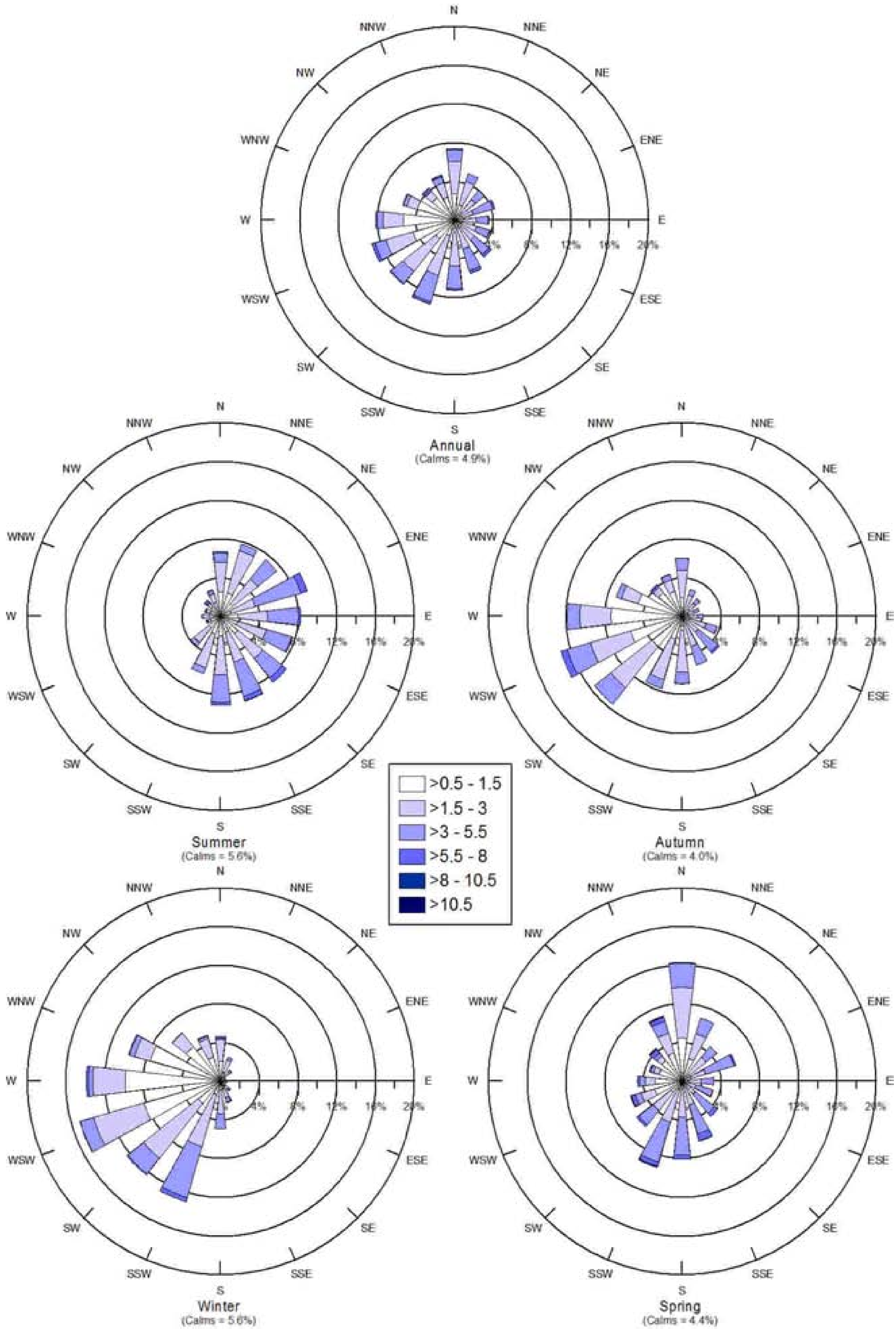
9 ABBREVIATIONS AND ACRONYMS

AWS	Automatic Weather Station
BoM	Bureau of Meteorology
DA	Development Application
DCP	Development Control Plan
DECC	NSW Department of Environment and Climate Change (previously the Department of Environment and Conservation, DEC)
EPA	NSW Environment Protection Authority
Heggies	Heggies Pty Ltd
MPIP	The Marsden Park Industrial Precinct
µg	Microgram (g X 10^{-6})
µm	Micrometre or micron (metre X 10^{-6})
m^3	Cubic metre
OU	Odour Units; concentration of odorous mixtures in odour units. The number of odour units is the concentration of a sample divided by the odour threshold or the number of dilutions required for the sample to reach the threshold. This threshold is equivalent to when 50% of a testing panel correctly detect an odour
OER	Odour Emission Rate ($OU.m^3/s$)
OUV	Odour Unit Volumes; odour units are not concentrations but are a ratio. As such, they may not be used to represent an odour emission. It is necessary to multiply the source odour level (OU) by the volume of air emitted per second, to produce an odour emission rate. Typically odour emission rates may be expressed as OUV/s (point/volume sources) and $OUV/m^2/s$ (area sources) with units of $OU.m^3/s$ and $OU.m^3/m^2/s$ respectively.
VOC	Volatile organic compound



Heggies Pty Ltd Consulting Engineers and Scientists 2 Lincoln Street Lane Cove NSW 2066 Australia PO Box 176 Lane Cove NSW 1595 Telephone +612 9427 8100 Facsimile +612 9427 8200 Email Sydney@heggies.com	Designed by MD	Checked by SF	Approved by - date	Filename 10-7391 P Site 2006	Dated 23/01/09
	Appendix A: Predicted Annual and Seasonal Windroses for Project Site, 2006				

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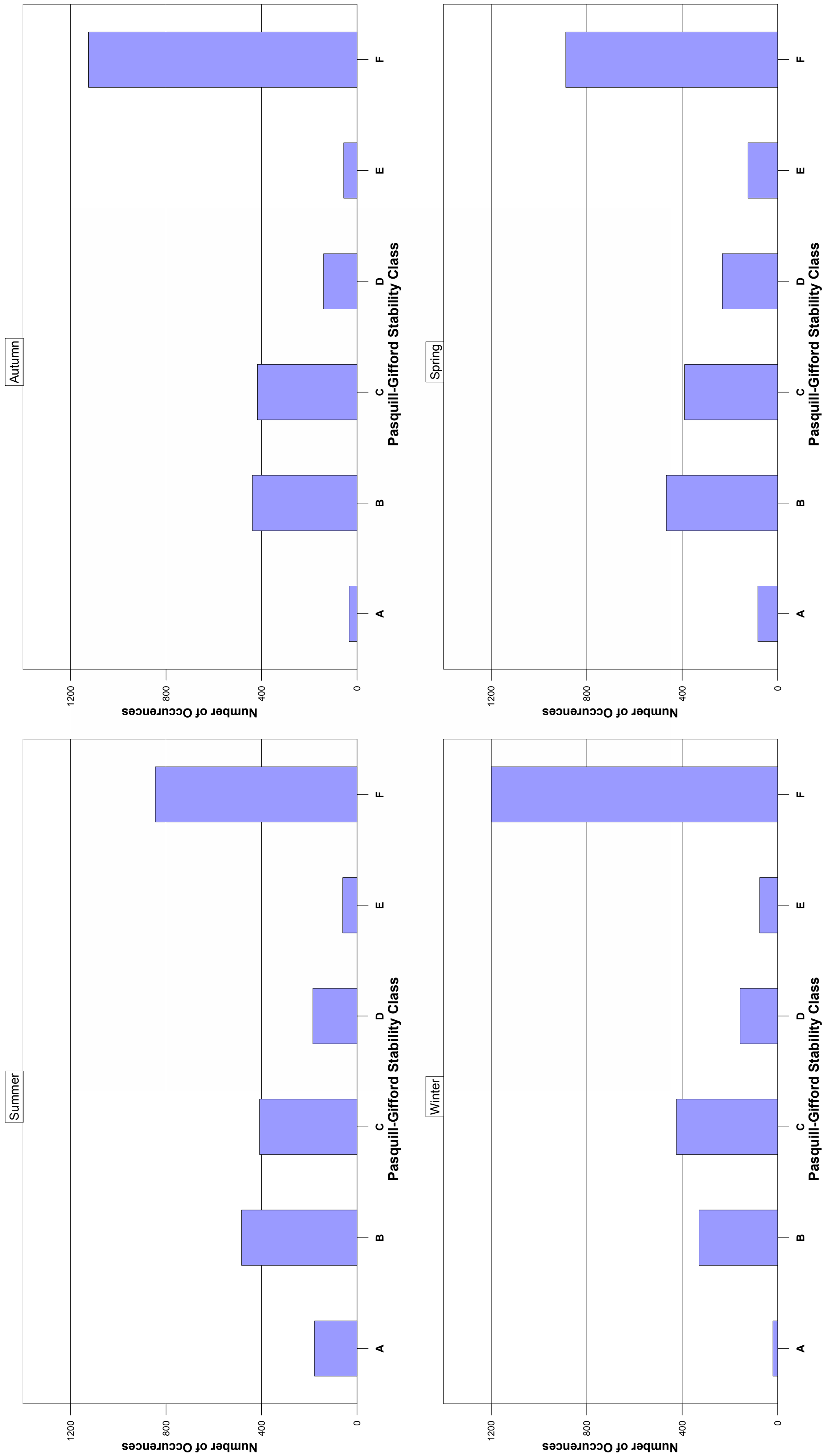
Standards Australia

Predicted Seasonal Stability Class Distribution for Project Site, 2006



Potential Odour Management and Mitigation Options - Poultry Sheds

Management measures could be applied to the poultry farm operations, the aim of which would be to reduce odour emissions, increase atmospheric dispersion of odour emissions, or a combination of both.

Current odour management practices at all poultry operations are unknown although general recommendations are provided here which may be of use should MPD decide that this course of action be required, or is indeed achievable.

- Vegetation buffers and fencing, as illustrated in **Figure 1**, could be established between the poultry farms and the MPIP. This would act to increase mechanical turbulence and improve dispersion and also as a physical barrier onto which odours can be adsorbed.
- Litter could be covered with fresh absorbent material such as sawdust or shavings to minimise moisture content of the manure.
- Good housekeeping practice should be implemented. The poultry farm should avoid stockpiling of manure.

The European Union Best Available Technology (EU BAT) in terms of housing systems for broilers is: (i) the naturally ventilated house with a fully littered floor and equipped with non-leaking drinking systems, or (ii) the well-insulated fan ventilated house with a fully littered floor and equipped with non-leaking drinking systems. Within the EU BAT, emphasis is also placed on avoidance of wet litter (to minimise ammonia emissions) by tailoring drinking systems, controlling stock density and/or use of floor insulation.

Figure 1 Example of vegetation buffers adjacent to poultry sheds

- Ensure that internal shed temperatures are accurately recorded on an ongoing basis and try to maintain temperatures near to 22°C. This temperature is given by the NSW Department of Agriculture (2004) as being optimal in terms of reduced litter degradation and odour volatilisation and improved bird welfare (healthy birds produce drier and less odorous manure).

- In summer, bird density should be reduced if internal shed temperatures cannot be maintained at recommended levels.
- Overstocking of birds should be avoided as per the thresholds provided by the NSW DECC (DEC 2005).
- Ventilation during clean out should be designed to achieve the maximum amount of odour dilution. Maintaining the maximum possible airflow through the shed will keep the litter dry and help disperse odours.
- The moisture content of the poultry litter should be kept as low as possible (15% - 30% is ideal to prevent both odour and dust problems) and a litter pH above 7.5 maintained to inhibit anaerobic bacterial activity.
- Removing wet patches of poultry litter and / or covering litter with fresh absorbent material.
- Roof insulation can prevent excessive radiation heat gain during hot parts of the day. Optimal thermal insulation will also reduce the requirements for ventilation within the sheds. Roof insulation will also reduce condensation/rain dripping back to wet litter.
- Dead birds should be collected from sheds each day and refrigerated if not immediately disposed of.

Several measures could also be implemented including:

- use of odour neutralising or inhibiting agents through manure treatment or litter amendment (e.g. oil sprinkling, application of proprietary products);
- oxidisation methods (ozone and oxygen treatments);
- diet manipulation;
- conversions to a tunnel ventilated system (where naturally ventilated systems exist);
- conversions to a tunnel ventilated system with addition of windbreak walls; and
- conversion to tunnel ventilation system with air vented to a cleaning device (e.g. bio filters, bio scubbers, wet scrubbers, etc.).

A synopsis of various control technologies developed to reduce livestock emissions including odorous gases and dust, is given in **Table 1**.

Odour neutralising agents reduce odour potentials through masking or diluting odour concentrations, eg, by encouraging biological or chemical interactions or increasing dispersion. There are a range of proprietary products on the market which specifically target poultry operations, eg, Alum and Poultry Litter Treatment.

The use of ozone, distributed inside sheds at low concentrations to oxidize odorous gases, is the subject of on-going research (Ullman *et al.*, 2004). High control efficiencies are being reported in more recent literature for ammonia. Research conducted also suggests that ozone breaks down the highly odorous organic molecule indole, and reacts with a number of odorants with potential reductions in amines, ammoniacal compounds, lower aliphatic acidic compounds, sulphurous compounds and others.

Table 1 Measures to reduce atmospheric emissions from poultry operations and associated control efficiencies

Measure	Pollutant	Control Efficiency	Reference	Application
Manure treatments / litter amendments	NH_3	90% (immediately after application); 50% (2 weeks after application)	Ullman *et al*., 2004	Application of sodium bisulfate in form of proprietary product Poultry Litter Treatment. Sodium bisulfate was also found to reduce the frequency and populations of certain pathogens (Ullman *et al*., 2004).
	NH_3	64% (up to 48 days after application)	Ullman *et al*., 2004	
	NH_3	Up to 99%	Ullman *et al*., 2004	Application of proprietary product Alum, a granular poultry litter amendment. Laboratory study indicates a 99% reduction in ammonia volatilisation.
Oil sprinkling	Dust	Up to 90%	Godbout *et al*. 2000	Control efficiency highly dependent on application rate and frequency. Primary implemented at pig housing facilities to date but increasingly finding alternative applications.
	Dust	40%	Kirychuk *et al*. 1999	Iowa pig finishing barn
	H_2S, NH_3	20 -30%	Zhang *et al*. 1996	
Diet manipulation	NH_3	40 – 50%	Rom *et al.* 2000	Food additive (juice extract from Yucca Schidigera plant) used
	NH_3	28 – 79%	Sutton *et al*. 1999	Lower protein diets
Air filtration(a)	Dust	50 – 60%	Carpenter and Fryer 1990	Filtration of air during air recirculation
Biofilters(a)	NH_3	9 – 99%	Earth Tech 2001a	
	H_2S	50 – 90%	Earth Tech 2001a	
	Dust	Up to 86%	Earth Tech 2001a	
	Other organics	Up to 46%	Earth Tech 2001a	
Bio scrubbers(a)	NH_3	22 – 54%	Earth Tech 2001a	
Wet scrubbers(a)	NH_3	8 – 94%	Earth Tech 2001a	
	Dust	44 – 90%	Earth Tech 2001a	
Electrostatic precipitators(a)	Dust	40 – 60%	Earth Tech 2001a	

Table 1 (continued) Measures to reduce atmospheric emissions from poultry operations and associated control efficiencies

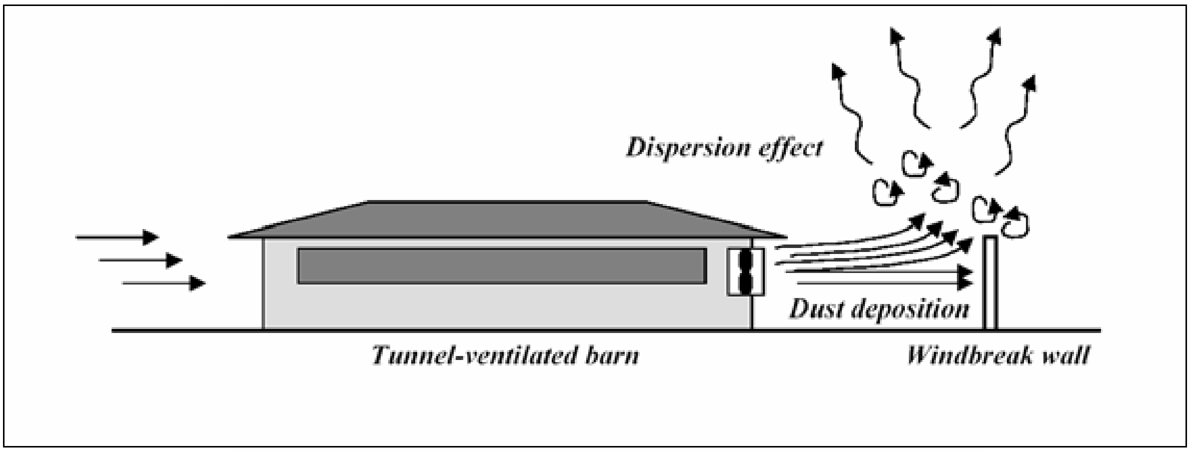
Measure	Pollutant	Control Efficiency	Reference	Application
Ozonation	NH_3	15 – 50%	Priem 1977	Odorous gases are oxidized by ozone that is distributed inside the shed at low concentrations. Care needs to be taken since ozone can be toxic to animals and humans at elevated concentrations. Earth Tech (2001a) noted that ozonation had not been thoroughly tested at that time and that additional research was needed to determine its efficiency and economic feasibility. The 15-50% control efficiency quoted by Earth Tech (2001a) was based on a 16-month experiment conducted by Priem in the 1970s at a swine barn. On-going research on the use of ozone to remove odours from livestock buildings has been conducted, e.g. in North Carolina. More positive reports are evident in more recent literature (Ullman *et al*. 2004). Gas chromatography analysis suggests that ozone breaks down the highly odorous organic molecule indole. Further studies indicate that ozone reacts with a number of odorants with potential reductions in amines, ammoniacal compounds, lower aliphatic acidic compounds, sulphurous compounds and others.
	NH_3	58%	Ullman *et al*. 2004	
	Dust	60%	Ullman *et al*. 2004	
Non-thermal Plasma(a)	H_2S, NH_3	Up to 100%	Earth Tech 2001a	Emission reductions achieved by creating highly reactive chemical species that convert targeted compounds to non-toxic molecules. 100% removal of NH_3 and H_2S concentrations during laboratory testing. Earth Tech (2001a) noted that this technology was still in its preliminary stages at that time and that additional research was needed to determine its efficiency and economic feasibility.
Wind break walls to be used with tunnel ventilation sheds	Dust, Odours	30 – 90% (odours)	Bottcher *et al*. 2000, 2001	Wind break walls constructed from tarpaulin can reduce odour concentration at sensitive receptors by 30-90% and the dispersion of dust emissions is promoted (Bottcher *et al*. 2000, 2001)
		Not given	Earth Tech 2001a	Wall made of wood panels, metal sheets or straw (etc.) placed about 10 to 20 feet from exhaust fans (Earth Tech 2001a).

(a) Require venting of air circulating within sheds to a cleaning device or treatment technology.

There is on-going research into manipulating feed additives to bind ammonia, change digesta pH, alter specific enzyme activity and mark odours. The majority of diet manipulation studies have focused on swine with less studies being conducted for poultry, dairy and beef. Some research has found such dietary modifications to either be costly or not consistently successful. Furthermore, it is argued that there is a trade-off to be made between animal productivity and odour reduction through diet manipulation (Earth Tech, 2001a). Much of the recent research on diet manipulation has been focussed on providing efficient and economic methods for reducing air emissions using diet manipulation thus not impacting on productivity. Certain researchers hold a positive view of the potential for dietary manipulation as a significant odour reduction measure based on recent work. Worley (2005), for example, states that odour control through dietary manipulation holds promise and "may revolutionise animal feeding practices within the next few years".

The installation of a tunnel-ventilation system could reduce odour potentials by directing exhaust vents away from residences. Wind break walls installed in front of exhaust vents can aid further in the dispersion of odour from these sources (**Figure 2**). Fan exhaust could also be vented to an abatement device, such as a water spray scrubber or chemical wet scrubber.

Figure 2 Tunnel ventilated shed with a windbreak wall (after Worley, 2005)



In conclusion, it is expected that significant emission reductions from poultry farms will need to be realised should odour performance goals be required to be met at the northern-most boundary of the MPIP. Such emission reductions will necessitate the investigation and adoption of additional measures, i.e. additional to "good practice" management of conventional shed operations.

Various options are available for the realisation of emission reductions. In the selection and tailoring of abatement options, care must be taken to investigate the technical feasibility and economic viability of such options in addition to obtaining realistic estimates of the site-specific control efficiencies likely to be achievable in practice.

Preliminary guidance is offered based on the project team's understanding of the poultry farms operations and documented abatement options. Dietary manipulation appears to require more conclusive local studies specifically with application for broiler operations. The cost of conversion to tunnel ventilated houses, with air vented to cleaning devices to ensure that the required control efficiencies are achieved, may be prohibitive and impractical.

It is therefore anticipated that litter amendment and manure treatment applications may represent the most cost-effective option for realising significant odour emission reductions in the short-term. The control efficiency to be achieved by such measures will depend on the specific product selected and the manner in which it is applied.

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