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ODOUR MODELLING AND IMPACT ASSESSMENT: BOMEN INDUSTRIAL ESTATE, WAGGA WAGGA

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Prepared for
Willana Associates

by
Holmes Air Sciences

Suite 2B, 14 Glen St
Eastwood NSW 2122
Phone : (02) 9874 8644
Fax : (02) 9874 8904
Email : has@holmair.com.au

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1. INTRODUCTION

This report has been prepared by Holmes Air Sciences for Willana Associates. The purpose of the report is to assist Wagga Wagga City Council ("Council") in their review of future development near the Bomen Industrial Estate. This report provides an assessment of the impacts of existing odorous industries in the area to assist in the planning process.

This assessment is based on the use of a computer-based dispersion model, AUSPLUME, to predict the extent of odour levels due to existing industries. To assess the impact of predicted odour levels, the dispersion model predictions have been compared to relevant regulatory air quality criteria.

The assessment is based on a conventional approach following the procedures outlined in the NSW Department of Environment and Climate Change's (DECC) document titled "Approved Methods for the Modelling and Assessment in NSW" (**DEC, 2005**).

In summary, this report provides information on the following:

- Air quality criteria for odour;
- Meteorological conditions in the area;
- Odour sources and estimates of emissions;
- Methods used to predict existing odour levels due to local industries, and
- Expected dispersion patterns and predicted impacts.

2. LOCAL SETTING

Council are reviewing the rezoning of land in and around the Bomen Industrial Estate, to the northeast of Wagga Wagga in central New South Wales (NSW). **Figure 1** shows the location of Bomen, relative to Wagga Wagga, as well as the industrial estate. The area to the west of the industrial estate, known as Cartwrights Hill, is the nearest residential area to Bomen while there is a small rural residential precinct to the north, known as Brucedale. The boundary of the area of interest for this study is also shown in **Figure 1**.

Bomen is a rural area comprising a mixture of residential properties and farms, industries and grazing land. Terrain in the area consists of gently undulating hills, which are shown by a pseudo three-dimensional picture in **Figure 2**.

A main objective of this study is to determine the extent of odour impacts arising from the existing odour generating industries. The extent of odour impacts can then be used for consideration in the rezoning process.

Some of the key odorous industries are identified below:

- Chargeurs Wool / Riverina Wool Combing;
- Cargill Foods; and
- Livestock Marketing Centre;

Estimation of odour emissions from these and other existing and proposed industries is provided in **Section 5**.

There is a history of odour complaints registered with the DECC for the study area - these data are not available for presentation in this assessment. In particular, most odour complaints have originated from the Cartwrights Hill area and directed at the odour generating industries at Bomen. The abattoir (Cargill Foods) is generally accepted as the operation most likely to cause odour impacts and Council have recognised that there have been potential incompatibilities between the residential land of Cartwrights Hill and the industrial land at Bomen. This lead Council to impose a moratorium on the erection of new dwellings in the Cartwrights Hill area.

Cargill Foods have recently upgraded their abattoir operations in an effort to reduce odour emissions and it has been reported (**Wilana Associates, 2007**) that there has been a considerable reduction in the number of complaints about industrial activity in Bomen since the abattoir upgrade. However, some complaints are still being received by DECC.

The upgrade of the abattoir and evidence of reduced complaints has prompted a review of the moratorium on further development at Cartwrights Hill. It is understood that DECC have concerns about allowing further residential development near the Bomen Industrial Estate, due primarily to periodic odour complaints that are being received. One objective of the DECC's position is likely to be the minimisation of odour impacts as far as practicable.

One requirement of the *Protection of the Environment Operations Act (POEO) 1997* (Section 129) is that there should be no offensive odour beyond the activity site boundary or at closest residences. The DECC extended the definition of offensive odour through the development of acceptable odour levels, discussed in **Section 3.2**.

The dispersion modelling carried out for the current study seeks to quantify the odour impacts of existing odorous activities by comparing model results with the DECC's odour criteria. The model results may assist Council in their review of the moratorium on further development at Cartwrights Hill.

3. ODOUR ISSUES

This section evaluates odour in terms of measurement and air quality criteria that relate to odour. There is still considerable debate in the scientific community about appropriate odour criteria as determined by dispersion modelling.

3.1 Measurement of Odour

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

Olfactometry can involve a "forced-choice" end point or a "free choice" endpoint. The "forced-choice" method is where panellists identify from multiple sniffing ports, the one port where odour is detected, regardless of whether they are sure they can detect odour. The "free choice" endpoint is a "yes/no" decision where panellists are required to say whether or not they can detect odour from one sniffing port. Forced-choice olfactometry generally detects lower odour levels than free choice olfactometry.

In both the "forced-choice" and "free choice" cases, odorous air is presented to the panellists in increasing concentrations. For the forced-choice method, where there are multiple ports for each panellist, the concentration is increased until all panellists consistently distinguish the port with the sample from the blanks. For a yes/no olfactometer (which has only one sniffing port) one method used is to increase the concentration of odour in the sample until all panellists respond. The sample is then shut off and once all panellists cease to respond, the sample is introduced again at random dilutions and the panellists are asked whether they can detect the odour.

An Australian Standard (AS/NZS 4323.3.2001) for olfactometry has been developed which is consistent with the European Standard, CEN. This enables results between laboratories to be more uniform.

An odour unit is a difficult unit to define precisely. Historically, it has been the level at which 50% of the population can just detect that there is an odour present. The standard defines 1 odour unit (ou) as that concentration of odorant(s) at standard conditions that elicits a physiological response from a panel (detection threshold) equivalent to that elicited by one Reference Odour Mass (ROM) evaporated into 1 cubic metre of neutral gas at standard conditions.

Some of the terms in this definition require further explanation as follows:

- Standard conditions for olfactometry are a temperature of 0°C (273K) and normal atmospheric pressure (101.3 kPa) on a wet basis.
- Neutral gas is air or nitrogen that is treated in such a way that it is as odourless as possible.
- One ROM evaporated into one cubic metre of neutral gas at standard conditions is the mass of a substance that will elicit the D_{50} physiological response assessed by a panel in conformity with the standard and has by definition a concentration of 1 ou.
- The D_{50} physiological response is the dose at which 50% of a population can detect a sensory stimulus.
- The detection threshold is the highest dilution factor at which the sample has a probability of 0.5 of eliciting with certainty the correct perception that an odour is present. This dilution factor will be too high for the sample to be recognised.
- It is common to use n-butanol as a reference gas and for this compound one ROM is 132 μg which, when evaporated into 1 cubic metre of neutral gas at standard conditions, produces a concentration of 40 ppb. Panellists are usually screened for sensitivity to n-butanol and the panel threshold reported as part of the odour measurement procedure. There is a requirement that a panellist's sensitivity to the reference material falls between 0.5 and two times the accepted reference value which for butanol is 20–80 ppb.

The purpose of these very precise definitions is to improve the repeatability and accuracy of odour measurements.

As with all sensory methods of identification there is variability between individuals. Consequently the results of odour measurements depend on the way in which the panel is selected and the way in which the panel responses are interpreted. The process by which these imprecise measurements are translated into regulatory criteria is still being refined. However, the DECC has recently published a Technical Framework for the assessment of odour from stationary sources, which includes recommendations for odour criteria (**DECC, 2006**). These are explained below and have been used for this assessment.

3.2 *Odour Criteria*

The determination of air quality criteria for odour and their use in the assessment of odour impact is recognised as a difficult topic in air pollution science. The topic has received considerable attention in recent years and the procedures for assessing odour impacts using dispersion models have been refined considerably.

The DECC has attempted to refine odour criteria and the way in which they should be applied with dispersion models to assess the likelihood of nuisance impact arising from the emission of odour. However, as discussed above these procedures are still being developed and odour criteria are likely to be revised in the future.

There are two factors that need to be considered:

1. what "level of exposure" to odour is considered acceptable to meet current community standards in NSW and

2. how can dispersion models be used to determine if a source of odour meets the criteria which are based on this acceptable level of exposure.

The term "level of exposure" has been used to reflect the fact that 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. Odour criteria need to take account of these factors.

The DECC Technical Framework includes some recommendations for odour criteria. The criteria have been refined by DECC to take account of population density in the area. **Table 1** lists the odour certainty thresholds, to be exceeded not more than 1% of the time, for different population densities.

Table 1 : DECC odour assessment criteria

Population of affected community	Odour performance criteria (nose response odour certainty units at the 99th percentile)
Rural single residence (≤2)	7
~10	6
~30	5
~125	4
~500	3
Urban (>2000) and/or schools and hospitals	2

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 assume that 7 odour units at the 99th percentile would be acceptable to the average person, but as the number of exposed people increases there is a chance that sensitive individuals would be exposed. The criterion of 2 odour units at the 99th percentile is considered to be acceptable for the whole population.

It is common practice to use dispersion models to determine compliance with odour criteria. This introduces a complication because Gaussian 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 Gaussian dispersion model, the DECC commissioned a study by Katestone Scientific Pty Ltd (see **Katestone 1995** and **1998**). This study recommended peak-to-mean ratios for a range of source types. The ratio is also dependent on atmospheric stability and the distance from the source. A summary table of these ratios is presented in **Appendix A**.

The DECC Technical Framework (**DECC, 2006**) takes account of this peaking factor and the criteria shown in **Table 1** are based on nose-response time.

4. DISPERSION METEOROLOGY

Meteorology is important for the transportation and dispersion of odour. The Gaussian dispersion model used for this assessment, AUSPLUME, requires information about the dispersion characteristics of the area. In particular, data are required on wind speed, wind direction, atmospheric stability class[1] and mixing height[2].

Meteorological data have been collected in the area by Pacific Power in 1998 (refer to **Figure 1** for the site location). Hourly records of wind speed, wind direction and sigma-theta (the standard deviation of the horizontal wind direction) were collected. Temperature data were not collected from this site and to produce a file suitable for the dispersion model, contemporaneous temperature data from the Bureau of Meteorology at Wagga Wagga airport were used. Data recovery in 1998 was 8,088 hours which is equivalent to just over 92% of the 8,760 possible hours available in that year.

Annual and seasonal windroses created from the wind speed and wind direction data are presented in **Figure 3**. Annually, the most common winds were from the west-southwest although winds from the eastern sector are also common. Very few winds were recorded from the north or south and this pattern of winds was present in all seasons.

Calm periods (winds less than or equal to 0.5 m/s) were recorded for 16% of the time and the mean wind speed from the 1998 dataset was 2.1 m/s.

To use the wind data to assess dispersion, it is necessary to also have available data on atmospheric stability. For the Pacific Power dataset, a stability class was assigned to each hour of the meteorological data using sigma-theta and according to the method recommended by the US EPA (**US EPA, 1996**). **Table 2** shows the frequency of occurrence of the stability categories expected in the area.

Table 2 : Frequency of occurrence of stability in the area

Stability Class	Wagga Wagga, Pacific Power data 1998 (%)
A	17.6
B	4.9
C	8.5
D	28.3
E	10.3
F	30.4
Total	100

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

[2] The term mixing height refers to the height of the turbulent layer of air near the earth's surface into which ground-level emissions will be rapidly mixed. A plume emitted above the mixed-layer will remain isolated from the ground until such time as the mixed-layer reaches the height of the plume. The height of the mixed-layer is controlled mainly by convection (resulting from solar heating of the ground) and by mechanically generated turbulence as the wind blows over the rough ground.

Both D class and F class atmospheric stabilities are calculated to occur most often in the Wagga Wagga area. Under D class conditions, odour emissions will disperse rapidly while under F class conditions, odour emissions will disperse slowly.

Mixing height is also required by the AUSPLUME model. Hourly estimates were determined empirically using methods by **Powell (1976)** and **Venkatram (1980)**.

The DECC has set minimum requirements for meteorological data used for air quality assessment purposes. These requirements include the following:

- At least one year of site-specific meteorological data
- The meteorological data must adequately describe the site under investigation
- Data must be at least 90% complete

The Pacific Power data are close to the area of interest and will be representative of conditions where odour emissions have been modelled. The data would also satisfy the DECC minimum data requirements for meteorological data used for dispersion modelling purposes.

Joint wind speed, wind direction and stability class frequency tables for the Pacific Power 1998 data are provided in **Appendix B**.

5. ESTIMATED EMISSIONS

As well as meteorological information which describes the dispersive capacity of the atmosphere, dispersion models require information on the emission sources. There are three main types of emission sources; point sources, area sources and volume sources. For point sources the dispersion model requires information on the source location, the source height, internal source tip diameter, temperature of emissions, exit velocity of emissions and the mass emission rate of the pollutants to be assessed. Area sources typically describe such things as ponds or exposed surfaces while volume sources can be used to represent emissions discharged from a single point, a building or even located in a series which may be used to represent a roadway. As well as the mass emission rate, area and volume sources require information on the dimensions of the source.

Odour emissions from area sources are probably the most difficult to measure for a variety of reasons. Firstly the source is often heterogeneous. For example in the case of a landfill site, there will be different odour emission rates from different sections of the landfill. Secondly, unlike stack emissions, area emission rates are dependent upon atmospheric conditions including wind speed, degree of turbulence, temperature, etc. This clearly adds another level of complexity to odour assessments.

Table 3 provides the quantitative information on each odour source used in the dispersion modelling. Total odour emission rates (TOER) were derived from odour measurements, estimates and dispersion modelling for Meat and Livestock Australia (MLA) (**The Odour Unit and PAE, 2003**).

Odour emissions data from the MLA study included only the source description, the source type, the source location and the TOER so various other parameters required for the dispersion model needed to be assumed. The assumptions were as follows:

- All stack sources were 20 m high with a diameter of 0.5 m, exhaust velocity of 15 m/s and exhaust temperature 5 degrees above the ambient temperature; and

- Areas of sources PR1 to PR9 (proposed sources) were taken to be 100 m by 100 m, in the absence of source dimension information;

These assumptions will introduce uncertainty into the modelling so the results should be considered as indicative only.

Table 3 : Odour sources and emissions used in the dispersion modelling

ID	Source	Description	Assumed source type	easting (m)	northing (m)	elevation (m)	Height (m)	Diameter (m)	Velocity (m/s)	Temperature (deg C)	Area (m^2)	SOER ($ou.m^3/m^2/s$)	TOER (ou.m3/s)
1	CW-Dr1	dryer stack 1	Point	539213	6120685	244	20	0.5	15	Amb+5			1500
2	CW-WS1	wool scour lines (ventilation) 1	Volume	539223	6120635	245							12000
3	CW-Dr2	dryer stack 2	Point	539223	6120685	244	20	0.5	15	Amb+5			1500
4	CW-WS2	wool scour lines (ventilation)	Volume	539233	6120635	245							12000
5	PR1-S1	Stack	Point	537551	6120385	219	20	0.5	15	Amb+5			50000
6	PR1-S2	Stack	Point	537571	6120385	220	20	0.5	15	Amb+5			40000
7	PR1-S3	Stack	Point	537561	6120365	220	20	0.5	15	Amb+5			10000
8	CW-AP7	aerobic ponds	Area	539213	6121135	237					68500	1.5	102750
9	CW-AnP	anaerobic ponds	Area	539320	6121185	235					22500	2	45000
10	CW-SP	sludge pits	Area	539355	6121095	237					100	5	500
11	CF-Pau	Paunch	Area	536763	6118315	229					1350	10	13500
12	CF-Hol	Holding Pens	Area	537282	6118295	220					4000	4.25	17000
13	CF-AeP	aerobic pond	Area	536682	6118455	236					12000	1	12000
14	LMC-Ea	Holding pen manure	Area	537508	6119475	215					55900	1.13	63200
15	ANL	Unknown	Area	537901	6118255	231					15000	6	90000
16	CW-AP3	aerobic ponds	Area	539480	6121655	231					82500	0	0
17	CW-AP4	aerobic ponds	Area	539806	6121595	223					73500	0	0
18	CW-AP5	aerobic ponds	Area	539956	6121555	220					135000	0	0
19	LMC-We		Area	537322	6119475	209					35000	0	0
20	PR1-A1	Area	Area	537513	6120395	218					10000	0.0707	707
21	PR3-A1	Area	Area	538113	6119135	232					10000	9	90000
22	PR3-A2	Area	Area	538063	6119085	230					10000	0.0785	785
23	PR7-A1	Area	Area	541235	6122885	238					10000	9	90000
24	PR7-A2	Area	Area	541113	6122885	240					10000	0.0785	785
25	PR8-A1	Area	Area	539363	6123235	233					10000	9	90000
26	PR8-A2	Area	Area	539513	6123185	234					10000	0.0785	785
27	PR9-A1	Area	Area	538113	6121485	220					10000	9	90000
28	PR9-A2	Area	Area	538113	6121385	222					10000	0.0785	785
29	CW-Ce1	centrifuges	Volume	539308	6120515	248							5000

ID	Source	Description	Assumed source type	easting (m)	northing (m)	elevation (m)	Height (m)	Diameter (m)	Velocity (m/s)	Temperature (deg C)	Area (m^2)	SOER (ou.$m^3/m^2/s$)	TOER (ou.m3/s)
30	CF-DAF	DAF	Volume	537323	6118535	225							28600
31	CF-Ren	Rendering	Volume	537223	6118505	222							109000
32	CF-S/A	Save-All	Volume	537233	6118535	223							20000
33	CW-Ce2		Volume	539298	6120515	248							5000
34	CF-ScT	Screening Tank	Volume	537333	6118535	225							18000
35	PR3-V1	Volume	Volume	537713	6119085	220							1500
36	PR3-V2	Volume	Volume	537813	6119085	223							5000
37	PR7-V1	Volume	Volume	541233	6122835	237							1500
38	PR7-V2	Volume	Volume	541233	6122855	237							5000
39	PR8-V1	Volume	Volume	539813	6123185	239							1500
40	PR8-V2	Volume	Volume	539513	6123205	234							5000
41	PR9-V1	Volume	Volume	538213	6121385	224							1500
42	PR9-V2	Volume	Volume	538263	6121385	226							5000

6. APPROACH TO ASSESSMENT

In August 2005, the DECC published guidelines for the assessment of air pollution sources using dispersion models (**DEC, 2005**). The guidelines specify how assessments based on the use of air dispersion models should be undertaken. They include guidelines for the preparation of meteorological data, emissions data and relevant air quality criteria. The approach taken in this assessment follows as closely as possible the approaches suggested by the guidelines.

Odour levels due to the identified industries have been predicted using AUSPLUME (Version 6.0). AUSPLUME is an advanced Gaussian dispersion model developed on behalf of the Victorian EPA (**VEPA, 1986**) and is based on the United States Environmental Protection Agency's Industrial Source Complex (ISC) model. It is widely used throughout Australia and is regarded as a "state-of-the-art" model. AUSPLUME is the model required for use by the DECC unless project characteristics dictate otherwise (**DEC, 2005**).

Odour levels have been predicted over an area of 10 km by 10 km. Local terrain has been included in the model. The modelling has been performed using the meteorological data discussed in **Section 4** and the emissions data from **Section 5**.

Odour emissions in the dispersion model have been multiplied by the recommended peak-to-mean ratios for different source types (see **Appendix A**) to predict odour levels for nose response times. Peak-to-mean factors for the far-field have been applied for the purposes of this assessment.

The way in which the model has been used in the odour assessment has been to predict the 1-hour average odour levels, corrected to nose response times and expressed in odour units, at each receptor. Model predictions have been made at 2601 gridded receptors (with grid spacing 200 m). The 1-hour averaging times have been used for consistency with the DECC odour criteria.

For the purposes of presenting the results, plots of odour levels at the 99th percentile have been compiled, showing the extent to which odours are predicted to occur for 99% of the time. The 99th percentile plots can be compared with the DECC odour criteria (refer **Section 3.2**).

As an example of the way in which the model has been configured, the AUSPLUME model output file is provided in **Appendix C**.

Various model scenarios have been developed, which are described by **Table 4**. Scenario 1 represents the modelling of all odour emission sources, as presented in **Table 3**. To examine the effect on odour impacts from the abattoir upgrade, Scenario 2 includes a 90% reduction in emissions from the rendering plant as well as some reduced emissions from ponds at Chargeurs Wool. Scenarios 3 to 6 represent the upgraded abattoir operations only, but also test the sensitivity of source height on the model predictions. Some increase to the modelled heights of area and volume sources was considered necessary to represent enhanced buoyancy since the ponds and processes are generally warmer than the surrounding environment. Four source heights were examined; ground-level and 10, 20 and 30 m above ground. The height that most accurately reflects the source buoyancy is unknown.

Table 4 : Dispersion model scenarios

Scenario	ID labels of source included	Description
1	1 to 42 (all sources in **Table 3**)	Assumes all modelled odour sources have a similar odour character and that all proposed activities with odour emissions are in operation.
2	1 to 42 (all sources in **Table 3**)	Assumes all modelled odour sources have a similar odour character and that all proposed activities with odour emissions are in operation. Reduced odour emissions from source "CF-Ren" (the abattoir rendering plant) to represent plant upgrade (109,000 ou/s to 10,900 ou/s). Reduced (50%) odour emissions from anaerobic and aerobicponds at Chargeurs Wool (CW-AnP and CW-AP7).
3	11, 12, 13, 30, 31, 32 and 34	Odour emissions from Cargill foods only (after upgrade).
4	11, 12, 13, 30, 31, 32 and 34	Odour emissions from Cargill foods only (after upgrade). Assumes the heat in the sources is important for dispersion so sources modelled at 10 m high.
5	11, 12, 13, 30, 31, 32 and 34	Odour emissions from Cargill foods only (after upgrade). Assumes the heat in the sources is important for dispersion so sources modelled at 20 m high.
6	11, 12, 13, 30, 31, 32 and 34	Odour emissions from Cargill foods only (after upgrade). Assumes the heat in the sources is important for dispersion so sources modelled at 30 m high.

7. ASSESSMENT OF IMPACTS

The dispersion model results have been presented as contour plots shown in **Figures 4** to **9**. It has been estimated that the population of the community around Cartwrights Hill is of the order of 20 which indicates that the appropriate odour criteria is 5 odour units at the 99th percentile (according to the DECC population-based criteria in **Table 1**). A more stringent odour criteria may need to be adopted if the population density of Cartwrights Hill were to increase.

Figure 4 shows model results for all odorous sources presented in the emissions inventory (refer **Table 3**). In addition to existing sources in the area, the results also include the effect of proposed odour sources but do not simulate any reduction to odour emissions from controls and/or recent upgrades. The model results suggest that odour levels at the 99th percentile are of the order of 50 odour units at Cartwrights Hill. Similar predictions are observed for the Brucedale area to the north of Bomen. This is one order of magnitude higher than the adopted odour criteria of 5 odour units.

The effect of odour controls (namely, the abattoir upgrade and reduced emissions from Chargeurs Wool ponds) is represented by the model results in **Figure 5**. At Cartwrights Hill the predicted odour levels are reduced from 50 odour units to approximately 30 odour units which is still well above all the DECC's population-based criteria. These predictions suggest that the modelled activities are likely to cause adverse odour impacts (that is, odour complaints).

Predicted odour impacts from only the Cargill Foods operation are shown in **Figures 6** to **9**. These results account for reduced odour emissions due to the abattoir upgrade. Sources heights ranging from ground-level to 30 m above ground-level were modelled to reflect the buoyancy that would be induced when the ponds are at a higher temperature than the ambient air. This is likely to occur on cool winter nights and early mornings. The actual plume rise induced by this effect is uncertain but is unlikely to exceed 30 m and the results shown in **Figures 9** should be taken to be optimistic predictions. Predictions for source heights at ground-level are likely to be overly conservative.

For sources heights at 10 m above ground-level (**Figure 7**), predicted odour levels at the 99th percentile are 30 odour units at Cartwrights Hill, similar to the result for the model of all sources (**Figure 5**). This suggests that the Cargill Foods operation is one of the highest contributors to odour impacts at Cartwrights Hill. As the assumed source heights increase, the predicted odour impacts decrease. For 20 m source heights the 99th percentile odour levels are predicted to be 20 odour units which decreases to 7 odour units for 30 m source heights. These levels are above the 5 odour units criterion that has been adopted for Cartwrights Hill.

8. CONCLUSIONS

This study has used computer-based dispersion modelling to quantify odour impacts around the Bomen Industrial Estate, to the north of Wagga Wagga. Particular attention has been on Cartwrights Hill located west of Bomen since Council is in the process of reviewing the zoning of land in this area. To assess the extent of odour impacts, the dispersion model predictions have been compared with odour criteria noted by the DECC.

The dispersion modelling has used local meteorological information and estimates of odour emissions from various industries around Bomen to predict odour levels in the study area. It is recognised that the are some uncertainties in the emission estimates. Nevertheless, the dispersion model results have indicated the following:

- Predicted odour levels at Cartwrights Hill due to existing and proposed odour sources in the Bomen area are above the DECC's criteria. The magnitude of model predictions suggest that odour complaints are very likely to occur on occasions;
- Odour controls on some processes are likely to have reduced off-site odour impacts slightly but not to the point where compliance with odour criteria can be demonstrated; and
- Cargill Foods is likely to be the most significant source of odour at Cartwrights Hill;

It should be noted also that an increase in population density in the Cartwrights Hill area may increase the likelihood of odour complaints.

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