JAMES POINT PTY LTD

JAMES POINT PORT

LIVESTOCK EXPORT ODOUR MODELLING

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ABBREVIATIONS

AODM	Austrian odour dispersion model
AMSA	Australian Maritime Safety Authority
AS	Australian Standard
EPA	Environmental Protection Authority
ERS	Environmental Risk Solutions Pty Ltd
FIDOL	frequency, intensity, duration, offensiveness & location [of odours]
JPPL	James Point Pty Ltd
kg	kilogram
km	kilometre
LWT	liveweight
m	metre
M	million
m/s	metre/second
m^2/hd	square metres per head of livestock
m^3/h/kg	cubic metres per hour per kilogram of livestock
m^3/s/sheep	cubic metres per second per sheep
NH_3	ammonia
NSW	New South Wales
OU	odour unit
OU/m^3	odour units per cubic metre
OU/s	odour unit per second
OU/sheep/s	odour units per sheep per second
s	second
SOU	standardised odour unit
WA	Western Australia
y	year

DEFINITIONS

AMG	Grid referencing system, superseded by GDA 94 (see below).
AUSPLUME	A Gaussian dispersion computer model developed by the Victorian Environmental Protection Authority.
CEN TC264	A standard for odour measurement by the European Committee for Standardisation, "Air Quality – Determination of Odour Concentration by Dynamic Olfactometry".
Detection Odour Threshold	The lowest odour concentration that will elicit a response without reference to odour quality. This is reproducible and the most widely reported odour measurement in literature. Note: For dynamic olfactometry, the point at which only half the panel can detect odour is called the odour threshold or one odour unit.
Description Odour Threshold	The point at which dynamic olfactory panellist is asked to distinguish the odour.
GDA 94	Grid referencing system superseding the previous AMG system.
NVN 2820	A standard for odour measurement, determined by the Dutch Normalisation Institute.
Odour Units	Concentration of odorous mixtures in odour units. (The number of odour units is the concentration of the sample divided by the odour threshold or the number of dilutions required for the environmental sample to reach the threshold. This threshold is the numerical value equivalent to when 50% of an Odour Panel correctly detect the odour.).
Olfactometry	A procedure where a selected and controlled panel of at least 8 panellists are exposed to precise variations in odour concentrations in a controlled sequence. The results are analysed using standard methods to determine the point at which half the panel can detect the odour.
Peak-to-mean-ratio	A conversion factor which adjusts mean dispersion model predictions to the peak concentrations perceived by the human nose.
Recognition Odour Threshold	The minimum concentration that is recognised as having a characteristic odour quality, typically is 3 – 10 times higher than the detection threshold.

1. SUMMARY

James Point Pty Ltd (JPPL) propose to construct and operate a sea-port with land-backed berths on reclaimed and adjacent land, west of Risely Road and north of the BHP's No. 1 Jetty, in the central-west of the Kwinana Industrial Area, Western Australia. The proposed port has three ship berths. Proposed cargoes include bulk liquids and solids, containerised cargo, machinery, motor vehicles, animal feed and livestock, primarily sheep.

The Port will incorporate best practice aspects in its operation to control odour generated during the export of livestock. It is recognised that even at best practice there will be odours generated by the livestock while the ships are in port being loaded.

An initial semi-quantitative odour analysis was undertaken in December 2000, "James Point Livestock, Holding Facility Proposal, Odour Impact Evaluation". Specifically, the report stated that:

> "The approach taken is semi-quantitative as the confidence level of modelling is limited … this approach is considered to provide an indication of the likely odour impacts and is better than having no assessment undertaken."

The purpose of that analysis was to provide a comparative indication of the odour levels with those currently experienced in Fremantle.

There are two key inputs into the odour modelling, the number of sheep present and the level of odour per sheep. In the initial modelling a single sheep ship was assumed to be present at all times and the odour level was assumed to be that of 1 OU/sheep. JPPL have requested that the modelling be revised to show odour levels that may be associated with an expected ship schedule in the Port. The actual ship schedule (including sheep numbers) at Fremantle during the course of a year was used to simulate JPPL operations. A review of the odour level per sheep was also undertaken by reviewing olfactometry work conducted at Fremantle.

To assess the potential impact of the odours from the Port, a source odour characteristic was derived from the ship schedule and the measured odour levels for Fremantle, and a dispersion model ("AUSPLUME") used to predict the area within which sheep odour might be recognisable. Version 5.4 of Ausplume was used, which enables hourly input data for odour emissions. This option provides for more representative modelling and was not available during earlier studies.

International, interstate and Western Australian Environmental Protection Authority's (WA EPA) standards and guidelines were reviewed to identify criteria for ground-level concentrations of odour that will not contribute to annoyance. The criterion adopted was 7 OU/m^3 (99.9 %, 1-hour average) based on a number of factors, including the WA EPA's draft publication Assessment of Odour Impacts (EPA 2000), which states:

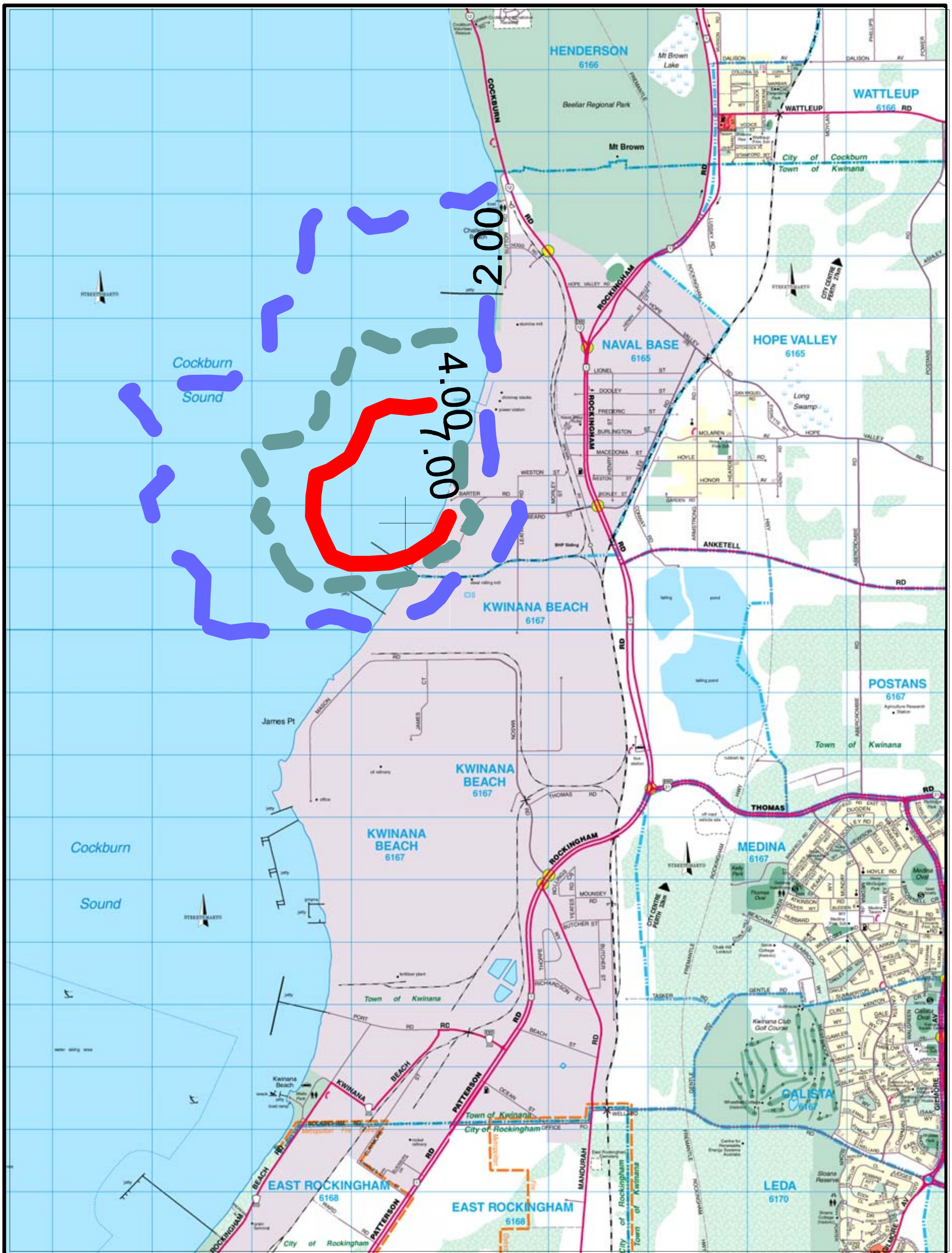
> *"It is possible that the proposed guideline [7 OU] is reasonably applicable to other industries where odour generation is similar to that for poultry farms – that is biological decomposition of organic material. ….the guideline would be most relevant to the following area or volume sources – cattle feedlots …".*

The value of 7 OU/m^3 is conservative compared to the Queensland Department of Environment proposed criteria of 17 OU/m^3 (Ref. 1).

Figure 1.1 shows that the area of the 7 OU/m^3 (99.9%, 1-hour average) contour to be restricted to south of Barter Road, north of the rail link to the BHP Transport site, and west of Leath Road, approximately the route of Riseley Road.

Therefore, it is predicted that odours from loading and holding ships at the proposed port will not contribute to annoyance (ie. impact on amenity) in the residential areas of Hope Valley, Medina or Wattleup. The 2 OU/m^3 contour is contained within the area west of Patterson Road. The area within the 7 OU/m^3 contour is predicted to be contained within the proposed JPPL site. This area will experience higher odour concentrations for greater than 0.1% of the time.

It is worthy of note that live-sheep trade through the proposed Port would correspondingly reduce exports through Fremantle, lowering the frequency of odour exposure in nearby residential, shopping and dining areas in Fremantle.



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ERS

James Point Pty Ltd

James Point Port

Odour Modelling

Odour Contours (2, 4 and 7 OU/s) for Emission from Ships at Sheep Emission Rate of 1.3 OU/sheep/s

Figure 1.1

2. INTRODUCTION

2.1. Background

James Point Pty Ltd (JPPL) proposes to construct and operate a sea-port with land-backed berths on reclaimed and adjacent land, west of Risely Road and north of BHP's No. 1 Jetty, in the central-west of the Kwinana Industrial Area, Western Australia.

Cargo that may be handled through the proposed James Point Port (the Port) includes:

- containerised cargos;
- bulk liquid and solid cargoes such as grain, crude minerals, animal feeds, ammonium sulphate, potash, petroleum products and sulphur;
- steel products, machinery, motor vehicles, scrap metal; and
- livestock, primarily sheep.

The export of livestock through the Port will be offset by a decrease in exports from Fremantle. The James Point Stage 1 Port will be capable of berthing three ships, of which normally only one and sometimes two would be livestock carriers. The livestock trade will involve approximately 120 ship visits per year, exporting approximately 4.2 million sheep and 100,000 cattle per year. The 120 livestock ships are anticipated to be comprised of approximately 70 large ships (30,000 or more sheep, 5,000 or more cattle) and 50 small ships (mainly cattle ships up to 3,000 head).

Although the proposed Port will incorporate best practice aspects in the design and operation, it is recognised that there will be odours produced from the livestock loading operations.

An initial semi-quantitative odour analysis was undertaken by Environmental Risk Solutions (ERS) in December 2000, "James Point Livestock, Holding Facility Proposal, Odour Impact Evaluation". Specifically, the report stated that:

> "The approach taken is semi-quantitative as the confidence level of modelling is limited … this approach is considered to provide an indication of the likely odour impacts and is better than having no assessment undertaken."

The purpose of that analysis was to provide a comparative indication of the odour levels with those currently experienced in Fremantle. For this initial modelling a single sheep ship was assumed to be present at all times and the odour level was assumed to be that of 1 OU/sheep.

Since this initial analysis, additional data and an improved dispersion modelling programme have become available namely:

- the schedule of livestock shipping operations for the proposed Port, including livestock numbers loaded per ship;
- olfactometry measurements on a ship loaded with sheep at Fremantle;
- Version 5.4 of Ausplume, allowing more representative dispersion modelling through using hourly or daily odour emission rates.

JPPL have requested that this information be used to refine the predictions of the likely odour impacts on residential and sensitive areas through dispersion modelling.

2.2. Objectives

Determine the extent of the cumulative odour plume from livestock being exported through the proposed Port.

2.3. Scope of Work

The scope of work included:

- researching published odour emission data for animals;
- reviewing ground level concentration odour criteria;
- reviewing the report on the olfactometry measurements conducted on a loaded ship at Fremantle;
- reviewing daily livestock numbers in ships loaded in Fremantle Port for the period of a year, and generating estimated hourly sheep numbers in ships from this data;
- undertaking dispersion modelling of the emissions of odour from the proposed Port during loading operations, using the data collected above; and
- preparing a report on the modelling results and impact evaluation.

This report focuses on the potential odour impacts on residential and industrial areas.

3. ODOUR CRITERIA & MODELLING PARAMETERS

3.1. General

Odour is defined as anything detected by the sense of smell. The New Zealand Ministry for the Environment (Ref. 1) suggests that there are five factors that influence odour complaints:

- frequency of the odour occurrence;
- intensity of the odour;
- duration of the exposure to the odour;
- offensiveness of the odour; and
- location of the odour.

These factors are often referred to as the FIDOL factors of odour sensation. Different regulatory bodies have concentrated on different aspects of the above odour factors in determining the best method to model odour dispersion and in determination of appropriate criteria. The following summarises the emphases of different regulators which is expanded upon below under respective headings:

- WA Environmental Protection Authority (EPA) – focus is on the relationship between the perceived strength versus the concentration of an odour;
- NSW EPA – focus is on providing a sliding scale of acceptable criteria versus exposed population; and
- Others including NSW EPA – peak-to-mean concentrations.

In addition to different approaches taken to modelling and setting criteria there is recognition that odour measurement is not an exact science and this has a bearing on the ability to rely on odour sampling and measurement when planning and regulating in respect of odour (Ref. 2).

Aspects of the above are reviewed below so that the most appropriate method of modelling and criteria is used in this analysis.

3.2. Environmental Protection Authority (WA)

The EPA have published draft guidance for the "Assessment of Odour Impacts" (Ref. 3), which provides advice on environmental aspects that will be considered by the EPA during the assessment of new proposals which have the potential for odour impacts which are incompatible with surrounding land uses.

Table 3.1 shows the recommended criteria and odour modelling parameters of the guidance document.

Table 3.1 EPA(WA) Recommended Criteria and Odour Dispersion Modelling Parameters

Parameter	Value
Odour criteria	Using intensity/concentration data determine the lowest concentration that gives a 'distinct' intensity in accordance with the German Standard VDI 3882 (Ref 4). Alternatively, if intensity/concentration data is not available use 2 OU. 7 OU for poultry farms that corresponds to an intensity level of being 'distinct' for poultry odours.
Averaging period	1 h
Percentile of dispersion model predictions	99.9 %

The EPA consider that the guideline odour level for poultry farms, due to the mechanism of odour generation being from biological decomposition of organic materials, would be applicable to area or volume sources such as cattle feedlots (Ref. 3).

3.3. Overseas and Other States

Warren Springs research (Ref. 4) indicates that:

- "complaints of odour nuisance are not received until the odour concentration, as perceived by the receptor, is greater than a concentration corresponding to 3 – 6 times the detection threshold. The weight of evidence points to a typical factor of about 5"; and
- "typical maximum or peak 5-second concentrations within any 3-minute period appear to be of the order of 5 times the 3-minute average. During very unstable conditions larger ratios, perhaps 10:1, are more appropriate, and these will tend to occur within a few chimney heights of the source."

Medina is approximately 4 km from the proposed Port. At this distance the peak to mean ratio is one for all stability classes and wind speeds greater than 2 m/s (Ref. 5). Based on the above, the odour concentration would need to be greater than 5 OU for complaints to occur. This conclusion is supported by the following:

> "Above 5 OUs odours can be identified by many people and complaints could be expected. Bearing in mind that 1 OU could just be sensed by half of the trained panel with no background odour present; in normal suburban situation 3 OUs may be considered to be an odour threshold." (Ref. 6); and

> "the whole chain of odour sensation (detection 1 OU/m^3), discrimination (3 OU/m^3), unmistakable perception (5 OU/m^3, complaint level), and as a last step the degree of annoyance. Following this definition, three distances were calculated using these limit values, named sensation distance, discrimination distance and complaint distance" (Ref. 5).

Table 3.2 details the odour performance criteria used by other jurisdictions.

Table 3.2 Odour Performance Criteria

Jurisdiction	Criteria (OU)
Manitoba	2 – 7
California Air Resources Board	5
California – South Coast Air Quality Management District	5 - 10
Massachusetts	5
Connecticut	7
Kentucky	7
Missouri	7
Wyoming	7
NSW – Dept. of Urban Affairs and Planning	5 - 8
Warren Springs	5
Queensland Dept. of Environmental and Heritage	6 - 17
Queensland Department of Primary Industries	1 - 5

The nuisance level of odour can be as low as 2 OU and as high as 10 OU for less offensive odours. The NSW EPA (Ref. 2) determined that an odour performance criteria of 7 OU as a reasonable compromise for offensive odours and would be an appropriate exposure level for an individual at a single affected residence. However, the NSW EPA also considered that the criteria be adjusted according to the number of people that may be exposed. For populations equal to or above 2,000 people, the recommended odour performance criterion is 2 OU. Table 3.3 provides a summary of odour performance criteria for various population densities with the modelling parameters shown in Table 3.4.

Table 3.3 NSW EPA Odour Performance Criteria for Different Population Densities

Population Size of Affected Community	Odour Performance Criteria (OU)
urban (≥ 2000)	2
500	3
125	4
30	5
10	6
single residence	7

Table 3.4 NSW EPA Recommended Odour Dispersion Modelling Parameters

Parameter	Value
Averaging period	1 h
Percentile of dispersion model predictions	99.0 % (Tier 3 – full meteorological data)
Adjustment for peak to mean(1)	2.3(2)

Notes
1. Instantaneous perception by the human nose typically occurs over a time scale of 1 second whilst dispersion model predictions are typically valid over time scales of 10 minutes to 1 hour averaging period. To estimate the effect of plume meandering and concentration fluctuations perceived by the human nose it is possible to multiply the dispersion model predictions by a correction factor called the 'peak-to-mean' ratio.
2. P/M60 is the peak to mean ratio for long averaging times of 1 hour, at a probability of 10^{-3} (at this probability a peak 1 s odour concentration over an hour period, 3,600 s, will occur 3 to 4 times).

The application of this approach includes varying the odour performance criteria depending on the population density for a single location (Ref. 2). That is the odour performance criteria may be higher in one wind direction compared to another wind direction for the same location (Ref. 7). The application of the criteria does not differentiate between industrial or residential populations but excludes transient population groups. That is, the criteria apply to all population groups outside the boundary of the operation.

3.4. Recommended Odour Criterion & Modelling Method

In determination of odour performance criterion recommended for the proposed location the following factors should be considered:

- the odour, when considered on an "offensive" scale is low compared to odours from rendering plants, odour dosing stations, ammonia and hydrogen sulphide emissions. Odours from poultry sheds are high in ammonia. The relationship between odour intensity and concentration for sheep sheds is considered to be less significant compared to poultry sheds, that is a higher odour level is required for sheep sheds to be 'distinct' compared to poultry sheds, for which the EPA have suggested a criteria of 7 OU;
- whilst there are odour complaints from existing operations at Fremantle Port the complaints are relatively few in consideration of commercial markets/outdoor dining facilities and residential areas being in close proximity (again indicating the relatively inoffensive nature of the odour); and
- population numbers in the Kwinana Industrial Area are relatively low.

In selecting modelling parameters it is recognised that the WA EPA recommends the 99.9 percentile 1-hour average with no peak-to-mean adjustment, while the NSW EPA recommends the 99.0 percentile 1-hour average with a peak-to-mean adjustment of 2.3. It is noted that in a Jiang and Sands' study on poultry farms (Ref. 8) it was reported that the area defined by the 40 OU maximum, 20 OU 99.9 percentile, 10 OU 99.5 percentile and 5 OU 98.5 percentile were approximately the same. Therefore the results using either model would be similar.

Whilst the above factors would indicate that the odour criteria should be higher for sheep odours compared to that recommended by the EPA, a conservative approach has been taken to use the criterion for poultry farms of 7 OU. Modelling has been undertaken using the WA EPA parameters of 1-hour average and 99.9 percentile value.

4. ODOUR DISPERSION MODELLING RESULTS

4.1. Emission Rates

4.1.1. Published Data

Table 4.1 below lists available data on the odour emission rate of livestock. Little data was found on odour emission rates for sheep. However, Vipac (Ref. 9) conducted an odour impact assessment of the live export sheep operations conducted at the Fremantle wharves. Odour samples were taken within the holds of a single ship.

FSA Environmental on behalf of the Pig Research and Development Corporation (Ref. 10) reviewed available research and data on pig odour emission to determine emission rate inputs recommended for use with the AUSPLUME dispersion model.

Martinec et al. (Ref. 11) undertook a survey of odour emission rates from livestock husbandry and established emission rates for poultry, pigs and cattle that showed that the highest rate was for pigs and the lowest for cattle. For a 60 kg pig the rate was 12 OU/s. The expectation of the odour emission rate from sheep is much less than that for pigs.

Table 4.1 Published Data on Animal Odour Emission

Animal	OU (AS)[1] (OU/animal)	Reference
Sheep	1.31 (average) 1.90 (maximum)	Ref. 9 Appendix A3 for calculation of average and maximum.
Pig	3.3 - 12	Ref. 10 From a range of data measured from piggeries.
	4	Ref. 10 From a new piggery shed in Australia.
	0.3 – 8 (average of 2)	Ref. 10 For deep-litter systems for 50 kg liveweight (LWT).
	12 and less for sheep	Ref. 11 For a 60 kg pig

Note 1. Where OU have been reported using NVN 2820 standard they have been divided by a factor of 3 to covert them to the AS.

4.1.2. Method of Calculating Emission Rates

The Vipac measurements are specific to the ship and the conditions at the time of sampling. Animal odour emission rates from ships can vary due to a number of factors as discussed in Appendix A. However, this data is likely to more closely represent odour emissions from ships than the qualitative characterisation used as the basis for previous modelling of emissions from the proposed Port (Ref. 12). In this case, odour emission rates were determined by measuring the distance that odours travelled from sheep-ship operations in Fremantle Harbour. Two persons established the maximum distance that sheep odour could be detected by both persons when approaching the ship from beyond the odour plume, when the ship was close to fully loaded. The odour source was then modelled under the meteorological conditions at the time of detection, to determine the odour emission rate required for the odour plume to extend to the measured distance.

The limitations of this qualitative characterisation include:

- odour detection was based on two persons only, not a full panel and therefore did not incorporate as broad a range of individual sensitivities; and
- the methods did not follow standard protocols for dynamic olfactometry;
- the emission rate was determined using a dispersion model rather than from olfactometry methods; and
- the odour sample population was limited.

While the data determined by Vipac is also from a limited sample population, it was determined using accepted dynamic olfactometry procedures using a eight member panel.

The odour emission rate used for the AUSPLUME model was calculated using the average emission per animal measured by Vipac (Ref. 9). Daily emission rate was calculated based on the ship schedule and sheep numbers for livestock ships loaded at the Fremantle Port between July 1, 2000 and June 30, 2001. From the date and time that each ship arrived and left the port, the estimated number of sheep in the ship on any day was calculated, assuming constant loading rate. The numbers for each ship were added to give the total estimated number of sheep per day in the Port. The daily emission rate was converted to an hourly basis for input into AUSPLUME to match the frequency of the meteorological data.

Table 4.2 summarises the data used for calculating hourly emission rates.

Table 4.2 Data Used for Calculating Hourly Emissions from Sheep Ships in James Point Port

Assumption	Value
Odour emission per sheep	1.3 OU/sheep/s (sensitivity model run at 1.9 OU/sheep/s)
Number of sheep in Port per day	Based on livestock shipments from Fremantle Port from 1/7/00 to 30/6/01. Total numbers for the year comprise: 4.464 M sheep 153,823 cattle 16,383 goats 517 deer 43 horses
Sheep odour equivalents	1 cattle = 8 sheep 1 goat = 1 sheep 1 deer = 1 sheep 1 horse = 1 sheep

4.2. Dispersion Model

The Victorian EPA's Gaussian dispersion model AUSPLUME (Ref. 13) was used to predict odour dispersion. For this study Version 5.4 of the model was used versus Version 4 used in the previous study (Ref. 12). To check for consistency in model outputs, Version 5.4 of the model was run with the inputs associated with the previous study. The output was found to be consistent with that from Version 4.

4.3. Model Assumptions

The sheep ships have open sides and ventilation fans on the top of the structures. This type of source is categorised by the AUSPLUME model as a volume source. That is, having a "well mixed emission downwind of buildings" (Ref. 13).

The pens in the ships are approximately 110 m long and extend approximately 10 m above the deck and the deck is typically 6 m above the water line. The AUSPLUME input parameters for the volume source for the ships are:

- height (plume centreline) = 16/2 = 8 m;
- horizontal spread = 110/4 = 27.5 m rounded to 28 m; and
- vertical spread = 16/4 = 4 m.

The averaging time and percentile of dispersion model predictions is 1-hour and 99.9% respectively (refer above for details on selection of these values).

Table 4.3 summarises the parameters used for modelling the sheep ships.

Table 4.3 Key Parameters Used for AUSPLUME Modelling of Sheep Ships

Parameter	Value
Averaging period	1 h
Percentile of dispersion model predictions	99.9
Adjustment for peak to mean	nil
Type of Source	Volume
Volume Source Parameters: - source height - horizontal spread - vertical spread	 8 m 28 m 4 m
Source location	383600 east, 6435863 north

The "Pasquil-Gifford" dispersion curves have been used for horizontal and vertical dispersion modelling in AUSPLUME, as recommended by the Department of Environmental Protection.

4.4. Dispersion Modelling Results

Appendix B details the dispersion model input parameters and output for the model run using the average level of odour emission per sheep. Figure 1.1 shows the odour contours for this case.

Figure 4.1 shows the odour contours for a sensitivity run assuming the maximum odour emission per sheep measured and reported by Vipac.

Figure 1.1 shows that the 7, 4 and 2 OU contours are contained entirely within the Kwinana Industrial Area, well to the west of the nearest residential area Hope Valley approximately 2km away and 4km from Medina to the south-east. Figure 4.1 shows that this is also the case even when the peak measured emission rate per sheep is used for emission rate calculation.

Compared to the previous odour modelling results (Ref. 12) the results of this study are more closely aligned with expected outcomes. In the previous study the odour emission rate was assumed to be constant. In this study, the emission rate has been set to vary with loading operations based on the ship schedule and sheep numbers at the Fremantle Port over a twelve month period. Use of the Fremantle Port ship schedule and livestock numbers for calculation of emission rates is considered to be conservative for the following reasons:

- during the period considered the overall livestock number at Fremantle Port (4.4 million sheep) was higher than that proposed for the James Point Port (4.2 million sheep);
- there were several occasions during the period considered when 3 ships containing livestock were in the port simultaneously, versus a maximum of two for the case of the James Point Port; and
- there was one occasion when 4 ships containing livestock were in the Fremantle port simultaneously.

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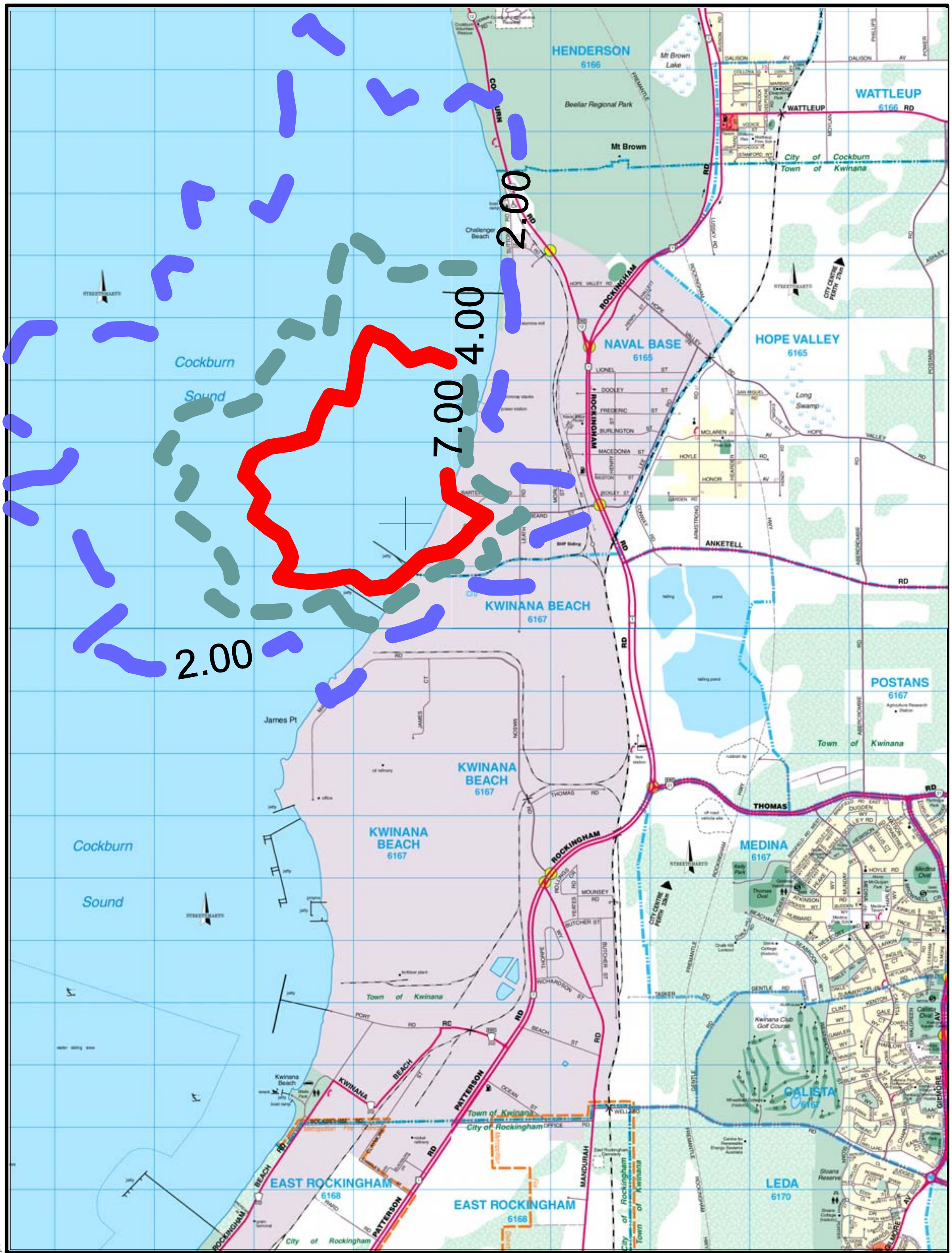

	James Point Pty Ltd **James Point Port** **Odour Modelling** **Odour Contours (2, 4 and 7 OU/s) for Emission from Ships at Sheep Emission Rate of 1.9 OU/sheep/s**	**Figure 4.1**

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5. CONCLUSION

The EPA Guidance for the Assessment of Odour Impacts (Ref. 3) has been adopted as the criterion for establishing the zone beyond which organic animal odour can confidently be predicted to not contribute to annoyance (99.9 percentile) – 7 OU/m^3.

Conservative odour modelling predicts that the area contained within the 2 OU/m^3 contour will not extend east of Rockingham Road. It can therefore be confidently predicted that residential areas, which are to the east of Rockingham Road, will not be subject to annoyance due to odours emanating from the loading of sheep at the proposed Port, and that the odour is not likely to be detectable in these areas.

An area of industrial land immediately surrounding the Port is predicted to experience odour levels exceeding 2 OU/m^3 for greater than 0.1 % of the time. The area within the contour is used for heavy industrial and related purposes, and is therefore not permanently occupied. Large areas within the contour are undeveloped, some as buffers to major industrial complexes. Persons working at these sites are familiar with industrial work-place odours and are believed to therefore be less sensitive to being annoyed by occasional recognisable odours.

Odour levels exceeding 7 OU/m^3 are predicted to be contained within the JPPL site.

6. REFERENCES

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APPENDIX A

ODOUR EMISSION RATES

A1. ODOUR EMISSION RATE FACTORS

A report into the ventilation efficacy on livestock vessels (Ref. 4) together with other sources indicates that odour level within a sheep ship and hence odour emission rate is dependent on the following factors:

- number of sheep;
- housekeeping of the ship;
- whether the ship coming into port has a partial load of sheep;
- the condition of the sheep being loaded;
- stocking density;
- condition/age /size/fat layer of sheep;
- ventilation system/design within the ship for cooling of the sheep;
- ventilation discharge system, including velocity of the discharge and whether the ship is enclosed or open;
- temperature;
- whether the sheep are wet or dry;
- humidity;
- wind speed (particularly if the ship is open sided);
- diet (high energy feeds may increase metabolic rate, the low energy, high roughage feeds liberate considerable heat when fermenting in the gut and hence may be no better, or even worse, in generating body heat, also the rate of NH_3 generation is dependent of feed type); and
- stress level of the sheep.

A2. ODOUR VARIATION WITH LOADING OPERATIONS

The number of livestock exported through Fremantle is approximately 4.2 million sheep/y and approximately 0.1 million cattle/y. The number of livestock ship visits per year is approximately 120, comprised of 70 large ships (30,000 or more sheep / 5,000 or more cattle) and 50 small ships (up to 12,000 sheep / up to 3,000 cattle).

Whilst all items listed in A1 above influence the odour emission rate, the number of sheep on the ship is one of the key aspects. The loading rate is approximately constant and hence the odour emission rate will, over the period of time that the ship is in port, vary from 0 to a maximum, dependent on the capacity of the ship. Figure A.1 shows predicted odour emission rates for a year assuming the ship loading schedule at the Fremantle Port between 1/7/00 and 30/6/01 and an odour emission rate of 1.3 OU/s/sheep:- the average odour value determined by olfactometry (see A3 below).

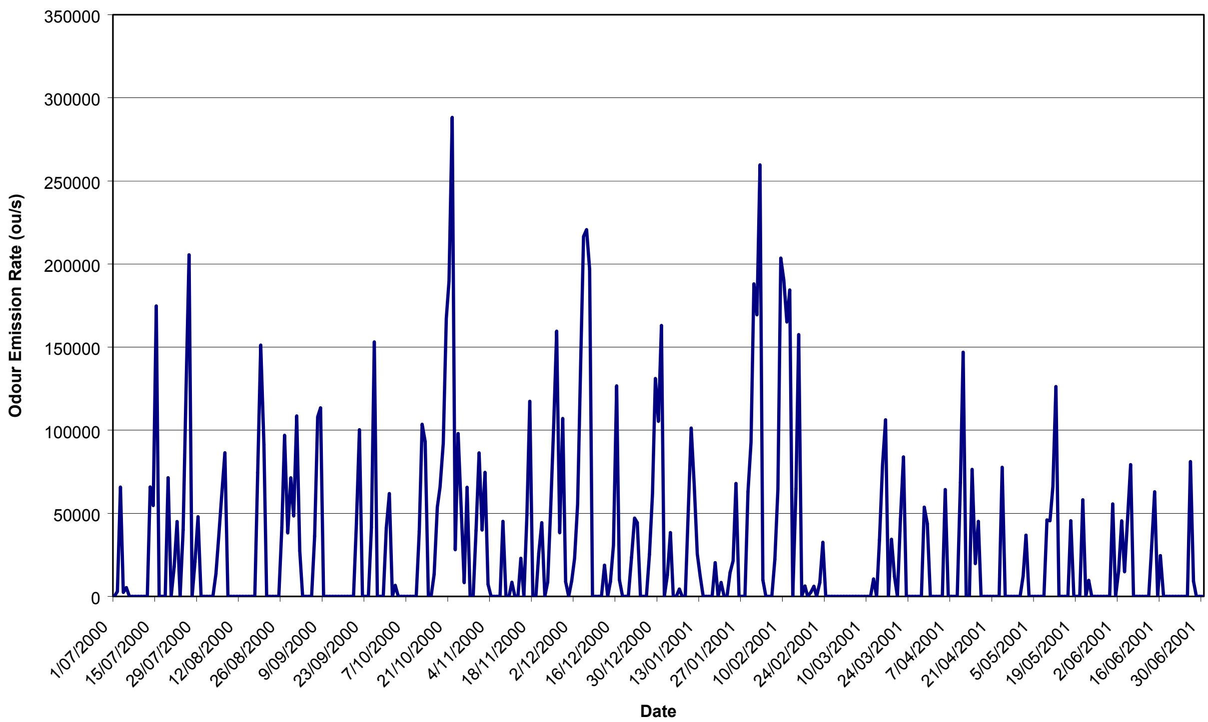

Figure A.1 Daily Odour Emission Rates Based On Fremantle Port Schedule and Emission Rate of 1.3 OU/sheep/s

A3. OLFACTOMETRY DATA

An odour impact assessment report for Fremantle (Ref. 9) included details of olfactometry measurements taken on the sheep ship Al Messilah, which are repeated in Table A1.

Table A3 Odour Concentration of Sheep Odour Samples

Sample No.	Measured Odour Concentration (OU)	Standardised Odour Concentration(1) (SOU)
1	87	98
2	51	57
3	179	190
4	160	180
Average	**119**	**131**

Note 1. Standardisation undertaken using 1-butanol (n-butyl alcohol) = 45 ppb.

The results show that the ratio of the highest to lowest reading is approximately 3.3 and highest to the average of 1.45. Due to this relatively high ratio, the confidence level that may be placed on the results is low. The assessment report (Ref. 9) conservatively used the highest odour concentration to represent the worst case scenario.

To calculate the odour emission rate the ventilation rate needs to be determined.

The above report used the flow rate through the ventilation stacks and incorporated fugitive odour emissions to simulate odour emitted from other sources such as loading areas and general odour escape from the ship. From the odour emission rate, 136,240 OU/s (Ref. 9 – sum of odour source emission rates) that is based on the maximum odour concentration, and the equivalent number of sheep being loaded, 71,518 (from records of sheep and cattle loaded on 13/10/00 on the Al Messilah – the ship upon which the sampling was conducted) the odour emission rate per sheep is approximately 136,240 OU/s / 71,518 sheep = 1.90 OU/sheep/s. If the average odour concentration was used as opposed to the maximum this value would be approximately 1.90 OU/sheep/s / 1.45 = 1.31

An investigation into the ventilation efficacy on livestock ships (Ref. 14) established that, for the ships investigated, the air flow per sheep = 0.92 m^3/h/kg live weight. These values were based on a stocking density of 0.352 m^2/hd that was marginally above AMSA's minimum permissible floor area per head of sheep for a 60 kg sheep, namely 0.340 m^2/hd. The report also detailed an average mass per sheep of 57 kg.

Air flow per sheep = 0.92 m^3/h/kg x 57 kg/sheep / 3600 s/h
0.0146 m^3/s/sheep

The Vipac report used a ventilation rate of approximately 0.013 m^3/s/sheep that is consistent with the rate above.

A4. OLFACTOMETRY MEASUREMENT

The following aspects of olfactometry measurement need to be considered when interpreting the above data.

Odour Sampling

There is no agreed method for sampling for odours from animal holding facilities. The location and duration of sampling will affect the results. Spot samples taken within the hold of a ship will be dependent on several factors including local ventilation conditions. Sampling from stacks is likely to be more reliable, if all of the odours are captured, however, such sampling would require permission from the ship owner to install sample points for such a purpose. This form of sampling will not account for fugitive types of emissions.

Sampling downstream of an emission may not be representative as background odour levels may be significant. For example, odours within a forest may be up to 100 OU and in suburbia are typically 3 – 5 OU. The same logic also applies to sampling within a hold as the background odour level should be accounted for in undertaking the odour measurement.

In the case of the sampling conducted on the Al Messilah, just four sets of duplicate samples were taken.

Measurement

The status of olfactometry measurement is described below (Ref.: http://www.fsaconsulting.net/pig_odour.htm):

> "Until recently, the human nose has been the only satisfactory device for odour measurement. However, various forms of electronic nose have been developed in recent years. These devices are still in the experimental phase and are not useful in a regulatory or legal context. There are many forms of olfactometry but, for various technical reasons, dynamic olfactometry is now the standard method. However, even within this method, there is a wide range of measurement techniques. In the early 1990's, the Dutch developed the NVN 2820 standard that greatly improved the repeatability and reproducibility of odour measurements. Most, good-quality pig research has used this method. Recently, a draft European standard (CEN TC264) has been proposed. This is the basis of the draft Australian standard. Although this should improve the repeatability and reproducibility of odour measurements, it is different from NVN 2820. A scientifically-rigorous conversion factor has not been determined but it could range from 2-4. This presents a problem in converting NVN 2820 (and other dynamic olfactometry) data to the new standard."

There are many types of olfactometry including:

- scentometer – a small box with sniffing ports at one end and odourous-air inlet ports at the other end;
- odour observation rooms – a test chamber where a known volume of sample is added and mixed by fans with air prior to panellists entering the room;
- static olfactometer – a container which holds the sample with no flowing air;
- butanol olfactometer – a method whereby accurate dilutions of a standard odorant (1-butanol) is added to a mask worn by an operator, who compares the intensity to the ambient odour intensity; and
- dynamic olfactometer – a dynamic odour dilution system, whereby the odourous air stream is continuously diluted with an odour-free air stream, a series of different odour / air dilutions are presented to the panellists to determine the number of odour units (OU).

The olfactometry levels measured on the Al Messilah (Ref. 9) were determined using dynamic olfactometry, a dilution to threshold technique. The sample was diluted to its odour threshold and assessed by an eight-member odour panel. The measured odour concentration in Odour Units (OU) is the number of dilutions of the sample at which 50% of the panellist responses confirmed odour detection.

APPENDIX B

ODOUR DISPERSION MODELLING RESULTS

1

Odour Emissions, J P Port only, hourly emission based on Freo data, 1.3 OU/sheep/s

Concentration or deposition Concentration
Emission rate units OUV/second
Concentration units Odour_Units
Units conversion factor 1.00E+00
Constant background concentration 0.00E+00
Terrain effects None
Smooth stability class changes? No
Other stability class adjustments ("urban modes") None
Ignore building wake effects? No
Decay coefficient (unless overridden by met. file) 0.000
Anemometer height 10 m
Roughness height at the wind vane site 0.300 m

DISPERSION CURVES

Horizontal dispersion curves for sources <100m high Pasquill-Gifford
Vertical dispersion curves for sources <100m high Pasquill-Gifford
Horizontal dispersion curves for sources >100m high Briggs Rural
Vertical dispersion curves for sources >100m high Briggs Rural
Enhance horizontal plume spreads for buoyancy? Yes
Enhance vertical plume spreads for buoyancy? Yes
Adjust horizontal P-G formulae for roughness height? Yes
Adjust vertical P-G formulae for roughness height? Yes
Roughness height 0.800m

Horizontal plume spreads will be adjusted taking into account the default wind directional shear values.

PLUME RISE OPTIONS

Gradual plume rise? Yes
Stack-tip downwash included? Yes
Building downwash algorithm: Schulman-Scire method.
Entrainment coeff. for neutral & stable lapse rates 0.60,0.60
Partial penetration of elevated inversions? No
Disregard temp. gradients in the hourly met. file? No

and in the absence of boundary-layer potential temperature gradients given by the hourly met. file, a value from the following table (in K/m) is used:

Wind Speed Category	Stability Class A	B	C	D	E	F
1	0.000	0.000	0.000	0.000	0.020	0.035
2	0.000	0.000	0.000	0.000	0.020	0.035
3	0.000	0.000	0.000	0.000	0.020	0.035
4	0.000	0.000	0.000	0.000	0.020	0.035
5	0.000	0.000	0.000	0.000	0.020	0.035
6	0.000	0.000	0.000	0.000	0.020	0.035

WIND SPEED CATEGORIES
Boundaries between categories (in m/s) are: 1.54, 3.09, 5.14, 8.23, 10.80

WIND PROFILE EXPONENTS: "Irwin Urban" values (unless overridden by met. file)

AVERAGING TIMES
1 hour

1

Odour Emissions, J P Port only, hourly emission based on Freo data, 1.3 OU/sheep/s

SOURCE CHARACTERISTICS

VOLUME SOURCE: SHIPS

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
383600	6435863	0m	8m	28m	4m

(Constant) emission rate = 1.00E+00 OUV/second

Hourly multiplicative factors will be used with
this emission factor.
No gravitational settling or scavenging.

1

Odour Emissions, J P Port only, hourly emission based on Freo data, 1.3 OU/sheep/s

RECEPTOR LOCATIONS

The Cartesian receptor grid has the following x-values (or eastings):

380400.m	380500.m	380600.m	380700.m	380800.m	380900.m	381000.m
381100.m	381200.m	381300.m	381400.m	381500.m	381600.m	381700.m
381800.m	381900.m	382000.m	382100.m	382200.m	382300.m	382400.m
382500.m	382600.m	382700.m	382800.m	382900.m	383000.m	383100.m
383200.m	383300.m	383400.m	383500.m	383600.m	383700.m	383800.m
383900.m	384000.m	384100.m	384200.m	384300.m	384400.m	384500.m
384600.m	384700.m	384800.m	384900.m	385000.m	385100.m	385200.m
385300.m	385400.m	385500.m	385600.m	385700.m	385800.m	385900.m
386000.m	386100.m	386200.m	386300.m	386400.m	386500.m	386600.m
386700.m	386800.m	386900.m	387000.m	387100.m	387200.m	387300.m
387400.m	387500.m	387600.m	387700.m	387800.m	387900.m	388000.m

and these y-values (or northings):

6432000.m	6432100.m	6432200.m	6432300.m	6432400.m	6432500.m	6432600.m
6432700.m	6432800.m	6432900.m	6433000.m	6433100.m	6433200.m	6433300.m
6433400.m	6433500.m	6433600.m	6433700.m	6433800.m	6433900.m	6434000.m
6434100.m	6434200.m	6434300.m	6434400.m	6434500.m	6434600.m	6434700.m
6434800.m	6434900.m	6435000.m	6435100.m	6435200.m	6435300.m	6435400.m

6435500.m 6435600.m 6435700.m 6435800.m 6435900.m 6436000.m 6436100.m
6436200.m 6436300.m 6436400.m 6436500.m 6436600.m 6436700.m 6436800.m
6436900.m 6437000.m 6437100.m 6437200.m 6437300.m 6437400.m 6437500.m
6437600.m 6437700.m 6437800.m 6437900.m 6438000.m 6438100.m 6438200.m
6438300.m 6438400.m 6438500.m 6438600.m 6438700.m 6438800.m 6438900.m
6439000.m 6439100.m 6439200.m 6439300.m 6439400.m 6439500.m 6439600.m
6439700.m 6439800.m 6439900.m 6440000.m

METEOROLOGICAL DATA : WA EPA Hope Valley Data Surface Roughness 0.3m Anemo m

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HOURLY VARIABLE EMISSION FACTOR INFORMATION

The input emission rates specfied above will be multiplied by hourly varying factors entered via the input file:
F:\J9452_James Point_Odour Modelling\5. Other\avgodour.src
For each stack source, hourly values within this file will be added to each declared exit velocity (m/sec) and temperature (K).

Title of input hourly emission factor file is:
TITLE RECORD: HOURLY EMISSION RATE FOR 1 YEAR, EMISSION RATE of 1.3 OU/sheep/s

HOURLY EMISSION FACTOR SOURCE TYPE ALLOCATION

Prefix SHIPS allocated: SHIPS

1 Peak values for the 100 worst cases (in Odour_Units)
Averaging time = 1 hour

Rank	Value	Time Recorded hour,date	Coordinates (* denotes polar)
1	8.25E+01	19,25/07/95	(383800, 6435800, 0.0)
2	7.21E+01	06,15/07/95	(383500, 6435900, 0.0)
3	7.11E+01	06,22/10/95	(383500, 6435900, 0.0)
4	7.08E+01	05,12/02/95	(383600, 6435900, 0.0)
5	7.01E+01	06,12/02/95	(383500, 6435900, 0.0)
6	6.99E+01	23,02/02/95	(383600, 6435900, 0.0)
7	6.64E+01	04,12/02/95	(383600, 6435900, 0.0)
8	6.55E+01	03,21/05/95	(383700, 6435800, 0.0)
9	6.54E+01	04,15/07/95	(383500, 6436000, 0.0)
10	6.39E+01	20,22/10/95	(383500, 6435900, 0.0)
11	6.32E+01	17,13/07/95	(383700, 6435900, 0.0)
12	6.29E+01	17,15/07/95	(383500, 6435900, 0.0)
13	6.27E+01	22,02/02/95	(383600, 6435900, 0.0)
14	6.27E+01	24,22/10/95	(383500, 6435900, 0.0)
15	6.25E+01	07,15/07/95	(383500, 6435800, 0.0)

16	6.25E+01	03,11/04/95	(383500, 6435800,	0.0)
17	6.18E+01	06,21/05/95	(383500, 6435800,	0.0)
18	6.08E+01	01,15/07/95	(383700, 6436000,	0.0)
19	6.06E+01	23,22/03/95	(383600, 6435800,	0.0)
20	6.00E+01	05,15/07/95	(383500, 6436000,	0.0)
21	6.00E+01	04,19/08/95	(383600, 6435800,	0.0)
22	5.97E+01	12,15/07/95	(383600, 6435900,	0.0)
23	5.94E+01	18,15/07/95	(383500, 6435800,	0.0)
24	5.83E+01	23,22/10/95	(383500, 6435900,	0.0)
25	5.76E+01	07,06/12/95	(383600, 6435900,	0.0)
26	5.71E+01	04,22/10/95	(383500, 6435900,	0.0)
27	5.49E+01	20,15/07/95	(383500, 6435900,	0.0)
28	5.33E+01	02,21/05/95	(383600, 6435900,	0.0)
29	5.28E+01	19,13/07/95	(383700, 6435900,	0.0)
30	5.26E+01	17,22/10/95	(383600, 6435900,	0.0)
31	5.25E+01	18,13/07/95	(383700, 6435800,	0.0)
32	5.23E+01	19,22/10/95	(383500, 6435900,	0.0)
33	5.22E+01	08,06/12/95	(383600, 6435900,	0.0)
34	5.20E+01	21,25/07/95	(383500, 6435800,	0.0)
35	5.06E+01	05,22/10/95	(383500, 6435900,	0.0)
36	5.05E+01	22,22/10/95	(383500, 6436000,	0.0)
37	5.03E+01	01,08/09/95	(383500, 6435900,	0.0)
38	5.03E+01	03,12/02/95	(383600, 6435900,	0.0)
39	5.02E+01	07,12/02/95	(383500, 6436000,	0.0)
40	5.01E+01	21,22/10/95	(383500, 6435900,	0.0)
41	5.01E+01	23,31/12/95	(383600, 6435900,	0.0)
42	4.81E+01	21,26/07/95	(383700, 6435900,	0.0)
43	4.81E+01	03,15/07/95	(383600, 6435900,	0.0)
44	4.77E+01	19,15/07/95	(383600, 6435800,	0.0)
45	4.71E+01	20,25/07/95	(383600, 6435800,	0.0)
46	4.69E+01	02,15/07/95	(383600, 6435900,	0.0)
47	4.63E+01	24,10/02/95	(383600, 6435900,	0.0)
48	4.61E+01	24,12/05/95	(383500, 6435900,	0.0)
49	4.56E+01	04,11/04/95	(383400, 6435800,	0.0)
50	4.56E+01	03,02/02/95	(383600, 6435900,	0.0)
51	4.54E+01	06,02/02/95	(383600, 6435900,	0.0)
52	4.52E+01	05,26/07/95	(383600, 6435800,	0.0)
53	4.50E+01	18,22/10/95	(383500, 6435900,	0.0)
54	4.48E+01	09,06/12/95	(383600, 6435900,	0.0)
55	4.43E+01	23,10/02/95	(383600, 6435900,	0.0)
56	4.42E+01	24,09/02/95	(383600, 6435900,	0.0)
57	4.42E+01	06,11/04/95	(383500, 6435900,	0.0)
58	4.40E+01	16,22/10/95	(383600, 6435900,	0.0)
59	4.37E+01	21,04/12/95	(383600, 6435900,	0.0)
60	4.36E+01	22,11/02/95	(383600, 6435900,	0.0)
61	4.36E+01	19,18/08/95	(383600, 6435900,	0.0)
62	4.35E+01	21,02/02/95	(383600, 6435900,	0.0)
63	4.33E+01	02,26/07/95	(383500, 6435800,	0.0)
64	4.30E+01	01,11/02/95	(383600, 6435900,	0.0)
65	4.26E+01	20,21/10/95	(383500, 6435900,	0.0)
66	4.23E+01	23,11/02/95	(383600, 6435900,	0.0)
67	4.21E+01	24,26/09/95	(383600, 6435900,	0.0)
68	4.20E+01	24,02/02/95	(383600, 6435900,	0.0)
69	4.20E+01	24,24/10/95	(383600, 6435800,	0.0)
70	4.19E+01	06,06/12/95	(383500, 6436000,	0.0)

71	4.19E+01	01,26/07/95	(383500, 6435800,	0.0)
72	4.16E+01	07,02/02/95	(383600, 6435900,	0.0)
73	4.16E+01	23,26/09/95	(383600, 6435900,	0.0)
74	4.10E+01	04,02/02/95	(383600, 6435900,	0.0)
75	4.08E+01	22,05/12/95	(383600, 6435900,	0.0)
76	4.07E+01	02,08/09/95	(383500, 6435900,	0.0)
77	4.06E+01	03,11/02/95	(383600, 6435900,	0.0)
78	4.03E+01	05,11/02/95	(383600, 6435900,	0.0)
79	4.02E+01	22,22/03/95	(383700, 6435900,	0.0)
80	4.01E+01	13,26/06/95	(383600, 6435900,	0.0)
81	3.98E+01	06,31/08/95	(383500, 6435800,	0.0)
82	3.97E+01	02,10/02/95	(383500, 6435900,	0.0)
83	3.95E+01	21,05/12/95	(383600, 6435900,	0.0)
84	3.95E+01	24,26/07/95	(383700, 6435800,	0.0)
85	3.94E+01	10,06/12/95	(383600, 6435900,	0.0)
86	3.94E+01	02,01/02/95	(383600, 6435900,	0.0)
87	3.93E+01	04,31/01/95	(383600, 6435900,	0.0)
88	3.88E+01	03,31/01/95	(383600, 6435900,	0.0)
89	3.87E+01	01,02/02/95	(383600, 6435900,	0.0)
90	3.86E+01	20,18/08/95	(383500, 6435900,	0.0)
91	3.86E+01	23,19/08/95	(383500, 6435900,	0.0)
92	3.86E+01	11,26/09/95	(383600, 6435900,	0.0)
93	3.84E+01	23,05/12/95	(383600, 6435900,	0.0)
94	3.84E+01	22,26/09/95	(383600, 6435900,	0.0)
95	3.84E+01	22,10/02/95	(383600, 6435900,	0.0)
96	3.83E+01	21,10/02/95	(383600, 6435900,	0.0)
97	3.79E+01	01,10/02/95	(383600, 6435900,	0.0)
98	3.79E+01	09,12/02/95	(383600, 6435900,	0.0)
99	3.78E+01	05,31/08/95	(383500, 6435800,	0.0)
100	3.78E+01	03,08/09/95	(383500, 6435900,	0.0)