final report

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Feedlot Odour Modelling R&D Workshop

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Abstract

Odour emissions from feedlots have been a contentious issue for many years and consequently, the subject of significant research. Despite this research, there is a paucity of reliable, quantitative data, measured using acceptable standards, on odour emissions arising directly from beef cattle feedlots. In 2003, it was recognised that recent changes in technology, standards and regulatory guidelines made the need to obtain more reliable and robust data on feedlot odour emissions imperative. The FLOT.323 project was called 'Development of odour performance criteria for the Australian feedlot industry' and it was completed in 2004. There were some uncertainties in the conclusions of that study. This uncertainty negated any adoption of the methodology by the state regulatory agencies.

Reviews of the project by two odour modelling experts were undertaken in 2007. These reviews delivered some useful suggestions and identified scope for some additional work and data analysis that could potentially enhance the value of the project. However, after these reviews were completed, the project lost momentum and nothing has happened in the past four years. This new project revisited the outcomes of the original odour project along with the outcomes of the reviews, within the context of the current regulatory environment and thinking on odour measurement and assessment techniques. The process involved an expert's workshop, held on the 13th May 2011, which engaged the main consultants and researchers working in the feedlot odour modelling area. The outcome of the workshop was recommendations on a program of work that can be implemented to address the identified shortcomings in the original project.

Executive Summary

Odour emissions from feedlots have been a contentious issue for many years. Consequently, these odours have been the subject of a significant amount of previous research. Despite this research, there is a paucity of reliable, quantitative data, measured using acceptable standards, on odour emissions arising directly from beef cattle feedlots as well as those associated with specific ancillary activities. In 2003, it was recognised that recent changes in technology, standards and regulatory guidelines made the need to obtain more reliable and robust data on feedlot odour emissions imperative.

Hence, in 2003, Meat & Livestock Australia funded a project (FLOT.323) to measure odour emissions from modern Australian feedlots. The data was to be used to develop an odour emissions model that could be used to develop industry-specific odour nuisance guidelines. Specifically, the projects objectives were:

1. Develop an agreed methodology for assessing and modelling odour impacts for the Australian feedlot industry and to develop industry-specific odour performance criteria, by undertaking the following process.
2. Develop industry-specific odour performance criteria for use by the feedlot industry in New South Wales and Queensland and potentially the other Australian States.
3. Derive a reliable conversion factor between the Dutch NVN 2880 and the Australian AS/NZS 4323.3 olfactometry standard to enable previously gathered research data to be utilised.
4. Evaluate the potential for TAPM generated meteorological datasets to fulfil the input meteorological data requirements for future odour modelling exercises for small to medium feedlots and/or Greenfield sites that do not have site-specific meteorological data.
5. Establish the relationship between the quantity of feed fed to a pen (DM basis) and manure depth to enable industry to develop an objective method for determining pen-cleaning intervals.
6. Assess the appropriateness of the current manure management specifications contained in the Queensland Guidelines for Class 1 and Class 2 feedlots, which are based on specified maximum manure depth or cleaning intervals.

There were some uncertainties in the conclusions of the study, principally related to the methodology for establishing odour performance criteria. This uncertainty negated any adoption of the methodology by the state regulatory agencies. In 2007, reviews of the original project outcomes by two odour modelling experts were requested. These reviews delivered some useful suggestions on how the project could be further progressed. The reviews identified scope for some additional work and data analysis that could potentially enhance the value of the project and increase the relevance of project outcomes to both regulatory agencies and industry consultants. However, after these reviews were completed, the project lost momentum and nothing has happened in the past four years.

This new project aimed to revisit the outcomes of the original odour project along with the outcomes of the reviews, within the context of the current regulatory environment and thinking on odour measurement and assessment techniques. The process involved an expert's workshop, held on the 13th May 2011, which engaged the main consultants and researchers working in the feedlot odour modelling area. The outcome of the workshop was recommendations on outstanding issues and a program of work that can be implemented to address the identified shortcomings in the original project. Any identified project work will be subsequently implemented as separate projects.

Recommendations from the workshop covered the following areas.

1. Industry-Specific Odour Criteria
2. Correlation between Flux Hood and Wind Tunnel Odour Emission Measurements
3. Proposed Methodology for Feedlot Odour Assessment
4. Use of the Project Results by Regulators
5. Use of the Feedlot Odour Measurements made in 1991-1994
6. Feedlot Hydrology Model
7. Which year to use for modelling – hydrology/dispersion
8. Publication of the FLOT.323 Final Reports
9. The Use of AUSPLUME or CALPUFF
10. The Use of TAPM Data
11. Adjustment of emission rates for wind speed and stability class
12. The Absence of Cold Temperature and Prolonged Wet Pad Odour Data
13. The Effect of Ration Ingredients on Odour Emission
14. Quantification of Manure Accumulation Rates in Pens
15. Dust as a vector for odour transport

These issues can now be discussed by Meat & Livestock Australia and the lot feeding industry to decide on future work in this area.

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1 Introduction

Odour emissions from feedlots have been a contentious issue and consequently the subject of a significant amount of previous research. Despite this research, there is a paucity of reliable, quantitative data, measured using acceptable standards, on odour emissions arising directly from beef cattle feedlots as well as those associated with specific ancillary activities. In 2003, it was recognised that recent changes in technology, standards and regulatory guidelines made the need to obtain more reliable and robust data on feedlot odour emissions imperative. This data needed to be derived using contemporary methodologies and standards. Further, in New South Wales and in the Queensland draft odour policy (Environmental Protection Agency – EPA), there was provision for the development of industry-specific odour performance criteria for formal incorporation into regulatory odour management and assessment policy. Development of such criteria might overcome some constraints resulting from the application of the conservative, generic performance criteria provided in the policy document. The outcome of new feedlot odour research could provide common criteria for the development and assessment of feedlots across New South Wales and Queensland, and then hopefully the rest of Australia.

Hence, in 2003, Meat & Livestock Australia funded a project (FLOT.323) to measure odour emissions from modern Australian feedlots. The data was to be used to develop an odour emissions model, which could be used to develop industry-specific odour nuisance guidelines. Specifically, the projects objectives were:

1. Develop an agreed methodology for assessing and modelling odour impacts for the Australian feedlot industry and to develop industry-specific odour performance criteria, by undertaking the following process.
2. Develop industry-specific odour performance criteria for use by the feedlot industry in New South Wales and Queensland and potentially the other Australian States.
3. Derive a reliable conversion factor between the Dutch NVN 2880 and the Australian AS/NZS 4323.3 olfactometry standard to enable previously gathered research data to be utilised.
4. Evaluate the potential for TAPM generated meteorological datasets to fulfil the input meteorological data requirements for future odour modelling exercises for small to medium feedlots and/or Greenfield sites that do not have site-specific meteorological data.
5. Establish the relationship between the quantity of feed fed to a pen (DM basis) and manure depth to enable industry to develop an objective method for determining pen-cleaning intervals.
6. Assess the appropriateness of the current manure management specifications contained in the Queensland Guidelines for Class 1 and Class 2 feedlots, which are based on specified maximum manure depth or cleaning intervals.

2 Background

The FLOT.323 project was called ‘Development of odour performance criteria for the Australian feedlot industry’. It was completed in 2004. The project was conducted by FSA Consulting with assistance from DEEDI (formerly DPI&F). FSA Consulting undertook extensive sampling and testing of odour emissions from the various odour sources found within the feedlot system. From this a proposed odour modelling methodology was developed as a means of standardising the assessment of the odour impact of feedlots. The methodology outlined protocols for odour sampling, measurement and impact assessment, including the establishment of odour performance criteria.

There were some uncertainties in the conclusions of the study, principally related to the methodology for establishing odour performance criteria. This uncertainty negated any adoption

of the methodology by the state regulatory agencies. Reviews of the original project outcomes by two odour modelling experts were requested. Robin Ormerod (Galvin et al. 2007) and Kerry Holmes (Holmes Air Sciences 2007) undertook reviews. These reviews delivered some useful suggestions on how the project could be further progressed. The reviews identified scope for some additional work and data analysis that could potentially enhance the value of the project and increase the relevance of project outcomes to both regulatory agencies and industry consultants. However, after these reviews were completed, the project lost momentum and nothing has happened in the past four years.

This new project aimed to revisit the outcomes of the original odour project along with the outcomes of the reviews, within the context of the current regulatory environment and thinking on odour measurement and assessment techniques. The process involved an expert's workshop, held on the 13th May 2011, which engaged the main consultants and researchers working in the feedlot odour modelling area. The outcome of the workshop was to identify outstanding issues and to develop a program of work that can be implemented to address the identified shortcomings in the original project. Any identified project work will be subsequently implemented as separate projects.

3 Project Methodology

In summary, the project methodology was:

1. Identify participants for a feedlot odour expert's workshop. The participants included researchers from the FLOT.323 project, odour consultants, odour researchers and industry representatives.
2. The FLOT.323 final report (Part A to Part G), along with the review reports, were circulated to the workshop participants prior to the day.
3. A one-day expert's workshop was facilitated by FSA Consulting to identify outstanding issues and make recommendations for future actions.
4. A report from that workshop was prepared, circulated to workshop participants for comments and finalised for submission to MLA.

4 Odour Experts Workshop

4.1 Attendance

FSA Consulting organised and facilitated a one-day workshop held at the MLA Brisbane office (527 Gregory Terrace, Fortitude Valley) on the 13th May 2011. There were 14 participants who attended the workshop representing Meat & Livestock Australia, the feedlot Industry (ALFA & lot feeders), odour emission consultants and researchers. The participants included:

- The major consultants currently working in the feedlot odour modelling area, ensuring sufficient representation to provide a perspective on the current regulatory environment in each of the eastern Australian states.
- Representatives from FSA Consulting and DEEDI that were involved in the original research project.
- Industry members of the Steering Committee for the original research project.
- Other consultants or researchers as necessary to provide a perspective on the current state of odour sampling and assessment methods.

A list of participants can be found in Section 8.1.

4.2 Workshop Objectives

The objectives of the workshop were circulated to participants prior to the day. The broad objectives were to conduct a one-day workshop to identify any opportunities to enhance the value and acceptance of the previous odour modelling methodology. The opportunities to be assessed within the context of:

- Current odour regulation and planning policy
- Latest science of odour sampling, assessment and modelling

4.3 Agenda

FSA Consulting, in consultation with MLA, developed an agenda for the day. The agenda was circulated to participants prior to the day. The agenda can be found in Section 8.2.

The workshop provided a good opportunity for information sharing with the morning devoted to an overview of the research undertaken, key outcomes, limitations with the results and challenges for the Industry.

The afternoon provided a forum to distil the previous discussion and to highlight the key challenges and explore appropriate solutions to the challenges identified.

4.4 Workshop Presentations

The workshop commenced with a welcome and introductions by Des Rinehart (MLA). A number of presentations followed. These included:

4.4.1 Summary of FLOT.323 Research Program – Dr Peter Watts

Dr Peter Watts provided an overview of the FLOT.323 project and its outcomes. This project included the collection and analysis of a large quantity of experimental data from operational feedlots. The development and validation of models and the development of the assessment process also generated large quantities of information. To ensure all of this data and information was presented in a suitable manner, eight reports were compiled.

A. *Sampling Results – Odour Emissions from Australian Feedlots.* (Nicholas et al. 2004) This report presents the background literature review, odour sampling methodology and results, as well as an analysis of the experimental data collected. A discussion of the relative merits of the currently available odour sampling methods is included, with a justification of the method used within this project. The report also includes a discussion of historical and current olfactometry standards, with a recommended conversion that can be used to compare previously collected feedlot odour emission rates with the odour emission rates collected within this project.

B. *Modelling of Feedlot Hydrology using MEDLI.* (Atzeni et al. 2005) This report presents a background literature review related specifically to Australian feedlot hydrology, as well as a review of the feedlot hydrology models developed in Australia. General usage guidelines for MEDLI are presented.

C. Feedlot Odour Sampling and Testing Techniques. (Hudson 2005) This report includes a literature review of odour sampling, collection, storage and testing. It provides a more detailed literature review on the merits of wind tunnels and flux hoods than is provided in

the Part A report. It provides evidence for the use of the wind tunnel as the preferred odour-sampling device for this feedlot odour study.

D. Modelling Guidance Document for the Livestock Industry. (D'Abreton 2005b) Meat and Livestock Australia (MLA) Limited commissioned Pacific Air & Environment (PAE) to develop guidance on sourcing, developing and quality-assuring meteorological data files for use in modelling and to develop guidance on the selection and use of dispersion models in relation to livestock applications in Australia.

E. *Validation of TAPM for Feedlot Odour Studies.* (D'Abreton 2005c) Comparison between surface observations at Feedlot A (10 m) and Feedlot B (10 m) and TAPM-derived data extracted for the same locations at the two observational sites has been performed for August 2003 to May 2004 (Feedlot A) and September 2003 to May 2004 (Feedlot B) to determine the suitability of using TAPM data in feedlot odour dispersion modelling.

F. *Development of an Odour Emissions Model for Australian Feedlots.* (Nicholas et al. 2005a) This report details the process used to develop a feedlot odour emissions model based primarily on the experimental data collected within this project. Model performance against measured data is discussed and general usage guidelines are presented.

G. *Odour Impact Assessment for Australian Feedlots.* (Nicholas et al. 2005b) This report will detail the development of an odour impact assessment method for Australian feedlots. The performance of the assessment process on feedlots not included in the experimental data collection will be discussed.

H. *AUSPLUME vs. CALPUFF Modelling Comparison.* (D'Abreton 2005a) This report compares odour dispersions modelling around two feedlot sites using the same odour emission file but with different dispersion models.

It was not possible to go through all of the research work during the workshop. However, all participants received copies of these reports prior to the workshop. Dr Watts noted that there were successes and failures in the project.

Notable successes included:

1. About 600 odour measurements were made in two feedlots in summer and winter conditions.
2. A feedlot pad temperature model was verified.
3. A feedlot hydrology model that could be used as the basis for an odour emission model was further developed.
4. A sound pond odour emission model was developed.
5. A conceptual feedlot pad odour emission model (BOP model) was proposed.
6. Spot odour emission samples were taken from minor odour sources such as silage pits and manure stockpiles.
7. The existing Smith & Lunney odour model (Lunney & Smith 1995) was shown to be of little use.
8. A 1:1 conversion between the old feedlot odour measurements and the new data was proposed on the basis that both olfactometers had a butanol threshold of about 50 ppb.

Notable short-comings included:

1. Statistical modelling to determine the effect of manure management (Class 1 vs. Class 2), cool pad temperatures, odours following pad wetting and odours from prolonged wet pads did not produce robust models.
2. An industry-specific odour nuisance criterion was not developed and submitted to regulatory agencies for approval.
3. Data on pad manure accumulation rates and subsequent changes to feedlot guidelines were not achieved.

At the end of the FLOT.323 project, some recommendations for further research were made. The following were suggestions for further research. They were not in order of priority.

1. A better understanding of the hydrology / pad moisture conditions for winter-dominant rainfall zone (southern NSW, Victoria, WA) is needed.
2. A better understanding of pad odour emissions for winter-dominant rainfall zone (southern NSW, Victoria, WA) is needed.
3. It is necessary to develop mechanistic odour emission models using controlled, well-designed odour emission experiments rather than relying on statistics to develop an odour emission model.
4. Odour character (intensity) should be a component in the assessment of odours from feedlots as different sources clearly have different odour characteristics.
5. More work is needed to "ground truth" model results. Well-documented information about the levels of odour experienced by neighbouring receptors was only available for one feedlot in this study. In order to have confidence in the results from modelling exercise such as this one for developing odour criteria from odour sources, more work needs to be done verifying receptor experiences. This may require odour surveys, diaries, or more sophisticated training of receptors to quantify odours. Methods exist to quantify ambient odours; such methods should be evaluated as a way of validating results from this process. The next logical step to better understand what criteria may be acceptable should include a thorough study of receptor experiences during the modelled periods.
6. This study was not able to define exactly what level of odour would constitute a nuisance, or what is an acceptable level of odour that does not impact the quality of life that people expect. More work in this area is needed in order to establish odour criteria.
7. Back-calculation of emission rates using dispersion models may be way of "filling" some of the shortcomings of the BOP model and further verifying its performance. Back-calculation techniques are discussed in further detail in the Part C report. There is good agreement between emission rates measured using a wind tunnel and those derived from back-calculation techniques.
8. While the model may have some short-comings, it is much more advanced than any models used to develop the Queensland (and subsequent) Level 1 separation formulae. The model could be used to assess the integrity of the relationships in the existing formulae, in particular, the effect of feedlot size and stocking density,

4.4.2 Review of FLOT.323 Research Program

At the completion of the FLOT.323 research project, the reports were peer reviewed separately by Pacific Air and Environment and Holmes Air Sciences.

4.4.2.1 Pacific Air & Environment (Now PAE Holmes) – Robin Ormerod

The outcomes of the PAE review were presented by Robin Ormerod. A summary of the key issues and the participant feedback in relation to the presentation are provided below. Appendix 3 provides the presentation delivered at the workshop.

Summary Points

- Overall well executed. However, limitations were imposed by design and practicalities.
- **The main issue is the magnitude of predicted odour emission rates**.
- The work could do with more critical analysis and rework.
- The conceptual model needs to be reconsidered. Pond issues are resolved but need to incorporate history of pad.
- Data suggests should be able to link data with old 1995 MRC data. (e.g. Watts et al. 1992, 1994, Watts & Tucker 1993).
- The linkages in the methodology are not well lined up within the context of odour assessment. The steps usually are Measure – Emission Model – Dispersion Model – Odour Criteria – Impacts
- Differences in dietary roughage between sites. Is this a significant factor?
- Literature review pretty good except a few notable omissions e.g. Windtrax?
- At least an order of magnitude difference between Flux hood and Wind Tunnel emissions.
- Supporting measurements – pad temperature, pad depth & moisture content are not independent, i.e. if you remove moisture, you may have right odour emission rate.
- Not clear if shaded pens were included or not. Were there measurements in shaded pens? (probably not).
- Throat speed influenced results at one site only. Why – This is a curious result.
- All emission rates were standardised. How - measured butanol threshold for each panel then reference results to 50 ppb i.e. result of 75 ppb, then ratio up results by 1.5.
- Little diurnal variation with device.
- Tunnel v hood flux rates. New work by Parker in the USA (e.g. Parker et al. 2011, Parker et al. 2008, Parker et al. 2009) would be helpful.
- Real odour emission rate is best tested by back calculation.
- **May be beneficial to use laboratory tests to systematically test sensitivity to changing one variable at a time. Odour measurement is difficult – gas measurement quicker – can we use this to answer questions about odour.** But what compound do we measure – data suggests para-Cresols.
- Emissions Model – statistical crunching not best, per se.
- Perhaps PCA better, although few variables.

- Agree with concept of use of conceptual BOP model. However, there is a need to critically evaluate model.

  Base emission rate influenced by feedlot location e.g. pad temperature and operating conditions. This represents dry pen with little manure accumulation.

  Slowly varying emission rate controlled by pad management.

  Rapidly varying emission rate controlled by pad condition (e.g. moisture content).

  Under old management techniques pens dry slowly.

  Under new management techniques pens dry more quickly.

  What is the effect of rapid v slower drying?

  Another element – nutrition / digestibility has improved – 3% starch i.e. no feedstock.

- **High odour emission rates at low temperatures can't be correct - misleading – limited data - should these data be considered as outliers.** May need to critically evaluate in laboratory under controlled conditions.

- AUSPLUME v CALPUFF

  For an Industry Specific Odour Criteria, there is a need to explicitly outline all links in the chain – It is the methodology we need to describe.

  Traditionally guidelines set up with AUSPLUME as this is the simplest modelling – but cannot do this under industry specific criteria.

- Key Technical Conclusion

  How to provide linkage between odour assessment criteria, odour emission rates and modelled odour concentrations?

  How to determine realistic emission rates from wind tunnel and flux hood measurements?
  How to refine the pad odour emissions model?

- Conclusions and Direction

  Odour criteria in Australia are based on guesswork.

  Odour emission rate estimates/models have traditionally ignored reality of emission rates – too hard?

  There should not be argument between wind tunnel and flux hood – each have their own uses.

  Conversions of emission rate are based on some guesswork – assumptions currently used are not good.

Ideally, an experiment should be set up to simultaneously use of wind tunnel, flux hood and back-calculation of downwind samples/observations to get coherent dataset.

Alternatively, rework using refined conceptual approach and squeezing goodness out of latest findings from research such as Parker (Parker et al. 2011, Parker et al. 2008, Parker et al. 2009).

4.4.2.2 Holmes Air Sciences (now PAE Holmes) – Aleks Todoroski

The outcomes of the Holmes Air Sciences review were presented by Alex Todoroski. A summary of the key issues and the participant feedback in relation to the presentation are provided below. Appendix 4 provides the presentation delivered at the workshop.

Summary Points

- **Based on measured data emissions, data gives unrealistically high results.**
- Modern feedlots don't fit old models and data.
- Wind tunnel data OK when wind is a factor, but flux hood seems appropriate when conditions are stable.
- **No simple relation between tunnel/flux hood data, log relationship promising.**
- BOP model promising.
- Large range in results – not yet clear why.
- **Substantial body of high quality work.**
- Note can be "self referencing" so long as correlates to complaints.
- Issue is we know ~2 to 7 OU criteria are OK - matches complaints, so we need to consider adjusting down. High values for wind tunnel data may be justification.
- Recommend comparison between CALPUFF v AUSPLUME for full year of met & also v TAPM.
- Recommend comparison of hydrology models under same met data to remove that variable. Test model at same feedlot but different meteorology data? If this is done, change one variable at a time.
- Revisit QDPI/NSW guidelines to refine separation distance methodology. There are a number of areas in which the guidelines are correct but issues include no accounting of ponds, pen cleaning frequency, SCU's – manure changes.
- The issue is the guidelines working or not working – National guidelines almost complete, maybe a simpler approach required for smaller feedlots as this methodology is quite complicated.

Individual Reports

Part A

- No correlation between Dutch (NVN2820) & AS/NZS Standard 4323.3.
- Assumed that emissions relate to wind speed and stability class. Rationale was that at the time no paper to validate this. However, plenty of papers assumed this – so we assumed this.
- Doesn't really matter if you get the emissions under dry conditions wrong – because wet conditions are the key driver for emissions and relationship ok at higher pad moistures.
- **New thinking – tested log odour emission rates from wind tunnel v flux hood emissions. For some data found good relationship (R^2 = 0.77) at pad moistures > 50% dry basis**. May be some equivalence between two devices.
- Suggest test "log adjustment" for other feedlots.

Part B

- Consider one met data set for comparing hydrology models.

Part C sampling

- Using liquid to gas theory – but in reality solid to gas.
- Consider Freeman & Dean Study (Dean & Freeman 1994) under stable conditions.
- Conclusions for wind tunnel OK as correlated to back-calculations. Note daytime only – not clear if OK under night time (stable) conditions.
- Adjustments for Peak to Mean results are in range, but too limited. If need Peak to Mean, need to scale back, except in NSW.

Part D

- Broadly ok but no discussion of Peak to Mean for NSW.

Part E

- Broadly OK but now have new version.
- Large scale feedlot – need on-site AWS.

Part F

Statistical model not OK
Too much inter-relation, no influence for time after wetting found.
BOP has a solid basis – some refinements required.

Part G

- **Variations between years - How do you choose a representative year – what do you base it on dispersion (climate), hydrology (rainfall) or other - No easy answer.**
- What do we have / know – relate to odour complaints in the field.
- Log adjusted data lines up for pad moistures > 50% – does it work for other feedlots.
- **Validation and field study is the key.**

Suggestions

- Self referencing approach based on complaints / validation – Establish an emission rate so that results correlate with known complaints. How do you establish complaints - Maybe field survey practically how is this done without enough people around feedlot.
- Validate emissions model under a range of conditions.
- Alternative approach to move forward – clinical measurements in lab.

  Hypothesis – odour emissions relates to individual compounds releasing off pad into air – maybe direct clinical measurements and in lab. Know compounds in air coming off pad, sample air a few mm off pad. Will give key components not odour – will need to link to odour.
  This approach may have been attempted in US – Parker. (Parker et al. 2011, Parker et al. 2008, Parker et al. 2009)

- **Regulators perspective was basis for this work – NSW wanted industry specific criteria – Is this possible? Is it worth pursuing?**
- Consider log adjustment for other feedlots.
- Attempt to develop an emissions vs. temperature, moisture, etc model to add into BOP. Model deficiency with short-term storm events vs. southern Australian conditions where pad never dries out.

  There is anecdotal evidence to suggest that for continued wet periods, there is an initial peak and after about 10 days, the offensiveness disappears. Pen surfaces and ponds react slightly different but in parallel do same thing. Firstly, there is an inflow event, then the offensive odours are generated and then the odour emission reduces. Both pens and ponds do this, but on a different time-scale.

  For the pens, odour is driven by organic content – VS. Subsequent work has shown a rapid decline in VS on the pad surface after deposition.

  It was noted that, for the ponds, this may be an artefact of the by-products of the digestion process. Odour is emitted with a large influx of organic matter, which the pond initially has difficulty in handling until the bug population stabilises. Essentially, biological process in which odour emitted until nothing left to consume.

4.4.3 Wind Tunnel versus Flux Hoods Odour Emission Rate Methods – Tim Pollock

Tim Pollock gave a presentation of southern Australia work on wind tunnels and flux hoods. A summary of the key issues and the participant feedback in relation to the presentation are provided below. Appendix 5 provides the presentation as delivered at the Workshop.

- **Key part of this exercise – if we go from industry criteria therefore need to solve this problem. Most early work done in daytime conditions - Need to repeat in night time stable conditions**

- Most comparative work done in sewage treatment works. Gholson et al. (Gholson et al. 1989) basis for validation and use in standard. Only on liquid surfaces – found some 6 fold underprediction.

- **In principle, use Wind Tunnels where possible. Limitation – large sweep rate – non detect rate, low sweep rate for flux – several orders below. Can demonstrate effect of wind stripping.**

- For wastewater – wind tunnels are used.

- Gostellow et al. (Gostellow et al. 2003) – Best reference for Odour Sampling Equipment.

- ANL GW Composting Coldstream – this court case will be benchmark for odour guidelines.

- Response of Regulators - Depends on who you talk to.

  Some Victorian regulators consider AS 4323.4 as bible. AS 4323.4 (i.e. Isolation Flux Chamber). Standard is limited to liquid surfaces, spatially and temporally.

  Others with more practical experience – prepare to accept other methods.

- **Test procedure does not significantly influence the emission rate of the source –With feedlot pads more source of restriction with Flux hoods in Tim Pollock's opinion**.

4.4.4 Update of State Odour Policies

It was reported at the workshop that, theoretically, NSW DEC still would allow the development of an industry-specific odour criteria. However, in the seven years since the end of the FLOT.323 project, no industry-specific criteria has been approved (although there have been two examples of site-specific odour criteria). This implies that the acceptance of an industry-specific odour criteria in not routine and probably difficult.

It was noted that the Victorian odour criteria (5 ou, 99.9%) has not changed in many years and thus, the likelihood of any new odour nuisance criteria in Victoria is negligible.

5 Workshop Outcomes

The outcomes from the workshop are a series of **Issues** that were discussed and, where possible, agreements and/or recommendations were made by the workshop participants. This section includes a discussion of those issues and the recommendations made during the workshop.

5.1 Issue 1 – Industry-Specific Odour Criteria

The original aim of the FLOT.323 project was to develop feedlot industry-specific odour criteria. Effectively, these criteria were proposed in the Part G report.

The criteria require complete specification of:

- Feedlot odour emissions model
- Olfactometry standards
- Sampling standards (i.e. wind tunnel or flux hood)
- Dispersion modelling standards (AUSPLUME vs. CALPUFF)
- Odour Impact Criteria.

It was reported at the workshop that, theoretically, NSW DEC still would allow the development of an industry-specific odour criteria. However, in the seven years since the end of the FLOT.323 project, no industry-specific criteria has been approved (although there have been two examples of site-specific odour criteria). This implies that the acceptance of an industry-specific odour criterion is not routine and probably difficult.

The general odour nuisance criteria typically used in Australian guidelines is 1 – 7 ou (99%) using odour emissions based on flux hood data. The range of odour nuisance criteria determined in this work for 99% are 50-250 ou, but this is based on measurements taken with a wind tunnel.

While odour experts can understand that a 50-250 ou criterion is technically acceptable when different sampling methods are used, the workshop agreed that this is a difficult concept for the general public to understand.

Any industry-specific odour criteria would have to be based on correlation against complaints. Industry has adopted some complaint registers but complaints can be for all sorts of reasons. Therefore verified complaints may be suspect. However, a complaints management system has worked well for some feedlots e.g. Kerwee. Given that there are statistically, very few neighbours around feedlots, it is probably technically impossible to verify an odour criterion against complaints. An odour annoyance survey may work but again, the limited numbers of neighbours is an issue.

Recommendation:

It was agreed by the participants to recommend that MLA should not pursue an industry-specific odour criterion. It was recommended that additional review and/or research work be undertaken to allow the adaption of the data and models developed in FLOT.323 to general odour nuisance criteria used by regulatory authorities. Principally, this revolves around the relationship between measurements obtained using flux hoods and wind tunnels. The objective is the use of the FLOT.323 data within the framework of existing odour guidelines.

5.2 Issue 2 – Correlation between Flux Hood and Wind Tunnel Odour Emission Measurements

Wind tunnels were the preferred method to collect odour samples to estimate emission rates in the FLOT.323 project. However, both wind tunnels and flux hood were used. The use of wind tunnels was based on a number of factors, including the lack of a suitable operational standard for flux hoods at the time.

It was reported at the workshop that in the seven years since the completion of the FLOT.323 project, a standard has been adopted for flux hood (AS4323.4). This standard is based on USEPA and 30 years of historical data. The standard was developed and only one researcher (Mark Dunlop) had the opportunity to provide comment on the draft standard. The CASANZ working group believe that the draft standard should have been more widely circulated and reviewed.

The current regulatory thinking on the use of Flux Hoods or Wind Tunnels is unclear. It was suggested that a seminal review paper comparing Flux Hood and Wind Tunnel may assist regulators. The proposition should be the development of a conversion model, not a single number.

Discussion points also included whether the results of either technology could be compared based on the data collected and whether the methodologies needed to stand alone.

There was a little discussion on Artificial Olfactometer Systems, e.g. E-Nose, at the workshop. These techniques offer some advantages such as real time measurements, relatively cheap (compared to olfactometer). The key limitations with these systems are the need to be at the source or near the source and the minimum detection level is 100 odour units.

DEEDI E-Nose has been calibrated against real data. This has some merit and can discriminate between odours but it has a long way to go.

Recommendation:

It was recommended that the measurements obtained using flux hoods and wind tunnels be reanalysed. A review paper on the conversion of wind tunnel data to flux hood equivalents should be commissioned.

5.3 Issue 3 – Proposed Methodology for Feedlot Odour Assessment

The original aim of the FLOT.323 project was to develop an agreed methodology for assessing and modelling odour impacts for the Australian feedlot Industry.

One of the key issues at the workshop was whether the previous work is something that industry could use in its current form or whether additional work is required.

It was reported at the workshop that if the methodology developed in the project is to be used for regulatory purposes, the feedlot industry needs to be confident that it is appropriate. A uniform methodology is required which is scientifically based and which can be applied across Australia, as a lot of time and effort was spent on the project.

A key consideration is whether the methodology in its current form is a tool for the industry or whether it could be misused and used against the industry.

It was noted that DEEDI QLD still uses the S-factor method and it was recommended that because there is confidence in this method, industry should not be proactive for change.

From a regulator's perspective, the methodology needs to demonstrate compliance with odour policy and demonstrate that the activity is being managed to minimise the emission rate. Therefore, there is a need to demonstrate the best management practice (BMP) is being implemented. Over the past 15 years, the industry can demonstrate adoption/implementation of BMP. However, science is needed to backup BMP.

Alternatively, it may be possible to validate it against complaints if there is a complaints history available. The issue is that, in most situations, historical complaint data are limited because there are only a few receptors.

The consensus was that the basis for a methodology exists but more analysis required. Industry wants the science to underpin the methodology as the long term future of the industry will be based on this. As a consequence, it was noted and agreed that there are holes in the data.

Key areas include:

- Winter conditions.
- Make adjustments for windspeed and stability class.
- Alternative areas e.g. back calculations.

It was concluded that more measurements may be warranted under field and/or under controlled laboratory conditions.

Recommendation:

It was agreed that the basis for a methodology exists but further is required. The exact nature of this work will become clearer after Final Reports F and G are reviewed.

5.4 Issue 4 – Use of the Project Results by Regulators

The workshop discussed how regulators may use the results of the project. A number of participants have a regulatory background and specific input was solicited from these participants.

From a NSW regulator perspective, the reports could provide mischief in their current form. For example, various positions and counterarguments could be used, e.g. as happened for the Balgowan court case, there was an agreed methodology. The reports require sufficient commentary and analysis, as well as the peer reviewed documents, as a whole package.

From a Victorian perspective, there are parts that don't need to be touched but other parts need to be simplified.

From a QLD perspective, the document could be more of a hindrance. Various information could be extracted and used, say for an appeal, depending on the situation. The outcomes are too far from DEEDI's current regulatory understanding; mainly because of the scaling issues with emissions and that the emission numbers are orders of magnitude different from current

guidelines. DEEDI regulators are happy with S-factor approach. Therefore the work does not significantly add anything. However, ponds are not included in the S-factor approach.

The point was raised that the S-factor approach does not take into consideration the impact of alternative feedlot designs e.g. new feedlot with covered anaerobic pond or fully covered feedlot. Hence, the current S-factor methods mean that licensing of novel designs in difficult.

Recommendation:

It was recommended that, in Queensland, alternative methods should not be pursed with DEEDI regulators because of their confidence in the S factor method.

5.5 Issue 5 – Use of the Feedlot Odour Measurements made in 1991-1994

It was noted that odour research was undertaken from 1990 to 1994 using the old NVN Dutch olfactometry standard. The participants discussed whether it is possible to use these odour measurements as part of a larger feedlot odour data set.

The generally accepted conversion from NVN to the current standard is 2-3 times. However, it was shown in the FLOT.323 project that the butanol detection threshold for the current standard is 20-80 ppb, while the mean butanol detection threshold for the 1990-1994 data was about 50 ppb. This means that no conversion of the odour data from 1990-1994 is necessary as both olfactometer systems have the same sensitivity (although the old olfactometer would have a greater variation around that mean threshold).

It was noted that, in both feedlot odour projects, odour data may have been “standardised” to a detection threshold of 50 ppb by applying a ratio of the actual butanol threshold for the panel against 50 ppb. This was a practice used by some odour researchers at that time but is not accepted practice now.

Recommendation:

It was recommended that this “standardisation” factor should be removed from the FLOT.323 results, if they were applied, because it is not in the standard. All FLOT.323 reports need to be reassessed and rewritten to remove “standardisation”.

5.6 Issue 6 – Feedlot Hydrology Model

It was noted that the odour emissions model reported in FLOT.323 was based on pad moisture, pad temperature and pond inflow data that was produced by a daily-time-step feedlot hydrology model. The model used was MEDLI because it is a publicly available model. At the time that the project was undertaken, DEEDI / DERM were suggesting that a new Version 2 of MEDLI would soon become available to the public. However, no new MEDLI model has become publically available and this is a short-coming of the project.

It was noted that the MEDLI model is not validated for feedlot pad moisture. Therefore, while there is confidence that runoff is modelled correctly; some form of verification of pad moisture and temperature modelling should be considered.

Recommendations:

1. A feedlot hydrology model is required as the basis of odour emissions modelling.

2. A feedlot hydrology model would have other uses such as re-assessing feedlot pond designs and undertaken greenhouse gas research.
3. MEDLI is still the best option for a publically-available feedlot hydrology model.
4. MLA should approach the current model owner (DERM) to discuss how the updated feedlot module can be incorporated in a new Windows 7 version of MEDLI. Key discussion points to include: What is the current status of MEDLI? Who owns the IP? How available will it be?

5.7 Issue 7 - Which year to use for modelling – hydrology/dispersion

It was noted that one issue for hydrology or dispersion modelling of feedlots was the selection of a statistically relevant year. It is known that odour emissions vary strongly with rainfall. Hence, drought years will produce less odour than wet years. The question is: should the representative year based on rainfall, temperature etc? Odour guidelines specify "representative" but offer no further guidance or clarity on this issue. Similarly, guidance from regulators is unclear. However NSW regulators are developing some guidelines around this issue.

Recommendation:

It was recommended that the latest regulatory guidance be relied on.

5.8 Issue 8 - Publication of the FLOT.323 Final Reports

It was noted that, due to the uncertainties in the work, none of the Final Reports from FLOT.323 have been released to the public. The possibility of public release of these documents was discussed.

It was noted that regulators might have a problem with the document in its current form due to the size of the odour nuisance criterion numbers. This is based on perception not on science.

It was recommended that, essentially, Parts A to E could be released as-is (subject to a review in light of any developments in the last seven years and adjustment of the "standardisation" issue). This is based on no new odour emission rates being available and that the work has been reviewed by two independent reviews. The independent reviews should be updated and published at the same time. However, before the Part F and G reports could be released, the issue of the conversion of wind tunnel to flux hood measurements need to be resolved. The Part F and G reports could be released after a wind tunnel to flux hood conversion protocol had been applied to the data. This would follow production of a review paper on wind tunnels vs. Flux hoods.

To progress the issues associated with these reports it was agreed that the logical way forward would be to:

- Review data and edit.
- If issues cannot be resolved by review, conduct experiments/measurements under controlled conditions and validate.

Recommendation:

It was agreed by the participants to recommend that MLA should make public Part A to E in their current form (with revision).

It was agreed by the participants not to release Part F or Part G in their current form. It was recommended that MLA initiate a review of the data to progress the issues associated with these reports.

5.9 Issue 9 – The Use of AUSPLUME or CALPUFF

It was noted that, at short distances from the odour source, AUSPLUME and CALPUFF dispersion models produce similar results. However, at larger distances and, particularly with complex terrain, CALPUFF produces superior results. AUSPLUME is easier and less complex than CALPUFF. Regulators are happy with AUSPLUME and recognise its limitations. For more complex situations CALPUFF would be used. It was agreed by the odour experts that the choice of odour dispersion model should be at the discretion of the odour modeller.

Recommendation:

No further action on the use of AUSPLUME and CALPUFF was recommended.

5.10 Issue 10 – The Use of TAPM Data

Generally, a minimum of one year of meteorological data is acceptance for dispersion modelling. For most locations, observational meteorological data (e.g. from AWS) is not available. Therefore, what is the best data to use in the dispersion model? The use of TAPM data was discussed. It was noted that, for a new site, prognostic models (e.g. TAPM or MM5) are important because obtaining 12 months data from an on-site AWS is an expensive and onerous exercise. However, the user needs to understand the risks associated with using TAPM (or MM5) models.

Recommendation:

No further action on the use of TAPM data was recommended.

5.11 Issue 11 – Adjustment of emission rates for wind speed and stability class

It was noted that adjustments were made to the odour emissions model reported in FLOT.323 for low wind speeds and stability class. It was assumed that emissions relate to wind speed and stability class. This was based on other studies which had used a similar approach. However, there is no literature available to validate this approach.

It was noted that this was an important issue in particular at sites with light winds. At these sites adjustments become more critical. Therefore, it was recommended that any future work should include measurements conducted at night under stable conditions.

Recommendation:

It was recommended that any future work should include measurements conducted at night under stable conditions.

5.12 Issue 12 – The Absence of Cold Temperature and Prolonged Wet Pad Odour Data

Dr Watts noted in his presentation that a limited number of odour emission rates from pens were measured under cold conditions and no measurements were made under prolonged wet pen conditions. The few cool pad measurements produced unexplained high odour emission rates.

When this data was used in statistical analysis, the odour emission model produced high odour emissions that did not seem to be intuitively correct. Effectively, the cool pad data was rejected in the model development. The workshop agreed that this is a deficiency of the work and that this has implications for feedlots in southern Australia.

There was some discussion that the early morning, cold temperature measurements could be a reflection of “odour stripping” due to dew on the pen surface. This could explain the anomalous data but there is no science to justify this theory yet.

From an industry perspective, it was noted that good science was essential. Hence, while the odour emission model is probably sound for use in Queensland, it could not be used in southern Australia without further work.

Recommendations:

1. It was suggested that some feedlots along the NSW – Victorian border may have relevant odour emission data. It was recommended that investigations should be undertaken to see if any data exists.
2. It was recommended that the odour emission data analysis (and the BOP model) be revisited to see if a better odour emission model can be developed.
3. It was noted that cold temperature / prolonged wet period measurements were needed but field-based, olfactometry research is expensive and difficult. It was recommended that investigations be undertaken into doing this work in a controlled laboratory environment using a surrogate odour chemical.

5.13 Issue 13 – The Effect of Ration Ingredients on Odour Emission

The effect of ration ingredients on odour emissions was noted to be a minor issue. Substantial progress has been made in nutrition, additives in oils and processing methods, leading to improvements in digestibility, lower manure production rates, etc. While it was accepted that ration ingredients do change the character of odour, it has not been proven that ration ingredients change odour emissions measured as odour units. No connection was obtained between odour characterisation and emission rate.

Recommendation:

No further action on the effect of ration ingredients on odour emissions was recommended.

5.14 Issue 14 – Quantification of Manure Accumulation Rates in Pens

It was noted that one of the original objectives of FLOT.323 was to determine manure accumulation rates in pens and to assess the appropriateness of current feedlot guidelines. It was noted that little work was done on this issue in FLOT.323 but that subsequent projects have recently addressed this issue. It was suggested that the recent work could be used to address the short-comings of FLOT.323 and, thus be used to amend feedlot guidelines. However, industry noted that there has been recent work on the updating of national feedlot guidelines and that these issues have been addressed.

Recommendation:

No further action on manure accumulation rates in pens and the relevance to feedlot guidelines.

5.15 Issue 15 - Dust as a vector for odour transport

The workshop noted the inability of olfactometry to account for dust and how this affects odour emission measurements. There is no data on the effect of dusty conditions on odour measurements. Although this may be an important feedlot odour issue, the workshop did not recommend any further work.

Recommendation:

No further action on effect of dust on odour measurements.

6 Success in achieving objectives

MLA and ALFA appreciate that this is an important area. The workshop has come some way in allowing industry to move forward in a more positive way.

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8 Appendices

8.1 Appendix 1 - List of Attendees

Name		Affiliation
Des Rinehart	Project Manager Feedlots	MLA
Dr Peter Watts	Consultant	FSA Consulting
Eugene McGahan	Consultant	FSA Consulting
Rod Davis	Consultant	FSA Consulting
Robin Ormerod	Consultant	PAE Holmes
Geordie Galvin	Consultant	PAE Holmes
Aleks Todoroski	Consultant	PAE Holmes
Mark Dunlop	Researcher	DEEDI
Dr Matt Redding	Researcher	DEEDI
Simon Welchman	Consultant	Katestone Environmental
Andrew Balch	Consultant	Katestone Environmental
Tim Pollock	Consultant	GHD
Jim Cudmore	Lot Feeder	ALFA
Kev Roberts	Lot Feeder	Lot Feeder

8.2 Appendix 2 – Workshop Agenda

MLA Feedlot Odour R& D Workshop

Facilitator – Dr Peter Watts

Agenda	Who	Start	Finish
Arrival - name tags, tea / coffee		8:45 AM	9:00AM
Welcome	Des Rinehart	9:00 AM	9:15 AM
Workshop purpose	Peter Watts	9:15 AM	9:30 AM
Summary of Research Program (2003/2004)	Peter Watts	9:30 AM	10:00 AM
Review of Research Program	Robin Ormerod Kerry Holmes	10:00 AM	11:00 AM
Morning tea		11:00 AM	11:15 AM
State Update - Overview of Odour Regulation and Planning Policy (QLD, NSW, VIC, SA) Cont'd	Robin Ormerod	11:15 AM	12:15 PM
Lunch		12:15 PM	1:00 PM
Pro's and Con's of Odour Sampling Methods - Wind Tunnels vs. Flux Hoods - Do Regulators favour a particular method?	Tim Pollock	1:00 PM	1:45 PM
Where to from here? How does the research assist current methods for assessing Odour issues in planning regulations?	PAE Holmes	1:45 PM	2:30 PM
Where to from here? What hydraulic simulation method will be used by the Industry in future? (e.g. MEDLI, or new / modified model)	Peter Watts	2:30 PM	3:15 PM
Where to from here? Brainstorm R&D Priorities for 2011-12	Peter Watts	3:15 PM	3:45 PM
Afternoon tea		3:45 PM	4:00 PM
Set 2011-12 R&D Roadmap	Peter Watts	4:00 PM	4:45 PM
Finish	Peter Watts / Des Rinehart	4:45 PM	5:00 PM