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# Feedlot Waste Management

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# Abstract

The significant expansion of the lot feeding industry that occurred in the late eighties at a time of significant and general greening of community attitudes. These changing perspectives on acceptable environmental performance of all industries together with changing demographics of the population living in rural areas resulted in considerable community and in turn regulatory pressure on the industry to improve its environmental performance. This project (DAQ-079) continues on from the previous feedlot waste management project (DAQ-064) further developing the work started on odour generation and dispersion from feedlots and hydrology of feedlots. State and national regulatory agencies will be able to develop better regulations, designs and guidelines based on research findings on odour and hydrology developed during this project. Feedlots will be better designed by designers and consultants using the tools and knowledge that are outcomes of this project. The extension of collected knowledge and research findings during the project better equips feedlot managers and owners to operate their waste management systems and to manage their enterprises to minimise odour impact on the surrounding community.

# Executive Summary

In the period from 1985 to 1990, the Australian lot feeding industry expanded rapidly. Concerns by the public and hence local authorities and regulatory agencies about the adverse impacts of cattle feedlots on the environment accompanied this expansion. During this period, state and local government regulators from the major lot feeding areas developed feedlot guidelines and by-laws. These guidelines were often contradictory and lacked a strong scientific basis. There was a strong feeling within the feedlot sector that environmental regulations were too onerous. The industry felt that the new regulations and guidelines were inhibiting their expansion and as a result felt threatened. However, the industry was aware of the environmental problems feedlots can cause if they are poorly designed or managed and wanted these issues addressed. In 1990, the then Australian Meat and Livestock Research and Development Corporation funded the Feedlot Waste Management project (DAQ-064). This project (DAQ-079) has continued the work started in that project focusing on defining and refining the measurement of feedlot odours, investigating the dispersion of odours from feedlot operations and surveying their impact on the surrounding community. Another key component of the project was the investigation of the hydrologic performance of feedlots under Australian conditions.

The measurement of odour is not a straight forward science, relying upon the human nose rather than an instrumental measure as its basis. A state of the art, forced choice, dynamic olfactometer was developed for use in the measurement of feedlot odours. Equipment and procedures for the sampling of ambient odours and direct measurement of emission rate from extensive feedlot surfaces have been developed and tested. Based on international standards, butanol standardisation trials with panellists and the results of over eight hundred feedlot odour measurements, procedures for panel selection and standardisation of results have been developed, adopted and promoted. Methods for comparing the results gained from wind tunnels of differing configuration and operating parameters have been developed and tested to allow comparison with other researchers work.

Odour measurements conducted during a series of experiments to investigate and quantify the factors affecting odour production has resulted in the development of an odour emission model for feedlots. This model was developed from seven datasets composed of over 800 odour determinations collected during the course of the project. The model is able to explain 64% of the variation for all experiments over the course of the project period and is a major improvement on the current method of assuming a constant emission rate.

Using a series of experiments designed to investigate the odour emission from different components of the feedlot system, a comparison of the direct measurement of feedlot emission rates by wind tunnel and that obtained indirectly by back calculating using a gaussian plume model from down wind measurements of odour concentration was made. The industry standard dispersion model Ausplume has been found to be satisfactory for the modelling of the dispersion of odours from feedlot operations. More recently developed puff models offer no advantages to the feedlot industry over the Ausplume model. Recommendations on setting the most appropriate parameters for modelling of the dispersion of odours from feedlots using Ausplume have been developed.

A survey of the receptors surrounding a large modern feedlot was undertaken using was undertaken using population panel methodology in an attempt to correlate the level of odour impact being experienced by the surrounding community with their perception of annoyance. While 60% of respondents reported annoyance at the level of odour experienced at some time during the month of the survey, only 18% thought that their overall level of exposure was unacceptable. The complex terrain of the feedlot locality, poor quality meteorology data and a non-uniform distribution of receptors around the feedlot made interpretation and analysis of the survey data difficult.

The hydrology of feedlots under Australian conditions was investigated through experimental work undertaken at five feedlots in south eastern Queensland, three of these feedlots were instrumented to allow the recording of runoff events. From the data gathered in the monitoring of the hydrologic performance of these feedlots and separate experimental investigations into evaporation from pen surfaces, the relationship between pad moisture content and bulk density, storage characteristics, a computer program that is able to model the effect of feedlot management and design options on the hydrologic performance has been developed. In validation studies, this program was able to model the runoff from feedlots with a high degree of confidence. Investigations into the settling behaviour of feedlot manure have led to the development of new design recommendations for sedimentation basins.

A workshop entitled "Designing Better Feedlots" was cooperatively planned and conducted by ALFA and QDPI in September 1993. The workshop ran over two days and was followed by a two day tour of feedlots. Speakers included a number of overseas experts, lot feeders, and Australian authorities on feedlot design. The workshop was attended by over 350 delegates with 155 delegates undertaking the tour of six feedlots. This workshop was used to extend the practical design and management information collected and developed during the project to ensure that environmentally acceptable feedlots are designed in the future. The compendium of papers was published of which over 450 copies have been sold to date. The transfer of the technical material and information developed during the course of the project was undertaken at the “Feedlot Waste Management Conference” which was held at the Royal Pines resort on the Gold Coast in June 1995. The primary audience for the conference was consultants, regulators, researchers and major lot feeders.

A series of workshops on feedlot waste management were conducted at Emerald, Dalby, Tamworth and Wagga in April 1995. The aim of these workshops was to provide outcomes of the Feedlot Waste Management project to lot feeders in a form which was able to be readily understood, adopted and implemented.

The outcomes of this project have been extended to the lot feeding industry as they became available during the course of the project through the series of conferences and seminars. These have been reinforced through extension material and media articles. By adopting the designs, construction practices and management strategies proposed, the lot feeding industry will be able to construct feedlots which are easier to manage and have less impact on the environment.

Through the adoption of better design, construction and management techniques by the lot feeding industry, the benefits of this project will flow to all client groups of this project including the lot feeding industry, local authorities, state regulatory agencies, environmental and design consultants and the general community.

# Contents

# 1 Background

The lot feeding industry started in Australia in the mid-60's. Development was steady until 1975 when a major downturn occurred. The industry slowly recovered and by 1985 a new phase of development had commenced. New feedlots were established and many existing feedlots were expanded. At that time, most Australian feedlot designs were based on US ideas developed in the late 1960's and early 1970's.

In the late 1980's, the period of expansion was accompanied by a rising concern over the environmental impact of cattle feedlots. The reasons for this concern were varied and included the following:

- Many feedlots were designed and managed using techniques that may have been appropriate in the USA in the 1970's but were not appropriate in Australia in the 1980's. Hence, some environmental problems developed. In particular, many neighbours complained about offensive odours. These complaints were vigorously conveyed to local shire councils and state regulatory authorities.
- Over the past ten years, there has been a significant 'greening' of the Australian community. Practices that would have been acceptable 20 years ago are no longer so in the general community. Feedlots became one of the many industries that were perceived as being in need of improvement in respect to their environmental performance.
- With the 'greening' of the community came increased activity in environmental regulatory authorities. These departments acquired more staff, resources and legislation with which to protect the environment. A major change has been the move from the correction of existing problems to the prevention of future problems. It has become difficult to establish any industry that is perceived to have a significant environmental impact.

These factors have combined so that, within the last five years:

- guidelines and regulations have become more stringent,
- licensing procedures have become more costly and time consuming,
- objections to feedlots have become more vocal and
- legal action has become more common.

Because of the above, the lot feeding industry, as a whole, identified several ways to improve environmental performance and public image: the Meat Research Corporation funded a large waste management project; National Feedlot Guidelines were developed and Codes of Practice for animal welfare and environmental management were adopted. In many areas, the technology base of the industry and the skills level of feedlot managers and designers improved significantly. One of the major areas of improvement was the development of Australian solutions to Australian problems.

# 2 Project Objectives

The objectives of the project as stated in the contract were:

1. To obtain a consistent and repeatable industry standard for the measurement of feedlot odours.
2. To identify the characteristics of rainfall runoff from feedlot surfaces.
3. To identify and quantify the rate of dispersion of odours from feedlot operations.
4. To conduct and report on community 'annoyance' surveys of odour dispersion from feedlots.

# 3 Methodology

The methodology of the project as taken directly from the MRC contract was:

1) Odour measurement

Extensive odour generation measurements to identify the frequency, intensity, duration and offensiveness of feedlot odours will be undertaken. Factors influencing odour generation in feedlots will be identified and the effect of these quantified. Odours will be measured downwind and from within feedlots to substantiate odour dispersion models. Some of the odour measurements will be performed at the time of pen cleaning and spreading in cooperation with Evan Powell.

Simulated feedlot pads will be used to identify changes in feedlot odour with respect to changes in pad moisture content, grain ration, temperature, relative humidity and diurnal effect.

The dynamic olfactometer and wind tunnels will be upgraded to make them more functional, mobile, efficient and representative of actual feedlot conditions. An industry standard and the minimum detectable levels for odour measurement will be obtained. Surveys will be conducted to evaluate the extent of feedlot odour nuisance levels in surrounding properties. Extensive odour measurements will be undertaken in conjunction with the survey.

2) Hydrology Research

There will be a continuation of surface hydrological studies using the established research sites and possibly one extra site. Data collected will be used to formulate designs suitable to the sub-tropical Australian environment. Cattle water usage will be monitored to substantiate the hydrologic and odour generation models.

3) The research team will organise workshops for consultants in Queensland and New South Wales to improve their knowledge of feedlot odour, hydrology and appropriate design of management practices to control air and water pollution. They will also discuss the environmental assessment of feedlots and the writing of acceptable environmental impact studies relating to feedlots.

# 4 Results and Discussion

The following sections cover the activities undertaken during the project. Appendices 1 and 2 are annual reports and these cover the activities in greater detail. All publications prepared as part of the project are listed in section 8.

## 4.1 Odour Research

*Extensive odour generation measurements to identify the frequency, intensity, duration and offensiveness of feedlot odours will be undertaken. Factors influencing odour generation in feedlots will be identified and the effect of these quantified.*

An odour emission model for feedlots has been developed from seven datasets of odour measurements collected during the course of the project (Lunney & Smith, 1995). These datasets contained a total of 803 odour determinations. The model is able to explain 64% of the variation for all experiments over the course of the project period. This model is a major improvement on the current method of assuming a constant emission rate.

*Odours will be measured downwind and from within feedlots to substantiate odour dispersion models. Some of the odour measurements will be performed at the time of pen cleaning and spreading in cooperation with Evan Powell.*

Comparison of odour emission rates determined by direct measurement using wind tunnels and by back calculation from determinations of down wind odour concentrations is discussed by Smith and Kelly, 1995. In this paper, data obtained in four experiments (feedlot pens , 'Ring of Manure', feedlot retention lagoon and feedlot manure spreading) is used in comparison of the direct and indirect obtained estimates of odour emissions from extensive surfaces.

A Gaussian plume model was modified to allow it to be used to predict the spatial average odour emissions from relatively large area sources given simultaneous point measurements of odour concentration and wind speed at a location immediately downwind of the source (Smith, 1995a).

*Simulated feedlot pads will be used to identify changes in feedlot odour with respect to changes in pad moisture content, grain ration, temperature, relative humidity and diurnal effect*.

The research team has pioneered the use of simulated feedlot pads as a method of understanding the factors that influence the generation of odour from feedlot surfaces. A trial was conducted in Toowoomba in January 1993 in which odour emissions were measured under wet and dry conditions from simulated feedlot pads that had heavy and light fresh manure loadings. Other pad parameters such as surface temperature, pH and volatile solids were monitored.

An experiment was undertaken in July 1993 with the objectives of: determining the effects of prolonged wetting on odour emission, to investigate the effects of manure age on odour emission and to study changes in anaerobic populations during the wetting and drying cycle. The experiment was interrupted by cold-wet weather. While this compromised the objectives of the experiment, the collected data has proved to be valuable in showing that odour generation is influenced by temperature, time since wetting and manure moisture content. The data collected during these experiments was used in the development of the feedlot emission model (Lunney and Smith, 1995).

*The dynamic olfactometer and wind tunnels will be upgraded to make them more functional, mobile, efficient and representative of actual feedlot conditions.*

The three-way forced choice dynamic olfactometer that was developed and constructed in the DAQ-064 project was rebuilt incorporating various design modifications in December 1992 (Jones et al, 1994). The main modifications made were: a more efficient filtration system for the odour-free air, a better dilution system less prone to odour contamination, an improved sniffing port design allowing more even flow rates and less contamination, a more flexible panellist communication system and controlling software to allow more flexibility in the procedure and more efficient processing of the

data. QDPI funds were used to purchase an air-conditioned industrial-grade caravan that was used as the mobile laboratory for the new olfactometer and a petrol-driven compressor-filtration system to alleviate the need to carry large numbers of compressed air cylinders to odour measurement sites. The dynamic olfactometer measures the strength of odours and was used to measure hundreds of odours at both feedlots and during controlled odour experiments.

*An industry standard and the minimum detectable levels for odour measurement will be obtained.*

The establishment of an appropriate standard for the measurement of odours was pursued throughout the course of the project through reports (DAQ-079.Milestone1), papers at professional symposiums (Lunney, 1995) and contact with regulatory agencies and other professionals in the area.

*Surveys will be conducted to evaluate the extent of feedlot odour nuisance levels in surrounding properties. Extensive odour measurements will be undertaken in conjunction with the survey.*

The methodology for conducting a survey of neighbours surrounding a feedlot was extensively researched and reviewed. After evaluating a number of different approaches including a postal survey, a market research/focus group approach and a survey based on the population panel methodology of Koster et al, (1984) and Punter et al (1996) was chosen as the most appropriate method to maximise the useful information obtained. The Odour Annoyance Index (OAI) as described by Punter et al (1995) was used to obtain a quantitative measure of odour annoyance from the qualitative responses provided by the respondents. This approach has been used in rural and residential areas surrounding intensive animal enterprises in the Netherlands and in areas surrounding sewage treatment plants in Australia. The conduct of this survey and the interpretation and analysis of the results are described by Walsh et al, (1995 a, b and c).

## 4.2 Hydrology Research

*There will be a continuation of surface hydrological studies using the established research sites and possibly one extra site.*

The studies utilising the hydrological monitoring facilities established at feedlots during the course of DAQ-064 were continued with data collection up to mid 1994. The analysis of this data was undertaken during the final year of the project with the major outcomes of these studies being presented in Lott, (1995 b and c)

*Data collected will be used to formulate designs suitable to the sub-tropical Australian environment.*

Data collected in the surface hydrological studies of Australian feedlots together with information collected and reviewed from the international literature was used in the development of designs for drainage systems, sedimentation and retention facilities. This design information was presented in a number of the papers prepared for the Designing Better Feedlots and Feedlot Waste Management conferences.

*Cattle water usage will be monitored to substantiate the hydrologic and odour generation models.*

Water consumption by Bos Taurus cattle at two feedlots under shaded and unshaded conditions was monitored from November 1993 until May 1994. The purpose of this experiment was to measure the water consumption of lot fed cattle so an understanding of the factors that influence the quantity and manner of water consumption could be developed. Information on the outcomes of this work as it affects water system design was presented at the Designing Better Feedlots conference (Watts et al, 1994) and subsequently an explanatory model of water consumption was developed from the data collected. This model of water consumption has been incorporated in the FSIM model.

## 4.3 Extension

### 4.3.1 "Designing Better Feedlots" - Workshop

A workshop entitled "Designing Better Feedlots" was cooperatively planned and conducted by ALFA and QDPI in conjunction with the ALFA annual general meeting. The workshop was held in September 1993 at "Twin Waters" resort, Mudjimba. It ran over two days and was followed by a two day tour of feedlots. The workshop covered all aspects of feedlot design. Speakers included a number of overseas experts, lot feeders, and Australian authorities on feedlot design.

The workshop was attended by over 350 delegates including a number of international attendees. During the feedlot tour, a total of six feedlots were visited by 155 delegates. Feedlot waste system design and management were discussed at each site with talks focusing on changes in feedlot waste management techniques and results from the DAQ-079 project.

This workshop was used to extend the practical design and management information collected and developed during the Feedlot Waste Management project to ensure that environmentally acceptable feedlots are designed in the future. The proceedings of the workshop have been compiled into a design manual for the lot feeding industry. After review of the papers presented at the workshop and incorporating information presented during the panel discussions, authors provided enhanced versions of their papers and several papers were commissioned to fill specific information gaps. The compendium of papers was published as “Designing Better Feedlots” of which over 450 copies have been sold to date.

### 4.3.2 Feedlot Waste Management Workshops

A series of workshops on feedlot waste management were conducted at Emerald, Dalby, Tamworth and Wagga in April 1995. The aim of these workshops was to provide outcomes of the Feedlot Waste Management project to lot feeders in a form which was able to be readily understood, adopted and implemented. Project team members prepared and presented the bulk of the papers. Dr John Sweeten of Texas A&M University, a local regulator and a local representative of the lot feeding industry also spoke at the workshop.

### 4.3.3 Feedlot Waste Management Conference

The transfer of the technical material and information developed during the course of the project was undertaken at the “Feedlot Waste Management Conference” which was held at the Royal Pines resort on the Gold Coast in June 1995. The primary audience for the conference was consultants, regulators, researchers and major lot feeders.

### 4.3.4 Extension material

The DPI Feedlot Notes were updated during 1995.

# 5 Success in Achieving Objectives

In general, all objectives of the project have been achieved (see section 2)

*1. To obtain a consistent and repeatable industry standard for the measurement of feedlot odours.*

During the course of this project, a state of the art olfactometer was developed for use in the measurement of feedlot odours. The equipment and procedures for the sampling of ambient odours and direct measurement of emission rate from extensive surfaces have been developed and tested. Methods for comparing the results gained from wind tunnels of differing configuration and operating parameters have been developed and tested to allow comparison with other researchers' work. Comparisons have been conducted of direct measurement of feedlot emission rates from wind tunnels and those obtained indirectly by back calculating using a gaussian plume model from down wind measurements of odour concentration.

Based on international standards, butanol standardisation trials with panellists and the results of over eight hundred feedlot odour measurements, procedures for panel selection and standardisation of results have been developed, adopted and promoted.

*2. To identify the characteristics of rainfall runoff from feedlot surfaces*

This work focused on the measurement of volume of runoff from three instrumented feedlot catchments. Experimental work was undertaken at five feedlots in south eastern Queensland, three of these feedlots were instrumented to allow the recording of runoff events. Some limited information was also obtained on the nutrient content and sediment content of the runoff at one of these sites. Work on the sediment and nutrient characteristics of feedlot runoff will continue within the Cattle and Beef Industry CRC Waste Management subprogram. Work on the settling behaviour of suspended material (faeces and manure) in the feedlot runoff was reported (Lott et al, 1994)

*3. To identify and quantify the rate of dispersion of odours from feedlot operations*

The use of the industry standard dispersion model Ausplume has been found to be satisfactory for the modelling of the dispersion of odours from feedlot operations. It is the best model that is currently available with more recently developed puff models offering no advantages to the feedlot industry. Guidance has been made available on setting the most appropriate parameters for modelling of the dispersion of odours from feedlots using Ausplume.

*4. To conduct and report on community 'annoyance' surveys of odour dispersion from feedlots*

A community annoyance survey was conducted in the area surrounding a large (15000 hd) feedlot on the eastern Darling Downs area of Queensland. This feedlot was chosen for the number and variety of neighbouring receptors. Forty-six receptors were contacted in a telephone poll every night (Monday - Friday) for four weeks. Although the feedlot was specifically chosen for its relatively large number of neighbours within a 10 km radius, the coverage obtained from these neighbours was not uniformly distributed, and a greater number of receptors may have improved the accuracy of results obtained. Surveys of this type have usually been undertaken in closely settled areas where there was a large population of receptors prepared to participate with little problem obtaining a good spatial distribution of participating receptors.

The terrain surrounding the feedlot covered by the survey was not ideal for the conduct of the survey with significant terrain effects on odour plume travel being evident during the analysis of the data. This problem was exacerbated by failure for the wind speed and direction sensors on our weather station at the feedlot. The feedlot's own weather station also proved to be faulty. Wind direction and wind speed records were reconstructed from weather stations at other feedlots and meteorologic observation stations in the surrounding area. While it is possible to

reconstruct the wind speed record from these neighbouring stations with some degree of certainty, it is very difficult to have confidence in the wind direction information especially given the difficult terrain in which the study was undertaken.

The community annoyance survey has been reported as milestones reports 18 and 19 of this project and as a paper at the Feedlot Waste Management Conference (Walsh et al, 1995).

# 6 Impact on Meat and Livestock Industry – Now and in Five Years Time

It is difficult to directly measure the effect of environmental research where the outcomes of the research may not be seen in tangibles on the balance sheet as either increased production or reduced costs. The worth of this research is seen in improved design and management practices in the feedlot industry that result in reduced environmental impact, less complaints and better community relations. Had the industry continued with the design standards and management practices in place at the beginning of this project it is unlikely that it would have achieved its current size. The rapid adoption of improved design and management techniques has made this expansion possible.

During the course of the project, the lot feeding industry responded to concerns about its environmental performance through the implementation of better management practices and the adoption of better design and construction practices as these have become available. This project has played a key role in this process through the rapid extension of the outcomes of the research to the lot feeding industry, state government extension services, local authorities, regulators and consultants.

In five years time, the outcomes of this project will be seen in better feedlot designs and better management practices by lot feeders. These will be necessary to meet the challenges that will be presented by the increased scrutiny from regulatory authorities. Current changes to environment protection acts in a number of states will have been implemented in this time. The lot feeding industry along with many others will be forced to move towards increased self regulation in environmental areas through the implementation of quality assurance systems. The lot feeding industry has moved rapidly to adopt a quality assurance approach for production but is likely to have to embrace a quality assurance approach based on the ISO14000 series Environmental Management Systems standards. Outcomes from this research, both in the form of design recommendations and management procedures will be critical to the development of effective and efficient environmental management systems.

Current environmental regulation requires some feedlot proposals to conduct dispersion modelling to demonstrate acceptable impact levels. As an outcome of this project, the lot feeding industry now has access to an emission model for use in odour modelling studies which is a significant advance over most other intensive livestock industries. This model allows the generation of odour emission rates based on a weather record, rather than having to adopt a constant emission rate for dispersion modelling purposes.

# 7 Conclusions and Recommendations

## 7.1 General

1. So that industry expands in harmony with public expectations and so that guidelines and by-laws for the establishment and operation of feedlots can be better formulated, research into feedlot waste management should continue. This would result in a smoother licensing and regulation process.
2. There should be continued community input into feedlot waste management research so that a standard of operation acceptable to the community can be met.

3. QDPI should continue to consult with local authorities, industry and regulatory authorities so all parties can agree on the revised feedlot guidelines.

4. To aid consultants and designers in making the best design decisions for a given case, there is a need to develop large integrated computer models incorporating sub-models of each of the major processes within the overall feedlot waste management system.

5. Research should be undertaken into the value adding of feedlot wastes to obtain the best economic return from its byproducts and facilitate export of excess nutrients from the generating property.

## 7.2 Odours

6. An acceptable Australian standard for odour sampling and measurement techniques needs to be finalised. This standard should include forced choice dynamic dilution olfactometry and the standardisation of the result to a panel with a butanol detection threshold of 50 ppb.

7. Research needs to be undertaken into the development of an objective design standard for odour concentrations at receptors. This research will need to be jointly sponsored by the Commonwealth and State Environment Protection agencies. Current odour design objectives have little relevance in the real world and have not recognised the changes in odour measurement technology and the changing nature of the odour standard. There is a clear difference between the odour concentration number which is predicted by a modelling approach and the odour concentration number which would be determined for a receptor. Currently these two numbers are assumed to be the same in regulation.

8. The Australian inter-laboratory olfactometer testing program should continue so that the performance of all Australian olfactometers can be assessed and compared.

9. Further work on enhancing the feedlot emission model is required. Tray (simulated pad) experiments should be undertaken in a controlled environment to isolate the effect of the different factors that impact on odour generation from the feedlot pad. This will require the construction of a controlled environment, recirculating wind tunnel facility.

10. Research should be undertaken to confirm the assumption of the conservative nature of odours in dispersion modelling.

11. Research should be undertaken to define the additive properties of odours where odours from two or more dissimilar sources are being modelled.

12. The effect of background odour levels on emission rate requires further research. This is of particular significance for large feedlot developments.

13. Verification of the use of Gaussian models for large area ground level sources is needed. Feedlots, manure spreading, sewage treatment plants and land fills are virtually the only examples of large areal odour emitting sources.

14. Odour modelling efforts for new or expanded large feedlots are likely to require the collection of long term site specific wind speed and direction data. Historical records of wind direction and wind speed are only available for a limited number of sites in Australia. Very few of these sites are located in rural Australia. The record available from the weather stations currently operated by a number of larger feedlots is often not of sufficient quality to be used for modelling or research purposes. The siting and maintenance of these weather stations on feedlots does not meet the required standards. The development of a procedure for use at sites where this information is not available is required.

15. Further odour impact surveys to refine the methodology and improve knowledge of the odour intensity that is objectionable to the general populace should be carried out at feedlot sites where population density and distribution, terrain, and density of meteorologic data recording stations are suitable

16. The feedlot hydrology model developed during this project should be integrated with the feedlot odour emission model also developed during this project. This would allow the investigation of the effects of feedlot management and design options on the level and duration of odour emission from the pen area.

17. Research is needed into the best design and management practices for retention facilities at feedlots. This research should include the role of bacterial and enzymatic products in assisting the lot feeder to minimise odour generation from these facilities.

18. The type and mass of gaseous and volatile products generated on the feedlot pad is controlled in part by the bacterial population present. The potential for changing the dominant bacterial species present from those that produce highly odourous compounds to those producing less odourous products should be investigated. By selecting/genetically engineering a “better” behaved” bacterial population over those naturally present, it may be possible to establish a bacterial population that out-competes the native population, produces faster breakdown of organic matter with less odour generation.

## 7.3 Hydrology

19. The project has defined the hydrologic performance of feedlots to the extent that is required for design and operation at this point in time. The feedlot hydrology model produced is able to accurately represent the hydrology of a conventional feedlot for design and investigation purposes.

20. Relevant state departments and national committees should utilise the findings and outcomes of this research project in the formulation of design recommendations and guidelines for operation of feedlots within their state constraints (climate, social, economic) and bearing in mind the National Guidelines.

# 8 Publications

## 8.1 Seminars / Conferences

During the project, members of the team attended various seminars and conferences where the research findings were disseminated.

### 8.1.1 1992 / 93

| | |
|---|---|
| July 6-10 | International Clean Air Society, Brisbane. Presentation of paper on odour measurement techniques by M. Jones. |
| July 8 | AGM of Qld Australian Institute of Agricultural Scientists, Toowoomba. Talk on Feedlot Research by P. Watts. |
| July 10 | Vet Update 92 - University of Queensland. Presentation on environmental impact of feedlots by P. Watts. |
| August 24 | Evidence on environmental impact of cattle feedlots given to Senate Standing Committee, Toowoomba by P. Watts. |
| September 25 | Seminar in South Australia "The Way Ahead For Feedlots in South Australia" Clare, South Australia. Presentation entitled - "The Environmental Impact of Cattle Feedlots" by P. Watts. |
| October 4-7 | Engineering in Agriculture Conference, Institution of Engineers, Australia. Albury, Presentation of papers on waste management research by R. Tucker and M. Jones. |
| December 14 | Feedlot odour seminar at Texas A&M University in co-operation with the Texas Air Control Board, presentation of paper by P. Watts. |
| December 15-17 | International Winter Conference of the American Society of Agricultural Engineers, Nashville, Tennessee, presentation of two papers on feedlot odour research by P. Watts. |
| April 19-21 | Recent Advances in Animal Nutrition Conference, University of New England, Armidale, presentation of paper by P. Watts. |
| April 22 | EPA Odour Workshop Attended by Dr PJ Watts and Dr RJ Smith. Further details are given in Milestone Report No 4. |

### 8.1.2 1993 / 94

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|---|---|
| August 15 | Institute of Engineers (Water Panel). Presentation of Paper on Feedlot Runoff Control by Simon Lott. |
| August 19-20 | Clean Air Society and NZ and Australian Water and Waste Water Society. Paper on "Creation and Reduction of Odour at Feedlots" by Peter Watts and Robyn Tucker Paper on "Estimating the Rate of Odour Emission from Extension Surface Sources" by Rod Smith and Peter Watts |
| September 22-23 | ALFA - DPI "Designing Better Feedlots Workshop". Papers presented by Peter Watts, Robyn Tucker, Simon Lott, Ted Gardner, |
| November 15-16 | CSIRO Division of Meat Science. Paper on "Feedlot Waste Management Research" presented by Peter Watts |

### 8.1.3 1994 / 95

August 17-20 — Beefex Conference, Gold Coast. Paper on "Feedlot Waste Management Research" presented by Ken Casey.

October 19-21 — Great Plains Animal Waste Conference on Confined Animal Production and Water Quality, Papers on “Mass-Balance Approach to Design of Nutrient Management Systems at Cattle Feedlots” and “Runoff from Australian Feedlots” presented by Peter Watts

May 3-9 — Managing Feedlot Waste Workshops held at Emerald (Qld), Dalby (Qld), Tamworth (NSW) and Wagga Wagga (NSW). Papers presented by Ken Casey, Chris Lunney, Alan Skerman, John Sweeten.

May 3-9 — Clean Air Society - Odour Special Interest Group Conference held at Bond University Gold Coast. Paper on “Methods for Investigating Odour from Cattle Feedlots in Queensland” presented by Chris Lunney.

June 13-14 — Feedlot Waste Management Conference. Papers presented by Ken Casey, Simon Lott, Chris Lunney, Rod Smith, Ted Gardner, Alan Skerman and Peter Watts.

## 8.2 Reports / Papers

### 8.2.1 1992 / 93

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# 9 Appendices

## 9.1 Appendix 1 - Annual Report 1992/1993

### 9.1.1 Introduction

MRC Project No. DAQ-079 is being undertaken by the Queensland Department of Primary Industries in association with the University of Southern Queensland. It commenced in July 1992 and will conclude in June 1995. It continues the work done in the MRC Project No. DAQ-064 "Feedlot Waste Management" (January 1990-June 1992).

The members of the team working on the project are:

Queensland Department of Primary Industries

| | |
|---|---|
| Dr Peter Watts | Project Leader - Executive Engineer |
| Robyn Tucker | Beef Cattle Husbandry Officer |
| Simon Lott | Agricultural Engineer |
| Ken Casey | Agricultural Engineer |

University of Southern Queensland

| | |
|---|---|
| Dr Rod Smith | Assoc. Professor |
| Michael Jones | Research Engineer |

The following is a summary of the activities performed during the first year of project - DAQ-079.

### 9.1.2 The KERWEE No. 2 Experiment - Effect of wind speed on odour emission

An odour measurement experiment was undertaken at Kerwee feedlot in September 1992. Kerwee is a 2000 head commercial feedlot situated near Jondaryan in south east Queensland. An odour measurement experiment had been performed at this feedlot in December 1991.

The aims of this experiment were to:

- examine the effect of wind speed on odour emission rates;
- compare odour emission results from wind tunnels of different sizes.

Little is known about the effect of wind speed on odour emission from feedlot pads. Also, the effects of wind tunnel dimensions and tunnel air speed on the strength of the odour emitted are poorly understood. This information is crucial because, without it, data collected using different wind tunnels and air speeds cannot be compared. Wind tunnel data are likely to be used in dispersion modelling of odours from feedlots. Serious errors in downwind predictions could occur if the effect of wind tunnel dimensions and wind speed are ignored.

Two wind tunnels were constructed for use in measuring odour emissions from feedlot surfaces. The first was identical with that used previously in this project. The second was similar to the most commonly used wind tunnel from Europe. The wind tunnels were fitted with sensors to measure average tunnel wind speed, tunnel humidity and air temperature, and pad temperature.

Measurements were made over a two week period with both wet and dry feedlot pad conditions. Wind tunnel size and air speed both affected the odour emission rate. Therefore, wind tunnel dimensions and air speeds must be known before comparing odour emission data collected by different researchers.

### 9.1.3 Overseas Trip to Inspect Feedlots in the USA and Odour Measurement Technology in Holland and the UK

In December 1992, Dr Peter Watts travelled to the USA, UK and Holland on an MRC sponsored trip. The purpose of the trip was:

- to study the feedlot industry in the USA, particularly Texas;
- to study odour measurement and sampling methodology in the UK and Holland; and
- to present papers relating to feedlot waste management and odour measurement at the American Society of Agricultural Engineers Winter Meeting at Nashville, Tennessee.

Dr Watts was able to meet with the leading overseas odour researchers. This enabled clarification of many issues that were somewhat unclear in the available literature. A significant amount of odour technology literature normally unattainable was obtained. In particular, Dr Watts obtained the latest version of the draft Dutch standard on odour measurement. The standard is becoming the *de facto* world standard and our adherence to this is essential for our research to gain worldwide acceptance.

The presentation of papers at the ASAE Winter Meeting allowed our research findings to be disseminated to a wide audience. The discussion and feedback on this is invaluable for our future research.

Many cattle, dairy and calf feedlots were inspected in Texas. Dr Watts was accompanied on this part of the trip by Dr. John Sweeten from Texas A&M University. A report on the trip has been prepared.

### 9.1.4 Continued Development of Dynamic Olfactometer

A three-way forced choice dynamic olfactometer was developed and constructed in the DAQ-064 project. This device measures the strength of odours and was used to measure hundreds of odours at both feedlots and during controlled odour experiments. This olfactometer was rebuilt incorporating various design modifications in December 1992.

QDPI funds were used to purchase an air-conditioned industrial-grade caravan to be used as the mobile laboratory for the new olfactometer. The caravan that previously housed the olfactometer did not belong to Feedlot Services and had to be returned. Most of the internal fittings from the old caravan were reused in the new olfactometer. The Dutch are recognised as world leaders in odour measurements and the new olfactometer was designed to conform as closely as possible with the latest Dutch standard. The main modifications made were as follows:

- a more efficient filtration system for the odour-free air;
- a better dilution system less prone to odour contamination;
- an improved sniffing port design allowing more even flow rates and less contamination;
- a more flexible panellist communication system; and
- controlling software to allow more flexibility in the procedure and more efficient processing of the data.

A petrol-driven compressor-filtration system was purchased using QDPI funds to alleviate the need to carry large numbers of compressed air cylinders to odour measurement sites. The

olfactometer system was completed in December 1992. Software upgrading was finished in May 1993.

### 9.1.5 Butanol Standardisation of Odour Panels

A major difficulty in odour research is the ability to compare odour results obtained using different panels and different olfactometers. Also, there are concerns that the odour sensitivity of a panel may vary from day to day due to changes in sensitivity of the panellists.

Butanol has been used in Holland and elsewhere as a reference to standardise panellists. However, we have seen no evidence that standardisation of panels using butanol is valid. To compare feedlot odour data obtained using different panels, it is essential that the sensitivity of the panels to the feedlot odours is standardised.

An experiment was conducted in January 1993 to test whether the sensitivity of an odour panel to feedlot odour is related to their sensitivity to butanol. Feedlot odour samples were measured using two separate panels of 8 people. The butanol threshold was also measured for both panels.

These data are currently being analysed (the delay is due to the office fire - see Section 7) and papers will be written on the results. This information is crucial as it determines if results from different panels and different olfactometers can reliably be compared.

### 9.1.6 Ring of Manure Experiment

Wind tunnels have been used to measure the odour emissions from feedlot surfaces. The reason for using wind tunnels is that it is far simpler to determine odour emissions from a surface using a wind tunnel and then predict downwind concentrations than it is to try to measure downwind concentrations directly. There are many other factors such as terrain and weather conditions that affect the odour levels downwind of a feedlot surface.

The validity of using wind tunnels to measure odour emission rates has not been conclusively proven. An experiment was performed in January 1993 to compare odour measurements made on feedlot surface emission samples taken using wind tunnels and downwind measurement of the ambient air.

A circular pad of manure, 40 m in diameter, was build in a field at the University of Southern Queensland. Ambient odour samples were taken at the centre of the pad while wind tunnel samples were taken from the upwind edge of pad surface. Wind speed and other meteorological data were collected. The reason for using a circular pad was that the variations in wind direction would have no effect on the ambient odour at centre of the pad.

The wind tunnel data were used to predict downwind concentrations using a dispersion model. The predicted downwind concentrations were compared to the measured levels. These data are yet to be reported.

### 9.1.7 Odour Generation from Feedlot Surfaces

The research team has pioneered the use of simulated feedlot pads as a method of understanding the factors that influence the generation of odour from feedlot surfaces. A trial was conducted in Toowoomba in January 1993 in which odour emissions were measured under wet and dry conditions from simulated feedlot pads that had heavy and light fresh manure loadings. Other pad parameters such as surface temperature, pH and volatile solids were monitored. Due to the office fire, these data have not yet been analysed.

### 9.1.8 Office Fire 1993

Feedlot Services' offices were vandalised in February 1993. Files and papers were spread around the offices and a fire was lit. The fire destroyed many files and much equipment. The loss amounted to about $80 000. Many reference journal papers accumulated by the Feedlot Services' staff were destroyed. All of the Feedlot Services' computers were lost but off-site backups allowed most of the data to be recovered.

The major cost of the fire has been the time lost in sorting through burnt files, organising replacement equipment, replacing lost reference papers and recreating the current work that was on our desks at the time of the fire.

The Feedlot Services' staff were able to move back into the offices about a month after the fire, but this was followed by several weeks restoring computers and files. It is hoped that there will be little disruption to the overall research schedule but all staff have had to spend time checking for lost information and attempting to replace it.

### 9.1.9 Odour Impact Survey

Odour nuisance is difficult to measure and must be assessed by community perception. One way of achieving this is to undertake a community acceptance survey.

It has been proposed to conduct an odour survey that will include neighbours of feedlots of a range of different sizes, locations, designs and management standards. Participants will be requested to supply personal details, feedlot details, locality details and estimates of odour exposure.

The survey will assess if the separation distances in the Queensland Guidelines are appropriate, the community response to odours, and the effect of various factors on odour nuisance eg. tree cover, valley drainage and time of year.

We believe that this would be a quick way to obtain consensus on acceptable odour nuisance levels and appropriate separation distances. A draft survey form has been prepared using an independent consultant. Consultation has begun between QDPI and ALFA to finalise the survey form and method of collecting data.

### 9.1.10 Manure Drying Experiment

There is disagreement among researchers over the best drying temperature for manure, the method of expressing moisture content and the method of determining volatile solids. When determining gravimetric moisture content, soils are generally dried at 105°C while plant material is often dried at lower temperatures (40°-80°C). Manure or faeces have some characteristics of soils but consist mainly of material from plant origin. However, this organic matter has been decomposed in the rumen and on the feedlot pen surface and should be mainly comprised of relatively inert matter. It is unclear which methods are most suitable for materials encountered in this project. It is not even clear if there are sound reasons for adopting the different techniques. It is possible that by using temperatures of 105°C, organic matter may be lost and that inaccurate moisture contents are being obtained.

An experiment was designed to measure the effect of different drying times and temperatures on the determination of moisture content and volatile solids of faeces and manure.

### 9.1.11 Feedlot Simulation Model

In response to increased community awareness of environmental issues, feedlots need to improve design and management to minimise environmental impact. There is an obvious need

to obtain local data and develop design methods to suit the industry's environmental issues that are specific to our climate. Furthermore there is a need for models to undertake site specific analysis of environmental impact of feedlots.

In mid 1992, Feedlot Services started work on such a model. It is being developed so that the environmental performance of a feedlot system can be modelled. Currently the model simulates the hydrological and physical characteristics of the feedlot control drainage area, the cropping sequence and irrigation of the liquid utilisation area, the cropping sequence and application of manure to the solid utilisation area and the management regime for each land use, on a daily time step. The model separately analyses all of the different land uses within the feedlot's controlled drainage area.

While this model has not yet been calibrated against the experimental data currently being collected, several relationships used in the model have been experimentally defined.

### 9.1.12 Water Balance of Feedlot Pens

In the previous project several feedlots were instrumented to measure rainfall, runoff and other meteorological factors. The information has been used to model the hydrology of feedlots. In order to do a full water balance of a feedlot, it is necessary to consider the water entering the feedlot as drinking water and feed. The weight gain of cattle is also a sink for water.

Three feedlots were instrumented with automatic water meters and data loggers that give a readout of water consumption verses time of day. Each feedlot has both shaded and unshaded pens. Water meters were placed in both a shaded and an unshaded pen at each feedlot. The number, type and weight gain of the cattle in the pens were recorded along with the feed type and feed moisture content. A weather station at each site records other environmental conditions such as temperature, humidity and net radiation.

This monitoring will continue until sufficient data is obtained to model the water balance of a feedlot pen. This model will be incorporated into the Feedlot Simulation Model described above. Also, the results of the water consumption trials will be incorporated in the Feedlot Design Manual.

In the summer of 1992-93, an experiment was conducted at a commercial feedlot where pad moisture content was carefully monitored before and after rainfall events. This has allowed an algorithm for the loss of water by evaporation from the pen surface to be developed.

### 9.1.13 “Designing Better Feedlots” Workshop

ALFA and QDPI have been cooperatively planning a workshop entitled "Designing Better Feedlots". The workshop will be held in September 1993 at "Twin Waters" resort, Mudjimba. It will run over two days and will be followed by a two day tour of feedlots. It will cover all aspects of feedlot design. The speakers include overseas experts, lot feeders, and Australian authorities on feedlot design. The associated tour will include visits to about eight feedlots including some of the best designed and managed feedlots in Australia.

This workshop will be used to extend the practical design and management information collected and developed in the Feedlot Waste Management project to ensure that environmentally acceptable feedlots are designed in the future.

## 9.2 APPENDIX 2 - Annual Report 1993/1994

### 9.2.1 Introduction

The MRC Project DAQ-079 focuses on Feedlot Waste Management. It is being undertaken by the Queensland Department of Primary Industries in association with the University of Southern Queensland.

A number of staff changes occurred in 1993/94. Regrettably, three of the team members left the project.

| | |
|---|---|
| Sept 1993 | Mr Michael Jones, Research Engineer, USQ |
| Jan 1994 | Dr Peter Watts, Project Leader, DPI |
| Jan 1994 | Ms Robyn Tucker, Beef Cattle Husbandry Officer, DPI |

Messrs Jones, Watts and Tucker have contributed significantly to DAQ-079 and also with the preceding project on Feedlot Waste Management DAQ-064.

Mr Simon Lott acted as Project Leader for DAQ-079 from January 1994 to June 1994. Despite the changes in staff the research effort has continued. A number of graduates have been employed part-time by the Queensland Department of Primary Industries since the inception of the project in July 1992. They have had a significant input into the continuation of the project since January 1994.

Mr Ken Casey was appointed to the position of Senior Environmental Scientist with the Department of Primary Industries in June 1994. His role assumes responsibility for DAQ-079 from July 1994.

Personnel working on the project are:

Mr Ken Casey, DPI
Mr Simon Lott, DPI
Dr Rod Smith, USQ
Mr Chris Lunney, USQ

Part-time personnel associated with the project are:

Mr Brian Rolfe, DPI
Ms Leanne Mottram, DPI
Mr Paul Sanders, DPI
Ms Cath De Voil, DPI

The position held by Ms Robyn Tucker has not yet been replaced.

The following is a summary of the activities performed during the second year of the project - 1993/94.

### 9.2.2 Odour Research

Considerable research has been undertaken in the past year. The following experiments have been performed.

- Toowoomba Trial 2
- Pond Odour Emissions
- Downwind Odour Measurements
- Odour Measurement with a Scentometer

A further experiment has been planned for June/July 1994. This experiment will occur at the Berwick feedlot.

A microbial study of aerobes that generate odour has been performed by Dr Athol Klieve of the Animal Research Institute, DPI.

A lot of time has been devoted to processing and computing the odour research that has been performed in both DAQ-079 and DAQ-064. The data is now, in a common format, processed and has been analysed. Predictive equations for odour emission have been constructed from the data analysis.

#### 9.2.2.1 Toowoomba Trial 2

This experiment was undertaken in July 1993. The objectives were:

1. to determine the effects of prolonged wetting on odour emission
2. to investigate the effects of manure age on odour emission
3. to study changes in anaerobic populations during the wetting and drying cycle.

The experiment was interrupted by cold-wet weather. While this compromised the above objectives the collected data has proved to be valuable. Odour generation is influenced by temperature, time since wetting and manure moisture content. The inclement weather has allowed the collection of odour emission rates in conditions not previously recorded.

#### 9.2.2.2 Pond Emission Rates

A comprehensive set of experiments aimed at measuring and furthering our understanding of odour emission and the anaerobic generation of odour was initiated in January 1994.

Unfortunately, over 75 mm of rain "washed-out" the planned experiments. However, this rainfall event resulted in the first substantial runoff and wet pen conditions for over 12 months and also an ideal opportunity to measure odour emissions following rainfall.

Runoff entering ponds suddenly loads the pond water with organic material. This destabilises the anaerobic pond environment and causes odours to be generated. Changes in odour emission from ponds were measured over time at tour feedlots. Odour intensities peaked at 4000 SOU.

The outcomes of this experiment will be presented in a scientific paper and also in the publication "Odour Minimisation for Feedlot Managers".

#### 9.2.2.3 Downwind Odour Intensity Measurements

This experiment was undertaken in conjunction with the Pond Emission Rate experiment. Odour intensities downwind of the Sandalwood Feedlot were measured over time. Measurements occurred in varying atmospheric stabilities and with varying upwind odour intensities.

The data is currently being used to calibrate an odour dispersion model.

#### 9.2.2.4 Scentometer Studies

The Scentometer is a simple tool that can be used to measure an intensity of odour. It is used in regulation of odour nuisance by some state authorities in the US.

An overseas study has calibrated odour measurements from a Scentometer and a Dynamic olfactometer. No such study exists in Australia.

Preliminary measurements in 1993/1994 of odour intensity using a Scentometer and the DPI Forced Choice 3 Way Dynamic Olfactometer indicate, that the Scentometer may be an

effective odour measurement tool. However, not enough data had been collected to statistically verify a relationship. Research on odour measurement using the Scentometer is ongoing.

#### 9.2.2.5 Odour Emission Model

Odour nuisance experienced by a receptor can be defined by the FIDO factors:

F - frequency
I - intensity/concentration
D - duration
O - offensiveness

Odour generated in a feedlot travels to a receptor. Changes in concentration between feedlot and receptor are determined by measuring downwind concentration and can be modelled using a dispersion model.

What remains to be defined are:

- The communities acceptable limit of odour nuisance
- Odour emissions from feedlots in terms of the FIDO factors.

Analysis of the odour experiments undertaken in the period 1990 - 1994 has resulted in the development of equations that can be used to predict odour emission rates over time (ie. following rainfall events). The USQ has played a leading role in construction of these equations.

These equations are currently being incorporated in an Emission Model that couples with the model that has developed to simulate the hydrology of a feedlot (FSIM). FSIM generates manure moisture content and climatic data on a daily basis. This information is passed to the Emission model which then calculates an odour emission rate. Consequently, odour emission rates can be calculated daily for a long period of time. This allows the frequency, intensity and duration of odour nuisance to be determined. Offensiveness of odours is very dependent on the receptor. However, it is strongly related to intensity.

We aim to complete the first version of the emission model by December 1994. By coupling FSIM, the Emission Model and Dispersion Model together, predictions of odour nuisance (in terms of the FIDO factors) can be made.

The data from this modelling needs to be linked with information from the Community Acceptance Survey before any revision of separation distances in guidelines can occur.

#### 9.2.2.6 Community Acceptance Survey

The Odour Impact Survey has been reviewed by ALFA, Dr John Sweeten and a consultant. The survey requires redrafting to shorten and remove bias to improve its response.

We believe that the Odour Impact Survey should:

- be renamed "Community Acceptance Survey"
- be altered from a broad industry wide survey to a definite study of say 4 feedlots and their surrounding communities
- be undertaken over a long period of time
- perform odour measurement at each feedlot and downwind of the feedlots from time to time
- identify other sources of odour impacting on each of the communities
- consider other aspects of community impact (eg. employment, commodity acquisition, business opportunity).

Consultation with ALFA and the MRC on these issues will proceed in the first quarter of the 1994/1995 year.

The survey aims to define the community's expectations for acceptable impact. Data from the survey to allow the results from the odour research to pass into guidelines for the siting and design of feedlots.

### 9.2.3 Hydrological Research

The hydrology of a feedlot can be considered in terms of a water balance which accounts for the inputs and outputs of the system.

The water balance includes:

Rainfall
Runoff
Evaporation
Water Consumption by Cattle

Defining the water balance of a feedlot is important because it influences:

- pen manure moisture content and hence odour generation
- feedlot pen design
- drainage system design
- the design method and thus the size of the holding ponds, and,
- the amount of effluent that must be disposed on waste utilisation areas.

Measurement of Rainfall and Runoff has occurred at three sites since 1990. The site at Lillyvale Feedlot was shut down in May 1994 and "shut-down at the Brisbane Valley Feedlot will be complete. by July 1994.

In 1993/94 three experiments that improved our understanding of the water balance were performed:

- Water consumption trial
- Pen surface roughness and slope
- Evaporation from pen surfaces

Analysis of all the Rainfall-Runoff data from the three feedlot catchments has been completed.

The data from the additional experiments has also been completed.

The results from this research is being presented in:

- Chapter 5 - Drainage Systems in "Designing Better Feedlots - Design Manual. Proceedings of the Designing Better Feedlot Workshop. Sunshine Coast. Queensland September 1993".
- MRC Report 12. Hydrology of Australian Feedlots - Part 2.
- Scientific Papers.

Findings of the research are:

- The quantity of feedlot runoff is influenced by:
  - feedlot manure management
  - feedlot design (pen slope)
  - climate
- Runoff volumes are greater than previously thought

Alternative methods for storing and disposing of feedlot runoff other than the conventional "retention" type of holding pond are available.

### 9.2.4 Guideline Review

A review of the Queensland and National guidelines started in March 1994. This work draws in other personnel that have not been previously associated with the project. They are:

Mr Allan Skerman, Environmental Engineer, DPI
Mr Peter Walsh, Executive Engineer, DPI
Mr John Round, Consultant.

These people will assist the research team in moving research findings into design methods and standards for best management practices. The feedlot industry and the community will be involved throughout the review process.

The review process has been split into three stages:

a) feedlot hydrology and drainage system design
b) waste utilisation area design
c) defining separation distances using predicted terms for odour nuisance.

### 9.2.5 Milestones

During the year a number of milestones were due. Milestone 9 was delayed until June 30 1994 and has been since submitted. Milestone 11 has been delayed until August 31, 1994. Milestone 12 will be submitted a month late. It will be presented to the MRC by July 30, 1994. All other milestones were completed on time.

### 9.2.6 Extension Activities

Extension of research results in 1993/94 was centred on the "Designing Better Feedlots" Workshop and Study Tour.

The Workshop was held from 17 - 19 September and the Tour from 20 - 23 September.

Organising this workshop proved to be a huge task. A committee of ALFA and DPI representatives was formed to oversee the organisation and co-ordination of the workshop and tour. DPI representatives were Dr Peter Watts and Ms Robyn Tucker. Ms Robyn Tucker was secretary on this committee. Mr Simon Lott organised and lead the study tour.

Essentially, the bulk of the work time for organising the workshop was undertaken by the DPI. This compromised research outputs for the period July 1993 - January 1994.

#### 9.2.6.1 "Designing Better Feedlots" - Workshop

Over 350 delegates attended the Workshop. A number of overseas consultants to the US lot feeding industry participated in the workshop. The proceedings of the workshop are currently being compiled into a Design Manual for the lot feeding industry.

#### 9.2.6.2 "Designing Better Feedlots" - Study Tour

155 people participated in the study tour. Six feedlots were visited. Feedlot Waste System design and management factors were openly discussed at each site. Talks centred on changes in feedlot waste management techniques and results from the DAQ-079 project.