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Environmental performance review of Australian feedlots

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Abstract

MLA has previously conducted environmental performance surveys of other sectors of the red-meat industry, in particular, the red-meat processing sector. MLA has not conducted similar studies for the feedlot sector. This project conducted an environmental performance review of the feedlot sector and, where possible, compared results to previous work. The most significant previous study was done in 1990 when the "Lot Feeding in Australia" report was produced. That survey gained the first insight into the general management and husbandry practices adopted by Australian lot feeders. Although it was not possible to calculate key performance indicators on environmental performance at this stage, it is clear that the feedlot sector has made significant improvements to environmental performance since the 1990 study. It is recommended that processes be put in place to allow the calculation of key performance indicators for future feedlot environmental performance reviews.

Executive summary

The public expect Australian rural industries to achieve a high standard of environmental performance and demonstrate continuous improvement. Recently, public discussions have revolved around the sustainability of agricultural industries in the context of resource consumption, particularly in reference to drought and climate change. The feedlot industry recognises its environmental stewardship responsibilities and aims to work with governments and stakeholders to achieve balanced, commercially viable, environmental protection systems.

Meat and Livestock Australia (MLA) has commissioned projects to investigate the specific aspects of environmental sustainability of the lot feeding sector from an eco-efficiency perspective. These projects provided data to enable the industry to quantify and improve environmental performance and provide credible information to the industry's supporters and critics. However, they have been limited in terms of the percentage of industry covered. Therefore, there is currently a lack of collated data on current practices pertaining to resource efficiency and the environmental performance of the entire Australian feedlot sector.

Environmental key performance indicators (KPIs)
MLA has conducted environmental surveys of another sector of the red meat industry, namely the red-meat processing sector. These surveys have occurred in 1998, 2003 and 2010. As part of these surveys, KPIs were developed to benchmark resource usage and environmental impact. In line with the red-meat processing sector KPIs, similar KPIs could be proposed for the lot feeding sector. However, to calculate these KPIs, it is necessary to obtain data on resource usage (energy, water) and environmental impact (effluent production, greenhouse gas emissions) per unit of production (head turn-off, liveweight gain in the feedlots). It was recognised early in this project that there was a small likelihood that these data would be available. However, an attempt would be made to collect this information where possible. A list of KPIs has been proposed and these would be regarded as aspirational targets for future work. This may encourage lot feeders or MLA to collect appropriate data so that future environmental surveys would allow the calculation of meaningful industry KPIs.

Previous environmental surveys
Unlike, the red-meat processing sector, the feedlot sector has not undertaken regular surveys. The only detailed survey of the Australian lot feeding sector was carried out by Tucker et al. in 1991 – "Lot feeding in Australia - a survey of the Australian feeding industry". The data presented in that survey is now out-of-date, as feedlot practices have improved and changed markedly over the past twenty years, but it can act as a benchmark against which to assess changes in the sector. Hence, while it is clear that substantial improvements in environmental performance have occurred, these cannot be compared accurately against past performance.

Environmental improvements in the past 23 years
Although quantitative data has not been collected since the 1991 report, there are several changes that have occurred in the lot feeding industry that have clearly led to improvements in environmental performance. These include:

1. Environmental research – MLA has funded numerous projects investigating various aspects of feedlot environmental performance.
2. Feedlot odour guidelines – In the past, odour was probably the most significant issue surrounding the licensing and operation of feedlots. In conjunction with environmental research, guidelines have been developed that ensure, with the correct siting, design and management, few odour nuisance issues occur.
3. National feedlot guidelines and code of practice – At the instigation of industry, as represented by the Australian Lot Feeders' Association (ALFA), national feedlot guidelines have been developed and revised three times. This, in conjunction with a code

of practice, has lead to nation-wide improvements in feedlot licensing, siting, design and management.

4. National feedlot accreditation scheme (NFAS) – NFAS is an industry-driven, self-regulatory quality assurance scheme that has led to overall improvement in all aspects of feedlot management.
5. Improvements to nutrition – In the past 20 years, nutritionists and researchers have greatly improved the feed conversion ratio of lot fed cattle from about 9:1 to less than 5:1. This means that the same amount of output (beef) can be produced from much less input (feed), with much less waste (manure) produced in the process.

Survey methodology

The steps in the survey methodology were:

1. Definitions – state clear definitions of a feedlot, licensed and current pen capacity, and other quantifiable parameters. Currently, there is a downturn in the lot feeding sector and some large feedlots are temporarily closed. Current pen capacity includes all feedlots that could be operational, even if they have not operated recently.
2. Survey form – develop a survey form covering all aspects of a feedlot's environmental performance including siting, design, management and monitoring.
3. Data collection – collect location and capacity data on the majority of feedlots in Australia and collect survey data on a representative sample of Australian feedlots.
4. Data analysis – statistical and GIS analysis of the collected data.

In line with the data collection period, the "current" data presented in this report applies as of March 2013.

Current and historical pen capacity

The survey indicates that there are currently about 850 feedlots in Australia with a combined pen capacity of 1,345,000 head. The ALFA quarterly survey for the same period indicated a total pen capacity of 1,189,000 head. While only 63 feedlots have a capacity of 5000 head or more, they represent 62% of total industry capacity. Queensland has about 52% of the industry's pen capacity followed by New South Wales with 28%. Western Australia has about 10% of the total pen capacity. Based on survey data from 1990 and 2005, the distribution by state and the size distribution of feedlots have not changed markedly. However, the total national pen capacity has steadily increased from 485,000 head in 1990 to 1,107,000 head in 2005 to the current level.

Geographic distribution of feedlots

The geographic location of a feedlot can affect its environmental performance. Feedlots are more difficult to manage in areas of high annual rainfall and/or winter dominant rainfall. It is generally recommended that feedlots should be located in areas with less than 750 mm annual rainfall. In 1990, 23% of pen capacity was located in the zone of greater than 750 mm annual rainfall. Currently, this has declined to only 12%. This indicates that, in general, feedlots have been sited in lower rainfall zones, which is a positive environmental outcome. In 1990, about 70% of pen capacity was in summer-dominant rainfall zones. This has declined to about 60% due to the increased preference to feed British breed cattle which prefer the cooler southern locations. Improved design and management of feedlots in winter-dominant rainfall zones has allowed this development to occur without adverse environmental outcomes.

In terms of river catchments, 67% of pen capacity is located within the Murray-Darling Basin, where most grain is grown in eastern Australia. About 17% of total pen capacity is located in the northern coastal catchments of Queensland, mainly the Fitzroy and Burnett catchments. The distribution of feedlots by river catchments has changed little since 1990.

About 25% of the total pen capacity is located within the Great Artesian Basin from which many draw their water supplies. About 8% of feedlots are located in areas where coal seam gas leases are being developed. There are concerns about the impact of coal seam gas development on the underlying aquifers and, hence, the security of some feedlot's water supplies.

Feedlot site selection
In the early days of feedlot development, there was limited information available on appropriate site selection for feedlots. Poor site selection can lead to ongoing environmental problems (e.g. close proximity to sensitive receptors, sensitive watercourse and ecosystems and shallow groundwater). In the past 20 years, state and national guidelines have been developed and planning processes have been improved. This has eliminated approval of feedlots at poor sites. A clear example is the trend of feedlots to be located in areas with lower rainfall where environmental issues can be managed more easily.

Feedlot design
In the past 20 years, every aspect of feedlot design has improved as more experience is gained with the Australian environment. A few design features are particularly relevant to environmental performance.

Stocking density has a significant influence on the environmental performance of a feedlot since it contributes to the average moisture content of the pad. Every day, cattle add moisture to the pen surface by manure (faeces and urine) deposition. A simple calculation assumes that cattle excrete 5% of their liveweight each day and manure is 90% moisture. Following the US example, feedlots in Australia initially (i.e. prior to 1990) stocked pens at about 10 m^2/head. Heavy cattle (750 kg) at 10 m^2/head can add over 1200 mm of moisture (effective rainfall) per year (3.3 mm/day). During winter, this can exceed the evaporation rate (depending on location) and the pen surface remains moist. Under these conditions, odour and cattle comfort problems can develop. On the other hand, light cattle kept at 20 m^2/head contribute less than 1 mm of moisture/day. In summer, evaporation readily removes this moisture and dust can become a problem. Therefore, the choice of stocking density should achieve a balance between a pen surface that is too dry and one that is too wet. This is dependent on local climate and cattle size. Manure deposition and accumulation rates are similarly related to stocking density. Experience has now shown that a stocking density of 10-12 m^2/head is only appropriate in drier zones (annual rainfall <500 mm/yr). For most feedlots, a stocking density of around 15 m^2/head achieves an optimum outcome for cattle, pen environment and pen maintenance. Unlike 1990 when many feedlots were stocked at 10 m^2/head, currently 45% of pen capacity is stocked at 12.6-15 m^2/head. This reduction in stocking density, along with the location of feedlots in drier areas, results in drier feedlot pens and less runoff. This is a clear environmental improvement.

Pen slope affects the rate at which rainfall drains from feedlot pens. Flat pens drain poorly resulting in wet, odorous pens. Many early feedlots had flat pens or low pen slopes (<2%). This survey found that only 2% of pen capacity had pens with slopes that are <2% and that 31% of pen capacity had pen slopes in excess of 4%. This change in feedlot pen design has a positive environmental outcome.

Poor design and location of water troughs in feedlot pens can lead to adverse environmental outcomes such as wet patches in pens and areas where wet manure accumulates and is difficult to clean. The survey indicated that the design and location within the pens of water troughs has improved. Furthermore, it was found that about 56% of pen capacity has water troughs that are sewered. This new design feature directs excess water out of the pen area reducing water patches in pens.

Feedlot runoff control
Stormwater runoff from feedlots contains contaminants that, if allowed to enter natural watercourses, would constitute an environmental hazard. Hence, feedlots must have a system that controls runoff from contaminated areas and provides for environmentally acceptable disposal.

A key feature of a feedlot's runoff control system is the formation of a controlled drainage area. It is typically established using:

- a series of catch drains to capture runoff from the feedlot pens and all other surfaces within the feedlot complex and to convey it to a collection system, and
- a series of diversion banks or drains placed immediately upslope of the feedlot complex, which are designed to divert 'clean' or uncontaminated upslope runoff (sometimes termed 'run-on') around the feedlot complex. Where feedlots are built close to the crest of a hill or ridge, there will be no runoff from upslope. In these cases, it is possible to have a controlled drainage area without any upslope diversion banks or drains.

The runoff generated within the controlled drainage area should be directed, via a series of drains, to a sediment removal system prior to flowing into a holding pond. The contaminated runoff in the holding pond can be disposed of by evaporation and/or irrigation.

Runoff control was often poorly managed when the 1990 survey was done. At that time, 74% of commercial feedlots and only 11% of opportunity feedlots had a sediment removal system. Now, over 90% of feedlot capacity has a sediment removal system. In 1990, only 76% of commercial feedlots and 36% of opportunity feedlots had a holding pond. This situation has changed markedly with 96% of feedlot pen capacity now having holding ponds to capture runoff. The 4% of pen capacity that does not have a holding pond allows runoff to disperse over a downslope dispersal area. This is acceptable practice for small feedlots. About 80% of feedlot pen capacity uses an effluent utilisation area to utilise runoff from the holding pond compared to about 60% in 1990. About 83% of the irrigation systems are spray irrigation which allows more precise applications of effluent than surface irrigation.

Clearly, due to improved awareness and design guidelines, there has been a significant improvement in the control of contaminated runoff from feedlots over the past 20 years.

Heat stress management

In 1990, heat stress was not considered to be a significant issue and no data were collected about this topic. In recent years, community and industry awareness has increased. MLA has invested significantly in all aspects of feedlot design and management to improve the welfare of cattle during heat stress periods.

Excessive heat load (EHL) on feedlot cattle during summer months can result in significant production losses, animal welfare considerations and, under extreme conditions, the loss of cattle. High body heat loads can develop in feedlot cattle when a combination of local environmental conditions and animal factors exceed the animal's ability to dissipate body heat. Feedlot operators often adopt various management strategies to reduce the risk of EHL in cattle which in turn minimises its impact on animal production, health and welfare. The provision of shade is one strategy used to reduce the impact of hot weather conditions on cattle.

Shade is a thermal radiation shield. It reduces the heat load on the animal. Shade does not readily affect air temperature, but can reduce exposure to solar radiation and also enhance minimal air movement for cooling. Hence, shade is most beneficial for dark coloured cattle, such as Angus.

In the survey, data were obtained on the percentage of cattle at the feedlot pen capacity that was provided with shade. Data were obtained from 158 feedlots (18% of total) with a combined capacity of 802 000 head (59% of total industry). It was found that 40 feedlots (25% of those surveyed) with a pen capacity of 539 000 head (67% of those surveyed) provided some shade. When the percentage of the pen capacity that is shaded is taken into account, it was found that 402 000 head (75% of surveyed capacity) were provided with shade. There was also a clear indication from surveyed feedlots that more shade will be installed in the near future so these data will soon under-represent that percentage of the industry where shade is provided. Where shade was provided, the lot feeders were asked about the shade area provided per head (m^2/head). Many lot feeders did not know this area. Data on shade area was obtained from 11 feedlots (1% of total) with a combined capacity of 272 000 head (20% of total industry). The average shade area was 3.6 m^2/head with a range of 1 to 10 m^2/head.

Automatic weather stations (AWS) assist in the management of heat stress. For AWS, 32 feedlots (4% of total) with a combined capacity of 399 000 head (30% of total industry) were surveyed. It was found that 22 feedlots (69% of those surveyed) with a pen capacity of 345 000 head (86% of those surveyed) had an automatic weather station.

Feedlot manure management

In 1990, pen cleaning and manure management was a major issue. Manure management was often seen as a chore and an additional cost for which no return was achieved. Consequently, manure depths in pens were often at levels that would be completely unacceptable by today's standards. Deep manure leads to odour issues and a poor public perception of feedlots. Regulators responded by including sometimes onerous pen cleaning and manure management requirements in guidelines and licence conditions. Fortunately, the situation has changed markedly in the past 23 years. The reasons for this change include:

1. Clear evidence has been provided by feedlot nutritionists that cattle performance is reduced with heavy manure loads in pens.
2. Manure is now seen as a resource that can be sold to neighbouring farms as a fertiliser or soil conditioner.
3. Lot feeders are concerned about public perceptions of poor animal welfare with cattle standing in deep manure and they take action to address welfare issues if they arise.
4. Dags (manure on cattle hides) are becoming an issue and can be reduced by better manure management.

The changes to pen cleaning and manure management in the past 20 years include:

1. More frequent pen cleaning and pen cleaning at intervals appropriate to the location and climate.
2. Improved pen cleaning equipment such as box scrapers and under-fence pushers.
3. A better understanding of the nutrient value of manure and the ability to sell manure to neighbouring farms as a fertiliser replacement.
4. An increased usage of composting to reduce manure volumes and improve manure quality.

Mortality management

A few cattle inevitably die during their time at a feedlot. Mortality rates at Australian feedlots are low and typically range from 0.2% to 1% depending on a range of factors.

In 1990, data on the disposal of mortalities was not reported. However, at that time, most mortalities were buried. In recent years, there has been a significant move to composting of carcasses. In this process, the carcass is laid out on a bed of straw or manure and then covered with manure. The composting is undertaken in either bins or bays or in windrows similar to manure composting. The composting process is usually very efficient with only some large bones remaining. Some lot feeders screen the carcass compost prior to sale or disposal to remove the few remaining bones. The finished compost is then disposed of in the same manner as other manure from the feedlot. This process is more environmentally friendly than burial (which may have leachate issues) or incineration.

Data on disposal of carcasses was obtained from 42 feedlots (5% of total) with a combined capacity of 474 000 head (35% of total industry). Over 80% of the industry now composts carcasses.

Environmental management plans and accreditation systems

In 1990, virtually no environmental management systems or plans were in use at Australian feedlots. Since that time, a number of different management systems and/or accreditation schemes have been introduced. These provide a framework in which a lot feeder can operate their feedlot in an environmentally sustainable manner. Some of these management systems and accreditation schemes include:

1. National Feedlot Accreditation Scheme (NFAS)
2. Environmental management plans and systems required by regulators
3. ISO 14000 and ISO 9000 accreditation
4. EU accreditation.

Resource usage - water

In 1990, no data were collected on water or energy usage at feedlots as resource usage was not considered to be an environmental issue. However, water is now regarded as a limited resource that is fundamental to the operation of a feedlot. Despite this, few feedlots accurately measure water usage, except for regulatory requirements. Hence, it was not possible to calculate KPIs on water usage for this report. However, other data were collected.

The majority of feedlots obtain their water supplies from shallow or deep bores (60% of pen capacity) as these supplies are reliable and of a suitable water quality. Only 10% of feedlots rely on water from drought-sensitive sources such as on-farm dams and flood harvesting. Few feedlots use local government water supplies as the cost per ML is very high. Lot feeders were asked if they believed that they had any water security issues. Responses were received from 42 feedlots (5% of total) with 506 000 head pen capacity. Of these, 10 feedlots with 118 000 head capacity (23% of pen capacity) believed that they had issues over water supply security. The specific issues included concerns about the impact of coal seam gas development on local aquifers and cuts to groundwater allocations and access rules since the feedlot was developed.

While no water usage KPI data is available from this study, Davis et al. (2010a) reported on a study where eight feedlots (Feedlots A to F) were selected to provide a sample group representative of the geographical, climatic and feeding regime diversity within the Australian feedlot industry. At seven of these feedlots, water meters were installed to allow an examination of water usage by individual activities from March 2007 to February 2009. The major water usage activities (drinking water, feed management, cattle washing, administration and sundry uses) were monitored and recorded. Water usage was standardised and presented as litres used per kilogram of hot standard carcase weight (HSCW) gain equivalent (L/kg HSCW gain) or litres per head on-hand per day (L/head/day). Total annual clean water use (without dilution of effluent) ranged from 33 L/kg HSCW gain/month at Feedlot D in 2008 to 73 L/kg HSCW gain/month at Feedlot C. The average monthly total water usage in 2007-2008 was 51.5 L/kg HSCW gain, slightly higher than the 49.5 L/kg HSCW gain measured in 2008-2009. Detailed breakdowns of water usage at each feedlot are available in this report and could be used for future KPI benchmarking.

As approximately 90% of water used at feedlots is drinking water for cattle, there is limited scope for the adoption of water use efficiency practices. However, some water use efficiency practices were noted.

Resource usage - energy

Due to the recent steep increases in the cost of energy, in particular electricity, many feedlots reported that they had started measuring energy usage and looking for energy savings.

However, this is a relatively recent activity and this has not been undertaken in a standard or co-ordinated manner that would allow the calculation of KPIs and benchmarking of energy usage.

MLA has previously undertaken a project (FLOT.328 – Davis and Watts (2006)) to measure the environmental costs associated with the production of one kilogram of meat from modern Australian feedlots. As part of that project, measured data on total energy use were obtained via a detailed on-line survey. Feedlot inputs and outputs including cattle numbers, intake and sale weights, dressing percentages were also collected to standardise resource usage on the basis of one kilogram of hot standard carcass weight gain (kg HSCW gain). This project demonstrated that whilst lot feeders usually have good records of total energy usage, few data exist on actual usage levels for the individual components of the operation, including water supply, feed management, waste management, cattle washing, administration and repairs and maintenance. Hence, foreseeing these drivers for industry change and a lack of credible data, MLA has provided significant investment to quantify energy usage of individual activities at Australian feedlots in a follow-up project (B.FLT.0350 – Davis (2010b)).

There are several sources of energy used at feedlots. Diesel is used in mobile plant such as feed trucks and pen cleaning equipment. Electricity is used in offices and for grain handling. However, one of the largest uses of energy is in boilers at feedlots that undertake steam-flaking. The average monthly total energy usage across all feedlots for March 2007 to February 2009 ranged from 1.6 MJ/kg HSCW gain/month at Feedlot A to 7.8 MJ/kg HSCW gain/month at Feedlot B, with an average in the order of 6 MJ/kg HSCW gain/month. The total annual energy usage in 2007-2008 ranged from 18.5 MJ/kg HSCW gain at Feedlot A to 82.9 MJ/kg HSCW gain at Feedlot B. The total annual energy usage in 2008-2009 was slightly higher when compared to the previous year with a range of 22.5 MJ/kg HSCW gain (Feedlot A) to 92.8 MJ/kg HSCW gain (Feedlot B).

The average monthly total energy usage across all feedlots for March 2007 to February 2009 ranged from 49 MJ/head-on-feed/month at Feedlot A to 160 MJ/head-on-feed/month at Feedlot E. Feedlots with steam-flaking feed processing systems had an average usage in the order of 120 MJ/head-on-feed/month, compared with an average of about 45 MJ/head-on-feed for feedlots that process grain by other means. The total annual energy usage in 2007-2008 ranged from 583 MJ/head-on-feed (Feedlot E) to 1483 MJ/head-on-feed (Feedlot D). The total annual energy usage in 2008-2009 was slightly higher when compared to the previous year with a range of 626 MJ/head-on-feed (Feedlot A) to 1624 MJ/head-on-feed (Feedlot B). Feedlot C had the greatest monthly variation in 2007-2008 and 2008-2009. More details on the breakdown of energy usage within these feedlots is available in the B.FLT.0350 report.

In this survey, feedlots were asked if they used a boiler. Data was obtained from 162 feedlots (19% of total) with a total pen capacity of 902 350 head (67% of industry capacity). Boilers were reported at 24 feedlots which represented 55% of the surveyed current pen capacity. Boilers can be fuelled by coal, diesel or gas. There were three types of gases used within feedlots with steam-flaking systems. These include LPG - propane, LPG - butane and LPG - natural gas. All of these gas sources have different calorific values (heating content) and pricing structures and therefore impact on energy consumption. About 74% of feedlots with boilers use some form of gas as their energy source. Many feedlots have investigated various options for improving energy use efficiency with varying degrees of success.

Conclusions

The objective of this study was to undertake a detailed survey and review of the environmental performance of the Australian feedlot industry, which documents current practices and identifies, quantifies and reports key performance indicators (KPIs). The KPIs to include water usage, nutrient production, energy usage, GHG emissions, solid waste management, liquid waste management, feed management, nuisances such as odour and noise, and overall site management. Unfortunately, it has not been possible to calculate any KPIs.

However, there is clear evidence that the environmental performance of Australian feedlots has improved significantly over the past 20 years. This is the result of the combined effects of well-funded research, improved regulation and guidelines, and the implementation of quality assurance systems. It should be explicitly noted that many of these improvements (e.g. MLA-funded research, NFAS, national guidelines) have occurred due to the proactive actions of the industry as represented by ALFA.

Recommendations

A clear short-coming of this study has been the inability to calculate KPIs of environmental performance and to compare them with past studies. Hence, the recommendations listed below assume that another feedlot environmental performance review may be conducted in a few years time and steps need to be taken now to ensure a successful outcome for that future work.

Apart from the environmental performance review, there are many uses for an up-to-date Australian feedlot database supported with GIS information. The applications include submissions on the behalf of the feedlot sector to government green papers or similar plus emergency response support to disease outbreak or natural disasters (floods and bushfires). Clearly, there are privacy and security issues to be resolved around the maintenance and usage of such a database as access to the database developed in this project is strictly limited. However, a large proportion of the time spent on this project involved locating and collecting up-to-date data. If this was maintained on an on-going basis, subsequent environmental performance reviews could be undertaken more quickly and efficiently.

> It is recommended that on-going maintenance of the database established for this project be supported and that privacy and security issues be formally resolved.

The majority of medium to large feedlots use herd management software that records cattle and feed data. This data is essential for any calculations of KPIs and data that could be used in life cycle assessments. Furthermore, it is clear that many larger feedlots are collecting some data on energy and water usage. However, this is ad-hoc, non-standard, uncoordinated and private.

The framework for collecting the data necessary to calculate most environmental KPIs was established in the previous MLA project – B.FLT.0350. This experience could be used to augment the data already being collected so that it could be used to calculate KPIs in future studies. In their environmental surveys, the red-meat processing sector chose to collect and analyse data on a selected number of representative processing plants rather than the industry as a whole. A similar approach could be used for feedlots.

> It is recommended that a number of representative feedlots (15-20) be selected for on-going KPI determination. Following an audit of existing instrumentation, some additional energy and water meters may need to be installed. Procedures and data analysis for the calculation of on-going KPIs should be established so that, when a future environmental performance survey is undertaken, good quality data is available and is ready for publication.

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1 Introduction

1.1 Background

The Australian beef industry is the largest agricultural industry in Australia, within which the feedlot sector is now playing a major role. The feedlot industry has a value of production of approximately $2.7 billion while employing approximately 2000 people directly and almost 7000 more indirectly. There are about 850 feedlots throughout Australia with the majority located in areas that are in close proximity to cattle and grain supplies. These areas are south-east and central Queensland; the northern tablelands of NSW and the Riverina area of NSW with expanding numbers in Victoria, South Australia and Western Australia.

The public expect Australian rural industries to achieve a high standard of environmental performance and demonstrate continuous improvement. Recently, public discussions have revolved around the sustainability of agricultural industries in the context of resource consumption, particularly in reference to drought and climate change. The feedlot industry recognises its environmental stewardship responsibilities and aims to work with governments and stakeholders to achieve balanced, commercially viable, environmental protection systems. Meat and Livestock Australia (MLA) has commissioned projects to investigate specific aspects of the environmental sustainability of the lot feeding sector from an eco-efficiency perspective. These projects provided data to enable the industry to quantify and improve environmental performance and provide credible information to the industry's supporters and critics. However, they have been limited in terms of the percentage of industry covered. Therefore, there is currently a lack of collated data on current practices pertaining to resource efficiency and the environmental performance of the entire Australian feedlot sector. The only detailed survey of the Australian lot feeding sector was carried out by Tucker et al. in 1991 – "Lot feeding in Australia - a survey of the Australian feeding industry". The data presented in this survey is now out-of-date, as feedlot practices have improved and changed markedly over the past twenty years, but it can act as a benchmark against which to assess changes in the sector.

This project (B.FLT.0468) has conducted an environmental performance review of the feedlot industry to benchmark current practices and performance and, where possible, to quantify improvements in environmental performance. Performance will be assessed against key performance indicators (KPIs) across several important areas, including manure and effluent management, odour management, greenhouse gas emissions and energy and water use.

1.2 Project objectives

As per the contract, the project objectives were to, by 30 April 2013:

1. Undertake a detailed survey and review of the environmental performance of the Australian feedlot industry, which documents current practices and identifies, quantifies and reports key performance indicators (KPIs). The KPIs to include water usage, nutrient production, energy usage, GHG emissions, solid waste management, liquid waste management, feed management, nuisances such as odour and noise, and overall site management.
2. Where possible, provide a comparison with the 1991 survey results from Tucker et al. (1991).

1.3 Project methodology

According to the project contract, the project was to be conducted in a number of stages. These included:

1.3.1 Activity 1 – Define project goal and scope

The first step was to scope out the requirements for the environmental performance review with MLA and industry. A meeting, involving appropriate MLA personnel, industry representatives and the project team, was to be held in Brisbane to establish the goal and scope of the review and identify key performance indicators (KPIs) and data to be collected. It was recognised at the steering committee meeting that there was a small likelihood that the data required to calculate KPIs was unlikely to be obtained. This is discussed further in Section 2.2.

1.3.2 Activity 2 – Data collection

Data were to be collected on a site-by-site basis. An environmental performance survey form was to be developed so that the data collected was consistent and could be collated into an appropriate database. The form was also to be available as the basis for future surveys. The survey form was to be circulated to lot feeders followed by site visits to facilities nationally. Industry statistics suggest there are about 55 feedlots with >5000 head capacity and these represent over 60% of total feedlot capacity. These feedlots were to be the target audience for the survey. Information was to be collected via telephone and email communication, with site visits to gather key information. Site visits were to be undertaken to fully document current practices, facilitate survey completion with direct input from an appropriate company representative and permit collection of quantitative and qualitative data related to water usage, energy usage, waste management and feed management as appropriate. The data collection phase was to cover both industry practices and performance statistics, where available. In order to develop KPIs related to productivity, some feedlot production data were also to be collated. Survey analysis results were to be presented on a productivity basis (per head and/or per kilogram of gain) where possible, providing useful input for standard modelling approaches such as life cycle assessment. This approach was to allow quantifiable, rather than subjective, output from the survey. Previous research related to environmental performance and resource use such as B.FLT.0339 “Quantifying water and energy use in Australian feedlots” was to form a strong basis for the survey. Data collected in these projects was to be incorporated (on an anonymous basis) to provide greater detail to the analysis.

1.3.3 Activity 3 – Data collation and reporting

Data were to be collated into a database and relevant statistics extracted. A report was to be prepared documenting the methodology, data collected and presentation of findings. To ensure confidentiality for the feedlots participating in the survey, only collated statistics were to be reported.

This report constitutes the Final Report for this project.

2 Methodology

2.1 Methodology summary

In general accordance with the contract, the methodology used in the study is summarised as follows:

1. Develop a set of draft key performance indicators (KPIs) and data definitions for the feedlot sector.
2. Conduct a meeting with MLA and industry representatives to discuss the draft KPIs, target audience, data sources and survey methodology.
3. Develop a survey form and related database to collect the data.
4. Obtain endorsement of survey form and collection methodology from industry.
5. Collect survey data from site visit, telephone calls and other public and private sources.

6. Analyse data and prepare GIS information.
7. Prepare Final Report.
8. Supply database information to MLA for use in any future environmental surveys.

2.2 Key performance indicators (KPIs)

MLA has conducted environmental surveys of another sector of the red meat industry, namely the red-meat processing sector. These surveys have occurred in 1998, 2003 and 2010. As part of these surveys, KPIs were developed to benchmark resource usage and environmental impact. Table 1 shows the KPIs used for the red-meat processing sector.

In line with the KPIs listed in Table 1, similar KPIs could be proposed for the lot feeding sector. Table 2 gives the KPIs proposed for this survey. However, to calculate these KPIs, it is necessary to obtain data on resource usage (energy, water) and environmental impact (effluent production, greenhouse gas emissions) per unit of production (head turn-off, liveweight gain in the feedlots). It was recognised early in the project that there was a small likelihood that these data would be available. However, an attempt would be made to collect this information where possible. If the data does not currently exist, the KPIs listed in Table 2 would be regarded as aspirational targets for future work. This may encourage lot feeders or MLA to collect appropriate data so that future environmental surveys would allow the calculation of meaningful industry KPIs.

Table 1 – KPIs used in red-meat processing sector environmental surveys

		Year		
KPI	**1998**	**2003**	**2010**	**Units**
Greenhouse Gas Emissions				
	NA	NA	Yes	kg CO_2-e/t HSCW
	NA	NA	Yes	kg CO_2-e/head
Energy				
Energy Usage	Yes	Yes	Yes	MJ/t HSCW
	NA	Yes	Yes	MJ/head
Energy Saved	NA	NA	Yes	MJ/t HSCW
	NA	NA	Yes	%
Water				
Raw water usage	Yes	Yes	Yes	kL/t HSCW
		Yes	Yes	L/head
Wastewater generation	Yes	Yes	Yes	kL/t HSCW
		Yes	Yes	L/head
Wastewater loads				
Phosphorus	Yes	Yes	Yes	kg/t HSCW
Nitrogen	Yes	Yes	Yes	kg/t HSCW
Phosphorus - untreated	NA	NA	Yes	kg/t HSCW
Nitrogen - untreated	NA	NA	Yes	kg/t HSCW
BOD - untreated	NA	NA	Yes	kg/t HSCW
O&G - untreated	NA	NA	Yes	kg/t HSCW
Solid Waste to landfill				
	Yes	Yes	Yes	kg/t HSCW
	NA	Yes	NA	kg/head
Complaints				
Odour complaints	Yes	Yes	Yes	complaints/kt HSCW
	NA	NA	Yes	complaints/site
Noise complaints	Yes	Yes	Yes	complaints/kt HSCW
	NA	NA	Yes	complaints/site

Table 2 – KPIs proposed for the feedlot sector environmental survey

KPI		Units
Greenhouse Gas Emissions		
		kg CO_2-e/kg gain
		kg CO_2-e/head-day
Energy		
	Energy Usage	MJ/kg gain
		MJ/head-day
Water		
	Clean water usage	kL/kg gain
		L/head-day
Wastewater loads (feedlot runoff)		
	Volume	ML/kg gain
		ML/head-day
	Phosphorus	kg/ kg gain
	Nitrogen	kg/ kg gain
Solid Waste (manure / compost) to land		
		kg/kg gain
		kg/head-day

2.3 Definitions and data sources

2.3.1 Feedlot definition

From the National Feedlot Guidelines (MLA 2012), a beef cattle feedlot is a confined yard area with watering and feeding facilities, where cattle are completely hand or mechanically fed for the purpose of beef production. This definition includes both covered and uncovered yards.

The above definition does not include the feeding or penning of cattle in the following situations:

- for weaning, dipping or similar husbandry practices
- for milk production
- at a depot operated exclusively for the assembly of cattle for live export
- for drought or emergency feeding purposes
- at a slaughtering facility, or
- in recognised saleyards.

This definition is of particular relevance to this study. There is some uncertainty regarding whether some large facilities in northern Queensland and the Northern Territory were solely live export assembly facilities or whether they were sometimes used as feedlots. These facilities have been included in the data for this report.

2.3.2 Pen capacity

There are different aspects to the term – pen capacity.

2.3.2.1 Licensed pen capacity

Most state and local government regulatory systems license feedlots on the basis of pen capacity, either as head or standard cattle units (SCU) (Skerman 2000). As there are inconsistencies across States on capacity definition, the term “head” and “standard cattle unit (SCU)” have been taken to have the same meaning in this study. Some regulatory systems do not specify capacity explicitly but the intended capacity may be stated in the Development Application documents that accompanied the licence application.

Some regulatory systems make these data publically available. An example is the Queensland Feedlot Register. These data is defined as “licensed capacity”. This capacity may not be equivalent to the actual constructed pen capacity. Large feedlots are often licensed to a maximum capacity and then constructed in stages. Furthermore, some feedlot applications are only obtained with the intent of increasing property value prior to sale. In these cases, the feedlot may never be constructed. Hence, “licensed capacity” usually exceeds the actual constructed pen capacity. The only exception to this is unlicensed feedlots (i.e. illegal developments) and those feedlots that are below the licensing threshold for the location.

2.3.2.2 Current pen capacity

“Current pen capacity” is meant to refer to the actual, currently-constructed, pen capacity of feedlots across Australia.

Currently (i.e. in 2012-13), there is a downturn in feedlot production due to economic and climatic circumstances. Hence, many feedlots are operating at low occupancy and some, such as JBS Prime City, are temporarily closed. Many small opportunity feedlots may not have been used for 2-3 years. However, for consistency, it was decided that all viable (licensed and constructed) pen capacity would be included in the data presented.

Hence, in this report, “current pen capacity” means the number of head that could legally be fed in a feedlot, as it is currently constructed, irrespective of its recent utilisation and operating status. The data effectively applies as per March 2013.

2.4 Steering committee meeting

In accordance with the contract conditions, a Steering Committee meeting was held (on 2 July 2012) to discuss and endorse the KPIs and the study methodology. The Steering Committee included lot feeders and representatives from MLA from the lot feeding sector and the red-meat processing sector. The types of KPIs used in the red-meat processing sector (Table 1) were discussed. It was agreed that it would be unlikely that the data needed to calculate the KPIs in Table 2 would be available. Consequently, it was agreed to extend the scope of the survey from solely an environmental performance survey to an industry position statement covering aspects such as geographical distribution, design and management. A survey questionnaire would be developed to cover these aspects. In addition, it was agreed that MLA would prepare a letter of introduction and support for the researchers to provide to lot feeders as part of the survey process (see Appendix A).

2.5 Survey questionnaire and process

A survey questionnaire was developed. This questionnaire aimed to collect data to calculate the KPIs (if possible) and to collect design and management information similar to that collected by Tucker et al. (1991). Appendix A provides the final survey questionnaire. A database was developed to collate and analyse the data.

2.5.1 Survey methodology

The survey methodology was as follows:

1. Develop a database that contains every known feedlot in Australia using a variety of data sources.
2. Determine the 50 largest feedlots to target for the survey in order to obtain data on about 60% of current pen capacity. This would be regarded as an adequate representation of the lot feeding sector. In addition to these large feedlots, as many smaller feedlots as

viable would be included in the survey in order to get representative data on smaller production units.

3. Make an initial approach to the feedlots about the survey including provision of the MLA introductory letter.
4. Undertake surveys either by telephone or by site visit. It was not intended that the survey form would be sent to and completed by lot feeders as it was felt this would result in a low response rate and that various comments about the answers obtained needed to be recorded on the forms.

2.5.2 Survey results presentation

Apart from a brief listing of the major feedlots in Australia, it was agreed that all data would remain anonymous. Only aggregated, industry-wide data would be presented in this report and any associated material.

2.6 Data sources

Prior to contacting any feedlots, data on the size and location of feedlots across Australia, as well as some design and management information, was obtained from a variety of sources. These sources included:

- state licensing databases that are publically available such as the Queensland Feedlot Register, the National Pollutant Inventory (NPI) database and the NSW and Western Australia government licensing portals
- industry magazines such as the ALFA Lot Feeding journal as well as rural newspapers
- internet searches
- Google Earth searching
- discussions with key lot feeders
- FSA Consulting's internal databases

It is important to note that, except for Queensland, the data on small feedlots (<1000 head) is difficult to obtain. However, in Queensland, the publically-available feedlot register provides data on all feedlots (>49 head). This means that the data quality on small feedlots is good in Queensland and poor in other states. The data presented in this report should be interpreted accordingly.

Where possible, historical pen-capacity data were collected in five years intervals from 1990 to 2010, as well as data on any feedlots that have closed. These data were used to understand geographical and size distribution changes in the lot feeding industry over time.

These data were used to create a baseline database of the size and location of feedlots across Australia with some design and management information obtained prior to contact with lot feeders.

After the major feedlots were identified, they were contacted and surveys were conducted. The data were entered into a database for later analysis. This process resulted in a data set of about 800 feedlots where the recorded data ranged from size and location only, to partially complete data, to about 40 fully complete surveys.

In addition to the survey results, data were obtained from the Australian Lot Feeders Association (ALFA). ALFA is an industry organisation that represents lot feeders throughout Australia. Membership of ALFA is voluntary. For many years, ALFA has been conducting quarterly surveys of feedlot capacity, numbers-on-feed and utilisation. Utilisation is the ratio of number-on-feed to pen capacity. It represents the current percentage of pen capacity that is being used to feed cattle. No attempt was made in this study to measure number-on-feed or utilisation as this varies constantly due to market and climatic conditions. It is understood that the ALFA survey data is obtained through a survey that is selective, but statistically weighted to represent all feedlot sizes, coupled with a statistical extrapolation to represent the whole industry.

2.7 Previous studies

There are two previous studies that are referenced in this report.

Tucker et al. (1991) was the first comprehensive survey of the Australian lot feeding sector. This report was written as part of the first major feedlot environmental research project funded by the forerunner of MLA. This was the Feedlot Waste Management Project (DAQ.064). This report attempted to provide statistics on the size and location of the feedlot industry in Australia as well as documenting current design and management practices. In that project, 148 feedlots with a total pen capacity of 239 850 head were surveyed. Unfortunately, the base data for this project has long since been lost.

In Tucker et al. (1991), feedlots were described as either “commercial” or “opportunity” feedlots. Data were presented for each category. Commercial feedlots were those that operated continuously and were generally a stand-alone business. Opportunity feedlots were those that only operated when the economic climate was suitable, i.e. when either grain or cattle were readily available for a low cost or when finished cattle were attracting very good prices. Drought conditions may also apply. Generally, opportunity feedlots are small (<500 head). In the Tucker et al. (1991) survey, commercial feedlots only represented 15% of the number of feedlots surveyed but contained 71% of the pen capacity.

In the current survey, no distinction has been drawn between commercial or opportunity feedlots. However, it is clear that many feedlots have not held cattle for some time, indicating that they are probably still operated as “opportunity” feedlots.

Davidson (2007) was a report on a GIS dataset for the Australian feedlot sector done as part of the MLA Red Meat Industry Undergraduate Program. As such, the project was undertaken on a limited budget and short time frame. This current survey has revealed some errors in the Davidson (2007) report. Nevertheless, this report provides good data on the state of the industry in 2006.

3 Potential environmental issues with feedlots

The potential environmental issues associated with operating a feedlot are listed below.

- Community amenity

The main community amenity issue with feedlots is odour nuisance. Other impacts may include dust, noise, light, flies, vermin and traffic.

- Surface water degradation

Polluted runoff from the main feedlot pen area or from waste utilisation areas may enter natural watercourses and cause degradation of water quality.

- Groundwater degradation

Polluted water from the main feedlot pen area or from waste utilisation areas may leach into groundwater aquifers and cause degradation of water quality.

- Land degradation

Excess nutrients, salts, pathogens or other contaminants contained in feedlot manure or runoff may have detrimental effects on the land where waste utilisation occurs.

- Impacts on flora and fauna

The construction and operation of the feedlot may have impacts on local natural ecosystems.

- Greenhouse gas emissions

Some greenhouse gases will be emitted during the operation of the feedlot.

- Inefficient resource usage

Resources used at a feedlot include feed, water and energy. Inefficient usage of these resources impacts negatively on the environment.

These issues are addressed by the National Feedlot Accreditation Scheme and by various state and national guidelines. Environmental issues are minimised through a combination of feedlot siting, design, management and environmental monitoring.

4 Environmental improvements in the past 23 years

While there is little quantifiable data available on many aspects of the improvement in environmental performance of Australian feedlots in the past 23 years (since the report of Tucker et al. 1991), there have been many changes that have contributed significantly to improved outcomes. These changes are listed below. Overall, these factors have led to a significant improvement in feedlot environmental performance.

4.1 Environmental research into feedlots

The Australian Meat and Livestock Research and Development Corporation (AMLRDC) and the Meat Research Corporation (MRC) were the bodies that managed beef research in Australia prior to MLA. In 1990, AMLRDC funded the first major feedlot waste management project (DAQ.064) which was followed by DAQ.079. These projects investigated feedlot runoff, feedlot odour and environmental design and management of Australian feedlots. These projects produced the first Australian data on feedlot environmental performance that lead to improved guidelines and extension material for lot feeders to use to improve their performance.

Since those initial projects, MLA has funded numerous feedlot environmental projects covering the management and reuse of feedlot wastes (runoff and manure), feedlot odour, pathogens in waste, fly management, energy and water use efficiency, greenhouse gas emissions and feedlot life cycle assessments. This research has put the Australian feedlot sector in a sound position to respond to changing environmental conditions and expectations.

4.2 Feedlot odour guidelines

Prior to 1989, there were no sound guidelines to assist in the licensing of feedlots. In 1989, the first Queensland guidelines were released which introduced three major steps forward. These were:

1. the adoption of the term – standard cattle unit (SCU) – to standardise the capacity definition for feedlots

2. the adoption of a feedlot class system to recognise differences in feedlot design and management and subsequent feedlot environmental performance for different styles of feedlots
3. the introduction of a formula to determine an acceptable separation distance between a proposed feedlot and sensitive receptors

The introduction of the separation distance formula was a major step forward. Prior to the use of this formula, local and state governments relied on poor anecdotal information to assess new feedlot applications. This lead to some poor licensing decisions and subsequent odour nuisance complaints. These odour complaints negatively impacted the public perception and licensing regime for feedlots for many years. Experience has now shown that, to a vast degree, feedlots that are licensed, designed and managed according to the separation distance formula result in few odour complaints.

There is no quantifiable data on odour nuisance from feedlots. However, the industry has increased in capacity by about 250% in the past 23 years and there has not been a similar increase in odour complaints. Odour issues remain but these are often associated with feedlots that were licensed prior to the new formula or where other local issues are involved.

In essence, the original Queensland separation distance formula has been adopted by most states and at a national level. This has led to a significant improvement in feedlot siting and fairer assessment of feedlot proposals.

4.3 National feedlot guidelines and code of practice

Following the adoption of the Queensland state-wide guidelines in 1989, other states developed their own guidelines. Considerable variation existed between states in the approval processes and the design and management requirements for new feedlots. Lot feeders complained about this lack of uniformity saying that it deterred investment and was working against Australia's ability to compete effectively in some of our major beef export markets (ARMCANZ 1997). A process was initiated to develop national feedlot guidelines. The third version of these guidelines is now available (MLA 2012).

In 1998, the Australian Lot Feeders' Association (ALFA) initiated the development of a code of practice for cattle lot feeding in Australia. The National Beef Cattle Feedlot Environmental Code of Practice (Code of Practice) was subsequently published by MLA in 2000 (MLA 2000).

After the publication of these documents, scientific knowledge, technology and community expectations changed. In 2006, the Feedlot Industry Accreditation Committee (FLIAC) initiated a review and update of the National Guidelines. It quickly became apparent that this could not be undertaken in isolation and the Code of Practice (FLIAC 2012) was also included in the review and update process. Both documents were extensively revised into new editions of both the national environmental code of practice and national environmental guidelines. The development of the new editions of the code and guidelines was a joint project of MLA and ALFA.

Apparent inconsistencies and differences between the various state and national publications has also been a concern to the lot feeding industry. These differences often simply reflect differences in what was accepted as best practice at the time of drafting the various documents. Accordingly, any inconsistencies between the current code of practice and existing state codes, guidelines and reference manuals are not to be considered a criticism of these other publications. It was also intended that the current code of practice could be used as a basis for any state guidelines developed in the future, thereby creating regulatory consistency between the states.

A secondary aim of publishing the new code of practice was to reach a consensus between regulatory authorities in the various states, so that similar conditions apply to feedlot developments throughout Australia. This aim for consensus was made while mindful of the different physical environments and the different legislative and regulatory frameworks that may apply in each state.

The production of this document was undertaken on behalf of the Feedlot Industry Accreditation Committee and was overseen by a steering committee consisting of representatives of the following organisations:

- MLA
- FLIAC
- ALFA
- AUS-MEAT.

This code of practice is designed to address the environmentally relevant aspects of the siting, design, construction and operation of a beef cattle feedlot. These are defined in terms of a series of outcomes that the code of practice is designed to achieve. That is, feedlots should be sited, designed, constructed and operated so they:

- prevent or minimise adverse impacts on surface waters external to the feedlot controlled drainage area and external to manure and effluent utilisation areas
- prevent or minimise adverse impacts on groundwater
- prevent or minimise adverse impacts on the amenity of the surrounding community
- prevent or minimise adverse impacts on native flora and fauna and ecological communities
- ensure access to sufficient natural resources to sustain the operations of the feedlot and sustainably utilise nutrients contained in feedlot wastes.

When the Tucker et al. (1991) report was written, there were no scientifically-sound feedlot guidelines or codes of practice. Not surprisingly, environmental performance was below community expectations. Australia now has good-quality, scientifically-based guidelines and codes of practice which has led to significant improvements in environmental performance and feedlot siting.

4.4 National feedlot accreditation scheme (NFAS)

AUS-MEAT is the Authority for the Uniform Specification of Meat and Livestock. AUS-MEAT administers the National Feedlot Accreditation Scheme (NFAS). NFAS is an industry self-regulatory quality assurance scheme that was initiated by ALFA and is managed by an industry committee, FLIAC. It is administered by AUS-MEAT. The objective of the NFAS is to develop a quality system for beef feedlots that impacts positively on product quality and acceptability and for which the lot feeders maintain responsibility. The mission of the NFAS is to ensure the Australian beef feedlot industry develops a responsible feedlot management program to:

- enhance the marketing prospects for grain fed beef by raising the integrity and quality of the product;
- establish a viable mechanism for industry self-regulation; and
- improve the image of feedlots held by the community, particularly relating to environment and animal welfare matters.

Although the main focus is on product quality, the NFAS quality assurance system includes sections on environmental performance. NFAS accreditation is not mandatory. However, the majority of large feedlots are accredited and this contributes to improved environmental performance. NFAS is owned by the Australian Lot Feeding Industry through AUS-MEAT Limited. AUS-MEAT maintains a register of approved feedlots through a collaborative inspection programme with state authorities. The NFAS feedlot database was not used in this study.

4.5 Major improvements to feed conversion ratio

Lot feeding is a high-turnover, low-margin industry. Hence, feedlot consultants (mainly nutritionists) aim to fine tune performance. This means more production for fewer inputs. In feedlot terms, this means an improvement in feed conversion ratio (FCR) which is the ratio of feed consumed to weight gained.

There is little published data in this area. However, through a combination of animal genetics, animal health and husbandry, improved ration formulation and improved feed preparation, the FCR in feedlots has improved from about 9:1 in 1990 to somewhere near 4.5:1 in well-managed feedlots. This means producing the same amount of production for about half of the feed input. By any means, this is a significant improvement in resource usage efficiency. Due to the improved digestibility of rations, it is generally believed that less manure is excreted for the same amount of weight gain. That is, the improvements in FCR are a form of waste minimisation in the feedlot sector. Less waste produced means less environmental impact.

5 Current and historical pen capacity

5.1 Feedlot database validation

5.1.1 Current pen capacity

Table 3 shows the current pen capacity data collected in the survey. These data applies as of March 2013. Table 3 also compares these data to the relevant ALFA quarterly survey data. These data shows that the survey database contains, on average, about 13% more pen capacity than the current ALFA survey. About 30% of the numerical difference (i.e. 46,000 out of 157,000) occurs in NSW. There are some large feedlots in NSW that are currently temporarily closed (namely Yambinya and JBS Prime City). Closed feedlots may not be included in the ALFA survey data. Nevertheless, it appears that this survey has found the majority of current feedlots in Australia.

Table 3 – Current feedlot capacity by state (March 2013)

State	No. of Feedlots	% Pen Capacity	Pen Capacity	No. of Feedlots	% Pen Capacity	Pen Capacity
	This survey			ALFA Mar 2013 Survey		
QLD	586	51.8	696576	-	55.8	662856
NSW	94	28.0	377187	-	27.9	331182
WA	96	9.5	127985	-	7.5	89226
VIC	27	6.4	85464	-	6.3	75356
SA	49	3.1	41713	-	2.5	30195
TAS	1	0.9	12500	-	0	0
NT	1	0.3	4000	-	0	0
TOTAL	854	100	1345425	-	100	1188815

5.1.2 Historical pen capacity

Table 7 provides the pen capacity data for 1990 collected in this survey compared to the 1990 distribution of feedlots presented by Tucker et al. (1991). These data shows that the current survey has only located about 66% of the capacity documented in 1990. This is perhaps not surprising as it was difficult to find data about feedlots 23 years ago. The current survey only found 13% of the 1990 feedlots (i.e. 79 out of 631) but this represents two-thirds of the pen capacity. The largest difference in pen capacity is in Queensland where it has been difficult to locate small feedlots that operated in 1990.

Table 4 – Feedlot pen capacity by state (1990)

State	No. of Feedlots	% Pen Capacity	Pen Capacity	No. of Feedlots	% Pen Capacity	Pen Capacity
	This survey			Tucker et al. 1991		
QLD	53	56	180588	471	54	262200
NSW	16	20	83025	90	25	120865
WA	2	3	2200	34	7	33720
VIC	4	5	44000	7	9	42840
SA	2	3	7500	27	5	22560
TAS	1	<1	2000	1	<1	2000
NT	1	<1	700	1	<1	700
TOTAL	79	100	320013	631	100	484885

Figure 1 shows the quarterly ALFA survey data of pen capacity from December 1995 to March 2013 by state. Figure 2 shows the historical data collected in this study in five year intervals from 1990 to 2010. This shows that the data is similar in 2010 – about 1.2 M head of pen capacity but the difference between the data sets gets greater in 2000 and 1995 due to the inability of collect all historical data in this survey. In both datasets, the greatest period of growth was from about 2000 to 2005. There has been little growth in the past five years.

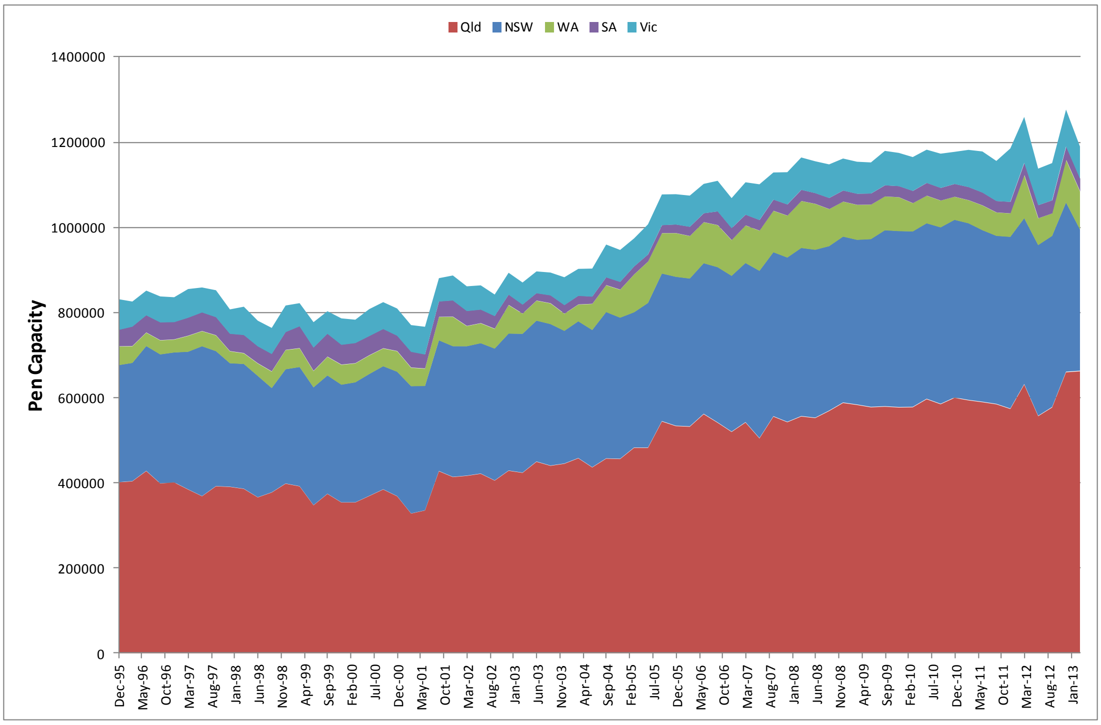

Figure 1 – Pen capacity over time (ALFA quarterly surveys)

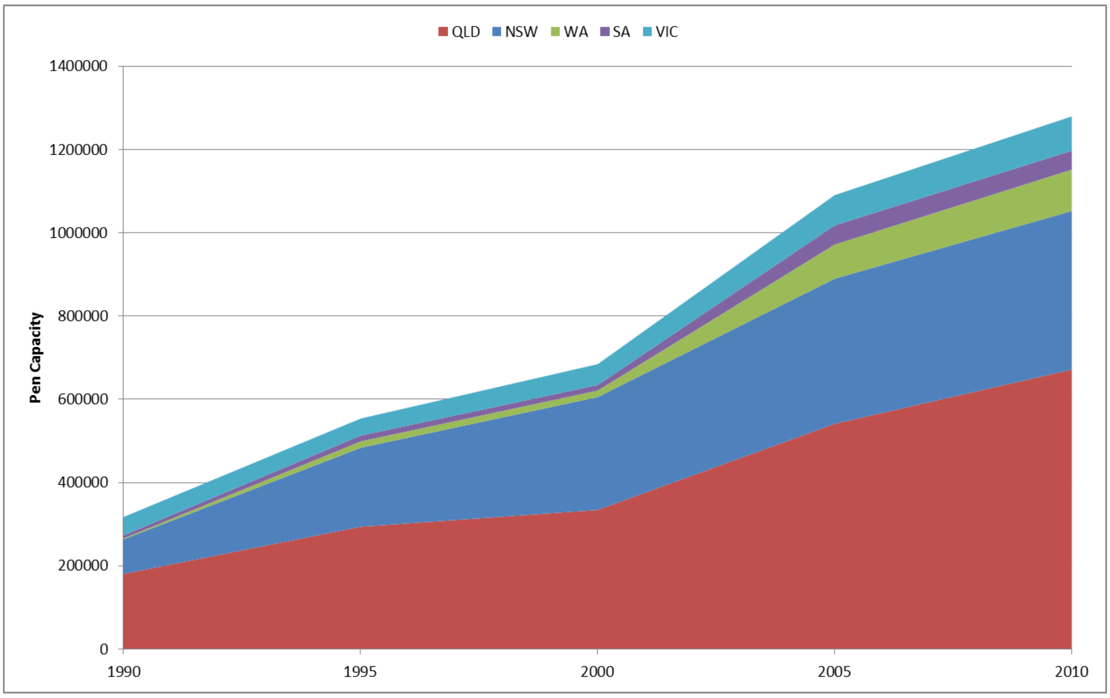

Figure 2 – Pen capacity over time (this study – 5 year increments)

5.2 Location by state

5.2.1 Feedlot distribution by state (current)

Table 5 and Figure 3 provide an analysis of the current distribution of feedlots by State. Currently, Queensland has the most feedlots by number and capacity. Although New South Wales and Western Australia both had a similar number of individual feedlots (94 and 96 respectively), their capacities are significantly different (377 187 head and 127 985 head respectively). This was reflected by New South Wales' average capacity being over three times greater than the average of Western Australia. On average capacity, (disregarding both Northern Territory and Tasmania, both with a single feedlot), New South Wales and Victoria had the highest average capacity. Queensland and Western Australia average were mid-range, while South Australia had the lowest average. However, as noted previously, these data may be skewed by the lack of data on smaller feedlots in states other than Queensland. A comparison of Table 5 with the ALFA data in Table 3 shows a fairly similar distribution by state.

Table 5 – Current distribution of feedlots by state

State	No. of Feedlots	% of Feedlots	Average Capacity	Pen Capacity	% Pen Capacity
QLD	586	68.6	1189	696576	51.8
NSW	94	11.1	4013	377187	28.0
WA	96	11.2	1333	127985	9.5
VIC	27	3.2	3165	85464	6.4
SA	49	5.7	851	41713	3.1
TAS	1	0.1	12500	12500	0.9
NT	1	0.1	4000	4000	0.3
TOTAL	854	100	3864	1345425	100

5.2.2 Feedlot distribution by state (2005)

Table 6 and Figure 4 provide an analysis of the 2005 distribution of feedlots by state compared to the ALFA data. Queensland had the most feedlots by count and capacity in 2005. These data shows a similar distribution by state to the current situation.

Table 6 – Distribution of feedlots by state (2005)

State	No. of Feedlots	% of Feedlots	Average Capacity	Pen Capacity	% Pen Capacity	% Capacity (ALFA)	Capacity (ALFA)
QLD	520	68.3	1041	541272	48.9	50	539185
NSW	86	11.3	4055	348688	31.5	33	537073
WA	85	11.2	965	82011	7.3	9	94576
VIC	21	2.8	3466	72791	6.6	7	71171
SA	47	6.2	978	45981	4.2	2	25811
TAS	1	0.1	12500	12500	1.1	0	0
NT	1	0.1	4000	4000	0.4	0	0
TOTAL	761	100	3858	1107243	100	100	1087815

5.2.3 Feedlot distribution by state (1990)

Table 7 provides an analysis of the 1990 distribution of feedlots by state compared to the Tucker et al. (1991) data in Table 8. This project has not been able to relocate all of the feedlots mapped in 1990 finding only data on 79 feedlots compared to the 631 feedlots in Tucker et al. (1991). However, this does represent about two-thirds of the pen capacity. The distribution between states is similar, except that this survey has not been able to locate many of the 1990 feedlots in Western Australia.

Figure 5 maps the 1990 feedlots found in this study. Figure 6 shows the 1990 distribution taken from Tucker et al. (1991). While the general distribution is similar, this study is deficient in feedlots in South Australia and Western Australia.

Table 7 – Distribution of 1990 feedlots by state (this survey)

State	No. of Feedlots	% of Feedlots	Average Capacity	Pen Capacity	% Pen Capacity
QLD	53	67	3407	180588	56.4
NSW	16	20	5189	83025	25.9
WA	2	3	1100	2200	0.8
VIC	4	5	11000	44000	13.7
SA	2	3	3750	7500	2.3
TAS	1	1	2000	2000	0.7
NT	1	1	700	700	0.2
TOTAL	79	100	3878	320013	100

Table 8 – Distribution of 1990 feedlots by state (Tucker et al. 1991)

State	No. of Feedlots	% of Feedlots	Average Capacity	Pen Capacity	% Pen Capacity
QLD	471	75	557	262200	54
NSW	90	14	1343	120865	25
WA	34	5	992	33720	7
VIC	7	1	6120	42840	9
TAS	1	<1	2000	2000	<1
SA	27	4	836	22560	5
NT	1	<1	700	700	<1
TOTAL	631	100	768	484885	100

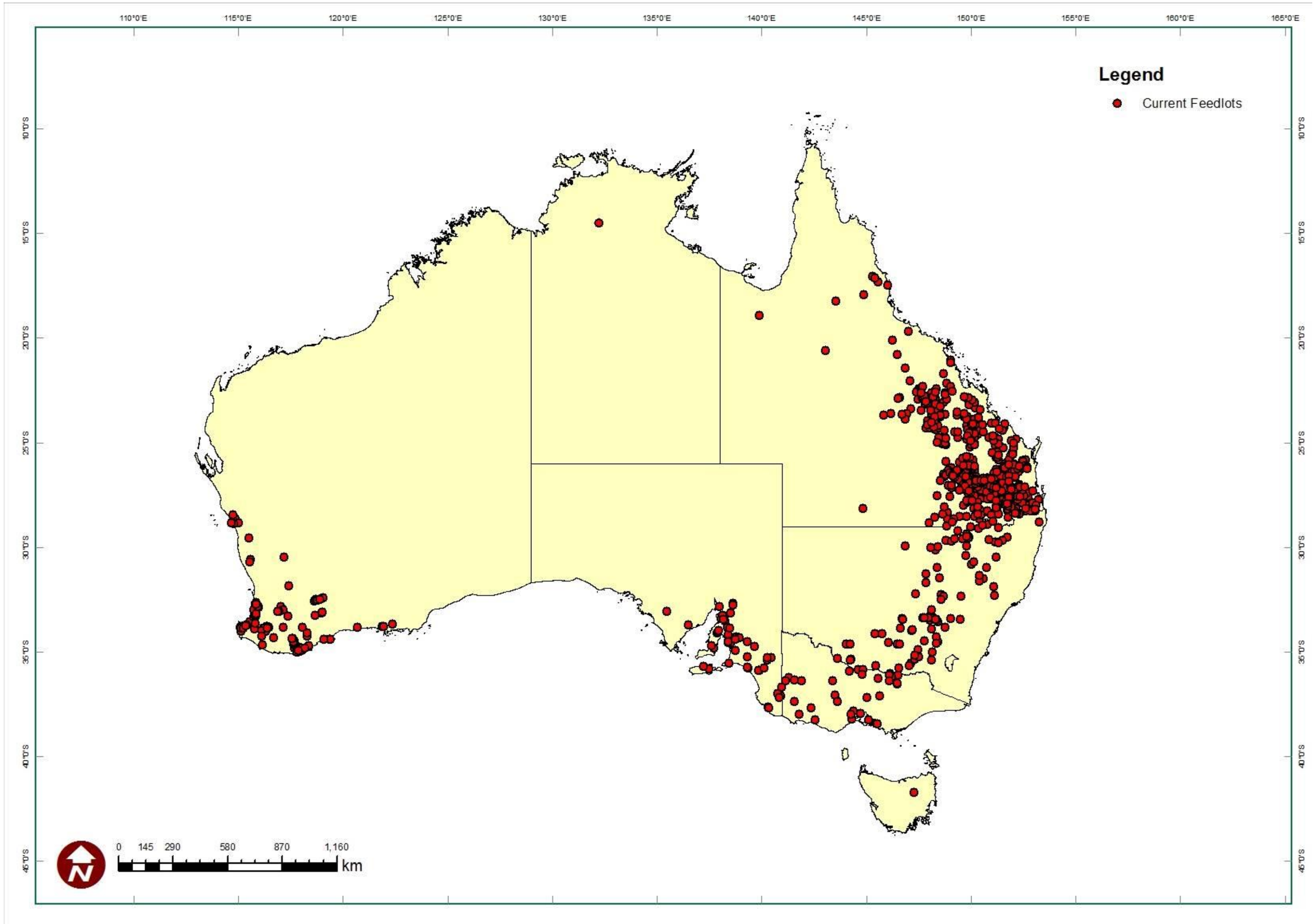

Figure 3 – Location of feedlots across Australia (current – March 2013)

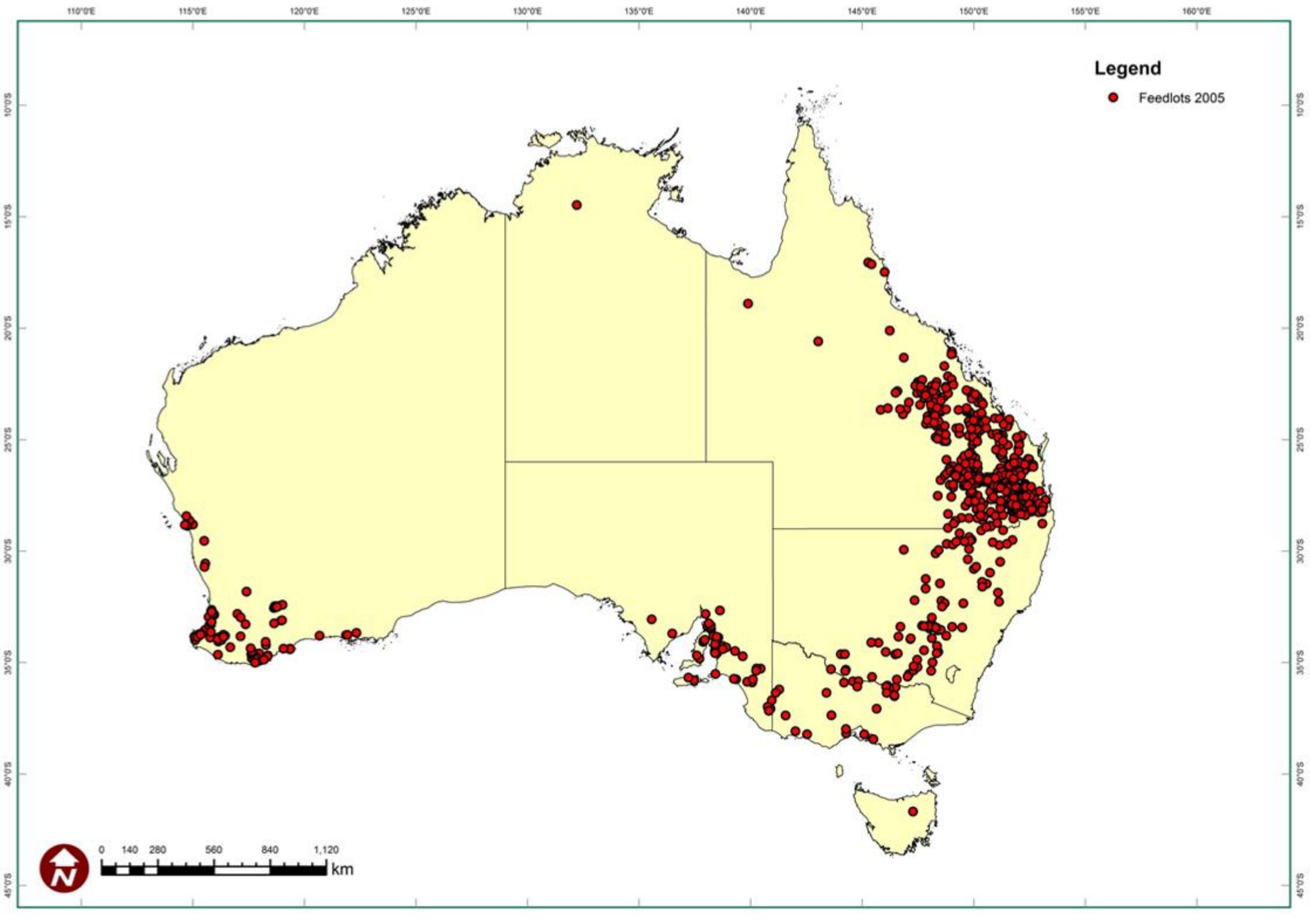

Figure 4 – Location of feedlots across Australia (2005)

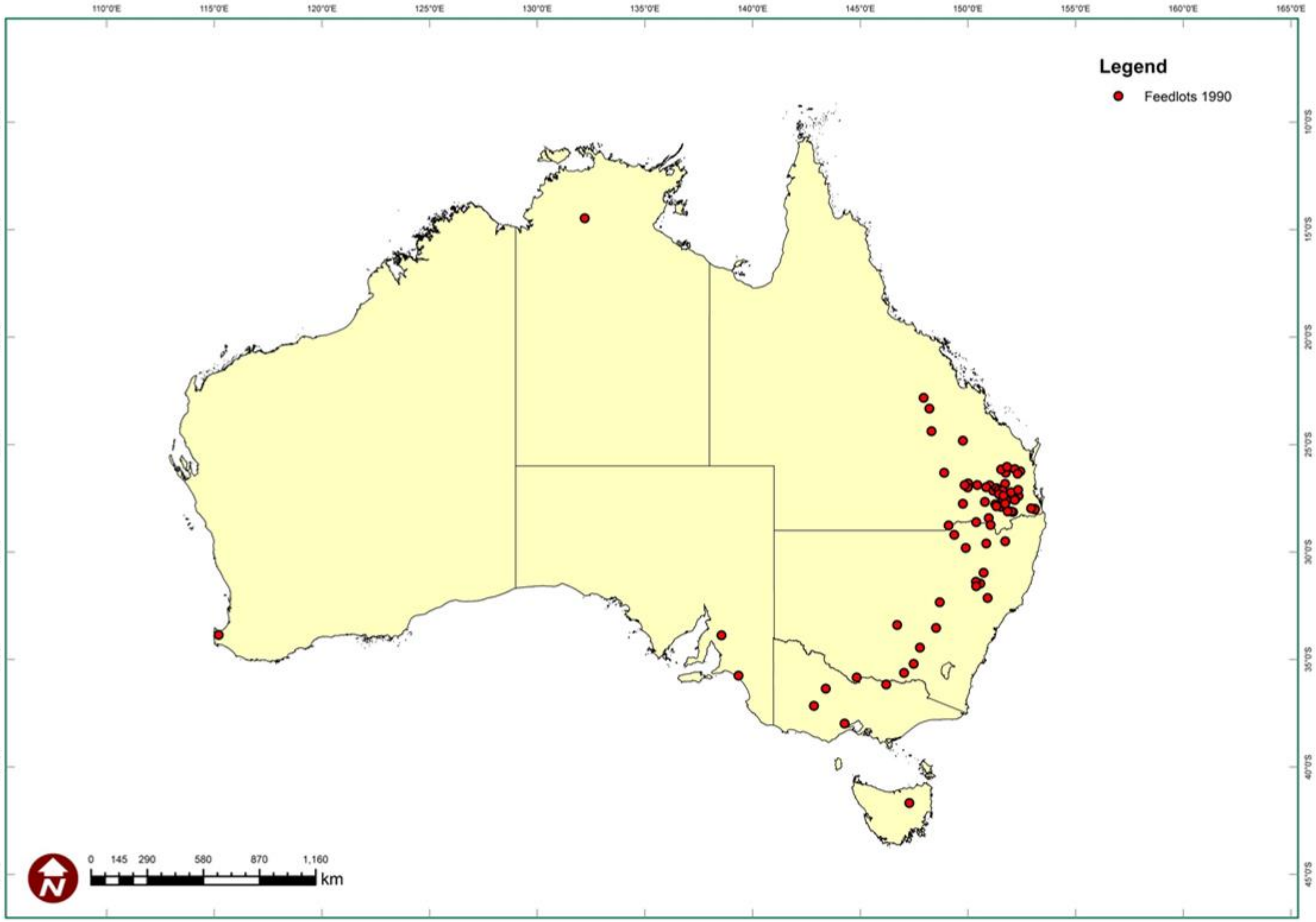

Figure 5 – Location of feedlots across Australia (1990) (this study)

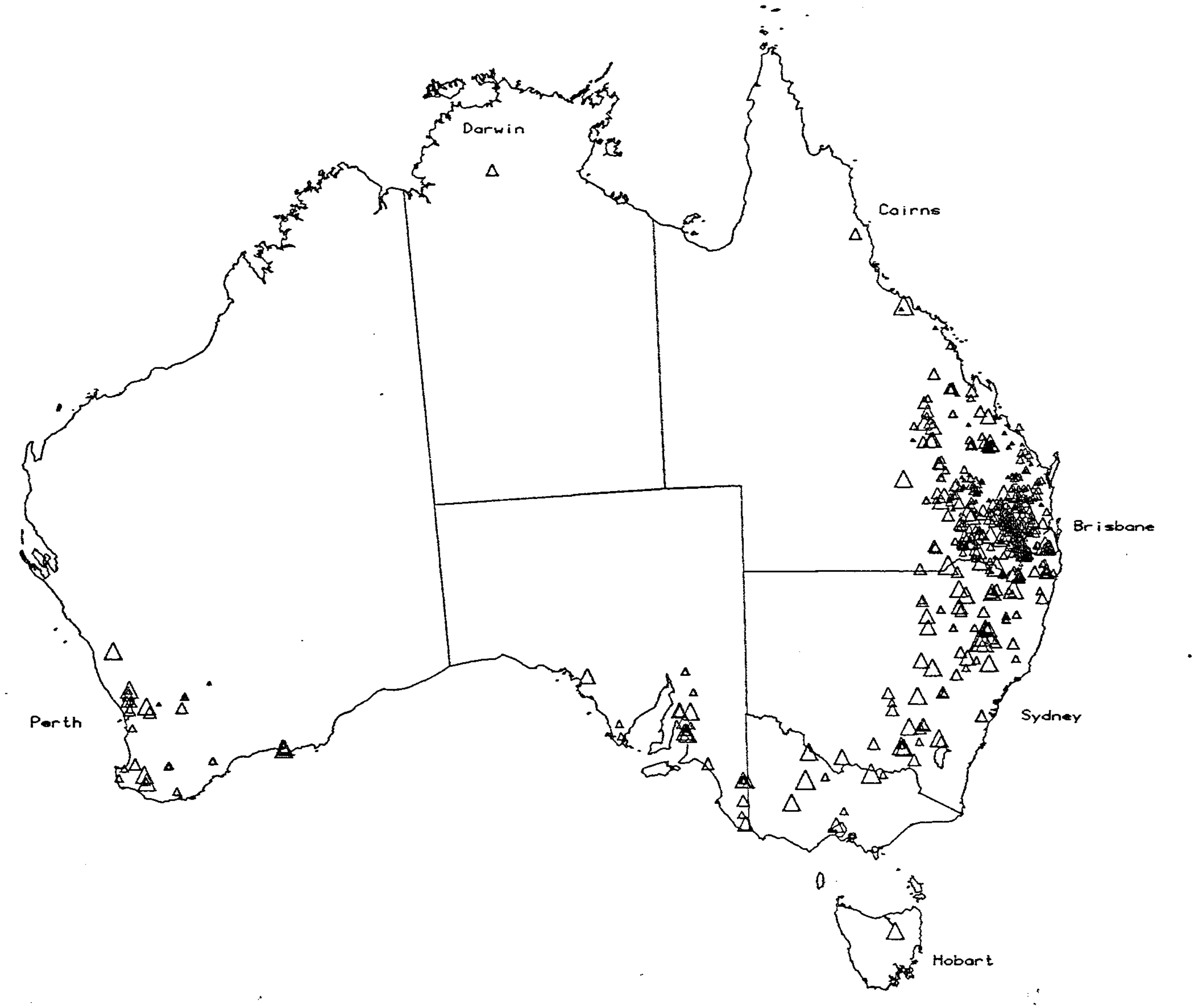

Figure 6 – Location of feedlots across Australia (1990) (taken from Tucker at al. 1991)

5.2.1 Licensed pen capacity

Table 9 shows the licensed feedlot capacity as of March 2013. As expected, this shows that the current licensed capacity exceeds current pen capacity, in this case by 573 000 head.

Table 9 – Licensed feedlot capacity by state (March 2013)

State	No. of Feedlots	% Licensed Capacity	Licensed Capacity
QLD	573	54.5	1045039
NSW	89	30.2	577751
WA	74	7.6	146339
VIC	25	4.1	79191
SA	39	2.4	46326
TAS	1	0.8	16000
NT	1	0.4	8000
TOTAL	802	100	1918646

5.3 Feedlot size distribution

5.3.1 Size distribution of feedlots (current)

Table 10 and Figure 7 provide an analysis of current pen capacity for feedlots of different size ranges. Figure 7 clearly shows how the representation of small feedlots in the database is much better in Queensland than the other states.

Feedlots with a capacity greater than 1000 head represent 25% of the number of feedlots but represent 84% of pen capacity. Feedlots greater than 5000 head capacity (63) are only 7.3% of number of feedlots but include 62% of pen capacity.

Figure 8, Figure 9, Figure 10 and Figure 11 show the size and distribution of feedlots in Queensland, south-east Queensland, Western Australia and southern Australia respectively.

Table 10 – Size distribution of feedlots (March 2013)

Feedlot Size Range	No. of Feedlots	% of Feedlots	Average Capacity	Pen Capacity	% Pen Capacity
< 400	416	48.7	114	61560	5
400 to 999	225	26.4	622	140030	10
1000 to 4999	150	17.6	2020	299809	22
5000 to 9999	32	3.7	6836	218754	16
>10000	31	3.6	2170	625272	46
Summary of above 5000	***63***	***7.3***	***13503***	***844026***	***62***
Grand Total:	854	100	5953	1345425	100

5.3.2 Size distribution of feedlots (2006)

Table 11 shows the size distribution of feedlots in 2006 (Davidson 2007). In 2006, 22% of feedlots (i.e. >1000 head capacity) had 84% of pen capacity. For feedlots greater than 5000 head, they were only 6.1% of feedlot numbers but included 61% of pen capacity. Hence, the size structure of feedlots has not altered much in the last seven years.

Table 11 – Size distribution of feedlots (2006)

Feedlot Size Range	No. of Feedlots	% of Feedlots	Average Capacity	Pen Capacity	% Pen Capacity
< 400	477	54.1	128	61076	5.2
400 to 999	210	23.8	619	129996	11.0
1000 to 4999	141	16.0	1903	268369	22.8
5000 to 9999	27	3.1	6746	182155	15.5
>10000	27	3.1	19893	537123	45.6
Summary of above 5000	***54***	***6.1***	***13320***	***719278***	***61.0***
Grand Total:	882	100	1336	1178719	100

5.3.3 Size distribution of feedlots (1990)

Table 12 presents feedlot size distribution data for 1990 from Tucker et al. (1991). As discussed in Section 5.2.3, the data collected in the current survey for 1990 is incomplete and is not presented here. In 1990, there were only 22 feedlots with a capacity of over 5000 head, compared to 63 current feedlots of this capacity. In 1990, feedlots with over 5000 head capacity represented only 46% of total capacity as compared to 62% now. Hence, in 1990, there was a proportionately higher percentage of small feedlots.

Table 12 – Size distribution of feedlots (1990) (Tucker et al. 1991)

	No. of Feedlots	% of Feedlots	Average	Pen Capacity	% Pen Capacity
<50	140	22.1	46	6400	1
50-399	284	45.0	151	42950	9
400-999	106	16.8	535	56705	12
1000-1999	42	6.7	1174	49320	10
2000-4999	37	5.9	2864	105990	22
>5000	22	3.5	10160	223520	46
Total	631	100	768	484885	100

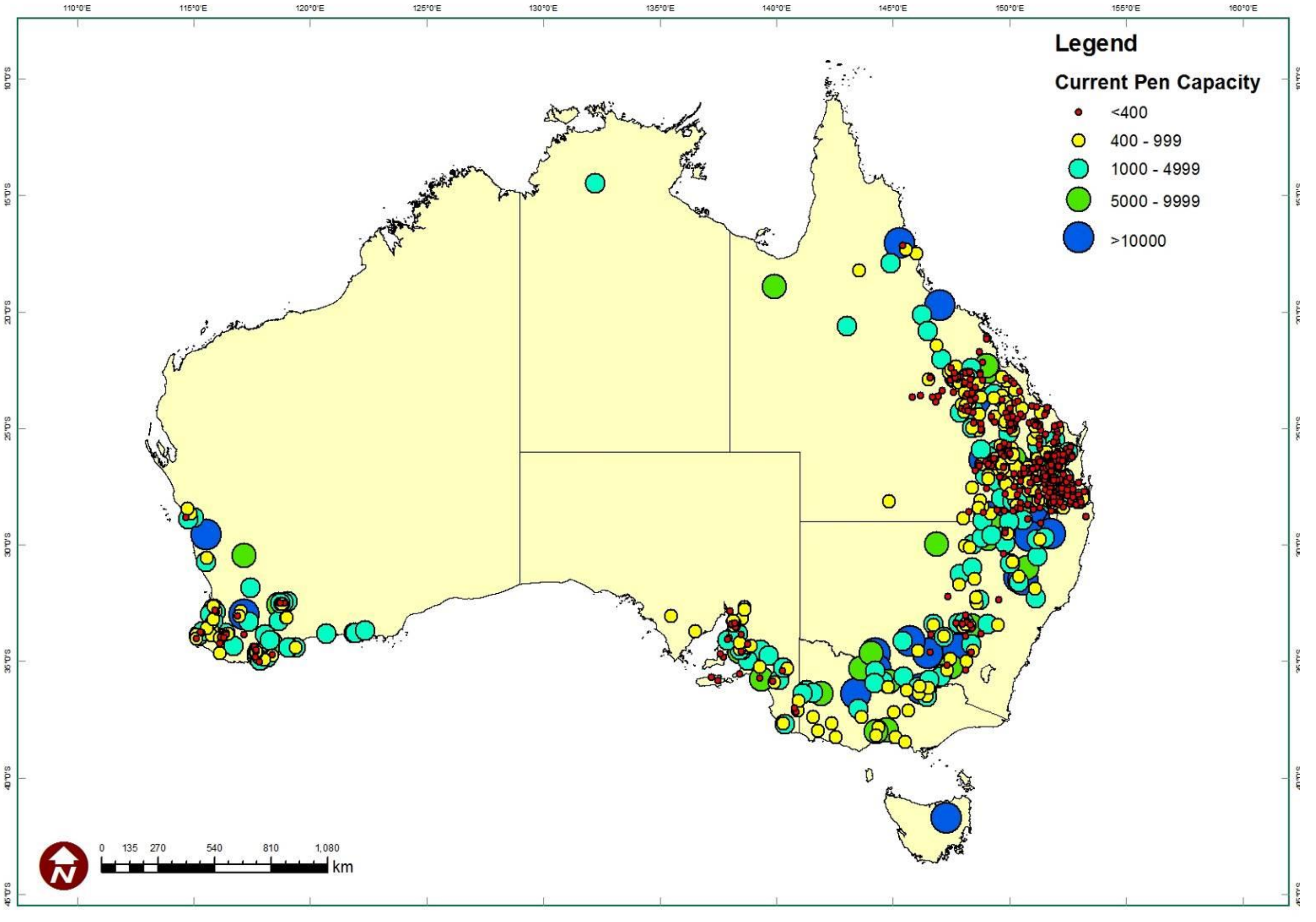

Figure 7 – Feedlot location vs. size (Australia) (current – March 2103)

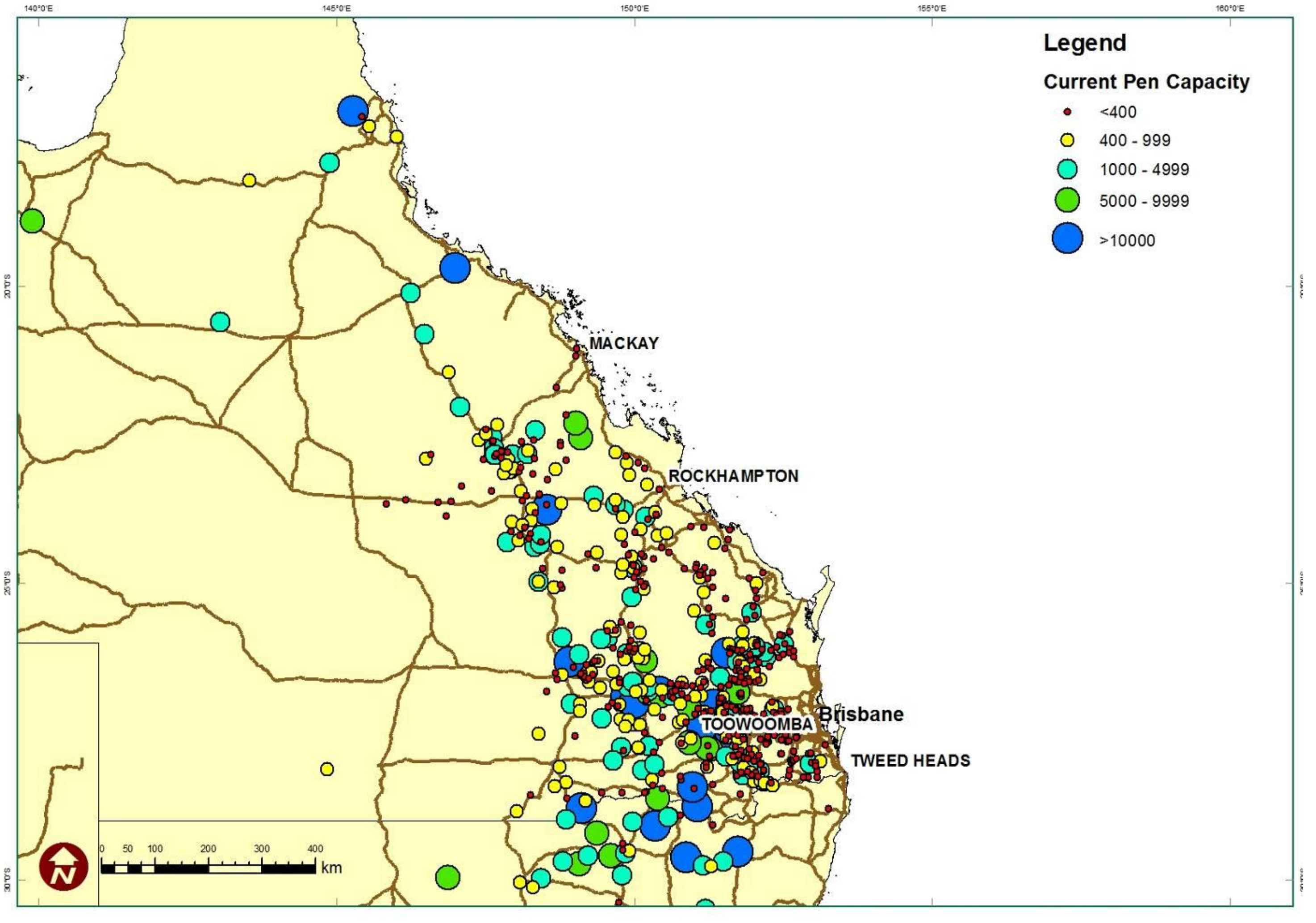

Figure 8 – Feedlot location vs. size (Queensland) (current – March 2013)

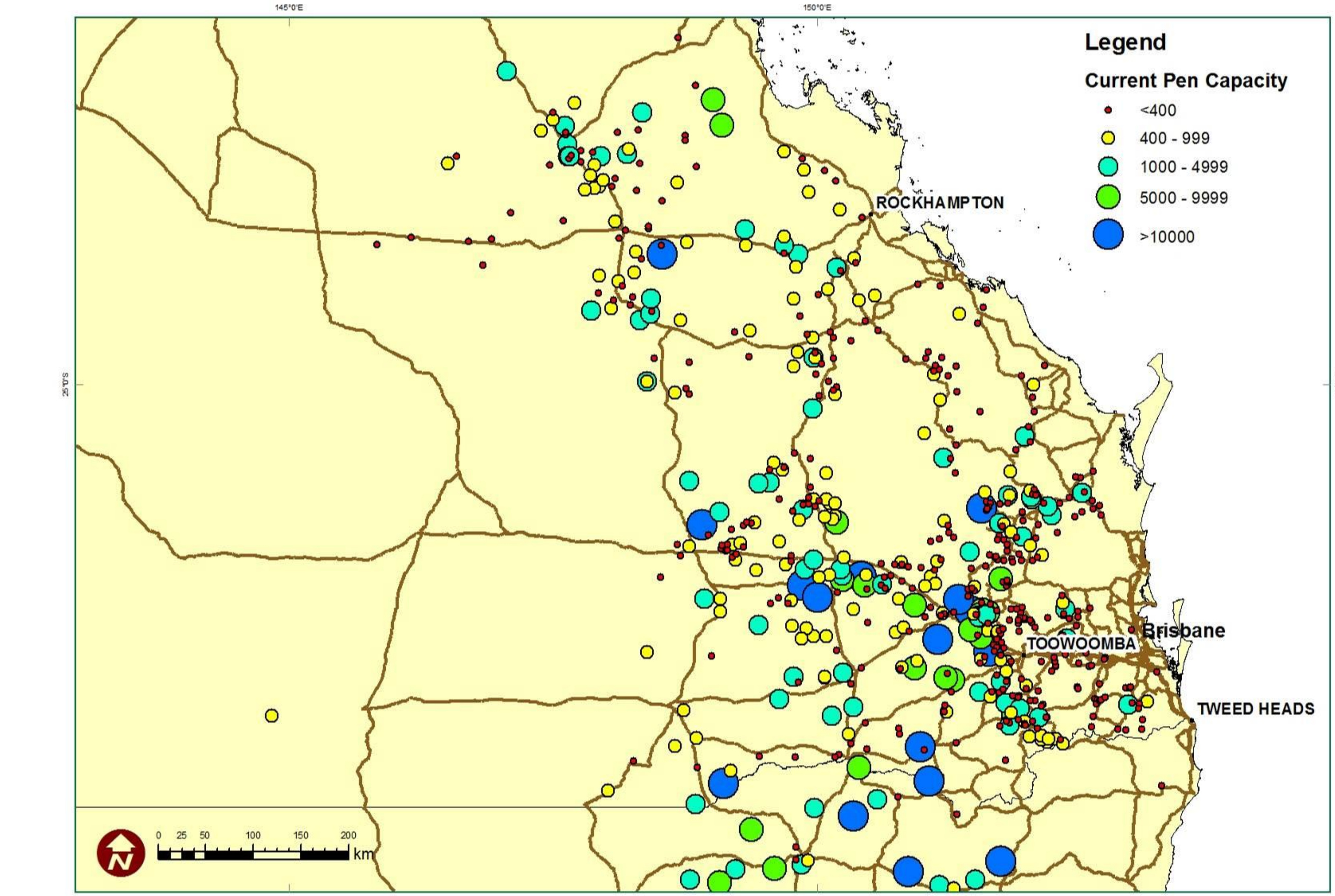

Figure 9 – Feedlot location vs. size (South East Queensland) (current – March 2013)

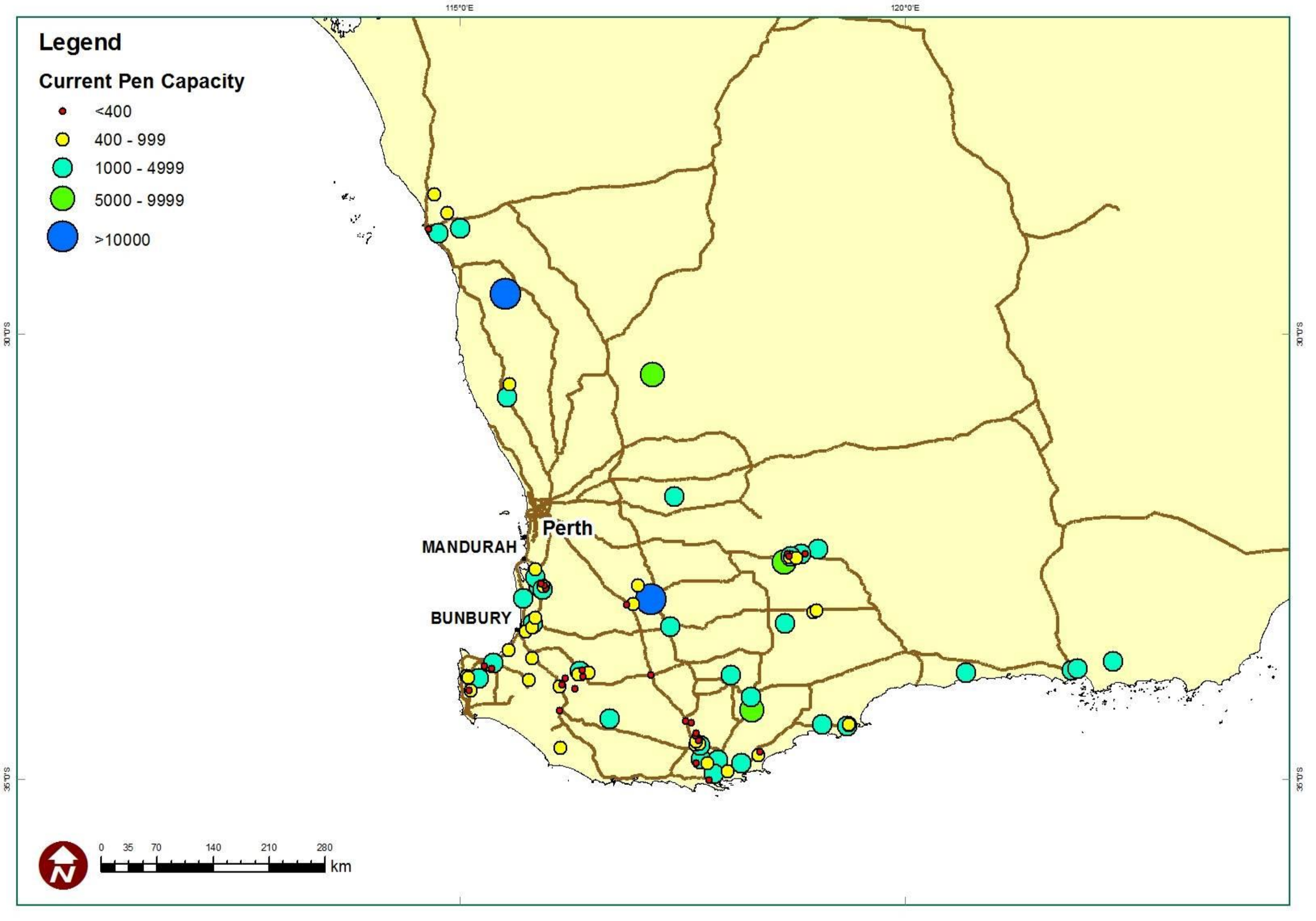

Figure 10 – Feedlot location vs. size (Western Australia) (current – March 2013)

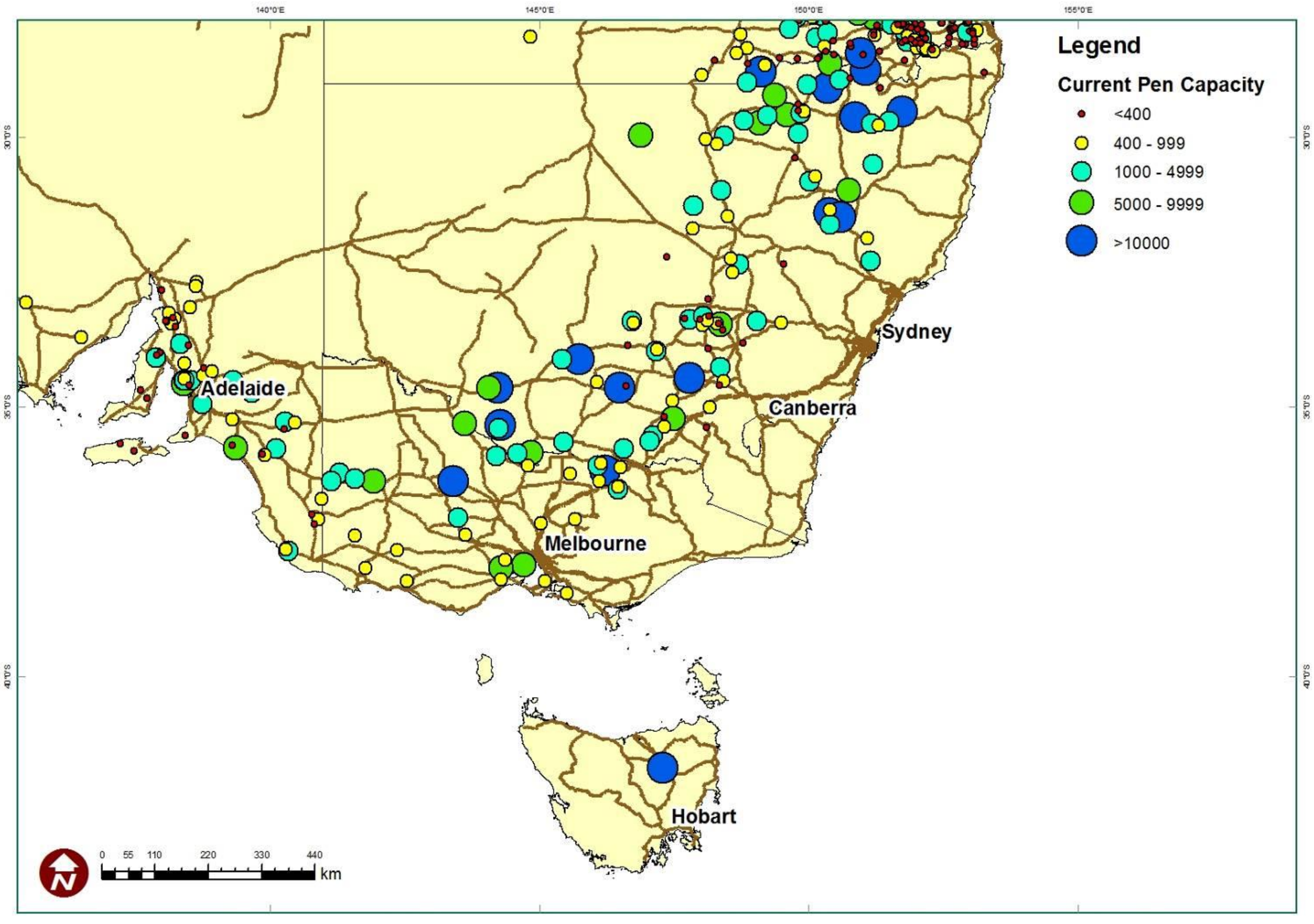

Figure 11 – Feedlot location vs. size (NSW, VIC & TAS) (current – March 2013)

5.4 Major Australian feedlots

5.4.1 Major Australian feedlots

Table 13 and Figure 12 shows the current major Australian feedlots. The current 22 largest feedlots make up 40% of the pen capacity. The top 22 were chosen as both the 2006 and the 1990 major Australian feedlot lists had 22 entries.

The top 22 have only changed marginally since the 2006 analysis (Davidson 2007) (Table 14). There have been three additions to the current list since the 2006 analysis. The highest current capacity (53 333 head of cattle) has not changed since 2006. The current capacity of the smallest feedlot in the list has also remained unchanged (12 000 head of cattle). However, the entire capacity has increased by 10%, from 487 123 head of cattle in 2006 to 539 272 head of cattle based on current data. In 2006, the major Australian feedlots made up 41% of the Australian industry's total capacity. Hence, the percent of total capacity made up of small feedlots has remained constant.

Table 13 – Major Australian feedlots (March 2013)

Feedlot Name	Locality	State	Current Pen Capacity
JBS Swift Riverina Beef (Rockdale)	YANCO	NSW	53 333
Whyalla	TEXAS	QLD	50 000
JBS Swift - Prime City**	TABBITA	NSW	35 000
Rangers Valley	GLEN INNES	NSW	32 000
Grassdale	DALBY	QLD	30 672
Miamba (Condamine)	CONDAMINE	QLD	28 944
ICM Peechelba	WANGARATTA	VIC	28 267
JBS Beef City	PURRAWANDA	QLD	26 500
JBS Caroona	QUIRINDI	NSW	23 500
Bottle Tree	CHINCHILLA	QLD	22 266
Charlton	CHARLTON	VIC	20 000
Killara	QUIRINDI	NSW	20 000
Myola	NORTH STAR	NSW	20 000
Smithfield	PROSTON	QLD	18 500
Jindalee	COOTAMUNDRA	NSW	18 000
Goonoo	COMET	QLD	17 500
Sandalwood	DALBY	QLD	15 290
Aronui	DALBY	QLD	15 000
Ravensworth**	HAY	NSW	15 000
Nebru Plains*	THREE SPRINGS	WA	13 000
Tasmania Feedlot Pty Ltd	PERTH	TAS	12 500
JBS Mungindi	MUNGINDI	QLD	12 000
Yambinya**	DENILIQUIN	NSW	12 000
	TOTAL		539 272

*Nebru Plains is not shown on Figure 12 and Figure 13 as it is in Western Australia. Most major feedlots are in eastern Australia.** Temporarily closed.

Table 14 – Major Australian feedlots (2006)

Feedlot Name	Locality	State	2006 Pen Capacity
Rockdale Beef	YANCO	NSW	53 333
Whyalla	TEXAS	QLD	50 000
AMH Prime City	TABBITA	NSW	35 000
Rangers Valley	GLEN INNES	NSW	30 000
AMH Beef City	PURRAWANDA	QLD	26 500
AMH Caroona	QUIRINDI	NSW	24 000
Peechelba	WANGARATTA	VIC	22 000*
Brindley Park	ROMA	QLD	21 000
Myola	NORTH STAR	NSW	20 000
Killara	QUIRINDI	NSW	20 000
Charlton	CHARLTON	VIC	20 000
Smithfield	PROSTON	QLD	18 500
Goonoo	COMET	QLD	17 500
Jindalee	COOTAMUNDRA	NSW	17 000
Sandalwood	DALBY	QLD	15 290
Miamba	CONDAMINE	QLD	15 000
Aronui	DALBY	QLD	15 000
Ravensworth	HAY	NSW	15 000
Mungindi	MUNGINDI	QLD	14 000*
Yambinya	DENILIQUIN	NSW	13 500
Tasmania Feedlot	PERTH	TAS	12 500
Lillyvale	CONDAMINE	QLD	12 000
	TOTAL		487 123

*Errors in Davidson (2007) dataset.

5.4.2 Major Australian feedlots (1990)

The 22 largest Australian feedlots in 1990 (Tucker et al. 1991) are presented in Table 15, including whether that feedlot closed in the last 23 years. Six feedlots that were in the 1990 top 22 have closed in the past 23 years.

Figure 13 shows the position of the current major Australian feedlots and the 1990 major Australian feedlots.

Table 15 – Major Australian feedlots (1990)

Feedlot Name	Locality	State	Closed	Current Capacity
Beef City	PURRAWANDA	QLD		25 000
Whyalla	TEXAS	QLD		20 000
Charlton	CHARLTON	VIC		18 000
Peechelba	WANGARATTA	VIC		17 000
Caroona	QUIRINDI	NSW		15 500
Rangers Valley	GLEN-INNES	NSW		12 000
Burdekin Valley Beeflot	HOME HILL	QLD	Y	12 000
AMH	BEAUDESERT	QLD	Y	12 000
Aronui	DALBY	QLD		10 000
AMH	MUNGINDI	QLD		10 000
Jindalee	COOTAMUNDRA	NSW		9 000
Gunnee	DELUNGRA	NSW		8 000
Killara	QUIRINDI	NSW		6 500
Crown Beef	STAWELL	VIC	Y	6 000
Lillyvale	CONDAMINE	QLD		5 300
Sandalwood	DALBY	QLD		5 000
Wide Bay	KILKIVAN	QLD		5 000
Gurley	MOREE	NSW	Y	5 000
Perenc	YASS	NSW	Y	5 000
Balgowan	ACLAND	QLD	Y	5 000
CRM (Ladysmith)	WAGGA WAGGA	NSW		4 500
Kurrawong	QUINALOW	QLD		4 000
	TOTAL			219 800

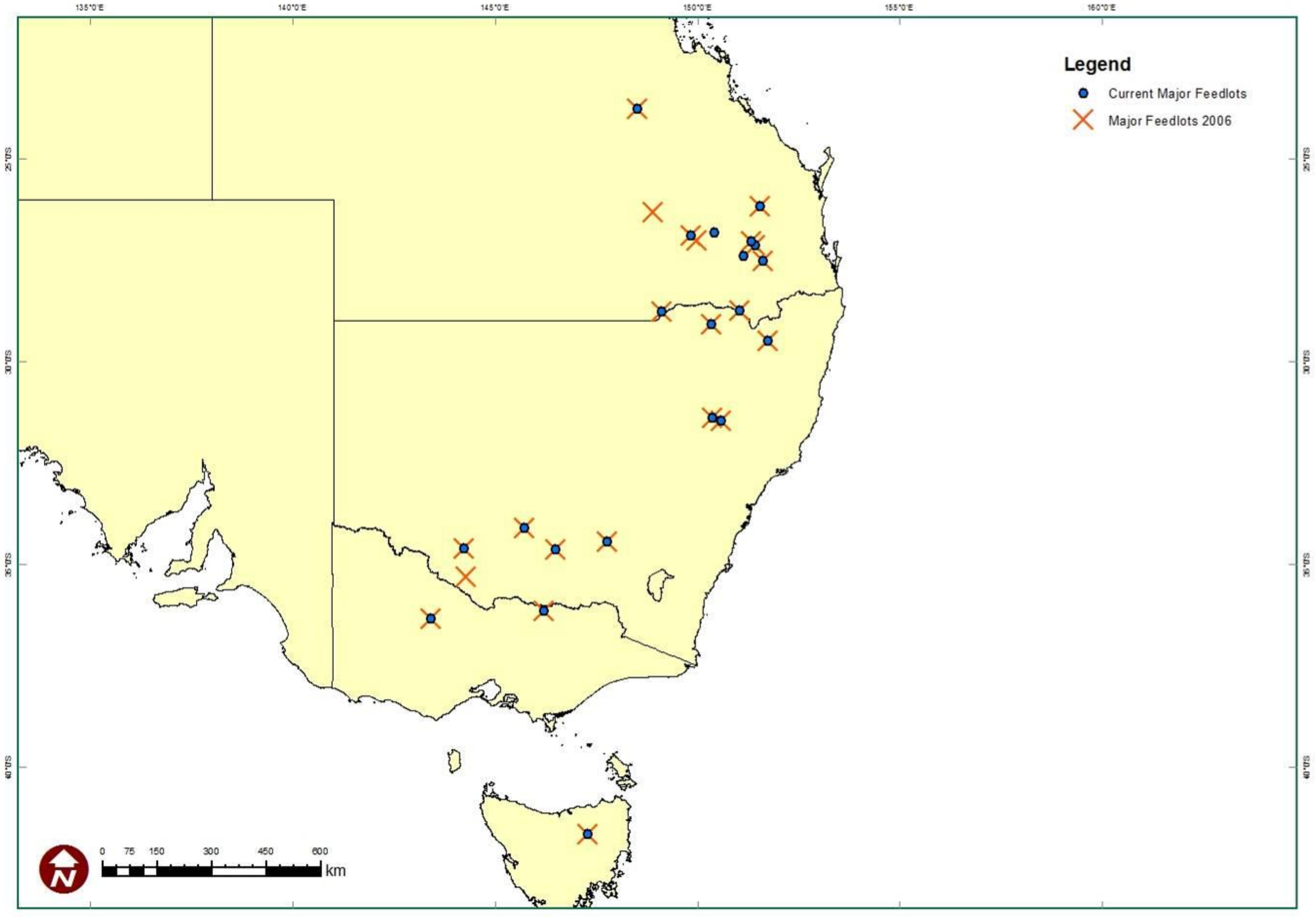

Figure 12 – Location of current major feedlots compared to 2006 major feedlots

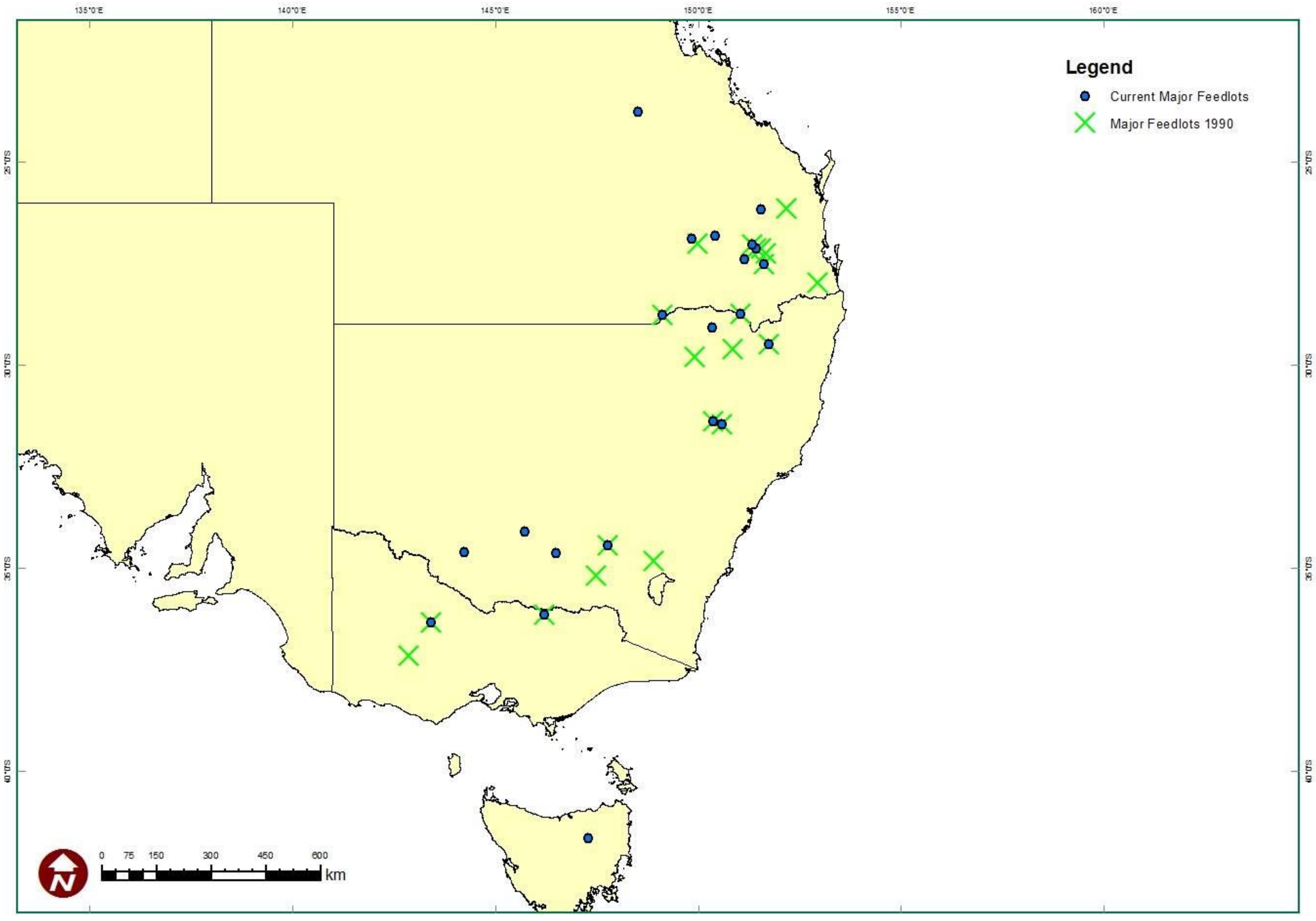

Figure 13 – Location of current major feedlots compared to 1990 major feedlots

6 Geographic distribution of Australian feedlots

6.1 Location by climatic zone

6.1.1 Feedlot distribution vs. mean annual rainfall

An important aspect of site selection for feedlots is annual rainfall. This single element affects a variety of issues in every feedlot. Climatic conditions affect both the environmental performance of a feedlot and the welfare of the animals fed there (Watts & Tucker 1994). Annual rainfall of less than 750 mm is recommended since a wet climate can increase the risk of water pollution and odour generation.

Table 16 shows the number and capacity of current feedlots in areas with above and below 750 mm of annual rainfall. Figure 14 shows the current feedlot distribution with annual rainfall. This shows that 26% of individual feedlots are in areas that have greater than 750 mm of annual rainfall. While this is a significant number of individual feedlots, it only represents 12% of Australia's current pen capacity. Another distinction is found in the average feedlot capacity. Feedlots in areas with under 750 mm of annual rainfall are larger with an average capacity that is 2.7 times greater than that of feedlots with annual rainfall greater than 750 mm.

Table 16 – Feedlot distribution vs. mean annual rainfall (current)

	No. of Feedlots	% of Feedlots	Average Capacity	Pen Capacity	% Pen Capacity
Summary					
< 750 mm	629	74	1940	1185809	88
> 750 mm	225	26	709	159636	12
< 600 mm	137	16	2579	353256	26
600-649 mm	77	9	1748	134569	10
650-699 mm	176	21	1953	343683	26
700-750 mm	239	28	1482	354301	26
> 750 mm	225	26	709	159636	12
TOTAL	854	100	1694	1345445	100

Table 17 shows a summary of Australia's feedlots in 2006 (Davidson 2007) that were situated in areas with annual rainfall above and below 750 mm. Table 18 shows a summary of Australia's feedlots in 1990 (Tucker et al. 1991) that were situated in areas with annual rainfall above and below 750 mm.

In most guidelines, it is suggested that feedlots be located in areas with an annual rainfall of less than 750 mm. In 1990, 40% of individual feedlots were located in areas with higher than 750 mm of rainfall per year. This was 23% of the industry capacity at the time. Currently, there are 26% of individual feedlots in areas with greater than 750 mm of annual rain but this is only 12% of the current pen capacity. Although the number of feedlots in this higher rainfall zone has only reduced from 232 feedlots in 1990 to 225 current feedlots, the pen capacity in this zone has reduced. This shows a clear trend for feedlots to move towards drier sites with fewer environmental issues and, usually, fewer close neighbours. This is a positive environmental outcome.

Table 17 – Feedlot distribution vs. mean annual rainfall (2006)

	No. of Feedlots	% of Feedlots	Average Capacity	Pen Capacity	% Pen Capacity
Summary					
< 750 mm	658	74.6	1573	1035189	87.8
> 750 mm	224	25.4	641	143530	12.2
< 600 mm	240	27.2	1648	395620	33.6
600-650 mm	183	20.8	1761	322319	27.3
650-700 mm	147	16.7	1544	226925	19.3
700-750 m	88	10.0	1026	90325	7.7
> 750 mm	224	25.4	641	143530	12.2
TOTAL	882	100	1336	1178719	100

Table 18 – Feedlot distribution vs. mean annual rainfall (1990) (Tucker et al 1991)

	No. of feedlots	% of Feedlots	Average Capacity	Pen Capacity	% Pen Capacity
Summary					
< 750 mm	351	60.2	1033	362605	77
> 750 mm	232	39.8	466	108160	23
< 500 mm	43	7.4	1130	48600	10
500-625 mm	96	16.5	1525	146465	31
625-750 mm	212	36.4	790	167540	36
750-825 mm	92	15.8	481	44260	9
>825 mm	140	24.0	456	63900	14
TOTAL	583	100	807	470830	100

6.1.2 Distribution of feedlots with respect to seasonal rainfall

The distribution of rainfall throughout the year has a significant bearing on the management of a feedlot (Tucker et al. 1991). Feedlots located in areas with high winter rainfall and/or low evaporation rates are more likely to have problems with odour management, as a wet pad is the main cause of odour generation (Tucker et al. 1991). Problems also occur with cattle comfort and welfare as the pen manure remains wet and manure dags can attach to cattle.

High evaporation and/or summer dominant rainfall allows pens to dry more rapidly after rainfall. Hence, the period in which odour is caused is reduced and manure dags are less of a problem.

Table 19 shows a summary of Australia's current feedlots in relation to seasonal rainfall. Figure 15 shows the current feedlot distribution with seasonal rainfall. Currently, 22.5% of individual feedlots are located in winter-dominant or winter rainfall areas. This accounts for 27% of current pen capacity. Table 20 shows the 2006 Australian feedlots in relation to seasonal rainfall (Davidson 2007). Table 21 shows the 1990 Australian feedlots in relation to seasonal rainfall (Tucker et al. 1991). Over the years, about 25% of pen capacity has been in winter-dominant or winter rainfall zones.

Table 19 – Current distribution of feedlots in seasonal rainfall regions

Climatic Zone	No. of Feedlots	% of Feedlots	Average Capacity	Pen Capacity	% Pen Capacity
Winter Dominant	56	6.6	1347	75404	6
Winter	136	15.9	2108	286718	21
Total Winter	***192***	**22.5**	**1727**	***362122***	**27**
Summer Dominant	34	4.0	1955	66472	5
Summer	580	67.9	1269	735932	55
Total Summer	***614***	***72***	***1612***	***802404***	***60***
Arid	1	0.1	400	400	<1
Uniform	47	5.5	3840	180499	13
TOTAL	**854**	**100**	**1895**	**1345425**	**100**

Table 20 – Distribution of feedlots in seasonal rainfall regions (2006)

Climatic Zone	No of Feedlots	% of Feedlots	Average Capacity	Pen Capacity	% Pen Capacity
Winter Dominant	58	6.6	866	50255	4.3
Winter	157	17.8	1574	247106	21.0
Total Winter	***215***	***24.4***	***1383***	***297361***	***25.2***
Summer Dominant	33	3.7	1828	60326	5.1
Summer	584	66.2	1103	644282	54.7
Total Summer	***617***	***69.9***	***1142***	***704608***	***59.8***
Arid	1	0.1	400	400	>0.1
Uniform	49	5.6	3599	176350	15.0
TOTAL	**882**	**100**	**1336**	**1178719**	**100**

Table 21 – Distribution of feedlots in seasonal rainfall regions (1990)

Climatic Zone	No. of Feedlots	% of Feedlots	Average Capacity	Pen Capacity	% Pen Capacity
Summer Dominant Rainfall – High Evap.	536	85	640	343415	71
Uniform Rainfall	18	3	1041	18750	4
Winter Dominant Rainfall – Low Evap.	77	12	1594	122720	25
TOTAL	631	100	1091	484885	100

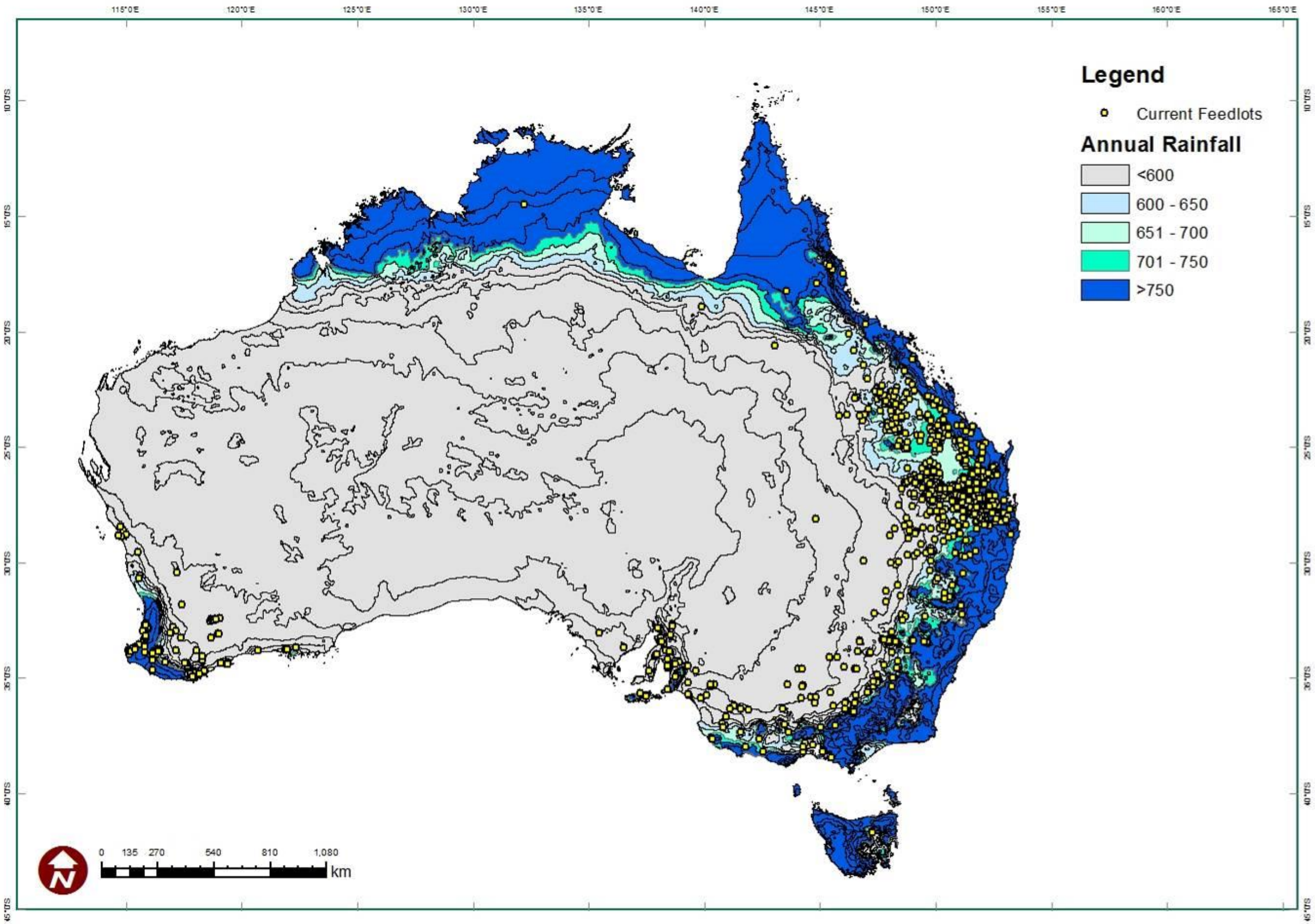

Figure 14 – Current feedlots distribution vs. mean annual rainfall

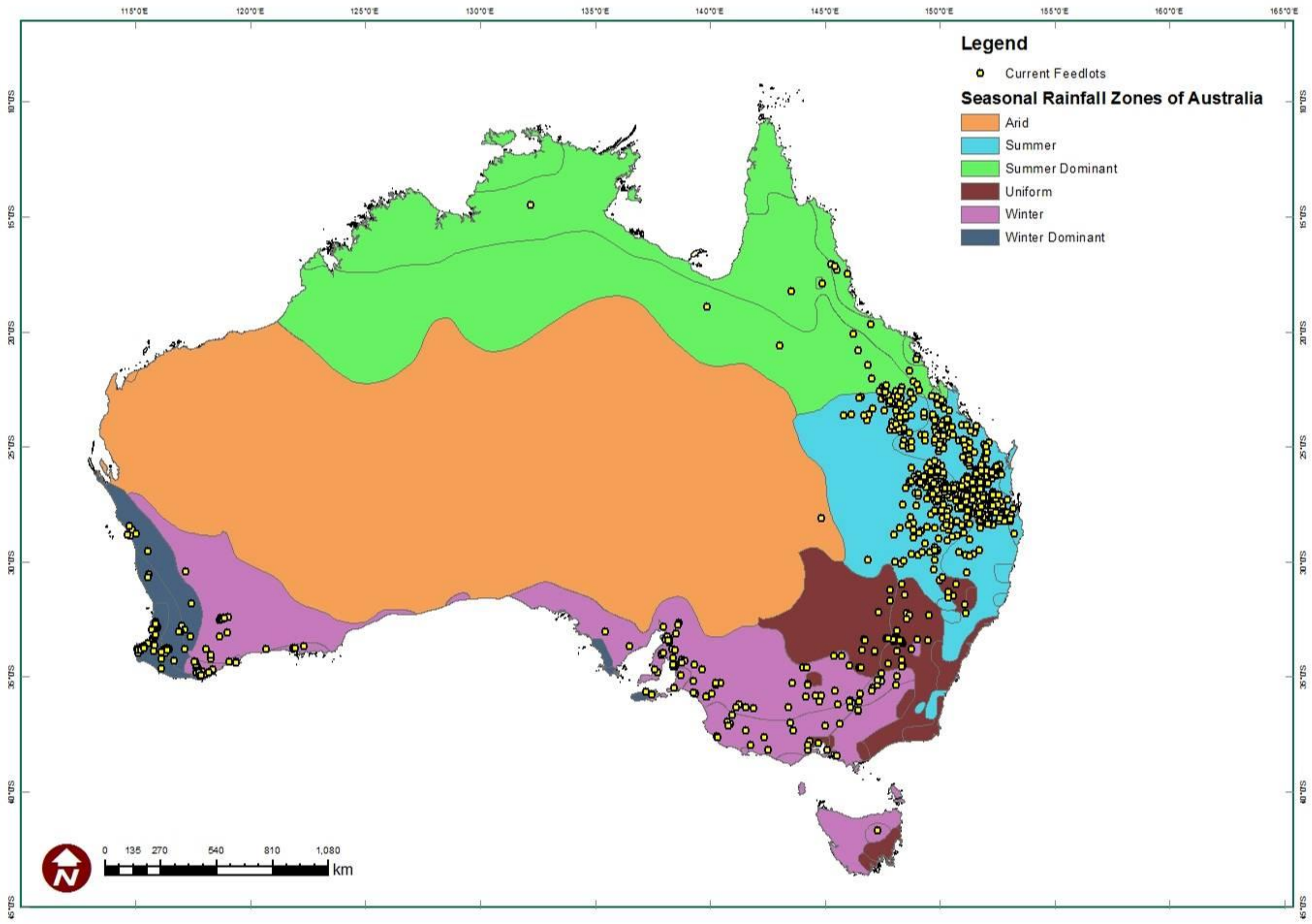

Figure 15 – Current feedlots distribution vs. seasonal rainfall zone

6.2 Location by river catchment

6.2.1 Distribution of current feedlot capacity by river catchment

Table 22 gives the current distribution of feedlots with respect to river catchments in Australia. The majority of the industry capacity is located in the Murray-Darling Catchment (MDC) (**Figure 16**) and the north-east coast (NEC) catchment (**Figure 17**). The MDC and NEC have a similar number of individual feedlots but there is a significant difference in their pen capacities. The MDC accounts for 67.3% of the industry's pen capacity whereas the NEC only accounts for 17% of the industry's pen capacity. Again, this is probably simply a reflection of better data on smaller feedlots in Queensland.

Table 22 – Distribution of current feedlot capacity by river catchment

Catchment	No. of Feedlots	% of Feedlots	Average Capacity	Pen Capacity	% Pen Capacity
Murray-Darling (MDB)	344	40.3	2632	905548	67.3
North-east coast (NEC)	348	40.7	657	228468	17.0
South-west coast	90	10.5	1226	110375	8.2
South-east coast	22	2.6	1164	25600	1.9
Gulf of Carpentaria	4	0.5	5250	20999	1.6
Tasmania	1	0.1	12500	12500	0.9
South Australian Gulf	33	3.9	558	18425	1.4
Timor Sea	1	0.1	4000	4000	0.3
Indian Ocean	6	0.7	2768	16610	1.2
Western Plateau	2	0.2	1000	2000	0.1
Lake Eyre	3	0.4	300	900	0.1
TOTAL	854	100	2914	1345425	100

The distribution of the feedlots within the MDC is summarised in Table 23 and Figure 16. The Condamine-Culgoa River catchment holds 54.4% of the individual feedlots in the MDC but only 37.8% of the capacity for this catchment. The Border Rivers catchment accounts for 11.7% of the number of individual feedlots but accounts for 17.3% of the capacity for this catchment. It should be noted that these figures may be biased due to the lack of god data on small feedlots outside of Queensland.

The distribution of the feedlots within the NEC is summarised in Table 24 and Figure 17. The Fitzroy River catchment holds 43.7% of the individual feedlots in the NEC that accounts for 51.4% of the capacity for this catchment. About 68.4% of individual feedlots and 77.5% of capacity for this catchment are located within two catchments, the Fitzroy River Basin and the Burnett River catchment. There are 14 individual feedlots located in the Burdekin catchment. This accounts for only 4% of the individual feedlots in the catchment but accounts for 5.2% of the capacity for this catchment.

Table 23 – Distribution of feedlot capacity in Murray-Darling sub-catchments

Catchment	No. of Feedlots	% of Feedlots	Average Capacity	Pen Capacity	% Pen Capacity
Condamine-Culgoa	186	54.4	1839	342023	37.8
Border Rivers	40	11.7	3899	155979	17.3
Murrumbidgee	17	5.0	5367	91232	10.1
Lachlan	23	6.7	3434	78978	8.7
Namoi	12	3.5	4858	58299	6.4
Gwydir	11	3.2	2659	29249	3.2
Murray-Riverina	6	1.8	5075	30450	3.4
Ovens	6	1.8	5398	32387	3.6
Avoca	2	0.6	11800	23600	2.6
Moonie	13	3.8	907	11787	1.3
Macquaire-Bogan	10	2.9	1190	11900	1.3
Mallee	3	0.9	1731	5192	0.6
Lower Murray	4	1.2	2925	11700	1.3
Benanee	0	0	0	0	0
Wimmera-Avon	2	0.6	3250	6500	0.7
Castlereagh	2	0.6	5500	10999	1.2
Broken River	2	0.6	687	1374	0.2
Loddon River	1	0.3	1000	1000	0.1
Goulburn River	2	0.6	700	1399	0.2
TOTAL	342	100	3275	904048	100

6.2.2 Distribution of feedlot capacity by river catchment (2006)

Table 25 summarises the distribution of feedlots in the 11 major catchments (Davidson 2007). **Table 26** summarises the sub-distribution of feedlots within the MDB. Table 27 summarises the sub-distribution of feedlots within the NEC. The distribution is similar to the current distribution with the majority of feedlots occupying the MDB and also the NEC.

6.2.3 Distribution of feedlot capacity by river catchment (1990)

The 1990 survey (Tucker et al. 1991) sub-divided the distribution of feedlots by river catchment slightly differently to the 2006 data (Davidson 2007) and current data. These data is still useful for comparison with the 2006 data as it breaks down the two major catchments, MDC and NEC, for further examination. Table 28 gives the 1990 distribution of feedlots by catchment.

Table 24 – Distribution of the current capacity in the NEC

Catchment	No. of Feedlots	% of Feedlots	Average Capacity	Pen Capacity	% Pen Capacity
Fitzroy	152	43.7	773	117504	51.4
Burnett	86	24.7	692	59528	26.1
Mary	17	4.9	744	12650	5.5
Burdekin	14	4.0	841	11778	5.2
Brisbane	42	12.1	187	7849	3.4
Logan Albert	20	5.7	173	3451	1.5
Herbert	1	0.3	2000	2000	0.9
Barron	2	0.6	275	550	0.2
Boyne	1	0.3	500	500	0.2
Johnstone River	1	0.3	499	499	0.2
Styx	1	0.3	499	499	0.2
Kolan	2	0.6	230	460	0.2
Baffle Creek	3	0.9	150	450	0.2
Calliope	2	0.6	150	300	0.1
O-Connell	1	0.3	150	150	0.1
Pine River	1	0.3	150	150	0.1
Plane Creek	1	0.3	150	150	0.1
Haughton River	1	0.3	10000	10000	4.4
TOTAL	348	100	1009	228468	100

Table 25 – Distribution of feedlot capacity by river catchment (2006)

Catchment	No. of Feedlots	% of Feedlots	Average Capacity	Pen Capacity	% Pen Capacity
Murray-Darling (MDB)	347	39.3	2277	790241	67.0
North-east coast (NEC)	348	39.5	603	209833	17.8
South-west coast	94	10.7	1013	95251	8.1
South-east coast	26	3.0	897	23313	2.0
Gulf of Carpentaria	4	0.5	5250	20999	1.8
Tasmania	1	0.1	12500	12500	1.1
South Australian Gulf	50	5.7	243	12172	1.0
Timor Sea	1	0.1	8000	8000	0.7
Indian Ocean	5	0.6	592	2960	0.3
Western Plateau	2	0.2	1000	2000	0.2
Lake Eyre	4	0.5	363	1450	0.1
TOTAL	882	100	1336	1178719	100

Table 26 – Distribution of feedlot capacity in MDB sub-catchments (2006)

Catchment	No. of Feedlots	% of Feedlots	Average Capacity	Pen Capacity	% Pen Capacity
Condamine-Culgoa	195	56.2	1429	278726	35.3
Border Rivers	37	10.7	3723	137764	17.4
Murrumbidgee	16	4.6	5380	86082	10.9
Lachlan	23	6.6	3558	81829	10.4
Namoi	10	2.9	5870	58699	7.4
Gwydir	12	3.5	2754	33049	4.2
Murray-Riverina	10	2.9	3050	30499	3.9
Ovens	6	1.7	4353	26120	3.3
Avoca	1	0.3	20000	20000	2.5
Moonie	12	3.5	862	10338	1.3
Macquarie-Bogan	10	2.9	835	8349	1.1
Mallee	6	1.7	965	5787	0.7
Lower Murray	4	1.2	1425	5700	0.7
Benamee	1	0.3	2500	2500	0.3
Wimmera-Avon	1	0.3	2000	2000	0.3
Castlereagh	2	0.6	1000	1999	0.3
Broken River	1	0.3	800	800	0.1
TOTAL	347	100	2277	790241	100

Table 27 – Distribution of feedlot capacity in the NEC (2006)

Catchment	No. of Feedlots	% of Feedlots	Average Capacity	Pen Capacity	% Pen Capacity
Fitzroy	149	42.8	762	113534	54.1
Burnett	86	24.7	641	55102	26.3
Mary	16	4.6	753	12050	5.7
Burdekin	17	4.9	655	11127	5.3
Brisbane	44	12.6	202	8897	4.2
Logan Albert	20	5.8	174	3485	1.7
Herbert	1	0.3	2000	2000	1.0
Barron	2	0.6	275	550	0.3
Boyne	1	0.3	500	500	0.2
Johnstone River	1	0.3	499	499	0.2
Styx	1	0.3	499	499	0.2
Kolan	2	0.6	230	460	0.2
Baffle Creek	3	0.9	150	450	0.2
Calliope	2	0.6	150	300	0.1
O-Connell	1	0.3	150	150	0.1
Pine River	1	0.3	150	150	0.1
Plane Creek	1	0.3	80	80	<0.1
TOTAL	348	100	603	209833	100

Table 28 – Distribution of feedlot capacity by river catchment (1990)

Catchment	No. of Feedlots	% of Feedlots	Pen Capacity	% Pen Capacity
QUEENSLAND COASTAL BASINS				
Qld. North Coast	3	1.4	12550	14.2
Burdekin	0	0.0	0	0.0
Qld Central Coast	3	1.4	600	0.7
Fitzroy	65	30.1	27870	31.5
Qld. South Coast	145	67.1	47345	53.6
Total Qld. Coastal	216	**38.6**	**88365**	**19.2**
MURRAY-DARLING BASIN (MDB)				
Upper Murray & Victoria	6	2.3	41240	13.4
Murrumbidgee	10	3.8	13450	4.4
Lachlan	4	1.5	10250	3.3
Border Rivers	31	11.7	55895	18.2
Moonie	17	6.4	5510	1.8
Gwydir	7	2.7	16300	5.3
Namoi	19	7.2	37400	12.2
Castlereagh	3	1.1	1800	0.6
Macquarie	5	1.9	6400	2.1
Condamine-Culgoa	161	61.0	119075	38.7
Other Murray-Darling	1	0.4	450	0.2
Total Murray-Darling	**264**	**47.2**	**307770**	**66.8**
OTHER BASINS				
New South Wales Coastal	16	20.3	9040	14.0
Western Australia	29	36.7	18120	28.0
South Australia (Central)	14	17.7	15400	23.8
Others	20	25.3	22210	34.3
Total Other Basins	**79**	**14.1**	**64770**	**14.1**
TOTAL	559	100	460905	100

6.2.4 Discussion of feedlot distribution by river catchment

The major change that has occurred in terms of growth in catchments is that the total percentage of individual feedlots has declined in the MDB. The total percent of individual feedlots has declined from 47.2% in 1990 to 40.5% for the current analysis. The percentage of individual feedlots in the NEC ("Queensland Coastal Basins" as described in Tucker et al. (1991)) has stayed relatively the same. In 1990, the figure for individual feedlots in the NEC was 38.6%. This has marginally increased to 40.3% in the current analysis.

Examination of the two major basins, the MDB and the NEC, including their sub-catchments, is limited by the lack of corresponding information reported in the 1990 data (Tucker et al. 1991). However, the data shows some changes. The MDB was home to 264 individual feedlots in 1990 with a capacity of 307 770 head. In 2006, this had grown to 347 feedlots with a capacity of 790 241 head. On analysis of the current feedlots the number of individual feedlots has slightly declined to 345 but the capacity has further increased to 771 741 head. In 1990, the NEC had 216 individual feedlots with a capacity of 88 365 head compared to 348 individual feedlots with 209 833 head of capacity in 2006. On analysis of the current feedlots, the number of individual feedlots has slightly declined to 343 but the capacity has further increased to 301 865 head of cattle.

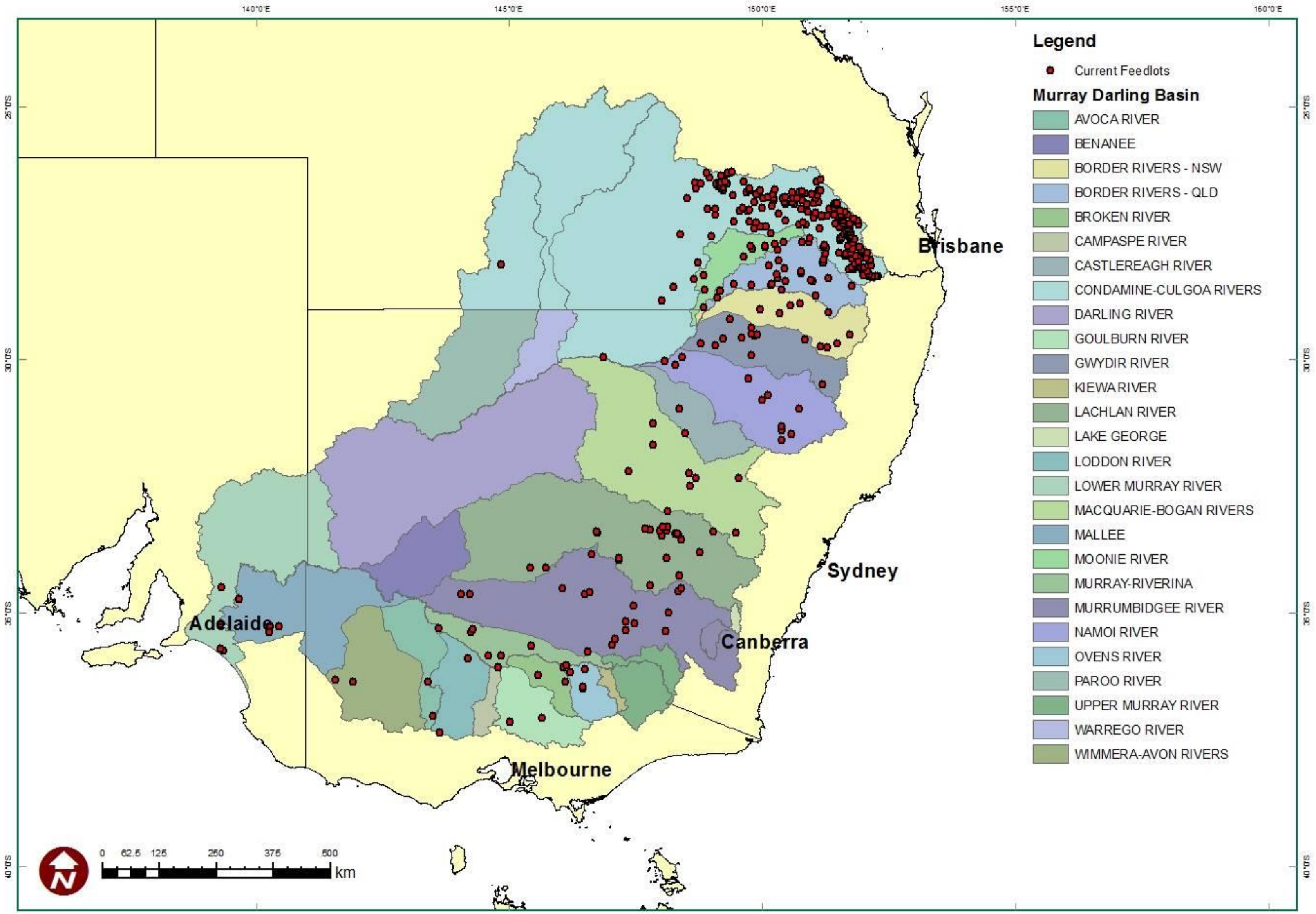

Figure 16 – Current feedlot distribution in the Murray-Darling basin

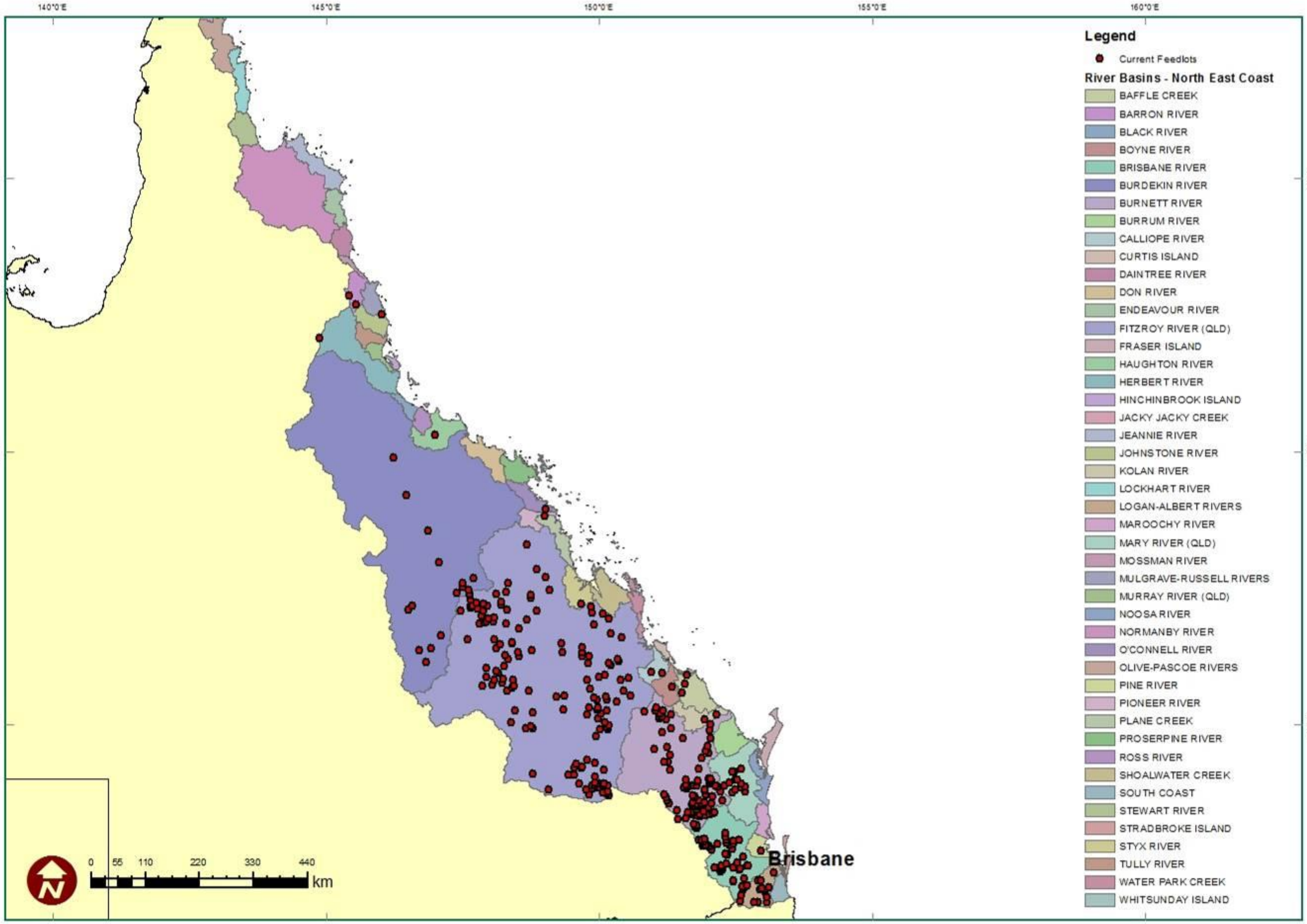

Figure 17 – Current feedlot distribution in the north east coast catchment

6.3 Location by groundwater basin

A number of feedlots are located within the Great Artesian Basin (GAB). Generally, these feedlots use GAB water as their drinking water supply. There are 194 feedlots with 337 330 head of capacity, which accounts 25% of the total industry capacity. Figure 18 shows the distribution of feedlots in relation to the GAB.

6.4 Location by proximity to mining (petroleum) leases

Coal seam gas (CSG) has rapidly become a major industry in Australia during the last five years. The multi-billion dollar industry has also become a controversial and divisive issue between feedlot owners and mining companies. It is still unclear what the impact of the CSG mining industry on the environment will be.

Australia is the driest continent on earth and, as it pushes towards an ever increasing population, it is imperative to recognise that water is a finite resource. With the increasing number of petroleum leases and gas producing CSG mines competing for water resources, feedlot owners could experience water security issues due to the greater economic potential associated with mining in Australia. Figure 19 shows the feedlots with a current pen capacity of greater than 2000 head and how they overlap with petroleum leases in Queensland, which mainly include the CSG leases.

Table 29 lists 12 feedlots (of greater than 2000 head capacity) that are currently located within petroleum lease areas. These 12 feedlots account for approximately 8% of the total industry capacity.

Table 29 – Current feedlots within petroleum lease areas

Feedlot Name	Pen Capacity
Grassdale	30 672
Bottle Tree	22 266
Brindley Park	12 000
Wallumba (Old Condabri)	8800
Wambo	8000
Opal Creek	5800
Wieambilla	5000
Condabri	4790
Amber Downs	3500
Roxborough	3120
Brig-O-Doon	2500
Spion Kop	2500
TOTAL	108 948

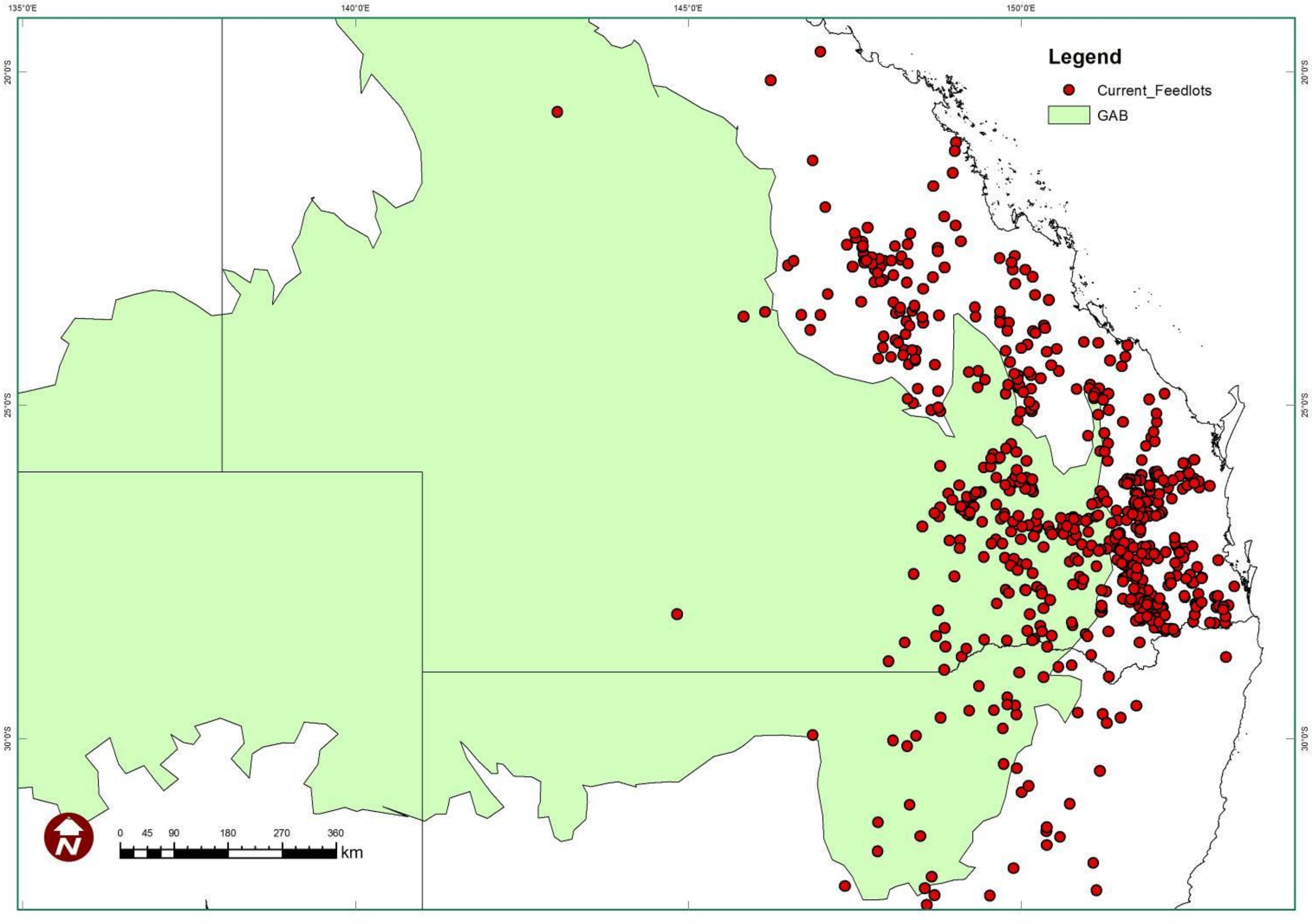

Figure 18 – Current distribution of feedlots across the Great Artesian Basin

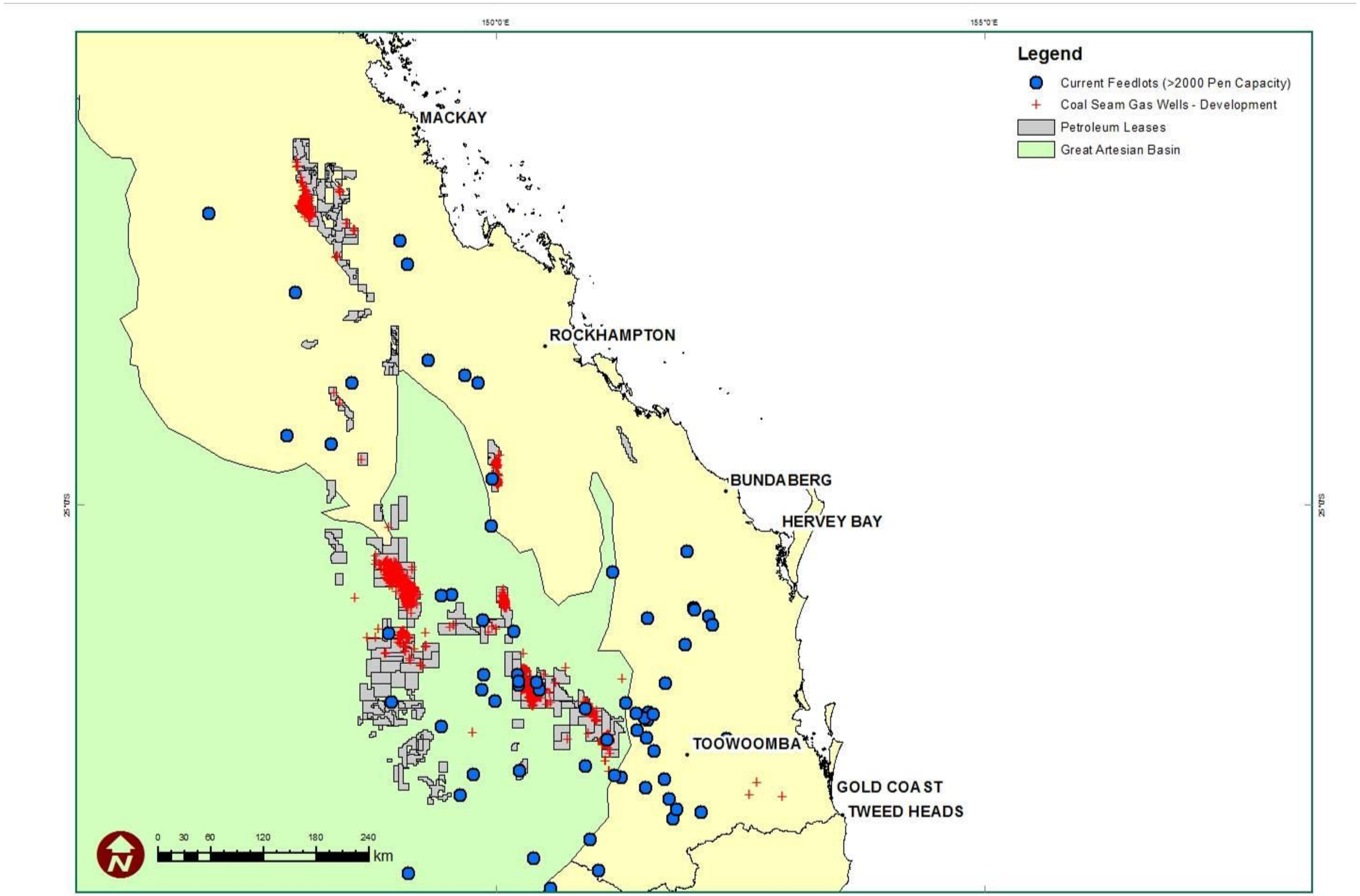

Figure 19 – Current distribution of feedlots with petroleum leases and CSG production wells

7 Feedlot site selection

Good site selection is the key to optimal economic, environmental and management performance for a feedlot. Poor site selection can significantly add to capital costs (excess earthworks, high infrastructure costs) and operating costs (large travel distances for commodities, livestock or finished cattle). Poor site selection can also complicate the approval process and lead to additional costly licence conditions. In the past, poor site selection has lead to poor environmental performance.

The objectives of feedlot site selection are to:
- maximise economic efficiency
- minimise environmental impact
- maximise cattle health and performance
- maximise social benefit.

To achieve these objectives, there are several important aspects that should be considered. These include:

Regional issues
- proximity to major arterial road networks
- prevailing climatic and seasonal conditions
- proximity to other feedlots or intensive livestock facilities
- proximity to abattoirs, saleyards and other services
- proximity to labour
- access to feedstuffs.

Site-specific issues
- suitable site topography which affects construction costs and site drainage
- distance to nearest receptors for odour, dust, noise or visual, aesthetic impact
- distance to nearest potable water supplies (i.e. reservoirs, water catchment areas)
- access to construction materials (e.g. clay and gravel)
- absence of archaeological and heritage sites or artefacts
- likely impact on threatened or endangered species or ecological communities
- flood or bushfire risk of the site
- legal security of an adequate supply of water
- risk of salinity or groundwater impacts
- risk of impacts on surface water quality and ecosystems
- site access in respect to traffic and road safety
- available land and soil suitability for waste utilisation.

In 1990, there was little documentation on site selection criteria. Experience from the USA was often used but it is now known that the climatic conditions where most US feedlots are located and community expectations are not relevant to Australia.

At a regional level, the data presented in Section 6.1 shows that there has been a change in site selection. In 1990, 23% of feedlot capacity was in areas which receive more than 750 mm of annual rainfall. This has now reduced to only 12% of pen capacity. There has been a clear move towards drier areas for large feedlot developments as feedlots are easier to manage environmentally in these areas. At a local level, the adoption of the various feedlot separation guidelines has ensured that feedlots are no longer sited too close to sensitive receptors thus reducing community amenity issues.

8 Feedlot design

8.1 Design information

The first Australian feedlots were often designed using experience from the USA and/or experience from extensive cattle production. There were no locally-available feedlot design guidelines. The first significant information was provided in 1994 with “Designing Better Feedlots” (Watts & Tucker 1994). In the intervening years, industry has continually improved feedlot design to suit Australian conditions.

A feedlot is a production system incorporating several system components. These components need to be carefully integrated so that performance criteria are met. An overview of the various system components are given in **Table 30**.

Table 30 – Feedlot system components

System	Components
Feeding system	feed delivery, feed storage, silage pits, hay storage, feed processing mill, feed mixing/batching, feed trucks, feed alleys and feed bunks or self-feeders.
Watering system	water source, pumps and mainlines, temporary storage, reticulation system, water troughs and sewer system.
Cattle handling system	receival and induction facility, cattle lanes, production pens, hospital, recovery pens and dispatch facilities.
Drainage system	pens, pen drains, main drains, sedimentation systems, holding ponds and effluent utilisation areas.
Manure handling system	manure storage and screening area, pen cleaning equipment, manure transport and processing equipment, and manure utilisation areas.
Staff and visitor facilities	offices, amenities, lunch rooms, car parks, horse stables and workplace health and safety facilities.
Security system	external fencing, gates, signage and security cameras to provide biosecurity and security to the site.

The drainage system and the manure handling system have the largest effect on environmental performance. The design and management of these systems will be discussed in more detail in following sections.

8.2 Overall feedlot layout

The overall layout of a feedlot affects environmental performance. Excess catchment area results in a greater volume of contaminated runoff for storage and utilisation. A poor layout affects operational efficiency, resulting in excess energy usage to operate the feedlot. In the past, there has been a tendency to group all of the feedlot facilities, in particular feed storage and preparation, cattle handling and office at one site in the middle of the feedlot. Experience has shown that this arrangement rarely results in optimal functional performance. The preferred arrangement of facilities separates these three main systems. All incoming and outgoing vehicles should travel past a single point at the main office where a truck weighbridge is located. This provides security and control over site entry as well as improved inventory control. After passing the office, vehicles travel to either the feed receival / processing area or to the cattle receival / dispatch area. The cattle handling and feeding systems can be managed separately and both operate fairly independently with little operational interference.

Feeding pens are typically grouped into rows. For a small feedlot, there is usually a single row of pens. For larger feedlots, the pen rows can be configured in two main ways.

1. **Back-to-back configuration**. In this layout, a central feed alley services pens on both sides of the roadway. Both sets of pens drain away from the feed alley in to a cattle lane and effluent drain.
2. **Sawtooth configuration**. In this layout, the feed alley services a single row of pens falling away from the road to a cattle lane or effluent drain. There is usually a cattle lane / drain on the top side of the feed alley.

Back-to-back configurations are often more efficient in terms of feed delivery, time and fuel usage. However, they are generally only suited to relatively flat sites (<2%) (**Photograph 1**). Sawtooth layouts are the only cost-effective layouts for steeper sites (>2%) where the pen slope matches the natural slope (**Photograph 2**). Pen slopes of less than 2.5% may experience drainage problems (see Section 8.3.2).

Pen rows should be straight. In the past, curved rows of pens were advocated as this configuration suits a curved hillside (**'round-the-hill' configuration** - Photograph 3) (Watts & Tucker 1994). However, pen dimensions and bunk length per head are rarely uniform in these layouts. It is also difficult to deliver feed to a curved feed bunk without feed spillage and/or damage to the bunk due to bumps from feed trucks. Correct pen floor preparation with adequate material selection and compaction is very difficult to achieve. This layout is rarely used in modern feedlots.

Data were obtained from 129 feedlots (15% of total) with a pen capacity of 579 000 head (43% of industry total). **Table 31** summarises the data on overall feedlot layout.

Table 31 – Overall feedlot layout

Feedlot Layout	No. of feedlots	% of feedlots	Pen Capacity	% Pen Capacity
Single Row	44	34	79222	14
Round-the-Hill	7	6	94600	16
Back-to-Back	36	28	86051	15
Sawtooth	34	26	268215	46
Other	8	6	51100	9
TOTAL	129	100	579188	100

Photograph 1 – “Back-to-back” feedlot layout

Photograph 2 – Sawtooth feedlot layout

Photograph 3 – “Round-the-hill” feedlot layout

8.3 Production pen design

The production pens are the main animal housing unit for a cattle feedlot. Sound design is essential to ensure optimum animal performance, good animal welfare and high standards of environmental performance.

The design objectives for a feedlot production pen are to:

- provide a housing environment for cattle where animal welfare is maximised
- provide a housing environment for cattle where production performance potential is maximised
- promote safe access for cattle to and from the pen
- minimise environmental impacts such as odour and dust
- promote drainage to provide a comfortable environment for cattle and minimise environmental issues
- optimise the management and removal of manure from the pens
- minimise on-going maintenance costs
- provide a safe working environment for pen riders and other feedlot personnel.

Once a particular feedlot layout has been chosen, the next step is pen design (see **Figure 20**). Factors requiring consideration include:

- stocking density
- bunk space per head
- pen slope
- pen head capacity
- access to the pen
- water trough location
- provision for shade, if required.

The dimensions of a feed pen depend on the capacity of the pen, stocking density and the amount of feed bunk required.

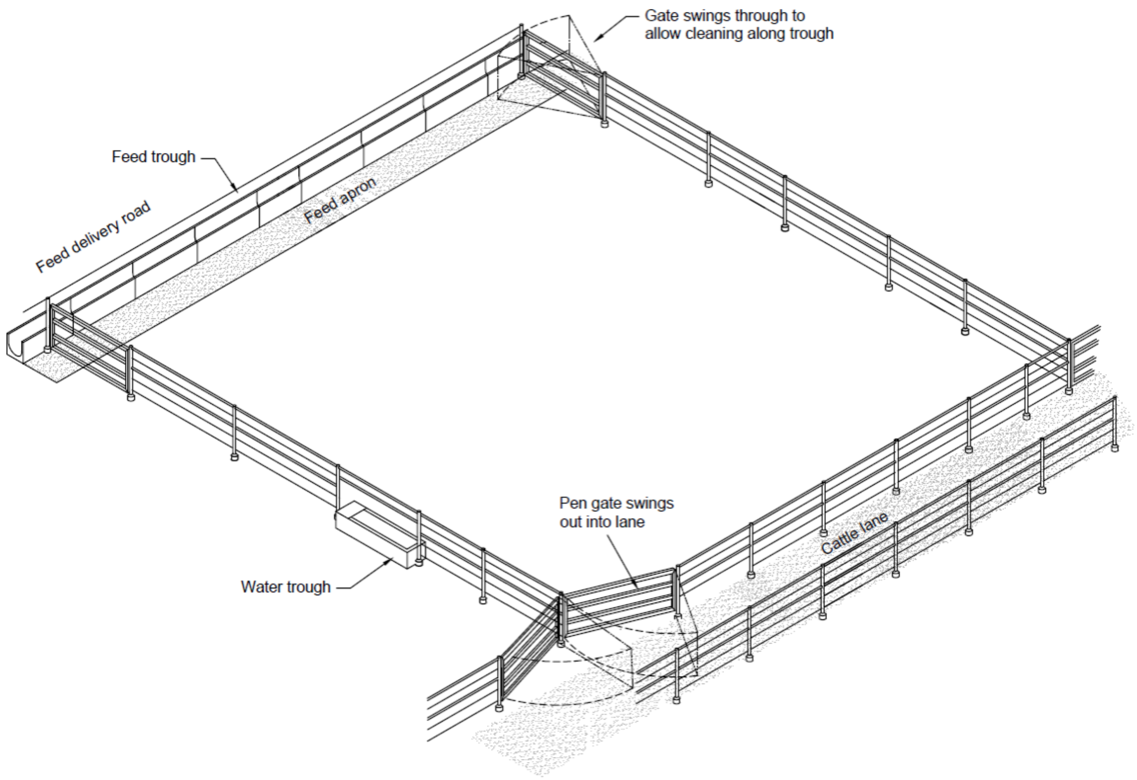

Figure 20 – Production pen design parameters

8.3.1 Stocking Density

Stocking density has a significant influence on the environmental performance of a feedlot since it contributes to the average moisture content of the pad. Every day, cattle add moisture to the pen surface by manure (faeces and urine) deposition. **Figure 21** shows the estimated moisture added to the pen surface each year for cattle of various weights kept at different stocking densities. This simple calculation assumes that cattle excrete 5% of their liveweight each day and manure is 90% moisture. Following the US example, feedlots in Australia initially (i.e. prior to 1990) stocked pens at about 10 m^2/head. Heavy cattle (750 kg) at 10 m^2/head can add over 1200 mm of moisture per year (3.3 mm/day). During winter, this can exceed the evaporation rate (depending on location) and the pad remains moist. Under these conditions, odour and cattle comfort problems can develop. On the other hand, light cattle kept at 20 m^2/head contribute less than 1 mm of moisture/day. In summer, evaporation readily removes this moisture and dust can become a problem. Therefore, the choice of stocking density should achieve a balance between a pen surface that is too dry and one that is too wet. This is dependent on local climate and cattle size. Manure deposition and accumulation rates are similarly related to stocking density.

Experience has now shown that a stocking density of 10-12 m^2/head is only appropriate in drier zones (annual rainfall <500 mm/yr). For most feedlots, a stocking density of about 15 m^2/head achieves an optimum outcome for cattle, pen environment and pen maintenance.

The effect of added moisture is a particular issue for covered feedlots where, for economic reasons, stocking densities are high (around 4-6 m^2/head). Even though rainfall is excluded, the added moisture can exceed 2000 mm/yr and pen surfaces quickly become wet. Under these circumstances, the use of a bedding material to absorb the moisture is essential. This bedding should be removed every few weeks.

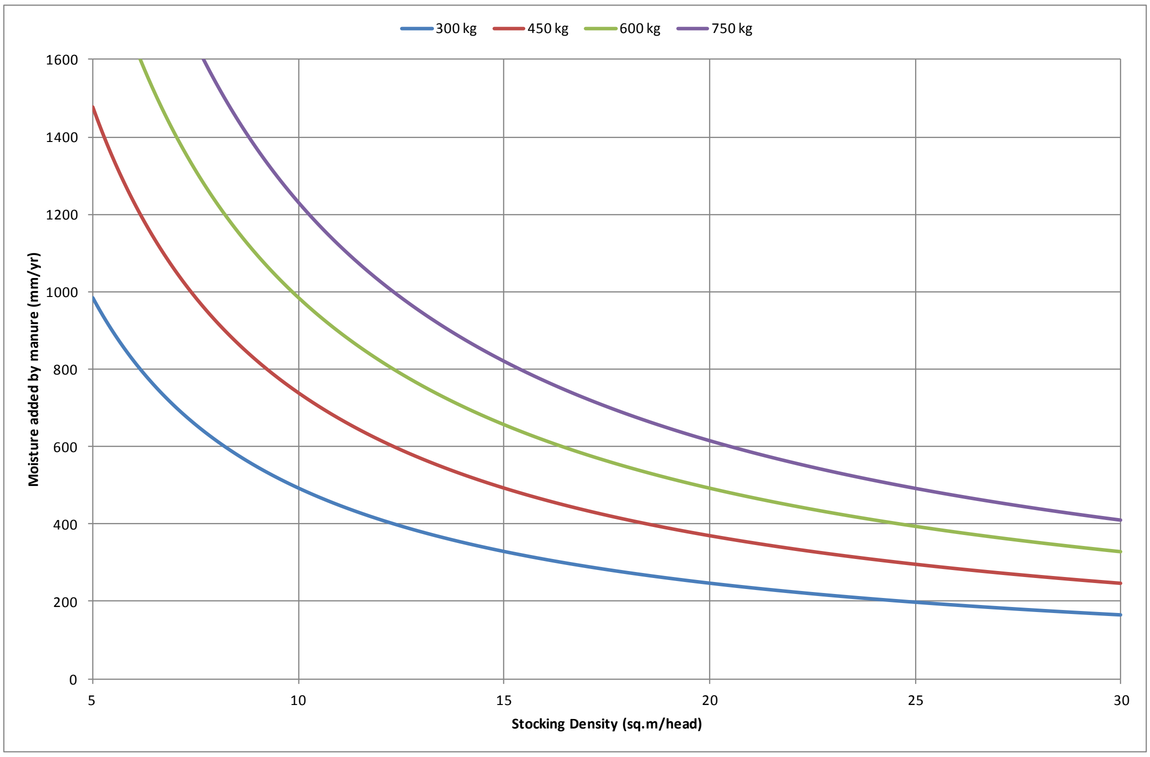

Figure 21 – Effect of stocking density and cattle liveweight on moisture added to pen surface

Data were sought from lot feeders on the stocking density used at each feedlot. Usually, the data provided was the nominal stocking density described in the licence application or approval. In reality, stocking densities vary from pen to pen based on the actual number of cattle in each consignment. In Queensland, the stocking density is expressed as m^2/SCU while the definition varies in other states between m^2/SCU and m^2/head.

Data were obtained for 84 feedlots (10% of total) with a combined pen capacity of 660 000 head (49% of industry total). **Table 32** shows that about 45% of current pen capacity stocks cattle at a stocking density in the range of 12.5-15 m^2/head.

Table 32 – Range of feedlot pen stocking densities

Stocking density range (m^2/head)	No. of feedlots	% of feedlots	Pen Capacity	% Pen Capacity
<10	4	5	33310	5
10-12.5	24	29	223439	34
12.6-15	33	38	295008	45
15.1-17.5	9	11	33715	5
17.6-20	11	13	69720	10
>20	3	4	4875	1
TOTAL	84	100	660067	100

Table 33 gives the range of stocking densities reported by Tucker et al. (1991). The median stocking density for commercial feedlots was found to be 14 m^2/head. Tucker et al. (1991) noted that "*until a few years ago, virtually all commercial lot feeders ran their feedlots at 10 m^2/beast or less. However, many found this density to be unmanageable in the long-term and have reduced their density (and hence their total feedlot capacity – this is shown in the reduction in feedlot capacity from 1980 to 1985). Most new large commercial feedlots are being designed for 15-20 m^2/beast.*"

Table 33 – Range of stocking densities (1990)

Stocking Density	Commercial Feedlots (m^2/head)	Opportunity Feedlots (m^2/head)
Median	14	31
Maximum	126	450
Minimum	7	8
No. of Feedlots surveyed	47	96

8.3.2 Pen slope

Adequate pen slope ensures that pens drain quickly after rainfall events, but runoff is not so rapid that it scours excessive amounts of manure from the pen surface. Pens should drain to the back fence where a drain is located. Drainage from one pen into another (pen-to-pen drainage) should not occur as this leads to large manure volumes in the lower pens that takes longer to dry and can add to dag issues.

Experience has shown that pen slopes of less than 2.5% do not drain well as any imperfection in the pen surface or accumulation of manure will cause ponding in the pens. Runoff ponding produces wet manure with subsequent odour emissions and livestock discomfort (**Photograph 4**).

Heavy rainfall on steep feedlot pens can result in large quantities of manure being transported in the runoff and, in extreme circumstances, erosion of the base of the pen surface. Feedlots have been built with pen slopes in excess of 6% and successfully managed but this requires an initial pen construction that provides a surface that is resistant to erosion and frequent pen cleaning so that there is little manure available for transport during storms (**Photograph 5**). In practice, most slopes in excess of 6% are too difficult to manage due to manure and pen surface material movement into the drain.

In the survey, lot feeders were asked to state the maximum and minimum pen slope in their feedlot. Many lot feeders did not have this information. Data were obtained for 38 feedlots (4% of total) with a combined pen capacity of 400 000 head (30% of industry total). Using this range, an average slope was obtained as per **Table 34**. Maximum pen slopes of up to 12% were observed during the survey. Over 30% of feedlots had pen slopes in excess of 4%.

Table 34 – Range of feedlot pen slopes

Pen Slope (%)	No. of feedlots	% of feedlots	Pen Capacity	% Pen Capacity
<2%	4	11	18700	5
2-3%	16	42	198922	50
3-4%	7	18	57482	14
>4%	11	29	124645	31
TOTAL	38	100	399749	100

Tucker et al. (1991) found that pen slopes ranged from 0% to 15% with a median value of 3% (98 feedlots surveyed). However, they did find that many lot feeders did not know the pen slope of their feedlot.

8.3.3 Pen surface construction

In the early days of lot feeding in Australia, many feedlot pens were built with minimal pen earthworks. Generally, topsoil and vegetation was stripped from the site and then the pen fencing was installed. Natural land slope was utilised. This was particularly true for "round-the-hill" type pen configurations. Inevitably, these pen surfaces break down during wet weather. Animal performance is reduced due to heavy mud and odour emissions increase.

Construction of most modern Australian feedlots involves considerable pen earthworks to ensure that a smooth, uniform pen with adequate slope is achieved. Careful selection and placement of suitable material is followed by watering and compaction to achieve a hard, uniform surface. Minimum specifications for pen surface construction are included in state and national guidelines.

Photograph 4 – Feedlot pen with inadequate pen slope and poor drainage (USA)

Photograph 5 – Well-drained feedlot pens with 6% pen slope

8.3.4 Fencing design

The design objectives for feedlot fences, gates and lanes are to:

- keep cattle securely contained in production pens or laneways during movement around the feedlot
- allow safe and efficient movement of cattle
- minimise stress and injury to cattle
- provide ready access for pen and drain cleaning
- provide ready access for the movement of feed trucks and pen cleaning equipment
- minimise on-going maintenance costs
- provide a safe working environment for pen riders and other feedlot personnel.

The only design objective for fencing that relates to environmental performance is pen and draining cleaning by allowing under-fence cleaning. Cattle can push wet manure under the fence line. When it dries, this can form a solid barrier preventing good pen drainage (**Photograph 6**). This can also be a breeding site for flies. Hence, this under-fence manure must be removed frequently. A poor fence design has posts or cables that hinders cleaning. A good fence design has the lowest cable at a sufficient height to allow under-fence cleaning equipment to easily remove manure (**Photograph 7**).

Tucker et al. (1991) identified this issue and provided photographs of poor fence design with significant manure accumulation. During the site visits undertaken for this review, no examples of poor fence design were found.

8.3.5 Feeding systems

Good design of the feeding system is essential for good cattle performance and efficient feedlot operation as well as maintaining high environmental standards. The feeding system can either be open feed bunks or self-feeder bins.

Feeding systems should:

- provide cattle with free and continual access to feed
- maintain fresh and palatable feed
- minimise waste, spilt feed and spoilage
- prevent all classes of cattle from fouling the feed and escaping from the pens
- allow for easy delivery of feed
- allow for easy cleaning and removal of spoiled feed after rainfall
- not inhibit pen cleaning
- minimise environmental impacts (odour, flies, dust)
- minimise on-going maintenance costs
- provide a safe working environment for mill staff and other feedlot staff.

Self-feeders are particularly common in smaller feedlots and where feed is milled and mixed off-site. One advantage of self-feeders is that they have their own storage bins and therefore need filling only once or twice a week. Because they are readily transportable, they can also be used elsewhere on the farm or can be used in a small paddock or yard for drought feeding. Unlike permanent concrete bunks, they can be installed quickly and can be moved around within pens.

On the other hand, self-feeders have some problems. It is difficult to use diets that are moist, contain large amounts of roughage (particularly coarse roughage) or contain too much molasses or liquid supplements as bridging can occur restricting feed supply. It is for this reason that hay racks are often used with self-feeders, particularly during the introductory feeding phase. Also, some moist feeds tend to spoil when stored in self-feeders for several days. The design of most self-feeders allows manure and spilt feed to accumulate under them that leads to odour generation and promotes fly breeding. However, careful design and frequent thorough cleaning can overcome this. Self-feeders must be located so that they can be filled during all weather conditions. If they are allowed to empty completely without prompt refilling, cattle may gorge on feed when it is delivered, which often results in acidosis and deaths. Ideally, self-feeders should be located such that they can be filled from outside the pens (**Photograph 8**). They should be located at the top side of pens so that they have minimal impact on pen drainage. Self-feeders with a trough on only one side can be placed parallel to and up against the top fence thus allowing easy filling from outside the pen in all weather conditions. Self-feeders with troughs on both sides must be placed at right angles to the top fence and can be more difficult to fill from outside of the pens. Self-feeders should not be located such that drainage is inhibited and manure accumulates under the self-feeder (**Photograph 9**).

Self-feeders are best suited to small and/or opportunity feedlots. Few large commercial feedlots would use self-feeders as the main feeding system.

Open feed bunks (troughs) are used by most commercial feedlots. These feedlots generally process their own feed and can feed-out more than once a day. All types of feeds, including moist ingredients or those containing large amounts of coarsely chopped roughage, can be fed in bunks. Most technical references recommend the provision of at least 150-300 mm of feed bunk length per head when cattle have continual access to feed.

Feed bunks should always be located along the fence line, never within the pen. They should be located along the higher end of the pen and must be able to be filled during all weather conditions. Drainage should be away from the trough on both the feed road and pen sides. This minimises boggy conditions on the pen side of the bunk and keeps the feed road firm and accessible. The cross-sectional shape of the feed bunk should be such that manure and spilt feed cannot accumulate underneath the bunk with subsequent odour generation and fly breeding. Concrete feed bunks with vertical outer walls and a concrete apron are preferred (**Photograph 10**). Aprons that allow manure and feed to accumulate where cleaning is difficult are not preferred (**Photograph 11**).

Data were obtained on the type of feeding system used at feedlots. **Table 35** shows data obtained from 174 feedlots (20% of total) with a combined pen capacity of 830 000 head (61% of industry total). Only 5% of pen capacity uses self-feeders and the largest feedlot using self-feeders is 4000 head capacity. Where a feedlot was using feed bunks, the lot feeder was asked the length of bunk provided per head (mm/head). Often, this was unknown. In the data collected, the range was from 150 to 550 mm/head with an average of all responses being 286 mm/head (from 31 feedlots).

Table 35 – Feeding systems at feedlots

Feeding System	No. of feedlots	% of feedlots	Pen Capacity	% Pen Capacity
Self-feeders	65	37	35886	4
Bunks	109	63	749366	96
TOTAL	174	100	830252	100

Photograph 6 – Accumulated manure under a fence preventing pen drainage

Photograph 7 – Under-fence pusher cleaning manure under a fence line

Photograph 8 – A self-feeder located on a concrete apron

Photograph 9 – A self-feeder without a concrete apron or good pen drainage

Photograph 10 – Good feed bunk design with vertical sides and concrete apron

Photograph 11 – Poor feed bunk design with open sides and no apron

8.3.6 Water troughs

Access to an adequate supply of good quality water is essential for the survival, welfare and performance of feedlot cattle. This needs to be provided without causing negative environmental impacts for the feedlot.

The watering system should:

- provide a fresh, cool, clean, palatable and high-quality supply of water to livestock
- be strong, durable and resistant to damage from cattle and pen cleaning equipment
- not allow manure to accumulate underneath the trough thus being a breeding space for flies or vermin
- provide sufficient access for all cattle to drink easily
- allow for easy cleaning of trough exterior and cause minimal disturbance to pen cleaning
- allow for easy and regular internal trough cleaning
- allow for easy maintenance of pipe and drainage fittings
- not cause wet areas or drainage problems in pens or lead to pen maintenance issues.

Water Trough Design

The design features that have an impact on the performance of a watering system include:

- the location of water troughs within and between pens
- the protection of float valves and other pipe fittings
- the construction material of the trough
- the support and size of the trough
- the size and shape of aprons.

Information collected in the survey showed that the design and maintenance of watering systems has a significant impact on the environmental performance of feedlots. The cross-sectional design of a water trough should prevent manure accumulating underneath where it is an odour source and fly breeding site. Water troughs that are open underneath should not be used (**Photograph 12**). Water troughs should have vertical sides and concrete aprons prevent this and allow easy manure removal (**Photograph 13**).

Water troughs need to be cleaned regularly to remove grain and algae. During cleaning, watering systems can be sources of moisture that will cause otherwise dry pens to become odorous. Cattle wallowing in the wet spots often exacerbates the problem. Water can enter the pens by two main ways:

- dumping of water into the pen during trough cleaning (**Photograph 14**)
- leakage from broken float valves, pipes or troughs (**Photograph 15**).

Water Trough Location

Figure 22 shows the options found during the surveys for water trough locations. Option A, on the fence line serving two pens is a conventional approach, as is Option B in the middle of the pen. However, in these locations, water released into the pen from trough cleaning or by a broken float valve can make a dry pen wet (**Photograph 15**). Options C and E are chosen so that excess water from the trough discharges out of the pen into the drain system (**Photograph 13**). Option D is a poor design choice as this inhibits drainage of the pen and halves the length of trough accessible by cattle.

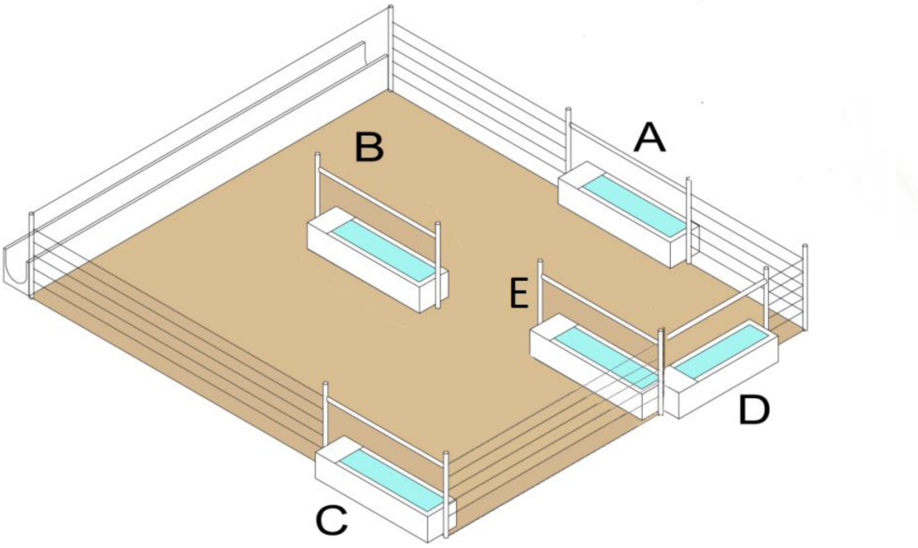

Figure 22 – Options for location of water troughs in pens

Table 36 shows that data on the location of water troughs was obtained from 130 feedlots (15% of total) representing 911 000 head of capacity (67% of total industry capacity). By far, the majority of feedlots locate water troughs on the dividing fence between pens (Position A). Only 8% of pen capacity has water troughs in Locations C and E where excess water flows directly out of the pens into the drains.

Table 36 – Location of water troughs in feed pens

Location	No. of feedlots	Pen Capacity	% of pen capacity
A	54	521366	57
B	25	189584	21
C	19	56411	6
E	7	14049	2
D	25	129476	14
Total	130	910886	100

Trough Sewers

One solution to the problem of water troughs causing wet pens is the use of a sewer system (**Figure 23**). In this design, a network of underground sewer pipes connect each water trough and discharge either into the drains or down to the sedimentation pond. The trough is connected to the sewer with a removable stand pipe. With the stand pipe in position (**Photograph 16**), excess water from a broken float valve overflows the standpipe and discharges out of the pen via the sewer system. To clean a water trough, the stand pipe is removed and the trough is scrubbed. This allows dirty water to discharge via the sewer system (**Photograph 17**). Once the cleaning is complete, the stand pipe is replaced and the trough fills with clean water.

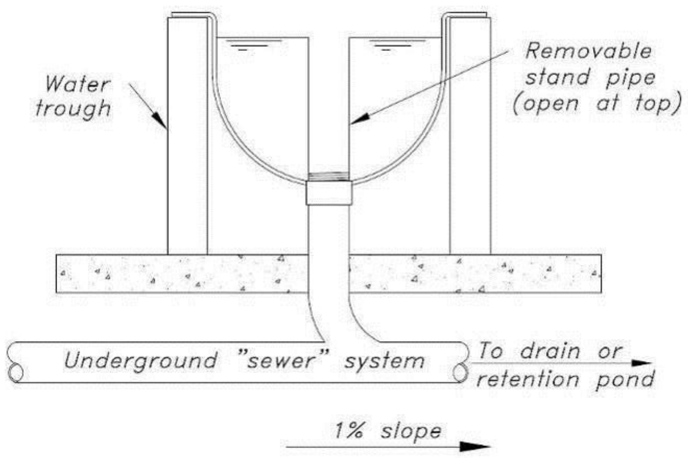

Figure 23 – Schematic layout of sewer system in a water trough

Data were obtained from 51 feedlots (6% of total) with a combined capacity of 503 000 head (37% of total industry). Of these, 23 (284 000 head) used a sewer system, which represents 56% of the sampled capacity. A sewer system is a reasonable capital investment. As it is difficult to retrofit into an existing feedlot, most sewer systems are found at newer feedlots.

Photograph 12 – Poor water trough design (Position A)

Photograph 13 – Good water trough design (Position E)

Photograph 14 – Water in pen from trough washing (Position A)

Photograph 15 – Water in pen due to broken float valve (Position A)

Photograph 16 – Water trough with sewer overflow standpipe (far end)

Photograph 17 – Cleaning a water trough with a sewer system

8.4 Runoff control and irrigation

8.4.1 Controlled drainage system

Stormwater runoff from feedlots contains contaminants that, if allowed to enter natural watercourses, would constitute an environmental hazard. Hence, feedlots must have a system that controls runoff from contaminated areas and provides for environmentally acceptable disposal.

A key feature of a feedlot's runoff control system is the formation of a controlled drainage area (Figure 24). It is typically established using:

- a series of catch drains to capture runoff from the feedlot pens and all other surfaces within the feedlot complex and to convey it to a collection system, and
- a series of diversion banks or drains placed immediately upslope of the feedlot complex, which are designed to divert 'clean' or uncontaminated upslope runoff (sometimes termed 'run-on') around the feedlot complex. Where feedlots are built close to the crest of a hill or ridge, there will be no runoff from upslope. In these cases, it is possible to have a controlled drainage area without any upslope diversion banks or drains.

Depending on the topography and layout of the site, a feedlot may have more than one controlled drainage area. The feedlot's controlled drainage system should only capture runoff from the following elements:

- production pens
- stock handling facilities
- hospital pens
- solid waste storage and processing facility including carcass composting area
- cattle and truck washdown facilities
- cattle lanes
- feed lanes or alleys
- silage pits
- runoff catch drains
- sedimentation system
- holding pond.

Photograph 18 shows the controlled drainage area of a large feedlot, with contaminated runoff captured by a holding pond.

8.4.1 Feedlot pens and drains

Feedlot pen and drains should be designed, constructed and maintained to ensure that:

- After rainfall events, all free water drains quickly and rapid pen drying is achieved.
- There is no pen surface erosion during runoff events.
- Pen-to-pen drainage is prevented.
- Odour emissions are minimal.
- Manure movement in pens is minimal.
- Flow constrictions that will cause deposition of manure (e.g. pipes/culverts) are minimal.
- Manure settling in drains is minimised.

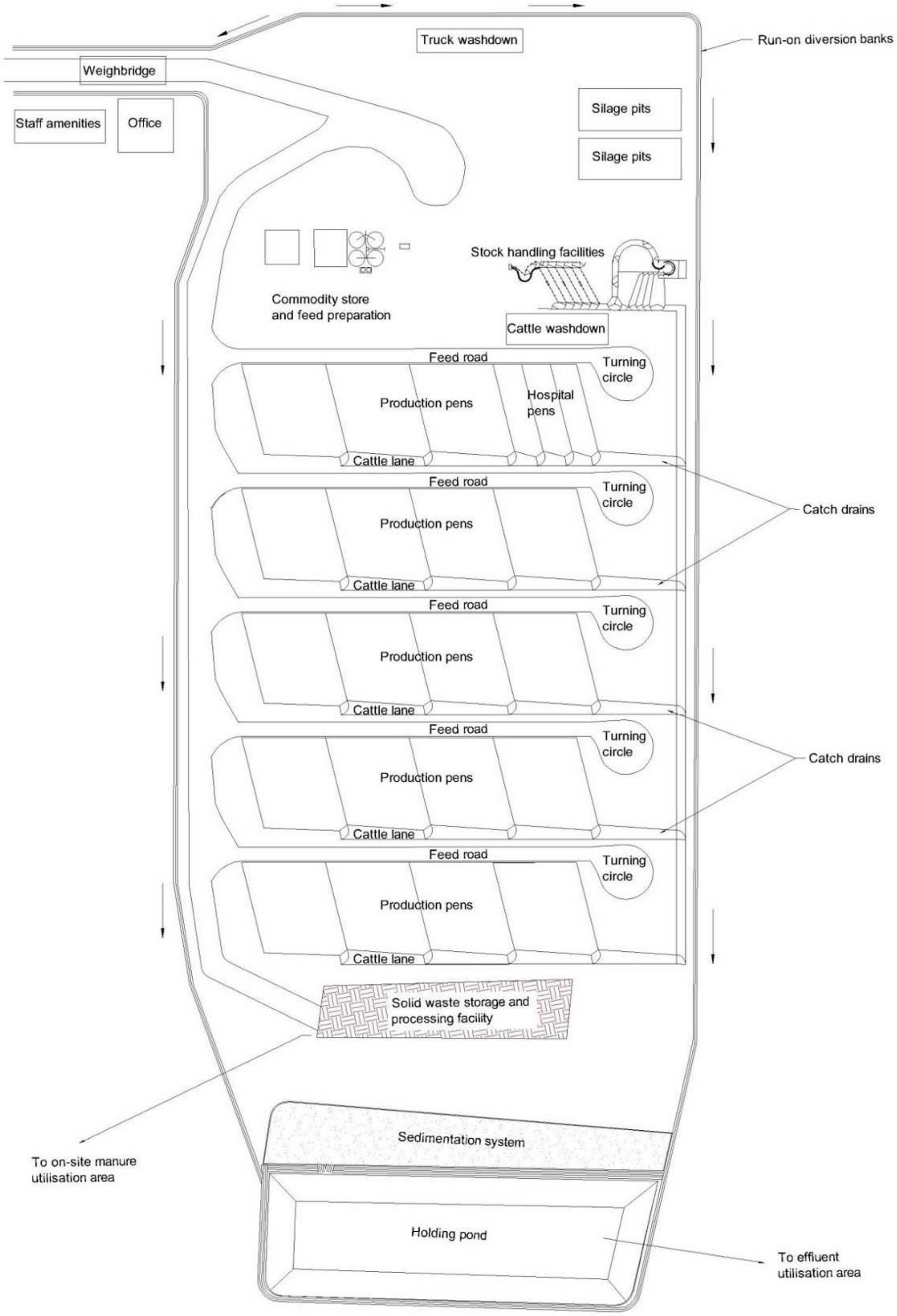

Figure 24 – Controlled drainage area for a feedlot

Photograph 18 – Controlled drainage area for a large feedlot

8.4.2 Sediment removal systems

Sediment removal systems are constructed to trap and detain runoff, allowing entrained sediment to 'settle out' before the runoff enters the feedlot holding pond. Their function is to reduce siltation of the holding pond.

Feedlot sediment removal systems should be designed, constructed, operated and maintained to ensure that:

- entrained manure and other settleable solids are removed from the runoff before it enters the holding pond, thereby:
  - maximising the active storage volume of the holding pond and reducing the probability of overtopping (pond spills);
  - reducing the required frequency of sludge removal from the holding pond; and
  - reducing the biological loading on the holding pond and therefore the intensity and duration of holding pond odour emissions.
- sedimentation systems drain freely, with minimal clogging of the 'control outlet'.
- solids deposited in sediment basins and terraces dry rapidly, thereby reducing the intensity and duration of sediment system odour emissions.
- contamination of underground water resources by the leaching of runoff below the bed of the sediment system is avoided by ensuring that the system is constructed on low permeability soils or is sealed with a suitable clay or synthetic liner.
- deposited sediments can be removed from the sedimentation system in a convenient, cost-effective and efficient manner without having to wait for the sedimentation pond/terrace/basin to go dry.

- to allow for the safe discharge of a design runoff event (1 in 50 year average recurrence interval (ARI)) through a spillway outlet structure to allow for bypass of high flows around a downstream treatment system.

Three basic types of sedimentation systems are currently used in feedlots. They include settling ponds and settling basins or terraces (that dry out after a runoff event) (**Photograph 19** and **Photograph 20**). A settling pond is a pond upstream of the holding pond that remains full of water at all times (**Photograph 21**). Entrained manure settles to the base of the pond. These systems need to be cleaned when still full of water and this is a problem with their management. Settling basins or terraces are designed to drain out completely after a storm. The settled manure dries in the shallow basin and can usually be removed easily.

Table 37 shows that data on sediment removal systems was obtained from 144 feedlots (17% of total) with a combined capacity of 833 000 head (62% of total industry).

Table 37 – Sediment removal systems at feedlots

Type of System	No. of feedlots	% of feedlots	Pen Capacity	% Pen Capacity
None	40	28	70168	9
Settling basin	88	61	594459	71
Settling pond	16	11	168379	20
TOTAL	144	100	833006	100

Runoff control was often poorly managed when the Tucker et al. (1991) survey was done. At that time, 74% of commercial feedlots and only 11% of opportunity feedlots had a sediment removal system. Now, over 90% of feedlot capacity has a sediment removal system.

Sediment Removal System Outlet Control

In all cases, the design principle of the sedimentation system is that solids entrained in the runoff are transported via drains at a high velocity until the runoff enters the sedimentation system where the flow velocity suddenly drops to a very low rate. The entrained solids settle to the base of the sedimentation system. Non-settleable, suspended solids stay in suspension and the runoff plus suspended solids slowly flows into the holding pond via an outlet weir. The function of the outlet is NOT to act as a filtering device. In designs originally taken from the USA, rock-filled weirs acting as a filter were used. These weirs inevitably clogged and became an odorous slurry of wet manure (**Photograph 22**). This type of weir has now been removed from most feedlots and none was seen during the survey visits.

The outlet weir functions as a discharge regulator that constrains the outflow from the sedimentation system, giving the settleable solids the opportunity to settle out and deposit upstream of the outlet weir (**Photograph 23**) but allowing the basin to dry out after the storm (**Photograph 24**).

Photograph 19 – Shallow sedimentation basin drying out after a runoff event

Photograph 20 – Aerial view of sedimentation basin upstream of holding pond

Photograph 21 – Settling pond

Photograph 22 – Rock filled weir

Photograph 23 – Outlet control – slatted weir during runoff event

Photograph 24 – Outlet control – slatted weir drying after runoff event

8.4.3 Holding ponds

Stormwater runoff from the controlled-drainage area of a feedlot is normally characterised by high concentrations of organic matter. Even after passing through a sediment removal system, it still contains substantial levels of organic matter, nutrients, pathogens and salts. This runoff should not be allowed to flow, uncontrolled, into the external environment.

Runoff from the feedlot controlled drainage area can be removed from the system by:

1. Downslope dispersal
2. Evaporation from the holding pond only
3. Evaporation from the holding pond and subsequent irrigation.

A holding pond is located at the lower end of the controlled drainage area immediately below the sediment removal system (**Photograph 20**). It is designed to capture and store the runoff from the controlled drainage area. The application of holding pond wastewater to land, where it is sustainably utilised by crops and soil, is generally the preferred form of wastewater management. Sometimes evaporation of the wastewater is acceptable, e.g. in arid areas, without access to other irrigation water and where cropping is not sustainable. However, it will still be necessary to show the regulatory authorities that the saline residue remaining after evaporation can be safely disposed of. Where evaporation is the sole or primary removal mechanism for wastewater (i.e. where captured effluent is not normally applied to land), these ponds are typically referred to as evaporation ponds.

The design objectives of holding ponds are:

- to store stormwater runoff until the captured wastewater is either applied to land, or evaporated.
- to temporarily store effluent from major storms and/or extended wet periods when irrigation or evaporation of effluent is limited.
- to provide sufficient storage capacity to safely store the captured wastewater, without overtopping (spilling) at an unacceptable frequency.
- to have a low base permeability, thereby minimising the risk of groundwater contamination by leaching of effluent.
- to be structurally stable to limit the probability of embankment failure and the uncontrolled release of large quantities of effluent causing surface water contamination.
- to be designed and managed to minimise odour emissions.

The National Feedlot Guidelines include a design protocol for holding ponds. In some cases, small feedlots away from sensitive watercourses are able to operate without a holding pond. In these circumstances, the feedlot should have a dedicated runoff dispersal area below the feedlot pens (**Photograph 25**).

Table 38 shows that data on runoff control systems was obtained from 127 feedlots (15% of total) with a combined capacity of 768 000 head (57% of total industry). Only 4% of the industry's pen capacity relies on a downslope dispersal system for runoff disposal. However, there is one feedlot of 9500 head capacity that does not have a holding pond.

Tucker et al. (1991) found that only 76% of commercial feedlots and 36% of opportunity feedlots had a holding pond. This situation has changed markedly with 96% of feedlot pen capacity having holding ponds to capture runoff. About 80% of feedlot pen capacity uses an effluent utilisation area to utilise runoff from the holding pond.

Tucker et al. (1991) found that 61% of commercial feedlots had an irrigation area while only 18% of opportunity feedlots had an irrigation area. Given that only 36% of opportunity feedlots had a holding pond, it is clear that the majority (64%) of opportunity feedlots were using downslope dispersal of some form.

Table 38 – Runoff control systems at feedlots

Type of System	No. of feedlots	% of feedlots	Pen Capacity	% Pen Capacity
None – dispersal area only	30	24	29178	4
Holding pond – evaporation only	39	31	142880	18
Holding pond with irrigation area	58	46	595634	78
TOTAL	127	100	767692	100

Photograph 25 – Small feedlot with runoff dispersal area below the pens

8.4.4 Irrigation systems

Feedlot runoff can contain high levels of nutrients. **Table 40** shows a summary of 194 effluent quality results from feedlot holding ponds. This shows the range of nutrient levels that can be expected in feedlot holding ponds. **Figure 25** and **Figure 26** provide some further analysis of the feedlot effluent quality showing the relationship between EC and SAR, and Total N and Total P respectively. It might be expected that as the nitrogen content of effluent increases so would other major nutrients such as P and K. However, **Figure 26** shows that there is no relationship between Total N and Total P content of feedlot effluent, probably due to variable atmospheric losses of nitrogen from holding ponds and phosphorus settling in pond sediment. Given the wide range of effluent quality measured across many feedlots, it is concluded that effluent management plans must be based on site-specific effluent analyses rather than generic data such as that given in **Table 40**.

When used for irrigation, feedlot effluent should be applied at nutrient and salt loading rates that are sustainable. Various guidelines provide design information for determining acceptable loading rates. Effluent should be applied in a controlled manner and uniformly across the effluent irrigation area. Hence, spray irrigation systems are generally preferred over surface irrigation systems where uniform application rates are much harder to achieve. Dilution of effluent with clean water may be required in some instances to achieve suitable results.

When effluent is irrigated, **Table 39** shows the data on the type of irrigation method was obtained from 57 feedlots (7% of total) with a combined capacity of 601 000 head (44% of total industry). The majority of feedlots use spray irrigation when effluent is utilised.

Table 39 – Irrigation methods at feedlots

Type of System	No. of feedlots	% of feedlots	Pen Capacity	% Pen Capacity
Surface irrigation	16	28	103273	17
Spray irrigation	41	7	497307	83
TOTAL	57	100	600580	100

Table 40 – Effluent quality in feedlot holding ponds

	Units	No. of samples	Mean	Median	Maximum	Minimum
Total Nitrogen	mg/L	175	220	165	1095	25
Total Kjeldahl Nitrogen	mg/L	173	218	153	1095	23
Ammonia	mg/L	99	115	69	861	0
Ammonia Nitrogen	mg/L	99	89	53	670	0
Nitrate	mg/L	101	10.1	1.0	305.0	0.1
Nitrate Nitrogen	mg/L	96	2.3	0.2	68.8	0.0
Nitrite	mg/L	19	1.7	1.0	16.8	0.0
Nitrite Nitrogen	mg/L	20	0.5	0.3	5.1	0.0
Total Phosphorus	mg/L	171	71	56	387	2
Phosphate-P	mg/L	102	17	10	133	0
Phosphate (PO_4)	mg/L	93	52	30	407	1
Phosphate P/Total P	-	94	31%	26%	91%	2%
Potassium	mg/L	122	1092	796	6390	21
pH	-	135	8	8	10	7
Electrical Conductivity	dS/m	187	7.8	6.9	37.8	1.0
Total Dissolved Ions	mg/L	60	6941	5552	37955	1134
Total Dissolved Solids	mg/L	57	4915	4329	18644	1002
Calcium	mg/L	114	126	113	597	13
Magnesium	mg/L	114	118	90	805	2
Sodium	mg/L	114	494	201	6700	12
Sodium Absorption Ratio	-	119	7.1	3.5	65.8	0.5
Chloride	mg/L	110	1261	806	12839	95
Sulphate	mg/L	51	74	40	378	1
Total Hardness	mg/L	61	943	838	3435	85
Temporary Hardness	mg/L	47	913	790	3435	85
Bicarbonate Alkalinity	mg/L	56	2105	1860	7100	206
Carbonate Alkalinity	mg/L	56	102	2	1820	0
Free Carbon Dioxide	mg/L	48	66	26	770	0
Hydroxide Alkalinity	mg/L	47	1.7	2.0	2.0	0.0
Residual Alkalinity	mg/L	54	22.4	18.5	110.0	0.0
Saturation Index		46	1.8	1.9	3.0	0.2
Total Alkalinity	mg/L	62	2082	1845	8920	168
Aluminium	µg/L	43	989	850	3435	47
Boron	µg/L	52	2180	1870	7100	56
Copper	mg/L	52	142	2	1820	0
Free Residual Chlorine	mg/L	44	81	25	770	0
Silica	mg/L	43	2.7	2.0	47.0	0.0
Total Iron	mg/L	50	24.1	18.3	110.0	0.0
Total Manganese	mg/L	42	2.9	2.0	46.0	0.2
Zinc	µg/L	58	2173	1847	8920	62

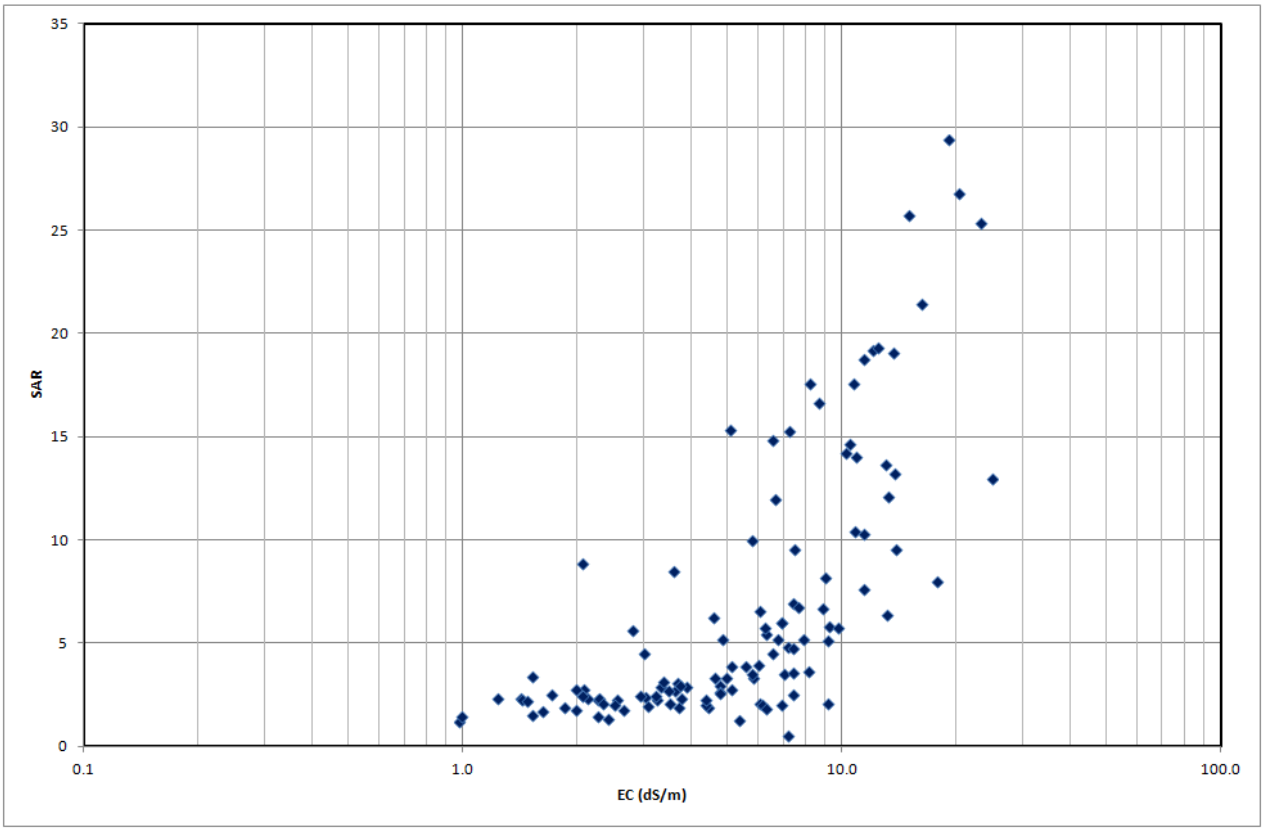

Figure 25 – Relationship between EC and SAR for feedlot effluent

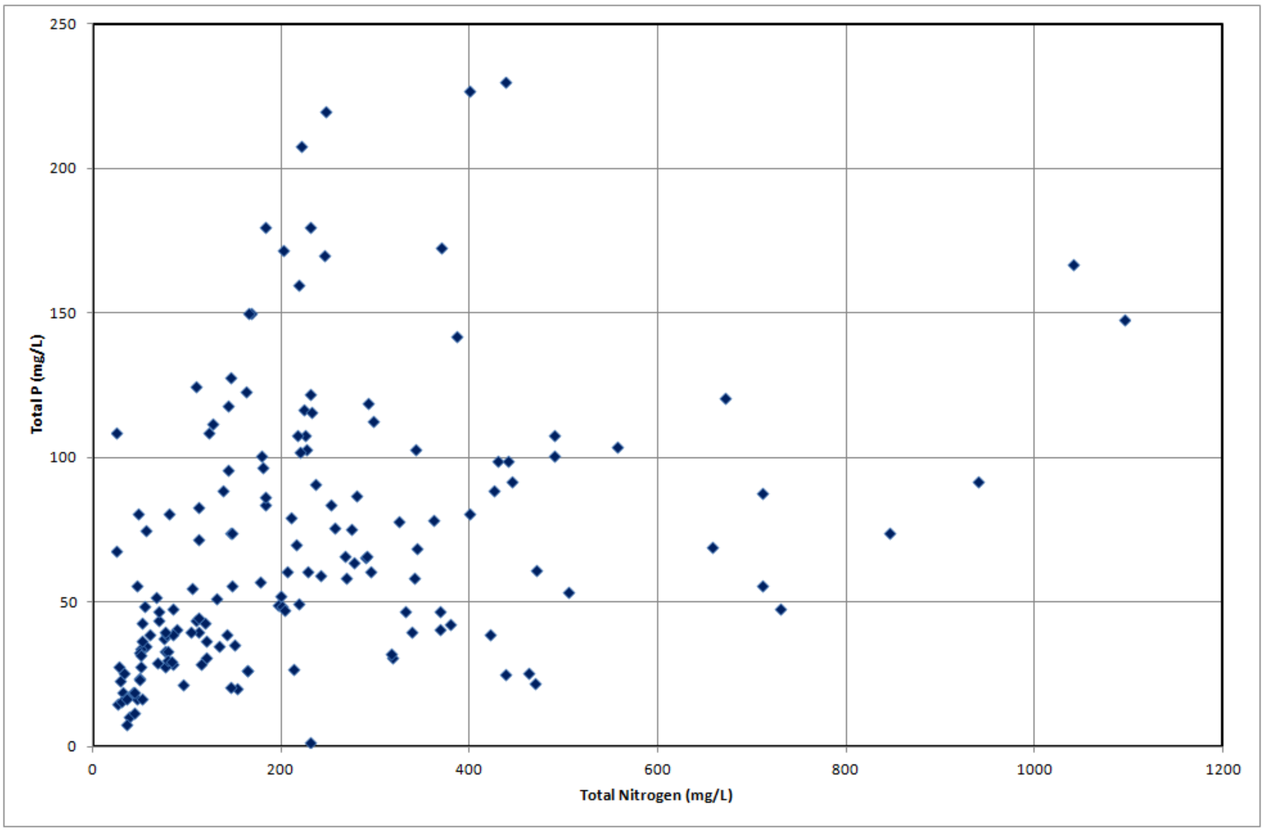

Figure 26 – Relationship between Total N and Total P for feedlot effluent

8.5 Cattle and truck washing

Under certain conditions, the hides of feedlot cattle can be partially covered in dags. These are balls of manure that have been rolled into the hair of the hide (**Photograph 26**). Dags usually only become a problem when pens have wet manure and the cattle have their long winter coats. They are only an issue for *Bos Taurus* (European) breeds of cattle and are not a problem for *Bos indicus* cattle. Dags are only a significant issue in winter (winter coats have long hair) and in southern feedlots where winter-dominant rainfall occurs. They are not a year-round issue at any site.

Abattoirs are not allowed to kill cattle with manure on their hides, particularly under the belly and on the cut lines, as this can contaminate carcases. While most abattoirs can wash cattle, some abattoirs will reject or discount cattle that have a heavy dag load when they arrive at the works. Hence, there has been a growing trend in recent years to wash cattle at feedlots just prior to dispatch to works. Some feedlots do not wash cattle on-site because they are part of a vertically integrated supply chain and they know that their cattle will be washed at the abattoir that is part of their company structure.

Two feedlots noted that they have removed dags by “shearing” cattle in a crush using hand shears from the sheep industry. However, this is expensive and can cost up to $10 per head. There may also be safety issues.

There are many designs for cattle washes. Long soaking times are required to soften the balls of manure. Photograph 27 shows cattle in a wash being soaked and partially washed. Often, this must be followed by high-pressure directional hosing to dislodge the remaining dags.

No data were obtained during this study on the volume of water used for washing cattle. However, Davis et al. (2010a) reports on a study where eight feedlots were selected to provide a sample group representative of the geographical, climatic and feeding regime diversity within the Australian feedlot industry. At seven of these feedlots, water meters were installed to allow an examination of water usage by individual activities in 2007-08. The major water usage activities (drinking water, feed management, cattle washing, administration and sundry uses) were monitored and recorded. Cattle washing was the second highest consumer of water in feedlots in months when it is undertaken. The total water usage in some feedlots comprised clean and recycled water. Cattle washing contributed up to 25% of the total water usage during winter months. In 2007, the average total cattle washing water usage ranged from 800 L/head to 2600 L/head, whilst in 2008 a range of 400 L/head to 3100 L/head was measured. However, a monthly average water usage up to 3900 L/head was measured in 2007, and 4400 L/head recorded in 2008. Recycled water accounted for 50 to 75% of the total washing water usage.

The volume of water required for cattle washing depends on the dirtiness of the cattle and the cleaning method. Davis et al. (2010a) reported that water usage decreased at one feedlot in 2008 when compared to 2007 due to drier conditions, whilst another feedlot increased water usage per head in 2008 due to dirtier cattle from higher rainfall in the winter months when compared with 2007.

Livestock transport trucks can carry significant loads of manure at the end of a journey. This manure needs to be washed from the truck at some locations, usually a dedicated truck washdown site. However, some trucks are washed at feedlots. Other feedlot vehicles, such as pen cleaning equipment or feed delivery trucks, needs to be washed occasionally. Lot feeders were asked during the survey if there was a truck washdown facility at the feedlot.

For cattle washing, data were obtained from 70 feedlots (8% of total) with a combined capacity of 612 000 head (45% of total industry). It was found that 15 feedlots (21% of those surveyed) with a pen capacity of 254 000 head (41% of those surveyed) had a cattle wash. However, the usage of the cattle wash varied greatly. The percentage of cattle turnoff that was washed varied from year to year depending on weather conditions. In some years, some southern feedlots with a cattle wash do not need to use it at all. The maximum percentage of cattle turnoff reported as being washed was 100%.

For truck washing, data were obtained from 59 feedlots (7% of total) with a combined capacity of 556 000 head (41% of total industry). It was found that 5 feedlots (8% of those surveyed) with a pen capacity of 73 200 head (13% of those surveyed) had a truck wash of some sort. Sometimes the truck wash was only for on-site vehicles and was not large enough to wash livestock trucks. No data were obtained on usage of truck washes or the water requirements.

Photograph 26 – Steer with heavy dag load

Photograph 27 – Cattle being soaked and washed in a cattle wash

8.6 Heat stress management

8.6.1 Shade

Excessive heat load (EHL) on feedlot cattle during summer months can result in significant production losses, animal welfare considerations and, under extreme conditions, the loss of cattle. High body heat loads can develop in feedlot cattle when a combination of local environmental conditions and animal factors exceed the animal's ability to dissipate body heat. Feedlot operators often adopt various management strategies to reduce the risk of EHL in cattle which in turn minimises its impact on animal production, health and welfare. The provision of shade is one strategy used to reduce the impact of hot weather conditions on cattle.

Shade is a thermal radiation shield. It reduces the heat load on the animal. Shade does not readily affect air temperature, but can reduce exposure to solar radiation and also enhance minimal air movement for cooling. Hence, shade is most beneficial for dark coloured cattle, such as Angus.

Major design considerations for shade structures are: orientation, space, height, and shading material. The design objectives for a shade structure are as follows:

- to provide adequate shade for each animal in the pen (square metres per animal)
- to provide a structurally sound structure
- to provide a durable structure
- to minimise obstructions when cleaning the pen
- to maximise pen drying under the shade
- to maximise the longevity of the shade structure.

Sullivan et al. (2011) investigated the effect of the area of shade provided per head on the performance and welfare of short-fed feedlot cattle in SE Queensland. They compared no shade with the provision of 2.0, 3.3 or 4.7 m^2/head of 70% solar block shade cloth. The cattle were stocked in pens at 19.2 m^2/head. The study commenced in mid-summer and finished in autumn. Water usage increased as heat load increased but was greater for the shaded cattle, even though the unshaded cattle spent more time at the water troughs, especially during the heat waves. Behavioural differences in terms of standing, lying, eating and drinking were evident between unshaded and shaded pens. Sullivan et al. (2011) concluded that access to shade improved the welfare and performance of cattle in their study. Provision of a shade area greater than 2.0 m^2/head did not appear to provide any additional production benefits for short-fed cattle. However, the mean panting score and the behavioural data, especially during the heat waves, suggest that the 2.0 m^2/head treatment did not produce the same welfare improvements as the 3.3 and 4.7 m^2/head treatments. Using these data, it would be reasonable to assume that, if shade is to be provided, a minimum of 2.0 m^2/head of shade be present.

In the survey, data were obtained on the percentage of cattle at the feedlot pen capacity that was provided with shade. Data were obtained from 158 feedlots (18% of total) with a combined capacity of 802 000 head (59% of total industry). It was found that 40 feedlots (25% of those surveyed) with a pen capacity of 539 000 head (67% of those surveyed) provided some shade. When the percentage of the pen capacity that is shaded is taken into account, it was found that 402 000 head (75% of surveyed capacity) was provided with shade. There was also a clear indication from surveyed feedlots that more shade will be installed in the near future so these data will soon under-represent that percentage of the industry where shade is provided. **Figure 27** shows the location of those feedlots that provide some shade.

Where shade was provided, the lot feeders were asked about the shade area provided per head (m^2/head). Many lot feeders did not know this area. Data on shade area was obtained from 11 feedlots (1% of total) with a combined capacity of 272 000 head (20% of total industry). The average shade area was 3.6 m^2/head with a range of 1 to 10 m^2/head.

In Australian feedlots, the shading material is either shade cloth (**Photograph 30**, **Photograph 31** and **Photograph 32**) or galvanised iron (GI) sheeting (**Photograph 34** and **Photograph 35**). The shade is usually configured so that the area under the shade does not become excessively wet. This is achieved by either having high shade that moves across the pen during the day allowing drying of all of the pen or gaps between the shade panels to allow even sun penetration. There are numerous designs used to date with no clear optimal design. **Table 41** provides data on the type of shade cover material used. Most of the first shade structures used shade cloth which was poorly attached and soon became torn and damaged. Subsequently, there was a trend towards more robust, GI structures. Recently, a new shade cloth design with better attachment and no posts in the pens has become popular (**Photograph 32**).

Table 41 – Type of shade cover at feedlots

Type	No. of feedlots	% of feedlots	Pen Capacity	% Pen Capacity
Shade cloth	24	54	368452	60
GI sheeting	19	42	242117	39
Other	2	4	3590	1
TOTAL	45	100	614159	100

*This includes 6 feedlots (with a pen capacity of 98 556) that use two different types of shade.

The amount and location of the shade provided varies considerably. Some feedlots are fully covered (see **Photograph 28** and Section 8.6.2). Sometimes, shade is only provided over the feed bunk and apron. This typically occurs in high rainfall areas (**Photograph 29**). Only one instance of this was found in this survey at a feedlot in northern Queensland.

When partial shade is provided, the location of the shade in the pen and the spacing of the shade panels can vary. Wherever possible, posts within the pen (**Photograph 34**) should be avoided as these can hinder pen cleaning operations. Data were obtained from 37 feedlots on where partial shade was provided within each pen. **Table 42** summaries the data collected on the location of partial shade within feedlot pens.

Table 42 – Location of shade within feedlot pens

Type	No. of feedlots	% of feedlots	Pen Capacity	% Pen Capacity
Top third of the pen	8	22	68506	13
Centre of the pen	26	70	413523	79
Bottom third of the pen	3	8	43766	8
TOTAL	37	100	525795	100

During wet winter conditions, shade may prevent pen drying. Hence, it could be desirable to retract the shade during winter. The design of retractable shade structures has yet to be perfected. No feedlot was found where galvanised sheeting shade could be retracted. Four feedlots were found that could retract shade-cloth shading in winter (Photograph 33). However, most of these feedlots noted that the process was difficult and was not always undertaken.

8.6.2 Fully-covered feedlots

In some environments, cattle can be housed in fully covered feedlots. These environments include northern America where winters are particularly cold or SE Asia where rainfall is very high (**Photograph 28**). In Australia, the need is low and the cost per head of covered feedlots is usually prohibitive. However, where high value cattle, such as Wagyus, are fed and winter conditions are particularly adverse, it can be viable to house cattle in fully covered feedlots. The survey found six feedlots where a covered feedlot was being used. In three cases, the feedlot also had conventional open pens and the covered feedlot was only used for cattle at the end of their feeding period. All covered feedlots operate at a higher stocking density than conventional open pens and require some form of soft bedding in the pens, e.g. sawdust or wood chips.

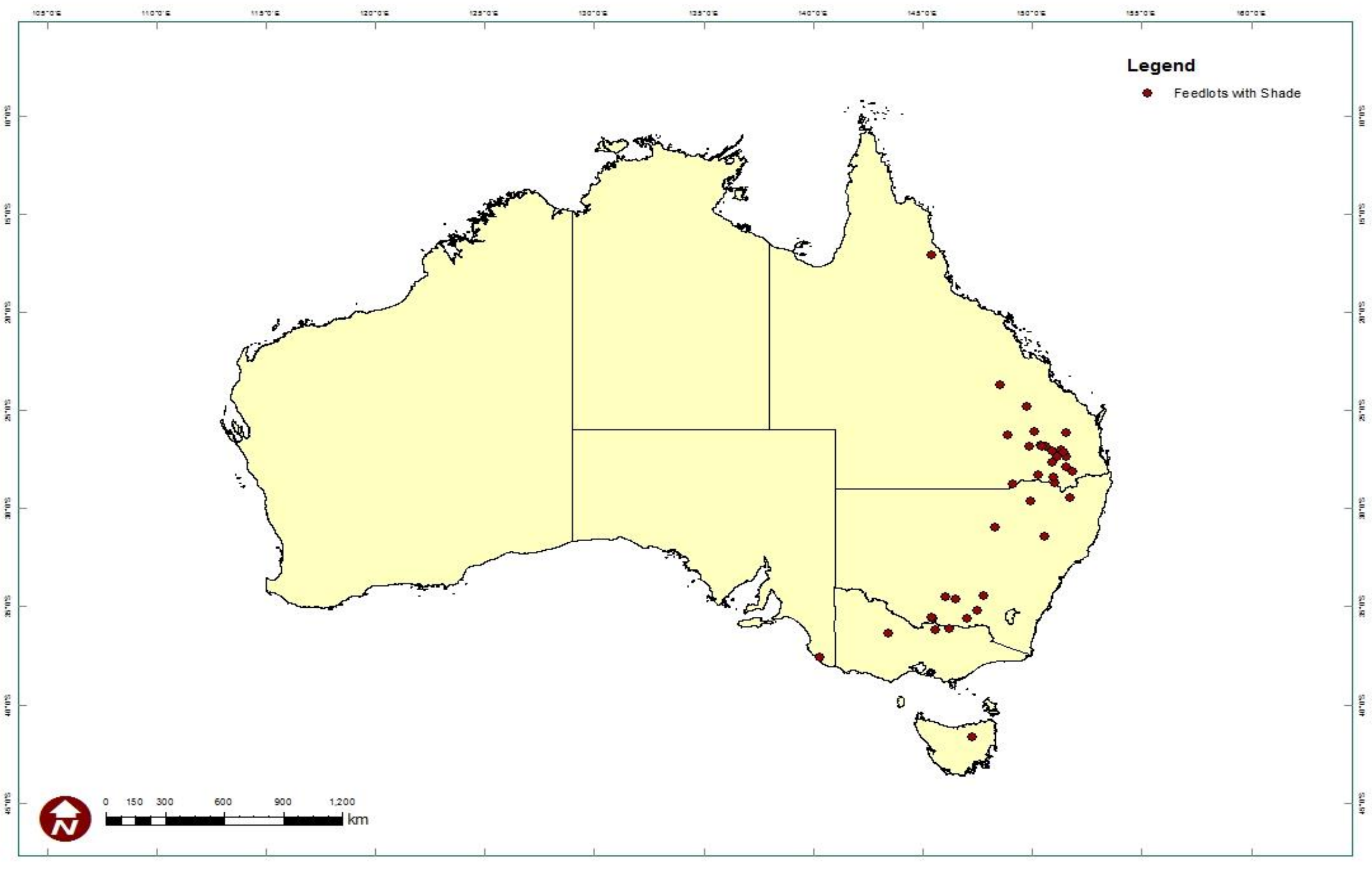

Figure 27 – Location of feedlots where some shade is provided for cattle

Photograph 28 – Fully-covered feedlot – SE Asia

Photograph 29 – Shade over feed bunk and apron – SE Asia

Photograph 30 – Solid shade cloth in the centre of a row of pens

Photograph 31 – Dome-style shade cloth in the centre of a pen

Photograph 32 – Panel style shade cloth across feedlot pens

Photograph 33 – Retractable shade cloth

Photograph 34 – Galvanised iron sheeting shade with gaps between sheets

Photograph 35 – Galvanised iron solid shade

8.6.1 Automatic weather stations (AWS)

Weather monitoring is an important aspect of feedlot management. Adverse weather conditions can affect cattle production and welfare, particularly during the hot weather. Feedlot operators should closely monitor local climatic conditions and review future weather forecasts to monitor and manage the risk of cattle experiencing elevated body heat loads through the calculation of an accumulated heat load index.

Weather monitoring may also be required to support feedlot environmental licences or development approval applications, particularly if there is the potential for odour or dust to impact on neighbouring properties. In NSW, the guidelines for odour assessment require the collection of at least 12-month's meteorological data for development approval applications where odour impact is expected. These data are used in odour dispersion modelling for the proposed site. Further, a weather station may be required to be installed at the site to collect data for a minimum of two to three months so that the results can be correlated with a local Bureau of Meteorology station if available.

In some cases, feedlot environmental licences and development approvals require the operator to collect meteorological measurements as part of feedlot management. The parameters to be recorded will be specified in the licence. This may be as simple as daily rainfall or as complex as wind stability on a 10-minute basis. In these cases, it is essential that the design and siting of the weather station complies with AS2922-1987 Ambient Air – Guide to the Siting of Sampling Units and AS2923-1987 Ambient Air – Guide for Measurement of Horizontal Wind for Air Quality. If the weather station does not comply with these standards, the data may not be useable in legal and licensing situations. Weather data can also be used for scheduling of effluent irrigation.

For AWS, 32 feedlots (4% of total) with a combined capacity of 399 000 head (30% of total industry) were surveyed. It was found that 22 feedlots (69% of those surveyed) with a pen capacity of 345 000 head (86% of those surveyed) had an automatic weather station.

Photograph 36 – Well sited AWS with no nearby obstructions

9 Feedlot management

9.1 Pen cleaning and maintenance

At the time of Tucker et al. (1991), pen cleaning and manure management was a major issue. Manure management was often seen as a chore and an additional cost for which no return was achieved. Consequently, manure depths in pens were often at levels that would be completely unacceptable by today's standards. Deep manure leads to odour issues and a poor public perception of feedlots. Regulators responded by including sometimes onerous pen cleaning and manure management requirements in guidelines and licence conditions.

Fortunately, the situation has changed markedly in the past 23 years. The reasons for this change include:

1. Clear evidence has been provided by feedlot nutritionists that cattle performance is reduced with heavy manure loads in pens.
2. Manure is now seen as a resource that can be sold to neighbouring farms as a fertiliser or soil conditioner.
3. Lot feeders are concerned about public perceptions of poor animal welfare with cattle standing in deep manure and they take action to address welfare issues if they arise.
4. Dags (see Section 8.5) are becoming an issue and can be reduced by better manure management.

9.1.1 Pen cleaning intervals

Tucker et al. (1991) presented data that suggested that 45% of commercial feedlots only cleaned their pens twice per year or less frequently. This increased to 78% for opportunity feedlots that often only cleaned their pens once per year. At 10 m^2/head, this led to deep manure at the time of cleaning, which meant that cleaning could be a difficult and time consuming activity.

In response, most guidelines specified minimum cleaning intervals for feedlots with different stocking densities. Alternatively, an accumulated depth of manure would be specified as a trigger to commence cleaning. For example, Skerman (2000) specifies that, for a Class 1 feedlot at 10 m^2/head, the pens should be cleaned every 7 weeks or when 50 mm of manure has accumulated.

In recognition of this regulatory environment, the survey form was designed to determine whether pen cleaning was triggered by either a time interval or a manure depth, and to quantify these triggers. However, during the conduct of the survey, it was found that very few feedlots operate according to these pre-subscribed limits. The trigger for pen cleaning was highly site-specific and variable. Specific licence requirements were usually a secondary consideration when deciding to clean pens.

Some findings were as follows.

1. Many feedlots reported that their nutritionists require frequent pen cleaning to ensure optimal cattle performance. This is usually more frequent than the guidelines specify.
2. Some feedlots, in particularly sensitive sites, choose to clean pens more frequently than specified in their licence to further minimise the likelihood of odour or dust complaints from neighbours.
3. Some feedlots undertake pen cleaning by scraping the pen and forming a mound of manure inside the pen (**Photograph 37**). The mound is subsequently removed, perhaps only once per year, while the pen cleaning (mound formation) occurs more frequently. The advantage of mounding is that manure breaks down in the mound and this ultimately

reduces the total volume of manure to be removed from the pen while maintaining shallow manure levels over most of the pen.

4. Most southern feedlots note that they aim to fully clean all pens prior to the start of the winter wet period. Once, the wet has commenced, it is difficult to clean pens when there is a "slurry" of manure. Proactive cleaning prior to winter offers many advantages.
5. Some northern feedlots stated that they try to clean all pens well prior to the summer wet season. This is done as part of the heat stress management plans as it is believed that deep wet manure can exacerbate a heat stress incident.
6. For feedlots feeding short-fed cattle (e.g. 60 days), pens were usually cleaned after each batch of cattle.
7. Pen cleaning can be triggered (or delayed) by pen moisture content. It is difficult to clean pens that are too dry or too wet. Many lot feeders noted that they take the opportunity to clean pens (or do internal mounding) when the pad moisture content is correct (about 35%).

9.1.2 The "interface" layer

At the time of Tucker et al. (1991), much attention was paid to the "interface" layer. This is a layer of moist, very well compacted manure that forms at the base of the manure layer in a pen. The material has the consistency of plasticine and can be peeled off in slabs (**Photograph 38**). In most guidelines, retention of the interface layer during pen cleaning is recommended (**Photograph 39**) as it is nearly impermeable and prevents seepage of nutrient-rich leachate below the feedlot pens.

It is well known that a 50 mm layer of dry, compacted manure can expand to over 200 mm following heavy rain. When cleaning pens, it is difficult to leave just a 25 mm interface layer. Thus, there is the risk that, if the intention is to leave the interface layer, much more manure will be left in the pen. Consequently, the survey found that some lot feeders (19% of pen capacity) now do not try to maintain an interface layer. They clean their pens down to the gravel base at all times (**Photograph 40**). This often means that some clay and gravel is taken up with the manure but they can be sure that very little manure remains in the pens. However, clay and/or gravel will inevitably need to be brought back into the pen to repair the surface.

Data on retention of the interface layer during pen cleaning was obtained from 38 feedlots (4% of total) with a combined capacity of 460 000 head (34% of total industry). **Table 43** provides these data. It shows that about 20% of feedlots are now removing the interface layer when they clean their pens.

Table 43 – Interface removal or retention at feedlots

Type	No. of feedlots	% of feedlots	Pen Capacity	% Pen Capacity
Interface retained	27	71	371976	81
Interface removed	11	29	88011	19
TOTAL	38	100	459987	100

9.1.1 Pen cleaning equipment

Different types of machinery are used to scrape manure from the pen surface and remove it from the pens. The equipment includes box scrapers (**Photograph 41**), front-end loaders (**Photograph 42**), excavators (**Photograph 43**) and in limited situations, graders (**Photograph 44**). Manure is then loaded into trucks (**Photograph 45**) and taken to a manure stockpile area.

9.2 Manure management

After manure is taken to the manure stockpile area, it may be statically stockpiled for period of time, composted in windrows and/or screened prior to spreading on land as a fertiliser or soil conditioner. Some manure is taken directly from pens and spread on-site or taken off-site.

O'Keefe et al. (2011) undertook a feedlot manure end-user analysis and compared the results to a similar survey done in 2006. End-users for feedlot cattle manure may be the feedlots themselves or off-site re-users. The second column of **Table 44** to **Table 50** (all taken from O'Keefe et al. (2011)) shows the number of responses received from the 39 feedlots that were surveyed. In some of the tables, the total number of responses exceeds the total number of feedlot surveyed (i.e. values >39). Where this happens, it means that one or more feedlots provided multiple answers for the same question. For example, some feedlots spread manure on-site as well as sending some off-site.

Table 44 shows details of the breakdown of manure management practices. Only nine feedlots representing 8% of surveyed feedlot capacity spread manure or remove it from the site immediately after harvesting it from the pens. The majority of feedlots and feedlot capacity surveyed either store manure for less than 12 months before spreading, or compost the manure. However, eleven feedlots representing 15% of capacity say that they store manure for greater than 12 months before spreading. The number of feedlots composting manure has increased from twelve in 2006 to eighteen in 2010. Those who compost do so for 6 months on average, turning the windrows 7-8 times over this period. However, the time for completion of a composting cycle ranged from 3-12 months.

Table 44 – Manure management after pen cleaning

Manure management (Directly after pen cleaning)	No. of responses	% of responses	Feedlot capacity represented ≥5000	% of responding feedlot capacity
Spread / transferred off-site	9	16	43954	8
Stored <12 months before spreading	20	19	214275	39
Stored >12 months before spreading	11	31	82413	15
Composted	18	34	208781	38
Total	58	100	549423	100

Table 45 shows details of manure spread on-site and off-site. On-site spreading occurred at 29 feedlots, whilst 24 feedlots send manure off-site, with a significant number of feedlots doing both. Since off-site spreading represents less than half the number of feedlots but 72% of the surveyed feedlot capacity, it appears that the larger feedlots need to send manure off-site. However, this may also indicate that these larger feedlots have the scale to produce manure in quantities that are sufficient to meet the needs of off-site users'. Larger feedlots may also be in a better position to undertake more capital and labour-intensive manure management methods such as composting (as shown in **Table 44**).

Table 45 – On-site vs. off-site manure spreading

Manure spreading practice	No. of responses	% of responses	Feedlot capacity represented	% of responding feedlot capacity
Spread on-site	25	51	155529	28
Spread off-site	24	49	393895	72
Total responses	49	100	549423	100

Some feedlots actively compost manure (**Photograph 46**) rather than simply storing it long-term. **Table 46** shows that eight of the 18 feedlots that compost (or 20% of responding feedlot capacity) amend their compost by adding substrates such as waste products from the feedlot (e.g. spoilt hay and / or grain). Four of the feedlots that compost (5% of the responding feedlot capacity) recorded windrow temperatures. Six of the feedlots that compost (10% of the responding feedlot capacity) added some form of moisture (either freshwater or effluent) to enhance the composting process.

Table 46 – Composting practices

Composting practice	No. of responses	% of responses	Feedlot capacity represented ≥5000	% of responding feedlot capacity
Amendment	8	45	110000	20
Record windrow temperature	4	22	30000	5
Addition of moisture	6	33	53500	10
Total	18	100	193500	35

Table 47 shows that 27 feedlots screen manure (**Photograph 47**) as part of their usual manure management practices. Most of these feedlots (18 feedlots or 58% of the total surveyed capacity) screen prior to spreading or on-selling. Three of the feedlots (9% of the responding feedlot capacity) that screen do so only when manure is dry, generally during the summer months. Four of the feedlots (6% of the total surveyed capacity) that screen manure do so about once every three months or only as part of their composting operation. Four of the feedlots (5% of the responding feedlot capacity) that screen manure do so approximately one month after stockpiling or at the completion of pen cleaning.

Twenty-five feedlots indicated that they only screen each batch of manure once, one feedlot screens each batch twice and one feedlot screens each batch three times.

Table 47 – Manure screening

Reason	No. of responses	% of responses	Feedlot capacity represented ≥5000	% of responding feedlot capacity
Prior to application or on-selling	18	67	320433	58
Screened in summer only	3	11	51500	9
At completion of pen cleaning	1	4	20000	4
1 month into stockpiling	1	4	7200	1
Every 3 months	2	7	16800	3
Within composting operation	2	7	16500	3
Total	27	100	432433	78

Twenty-five feedlots reported on-site manure/compost spreading rates (**Photograph 48**). These are summarised in **Table 48**. They are highly variable, ranging from less than 5 t/ha to >30 t/ha. The majority by number (10) and percentage of responding feedlot capacity (10%) spread at a rate of >5-10 t/ha, with six feedlots also representing 10% of the responding feedlot capacity spread manure at a rate of >20-30 t/ha.

Table 48 – Manure/compost spreading rates

Rate	No. of responses	% of responses	Feedlot capacity represented	% of responding feedlot capacity
0-5 t/ha	5	20	10300	2
>5-10 t/ha	10	40	52947	10
>10-20 t/ha	1	4	24175	4
>20-30 t/ha	6	24	52832	10
>30 t/ha	3	12	15275	3
Total	25	100	155529	28

Table 49 shows a breakdown of how feedlots spread manure on-site. Most spread on hay or silage crops or grain crops.

Table 49 – On-site land use for manure spreading

Land use	No. of responses	% of responses	Feedlot capacity represented	% of responding feedlot capacity
Grazed pasture	7	16	22693	4
Hay or silage crops	20	44	49860	9
Grain crops	15	33	69533	13
Cotton	3	7	13443	2
Total responses	45	100	155529	28

Table 50 shows a breakdown of how feedlots, or the enterprises that they sell manure to, spread manure off-site. Manure is used across a range of purposes. Approximately 17% of the responding feedlot capacity spread manure on areas used to grow grain, 15% on areas used to grow cotton / sugar cane, 13% on land used for horticultural crops (olives, vegetables, grapes, citrus and tomatoes), 10% on areas used to grow hay / silage and 7% spread on pastures that are grazed by livestock. Nurseries / landscapers receive approximately 11%, which is used directly or processed further within their businesses'.

Table 50 – Off-site land use for manure spreading

Land use	No. of responses	% of responses	Feedlot capacity represented	% of responding feedlot capacity
Grazed pasture	8	17	36662	7
Hay or silage crops	8	17	54091	10
Grain crops	15	31	91028	17
*Other crops	13	27	81225	15
Horticulture	13	27	73741	13
Nursery / Landscaping	7	15	57147	11
Total responses	64	100	393893	72

*Other crops identified were cotton and sugar cane.

Photograph 37 – Temporary manure mound within a feedlot pen

Photograph 38 – Manure “interface” layer over compacted gravel base

Photograph 39 – Feedlot pen cleaning with retention of interface layer

Photograph 40 – Feedlot pen cleaning to gravel base with interface removal

Photograph 41 – Pen scraping using a box scraper

Photograph 42 – Pen scraping using a front-end loader

Photograph 43 – Pen scraping using an excavator

Photograph 44 – Pen scraping using a grader

Photograph 45 – Loading scraped pen manure into trucks

Photograph 46 – Windrow composting of feedlot manure

Photograph 47 – Screening of feedlot manure

Photograph 48 – Spreading feedlot manure on cropping land

9.2.1 Manure moisture, ash, energy and nutrient characteristics

Pen cleaning timing, frequency and method affects the quality of the manure removed. Davis et al. (2012) undertook a study of manure accumulation rates in feedlot pens. Watts et al. (2013) undertook a study into the use of manure as a thermal fuel. In both studies, a large number of feedlot manure samples were collected and analysed. The results are shown in Figure 28 and Figure 29.

The manure samples were divided into three groups.

1. Fresh faeces –fresh faeces taken on the pen surface.
2. Pen manure –samples taken from a single point on the pen surface. These do not represent an average sample across the pen nor do they represent the full depth of the manure profile on the pen surface.
3. Stockpiled / composted manure – samples taken from manure stockpile / composting areas. There is significant, un-documented variability in the age and handling method of these samples. Some samples could effectively be fresh pen manure while other samples may have been in a stockpile for months. Other samples may have been composted and regularly turned in windrows.

The fresh faeces samples are fairly closely grouped. All have a moisture content of 75% or more. Most fresh faeces samples have an ash content of 10% - 25% (VS content of 75% - 90%). These samples are too wet to be a thermal fuel but if they could be dried without any increase in ash content, they would be a suitable fuel.

The range in values for both the pen and stockpiled / composted samples is large. On average, the ash content of the stockpiled / composted samples is higher than pen manure samples. This is expected. If the interface layer is removed during pen cleaning (**Photograph 40**), clay and gravel can be mixed with the manure. This downgrades the manure and increases the ash content. Similarly, as the organic matter in the manure decomposes, the relative ash content increases.

Very few stockpiled / compost manure samples lie under the Higher Heating Value (HHV) target curve of 8.1 MJ/kg. HHV is the amount of heat (energy) produced by the complete combustion of a fuel. Hence, they are unsuitable as a thermal energy fuel. While there is a large range in the analyses of the pen manure samples, it is clear that a significant number of the samples lie under the HHV target curve of 8.1 MJ/kg.

Figure 29 was prepared to provide more information on the characteristics of pen manure. In this figure, the pen manure was grouped by feedlot and the average data for each feedlot were plotted. **Figure 29** shows that the ash content of pen manure is highly variable. It can be similar to fresh faeces or similar to highly degraded manure.

Figure 29 shows significant differences between feedlots. For example, Feedlot 1 is consistently wetter than other sites and has some very degraded manure samples. This feedlot is located in southern Australia in a winter-dominant rainfall zone. Feedlot 2 similarly has wetter manure but significantly less degraded than Feedlot 1. Except for a few outliers, Feedlot 3 has very dry pen manure. This feedlot is located in a summer-dominant rainfall zone and it operates at a low stocking density, which results in drier pens. Feedlot 3 also retains the interface layer when pen cleaning so the ash content of that pen manure is quite low. In summary, there are significant differences between feedlots. At each feedlot, there is a large range in pen manure characteristics due to management and climate. Hence, it is difficult, but not impossible, to have pen manure that consistently lies under the HHV target curve for thermal combustion of 8.1 MJ/kg.

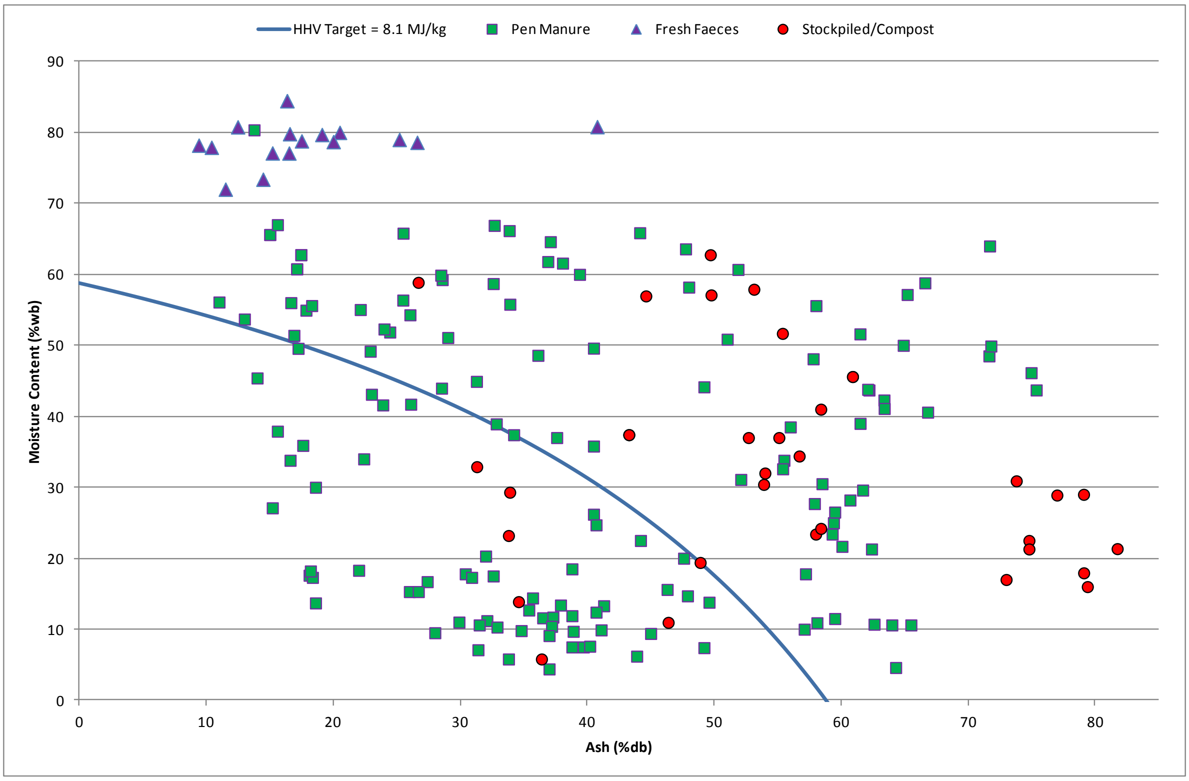

Figure 28 – Relationship between ash content and moisture content for various feedlot manure samples

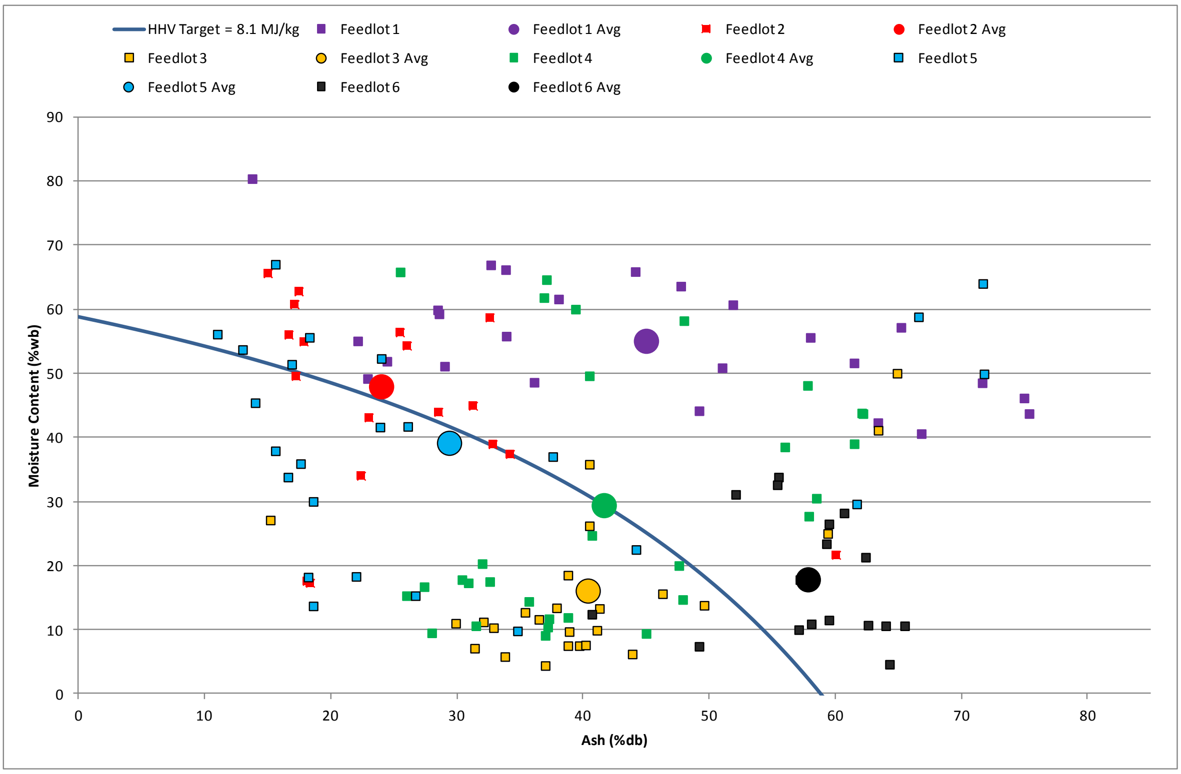

Figure 29 – Relationship between ash content and moisture content for pen surface manure

Similarly, the nutrient content of feedlot manure is highly variable. **Table 51**, **Table 52** and **Table 53** summarise data from numerous feedlot manure analyses for pen manure, aged (stockpiled) manure and composted (windrowed) manure respectively. For each parameter, there is a wide range of results. As with feedlot effluent, given the wide range of manure quality measured across many feedlots, it is concluded that manure nutrient management plans must be based on site-specific manure analyses rather than generic data such as in these tables.

Table 51 – Typical composition of feedlot pen manure (dry matter)

Parameter	Av. Result	Min	Max	No of Samples
Dry Matter (%)	67.5	33.1	95.6	127
Total Nitrogen (% db)	2.31	0.95	4	67
Total Phosphorus (% db)	0.81	0.23	1.21	27
Potassium (% db)	1.77	0.58	3.1	27
Sodium (% db)	0.33	0.08	0.5	27
Sulfur (% db)	0.47	0.31	0.73	29
$EC_{1:5}$ (dS/m)	14.3	5.9	18.8	22
Ammonia-N (mg/kg db)	1612	130	4700	38
Nitrate-N (mg/kg db)	144	0	774	39
Copper (mg/kg db)	43.8	11	68	23
Iron (mg/kg db)	11783	1900	27,000	23
Zinc (mg/kg db)	280	79	430	23

Table 52 – Typical composition of feedlot aged (stockpiled) manure

Parameter	Av. Result	Min	Max	No of Samples
Dry Matter (%)	61.1	37.2	89.0	19
Total Nitrogen (% db)	2.0	0.77	3.3	78
Total Phosphorus (% db)	0.79	0.23	1.5	62
Potassium (% db)	1.94	0.75	3.8	64
Sodium (% db)	0.36	0.049	1.7	59
Sulfur (% db)	0.47	0.18	0.84	57
Calcium (% db)	2.39	0.77	17.7	59
Magnesium (%db)	0.84	0.24	1.58	57
$EC_{1:5}$ (dS/m)	8.71	0.161	20.4	52
pH	7.21	6.3	8.66	54
Ammonia-N (mg/kg db)	1830	0	11,200	38
Nitrate-N (mg/kg db)	121	0	862	33
Boron (mg/kg db)	35.4	0	240	34
Cobalt (mg/kg db)	9.62	2.3	30	13
Copper (mg/kg db)	35.3	3.9	78	34
Iron (mg/kg db)	14,145	200	54,000	31
Manganese (mg/kg db)	349	53	870	34
Molybdenum (mg/kg db)	6.06	0.8	19	20
Ortho-phosphate (mg/kg db)	1200	0	3173	13
Zinc (mg/kg db)	221	70	490	58

Table 53 – Typical composition of feedlot composted (windrowed) manure

Parameter	Av. Result	Min	Max	Number of Samples
Dry Matter (%)	72.9	59	84	22
Total Nitrogen (% db)	2.33	0.7	5.6	27
Total Phosphorus (% db)	1.32	0.49	2.61	21
Potassium (% db)	2.49	0.96	3.4	19
Sodium (% db)	0.41	0.07	0.99	20
Sulfur (% db)	0.54	0.02	1.3	18
Calcium (% db)	2.42	0.5	5.56	21
Magnesium (%db)	0.90	0.24	1.77	20
$EC_{1:5}$ (dS/m)	16.6	2.82	24.8	7
pH	7.46	7	8.31	9
Ammonia-N (mg/kg db)	958	0	2200	14
Nitrate-N (mg/kg db)	588	0	1700	17
Boron (mg/kg db)	33.9	2.81	190	14
Copper (mg/kg db)	41.9	3	170	20
Iron (mg/kg db)	6953	940	22000	18
Molybdenum (mg/kg db)	5.67	2.4	13	5
Ortho-phosphate (mg/kg db)	3115	11	7521	8
Zinc (mg/kg db)	275	70	1000	20

9.3 Mortality management

A few cattle inevitably die during their time at a feedlot. Mortality rates at Australian feedlots are low and typically range from 0.2% to 1% depending on a range of factors.

Tucker et al. (1991) did not report data on the disposal of mortalities. However, at that time, most mortalities were buried. In recent years, there has been a significant move to composting of carcasses. In this process, the carcass is laid out on a bed of straw or manure (Photograph 49) and then covered with manure. The composting is undertaken in either bins or bays (Photograph 50) or in windrows similar to manure composting (Photograph 51). The composting process is usually very efficient with only some large bones remaining. Some lot feeders screen the carcass compost prior to sale or disposal to remove the few remaining bones. The finished compost is then disposed of in the same manner as other manure from the feedlot. This process is more environmentally friendly than burial (which may have leachate issues) or incineration.

Data on disposal of carcasses was obtained from 42 feedlots (5% of total) with a combined capacity of 474 000 head (35% of total industry). Table 41 provides data on the type of carcass disposal method used. It shows that over 80% of the industry now composts carcasses.

Table 54 – Carcass disposal methods at feedlots

Type	No. of feedlots	% of feedlots	Pen Capacity	% Pen Capacity
Composting	34	81	394093	83
Burial	5	12	38990	8
Rendering	2	5	33267	7
Incineration	1	2	7200	2
TOTAL	42	100	473550	100

Photograph 49 – Feedlot mortality about to be composted

Photograph 50 – Carcass compost bays

Photograph 51 – Carcass compost windrows

10 Environmental management plans and accreditation systems

At the time of the Tucker et al. (1991) survey, virtually no environmental management systems or plans were in use at Australian feedlots. Since that time, a number of different management systems and/or accreditation schemes have been introduced. These provide a framework in which a lot feeder can operate their feedlot in an environmentally sustainable manner. Some of these management systems and accreditation schemes are described below.

10.1 National feedlot accreditation scheme (NFAS)

The National Feedlot Accreditation Scheme (see Section 4.4) was the first agriculturally-based quality assurance scheme implemented in Australia and was proactively developed to ensure that every accredited feedlot met legislative requirements and exceeded community expectations. It is managed by FLIAC and is recognised under various state legislation. Under the scheme, feedlots are independently audited each year to ensure compliance with animal welfare, environment, biosecurity, food safety and product integrity legislation. NFAS requirements are continually updated as developments in legislation, codes of practice, guidelines, technology, best management practice and science occur.

The NFAS manual includes modules on environmental management. ALFA has secured Queensland Government support for NFAS accredited lot feeders in Queensland to receive a 20% discount on their environment licence fees. This is a recognition that NFAS accreditation ensures sound environmental management. However, to access this discount, the responsible person and other staff who make environmental decisions at the feedlot must complete environment training. ALFA and MLA have come together to provide environmental training workshops for lot feeders so that they can access the 20% fee discount. The training module requires workshop attendees to bring along a copy of the latest version of the National Beef

Cattle Feedlot Environmental Code of Practice, their Environmental Feedlot Licence and Environment Licence Conditions so these can be incorporated into their HFAS manual.

10.2 Environmental management plans and systems (EMPs and EMS)

Environmental management plans and/or environmental management systems became popular in agriculture in the late 1990s and early 2000s. Many departments of agriculture and industry bodies promoted their adoption on farms and several regulatory agencies mandated the development of EMPs for feedlots.

An EMP is a site-specific plan developed to ensure that all necessary measures are identified and implemented to protect the environment and comply with environmental legislation. An EMS refers to the management of an organisation's environmental programs in a comprehensive, systematic, planned and documented way. It includes the organisational structure, planning and resources for developing, implementing and maintaining, solely for environmental protection. It follows a Plan – Do – Check – Act cycle.

Many feedlots still have an EMP or EMS but these became obsolete as stand-alone documents when their operating procedures and environmental monitoring requirements were integrated into the NFAS manual.

10.3 ISO 14000 and ISO 9000 accreditation

ISO 14000 is a set of internationally recognised voluntary environmental standards developed by the International Organization for Standardization (ISO) in Amsterdam. ISO 14001 is the international EMS standard. It describes specific EMS requirements. ISO14001 is a specification standard for which an organisation may receive certification. ISO 14000 standards simply set general requirements for organisations to meet. These standards are flexible in delivery and do not specify environmental performance requirements. ISO 9000 is a similar set of standards on quality control. Together, they represent the highest international standards for accreditation.

About 10-15 years ago, various organisations promoted the adoption of ISO 9000 and ISO 14000 in feedlots. The maintenance of ISO accreditation involves regular detailed auditing. Some feedlots adopted these systems but have since let them lapse as the cost of accreditation does not match the perceived benefits, particularly when they have NFAS accreditation.

During the survey, only five feedlots were identified as having ISO 9000 and/or ISO 14000 accreditation. In all cases, these feedlots were part of a larger integrated supply chain and accreditation was part of a corporate quality / environmental management system.

10.4 EU accreditation

The European Union (EU) will not accept Australian beef unless it meets certain production requirements. These requirements include:

- Individual animal ID for trace-back of cattle slaughtered for the EU market
- Evidence that the beef is from cattle that have not been treated with hormonal growth promotants (HGPs)

The European Union Cattle Accreditation Scheme (EUCAS) is a national animal production scheme that guarantees full traceability of all animals through the National Livestock Identification System (NLIS), linking individual animal identification to a central database. EUCAS allows Australia to meet EU market requirements for beef by segregating cattle that have never been treated with HGPs at any time. Feedlots must be EUCAS accredited if they want to produce animals that can be exported as meat to the EU. A feedlot is a registered business covered by a single Property Identification Code (PIC) under State or Territory legislation where cattle are confined and fed high–energy diets to maximise their growth prior to slaughter. Feedlots may contain segregated EUCAS and non–EUCAS cattle. EU accreditation rules for feedlots are available at http://www.daff.gov.au/biosecurity/export/meat/elmer-3/eucas/feedlots.

A list of EU accredited feedlots is available at the above website. There are 41 accredited feedlots with a total pen capacity of 516 124 head. This represents 38% of the total industry. However, most accredited feedlots assign only a small section of the feedlot specifically to EU cattle.

10.5 National pollutant inventory (NPI)

The following information about the National Pollutant Inventory is taken from the website (http://www.npi.gov.au/).

The National Pollutant Inventory (NPI) is tracking pollution across Australia, and ensuring that the community has access to information about the emission and transfer of toxic substances which may affect them locally.

There has been increasing community demand to know about toxic substances emitted to the local environment. Australian, state and territory governments have agreed to legislation called National Environment Protection Measures (NEPMs), which help protect or manage particular aspects of the environment. Australian industries are required to monitor, measure and report their emissions under this legislation.

The desired environmental outcomes of the NPI program are to:

- *maintain and improve air and water quality*
- *minimise environmental impacts associated with hazardous waste, and*
- *improve the sustainable use of resources.*

The NPI contains data on 93 substances that have been identified as important due to their possible effect on human health and the environment. The data comes from facilities like mines, power stations and factories, and from other sources such as households and transport.

Facility operators determine their own emissions and transfers, and diffuse emissions from households and other sources like motor vehicles are estimated by government agencies. Tracking pollution through the NPI is essential to enhance environmental quality; increase public and industry understanding of the types and quantities of toxic substances emitted into the environment and transferred off-site as waste; encourage industry to use cleaner production techniques to reduce emissions and waste generation; track environmental progress; meet community right-to-know obligations; and assist government in identifying priorities for environmental decision-making.

A manual produced by the NPI (Department of the Environment and Water Resources 2007) describes the procedures and recommended approaches for estimating emissions from facilities engaged in the operation of beef cattle feedlots. In this manual, a minimum threshold for reporting can be calculated assuming that Category 1 – Ammonia is the only significant emission. On this basis, all feedlots greater than 122 SCU on-hand during the year should report to the NPI as the manual estimates an annual emission of more than 10 t ammonia per year. Larger feedlots may also need to report on substances used as a result of fuel and power consumption (Department of the Environment and Water Resources 2007)

Data reported to NPI, including the location of each facility, is publicly available on the NPI website. Assuming an average occupancy of 60%, this means all feedlots with a pen capacity of more than 200 SCU. Using these data, 552 feedlots with greater than 200 SCU average operating capacity should have reported. From the database created for this project, this represents about 64% of feedlots and about 97% of pen capacity. However, according to the NPI database, 119 feedlots with a capacity of 825 316 head have reported. This only represents 61% of the total industry. This incomplete reporting for the feedlot sector would suggest that the NPI inventory is not enforced and a poor guide to the pollution caused by feedlots across Australia. Feedlots are opposed to reporting because it identifies their location. Their operation can then be targeted by special-interest groups.

11 Resource usage

At the time that the Tucker et al. (1991) report was prepared, the main focus was on environmental performance, which meant odour, runoff control and manure management. At that time, greenhouse gases were not an issue. Energy and water were low cost inputs and, essentially, not considered to be limited resources. Hence, these issues were not discussed by Tucker et al. (1991).

In the intervening years, water and energy have become major issues for the lot feeding sector.

11.1 Water

With increasing variability in climate and greater stresses being placed on water resources, water availability and security cannot be taken for granted. Water is a critical resource for lot feeding and can be a significant expense. Water is essential for cattle drinking needs, feed processing, cleaning (including yards, machinery and cattle washing) and other general practices around the feedlot. Water is also ‘used’ or lost as evaporation and seepage from open storages. Of these, the vast majority of water is used for cattle drinking requirements.

11.1.1 Water sources

A feedlot needs a reliable source of good quality water. Data on water sources was collected from 73 feedlots with a combined pen capacity of 636 000 head. In some instances, water is obtained from more than one source. In these cases, the pen capacity supplied was distributed according to the percentage obtained from each source.

The descriptions of the water sources are as follows:

1. Groundwater – deep bore, GAB. This is water from a bore accessing an aquifer that is deep (probably >100 m). The aquifer would not be recharged locally. In most cases, this is water supplied from the Great Artesian Basin (GAB). This water supply is generally highly reliable but may have salinity issues.
2. Groundwater – shallow bore. This is water obtained from a shallow aquifer that is probably recharged locally. Typically, this would be aquifers accessed by windmills. This water supply is more reliable than an on-farm dam but less reliable than the GAB.
3. On-farm dam. This is water stored in on-farm dams that fill from local runoff. This does not include ring-tank type storage where the dam is mainly filled by pumping from rivers. On-farm dams can have an unreliable supply due to drought conditions.
4. Unregulated stream. This is water pumped directly from a watercourse under natural flow conditions. This may be during a flood (flood harvesting) or during low flow conditions under a licence. These water supplies can be unreliable and unpredictable in occurrence. Large on-farm storages are generally required to provide a reliable water supply to the feedlot.

5. Regulated stream. This is water taken from a government or water authority (e.g. Goulburn Valley Water) supply scheme (large dam) either pumped from a watercourse or supplied to the farm via channels or pipes. These water supplies are generally reliable except in times of drought when reduced allocations are provided. In some cases, high-security licences can be obtained that provide priority water access during drought conditions.
6. Local government water supply. In a limited number of cases, water is supplied by local government as part of a town water supply scheme. Typically, this water supply is highly reliable but expensive.

Table 55 shows the breakdown of water sources for feedlots. The majority of feedlots obtain their water supplies from shallow or deep bores (60% of pen capacity) as these supplies are reliable and of a suitable water quality. Only 10% of feedlots rely on water from drought-sensitive sources such as on-farm dams and flood harvesting. Few feedlots use local government water supplies as the cost per ML is very high.

Table 55 – Sources of water for feedlots

Water Source	No. of cattle (pen capacity) supplied	% of cattle supplied
Groundwater – deep bore, GAB	212 837	33
Groundwater – shallow bore	175 124	27
On-farm dam	31 951	5
Unregulated stream – flood harvesting	29 400	5
Regulated stream – government allocation	164 010	26
Local government water supply	22 525	4
TOTAL	635 847	100

11.1.2 Water security issues

Lot feeders were asked if they believed that they had any water security issues. Responses were received from 42 feedlots (5% of total) with 506 000 head pen capacity. Of these, 10 feedlots with 118 000 head capacity (23% of pen capacity) believed that they had issues over water supply security. The specific issues included concerns about the impact of coal seam gas development on local aquifers and cuts to groundwater allocations and assess rules since the feedlot was developed.

11.1.3 Temporary water storage

Most feedlots have a temporary water storage adjacent to the feedlot. This storage can provide water to cattle in the event of a breakdown in delivery from the main water source. This temporary water source is usually designed to supply several days of peak water demand depending on the supply circumstances at the feedlot. Usually, the temporary water storage is located in a position that allows gravity supply of water to the feedlot. This allows for continuous water supply to the cattle even during periods of power loss. Where the temporary water storage could not supply water by gravity, a back-up generator or a diesel engine was provided to ensure continuous supply.

For larger feedlots, these storages need to be fairly large and conventional concrete tanks become cost-prohibitive. The usual solution is a “turkey’s nest” storage. These storages can lose water due to evaporation and can become contaminated with algal growths. Hence, in recent years, some feedlots have covered their temporary water storages. However, where the water supply is from the GAB, the water can be hot. An open temporary storage is required to allow the water to cool (with a subsequent evaporation loss). Concrete tanks are usually covered.

The survey sought information on temporary water storage. Most data were readily available except for the number of days of storage on hand. Data were obtained from 73 feedlots (9% of total) with a total pen capacity of 676 000 head (50% of total pen capacity). Most lot feeders were unable to state with certainty the number of days of storage available during peak demand. Of those who did know the number of days available (34 feedlots), this ranged from 1 day to 500 days with an average of 34 days.

Table 56 – Temporary water storage at feedlots

Item	Yes		No	
	Pen Capacity	% Pen Capacity	Pen Capacity	% Pen Capacity
Temporary storage on-site	665 868	44	0	0
Gravity feed to feedlot	560 268	38	75 750	17
Covered storage	273 609	18	365 759	83

11.1.4 Water metering

Lot feeders were asked if they metered the water usage at the feedlot. Some feedlots meter the bulk water used on-site as a requirement of the water supply licence.

Most feedlots surveyed (53% of 396 000 pen capacity surveyed) do not measure against any activity in the feedlot or benchmark water usage. Hence, it is not possible to determine KPI's based on water usage at this time. However, there is increasing interest in the need to understand water consumption.

One feedlot did meter water usage and stated that the average water usage was 52 L/head/day with a range of 36 to 64 L/head/day.

11.1.5 Water usage and KPIs

No water usage KPI data is available from this study. However, Davis et al. (2010a) reports on a study where eight feedlots (Feedlots A to F) were selected to provide a sample group representative of the geographical, climatic and feeding regime diversity within the Australian feedlot industry. At seven of these feedlots, water meters were installed to allow an examination of water usage by individual activities from March 2007 to February 2009. The major water usage activities (drinking water, feed management, cattle washing, administration and sundry uses) were monitored and recorded. Water usage was standardised and presented as litres used per kilogram of hot standard carcase weight (HSCW) gain equivalent (L/kg HSCW gain) or litres per head on-hand per day (L/head/day).

Total annual clean water use (without dilution of effluent) ranged from 33 L/kg HSCW gain/month at Feedlot D in 2008 to 73 L/kg HSCW gain/month at Feedlot C. The average monthly total water usage in 2007-2008 was 51.5 L/kg HSCW gain, slightly higher than the 49.5 L/kg HSCW gain measured in 2008-2009.

When issuing a licence for a feedlot in Queensland, the licensing authority requires that the feedlot has a correctly licensed, high-reliability water supply equivalent to 24 ML per year for each 1000 SCU of licensed capacity. This requirement makes a small allowance for other uses such as trough cleaning, minor leakages but does not allow for significant usage for the purposes of dust control, grain processing or evaporation from open storages. In the Davis et al. (2010a) study, the total water usage on a 1000 head-on-feed basis for the period March 2007 to February 2009 ranged from 13 to 20.5 ML/1000 head-on-feed, well below the required amount.

Drinking water contributed in the order of 90% of the total water usage in the months when no cattle where washed and contributed on average 27.6 to 60.8 L/kg HSCW gain across all feedlots. Up to 87 L/kg HSCW gain was measured in one month. This reduced to about 75% during months when cattle washing was undertaken. Drinking water consumption is driven by rainfall and heat load as expected. During rainfall, drinking water consumption is suppressed and increases to maximum levels during periods of high heat loading. The differences between feedlot drinking water consumption on a kg HSCW gain basis could be attributed to the differences between market types (long fed - low daily gain vs. domestic - higher daily gain). However, the primary driver of drinking water consumption was climatic variation.

Davis et al. (2010a) reported that the average drinking water consumption ranged from 29 to 46 L/head/day. The average monthly drinking water consumption in 2007-2008 was 39.1 L/head/day, slightly higher than the 37.2 L/head/day measured in 2008-2009. When averaged over a month, the highest average drinking water consumption was 44 L/head/day measured in a sub-tropical environment, whilst the lowest average drinking water consumption of 30 L/head/day was measured in an environment with cold winters, mild summers and high rainfall. These levels are less than the often quoted figure within the industry of an average of 65 L/head/day.

The maximum drinking water consumption recorded was 80 L/head/day at Feedlot A during January 2009 and the minimum of 12 L/head/day was recorded at Feedlot B in June 2007 and 2008. This difference could be attributed to differences in climatic conditions between these two feedlots including temperature and rainfall. Feedlot B experienced a very cold and wet June 2007 and 2008, whilst Feedlot B experienced a hot and dry January 2009.

The relationship between drinking water consumption, heat load index and rainfall was clearly evident on a daily basis. During periods of rainfall, drinking water consumption was suppressed, whilst during periods of high heat load, drinking water was at its highest.

Data on the water usage in cattle washing is given in Section 8.5. Where no cattle washing was undertaken, grain processing water usage was the second highest consumer of water in feedlots. Three different grain processing systems were represented within the seven feedlots and included tempering, reconstitution and steam flaking. Grain processing contributed about 4% of water use per kg HSCW gain depending on the grain processing system used. This figure varied slightly from month to month depending on the management of the various systems. However, on average the levels were similar between years.

The average grain processing water usage ranged from 80 to 390 L/t grain processed. For feedlots that process grain by tempering only or tempering and reconstitution, the total water added to the grain accounted for 90% of the total water used in feed processing. For tempering only systems, the water added to the grain was similar to the total water used. Hence, tempering had a very low volume of unaccounted-for water. For reconstitution, an average of 40 L/t grain was unaccounted-for.

For feedlots that steam flaked grain, the total water added to the grain accounted for about 45% of the total water used for feed processing. Water usage and unaccounted-for water within steam flaked systems was variable with an average unaccounted-for loss of 225 L/t grain. Therefore, in steam flaking, if the tempering component water usage was reflected in additional water in the grain, the majority of unaccounted-for water could be attributed to the process of steam generation and delivery. A number of factors influence grain processing water usage including system employed, grain type, target moisture and management of the system.

Administration water usage comprised that used in office and staff amenities and for watering of lawns and gardens. Average administration water usage ranged from 0.6 to 5.2 L/kg HSCW gain over the period March 2007 to February 2009. Administration represents a small proportion of the total usage, about 2%, and is driven primarily by the volume of water irrigated onto lawns and gardens.

The sundry water losses ranged from 0.03 L/head/day to 4.1 L/head/day. Water storage evaporation, trough cleaning and road watering are the three largest sundry water uses. Variation between feedlots could be explained by feedlot design (surface area open water storages, size of troughs), location (climate) and management operations including frequency of trough cleaning and road maintenance (dust control).

11.1.6 Water use efficiency

As approximately 90% of water used at feedlots is drinking water for cattle, there is limited scope for the adoption of water use efficiency practices. However, some water use efficiency practices were noted.

1. Covering of temporary water storages. Some feedlots have placed plastic covers over temporary water storages to reduce evaporation losses. The cost is significant and is only justified when the cost of water is high or when there is another benefit such as algae control.
2. Changes to water quality and supply to boilers and steam chests. Some feedlots noted that water usage at the steam flaker could be reduced through using better quality water (e.g. treatment by reverse osmosis) or changing the flow rate into the steam chest.

These water use efficiency activities are fairly minor in the context of the overall water usage at a feedlot. The only significant change that could possibly be made is the elimination of cattle washing where this occurs.

11.2 Energy

11.2.1 Energy usage measurement

Due to the recent steep increases in the cost of energy, in particular electricity, many feedlots reported that they had started measuring energy usage and looking for energy savings. However, this is a relatively recent activity and this has not been undertaken in a standard or co-ordinated manner that would allow the calculation of KPIs and benchmarking energy usage. A number of the consulting nutritionists that work for the major feedlots have been trying to get energy usage measured and a number of the larger, corporate feedlots measure energy usage because this is required throughout the whole of the corporate's enterprises. There is very little data available to report as representative of the industry as a whole.

11.2.2 Energy usage at feedlots and KPIs

Energy usage is an increasing input cost for feedlot operations. Energy costs, particularly electricity, have been rising significantly in recent years. In addition, these costs rose even more with the introduction of a carbon tax on energy production, although this may be removed in the near future. These factors have made energy savings an important research focus area for feedlots.

MLA has previously undertaken a project (FLOT.328 – Davis and Watts (2006)) to measure the environmental costs associated with the production of one kilogram of meat from modern

Australian feedlots. As part of that project, measured data on total water and energy use were obtained via a detailed on-line survey. Feedlot inputs and outputs including cattle numbers, intake and sale weights, dressing percentages were also collected to standardise resource usage on the basis of one kilogram of hot standard carcass weight gain (kg HSCW gain). This project demonstrated that whilst lot feeders usually have good records of total annual clean water and energy usage, little data exists on actual usage levels for the individual components of the operation, including water supply, feed management, waste management, cattle washing, administration and repairs and maintenance. Hence, foreseeing these drivers for industry change and a lack of credible data, MLA has provided significant investment to quantify the water and energy usage of individual activities at Australian feedlots in a follow-up project (B.FLT.0350 – Davis (2010b)).

The purpose of the B.FLT.0350 study was to quantify the clean water, indirect and direct energy usage from individual feedlot activities. Eight feedlots were selected such that the feedlots represent a cross section of geographical, climatic and feeding regime diversity within the Australian feedlot industry. The sub-system boundary as defined here is the feedlot site itself plus the transport component of bringing cattle and feed into the feedlot and delivering cattle from the feedlot.

Water meters and/or power meters were installed at the eight feedlots to allow an examination of usage by individual activities. The major clean water-using activities include cattle drinking water, feed management, cattle washing, administration, repairs and maintenance and dilution of effluent. Similarly activities that use a significant amount of energy include water supply, feed management, waste management, administration and repairs and maintenance. Data was collected from March 2007 to February 2009.

The water and power meter data collected were supplemented with existing data collected on-site including fuel consumption (diesel, LPG) and cattle performance data. Performance data includes market types, incoming and outgoing liveweights, dressing percentages, feed data and other parameters that allow HSCW gain to be estimated. Information was collected on a monthly basis and collated.

The data were analysed to obtain water and energy use associated with a number of feedlot indices including a per head-on-feed basis, per tonne grain processed and per kg HSCW. A breakdown of resource use by feedlot activities and associated operations was undertaken.

For energy, the results from the seven feedlots studied showed that total annual indirect energy use ranged from 32.1 MJ/kg HSCW gain (Feedlot C) to 71.9 MJ/kg HSCW gain (Feedlot E) over the study period. The energy used in transporting cattle and commodities to the feedlot showed the greatest variation between months and years. Between March 2007 and February 2008, commodity energy usage, on average, was greater than incoming cattle. However this was reversed over the period March 2008 to February 2009. This is a reflection of tighter cattle supply and improved availability of commodities over the previous 12 months. Distance travelled by trucks transporting cattle and delivering feed has a large impact on the energy consumed. Combined these represent a similar usage level to direct energy consumed within the feedlot subsystem.

Incoming cattle energy usage typically ranges from 1.0 MJ/kg HSCW gain/month to 2.0 MJ/kg HSCW gain/month, when cattle are sourced close to feedlots. However, energy usage up to 7 MJ/kg HSCW gain/month were measured in May to August 2008 at Feedlot G. Outgoing cattle energy usage typically ranges from 0.5 MJ/kg HSCW gain/month to 0.9 MJ/kg HSCW gain/month. However, 2.8 MJ/kg HSCW gain/month has been measured. On average, the monthly commodity delivery energy usage ranged from 1 MJ/kg HSCW gain to 3 MJ/kg HSCW gain but a figure of 6 MJ/kg HSCW gain has been recorded.

The indirect energy usage illustrates the proximity of respective feedlots to cattle, abattoirs and commodities. Energy usage levels are influenced by the differences in average daily gain between long fed cattle and domestic cattle, number and type of commodities used in rations (high grain versus high roughage). These results also clearly show the impact of the drought (grain and available cattle supply) and high grain prices on the industry in particular during the latter half of 2007 and early 2008, where higher energy usage figures were recorded. When possible, commodities (& cattle) are sourced close to feedlots and this is shown through the second half of 2008 when energy usage for commodities reduced and incoming cattle increased compared with previous months.

The average monthly total energy usage across all feedlots for March 2007 to February 2009 ranged from 1.6 MJ/kg HSCW gain/month at Feedlot A to 7.8 MJ/kg HSCW gain/month at Feedlot B, with an average in the order of 6 MJ/kg HSCW gain/month. The total annual energy usage in 2007-2008 ranged from 18.5 MJ/kg HSCW gain at Feedlot A to 82.9 MJ/kg HSCW gain at Feedlot B. The total annual energy usage in 2008-2009 was slightly higher when compared to the previous year with a range of 22.5 MJ/kg HSCW gain (Feedlot A) to 92.8 MJ/kg HSCW gain (Feedlot B) (see **Figure 30**).

The average monthly total energy usage across all feedlots for March 2007 to February 2009 ranged from 49 MJ/head-on-feed/month at Feedlot A to 160 MJ/head-on-feed/month at Feedlot E. Feedlots with steam-flaking feed processing systems had an average usage in the order of 120 MJ/head-on-feed/month, compared with an average of about 45 MJ/head-on-feed for feedlots that process grain by other means. The total annual energy usage in 2007-2008 ranged from 583 MJ/head-on-feed (Feedlot E) to 1483 MJ/head-on-feed (Feedlot D). The total annual energy usage in 2008-2009 was slightly higher when compared to the previous year with a range of 626 MJ/head-on-feed (Feedlot A) to 1624 MJ/head-on-feed (Feedlot B). Feedlot C had the greatest monthly variation in 2007-2008 and 2008-2009 (see **Figure 31**).

A wide variation was measured in water supply energy usage. On average, water supply represents in the order of 3% of the total energy usage. Water supply energy usage between feedlots is dependent on a number of factors, including depth to groundwater and distance to supply. Within feedlots, water supply energy usage is directly proportional to the water pumped per month.

The average monthly water supply energy usage across all feedlots for March 2007 to February 2008 ranged from 0.04 MJ/head-on-feed/month at Feedlot G to 6.6 MJ/head-on-feed/month at Feedlot A, with an average in the order of 2.5 MJ/head-on-feed/month. Feedlot A had the highest average water supply energy consumption due to sourcing its water from bores located some distance to the feedlot and pumping against high head. Similar, levels were measured across all feedlots between March 2008 and February 2009 with the exception of Feedlot F, which doubled its energy usage. This increase can be explained by the commissioning of a series of bores to supplement their water supply.

Feedlots A, B, C and F have gravity fed water reticulation systems. Feedlot D, demonstrates the additional energy usage incurred by delivery of water to the pens via a pumping system compared with a gravity supply system.

As expected, feed management is the largest single consumer of energy in the feedlot. For those feedlots with steam-flaking systems, it contributed on average approximately 80% of total usage, whilst for those feedlots which process their grain by other means it represents around 45% of total energy usage. Feed management energy usage has been proportioned into feed processing and feed delivery usage.

Feed processing energy usage is the largest single consumer of energy in feedlots. The average monthly feed processing energy usage measured between March 2007 and February 2009 ranged from 20 (Feedlot D) to 480 MJ/t grain processed at Feedlot C. Three different feed processing systems are represented within the seven feedlots. Feedlots C, E and F steam-flake grain whilst Feedlots A, D and G either temper only or temper and reconstitute grain. Feedlot B tempered grain from March 2007 to May 2007, then commissioned a steam-flaker in June 2007. For feed processing systems other than steam-flaking, average energy usage is typically less than 50 MJ/t grain processed. For steam-flaking, the total energy usage ranges from 280 to 480 MJ/t grain processed (**Figure 32**). Hence, there is a large variation between feed processing systems and between feedlots with the same system.

Feedlots D, E and G have similar feed processing levels between years, whilst Feedlot C and F recorded a higher usage in 2008-2009. The higher usage by Feedlot F can be explained by type of grain processed and the installation of a liquid supplements and batch-box system in March and June 2008 respectively. The power for the liquid supplements and batch-box system is provided by the feed mill and was not metered separately. In 2007-2008, barley was the grain used, whilst sorghum was used throughout 2008-2009.

The average monthly feed processing electricity energy usage measured ranged from 20 to 50 MJ/t grain processed. The variation in electricity energy usage may be attributed to monthly variation in grain delivery, movement and storage, milling efficiency (tonnes per mill) and type of grain milled.

For steam-flaking systems, a review of monthly feed processing data showed that there was an increase in energy usage during the cooler winter months. Hence, more energy is required to heat water and compensate for increased heat transfer losses. Setup and operation of feed processing systems will also influence total energy usage.

For steam-flaking systems, the average monthly gas energy usage measured in 2007-2008 ranged from 240 to 380 MJ/t grain processed. Slightly higher levels were measured in 2008-2009 (260-430 MJ/t grain processed). Some of the variation in gas usage can be attributed to heating efficiency during winter months but mill management also impacts on energy consumption.

Feed delivery energy was measured and comprised electricity used by stationary mixers, diesel consumed by loaders during feed loading and by feed trucks delivering ration to pens where appropriate.

The total monthly average feed delivery energy usage measured ranged from 24 (Feedlot E in 2008) to 52 MJ/t ration delivered (Feedlot F in 2007). A number of different feed delivery systems are represented within the seven feedlots. This includes stationary mixing, bunker system, batch-box and a number of varying combinations in mobile equipment. Mobile equipment combinations included tractor/trailed mixer units, ROTO-mix trucks (various capacities and number), loaders (number, no of ingredients and bucket capacities) and screw mixer trucks.

Feedlots A, B, D, F and G have an average monthly feed delivery energy usage ranging from 45 to 52 MJ/t ration delivered. Feedlot C (34 MJ/t ration) and Feedlot E (26 MJ/t ration) have considerably less energy usage when compared with the remaining feedlots. Feedlots B, E, F and G reduced their average monthly feed delivery energy usage in 2008-2009 when compared with 2007-2008 levels. Feedlots C and D increased energy usage. This may be a reflection of lower cattle numbers on feed and their distribution of cattle throughout the feedlot.

The feedlot with the highest average feed delivery usage was double that of the lowest. Whilst feed delivery energy usage is dependent on the system and equipment utilised, pen layout and feed-out method also influence the energy used.

The total feed delivery energy usage was able to be divided into that consumed during loading of commodities and that used by the mobile equipment during delivery. The average monthly energy usage by loaders ranges from 7 (Feedlot E) to 22 (Feedlot B) MJ/t ration delivered/month and are similar between 2007-2008 and 2008-2009.

The energy used by loaders is dependent on a number of factors including the size of loader, bucket capacity, number of ingredients loaded and the other feed related activities that the loader/s may need to undertake. Other feed related activities may include transporting hay/straw from storage areas to tub grinders, silage from silage pits, high moisture grain from storage areas etc. The lower number of ingredients in the ration at Feedlot E compared with Feedlot B may be a plausible explanation for the lower energy usage.

The energy used by feed delivery equipment is dependent on a number of factors including the number, volumetric capacity, engine capacity, commodity loading positions and pen layout. Feedlots A, B, D, F and G had an average feed delivery energy usage ranging from 45 to 52 MJ/t ration delivered. Feedlot C (34 MJ/t ration) and Feedlot E (26 MJ/t ration) had considerably less energy usage when compared with the remaining feedlots.

Feedlots B, E, F and G reduced their average monthly feed delivery energy usage in 2008-2009 when compared with 2007-2008 levels. Feedlot C and D increased energy usage, a reflection of lower cattle numbers on feed and their distribution of cattle throughout the feedlot.

Feedlot E used, on average, half of the energy of the highest average feed delivery energy usage (Feedlot F). Whilst feed delivery energy usage is dependent on the system and equipment utilised, pen layout and feed-out method, number of ingredients in the ration and density of the ration also influences the energy used. Consider, Feedlot E and Feedlot C. At Feedlot E, feed delivery was undertaken with two primary ROTO-Mix trucks with a combined horsepower of 535 hp (26 hp per tonne capacity) and cattle are fed twice per day. The hp per tonne capacity for Feedlot C was similar to Feedlot E along with a similar density ration. Feedlot E delivered a higher density finisher ration to consecutive rows and pens thus minimising travel distance. Hence, the feed out approach may be a plausible explanation for the lower energy usage measured.

Feedlot F implemented a new feed delivery system in June 2008 with the commissioning of a liquid supplements, larger capacity loader and batch-box system. This new system translated into a significant reduction in average monthly feed delivery energy usage.

Typically, waste management contributed 18 % of total energy usage. However, this was quite variable between months. Waste management energy usage contributed between 0.12 MJ/kg HSCW gain and 1.26 MJ/kg HSCW gain of total energy usage.

Expressed on a per head-on-feed basis, the average monthly waste management energy usage ranged from 4 MJ/head-on-feed/month at Feedlot B in 2008 to 15 MJ/head-on-feed/month at Feedlot F in 2007. The variation between feedlots can be attributed to the various manure management systems employed at each feedlot. It was driven by the frequency of cleaning, equipment used and the volume of manure removed. There was significant variation between months due to climatic conditions, frequency of cleaning and volume of manure removed. The environment at Feedlots F and G are characterised by cool temperatures and winter dominant rainfall and therefore they have a higher monthly average usage compared with other feedlots.

As expected, pen cleaning contributed the highest proportion of the total monthly waste management energy usage. On average, pen cleaning energy usage ranged from 4 (Feedlot B in 2008) to 8.5 MJ/head-on-feed/month (Feedlot B in 2007). However, usage figures up to 27 MJ/head-on-feed/month were measured in one month at Feedlot E in 2007. On average, there was less energy usage in 2008 compared with 2007, a reflection of drier conditions experienced at most feedlots, with the exception of Feedlot F, which maintained a consistent program of pen cleaning. Interestingly, whilst pen cleaning energy usage remained at similar levels between years at Feedlot F, energy used to stockpile manure reduced. This is a reflection of using one truck rather than two for this task.

Cattle washing energy usage ranged between an average 0.02 MJ/kg HSCW gain (0.3%) and 0.1 MJ/kg HSCW gain (1%) of total energy usage. The energy consumed in cattle washing was directly related to the volume of water used. Water usage was dependent on the dirtiness of cattle and the cleaning requirements.

Expressed on a per-head washed basis, the average monthly cattle washing energy usage measured in 2007 ranged from 1 MJ/head-washed/month at Feedlot F to 12 MJ/head-washed/month at Feedlot B. In 2008, slightly less average monthly cattle washing energy usage was measured with 0.8 MJ/head-washed at Feedlot A to 11 MJ/head-washed at Feedlot B. This reflected the drier conditions experienced and therefore reduced cleaning requirements for cattle.

Administration and minor activities (cattle management, repairs and maintenance) contributed on average between 0.2 MJ/kg HSCW gain (Feedlot E) and 1.2 MJ/kg HSCW gain (Feedlot D) of total energy usage. Typically, administration and minor activities represented between 4 and 50% of the total energy usage on a per kg HSCW gain basis.

In 2007-2008, the average monthly administration energy usage ranged from 240 MJ/staff FTE at Feedlot E to 565 MJ/ staff FTE at Feedlot G where administration electricity usage was metered separately. Average monthly administration energy usage increased in 2008-2009 at Feedlots D, F and G. This was a reflection of lower staffing levels in 2008-2009, compared with previous year due to the state of the industry.

Average monthly usage was usually higher in the summer months suggesting that air conditioning of office facilities is driving energy usage.

Cattle management energy usage includes both processing and hospital activities and was expressed on basis of per total head processed (inducted and shipped) not head-on-feed. Energy usage was predominantly electricity used for lighting, cleaning and restraint facilities. The average monthly energy usage for cattle management ranged from 0.10 MJ/head processed at Feedlot A to 5 MJ/head processed at Feedlot E in 2007-2008.

Repairs and maintenance includes electricity usage in workshop facilities as well as diesel usage from mobile plant used in repair and maintenance activities. It was expressed as head-on-feed. The average monthly energy usage for repairs and maintenance ranged from 0.4 MJ/head-on-feed/month at Feedlot D to 9 MJ/head-on-feed/month at Feedlot C in 2008-2009. The significant increase in Feedlot C energy usage per head-on-feed can be attributed to the combined effect of lower numbers of head-on-feed in 2008-2009 compared with 2007-2008 and an increased opportunity repairs and maintenance program due to lower cattle numbers. This highlights that certain activities have a inherent minimum level of energy usage, independent of cattle on feed.

Actual energy usage levels within individual activities were recorded on a monthly basis at seven feedlots representative of the Australian feedlot industry. The activities measured included water supply, feed management, waste management, cattle washing and administration and minor activities (cattle management and repairs and maintenance).

The outcomes of this study will allow the feedlot industry to develop a better understanding of the impact and relativity that various feedlot activities have on overall energy consumption. This information is invaluable for future design and management considerations. This study offers individual feedlot operators the opportunity to identify options for conserving energy in the feedlot and estimated cost benefits for alternative management practices if they were implemented.

Although little data was obtained in this survey, the work of Davis et al. (2009) should allow interested lot feeders to measure and benchmark their energy usage against this published data.

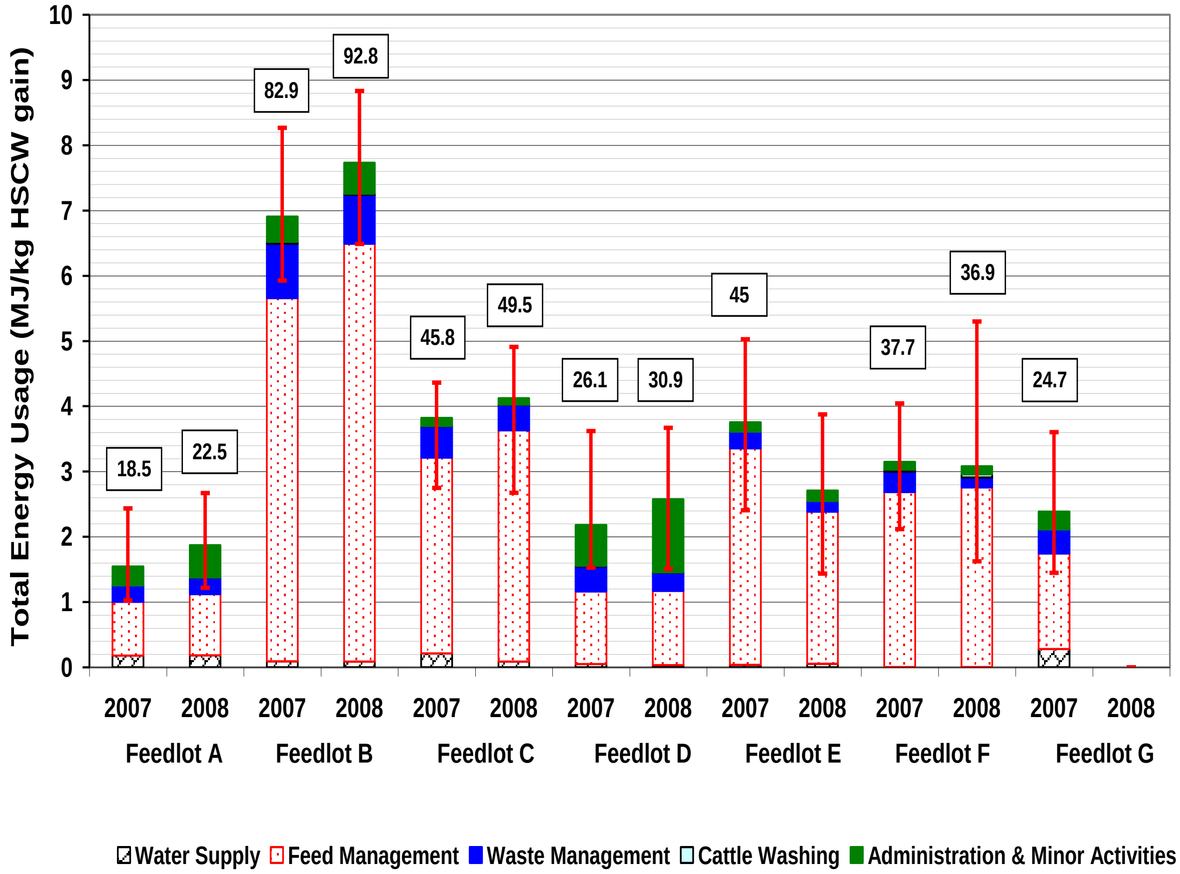

Figure 30 – Average Monthly Total Energy Usage (MJ/kg HSCW gain/Month)

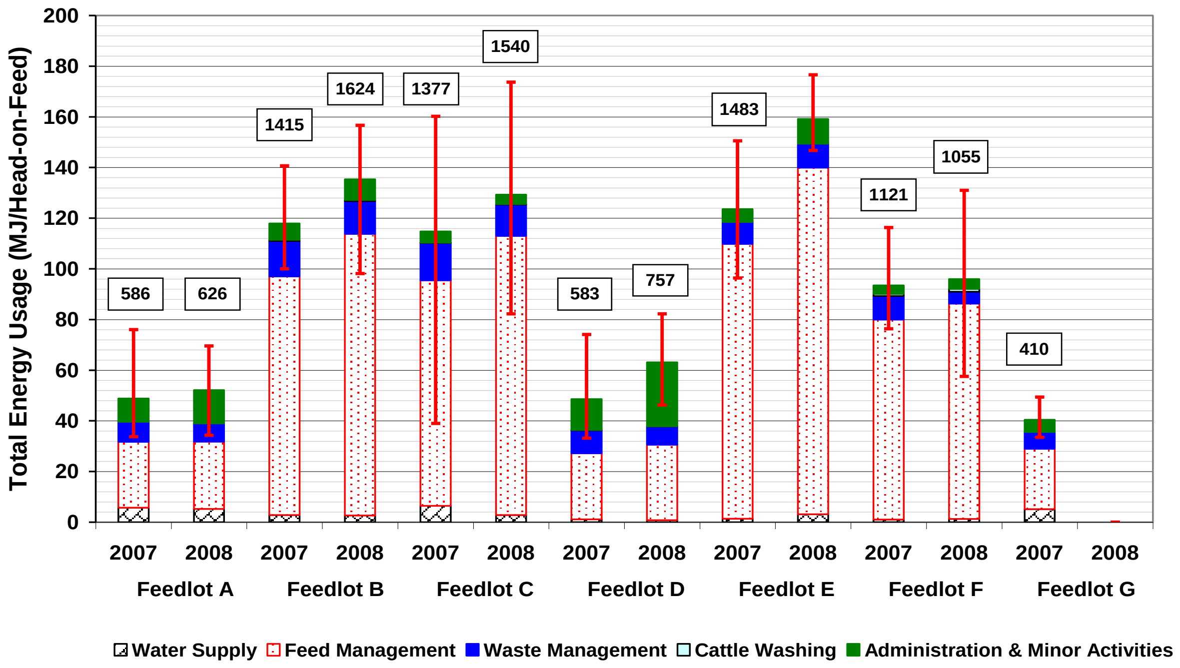

Figure 31 – Average Monthly Total Energy Usage (MJ/Head-on-Feed/Month)

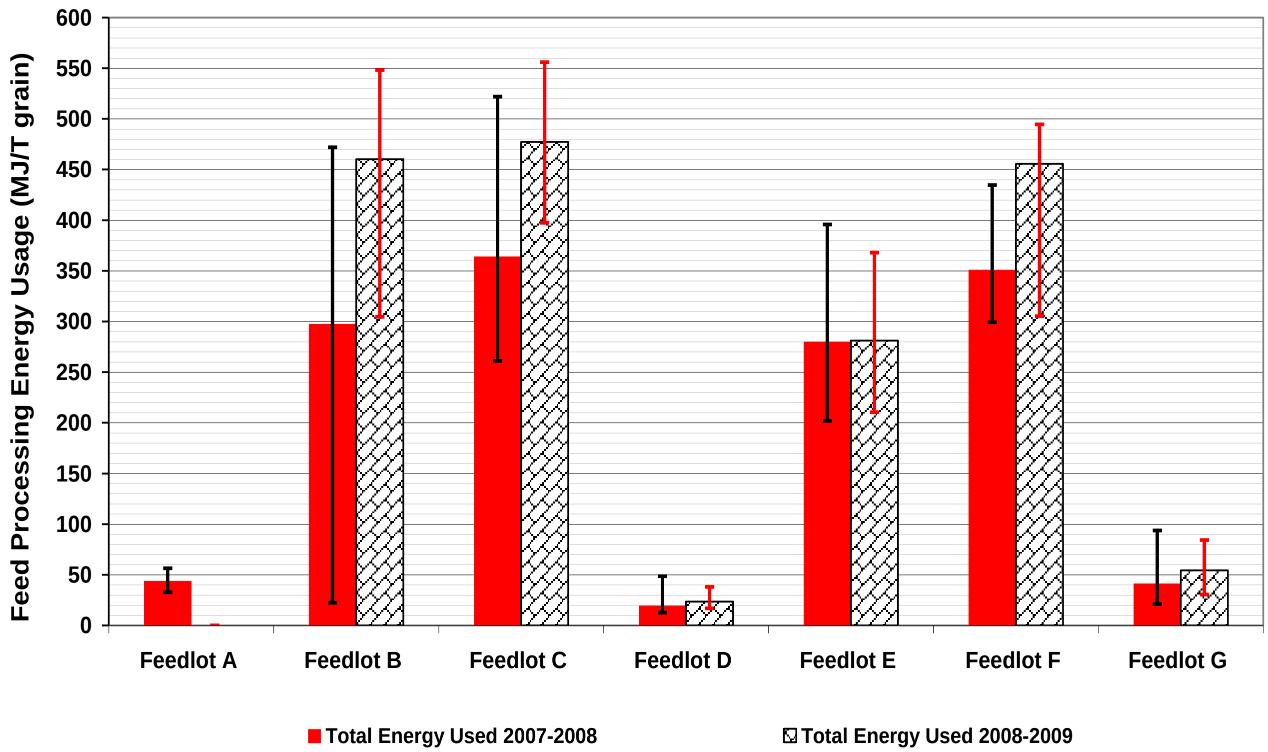

Figure 32 – Total Feed Processing Energy Usage (MJ/T Grain)

11.2.3 Sources of energy

There are several sources of energy used at feedlots. Diesel is used in mobile plant such as feed trucks and pen cleaning equipment. Electricity is used in offices and for grain handling. However, one of the largest uses of energy is in boilers at feedlots that undertake steam-flaking.

In the survey, feedlots were asked if they used a boiler. Data was obtained from 162 feedlots (19% of total) with a total pen capacity of 902 350 head (67% of industry capacity). Boilers were reported at 24 feedlots which represented 55% of the surveyed current pen capacity.

Boilers can be fuelled by coal, diesel or gas. There were four types of gases used within feedlots with steam-flaking systems. These include LPG - propane, butane and LPG - natural gas. All of these gas sources have different calorific values (heating content) and pricing structures and therefore impact on energy consumption. **Table 57** shows the breakdown of energy source for boilers used at feedlots. Hence, about 74% of feedlots with boilers use some form of gas as their energy source.

Table 57 – Energy sources for fuel used in boilers

Energy Source	% of Pen Capacity with boilers
Coal	15
Diesel	11
Coal seam gas (CSG)	9
LPG – propane	28
Butane	10
LPG – natural gas	27

11.2.4 Energy use efficiency

When asked about any improvements to energy use efficiency, many lot feeders responded that they could not see economically viable improvements or did not see this to be a sufficiently important issue. However, there are several feedlots that have made some improvements. Some of the types of energy use efficiency steps taken are listed below:

- changing the type of fuel used in boilers, e.g. diesel to waste oil, LNG to butane.
- replaced old, inefficient boilers
- improving steam management in the steam flakers
- move to longer period of tempering grain prior to steam flaking, which results in reduced steam requirements in the flaker
- changing to batch-box feed preparation
- better training of feed mill operators
- changing the routes taken by feed trucks to minimise travel distances
- changing the location of starter pens to all be in one area which reduced feed truck travel times when feeding starter rations
- more use of off-peak electricity
- installation of smart meters on power supplies and monitoring peak electricity usage.

One feedlot reported that a range of energy use efficiency strategies had been adopted including replacement of an old boiler and changing feed truck operations and routes. Over a three-year period, this had resulted in a reduction of total energy usage from 5.1 MJ to 3.6 MJ per unit of output. This is a 29% reduction in gross energy usage.

11.2.5 Renewable energy

During the survey, information was sought on the use of renewable energy. This would include:

- energy from manure (biogas, thermal energy)
- solar energy
- wind energy

No feedlot was found to be using biogas although many feedlots had been approached by companies promoting covered anaerobic ponds or anaerobic digesters. While this technology is being used increasingly in piggeries in Australia, there is not yet confidence that the technology will work at feedlots. One company had experimented with burning manure in the furnace for their boiler but no longer-term use of manure for combustion has been undertaken.

One large feedlot has installed solar panels to generate electricity and this is reported as being successful.

No feedlot was found that is using on-farm wind energy.

12 Summary and conclusions

The public expect Australian rural industries to achieve a high standard of environmental performance and demonstrate continuous improvement. Recently, public discussions have revolved around the sustainability of agricultural industries in the context of resource consumption, particularly in reference to drought and climate change. The feedlot industry recognises its environmental stewardship responsibilities and aims to work with governments and stakeholders to achieve balanced, commercially viable, environmental protection systems. Meat and Livestock Australia (MLA) has commissioned projects to investigate the specific aspects of environmental sustainability of the lot feeding sector from an eco-efficiency perspective. These projects provided data to enable the industry to quantify and improve environmental performance and provide credible information to the industry's supporters and critics. However, they have been limited in terms of the percentage of industry covered. Therefore, there is currently a lack of collated data on current practices pertaining to resource efficiency and the environmental performance of the entire Australian feedlot sector.

12.1 Environmental key performance indicators (KPIs)

MLA has conducted environmental surveys of another sector of the red meat industry, namely the red-meat processing sector. These surveys have occurred in 1998, 2003 and 2010. As part of these surveys, KPIs were developed to benchmark resource usage and environmental impact. In line with the red-meat processing sector KPIs, similar KPIs could be proposed for the lot feeding sector. However, to calculate these KPIs, it is necessary to obtain data on resource usage (energy, water) and environmental impact (effluent production, greenhouse gas emissions) per unit of production (head turn-off, liveweight gain in the feedlots). It was recognised early in this project that there was a small likelihood that these data would be available. However, an attempt would be made to collect this information where possible. A list f KPIs has been proposed and these would be regarded as aspirational targets for future work. This may encourage lot feeders or MLA to collect appropriate data so that future environmental surveys would allow the calculation of meaningful industry KPIs.

12.2 Previous environmental surveys

Unlike, the red-meat processing sector, the feedlot sector has not undertaken regular surveys. The only detailed survey of the Australian lot feeding sector was carried out by Tucker et al. in 1991 – "Lot feeding in Australia - a survey of the Australian feeding industry". The data presented in that survey is now out-of-date, as feedlot practices have improved and changed markedly over the past twenty years, but it can act as a benchmark against which to assess changes in the sector. Hence, while it is clear that substantial improvements in environmental performance have occurred, these cannot be compared accurately against past performance.

12.3 Environmental improvements in the past 23 years

Although quantitative data has not been collected since the 1991 report, there are several changes that have occurred in the lot feeding industry that have clearly lead to improvements in environmental performance. These include:

6. Environmental research – MLA has funded numerous projects investigating various aspects of feedlot environmental performance.
7. Feedlot odour guidelines – In the past, odour was probably the most significant issue surrounding the licensing and operation of feedlots. In conjunction with environmental research, guidelines have been developed that ensure with the correct siting, design and management, few odour nuisance issues occur.
8. National feedlot guidelines and code of practice – At the instigation of industry, as represented by the Australian Lot Feeders Association (ALFA), national feedlot guidelines have been developed and revised three times. This, in conjunction with a code of practice, has lead to nation-wide improvements in feedlot licensing, siting, design and management.
9. National feedlot accreditation scheme (NFAS) - NFAS is an industry-driven, self-regulatory quality assurance scheme that has lead to overall improvement in all aspects of feedlot management.
10. Improvements to nutrition – In the past 20 years, nutritionists and researchers have greatly improved the feed conversion ratio of lot fed cattle from about 9:1 to less than 5:1. This means that the same amount of output (beef) can be produced for much less inputs (feed) and much less waste (manure) is produced in the process.

12.4 Survey methodology

The steps in the survey methodology were:

5. Definitions – state clear definitions of a feedlot, licensed and current pen capacity, and other quantifiable parameters. Currently, there is a downturn in the lot feeding sector and some large feedlots are temporarily closed. Current pen capacity includes all feedlots that could be operational, even if they have not operated recently.
6. Survey form – develop a survey form covering all aspects of a feedlot's environmental performance including siting, design, management and monitoring.
7. Data collection – collect location and capacity data on the majority of feedlots in Australia and collect survey data on a representative sample of Australian feedlots.
8. Data analysis – statistical and GIS analysis of the collected data.

In line with the data collection period, the "current" data presented in this report applies as of March 2013.

12.5 Current and historical pen capacity

The survey indicates that there are currently about 850 feedlots in Australia with a combined pen capacity of 1,345,000 head. The ALFA quarterly survey for the same period indicated a total pen capacity of 1,189,000 head. While only 63 feedlots have a capacity of 5000 head or more, they represent 62% of total industry capacity. Queensland has about 52% of the industry's pen capacity followed by New South Wales with 28%. Western Australia has about 10% of the total pen capacity. Based on survey data from 1990 and 2005, the distribution by state and the size distribution of feedlots has not changed markedly. However, the total national pen capacity has steadily increased from 485,000 head in 1990 to 1,107,000 head in 2005 to the current level.

12.6 Geographic distribution of feedlots

The geographic location of a feedlot can affect its environmental performance. Feedlots are more difficult to manage in areas of high annual rainfall and/or winter dominant rainfall. It is generally recommended that feedlots should be located in areas with less than 750 mm annual rainfall. In 1990, 23% of pen capacity was in zone of greater than 750 mm annual rainfall. Currently, this has declined to only 12%. This indicates that, in general, feedlots have been sited in lower rainfall zones, which is a positive environmental outcome. In 1990, about 70% of pen capacity was in summer-dominant rainfall zones. This has declined to about 60% due to the increased preference to feed European breed cattle which prefer the cooler southern locations. Improved design and management of feedlots in winter-dominant rainfall zones has allowed this development to occur without adverse environmental outcomes.

In terms of river catchments, 67% of pen capacity is located within the Murray-Darling Basin, where most grain is grown in eastern Australia. About 17% of total pen capacity is located in the northern coastal catchments of Queensland, mainly the Fitzroy and Burnett catchments. The distribution of feedlots by river catchments has changed little since 1990.

About 25% of the total pen capacity is located within the Great Artesian Basin from which many draw their water supplies. About 8% of feedlots are located in areas where coal seam gas leases are being developed. There are concerns about the impact of coal seam gas development on the underlying aquifers and, hence, the security of some feedlot's water supplies.

12.7 Feedlot site selection

In the early days of feedlot development, there was limited information available on appropriate site selection for feedlot. Poor site selection can lead to ongoing environmental problems (e.g. close proximity to sensitive receptors, sensitive watercourse and ecosystems and shallow groundwater). In the past 20 years, state and national guidelines have been developed and planning processes have been improved. This has eliminated approval of feedlots at poor sites. A clear example is the trend of feedlots to be located in areas with lower rainfall where environmental issues can be managed more easily.

12.8 Feedlot design

In the past 20 years, every aspect of feedlot design has improved as more experience is gained with the Australian environment. A few design features are particularly relevant to environmental performance.

Stocking density has a significant influence on the environmental performance of a feedlot since it contributes to the average moisture content of the pad. Every day, cattle add moisture to the pen surface by manure (faeces and urine) deposition. A simple calculation assumes that cattle excrete 5% of their liveweight each day and manure is 90% moisture. Following the US example, feedlots in Australia initially (i.e. prior to 1990) stocked pens at about 10 m^2/head. Heavy cattle (750 kg) at 10 m^2/head can add over 1200 mm of moisture (effective rainfall) per year (3.3 mm/day). During winter, this can exceed the evaporation rate (depending on location) and the pen surface remains moist. Under these conditions, odour and cattle comfort problems can develop. On the other hand, light cattle kept at 20 m^2/head contribute less than 1 mm of moisture/day. In summer, evaporation readily removes this moisture and dust can become a problem. Therefore, the choice of stocking density should achieve a balance between a pen surface that is too dry and one that is too wet. This is dependent on local climate and cattle size. Manure deposition and accumulation rates are similarly related to stocking density. Experience has now shown that a stocking density of 10-12 m^2/head is only appropriate in drier zones (annual rainfall <500 mm/yr). For most feedlots, a stocking density of about 15 m^2/head achieves an optimum outcome for cattle, pen environment and pen maintenance. Unlike 1990 when many feedlots were stocked at 10 m^2/head, currently 45% of pen capacity is stocked at 12.6-15 m^2/head. This reduction in stocking density, along with the location of feedlots in drier areas, results in drier feedlot pens and less runoff. This is a clear environmental improvement.

Pen slope affects the rate at which rainfall drains from feedlot pens. Flat pens drain poorly resulting in wet, odorous pens. Many early feedlots had flat pens or low pen slopes (<2%). This survey found that only 2% of pen capacity had pens with slopes that are <2% and that 31% of pen capacity had pen slopes in excess of 4%. This change in feedlot pen design has a positive environmental outcome.

Poor design and location of water troughs in feedlot pens can lead to adverse environmental outcomes such as wet patches in pens and areas where wet manure accumulates and is difficult to clean. The survey indicated that the design and location within the pens of water troughs has improved. Furthermore, it was found that about 56% of pen capacity has water troughs that are sewered. This new design feature directs excess water out of the pen area reducing water patches in pens.

12.9 Feedlot runoff control

Stormwater runoff from feedlots contains contaminants that, if allowed to enter natural watercourses, would constitute an environmental hazard. Hence, feedlots must have a system that controls runoff from contaminated areas and provides for environmentally acceptable disposal.

A key feature of a feedlot's runoff control system is the formation of a controlled drainage area. It is typically established using:

- a series of catch drains to capture runoff from the feedlot pens and all other surfaces within the feedlot complex and to convey it to a collection system, and
- a series of diversion banks or drains placed immediately upslope of the feedlot complex, which are designed to divert 'clean' or uncontaminated upslope runoff (sometimes termed 'run-on') around the feedlot complex. Where feedlots are built close to the crest of a hill or ridge, there will be no runoff from upslope. In these cases, it is possible to have a controlled drainage area without any upslope diversion banks or drains.

The runoff generated within the controlled drainage area should be directed, via a series of drains, to a sediment removal system prior to flowing into a holding pond. The contaminated runoff in the holding pond can be disposed of by evaporation and/or irrigation.

Runoff control was often poorly managed when the 1990 survey was done. At that time, 74% of commercial feedlots and only 11% of opportunity feedlots had a sediment removal system. Now, over 90% of feedlot capacity has a sediment removal system. In 1990, only 76% of commercial feedlots and 36% of opportunity feedlots had a holding pond. This situation has changed markedly with 96% of feedlot pen capacity now having holding ponds to capture runoff. The 4% of pen capacity that does not have a holding pond allows runoff to disperse over a downslope dispersal area. This is acceptable practice for small feedlots.

About 80% of feedlot pen capacity uses an effluent utilisation area to utilise runoff from the holding pond compared to about 60% in 1990. About 83% of the irrigation systems are spray irrigation which allows more precise applications of effluent than surface irrigation.

Clearly, due to improved awareness and design guidelines, there has been a significant improvement in the control of contaminated runoff from feedlots over the past 20 years.

12.10 Heat stress management

In 1990, heat stress was not considered to be a significant issue and no data were collected about this topic. In recent years, community and industry awareness has increased. MLA has invested significantly in all aspects of feedlot design and management to improve the welfare of cattle during heat stress periods.

Excessive heat load (EHL) on feedlot cattle during summer months can result in significant production losses, animal welfare considerations and, under extreme conditions, the loss of cattle. High body heat loads can develop in feedlot cattle when a combination of local environmental conditions and animal factors exceed the animal's ability to dissipate body heat. Feedlot operators often adopt various management strategies to reduce the risk of EHL in cattle which in turn minimises its impact on animal production, health and welfare. The provision of shade is one strategy used to reduce the impact of hot weather conditions on cattle.

Shade is a thermal radiation shield. It reduces the heat load on the animal. Shade does not readily affect air temperature, but can reduce exposure to solar radiation and also enhance minimal air movement for cooling. Hence, shade is most beneficial for dark coloured cattle, such as Angus.

In the survey, data were obtained on the percentage of cattle at the feedlot pen capacity that was provided with shade. Data were obtained from 158 feedlots (18% of total) with a combined capacity of 802 000 head (59% of total industry). It was found that 40 feedlots (25% of those surveyed) with a pen capacity of 539 000 head (67% of those surveyed) provided some shade. When the percentage of the pen capacity that is shaded is taken into account, it was found that 402 000 head (75% of surveyed capacity) were provided with shade. There was also a clear indication from surveyed feedlots that more shade will be installed in the near future so these data will soon under-represent that percentage of the industry where shade is provided. Where shade was provided, the lot feeders were asked about the shade area provided per head (m^2/head). Many lot feeders did not know this area. Data on shade area was obtained from 11 feedlots (1% of total) with a combined capacity of 272 000 head (20% of total industry). The average shade area was 3.6 m^2/head with a range of 1 to 10 m^2/head.

Automatic weather stations (AWS) assist in the management of heat stress. For AWS, 32 feedlots (4% of total) with a combined capacity of 399 000 head (30% of total industry) were surveyed. It was found that 22 feedlots (69% of those surveyed) with a pen capacity of 345 000 head (86% of those surveyed) had an automatic weather station.

12.11 Feedlot manure management

In 1990, pen cleaning and manure management was a major issue. Manure management was often seen as a chore and an additional cost for which no return was achieved. Consequently, manure depths in pens were often at levels that would be completely unacceptable by today's standards. Deep manure leads to odour issues and a poor public perception of feedlots. Regulators responded by including sometimes onerous pen cleaning and manure management requirements in guidelines and licence conditions. Fortunately, the situation has changed markedly in the past 23 years. The reasons for this change include:

5. Clear evidence has been provided by feedlot nutritionists that cattle performance is reduced with heavy manure loads in pens.
6. Manure is now seen as a resource that can be sold to neighbouring farms as a fertiliser or soil conditioner.
7. Lot feeders are concerned about public perceptions of poor animal welfare with cattle standing in deep manure and they take action to address welfare issues if they arise.
8. Dags (manure on cattle hides) are becoming an issue and can be reduced by better manure management.

The changes to pen cleaning and manure management in the past 20 years include:

5. More frequent pen cleaning and pen cleaning at intervals appropriate to the location and climate.
6. Improved pen cleaning equipment such as box scrapers and under-fence pushers.
7. A better understanding of the nutrient value of manure and the ability to sell manure to neighbouring farms as a fertiliser replacement.
8. An increased usage of composting to reduce manure volumes and improve manure quality.

12.12 Mortality management

A few cattle inevitably die during their time at a feedlot. Mortality rates at Australian feedlots are low and typically range from 0.2% to 1% depending on a range of factors.

In 1990, data on the disposal of mortalities was not reported. However, at that time, most mortalities were buried. In recent years, there has been a significant move to composting of carcasses. In this process, the carcass is laid out on a bed of straw or manure and then covered with manure. The composting is undertaken in either bins or bays or in windrows similar to manure composting. The composting process is usually very efficient with only some large bones remaining. Some lot feeders screen the carcass compost prior to sale or disposal to remove the few remaining bones. The finished compost is then disposed of in the same manner as other manure from the feedlot. This process is more environmentally friendly than burial (which may have leachate issues) or incineration.

Data on disposal of carcasses was obtained from 42 feedlots (5% of total) with a combined capacity of 474 000 head (35% of total industry). Over 80% of the industry now composts carcasses.

12.13 Environmental management plans and accreditation systems

In 1990, virtually no environmental management systems or plans were in use at Australian feedlots. Since that time, a number of different management systems and/or accreditation schemes have been introduced. These provide a framework in which a lot feeder can operate their feedlot in an environmentally sustainable manner. Some of these management systems and accreditation schemes include:

5. National feedlot accreditation scheme (NFAS)
6. Environmental management plans and systems required by regulators
7. ISO 14000 and ISO 9000 accreditation
8. EU accreditation.

12.14 Resource usage - water

In 1990, no data were collected on water or energy usage at feedlots as resource usage was not considered to be an environmental issue. However, water is no regarded as a limited resource that is fundamental to the operation of a feedlot. Despite this, few feedlots accurately measure water usage, expect for regulatory requirements. Hence, it was no possible to calculate KPIs on water usage for this report. However, other data were collected.

The majority of feedlots obtain their water supplies from shallow or deep bores (60% of pen capacity) as these supplies are reliable and of a suitable water quality. Only 10% of feedlots rely on water from drought-sensitive sources such as on-farm dams and flood harvesting. Few feedlots use local government water supplies as the cost per ML is very high. Lot feeders were asked if they believed that they had any water security issues. Responses were received from 42 feedlots (5% of total) with 506 000 head pen capacity. Of these, 10 feedlots with 118 000 head capacity (23% of pen capacity) believed that they had issues over water supply security. The specific issues included concerns about the impact of coal seam gas development on local aquifers and cuts to groundwater allocations and assess rules since the feedlot was developed.

No water usage KPI data is available from this study. However, Davis et al. (2010a) reports on a study where eight feedlots (Feedlots A to F) were selected to provide a sample group representative of the geographical, climatic and feeding regime diversity within the Australian feedlot industry. At seven of these feedlots, water meters were installed to allow an examination of water usage by individual activities from March 2007 to February 2009. The major water usage activities (drinking water, feed management, cattle washing, administration and sundry uses) were monitored and recorded. Water usage was standardised and presented as litres used per kilogram of hot standard carcase weight (HSCW) gain equivalent (L/kg HSCW gain) or litres per head on-hand per day (L/head/day). Total annual clean water use (without dilution of effluent) ranged from 33 L/kg HSCW gain/month at Feedlot D in 2008 to 73 L/kg HSCW gain/month at Feedlot C. The average monthly total water usage in 2007-2008 was 51.5 L/kg HSCW gain, slightly higher than the 49.5 L/kg HSCW gain measured in 2008-2009. Detailed breakdowns of water usage at each feedlot is available in this report and could be used for future KPI benchmarking.

As approximately 90% of water used at feedlots is drinking water for cattle, there is limited scope for the adoption of water use efficiency practices. However, some water use efficiency practices were noted.

12.15 Resource usage - energy

Due to the recent steep increases in the cost of energy, in particular electricity, many feedlots reported that they had started measuring energy usage and looking for energy savings. However, this is a relatively recent activity and this has not been undertaken in a standard or co-ordinated manner that would allow the calculation of KPIs and benchmarking energy usage.

MLA has previously undertaken a project (FLOT.328 – Davis and Watts (2006)) to measure the environmental costs associated with the production of one kilogram of meat from modern Australian feedlots. As part of that project, measured data on total energy use were obtained via a detailed on-line survey. Feedlot inputs and outputs including cattle numbers, intake and sale weights, dressing percentages were also collected to standardise resource usage on the basis of one kilogram of hot standard carcass weight gain (kg HSCW gain). This project demonstrated that whilst lot feeders usually have good records of total energy usage, few data exist on actual usage levels for the individual components of the operation, including water supply, feed management, waste management, cattle washing, administration and repairs and maintenance. Hence, foreseeing these drivers for industry change and a lack of credible data, MLA has provided significant investment to quantify energy usage of individual activities at Australian feedlots in a follow-up project (B.FLT.0350 – Davis (2010b)).

There are several sources of energy used at feedlots. Diesel is used in mobile plant such as feed trucks and pen cleaning equipment. Electricity is used in offices and for grain handling. However, one of the largest uses of energy is in boilers at feedlots that undertake steam-flaking. The average monthly total energy usage across all feedlots for March 2007 to February 2009 ranged from 1.6 MJ/kg HSCW gain/month at Feedlot A to 7.8 MJ/kg HSCW gain/month at Feedlot B, with an average in the order of 6 MJ/kg HSCW gain/month. The total annual energy usage in 2007-2008 ranged from 18.5 MJ/kg HSCW gain at Feedlot A to 82.9 MJ/kg HSCW gain at Feedlot B. The total annual energy usage in 2008-2009 was slightly higher when compared to the previous year with a range of 22.5 MJ/kg HSCW gain (Feedlot A) to 92.8 MJ/kg HSCW gain (Feedlot B).

The average monthly total energy usage across all feedlots for March 2007 to February 2009 ranged from 49 MJ/head-on-feed/month at Feedlot A to 160 MJ/head-on-feed/month at Feedlot E. Feedlots with steam-flaking feed processing systems had an average usage in the order of 120 MJ/head-on-feed/month, compared with an average of about 45 MJ/head-on-feed for feedlots that process grain by other means. The total annual energy usage in 2007-2008 ranged from 583 MJ/head-on-feed (Feedlot E) to 1483 MJ/head-on-feed (Feedlot D). The total annual energy usage in 2008-2009 was slightly higher when compared to the previous year with a range of 626 MJ/head-on-feed (Feedlot A) to 1624 MJ/head-on-feed (Feedlot B). Feedlot C had the greatest monthly variation in 2007-2008 and 2008-2009. More details on the breakdown of energy usage within these feedlots is available in the B.FLT.0350 report.

In this survey, feedlots were asked if they used a boiler. Data was obtained from 162 feedlots (19% of total) with a total pen capacity of 902 350 head (67% of industry capacity). Boilers were reported at 24 feedlots which represented 55% of the surveyed current pen capacity. Boilers can be fuelled by coal, diesel or gas. There were four types of gases used within feedlots with steam-flaking systems. These include LPG - propane, butane and LPG - natural gas. All of these gas sources have different calorific values (heating content) and pricing structures and therefore impact on energy consumption. About 74% of feedlots with boilers use some form of gas as their energy source.

Many feedlots have investigated various options for improving energy use efficiency with varying degrees of success.

12.16 Overall conclusions

The objective of this study was to undertake a detailed survey and review of the environmental performance of the Australian feedlot industry, which documents current practices and identifies, quantifies and reports key performance indicators (KPIs). The KPIs to include water usage, nutrient production, energy usage, GHG emissions, solid waste management, liquid waste management, feed management, nuisances such as odour and noise, and overall site management. Unfortunately, it has not been possible to calculate any KPIs.

However, there is clear evidence that the environmental performance of Australian feedlots has improved significantly over the past 20 years. This is the result of the combined effects of well-funded research, improved regulation and guidelines, and the implementation of quality assurance systems. It should be explicitly noted that many of these improvements (e.g. MLA-funded research, NFAS, national guidelines) have occurred due to the proactive actions of the industry as represented by ALFA.

13 Recommendations

A clear short-coming of this study has been the inability to calculate KPIs of environmental performance and to compare them with past studies. Hence, the recommendations listed below assume that another feedlot environmental performance review may be conducted in a few years time and steps need to be taken now to ensure a successful outcome for that future work.

13.1 Maintenance of the Australian feedlot database

Apart from the environmental performance review, there are many uses for an up-to-date Australian feedlot database supported with GIS information. The applications include submissions on the behalf of the feedlot sector to government green papers or similar plus emergency response support to disease outbreak or natural disasters (floods and bushfires). Clearly, there are privacy and security issues to be resolved around the maintenance and usage of such a database as access to the database developed in this project is strictly limited. However, a large proportion of the time spent on this project involved locating and collecting up-to-date data. If this was maintained on an on-going basis, subsequent environmental performance reviews could be undertaken more quickly and efficiently.

It is recommended that on-going maintenance of the database established for this project be supported and that privacy and security issues be formally resolved.

13.2 Establishment of selected feedlots for environmental performance monitoring and KPI calculation

The majority of medium to large feedlots use herd management software that records cattle and feed data. This data is essential for any calculations of KPIs and data that could be used in life cycle assessments. Furthermore, it is clear that many larger feedlots are collecting some data on energy and water usage. However, this is ad-hoc, non-standard, uncoordinated and private.

The framework for collecting the data necessary to calculate most environmental KPIs was established in the previous MLA project – B.FLT.0350. This experience could be used to augment the data already being collected so that it could be used to calculate KPIs in future studies. In their environmental surveys, the red-meat processing sector chose to collect and analyse data on a selected number of representative processing plants rather than the industry as a whole. A similar approach could be used for feedlots.

It is recommended that a number of representative feedlots (15-20) be selected for on-going KPI determination. Following an audit of existing instrumentation, some additional energy and water meters may need to be installed. Procedures and data analysis for the calculation of on-going KPIs should be established so that, when a future environmental performance survey is undertaken, good quality data is available and is ready for publication.

14 References

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Appendix A – Letter of introduction and survey form – 2012 environmental performance

27 September 2012

TO WHOM IT MAY CONCERN

RE: Project B.FLT.0468 – 'Environmental performance review of Australian feedlots (2012)'

The Australian public expect industries to achieve a high standard of environmental performance and demonstrate continuous improvement. In order to address these requirements meaningfully, industry requires credible information that can be utilised to demonstrate its environmental credentials to both supporters and critics.

There is currently, however, a lack of collated data on current practices pertaining to resource efficiency and environmental performance of the Australian feedlot sector. The only detailed survey of the Australian lot feeding sector was carried out by Tucker et al. in 1991 – "Lot feeding in Australia - a survey of the Australian feeding industry". This report is now out of date, as feedlot practices have improved and changed over the past twenty years.

Industry has requested MLA to obtain updated information by undertaking a performance review of Australian feedlots. This project will benchmark current practices and performance and quantify improvements in environmental performance, utilising the 1991 study as a baseline. Performance will be assessed against key performance indicators across several important areas, including manure and effluent management, odour management, greenhouse gas emissions and energy and water use. MLA has commissioned FSA Consulting to undertake the project, including all necessary data collection, analysis and reporting.

MLA seeks your participation in this undertaking to make the dataset as comprehensive as possible. In requesting this participation, MLA provides an assurance that all data you provide will be treated confidentially. Data will only be presented in an aggregated format, and no data identifying any specific feedlot or its performance will be presented in the report. FSA Consulting has an excellent track record in handling information confidentially, and this was a major consideration when selecting them to undertake the project.

Industry values your contribution and looks forward to your participation in the project. If you have any queries, or require further detail, please feel free to contact me directly on the mobile number shown below.

Yours faithfully

Des Rinehart
MLA Feedlot R&D Program Manager

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Survey form – 2012 environmental performance

FEEDLOT SAMPLE DATA COLLECTION FORM

Site ID: ____________________
Data Collected by: ____________________
Date Collected: ____________________

Monitoring:

EMP:

NPI Return:

Nutrient Management Plan:

Complaints Record

If yes, is it a requirement of licence:

If yes, what complaints have you recorded:

Environmental training for staff at feedlot

If yes, what level of training is provided:

Environmental monitoring on site:

If yes, is it part of licence requirements

If yes, what monitoring is done:

If yes, what do you use the results for:

Continuous environmental improvements:

If yes, what was done:

On-site automatic weather station

Comments

Accreditation:

EU Accredited:

ALFA Member:

ISO 9000:

ISO 14000:

NFAS (AUSMEAT) Accredited

AUSMEAT Accreditation No

Current NFAS Capacity:

Is there a local government operation licence?

Is there a state feedlot operation licence?

Comments

Bio-security:

Bio-security procedures implemented:

Security/Boom gate

Incoming animals

Livestock trucks

Visitors

Visitor's vehicles

Comments

Feedlot Licence and Capacity Data:

Year Closed:

Year Opened:

Year Licensed:

Operating Status

Licence Cap 1990:

Licence Cap 1995:

Licence Cap 2000:

Licence Cap 2005:

Licence Cap 2010:

Licence Cap Current:

Pen Capacity 1990:

Pen Capacity 1995:

Pen Capacity 2000:

Pen Capacity 2005:

Pen Capacity 2010:

Pen Capacity Current:

Stocking Density (m2/SCU) 1990:		Class 1990:	
Stocking Density (m2/SCU) 1995:		Class 1995:	
Stocking Density (m2/SCU) 2000:		Class 2000:	
Stocking Density (m2/SCU) 2005:		Class 2005:	
Stocking Density (m2/SCU) 2010:		Class 2010:	
Stocking Density (m2/SCU) Current:		Class Current:	

Comments

Feedlot and Pen Layout:

Layout Design

- Single straight row
- Round the hill
- Back-to-back
- Sawtooth
- Other, please specify:

Weighbridge

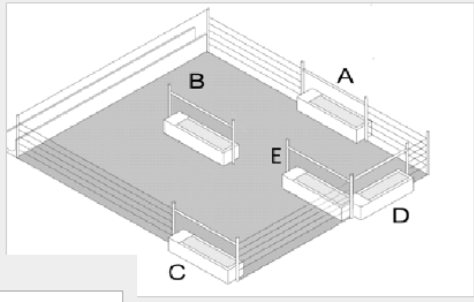
Range of pen slope in feedlc

Minimum (%):

Maximum (%):

Comments

Location of Water Troughs:



Aprons around water troug	
Sewered water troughs	
Water trough location - A	
Water trough location - B	
Water trough location - C	
Water trough location - D	
Water trough location - E	

Shade:

Percentage of pen capacity with shade structures (%):	
For pens with shade, m2 of shade per head/SCU (m2):	

Type of shade structure (Respond yes to all types on-sit

Shade cloth	
Iron sheeting	
Other	
If other, plaese specify:	

Position of shade structure:

- Fully covered pens	
- Feed bunk and apron	
- Top third of pen	
- Centre of pen	
- Bottom third of pen	

Position of shade posts:

- ALL in the fence line/external to pe	
- ALL in the centre of the pen	
- SOME poles in centre of pen	
Are shade structures retracted in wint	

Comments

Resource Management:

Water - Clean Water (Excluding Irrigation):

Percentage of water supply from following sources (9

Groundwater:

Pecentage of water supply - Deep water/Artesian bore:	
Pecentage of water supply - Shallow bore:	

Surface water:

Pecentage of water supply - Farm dam:	
Pecentage of water supply - River pumping - flood:	
Pecentage of water supply - River pumping- government allocation:	
Pecentage of water supply - Town water supply:	

Temporary cattle drinking water storage on-site	
Days storage (days):	
Can temporary water be gravity fed to the feedlot	
Temporary storage water covered	
Water security issues	
Measure water usage	
Benchmark water usage (Litres per head turnoff, L/hd):	
Percentage of cattle(turnover) washed (%):	
Cattle washed with recycled effluent (%):	
Cattle washed with clean water (%):	
Cattle trucks washed on-site	

Comments

Pen Cleaning and Maintenance:

Trigger of pen cleaning
Time at which pen cleaning is triggered (weeks
Accumulated depth at which pen cleaning is triggered (mm)
Trigger of pen cleaning changed in last 5 years?
If yes, why/how?:
Is pen cleaning not possible at some time of year
If yes, when:
Manure interface layer left when cleaning
If yes, how is depth controled:
Pen cleaning machinery:
Box scaper
Excavator
Bulldozer
Front end loader (wheel steer
Articulated Front end loader
Under fence pushing in practice
Does under fence pushing occur at pen cleanin
If no, when (frequency in weeks
Under fence cleaning machinery
Box scraper and push bar
Excavator and push bar
Bulldozer and push bar
Front end loader (wheel) and push bar
Bob cat and push bar
Any bedding in pens
If yes, what type:
If yes, why was it done:
Welfare/health
Performance
Dags
Environmental issues
Pen surface:
Smooth natural surface
Compacted clay, little earthworks
Compacted clay, major landforming
Compacted gravel over clay, major landformir
In-pen manure mounding in practice
Are potholes within pen repaired at pen cleaning?
If no, when (frequency in weeks)

Comments

Manure Management (Stockpiling, Spreading, Sales):

Separate manure stockpiling area

Percentage of pen manure managed using following methods:

- Taken directly from pens to fields or off-site (%):
- Short-term stockpiling, then spreading on-site (%):
- Short-term stockpiling, then sent off-site (%):
- Long-term (>3 months) stockpiling, then spreading on-site (%):
- Long-term (>3 months) stockpiling, then sent off-site (%):
- Windrow composted, then spreading on-site (%):
- Windrow composted, then sent off-site (%):
- Screened through a screen/trommel (%):

Manure processing equipment: Size (tonnes/hour)

- Articulated front end loader
- Front end loader (wheel steer)
- Excavator
- Screen

Windrow composting:

- Regularly monitor windrow core temperature
- Turn the windrows
- Turn the windrows at least 3 times when composting
- Water as needed to maintain optimum moisture content
- Add materials other than manure, water and effluent

Size piles/windrows used for storing compacting manure: Width (m) Height (m):

If ageing manure, are piles/windrows compacted?

If composted manure watered, what method is used?

Spread manure (composted or otherwise) on-farm

Percentage of manure used on-farm (%):

Area of land on-farm available for manure spreading (ha):

Is manure incorporated into soil after spreading

How are mortalities disposed of?

Manure spreading equipment: Capacity (m3)

- Trailing spreader with discs or beaters
- Self-propelled spreader with discs or beaters

AND:

- Own equipment
- Contractor or hire equipment

Min application rate of equipment (t/ha):

Percentage of manure sold (%):

Sell to agricultural markets

Sell to compost / potting mix manufacturers

Comments

Runoff Control and Irrigation:

Sedimentation basin, terrace or tank:

- None
- Shallow basin (dries out)
- Settling tank / pond (stays wet)

Trigger of sedimentation basin cleaning

Are drains cleaned at pen cleaning

- If no, please state frequency (weeks):

Cleaning machinery:	*Sedimentation:*	*Drain:*
Box scraper		
Excavator		
Front end loader (wheel steer)		
Bulldozer		
Articulated front end loader		
Bob cat		

Holding pond

Effluent (feedlot runoff) management method:

- Down slope dispersal
- Evaporation only
- Evaporation and irrigation

Method of irrigation:

- None
- Surface
- Spray

Effluent dilution before irrigation

Percentage of crops irrigated:

- Pasture (%):
- Silage or hay (%):
- Broad Acre (cotton, grain etc) (%):
- Horticulture (%):
- Other (%):

Size of effluent reuse area (ha):

Feed Storage, Processing and Delivery:

Feed delivery system:

- Self-feeders
- Bunks

If bunks, what is the bunk space per head of cattle (mm/head):

Apron for self-feeder/bunk

Percentage of annual feed used grown on site:

- Percentage of annual feed used grown on site - Silage (%):
- Percentage of annual feed used grown on site - Hay (%):
- Percentage of annual feed used grown on site - Grain (%):

Method of grain processing:

- None
- Hammer mill
- Dry rolling
- Tempering
- Reconstitution
- Steam flaking
- Pre-prepared off-site (TMR) (Total mixed ration)

Comments

Dust:

Main dust sources at feedlot:

- Roads
- Pens
- Feedmill

Are dust control measures used in pens?

- Frequency

Are dust control measures used on roads?

- Frequency

Are dust control measures used in the manure processing area?

- Frequency

Methods of dust control:	Pens:	Roads:	Manure Processing Area:
Fixed sprinkler system			
Mobile tanker			
Woodchips			
Saw dust			

Odours and Flies:

Main odour sources at feedlot:

- Pens (eg poor drainage, not accessible for winter cleaning)
- Manure/carcass handling area (eg poor drainage)
- Feed storage area (eg poor drainage)
- Other

If other, please specify:

Main fly breeding area at feedlot:

- Feedbunk
- Feedmill
- Pens
- Manure/carcass handling area
- Other

If other please specify:

Program to manage flies:

- Yes, controlled baiting
- Yes, integrated pest management
- No

Are odour control measures in place

If yes, please specify:

Comments

Energy and Fuel Sources:

Boiler in use

If yes, fuel type:

Measure energy usage

Benchmark energy use (MJ per head of turnoff, MJ/hd):

Energy efficiency improvements made

If yes, what was done:

Electricty supply reliability

Bio-energy recovery

If yes, what is done:

GHG emissions known

If yes, what:

Comments