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FEEDLOTS

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Improving water and energy use efficiency in the Australian feedlot industry

Part A Report: Water usage 2007-2009

Abstract

Water availability and cost of supply is changing rapidly, driven by increased demand for industry, urban water supply and the environment. With droughts adding to low river flows, water supplies are very tight in many feedlot regions. Capped water supply and water trading in the Murray Darling Basin have increased the value of water significantly. In Victoria, large feedlots are now required to quantify and reduce their water usage. These pressures will promote careful management of water resources throughout the industry to ensure continued supply and minimise costs.

Little work has been undertaken to evaluate total water consumption by feedlots. The amount of water used at feedlots was studied in North America in the 1980's. To date, only a limited study on drinking water requirements has been undertaken in Australia. Water is the most important feed component fed to cattle, hence, it is of critical importance to lot feeders.

Whilst lot feeders usually have good records of total annual water usage, little data exists on actual usage levels for the individual components of the operation, including drinking water, feed management, cattle washing, administration and sundry activities.

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. The major water usage activities (drinking water, feed management, cattle washing) were monitored and recorded.

This report provides factual information on the quantity of water used within individual activities at seven Australian feedlots on a monthly basis. This puts valuable information in the hands of the industry to improve resource efficiency, meet the requirements of legislation and improve the sustainability of the industry in the face of a variable climate.

Executive summary

Water availability and cost of supply is changing rapidly, driven by increased demand for industry, urban water supply and the environment. With droughts adding to low river flows, water supplies are very tight in many feedlot regions. Capped water supply and water trading in the Murray Darling Basin have increased the value of water significantly. In Victoria, large feedlots are now required to quantify and reduce their water usage. These pressures will promote careful management of water resources throughout the industry to ensure continued supply and minimise costs.

Energy usage is an increasing input cost for feedlot operation. These costs will rise significantly with the introduction of a carbon tax on energy production. These factors will make energy savings an important focus area for feedlots.

Meat and Livestock Australia (MLA) has previously undertaken a project (FLOT.328) to measure the environmental costs associated with the production of one kilogram of meat from modern Australian feedlots. As part of this project factual 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.

The purpose of this study is 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.

The water and power meter data collected was supplemented with existing data collected on-site including fuel consumption (diesel, gas) 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.

At most feedlots, intensive assessments of minor water use operations was undertaken. Activities that were investigated this way included trough cleaning, hospital cleaning, induction yard cleaning and vehicle washing. These minor activities are too numerous to monitor economically using inline water meters.

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

This report covers the issue of water usage by feedlots.

Water availability and cost of supply is changing rapidly, driven by increased demand for industry, urban water supply and the environment. With droughts adding to low river flows, water supplies are very tight in many feedlot regions. Capped water supply and water trading in the Murray Darling Basin have increased the value of water significantly. In Victoria, large feedlots are now required to quantify and reduce their water usage. These pressures will promote careful management of water resources throughout the industry to ensure continued supply and minimise costs.

Little work has been undertaken to evaluate total water consumption by feedlots. The amount of water used at feedlots was studied in North America in the 1980's. To date, only a limited study on drinking water requirements has been undertaken in Australia. Water is the most important feed component fed to cattle, hence, it is of critical importance to lot feeders.

Little information exists on the water usage of individual components of the feedlot system, viz drinking water, feed processing, cattle washing, administration and dilution of effluent irrigation. Factual information on water usage was collected on individual feedlot sector operations where possible.

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. The major water usage activities (drinking water, feed management, cattle washing, administration and sundry uses) were monitored and recorded.

Results from the seven feedlots studied showed that total annual clean water use (without dilution of effluent) for March 2007 to February 2009 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, Queensland Department of Primary Industries and Fisheries (QDPI&F) 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. The QDPI 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, feed processing or evaporation from open storages. In this 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 and is below that required by the QDPI&F.

Drinking water contributed in the order of 90% of the total water usage in the months when no cattle where washed. This reduces to a figure in the order of 75% during months when cattle washing is 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.

Drinking water is the single largest consumer of water in the feedlot and contributed on average 27.6 to 60.8 L/kg HSCW gain across all feedlots. However, up to 87 L/kg HSCW gain was measured in one month. The differences between feedlot drinking water consumption on a kg HSCW gain basis can be attributed to the differences between market types (long fed - low daily gain v domestic - higher daily gain). However, the primary driver of drinking water consumption is climatic variation.

In this study, the average drinking water consumption on a per head basis ranged from 29 to 46 L/head/day. The average monthly drinking water in 2007-2008 was 39.1 L/head/day, slightly higher than the 37.2 L/head/day measured in 2008-2009. The highest average monthly 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 monthly 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 can 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 is clearly evident on a daily basis. During periods of rainfall, drinking water consumption is suppressed, whilst during periods of high heat load, drinking water is at its highest.

Where no cattle washing is undertaken, feed processing water usage is the second highest consumer of water in feedlots. Three different feed processing systems are represented within the seven feedlots and included tempering, reconstitution and steam flaking. Feed processing contributes in the order of 4% as a function of HSCW gain and is dependent on the grain processing system employed at the feedlot. This figure can vary slightly from month to month depending on the management of the various systems. However, on average the levels are similar between years.

The average feed processing water usage ranged from 80 to 390 L/t grain processed. For feedlots that process grain by tempering or tempering and reconstitution the total water added to the grain accounts for 90% of the total water used. Feedlots that steam flake grain the total water added to the grain accounts for about 45% of the total water used. For tempering only systems, the water added to the grain is similar to the total water used, hence has a very low volume of unaccounted-for water. For reconstitution, an average of 40 L/t grain is unaccounted-for whilst water usage and unaccounted-for water within steam flaked systems is variable with an average unaccounted-for loss of 225L/t grain. Therefore, in steam flaking, if the tempering component water usage is reflected in additional water in the grain, then the majority of unaccounted-for water can be attributed to the process of steam generation and delivery. A number of factors will influence feed processing water usage include system employed, grain type, target moisture and management of the system.

Cattle washing is the second highest consumer of water in feedlots in months when it is undertaken. The total water usage in some feedlots comprises clean and recycled water. Cattle washing can contribute up to 25% as a function of HSCW gain of the total water usage.

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 can account for 50 to 75% of the total washing water usage.

The water required for cattle washing is dependent on the dirtiness of the cattle and the cleaning requirements. Hence, water usage decreased at Feedlot A in 2008 when compared to 2007 due to drier conditions, whilst Feedlot F increased water usage per head in 2008 due to dirtier cattle from higher rainfall in the winter months when compared with 2007.

Administration water usage comprises 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, representing in the order of 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 water trough cleaning and road watering are the three largest sundry water uses. Variation between feedlots may 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).

Actual water usage levels within individual activities have been recorded in seven feedlots representative of the Australian Feedlot Industry. These included drinking water, feed processing, cattle washing, administration and sundry uses. The selected feedlots provide a range of climatic conditions from a northern feedlot in a hot, humid summer-dominant rainfall to southern feedlots in cooler, winter-dominant rainfall zones. Grain processing methods vary from simple tempering to reconstitution and steam flaking. Some feedlots wash cattle (mainly in winter) while other feedlots do not undertake any cattle washing.

The outcomes of this study will allow the feedlot industry to start benchmarking total water usage. This information is invaluable for participating feedlots in understanding the drivers of water consumption and targeting high water use areas for efficiency gains and for future design and management considerations. The first step to making savings is to understand where water is used around the feedlot.

To assist the feedlot industry to improve water resource efficiency, a framework has been developed to step individual feedlot operators through the process of measuring and reducing water usage at the feedlot. This framework is presented as fact sheets, arranged in 3 series:

- Measuring and Understanding resource usage;
- Benchmarking, and
- Improving resource efficiency

The outcomes of this study puts valuable information in the hands of the industry to improve resource efficiency, meet the requirements of legislation and improve the sustainability of the industry in the face of a variable climate.

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1 Background

The Australian red meat industry, as with most primary industries, is coming under increasing pressure from both the community and government to document and justify its impacts on the environment. Currently, a lack of credible supply chain data prevents the industry from being able to respond in a meaningful manner.

Meat and Livestock Australia (MLA) is undertaking a project (COMP.094) to address these issues and provide credible data on the industry's environmental impacts and sustainability for use by industry, including its interactions with government, community groups and the media. This project will use the standardised tool, Life Cycle Assessment (LCA), to quantify natural resource consumption and environmental interventions to water, soil and air. The goal of the LCA is to identify key environmental impacts of products. Environmental impact categories considered in LCA include but are not limited to resource energy, climate change (global warming), eutrophication, acidification, human toxicity (pesticide use) and land use.

LCA is a form of cradle-to-grave systems analysis developed for use in manufacturing and processing industries to assess the environmental impacts of products, processes and activities by quantifying their environmental effects throughout the entire life cycle. LCA can be used to compare alternative products, processes or services; compare alternative life cycles for a product or service; and identify those parts of the life cycle where the greatest improvements can be made. An international standard has now been developed to specify the general framework, principles and requirements for conducting and reporting LCA studies (Standards Australia, 1998). LCA differs from other environmental tools (e.g. risk assessment, environmental performance evaluation, environmental auditing, and environmental impact assessment) in a number of significant ways. In LCA, the environmental impact of a product or the function a product is designed to perform is assessed, the data obtained are independent of any ideology and it is much more complex than other environmental tools. As a systems analysis, it surpasses the purely local effects of a decision and indicates the overall effects (Peters et al. 2005).

The functional unit for COMP.094 was the output of 1 kg of Hot Standard Carcass Weight (HSCW) meat at the abattoir gate. “Hot” indicates the meat in question has not entered any chilling operations. This output-related functional unit was chosen, rather than an input-related one, in order to describe the human utility of the processes under consideration – the provision of nutrition for people. Although the meat could be served in different ways, this functional unit makes the different processes under consideration “functionally equivalent” from a dietary perspective.

In LCA methodology, usually all inputs and outputs from the system are based on the ‘cradle-to-grave’ approach. This means that inputs into the system should be flows from the environment without any transformation from humans and outputs should be discarded to the environment without subsequent human transformation (Standards Australia, 1998). Each system considers upstream processes with regard to the extraction of raw materials and the manufacturing of products being used in the system and it considers downstream processes as well as all final emissions to the environment.

Figure 1 shows the generalised system boundary for the red-meat sector as defined for the COMP.094 project. Within this boundary, there is a sub-system for the feedlot sector. The boundary chosen here (shown in red on Figure 1) is the feedlot site itself plus the transport component of bringing cattle and feed into the feedlot and delivering cattle from the feedlot.

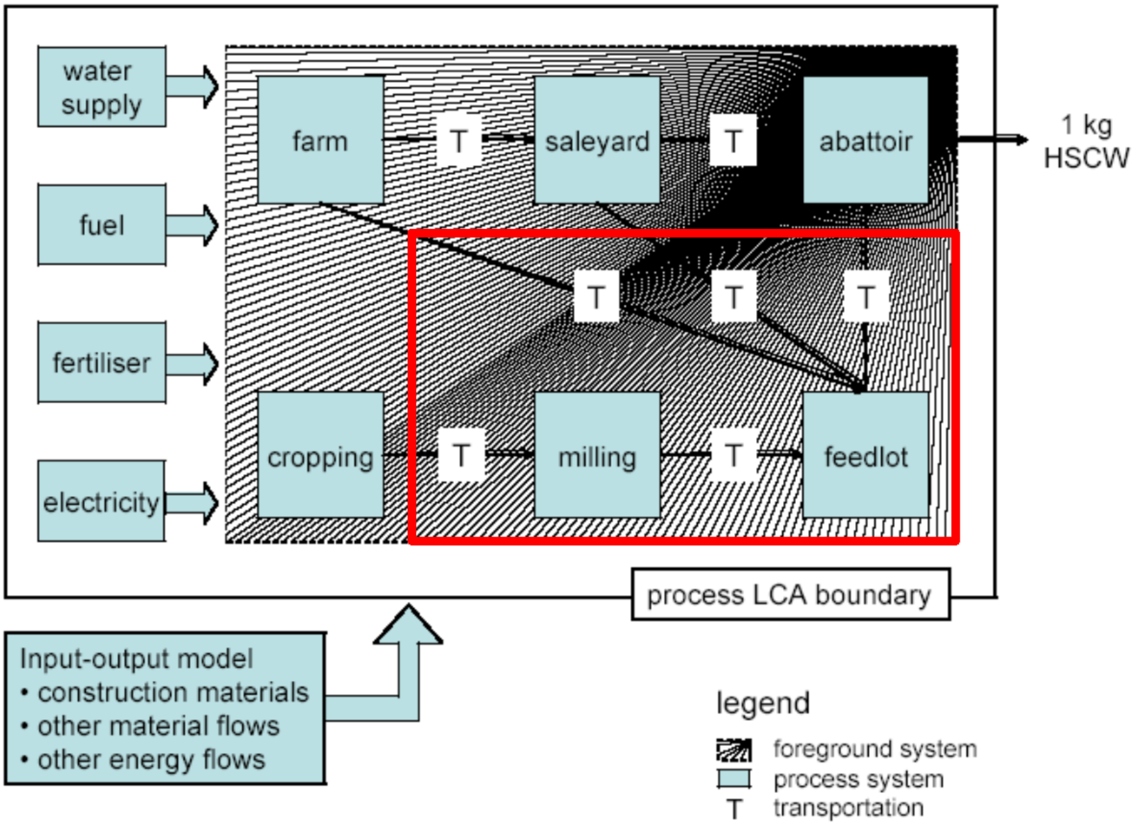

Figure 1 – Generalised system model for the red meat sector with feedlot sub-system

As part of the COMP.094 industry project, the beef cattle lot feeding sector has recently completed a related MLA project (FLOT.328) that will contribute to the whole-of-industry dataset, but more importantly addresses the public misconceptions concerning the environmental sustainability of the feedlot industry. The Terms of Reference for FLOT.328 required the researchers to address, in the context of a LCA, the feedlot-relevant natural resource management (NRM) issues water quality and water use efficiency, salinity, soil erosion, nutrient management and soil acidification, weeds, feral animals, biodiversity, vegetation management, energy efficiency and greenhouse gas emissions and solid waste. These issues were identified as issues of concern to the red meat industry.

The outcomes of FLOT.328 identified and quantified, where possible, the environmental costs (water, energy, GHG, and nutrient cycling) associated with the production of one kilogram of grainfed beef. It provided factual information on the volume of clean water and energy used at Australian cattle feedlots under a range of climatic, size and management conditions.

This study found that, whilst lot feeders usually had good records of total annual clean water usage, little data existed on actual usage levels for individual activities within the operation (eg. drinking water, feed processing and cattle washing). In addition, little was known about the variation in water use throughout the year. Similarly, total annual energy consumption records were usually limited by the lot feeders' inability to separate out the electricity consumption of individual activities. Hence, more information was required on the water usage and energy usage of individual components before these figures could be reliably reported.

Water availability and cost of supply is changing rapidly, driven by increased demand for industry, urban water supply and the environment. With droughts adding to low river flows, water supplies are very tight in many feedlot regions. Capped water supply and water trading in the Murray Darling Basin have increased the value of water significantly. In Victoria, large feedlots are now required to quantify and reduce their water usage. These pressures will promote careful management of water resources throughout the industry to ensure continued supply and minimise costs.

Additionally, the lot-feeding industry is under pressure from all levels of Government to report and reduce energy usage and GHG emissions. The growing competition for water has also led the government in Victoria to introduce water efficiency regulations.

Currently, federal energy and greenhouse gas reporting obligations only apply at relatively high levels of energy usage (0.5 petajoules of energy, 25,000 tonnes of CO_2-e for a single facility or 125,000 tonnes of CO_2-e for a corporation). Large, vertically integrated agricultural companies may meet these thresholds, resulting in reporting requirements for all subsidiary companies and feedlots in their control.

In Victoria, participation in the Environmental Resource Efficiency Plan (EREP) program is mandatory for feedlots that use more than 120 ML of water, which represent the water requirements for about 6,000-7,000 head-on-feed. There are other initiatives such as the National Pollutant Inventory (NPI) which could provide energy resource profiles.

MLA's goal in commissioning this project was to address the lack of accurate data and quantify the contribution of individual feedlot activities on the total annual water usage and total indirect and direct energy usage. A breakdown on energy usage within a feedlot and comparison against other sites will allow energy efficiency programs to be instigated.

1.1 B.FLT.0350 project description

The purpose of this study was to quantify the clean water usage and indirect and direct energy usage of individual feedlot activities. An MLA steering committee oversaw the selection of the feedlots such that the feedlots represented a cross section of geographical, climatic and feeding regimes within the Australian feedlot industry.

The sub-system boundary, as defined for the feedlot sector in FLOT.328, has been adopted for this project. The boundary (shown in red on Figure 1) 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 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, sundry uses 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.

The water and power meter data collected was supplemented with existing data collected on-site including fuel consumption (diesel, gas) and cattle performance data. Performance data included 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.

At most feedlots, a series of intensive assessments of minor water use operations were undertaken. Activities that were investigated in this way included trough cleaning, hospital cleaning, induction yard cleaning and vehicle washing. These minor activities were too numerous to monitor economically using inline water meters.

The data was analysed to obtain water and energy usage associated with a number of feedlot indices including a per head basis, per tonne grain processed and per kilogram of hot standard carcase weight gain (kg HSCW gain). A breakdown of resource use within the major feedlot activities and associated operations was provided.

2 Project objectives

The primary objectives of the project were as follows:

- To capture the clean water and energy usage from individual activities and performance data from eight feedlots representing a cross section of geographical, climatic and feeding regime diversity within the Australian feedlot industry, thus allowing the clean water and energy usage to be evaluated on the basis of one kilogram of hot standard carcass weight gain (kg HSCW gain).
- To communicate the results of the study to MLA in a format suitable for dissemination to industry stakeholders.
- Develop a framework for water and energy monitoring and efficiency in feedlots.

The outcomes of this project will allow the feedlot industry to develop a better understanding of the total annual clean water and energy usage and the relativity and contributions that various feedlot activities have on annual clean water and energy usage. This will allow the industry to reliably report actual usage levels for individual components such as drinking water, feed management, cattle washing, etc. Data will be used for individual feedlot planning, for industry wide planning (e.g. FLOT.132 – Vision 2020 project) and to propose water and energy use efficiency options for feedlots.

This report covers the area of water usage by feedlots. Water usage includes consumption within the major feedlot activities of feed management, drinking water, cattle washing and other minor uses including administration and sundry uses. Water losses due to evaporation in storages and water troughs are also included.

Water is both the most important feed component fed to cattle and the most valuable natural resource (after land) in Australia. Hence, it is of critical importance to lot feeders. There is a perception in the popular press that red meat production requires large quantities of fresh water. For example, it is often stated (with little presentation of reference material) that it takes 50,000 L of water to produce 1 kg of beef. However, in Australia, there are few facts to back up these claims.

For this report, the definition of water use is that used by Foran et al. (2005).

‘Managed water use denotes the consumption of self-extracted water (water from rivers, lakes and aquifers, mainly extracted by farmers for irrigation) as well as mains water, in units of litres (L). Collected rainfall, such as in livestock dams on grazing properties is not included in these figures’.

Water for feedlots can be obtained from a variety of sources including shallow and artesian bores, rivers, creeks, irrigation channels, water harvesting of overland flow into on-farm dams and reticulated pipelines. In this analysis, only water supplied from bores, rivers, creeks, irrigation channels, reticulated pipelines and on-farm storages is considered. Rainfall on the feedlot surface is not considered. This report includes a literature review of clean water usage at feedlots, data collection and results as well as an analysis and discussion of the data collected.

This report includes water usage data collected from March 2008 to February 2009, as well as a comparative analysis and discussion with the data collected from March 2007 to February 2008.

2.1 Project reporting structure

The project involved the collection and analysis of a large quantity of data from operational feedlots on the water and energy usage associated with feedlot operation. All data was standardised to a number of indices including a per head basis, per tonne grain processed and per kg HSCW gain. To ensure all this data and information was presented in a suitable manner, two reports were compiled.

A. Water usage at Australian feedlots. This report presents a background literature review of water usage within individual activities of feedlots, data collection and results, as well as an analysis and discussion of the data collected. It includes consumption within the major activities of cattle drinking water, feed management and cattle washing and other minor uses such as administration and sundry uses.

B. Energy usage at Australian feedlots. This report presents a review of total direct and indirect energy usage at feedlots, data collection and results, as well as an analysis and discussion of the data collected. It includes consumption within the major feedlot activities of feed management, water supply, waste management, cattle washing and other minor uses including administration and repairs and maintenance. In addition, indirect energy consumption within the areas of incoming and outgoing cattle and commodity delivery are included.

C. A framework for water and energy monitoring in feedlots. To assist the feedlot industry to improve energy efficiency, a framework has been developed to step through the process of measuring and reducing water and energy usage at the feedlot. This framework is presented as fact sheets, arranged in 3 series:

   a. Measuring and Understanding resource usage
   b. Benchmarking, and
   c. Improving resource efficiency

3 Materials and methods

3.1 Overview – experimental work

The objective of the project was to collect good-quality data on water usage and relate this to production parameters in feedlots so that the information could be used across Australia. To that end, it was necessary to ensure that the feedlots involved were representative and that reliable data could be obtained. The steps in the project were:

1. Select a range of feedlots across Australia that were representative of climatic zones, feeding regimes, management styles and cattle markets.
2. Review the design and management of these feedlots to select those where reliable data could be collected at a reasonable cost.
3. Select the preferred feedlots and complete negotiations at each site.
4. Design an instrumentation system for each feedlot.
5. Design a data collection system for each feedlot.
6. Undertake regular (monthly or fortnightly) data collection.
7. Undertake short-term detailed data collection for specific aspects of water usage.
8. Analyse and review the data.

3.2 Selected feedlots

Following a lengthy process, eight feedlots were selected to provide a representative sample. Table 1 summarises the key characteristics of the selected feedlots. To maintain confidentiality, none of the feedlots are identified by name and will be referred to as Feedlots A to H.

The selected feedlots provide a range of climatic conditions from a northern feedlot in a hot, humid summer-dominant rainfall to southern feedlots in cooler, winter-dominant rainfall zones.

Grain processing methods vary from simple tempering to reconstitution and steam flaking. Some feedlots wash cattle (mainly in winter) while other feedlots do not undertake any cattle washing.

Feedlot D was not included in the water studies and Feedlot G was not included in the energy studies.

Table 1 – Characteristics of selected feedlots

Feedlot Name		A	B	C	D	E	F	G	H
Climate									
Mean Annual Rainfall	mm	577	582	403	641	679	831	640	716
Rainfall Pattern		Summer dominant	Winter dominant	Winter dominant	Summer dominant	Summer dominant	Uniform	Summer dominant	Summer dominant
Mean Annual Class A Pan Evaporation	mm	2372	1825	1788	1934	1934	1423	1934	1715
Mean Max Temp – January	°C	34.1	31.2	29.6	31.6	31.6	25.9	31.6	29.7
Mean Min Temp – June	°C	8.9	2.7	4.3	5.7	5.7	2.0	5.7	4.6
Feedlot Capacity and Design									
Licensed Capacity	head	>15000	>15000	>15000	>15000	>15000	>15000	>5000	>1000
Cattle Washing	% of turnoff	0	30	40	0	10	40	0	65
Feed Processing									
Grain Processing Method		Steam Flaked	Steam Flaked	Steam Flaked	Reconstitution	Reconstitution	Steam Flaked	Steam Flaked	Tempering
Main Energy Source		LPG	Natural Gas	LPG	Electricity	Electricity	Butane	LPG	Electricity

3.3 Water supply and reticulation system layouts

The project needed to measure total clean water usage, as well as the water usage in the main feedlot activities. The main areas of interest were:

1. Focus Area 2 - Pen Area
2. Focus Area 3 - Feed Processing
3. Focus Area 4 - Cattle Washing
4. Focus Area 5 – Administration

Water usage in the pen area is primarily cattle drinking water but can include other uses of water within the pen area. This could include:

- Trough cleaning
- Trough evaporation losses
- Hospital wash down
- Receival / dispatch facility washdown
- Vehicle washing
- Dust control
- Stables

Site-specific measurements were undertaken at each feedlot to quantify these additional water uses within the drinking water sector (see Section 3.6).

Any existing water meters were located and the required positioning of additional water meters was determined.

A gap analysis was undertaken to determine the quantity and type of water measurement instrumentation required to allow direct or indirect measurement of these major activities. This was undertaken in collaboration with the Condamine Electric Company (CEC), a company that specialises in irrigation installations.

In most cases, the water reticulation system at each feedlot was a complex layout. This is due to a number of factors including evolutionary design as the feedlot has expanded and developed over time and a built-in redundancy factor. The redundancy factor allows water to flow to pens from more than one direction. Drinking water supply lines are usually ring line systems, making direct measurement very difficult.

A comprehensive description of the water supply monitoring system installed at each feedlot can be found in MLA project B.FLT.0339 report '*Quantifying the Water and Energy Usage of Individual Activities within Australian Feedlots*' Part A Report: Water Usage at Australian Feedlots (Davis et al. 2008).

3.4 Monthly water usage recording

As most of the water meters did not have any digital recording capability, each meter had to be read manually at the end of each period. The nominal period was monthly, however if the last day of the month fell on a weekend then the meters were read either prior to or at the earliest convenience after the last day of the month. Therefore, the nominal period varied from a minimum of 27 to a maximum of 33 days.

Each feedlot was given a recording sheet which detailed the meter number and location. The feedlot manager or a nominated staff member read the water meters. The reading along with the respective units either megalitres (ML), kilolitres (kL) or cubic metres (m^3) were recorded on the recording sheet and faxed or emailed to FSA Consulting at the end of each month.

The M8 water meter installed at Feedlot G had a single channel logger installed to log a pulse signal from the meter. The logger recorded the date, time and counted the pulses between a user defined logging period. It then translated the data into a flow rate and total flow per minute. In this case, the data from the meter was downloaded via computer every month and the resulting dataset emailed to FSA Consulting.

3.5 Monthly herd performance and feed consumption recording

Due to the potentially sensitive nature of the information produced by this research, the reported information has been presented in such a way that individual feedlots cannot be identified. Therefore, water use is presented as a function of a number of feedlot indices to protect the anonymity of the feedlot. The feedlot indices corresponded to the activity measured and included usage on a per head basis, per tonne grain processed and per kilogram of hot standard carcase weight gain (kg HSCW gain).

In this context, HSCW gain is the difference between total dressed carcase weight of cattle leaving the feedlot less the estimated total dressed carcase weight of cattle entering the feedlot.

To enable the respective indices to be estimated, herd performance and feed consumption data was provided. Herd performance data was provided on a market type basis and included liveweight of incoming and shipped cattle, days on feed, average daily gain, dressing percentage, number of cattle entering the feedlot along with number shipped. Commodity usage for the period was provided, broken into categories of major grains, protein sources, roughages/silages, liquids and supplements.

The herd performance and feed consumption data was obtained directly from the respective feedlots in-house feedlot management software (e.g. Bunk Management System, Possum Gully, Feedlot 3000). These systems are dedicated cattle feeding software systems to assist operations in better managing assets, inventories, commodities and maintenance of financial records.

3.6 Sundry water uses

Sundry water usage was assessed at all feedlots between February and August 2007. These assessments involved discussion with feedlot managers and staff together with on-ground measurements and observations for various operations. Activities investigated included trough cleaning, hospital cleaning, induction yard cleaning and vehicle washing. These minor activities are too numerous to monitor economically using in-line water meters. An assessment of evaporation loss at each feedlot used field measurements and climate data. These losses occur from troughs and open storages, and consequently, evaporation losses vary greatly between feedlots.

A comprehensive description of the sundry water usage at each feedlot can be found in MLA project B.FLT.0339 report '*Quantifying the Water and Energy Usage of Individual Activities within Australian Feedlots*' Part A Report: Water Usage at Australian Feedlots (Davis et al. 2008).

It was assumed that sundry water usage measured in 2007 was similar in 2008. Evaporative loss was based on monthly climate data from each respective feedlot where available.

3.7 Data collection period

Monthly data were collected over a 24-month period from March 2007 to February 2009. This period allowed for the annual variation in total water usage to be quantified along with the variation in individual feedlot activities. This report presents data from the March 2008 to February 2009 period along with a comparative summary with the data collected between March 2007 and February 2008.

Intensive measurements of trough cleaning and other minor water uses were undertaken between February and August 2007 by FSA Consulting staff (Stephen Wiedemann, Rod Davis, Nathan Heinrich and Peter Watts).

3.8 Data analysis

Monthly water meter readings were imported into a large Excel spreadsheet and cross checked with previous month's readings. Where anomalous data were detected, the participating feedlot was contacted and the data were examined in more detail. Anomalous data may have included a reduction in meter reading from previous or unexplained extraordinarily large increases in water usage.

Herd performance and feed consumption data were imported into the same spreadsheet. Similarly, data quality checks were undertaken. For example, the mean number of cattle-on-hand were compared with licensed capacity to ensure market types were not counted twice or missed. Where anomalous data were detected, the participating feedlot was contacted and the data were examined in more detail. The total HSCW gain per month was calculated from the data for estimated liveweight in lot at the start of the month, total liveweight in, total liveweight out and estimated liveweight in lot at the end of the month.

The spreadsheet then calculated the water usage of the major feedlot activities as a function of their respective indices including on a per head basis, per tonne grain processed and per kilogram of hot standard carcase weight gain (kg HSCW gain).

4 Results and discussion

Total water usage and activity water usage are presented in the following sections. It is important to note that the feedlot numbering system in the methodology section does not align with the number system in the results and discussion sections. That is, Feedlot B in Section 3.2 is not Feedlot B in Section 4.1. This provides anonymity for the participating feedlots.

4.1 Total water usage

Figure 2 illustrates the average monthly total clean water use for the seven feedlots from March 2007 to February 2009, expressed per kg HSCW gain. Total water usage is the combination of drinking water, feed processing, cattle washing (where this practice is undertaken), administration and sundry uses. The minimum and maximum total water consumption for any one month in the study period is also presented.

The average monthly total clean water usage across all feedlots for March 2007 to February 2009 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.

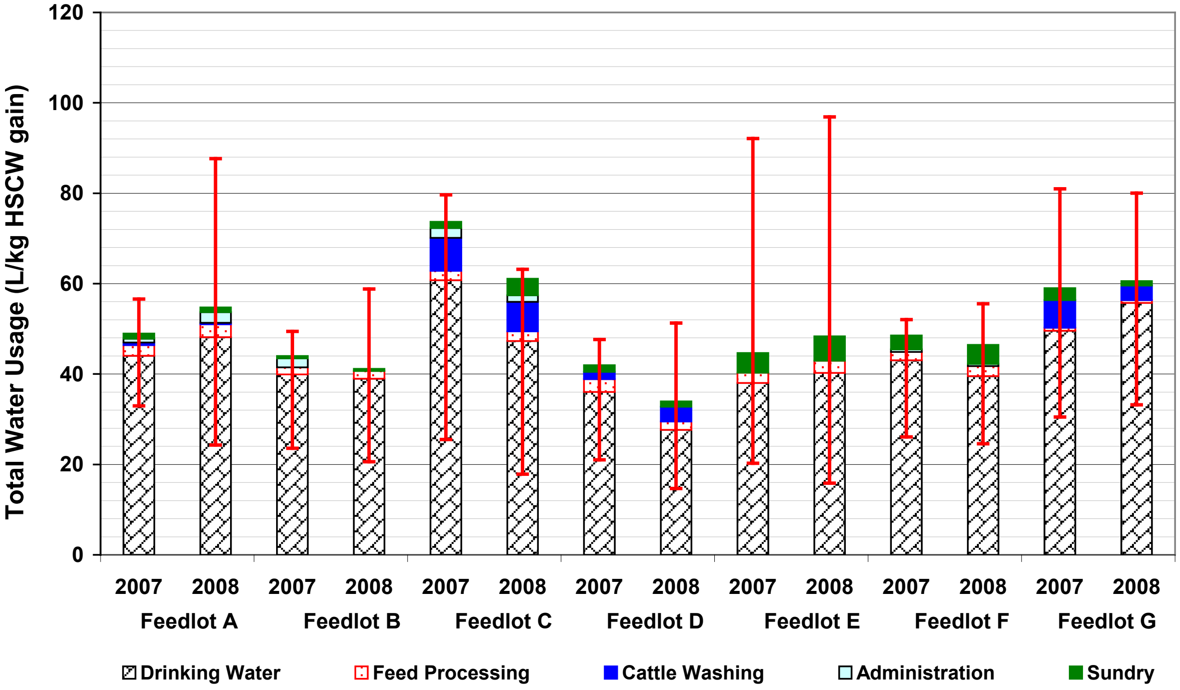

Figure 2 – Average monthly total water usage (MJ/kg HSCW gain/month)

Figure 3 to Figure 9 inclusive present the monthly results for the period March 2007 to February 2008 of the total clean water use for the seven feedlots. Total clean water usage is the combination of drinking water, feed processing, cattle washing (where this practice is undertaken), administration and direct sundry uses such as trough cleaning, dust control, vehicle and facility cleaning and indirect sundry 'uses' such as evaporation. There was no clean water usage reported for effluent dilution. For cattle washing, only the clean water usage is presented in this section. At a number of feedlots, recycled water is also used for cattle washing. These data will be presented in Section 4.4. The usage for the respective activities was standardised per kg HSCW gain for the respective month.

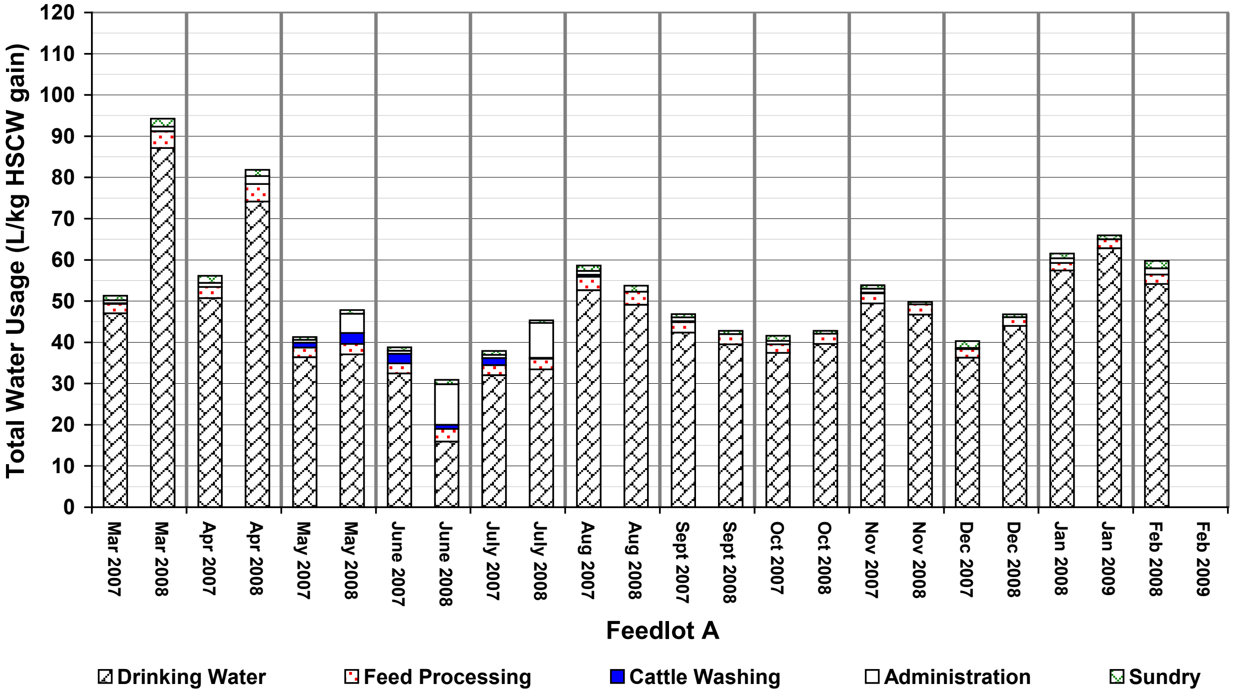

Figure 3 – Monthly total water usage at Feedlot A (L/kg HSCW gain/month)

Figure 3 shows the total monthly clean water usage at Feedlot A for the period March 2007 to February 2009. The average monthly total water usage in 2007-2008 was 49 L/kg HSCW gain, slightly lower than the 54.7 L/kg HSCW gain measured in 2008-2009. This average is skewed by two extreme hot months of March and April 2008 when drinking water increased significantly. The total monthly clean water use ranges from 31 in July 2008 to 95 L/kg HSCW gain in March 2009. The lowest water usage was measured in winter (July) and the highest in summer period. Drinking water is the single largest consumer of water in the feedlot as expected and contributed 15 to 87 L/kg HSCW gain or in the order of 89 % of total usage.

In June and July, cattle washing water usage contributed between 1.7 to 2.4 L/kg HSCW gain in 2007 (4 %) and 0.2 to 1.0 L/kg HSCW gain (1 %) in 2008 of total water usage respectively. Feed processing contributed an average of 2.6 L/kg HSCW gain or around 5 % of total usage. Administration (2 %) and sundry uses (1 %) contribute the remaining usage. Further discussion on activity water usage is presented in Sections 4.2 to 4.6.

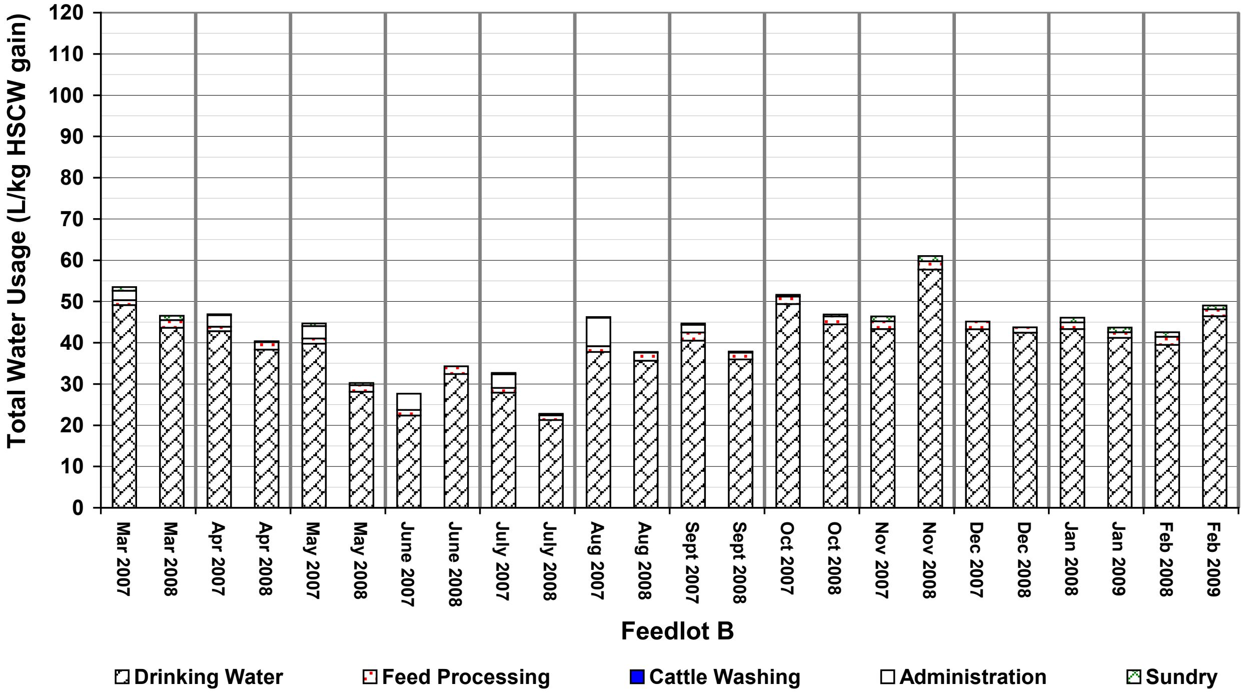

Figure 4 – Monthly total water usage at Feedlot B (L/kg HSCW gain/month)

Figure 4 shows the total monthly clean water usage at Feedlot B for the period March 2007 to February 2009. The average monthly total water usage in 2007-2008 was 44 L/kg HSCW gain, slightly higher than the 41 L/kg HSCW gain measured in 2008-2009.

Total monthly clean water use ranges from 23 L/kg HSCW gain in July 2008 to 61 L/kg HSCW gain in November 2008. The lowest water usage was measured in winter (June), with remaining months showing a fairly consistent level of usage. Drinking water is the single largest consumer of water in the feedlot as expected and contributed between 21 to 57 L/kg HSCW gain or an average of 90 % of total usage. Feedlot B does not wash cattle and administration water usage was not recorded from September 2007 to February 2009 due to a broken water meter. Feed processing contributed an average of 1.6 L/kg HSCW gain or around 4 % of total usage. Administration (5 %) and sundry uses (1 %) contributed the remaining usage. Further discussion on activity water usage is presented in Sections 4.2 to 4.6.

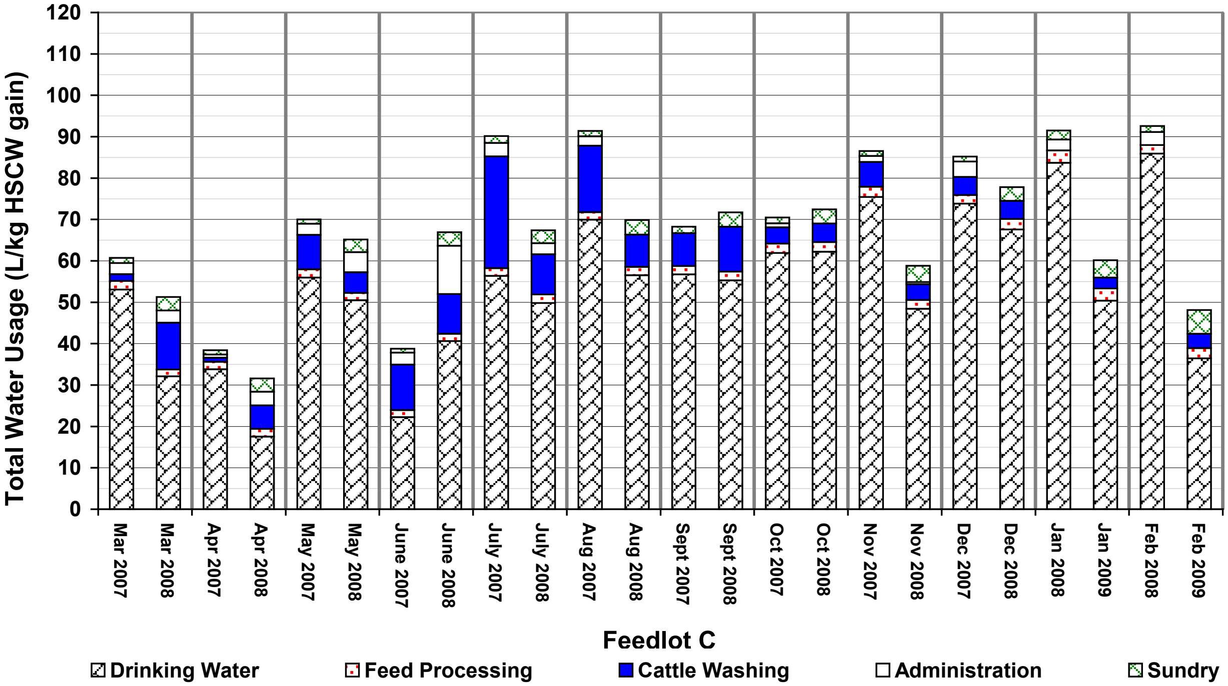

Figure 5 – Monthly total water usage at Feedlot C (L/kg HSCW gain/month)

Figure 5 shows the total monthly clean water usage at Feedlot C for the period March 2007 to February 2009. The average monthly total water usage in 2007-2008 was 73.1 L/kg HSCW gain, slightly higher than the 61.1 L/kg HSCW gain measured in 2008-2009.

Total monthly clean water use ranges from 32 L/kg HSCW gain in April 2008 to 93 L/kg HSCW gain in February 2008. The lowest water usage was measured between March and June, whilst highest on average is across July to November. Drinking water is the single largest consumer of water in the feedlot as expected and contributed 18 to 86 L/kg HSCW gain or an average of 89 % of total usage in months with no cattle washing and an average 73 % in months when cattle were washed.

Feed processing contributed an average of 2.1 L/kg HSCW gain or around 3 % of total usage. Cattle washing was undertaken continually from May 2007 to February 2009 and cattle washing water usage contributed an average of 8 L/kg HSCW gain (12 %) of total water usage. Administration (4 %) and sundry uses (2 %) contributed the remaining usage. Further discussion on activity water usage is presented in Sections 4.2 to 4.6.

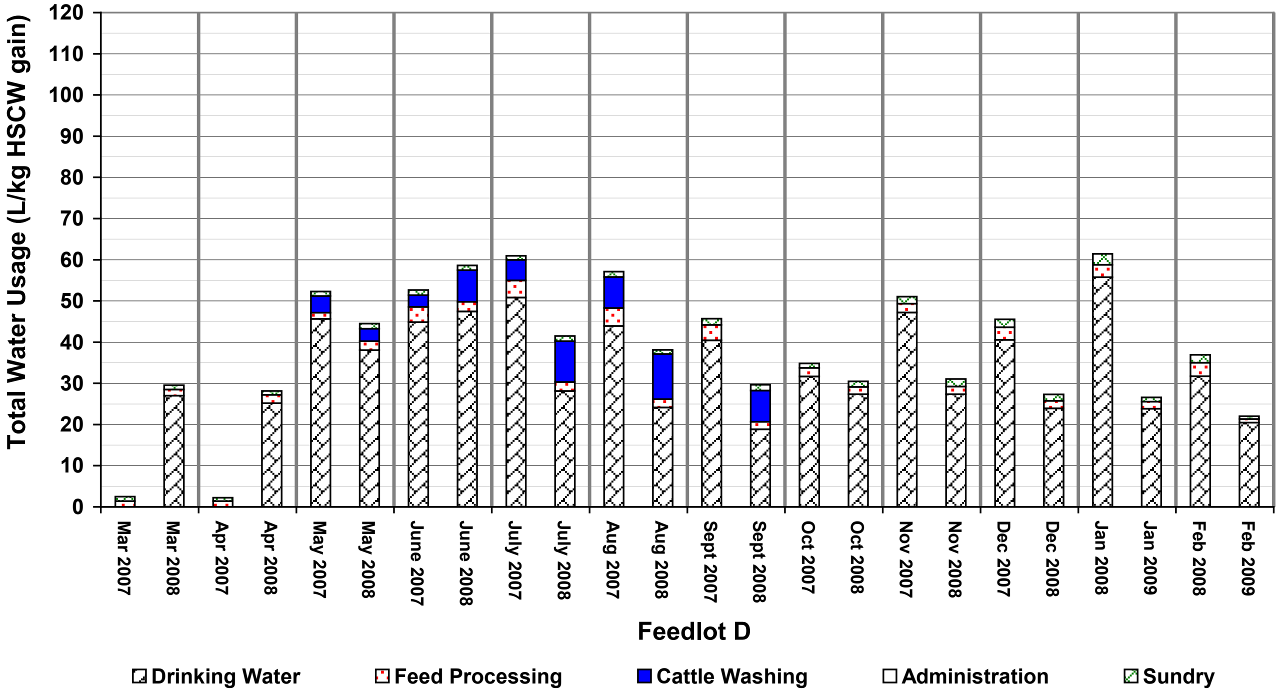

Figure 6 – Monthly total water usage at Feedlot D (L/kg HSCW gain/month)

Figure 6 shows the total monthly clean water usage at Feedlot D for the period March 2007 to February 2009. Drinking water was not measured in March and April 2007. The average monthly total water usage in 2007-2008 was 41.9 L/kg HSCW gain, substantially higher than the 34 L/kg HSCW gain measured in 2008-2009.

Total monthly clean water use ranges from 22 to 62 L/kg HSCW gain. The lowest water usage was January and February 2009 and the highest in July and August. At this feedlot, office water usage could not be measured directly and therefore is included in the drinking water total. Drinking water is the single largest consumer of water in the feedlot as expected and contributed 18 to 55 L/kg HSCW gain or an average of 92 % of total usage in months with no cattle washing and an average 85 % in months when cattle were washed.

At this feedlot, a steam flaking feed processing system was commissioned in June 2007. Prior to this, grain was tempered only. Feed processing contributed an average of 1.5 L/kg HSCW gain or around 3 % of total usage when tempered only compared with 2.5 L/HSCW gain (7%) when steam flaked. From May to September, cattle washing water usage contributed an average of 6.5 L/kg HSCW gain (12 %) of total water usage. Sundry uses (2 %) contributed the remaining usage. Further discussion on activity water usage is presented in Sections 4.2 to 4.6.

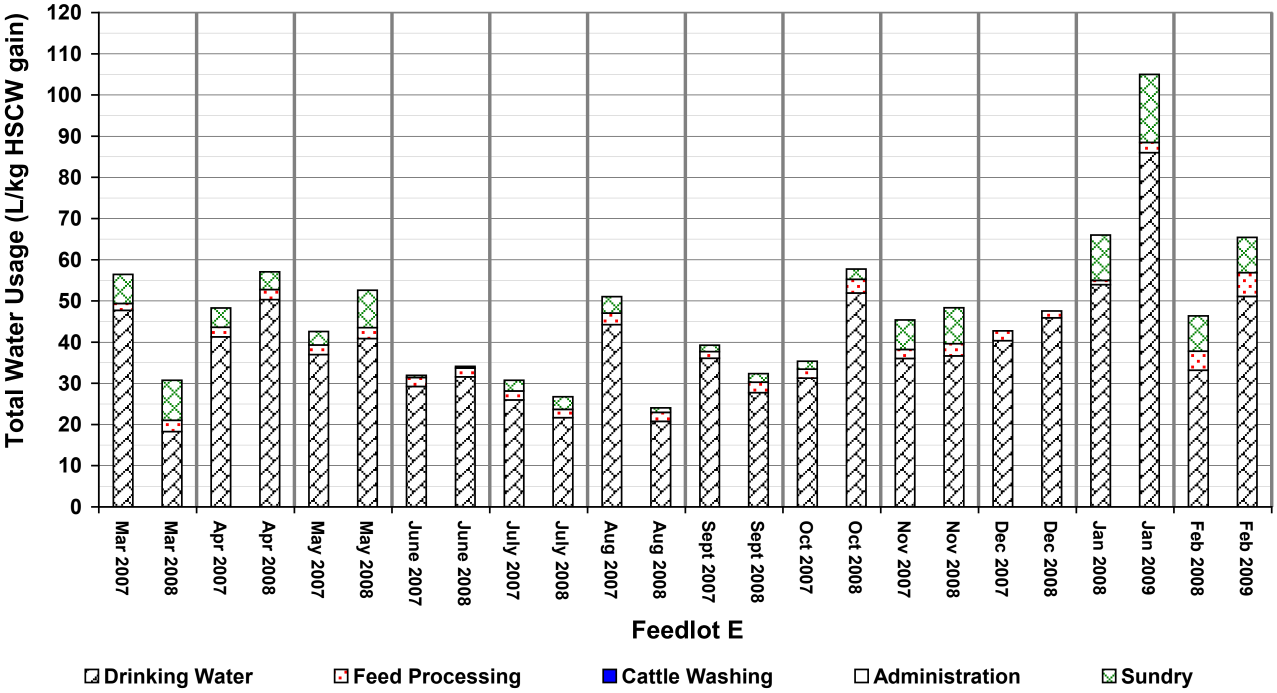

Figure 7 – Monthly total water usage at Feedlot E (L/kg HSCW gain/month)

Figure 7 shows the total monthly clean water usage at Feedlot E for the period March 2007 to February 2009. The average monthly total water usage in 2007-2008 was 44.7 L/kg HSCW gain, slightly lower than the 48.4 L/kg HSCW gain measured in 2008-2009.

Total monthly clean water use ranges from 24 L/kg HSCW gain in August 2008 to 105 L/kg HSCW gain in January 2009. The lowest water usage was measured in winter (July) and the highest in summer (January). At this feedlot, office water usage could not be measured directly and therefore is included in the drinking water total.

Drinking water is the single largest consumer of water in the feedlot as expected and contributed 18 to 86 L/kg HSCW gain or an average of 91 % of total usage. The variation in drinking water consumption can be explained through climatic variation throughout the study period.

Feedlot E did not wash any cattle during the reporting period. Feed processing contributed an average of 2.5 L/kg HSCW gain or around 5 % of total usage. Sundry uses (3 %), in particular dust control contributed the remaining usage. Further discussion on activity water usage is presented in Sections 4.2 to 4.6.

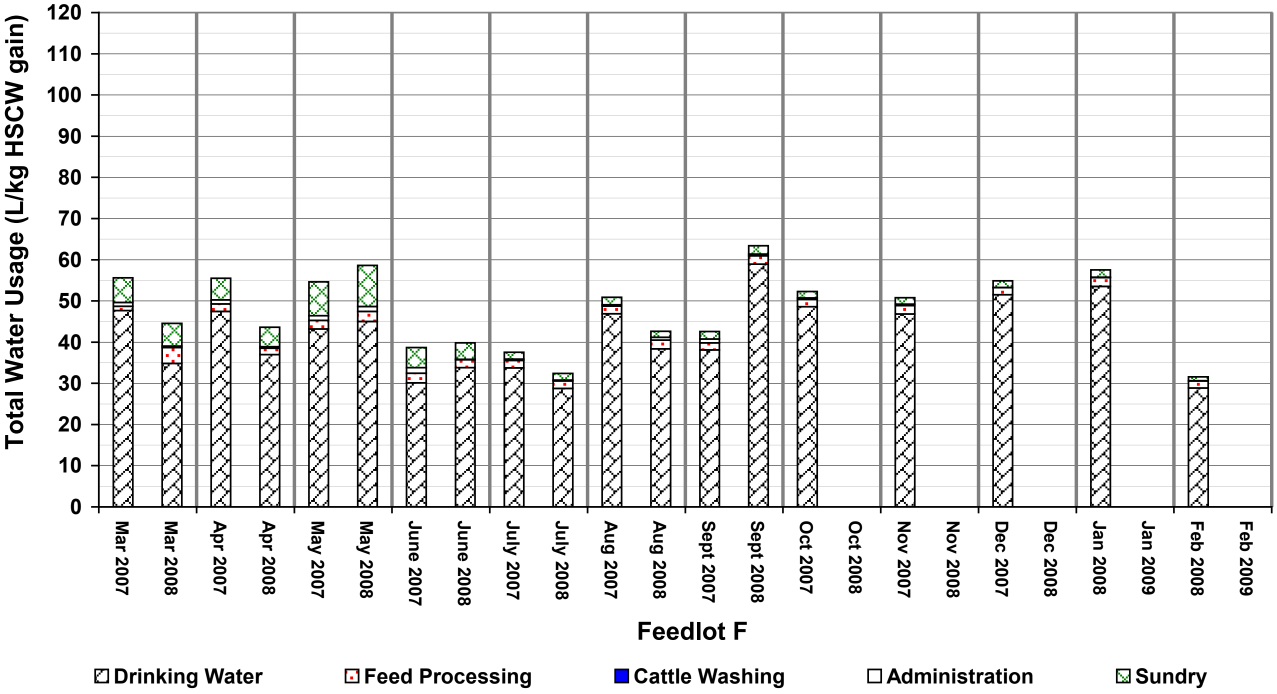

Figure 8 – Monthly total water usage at Feedlot F (L/kg HSCW gain/month)

Figure 8 shows the total monthly clean water usage at Feedlot F for the period March 2007 to February 2009. Due to a company restructure and subsequent tightening of labour resources, data collection for this study ceased at the end of September 2008. The average monthly total water usage in 2007-2008 was 44.7 L/kg HSCW gain. Between March 2008 and September 2008 the monthly total water usage measured was 46.4 L/kg HSCW gain.

Total monthly clean water use ranges from 32 L/kg HSCW gain in August and February 2008 to 64 L/kg HSCW gain in September 2008. The highest water usage was measured in September and January 2008 and the lowest in February and July 2008, both high rainfall months.

Drinking water is the single largest consumer of water in the feedlot as expected and contributed 28 to 59 L/kg HSCW gain or an average of 91 % of total monthly usage. Feed processing contributed an average of 2 L/kg HSCW gain or around 4 % of total usage. Administration contributed an average of 0.6 L/kg HSCW gain (1 %) predominantly in garden maintenance. Sundry uses, in particular dust control contributed an average of 4.0 L/kg HSCW gain or 8 % usage. Further discussion on activity water usage is presented in Sections 4.2 to 4.6.

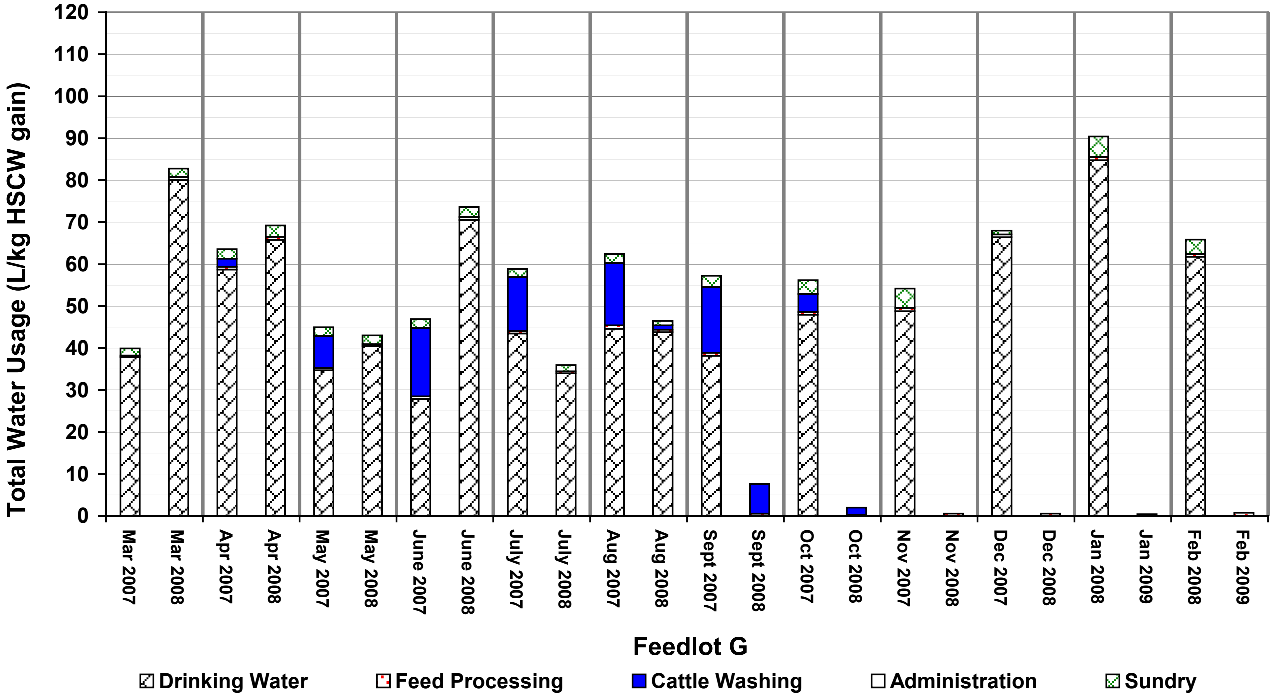

Figure 9 – Monthly total water usage at Feedlot G (L/kg HSCW gain/month)

Figure 9 shows the total monthly clean water usage at Feedlot G for the period March 2007 to February 2009. Drinking water was not measured from September 2008 to February 2009.

The average monthly total water usage in 2007-2008 was 59 L/kg HSCW gain. Between March 2008 and August 2008 the monthly total water usage measured was 60.9 L/kg HSCW gain.

Total monthly clean water use ranges from 36 L/kg HSCW gain in July 2008 to 90 L/kg HSCW gain in January 2008. The lowest water usage was measured in the winter months and the highest in summer (January).

At this feedlot, office water usage could not be measured directly and therefore is included in the drinking water total. Drinking water is the single largest consumer of water in the feedlot as expected and contributed 28 to 85 L/kg HSCW gain or an average of 95 % of total usage in months with no cattle washing and an average 75 % in months when cattle were washed.

Feed processing contributed an average of 0.6 L/kg HSCW gain or around 1 % of total usage. From May to October, cattle washing water usage contributed an average of 11.3 L/kg HSCW gain (21 %) of total water usage. Sundry uses contributed the remaining usage representing an average of 2.0 L/kg HSCW gain (4 %). Further discussion on activity water usage is presented in Sections 4.2 to 4.6.

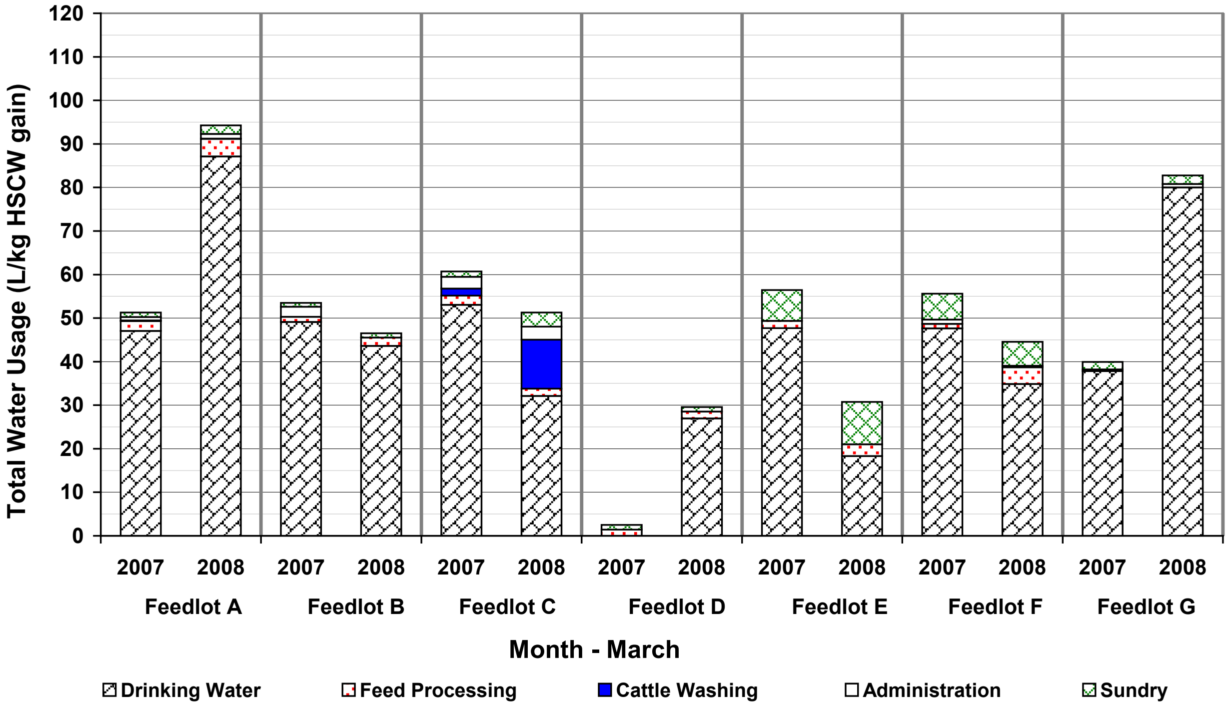

Figure 10 – Total water usage for March (L/kg HSCW gain)

Figure 10 shows the total clean water usage across all feedlots for March 2007 and 2008. Total monthly clean water use ranges from 30 L/kg HSCW gain (Feedlots D and E) to 95 L/kg HSCW gain at Feedlot A. In March 2008, hot weather was experienced on the Darling downs and combined with lower cattle on feed during this period translates into a higher total water usage per kg HSCW gain when compared to 2007 levels. Feedlot B, C and F showed similar levels in total water usage between years. Feedlot E had a lower total water usage in 2008 when compared with 2007 levels. Drinking water was not recorded at Feedlot D during March 2007.

Drinking water consumption ranged from 18 to 87 L/kg HSCW gain for all feedlots. Feed processing water usage ranged from 0.4 to 4.0 L/kg HSCW gain. Administration water usage was directly measured at Feedlots A, B, C and F and was found to range from 0.4 to 3.0 L/kg HSCW gain. Sundry water uses contributed 0.9 to 9.7 L/kg HSCW gain. Dust control and evaporative losses are the primary drivers of sundry water usage. Further discussion on activity water usage is presented in Sections 4.2 to 4.6.

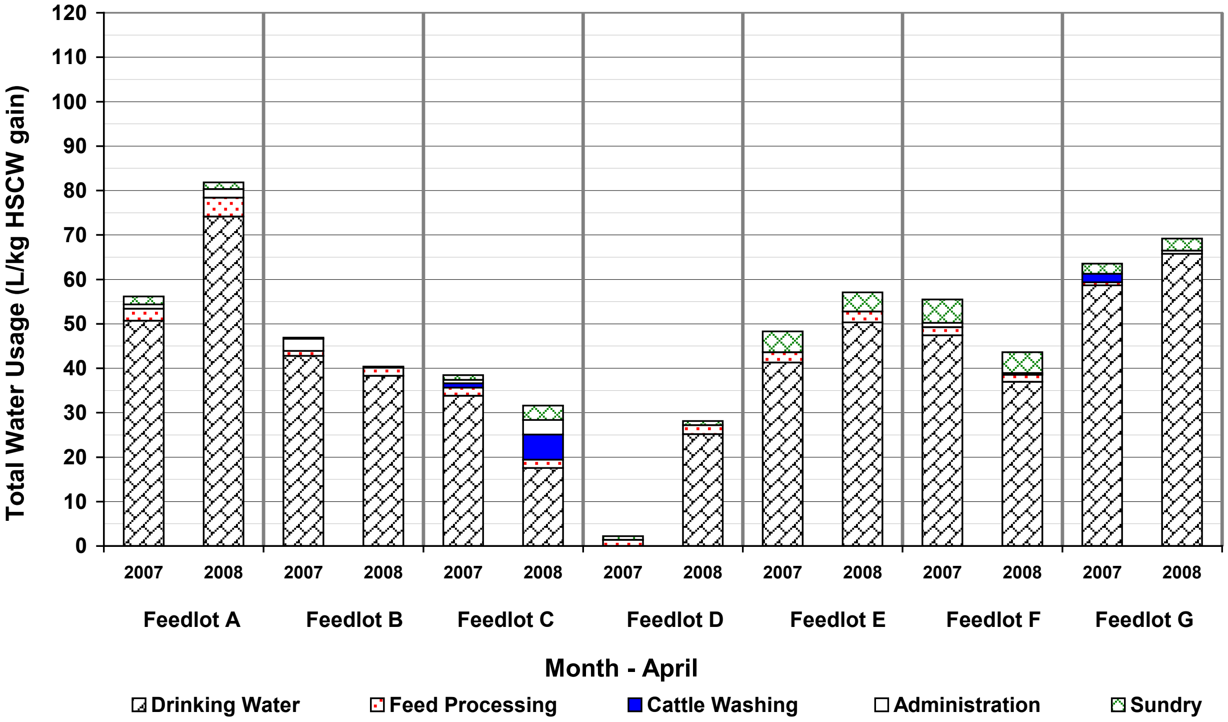

Figure 11 – Total water usage for April (L/kg HSCW gain)

Figure 11 shows the total clean water usage across all feedlots for April 2007 and 2008. Total monthly clean water use ranges from 28 (Feedlot D) to 82 L/kg HSCW gain (Feedlot A).

The lowest water usage was measured at Feedlot C and the highest at Feedlot G. Drinking water was not recorded at Feedlot D during April 2007. Feedlots A, B and G recorded a higher level of total water usage on a per kg HSCW gain in 2008 when compared with 2007 levels. Feedlots B, C and F recorded a lower level of total water usage on a per kg HSCW gain in 2008 when compared with 2007 levels.

Drinking water consumption ranged from 17.5 to 74.2 L/kg HSCW gain across all feedlots with an average of 44 L/kg HSCW gain. This is a similar range and average to that measured in March. Feed processing water usage ranged from 0.7 to 4.2 L/kg HSCW gain, similar levels to March. Administration water usage are similar to that measured in March at Feedlots A, B, C and F, ranging from 0.4 to 3.3 L/kg HSCW gain. Sundry water uses contributed 0.2 to 5.3 L/kg HSCW gain. Further discussion on activity water usage is presented in Sections 4.2 to 4.6.

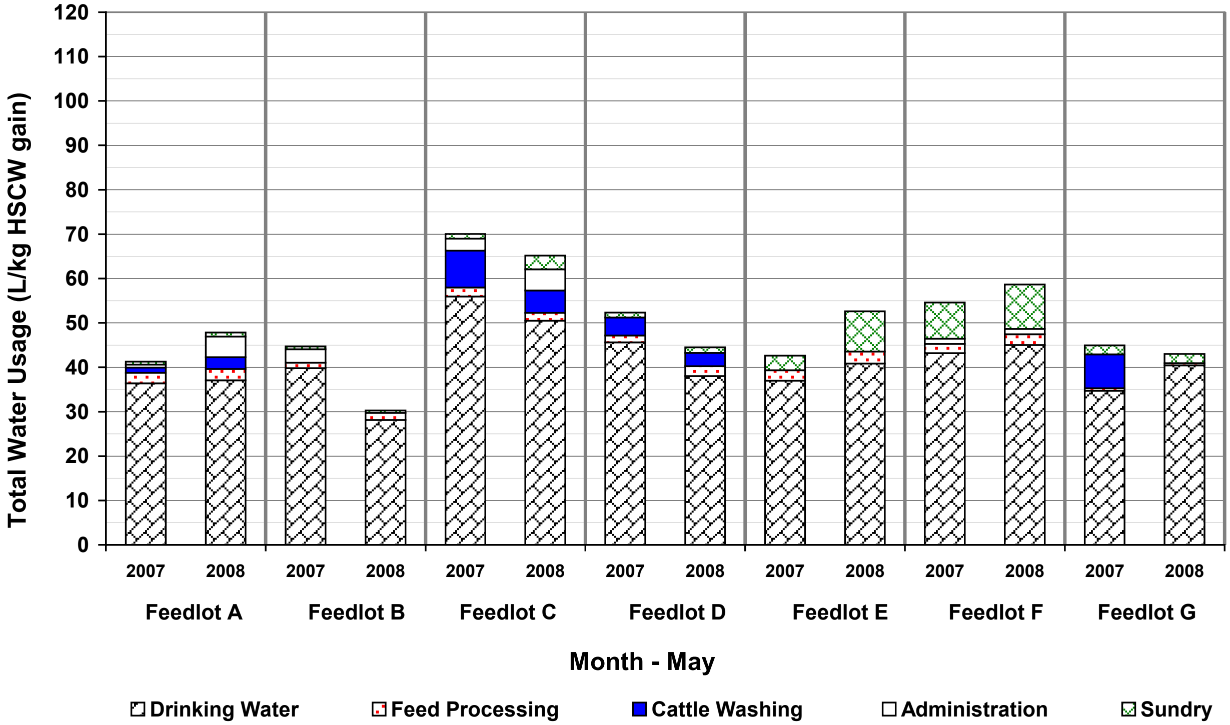

Figure 12 – Total water usage for May (L/kg HSCW gain)

Figure 12 shows the total clean water usage across all feedlots for May 2007 and 2008. Total monthly clean water usage levels range from 30 to 70 L/kg HSCW gain. In May, there is less variability between years, when compared with April.

The main driver of total monthly clean water use is drinking water consumption level, which is determined by prevailing climatic conditions.

Consider Feedlot C, which has increased its drinking water consumption considerably and has commenced washing cattle. Feedlot F has a similar level to previous months, whilst Feedlot G has recorded a lower drinking water consumption than previous.

Drinking water consumption ranged from 28 to 55 L/kg HSCW gain a similar range and more consistent levels between years when compared to April. The minimum feed processing water usage recorded was 0.5 L/kg HSCW gain and similar to April, whilst the maximum had reduced to 2.7 L/kg HSCW gain. Cattle washing water usage ranged from 1.2 to 8.3 L/kg HSCW gain. Administration water usage are similar to that measured in April at Feedlots A, B, C and F, ranging from 0.7 to 4.8 L/kg HSCW gain. Sundry water uses contributed 0.6 to 10.0 L/kg HSCW gain. At Feedlot F, the increased sundry water usage is due to irrigation of gardens. Further discussion on activity water usage is presented in Sections 4.2 to 4.6.

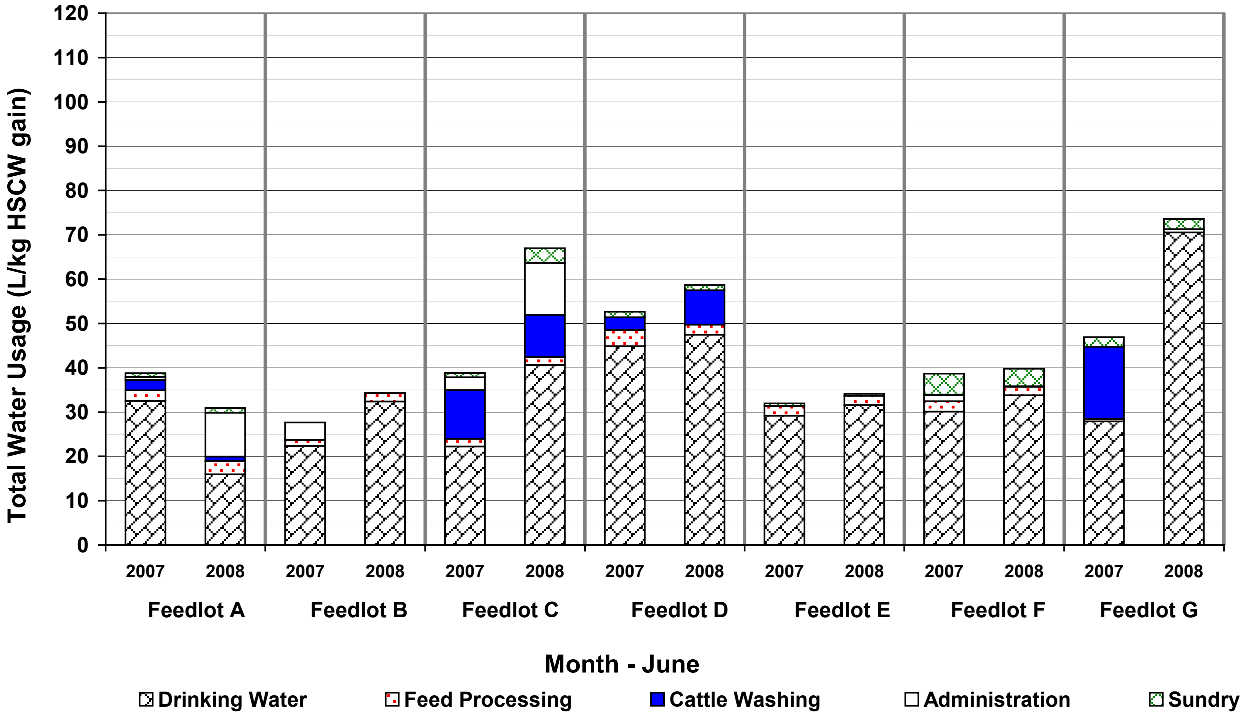

Figure 13 – Total water usage for June (L/kg HSCW gain)

Figure 13 shows the total clean water usage across all feedlots for June 2007 and 2008.

Total monthly clean water usage levels have reduced from 28 (Feedlot B) to 74 L/kg HSCW gain (Feedlot G). The greatest reduction was at Feedlot C, where levels reduced from 70 to 38 L/kg HSCW gain, and this was driven by a reduction in drinking water consumption level, a result of prevailing climatic conditions. In 2008, Feedlot G recorded a significant increase in total water usage when compared with May levels. However, Feedlots A and E recorded similar levels in total water usage when compared with May.

Drinking water consumption ranged from 15 to 70 L/kg HSCW gain. Feed processing water usage ranged from 0.6 to 3.7 L/kg HSCW gain, a slightly greater range when compared to May, due primarily to variation in feedlots with steam flaking systems. Cattle washing water usage ranged from 1.0 to 16.3 L/kg HSCW gain. Administration water usage levels are similar to that measured in May at Feedlots B and F. However, Feedlot B and C recorded a large increase from June levels. Sundry water uses contributed 0.4 to 4.9 L/kg HSCW gain. The reduction in sundry water use for Feedlot F, is driven by reduced irrigation of gardens. Further discussion on activity water usage is presented in Sections 4.2 to 4.6.

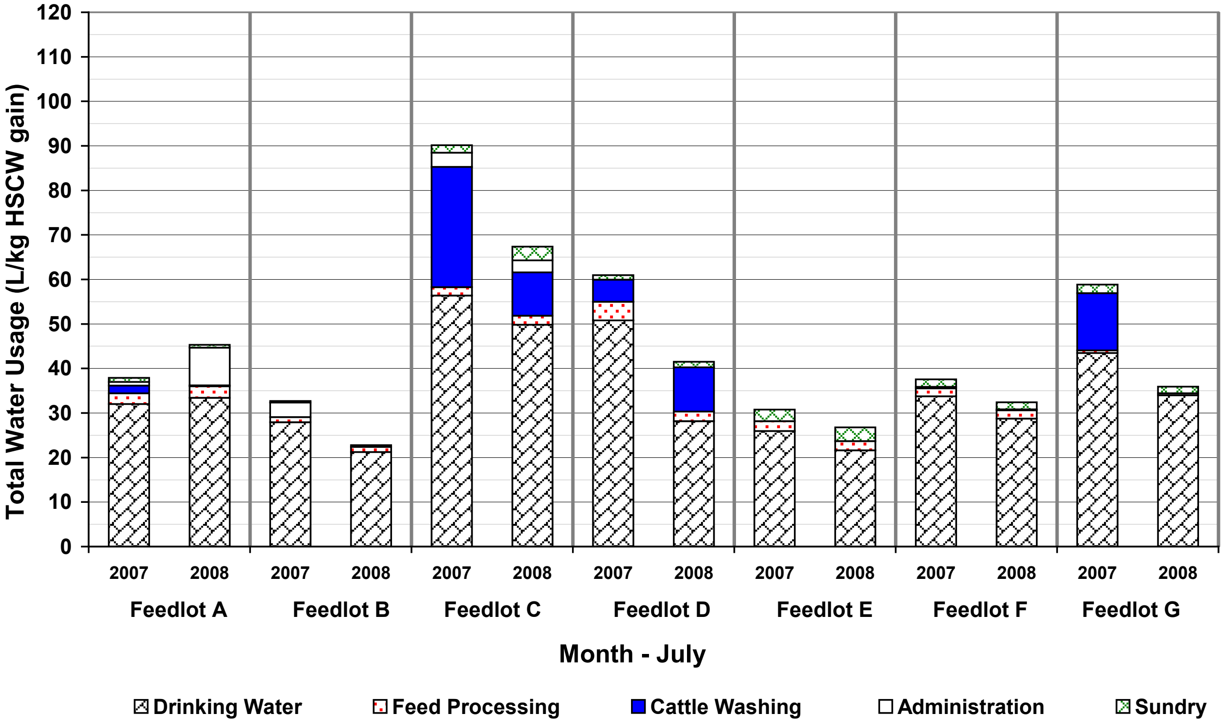

Figure 14 – Total water usage for July (L/kg HSCW gain)

Figure 14 shows the total clean water usage across all feedlots for July 2007 and 2008. Total monthly clean water usage levels have increased and range from 23 (Feedlot B) to 90 L/kg HSCW gain (Feedlot C). Feedlots C, D and G have increased total usage levels when compared with June, with the greatest increase at Feedlot C. At Feedlot C, the total usage level has increased from 38 to 90 L/kg HSCW gain, driven by an increase drinking water consumption and cattle washing usage levels.

Drinking water consumption ranged from 21 to 56 L/kg HSCW gain. Feed processing water usage ranged from 0.4 to 4.2 L/kg HSCW gain, a similar range when compared to June. Cattle washing water usage ranged from 1.7 to 27.0 L/kg HSCW gain (June 2007). With the exception of Feedlot C in 2007, all feedlots decreased usage when compared with June 2007 and 2008. Climatic variability is also reflected in cattle washing usage with drier conditions in 2008 translating into a reduction in water usage from cleaner cattle. Administration water usage increased when compared to that measured in June at Feedlots A, B, C and F and ranged from 0.3 to 8.5 L/kg HSCW gain. Higher administration water usage was recorded in 2008 per kg HSCW gain. Sundry water uses contributed 0.3 to 3.1 L/kg HSCW gain and was similar to June levels. Further discussion on activity water usage is presented in Sections 4.2 to 4.6.

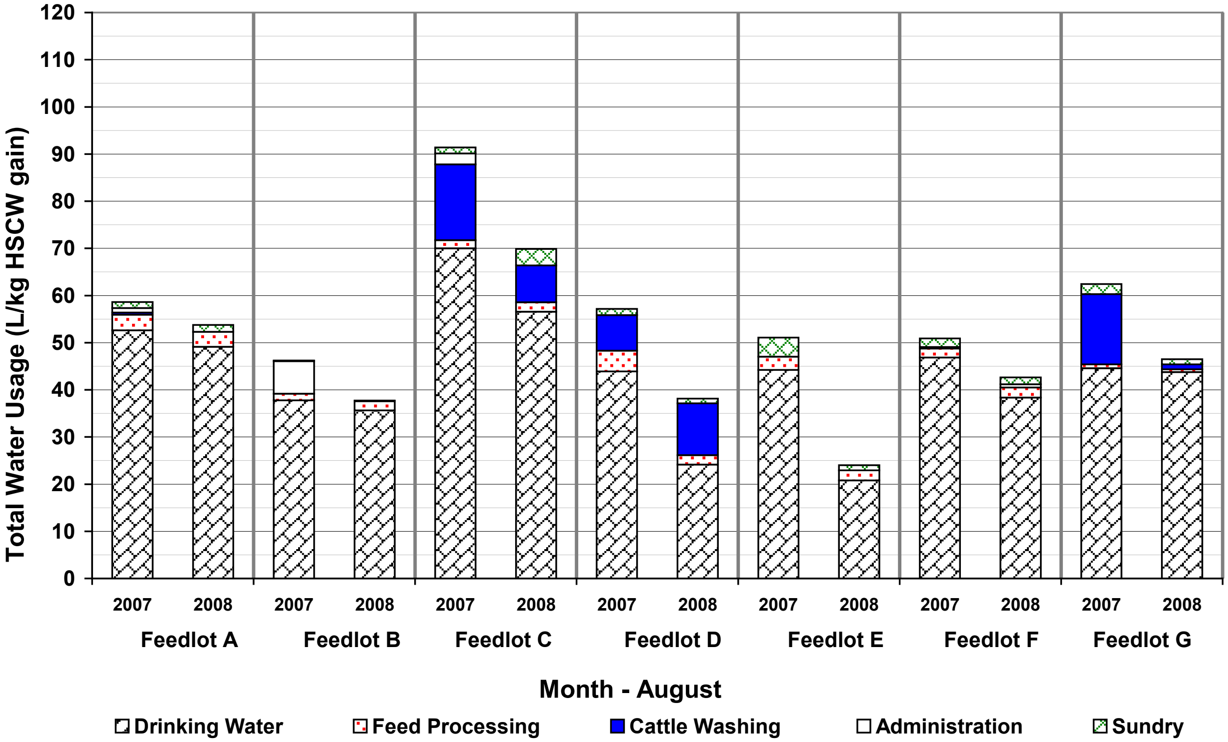

Figure 15 – Total water usage for August (L/kg HSCW gain)

Figure 15 shows the total clean water usage across all feedlots for August 2007 and 2008. Total monthly clean water usage levels are about the same when compared to July and range from 25 to 90 L/kg HSCW gain. The average August monthly usage across all feedlots in 2007 was 59.7 L/kg HSCW gain, greater than the 45.1 L/kg HSCW gain measured in 2008. This reduction is largely driven by Feedlot D and Feedlot E which recorded significant reductions in water usage in 2008.

Drinking water consumption ranged from 20.8 (Feedlot E, 2008) to 70 L/kg HSCW gain (Feedlot C). Feed processing water usage ranged from 0.6 to 4.4 L/kg HSCW gain, a similar range when compared to July. Cattle washing water usage ranged from 7.5 to 16.1 L/kg HSCW gain, a similar range when compared with June. Administration water usage has increased from July levels at Feedlots A, B, C and F and ranged from 0.3 to 6.9 L/kg HSCW gain. Sundry water uses contributed 0.1 to 4.0 L/kg HSCW gain. Further discussion on activity water usage is presented in Sections 4.2 to 4.6.

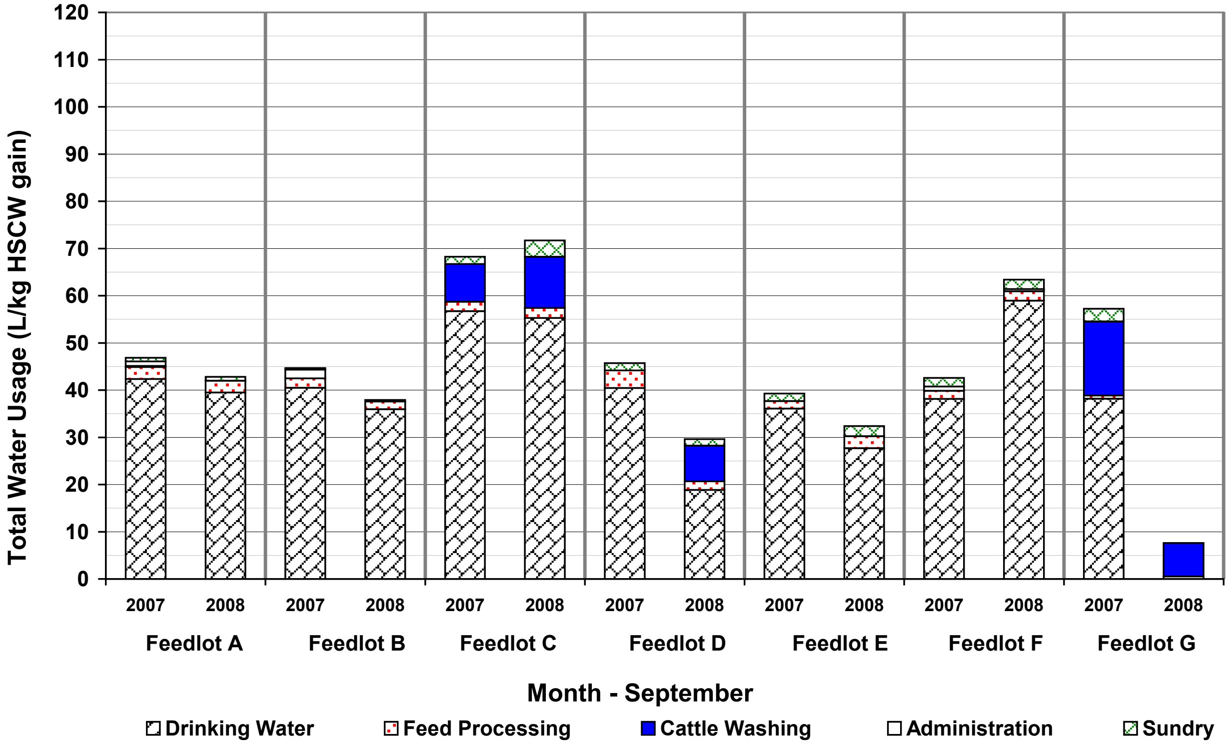

Figure 16 – Total water usage for September (L/kg HSCW)

Figure 16 shows the total clean water usage across all feedlots for September 2007 and 2008. The average September monthly usage across all feedlots in 2007 was 49.2 L/kg HSCW gain, slightly greater than the 45.6 L/kg HSCW gain measured in 2008. Total monthly clean water usage levels have reduced when compared to August levels in 2007 and 2008.

Drinking water consumption levels averaged 41.8 and 33.1 L/kg HSCW gain in 2007 and 2008 respectively. Feedlot C recorded 57 L/kg HSCW gain in 2008 an increase of 45% compared with 2007 levels. Feed processing water usage ranged from 0.7 to 3.7 L/kg HSCW gain, a slight reduction when compared to August. Feed processing water usage is very consistent between years averaging 2.0 L/kg HSCW gain in 2007 and 1.9 L/kg HSCW gain in 2008.

Cattle washing water usage ranged from 7.1 to 15.7 L/kg HSCW gain, a similar range when compared with August. Administration water usage has reduced from August levels at Feedlots A, B, C and F and ranges from 0.5 to 1.9 L/kg HSCW gain. Sundry water uses contributed 0.3 to 2.4 L/kg HSCW gain. Further discussion on activity water usage is presented in Sections 4.2 to 4.6.

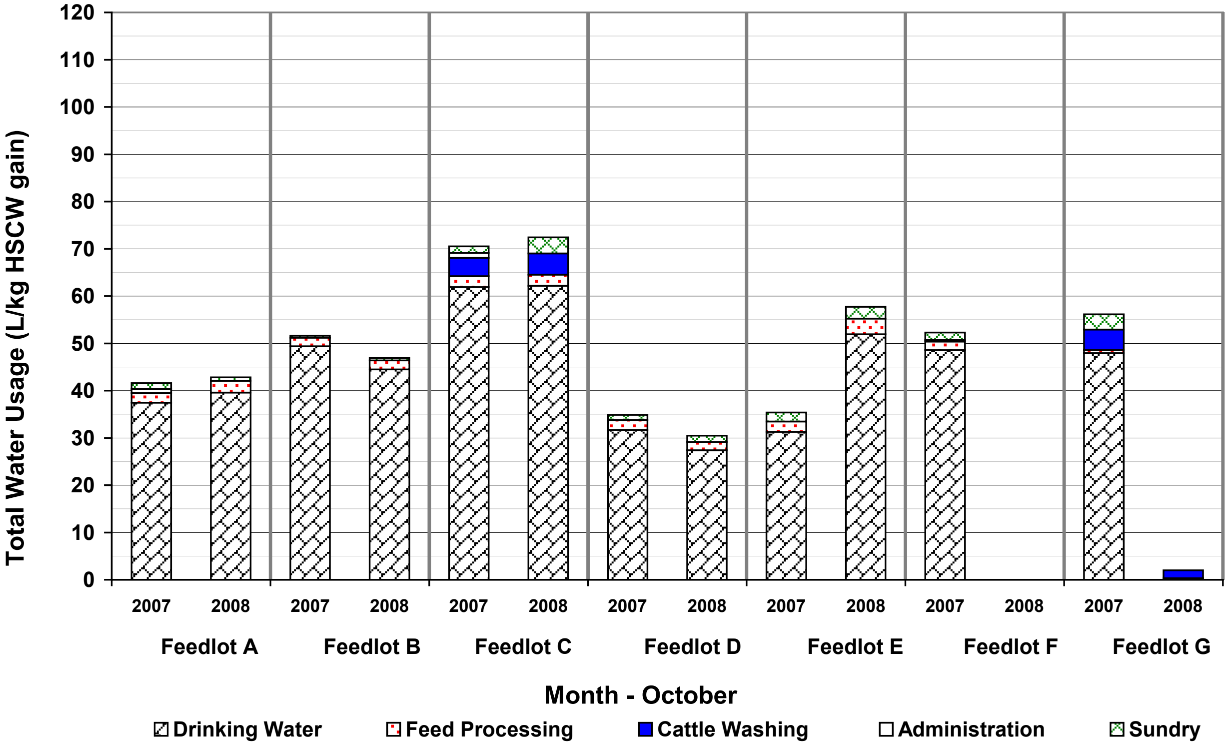

Figure 17 – Total water usage for October (L/kg HSCW gain)

Figure 17 shows the total clean water usage across all feedlots for October 2007 and 2008. The average October monthly usage across all feedlots in 2007 was 48.9 L/kg HSCW gain, similar to the 2008 level of 47.2 L/kg HSCW gain. The total water usage level ranges from 30 (Feedlot D) to 72 L/kg HSCW gain (Feedlot C).

The average October monthly drinking water consumption across all feedlots in 2007 was 44 L/kg HSCW gain, similar to the 2008 level of 42.5 L/kg HSCW gain. Feed processing water usage ranged from 0.3 to 3.3 L/kg HSCW gain, a larger range when compared to August. Cattle washing water usage ranged from 1.7 to 4.5 L/kg HSCW gain, a slight reduction from September levels. Administration water usage levels at Feedlots A, B, C and F have reduced when compared to September and range from 0.3 to 0.8 L/kg HSCW gain. Sundry water uses are similar when compared to September levels and contributed on average 1.6 and 1.7 L/kg HSCW gain in 2007 and 2008 respectively. Further discussion on activity water usage is presented in Sections 4.2 to 4.6.

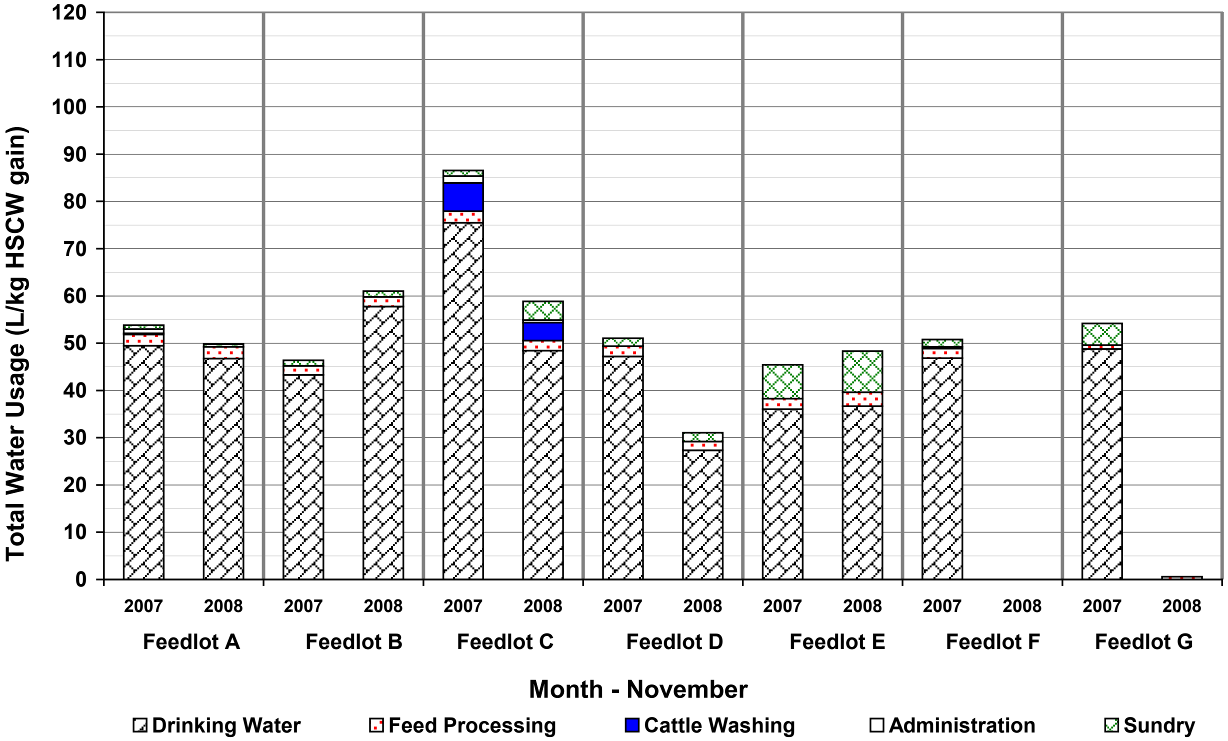

Figure 18 – Total water usage for November (L/kg HSCW gain)

Figure 18 shows the total clean water usage across all feedlots for November 2007 and 2008. Total monthly clean water usage levels are similar between feedlots ranging from 46 to 54 L/kg HSCW gain, whilst Feedlot C recorded a usage level of 87 L/kg HSCW gain in 2007. The average November monthly usage across all feedlots in 2007 was 55.5 L/kg HSCW gain, slightly greater than the 2008 level of 48.2 L/kg HSCW gain.

Drinking water consumption levels have increased and ranged between 27 (Feedlot D, 2008) and 75.5 L/kg HSCW gain (Feedlot C 2007). The average November monthly drinking water consumption across all feedlots in 2007 was 49.6 L/kg HSCW gain, about 18% higher when compared to the 2008 level of 41.8 L/kg HSCW gain.

Feed processing water usage ranged from 0.6 to 3.0 L/kg HSCW gain, a similar range when compared to October. Feedlot C was the only feedlot still washing cattle and this contributed 3.8 L/kg HSCW gain (2007) and 6.0 L/kg HSCW gain (2008) to the total water usage level. Administration water usage levels at Feedlots A, B, C and F are similar to October levels and range from 0.3 to 1.4 L/kg HSCW gain. Sundry water uses have increased slightly when compared to October levels and contributed between 0.8 to 8.7 L/kg HSCW gain. Further discussion on activity water usage is presented in Sections 4.2 to 4.6.

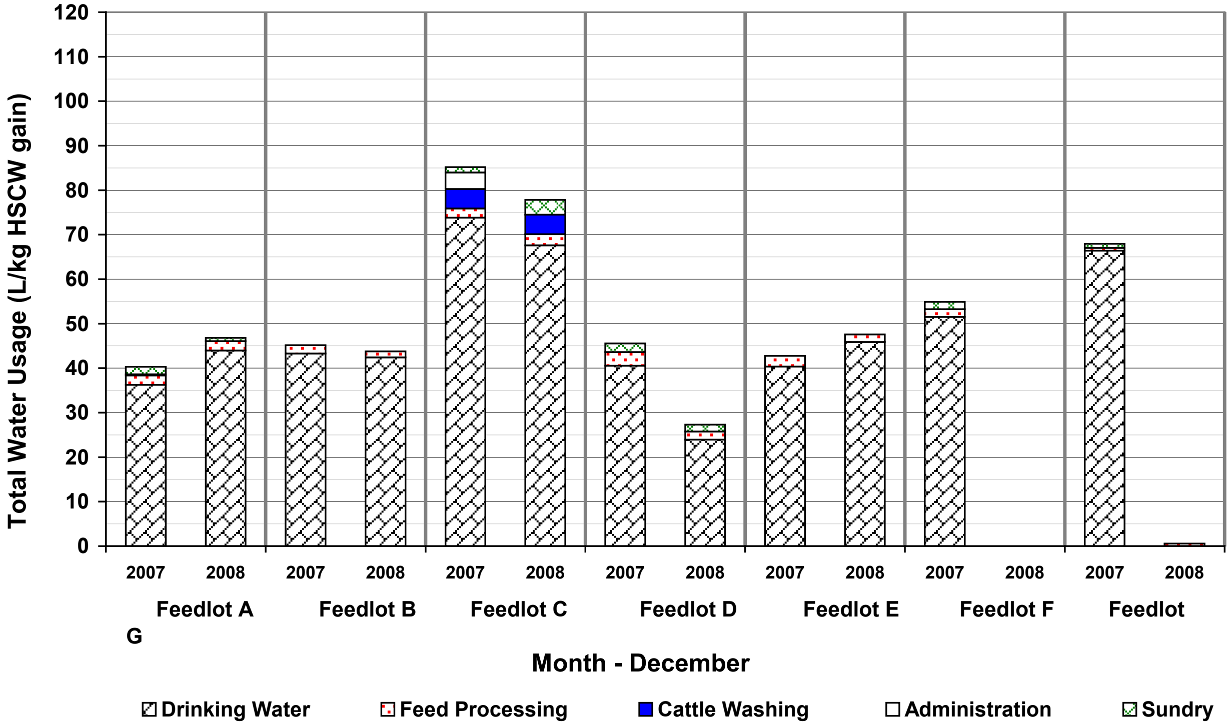

Figure 19 – Total water usage for December (L/kg HSCW gain)

Figure 19 shows the total clean water usage across all feedlots for December 2007 and 2008. Total monthly clean water usage levels at Feedlots B, C, D and E are similar whilst F and G have increased and Feedlot A decreased when compared with November levels. Total water usage ranges from 40 to 86 L/kg HSCW gain. The average December monthly usage across all feedlots in 2007 was 54.5 L/kg HSCW gain, slightly greater than the 2008 level of 49.1 L/kg HSCW gain.

Drinking water consumption levels ranged between 25 (Feedlot D 2008) and 73 L/kg HSCW gain (Feedlot C 2007). The average December monthly drinking water consumption across all feedlots in 2007 was 50.3 L/kg HSCW gain, about 10% higher when compared to the 2008 level of 45.6 L/kg HSCW gain.

Feed processing water usage ranged from 0.6 to 3.1 L/kg HSCW gain, a similar range when compared to November. The average December monthly feed processing water usage across all feedlots was 2.0 L/kg HSCW gain in 2007, similar to the 2008 level of 1.9 L/kg HSCW gain.

Feedlot C was the only feedlot still washing cattle and this contributed 4.4 L/kg HSCW gain to the total water usage level. Administration water usage levels at Feedlots A, B and F have reduced, whilst Feedlot C has increased when compared to November levels and range from 0.2 to 3.7 L/kg HSCW gain. Sundry water uses have increased slightly when compared to November levels and contributed between 0.7 to 3.3 L/kg HSCW gain. Further discussion on activity water usage is presented in Sections 4.2 to 4.6.

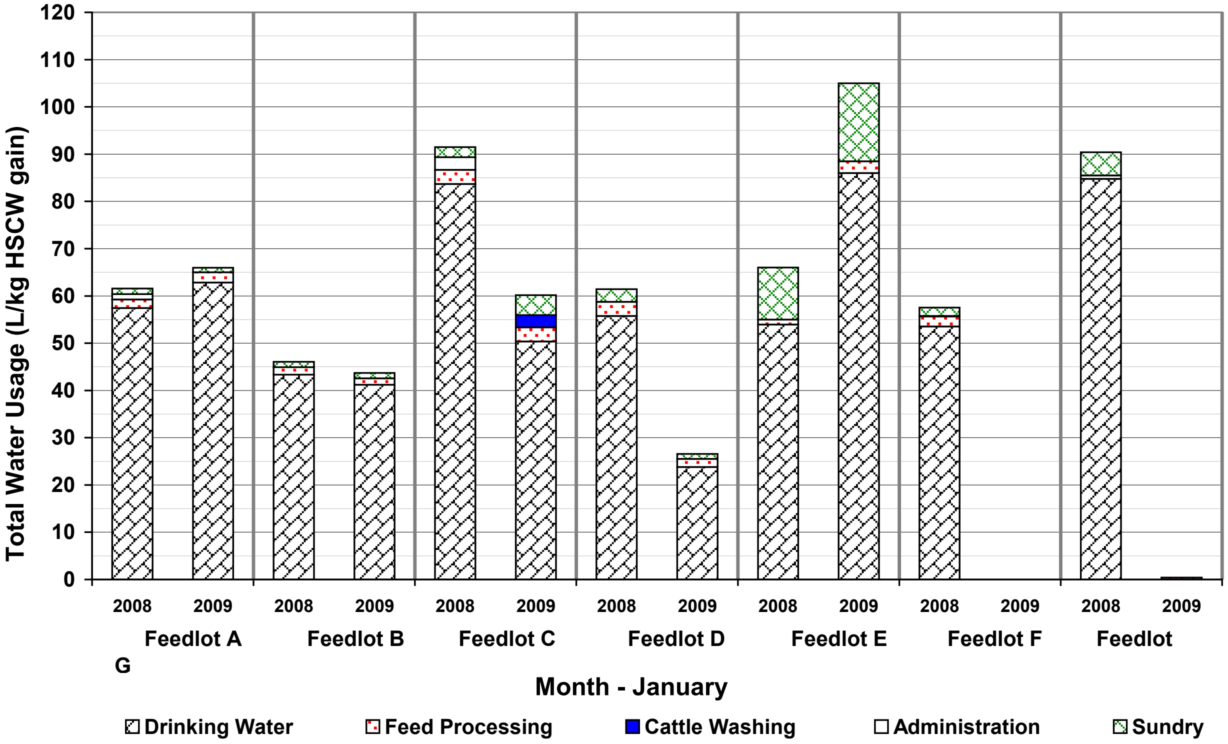

Figure 20 – Total water usage for January (L/kg HSCW gain)

Figure 20 shows the total clean water usage across all feedlots for January 2008 and 2009. Total monthly clean water usage levels at Feedlots A, C, D, E and G has increased whilst B and F are similar when compared with December levels. The average January monthly usage across all feedlots in 2007 was 67.8 L/kg HSCW gain, an increase of 9 L/kg HSCW gain compared with the 2008 level of 58.8 L/kg HSCW gain. Total water usage has increased by about 23% and 10% from December levels in 2007 and 2008 respectively.

Drinking water consumption levels ranged between 23 L/kg HSCW gain (Feedlot D 2009) and 86 L/kg HSCW gain (Feedlot E 2009). Feed processing water usage ranged from 0.4 to 3.0 L/kg HSCW gain, a similar range when compared to December. The average January monthly feed processing water usage across all feedlots was 1.9 L/kg HSCW gain in 2007, similar to the 2008 level of 2.1 L/kg HSCW gain. All feedlots had ceased cattle washing with the exception of Feedlot C which continued to wash cattle in January 2009.

Administration water usage levels at Feedlots A, B, C and F have reduced, when compared to December levels and range from 0.1 to 2.7 L/kg HSCW gain. Sundry water uses have increased slightly when compared to December levels and contributed between 0.4 to 16.5 L/kg HSCW gain. At Feedlot E, this is due to increased evaporative losses. Further discussion on activity water usage is presented in Sections 4.2 to 4.6.

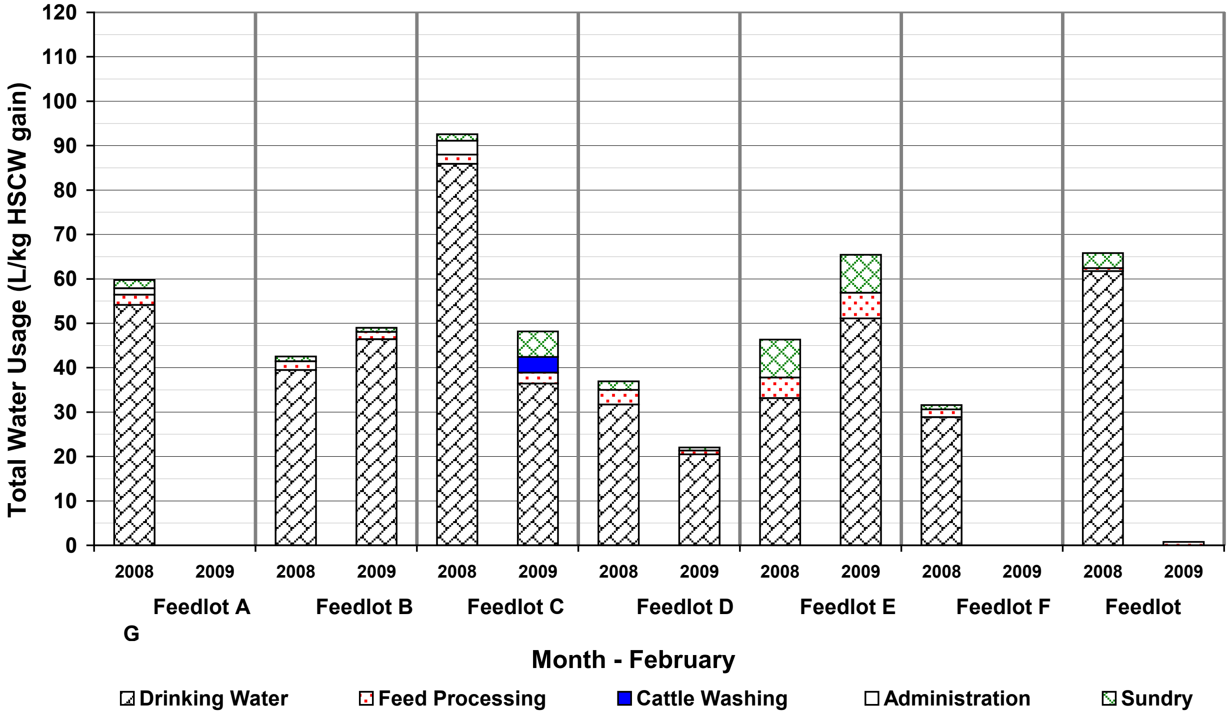

Figure 21 – Total water usage for February (L/kg HSCW gain)

Figure 21 shows the total clean water usage across all feedlots for February 2008. Total monthly clean water usage levels at Feedlots A, B, C and D are similar, Feedlot F has reduced, whilst E and G are similar when compared with January levels. The average February monthly usage across all feedlots in 2007 was 53.6 L/kg HSCW gain, about 18% higher than the 2008 level of 45.2 L/kg HSCW gain. Total water usage has decreased by about 20% and 24% from January levels in 2007 and 2008 respectively.

Drinking water consumption levels ranged between 29-86 L/kg HSCW gain in 2007 and 29-86 L/kg HSCW gain in 2008. The average February monthly usage across all feedlots in 2007 was 47.9 L/kg HSCW gain with 42.7 L/kg HSCW gain measured in 2008. Drinking water accounts for 90% of the total water usage.

Feed processing water usage ranged from 0.7 to 5.8 L/kg HSCW gain, an increase when compared to January. The average February monthly feed processing water usage across all feedlots was 2.4 L/kg HSCW gain in 2007, slightly higher than the 2008 level of 2.2 L/kg HSCW gain. Feed processing has increased slightly when compared with January levels.

All feedlots had ceased cattle washing with the exception of Feedlot C which continued to wash cattle in February 2009 and used 3.5 L/kg HSCW gain for this purpose.

Administration water usage levels at Feedlots A, B, C and F have increased, when compared to January levels and range from 1.5 to 3.2 L/kg HSCW gain. Sundry water uses have increased slightly when compared to January levels and contributed between 0.4 to 8.5 L/kg HSCW gain. Further discussion on activity water usage is presented in Sections 4.2 to 4.6.

The monthly variation and variation between feedlots, when standardised to a per kg of HSCW gain, can be attributed to a number of factors. These include climatic variation, cattle genotype, cattle market types and management operations including frequency of trough cleaning, cattle washing, dust control and feed processing. Further discussion on individual activity water usage is presented in the following sections.

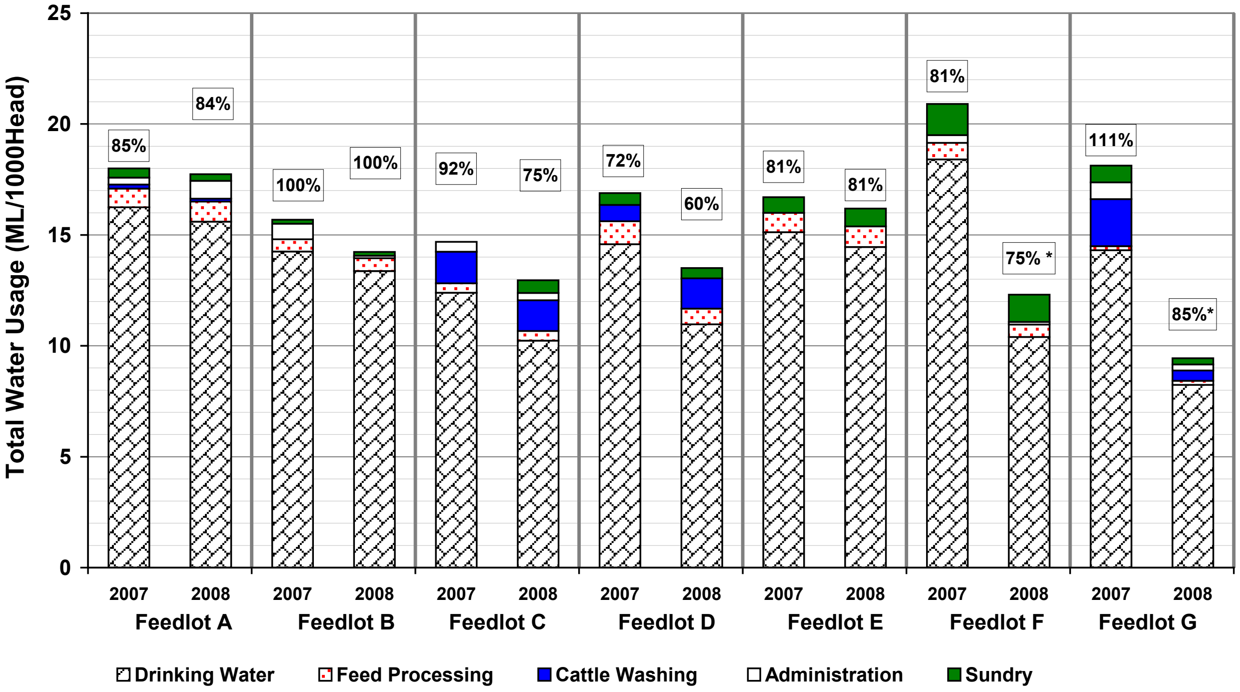

Figure 22 – Total water usage (ML/1000 head-on-feed) and occupancy

When issuing a licence for a feedlot in Queensland, Queensland Department of Primary Industries and Fisheries (QDPI&F) 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. Figure 22 illustrates the total water usage on a megalitre per head on feed basis (Head is used rather than SCU for those states where SCU does not apply) for the seven feedlots that participated in the water usage investigation. The average occupancy, defined as mean number of cattle on hand divided by the licensed pen capacity) and the QDPI water supply licensing requirement of 24 ML/1000 head (DPI, 2000) are also shown. For Feedlot G, the head on feed also incorporates background and starter cattle and therefore, occupancy is apparently greater than 100%. Feedlot F and G in 2008 have incomplete data sets.

The QDPI 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, feed processing or evaporation from open storages. From Figure 22, the total water usage for the period March 2007 to

February 2009 ranged from 13 (Feedlot C) to 20.5 ML/1000 head (Feedlot F) and is below that required by the QDPI&F.

4.2 Drinking water consumption

4.2.1 Monthly variation in drinking water consumption

Drinking water is the single largest consumer of water in the feedlot and contributed on average 27.6 to 60.8 L/kg HSCW gain across all feedlots. However, up to 87 L/kg HSCW gain was measured in one month. The differences between feedlot drinking water consumption on a kg HSCW gain basis can be attributed to the differences between market types (long fed - low daily gain v domestic - higher daily gain). However, the primary driver of drinking water consumption is climatic variation.

Figure 23 illustrates the average drinking water consumption on a per head per day basis for the seven feedlots that participated in the water usage investigation. The minimum and maximum drinking water consumption per head per day for any one month is also presented. Note that feedlot numbering in this section does not match the numbering in previous sections to maintain anonymity for the participating feedlots. Whilst a summary is provided in this section, complete individual feedlot monthly drinking water consumption figures on a per head per day basis are presented in Appendix A.

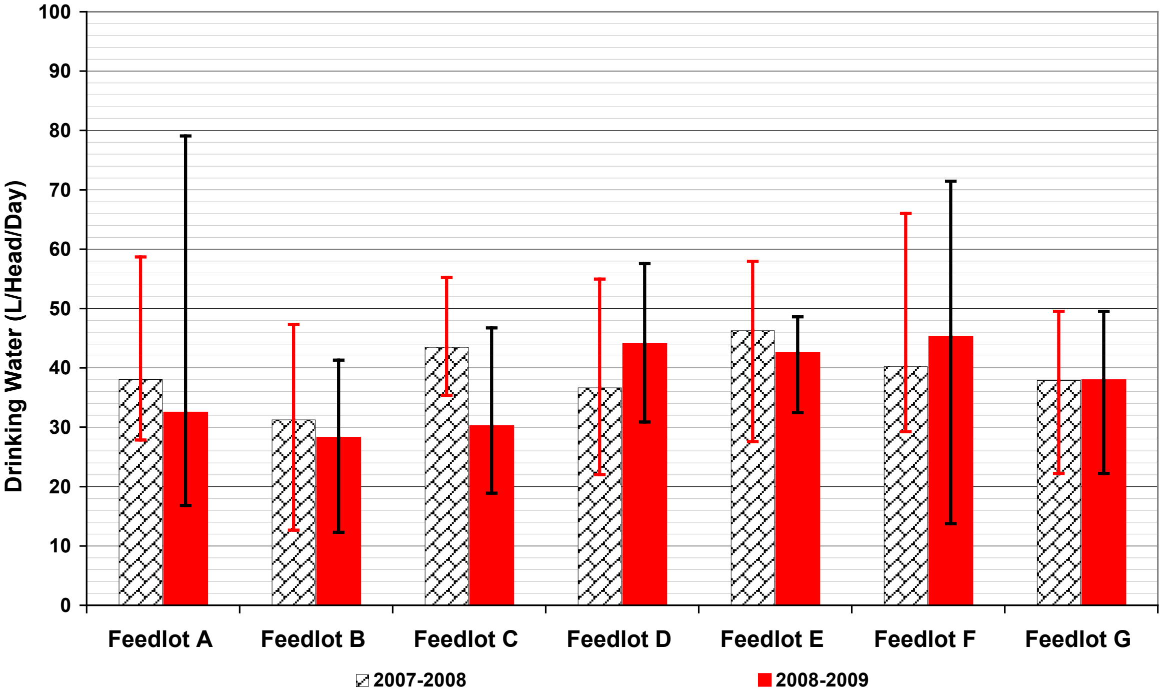

Figure 23 – Average / maximum / minimum drinking water for March 2007 to February 2009 (L/head-on-feed/day)

The average drinking water consumption across all feedlots for March 2007 to February 2009 ranged from 29 L/head/day at Feedlot B to 46 L/head/day at Feedlot E. The average monthly drinking water in 2007-2008 was 39.1 L/head/day, slightly higher than the 37.2 L/head/day measured in 2008-2009.

Feedlot E located in a sub-tropical environment had the highest average drinking water consumption of 44 L/head/day, whilst Feedlot B, which experiences cold winters, mild summers and high rainfall when compared with other feedlot locations, had the lowest average drinking water consumption of 30 L/head/day.

These levels are less than the often quoted figure within the industry of an average of 65 L/head/day. It is believed that the 65 L/head/day figure is based on the maximum daily requirement of 5 L per 50 kg LWT, hence representing the water requirements of a 650 kg beast. Parker et al. (2000) in their US study found drinking water consumption to average 34.1 and 43.9 L/head/day in winter and summer respectively, comparable to the figures found in this study.

The maximum monthly 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 can 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.

An indication of the monthly variability in drinking water consumption levels can be gained through comparison of the maximum, minimum and average consumption levels. Feedlots A and F have more variability than other feedlots. Typically, there is a minimum monthly variation of 20 L/head/day In 2007, Feedlot C recorded less variability between months.

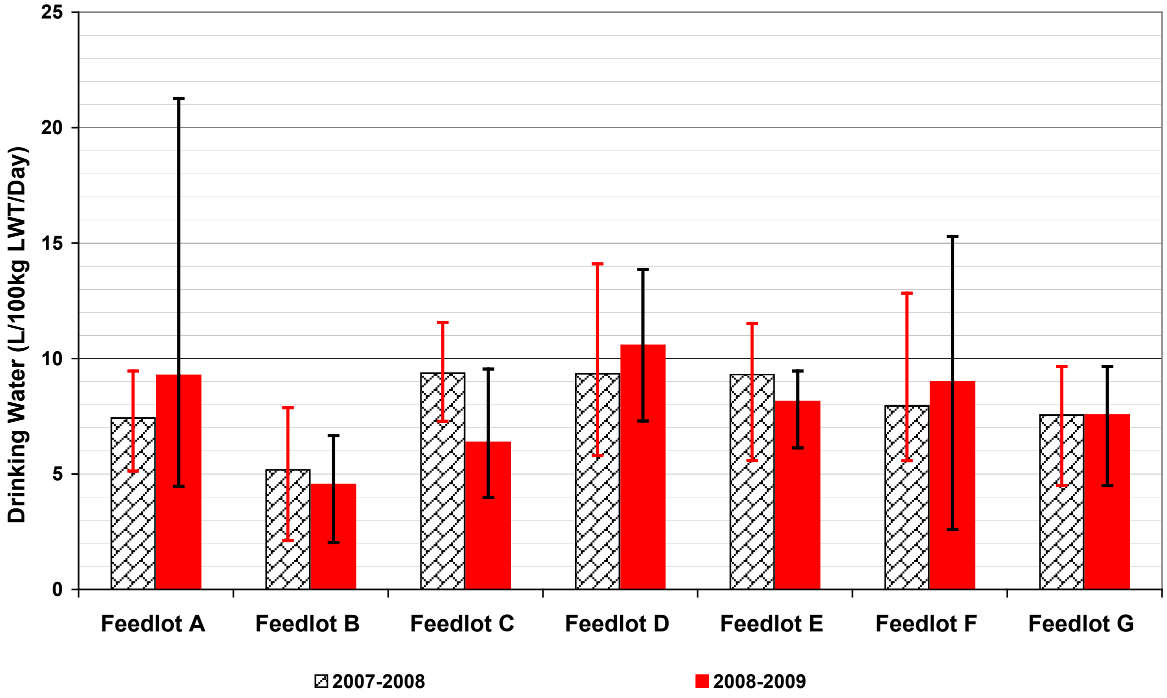

Figure 24 – Average / maximum / minimum drinking water for March 2007 to February 2009 (L/100 kg LWT/day)

Figure 24 illustrates the average drinking water consumption standardised on a per 100 kg LWT per day basis for the seven feedlots that participated in the water usage investigation. The minimum and maximum drinking water consumption per 100 kg per day for any one month is also presented.

The average drinking water consumption across all feedlots for March 2007 to February 2009 ranged from 4 L/100 kg LWT/day at Feedlot B to 10.5 L/100 kg LWT/day at Feedlot D in 2008. The average drinking water consumption across all feedlots is in the order of 8 L/100 kg LWT/day in 2007 and 2008.

With the exception of Feedlot B the average drinking water consumption is similar to the daily requirement for stock watering of 5 L per 50 kg LWT (DPI Site Selection Farm Note 1995). Whilst for Feedlot B, it is about half of the quoted daily requirement.

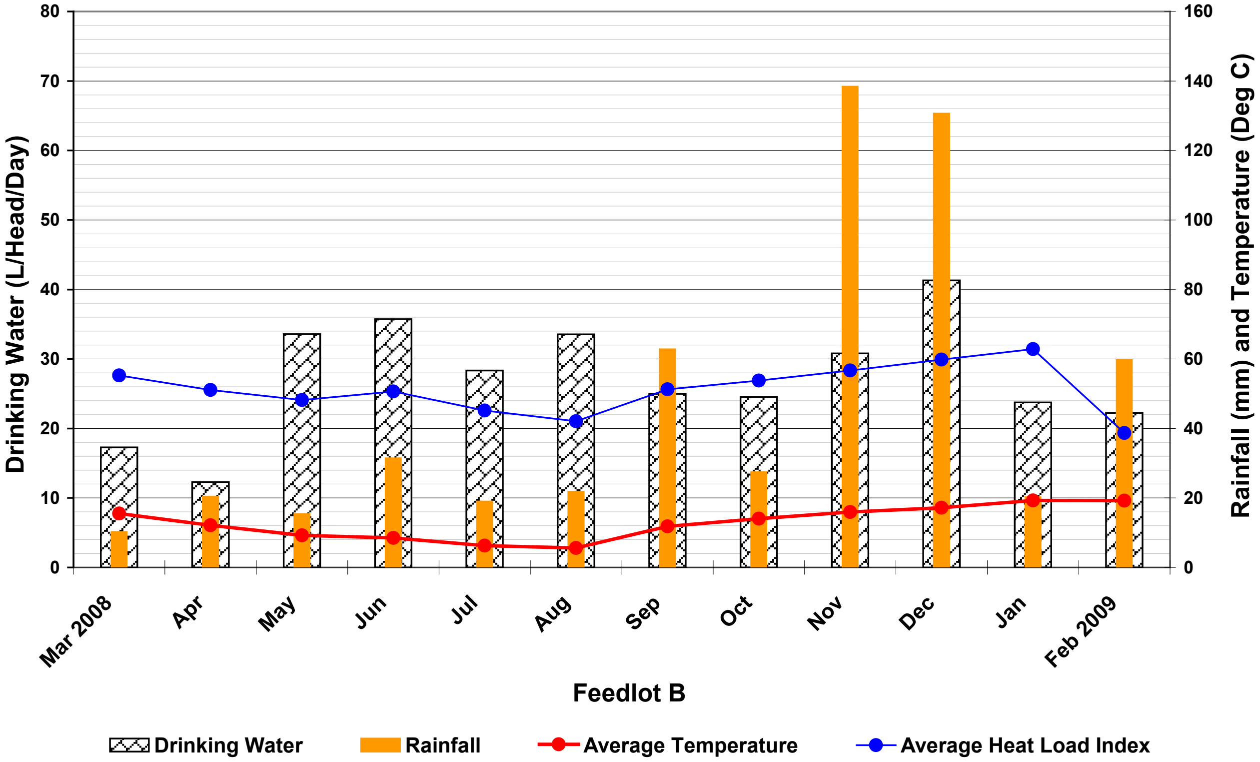

Figure 25 – Drinking water consumption March 2008 to February 2009 - Feedlot B (L/head/day)

Figure 25 illustrates the average drinking water consumption on a per head per day basis for Feedlot B between March 2008 and February 2009. Monthly rainfall, average daily temperature and average heat load index are also presented. Over this period, Feedlot B experienced a cold winter, mild summer and over 50 mm of rainfall in September, November, December and February. There appears to be no distinct relationship between heat load index, rainfall and temperature on drinking water consumption. Very low drinking water consumption per head per day was recorded in March and April compared with June and October which recorded similar heat load. This result contrasts with the consumption patterns found between March 2007 and 2008 as shown in Figure 26.

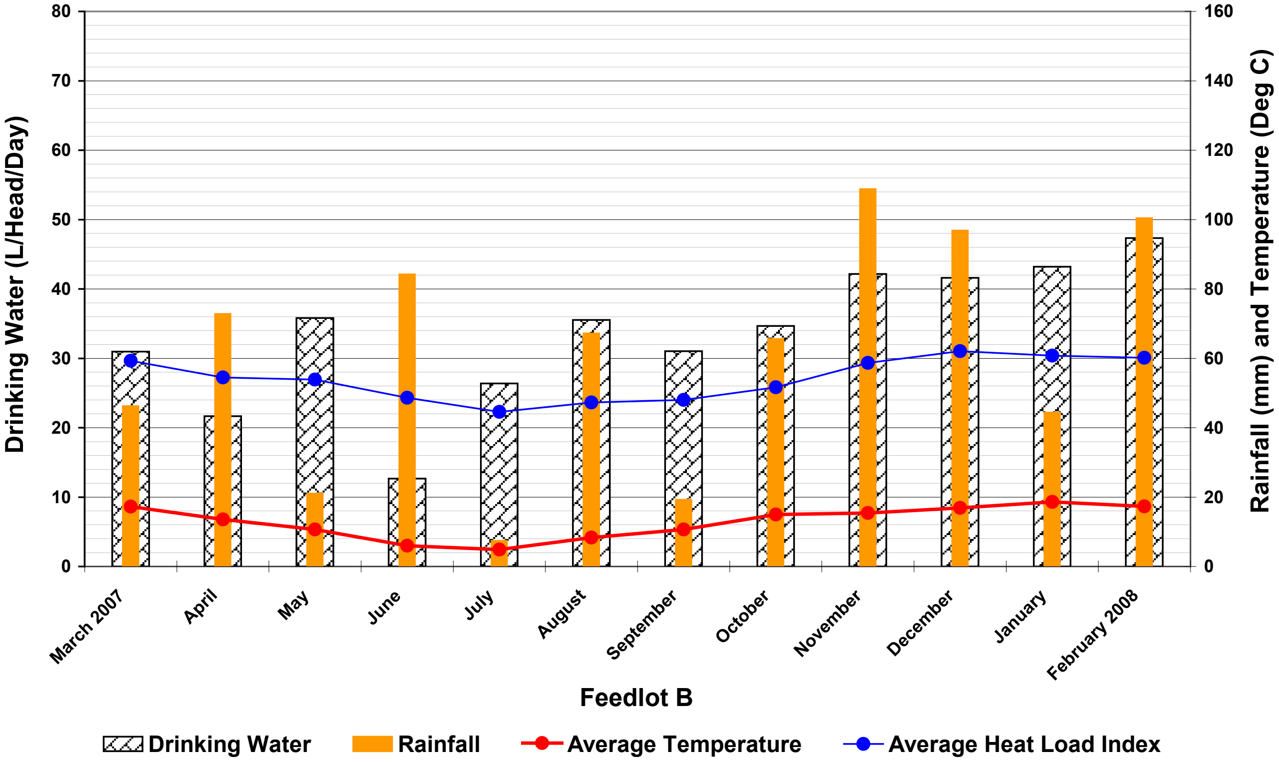

Figure 26 – Drinking water consumption March 2007 to February 2008 - Feedlot B (L/head/day)

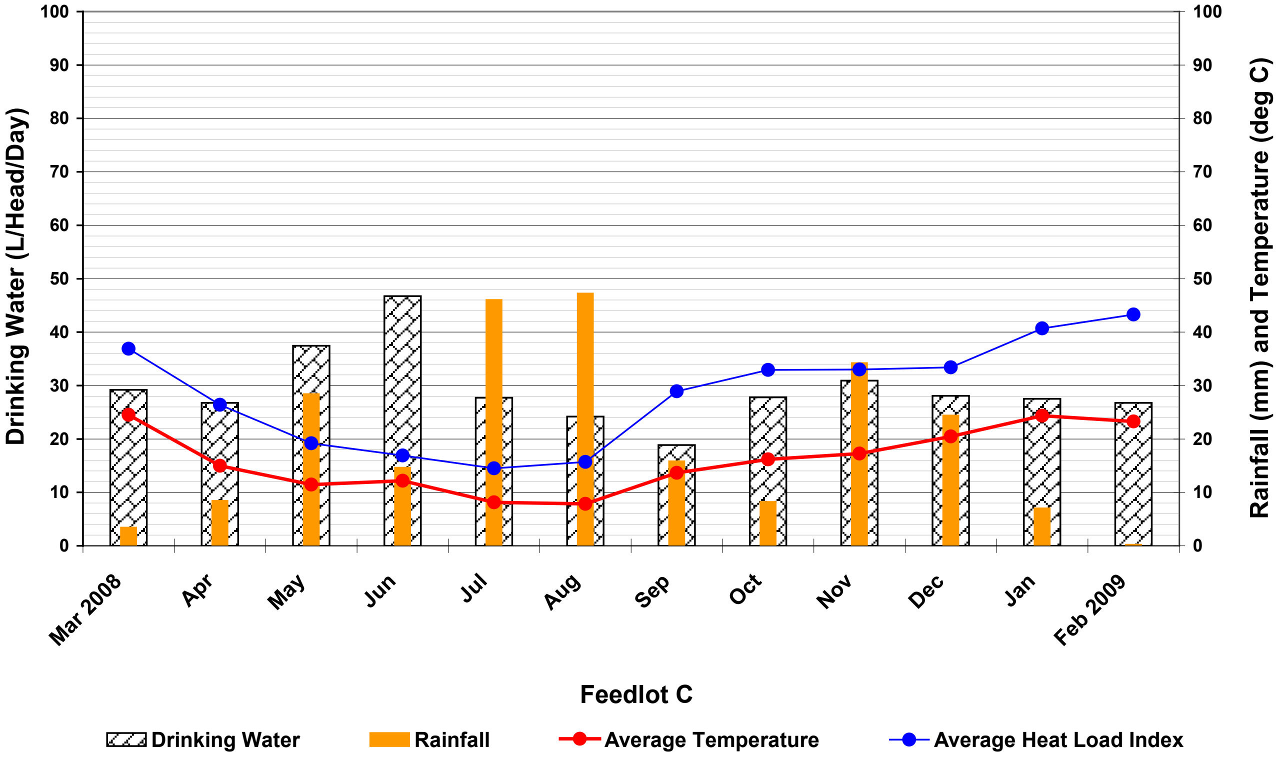

Figure 27 – Drinking water consumption for March 2008 to February 2009 – Feedlot C (L/head/day)

Figure 27 illustrates the average drinking water consumption on a per head per day basis for Feedlot C between March 2008 and February 2009. Monthly rainfall, average daily temperature and average heat load index are also presented. This feedlot experienced a cold winter, mild summer and below average rainfall.

For the majority of months, a trend of increased drinking water with increased heat load index is apparent at this feedlot, with the exception of the winter months May, June July and August. Hence, for these months there are other factors that are also influencing consumption levels. For example January has a higher heat load index and less rainfall than November but drinking water is less.

This result contrasts with the consumption patterns found between March 2007 and 2008 as shown in Figure 28. Between March 2007 and February 2008 there was a stronger pattern between heat load index, rainfall and drinking water consumption. During this period, increasing heat load translated into higher water consumption, whilst rainfall strongly suppressed drinking water consumption.

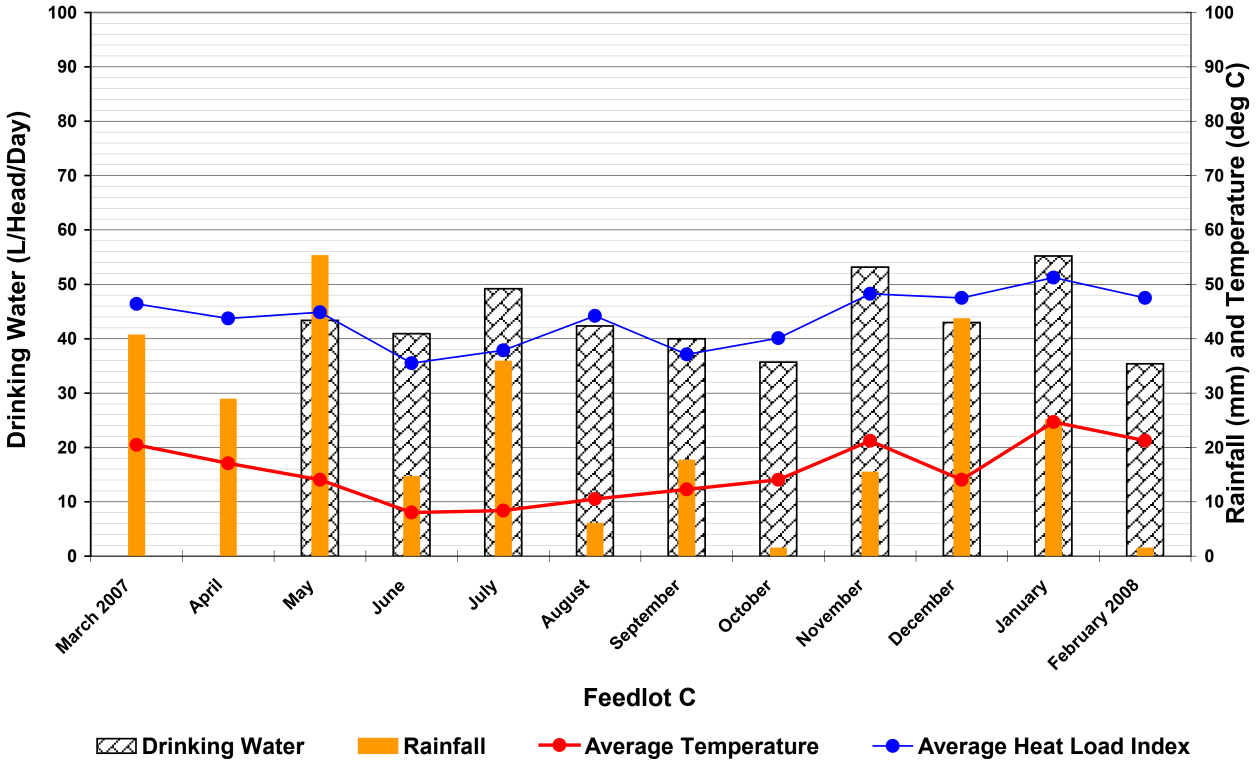

Figure 28 – Drinking water consumption March 2007 to February 2008 - Feedlot B (L/head/day)

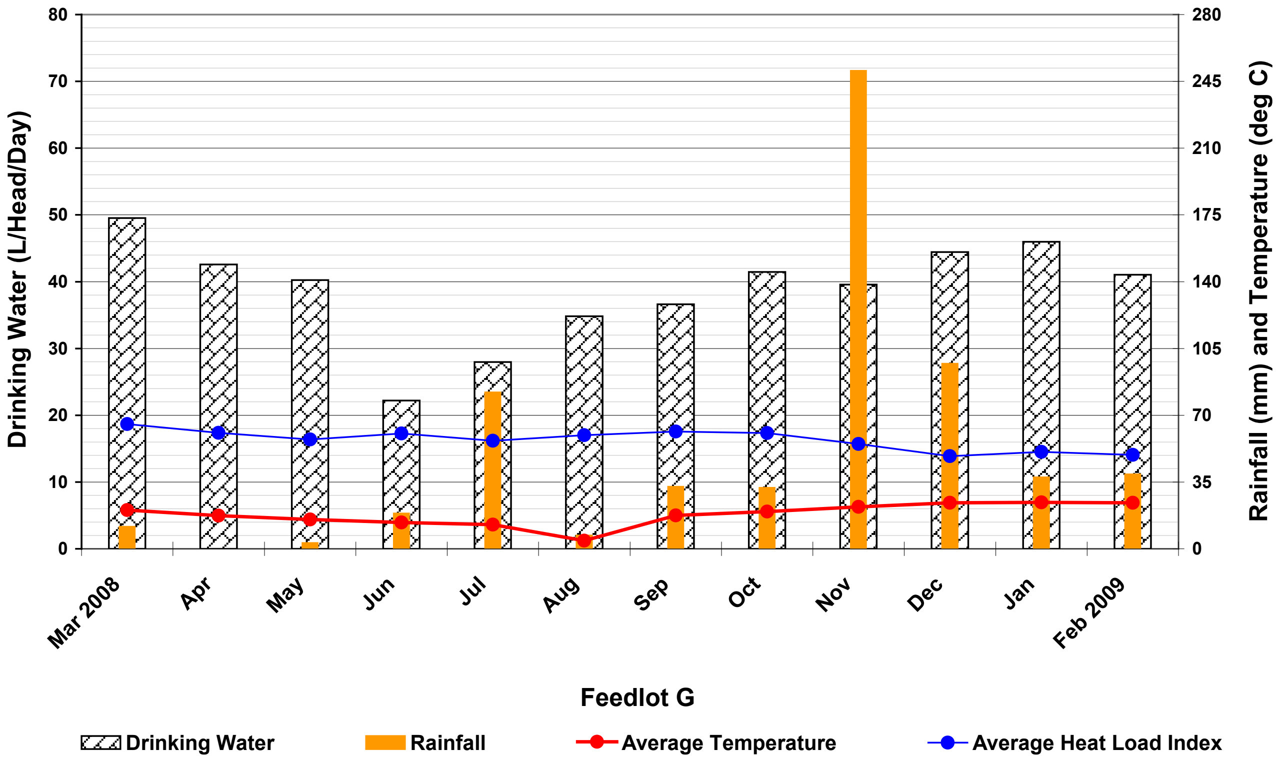

Figure 29 – Drinking water consumption March 2008 to February 2009 – Feedlot G (L/head/day)

Figure 29 illustrates the average drinking water consumption on a per head per day basis for Feedlot G between March 2008 and February 2009. Monthly rainfall, average daily temperature and average heat load index are also presented.

This feedlot experienced a cool winter, mild summer and summer dominant rainfall. At this feedlot, there is a distinct seasonal variation in drinking water consumption, with lower consumption during the cooler months and higher during summer. Typically, as heat load index increases, then drinking water intake increases. However, heat load reduced during November and December, whilst drinking water increased. Conversely, drinking water decreases with cool wet weather (June) and periods of rainfall even when heat load index level remain elevated. This is evident when comparing June, September and August 2008 data.

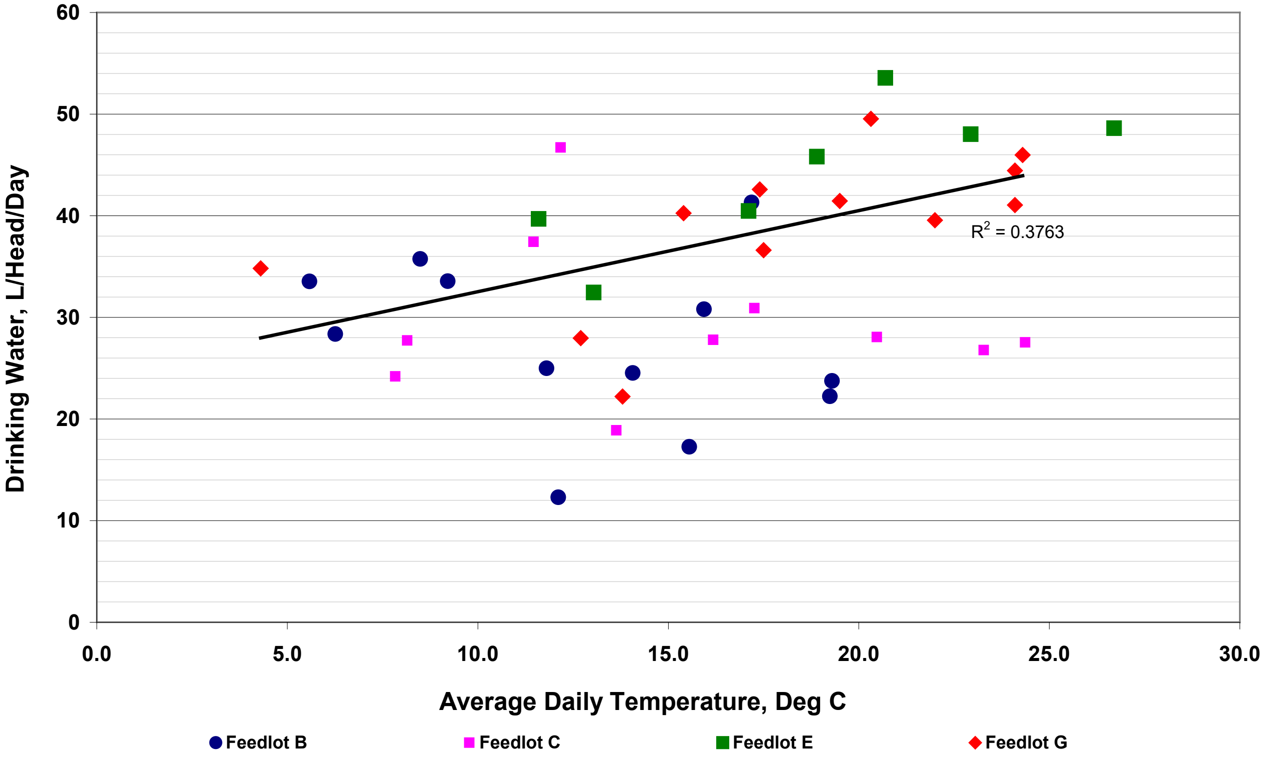

Figure 30 – Drinking water consumption (L/head/day) versus average monthly temperature for Feedlots B, C, E and G (2008-2009)

Figure 30 illustrates the average drinking water consumption on a per head per day basis versus the average temperature for the corresponding month between March 2008 and February 2009. Figure 31 shows the same information between the period March 2008 and February 2009. Data from Feedlot B, C, E and G are presented. The trend line in both figures s based on Feedlot G data set.

These figures show the relationship between drinking water consumption and temperature. Overall as temperature increases so does drinking water consumption. There is more spread in the data for 2008-2009 when compared with 2007-2008. The relationship is strongest with Feedlot G and Feedlot E. These feedlots experience less climatic variation than Feedlots B and C.

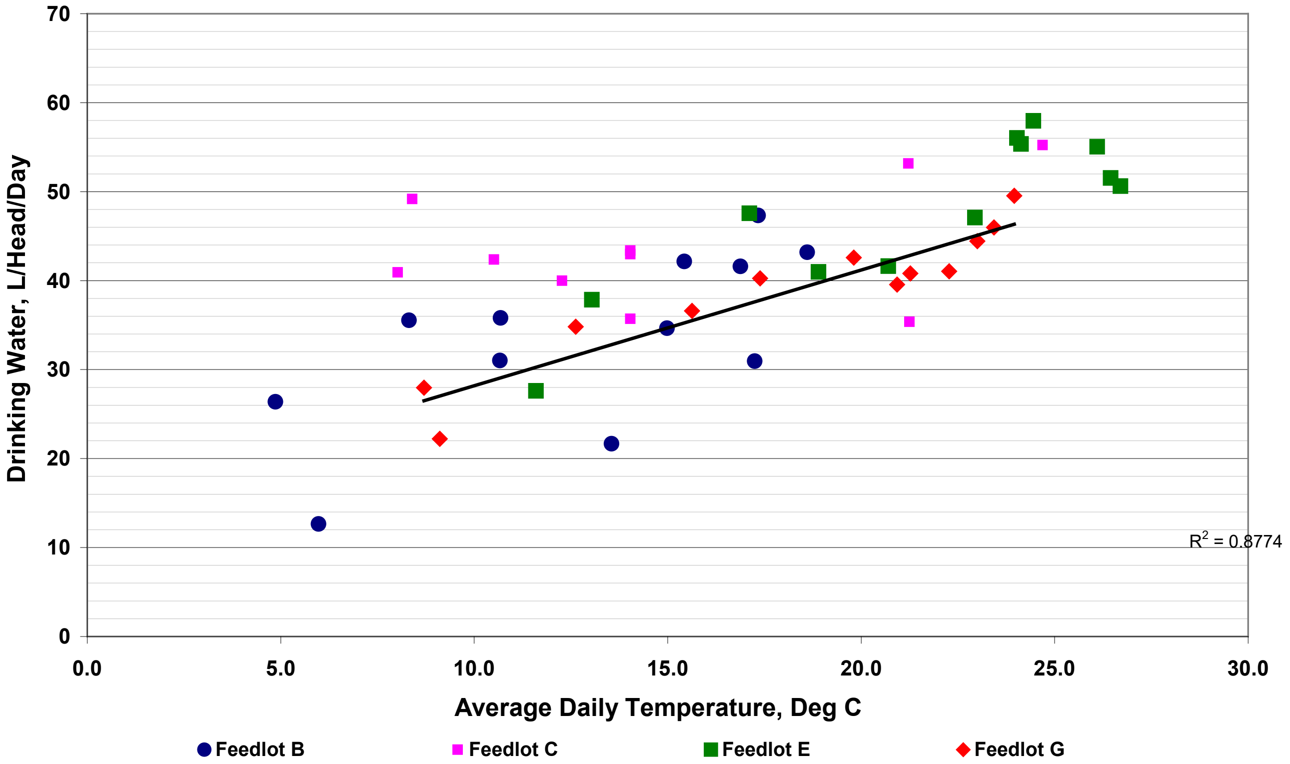

Figure 31 – Drinking water consumption (L/head/day) versus average monthly temperature for Feedlots B, C, E and G (2007-2008)

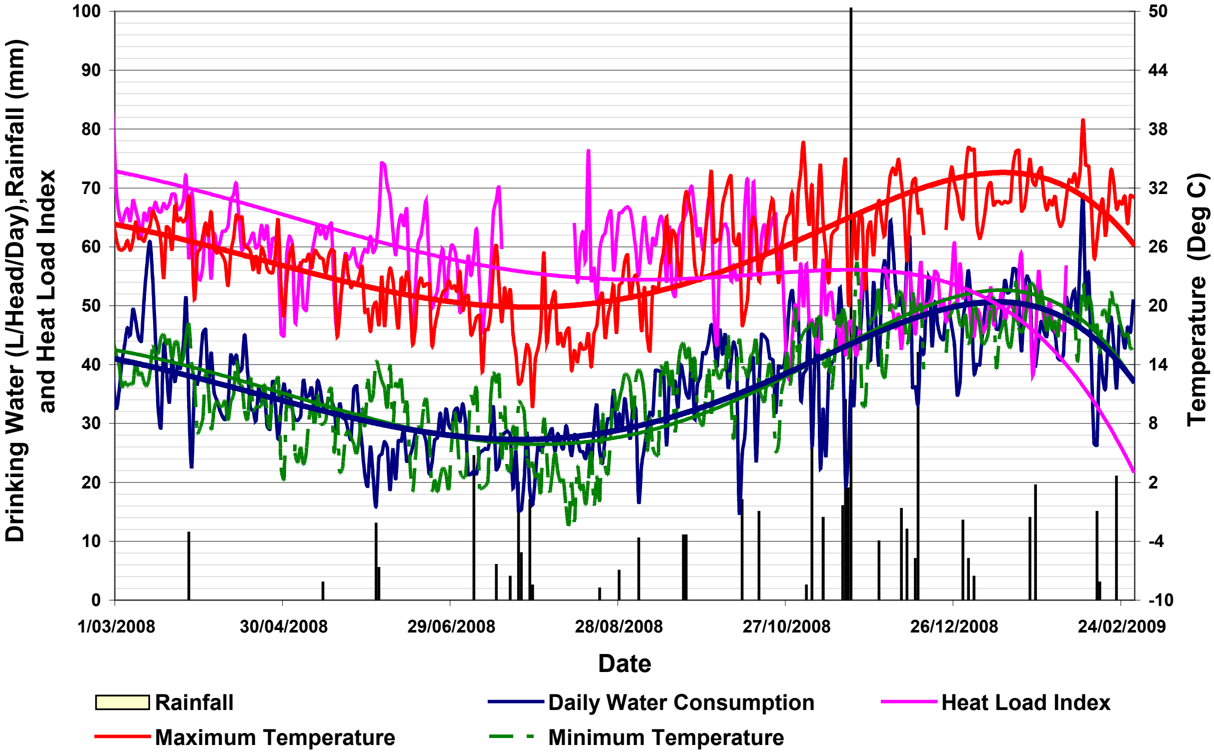

Figure 32 – Daily variation in drinking water consumption March 2008 to February 2009 – Feedlot G (L/head/day)

Figure 32 illustrates the drinking water consumption on a per head per day basis for Feedlot G for the period March 2007 and February 2008. Daily rainfall, heat load index, minimum and maximum temperatures are also presented. A polynomial regression trend line averaging the daily data for the respective indices is also presented. Figure 33 shows the same data for the period March 2008 and February 2009. At this feedlot, daily drinking water consumption was logged every three minutes so that hourly and daily total flows were recorded. This, in combination with climatic data, allows a more detailed examination of the drivers of drinking water consumption.

The daily drinking water consumption for the period March 2008 to February 2009 ranged from 13 L/head/day in July to 69 L/head/day in February. Throughout late autumn and early winter, drinking water consumption levels were at their lowest in the order of 24 L/head/day. Drinking water consumption levels start to increase as temperature increases and were at their highest in the summer months when consumption levels in the order of 52 L/head/day was recorded. A slightly lower average drinking water consumption was measured in 2008-2009 when compared with 2007-2008 levels. The relationship between drinking water consumption, heat load index and rainfall is clearly evident on a daily basis. During periods of rainfall, drinking water consumption is suppressed, whilst during periods of high heat load, drinking water is at its highest.

The daily drinking water consumption for the period March 2007 to February 2008 ranged from 11 L/head/day in April to 75 L/head/day in March. Throughout late autumn and early winter, drinking water consumption levels were at their lowest in the order of 24 L/head/day. Drinking water consumption levels start to increase as temperature increases and were at their highest in March

2007 when consumption levels in the order of 55 L/head/day were recorded. The relationship between drinking water consumption, heat load index and rainfall is clearly evident on a daily basis. During periods of rainfall, drinking water consumption is suppressed, whilst during periods of high heat load, drinking water is at its highest.

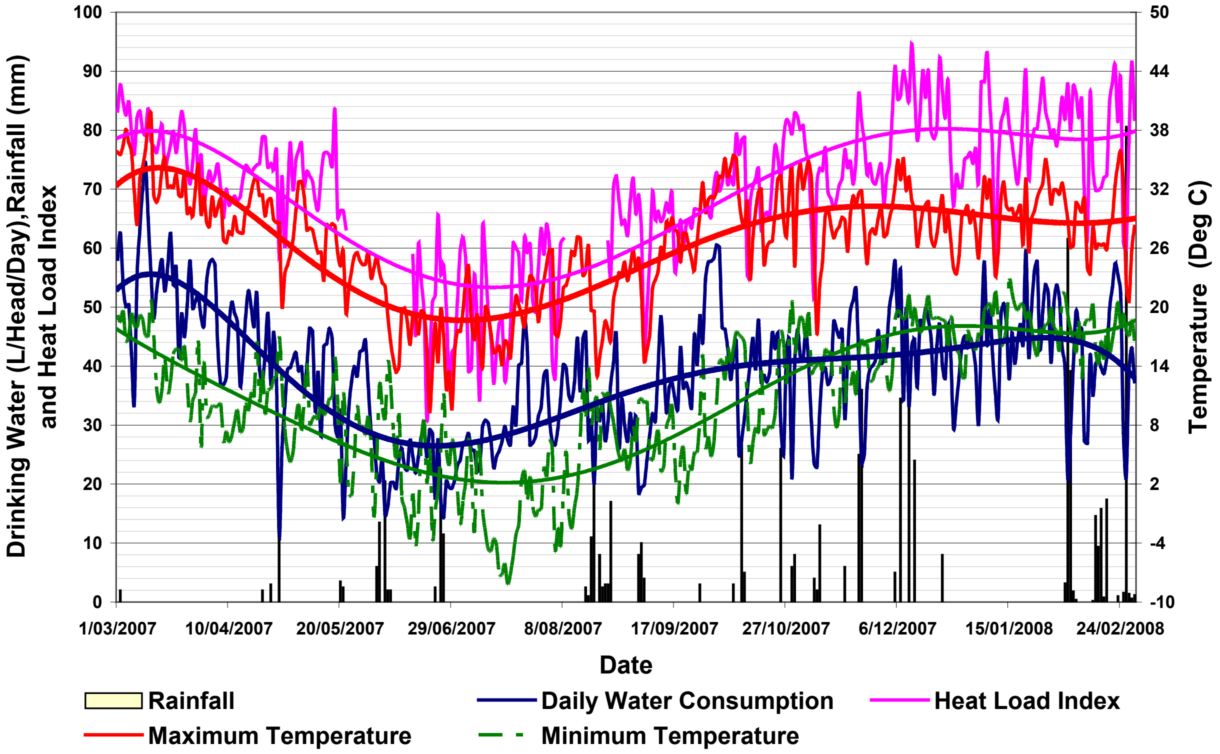

Figure 33 – Daily variation in drinking water consumption March 2007 to February 2008 – Feedlot G (L/head/day)

4.2.2 Diurnal variation in drinking water consumption

The diurnal variation in water consumption has been investigated across a one-week period in summer, in which heat load index was at its greatest and demand for drinking water was at its greatest. The diurnal variation influences the demand throughout the day, and is an important design component of the feedlot water supply and reticulation system. Diurnal water consumption patterns were assessed by plotting water consumption flow rates throughout the day.

Figure 34 to Figure 35 illustrates the drinking water consumption on a per head per hour basis for the same seven-day period in 2008 and 2009. Hourly heat load index, ambient temperature and rainfall are presented.

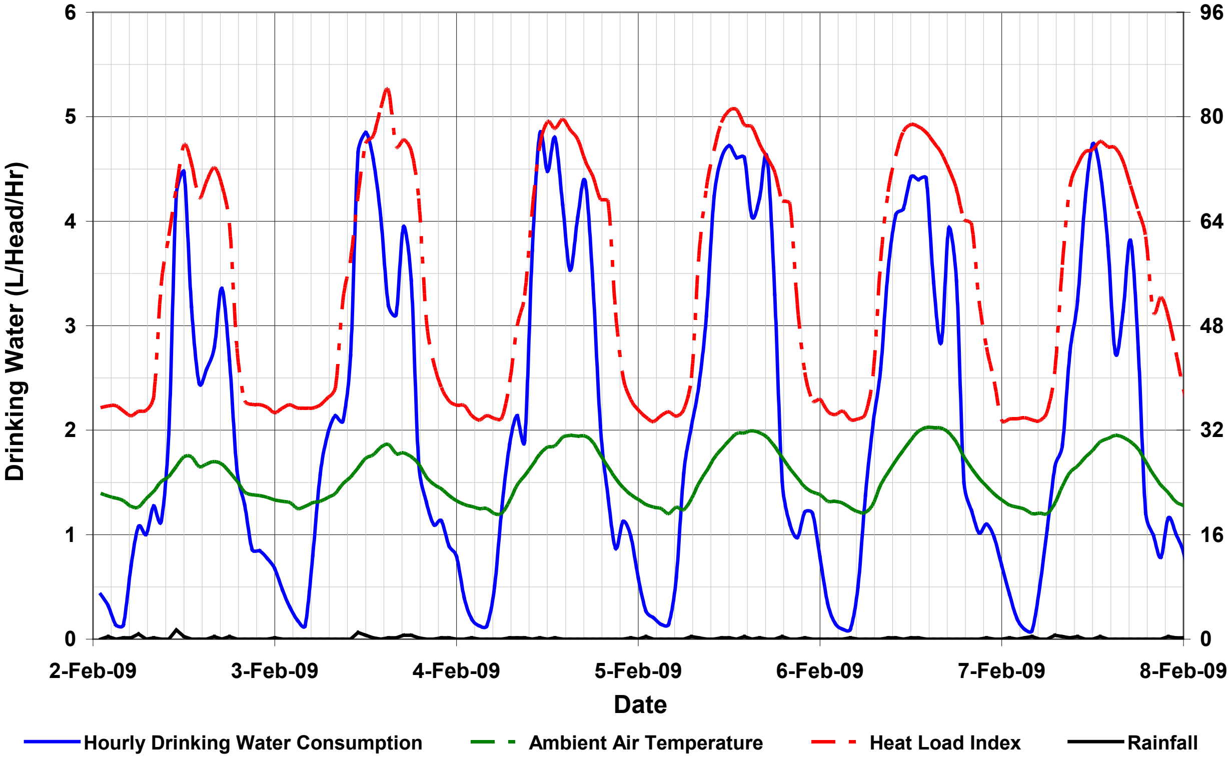

Figure 34 – Daily variation in drinking water consumption 2nd February 2009 to 9th February 2009 - Feedlot G (L/head/hour)

Figure 34 shows drinking water consumption (L/head/hour) for Feedlot G for the period 2nd February to 9th February 2009. Drinking water consumption clearly increases with increasing heat load. During this period, the peak drinking water requirement measured was in the order of 4.75 L/head/hour. For the number head-on-feed during this time it represents a maximum flow rate required of approximately 660 L/minute. This figure also shows that there is a lag of around 2 hours between peak heat load and peak drinking water consumption. Additionally, there is two distinct drinking periods throughout each day. Hence, it is at this time that the reticulation system must be capable of supplying the necessary water to the cattle.

The peak daily demand can be compared with the pumping capacity of the water reticulation system to determine if sufficient capacity is available to deliver water. The pumping capacity of the reticulation system is designed to be 1800 L/minute. Peak flow rates in the order of 660 L/minute were measured. However, during this time, the feedlot manager advised that the water supply could not keep up with consumption. Therefore, the delivery lines must be a limiting factor within the water reticulation system at this feedlot. Peak flow rates are an important criteria when planning and designing reticulation systems.

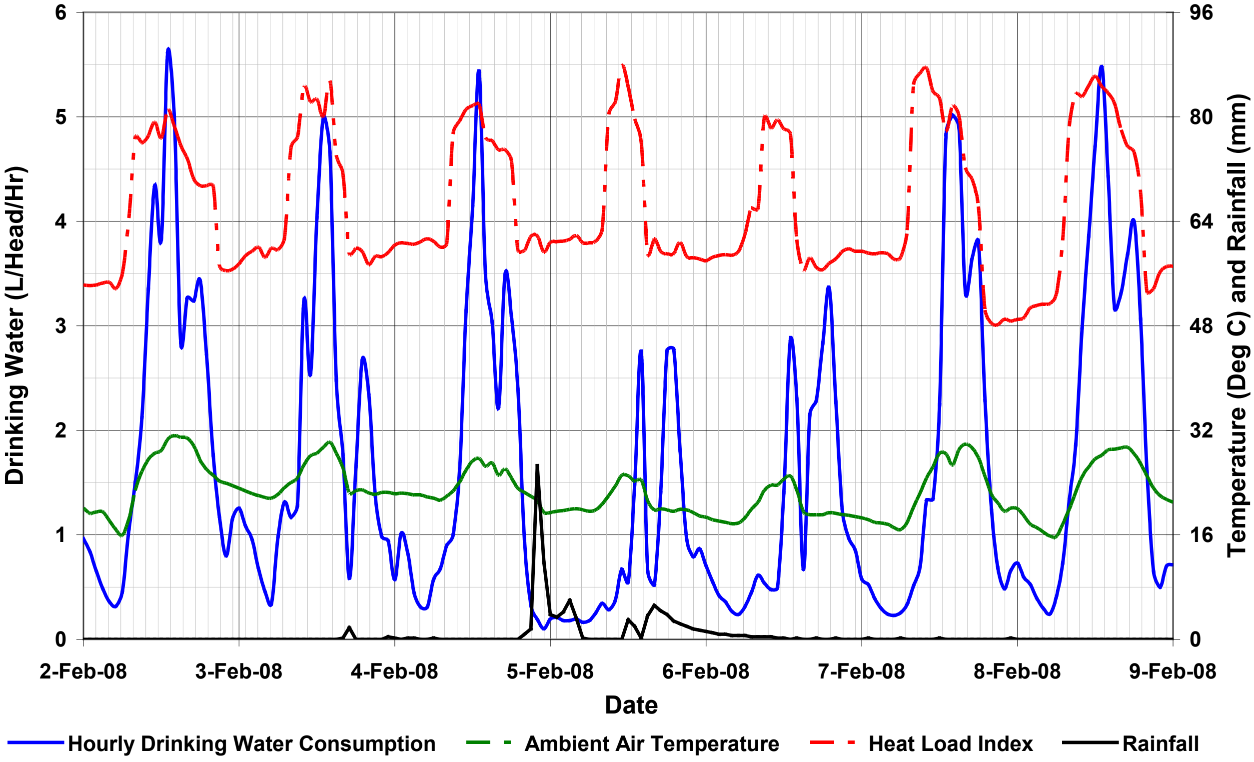

Figure 35 – Daily variation in drinking water consumption 2nd February 2008 to 9th February 2008 - Feedlot G (L/head/hour)

Figure 35 shows drinking water consumption (L/head/hour) for Feedlot G for the period 2nd February to 9th February 2008. This period clearly shows the effect of rainfall on drinking water consumption. Rainfall on the 5th and 6th of February suppresses consumption even whilst the heat load index remains high. In this case, relative humidity is the driver of heat load, not temperature. During this period, the peak drinking water requirement measured ranged from 3.0 to 5.5 L/head/hour. Similarly, to the Figure 34, a lag of around 2 hours between peak heat load and peak drinking water consumption is also evident.

4.3 Feed processing water usage

Figure 36 illustrates the average feed processing water usage on a tonne of grain processed basis for the seven feedlots that participated in the water usage investigation. The minimum and maximum feed processing water usage, on a tonne of grain processed basis, for any one month is also presented. The feedlot numbering in this section does not match the numbering in previous sections to maintain anonymity for the participating feedlots. Whilst a summary is provided in this section, complete individual feedlot monthly feed processing water usage is presented in Appendix B.

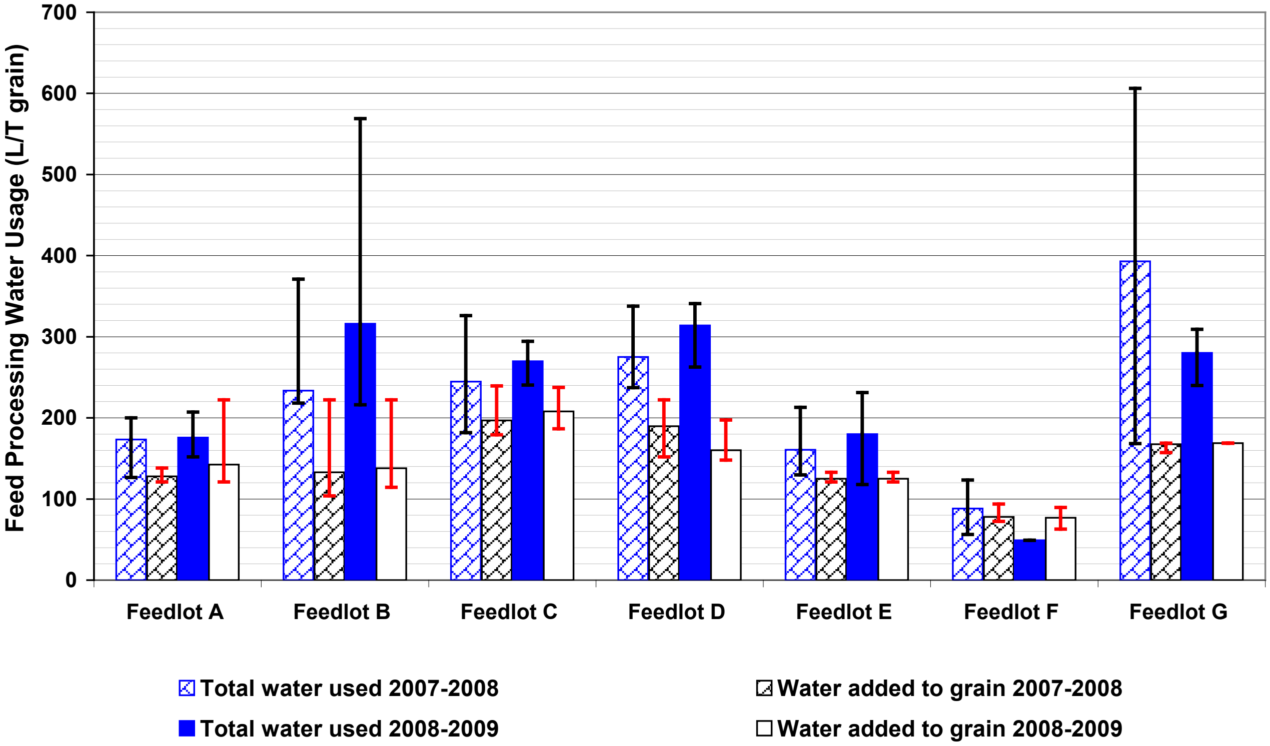

Figure 36 – Total feed processing water usage (L/t grain)

Feed processing water usage is the second highest consumer of water in feedlots where no cattle washing is undertaken. Figure 36 illustrates the average total feed processing water usage on a tonne of grain processed basis for the seven feedlots for 2007-2008 and 2008-2009. Feed processing water has two components. They are:

- water stored in the moistened grain (moisture difference between dry and wet grain), and
- unaccounted-for losses, which are a function of the feed processing method.

The average water stored in the grain was calculated from the moisture content of incoming and processed grain and the quantity processed for each month. These data were supplied by each feedlot. Unaccounted-for water is the measured total feed processing water less the water stored in grain.

The average feed processing water usage ranges from 80 (Feedlot F) to 390 L/t grain processed (Feedlot G). For feedlots that process grain by tempering or tempering and reconstitution the total water added to the grain accounts for 90% of the total water used. Feedlots that steam flake grain the total water added to the grain accounts for about 45% of the total water used. Three different feed processing systems are represented within the seven feedlots. Feedlot F tempers grain only, Feedlot C tempers and reconstitutes grain whilst the remaining feedlots temper and steam flake grain. For Feedlot F, the water stored in the grain is similar to the total water used. Hence, it has a very low volume of unaccounted-for water. At Feedlot C, an average of 40 L/t grain is unaccounted-for whilst water usage and unaccounted-for water within steam flaked systems is variable. Therefore, in steam flaking, if the tempering component water usage is reflected in the water stored in the grain, then the majority of unaccounted-for water can be attributed to the process of steam generation and delivery. Feedlots A and E have lower unaccounted-for water than Feedlot B, D and G. A number of factors will influence feed processing water usage including system employed, grain type, target moisture and management of the system.

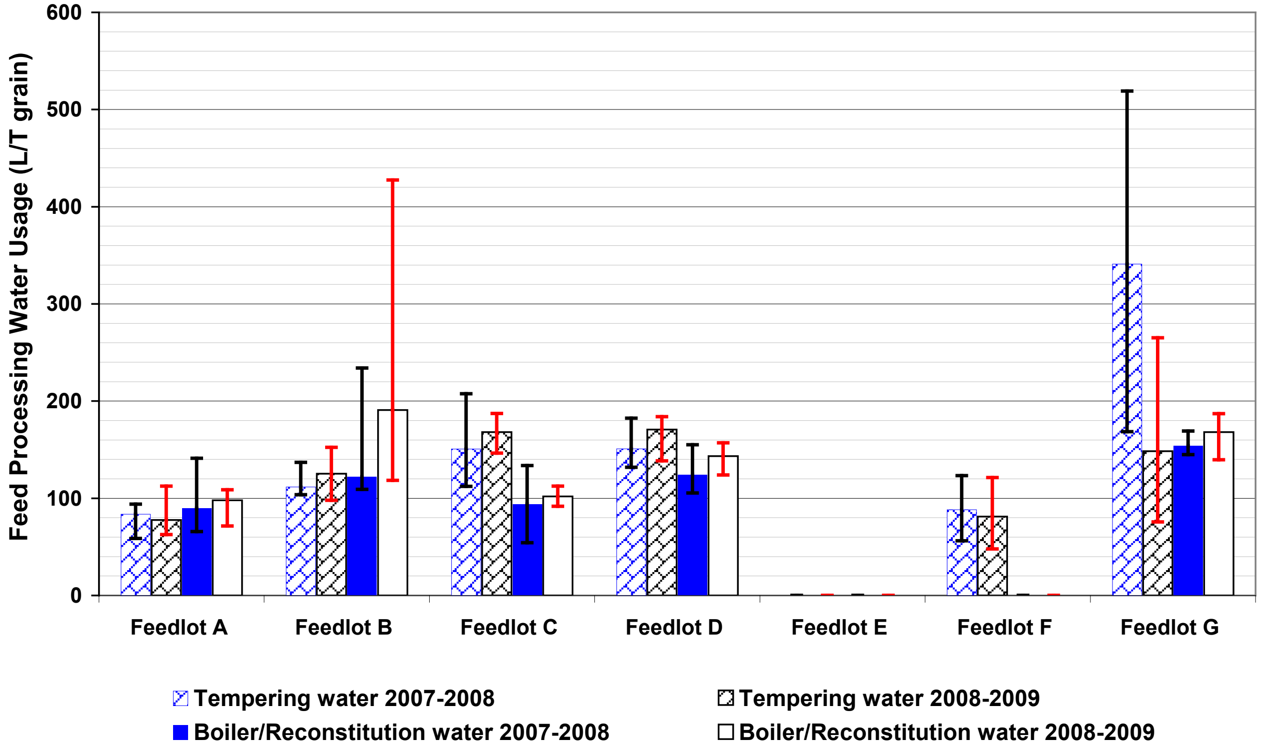

Figure 37 – Feed processing water usage (L/t grain)

At the majority of feedlots, the feed processing water was able to be divided into tempering, boiler and reconstitution water usage. Figure 37 illustrates the average feed processing component water usage on a tonne of grain processed basis for the seven feedlots. The minimum and maximum water usage for each component for any one month is also presented. Feedlot E was not able to supply individual usage for tempering and boiler water use. Feedlot F tempers grain only, Feedlot C tempers and reconstitutes grain whilst the remaining feedlots temper and steam flake grain.

The measured tempering water usage ranges from 80 (Feedlot F) to 150 L/t grain (Feedlots C & D) processed for all feedlots with the exception of Feedlot G which recorded an average tempering water usage of 340 L/t grain processed in 2007. However, this reduced significantly in 2008 to 145 L/t grain. Steam flaking boiler average water usage ranges from 130 (Feedlot D) to 190 L/t grain processed (Feedlot B) . Hence, there is a large variation between and within feedlots. Feedlot G and D have a narrow water usage range, whilst Feedlot A has a wider range. Feedlot B has two months where boiler water usage per tonne of grain processed is higher than the average. Setup and operation of the various components (tempering bin/boiler) appears to be the principal driver of water usage within respective feed processing systems.

4.4 Cattle washing

Figure 38 illustrates the average total water usage for washing cattle (L/head) for the seven feedlots. The total water usage in some feedlots comprises clean and recycled water. Figure 39 shows the break-down between clean and recycled washing water. Feedlot C and Feedlot E do not wash cattle. Feedlot D did not wash any cattle during the study period. The minimum and maximum water usage per head washed for any one month is also presented. The feedlot numbering in this section does not match the numbering in previous sections to maintain anonymity for the participating feedlots. Appendix C gives more complete individual feedlot monthly cattle washing water usage.

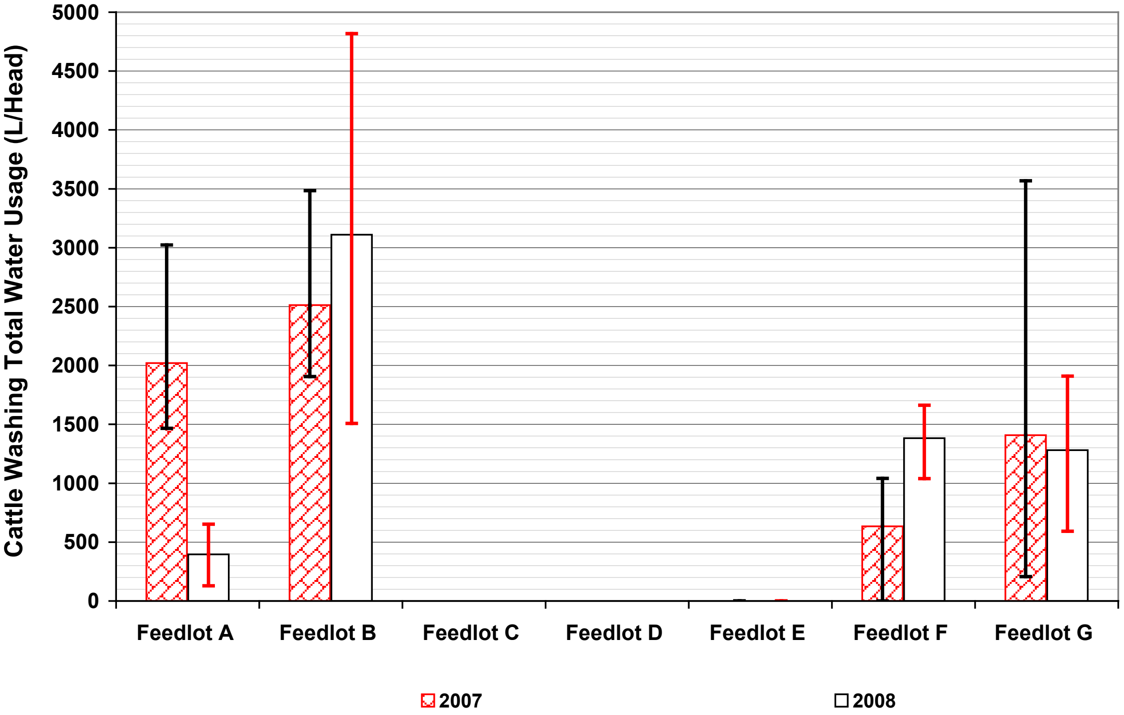

Figure 38 – Average / maximum / minimum cattle washing water usage (L/head)

The total cattle washing water usage ranges from an annual average per feedlot of 400 L/head at Feedlot A in 2008 to 3100 L/head at Feedlot B in 2008. However, a monthly average water usage up to 4400 L/head has been recorded at Feedlot B. The water required for cattle washing is dependent on the dirtiness of the cattle and the cleaning requirements. Feedlot A experienced a drier 2008 when compared to 2007, hence a reduction in cattle washing usage. Feedlot F increased water usage per head due to dirtier cattle from higher rainfall in the winter months when compared with 2007.

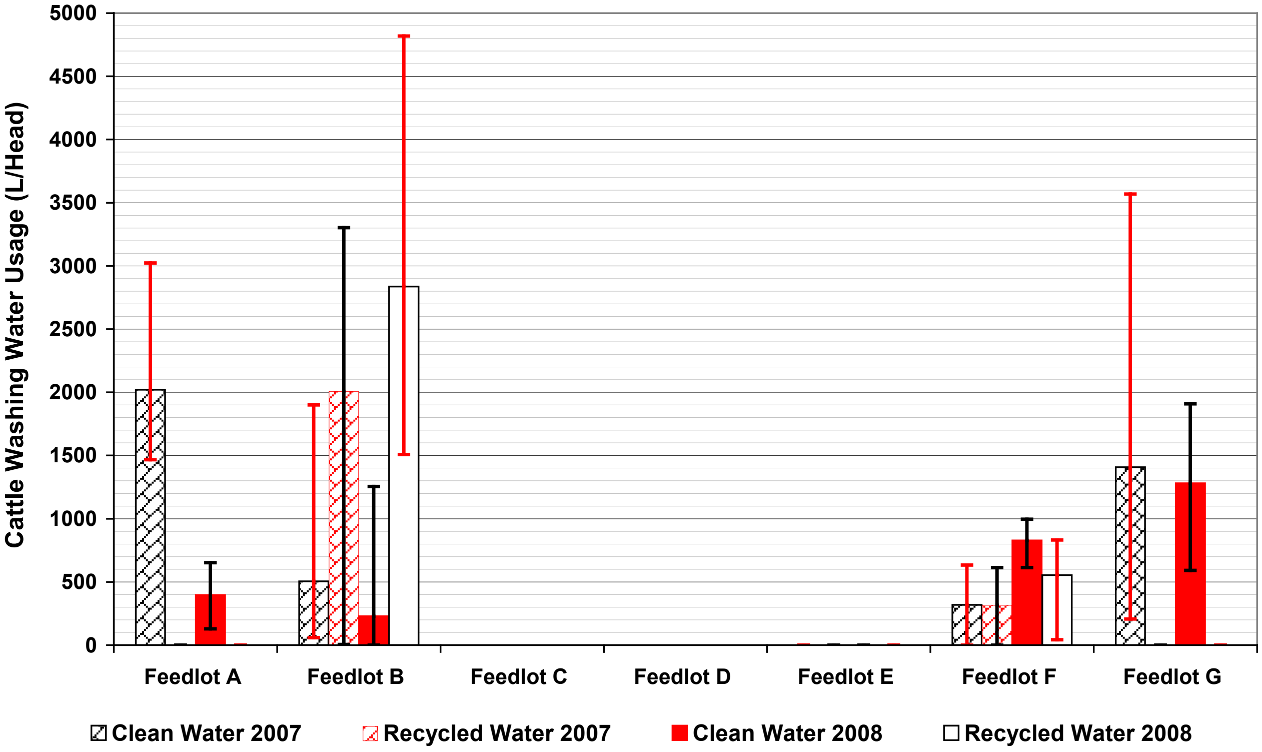

Figure 39 – Components of cattle washing water usage (L/head)

Figure 39 illustrates the average clean water and recycled water usage for washing cattle (L/head) for the seven feedlots. Whilst Feedlot B has recorded the highest average monthly total water usage, it is noted that the majority of this water is recycled water from washing cattle. The use of recycled water may also increase the water requirements due to the dirtiness of the water and relaxing of soaking times. Feedlot A and Feedlot G do not recycle water.

4.5 Administration

Figure 40 shows the average total water usage for administration (L/kg HSCW gain basis). The minimum and maximum water usage for any one month is also presented. Administration water usage was only able to be directly measured at Feedlot D, E, F and G. In addition, feedlot numbering in this section does not match the numbering in previous sections to maintain anonymity for the participating feedlots. Whilst a summary is provided in this section, complete individual feedlot monthly administration water usage is presented in Section 4.1.

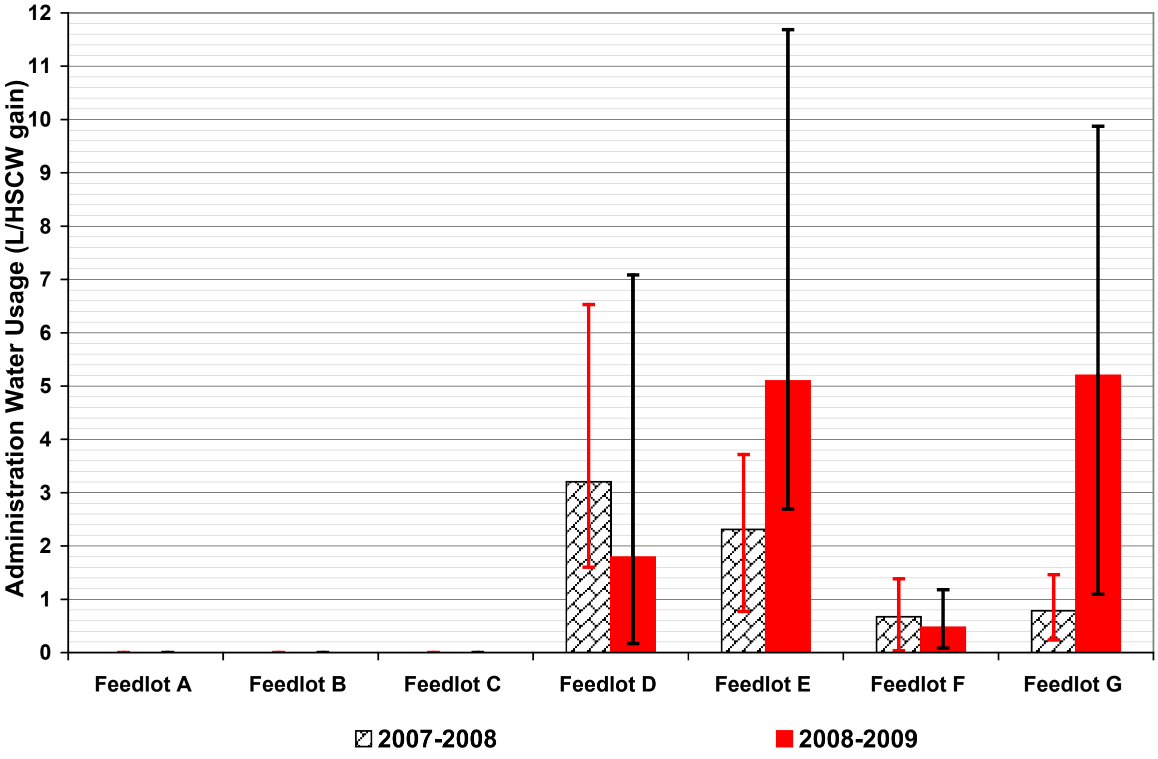

Figure 40 – Average administration water usage (L/kg HSCW gain)

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

4.6 Sundry water uses

Table 2 gives a summary of the measured and estimated sundry water uses at each feedlot in L/kg HSCW gain whilst Table 3 presents these sundry water uses per head on feed basis. The feedlot numbering is consistent with Section 3.6. Where appropriate, these data were deducted from the total water use data to gain a better estimate of drinking water use.

Table 2 – Sundry water uses for each feedlot (L/kg HSCW gain)

Feedlot	**A**	**B**	**C**	**E**	**F**	**G**	**H**
Water trough evaporation	0.08	0.03	0.17	0.01	0.02	0.01	0.02
Water trough cleaning	4.60	0.84	0.53	0.34	0.23	0.04	0.65
Hospital/Induction Cleaning	2.03	0*	0.25	0.42	0.13	0.28	0.29
Vehicle washing	0.64	0*	0.48	0.02	0*	0.00	0.23
Road Watering	5.73	0.33	0.10	1.28	0*	0.00	0.00
Water Storage evaporation	2.61	0.00	3.34	1.82	0.02	0.45	0.00
TOTAL (L/kg HSCW gain)	15.69	1.20	4.86	3.90	0.39	0.78	1.18

* Data unavailable

Table 3 – Sundry water uses for each feedlot (L/head/day)

Feedlot	**A**	**B**	**C**	**E**	**F**	**G**	**H**
Water trough evaporation	0.6	0.7	5.1	0.4	0.3	0.3	0.4
Water trough cleaning	35.2	24.2	16.1	10.8	3.9	1.2	15.9
Hospital/Induction Cleaning	15.5	0.0	7.7	13.4	2.2	8.4	7.0
Vehicle washing	4.9	0.0	14.5	0.6	0*	0.0	5.5
Road Watering	43.8	9.5	3.1	40.6	0*	0.0	0.0
Water Storage evaporation	230.3	0.0	1450.0	910.6	4.3	161.1	0.0
TOTAL L/head/year	330.3	34.5	1497	977	10.7	171.0	28.9
TOTAL L/head/day	0.9	0.1	4.1	2.7	0.03	0.5	0.1

* Data unavailable

The sundry water losses ranged from 0.03 L/head/day to 4.1 L/head/day. Water storage evaporation contributed the largest use in those feedlots with open water storages. Water trough cleaning is the second largest use in those feedlots with no road watering. Road watering can contribute up to 44L/head. Hence, the three largest sundry water uses viz. water storage evaporation, trough cleaning and road watering are dependent on the total open water surface area, net evaporative losses, trough size and frequency of cleaning and cleaning method and road maintenance. Hence, sundry losses are dependent on feedlot design, location (climate) and operational management.

5 Opportunities for water use efficiency improvements

The majority (75-90%) of clean water usage at Australian feedlots is cattle drinking water and there is little scope to reduce this component. However, there is scope to minimise losses in the remaining 10-25% of water usage.

This study has estimated the magnitude of evaporative losses from open water storages during March 2007 and February 2009. The magnitude of these losses can be up to 4.1 L/head/day dependent on total surface area and net evaporation. This represents up to 10% of the total water usage at Feedlot C. Hence, this is a significant loss of valuable water.

Evaporation from open water storages has always been known to be large but the cost of the solution has always been considered far higher than the value of the water saved. However, over the last few years new materials and inventive solutions for applying those materials, have come along which have reduced the costs of potential solutions. At the same time, the value of water has risen considerably and it is possible that a balancing point has now been reached. Lining storages to prevent seepage losses may also be a consideration.

One feedlot has already lined (with HDPE) and covered one of its drinking water buffer storages with a cover to control evaporation. Whilst obviously reducing evaporative losses, this solution also has provided additional benefits such as cleaner (effective barrier to light therefore less algal growth) and cooler water (reflection of solar radiation). This has resulted in more water consumed, translating into increased performance. Hence, it is recommended that is one area that could be considered by feedlots with open water storages.

However, the total cost is very site specific and depends upon the remoteness of the site and other issues such as whether the top edge of the storage has been graded for easy vehicular access.

As a guide, the covers have a base cost in the order of $6.50 per square metre (plus GST). These covers have an estimated lifespan of 10 years and probably can be depreciated over 5 years. It has a 5-year pro rata warranty.

The water required for cattle washing is dependent on the dirtiness of the cattle a result of prevailing climatic conditions and genotype and the cleaning requirements set by the processing company.

The average water required for cattle washing can be up to 3100 L/head. However a maximum usage of 4400 L/head over one month was recorded. If there is no recycling, then this must be sourced from clean water. Therefore, recycling of washing water for soaking should also be an important consideration for those feedlots that are required to wash cattle.

There are also efficiency gains to be made from an operational perspective such as overflowing cattle wash storage tanks, cleaning hoses remaining on during breaks, attention to storage and trough leakages and float shut off.

6 Conclusions and recommendations

6.1 Conclusions

Water availability and cost of supply is changing rapidly, driven by increased demand for industry, urban water supply and the environment. With droughts adding to low river flows, water supplies are very tight in many feedlot regions. Capped water supply and water trading in the Murray Darling Basin have increased the value of water significantly. In Victoria, large feedlots are now required to quantify and reduce their water usage. These pressures will promote careful management of water resources throughout the industry to ensure continued supply and minimise costs.

Little work has been undertaken to evaluate total water consumption by feedlots. The amount of water used at feedlots was studied in North America in the 1980's. To date, only a limited study on drinking water requirements has been undertaken in Australia. Water is the most important feed component fed to cattle, hence, it is of critical importance to lot feeders.

Little information exists on the water usage of individual components of the feedlot system, viz drinking water, feed processing, cattle washing, administration and dilution of effluent irrigation. Factual information on water usage was collected on individual feedlot sector operations where possible.

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. The major water usage activities (drinking water, feed management, cattle washing, administration and sundry uses) were monitored and recorded.

Results from the seven feedlots studied showed that total annual clean water use (without dilution of effluent) for March 2007 to February 2009 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, Queensland Department of Primary Industries and Fisheries (QDPI&F) 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. The QDPI 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, feed processing or evaporation from open storages. In this 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 and is below that required by the QDPI&F.

Drinking water contributed in the order of 90% of the total water usage in the months when no cattle where washed. This reduces to a figure in the order of 75% during months when cattle washing is 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.

Drinking water is the single largest consumer of water in the feedlot and contributed on average 27.6 to 60.8 L/kg HSCW gain across all feedlots. However, up to 87 L/kg HSCW gain was measured in one month. The differences between feedlot drinking water consumption on a kg HSCW gain basis can be attributed to the differences between market types (long fed - low daily gain v domestic - higher daily gain). However, the primary driver of drinking water consumption is climatic variation.

In this study, the average drinking water consumption on a per head basis ranged from 29 to 46 L/head/day. The average monthly drinking water in 2007-2008 was 39.1 L/head/day, slightly higher than the 37.2 L/head/day measured in 2008-2009. The highest average monthly 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 monthly 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 can 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 is clearly evident on a daily basis. During periods of rainfall, drinking water consumption is suppressed, whilst during periods of high heat load, drinking water is at its highest.

Where no cattle washing is undertaken, feed processing water usage is the second highest consumer of water in feedlots. Three different feed processing systems are represented within the seven feedlots and included tempering, reconstitution and steam flaking. Feed processing contributes in the order of 4% as a function of HSCW gain and is dependent on the grain processing system employed at the feedlot. This figure can vary slightly from month to month depending on the management of the various systems. However, on average the levels are similar between years.

The average feed processing water usage ranged from 80 to 390 L/t grain processed. For feedlots that process grain by tempering or tempering and reconstitution the total water added to the grain accounts for 90% of the total water used. Feedlots that steam flake grain the total water added to the grain accounts for about 45% of the total water used. For tempering only systems, the water added to the grain is similar to the total water used, hence has a very low volume of unaccounted-for water. For reconstitution, an average of 40 L/t grain is unaccounted-for whilst water usage and unaccounted-for water within steam flaked systems is variable with an average unaccounted-for loss of 225L/t grain. Therefore, in steam flaking, if the tempering component water usage is reflected in additional water in the grain, then the majority of unaccounted-for water can be attributed to the process of steam generation and delivery. A number of factors will influence feed processing water usage include system employed, grain type, target moisture and management of the system.

Cattle washing is the second highest consumer of water in feedlots in months when it is undertaken. The total water usage in some feedlots comprises clean and recycled water. Cattle washing can contribute up to 25% as a function of HSCW gain of the total water usage.

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 can account for 50 to 75% of the total washing water usage.

The water required for cattle washing is dependent on the dirtiness of the cattle and the cleaning requirements. Hence, water usage decreased at Feedlot A in 2008 when compared to 2007 due to drier conditions, whilst Feedlot F increased water usage per head in 2008 due to dirtier cattle from higher rainfall in the winter months when compared with 2007.

Administration water usage comprises 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, representing in the order of 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 water trough cleaning and road watering are the three largest sundry water uses. Variation between feedlots may 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).

Actual water usage levels within individual activities have been recorded in seven feedlots representative of the Australian Feedlot Industry. These included drinking water, feed processing, cattle washing, administration and sundry uses. The selected feedlots provide a range of climatic conditions from a northern feedlot in a hot, humid summer-dominant rainfall to southern feedlots in cooler, winter-dominant rainfall zones. Grain processing methods vary from simple tempering to reconstitution and steam flaking. Some feedlots wash cattle (mainly in winter) while other feedlots do not undertake any cattle washing.

The outcomes of this study will allow the feedlot industry to start benchmarking total water usage. This information is invaluable for participating feedlots in understanding the drivers of water consumption and targeting high water use areas for efficiency gains and for future design and management considerations. The first step to making savings is to understand where water is used around the feedlot. Remember, ***measure to manage.***

To assist the feedlot industry to improve water resource efficiency, a framework has been developed to step individual feedlot operators through the process of measuring and reducing water usage at the feedlot. This framework is presented as fact sheets, arranged in 3 series:

- Measuring and Understanding resource usage;
- Benchmarking, and
- Improving resource efficiency

Figure 41 illustrates the first phase in developing the framework. Factsheets in this series outline the steps involved and the tools required for implementing a water usage measurement system and understanding what the numbers mean. There are three factsheets common to both the water and energy framework. These are the collection of production data, analysing water and energy data and developing analysis tools.

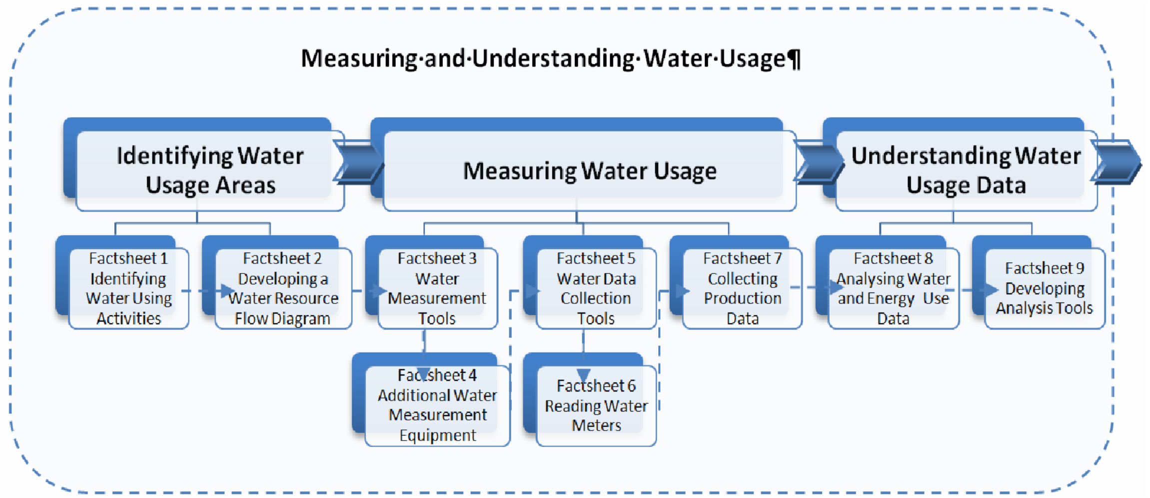

Figure 41 – Measuring and understanding phase flowchart for water usage

Figure 42 illustrates the second phase in developing the water framework. Factsheets in this series provide industry data on water usage within individual activities which can be used to benchmark feedlot water usage levels against.

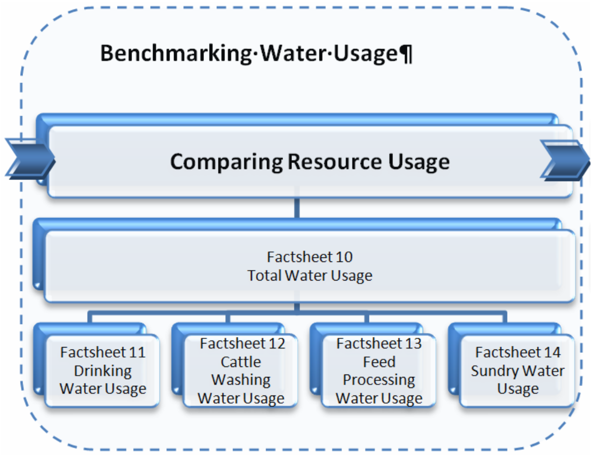

Figure 42 – Benchmarking phase flowchart for water usage

Figure 43 illustrate the last phase in developing the water framework. Factsheets in this series provide case studies which you can use to gain a better understanding of the process and to benchmark water usage levels.

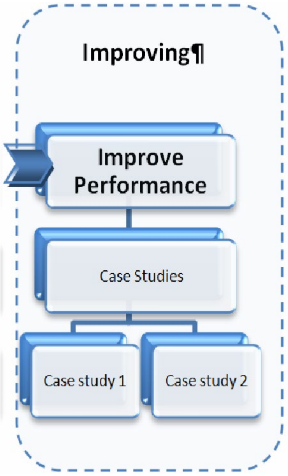

Figure 43 – Improving phase flowchart for water usage

The outcomes of this study puts valuable information in the hands of the industry to improve resource efficiency, meet the requirements of legislation and improve the sustainability of the industry in the face of a variable climate.

6.2 Recommendations

The data collected to date have indicated a large variation in total water usage between participating feedlots. This variation can be attributed to location (climatic variation), operation and management of the respective activities.

Benchmarking of this information has raised awareness of water usage within the participating feedlots. This project has also provided industry with a set of industry statistics on water usage over a 24-month period.

It is important that this information is extended to industry. Therefore, it is recommended that a roll out of the fact sheet series be undertaken. This will assist lot feeders in understanding, planning and organising, implementing and monitoring a water use efficiency program based on the outcomes of this work. Additionally, this may also facilitate lot feeders being prepared for the introduction of government initiatives such as the Victorian EREP program.

These data can be used by the industry to establish drinking water consumption levels and also as a base for the development of predictive models. However, using these data for the development predictive modelling was outside the scope of this work. In addition, this dataset is limited to the Darling Downs area and does not contain extended periods of hot, dry weather or extremely cool and wet wintertime conditions. These data also highlight the diurnal variation in drinking water consumption and shows that are distinct winter and summer patterns.

Therefore, it is recommended to obtain additional drinking water consumption patterns within a hot and humid environment and further detailed analysis of drinking water consumption. The detailed work could be undertaken as part of a PhD study.

For example, the detailed study may include a comparison of drinking water consumption of cattle in shaded and unshaded pens and influence of a covered water supply on consumption.

7 References

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Standards Australia, 1998, AS/NZS ISO 14040 – Environmental Management - Life Cycle Assessment – Principles and Framework. Standards Association of Australia, Homebush.

Appendix A – Drinking water consumption

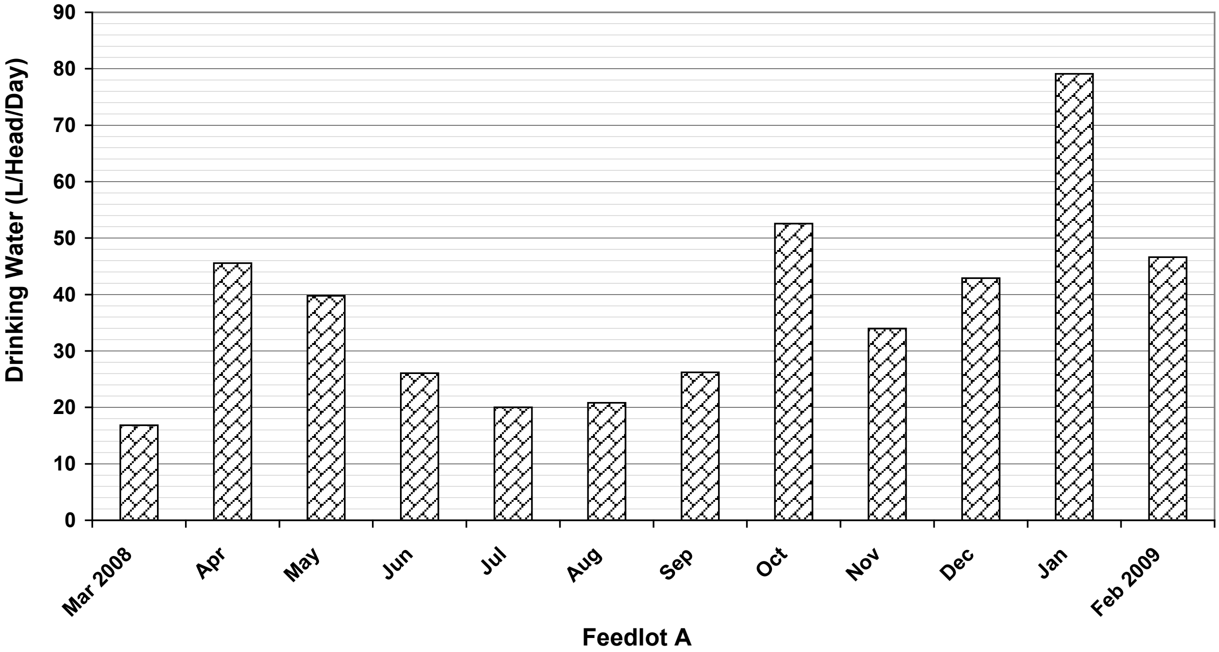

Figure 44 – Drinking water consumption for Feedlot A (L/head/day)

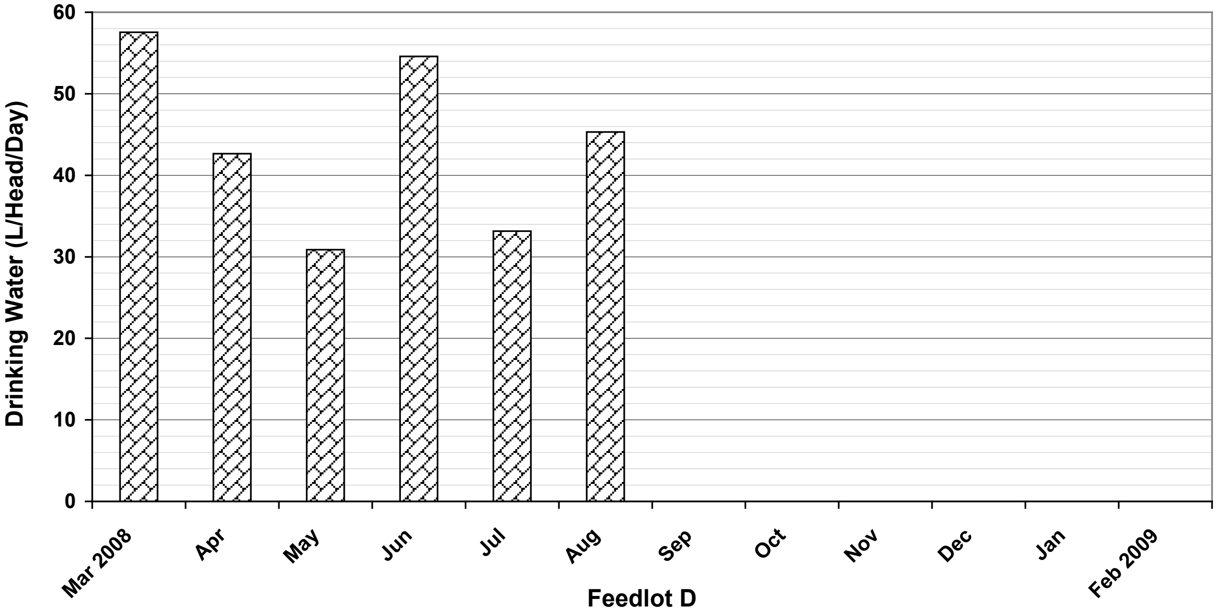

Figure 45 – Drinking water consumption for Feedlot D (L/head/day)

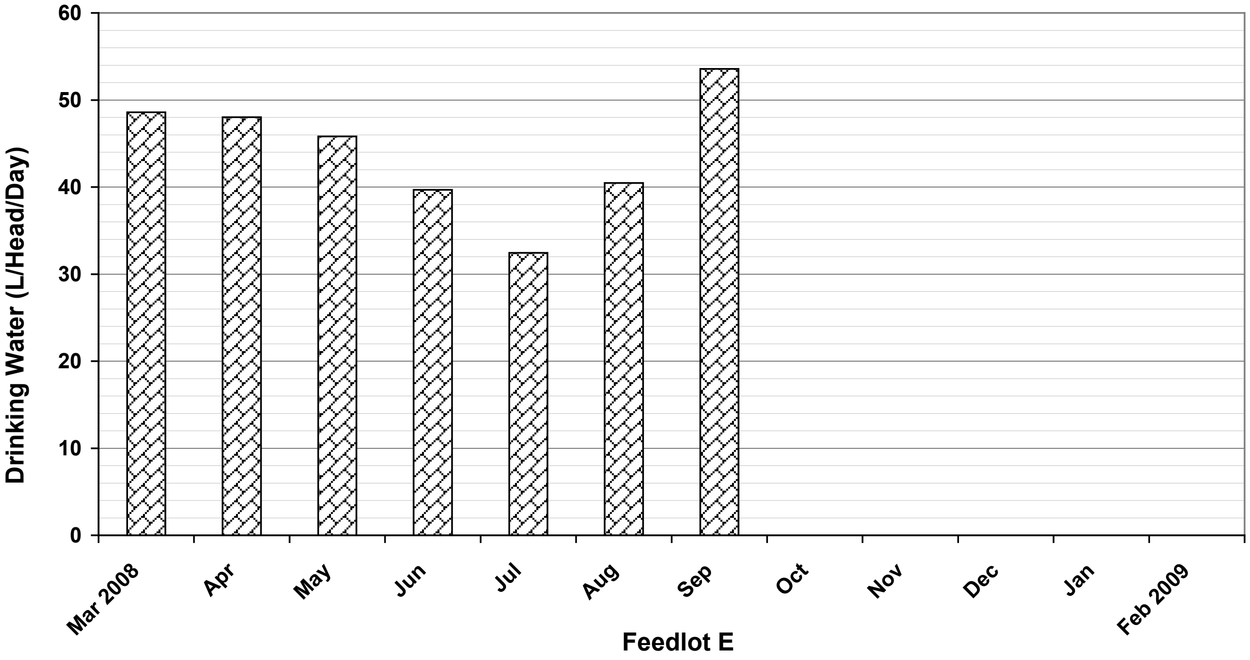

Figure 46 – Drinking water consumption for Feedlot E (L/head/day)

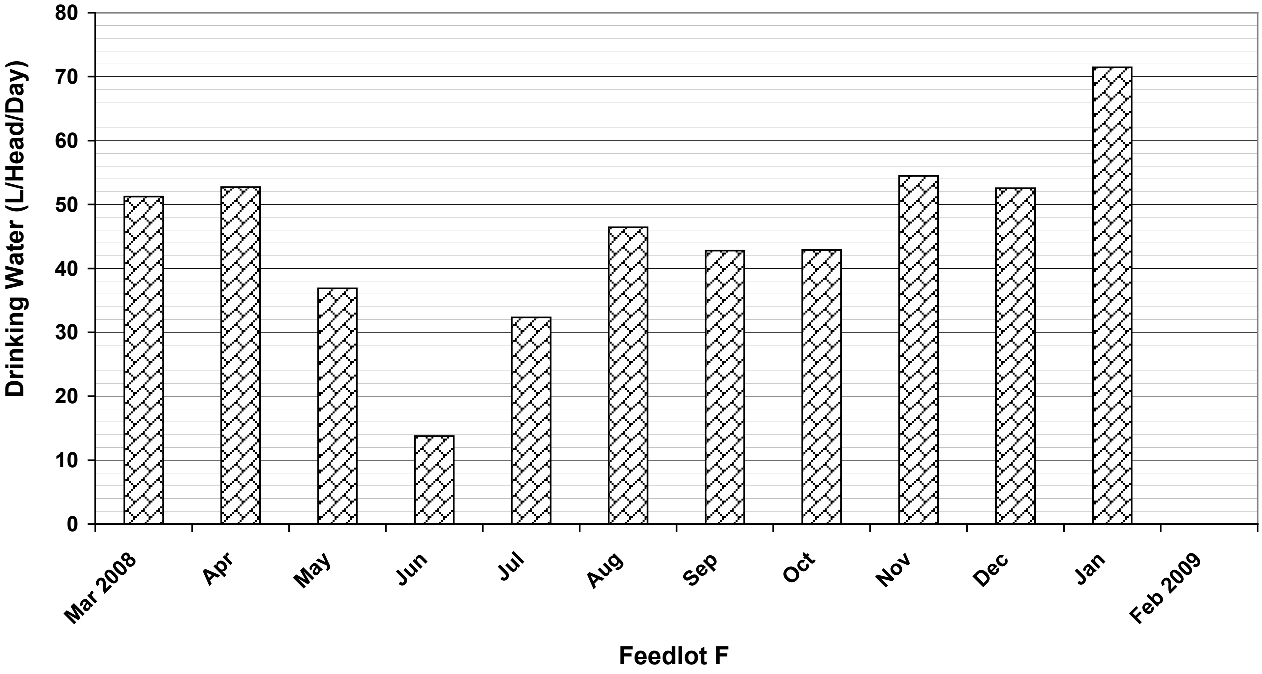

Figure 47 – Drinking water consumption for Feedlot F (L/head/day)

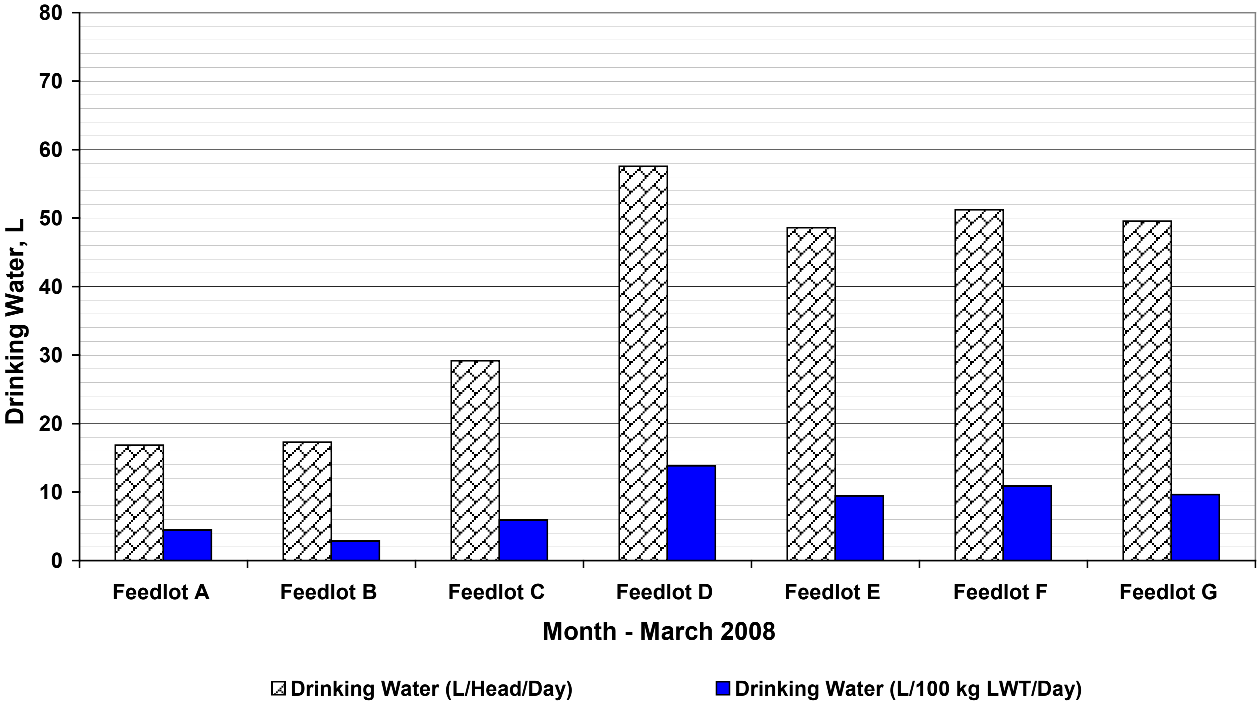

Figure 48 – Drinking water consumption for March 2008 (L/head/day & L/100 kg LWT/day)

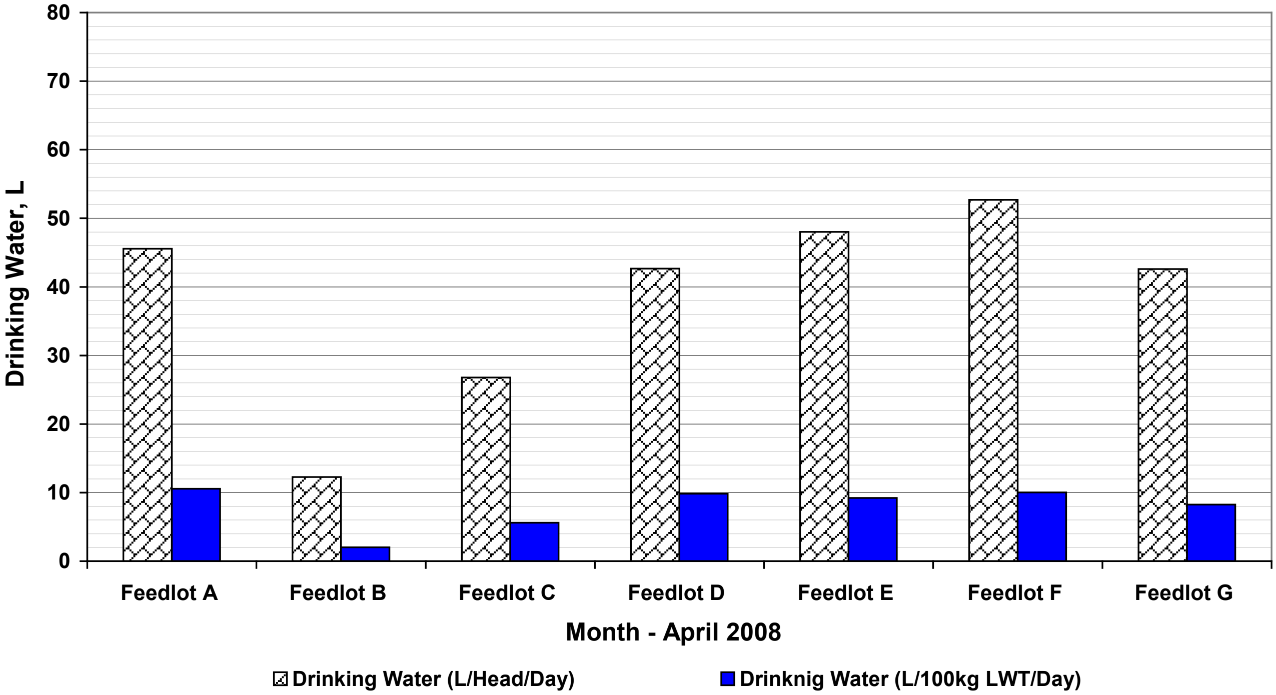

Figure 49 – Drinking water consumption for April 2008 (L/head/day & L/100 kg LWT/day)

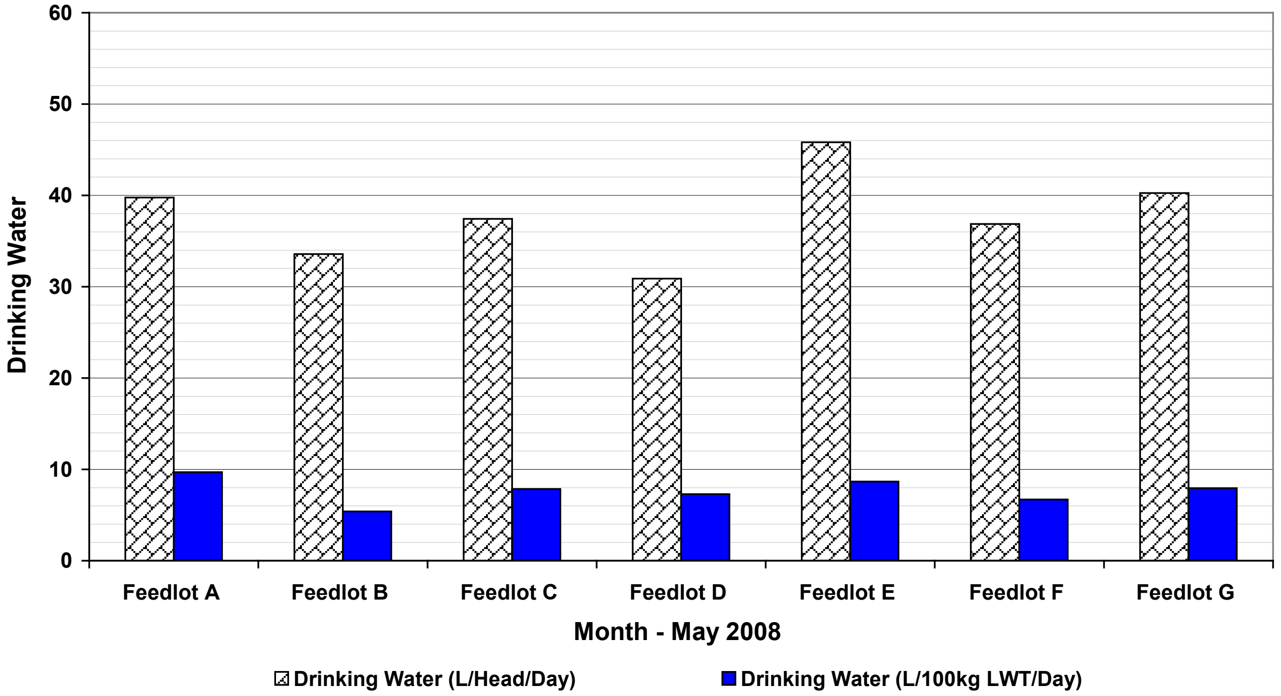

Figure 50 – Drinking water consumption for May 2008 (L/head/day & L/100 kg LWT/day)

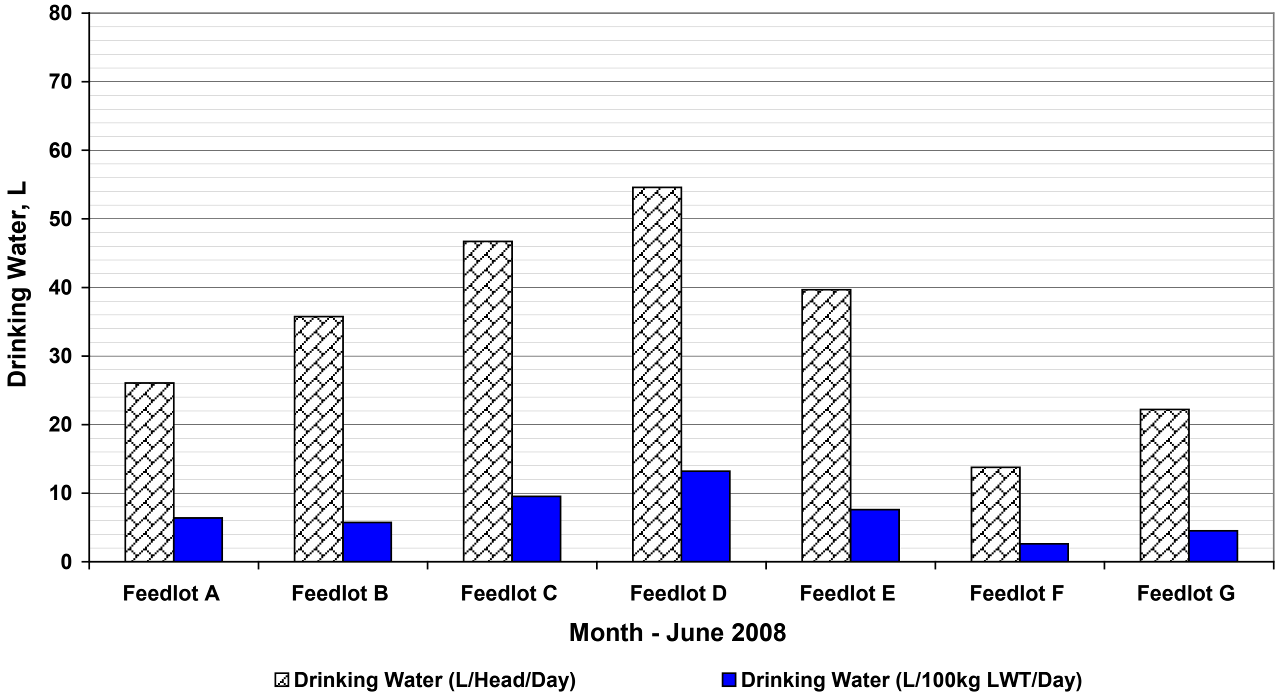

Figure 51 – Drinking water consumption for June 2008 (L/head/day & L/100 kg LWT/day)

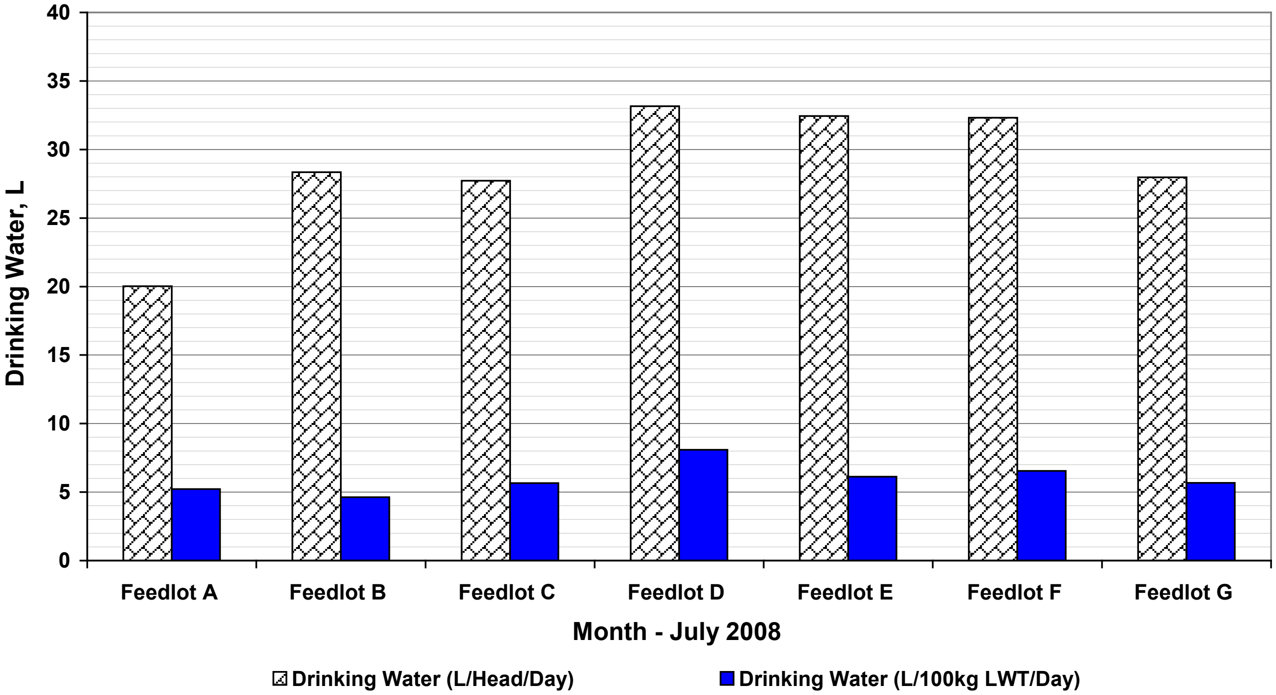

Figure 52 – Drinking water consumption for July 2008 (L/head/day & L/100 kg LWT/day)

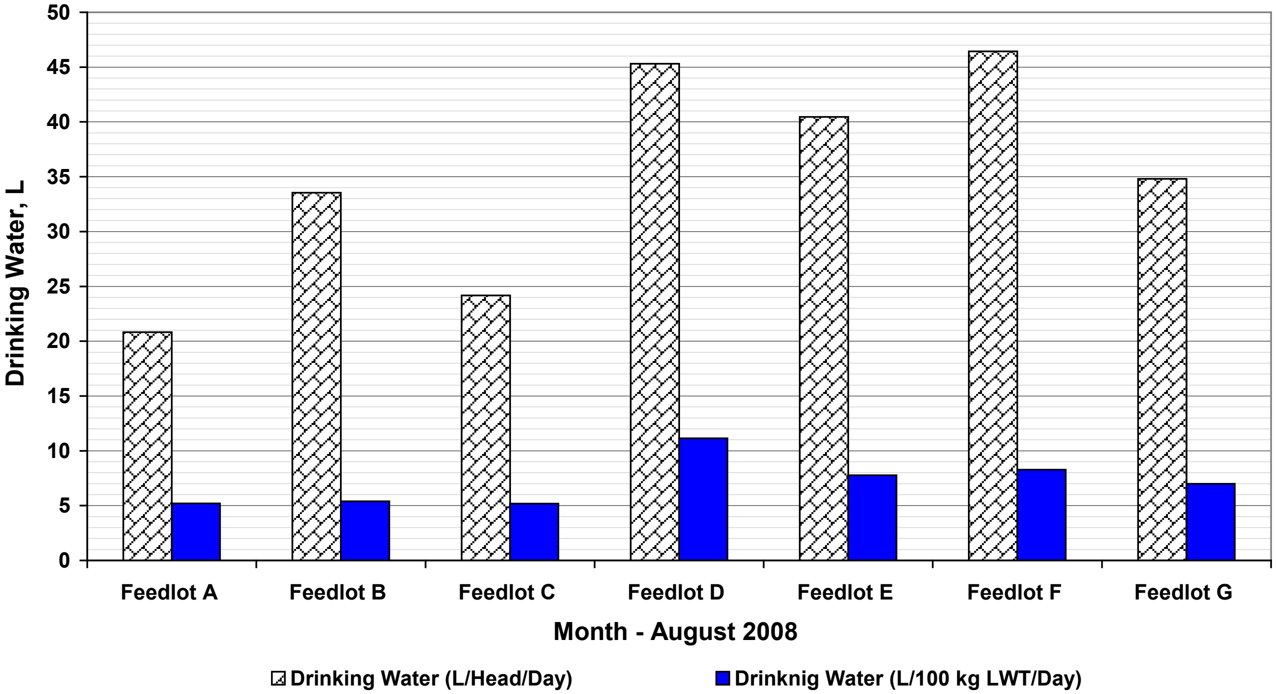

Figure 53 – Drinking water consumption for August 2008 (L/head/day & L/100 kg LWT/day)

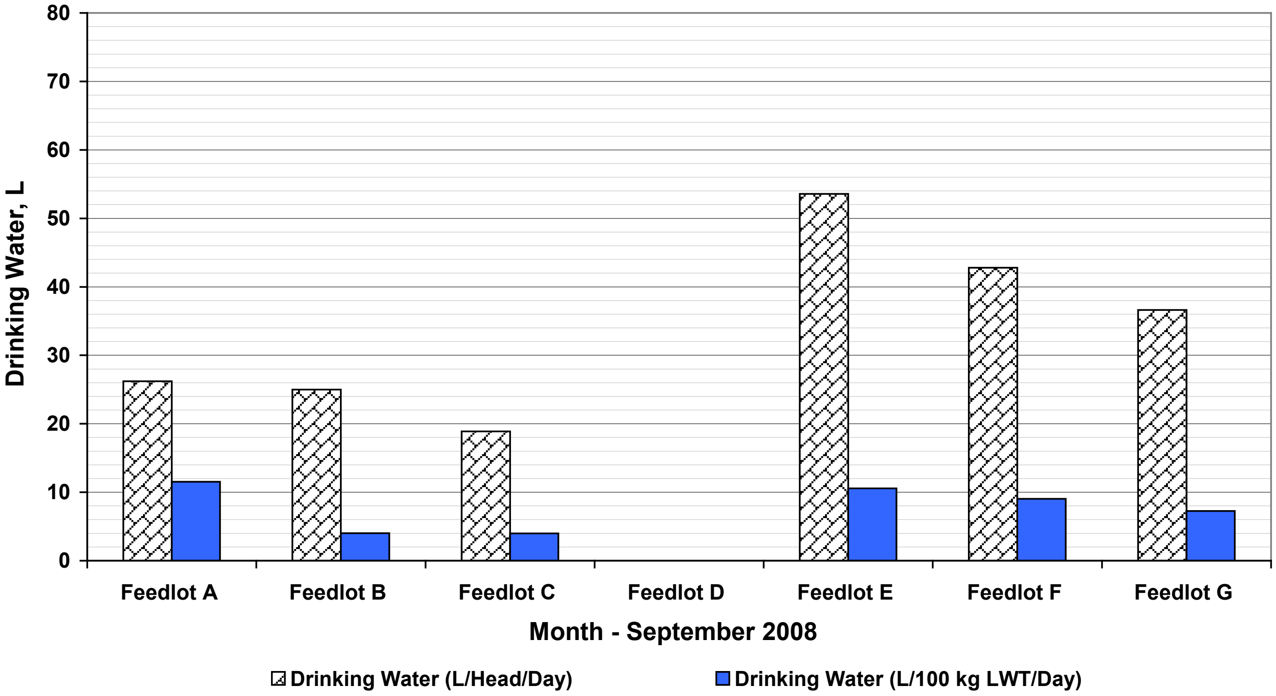

Figure 54 – Drinking water consumption for September 2008 (L/head/day & L/100 kg LWT/day)

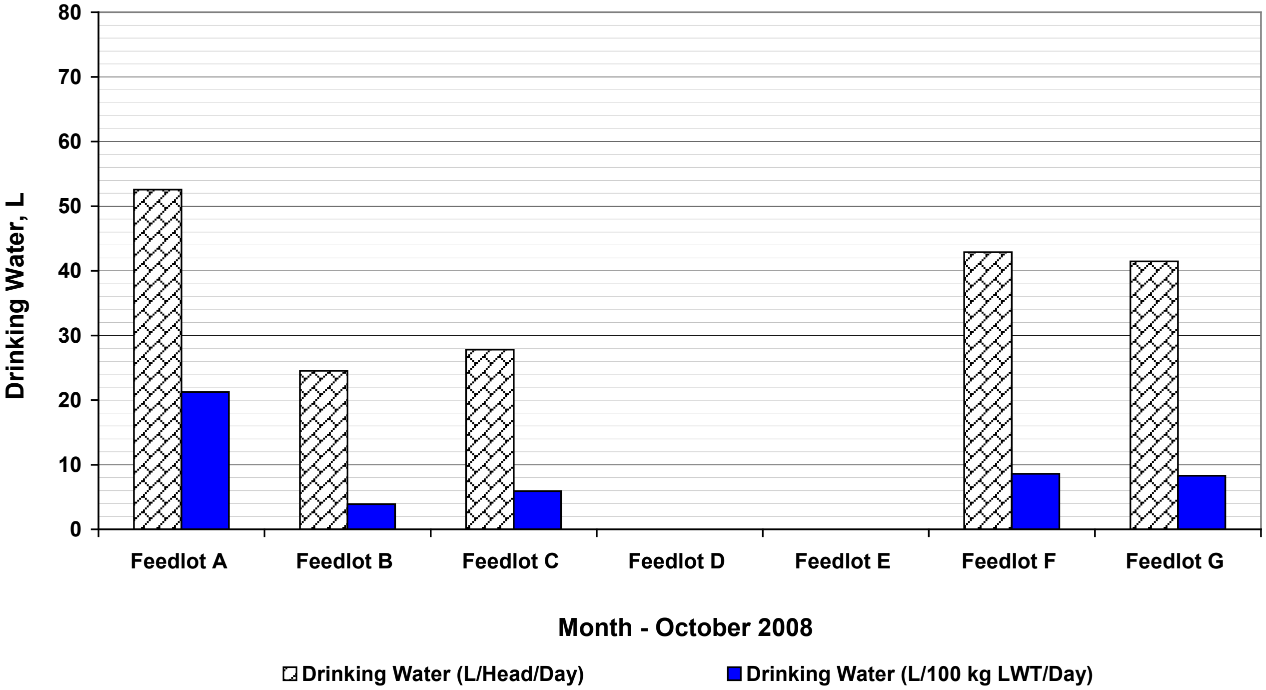

Figure 55 – Drinking water consumption for October 2008 (L/head/day & L/100 kg LWT/day)

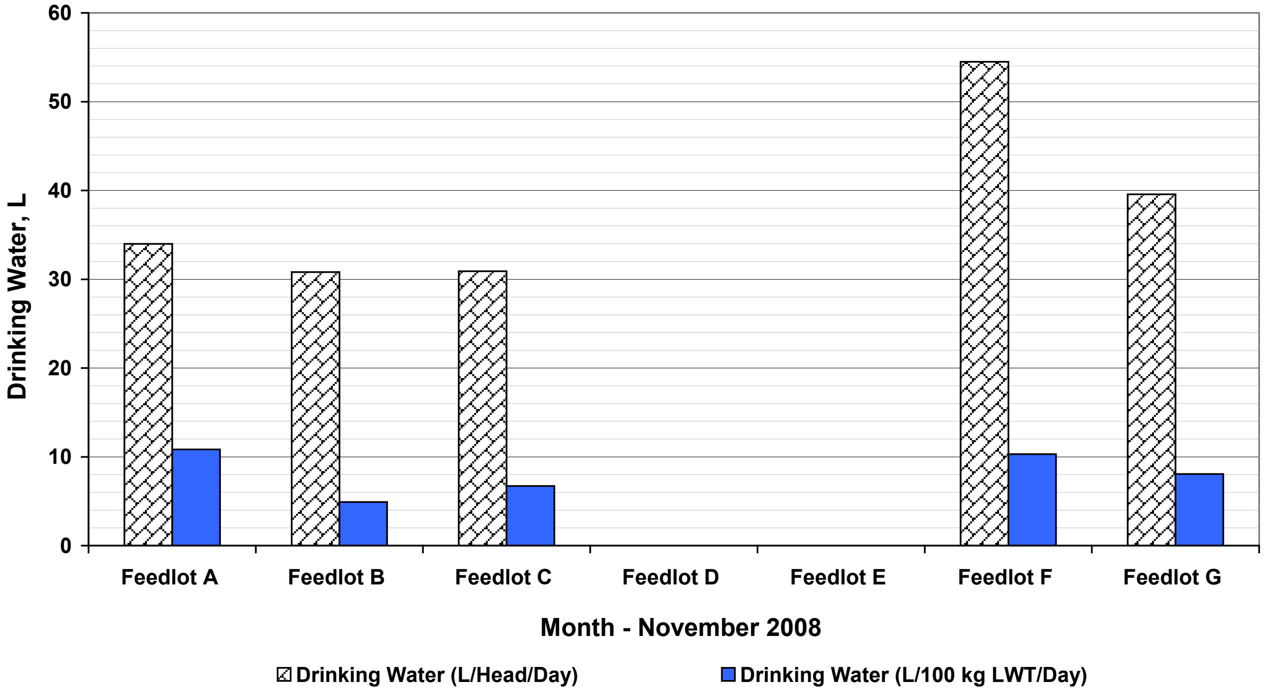

Figure 56 – Drinking water consumption for November 2008 (L/head/day & L/100 kg LWT/day)

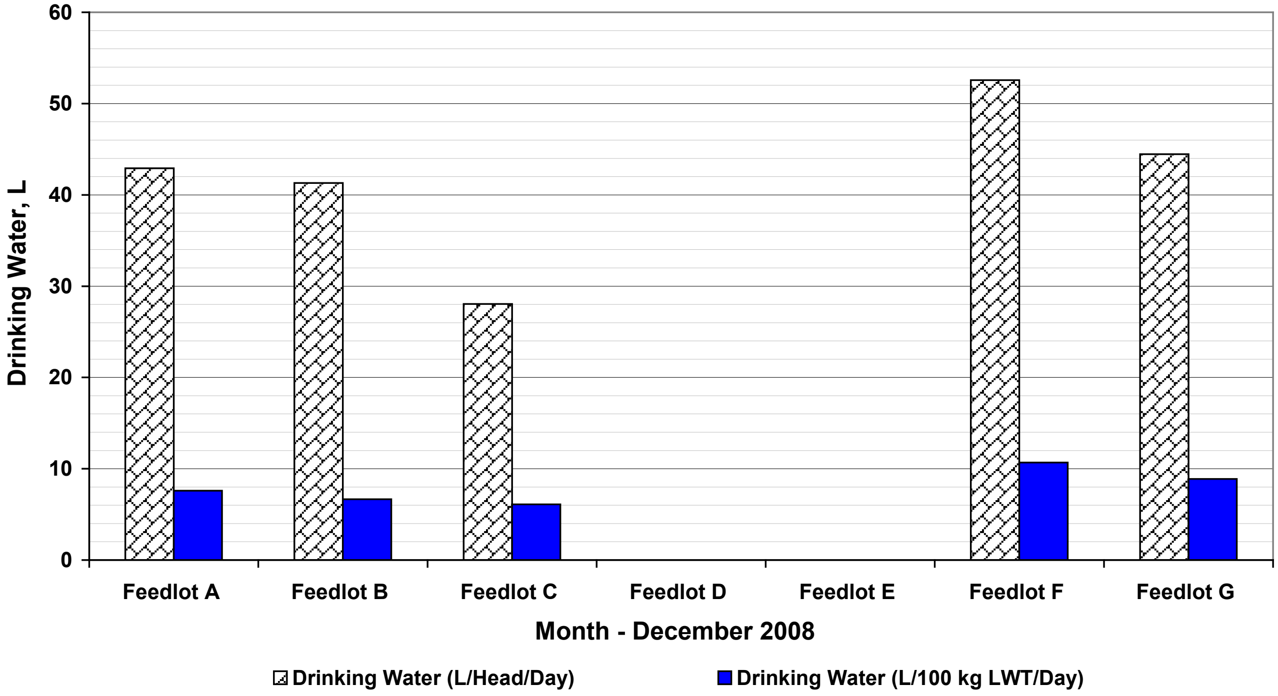

Figure 57 – Drinking water consumption for December 2008 (L/head/day & L/100 kg LWT/day)

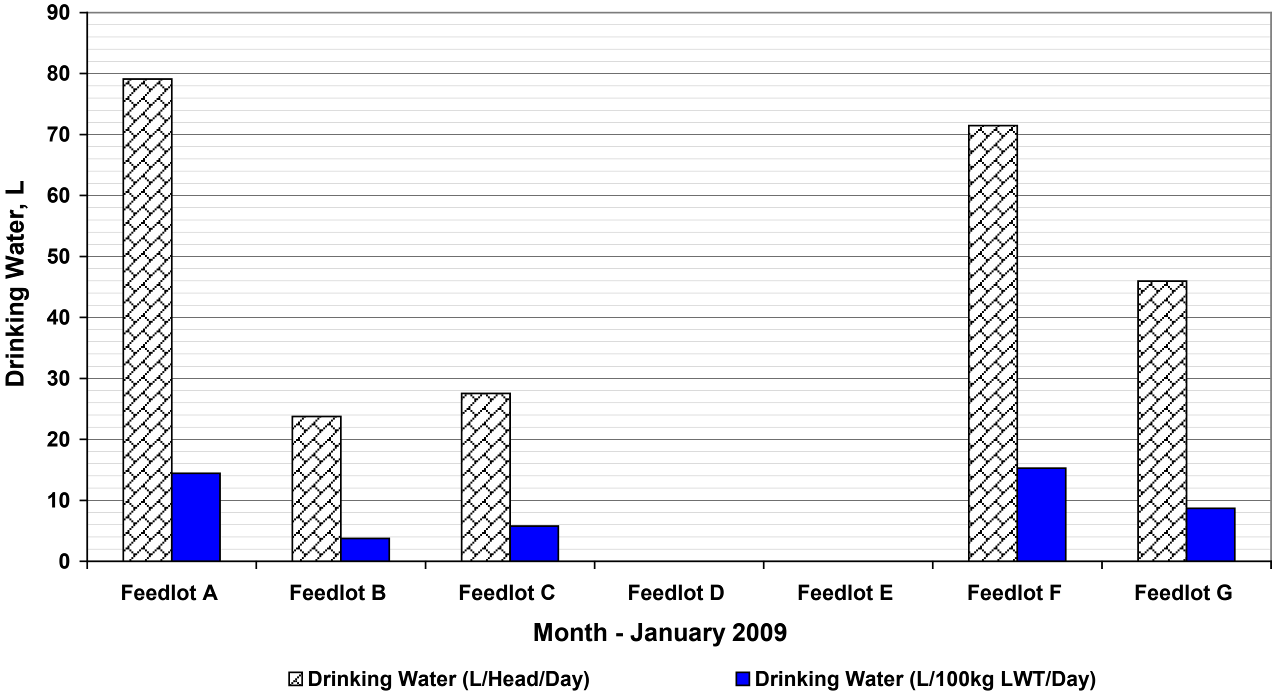

Figure 58 – Drinking water consumption for January 2009 (L/head/day & L/100 kg LWT/day)

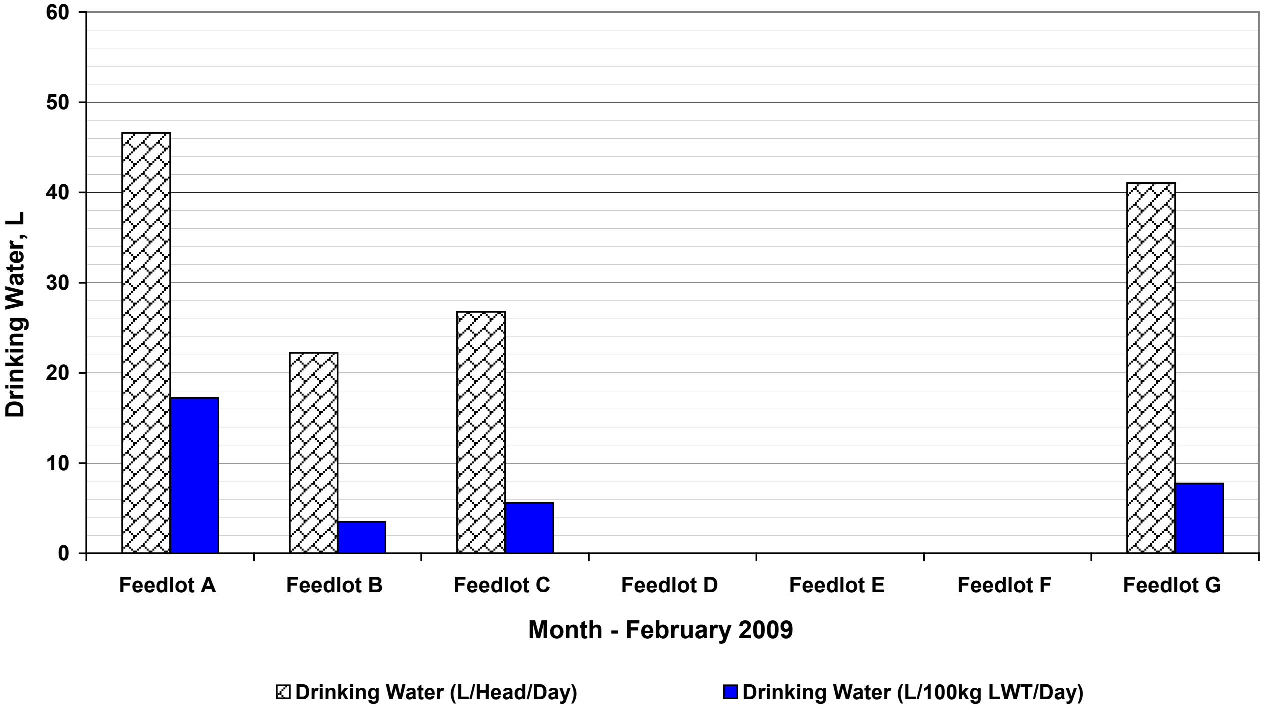

Figure 59 – Drinking water consumption for February 2009 (L/head/day & L/100 kg LWT/day)

Appendix B – Feed processing water usage

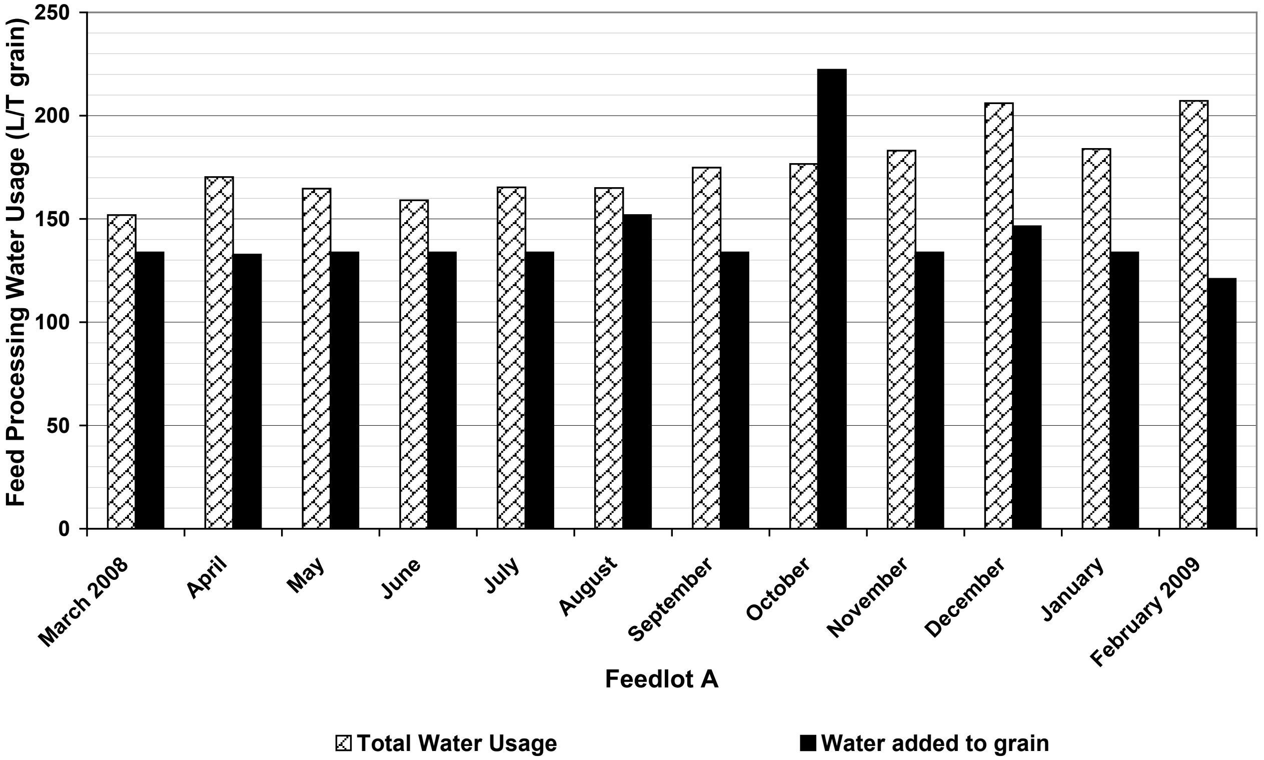

Figure 60 – Feed processing water usage for Feedlot A (L/t grain)

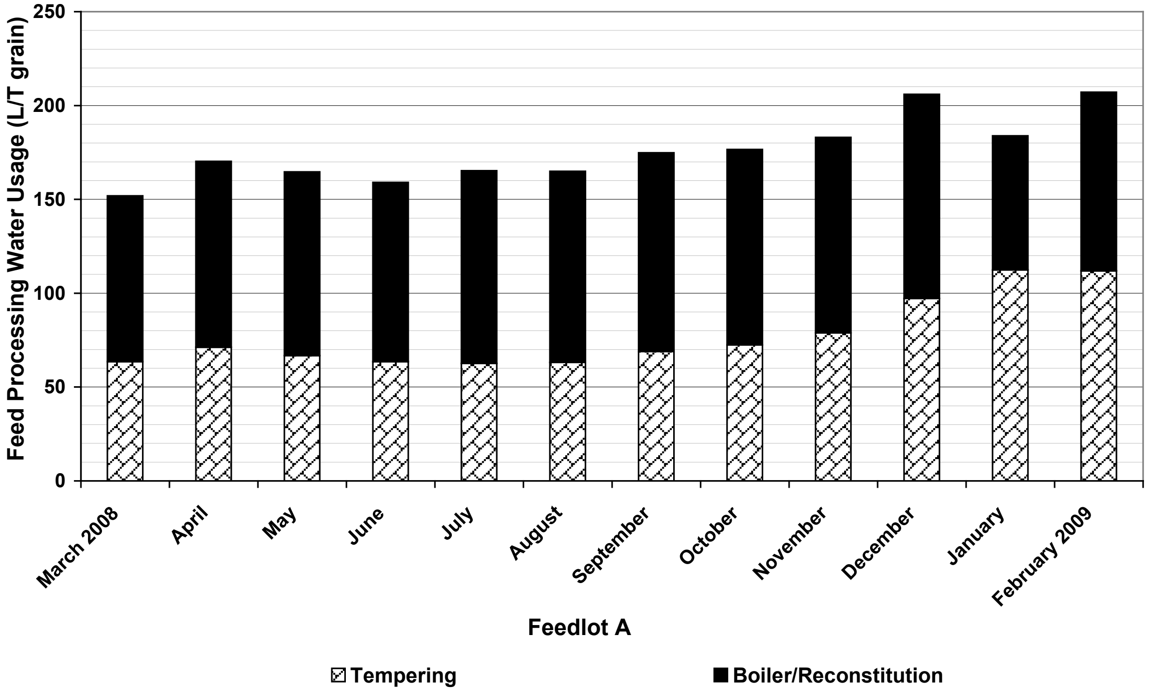

Figure 61 – Feed processing component water usage for Feedlot A (L/t grain)

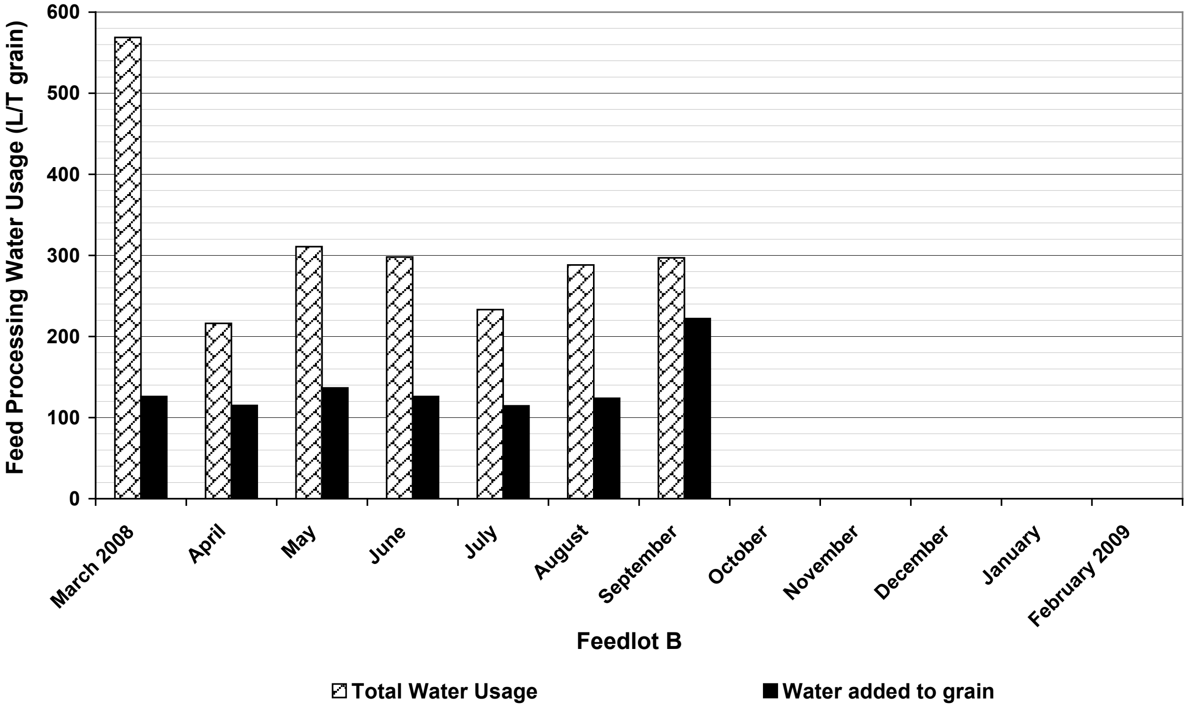

Figure 62 – Feed processing water usage for Feedlot B (L/t grain)

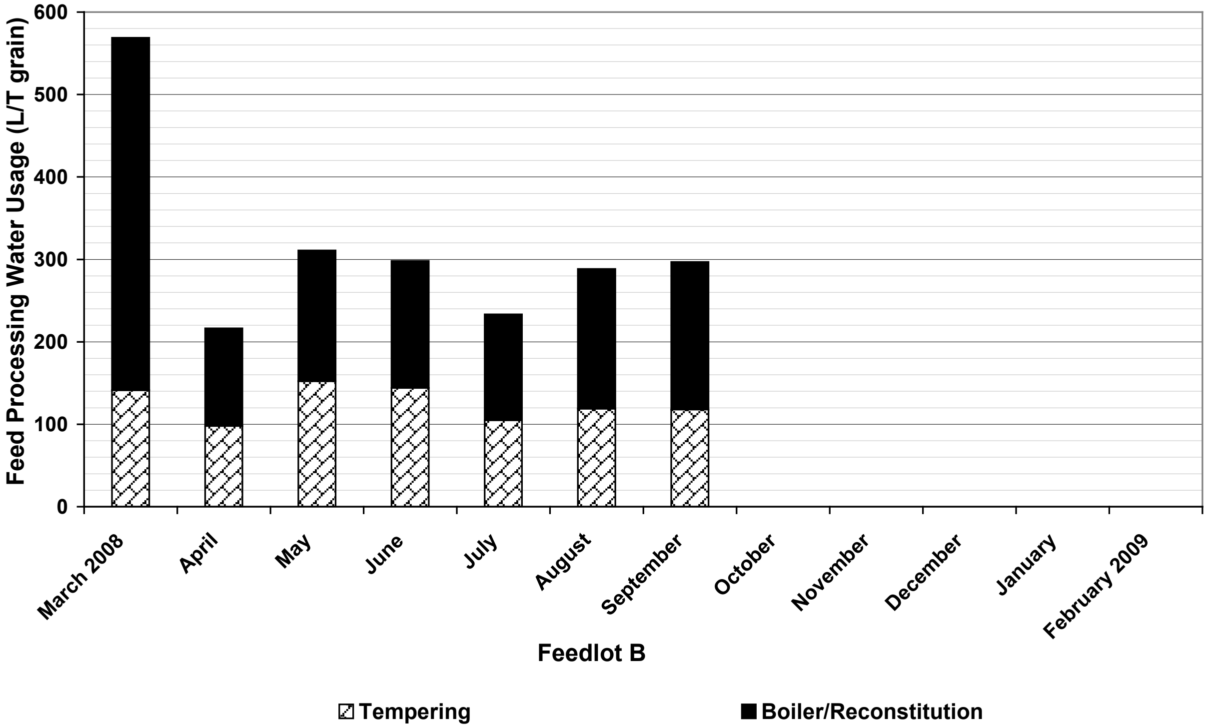

Figure 63 – Feed processing component water usage for Feedlot B (L/t grain)

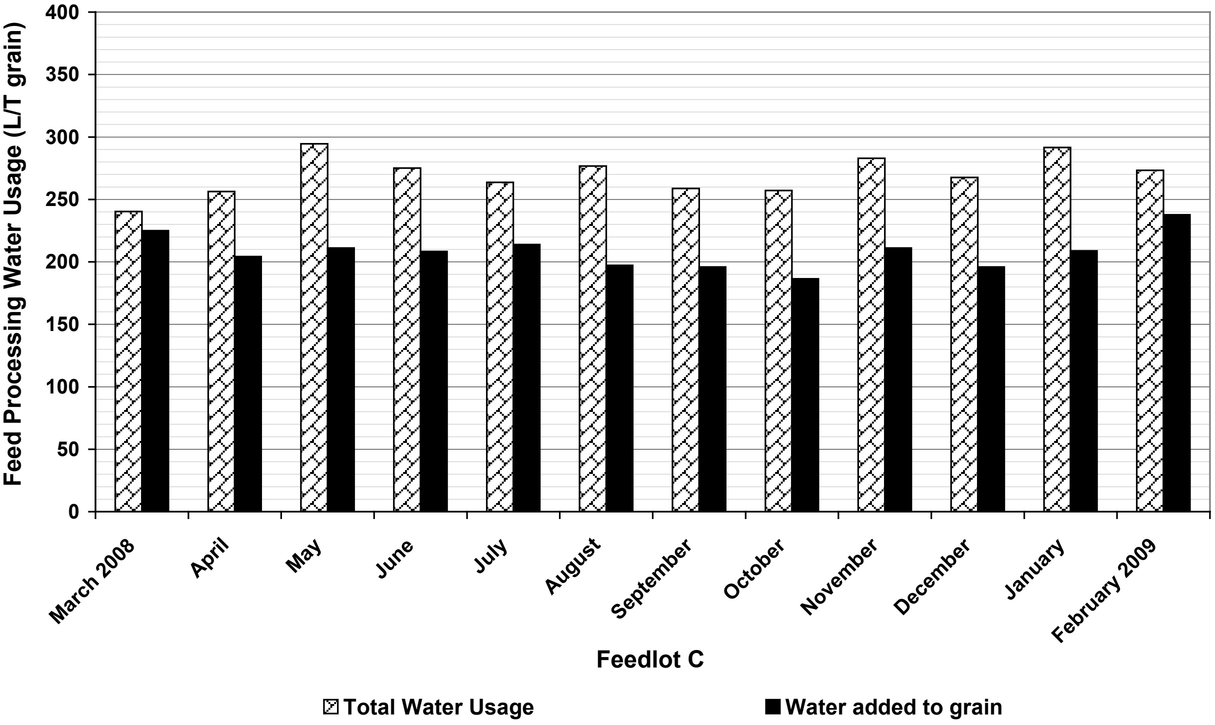

Figure 64 – Feed processing water usage for Feedlot C (L/t grain)

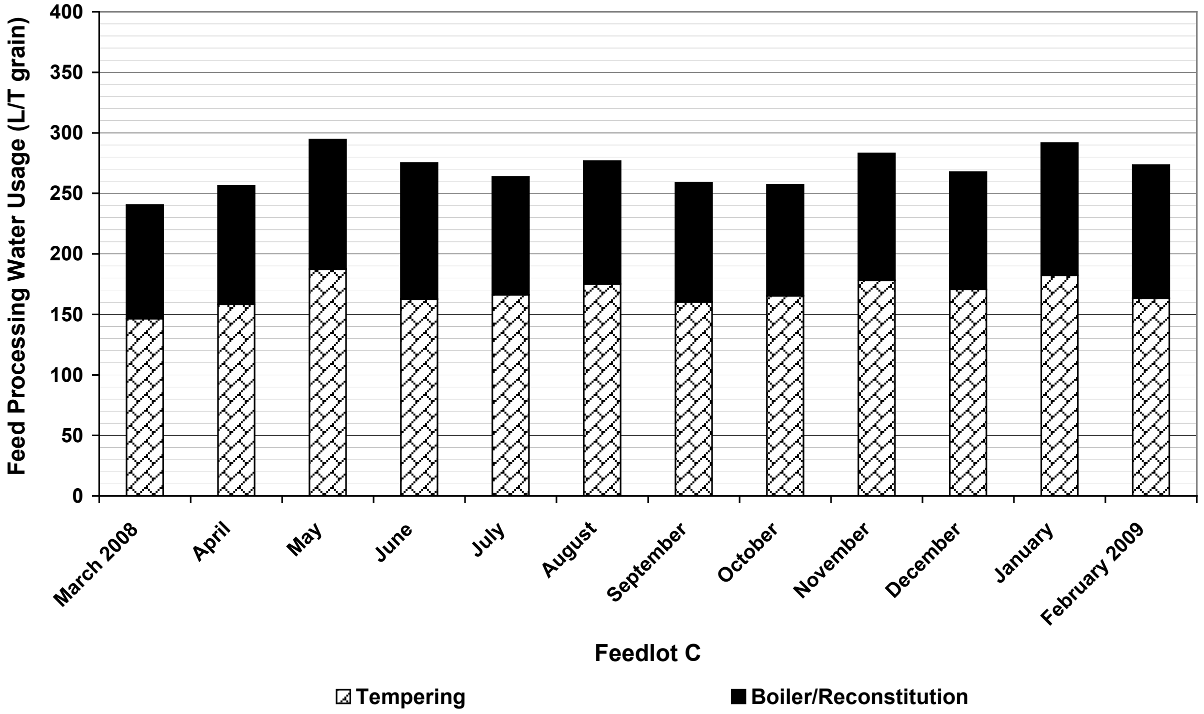

Figure 65 – Feed processing component water usage for Feedlot C (L/t grain)

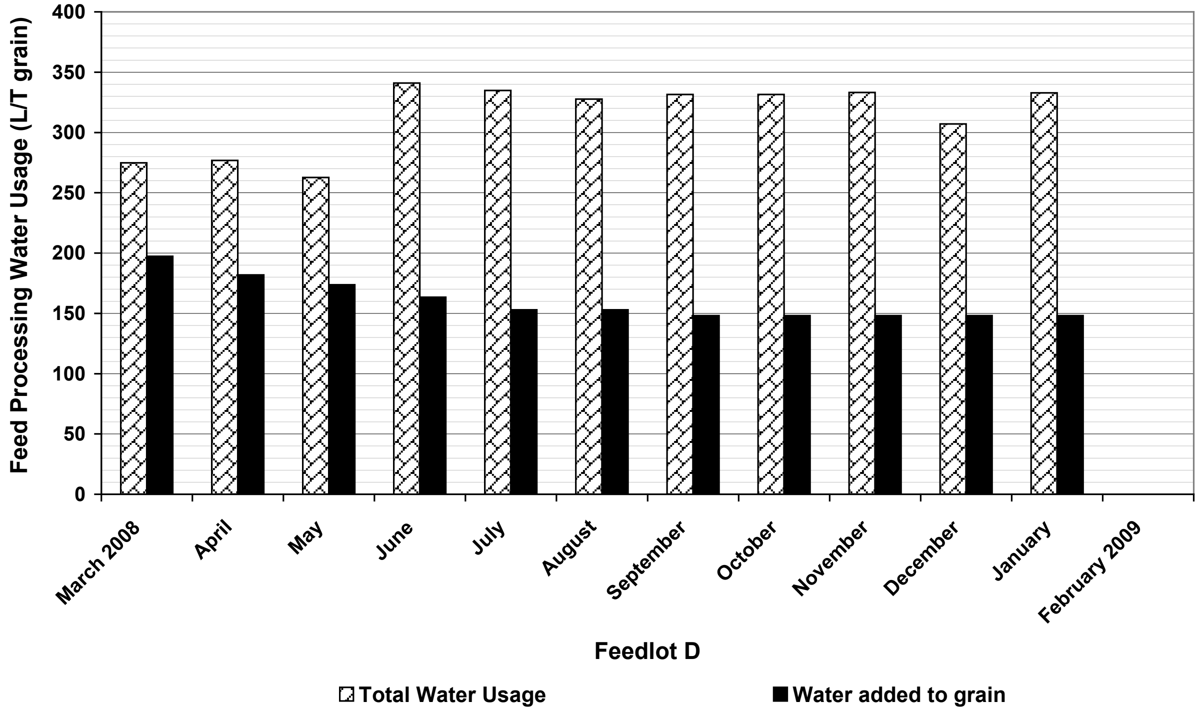

Figure 66 – Feed processing water usage for Feedlot D (L/t grain)

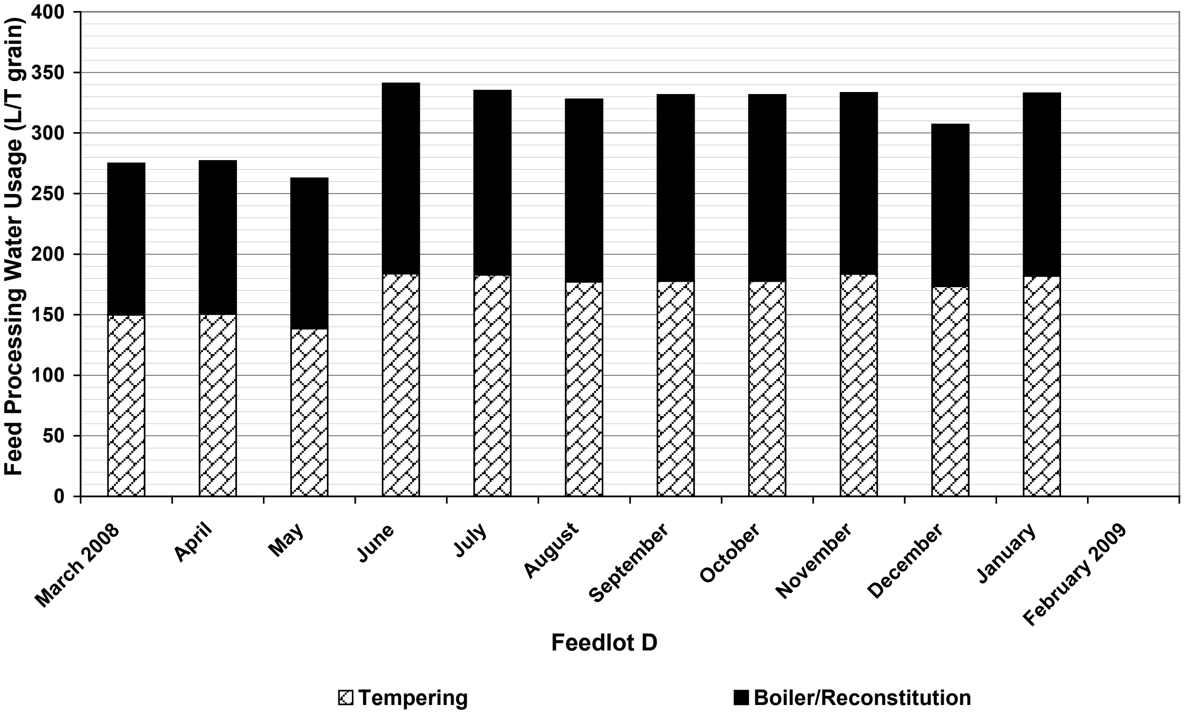

Figure 67 – Feed processing component water usage for Feedlot D (L/t grain)

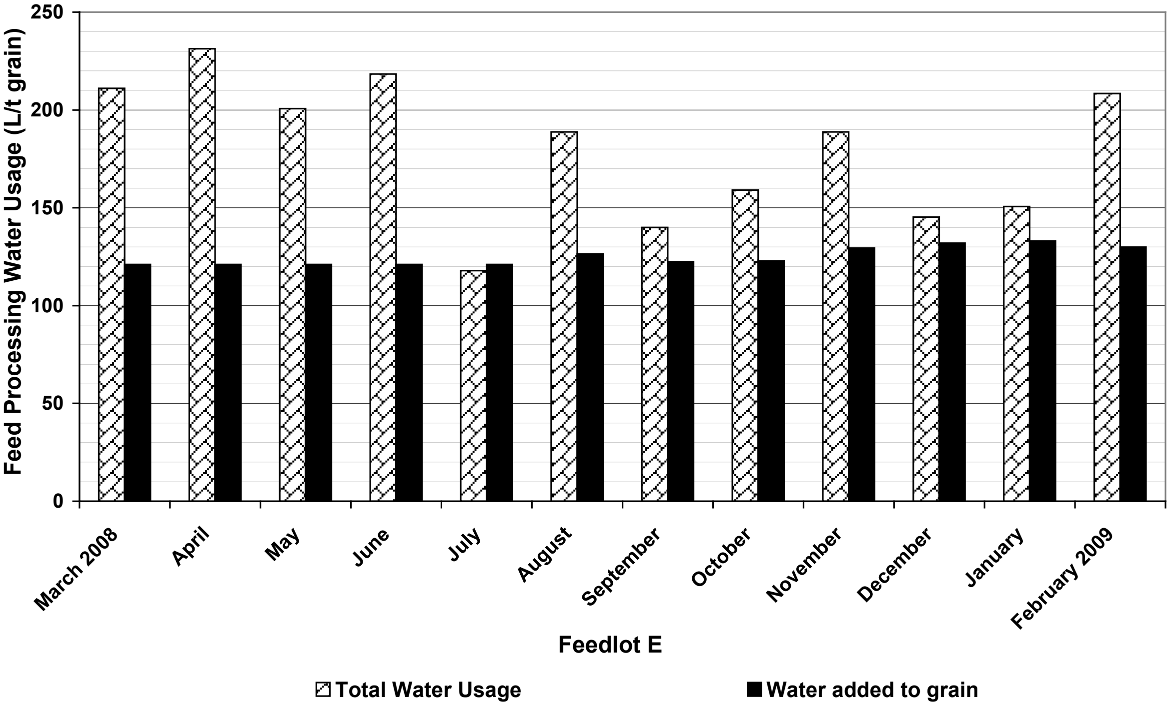

Figure 68 – Feed processing water usage for Feedlot E (L/t grain)

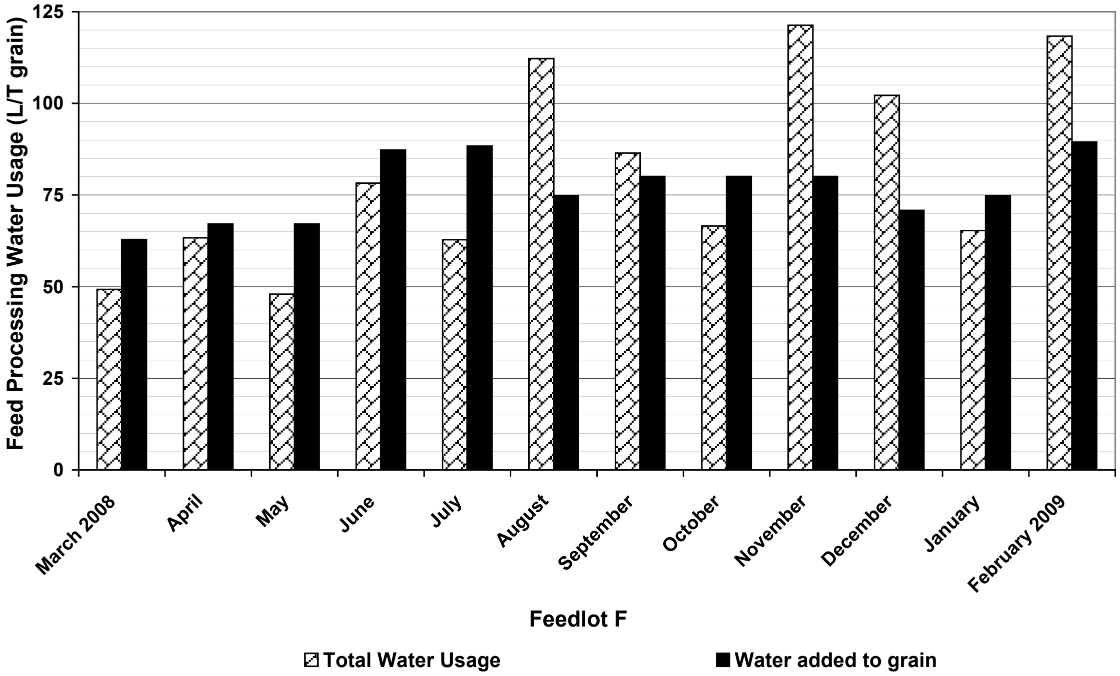

Figure 69 – Feed processing water usage for Feedlot F (L/t grain)

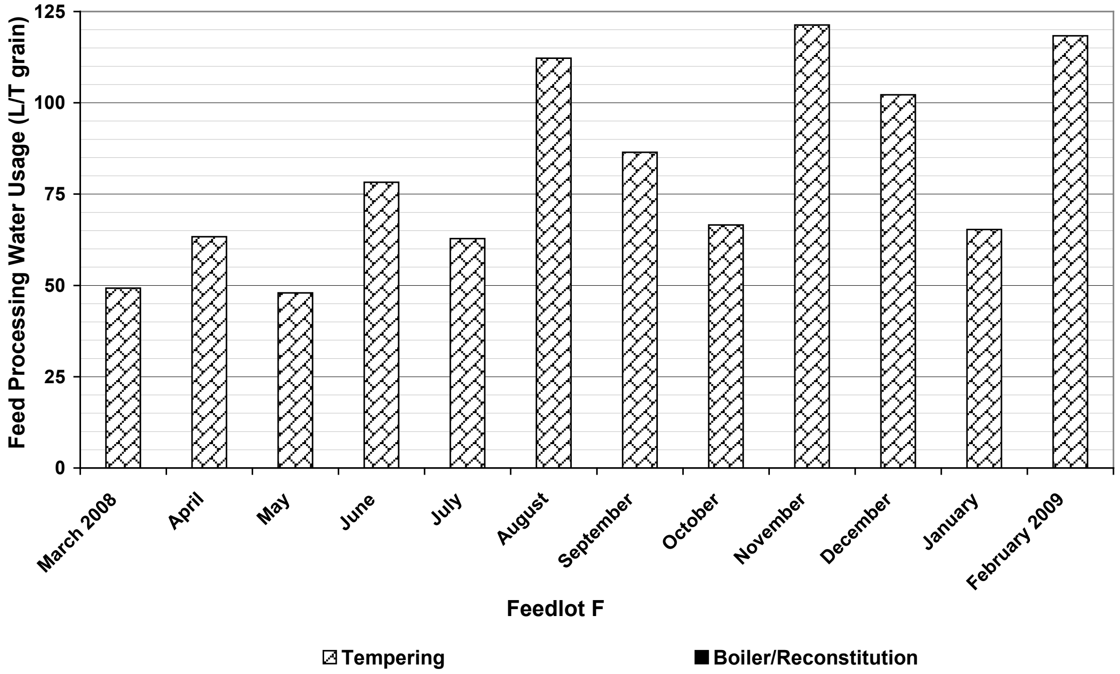

Figure 70 – Feed processing component water usage for Feedlot F (L/t grain)

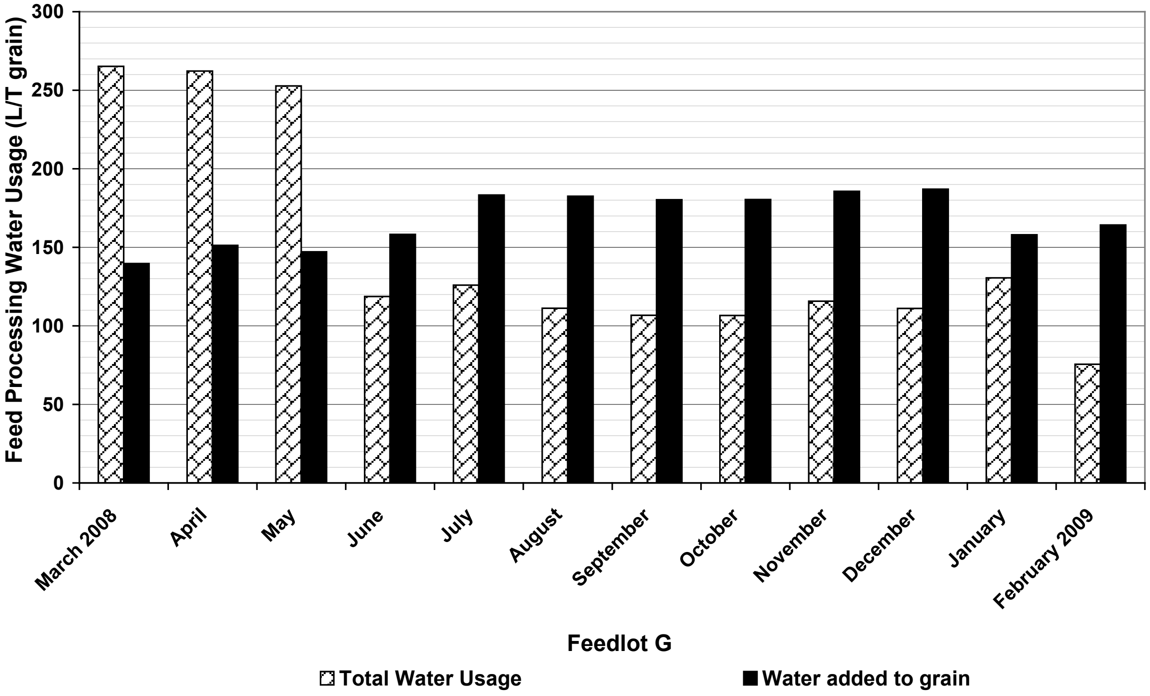

Figure 71 – Feed processing water usage for Feedlot G (L/t grain)

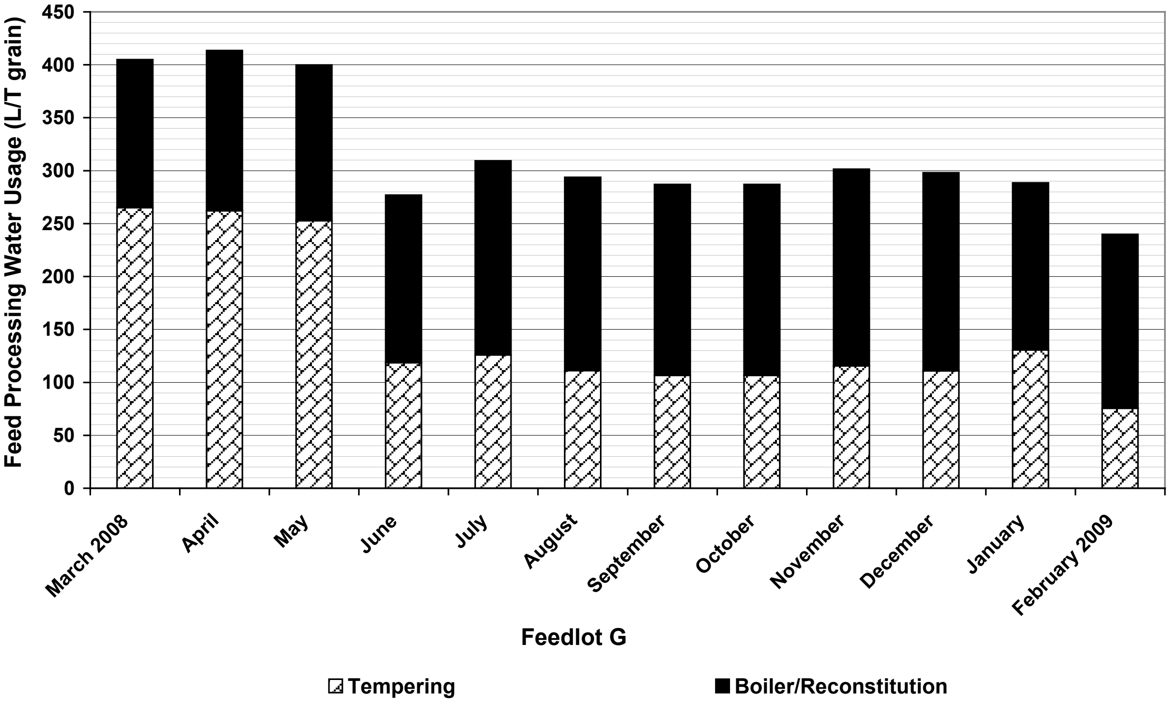

Figure 72 – Feed processing component water usage for Feedlot G (L/t grain)

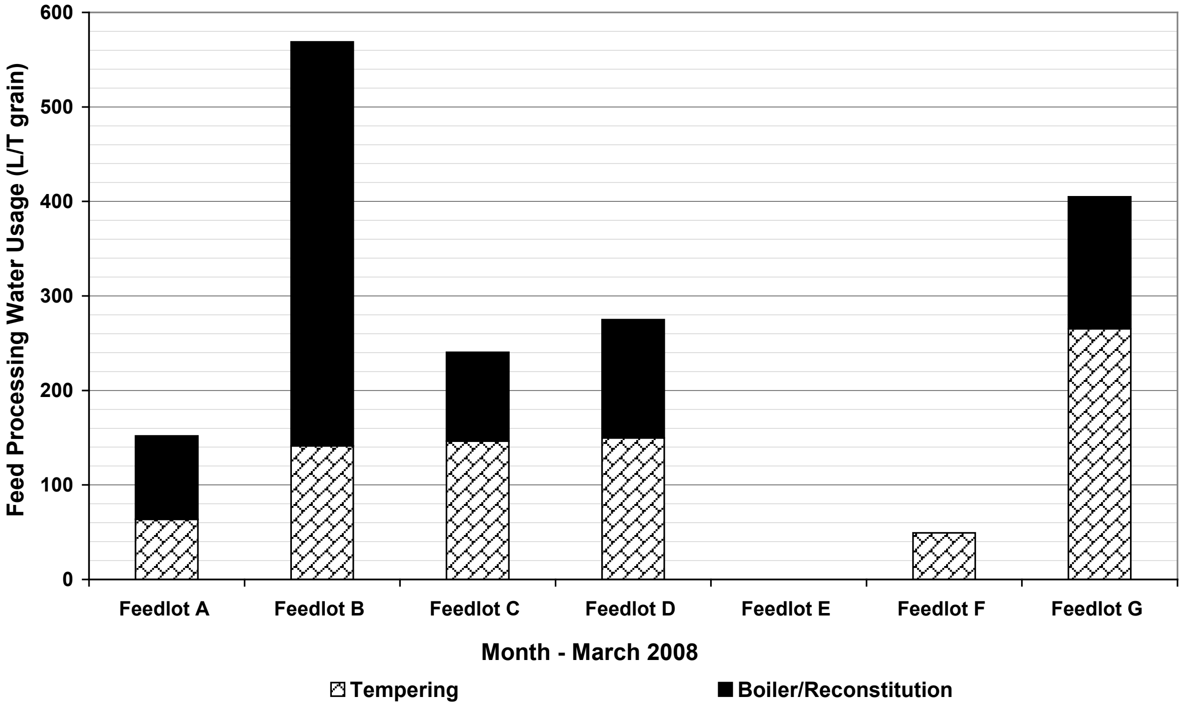

Figure 73 – Feed processing component water usage for March 2008 (L/t grain)

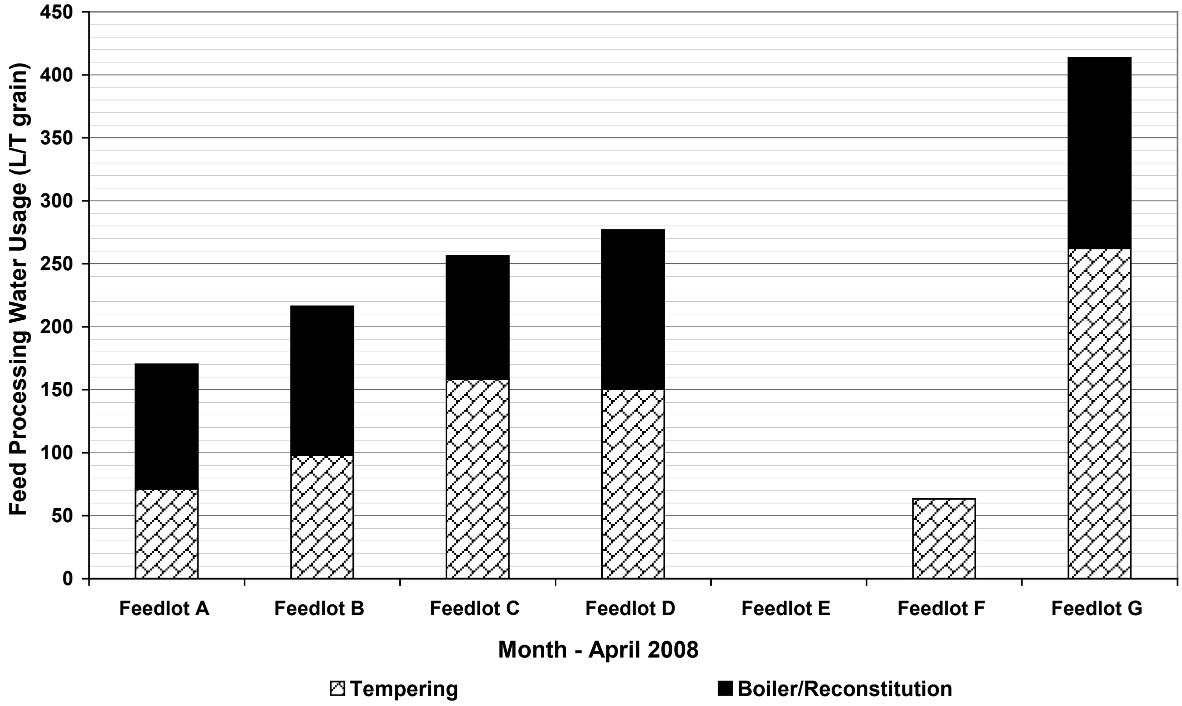

Figure 74 – Feed processing component water usage for April 2008 (L/t grain)

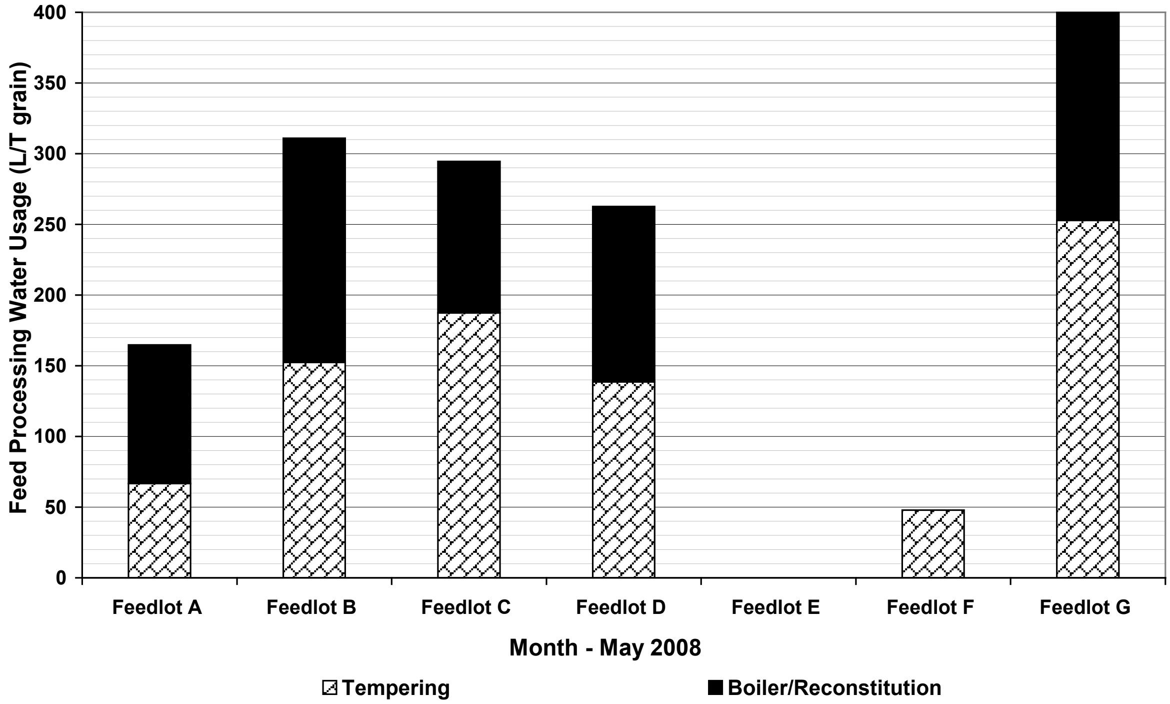

Figure 75 – Feed processing component water usage for May 2008 (L/t grain)

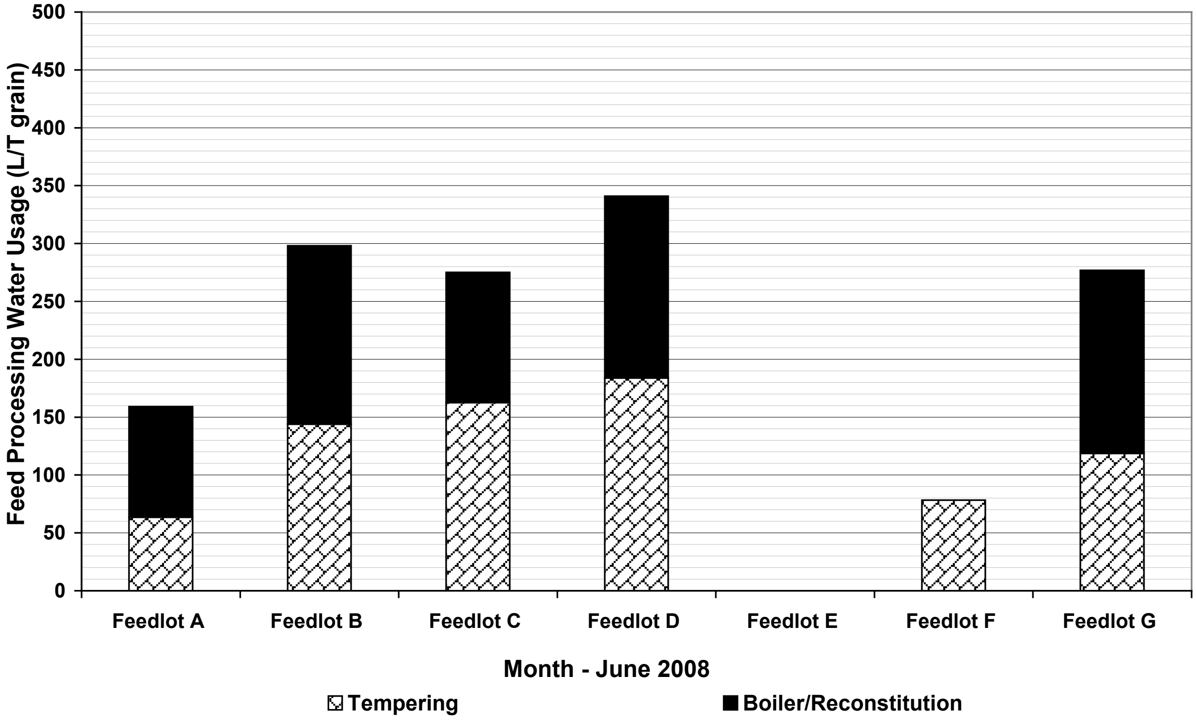

Figure 76 – Feed processing component water usage for June 2008 (L/t grain)

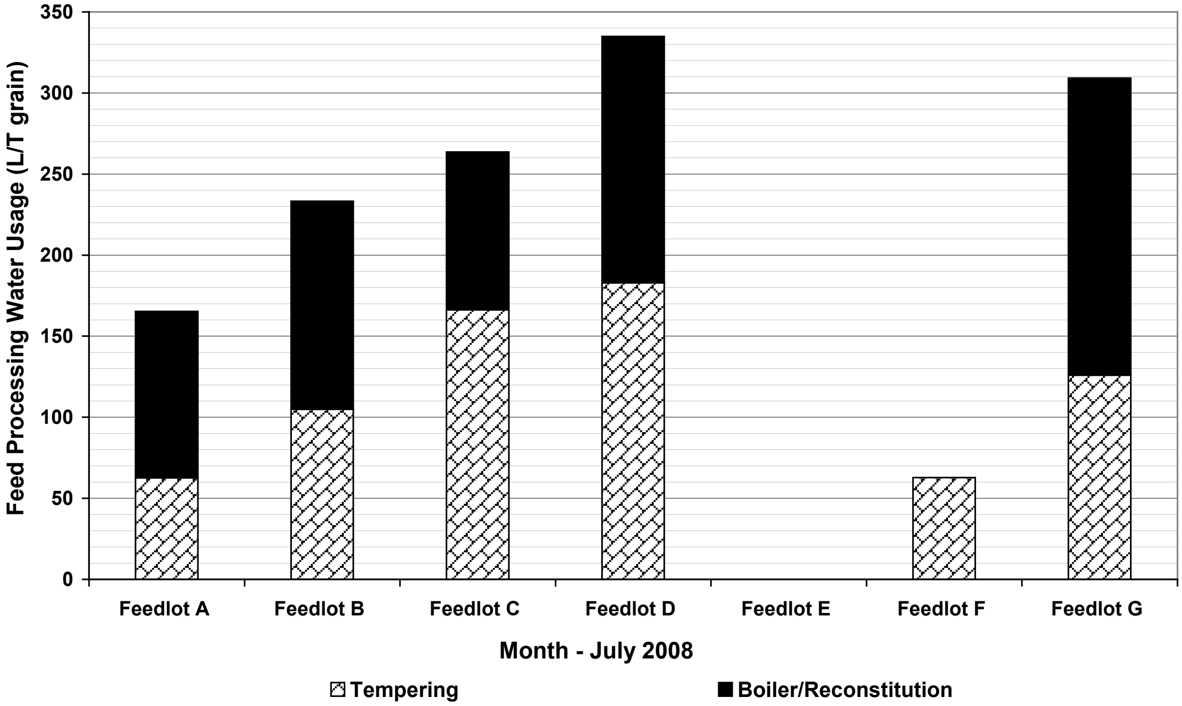

Figure 77 – Feed processing component water usage for July 2008 (L/t grain)

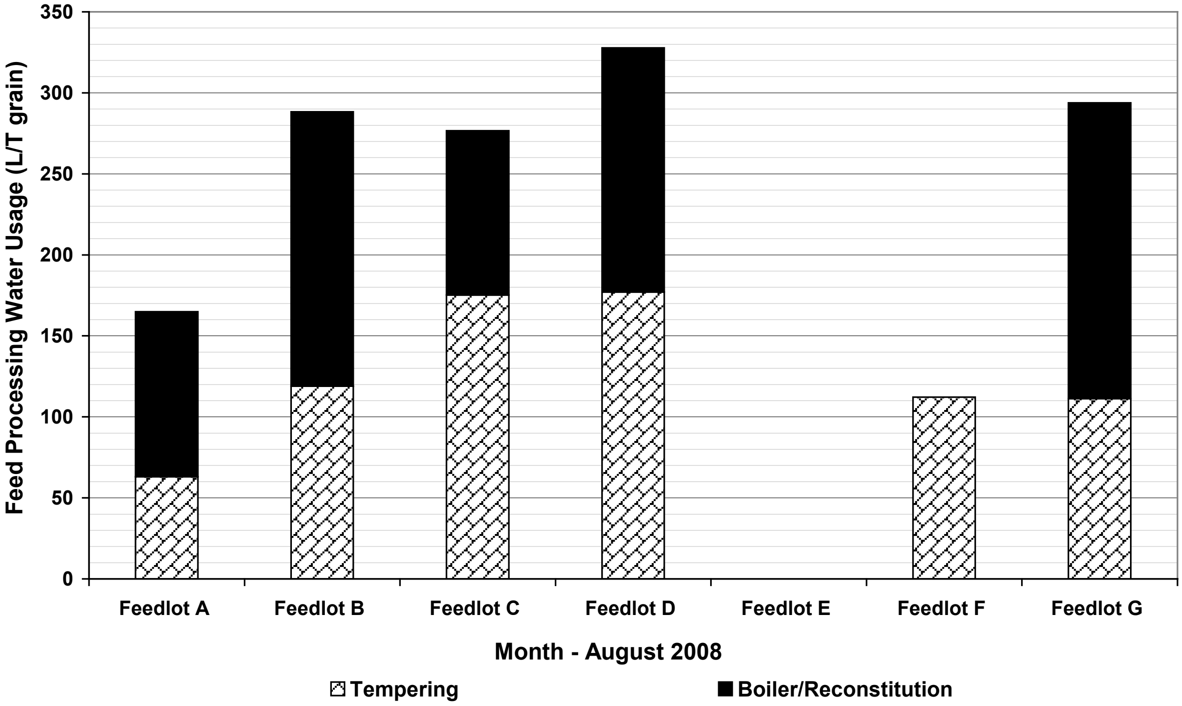

Figure 78 – Feed processing component water usage for August 2008 (L/t grain)

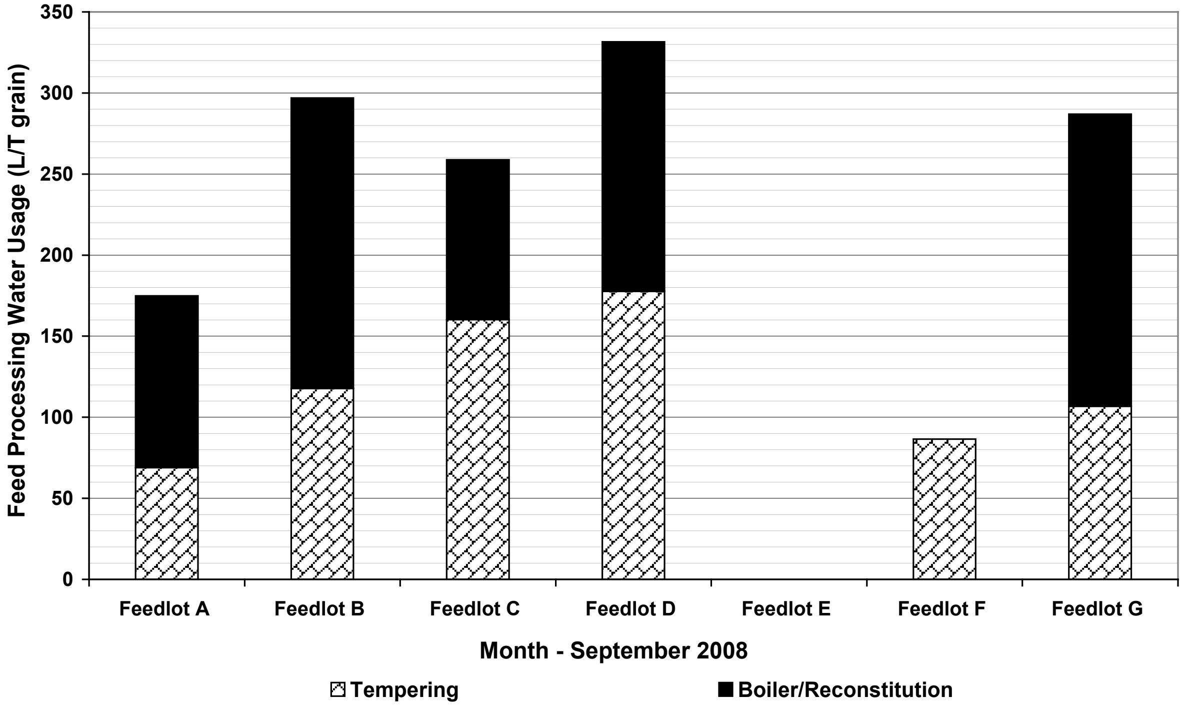

Figure 79 – Feed processing component water usage for September 2008 (L/t grain)

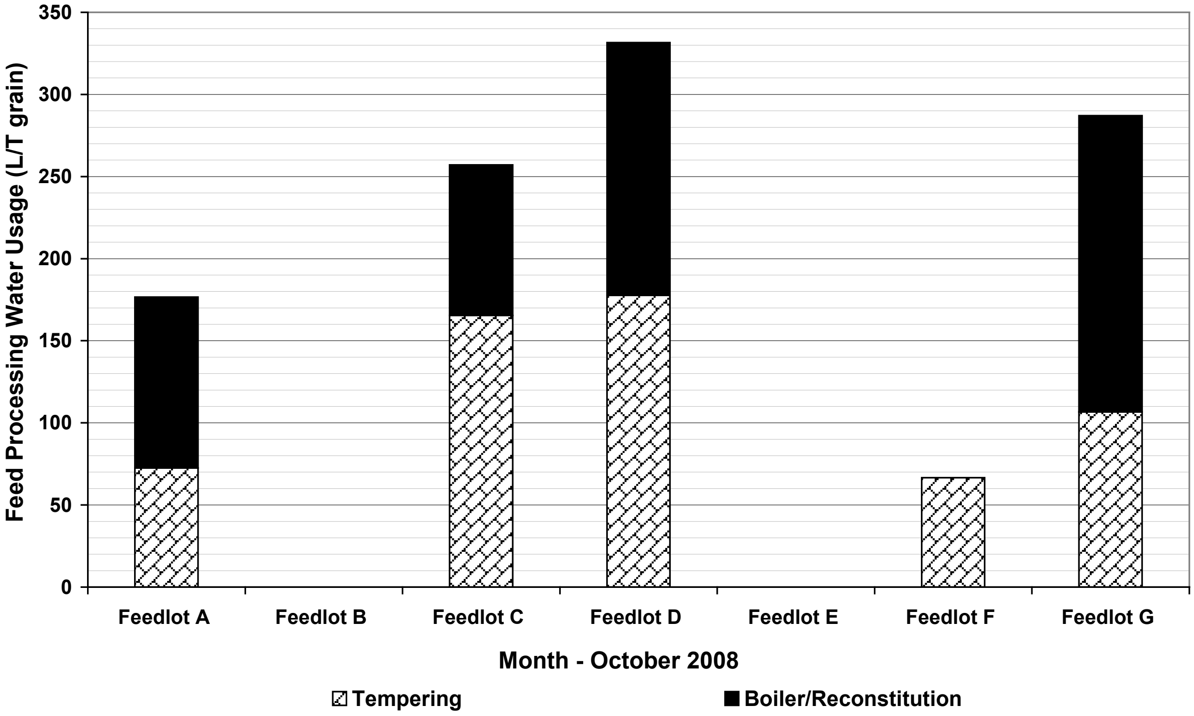

Figure 80 – Feed processing component water usage for October 2008 (L/t grain)

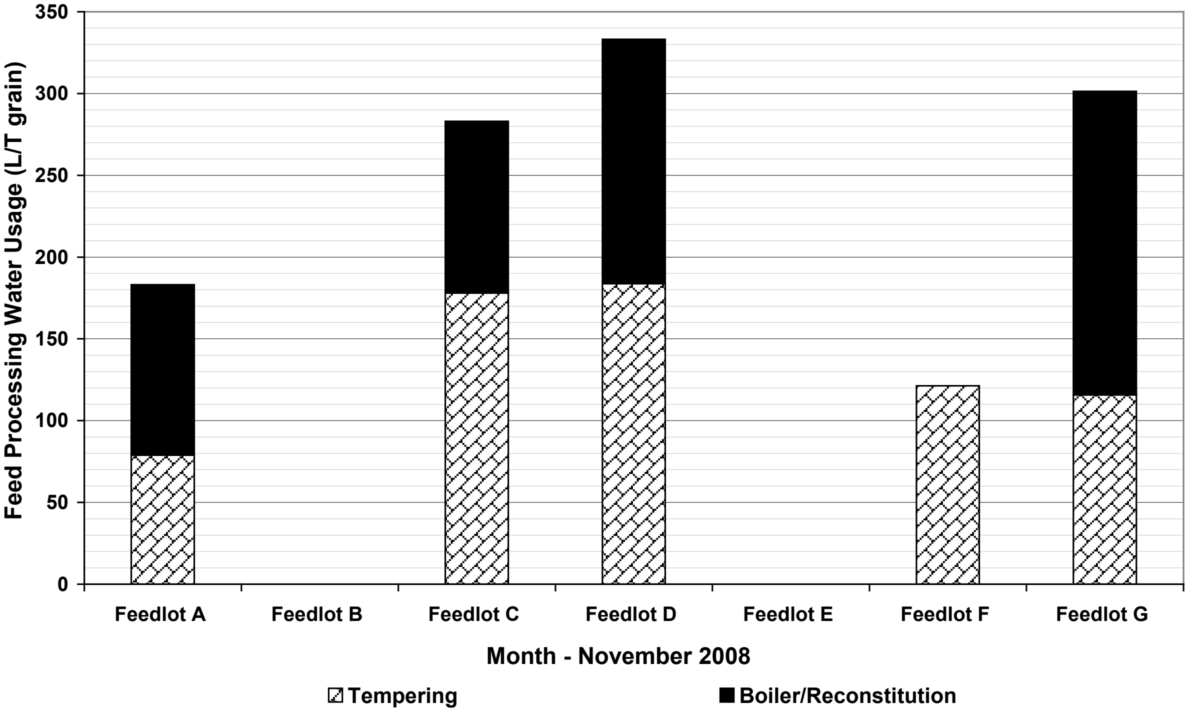

Figure 81 – Feed processing component water usage for November 2008 (L/t grain)

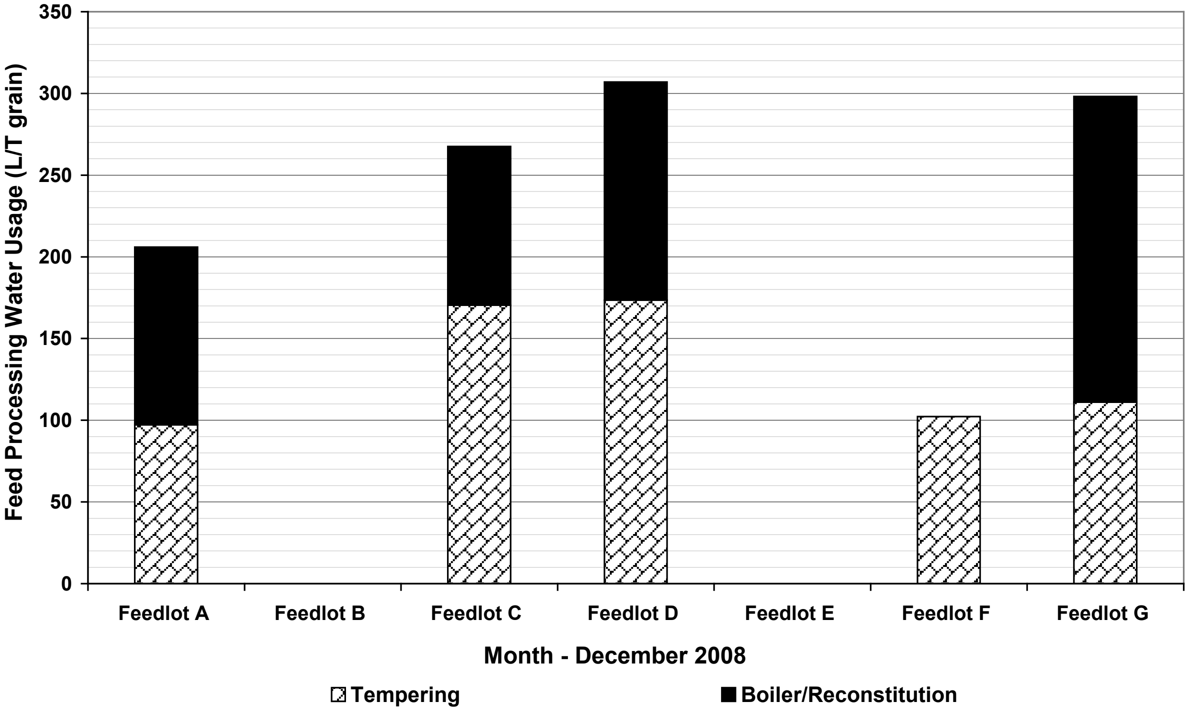

Figure 82 – Feed processing component water usage for December 2008 (L/t grain)

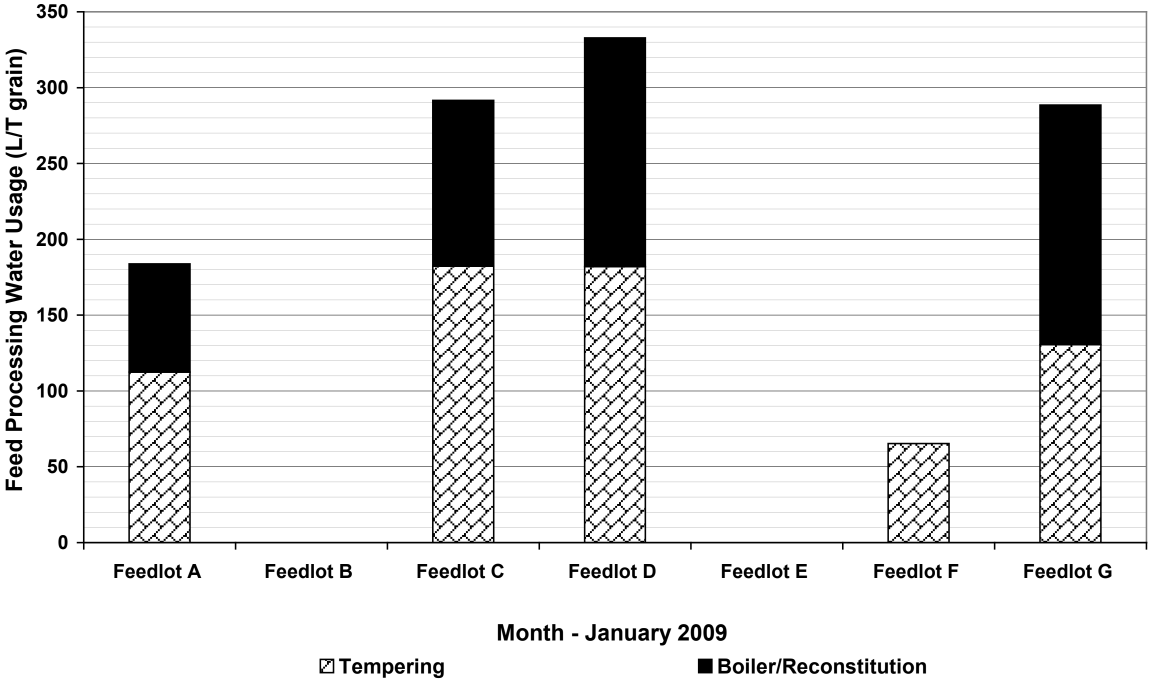

Figure 83 – Feed processing component water usage for January 2009 (L/t grain)

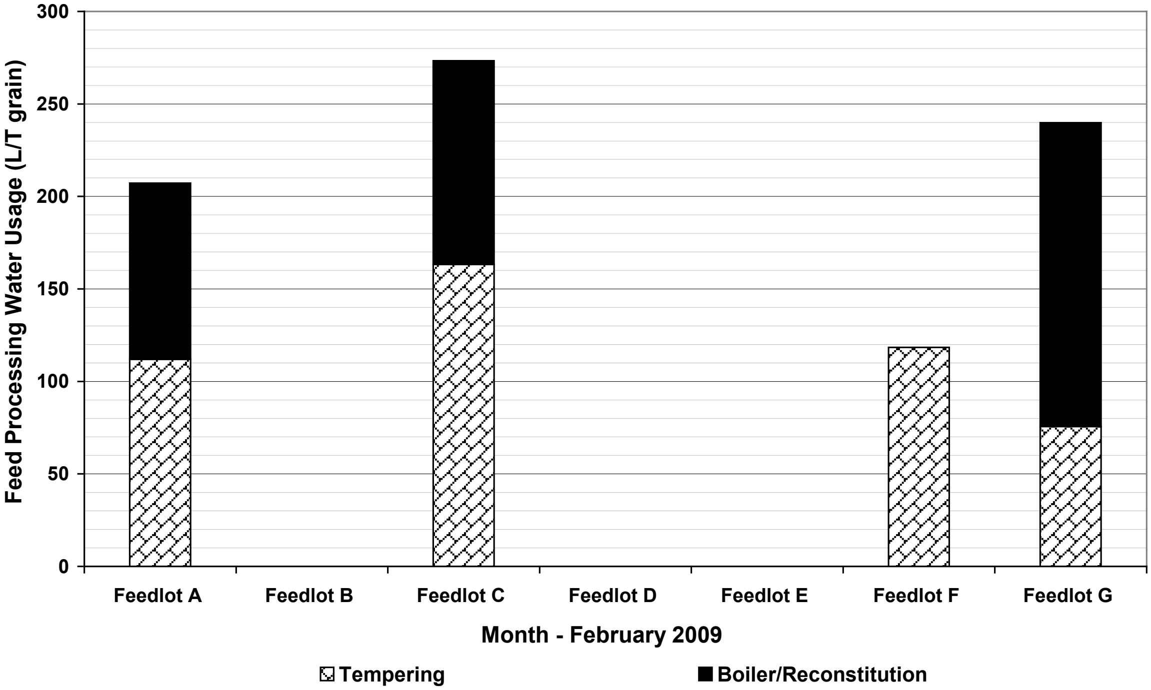

FIGURE 84 – FEED PROCESSING COMPONENT WATER USAGE FOR FEBRUARY 2009 (L/T GRAIN)

Appendix C – Cattle washing water usage

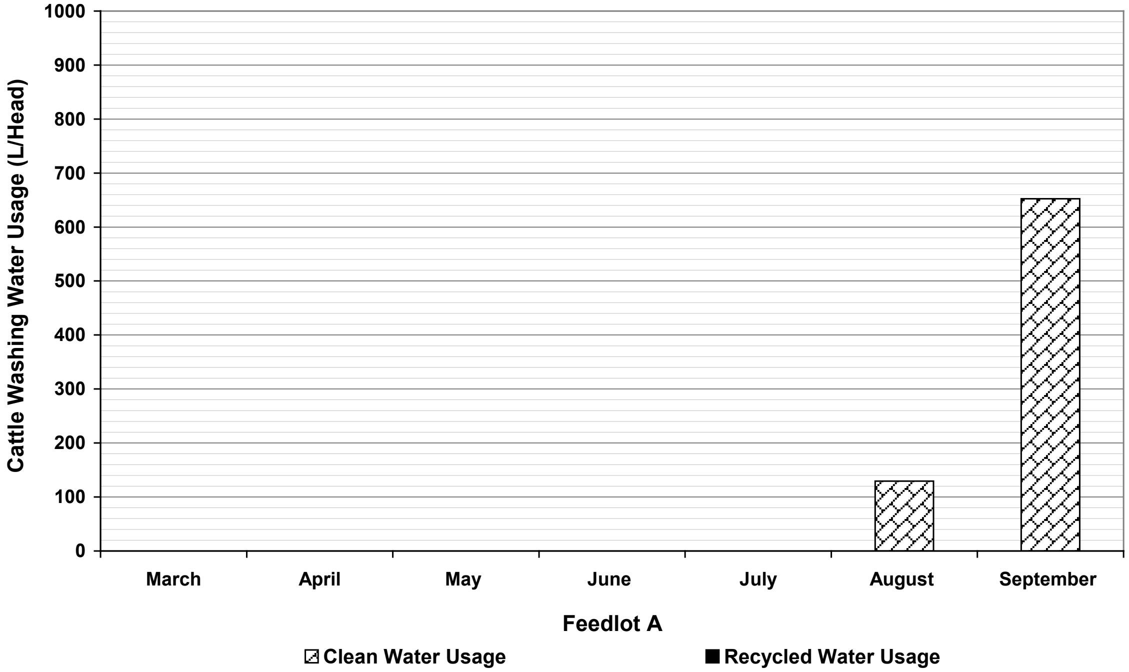

Figure 85 – Cattle washing water usage for Feedlot A (L/head)

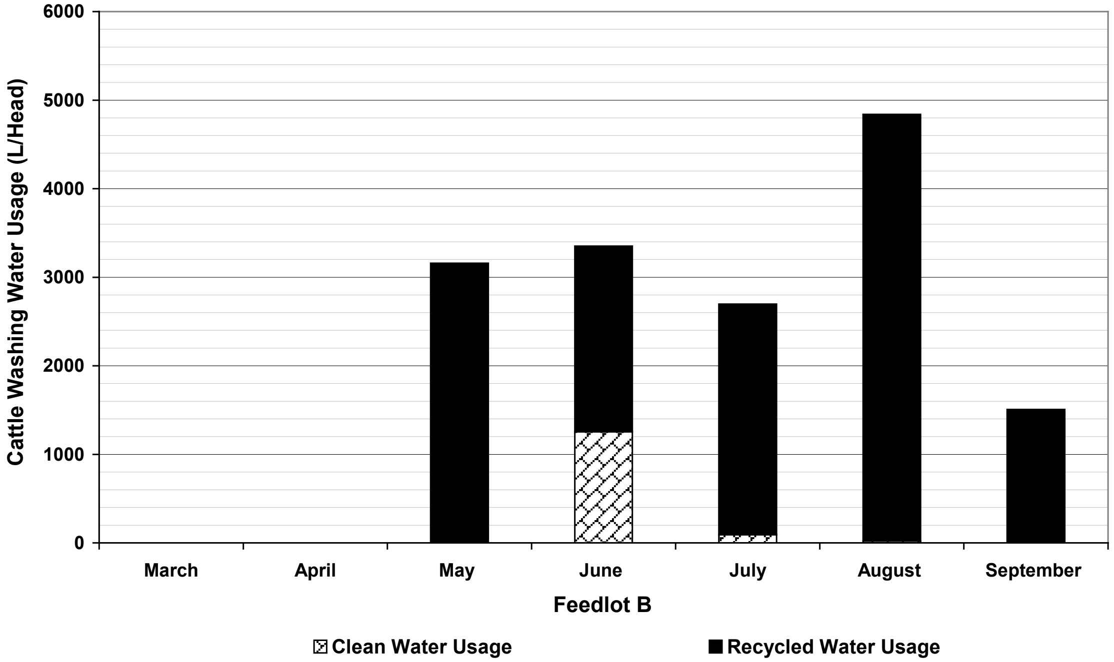

Figure 86 – Cattle washing water usage for Feedlot B (L/head)

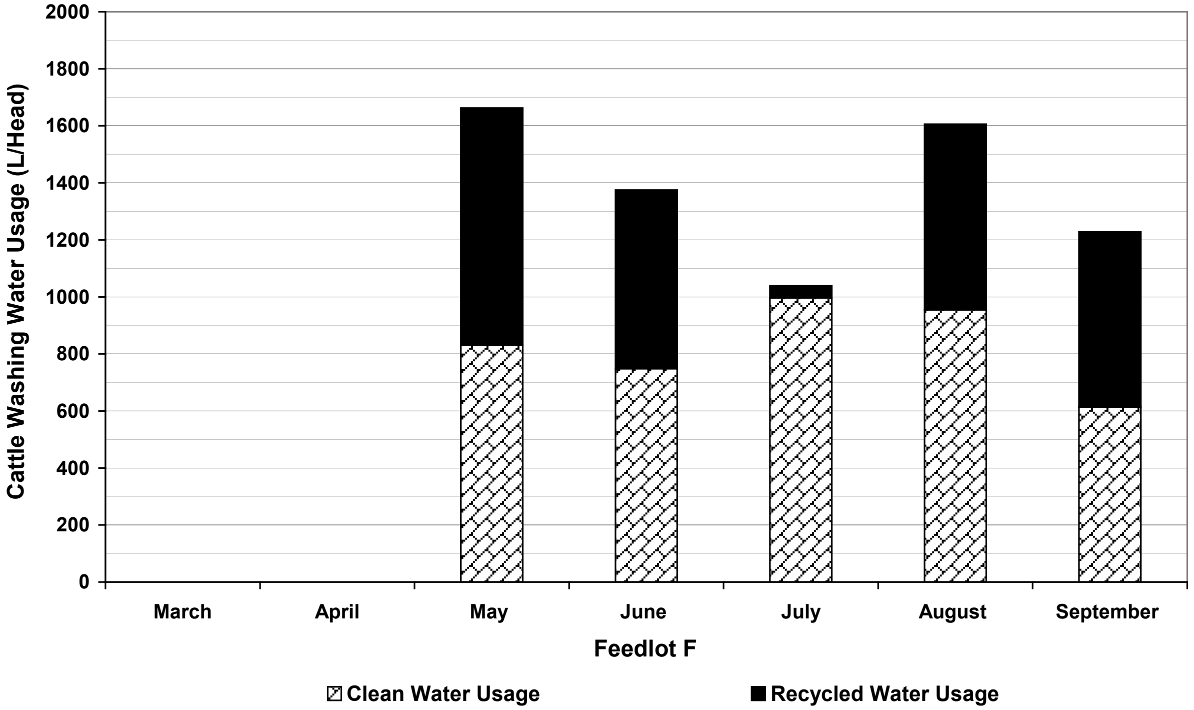

Figure 87 – Cattle washing water usage for Feedlot F (L/head)

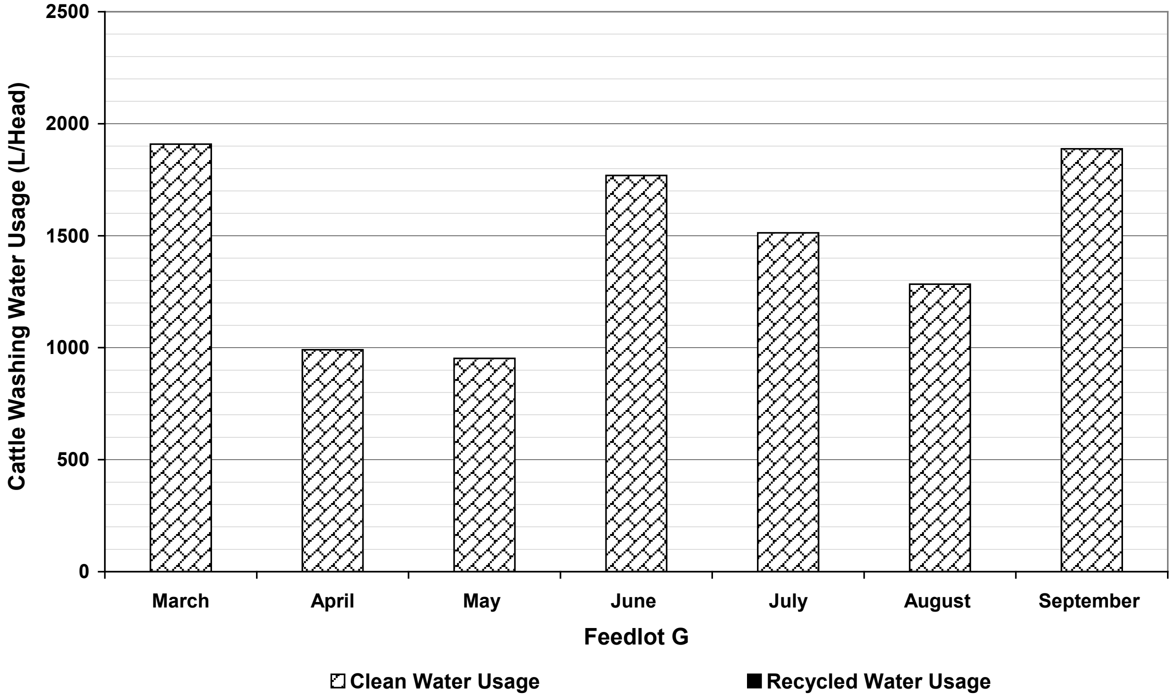

Figure 88 – Cattle washing water usage for Feedlot G (L/head)

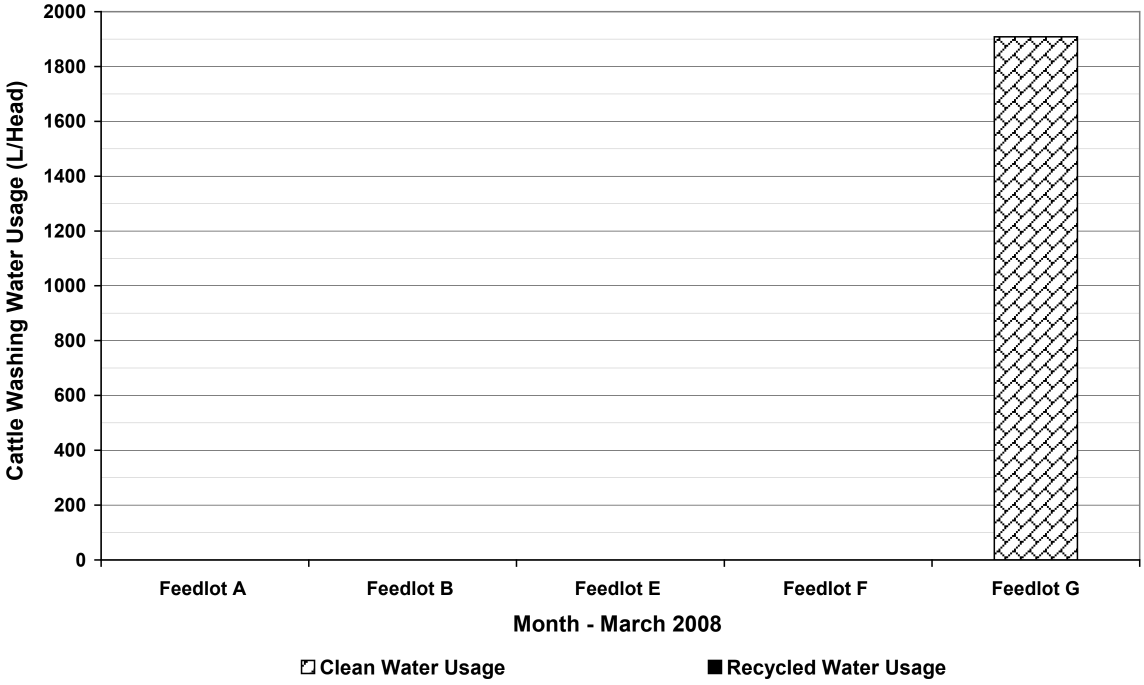

Figure 89 – Cattle washing water usage for March 2008 (L/head)

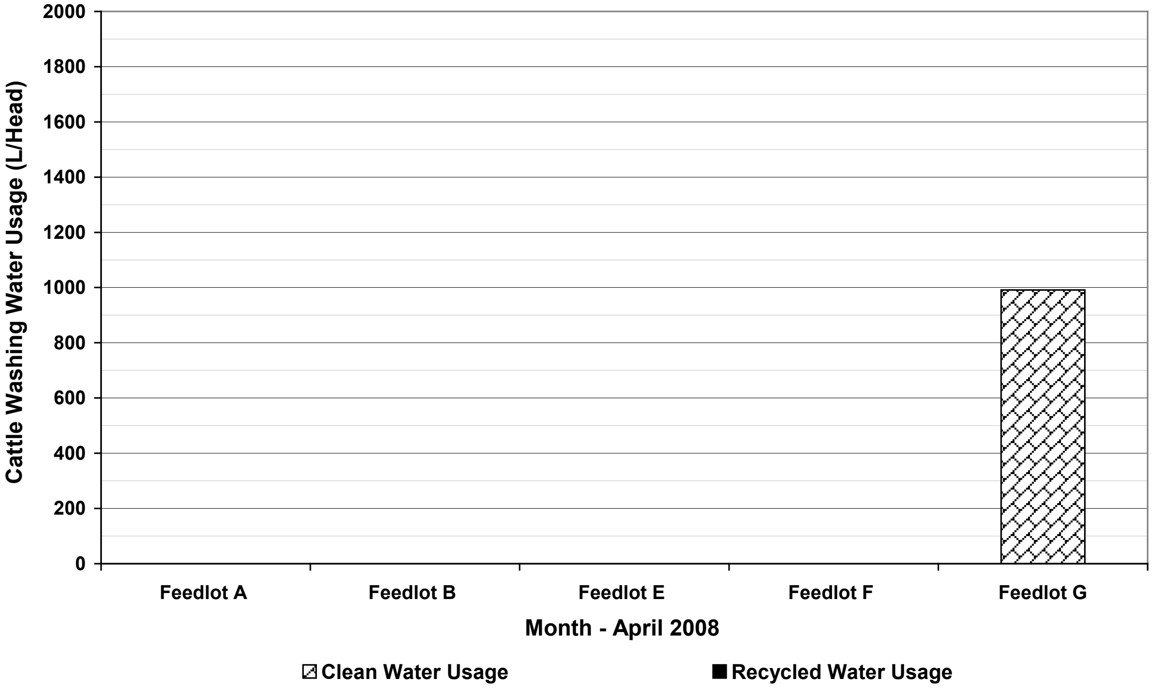

Figure 90 – Cattle washing water usage for April 2008 (L/head)

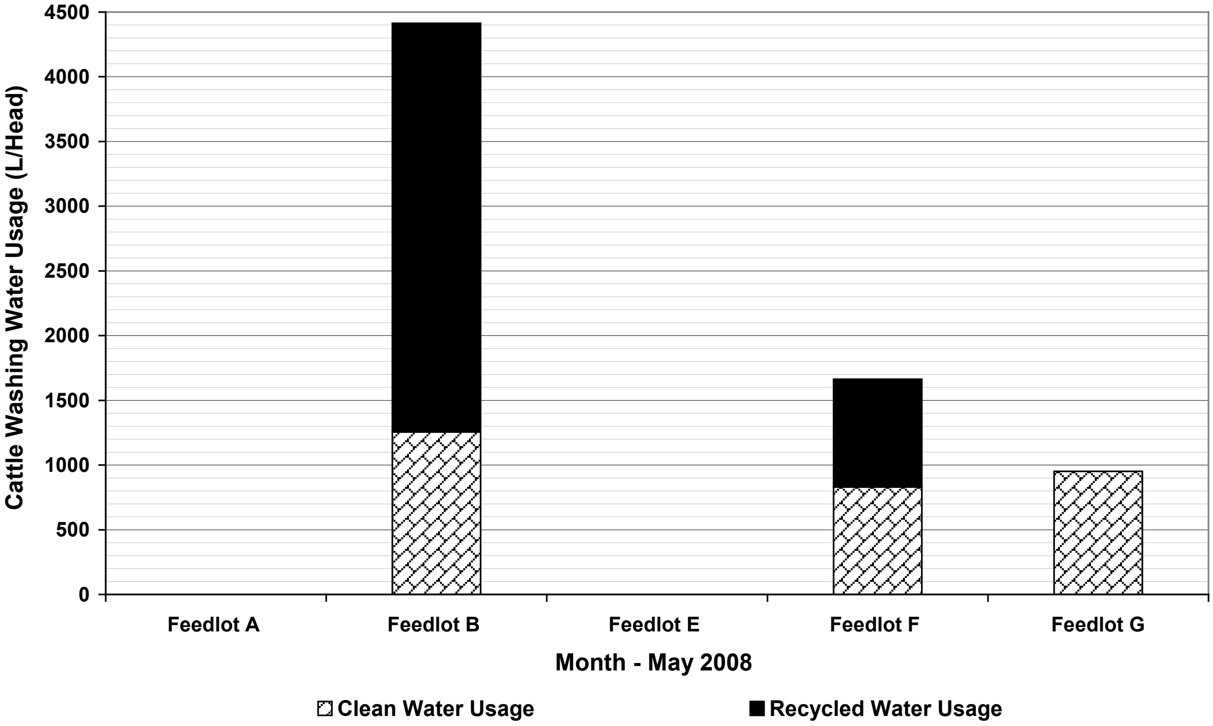

Figure 91 – Cattle washing water usage for May 2008 (L/head)

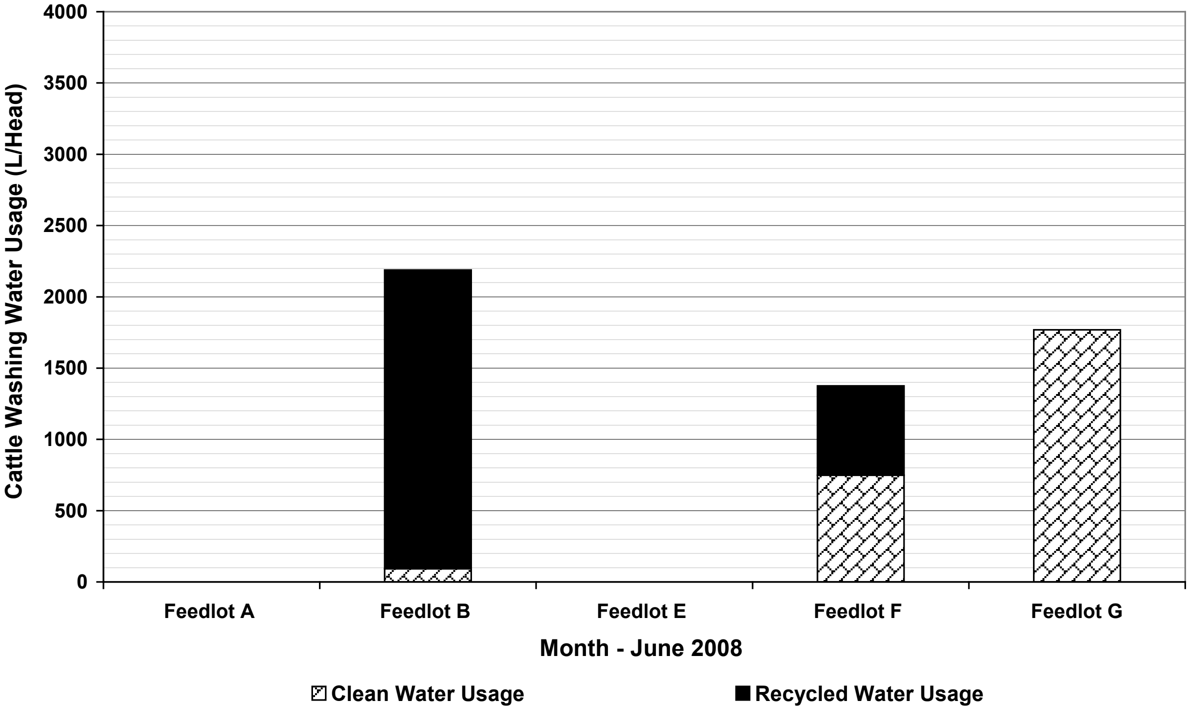

Figure 92 – Cattle washing water usage for June 2008 (L/head)

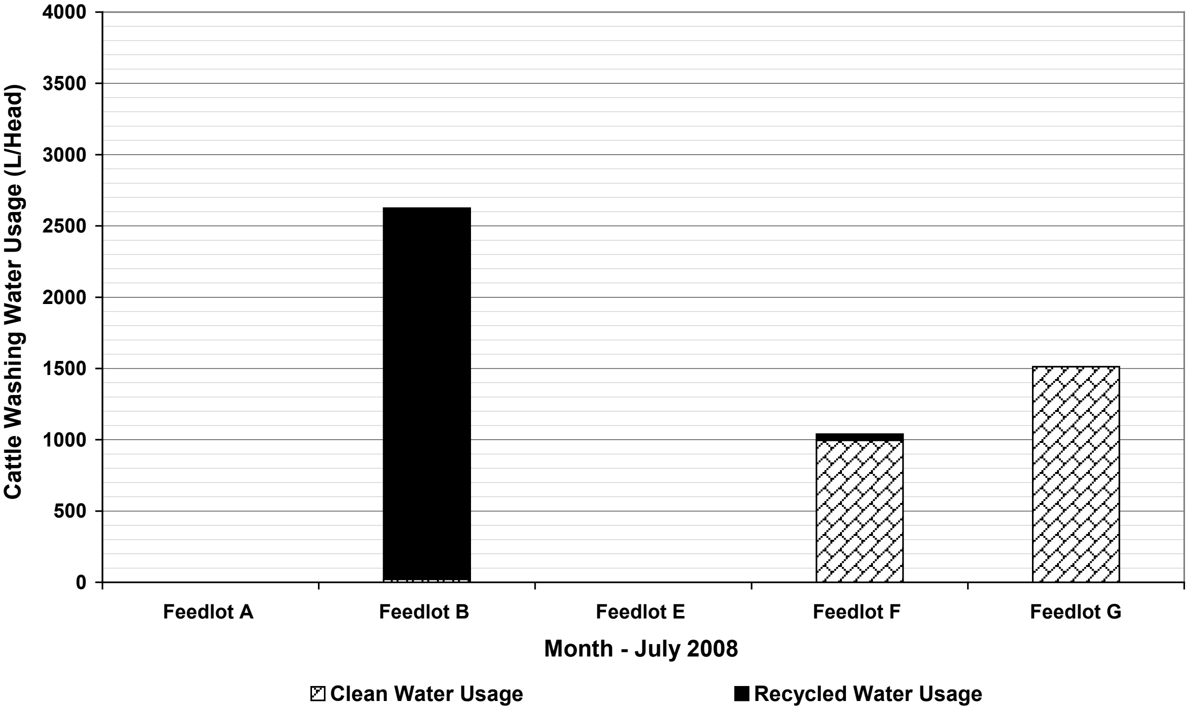

Figure 93 – Cattle washing water usage for July 2008 (L/head)

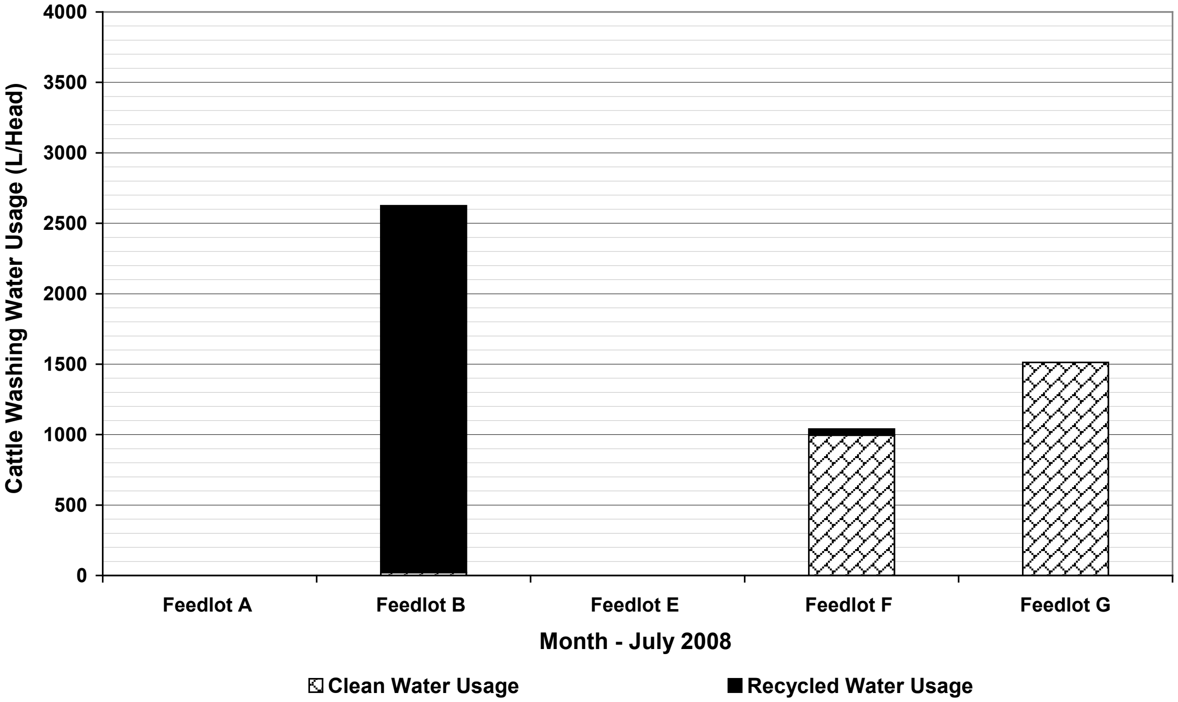

Figure 94 – Cattle washing water usage for August 2008 (L/head)

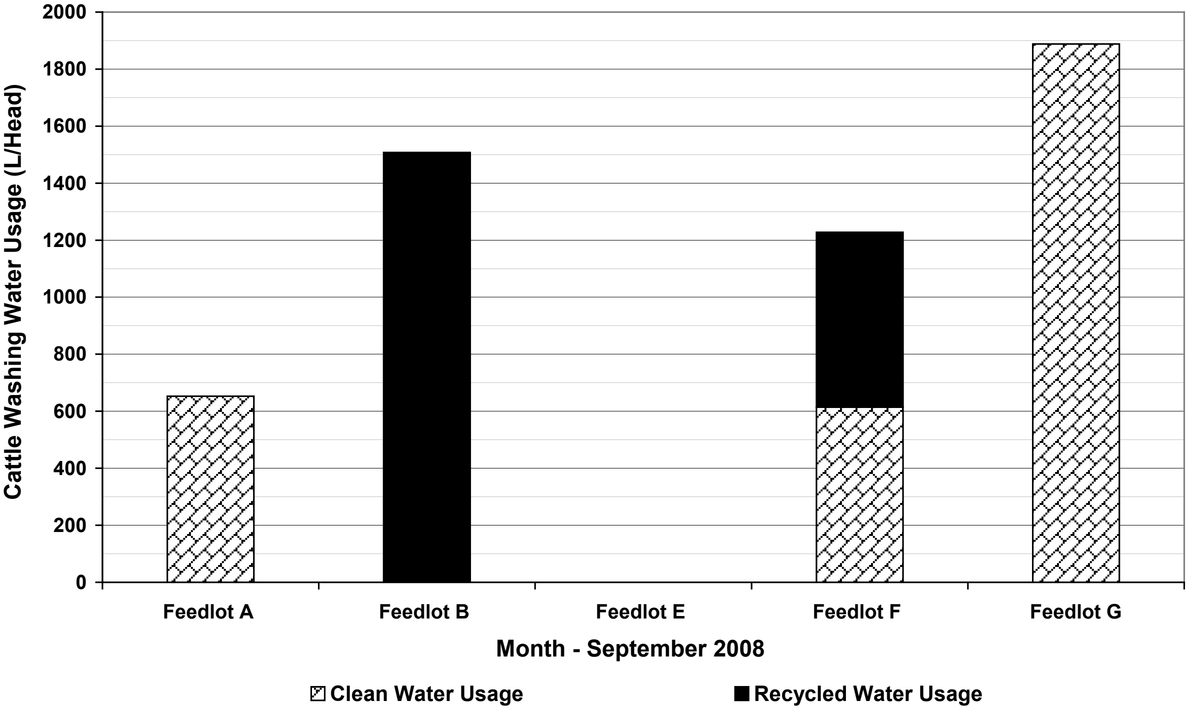

Figure 95 – Cattle washing water usage for September 2008 (L/head)

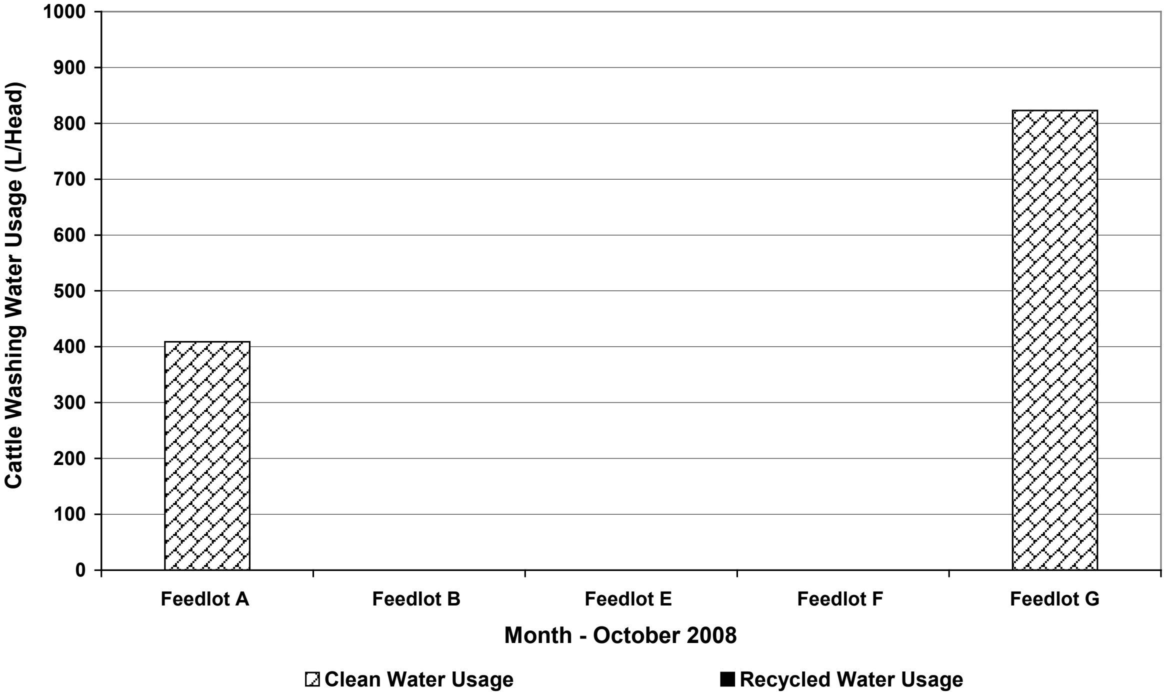

Figure 96 – Cattle washing water usage for October 2008 (L/head)

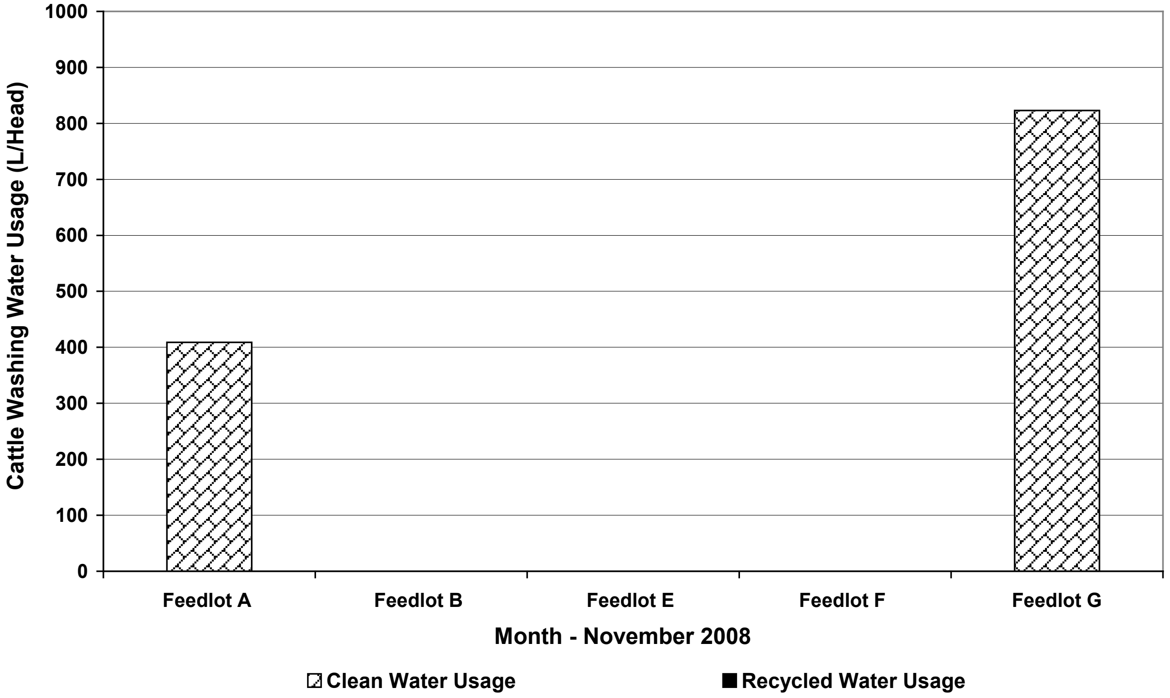

Figure 97 – Cattle washing water usage for November 2008 (L/head)

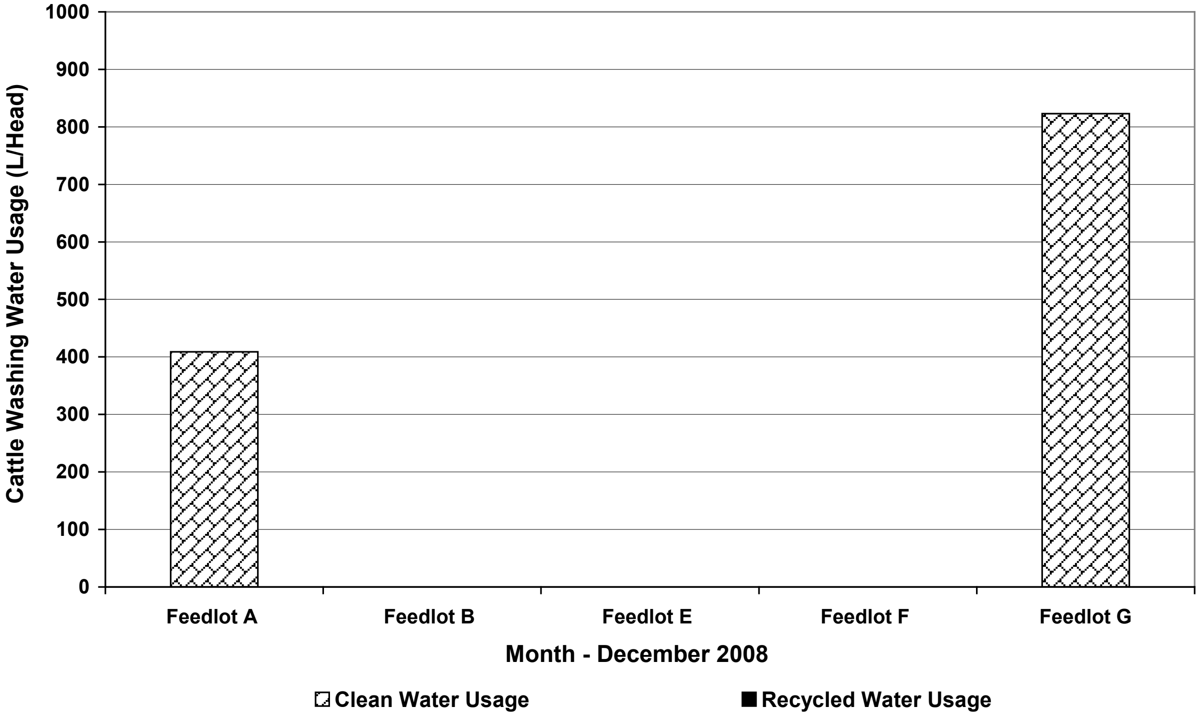

Figure 98 – Cattle washing water usage for December 2008 (L/head)

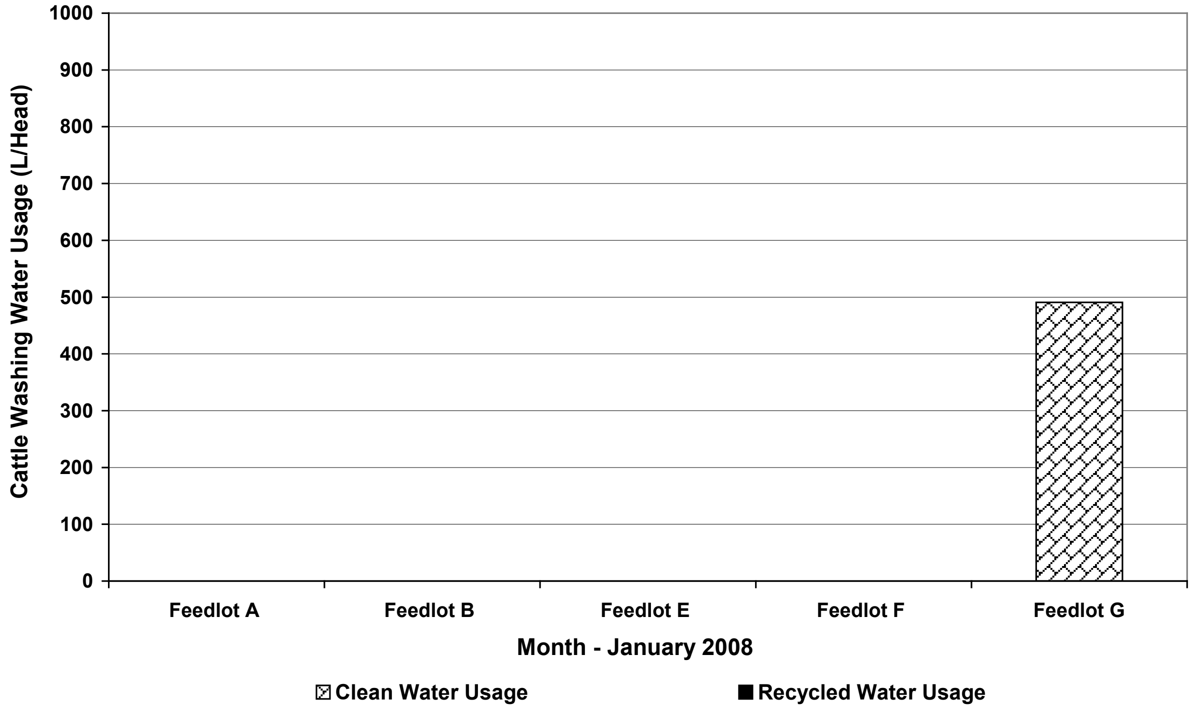

Figure 99 – Cattle washing water usage for January 2009 (L/head)

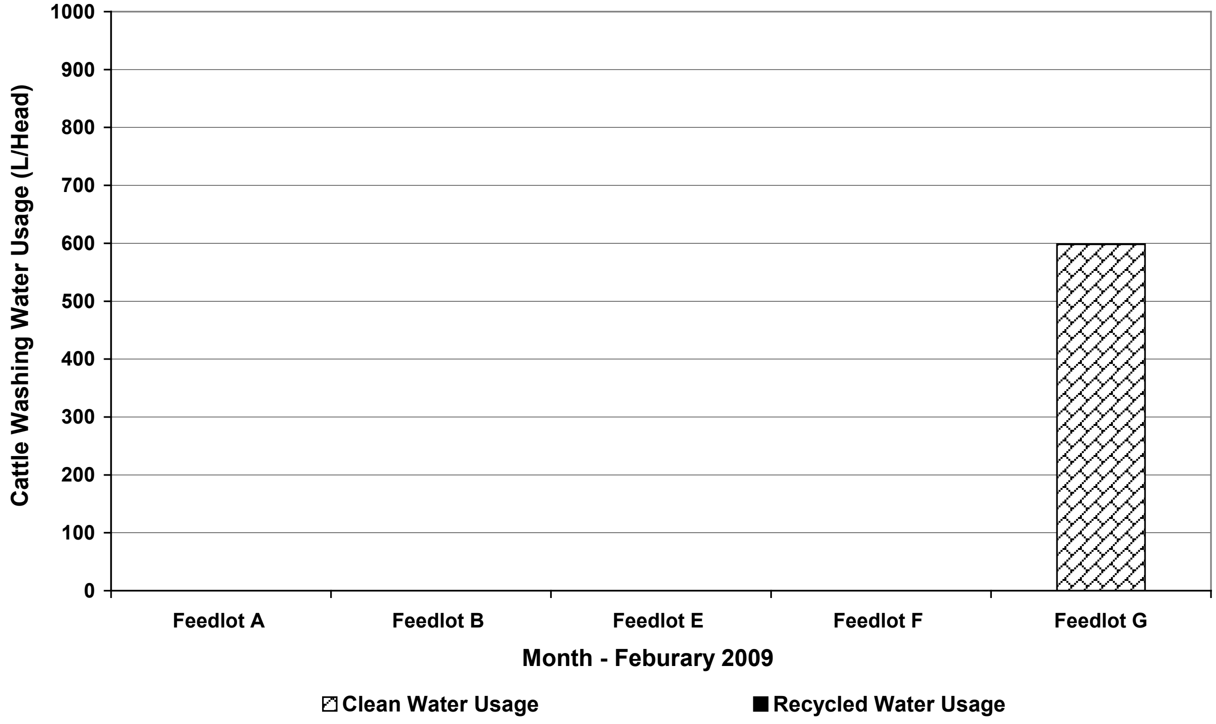

Figure 100 – Cattle washing water usage for February 2009 (L/head)

finalreport

FEEDLOTS

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Improving water and energy use efficiency in the Australian feedlot industry

Part B Report: Energy usage 2007-2009

Abstract

Energy usage is an increasing input cost for feedlot operation. These costs will rise significantly with the introduction of a carbon tax on energy production. These factors will make energy savings an important focus area for feedlots.

Whilst lot feeders usually have good records of total annual 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. Foreseeing these drivers for industry change, MLA has provided significant investment to quantify the water and energy usage of individual activities at Australian feedlots.

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, power meters were installed to allow an examination of energy usage by individual activities. The major energy usage activities (water supply, feed management, waste management, cattle washing) were monitored and recorded over a 24 month period.

This report provides factual information on the quantity of energy used within individual activities at seven Australian feedlots on a monthly basis. This puts valuable information in the hands of the industry to improve resource efficiency, meet the requirements of legislation and improve the sustainability of the industry in the face of a variable climate.

Executive summary

The Australian red meat industry, as with most primary industries, is coming under increasing pressure from both the community and government to document and justify its impacts on the environment.

Water availability and cost of supply is changing rapidly, driven by increased demand for industry, urban water supply and the environment. With droughts adding to low river flows, water supplies are very tight in many feedlot regions. Capped water supply and water trading in the Murray Darling Basin have increased the value of water significantly. In Victoria, large feedlots are now required to quantify and reduce their water usage. These pressures will promote careful management of water resources throughout the industry to ensure continued supply and minimise costs.

Energy usage is an increasing input cost for feedlot operation. These costs will rise significantly with the introduction of a carbon tax on energy production. These factors will make energy savings an important focus area for feedlots.

Meat and Livestock Australia (MLA) has previously undertaken a project (FLOT.328) to measure the environmental costs associated with the production of one kilogram of meat from modern Australian feedlots. As part of this project factual 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.

The purpose of this study is 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.

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.

This report covers the area of energy usage by feedlots.

Results from the seven feedlots studied showed that total annual indirect energy use ranged from 2.7 MJ/kg HSCW gain (Feedlot C) to 5.99 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 past 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 levels 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 a figure of 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, however 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 1.5 MJ/kg HSCW gain at Feedlot A to 6.9 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 1.9 MJ/kg HSCW gain (Feedlot A) to 7.7 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.

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.

Feed management is the largest single consumer of energy in the feedlot as expected. 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 25 (Feedlot D) to 600 MJ/t dry matter 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 310 to 600 MJ/t dry matter grain processed. 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 dry matter 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 shows that there is 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 270 to 425 MJ/t dry matter grain processed. Slightly higher levels were measured in 2008-2009 (290-600 MJ/t grain processed). There were three types of gases used within the four feedlots with steam flaking systems. These included LPG, butane and natural gas. All of these gas sources have different calorific values (heating content) and pricing structures and therefore impact on energy consumption. Some of the variation in gas usage can be attributed to heating efficiency during winter months, however 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 have reduced their average monthly feed delivery energy usage in 2008-2009 when compared with 2007-2008 levels. Feedlot C and D have 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 have 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) have considerably less energy usage when compared with the remaining feedlots.

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

Feedlot E uses, 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 is 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 is similar to Feedlot E along with a similar density ration. Feedlot E delivers 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 has translated into a significant reduction in average monthly feed delivery energy usage.

Typically, waste management contributes 18 % of total energy usage, however is quite variable between months. Waste management energy usage contributes 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 ranges 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 is driven by the frequency of cleaning, equipment used and the volume of manure removed. There is 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 is directly related to the volume of water used. Water usage is 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 reflects 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 is a reflection of lower staffing levels in 2008-2009, compared with previous year due to the state of the industry.

Average monthly usage is 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 is expressed on basis of per total head processed (inducted and shipped) not head-on-feed. Energy usage is 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 is 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 have been 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.

Knowledge of the total energy consumption will allow the industry to benchmark itself against other intensive or extensive livestock industries and/or industrial processes.

The outcomes of this study will allow the feedlot industry to start benchmarking total and individual activities energy usage. In addition, this information is invaluable for participating feedlots in understanding the drivers of energy consumption and targeting high energy use areas for efficiency gains and for future design and management considerations. The first step to making savings is to understand where energy is used around the feedlot.

To assist the feedlot industry to improve energy efficiency, a framework has been developed which steps through the process of measuring and reducing energy usage at the feedlot. This framework is presented as fact sheets, arranged in 3 series:

- Measuring and Understanding resource usage;
- Benchmarking, and
- Improving resource efficiency

It is important that this information is extended to industry. Therefore, it is recommended that a roll out of the resource efficiency fact sheet series be undertaken. This will assist lot feeders in understanding, planning and organising, implementing and monitoring an energy efficiency program based on the outcomes of this work. Additionally, this may also facilitate lot feeders being prepared for the introduction of a carbon pollution reduction scheme and the implications of increased energy costs and carbon taxes.

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1 Background

The Australian red meat industry, as with most primary industries, is coming under increasing pressure from both the community and government to document and justify its impacts on the environment. Currently, a lack of credible supply chain data prevents the industry from being able to respond in a meaningful manner.

Meat and Livestock Australia (MLA) is undertaking a project (COMP.094) to address these issues and provide credible data on the industry's environmental impacts and sustainability for use by industry, including its interactions with government, community groups and the media. This project will use the standardised tool, Life Cycle Assessment (LCA), to quantify natural resource consumption and environmental interventions to water, soil and air. The goal of the LCA is to identify key environmental impacts of products. Environmental impact categories considered in LCA include but are not limited to resource energy, climate change (global warming), eutrophication, acidification, human toxicity (pesticide use) and land use.

LCA is a form of cradle-to-grave systems analysis developed for use in manufacturing and processing industries to assess the environmental impacts of products, processes and activities by quantifying their environmental effects throughout the entire life cycle. LCA can be used to compare alternative products, processes or services; compare alternative life cycles for a product or service; and identify those parts of the life cycle where the greatest improvements can be made. An international standard has now been developed to specify the general framework, principles and requirements for conducting and reporting LCA studies (Standards Australia, 1998). LCA differs from other environmental tools (e.g. risk assessment, environmental performance evaluation, environmental auditing, and environmental impact assessment) in a number of significant ways. In LCA, the environmental impact of a product or the function a product is designed to perform is assessed, the data obtained are independent of any ideology and it is much more complex than other environmental tools. As a systems analysis, it surpasses the purely local effects of a decision and indicates the overall effects (Peters et al. 2005).

The functional unit for COMP.094 was the output of 1 kg of Hot Standard Carcass Weight (HSCW) meat at the abattoir gate. “Hot” indicates the meat in question has not entered any chilling operations. This output-related functional unit was chosen, rather than an input-related one, in order to describe the human utility of the processes under consideration – the provision of nutrition for people. Although the meat could be served in different ways, this functional unit makes the different processes under consideration “functionally equivalent” from a dietary perspective.

In LCA methodology, usually all inputs and outputs from the system are based on the ‘cradle-to-grave’ approach. This means that inputs into the system should be flows from the environment without any transformation from humans and outputs should be discarded to the environment without subsequent human transformation (Standards Australia, 1998). Each system considers upstream processes with regard to the extraction of raw materials and the manufacturing of products being used in the system and it considers downstream processes as well as all final emissions to the environment.

FIGURE 1 shows the generalised system boundary for the red-meat sector as defined for the COMP.094 project. Within this boundary, there is a sub-system for the feedlot sector. The boundary chosen here (shown in red on FIGURE 1) is the feedlot site itself plus the transport component of bringing cattle and feed into the feedlot and delivering cattle from the feedlot.

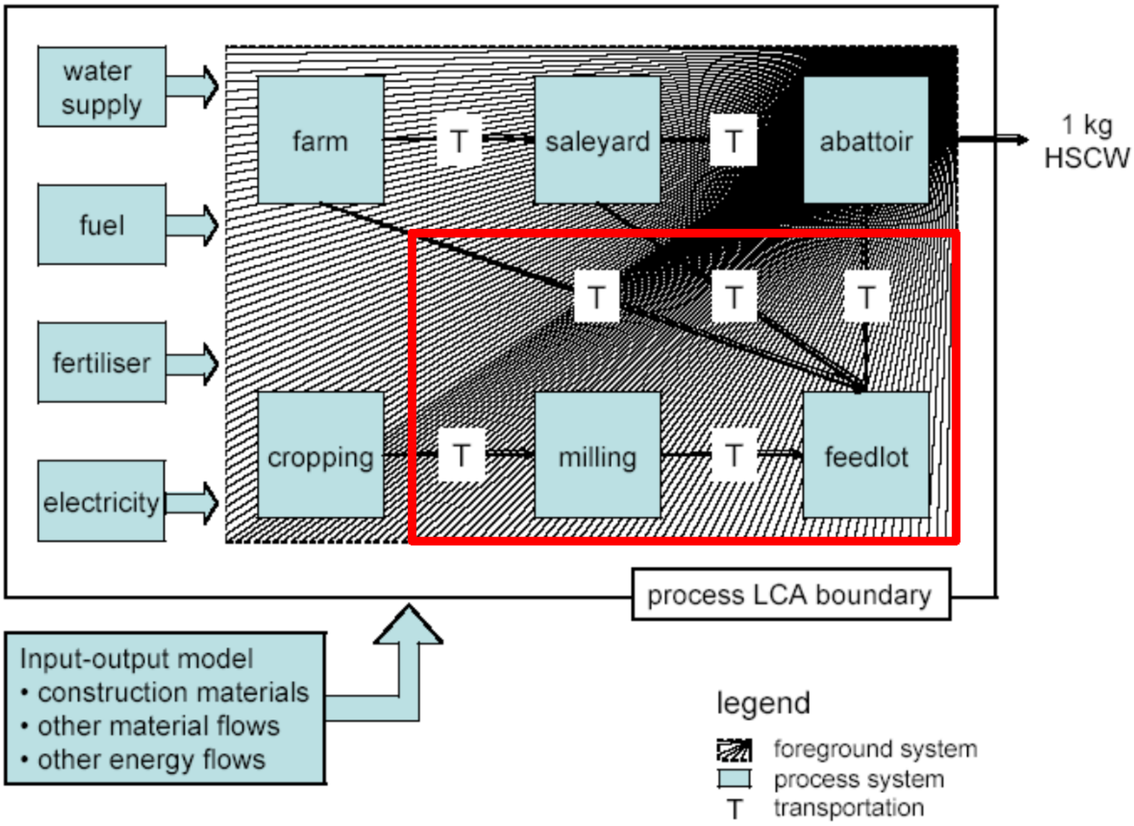

Figure 1 - Generalised system model for the red meat sector with feedlot sub-system

As part of the COMP.094 industry project, the beef cattle lot feeding sector has recently completed a related MLA project (FLOT.328) that will contribute to the whole-of-industry dataset, but more importantly addresses the public misconceptions concerning the environmental sustainability of the feedlot industry. The terms of reference for FLOT.328 required the researchers to address, in the context of a LCA, the feedlot-relevant natural resource management (NRM) issues water quality and water use efficiency, salinity, soil erosion, nutrient management and soil acidification, weeds, feral animals, biodiversity, vegetation management, energy efficiency and greenhouse gas emissions and solid waste. These issues were identified as issues of concern to the red meat industry.

The outcomes of FLOT.328 identified and quantified, where possible, the environmental costs (water, energy, GHG, and nutrient cycling) associated with the production of one kilogram of grainfed beef. It provided factual information on the volume of clean water and energy used at Australian cattle feedlots under a range of climatic, size and management conditions.

This study found that, whilst lot feeders usually had good records of total annual clean water usage, little data existed on actual usage levels for individual activities within the operation (eg. drinking water, feed processing and cattle washing). In addition, little was known about the variation in water and energy use throughout the year. Similarly, total annual energy consumption records were usually limited by the lot feeders' inability to separate out the electricity consumption of individual activities. Hence, more information was required on the water usage and energy usage of individual components before these figures could be reliably reported.

Water availability and cost of supply is changing rapidly, driven by increased demand for industry, urban water supply and the environment. With droughts adding to low river flows, water supplies are very tight in many feedlot regions. Capped water supply and water trading in the Murray Darling Basin have increased the value of water significantly. In Victoria, large feedlots are now required to quantify and reduce their water usage. These pressures will promote careful management of water resources throughout the industry to ensure continued supply and minimise costs.

Additionally, the lot-feeding industry is under pressure from all levels of Government to report and reduce energy usage and GHG emissions. The growing competition for water has also led the government in Victoria to introduce water efficiency regulations.

Currently, federal energy and greenhouse gas reporting obligations only apply at relatively high levels of energy usage (0.5 petajoules of energy, 25,000 tonnes of CO_2-e for a single facility or 125,000 tonnes of CO_2-e for a corporation). Large, vertically integrated agricultural companies may meet these thresholds, resulting in reporting requirements for all subsidiary companies and feedlots in their control.

In Victoria, participation in the Environmental Resource Efficiency Plan (EREP) program is mandatory for feedlots that use more than 120 ML of water, which represent the water requirements for about 6,000-7,000 head-on-feed. There are other initiatives such as the National Pollutant Inventory (NPI) which could provide energy resource profiles.

MLA's goal in commissioning this project was to address the lack of accurate data and quantify the contribution of individual feedlot activities on the total annual water usage and total indirect and direct energy usage. This puts valuable information in the hands of the industry to improve resource efficiency, meet the requirements of legislation and improve the sustainability of the industry in the face of a variable climate.

1.1 B.FLT.0350 Project description

The purpose of this study was to quantify the clean water usage and indirect and direct energy usage of individual feedlot activities. An MLA steering committee oversaw the selection of the feedlots such that the feedlots represented a cross section of geographical, climatic and feeding regimes within the Australian feedlot industry.

The sub-system boundary, as defined for the feedlot sector in FLOT.328, has been adopted for this project. The boundary (shown in red on FIGURE 1) 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 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.

The water and power meter data collected was supplemented with existing data collected on-site including fuel consumption (diesel, LPG) and cattle performance data. Performance data included 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.

The data was analysed to obtain water and energy usage associated with a number of feedlot indices including a per head-on-feed basis, per tonne grain processed and per kilogram of hot standard carcase weight gain (kg HSCW gain). A breakdown of resource use within the major feedlot activities and associated operations was provided.

2 Project objectives

The primary objectives of the project were as follows:

- To capture the clean water and energy usage from individual activities and performance data from eight feedlots representing a cross section of geographical, climatic and feeding regime diversity within the Australian feedlot industry, thus allowing the clean water and energy usage to be evaluated on the basis of one kilogram of hot standard carcass weight gain (kg HSCW gain).
- To communicate the results of the study to MLA in a format suitable for dissemination to industry stakeholders.
- Develop a framework for water and energy monitoring and efficiency in feedlots.

The outcomes of this project will allow the feedlot industry to develop a better understanding of the total annual clean water and energy usage and the relativity and contributions that various feedlot activities have on total usage. This will allow the industry to reliably report actual usage levels in individual components, viz. drinking water, feed management, cattle washing etc. Data will be used for individual feedlot planning, for industry wide planning, e.g. FLOT.132 – Vision 2020 project, and to propose water use and energy efficiency options for feedlots.

This report covers the issue of indirect and direct energy usage by feedlots. Indirect energy usage within the feedlot sub-system includes transport of cattle into and exiting the feedlot and commodity delivery. Direct energy usage includes consumption within the major feedlot activities of water supply, feed management, waste management, cattle washing and other minor uses including administration and repairs and maintenance.

This report includes energy usage data collected from March 2008 to February 2009, as well as a comparative analysis and discussion with the data collected from March 2007 to February 2008.

2.1 Project reporting structure

This project includes the collection and analysis of a large quantity of data from commercial feedlots on the water and energy usage associated with feedlot operation. All data is standardised to a number of feedlot indices including a per head-on-feed basis, per tonne grain processed and per kilogram of hot standard carcase weight gain (kg HSCW gain). To ensure all this data and information is presented in a suitable manner, two reports will be compiled. Additionally, a framework for water and energy monitoring and efficiency in feedlots was developed. This framework is presented as a series of fact sheets.

A. Water usage at Australian feedlots 2008-2009. This report presents an overview of the project methodology, water usage data collected from March 2008 to February 2009, as well as a comparative analysis and discussion with the data collected from March 2007 to February 2008. It includes consumption within the major activities of cattle drinking water, feed management and cattle washing and other minor uses such as administration and repairs and maintenance.

B. Energy usage at Australian feedlots. This report presents an overview of the project methodology, total direct and indirect energy usage data collected from March 2008 to February 2009, as well as a comparative analysis and discussion with the data collected from March 2007 to February 2008. It includes consumption within the major feedlot activities of feed management, water supply, waste management, cattle washing and other minor uses including administration and repairs and maintenance. In addition, indirect energy consumption within the areas of incoming and outgoing cattle and commodity delivery are included.

C. A framework for water and energy monitoring in feedlots. To assist the feedlot industry to improve energy efficiency, a framework has been developed to step through the process of measuring and reducing water and energy usage at the feedlot. This framework is presented as fact sheets, arranged in 3 series:

   a. Measuring and Understanding resource usage
   b. Benchmarking, and
   c. Improving resource efficiency

3 Materials and methods

3.1 Overview – Experimental work

The objective of the project was to collect good-quality data on energy usage and relate this to production parameters in feedlots so that the information could be used across Australia. To that end, it was necessary to ensure that the feedlots involved were representative and that reliable data could be obtained. The steps in the project were:

1. Select a range of feedlots across Australia that were representative of climatic zones, feeding regimes, management styles and cattle markets.
2. Review the design and management of these feedlots to select those where reliable data could be collected at a reasonable cost.
3. Select the preferred feedlots and complete negotiations at each site.
4. Design an instrumentation system for each feedlot.
5. Design a data collection system for each feedlot.
6. Undertake regular (monthly or fortnightly) data collection.
7. Undertake short-term detailed data collection for specific aspects of water usage.
8. Analyse and review the data.

3.2 Selected feedlots

Following a lengthy process, eight feedlots were selected to provide a representative sample. TABLE 1 summarises the key characteristics of the selected feedlots. To maintain confidentiality, none of the feedlots are identified by name and will be referred to as Feedlots A to H.

The selected feedlots provide a range of climatic conditions from a northern feedlot in a hot, humid summer-dominant rainfall to southern feedlots in cooler, winter-dominant rainfall zones.

Grain processing methods vary from simple tempering to reconstitution and steam flaking. Some feedlots wash cattle (mainly in winter) while other feedlots do not undertake any cattle washing.

Feedlot D was not included in the water studies and Feedlot G was not included in the energy studies.

Table 1 – Characteristics of selected feedlots

Feedlot name		A	B	C	D	E	F	G	H
Climate									
Mean Annual Rainfall	mm	577	582	403	641	679	831	640	716
Rainfall Pattern		Summer dominant	Winter dominant	Winter dominant	Summer dominant	Summer dominant	Uniform	Summer dominant	Summer dominant
Mean Annual Class A Pan Evaporation	mm	2372	1825	1788	1934	1934	1423	1934	1715
Mean Max Temp – January	°C	34.1	31.2	29.6	31.6	31.6	25.9	31.6	29.7
Mean Min Temp – June	°C	8.9	2.7	4.3	5.7	5.7	2.0	5.7	4.6
Feedlot capacity and design									
Licensed Capacity	head	>15000	>15000	>15000	>15000	>15000	>15000	>5000	>1000
Cattle Washing	% of turnoff	0	30	40	0	10*	40	0	65
Feed processing									
Grain Processing Method		Steam Flaked	Steam Flaked	Steam Flaked	Reconstitution	Reconstitution	Steam Flaked	Steam Flaked	Tempering
Main Energy Source		LPG	Natural Gas	LPG	Electricity	Electricity	Butane	LPG	Electricity

3.3 Energy supply monitoring system

The project needed to measure total energy usage, the direct energy usage in the main feedlot activities and indirect energy usage at each feedlot. The main areas of interest were:

1. Focus Area 1 - Total Energy Usage
2. Focus Area 2 - Water Supply
3. Focus Area 3 - Feed management - Processing & Delivery
4. Focus Area 4 - Waste management - Pen cleaning, manure stockpiling, effluent irrigation
5. Focus Area 5 - Cattle Washing
6. Focus Area 6 - Administration

Energy sources included electricity, diesel, petrol and gas (e.g. LPG - Propane, LPG - Butane, Natural etc). Usage of diesel, petrol and gas were typically available from existing fuel bowser and gas meters. In most cases, electricity was provided by overhead supply to a main switchboard then distributed internally throughout the feedlot. Therefore, total feedlot electricity usage was easily recorded from onsite power authority metering. However, electricity usage by individual activities or components within activities were unable to be determined without installation of power metering on the individual supply of these activities.

A comprehensive description of the energy supply monitoring system installed at each feedlot can be found in MLA project B.FLT.0339 report '*Quantifying the Water and Energy Usage of Individual Activities within Australian Feedlots*' Part B Report: Energy Usage at Australian Feedlots (Davis et al. 2008).

3.4 Monthly direct and indirect energy usage recording

Each feedlot was given a recording sheet that detailed all energy metering onsite. This included power authority electricity metering, new power metering, gas metering and fuel metering.

No onsite metering had any digital recording capability. Hence, each meter had to be read manually at the end of each period. The nominal period was monthly. However, if the last day of the month fell on a weekend, the meters were read either prior to or soon after the last day of the month. Therefore, the nominal period varied from a minimum of 27 to a maximum of 33 days.

The power authority meters and newly installed power meters had a number allocated. The feedlot manager or a nominated staff member read the power authority and new power meters and recorded the reading on the recording sheet. The power authority metering allowed each phase power usage, high or off-peak supply usage or the total usage to be recorded. The new power meters provided only a total power usage. The reading along with the respective units in kilowatt hours (kWh) were recorded on the recording sheet.

At the same time, the gas reading in litres or cubic metres was recorded on the sheet. Fuel consumption was broken up into diesel and petrol usage. This information was obtained from fuel logbooks and grouped by the respective categories and recorded. The recording sheet was then faxed or emailed to FSA Consulting at the end of each month.

Indirect energy usage was estimated from cattle and commodity transport distances, and typical truck types. Information on transport distances and typical truck types was obtained directly from the respective feedlots in-house feedlot management software (e.g. FY3000). This information was recorded on the recording sheet and then faxed or emailed to FSA Consulting at the end of each month.

3.5 Monthly herd performance and feed consumption recording

Due to the potentially sensitive nature of the information produced by this research, the reported information is presented in such a way that individual feedlots cannot be identified. Therefore, energy use is presented as a function of a number of feedlot indices to protect the anonymity of the feedlot. The feedlot indices corresponded to the activity measured and included usage on a per head basis, per tonne grain processed and per kilogram of hot standard carcase weight gain (kg HSCW gain). In this context, HSCW gain is the difference between total dressed carcase weight of cattle leaving the feedlot less the estimated total dressed carcase weight of cattle entering the feedlot.

To enable the respective indices to be estimated, herd performance and feed consumption data was provided. Herd performance data was provided on a market type basis and included liveweight of incoming and shipped cattle, days on feed, average daily gain, dressing percentage, number of cattle entering the feedlot along with number shipped. Commodity usage for the period was provided, broken into categories of major grains, protein sources, roughages/silages, liquids and supplements.

The herd performance and feed consumption data was obtained directly from the respective feedlots in-house feedlot management software (e.g. Bunk Management System, Possum Gully, Feedlot 3000). These systems are dedicated cattle feeding software systems to assist operations in better managing assets, inventories, commodities and maintenance of financial records.

3.6 Data collection period

Monthly data was collected over a 24-month period from March 2007 to February 2009. This period allowed for the annual variation in total energy usage to be quantified along with the variation in individual feedlot activities. This report presents data from the March 2008 to February 2009 period along with a comparative summary with the data collected between March 2007 and February 2008.

3.7 Data analysis

Monthly power meter readings, fuel and gas usage figures were imported into a large Excel spreadsheet and cross-checked with previous month’s readings. Where anomalous data were detected, the participating feedlot was contacted and the data were examined in more detail. Anomalous data may have included a reduction in meter reading from previous or unexplained extraordinarily large increases in power, fuel or gas usage.

Herd performance and feed consumption data were imported into the same spreadsheet. Similarly, data quality checks were undertaken. For example, the mean number of cattle on hand were compared with licensed capacity to ensure market types were not counted twice or missed. Where anomalous data was detected, the participating feedlot was contacted and the data were examined in more detail. The HSCW gain was calculated from the data for estimated liveweight in lot at the start of the month, total liveweight in, total liveweight out and estimated liveweight in lot at the end of the month. In some cases, feedlots were able to directly supply kilograms of beef produced for the month calculated from a similar method.

The spreadsheet then calculated the energy usage of the major feedlot activities as a function of their respective indices including on a per head-on-feed basis, per tonne grain processed and per kilogram of hot standard carcase weight gain (kg HSCW gain).

4 Results and discussion

Total indirect and direct energy usage and activity energy usage are presented in the following sections. It is important to note that the feedlot numbering system in the methodology section does not align with the number system in the results and discussion section. That is, Feedlot B in Section 4.1 is not Feedlot B in Section 3.2. This has been deliberate to maintain anonymity for the participating feedlots.

TABLE 1 gives the conversion factors used to convert fuel usage to energy (MJ).

Table 2 – Energy conversion factors for common fuels

Energy Form	Units of Measure	Energy Conversion Factor MJ
Diesel	Litres	38.6
Petrol	Litres	34.2
LPG – Propane	Litres	25.7
Natural Gas	m^3	38.5
LPG - Butane	Litres	28.1
LPG - Butane	m^3	122
Electricity	kWh	3.6

4.1 Total indirect energy usage

The energy (fuel consumed) for transport of incoming and outgoing livestock was calculated from cattle numbers, intake and exit liveweight, truck transport type (fuel usage & loading capacity) and estimated mean distance travelled to and from the feedlot. These data were supplied directly by the participating feedlots. Truck fuel usage and loading capacity was calculated from best available data. The raw consumption data for the respective fuel type was then converted into an equivalent energy consumption and then standardised per kg HSCW gain.

Truck transport fuel usage was determined from gathering transport industry data on average fuel use per 100 km for different truck types. TABLE 3 shows the average fuel use per 100 km for different truck types commonly used for livestock transport. Fuel consumption is a function of the efficiency of vehicle weight, fuel technology, topography, road conditions as well as other factors. The fuel usage presented here is only an average based typical highway performance for fully loaded vehicles.

Table 3 – Fuel usage for livestock and commodity transport vehicles

	Table Top	Semi Trailer	Semi Trailer	B Double	Road Train
	1 Deck	1 Deck	2 Deck	3 Decks	4 Decks
Fuel (L) / 100 km	23.8	34.55	42.6	56.8	68.4

Loading capacity depends upon truck type and size of the livestock. Loading rates were taken from Davies, Blackwood and Richards (2002).

TABLE 4 shows average livestock loading rates for different truck types commonly used for livestock transport.

From TABLE 4, and the number of incoming and outgoing cattle, it was possible to calculate the number of incoming and outgoing vehicles. When multiplied by the estimated travel distance, the total kilometres of livestock transport was calculated. From TABLE 3, it was possible to estimate fuel use.

Table 4 – Livestock loading rates (head per vehicle) for livestock transport truck types

Animal LWT	Table Top	Semi Trailer	Semi Trailer	B double	Road Train
kg	1 deck	1 deck	2 decks	3 decks	4 decks
250	22	38	75	114	150
300	20	34	67	102	134
350	18	30	60	91	120
400	16	28	55	83	110
450	15	25	51	77	102
500	14	24	47	71	94
550	13	22	43	65	86
600	12	20	39	59	78
650	11	18	35	54	70
700	10	16	32	49	64
750	9	14	28	44	56
800	8	12	24	39	48

Similarly, the energy (fuel consumed) for transport of off-farm feed commodities to the feedlot was calculated from the mass of each commodity delivered, type of truck delivering commodity (fuel usage & loading capacity) and estimated mean delivery distance. These data were provided by the participating feedlot. Truck fuel usage and loading capacity was calculated from best available data. The energy used to transport commodities produced on-farm to the feedlot were not included in these figures.

TABLE 3 shows the average fuel use per 100 km for different truck types commonly used for commodity transport.

Loading capacity depends upon truck type and the density of the commodity delivered. The loading capacity was determined from gathering transport industry data on average commodity loading rates for different truck types. TABLE 5 shows average loading capacity for different truck types commonly used for commodity transport.

Table 5 – Loading rates for commodity delivery vehicles

Commodity	Body Truck, 10t	Truck and Dog	Semi Trailer	B Double	Road Train
	tonnes	tonnes	tonnes	tonnes	tonnes
Roughages/Straws	6	12	12	18	24
Fully prepared ration	12	24	24	36	48
Liquids	12	24	24	36	48
Major Grains	12	24	24	36	48
Molasses	12	24	24	36	48
Protein Sources	12	24.5	25.5	37	50
Silage	12	25	25	36	50

Figure 2 to Figure 8 inclusive present the results of energy use for livestock transport and commodity delivery for the seven feedlots over the study period. Usage for respective activities has been standardised per kg HSCW gain and is presented on a monthly basis from March 2007 to February 2009. These figures clearly show the impact of travel distance on energy consumption for livestock transport and commodity delivery and the variation in usage over 24 months of the study.

Figure 2 shows the total monthly indirect energy usage for Feedlot A during the period March 2008 to February 2009 and the usage from the same months from March 2007 to February 2008 is shown for comparison.

For Feedlot A in the 2008-2009 period, the total monthly indirect energy usage ranged from 4.4 MJ/kg HSCW gain in March 2008 to 7.4 MJ/kg HSCW gain in October 2008. Energy used in transporting cattle to slaughter represents the largest contribution with 50% of the total indirect energy usage and is consistent between months. Similarly, commodity delivery energy usage is similar between months and contributes about 15% of total indirect energy usage.

The primary driver of total indirect energy usage is incoming cattle. Hence, in 2008-2009 cattle were sourced closer to the feedlot, thus reducing indirect energy usage when compared to the previous year.

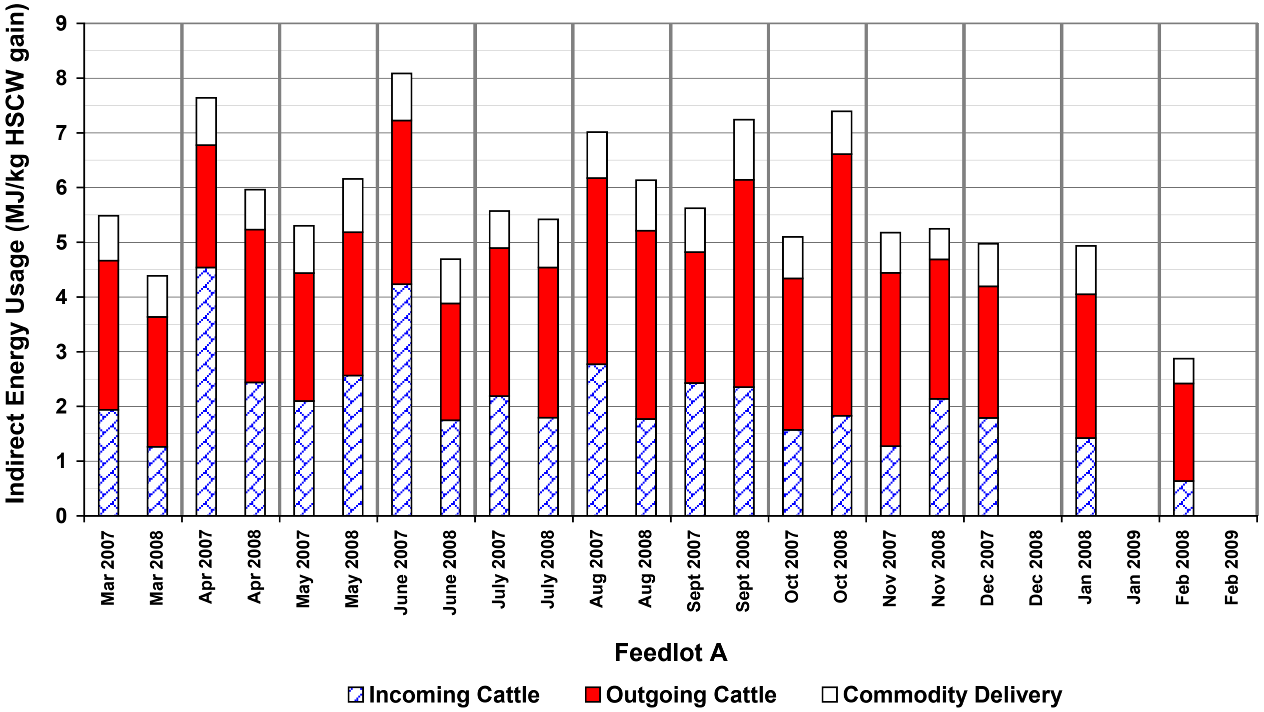

Figure 2 – Monthly total indirect energy usage at Feedlot A (MJ/kg HSCW gain)

Figure 3 shows the total monthly indirect energy usage for Feedlot B during the period March 2007 to February 2009. For Feedlot B, the total monthly indirect energy usage ranged from 1.9 MJ/kg HSCW gain in May 2008 to 7.1 MJ/kg HSCW gain in February 2007. Energy consumed in transport of cattle to slaughter ranges from 0.5 MJ/kg HSCW gain to 2.0 MJ/kg HSCW gain, and represents the most variable indirect energy usage activity.

The indirect energy usage for 2007-2008 (3.8 MJ/kg HSCW gain) was slightly greater than that measured in 2008-2009 (3.6 MJ/kg HSCW gain).

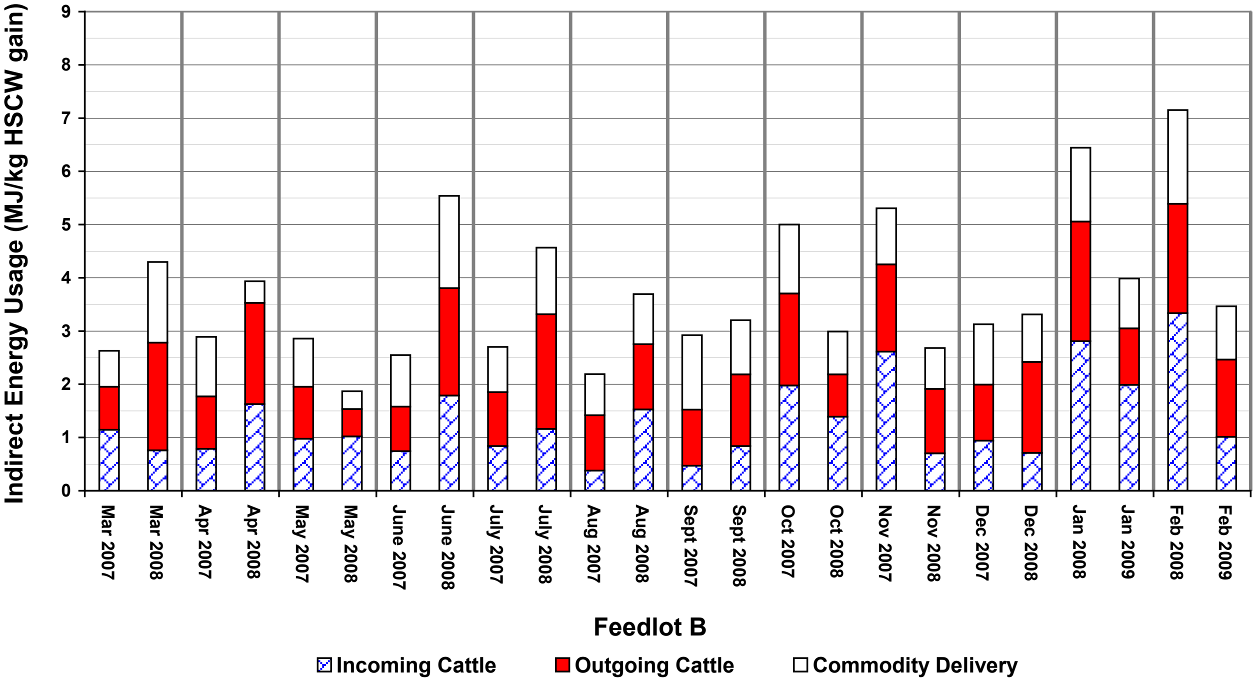

Figure 3 – Monthly total indirect energy usage at Feedlot B (MJ/kg HSCW gain)

Figure 4 shows the total monthly indirect energy usage for Feedlot C during the period March 2007 to March 2009. For Feedlot C, the total indirect energy usage ranged from 1.6 MJ/kg HSCW gain in October 2007 to 7.4 MJ/kg HSCW gain in July 2008. Feedlot C and Feedlot G have the lowest average total indirect energy usage across all feedlots. The largest component of total indirect energy usage is commodity delivery, representing on average 53% of total usage. The indirect energy usage for 2008-2009 (3.5 MJ/kg HSCW gain) was greater than the 2007-2008 level (2.7 MJ/kg HSCW gain) due to the commodity delivery energy usage. This higher indirect energy usage can be attributed to the seasonal availability of commodities especially during winter 2008.

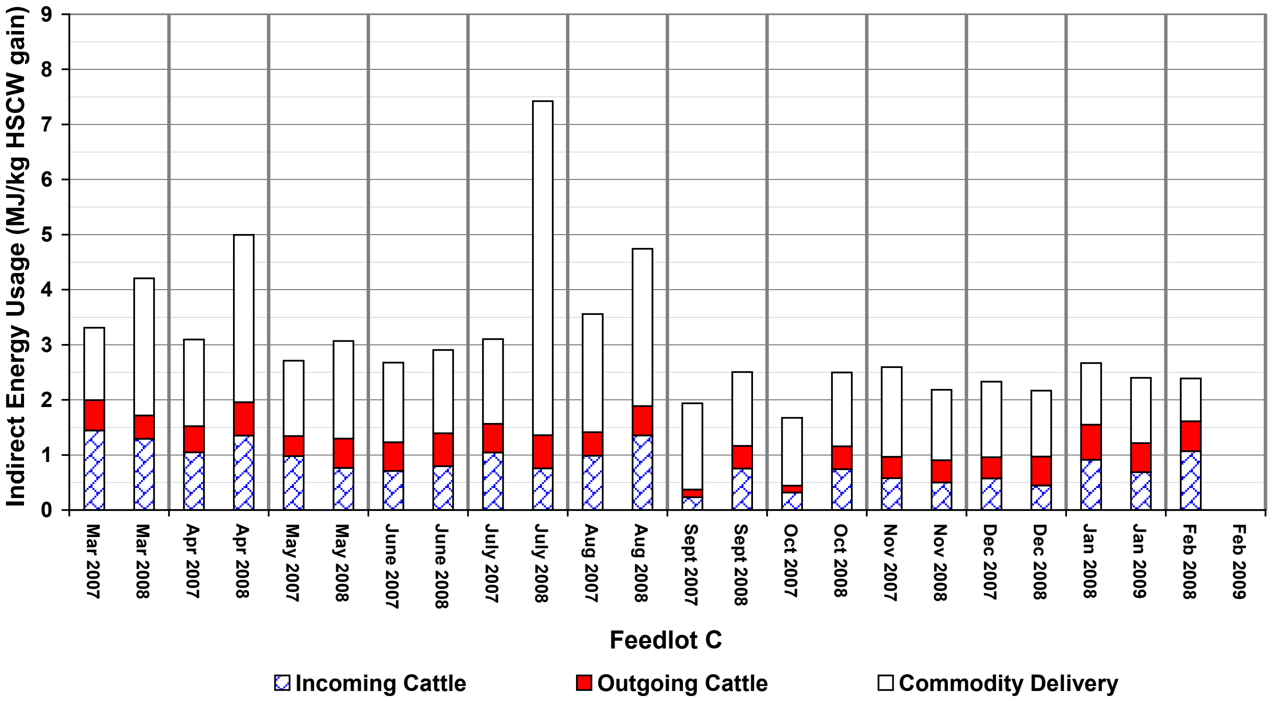

Figure 4 – Monthly total indirect energy usage at Feedlot C (MJ/kg HSCW gain)

Figure 5 shows the total monthly indirect energy usage for Feedlot D during the period March 2007 to March 2009. For Feedlot D, the total monthly indirect energy usage ranges from 4.0 MJ/kg HSCW gain in June 2007 to 6.6 MJ/kg HSCW gain in January 2008. The largest component of total indirect energy usage is commodity delivery, representing on average 62% of total usage. Incoming and outgoing cattle energy usage are similar between all months. Monthly commodity delivery energy usage ranges from 2.6 MJ/kg HSCW gain to 4.4 MJ/kg HSCW gain. Monthly outgoing cattle energy usage ranges from 0.5 MJ/kg HSCW gain to 0.9 MJ/kg HSCW gain.

The indirect energy usage for 2008-2009 (5.0 MJ/kg HSCW gain) was slightly lower than the 2007-2008 level (5.25 MJ/kg HSCW gain) due to a lower commodity delivery energy usage.

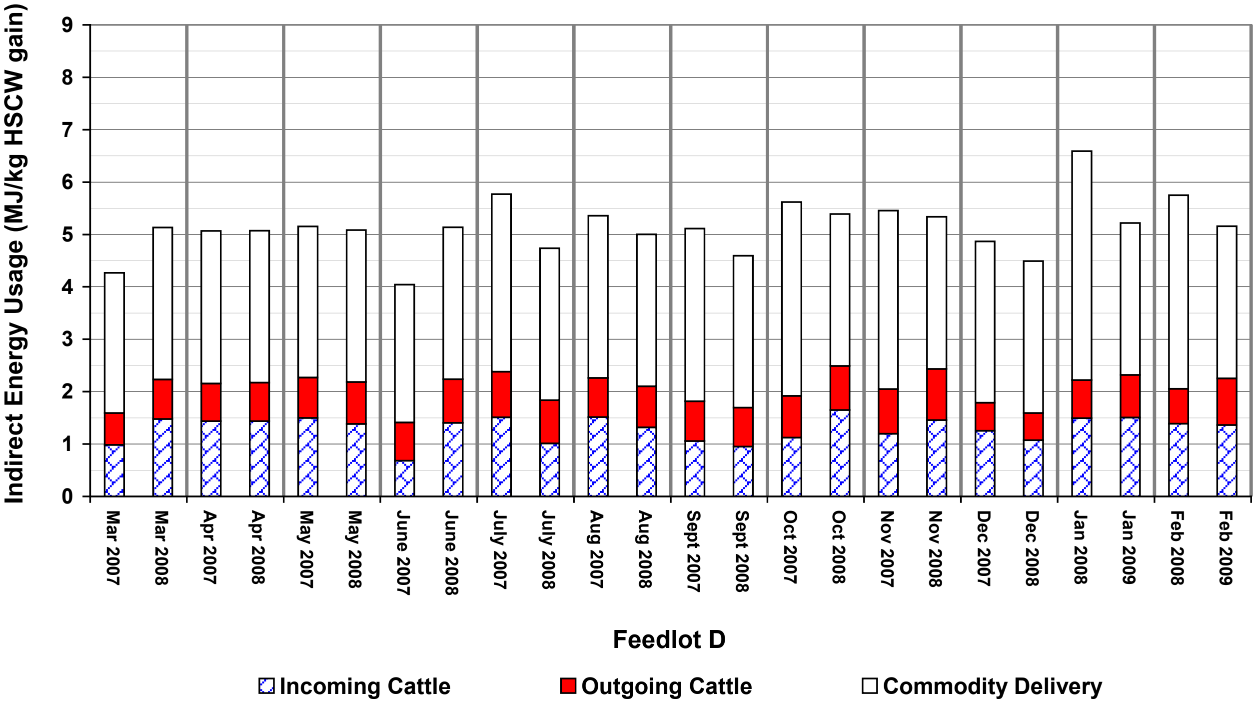

Figure 5 – Monthly total indirect energy usage at Feedlot D (MJ/kg HSCW gain)

FIGURE 6 shows the total monthly indirect energy usage for Feedlot E during the period March 2007 to March 2009. For Feedlot E, the total indirect energy usage ranges from 2.1 MJ/kg HSCW gain in February 2009 to 7.4 MJ/kg HSCW gain in January 2008. For this feedlot, incoming cattle represents the lowest component of total indirect energy usage in the order of 27%, whilst outgoing cattle (38%) and commodity delivery (35%) contributed the remaining energy usage. Monthly commodity delivery energy usage ranges from 1.1 MJ/kg HSCW gain to 2.9 MJ/kg HSCW gain. Monthly outgoing cattle energy usage ranges from 1.9 MJ/kg HSCW gain to 2.8 MJ/kg HSCW gain.

The total indirect energy usage for the 2007-2008 (5.9 MJ/kg HSCW gain) was much greater when compared with 2007-2008 levels (4.3 MJ/kg HSCW gain) due to a greater total commodity delivery and outgoing cattle energy usage. This demonstrates that commodities will be preferentially sourced close to feedlots if available.

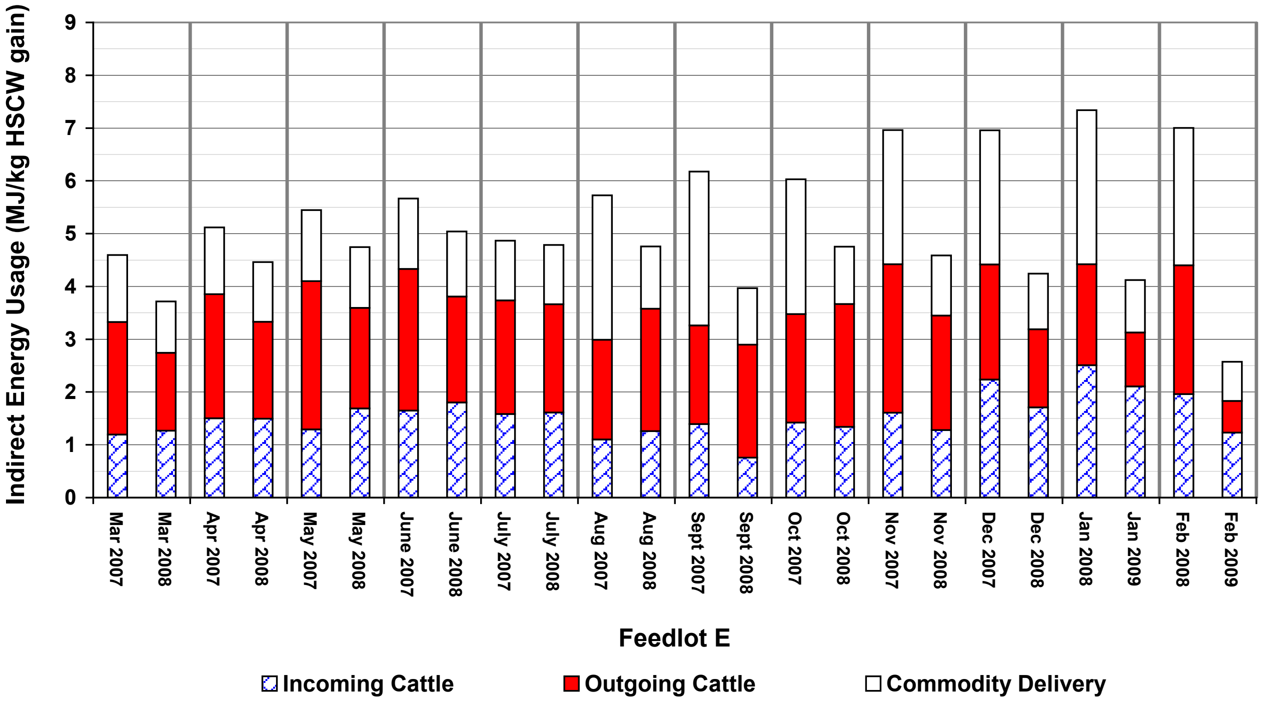

Figure 6 – Monthly total indirect energy usage at Feedlot E (MJ/kg HSCW gain)

Figure 7 shows the total indirect energy usage for Feedlot F during the period March 2007 to March 2009. No data for the 2008-2009 was made available. For Feedlot F, the total indirect energy usage ranges from 3.5 MJ/kg HSCW gain in September 2007 to 7.9 MJ/kg HSCW gain in November 2007.

Commodity delivery energy usage ranges from 2.2 MJ/kg HSCW gain to 5.2 MJ/kg HSCW gain. Outgoing cattle energy usage ranges from 0.5 MJ/kg HSCW gain to 0.9 MJ/kg HSCW gain, whilst incoming cattle energy usage ranges from 0.3 MJ/kg HSCW gain to 4.3 MJ/kg HSCW gain.

The indirect energy usage for the 2007-2008 was 4.6 MJ/kg HSCW gain.

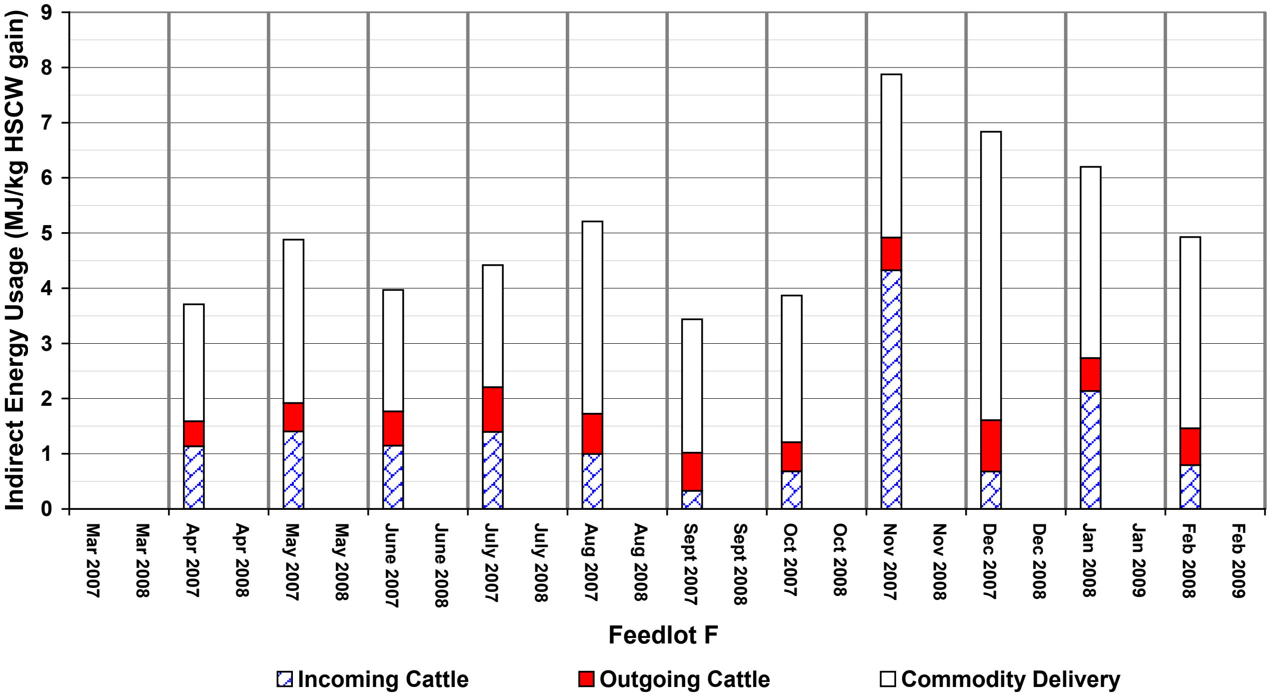

Figure 7 – Monthly total indirect energy usage at Feedlot F (MJ/kg HSCW gain)

FIGURE 8 shows the total indirect energy usage for Feedlot G during the period March 2007 to March 2009. For Feedlot G, the total indirect energy usage ranges from 1.1 MJ/kg HSCW gain in May 2007 to 7.6 MJ/kg HSCW gain in August 2008. Feedlot G and Feedlot C have the lowest average total indirect energy usage across all feedlots.

The total indirect energy usage for 2008-2009 (3.9 MJ/kg HSCW gain) was substantially greater than the 2007-2008 level (2.7 MJ/kg HSCW gain). This is due to a much greater total incoming cattle energy usage of 2.6 MJ/kg HSCW gain (2008-2009) compared with 0.7 MJ/kg HSCW gain in 2007-2008. For this feedlot, transport of cattle to slaughter represents the lowest energy usage in the order of 13%. Incoming cattle (35%-65%) and commodity delivery (19%-60%) contributed the remaining energy usage depending on year.

Total commodity delivery energy usage was 1.6 MJ/kg HSCW gain in 2007-2008 and reduced to 0.76 MJ/kg HSCW gain in 2008-2009. Total outgoing cattle energy usage was 0.42 MJ/kg HSCW gain in 2007-2008 and 0.52 MJ/kg HSCW gain in 2008-2009.

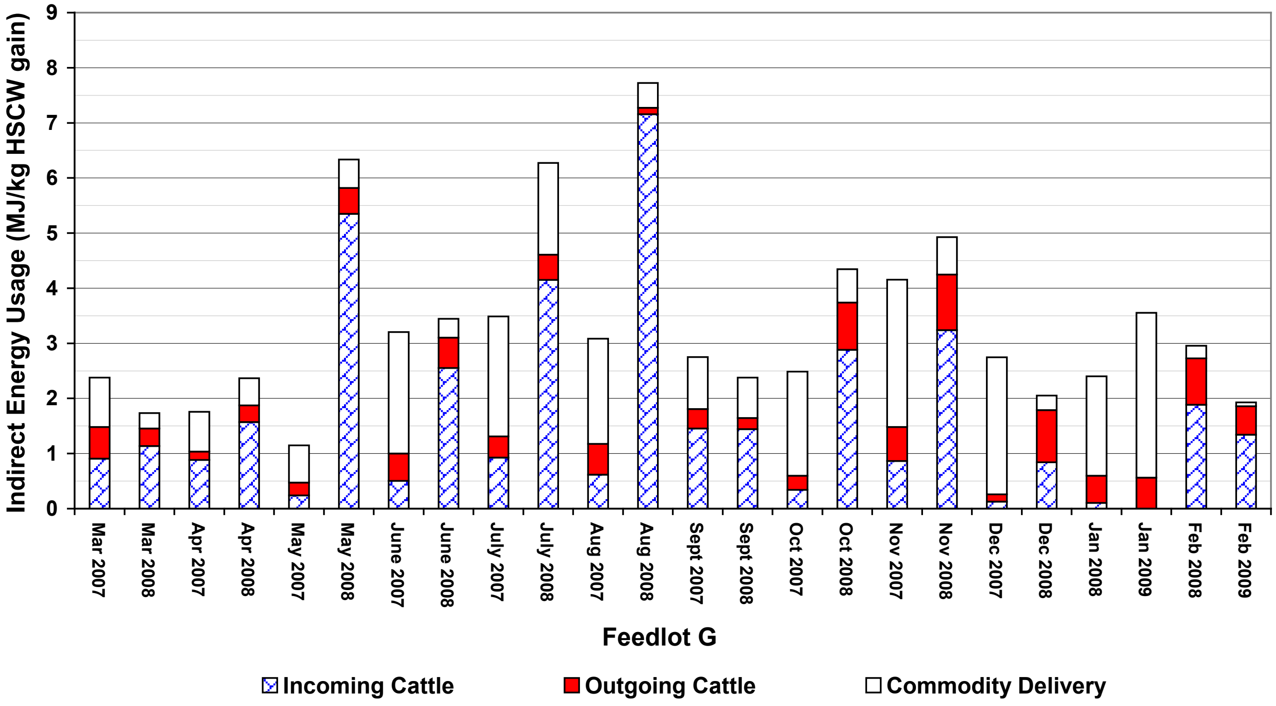

Figure 8 – Monthly total indirect energy usage at Feedlot G (MJ/kg HSCW gain)

The indirect energy usage figures illustrate the proximity of respective feedlots to cattle, abattoirs and commodities. These figures also 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 effect 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. Feedlot G is a custom feeder and feeder cattle were sourced further from the feedlot in 2008-2009. This is reflected in higher indirect incoming cattle energy costs.

4.2 Total direct energy usage

FIGURE 9 and FIGURE 10 illustrate the average monthly total direct energy use for the seven feedlots from March 2007 to February 2009, expressed per kg HSCW gain and per head-on-feed. Total energy usage is the combination of water supply, feed management (processing and delivery), cattle washing (where this practice is undertaken), administration and minor activities uses such as repairs and maintenance and cattle management. The minimum and maximum total energy consumption for any one month in the study period along with the total annual energy usage is also presented. Feedlot E has an incomplete data set in 2008-2009 and therefore the total energy usage is not presented. Feedlot G did not supply energy usage data for 2008-2009.

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 4 MJ/kg HSCW gain/month. The total annual energy usage in 2007-2008 ranged from 1.6 MJ/kg HSCW gain to 6.9 MJ/kg HSCW gain. The total annual energy usage in 2008-2009 was slightly higher when compared to the previous year with a range of 1.9 MJ/kg HSCW gain to 7.7 MJ/kg HSCW gain.

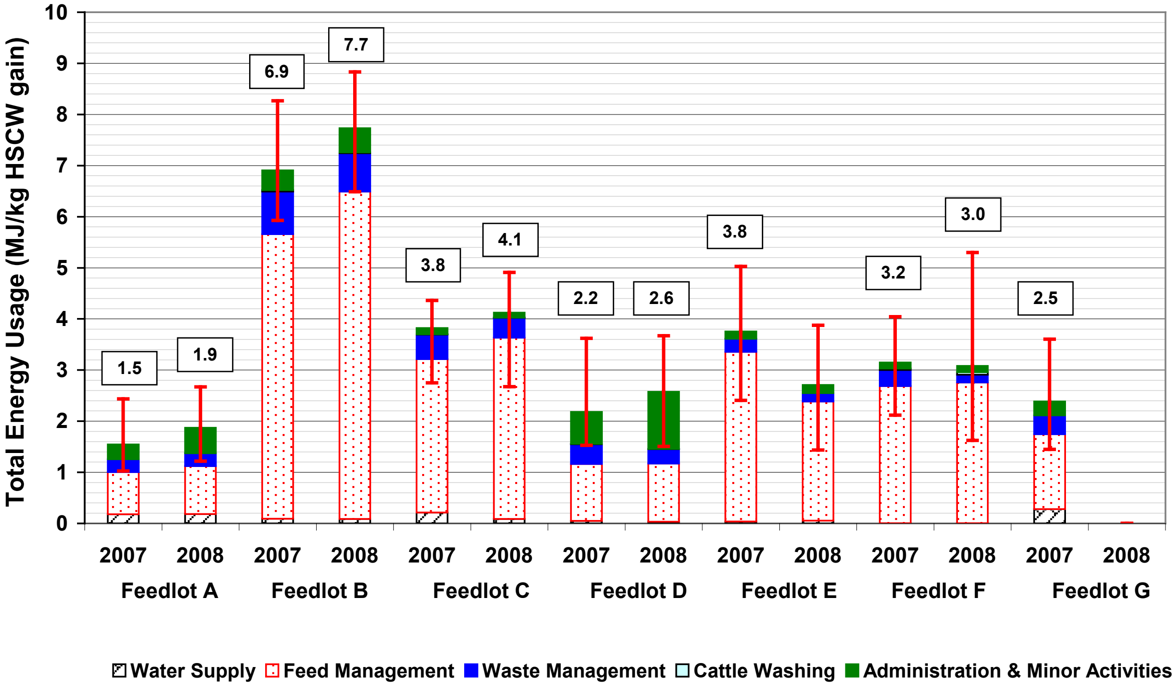

Figure 9 – Average monthly total energy usage (MJ/kg HSCW gain/month)

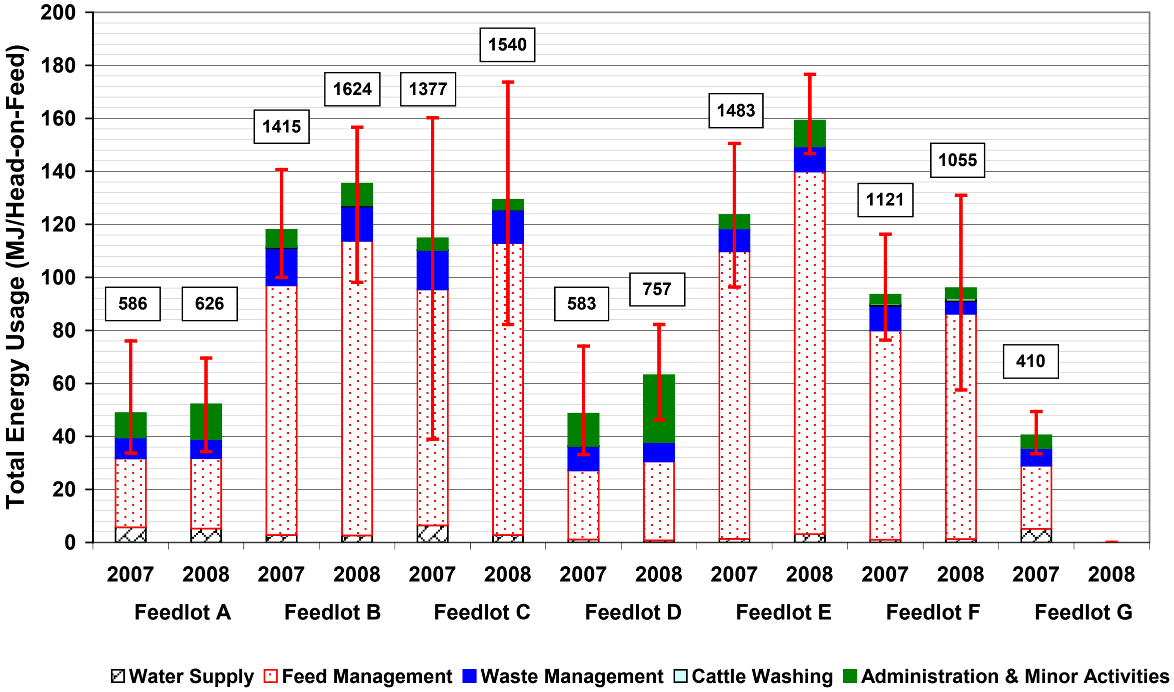

Figure 10 – Average monthly total energy usage (MJ/head-on-feed/month)

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 grains by other means. The total annual energy usage in 2007-2008 ranged from 583 MJ/head-on-feed to 1483 MJ/head-on-feed. 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 to 1624 MJ/head-on-feed. Feedlot C had the greatest monthly variation in 2007-2008 and 2008-2009.

FIGURE 11 to FIGURE 24 inclusive present the monthly total direct energy use for the seven feedlots from March 2007 to February 2009. Total energy usage is the combination of water supply, feed management (processing and delivery), cattle washing (where this practice is undertaken), administration and minor activities uses such as repairs and maintenance and cattle management. The usage for the respective activities was standardised per kg HSCW gain and per head-on-feed for the respective month.

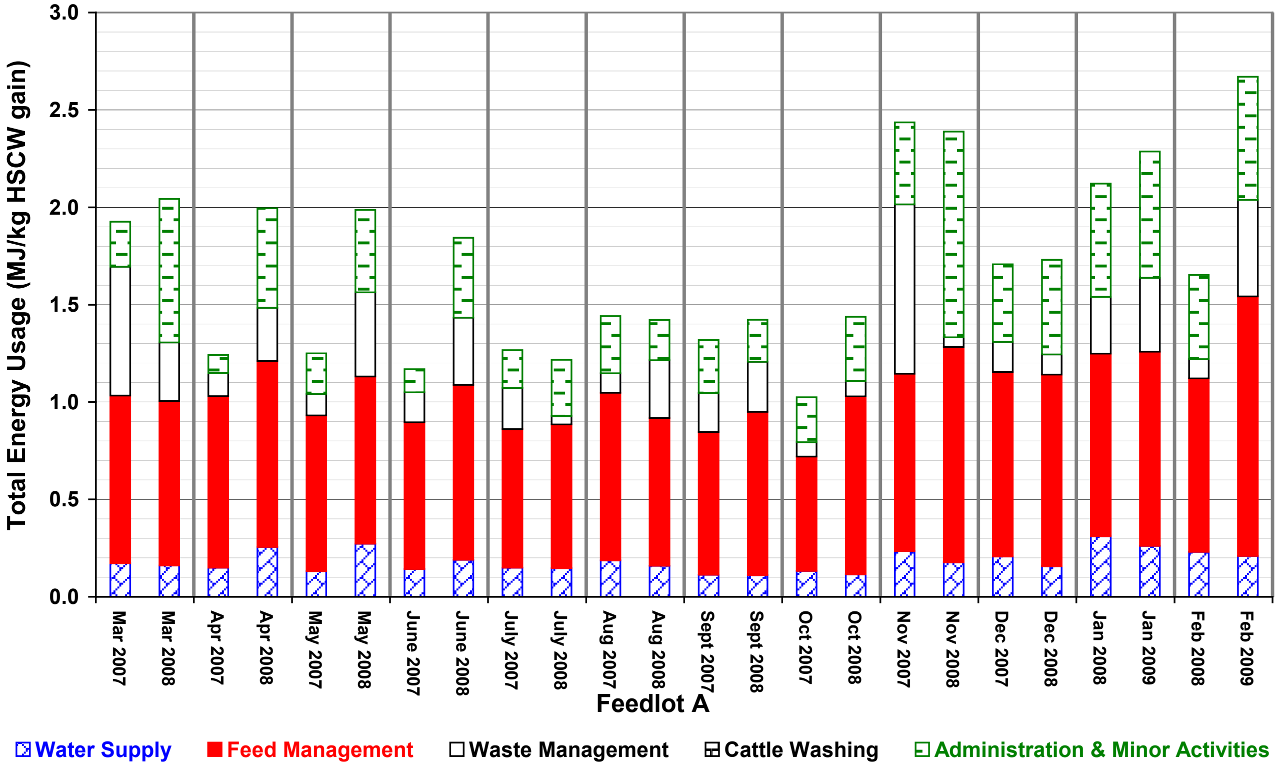

Figure 11 – Total monthly energy usage at Feedlot A (MJ/kg HSCW gain/month)

FIGURE 11 shows the total monthly energy usage at Feedlot A for the period March 2007 to February 2009. At Feedlot A, the total monthly energy use ranges from 1.0 (October 2007) to 2.7 MJ/kg HSCW gain/month in February 2009. The lowest energy usage was measured between July and October and the highest between November to March. In months where pen cleaning only is undertaken, feed management is the single largest consumer of energy in the feedlot as expected and contributed 0.6 to 0.95 MJ/kg HSCW gain/month or in the order of 50 % of total usage. The total usage recorded in 2008-2009 was 1.9 MJ/kg HSCW gain and about 20 % greater than the energy consumption recorded in 2007-2008 (1.6 MJ/kg HSCW gain/month). The total kilograms of HSCW gain produced was less in 2008-2009 due to lower cattle numbers when compared with 2007-2008, whilst total energy consumption remained at similar levels.

Waste management and administration and minor activities energy usage have the greatest monthly variation, whilst feed processing and water supply are relatively consistent. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

FIGURE 12 shows the total monthly energy usage at Feedlot A on a MJ/head-on-feed basis for the period March 2007 to February 2009.

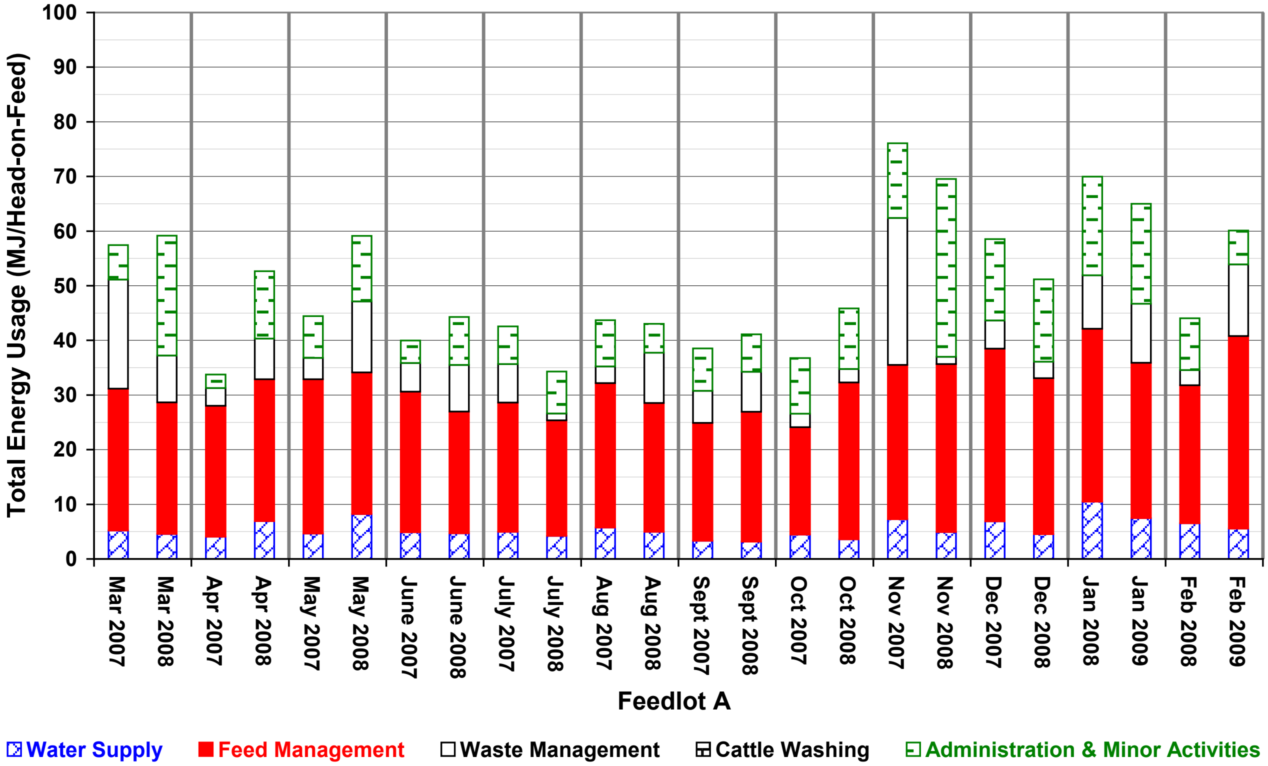

Figure 12 – Total monthly energy usage at Feedlot A (MJ/head-on-feed/month)

At Feedlot A during 2007-2008, the total monthly energy use ranged from 32 to 76 MJ/head-on-feed/month and the total energy usage for the 12 months was 585 MJ/head-on-feed. During 2008-2009, the total monthly energy use ranged from 41 to 69 MJ/head-on-feed/month and the total energy usage was 625 MJ/head-on-feed. This compares with the lower end of the range of 450 – 1300 MJ/head-on-feed/year found by Davis and Watts (2006). In months where pen cleaning only is undertaken, feed management is the single largest consumer of energy in the feedlot.

The period from November to March has lower numbers of head-on-feed when compared to other months and thus this translates into a higher energy usage per head-on-feed. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

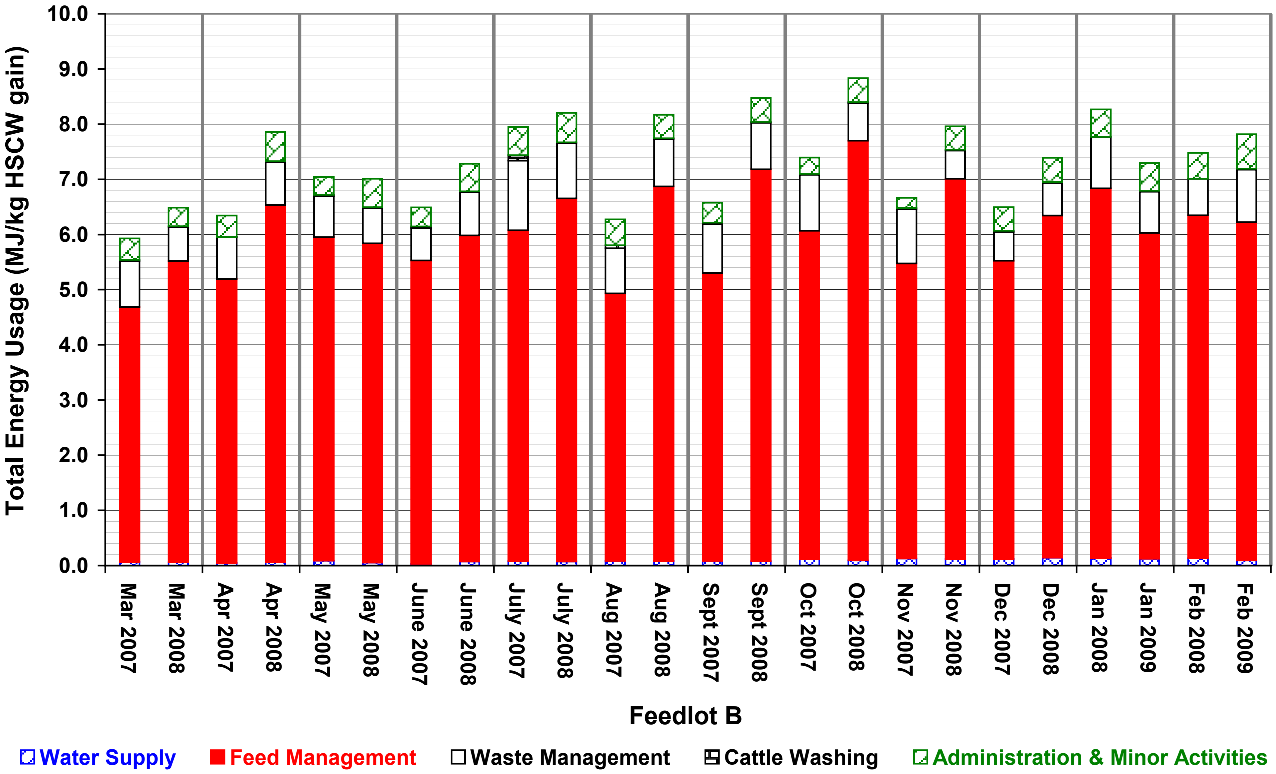

Figure 13 –Total monthly energy usage at Feedlot B (MJ/kg HSCW gain/month)

FIGURE 13 shows the total monthly energy usage at Feedlot B for the period March 2007 to February 2009. At Feedlot B, the total monthly energy use ranges from 6.0 (March 2007) to 8.8 MJ/kg HSCW gain/month (October 2008). Feed management is the single largest consumer of energy in the feedlot as expected and contributed 4.8 to 7.6 MJ/kg HSCW gain/month or in the order of 80 % of total usage. Feed management energy usage increased by about 1 MJ/kg HSCW gain/month in 2008-2009 due to the type of grain processed. In 2007-2008, barley and wheat were used whilst in 2008/2009 sorghum was used.

Waste management energy usage contributed on average about 0.7 MJ/kg HSCW gain/month (10 %) of total energy usage. Water supply contributed an average of 0.09 MJ/kg HSCW gain/month or around 1 % of total usage. The monthly energy used in waste management and water supply are relatively similar over the study period. Cattle washing contributes about 0.5 % of total energy usage and is directly related to the volume of water used in this activity. Administration and minor activities (5 %) contribute the remaining usage. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

FIGURE 14 shows the total monthly energy usage at Feedlot B on a MJ/head-on-feed basis for the period March 2007 to February 2009.

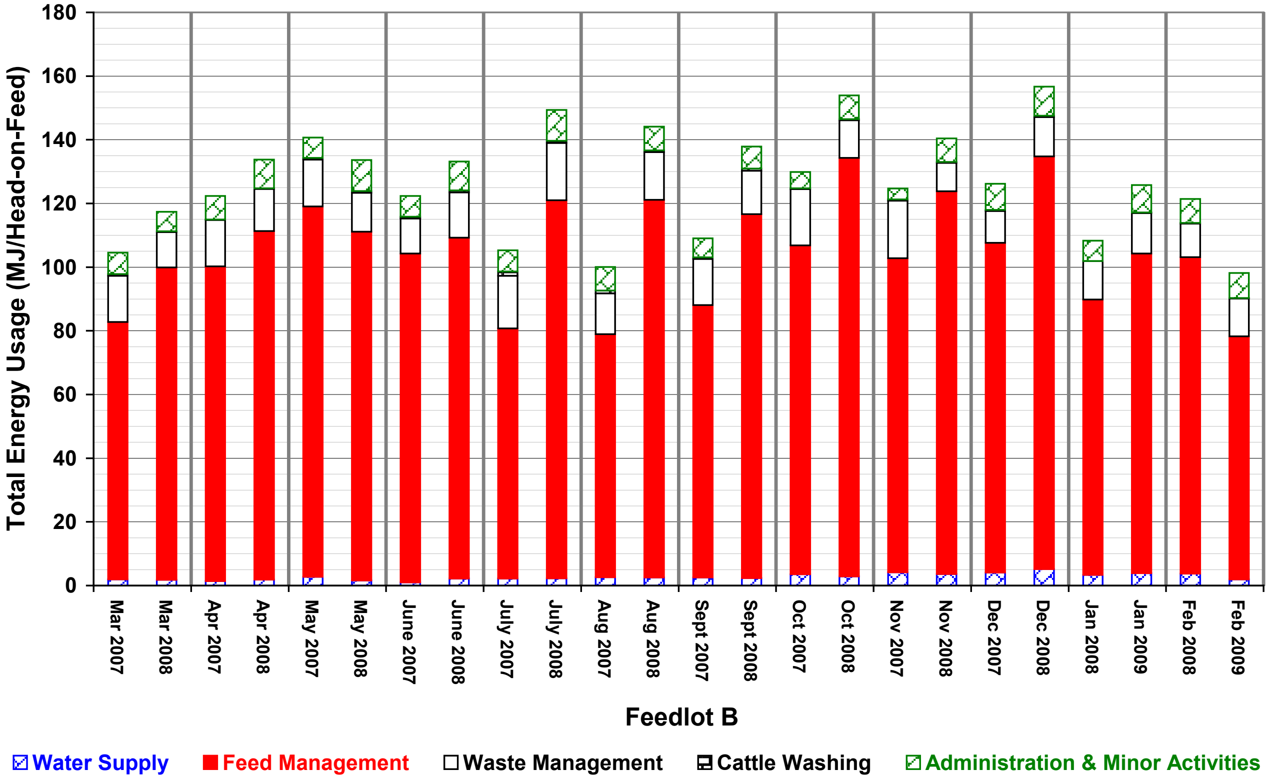

Figure 14 – Total monthly energy usage at Feedlot B (MJ/head-on-feed/month)

At Feedlot B, the total monthly energy use ranged from 100 to 141 MJ/head-on-feed/month during March 2007 to February 2008 and the total energy usage for the same period was 1415 MJ/head-on-feed. From March 2008 to February 2009, the total monthly energy use ranged from 98 to 156 MJ/head-on-feed/month and the total energy usage for the same period was 1624 MJ/head-on-feed. The total feed management energy usage increased by about 18% on a per head-on-feed basis in 2008-2009 when compared with 2007-2008. This is due to a change in the type of grain processed (barley v sorghum). This is a higher figure than the 1300 MJ/head-on-feed maximum recorded by Davis and Watts (2006). Feed management is the single largest consumer of energy in the feedlot. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

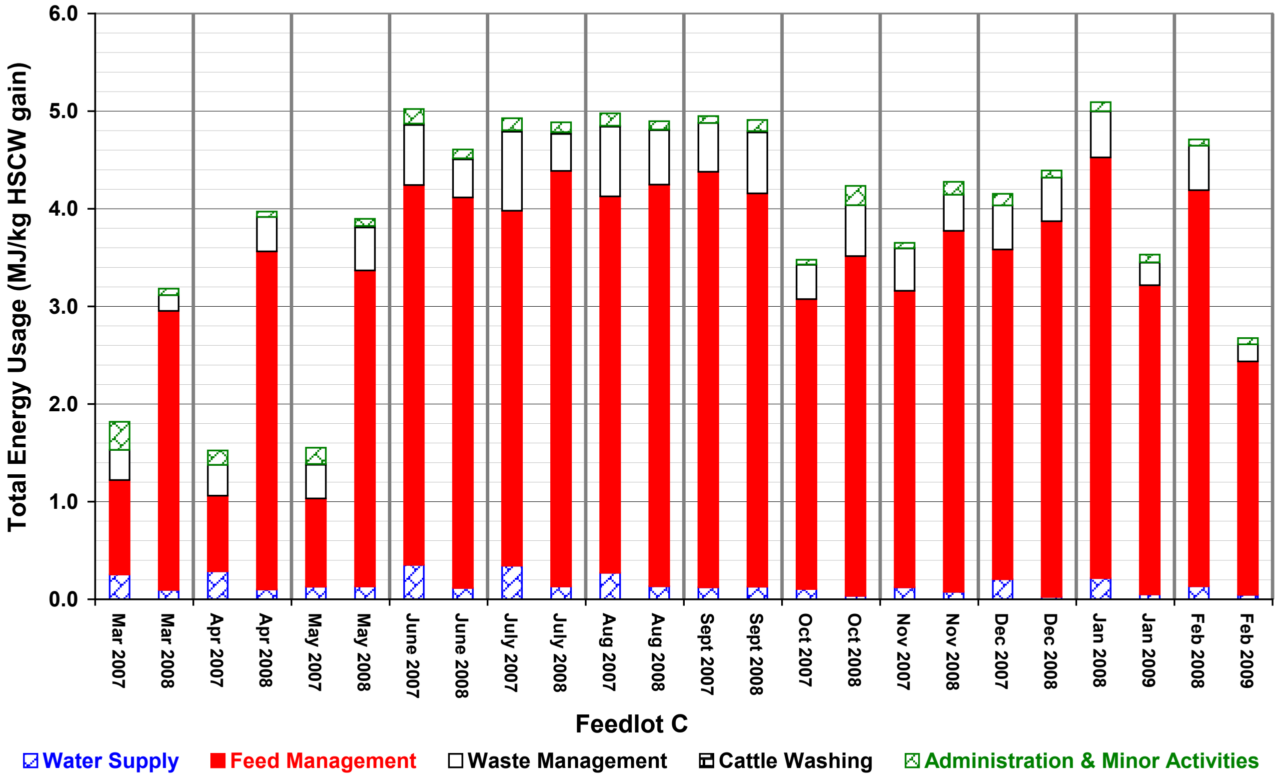

Figure 15 – Total monthly energy usage at Feedlot C (MJ/kg HSCW gain/month)

FIGURE 15 shows the total monthly energy usage at Feedlot C for the period March 2007 to February 2009. At Feedlot C, for months March to May 2007 the total monthly energy use ranged from 1.5 to 1.9 MJ/kg HSCW gain/month whilst for June 2007 to February 2009, the total monthly energy use ranged from 3.4 to 5.1MJ/kg HSCW gain/month. Commissioning of a steam flaking feed processing system in June 2007, accounts for the increased total energy usage. Feed management is the largest single consumer of energy in the feedlot. For the period, June 2007 to February 2009 feed management contributed 2.9 to 4.3 MJ/kg HSCW gain/month or in the order of 80 % of total usage. Waste management energy usage increases during the wet winter months and reduces during the dry summer months. Waste management contributed an average 0.34 MJ/kg HSCW gain/month (23 %) for September to May, whilst from June to September averaged 0.57 MJ/kg HSCW gain/month or 12 % of total energy usage.

Water supply contributed an average of 0.15 MJ/kg HSCW gain/month or around 5 % of total usage with steam flaking. Cattle washing contributed an average of 0.02 MJ/kg HSCW gain/month (<1 %) of total energy usage. The energy consumed in cattle washing is directly related to the volume of water used. Administration and minor activities (3 %) contribute the remaining usage. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

FIGURE 16 shows the total monthly energy usage at Feedlot C on a MJ/head-on-feed basis for the period March 2007 to February 2008.

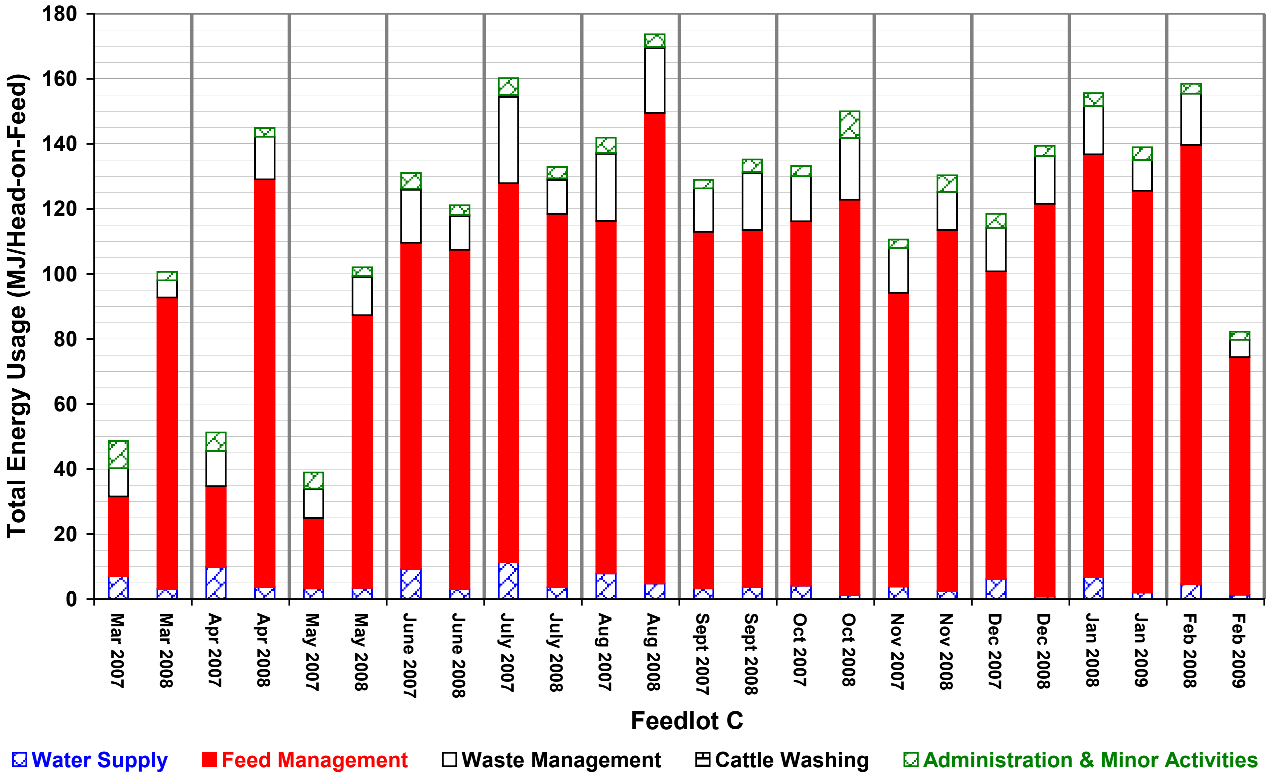

Figure 16 – Total monthly energy usage at Feedlot C (MJ/head-on-feed/month)

At Feedlot C, for the period March 2007 to May 2007, the total monthly energy use ranged from 40 to 51 MJ/head-on-feed/month when grain was tempered only. This increased to a minimum of 110 and maximum of 160 MJ/head-on-feed when the steam flaking system was commissioned in June 2007. The total energy usage for 2007-2008 is 1377 MJ/head-on-feed. From March 2008 to February 2009, the total monthly energy use ranged from 80 to 176 MJ/head-on-feed/month and the total energy usage for the same period was 1540 MJ/head-on-feed. Feed management is the single largest consumer of energy in the feedlot.

Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

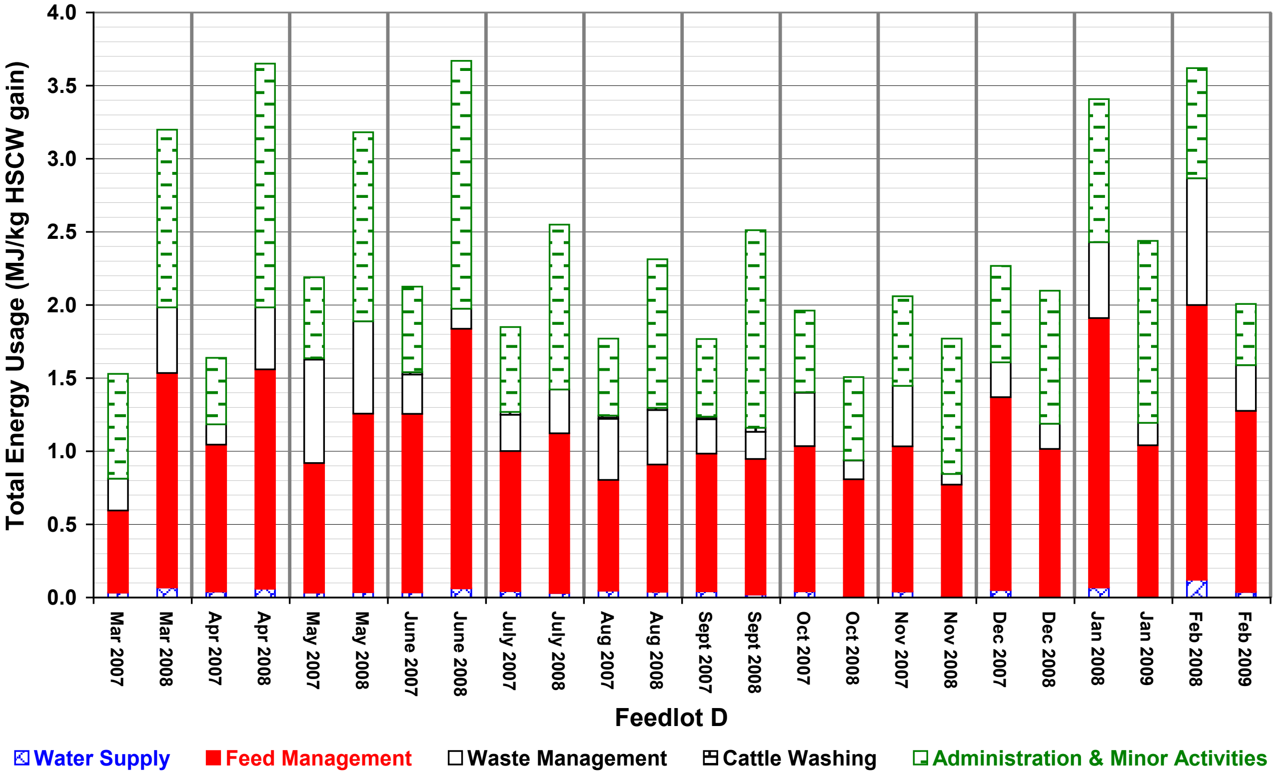

Figure 17 – Total monthly energy usage at Feedlot D (MJ/kg HSCW gain/month)

FIGURE 17 shows the total monthly energy usage at Feedlot D for the period March 2007 to February 2009. At Feedlot D, between March 2007 and February 2008 the total monthly energy use ranged from 1.5 to 3.6 MJ/kg HSCW gain/month. The lowest energy usage was measured in March 2007 and the highest in January 2008. Between March 2008 and February 2009, the total monthly energy use ranged from 1.5 to 2.5 MJ/kg HSCW gain/month. The total energy usage in 2008-2009 (2.5 MJ/kg HSCW gain) is about 15% higher than 2007-2008 levels (2.2 MJ/kg HSCW gain).

Feed management and Administration and minor activities are the largest consumers of energy in the feedlot. Combined they contribute about 87% of total usage. Waste management energy usage contributed on average 11% of the total energy usage. Water supply contributed an average of 0.05 MJ/kg HSCW gain/month or around 1 % of total usage. Cattle washing contributed an average of 0.02 MJ/kg HSCW gain/month (1 %) of total energy usage. The energy consumed in cattle washing is directly related to the volume of water used. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

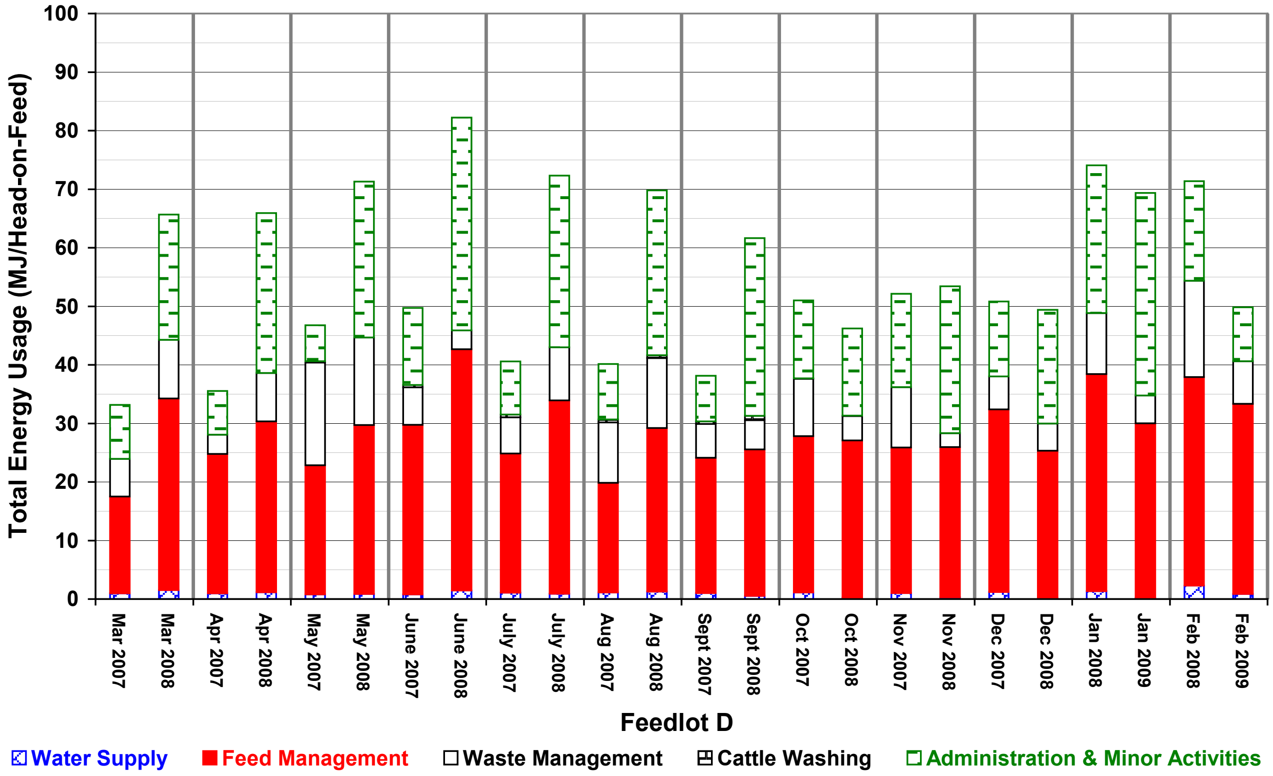

Figure 18 –Total monthly energy usage at Feedlot D (MJ/head-on-feed/month)

FIGURE 18 shows the total monthly energy usage at Feedlot D on a MJ/head-on-feed/month basis for the period March 2007 to February 2009.

At Feedlot D, the total monthly energy use ranged from 33 to 75 MJ/head-on-feed/month during March 2007 to February 2008 and the total energy usage for the same period was 583 MJ/head-on-feed. From March 2008 to February 2009, the total monthly energy use ranged from 46 to 82 MJ/head-on-feed/month and the total energy usage for the same period was 757 MJ/head-on-feed. The total feed management energy usage increased by about 30% on a per head-on-feed basis in 2008-2009 when compared with 2007-2008. This is due to an increase in feed management energy usage and a doubling of administration energy usage driven by increased fuel usage.

Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

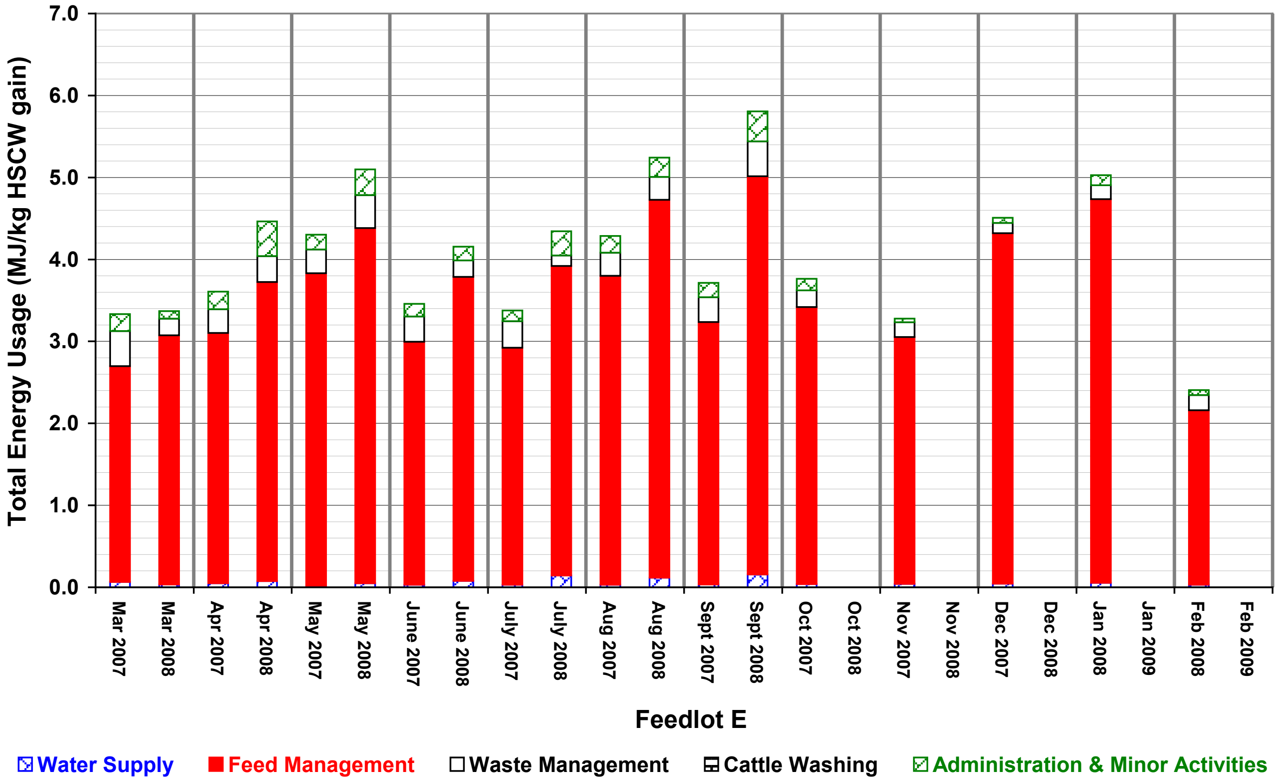

Figure 19 –Total monthly energy usage at Feedlot E (MJ/kg HSCW gain/month)

FIGURE 19 shows the total monthly energy usage at Feedlot E for the period March 2007 to February 2009. Due to a company restructure and subsequent tightening of labour resources, data collection for this study ceased at the end of September 2008.

At Feedlot E, the total monthly energy use ranges from 2.4 (February 2008) to 5.8 MJ/kg HSCW gain/month (September 2008). The total energy usage between March 2008 and October 2008 was 2.7 MJ/kg HSCW gain or about 7% higher when compared with the corresponding period in 2007 (2.5 MJ/kg HSCW gain). Feed management is the largest single consumer of energy in the feedlot as expected and contributed 2.1 to 4.9 MJ/kg HSCW gain/month or in the order of 88 % of total usage. Waste management energy usage contributed between 0.13 MJ/kg HSCW gain/month (3 %) and 0.43 MJ/kg HSCW gain/month (13 %) of total energy usage, however on average represents 7% of the total energy usage. Water supply contributed an average of 0.04 MJ/kg HSCW gain/month or around 1 % of total usage. This feedlot does not wash cattle. Administration and minor activities contribute in the order of 4% of the total energy usage. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

FIGURE 20 shows the total monthly energy usage at Feedlot E on a MJ/head-on-feed/month basis for the period March 2007 to February 2008.

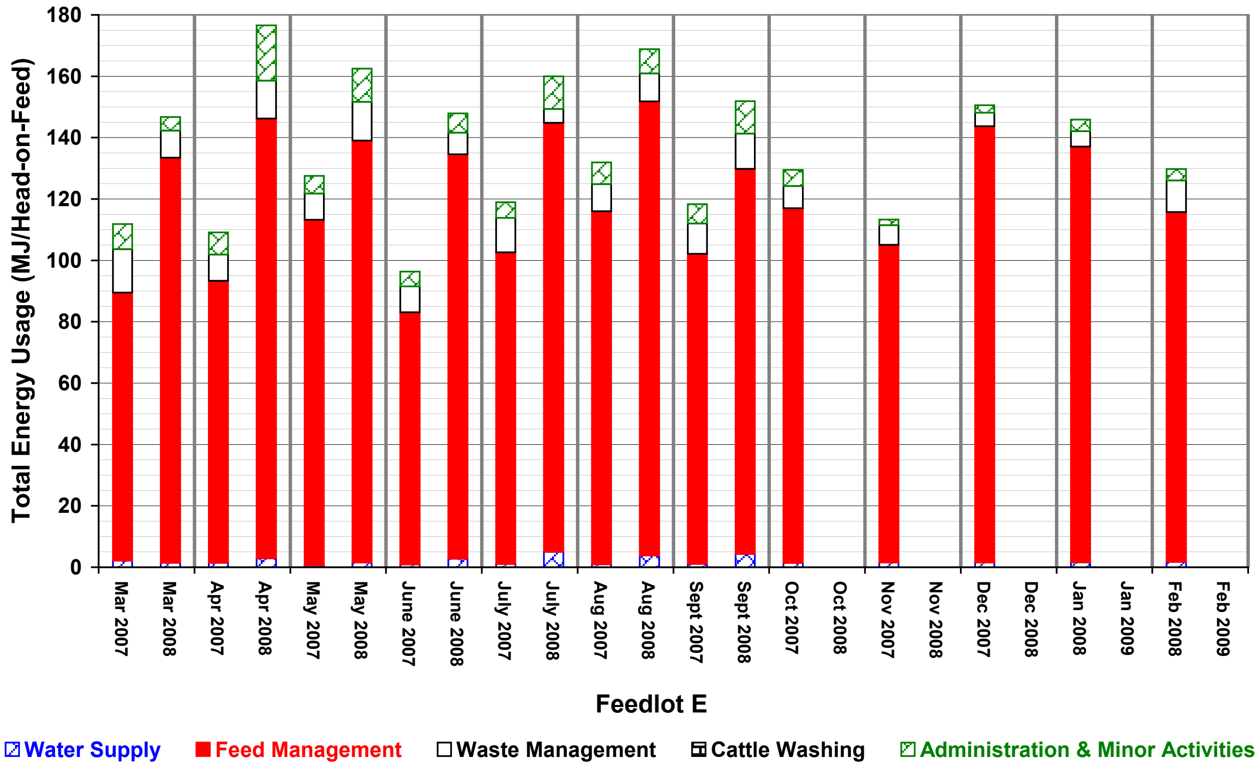

Figure 20 – Monthly total energy usage at Feedlot E (MJ/head-on-feed/month)

At Feedlot E, the total monthly energy use ranges from 95 to 151 MJ/head-on-feed/month between March 2007 to February 2008 and the total energy usage for the same period was 1483 MJ/head-on-feed. From March 2008 to October 2009, the total monthly energy use ranged from 146 to 176 MJ/head-on-feed/month. The total energy usage for the period March 2007 and October 2007 was 814 MJ/head-on-feed compared with the same period in 2008 of 1114 MJ/head-on-feed. Therefore, the total energy usage increased by 36% in 2008 when compared with 2007 levels. Feed processing and additional water supply drawn from bores accounts for the increased usage. Feed management is the single largest consumer of energy in the feedlot.

Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

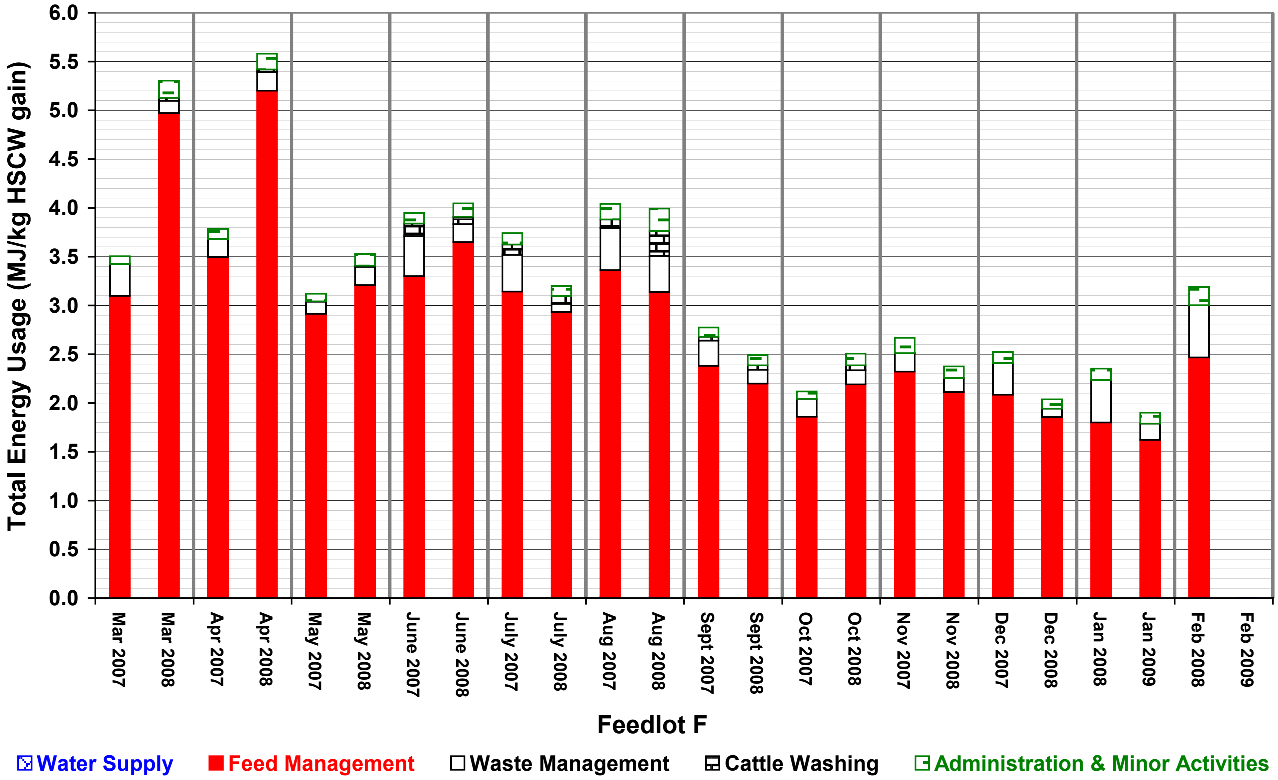

Figure 21 –Total monthly energy usage at Feedlot F (MJ/kg HSCW gain/month)

FIGURE 21 shows the total monthly energy usage at Feedlot F for the period March 2007 to February 2009. The total energy usage in 2008-2009 (3.2 MJ/kg HSCW gain) is similar to 2007-2008 levels (3.1 MJ/kg HSCW gain).

At Feedlot F, the total monthly energy use ranges from 1.8 (October 2007) to 5.2 MJ/kg HSCW gain (April 2008). Feed management is the largest single consumer of energy in the feedlot as expected and contributed between 1.6 to 5.2 MJ/kg HSCW gain/month or on average approximately 87 % of total usage. For the period, March 2007 to February 2008, waste management energy usage contributed between 0.12 MJ/kg HSCW gain/month (4 %) and 0.54 MJ/kg HSCW gain/month (17 %) of total energy usage, on average about 10% of the total energy usage. Waste management energy usage between March 2008 to February 2009 was about half of that recorded from the previous year. Water supply contributed an average of 0.006 MJ/kg HSCW gain/month or less than 0.2 % of total usage. Cattle washing contributed about 1% of total energy usage in those months when cattle are washed. Administration and minor activities contribute in the order of 4% of the total energy usage. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

FIGURE 22 shows the total monthly energy usage at Feedlot F on a MJ/head-on-feed/month basis for the period March 2007 to February 2009.

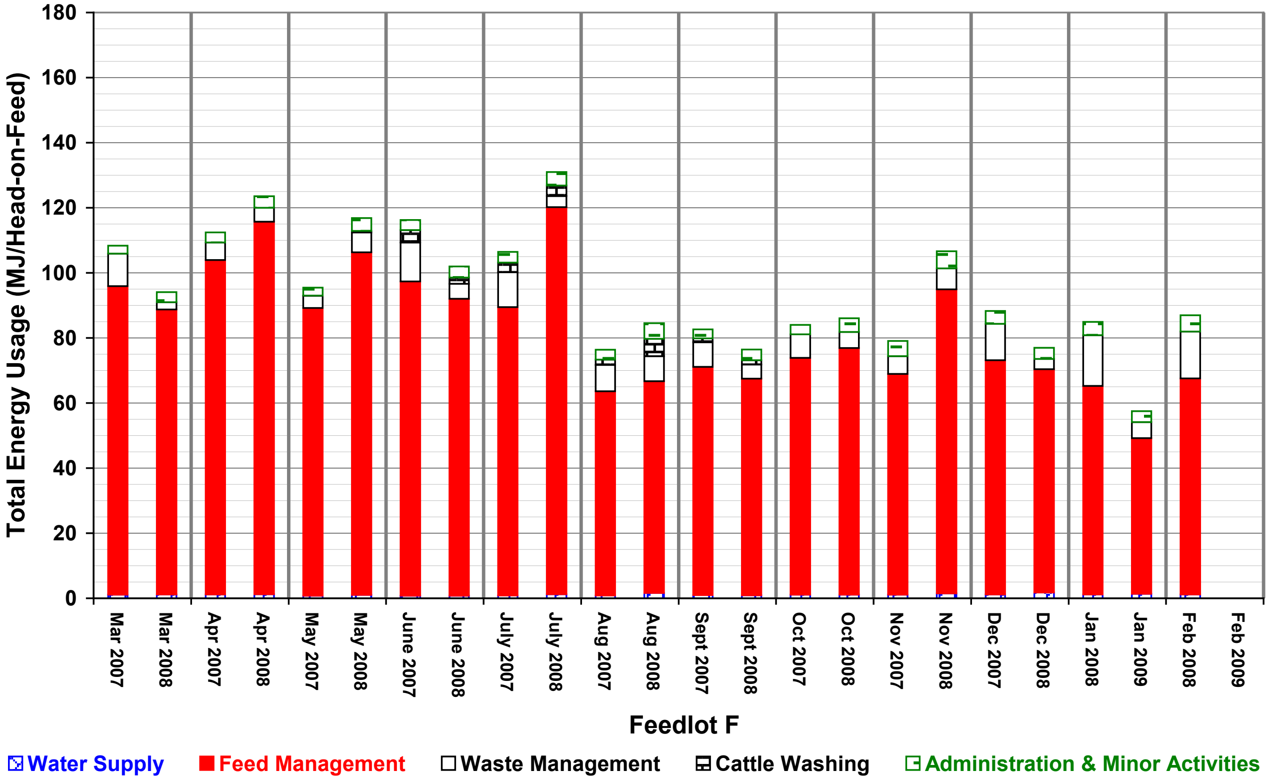

Figure 22 – Monthly total energy usage at Feedlot F (MJ/head-on-feed/month)

At Feedlot F, the total monthly energy use ranges from 75 to 115 MJ/head-on-feed/month between March 2007 to January 2008 and the total energy usage for the same period was 1034 MJ/head-on-feed. From March 2008 to January 2009, the total monthly energy use ranged from 57 to 130 MJ/head-on-feed/month for a total of 1055 MJ/head-on-feed. Data for February 2009 was unavailable. Hence, the total energy usage was very similar between years across the study period. The seasonal variation is clearly shown with a consistent reduction in energy usage from August through to February, then an increase through autumn and winter months. Feed management energy usage is the primary driver of this variation.

The total energy usage for 2007-2008 is 1121 MJ/head, a figure slightly lower than that recorded by Sweeten et al. (1986) and Davis and Watts (2006). Feed management is the single largest consumer of energy in the feedlot. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

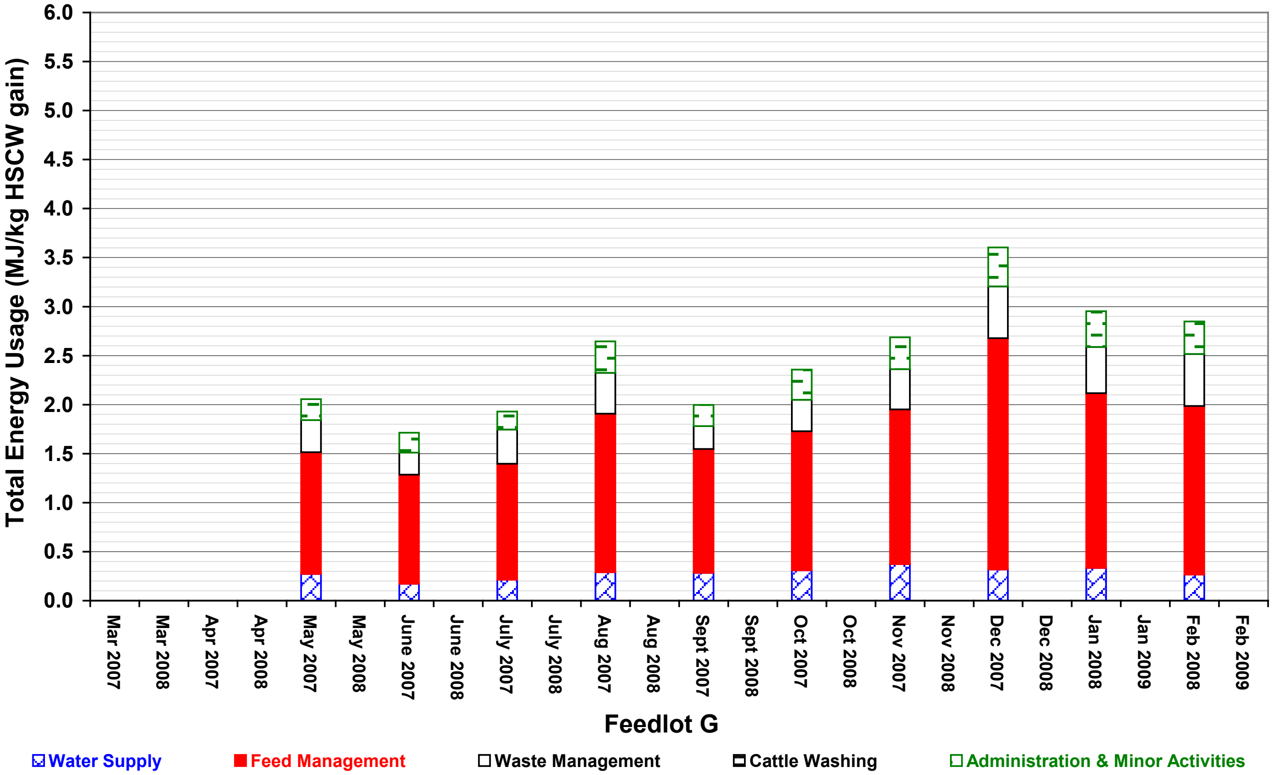

Figure 23 – Monthly total energy usage at Feedlot G (MJ/kg HSCW gain/month)

FIGURE 23 shows the total monthly energy usage at Feedlot G for the period March 2007 to February 2008. Whilst, raw energy usage data was supplied from this feedlot from July 2008 to February 2009, no performance data was supplied to allow for standardisation. Hence, no data for July 2008 to February 2009 is presented.

At Feedlot G, the total monthly energy use ranges from 1.4 (April 2007) to 3.6 MJ/kg HSCW gain/month (December 2007). Water supply contributed an average of 0.28 MJ/kg HSCW gain/month or approximately 13 % of total usage. Feed management is the largest single consumer of energy in the feedlot as expected and contributed between 0.88 to 2.4 MJ/kg HSCW gain/month or on average approximately 55 % of total usage. Waste management energy usage contributed between 0.22 MJ/kg HSCW gain/month (15 %) and 0.53 MJ/kg HSCW gain/month (21 %) of total energy usage, however on average represents 18% of the total energy usage. Administration and minor activities contribute in the order of 13% of the total energy usage. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

FIGURE 24 shows the total monthly energy usage at Feedlot G on a MJ/head-on-feed/month basis for the period March 2007 to February 2008.

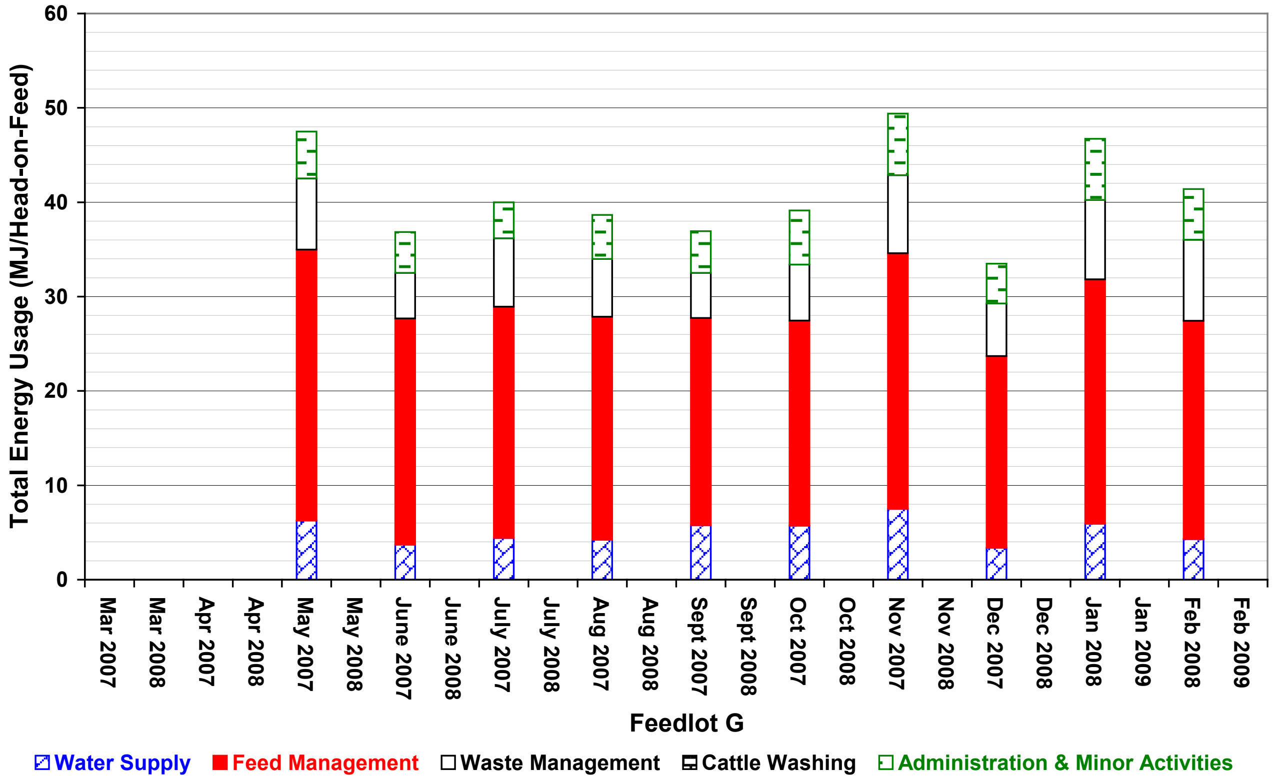

Figure 24 – Monthly total energy usage at Feedlot G (MJ/head-on-feed/month)

Whilst, raw energy usage data was supplied from this feedlot from July 2008 to February 2009, no performance data was supplied to allow for standardisation. Hence, no data between March 2008 and February 2009 are presented.

At Feedlot G, between May 2007 and February 2008, the total monthly energy use ranges from 30 to 43 MJ/head-on-feed/month. The total energy usage for this period is 444 MJ/head-on-feed. Feed management is the single largest consumer of energy in the feedlot. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

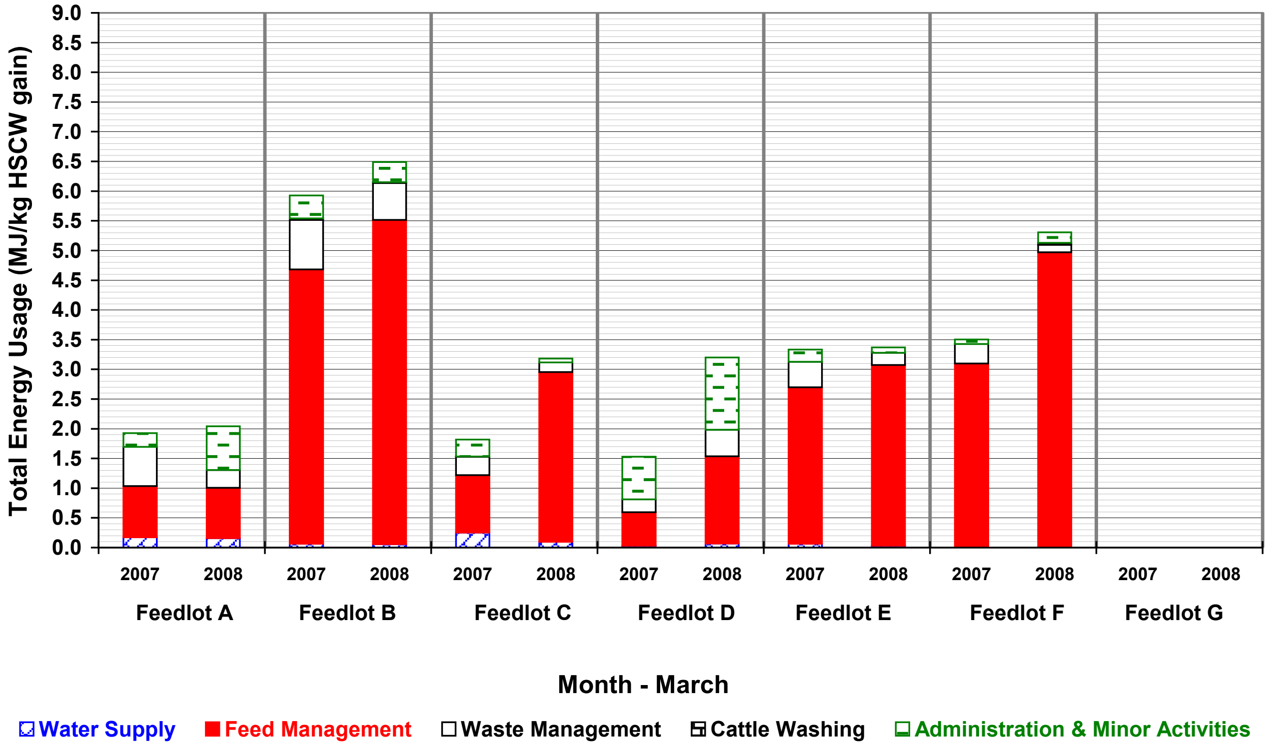

Figure 25 – Total energy usage for March (MJ/kg HSCW gain)

FIGURE 25 shows the total energy usage across all feedlots for March 2007 and March 2008. Total monthly energy use ranges from 1.5 (Feedlot D) to 6.5 MJ/kg HSCW gain (Feedlot B) and is primarily determined by the type of feed processing system in operation. Feedlots A, B and E have a similar total monthly usage, however individual usage is slightly different. Feedlots C, D and F have a greater monthly total usage in 2008 when compared with 2007 due to an increase in feed management energy usage. However, Feedlot C, in March 2007 tempered grain only, whilst in March 2008 grain was processed by steam flaking. The lowest energy usage was measured at Feedlot A (tempering) and the highest at Feedlot B (steam flaking). Feedlot B was steam flaking sorghum in 2008 compared with barley in 2007 and this explains the higher energy usage. Total energy usage was not recorded at Feedlot G during March 2007 or March 2008.

Water supply energy consumption is dependent on the type of supply and reticulation system. Feedlots may access water from deep bores (Feedlot A) or source water from greater distances (Feedlot C) than feedlots on reticulated supply (Feedlot F) and /or gravity fed reticulation systems. Water supply energy usage ranged from 0.004 to 0.25 MJ/kg HSCW gain across all feedlots.

Feed processing energy usage ranged from 0.56 (Feedlot D) to 5.5 MJ/kg HSCW gain (Feedlot B). Waste management energy usage ranged from 0.13 (Feedlot F) to 0.83 MJ/kg HSCW gain (Feedlot B). Administration and minor activities energy usage was found to range from 0.08 to 1.2 MJ/kg HSCW gain at Feedlot D in 2008. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

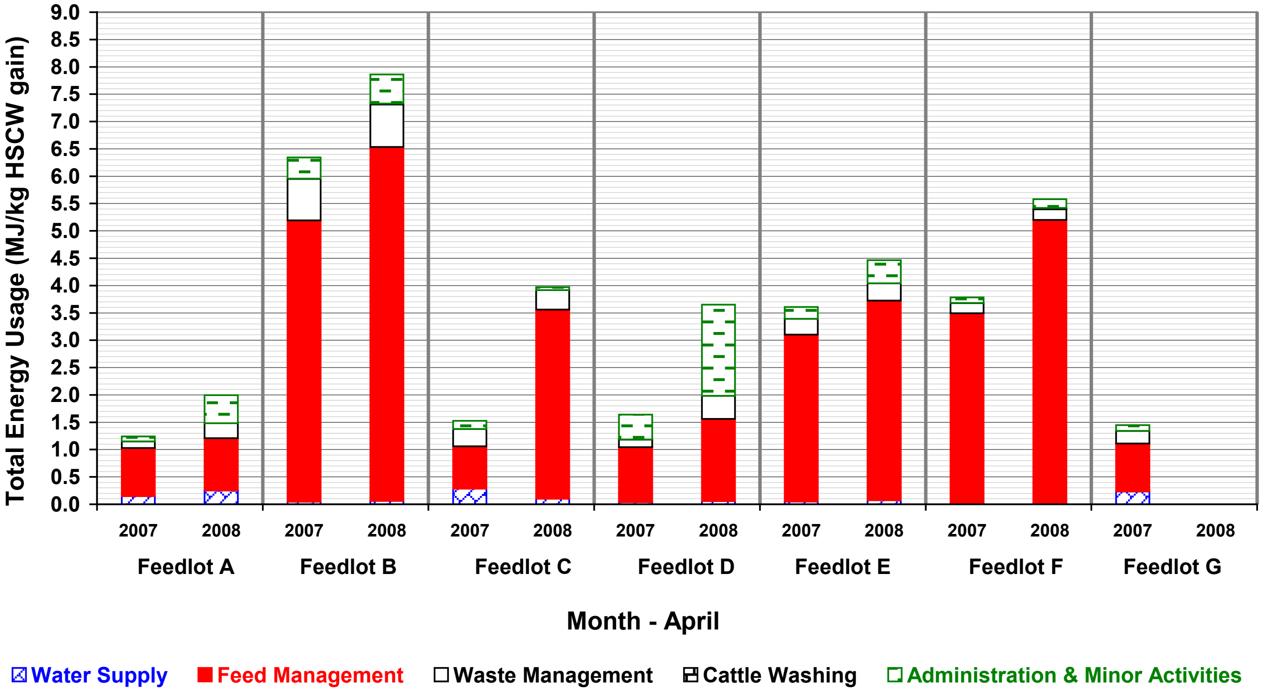

Figure 26 – Total energy usage for April (MJ/kg HSCW gain)

FIGURE 26 shows the total energy usage across all feedlots for April 2007 and 2008. No data for Feedlot G was available. Total monthly energy use ranges from 1.3 (Feedlot A) to 7.9 MJ/kg HSCW gain (Feedlot B), similar levels to March. The lowest energy usage was measured with reconstitution and tempering grain processing methods (Feedlots A, C (2007), D, G) with higher energy usage with steam flaking (Feedlots B, C (2008), E and F) as expected. Feedlot B was steam flaking sorghum in 2008 compared with barley in 2007 and this explains the higher energy usage.

Water supply energy consumption is dependent on the type of supply and reticulation system and is similar to March levels. Water supply energy usage ranged from 0.005 MJ/kg HSCW gain at Feedlot F to 0.29 MJ/kg HSCW gain at Feedlot C. Feed processing energy usage ranged from 0.77 (Feedlots A and G) to 6.5 (Feedlot B) MJ/kg HSCW gain. Waste management energy usage was similar to March levels with a range from 0.12 to 0.78 MJ/kg HSCW gain. Administration and minor activities energy usage were found to range from 0.01 to 1.6 MJ/kg HSCW gain. Feedlot D, had a very high level of administration energy usage in 2008 when compared with 2007 levels due to an increase in monthly vehicle fuel usage. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

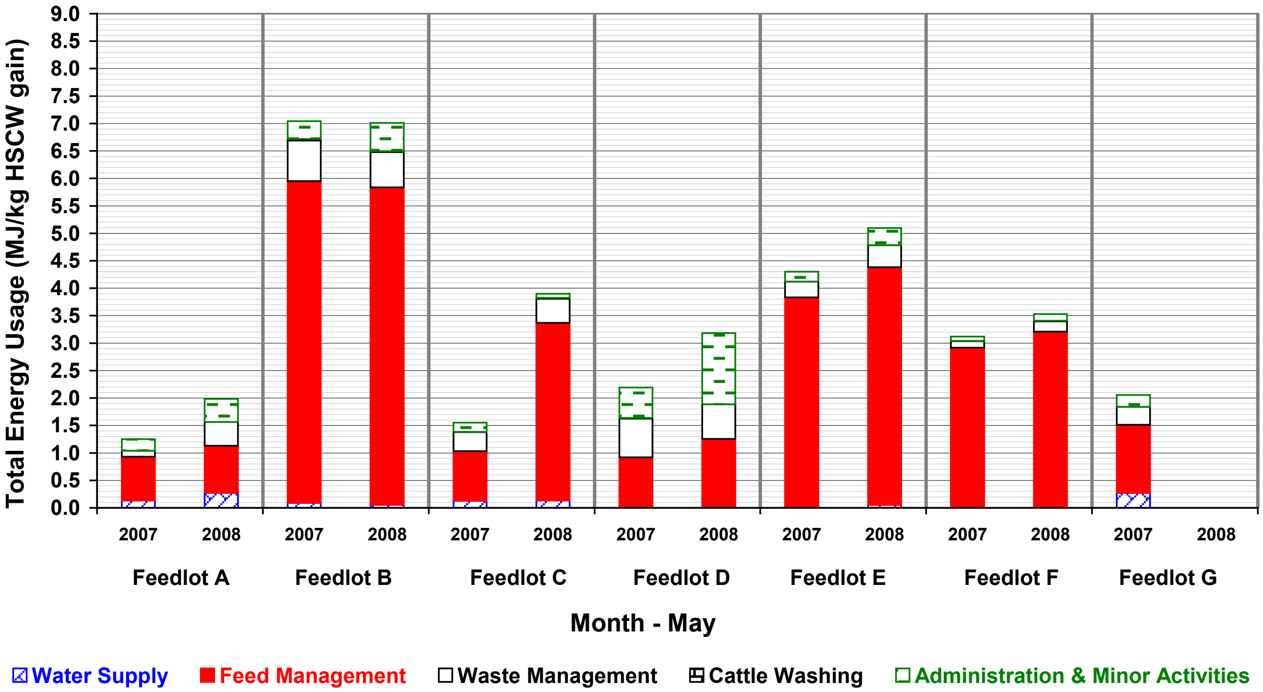

Figure 27 – Total energy usage for May (MJ/kg HSCW gain)

FIGURE 27 shows the total energy usage across all feedlots for May 2007 and 2008. Total monthly energy use ranged from 1.25 (Feedlot A) to 7.0 MJ/kg HSCW gain (Feedlot B). Feedlots B, D, E and F have similar total energy usage levels in 2008 when compared with 2007 levels.

The lowest energy usage was measured at feedlots A, C (2007), D and G (reconstitution and tempering) with higher energy usage at feedlots B, C (2008) E and F (steam flaking). Feedlots C, E and G have a lower total energy usage per kg HSCW gain than Feedlot B. Differences in market type is a plausible explanation for this, with long fed cattle at Feedlot B compared with short fed cattle at the other feedlots. For May 2007 and 2008, water supply energy usage ranged from 0.004 MJ/kg HSCW gain at Feedlot F to 0.27 MJ/kg HSCW gain at Feedlot G. Energy used in water supply has less variability between months when compared with other activities. Feed processing energy usage ranged from 0.80 (Feedlot A) to 5.8 (Feedlot B) MJ/kg HSCW gain. Waste management energy usage ranged from 0.11 to 0.74 MJ/kg HSCW gain, a similar range to April. Energy usage within administration and minor activities was found to range from 0.08 to 1.3 MJ/kg HSCW gain. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

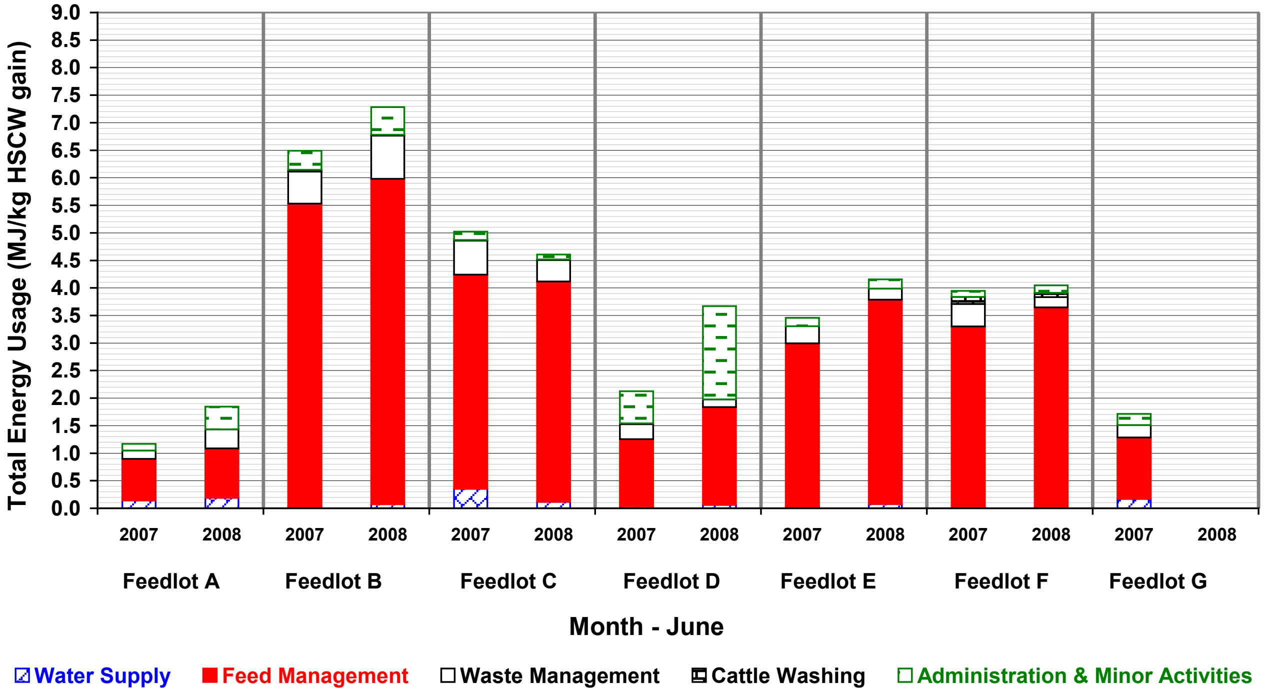

Figure 28 – Total energy usage for June (MJ/kg HSCW gain)

FIGURE 28 shows the total energy usage across all feedlots for June 2007 and 2008. Total monthly energy use ranged from 1.15 to 7.3 MJ/kg HSCW gain. The impact of an energy dominant feed processing system on total energy usage can be seen with Feedlot C. In June 2007, a steam flaking system was commissioned and hence energy usage has increased considerably from 1.6 in May 2007 to 5.0 MJ/kg HSCW gain in June 2007.

Water supply energy usage ranged from 0.007 MJ/kg HSCW gain at Feedlot F to 0.35 MJ/kg HSCW gain at Feedlot C in June 2007. Feedlot C had a substantially lower water supply energy usage in June 2008 when compared with the previous year.

Feed management energy usage was similar to May levels, with a range from 0.75 (Feedlot A) to 5.9 (Feedlot B) MJ/kg HSCW gain. Waste management energy usage ranged from 0.14 to 0.79 MJ/kg HSCW gain, a similar range to previous months. Administration and minor activities energy usage was found to range from 0.10 to 1.7 MJ/kg HSCW gain at Feedlot D. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

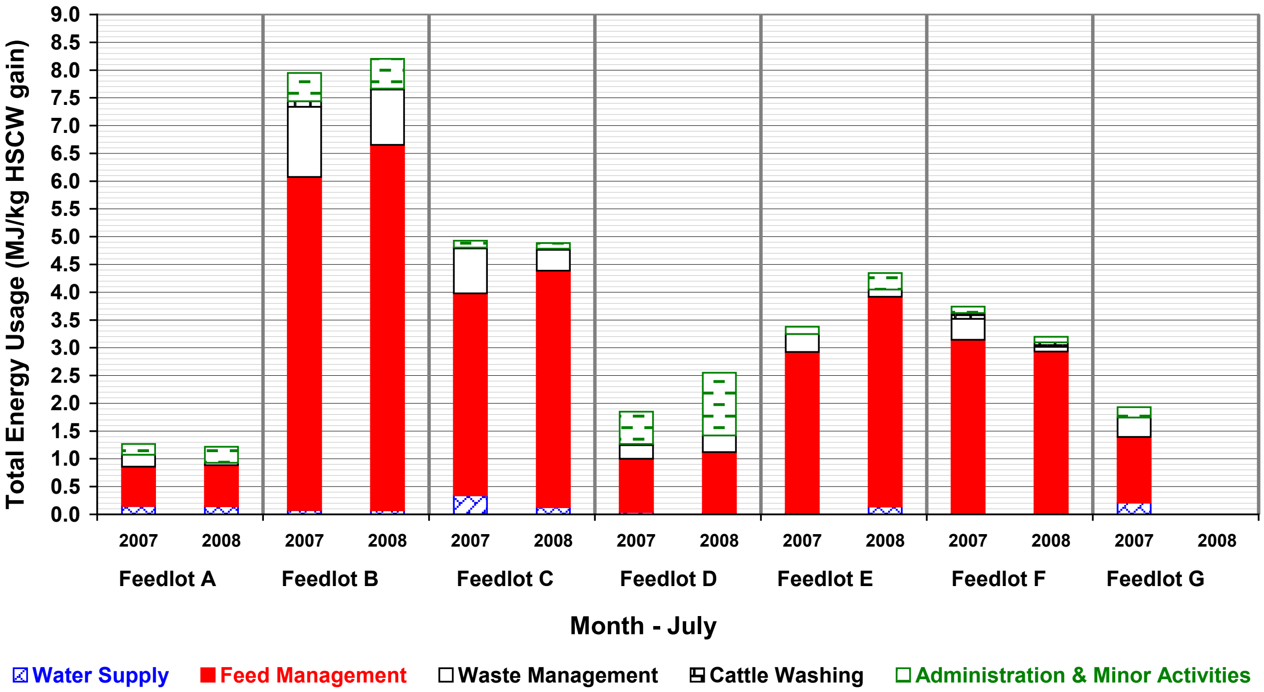

Figure 29 – Total energy usage for July (MJ/kg HSCW gain)

FIGURE 29 shows the total energy usage across all feedlots for July 2007 and 2008. Total monthly energy use ranged from 1.2 (Feedlot A) to 8.2 MJ/kg HSCW gain (Feedlot B). Feedlot B has a higher total energy usage, driven by increased feed management than previously measured, whilst Feedlot D has a lower total energy usage than previously measured. Feedlot B was steam flaking sorghum in 2008 compared with barley in 2007 and this explains the higher energy usage.

The lowest energy usage was measured at Feedlots A, D and G (reconstitution and tempering) with higher energy usage at feedlots B, C, E and F (steam flaking). For July 2007, water supply energy usage ranged from 0.01 MJ/kg HSCW gain at Feedlot F to 0.34 MJ/kg HSCW gain in 2007 at Feedlot C. Feed management energy usage ranged from 0.71 (Feedlot A) to 6.8 (Feedlot B) MJ/kg HSCW gain. Waste management energy usage ranged from 0.21 to 1.26 MJ/kg HSCW gain, a higher range than previously measured. Feedlot B and Feedlot C have a higher waste management energy usage when compared to other feedlots due to weather conditions (wet and cool).

Cattle washing has commenced for southern feedlots and energy usage ranges from 0.02 MJ/kg HSCW gain at Feedlots C and D to 0.1 MJ/kg HSCW gain at Feedlot B. Energy usage within administration and minor activities was found to range from 0.12 to 1.1 MJ/kg HSCW gain. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

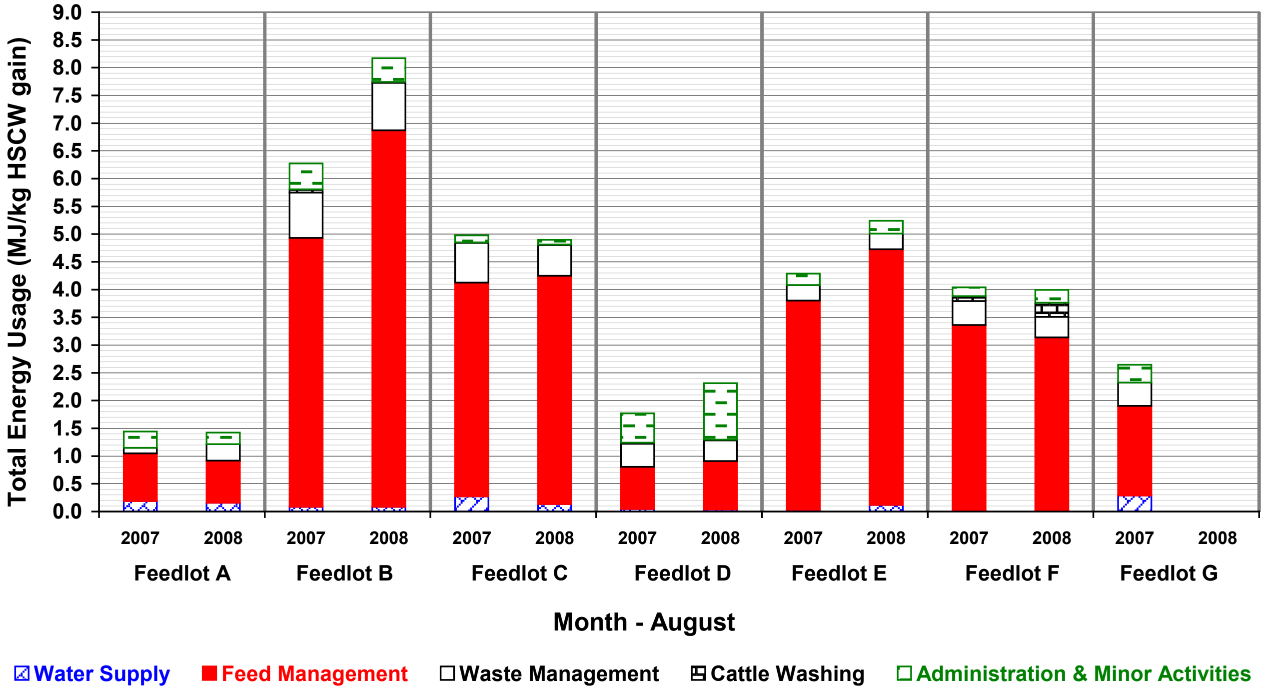

Figure 30 – Total energy usage for August (MJ/kg HSCW gain)

FIGURE 30 shows the total energy usage across all feedlots for August 2007 and 2008. Total monthly energy use ranged from 1.5 to 8.2 MJ/kg HSCW gain. In 2007, Feedlot B significantly reduced its total energy usage from 8 to 6.25 MJ /kg HSCW gain, whilst in 2008, a similar level was measured. Feedlots E and G have slightly increased their total energy usage when compared to July.

The lowest energy usage was measured at Feedlots A, D and G (reconstitution and tempering) with higher energy usage at feedlots B, C, E and F (steam flaking). There remains a large range in feed management energy usage between feedlots with steam flaking. In these feedlots, feed management energy usage ranged from an average 3.2 MJ/kg HSCW gain at Feedlot F to 5.8 MJ/kg HSCW gain at Feedlot B. Feedlot B, has a significant increase in feed management energy usage in 2008 when compared with 2007 levels due to the type of grain processed (sorghum v barley).

Water supply energy usage is similar to previous months. Waste management energy usage has the most variability between months and feedlots as this activity is dependent on climatic conditions and management strategies. For August, it ranged from 0.10 to 0.82 MJ/kg HSCW gain at Feedlot A and Feedlot B respectively. Cattle washing energy usage ranges from 0.01 MJ/kg HSCW gain at Feedlots C and D to 0.09 MJ/kg HSCW gain at Feedlot F. Energy usage within administration and minor activities was found to range from 0.09 to 1.0 MJ/kg HSCW gain. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

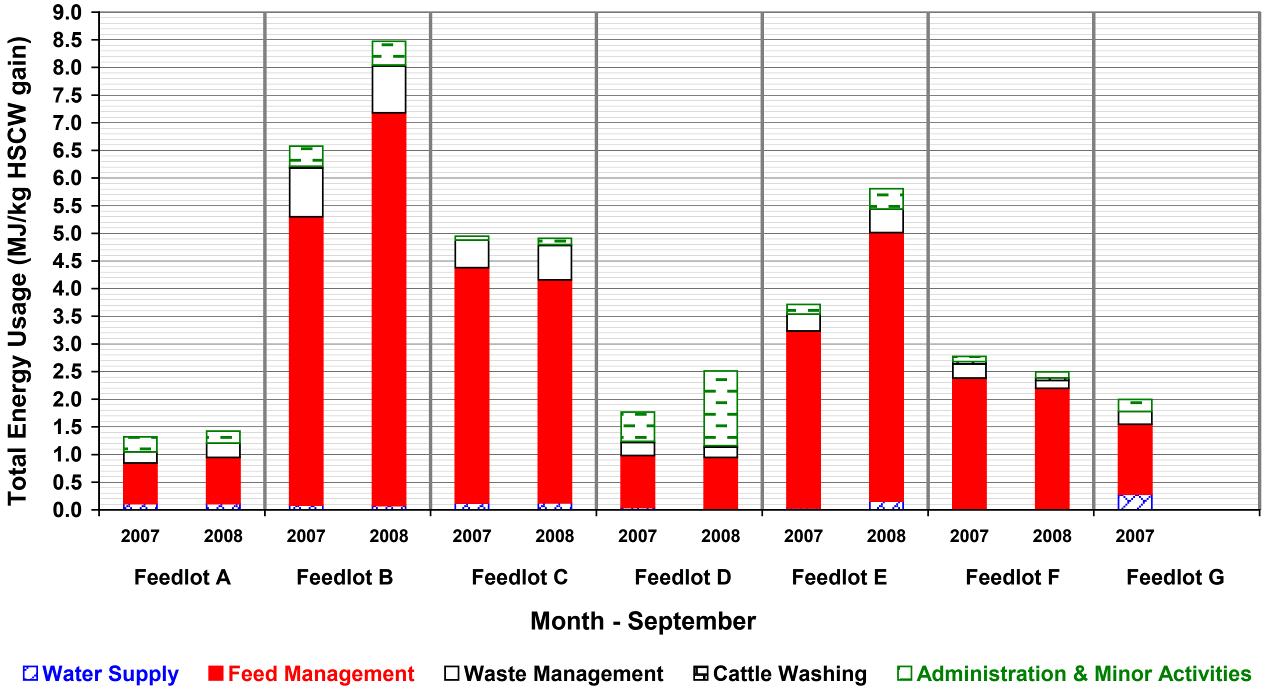

Figure 31 – Total energy usage for September (MJ/kg HSCW gain)

FIGURE 31 shows the total energy usage across all feedlots for September 2007 and 2008. Total monthly energy use ranged from 1.3 to 8.5 MJ/kg HSCW gain at Feedlot B, a similar range to August. No data is available for Feedlot G in 2008.

Water supply energy usage is similar to previous months in all feedlots. Feed management energy usage ranged from 0.73 (Feedlot A) to 7.1 (Feedlot B) MJ/kg HSCW gain. Waste management energy usage ranged from 0.2 to 0.88 MJ/kg HSCW gain, a similar range to previous months. Additionally, waste management is higher in those feedlots which experienced, cool and wet winters. Cattle washing energy usage ranges from 0.001 MJ/kg HSCW gain at Feedlot C to 0.40 MJ/kg HSCW gain at Feedlot F. Similar energy usage levels to previous months was measured within administration and minor activities and was found to range from 0.07 to 1.35 MJ/kg HSCW gain. Feedlot D has a greater administration energy usage when compared with other feedlots and previous months. This is due to electricity usage in the workshop and vehicle fuel usage. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

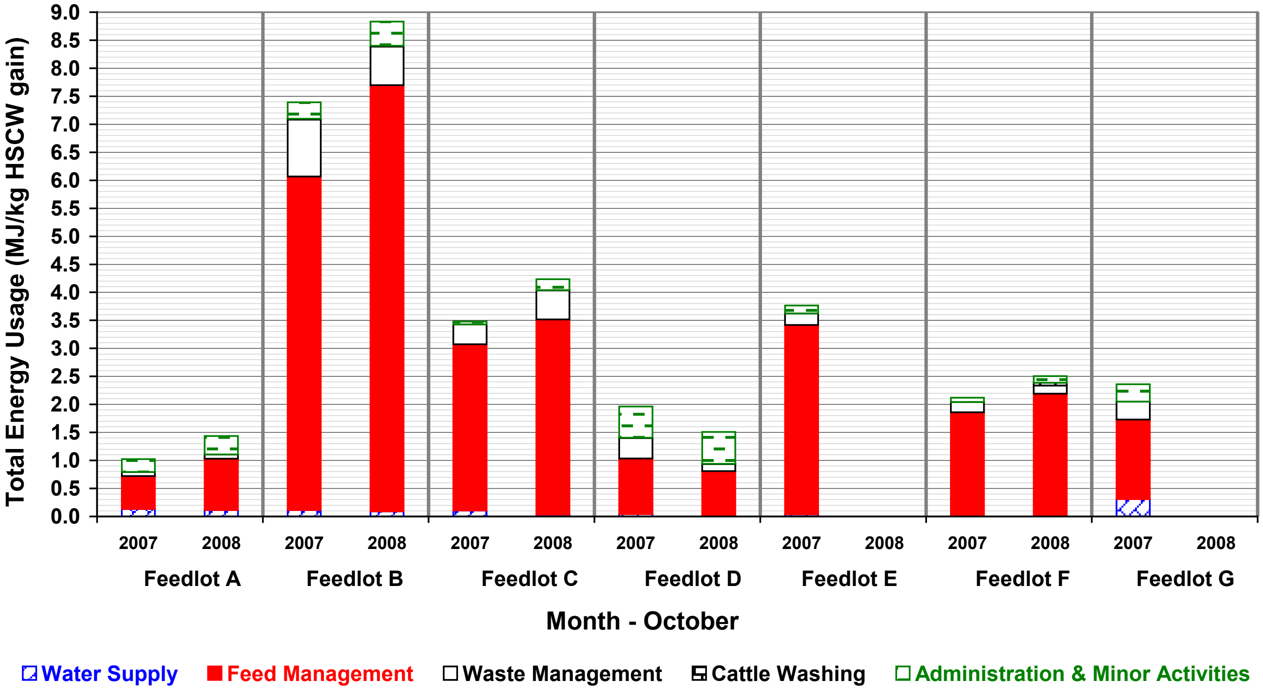

Figure 32 – Total energy usage for October (MJ/kg HSCW gain)

The total energy usage across all feedlots for October 2007 and 2008 is shown in FIGURE 32. Total monthly energy use ranged from 1 to 8.8 MJ/kg HSCW gain. Feedlot A and Feedlot B continue to have the lowest and highest total energy usage per kg HSCW gain respectively. Data from Feedlot E and G are unavailable.

Feedlots A, C, D and F have reduced their total energy usage when compared with previous months, whilst feedlot B, E and G have increased their total usage when compared with September levels.

Water supply energy usage is similar to previous months in all feedlots and ranges from 0.003 MJ/kg HSCW gain to 0.31 MJ/kg HSCW gain. Feed management energy usage ranged from 0.59 (Feedlot A) to 7.6 (Feedlot B) MJ/kg HSCW gain. Feedlot F has the lowest feed management energy usage of all feedlots who process their grain by steam flaking.

Waste management energy usage ranged from 0.07 to 1.02 MJ/kg HSCW gain at Feedlot B. Cattle washing energy usage ranges from 0.001 MJ/kg HSCW gain at Feedlot C to 0.017 MJ/kg HSCW gain at Feedlot B.

Similar energy usage levels to previous months was measured within administration and minor activities and was found to range from 0.05 to 0.5 MJ/kg HSCW gain. Feedlot B continues to record the highest total energy usage per kg HSCW gain across all the feedlots, this in part is due to this feedlot having long fed cattle with low average daily gain and processing of sorghum compared with barley in 2008. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

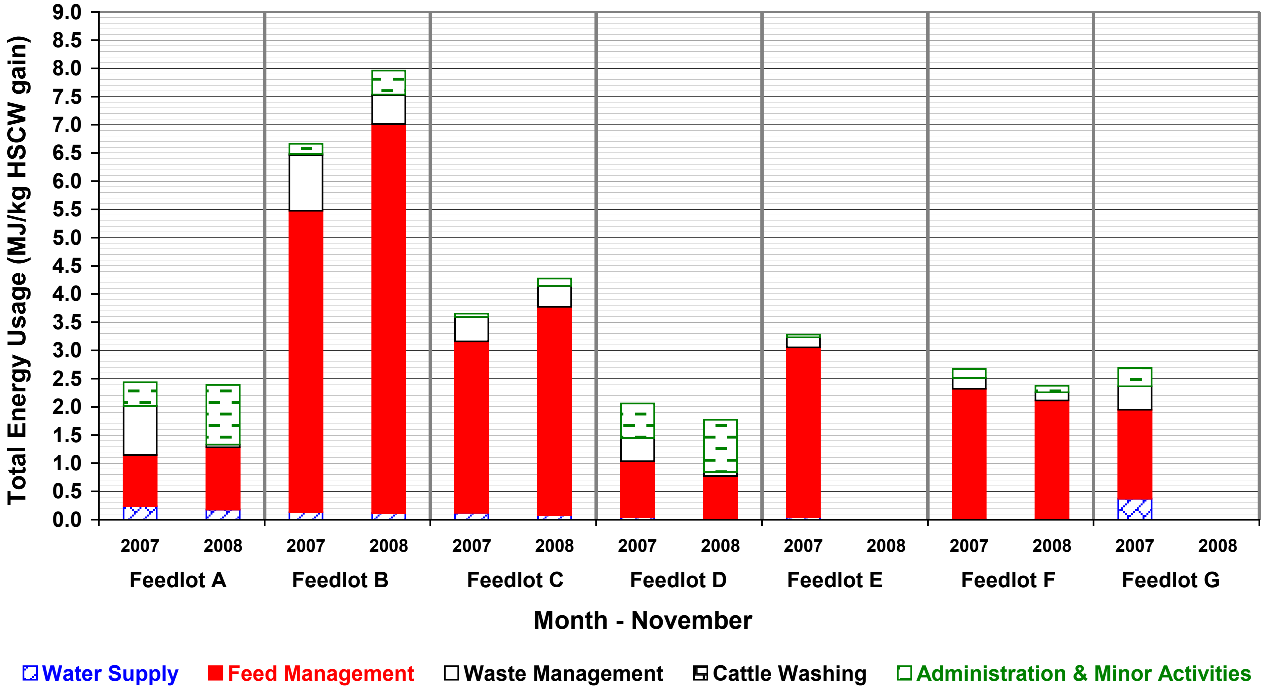

Figure 33 – Total energy usage for November (MJ/kg HSCW gain)

The total energy usage across all feedlots for November 2007 and 2008 is shown in FIGURE 33. Total monthly energy use ranged from 2.5 (Feedlot A) to 8.0 MJ/kg HSCW gain (Feedlot B). Feedlot A has doubled its energy usage from October 2007, driven by a marked increase in waste management, a resultant of the high level of pen cleaning undertaken during November 2007. Whilst, in 2008 Feedlot A has recorded a substantially greater administration energy usage than in previous months.

Feedlots F and G have slightly increased their total energy usage when compared with previous months, whilst feedlots C and D are similar. Feedlot B has reduced their total usage when compared with October levels, due to a reduction in feed management and administration and minor activities usage. Water supply energy usage is similar to previous months and ranges from 0.004 MJ/kg HSCW gain to 0.37 MJ/kg HSCW gain at Feedlot G. Feed management energy usage ranged from 0.9 (Feedlot A) to 6.9 (Feedlot B) MJ/kg HSCW gain. Waste management energy usage ranged from 0.18 MJ/kg HSCW gain at Feedlot F to 0.98 MJ/kg HSCW gain at Feedlot B. Cattle washing had ceased for the season at all feedlots except Feedlot B where a energy usage of 0.02 MJ/kg HSCW gain was measured.

Similar energy usage levels to previous months was measured within administration and minor activities and was found to range from 0.06 at Feedlot C to 0.9 MJ/kg HSCW gain at Feedlot D. Administration and minor activities energy usage is the most variable of all activities. Variability in vehicle fuel usage and workshop activities are plausible explanation for this. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

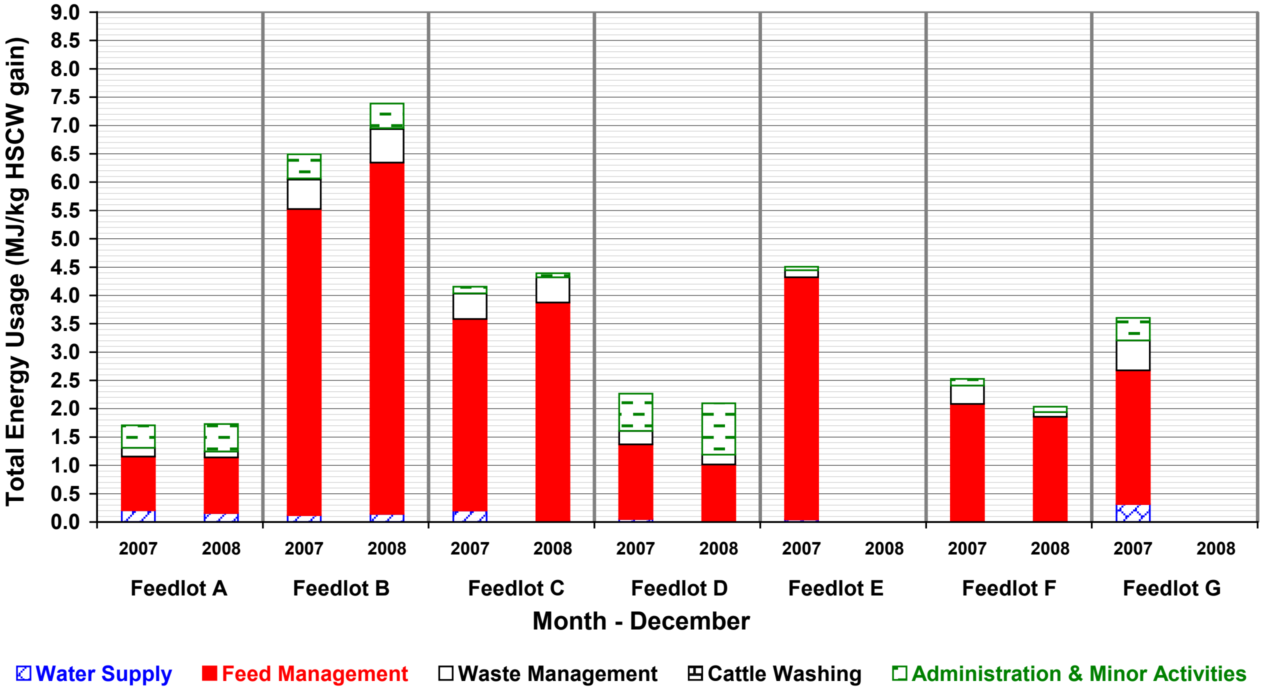

Figure 34 – Total energy usage for December (MJ/kg HSCW gain)

The total energy usage across all feedlots for December 2007 and 2008 is shown in FIGURE 34. Total monthly energy use ranged from 1.7 MJ/kg HSCW gain at Feedlot A to 7.4 MJ/kg HSCW gain at Feedlot B. The impact of lower cattle numbers on feed and hence lower HSCW gain may be contributing to the increases in total energy usage when compared with previous months at feedlots E and G. Feedlot A has reduced their total usage when compared with November levels, due to a reduction in waste management energy usage in 2007 and administration in 2008.Water supply energy usage is similar to previous months and ranges from 0.004 MJ/kg HSCW gain to 0.32 MJ/kg HSCW gain. Feed management energy usage ranged from 0.95 (Feedlot A) to 6.2 (Feedlot B) MJ/kg HSCW gain. Waste management energy usage ranged from 0.13 MJ/kg HSCW gain at Feedlot E to 0.53 MJ/kg HSCW gain at Feedlot G. In December cattle were continued to be washed at Feedlot B, where an energy usage of 0.02 MJ/kg HSCW gain was measured. Similar energy usage levels to previous months was measured within administration and minor activities and was found to range from 0.06 to 0.9 MJ/kg HSCW gain. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

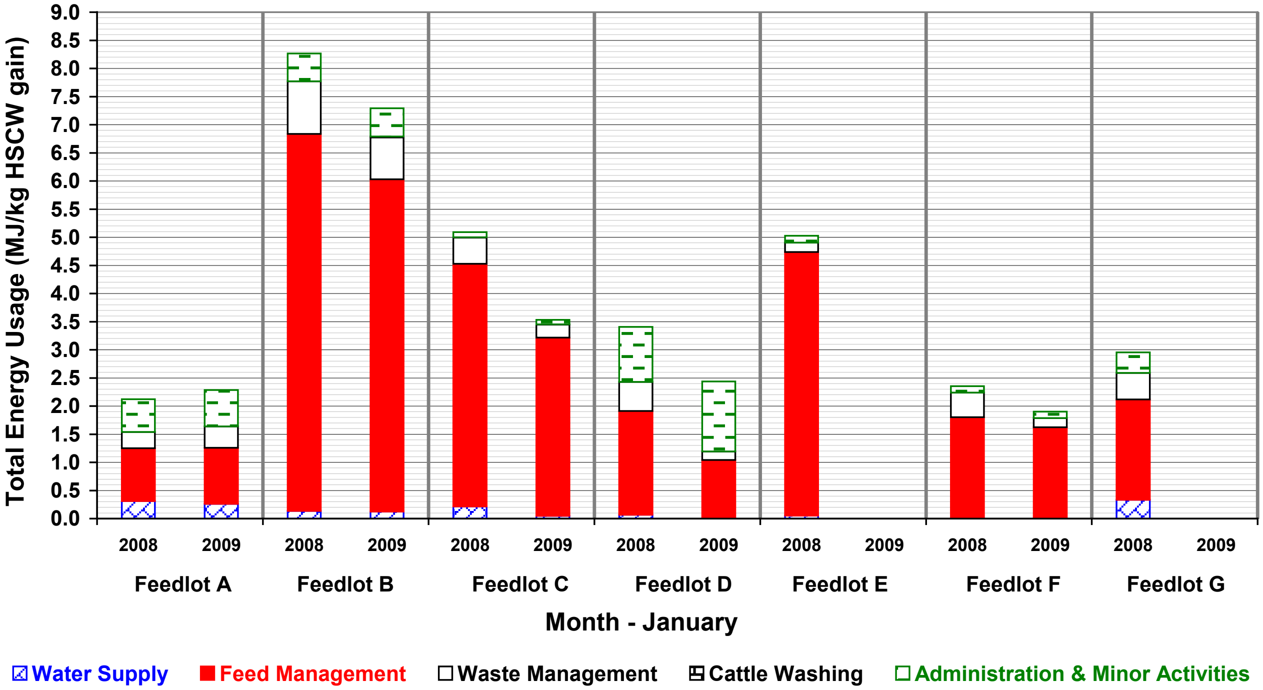

Figure 35 – Total energy usage for January (MJ/kg HSCW gain)

FIGURE 35 shows the total energy usage across all feedlots for January 2008 and 2009. Total monthly energy use ranged from 2.1 MJ/kg HSCW gain at Feedlot A to 8.25 MJ/kg HSCW gain at Feedlot B. Feedlot B has decreased their total usage from 8.3 to 7.3 MJ/kg HSCW gain when compared with 2008 levels, due to a change to a barley based ration rather than sorghum. No data is available from Feedlot E and Feedlot G.

Water supply energy usage is similar to previous months and ranges from 0.004 MJ/kg HSCW gain to 0.33 MJ/kg HSCW gain.

Feed management energy usage ranged from 0.94 (Feedlot A) to 6.7 (Feedlot B) MJ/kg HSCW gain. Waste management energy usage ranged from 0.17 MJ/kg HSCW gain at Feedlot E to 0.94 MJ/kg HSCW gain at Feedlot B.

In 2008, all feedlots had ceased cattle washing by January. However, Feedlot B continued to wash cattle in January 2009. Similar energy usage levels to previous months was measured within administration and minor activities and was found to range from 0.09 to 1.2 MJ/kg HSCW gain.

For Feedlots A, D and E, hotter temperatures in January 2008 have led to an increase in administration (cooling) energy usage. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

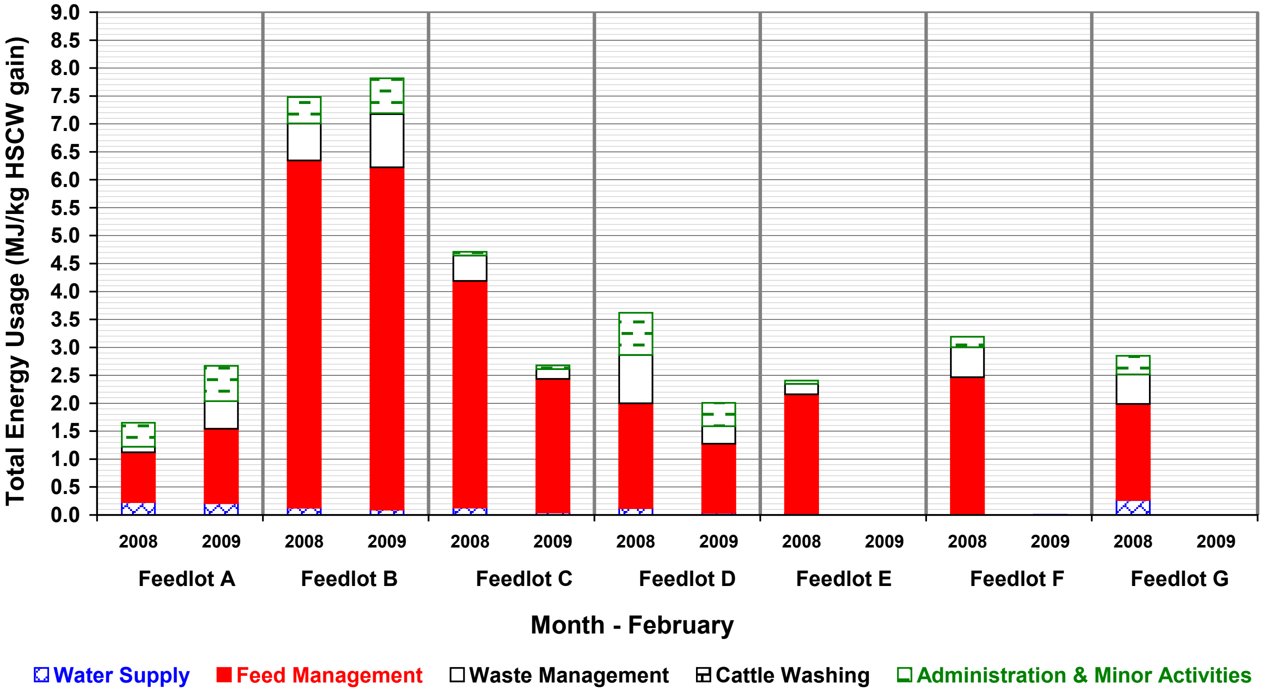

Figure 36 – Total energy usage for February (MJ/kg HSCW gain)

Figure 36 shows the total energy usage across all feedlots for February 2008 and 2009. Total monthly energy use ranged from 1.6 MJ/kg HSCW gain at Feedlot A to 7.9 MJ/kg HSCW gain at Feedlot B. In 2008, Feedlot E has almost halved their total energy usage for February when compared to January levels. This is due to a large increase in cattle numbers on feed and hence, HSCW gain for this month.

Water supply energy usage is similar to previous months and ranges from 0.004 MJ/kg HSCW gain to 0.27 MJ/kg HSCW gain. Feed management energy usage ranged from 0.89 (Feedlot A) to 6.2 (Feedlot B) MJ/kg HSCW gain. Waste management energy usage ranged from 0.1 MJ/kg HSCW gain at Feedlot A to 0.95 MJ/kg HSCW gain at Feedlot D. Cattle were continued to be washed only at Feedlot B in February 2009. Administration and minor activities energy usage levels had reduced slightly in February when compared to January readings and were found to range from 0.06 to 0.75 MJ/kg HSCW gain. For Feedlots A, D and E, cooler temperatures in February 2008 led to a decrease in administration (cooling) energy usage when compared with January 2008. Further discussion on activity energy usage is presented in Sections 4.3 to 4.7.

The monthly variation and variation between feedlots when standardised on a per kg of HSCW can be attributed to a number of factors. These include the design and layout of the water supply system, feed processing and feed delivery system, cattle market types (short fed v long fed) and management operations. Energy usage is less dependent on climatic variation when compared with water usage. Further discussion on individual activity energy usage is presented in the following sections.

4.3 Water supply energy usage

FIGURE 37 illustrates the average water supply energy consumption on a MJ/head-on-feed/month basis for the seven feedlots. Water supply energy usage was divided into supply (delivery from source) and reticulation around the feedlot (secondary pumping). The water supply systems ranged from combinations of delivery and gravity fed to delivery and reticulation. No data was available from Feedlot D in 2008-2009.

The minimum and maximum energy usage per head for any one month is presented. Note that feedlot numbering in this section does not match the numbering in previous sections to maintain anonymity for the participating feedlots. Whilst a summary is provided in this section, complete individual feedlot monthly water supply energy usage figures on a per head basis are presented in Appendix A.

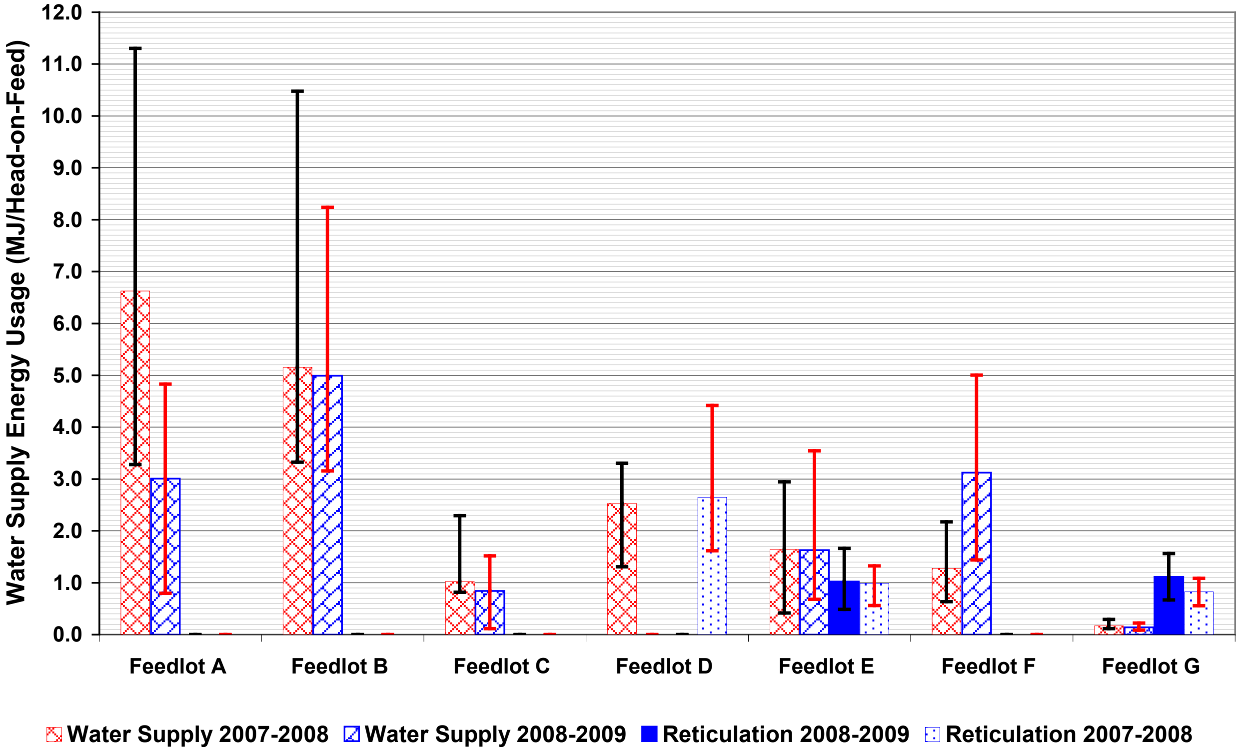

Figure 37 – Water supply energy usage (MJ/head-on-feed/month)

The average water supply energy usage across all feedlots between March 2007 and 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. The average water supply energy usage across all feedlots between March 2008 and February 2009 ranged from 0.04 MJ/head-on-feed/month at Feedlot G to 5.0 MJ/head-on-feed/month at Feedlot B. Feedlot A recorded a significant reduction in water supply energy usage in 2008-2009 when compared with 2007-2008. Feedlot F recorded a doubling of water supply energy usage in 2008-2009, explained by the commissioning of a series of bores to supplement their water supply.

The data presented is based on total kWh used in water supply and or reticulation. In most cases, total kWh is made up of a combination of off-peak and peak electricity tariffs. Therefore, only an approximate cost of supply can be gained from this figure, if desired.

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. Feedlot A had the highest average water supply energy consumption due to sourcing its water from a number of bores located some distance to the feedlot and pumping against high head. However, a significant reduction in energy usage has been realised through sourcing water from one bore closer to the feedlot.

Feedlots A, B, C and F have gravity fed water reticulation systems. Feedlot D demonstrates the additional energy usage with having to deliver water to the pens via a pumping system compared with a gravity supply system. In this case, energy consumed in delivering water to the pens is greater than supplying water to buffer storage facilities. Future consideration should be given to gravity supply if possible. For example, an energy usage of 2.5 MJ/head-on-feed/month for a feedlot with 10,000 head-on-feed will utilise 300000 MJ/year or approximately 83,000 kWh in direct electricity usage. At 0.15c/kWh, this equates to about $12,500/year.

An indication of the monthly variability in water supply energy usage can be gained through comparison of the maximum, minimum and average consumption levels. FIGURE 37 shows that the majority of feedlots, with the exception of feedlots C, D, E, F and G, have a degree of variability in energy usage. Feedlots A and B have large range between the lowest and highest monthly energy usage. This variability can be explained by the climatic variation between months and water usage requirements. Hence, as water usage increases so does the energy required to supply.

4.4 Feed management energy usage

Feed management energy usage has been proportioned into feed processing and feed delivery usage. The energy used within each respective activity is presented in the following sections.

4.4.1 Feed processing energy usage

FIGURE 38 illustrates the average feed management processing energy usage on a dry matter tonne of grain processed basis for the seven feedlots. In this section, as feed processing energy used is expressed on a per dry matter tonne of grain basis, it only includes the electricity and gas used in grain storage, movement and preparation. It does not include the energy used in tub grinding. Energy used in tub grinding is included in Appendix C, Section C.1.

The minimum and maximum feed processing water usage on a dry matter tonne of grain processed basis for any one month is also presented. The feedlot numbering in this section does not match the numbering in previous sections to maintain anonymity for the participating feedlots. Whilst a summary is provided in this section, complete individual feedlot monthly feed processing energy usage on a MJ used per tonne of ration (including tub grinding) and dry matter grain processed basis are presented in Appendix C, Section C.1.

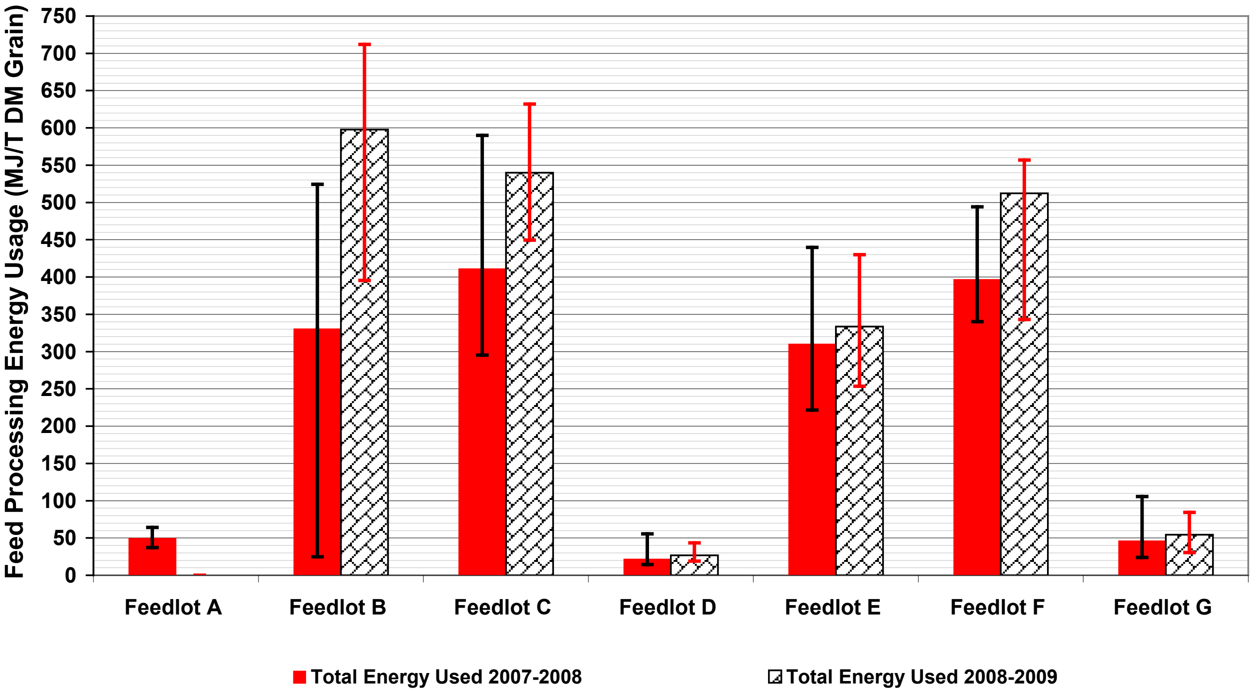

Figure 38 – Total feed processing energy usage (MJ/T DM grain)

Feed processing energy usage is the largest single consumer of energy in feedlots. The average monthly feed processing energy usage measured ranges from 25 (Feedlot D) to 600 MJ/t dry matter grain processed at Feedlot B. 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. This accounts for the large range in monthly usage. For feed processing systems other than steam flaking, average energy usage is typically less than 50 MJ/t dry matter grain processed. For steam flaking, the total energy usage ranges from 310 to 600 MJ/t dry matter grain processed. 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 B, 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. Similarly, Feedlot B commissioned a steam flaker in July 2007 and this explains the increased usage in 2008.

An indication of the monthly variability in feed processing energy usage can be gained through comparison of the maximum, minimum and average consumption levels. FIGURE 38 shows that, at the majority of feedlots with the exception of feedlots A, D and G, there is a large variability in energy usage. In some cases, e.g. Feedlot C in 2007, there can be up to a 100 % difference between the minimum and maximum monthly usage. The doubling of energy usage in Feedlot B between 2007 and 2008 can be explained by a change from tempering to steam flaking the study period.

Feedlot A, D and G have a consistent usage with only one or two months of high usage. For steam flaking systems, a review of individual feedlot monthly feed processing data from Appendix C.1, indicates there is 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. Additionally, it would appear that management of the boiler (operational efficiency) and steam system and type of grain processed are important factors which contribute to total feed processing usage levels. Feedlot E has a consistently lower feed processing energy usage than other feedlots with steam flaking systems.

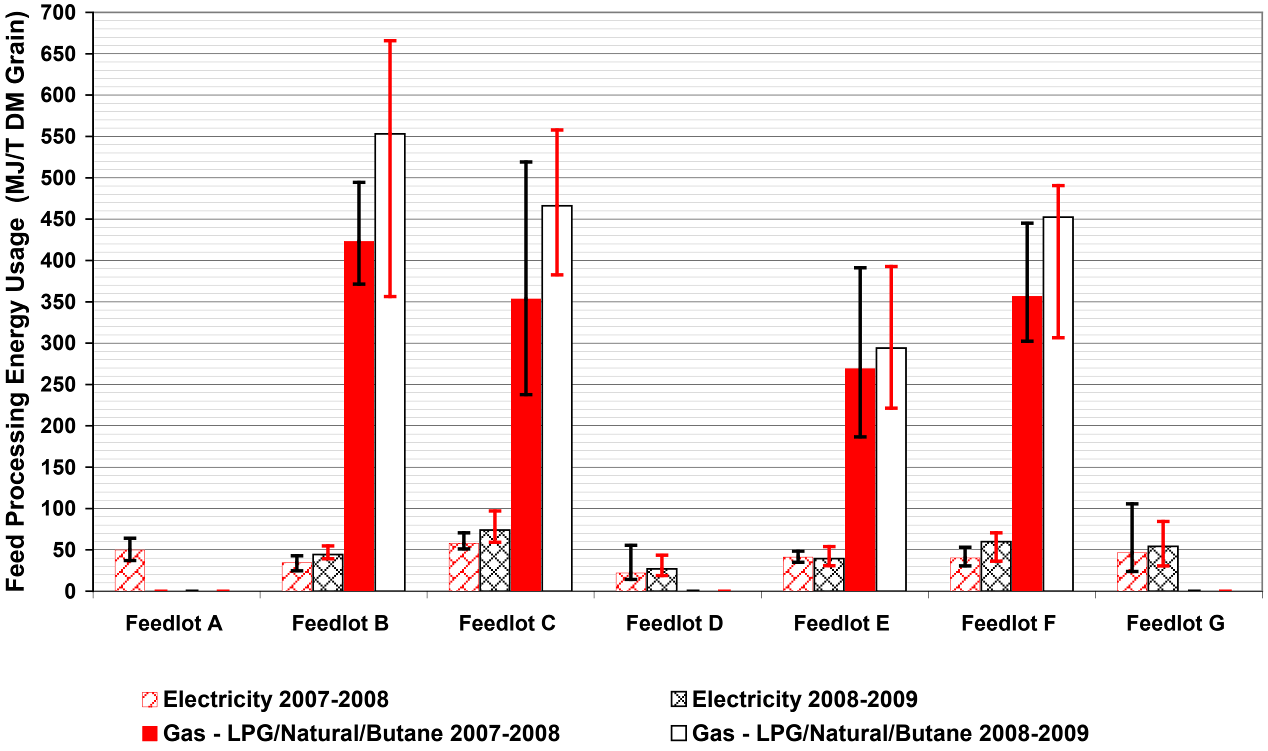

Figure 39 – Feed processing component energy Usage (MJ/T grain)

At all feedlots, the feed processing energy usage was able to be divided into that consumed in electricity usage (grain delivery, movement and milling) and gas usage for boiler fuel in steam flaking systems. Note that the feedlot numbering in FIGURE 39 is consistent with the numbering in FIGURE 38. FIGURE 39 illustrates the average feed processing component energy usage on a dry matter tonne of grain-processed basis for the seven feedlots.

The average monthly feed processing electricity energy usage measured ranges from 20 to 75 MJ/t dry matter grain processed over the study period. Feedlots A, B, E and G had similar average electricity energy usage around 40 to 50 MJ/t dry matter grain in 2007-2008. Feedlot C recorded a lower energy usage in 2007-2008 (60 MJ/t dry matter grain) than 2008-2009 (75 MJ/t dry matter grain). This can be attributed to additional grain movement equipment required with the steam flaking system. Feedlot F has a usage of 40 MJ/t dry matter grain in 2007-2008 and 60 MJ/t dry matter grain in 2008-2009. The higher energy usage in 2008-2009 can be attributed to the processing of sorghum throughout that year compared with barley in 2007-2008. Additionally, the commissioning of a liquid supplements and batch-box system in June 2008 will have added to the electricity usage in feed processing. Feedlot E had very similar average monthly energy per tonne dry matter grain processed in 2008-2009 and 2007-2008.

The variation in electricity energy usage may be attributed to monthly variation in grain delivery, movement and storage and milling efficiency (tonnes per mill). Note that in the majority of feedlots, the electricity used in grain delivery and storage could not be partitioned from total feed mill electricity usage. Additionally, the type of grain processed has a great impact on feed processing energy usage. Steam flaking sorghum is a slower process compared with barley, hence energy per tonne of grain increases.

For steam flaking systems, the average gas energy usage measured ranged from 270 to 555 MJ/t dry matter grain processed. Feedlots B, C and F had a significantly higher average monthly usage in 2008-2009 when compared with 2007-2008.

There were three types of gases used within the four feedlots with steam flaking systems. These included LPG - Propane, LPG - Butane and natural gas. All of these gas sources have different calorific values (heating content) and pricing structures. Some of the variation in gas usage can be attributed to boiler and steam system efficiency during winter months.

4.4.2 Feed delivery energy usage

FIGURE 40 illustrates the average feed delivery energy usage on a tonne of ration delivered for the seven feedlots. In this section, feed delivery energy use comprises electricity used by stationary mixers, diesel consumed by loaders during feed loading and by feed trucks delivering ration to pens where appropriate.

The minimum and maximum feed processing energy usage on a tonne of ration delivered basis for any one month is presented. The feedlot numbering in this section is consistent with the numbering is Section 4.4.1. Whilst a summary is provided in this section, complete individual feedlot monthly feed delivery energy usage on a MJ used per tonne of ration delivered basis are presented in Appendix C, Section C.2.

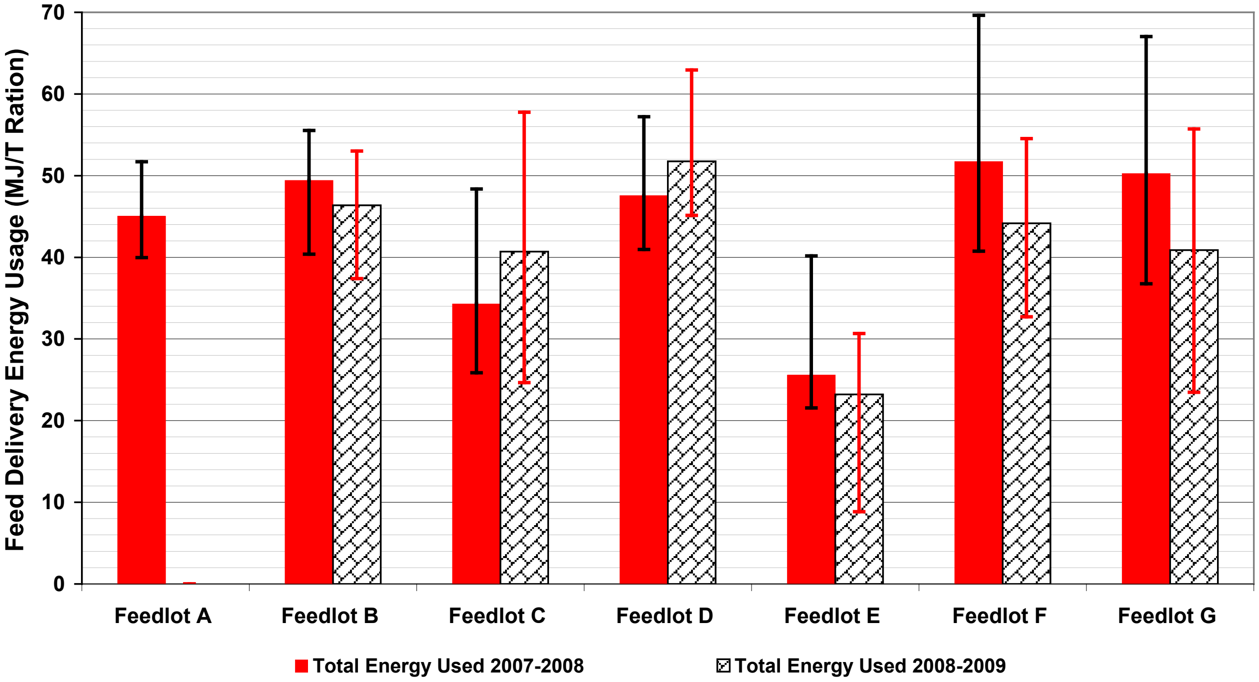

Figure 40 – Total feed delivery energy usage (MJ/t ration)

The average feed delivery energy usage measured ranges 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-boxes 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 feed delivery energy usage measured range 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 have reduced their average monthly feed delivery energy usage in 2008-2009 when compared with 2007-2008 levels. Feedlot C and D have increased energy usage. This may be a reflection of lower cattle numbers on feed and distribution of cattle throughout the feedlot.

Feedlot E uses, 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 is 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 is similar to Feedlot E along with a similar density ration. Feedlot E delivers a higher density finisher rations 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 has translated into a significant reduction in average monthly energy usage as shown in FIGURE 40. The monthly variation in energy usage can be found in Appendix C, Section C.2 with further comparative data shown in the case study fact sheet CS4.

An indication of the monthly variability in feed processing energy usage can be gained through comparison of the maximum, minimum and average consumption levels. FIGURE 40 shows that, at the majority of feedlots with the exception of Feedlot E, there is a large variability in energy usage. In some cases, such as Feedlots C and D, there is close to a 100 % difference between minimum and maximum monthly usage.

The results from the feed delivery energy usage figures show that there appears to be little energy efficiency gained from economies of scale with larger feedlots. However, Feedlot F has clearly gained an overall reduction in energy usage through the changes implemented to their feed delivery system (ie a batch-box system, larger capacity loader, liquid supplement system).

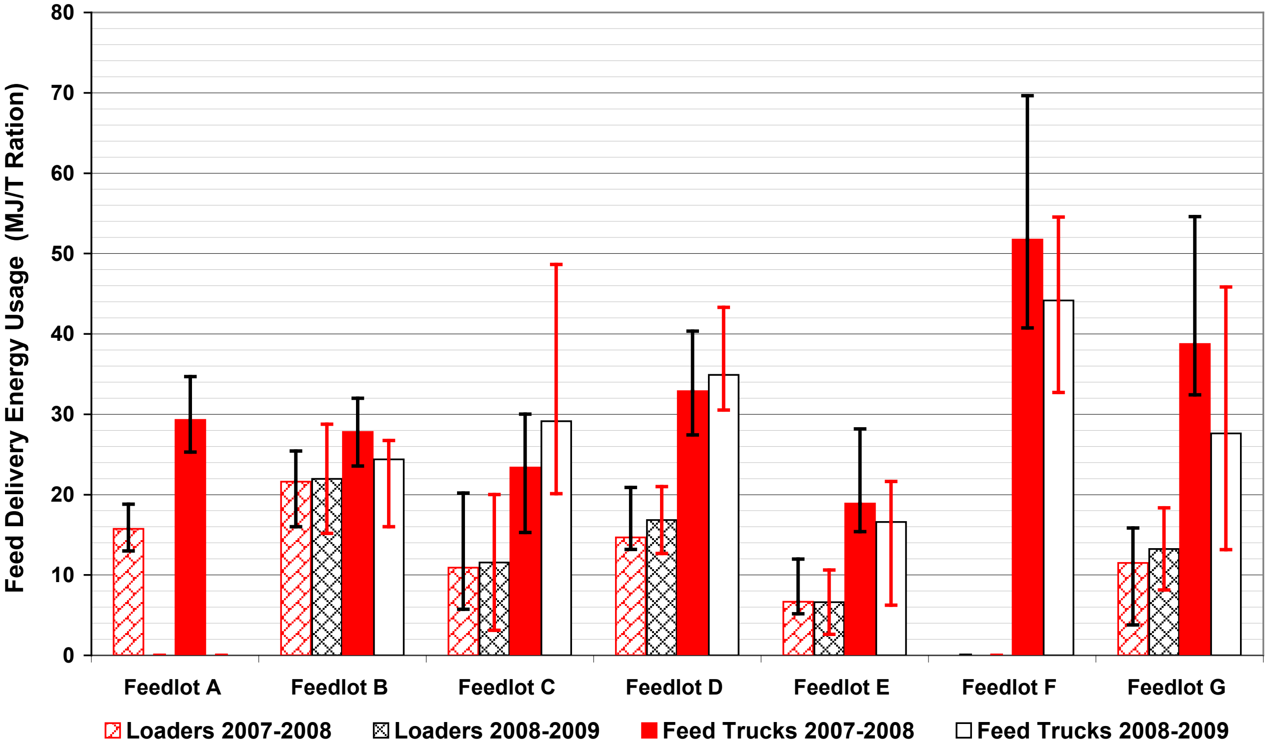

Figure 41 – Feed delivery component energy usage (MJ/t ration)

At all feedlots, with the exception of Feedlot F, 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. Data for Feedlot A was not available in 2008-2009. The feedlot numbering in FIGURE 41 is consistent with the numbering in FIGURE 40. FIGURE 41 illustrates the average feed delivery component energy usage on a tonne of ration delivered for the seven feedlots.

The average energy usage by loaders ranges from 7 to 22 MJ/t ration delivered. 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 energy levels for loaders between years are similar as expected.

The average energy usage by feed delivery equipment ranges from 17 (Feedlot E) to 39 MJ/t ration delivered (Feedlot G in 2007). 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.

A number of different feed delivery systems are represented within the seven feedlots. This includes stationary mixing, bunker system, batch-boxes 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.

Whilst it is appreciated that mobile equipment is selected based on a number of criteria, it would appear that the major drivers of feed delivery energy usage are the type of feed delivery system, feed-out strategy and distribution of cattle within the feedlot during periods of lower capacity.

For example, an energy saving of 5 MJ/t ration for a feedlot delivering 100,000 t of ration per year, will reduce energy usage by 500000 MJ/year or approximately 12 kL in diesel usage. At 1.50 c/L, (including rebate) this equates to about $18,000/year.

4.5 Waste management energy usage

FIGURE 42 illustrates the average waste management energy usage on a head-on-feed basis for the seven feedlots. Whilst standardising energy usage on a tonne of manure basis may be more appropriate, this information was not collected from each feedlot. Note that in this section, waste management energy use comprises diesel consumed by mobile plant in pen cleaning, manure stockpiling and manure spreading. Where these activities are undertaken by contractors, their fuel has been included.

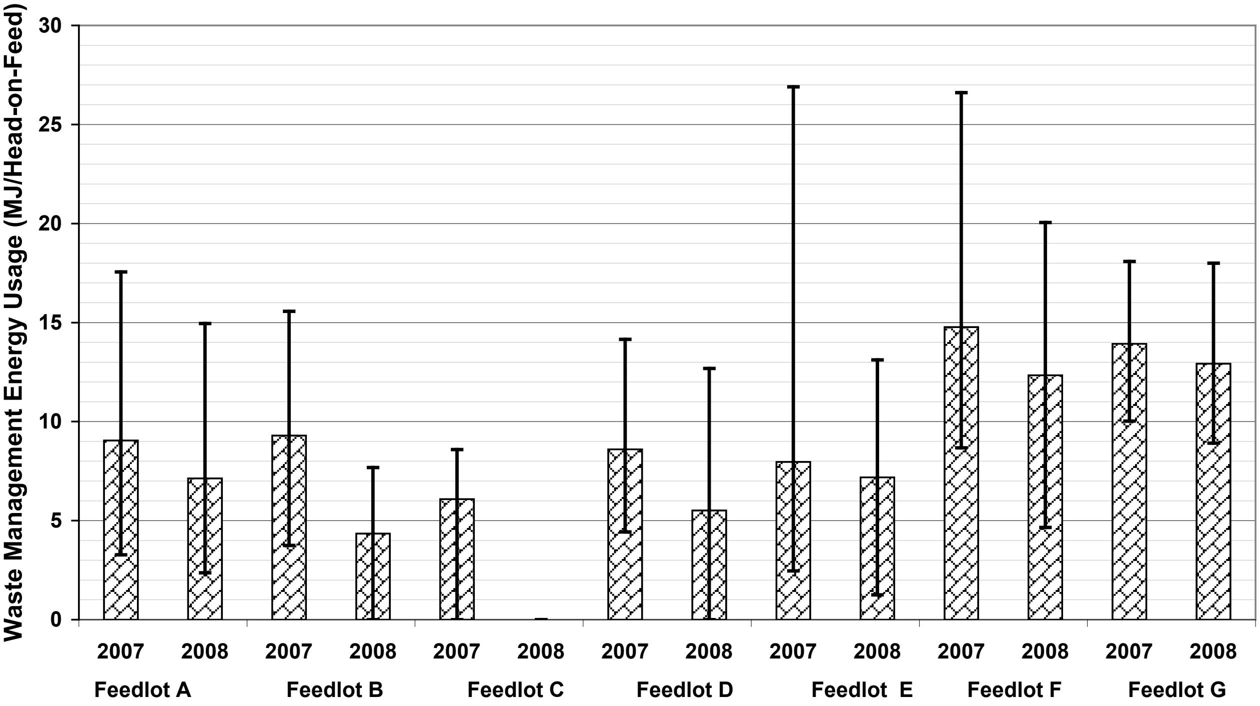

Figure 42 – Total waste management energy usage (MJ/head-on-feed/month)

The average waste management energy usage ranges 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 is driven by the frequency of cleaning, equipment used and the volume of manure removed. There is 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.

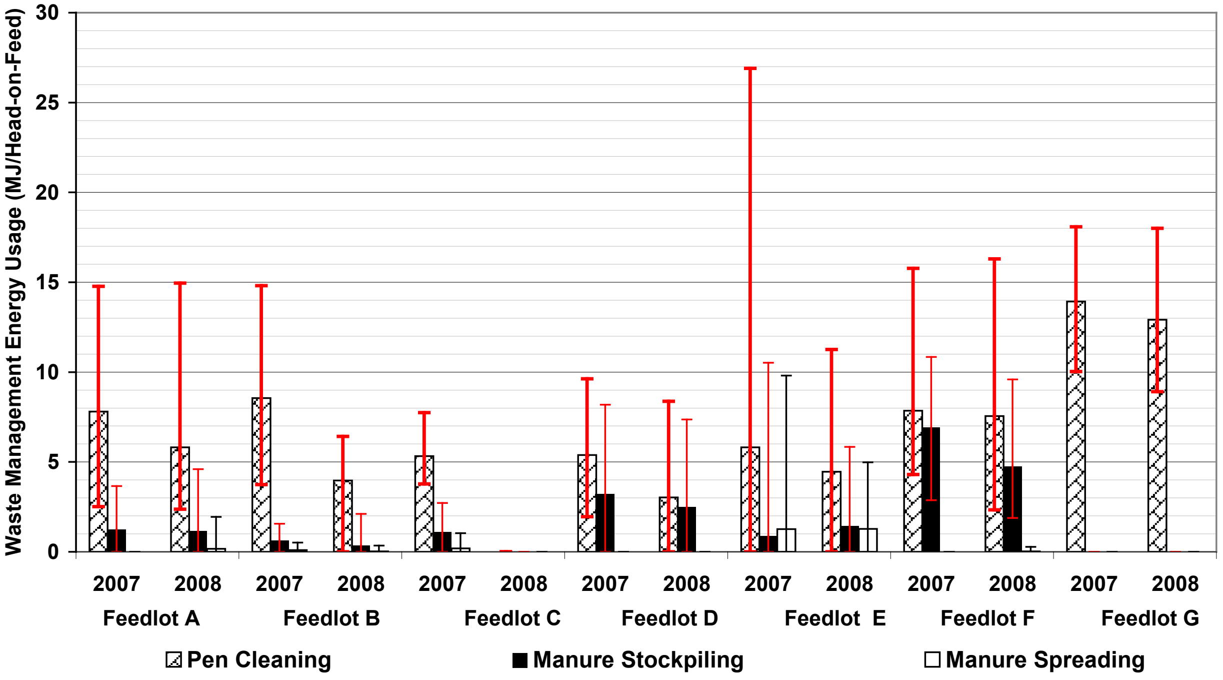

Figure 43 – Waste management energy usage (MJ/head-on-feed/month)

FIGURE 43 illustrates the average waste management component energy usage on a MJ/head-on-feed/month basis for the seven feedlots during the study period. Energy use for pen cleaning, manure stockpiling and manure spreading was able to be determined for all feedlots, with the exception of Feedlot G. At Feedlot G, pen cleaning energy usage also includes energy used to transport manure to the stockpile. Where these activities are undertaken by contractors, their fuel has been included.

As expected, pen cleaning contributed the highest proportion of the total 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 average monthly 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.

Manure stockpiling represents on average around 15% of the total energy usage. At Feedlots D and F, stockpiling is 38 and 45% respectively. Feedlots B, C and E reported manure spreading during the study period. For Feedlot E, manure spreading energy usage was slightly higher than manure stockpiling energy usage. The variation between feedlots can be attributed to the various manure management systems employed at each feedlot. It is driven by the frequency of cleaning, equipment used and the volume of manure removed.

4.6 Cattle washing energy usage

FIGURE 44 illustrates the average energy usage during cattle washing on a MJ per head washed basis for the seven feedlots. Feedlot C and Feedlot D do not wash cattle and Feedlot E did not wash any cattle during the study period. The minimum and maximum energy usage per head washed for any one month is presented. The feedlot numbering in this section does not match the numbering in previous sections to maintain anonymity for the participating feedlots. Whilst a summary is provided in this section, complete individual feedlot monthly cattle washing energy usage on a per head basis for the individual feedlots are presented in Appendix E.

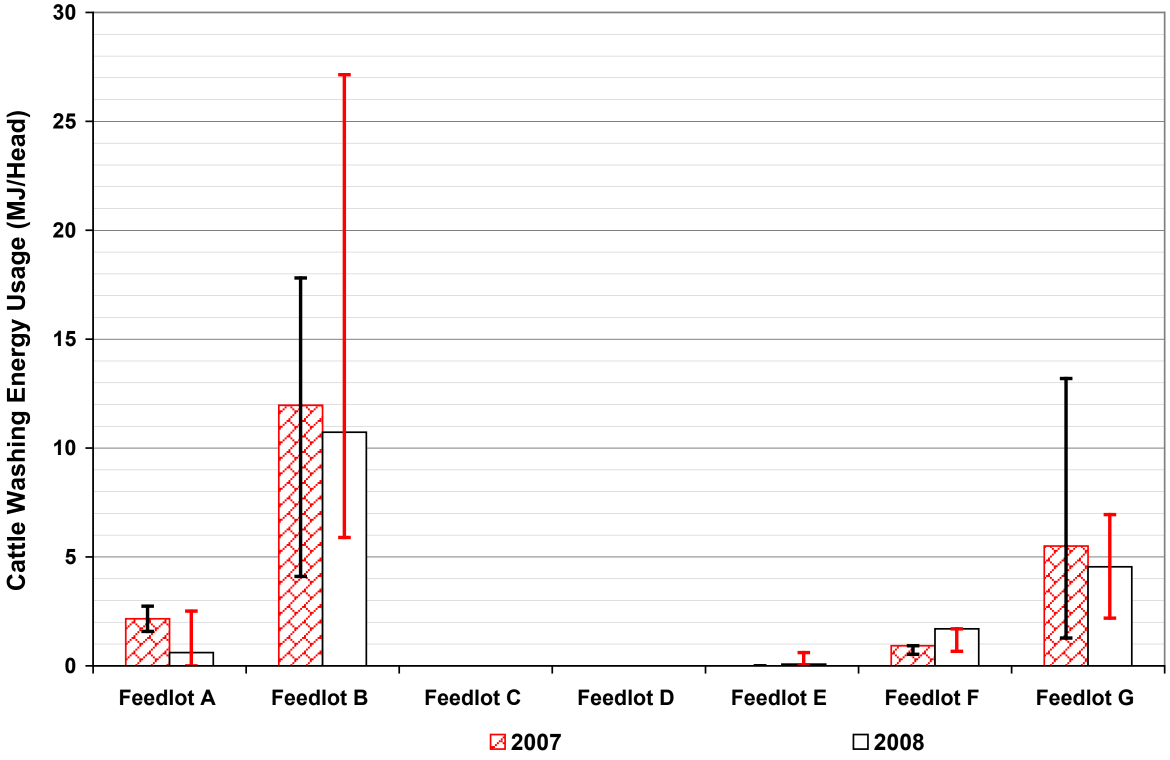

Figure 44 – Cattle washing energy usage (MJ/Head washed)

The average cattle washing energy usage measured in 2007 ranged from 1 MJ/head washed at Feedlot F to 12 MJ/head washed 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 reflects the drier conditions experienced and therefore reduced cleaning requirements for cattle.

The predominant energy source is electric but an electric and diesel powered pumping system is used at Feedlot B. The energy usage is directly proportional to the volume of water pumped and the energy source. For example, Feedlot G uses more water on average per head than Feedlot B, however energy usage is half that used when compared with Feedlot B. This is due to one litre of diesel having a higher energy conversion than one kWh. The variability between feedlots A, F and G is directly related to respective water used in each feedlot.

4.7 Administration and minor activities energy usage

FIGURE 45 illustrates the average administration energy usage on a MJ per full time staff equivalent basis for the seven feedlots. In this context, administration energy usage is only that electricity used in the office facilities and weighbridge. The minimum and maximum administration usage per full time staff equivalent for any one month is presented. The feedlot numbering in this section does not match the numbering in previous sections to maintain anonymity for the participating feedlots. Whilst a summary is provided in this section, complete details of the monthly administration energy usage on a MJ per kg HSCW gain basis for the individual feedlots are presented in Appendix E, Section E.1.

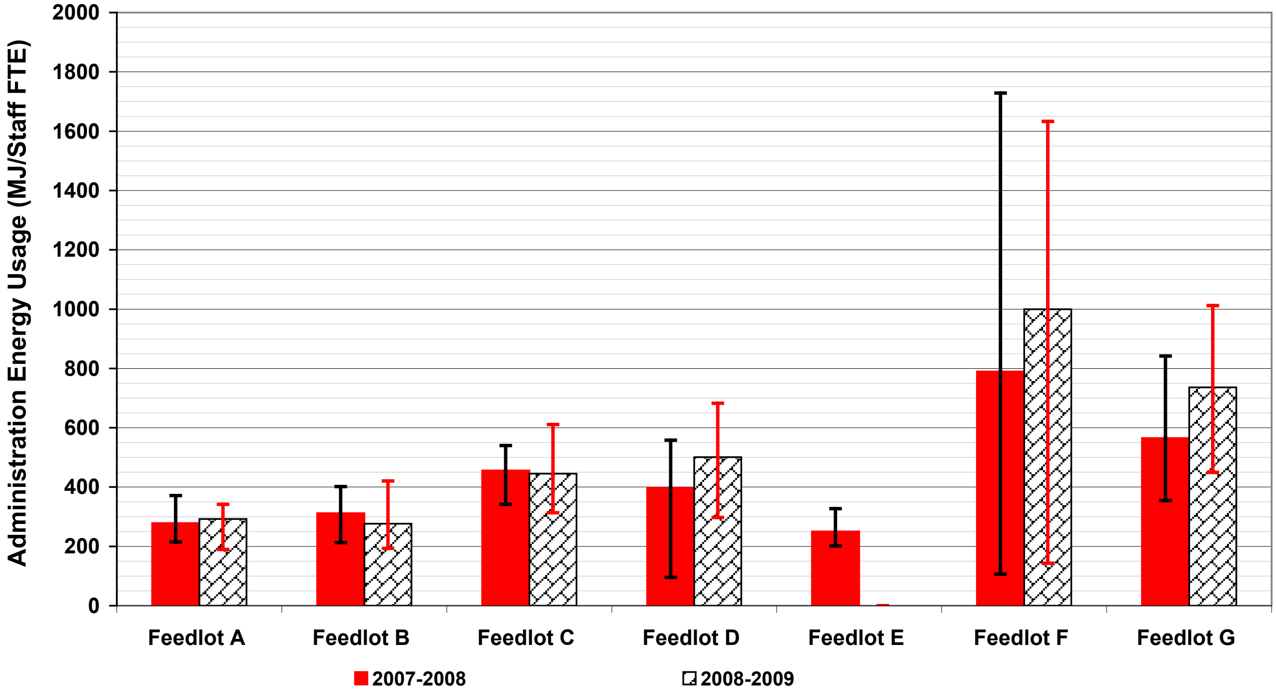

Figure 45 – Administration energy usage (MJ/staff FTE/month)

In 2007-2008, the average monthly administration energy usage ranges 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 is a reflection of lower staffing levels in 2008-2009, compared with previous year due to lower numbers of cattle on feed and hence less staff resources.

For Feedlot F, electricity usage for administration purposes includes a residence, office and workshop. There is a high variation in usage at feedlots D, F and G with Feedlot F having ranged from 40 to 1600 MJ/Staff FTE. The higher monthly usage is associated with the warmer months suggesting that air conditioning of office facilities is driving energy usage.

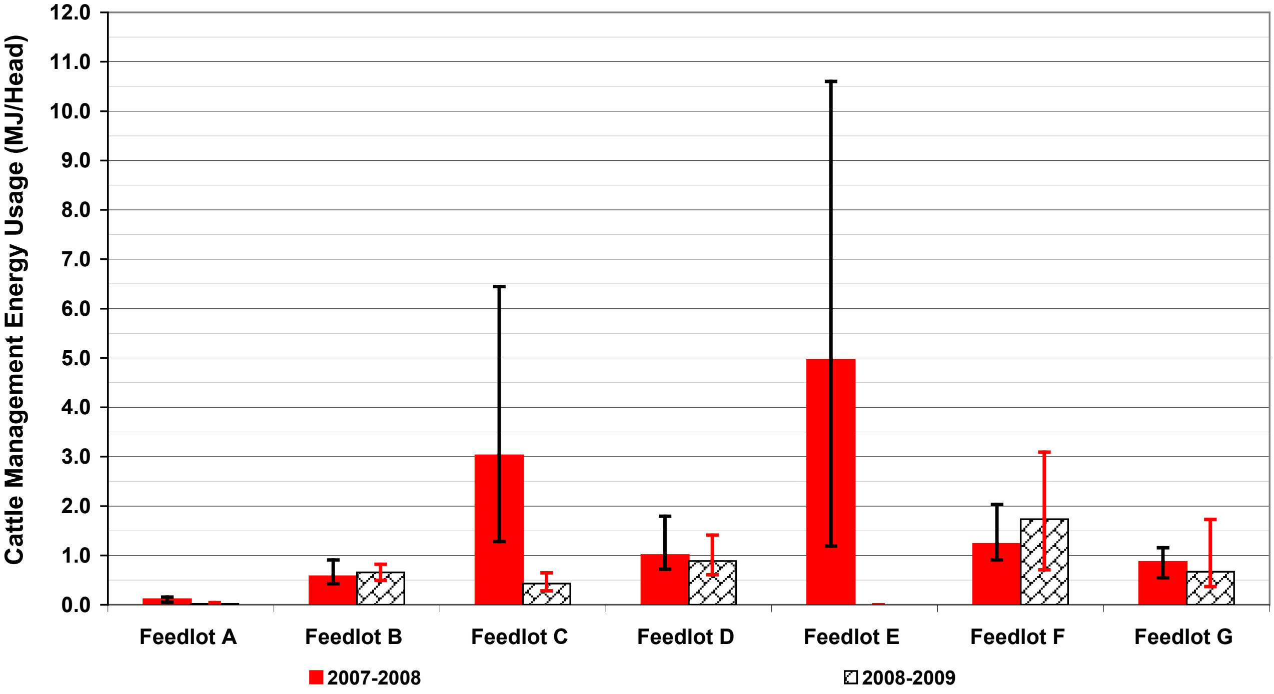

Figure 46 – Cattle management energy usage (MJ/Head processed/month)

FIGURE 46 illustrates the average cattle management energy usage on a MJ per head processed basis for the seven feedlots. This represents a very minor energy usage activity compared with other feedlot activities. In this context, cattle management energy usage includes that electricity used in induction and hospital and is expressed on a per total head processed (inducted and shipped), not head-on-feed. Energy usage is predominantly electricity used for lighting, cleaning and restraint facilities. Note that the energy usage for Feedlot C and E was determined by residual and includes other minor uses such as fuel bowser, staff amenities, stables and residence. The minimum and maximum cattle management usage per head basis for any one month is presented. Whilst a summary is provided in this section, complete individual feedlot monthly cattle management energy usage on a MJ per kg HSCW gain basis are presented in Appendix E, Section E.2.

The average monthly energy usage for cattle management ranges from 0.10 MJ/head processed at Feedlot A to 5 MJ/head processed at Feedlot E in 2007-2008. Note that the reported energy usage for Feedlot E includes the stables and one residence and no data was reported for 2008-2009.

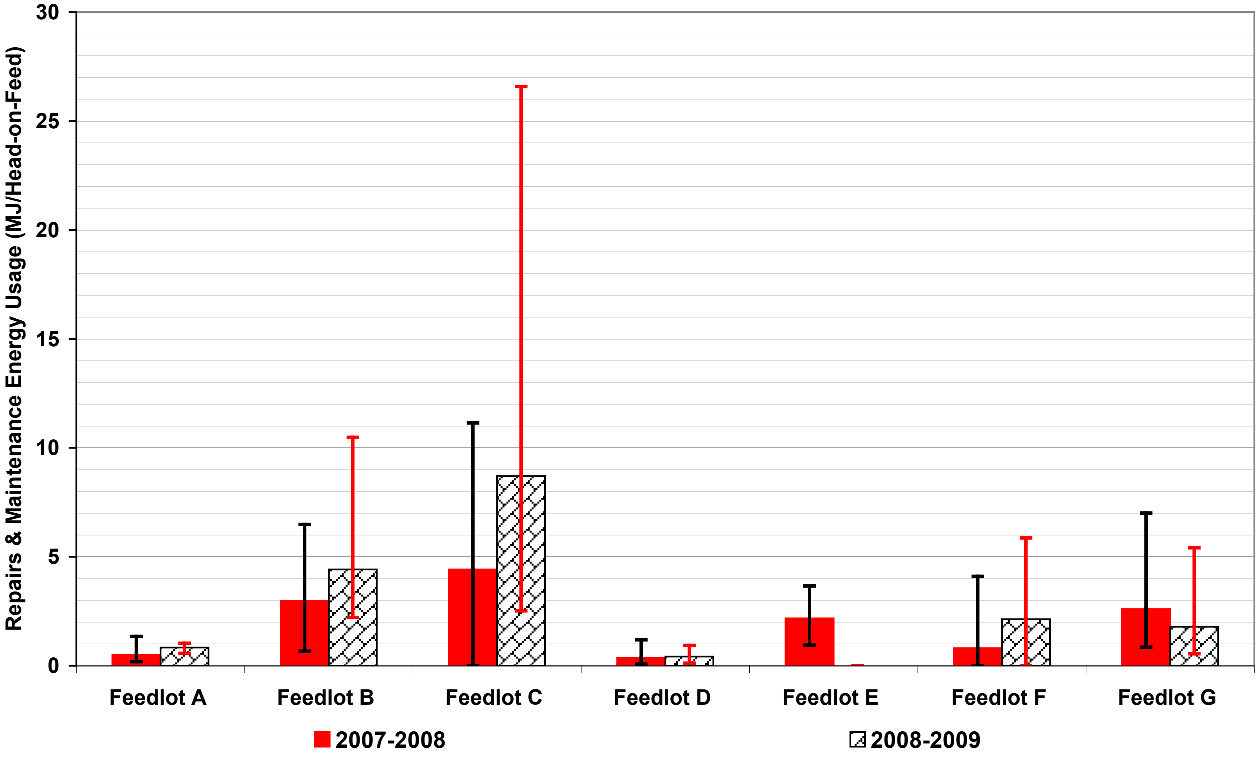

Figure 47 – Repairs and maintenance energy usage (MJ/head-on-feed/month)

FIGURE 47 illustrates the average repairs and maintenance energy usage on a MJ/head-on-feed/month basis for the seven feedlots. In this context, repairs and maintenance includes electricity usage in workshop facilities as well as diesel usage from mobile plant used in repair and maintenance activities. It is expressed as MJ/head-on-feed/month. The minimum and maximum repairs and maintenance usage per head basis for any one month is presented. Whilst a summary is provided in this section, complete individual feedlot monthly repairs and maintenance energy usage on a MJ per kg HSCW gain basis are presented in Appendix E, Section E.2.

The average energy usage for repairs and maintenance ranges 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.

The large variation in repairs and maintenance energy usage is due to the variation in mobile plant fuel usage between months derived from type, number and frequency of operations.

5 Opportunities for energy use efficiency improvements

5.1 Improvements to total energy usage

The feedlot Industry is acutely aware of the direct costs of energy consumption and the effect of this cost on the economic sustainability of individual feedlots within the industry. Energy usage is an increasing input cost for feedlot operation. These costs will rise significantly with the introduction of a carbon tax on energy production. These factors will make energy savings an important focus area for feedlots. Furthermore, any reduction in energy usage will also contribute to lower carbon emissions which will benefit the environment.

A number of energy sources are used in a feedlot. Electricity is principally used for grain movement, feed processing, administration and to pump water from bores and to wash cattle. Gas (Natural, LPG - Propane, LPG - Butane) is the predominant energy source for boiler equipment used in heat/steam generation. Diesel predominantly and to a lesser extent petrol is used in mobile plant and equipment. Energy usage is largely driven by the feed management and the processing system employed by the feedlot.

Two areas have been identified in which energy or cost efficiency improvements could be targeted. These are feed processing and feed delivery.

Feed processing is an added cost to the feedstuff due to the cost of energy expended, equipment maintenance, person hours, etc. Processing is economically feasible only when the increased cost of the feedstuff is more than offset by the reduced kilograms of the feedstuff required to yield a kilogram of animal liveweight gain. Energy required for processing contributes much of the added cost.

Grain preparation accounts for the majority of energy consumed during feed processing. Results from this work have shown that the energy consumed in grain preparation can account for up to 70% of the total feedlot energy consumption. Similarly, a large variation in grain preparation energy usage has been measured across feedlots.

The most common energy source and a common element in all grain preparation systems is electricity consumption. In most cases, electricity is provided by an overhead supply to a main switchboard then distributed internally throughout the feedlot. Electricity is used for a number of activities within grain preparation including grain movement (in-loading, tempering, storage) and processing (rolling, hammer milling).

Processing grain at night to utilise ‘off-peak’ electricity tariffs in an attempt to reduce energy costs may be a realisable opportunity. However, there are obvious social and workplace health and safety issues to be considered. This approach to feed processing could provide significant cost and energy savings and is transferable to any feedlot within the industry.

It is likely that a review of feed processing energy usage will result in cost saving opportunities for many feedlots. However, in most situations, the total feedlot energy usage should be assessed. Of interest to lot feeders are electrical energy, boiler and steam system assessments. Australian standard AS/NZS 3598:2000 provides guidance on what level of assessment is appropriate and a guide when commissioning energy assessments. A review of diesel powered equipment (eg size, number etc) could also be undertaken as part of the energy usage review.

The key elements of an electrical energy, boiler and steam system assessment are outlined below.

An electrical energy assessment needs to be undertaken by certified electrical personnel. There are firms who specialise in providing assessment services, however your local electrical contractor should be able to undertake all of the actions required. Typically, an electrical energy assessment includes the following actions:

- Electrical and control diagrams are reviewed to understand the uses of electrical energy.
- Electrical loads are measured during operations to identify their contribution to site maximum demand and consumption.
- Electrical load profiles are analysed. Load profiles can be obtained from your electricity supplier i.e. Country Energy.
- Existing maintenance and operating procedures including intervention levels or trigger points for maintenance are reviewed.
- Existing electrical supply contract to understand the implications of modifying the electrical load profile are reviewed.
- An improvement strategy to optimise the electricity demand and consumption without adversely impacting the operation of the feedlot is developed.
- Key performance indicators to benchmark energy consumption are recommended.

A boiler and/or steam system assessment needs to be undertaken by certified personnel. There are firms who specialise in providing these services such as boiler supply companies e.g. East Coast Steam or steam system equipment suppliers e.g. Spirax Sarco.

Typically, a boiler assessment includes the following actions:

- The layout and control systems of the boiler and associated equipment (piping etc.) are reviewed to understand the inputs, outputs and operations of the boiler.
- Historical boiler performance is reviewed from input records and operating performance assessed against benchmarked data.
- Combustion efficiency is assessed through measurement of stack temperature and flue gas composition under normal operating conditions.
- Inspect (where possible) the condition of the boiler for scale build-up and the performance of blow-down systems.
- Inspect the boiler for leaks and/or pressure losses.
- The condition of insulation of the boiler is assessed (if applicable).
- Review existing operating and maintenance procedures and identify where improvements can be made.
- Develop an improvement strategy to optimise the operational efficiency without adversely impacting the operation of the feedlot.

Typically, the scope of a steam system assessment should include the following actions:

- The layout and control systems of the steam system are reviewed to understand where steam is generated, used and circulated.
- The performance of heat-recovery systems (where systems are installed) are reviewed, or the opportunities for head-recovery systems to improve efficiency are assessed.
- The condition of any existing insulation and the opportunities for further insulation of pipes and process vessels are assessed.
- Inspect pipes, valves, joints and flanges for steam leaks and pressure losses.
- Inspect the condition and assess the performance of steam traps to ensure optimum efficiency of the steam system is achieved.
- Review the performance requirements of the steam system to assess whether the system is over or under performing.

Similarly, with feed delivery an analysis of total system usage should be undertaken. A number of different feed delivery systems are represented within the seven feedlots. This includes stationary mixing, bunker system, batch boxes 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.

Feed delivery energy usage is dependent on the system and equipment utilised, pen layout and feed-out method also influences the energy used. Whilst pen layout is fixed in existing facilities, mobile equipment (during replacement) and feed-out strategy could be targeted for energy efficiency improvements. For example, consideration of a larger bucket capacity loader which may require a larger engine capacity, may reduce energy usage through reduced trips and associated reduction in acceleration/deceleration loads. One feedlot implemented changes to their feed delivery system in 2008 and a reduction in energy usage was measured with the new system.

6 Conclusions and recommendations

6.1 Conclusions

Energy is a fundamental input to the feedlot production system and is an increasing input cost for feedlot operation. To date, only a limited study on feedlot energy usage has been undertaken in Australia.

Whilst lot feeders usually have good records of total annual 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.

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, power meters were installed to allow an examination of energy usage by individual activities. The major energy usage activities (water supply, feed management, waste management, cattle washing) were monitored and recorded.

Energy consumption was classified into two categories, indirect and direct sources. Indirect sources arise mainly from the transport of cattle in and out of the feedlot and commodity delivery. Energy is used directly in the operation of the feedlot for the production of beef – feed processing, feed delivery, water supply, administration etc.

Factual information on indirect and direct energy usage was collected on individual activities within seven Australian feedlots between March 2007 and February 2009.

Results from the seven feedlots studied showed that total annual indirect energy use ranged from 2.7 MJ/kg HSCW gain (Feedlot C) to 5.99 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 past 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 levels 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 a figure of 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, however 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 1.5 MJ/kg HSCW gain (Feedlot A) to 6.9 MJ/kg HSCW gain (Feedlot B). The total annual energy usage in 2008-2009 was slightly higher when compared to the previous year with a range of 1.9 MJ/kg HSCW gain (Feedlot A) to 7.7 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 D) to 1483 MJ/head-on-feed (Feedlot E). 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.

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.

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.

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. 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. 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. Feedlot F recorded a doubling of water supply energy usage in 2008-2009, explained by the commissioning of a series of bores to supplement their water supply.

Feed management is the largest single consumer of energy in the feedlot as expected. 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 25 (Feedlot D) to 600 MJ/t dry matter 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 dry matter grain processed. For steam flaking, the total energy usage ranges from 310 to 600 MJ/t dry matter grain processed. 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 shows that there is 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 270 to 425 MJ/t grain processed. Slightly higher levels were measured in 2008-2009 (290-600 MJ/t grain processed). There were three types of gases used within the four feedlots with steam flaking systems. These included LPG, butane and natural gas. All of these gas sources have different calorific values (heating content) and pricing structures and therefore impact on energy consumption. Some of the variation in gas usage can be attributed to heating efficiency during winter months, however 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 have reduced their average monthly feed delivery energy usage in 2008-2009 when compared with 2007-2008 levels. Feedlot C and D have 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 levels 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 have 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) have considerably less energy usage when compared with the remaining feedlots.

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

Feedlot E uses, 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 is 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 is similar to Feedlot E along with a similar density ration. Feedlot E delivers 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 has translated into a significant reduction in average monthly energy usage.

Typically, waste management contributes 18 % of total energy usage, however is quite variable between months. Waste management energy usage contributes 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 ranges 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 is driven by the frequency of cleaning, equipment used and the volume of manure removed. There is 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 monthly 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 is directly related to the volume of water used. Water usage is 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 reflects the drier conditions experienced and therefore reduced cleaning requirements for cattle.

Administration and minor activities (cattle management, repairs and maintenance) contributed an average 0.2 MJ/kg HSCW gain 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 is a reflection of lower staffing levels in 2008-2009, compared with previous year due to the state of the industry.

Average monthly usage is 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 is expressed on basis of per total head processed (inducted and shipped) not head-on-feed. Energy usage is 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 is 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 have been 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 sector operations 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.

Knowledge of the total energy consumption will allow the industry to benchmark itself against other intensive or extensive livestock industries and/or industrial processes.

The outcomes of this study will allow the feedlot industry to start benchmarking total energy usage. In addition, this information is invaluable for participating feedlots in understanding the drivers of energy consumption and targeting high energy use areas for efficiency gains and for future design and management considerations. The first step to making savings is to understand where energy is used around the feedlot. Remember, ***measure to manage.***

To assist the feedlot industry to improve energy efficiency, a framework has been developed to step individual feedlot operators through the process of measuring and reducing energy usage at the feedlot. This framework is presented as fact sheets, arranged in 3 series:

- Measuring and Understanding resource usage;
- Benchmarking, and
- Improving resource efficiency

FIGURE 48 illustrates the first phase in developing the framework. Factsheets in this series outline the steps involved and the tools required for implementing an energy usage measurement system and understanding what the numbers mean. There are three factsheets common to both the water and energy framework. These are the collection of production data, analysing water and energy data and developing analysis tools.

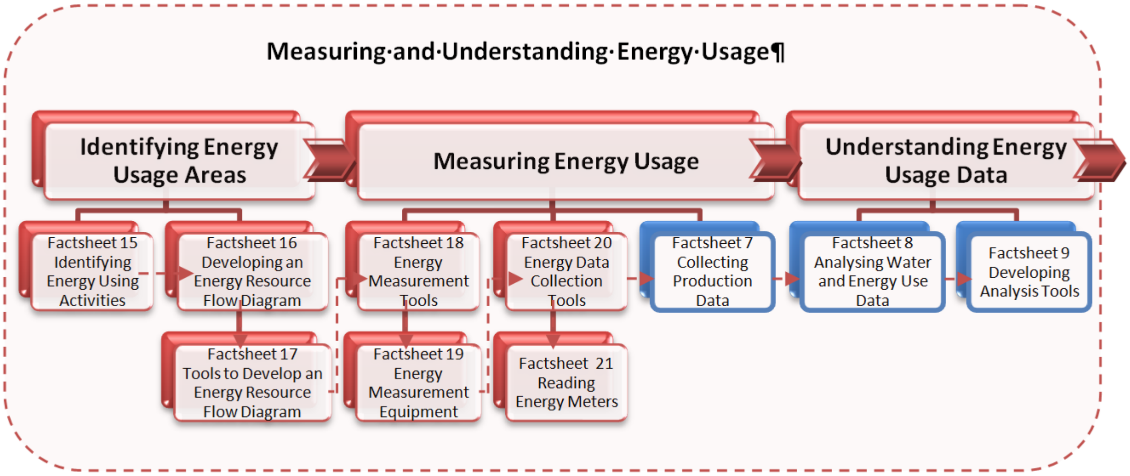

Figure 48 – Measuring and understanding phase flowchart for energy usage

FIGURE 49 illustrate the second phase in developing the energy framework. Factsheets in this series provide industry data on energy usage within individual activities which can be used to benchmark feedlot energy usage levels against.

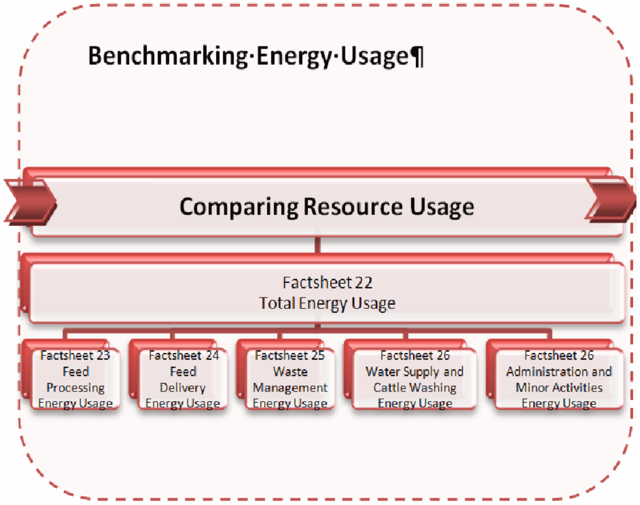

Figure 49 – Benchmarking phase flowchart for energy usage

Figure 50 illustrate the last phase in developing the energy framework. Factsheets in this series provide case studies which you can use to gain a better understanding of the process and to benchmark energy usage levels.

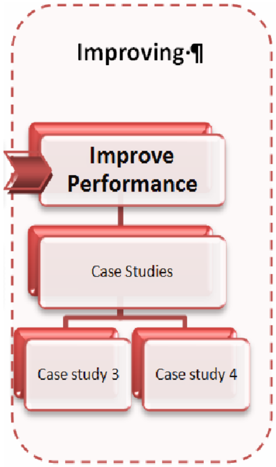

Figure 50 – Improving phase flowchart for energy usage

6.2 Recommendations

The data collected in this study have indicated a large variation in energy usage between participating feedlots. This variation can be attributed to a number of factors including water supply and reticulation, feedlot design and layout, type of feed processing and delivery systems, mobile plant involved in waste management and management and operation of these activities.

Energy usage is less dependent on climatic variation when compared with water usage. However, climatic factors will directly affect waste management (pen cleaning) and indirectly on other areas such as water supply (water requirements) and cattle washing (dagginess of cattle) energy usage. Results have also shown that energy usage in steam flaking systems is variable and increases during periods of cooler weather.

Benchmarking of this information has raised awareness of energy usage within the participating feedlots. This project has also provided industry with a set of industry statistics on energy usage over a 24-month period. A number of feedlots have installed or upgraded plant and mobile equipment after the first 12-month period or conducted a review of electrical, boiler and steam system energy consumption.

It is important that this information is extended to industry. Therefore, it is recommended that a roll out of the fact sheet series be undertaken. This will assist lot feeders in understanding, planning and organising, implementing and monitoring an energy efficiency program based on the outcomes of this work. Additionally, this may also facilitate lot feeders being prepared for the introduction of a carbon pollution reduction scheme and the implications of increased energy costs and carbon taxes.

7 References

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Appendix A – Cattle transport and commodity delivery energy usage

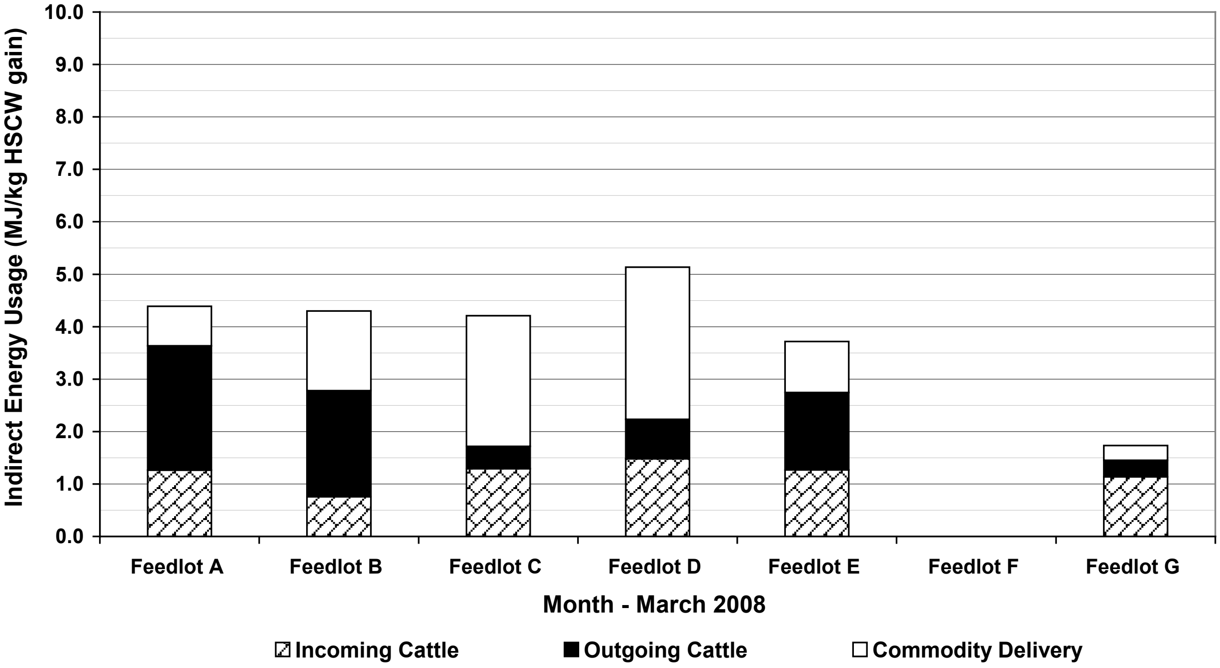

Figure 51 – Indirect energy usage for March 2008 (MJ/kg HSCW gain)

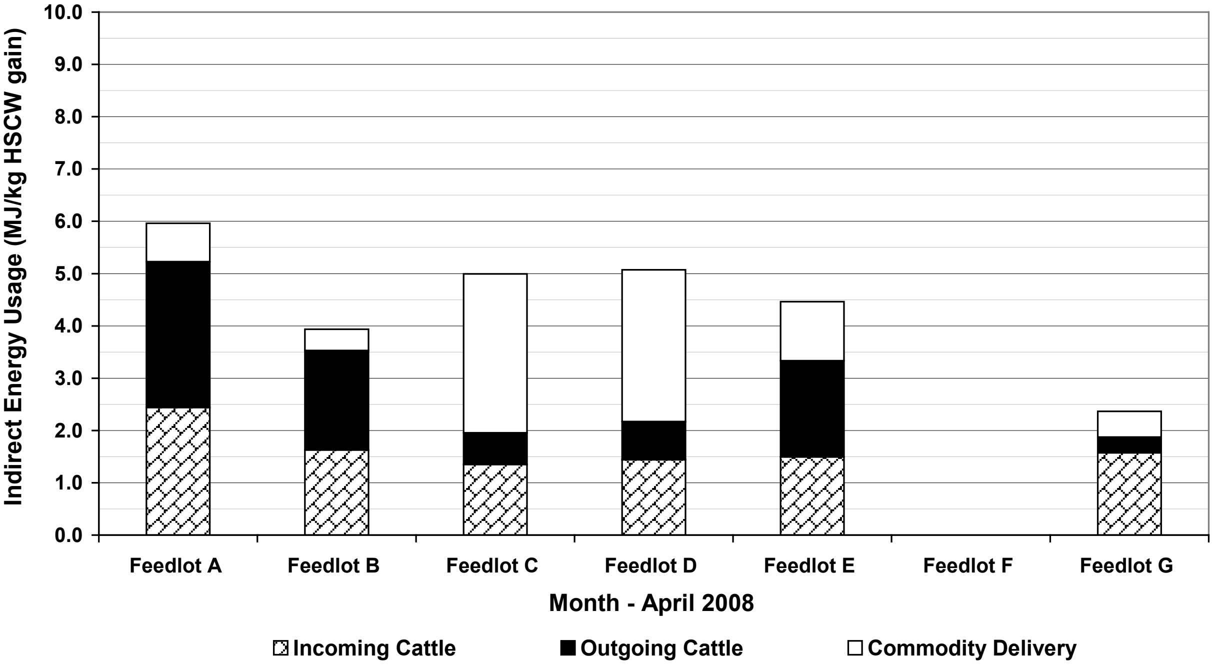

Figure 52 – Indirect energy usage for April 2008 (MJ/kg HSCW gain)

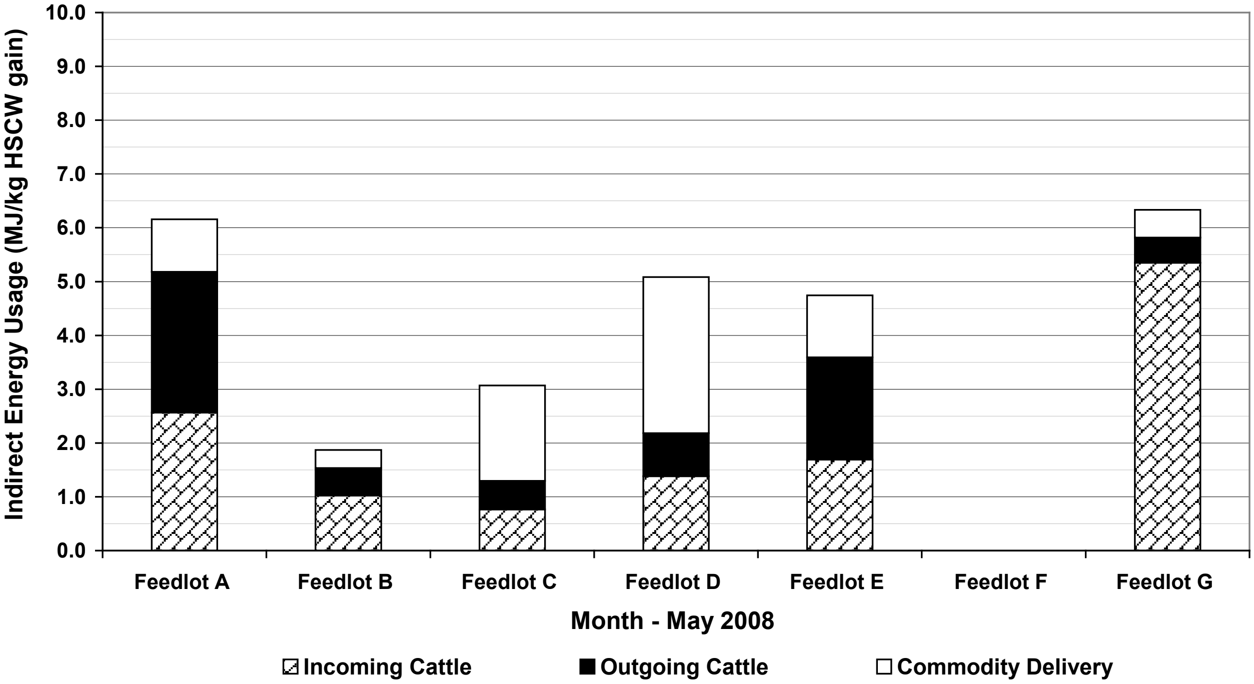

Figure 53 – Indirect energy usage for May 2008 (MJ/kg HSCW gain)

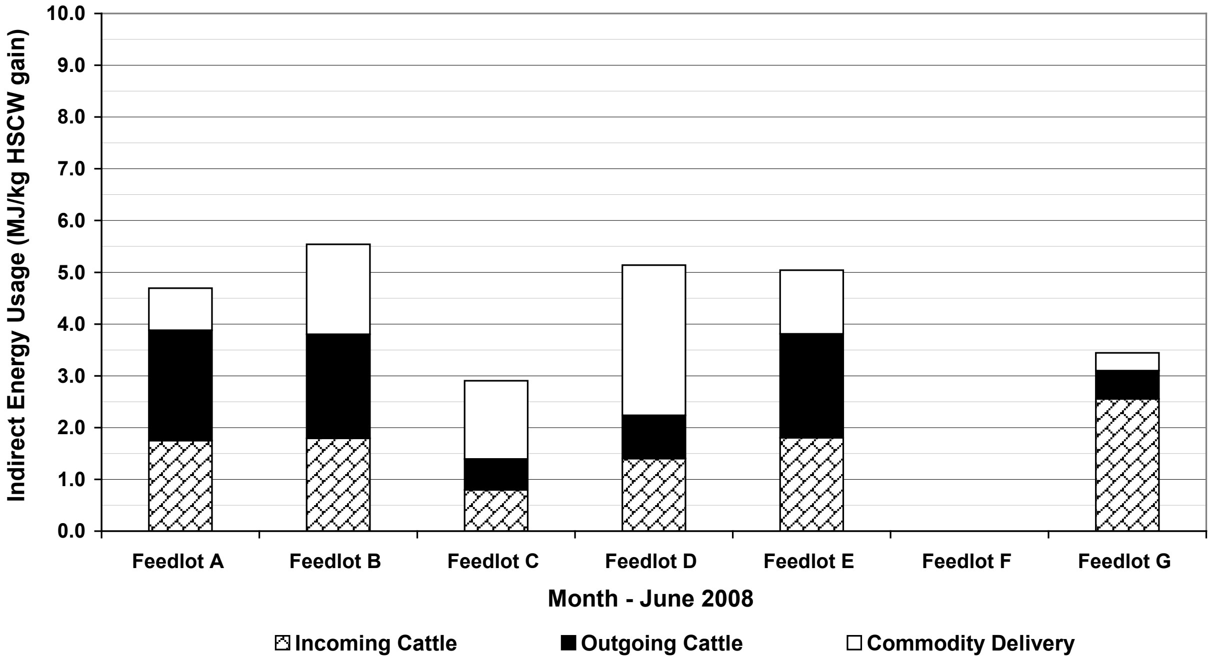

Figure 54 – Indirect energy usage for June 2008 (MJ/kg HSCW gain)

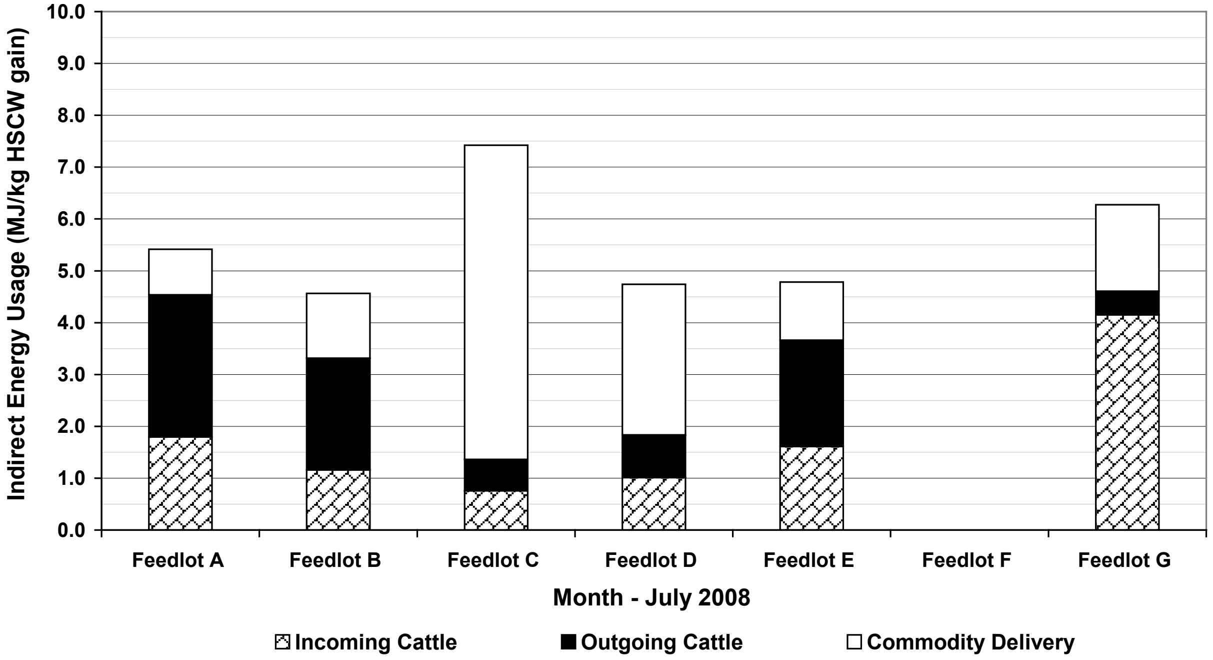

Figure 55 – Indirect energy usage for July 2008 (MJ/kg HSCW gain)

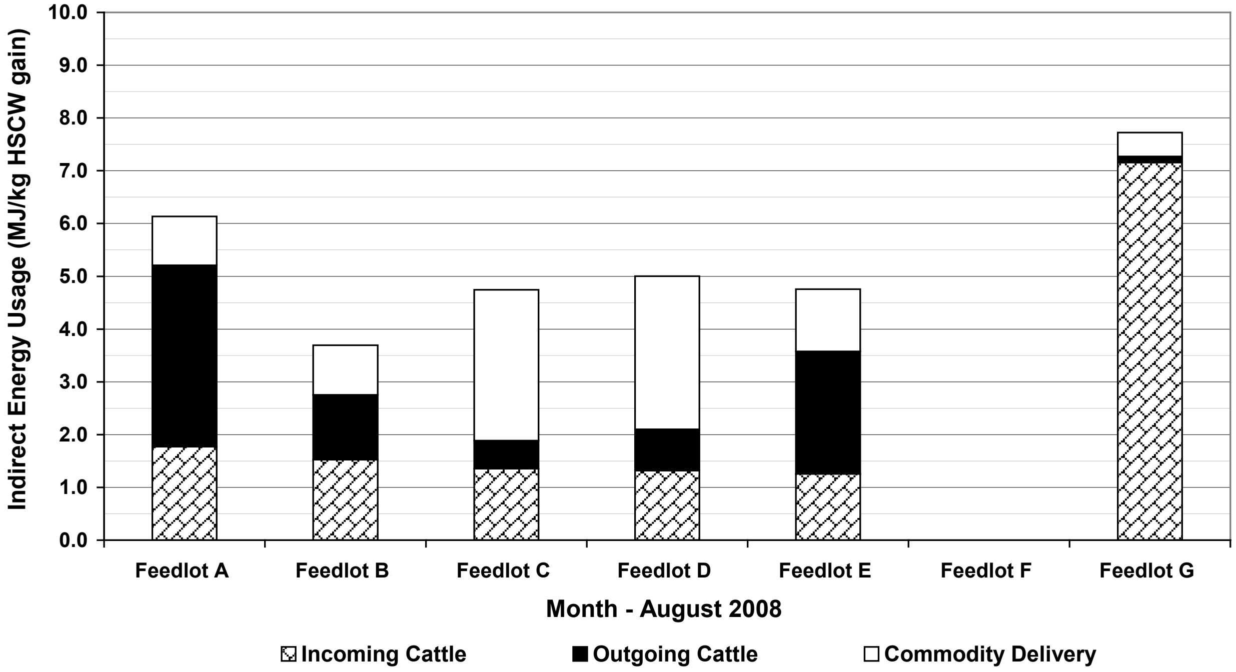

Figure 56 – Indirect energy usage for August 2008 (MJ/kg HSCW gain)

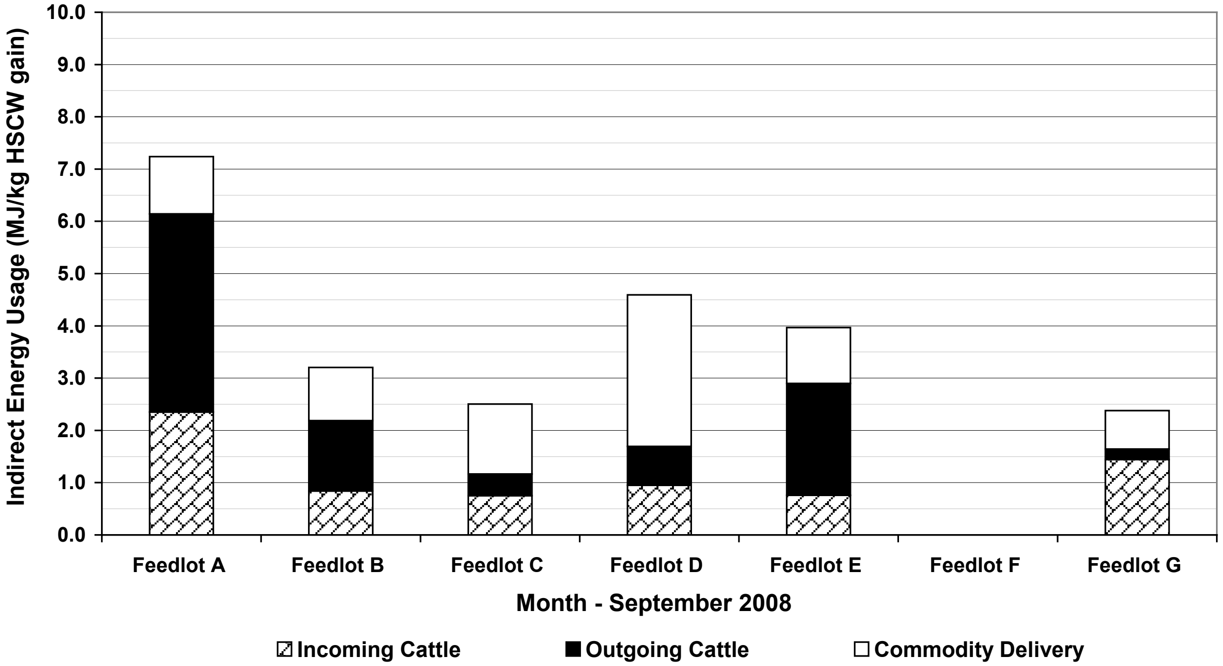

Figure 57 – Indirect energy usage for September 2008 (MJ/kg HSCW gain)

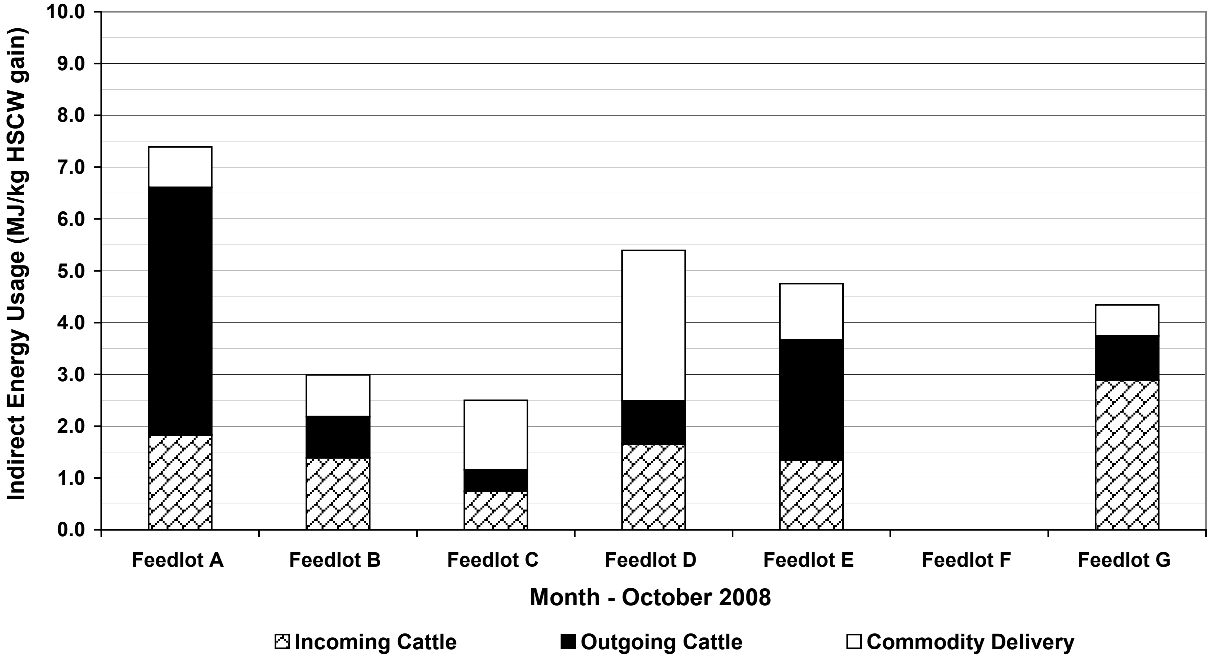

Figure 58 – Indirect energy usage for October 2008 (MJ/kg HSCW gain)

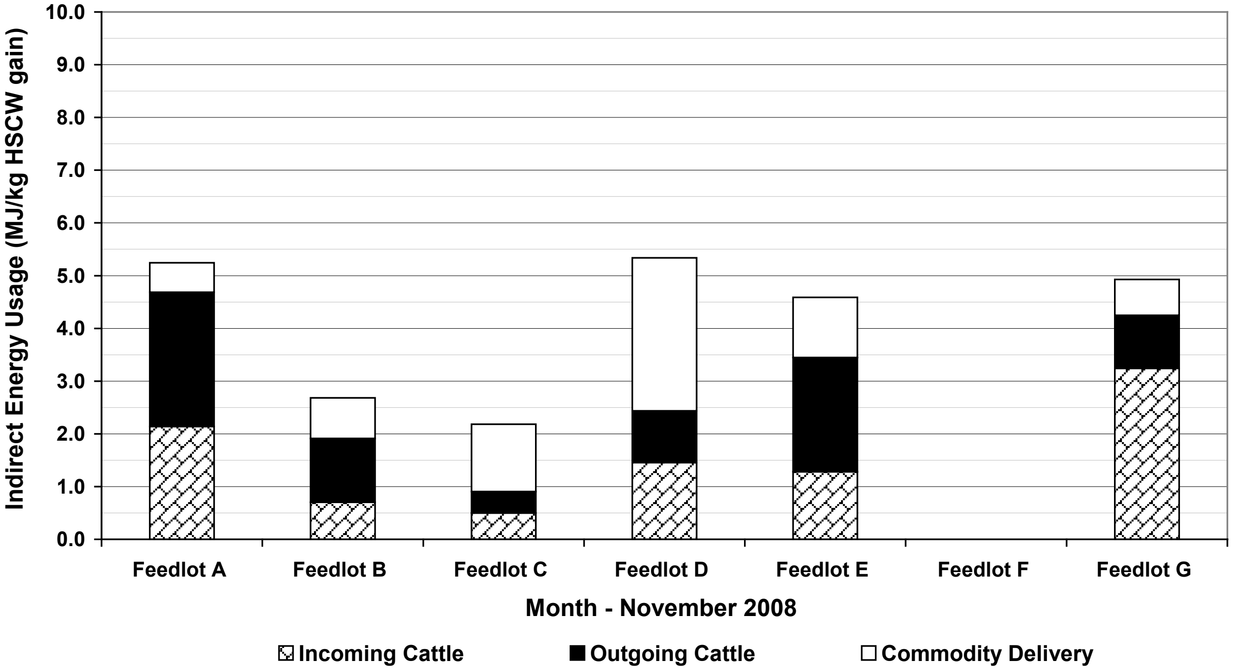

Figure 59 – Indirect energy usage for November 2008 (MJ/kg HSCW gain)

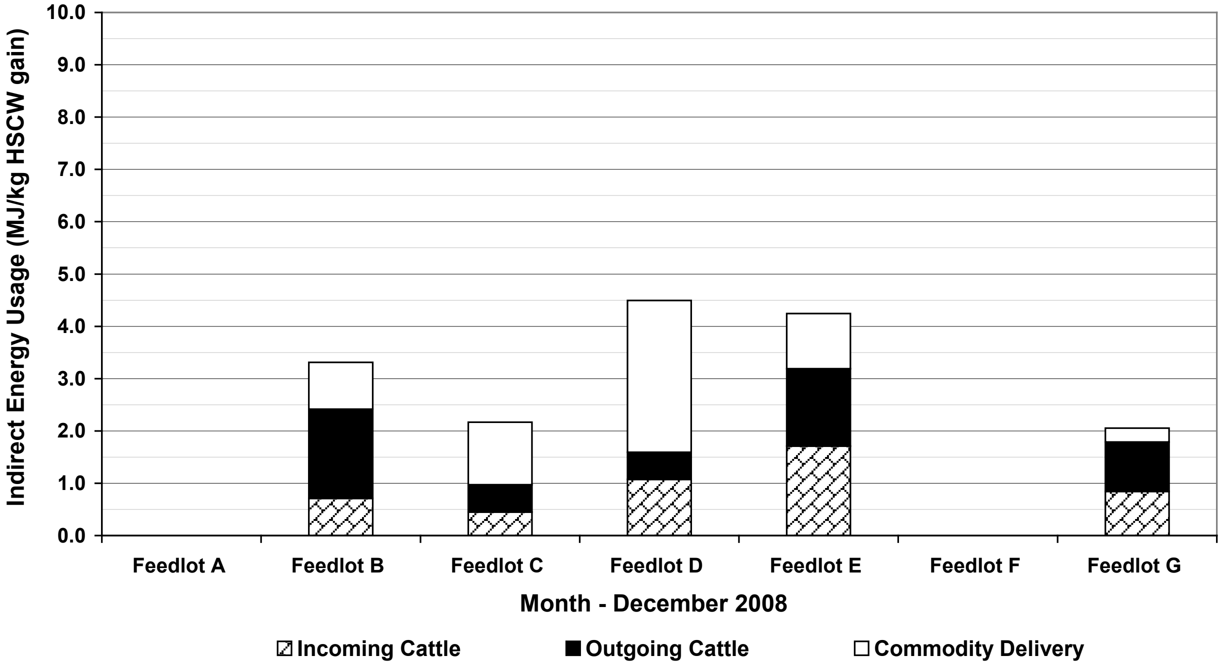

Figure 60 – Indirect energy usage for December 2008 (MJ/kg HSCW gain)

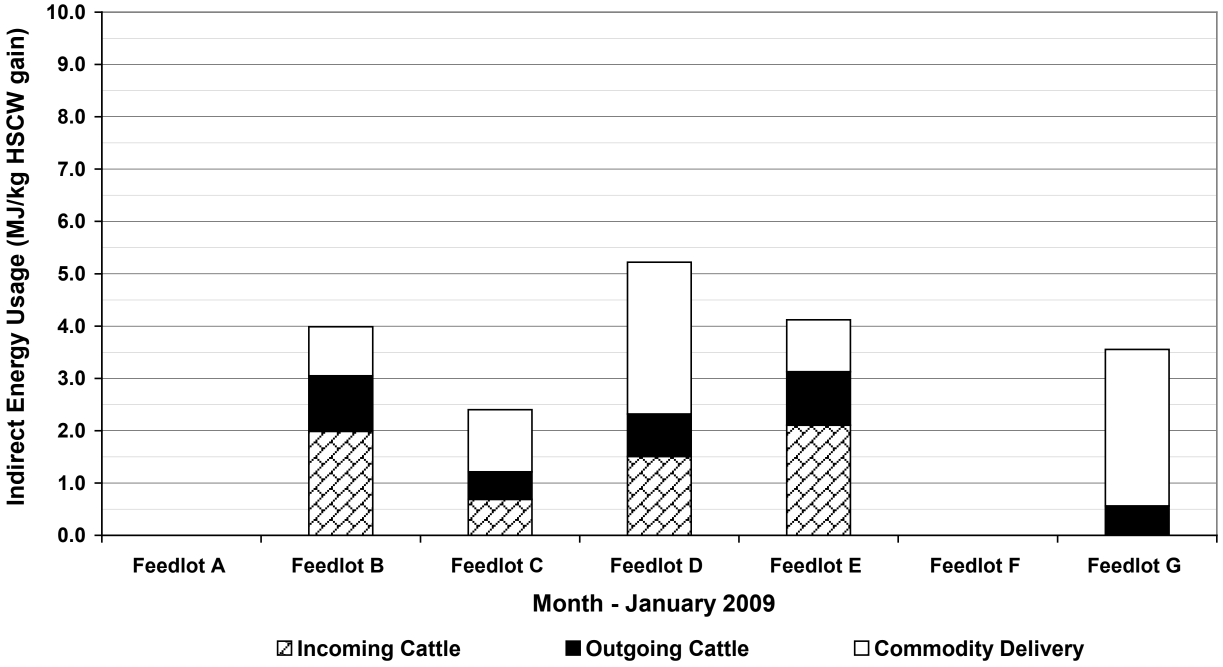

Figure 61 – Indirect energy usage for January 2009 (MJ/kg HSCW gain)

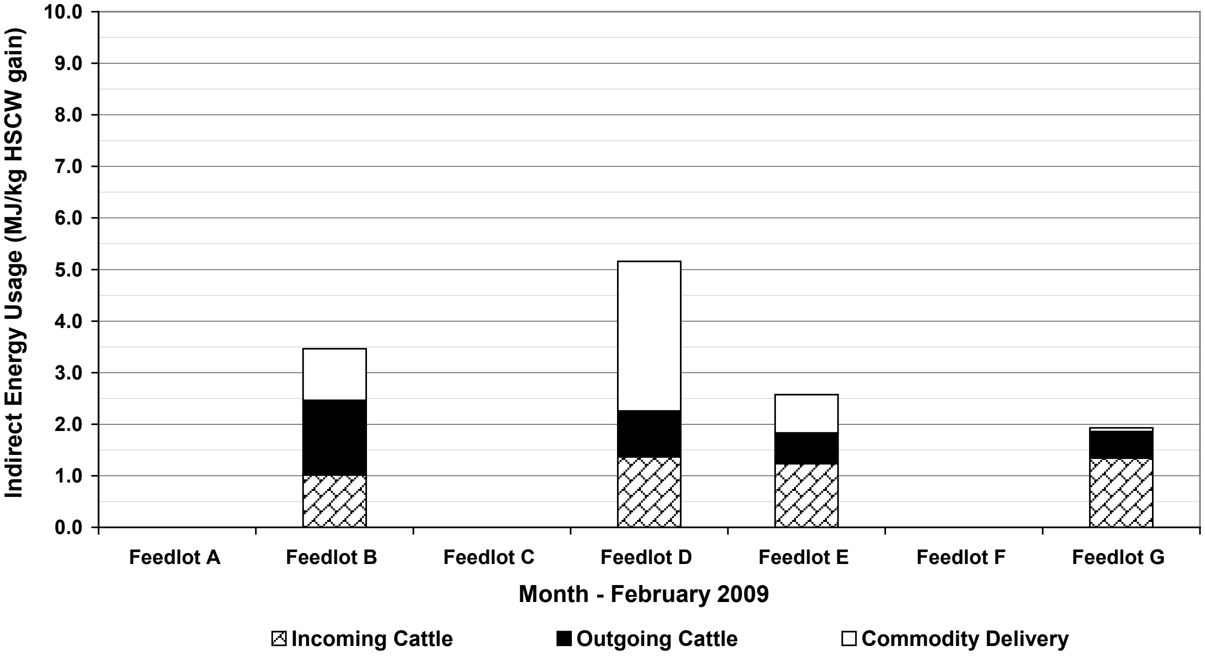

Figure 62 – Indirect energy usage for February 2009 (MJ/kg HSCW gain)

Appendix B – Water supply energy usage

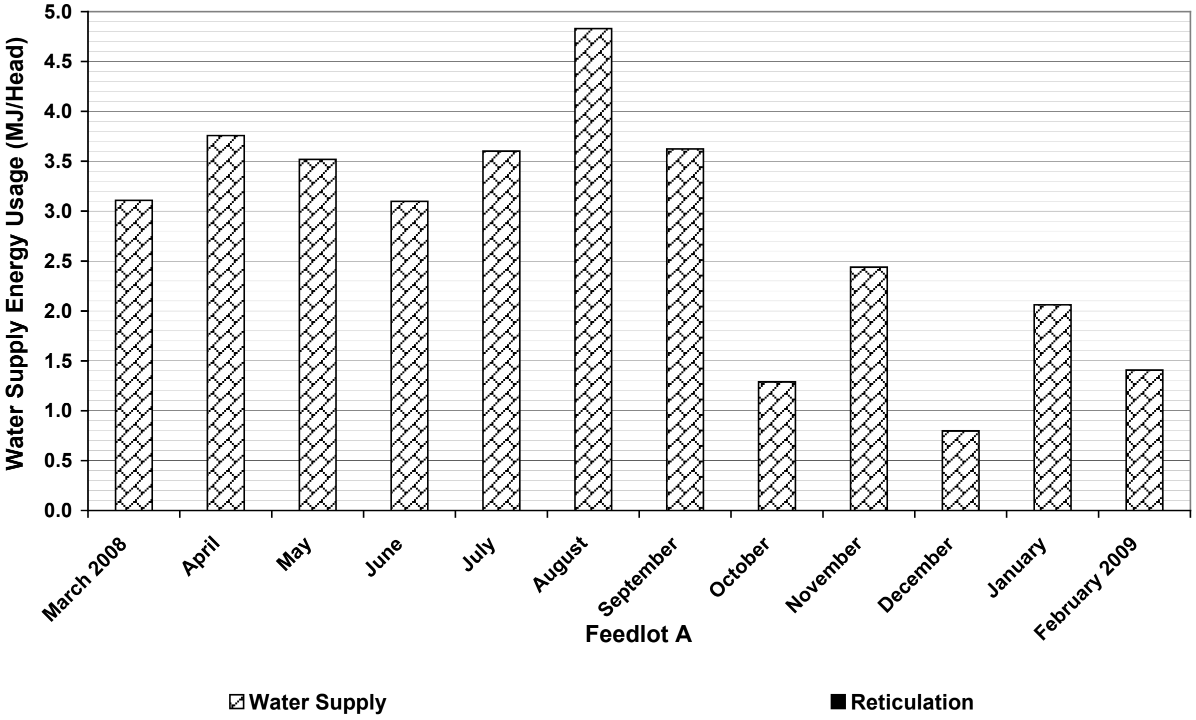

Figure 63 – Water supply energy usage for Feedlot A (MJ/head-on-feed/month)

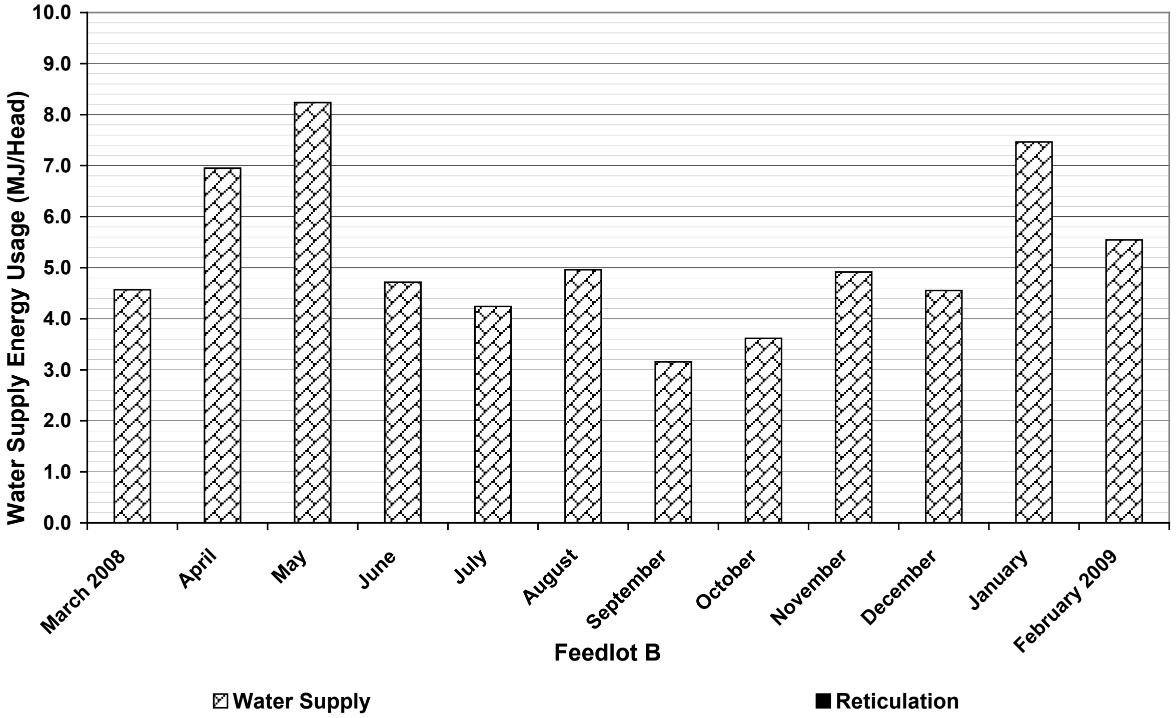

Figure 64 – Water supply energy usage for Feedlot B (MJ/head-on-feed/month)

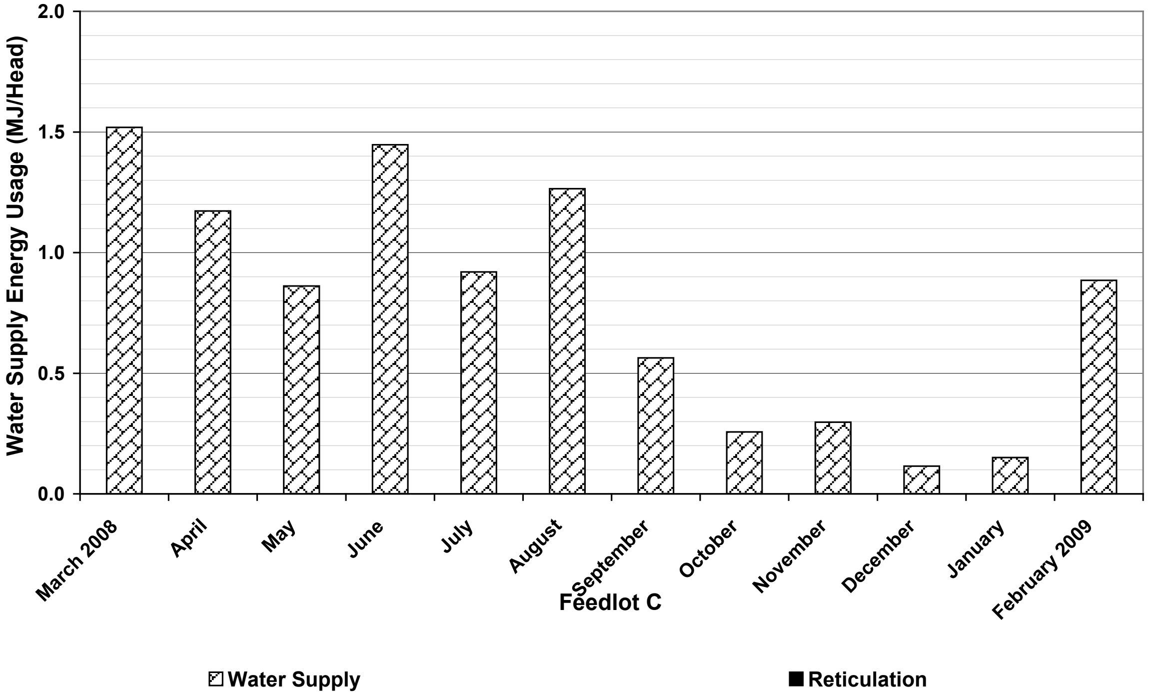

Figure 65 – Water supply energy usage for Feedlot C (MJ/head-on-feed/month)

NA

Figure 66 – Water supply energy usage for Feedlot D (MJ/head-on-feed/month)

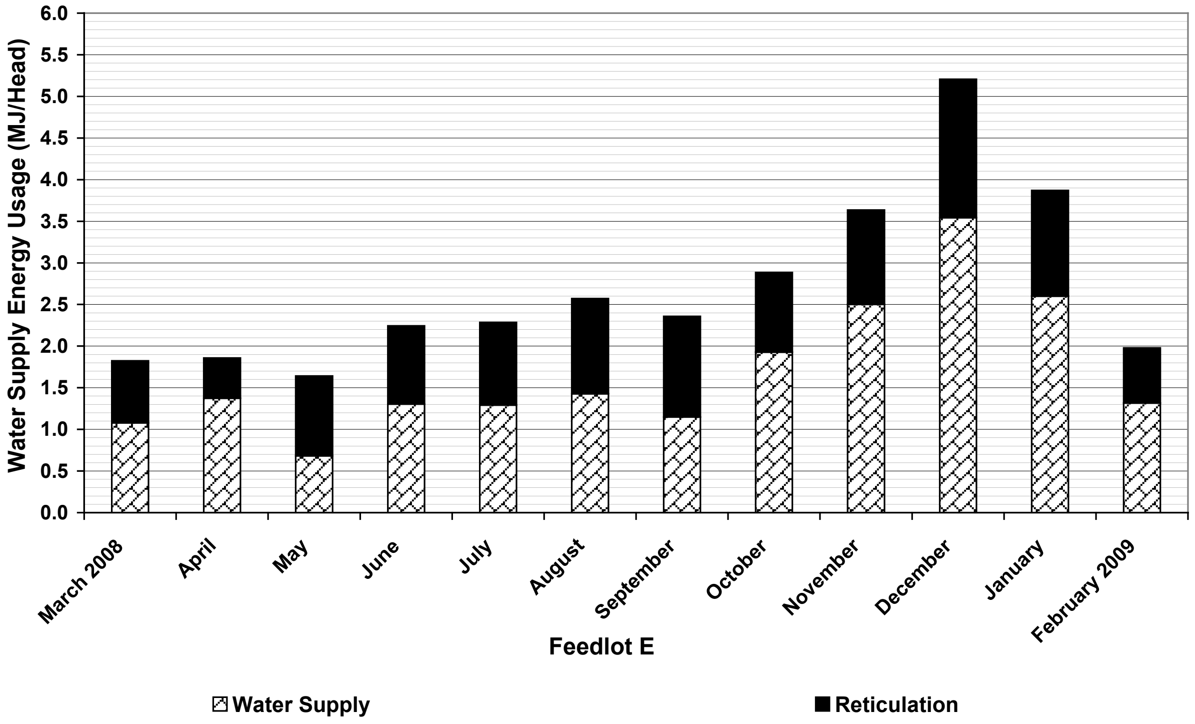

Figure 67 – Water supply energy usage for Feedlot E (MJ/head-on-feed/month)

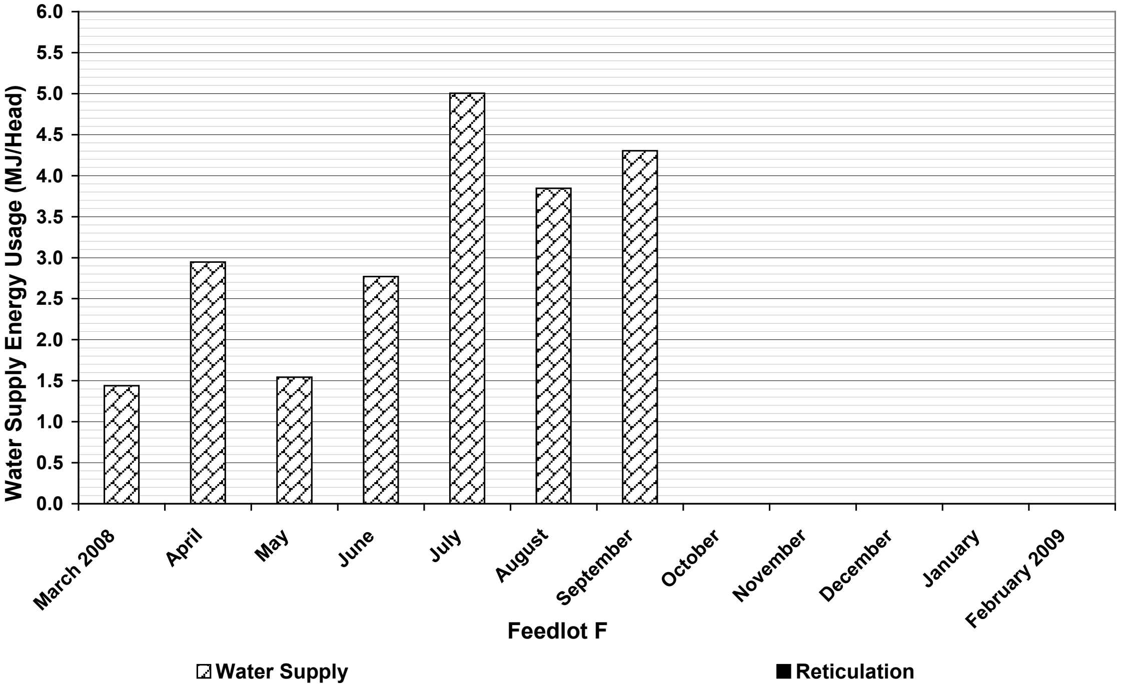

Figure 68 – Water supply energy usage for Feedlot F (MJ/head-on-feed/month)

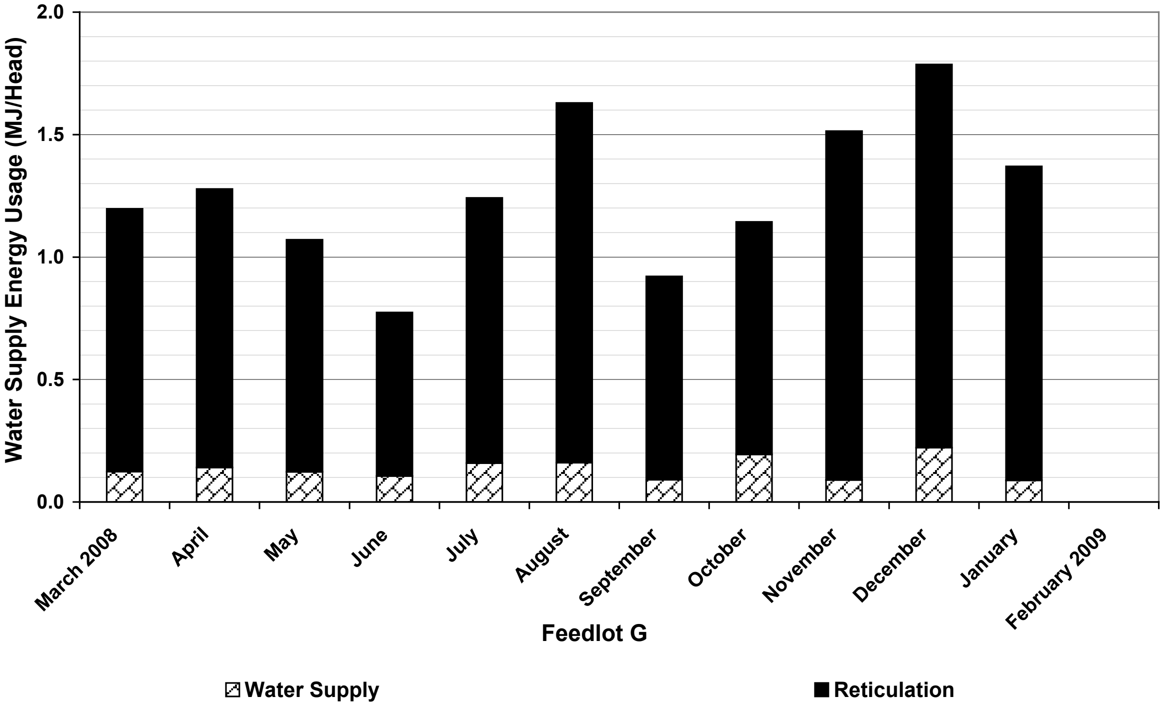

Figure 69 – Water supply energy usage for Feedlot G (MJ/head-on-feed/month)

Appendix C – Feed management energy usage

Appendix C.1 – Feed processing energy usage

NA

Figure 70 – Feed processing energy consumption for Feedlot A (MJ/t ration)

NA

Figure 71 – Feed processing energy consumption for Feedlot A (MJ/t dm grain)

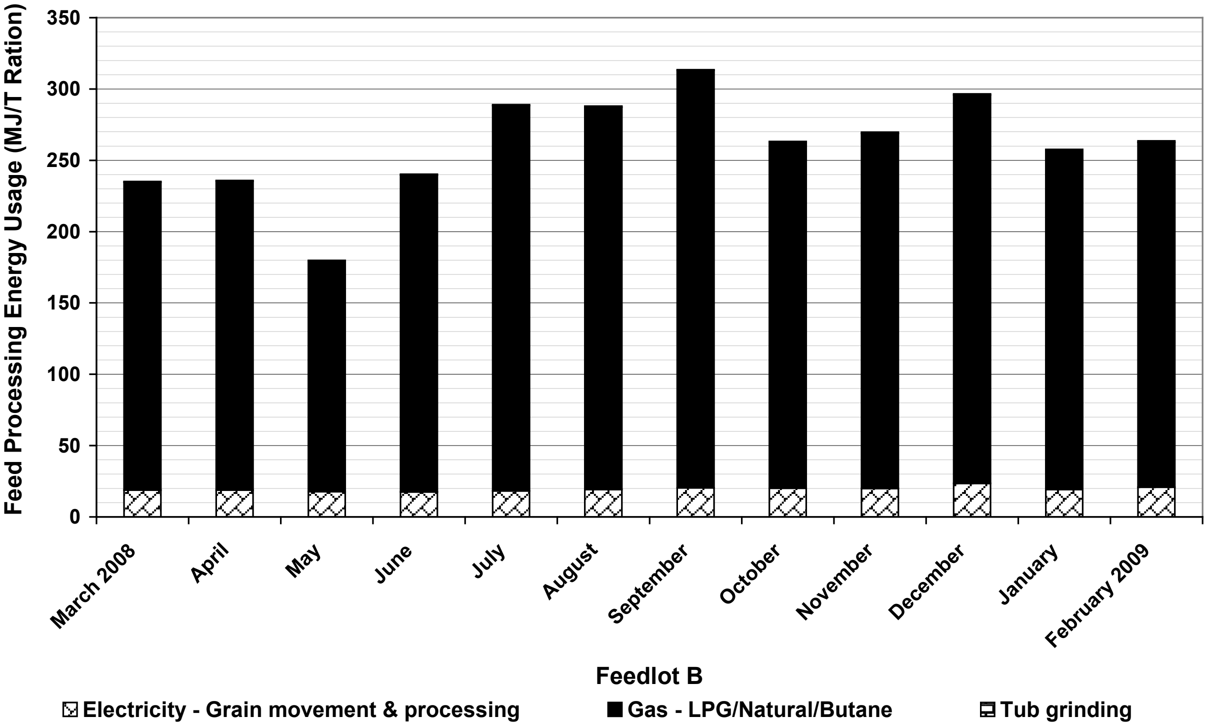

Figure 72 – Feed processing energy consumption for Feedlot B (MJ/t ration)

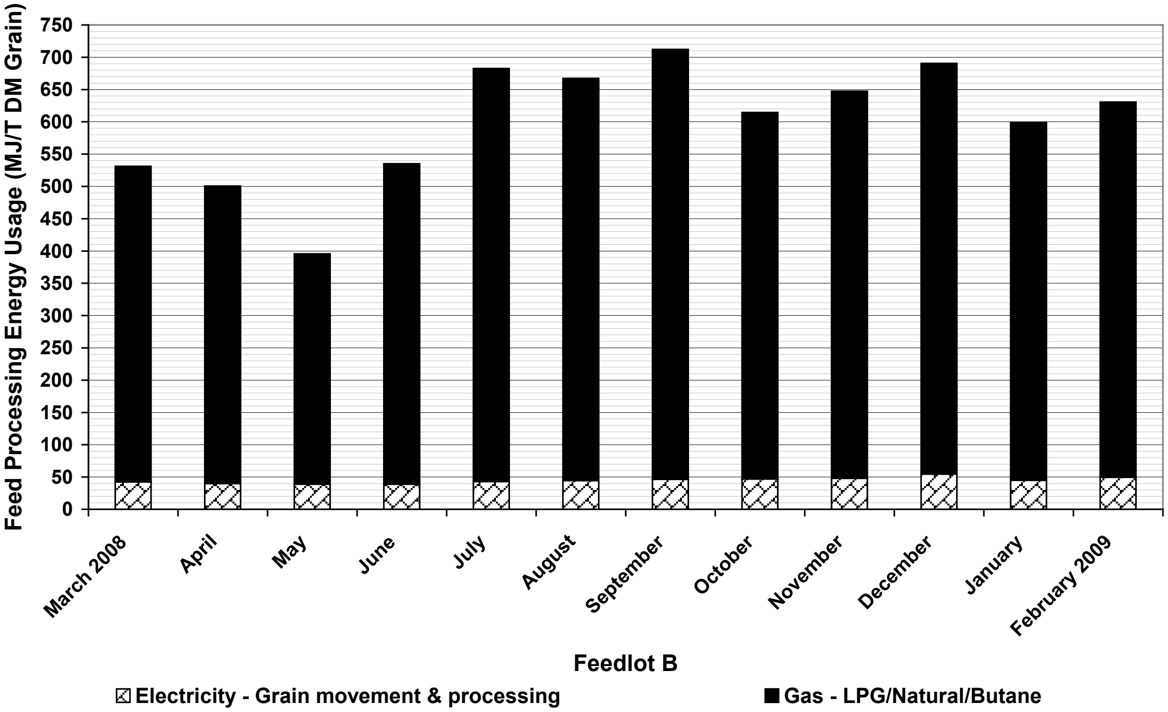

Figure 73 – Feed processing energy consumption for Feedlot B (MJ/t dm grain)

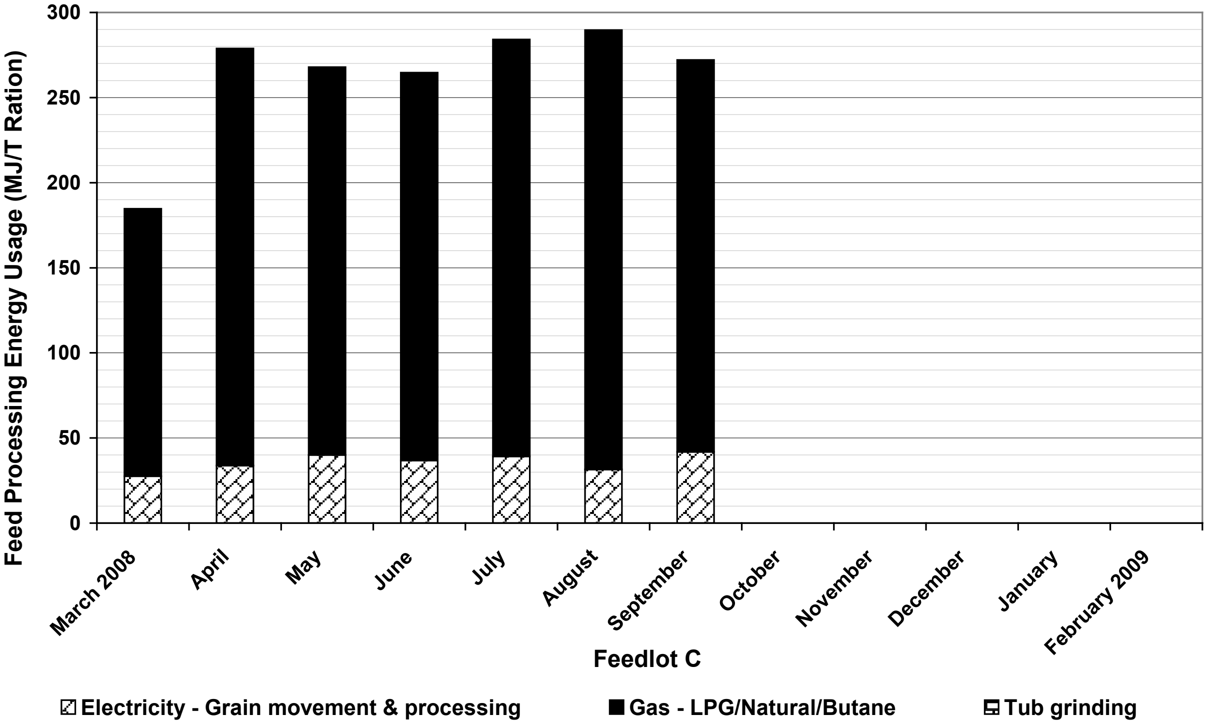

Figure 74 – Feed processing energy consumption for Feedlot C (MJ/t ration)

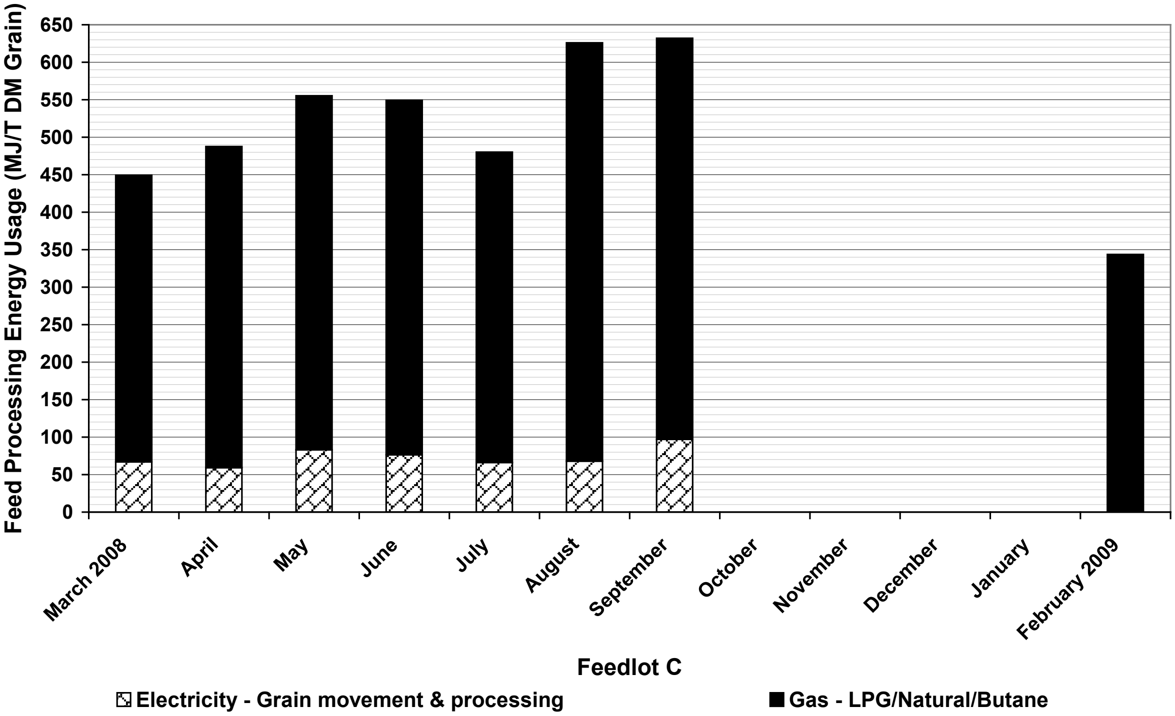

Figure 75 – Feed processing energy consumption for Feedlot C (MJ/t dm grain)

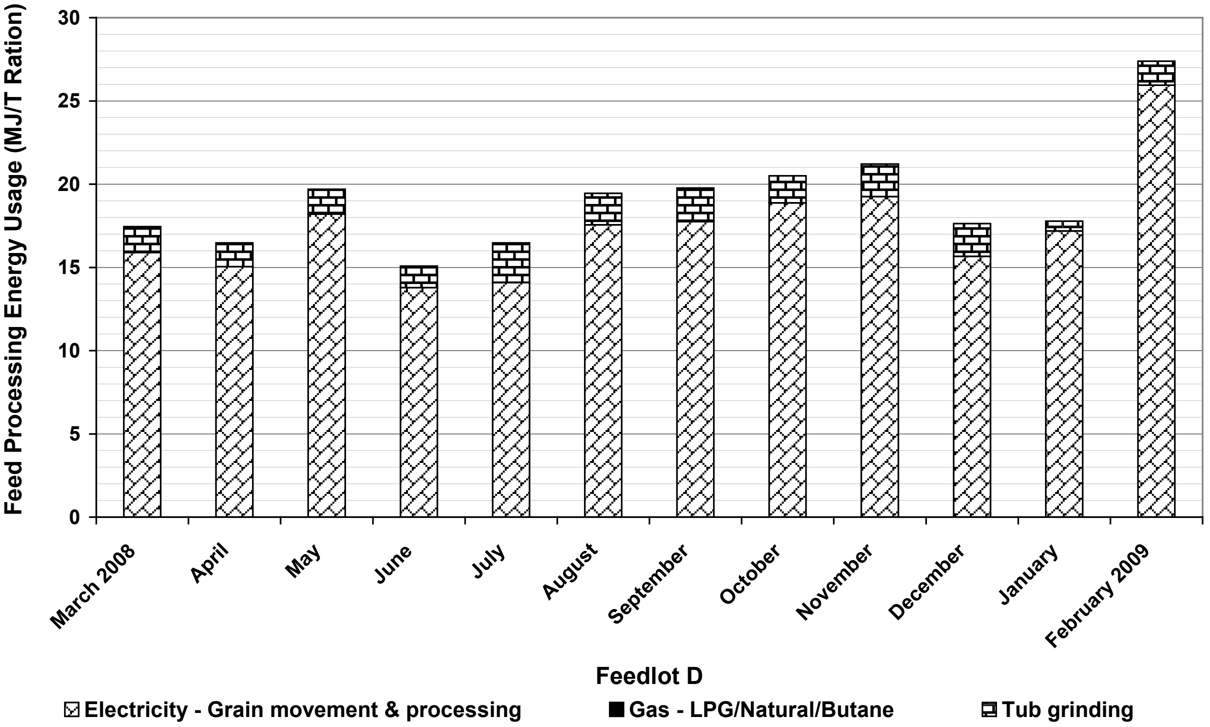

Figure 76 – Feed processing energy consumption for Feedlot D (MJ/t ration)

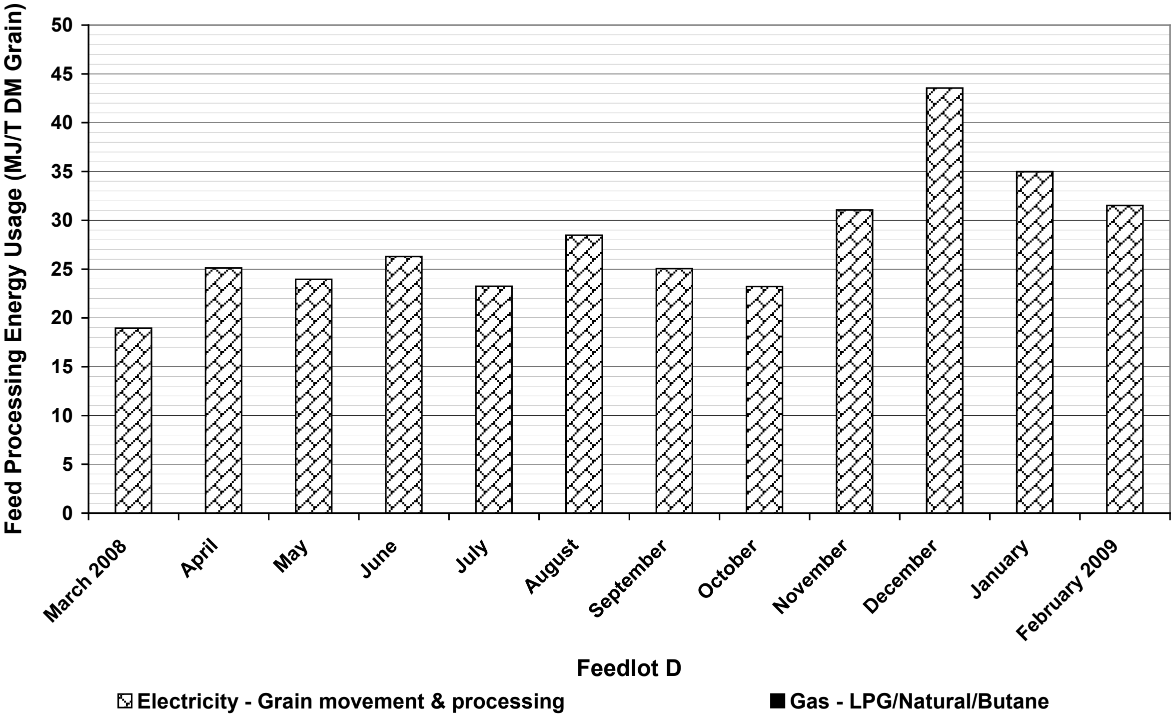

Figure 77 – Feed processing energy consumption for Feedlot D (MJ/t dm grain)

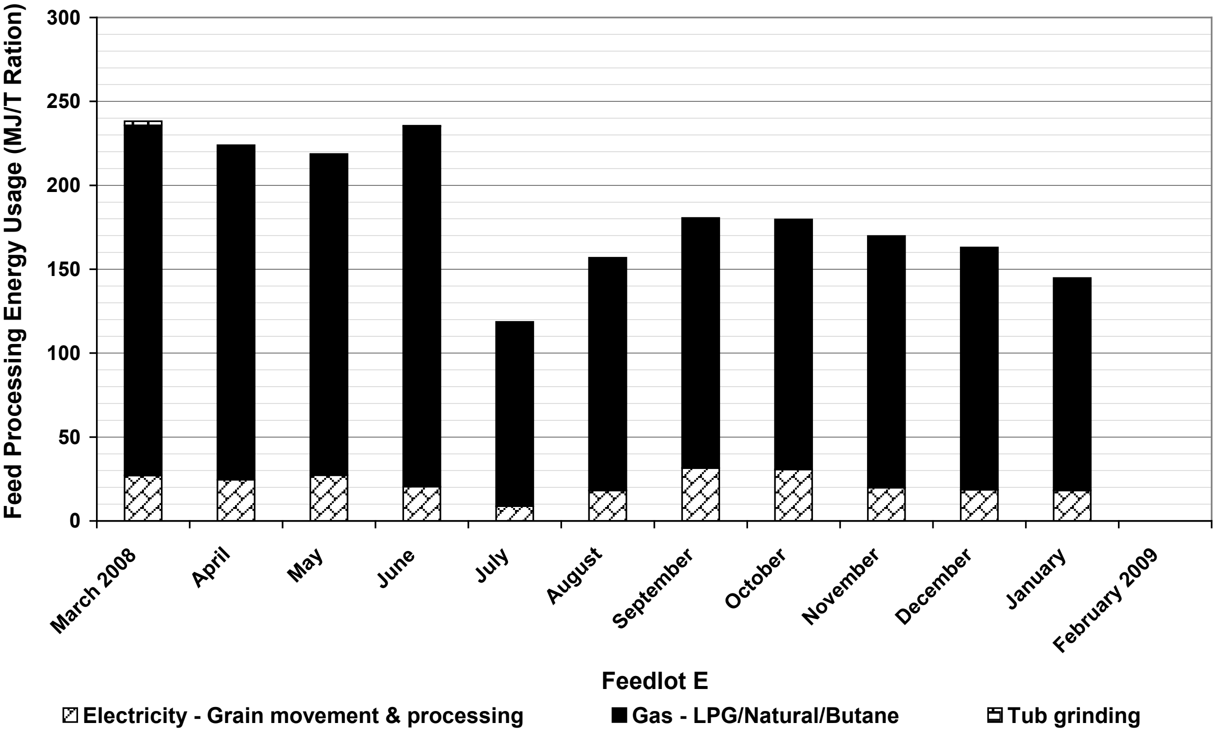

Figure 78 – Feed processing energy consumption for Feedlot E (MJ/t ration)

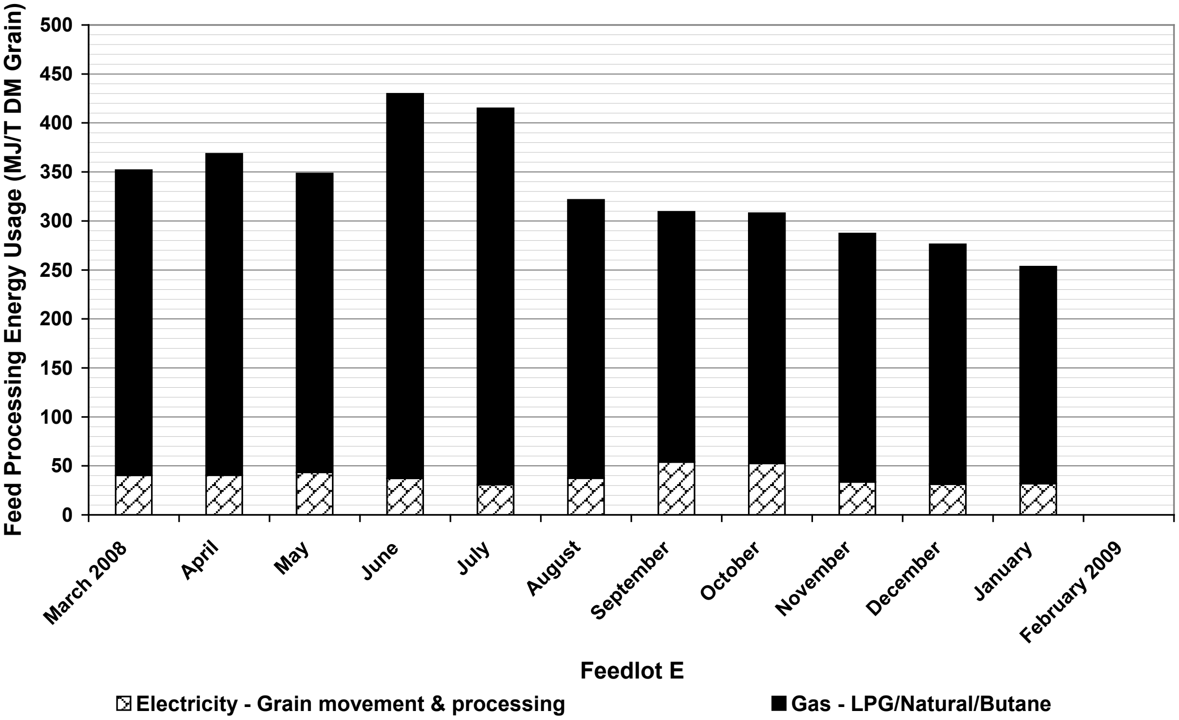

Figure 79 – Feed processing energy consumption for Feedlot E (MJ/t dm grain)

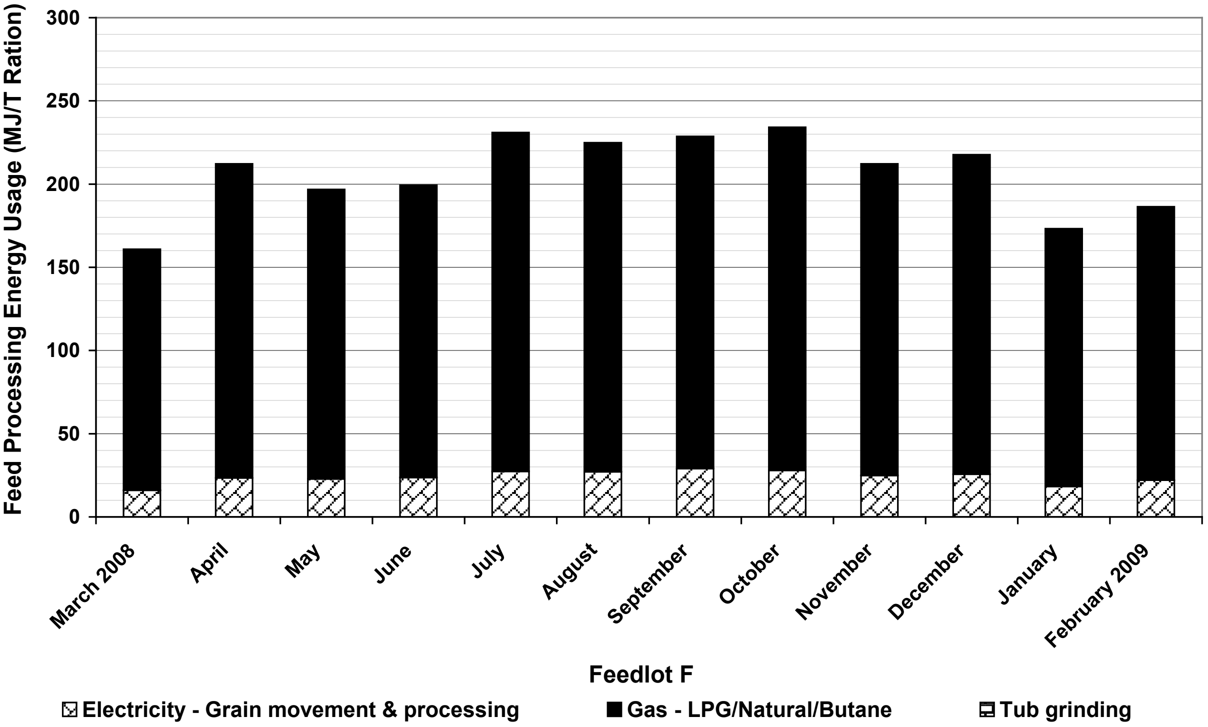

Figure 80 – Feed processing energy consumption for Feedlot F (MJ/t ration)

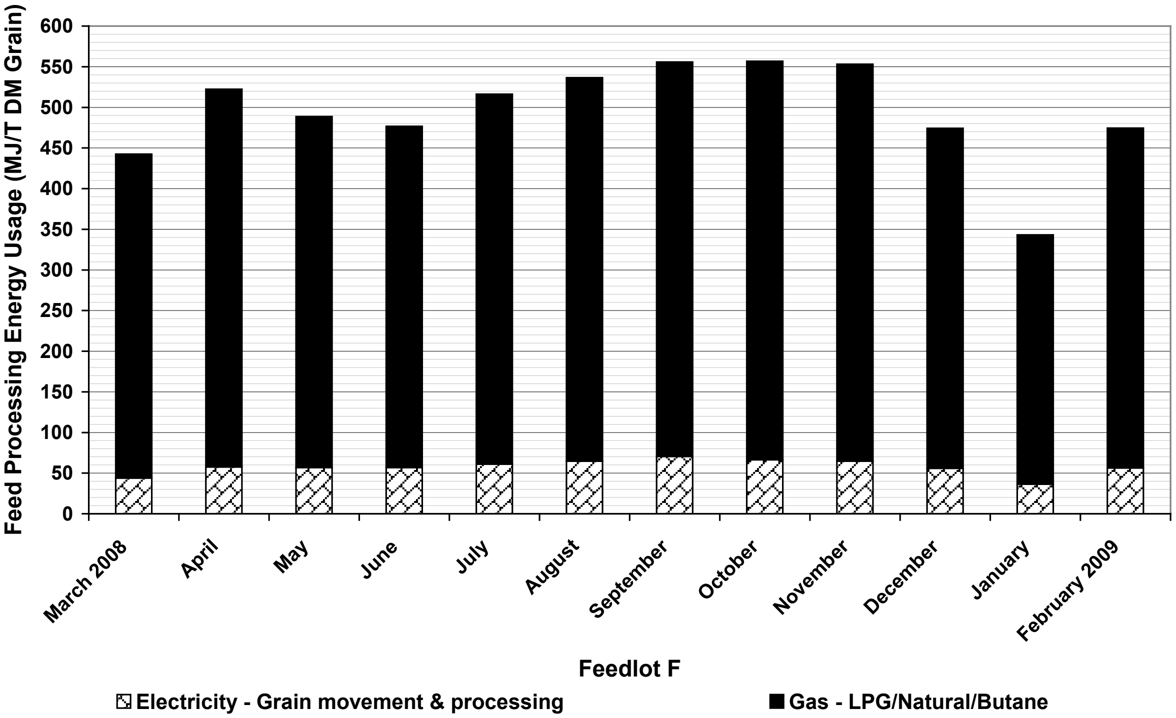

Figure 81 – Feed processing energy consumption for Feedlot F (MJ/t dm grain)

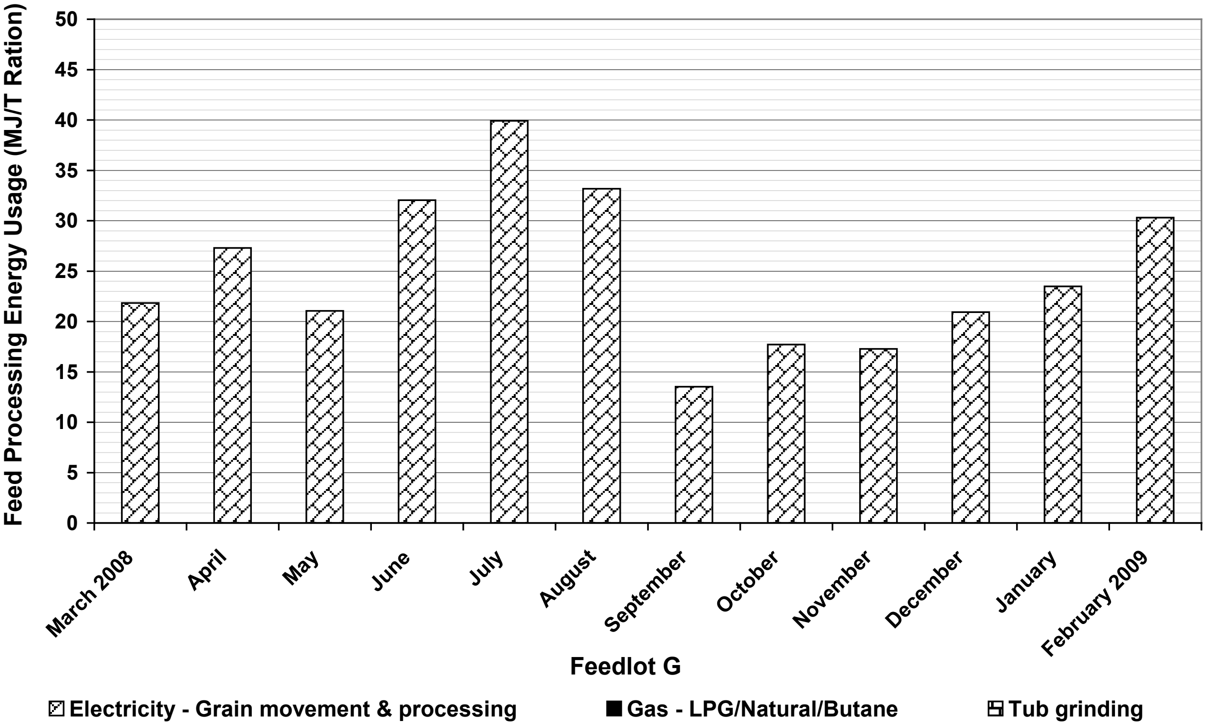

Figure 82 – Feed processing energy consumption for Feedlot G (MJ/t ration)

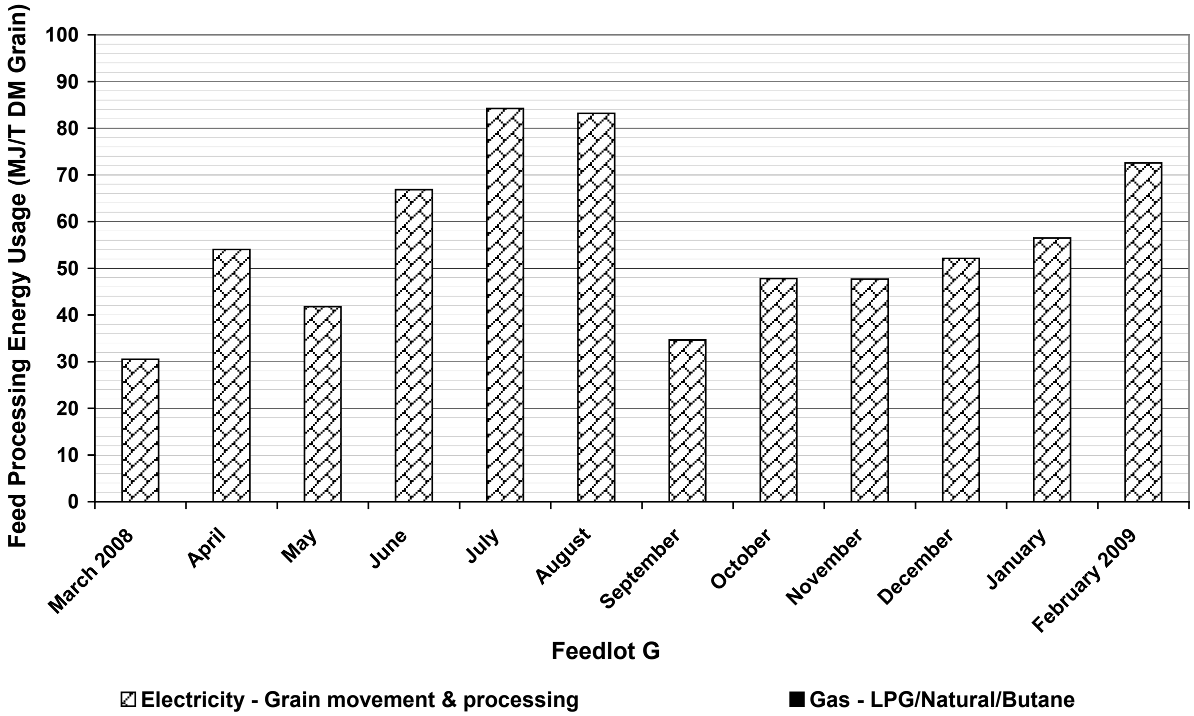

Figure 83 – Feed processing energy consumption for Feedlot G (MJ/t dm grain)

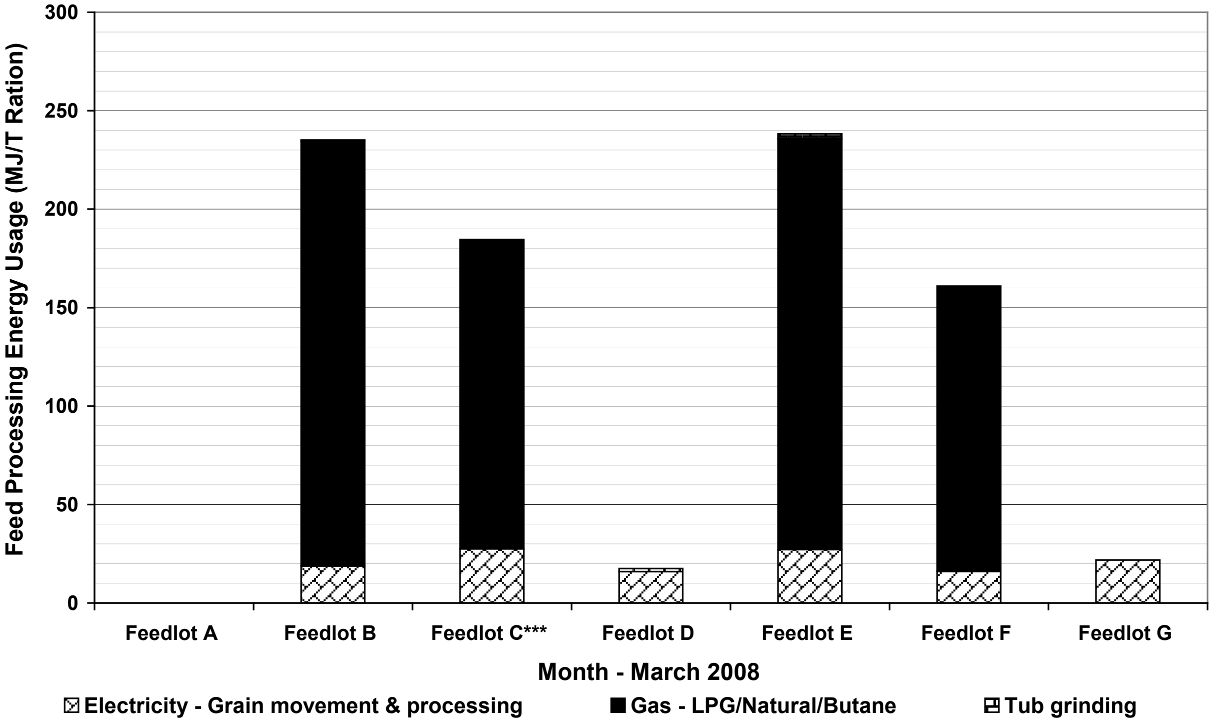

Figure 84 – Feed processing energy consumption for March 2008 (MJ/t ration)

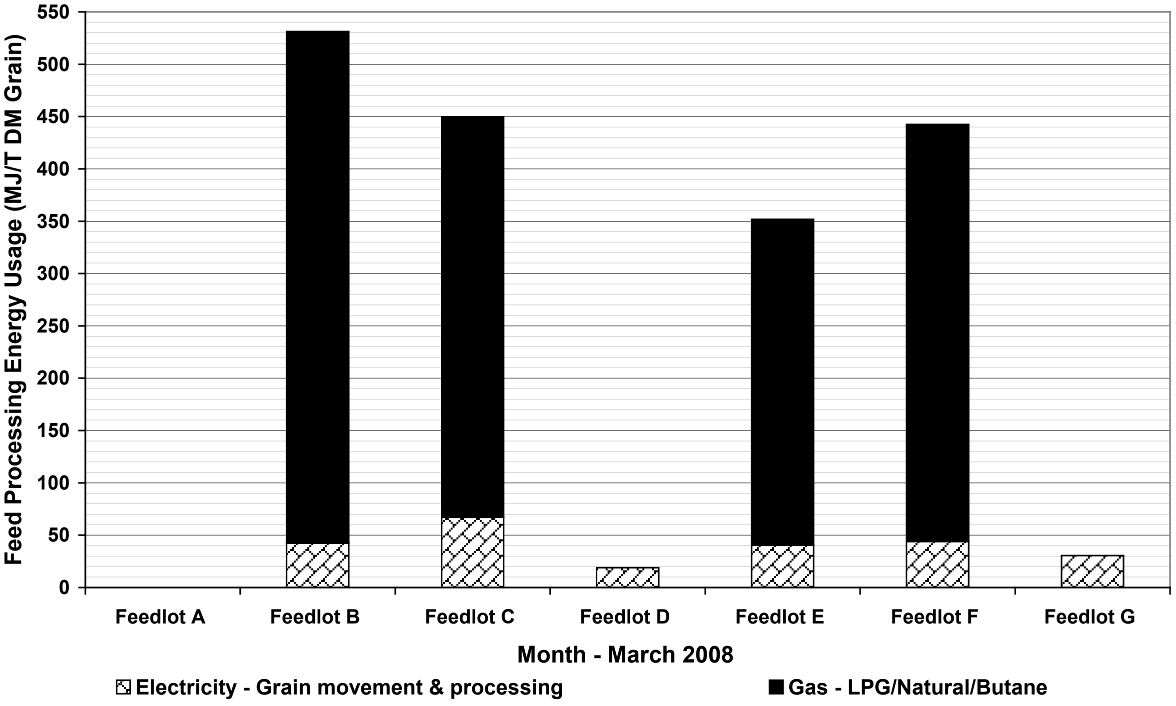

Figure 85 – Feed processing energy consumption for March 2008 (MJ/t dm grain)

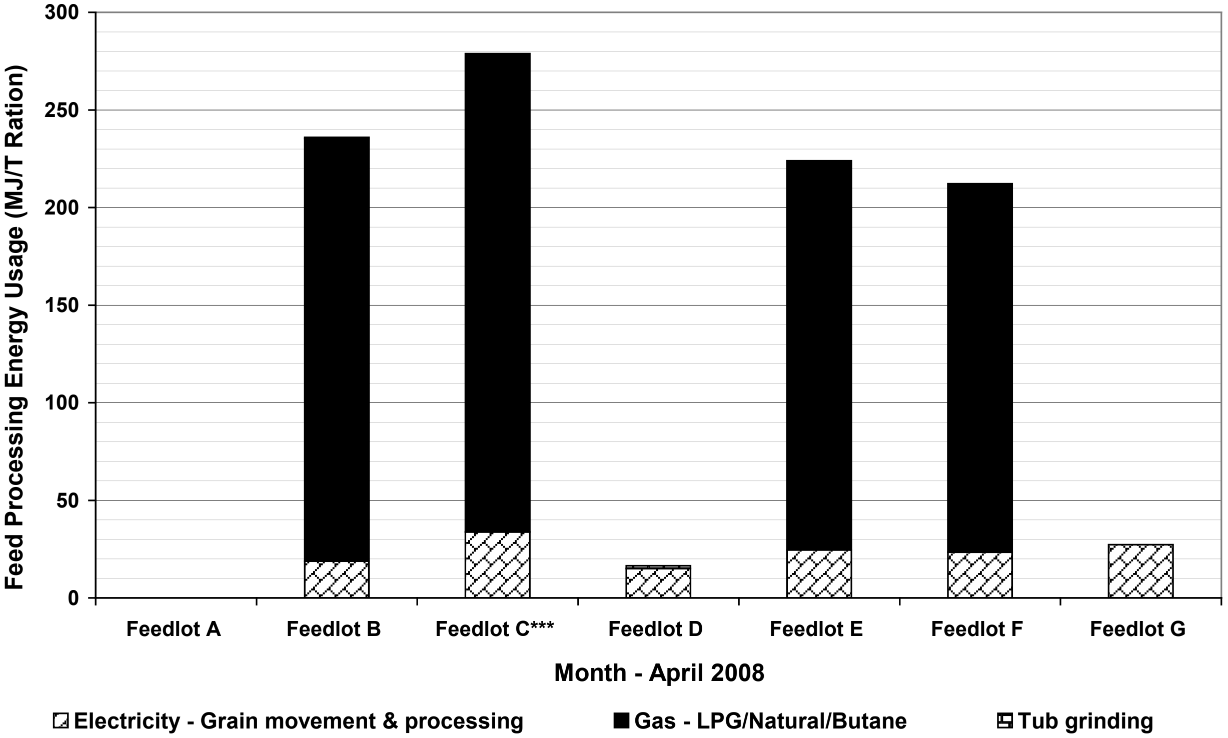

Figure 86 – Feed processing energy consumption for April 2008 (MJ/t ration)

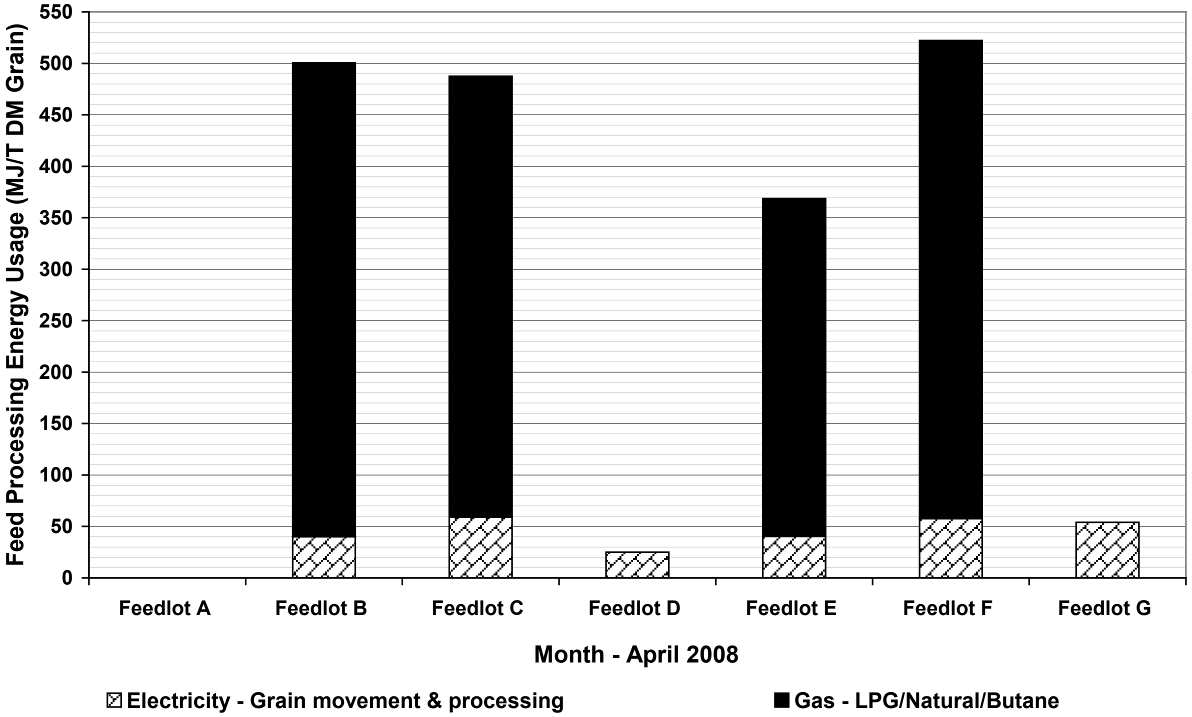

Figure 87 – Feed processing energy consumption for April 2007 (MJ/t dm grain)

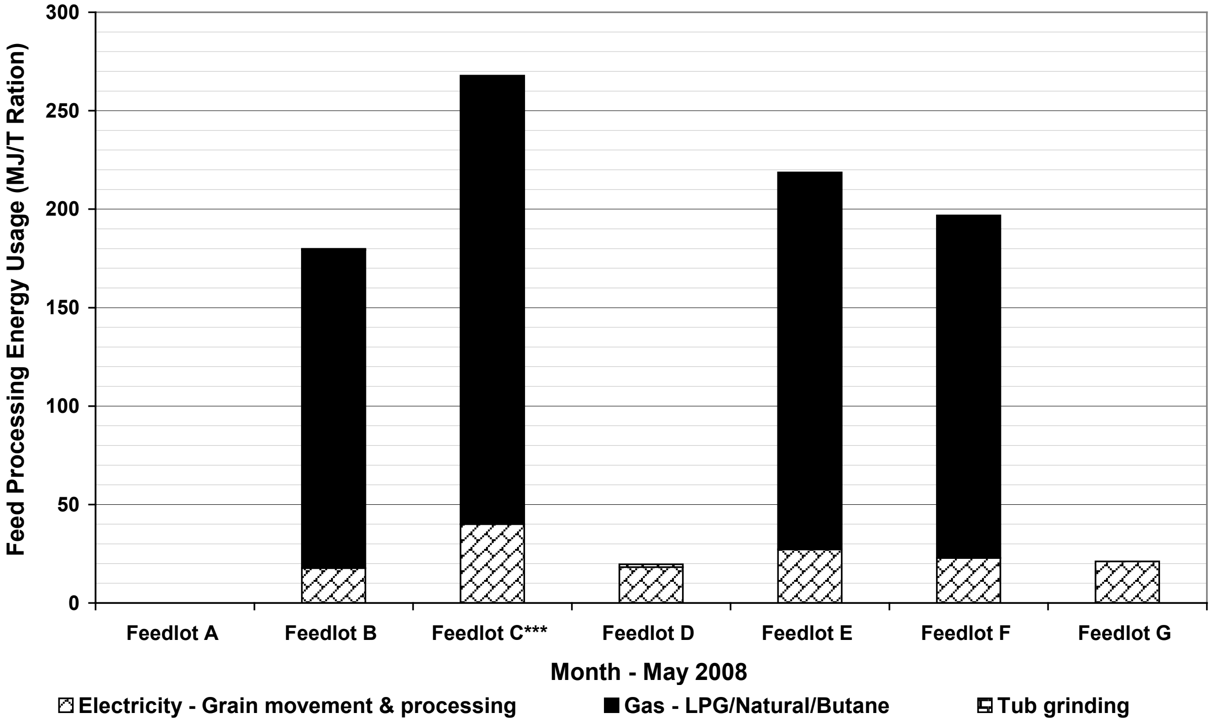

Figure 88 – Feed processing energy consumption for May 2008 (MJ/t ration)

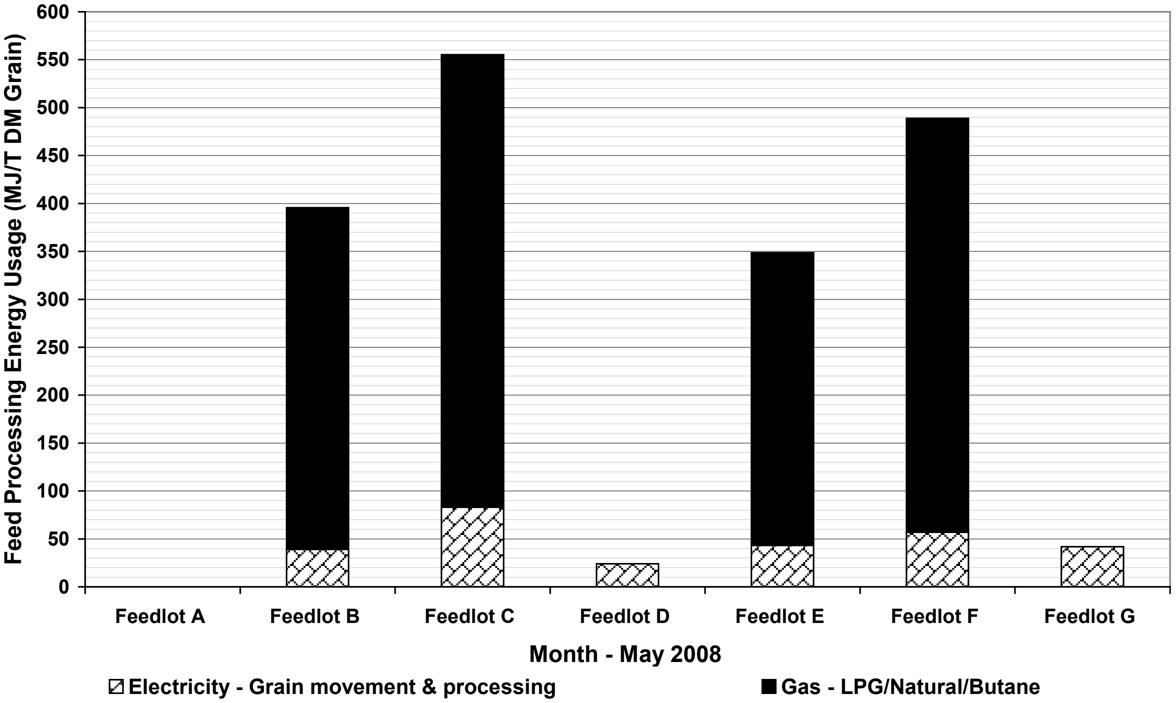

Figure 89 – Feed processing energy consumption for May 2008 (MJ/t dm grain)

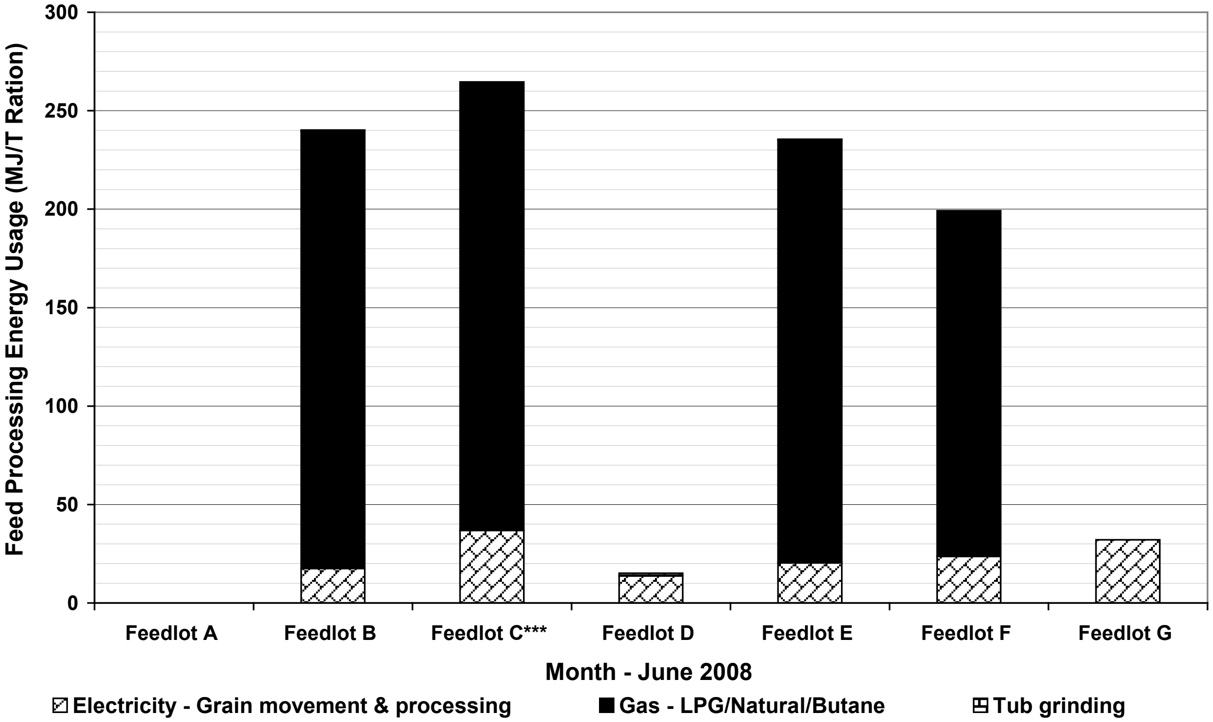

Figure 90 – Feed processing energy consumption for June 2008 (MJ/t ration)

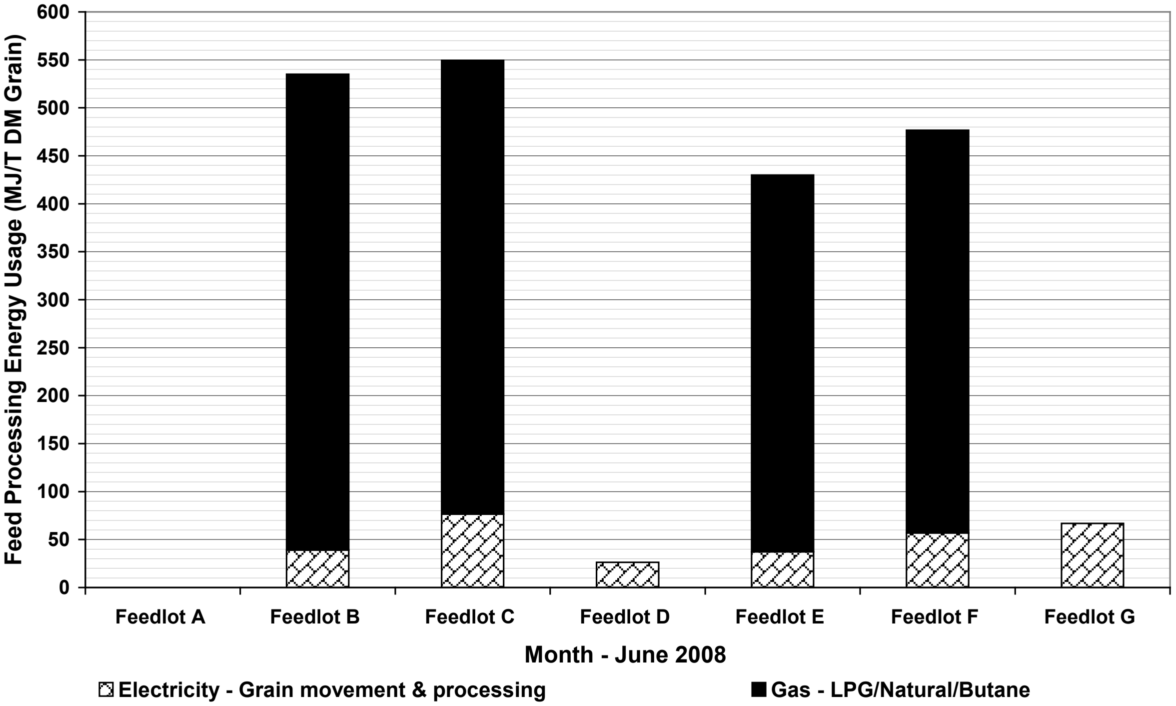

Figure 91 – Feed processing energy consumption for June 2008 (MJ/t dm grain)

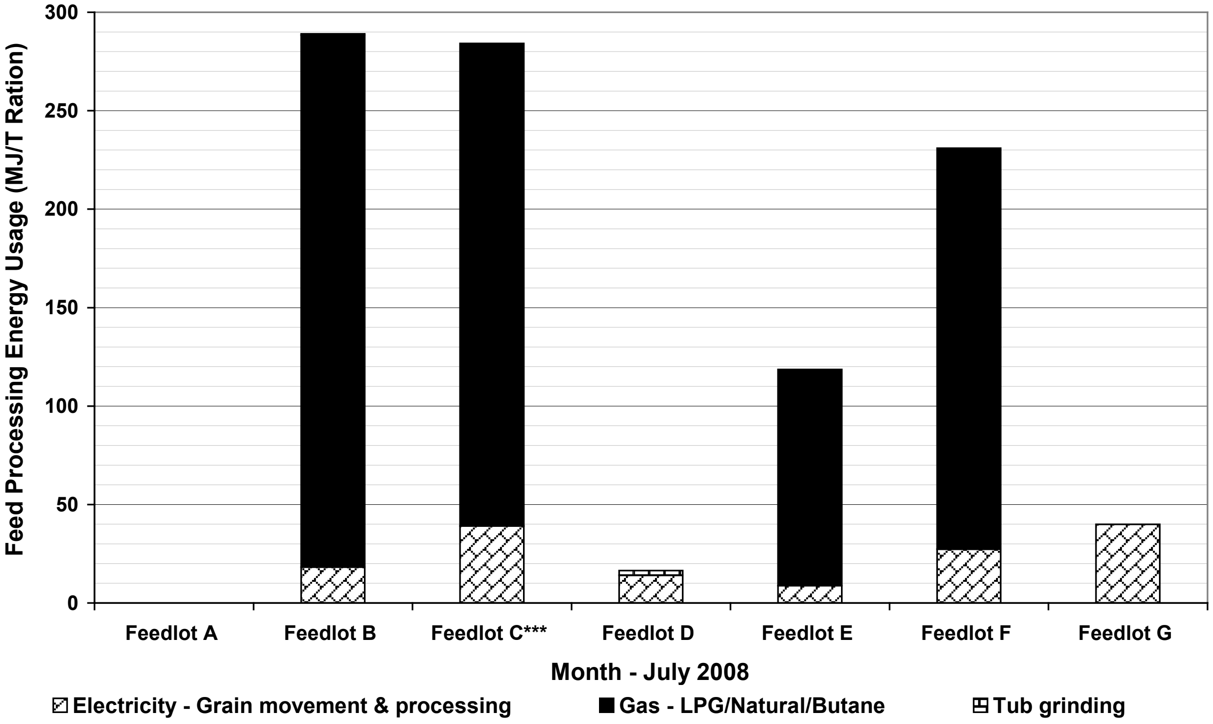

Figure 92 – Feed processing energy consumption for July 2008 (MJ/t ration)

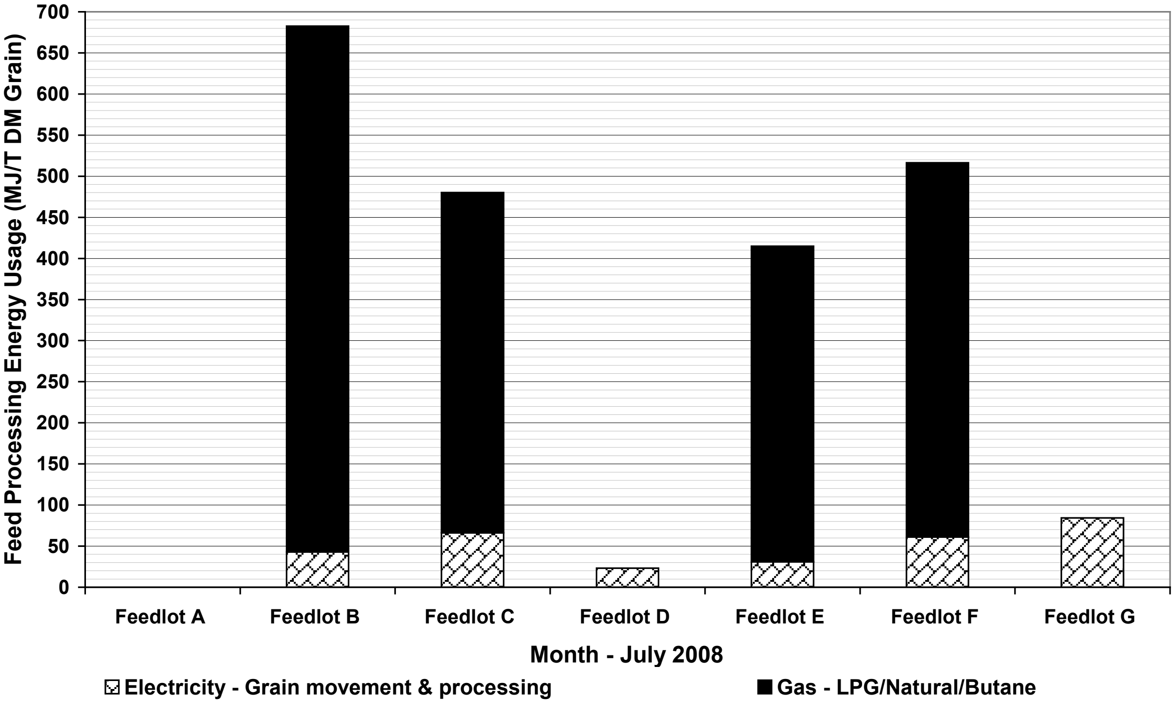

Figure 93 – Feed processing energy consumption for July 2008 (MJ/t dm grain)

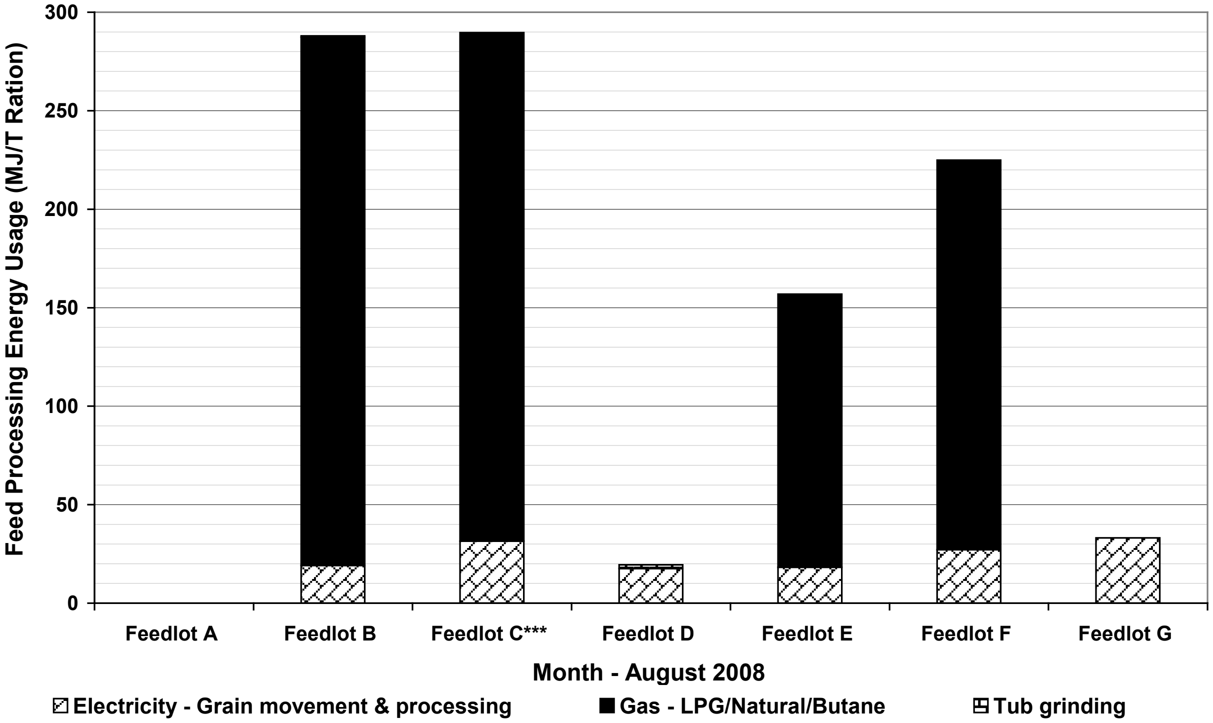

Figure 94 – Feed processing energy consumption for August 2008 (MJ/t ration)

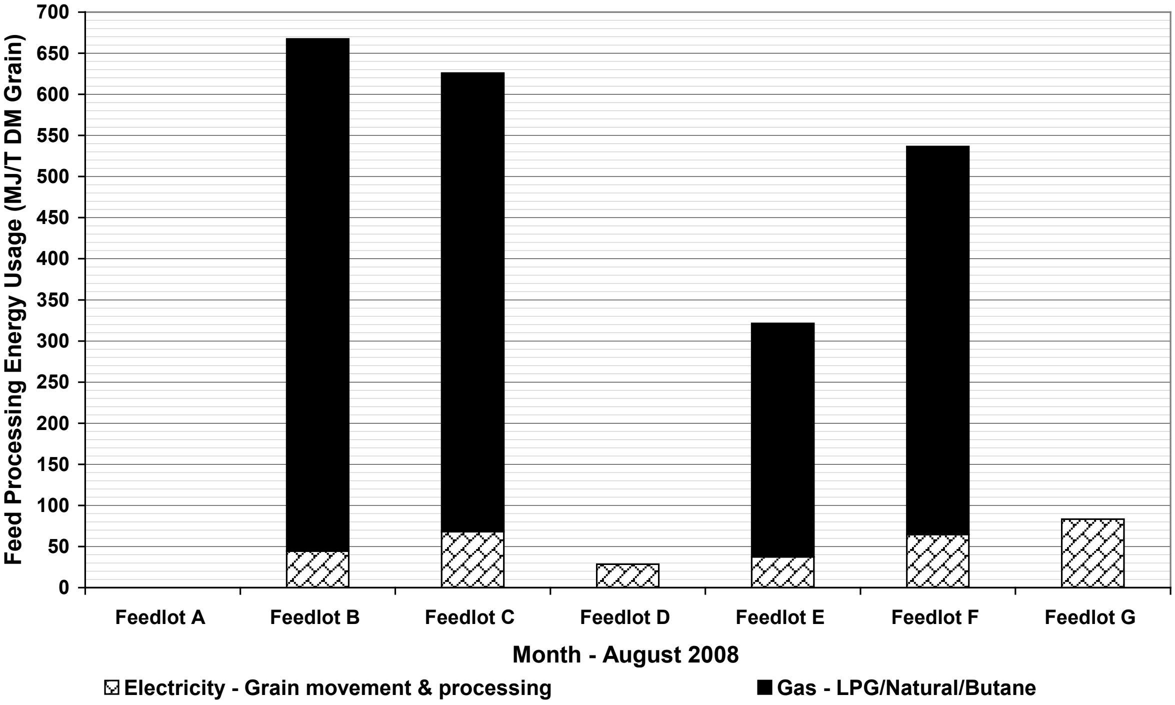

Figure 95 – Feed processing energy consumption for August 2008 (MJ/t dm grain)

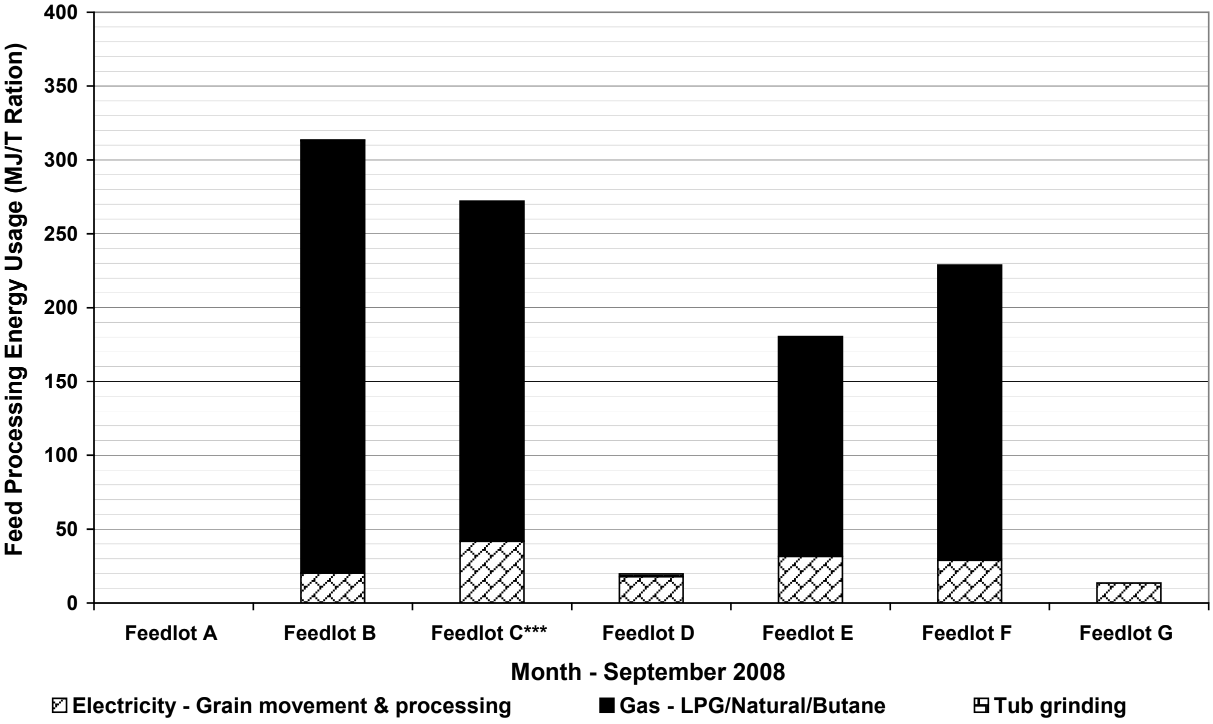

Figure 96 – Feed processing energy consumption for September 2008 (MJ/t ration)

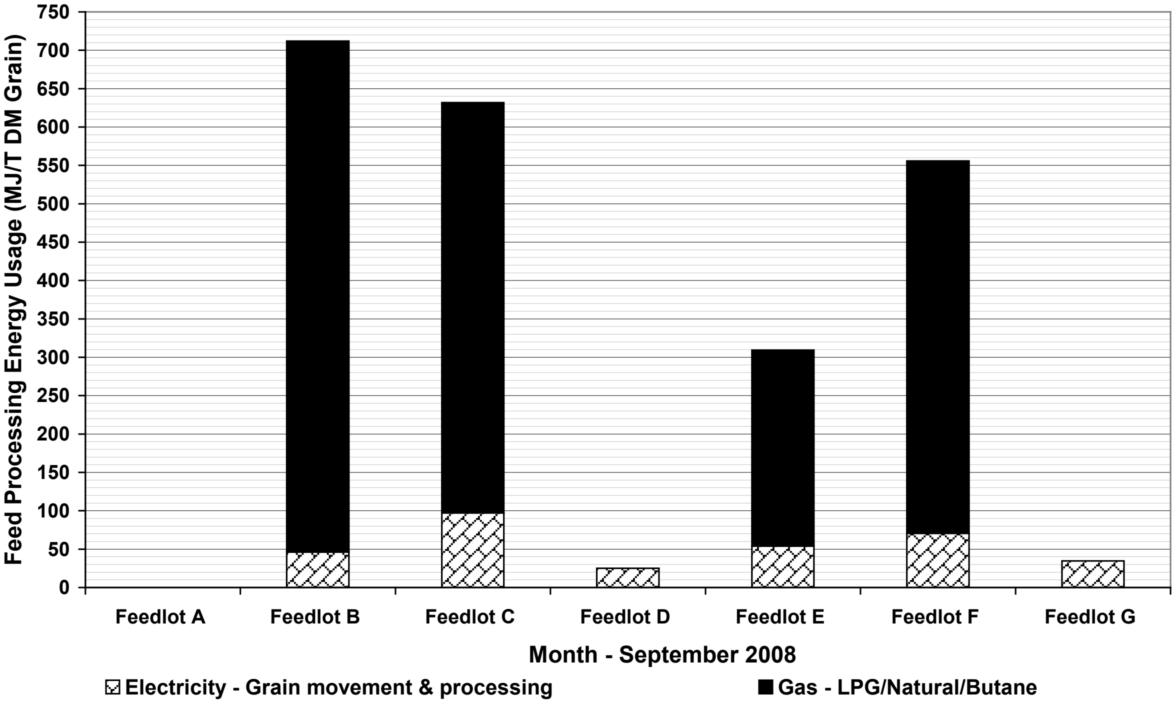

Figure 97 – Feed processing energy consumption for September 2008 (MJ/t dm grain)

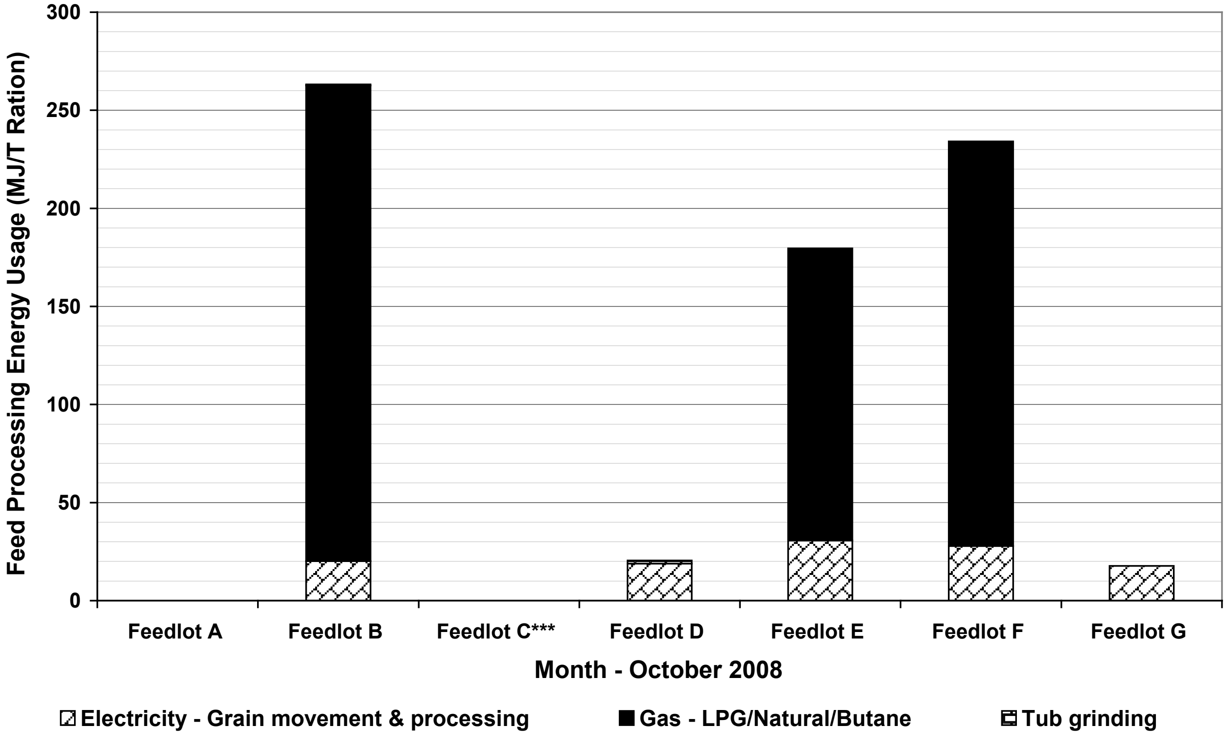

Figure 98 – Feed processing energy consumption for October 2008 (MJ/t ration)

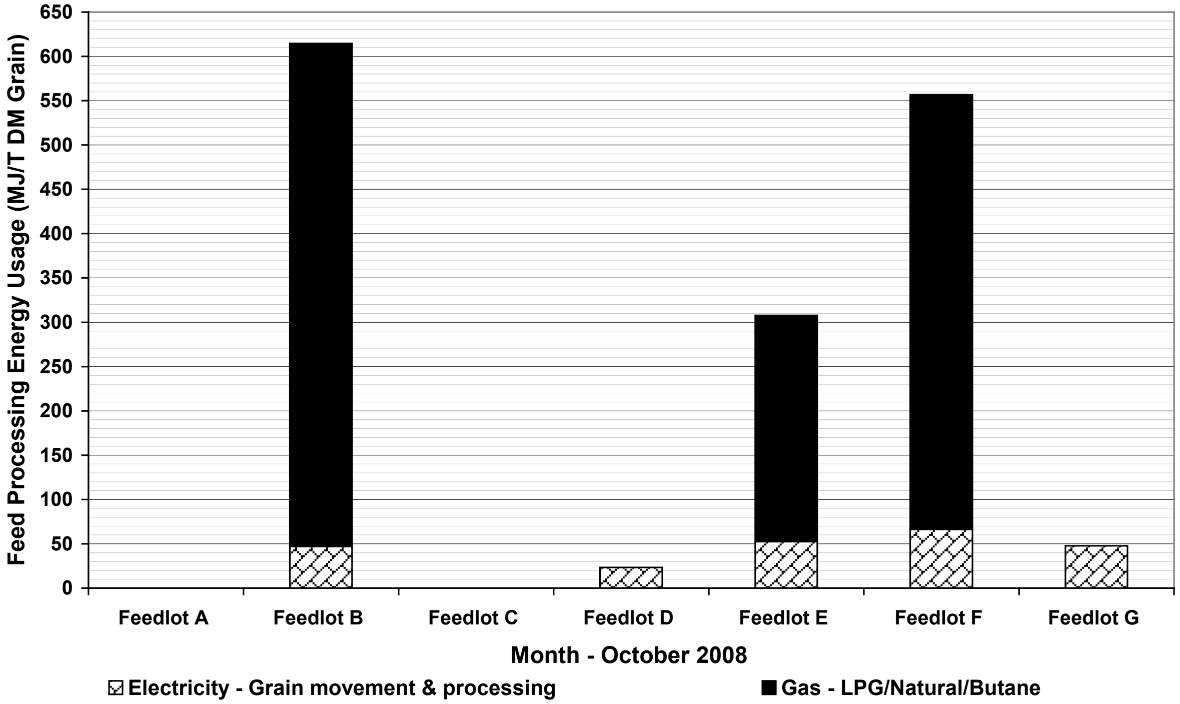

Figure 99 – Feed processing energy consumption for October 2008 (MJ/t dm grain)

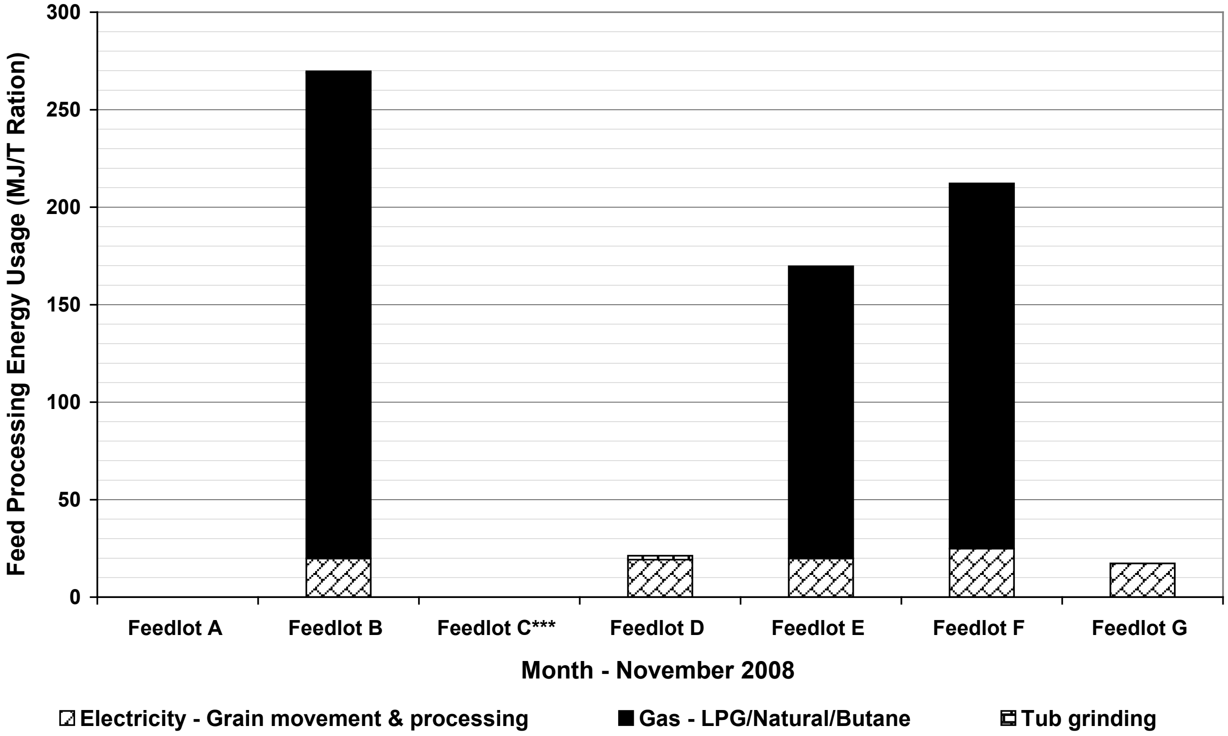

Figure 100 – Feed processing energy consumption for November 2008 (MJ/t ration)

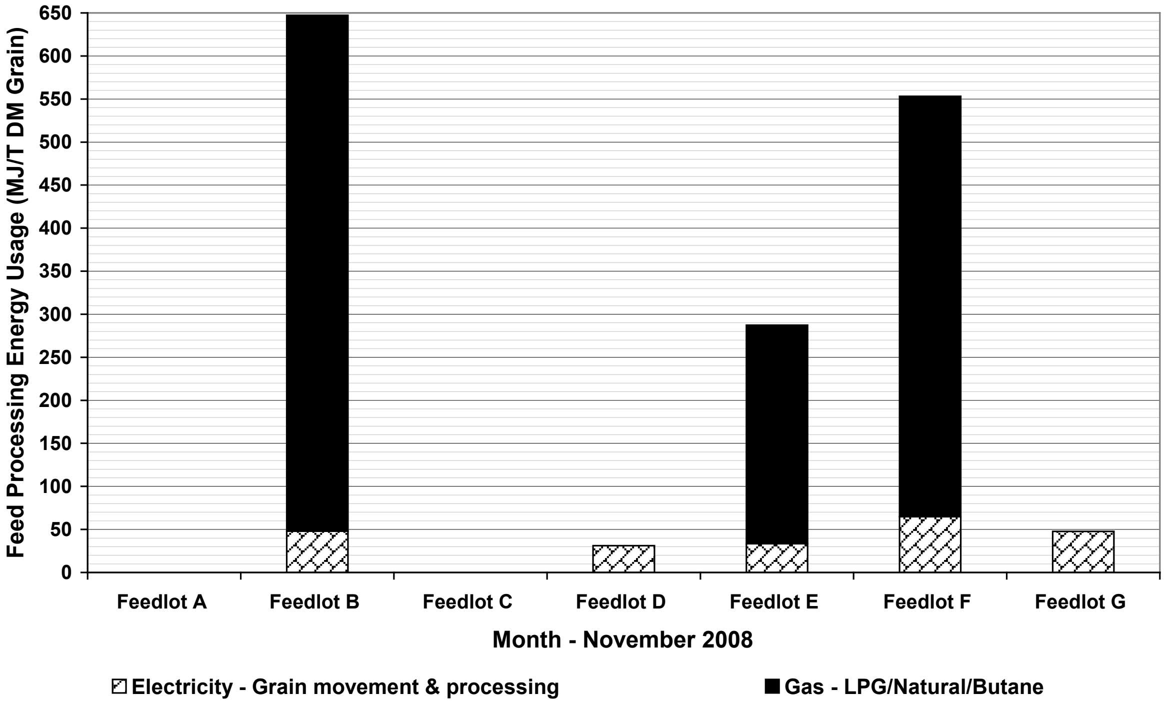

Figure 101 – Feed processing energy consumption for November 2008 (MJ/t dm grain)

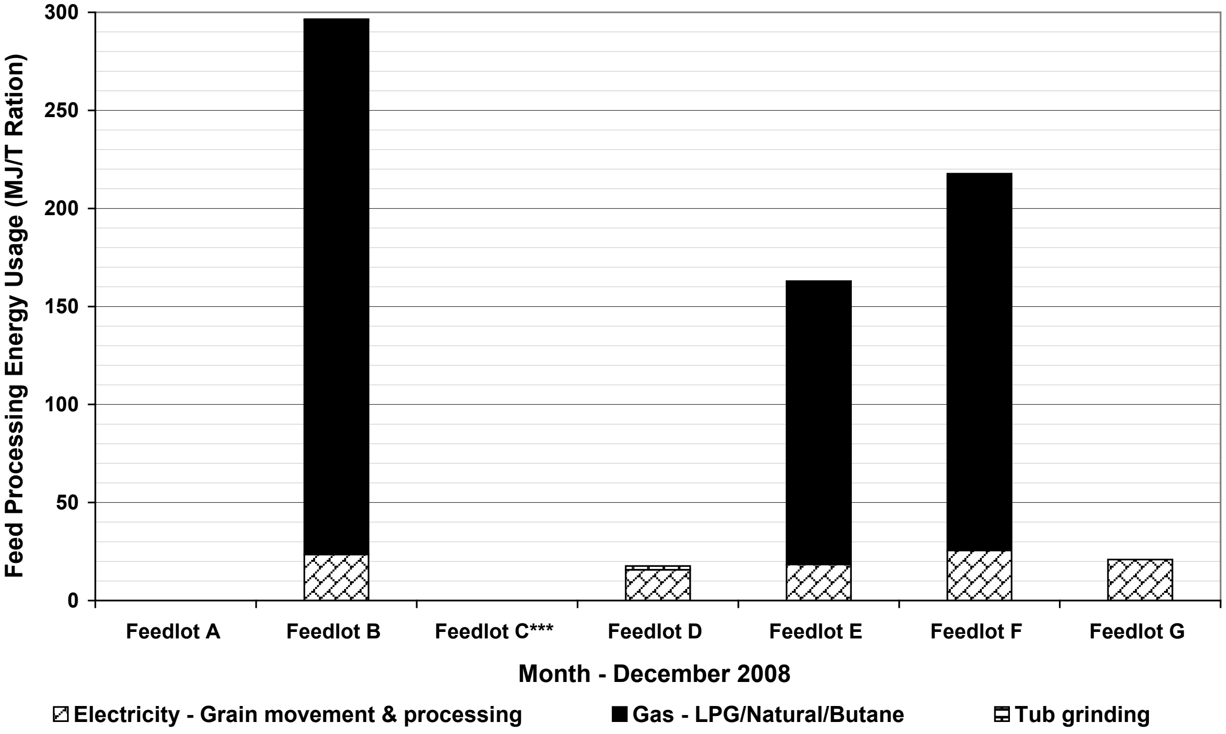

Figure 102 – Feed processing energy consumption for December 2008 (MJ/t ration)

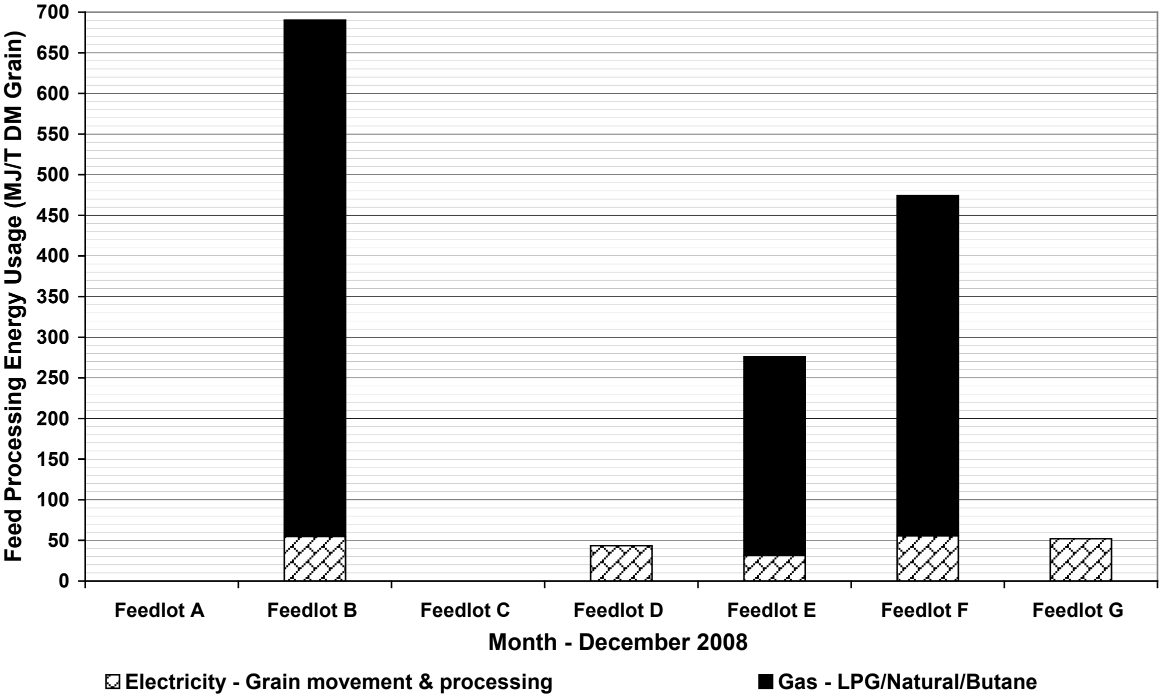

Figure 103 – Feed processing energy consumption for December 2008 (MJ/t dm grain)

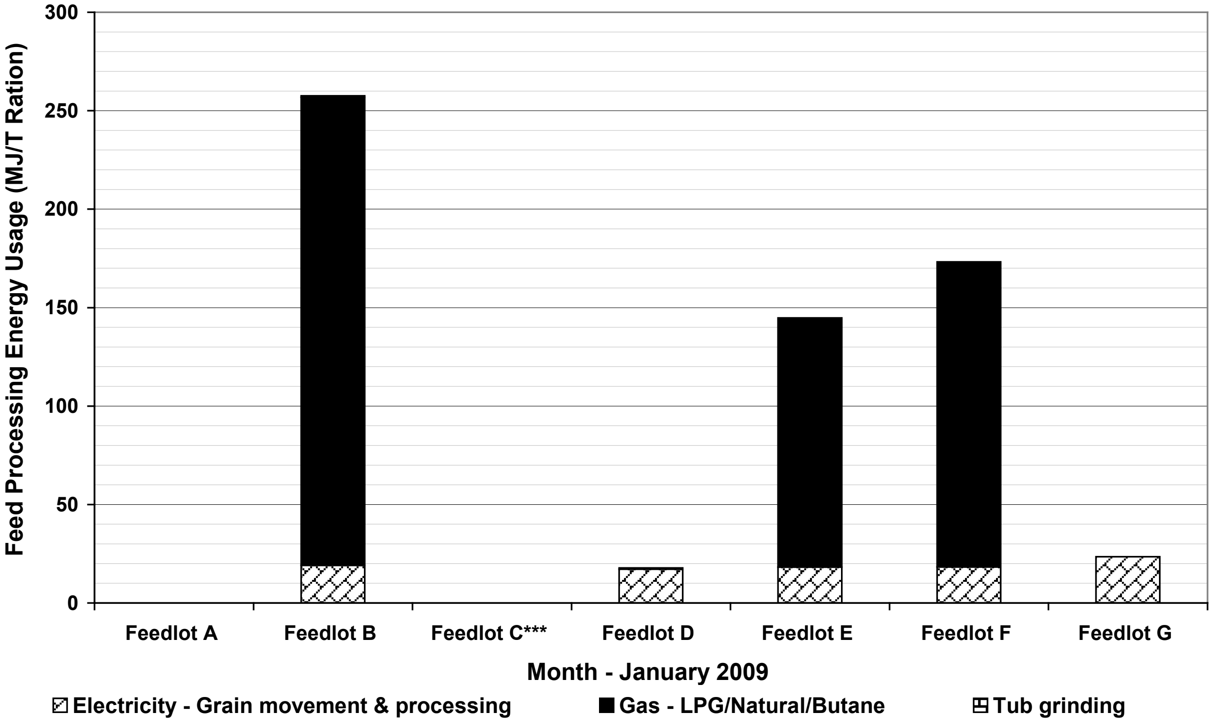

Figure 104 – Feed processing energy consumption for January 2009 (MJ/t ration)

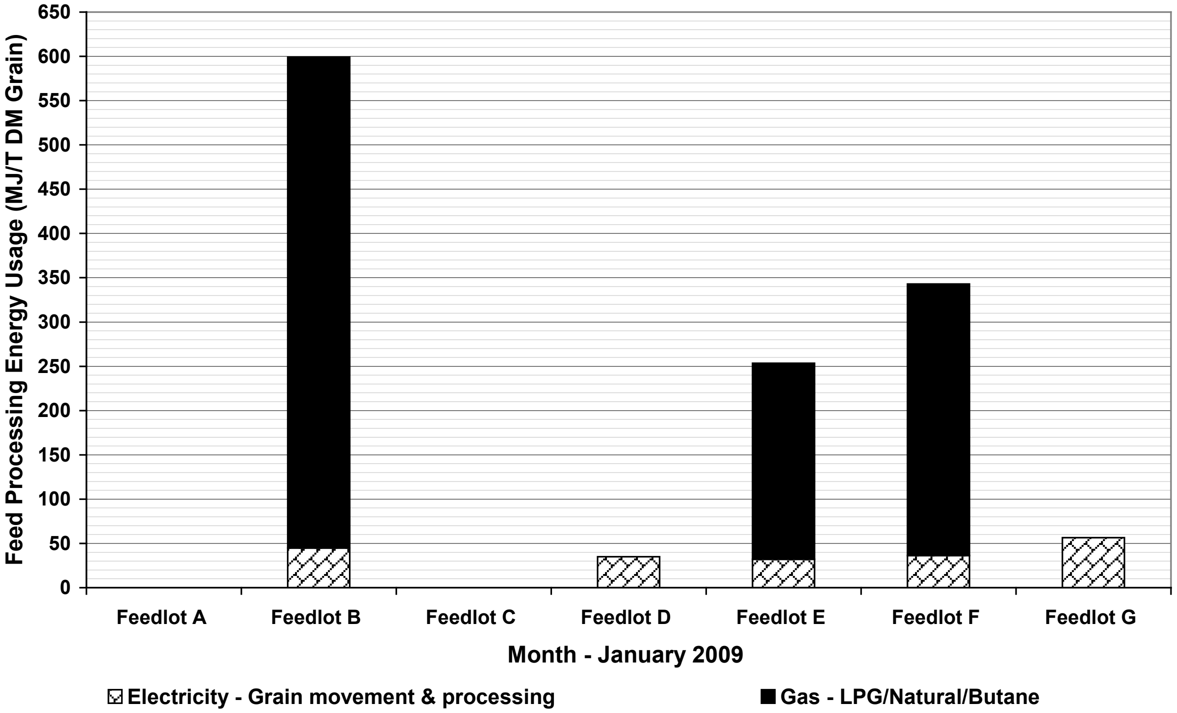

Figure 105 – Feed processing energy consumption for January 2009 (MJ/t dm grain)

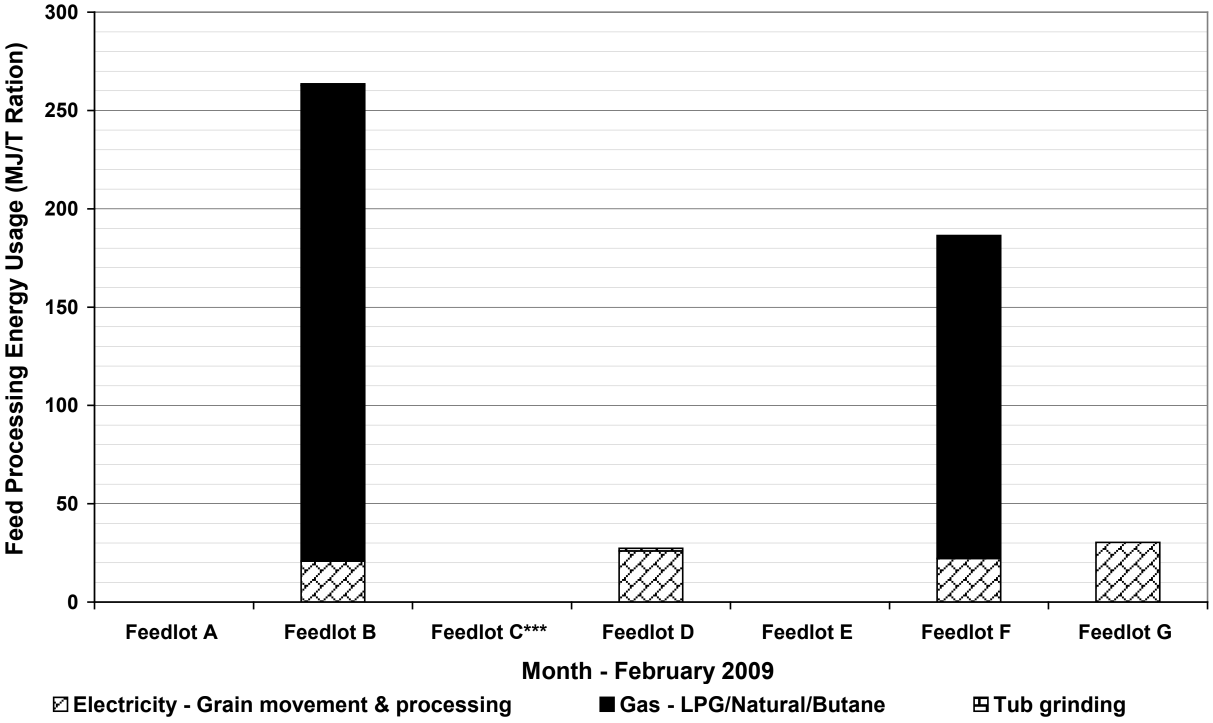

Figure 106 – Feed processing energy consumption for February 2009 (MJ/t ration)

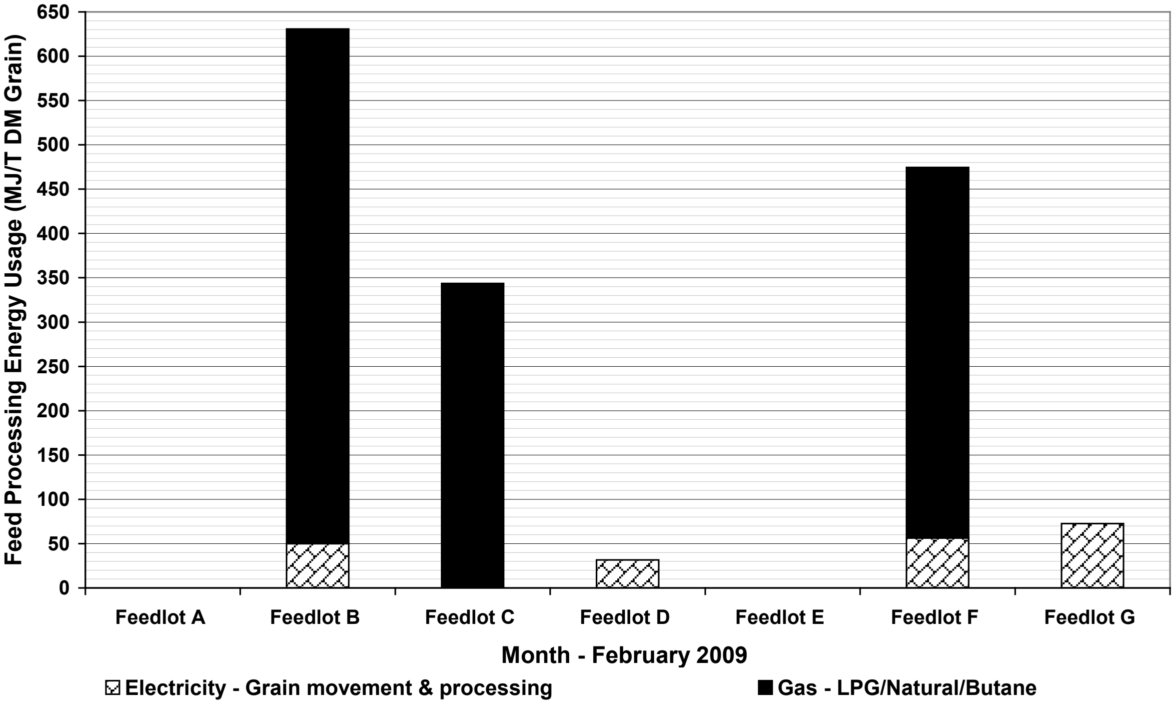

Figure 107 – Feed processing energy consumption for February 2009 (MJ/t dm grain)

Appendix C.2 – Feed delivery energy usage

NA

Figure 108 – Feed delivery energy consumption for Feedlot A (MJ/t ration)

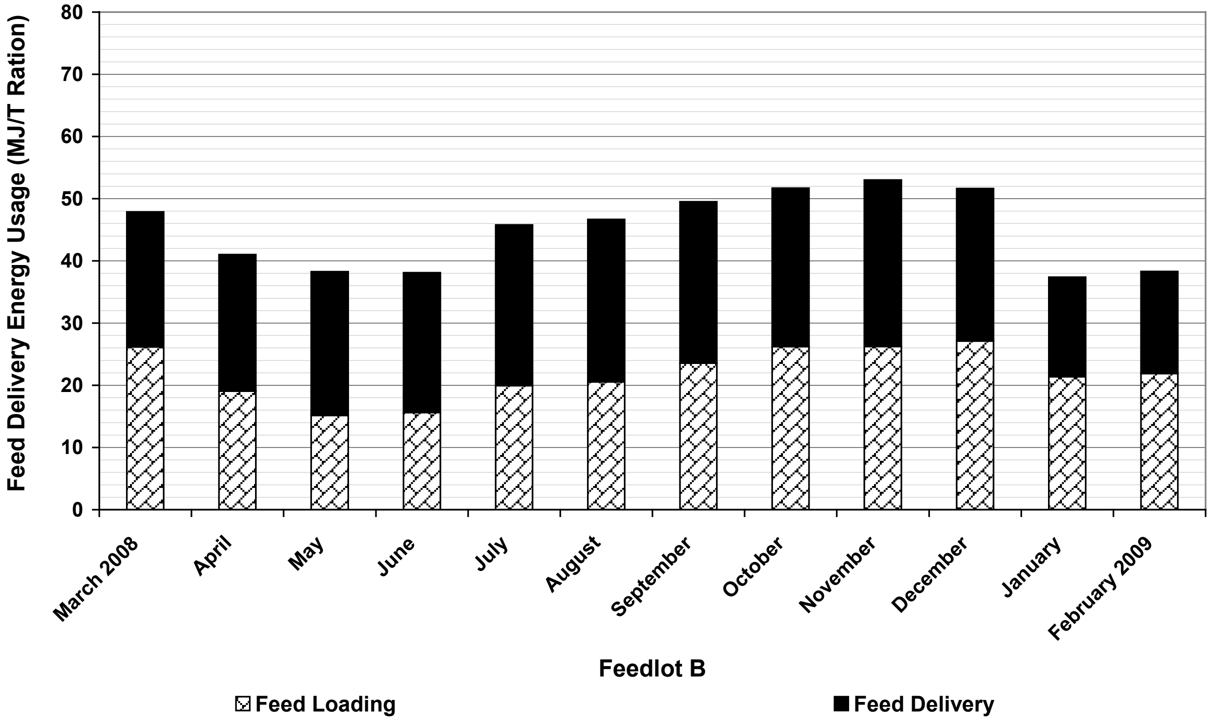

Figure 109 – Feed delivery energy consumption for Feedlot B (MJ/t ration)

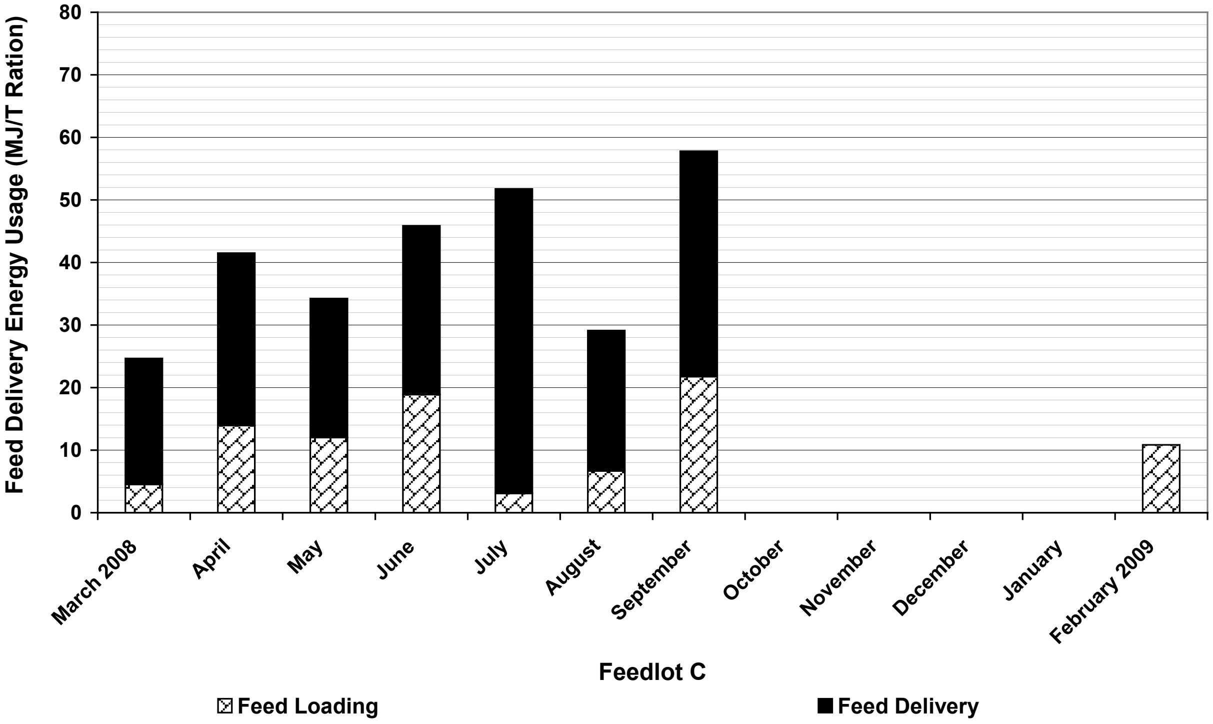

Figure 110 – Feed delivery energy consumption for Feedlot C (MJ/t ration)

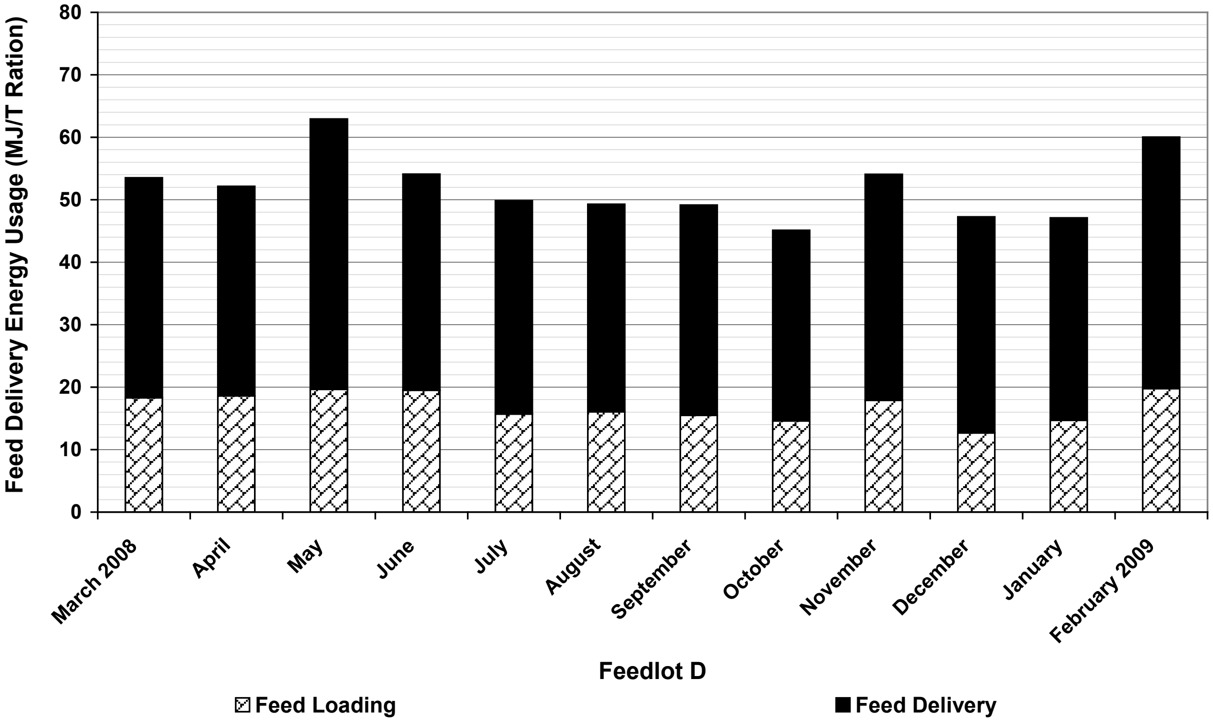

Figure 111 – Feed delivery energy consumption for Feedlot D (MJ/t ration)

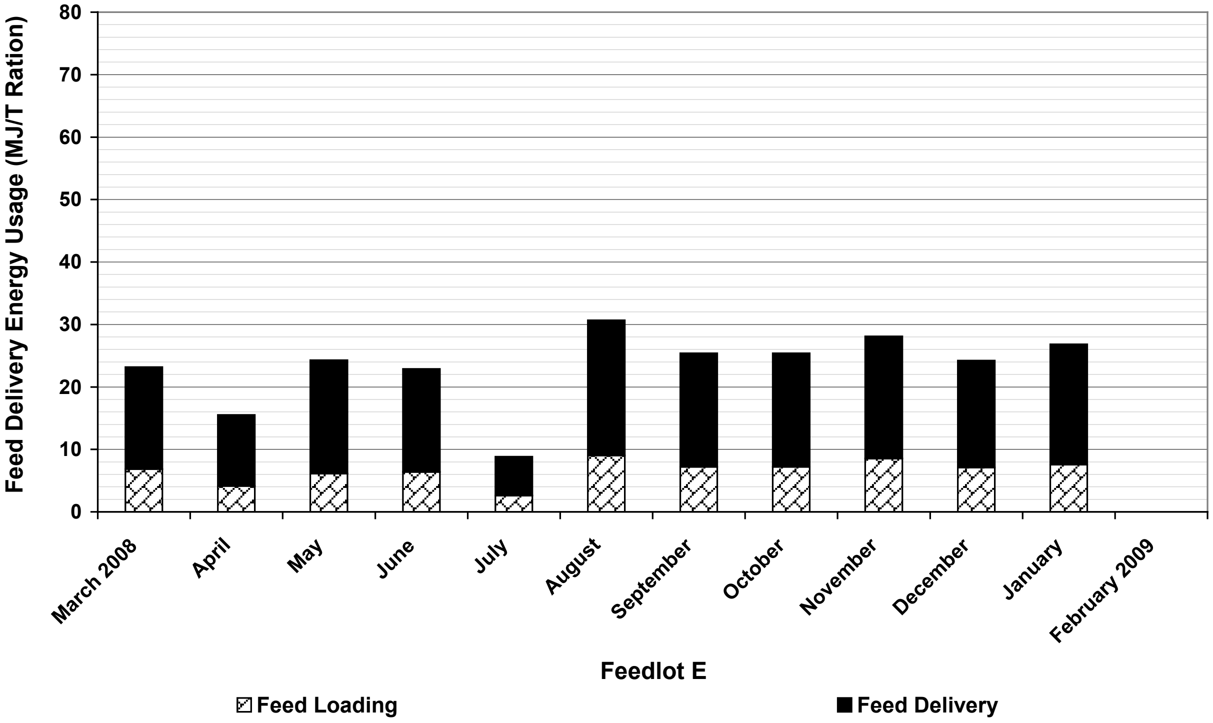

Figure 112 – Feed delivery energy consumption for Feedlot E (MJ/t ration)

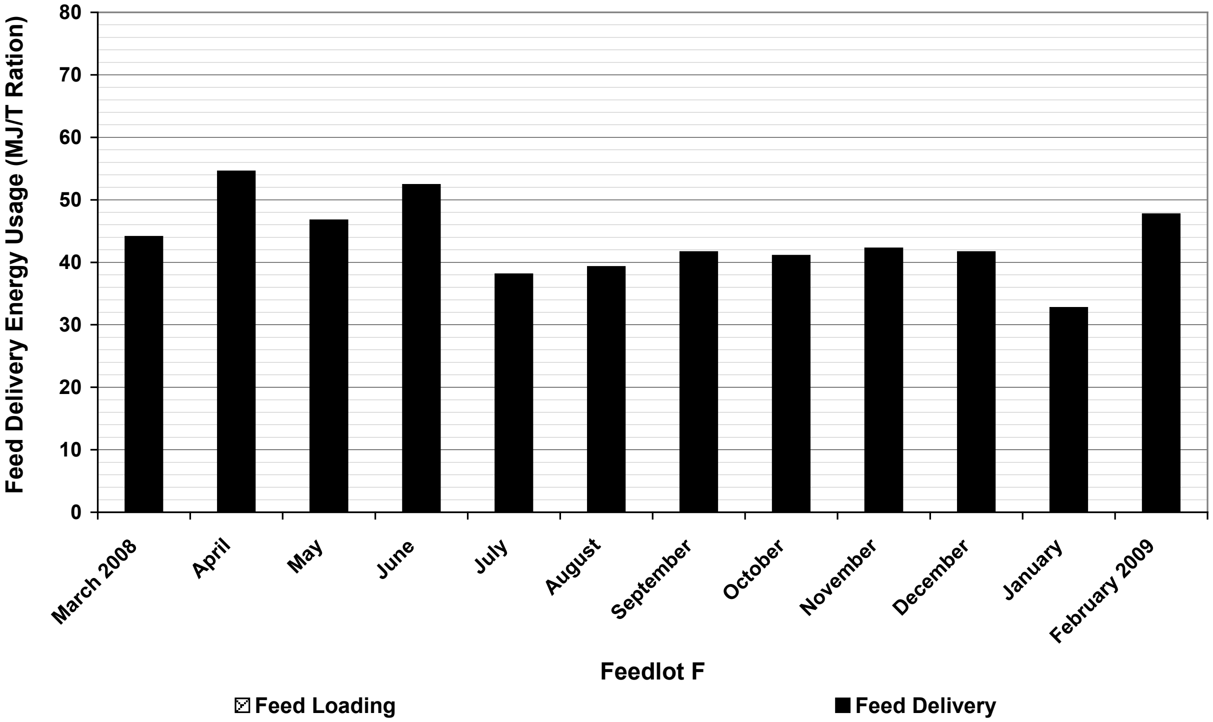

FIGURE 113 – FEED DELIVERY ENERGY CONSUMPTION FOR FEEDLOT F (MJ/T RATION)

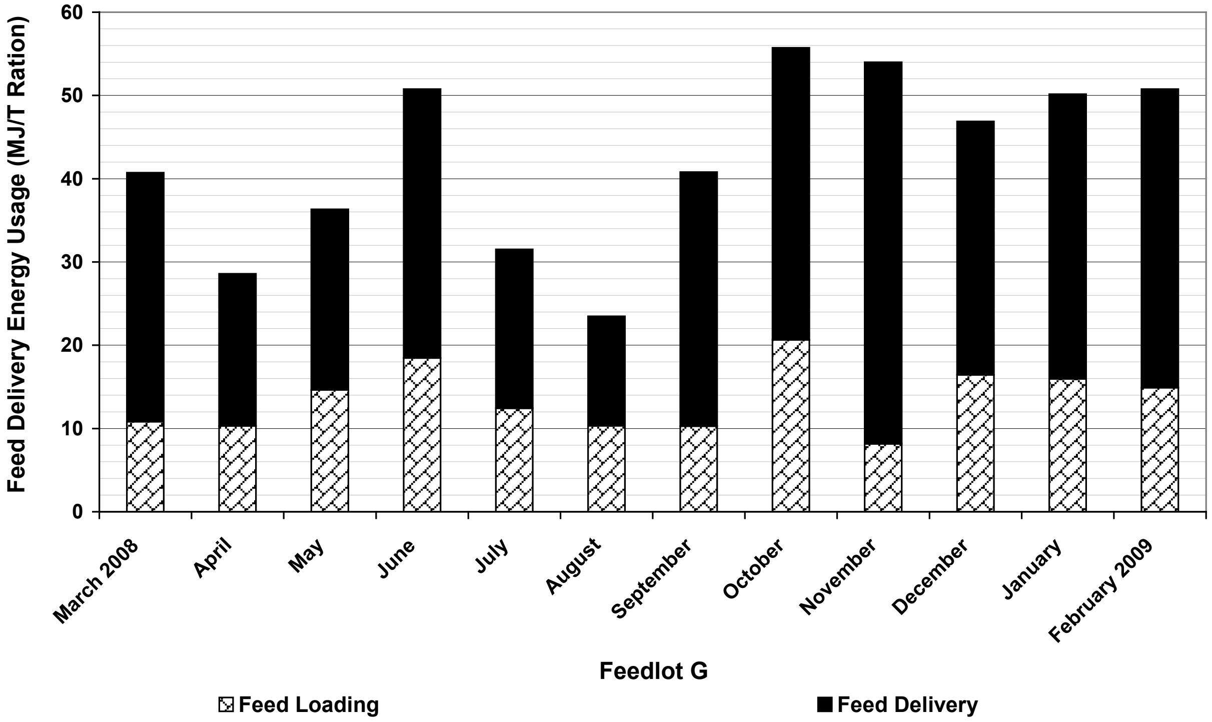

Figure 114 – Feed delivery energy consumption for Feedlot G (MJ/t ration)

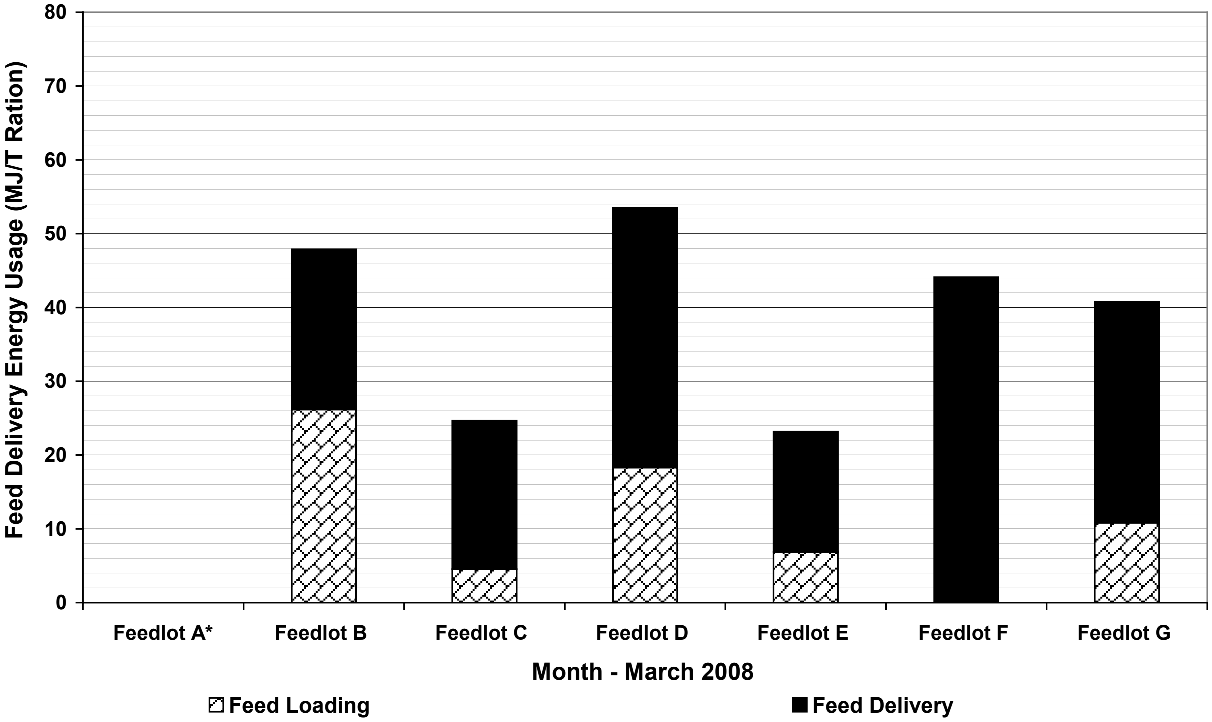

Figure 115 – Feed delivery energy consumption for March 2008 (MJ/t ration)

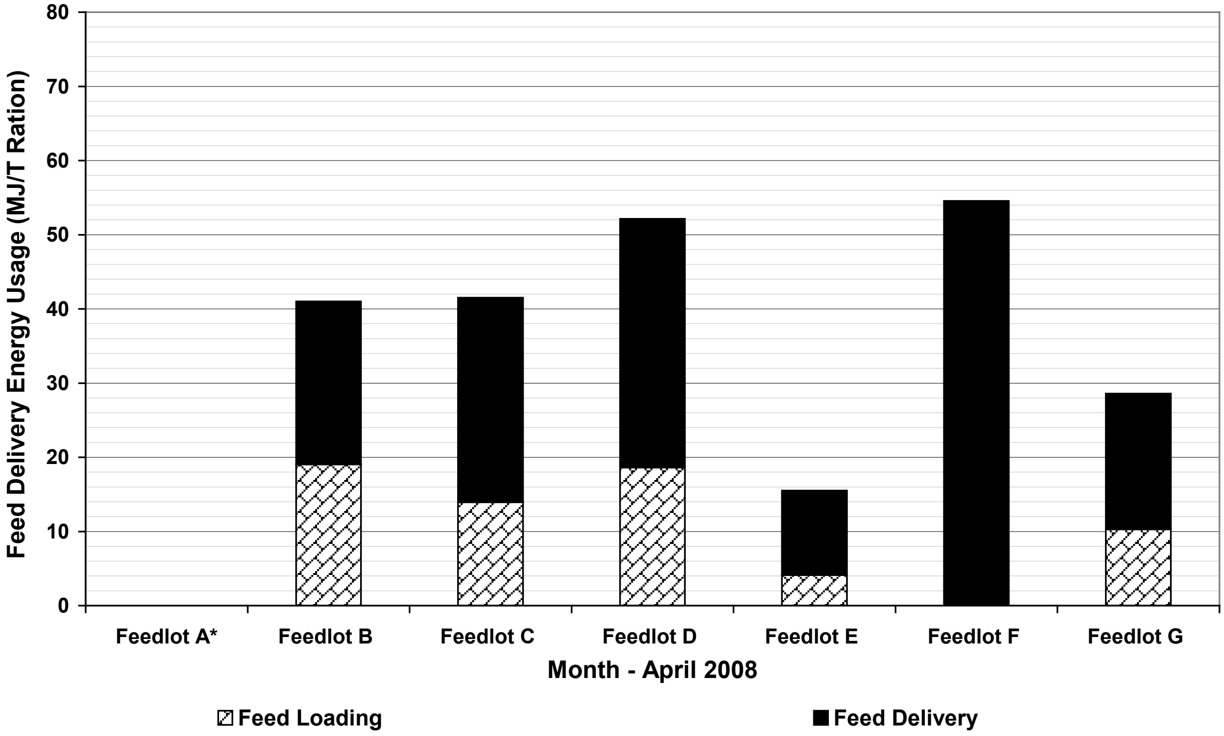

Figure 116 – Feed delivery energy consumption for April 2008 (MJ/t ration)

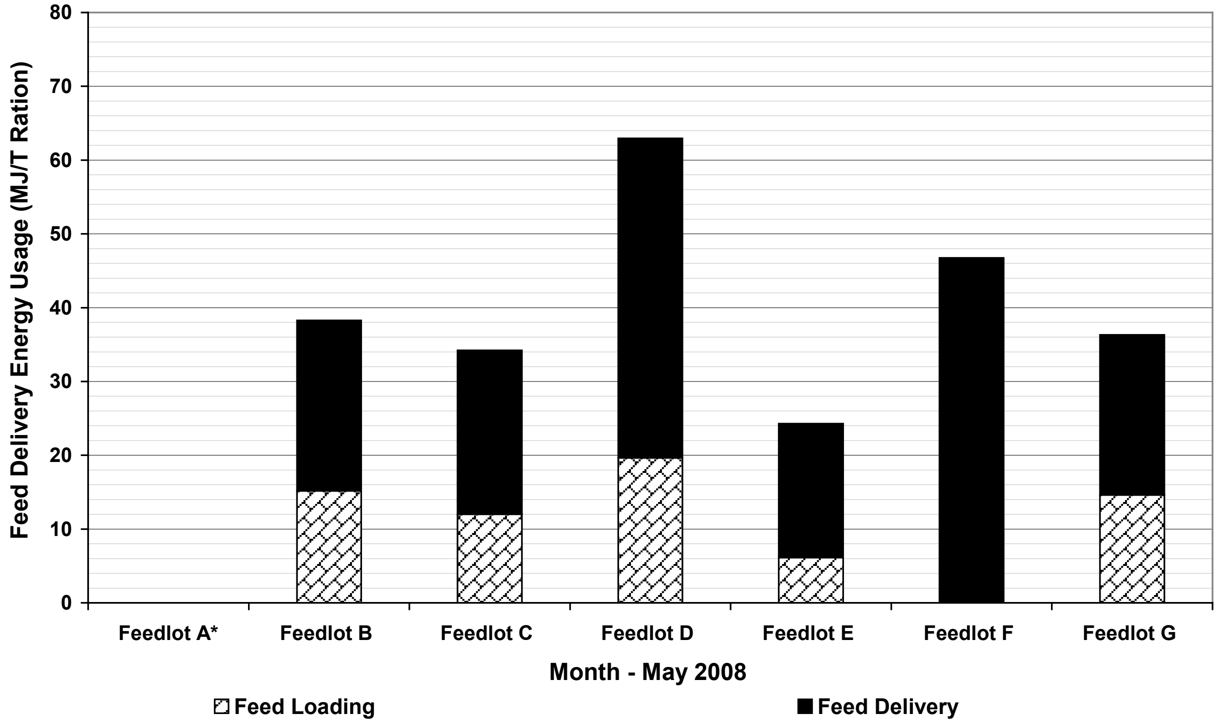

Figure 117 – Feed delivery energy consumption for May 2008 (MJ/t ration)

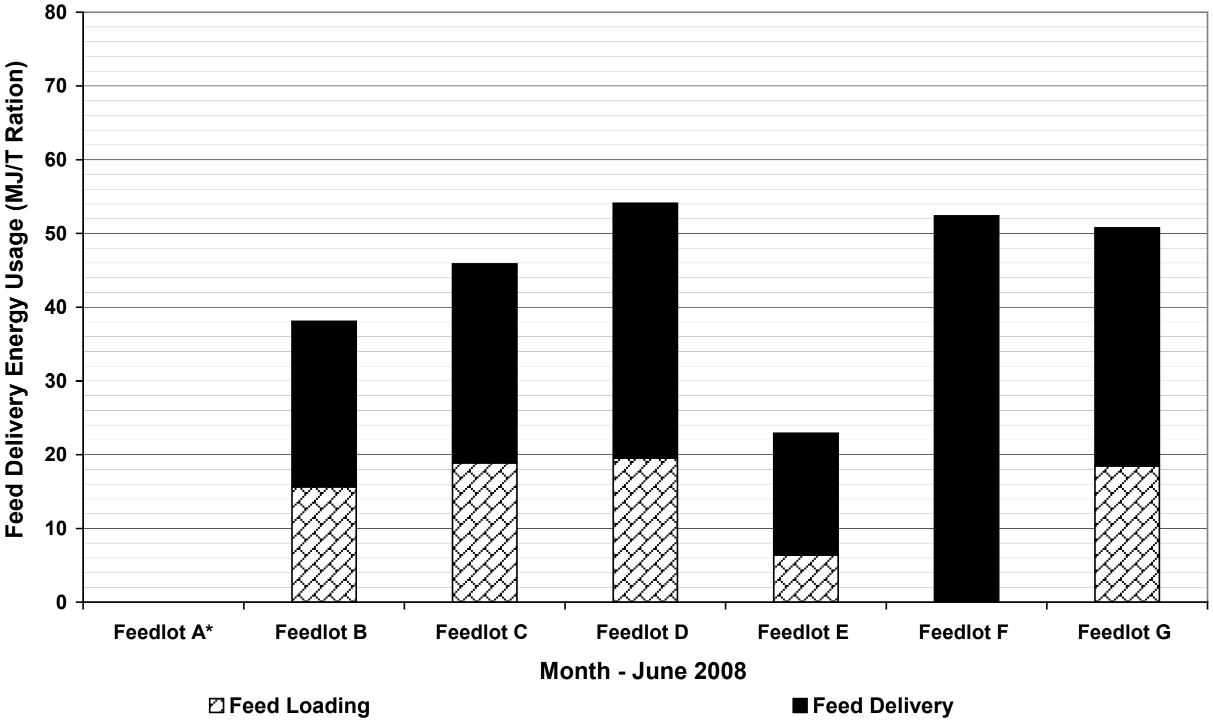

Figure 118 – Feed delivery energy consumption for June 2008 (MJ/t ration)

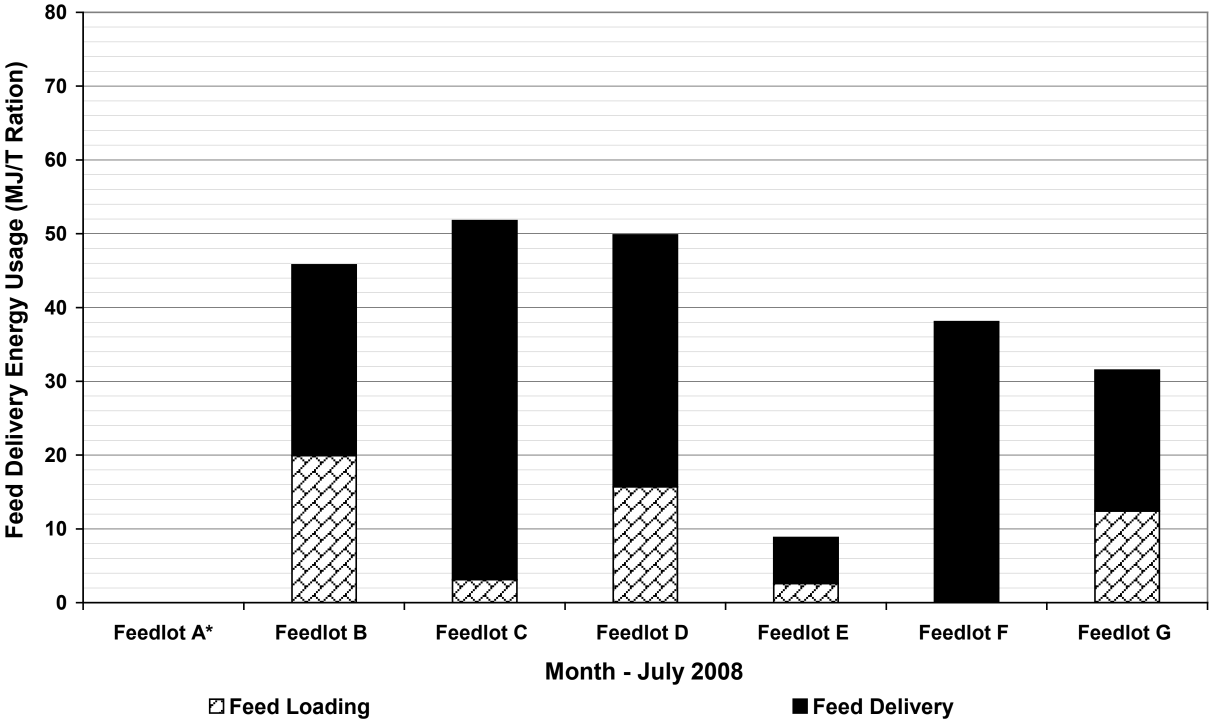

Figure 119 – Feed delivery energy consumption for July 2008 (MJ/t ration)

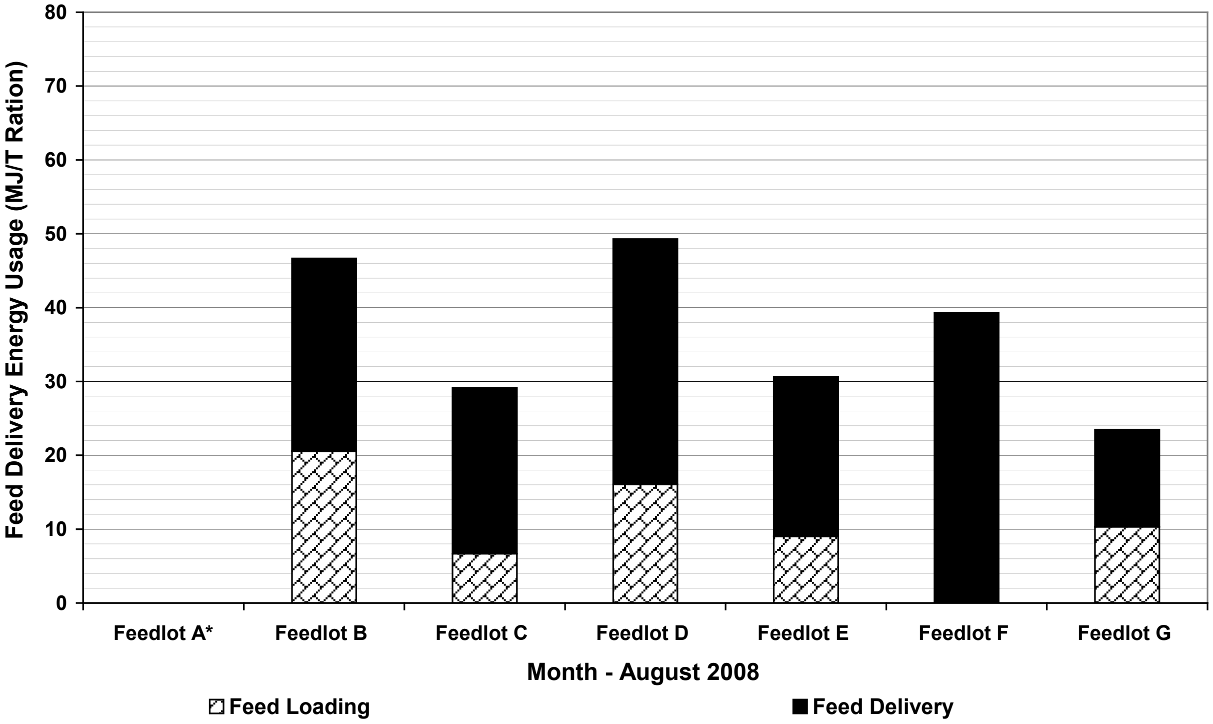

Figure 120 – Feed delivery energy consumption for August 2008 (MJ/t ration)

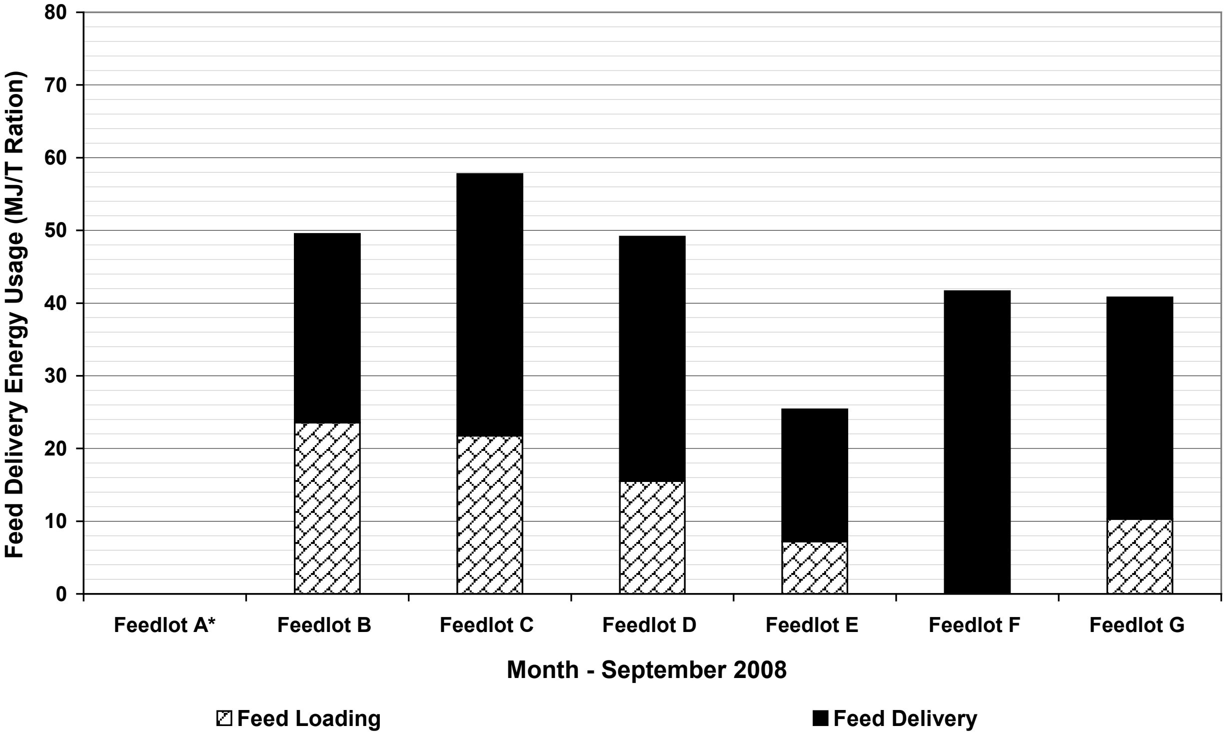

Figure 121 – Feed delivery energy consumption for September 2008 (MJ/t ration)

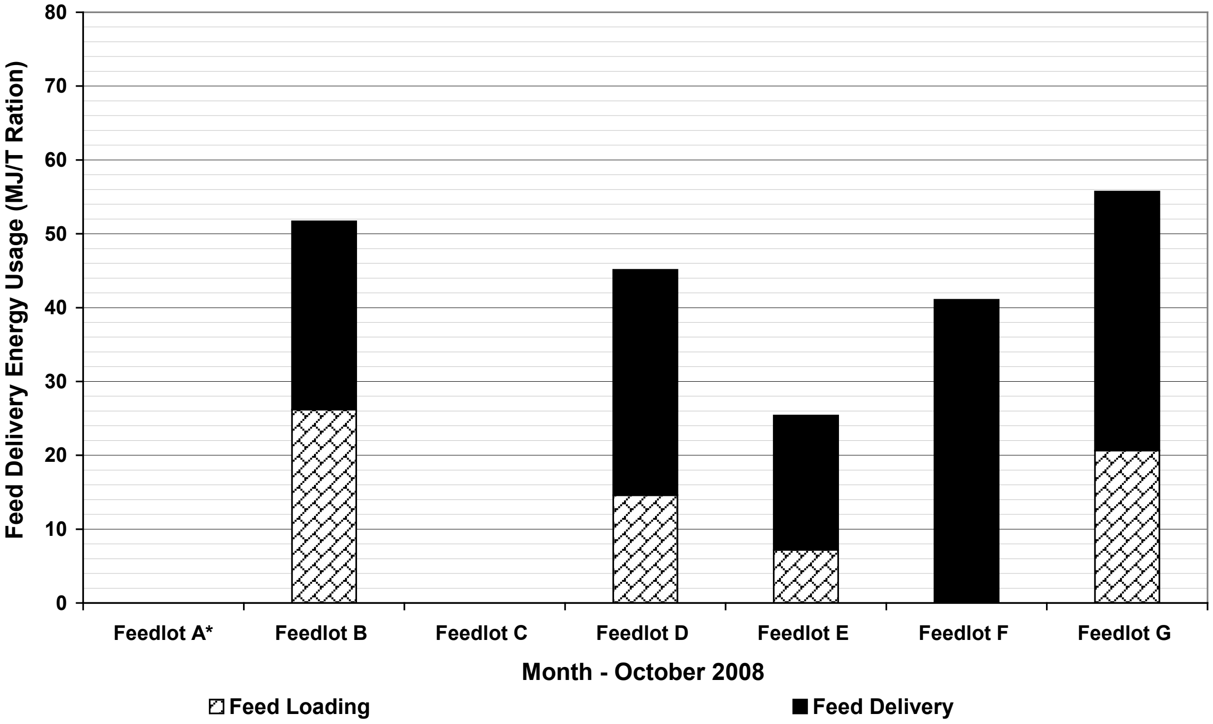

Figure 122 – Feed delivery energy consumption for October 2008 (MJ/t ration)

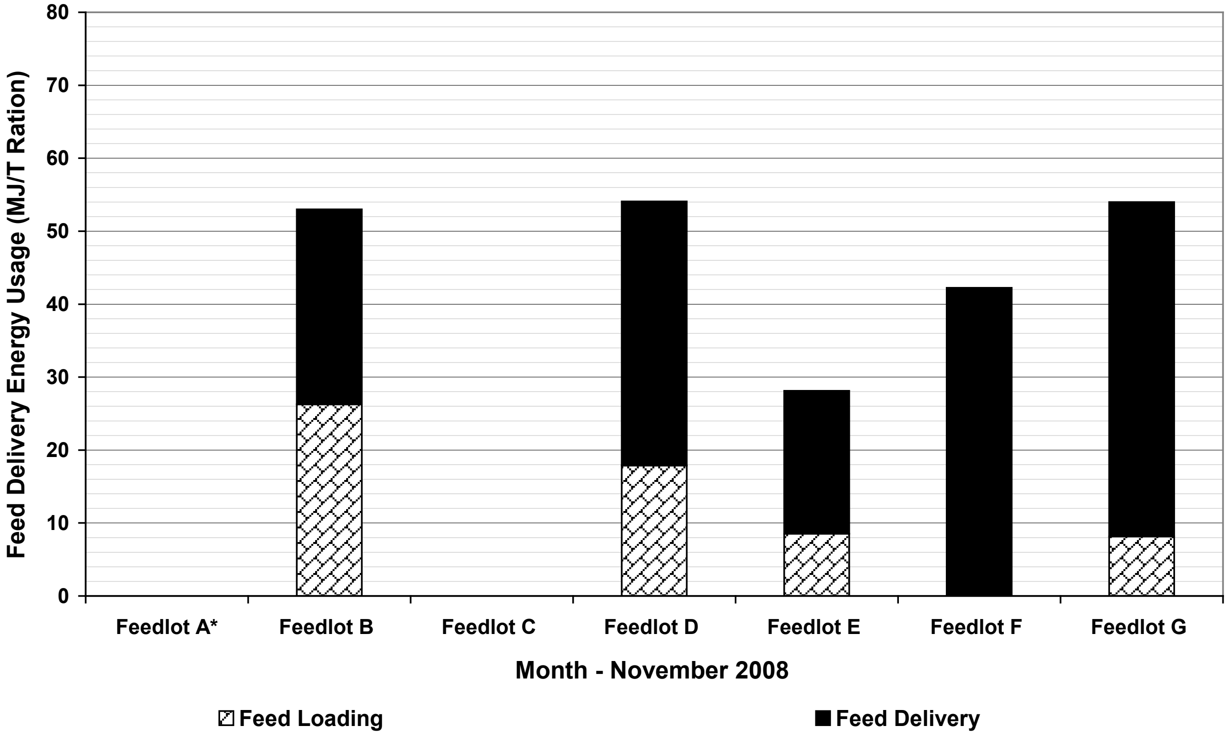

Figure 123 – Feed delivery energy consumption for November 2008 (MJ/t ration)

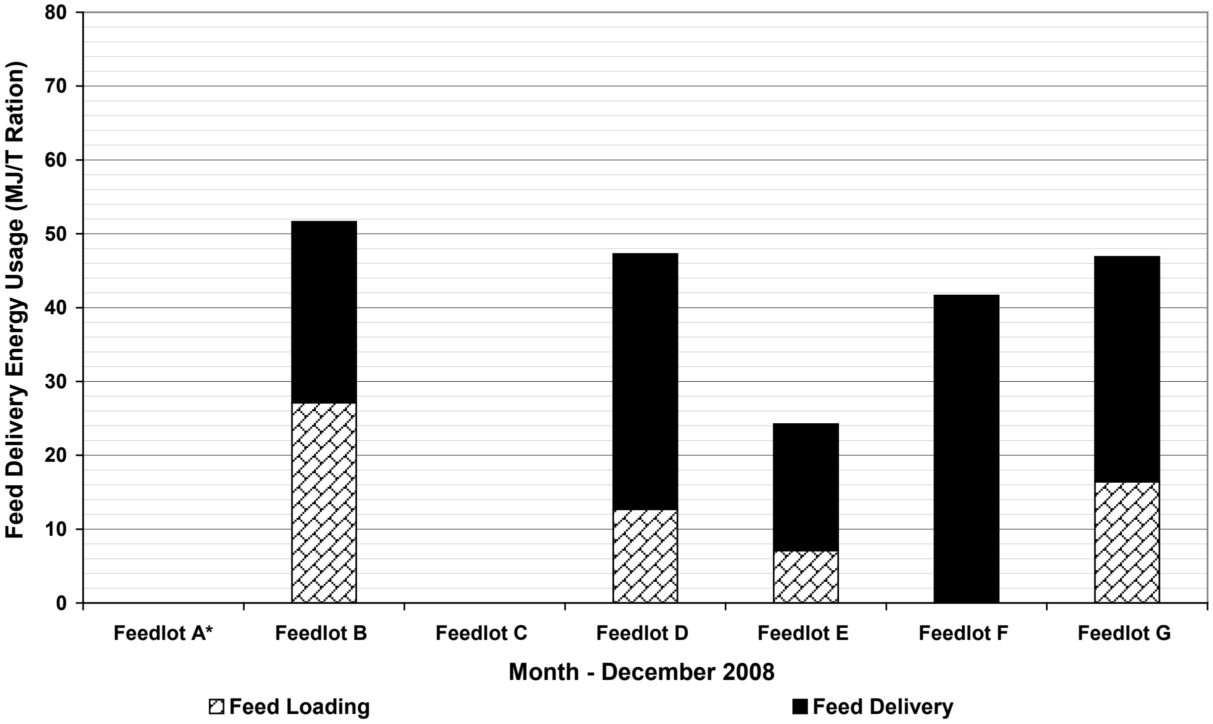

Figure 124 – Feed delivery energy consumption for December 2008 (MJ/t ration)

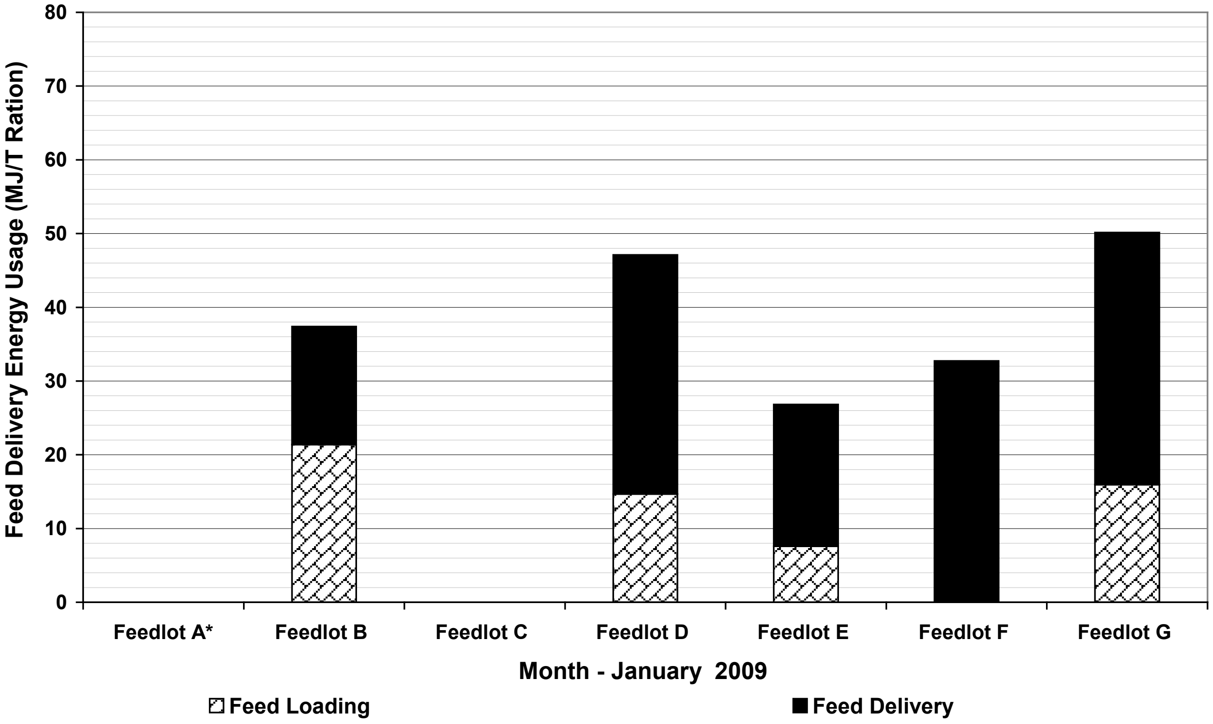

Figure 125 – Feed delivery energy consumption for January 2009 (MJ/t ration)

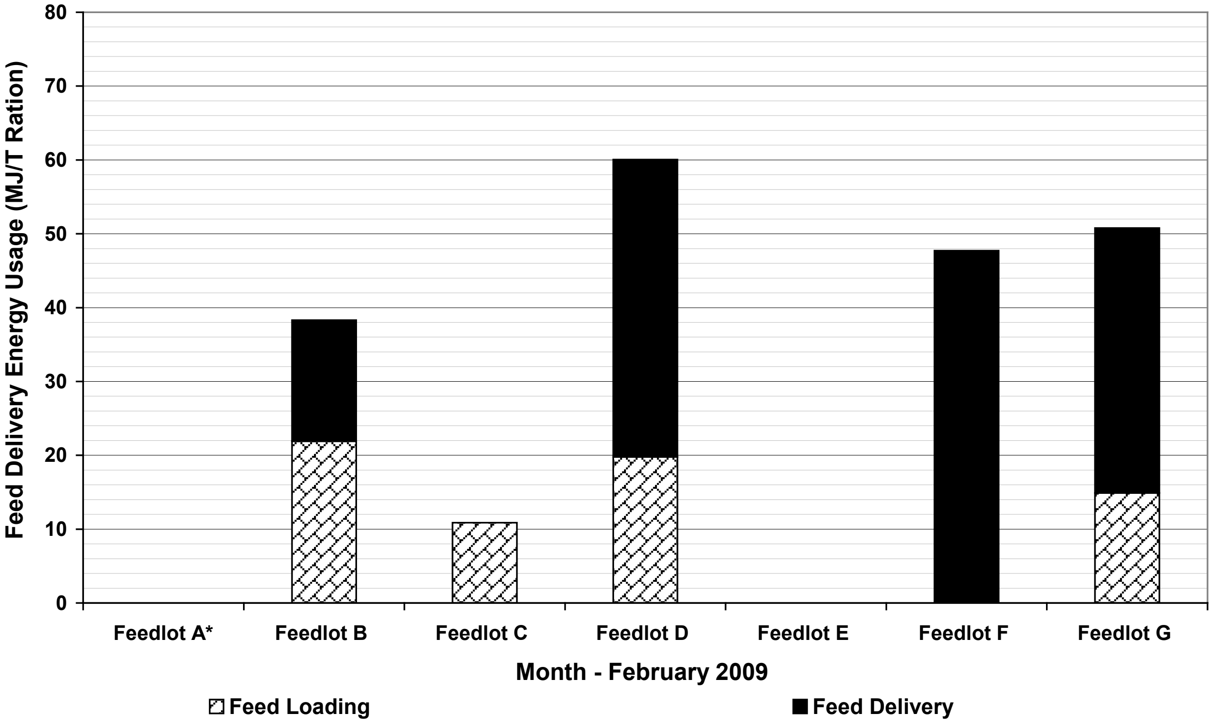

Figure 126 – Feed delivery energy consumption for February 2009 (MJ/t ration)

Appendix D – Waste management energy usage

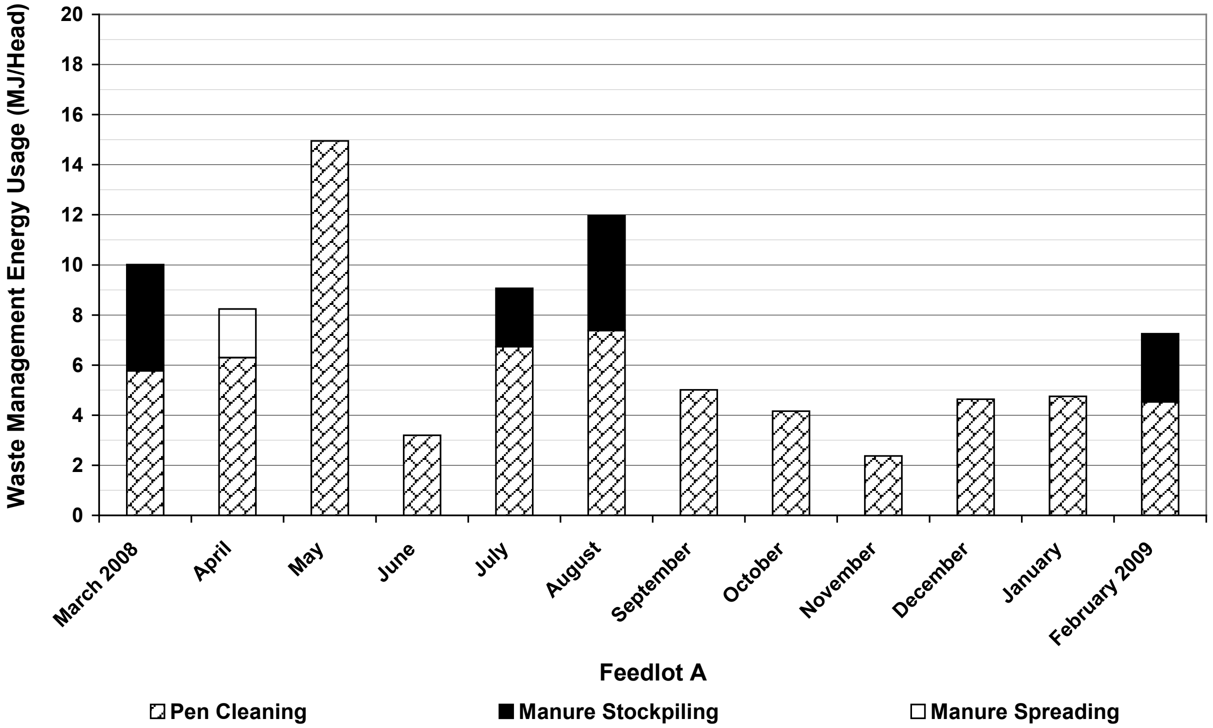

Figure 127 – Waste management energy consumption for Feedlot A (MJ/head-on-feed/month)

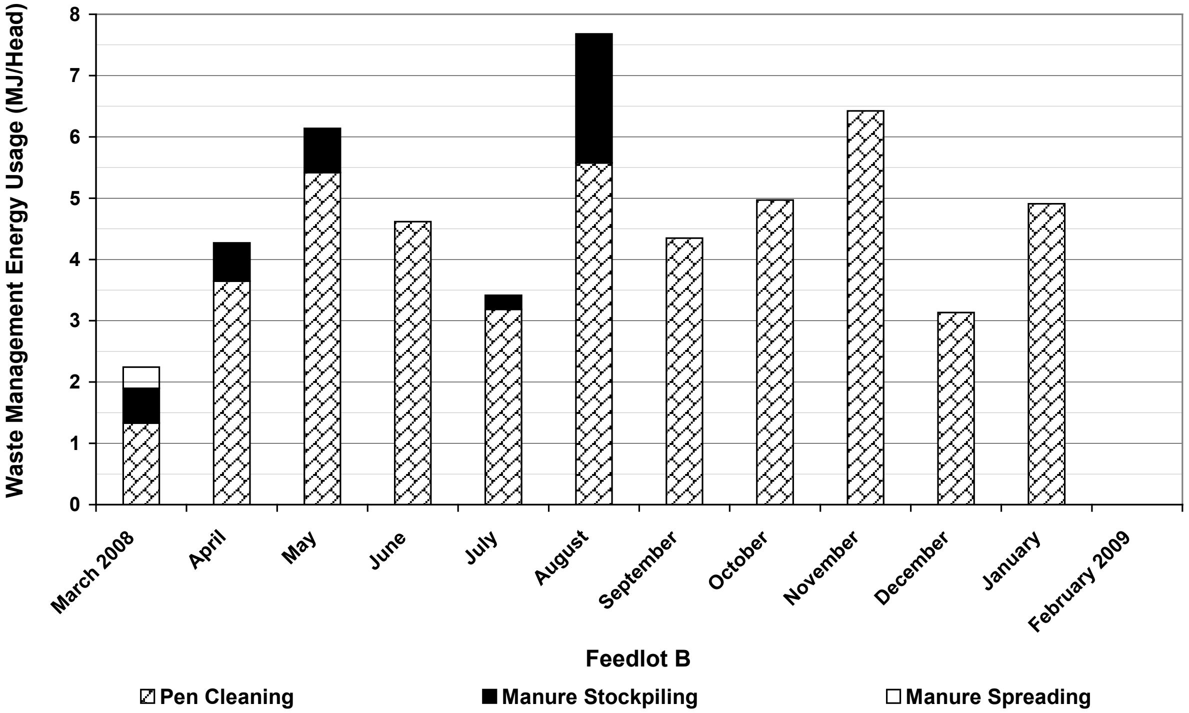

Figure 128 – Waste management energy consumption for Feedlot B (MJ/head-on-feed/month)

NA

Figure 129 – Waste management energy consumption for Feedlot C (MJ/head-on-feed/month)

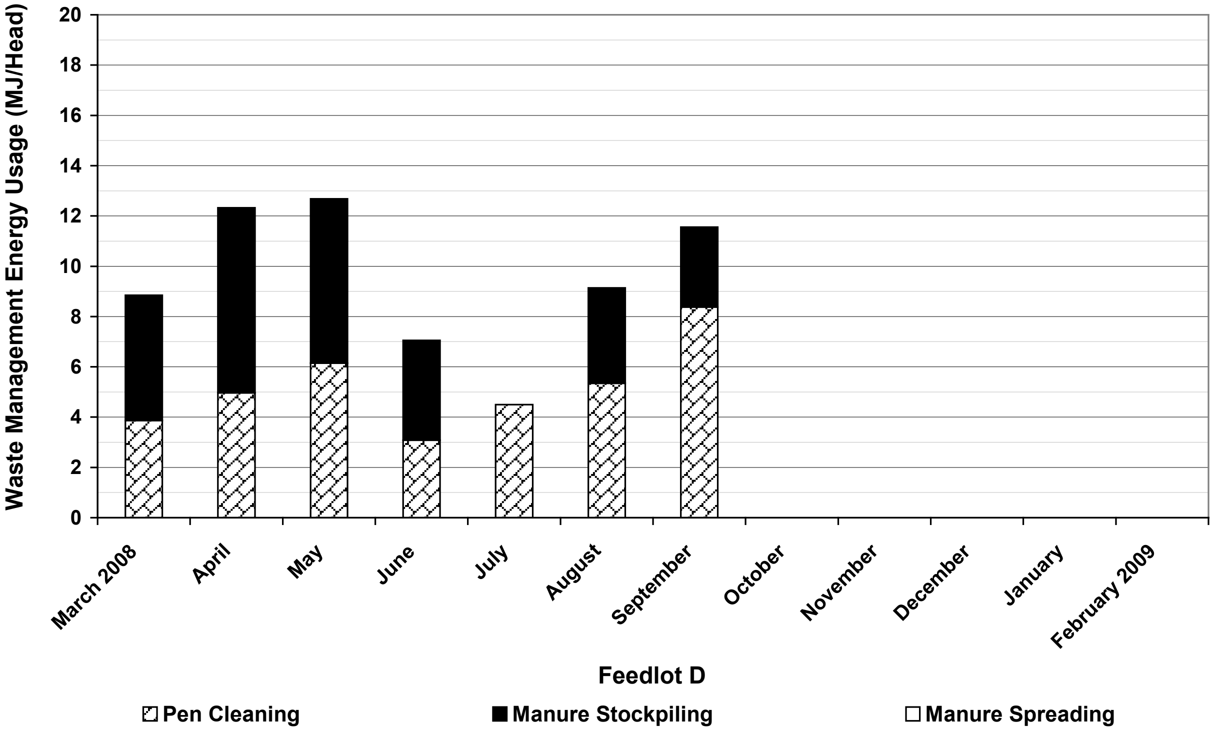

Figure 130 – Waste management energy consumption for Feedlot D (MJ/head-on-feed/month)

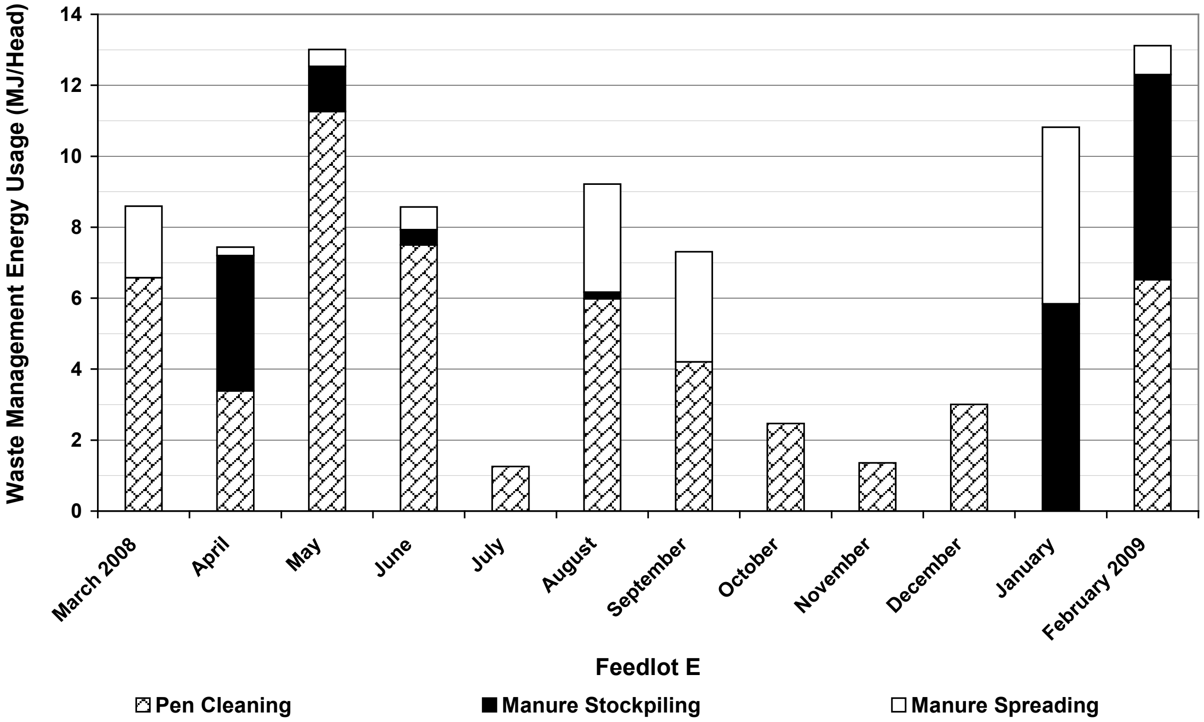

Figure 131 – Waste management energy consumption for Feedlot E (MJ/head-on-feed/month)

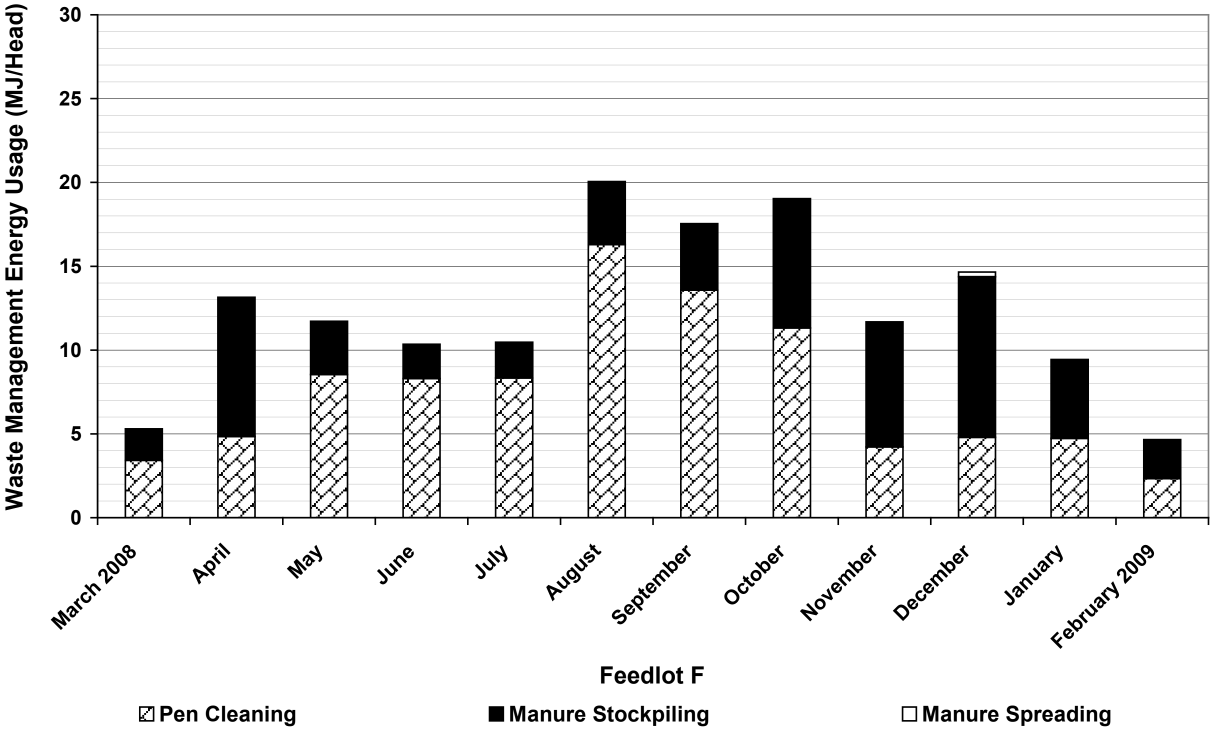

Figure 132 – Waste management energy consumption for Feedlot F (MJ/head-on-feed/month)

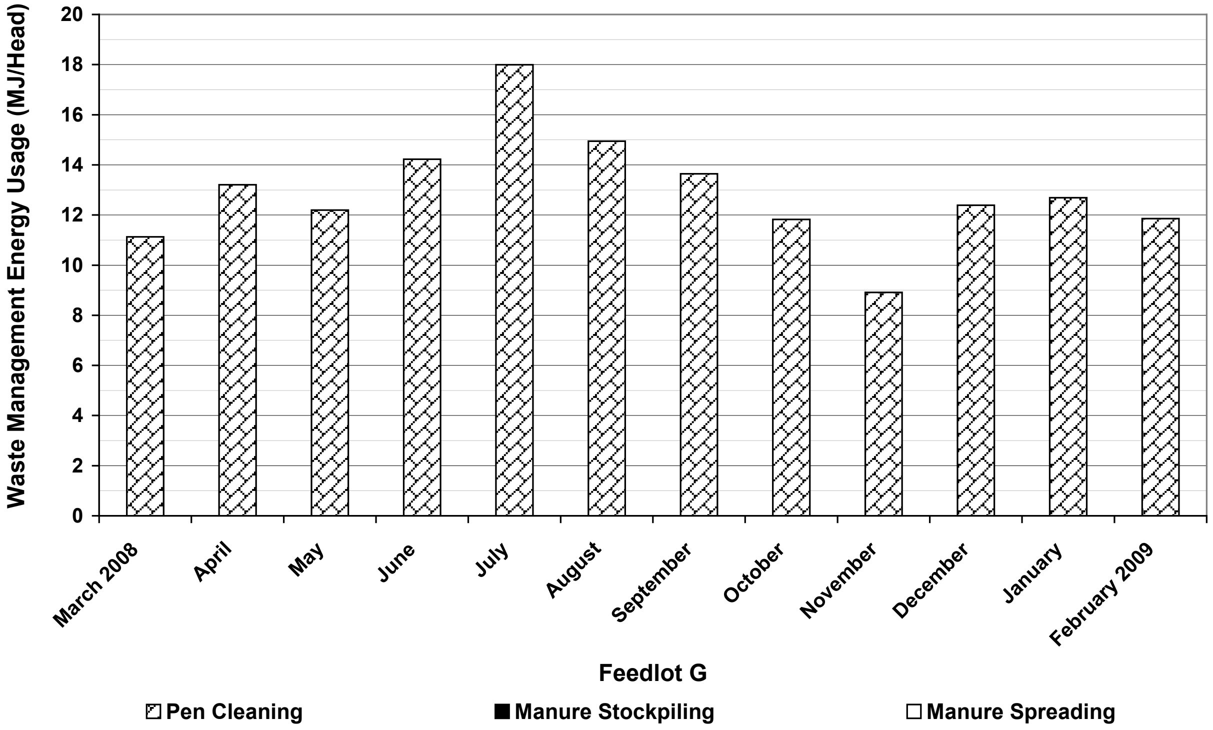

Figure 133 – Waste management energy consumption for Feedlot G (MJ/head-on-feed/month)

Appendix E – Cattle washing energy usage

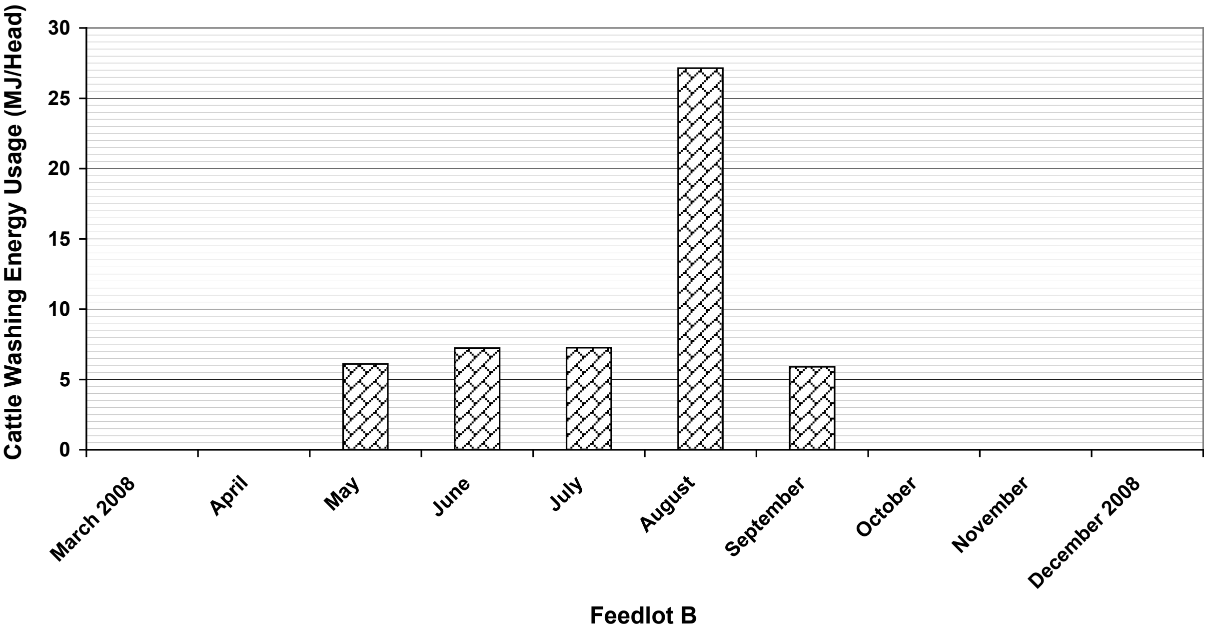

Figure 134 – Cattle washing energy consumption for Feedlot B (MJ/head washed)

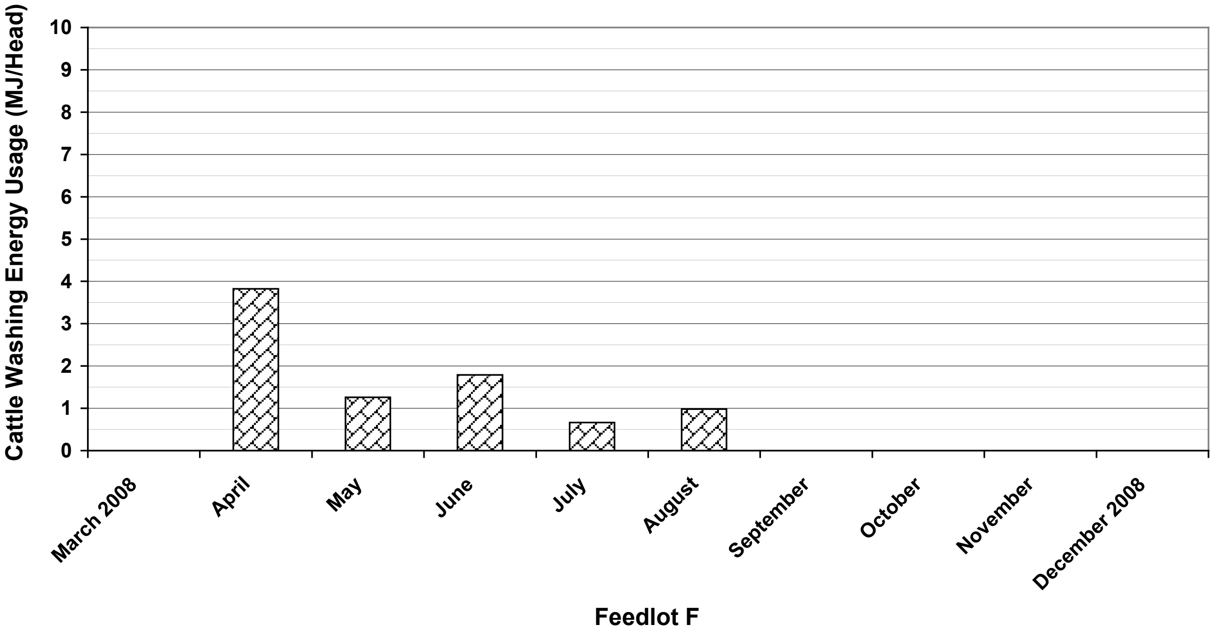

Figure 135 – Cattle washing energy consumption for Feedlot F (MJ/head washed)

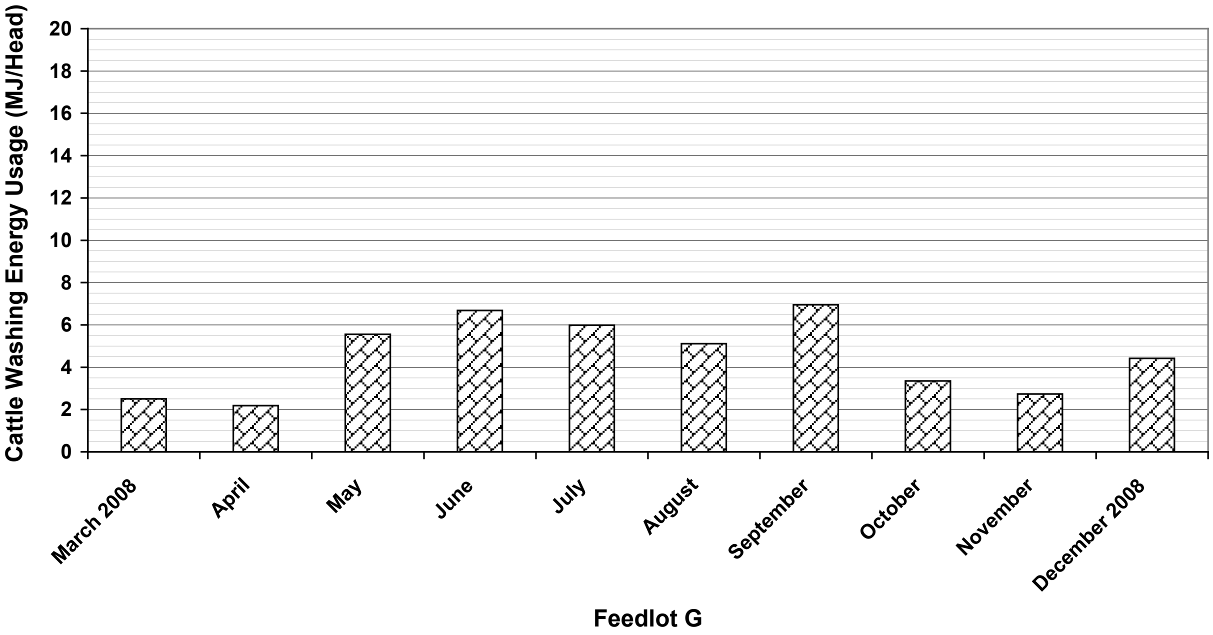

FIGURE 136 – CATTLE WASHING ENERGY CONSUMPTION FOR FEEDLOT G (MJ/HEAD WASHED)

Appendix F - Administration and minor activities energy usage

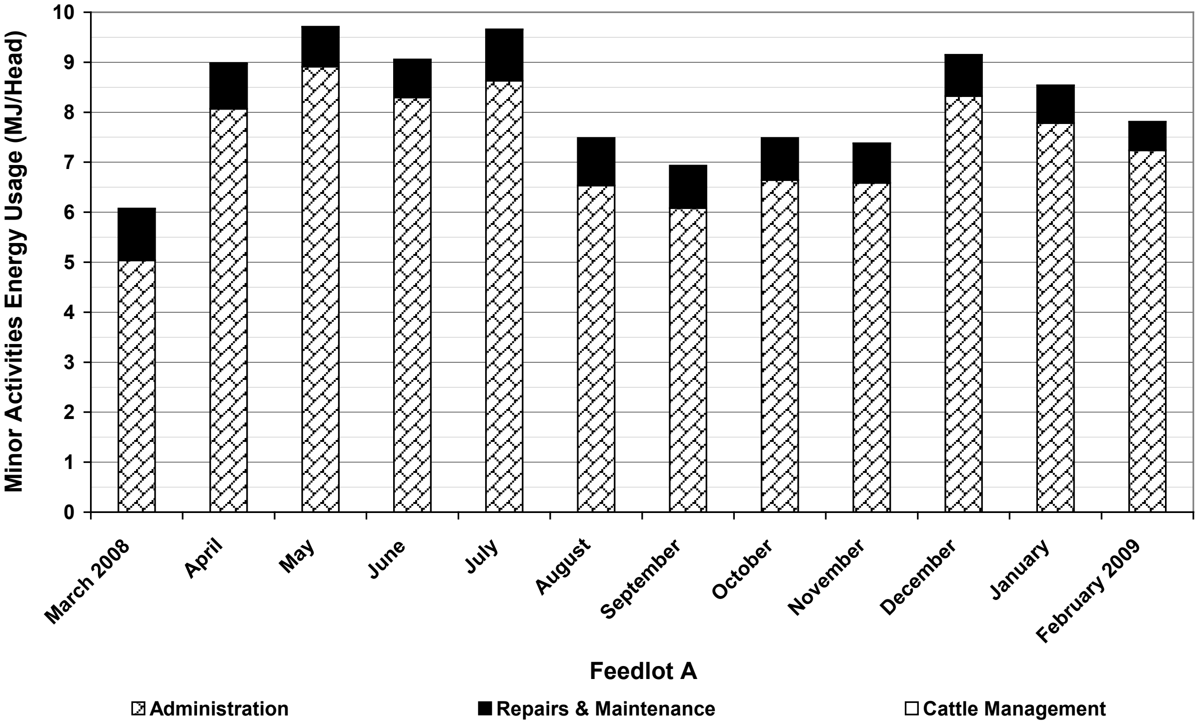

Figure 137 – Administration and minor activities energy consumption for Feedlot A (MJ/head-on-feed/month)

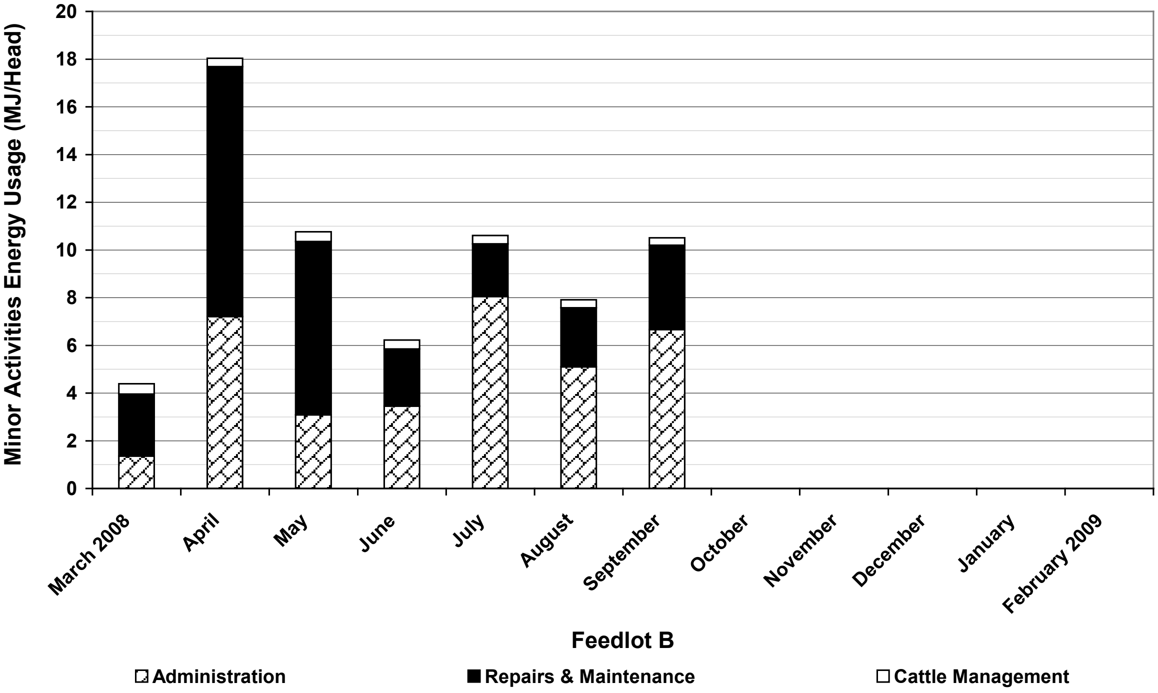

Figure 138 – Administration and minor activities energy consumption for Feedlot B (MJ/head-on-feed/month)

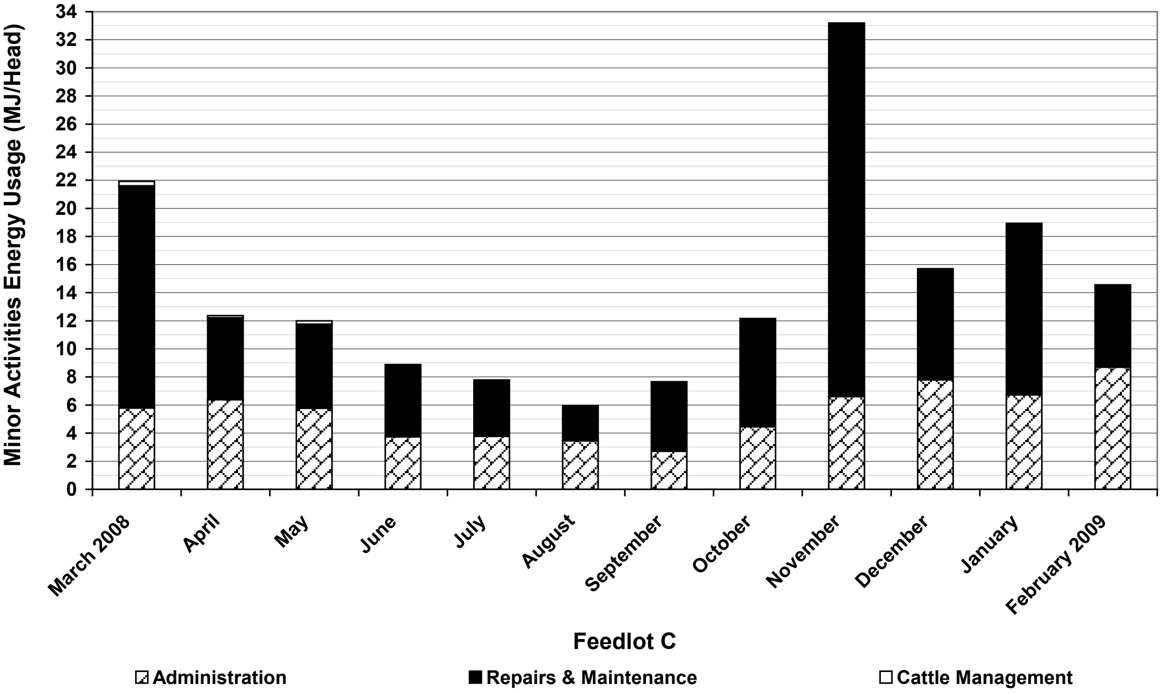

Figure 139 – Administration and minor activities energy consumption for Feedlot C (MJ/head-on-feed/month)

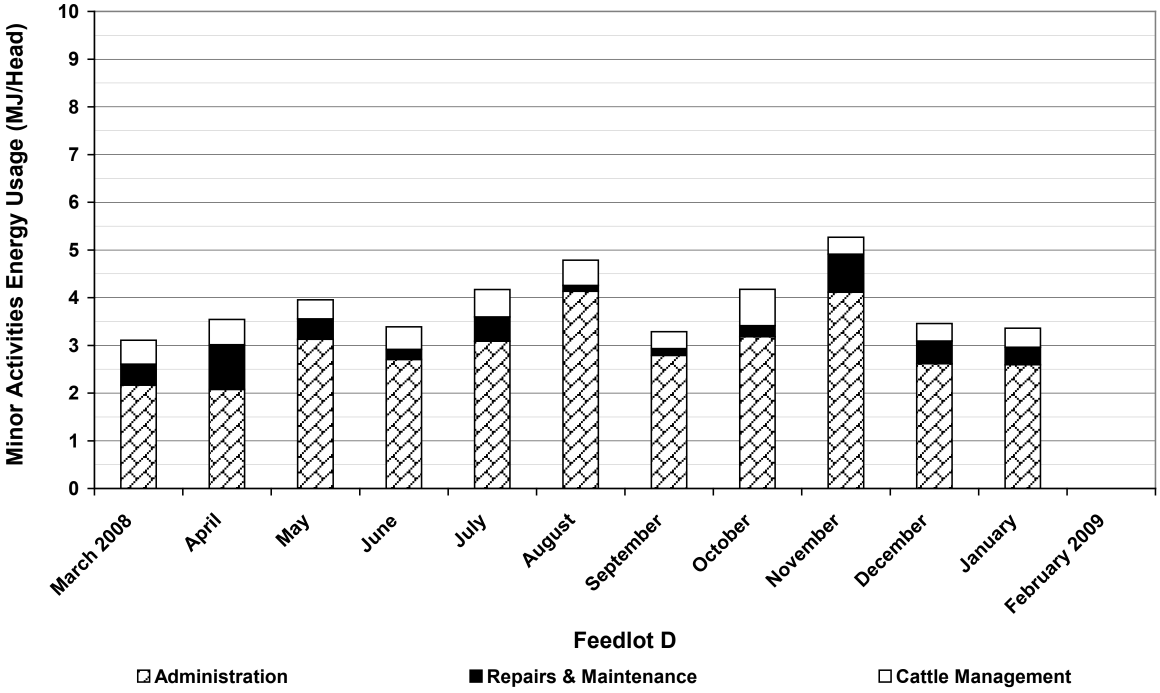

Figure 140 – Administration and minor activities energy consumption for Feedlot D (MJ/head-on-feed/month)

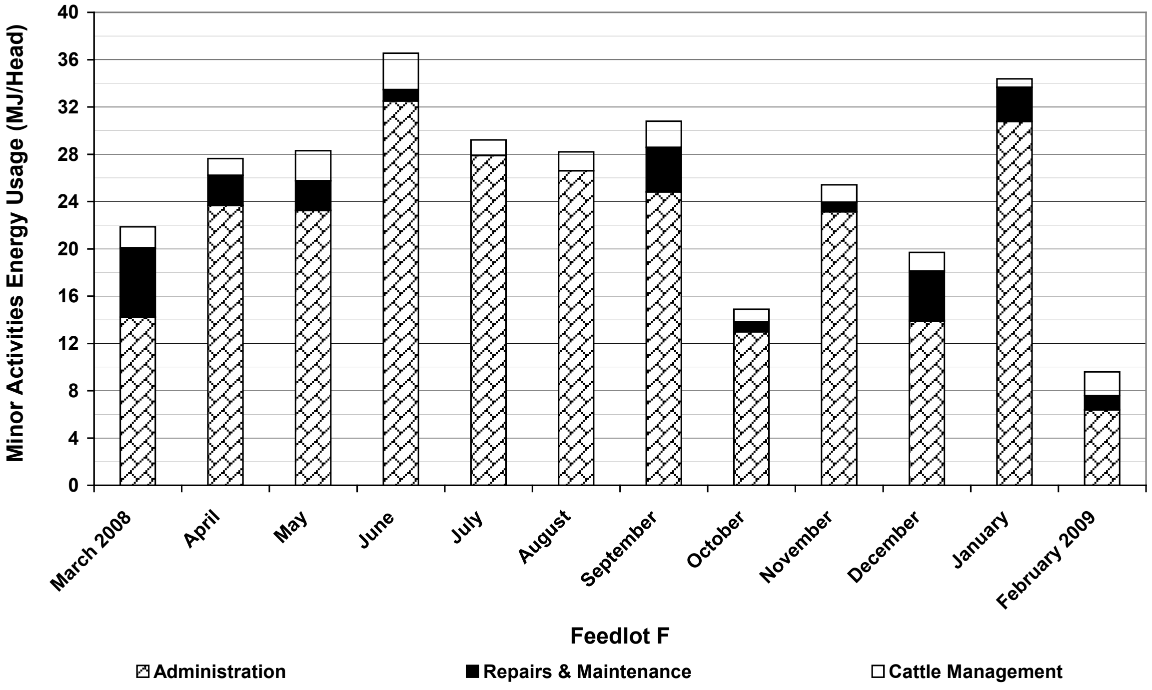

Figure 141 – Administration and minor activities energy consumption for Feedlot F (MJ/head-on-feed/month)

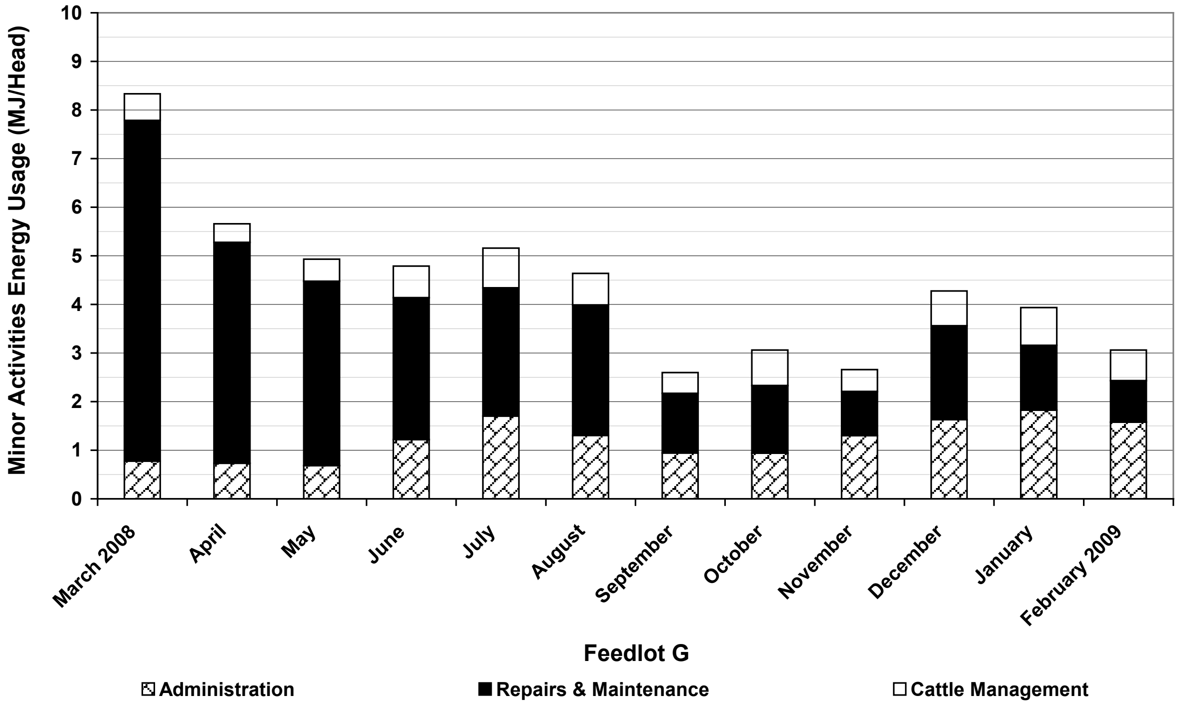

Figure 142 – Administration and minor activities energy consumption for Feedlot G (MJ/head-on-feed/month)