final report

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Prepared by: Dr Ron B Brooks
William Spooncer AM
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Meat and Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Effects of rendering / blood processing on abbatoir waste and emissions

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Abstract

Rendering plants attached to abattoirs generally do not measure either the quantity or quality of the incoming raw material for rendering or for blood processing. They generally do not measure the quantity or the quality of the outgoing waste streams individually or combined. This was the case at four of the five representative rendering plants chosen by AMPC for this project. One of the plants measured the quantity of the raw material and blood but not the quality, that is, no analyses were done. Material is lost in the effluent which if not lost may contribute to revenue and will reduce the load on the environment. It is not possible to improve what you do not measure as the efficiency improvement cannot be quantified. The plants visited generally back calculated the input of blood and raw material from the final MBM, tallow, and BM.

Five rendering sites were visited for three days each. There were two dry-rendering plants that processed bovine raw material, one dry-rendering plant that processed ovine raw material, one dry-rendering plant that processed mixed species raw material, and one continuous bovine wet-rendering plant. Sites were chosen that also had blood processing facilities.

Where possible, the major rendering streams were sampled. They included raw material bin drainage, cooker condensate, tallow stickwater and separator discharge, meat and bone meal (MBM) dryer condensate, and wet-rendering stickwater, plus blood, blood stickwater, blood meal (BM) dryer condensate. The streams were analysed for COD, TN, TP, TDS, NH_3-N and O&G where appropriate. Calculations for all plants estimated the size of anaerobic and aerobic lagoons that would be needed to treat the COD going to waste, the electrical cost of treatment and the quantity and value of any biogas and possible carbon tax offsets.

The report details how any rendering plant can conduct a similar trial and how to estimate what is going to drain.

The following results show the discharges of COD, TN, TP, O&G and TDS from the five plants.

The volume of effluent from the wet-rendering plant was 1.87m^3/tHSCW compared to an average of 1.01m^3 /tHSCW for the four dry rendering plants.

The COD discharged to waste by the rendering plants was very variable from 13.7t/ 1,000tHSCW to 59.9t/tHSCW. While there is a very high load coming from wet rendering plant cooker stickwater of 22t/1,000tHSCW compared to 0.7t/1,000tHSCW from dry rendering cooker condensate, the raw material bin drainage and tallow stickwater are also major and variable contributors.

The wet rendering plant discharged 17% more total nitrogen to effluent than any of the dry rendering plants mainly due to the fact that it discharged 1.0t TN/1,000tHSCW in the stickwater from the cooker compared to an average of 0.16t/1,000tHSCW in the condensate from the cookers of the four dry rendering plants. Raw material bin drainage was a major variable contributor of TN.

The wet rendering plant discharged almost 4 times the TP of the four dry rendering plants 0.19t TP/1,000t HSCW compared to an average of 0.05t TP/1,000tHSCW. This was due mainly to the 0.1t TP/1,000tHSCW in the cooker stickwater. Raw material bin drainage was also a major variable contributor.

The O&G varied from two plants averaging 3.8t/1,000tHSCW and two averaging 1.3t/1,000tHSCW. The cause of the high discharges were totally different and even the two better performing plants had O&G loss in different streams.

The wet rendering plant discharged no more TDS than one of the dry rendering plants but the wet rendering had its discharge caused by the 1.5t/1,000tHSCW from the stickwater whereas the dry-rendering plant's was from raw material bin drainage. The first is inevitable whereas the latter can be substantially reduced. TDS from blood stickwater averaged 0.52t/1,000tHSCW+/- 50% for all plants. Blood processing adds an average of 439mg/L to the TDS of the rendering plant waste equivalent to about 35mg/L to the overall abattoir waste which is not critical to disposal by irrigation.

Different rendering plants demonstrated differing abilities to reduce discharge of materials to drain. The report has tables showing the value of material lost. In general, there is no need for extra equipment to reduce these losses. If rendering plants managed their effluent streams then the only effluent streams containing possible recoverable product are raw material bin drainings and wet-rendered stickwater. The raw material bin drainings can be recovered by admixture with blood and the wet-rendered stickwater can, and is recovered using waste heat evaporation unless a cascading rotary dryer is installed. Some plants with cascading rotary dryers use chemical flocculation for solids recovery.

Without doing the calculations and analysis, such as provided by this report, rendering plants do not know the size of the losses that are occurring so there is no incentive to reduce them.

1 Background

Rendering plants lose potential products in waste streams. Waste streams from rendering and blood processing contain environmental pollutants which have to be removed by effluent treatment. They also contain protein, fat and other solids which represent product loss. Losses from abattoir rendering plants that use wet rendering (low-temperature rendering) systems were thought to be about $2.5 million per year. These losses add to the load on waste treatment and the environment.

The major streams are blood stickwater, wet rendering stickwater, dry rendering condensate, blood dryer and meat and bone meal (MBM) dryer condensates, tallow centrifuge water and sludge discharge. These streams contain protein, fat, carbohydrate, and dissolved salts (measured as ash or conductivity). They result in various environmental problems and represent product losses. These losses can be recovered to some extent and have value when recovered.

The streams have high CODs which cost money to either dispose to sewer or when they breakdown to carbon dioxide and biogas (methane) in an on-site waste treatment facility. The biogas and carbon dioxide increase the abattoir carbon footprint. These streams are also sources of phosphate and various nitrogenous compounds which generally are not reduced during waste treatment unless special extra systems are put in. The various inorganics add to the waste streams conductivity which potentially limits the opportunities for irrigation. This project was designed to quantify pollutants and product losses in waste streams from both wet and dry rendering plants handling material from both ovine and bovine sources, and associated blood processing.

The over riding premise of the project is that **<u>you cannot improve what you do not measure</u>**.

Rendering plants attached to abattoirs generally do not measure either the quantity or quality of

the incoming raw material for rendering or for blood processing. They generally do not measure the quantity or the quality of the outgoing waste streams individually or combined. They generally do not cost the treatment of these waste streams. This makes it very difficult to improve recoveries or efficiencies of the rendering plant or blood processing plant, or to quantify any improvement.

2 Project Objectives

The aim of the project was to provide benchmarks of the composition of rendering plant waste streams and identify strategies to reduce the contribution of waste streams to environmental loads and product losses. The following five objectives were written into the contract.

2.1 Survey five (5) sites – two beef wet rendering plants, a beef dry rendering plant, a sheep dry rendering plant, and a mixed species rendering plant to define the size of these problems to the red meat industry and suggest remedies. Survey blood processing plants at the same five (5) sites.

Due to the large number of dry rendering compared to wet rendering plants in Australia, this was later changed to one wet and two dry beef rendering plants as being much more representative of the industry.

2.2 The survey will take 2-3 days per site to complete during which time the provider will organise any piping changes, ather generic information and take the samples of input and output streams for analysis. The major waste streams from rendering and blood processing will be mapped in terms of COD, TN, TP, fats and total solids.

2.3 Provide benchmarks of the composition of waste streams and identify strategies to reduce the contribution of waste streams to environmental loads and product losses.

2.4 Relate the outputs to annual abattoir production figures to produce generic ratios and relate these numbers to overall industry losses.

2.5 Report on available value add technologies.

3 Methodology

3.1 Introduction

The red meat industry needs to be proactive in dealing with environmental pressures and the rendering part of that industry should play a role in the process. To be proactive requires facts. The rendering industry discharges waste into the environment. Some of this waste is potential product that could be recovered, but at a cost. The potential value of this lost material is often defined in just product recovery terms without adding the other values and costs which are "hidden", or just not considered. These hidden values include the cost of on site waste treatment or alternatively, the sewer charges, and potentially the cost of carbon credits i.e. how much does the discharge increase the company carbon footprint.

The effect of the discharge to the environment is not just in the oxygen demand from the carbon containing material i.e. the COD or BOD. Total nitrogen, total phosphate and total dissolved inorganics (salts) also need to be accounted for. When carbon containing organic material goes to waste it is generally converted into methane and carbon dioxide anaerobically and/or aerobically and it generates a sludge which at intervals needs to be disposed of. The sludge is both coagulated colloidal and suspended solids in the waste and also the microflora which grow when they metabolise the soluble organic material. The aerobic removal process may come at the cost of the electricity used by aerators to introduce the dissolved oxygen from the air that bacteria use to breakdown the waste. There is often a sewer charge for ammonia nitrogen or total nitrogen, or the discharge quantity may be capped. This also applies to TDS/dissolved salts. Carbon and nitrogen may be removed from the effluent before discharge to surface water but this still leaves the phosphate which on its own can cause algal blooms. Even if the carbon, nitrogen and phosphorus are removed, the dissolved salts can limit what type of soil and/or crop the final treated wastewater can be irrigated on to.

So, the rendering plant discharge needs to be quantified both in terms of lost product and in terms of the positive and negative impacts on the environment. This was the basis of the project, targeting the processing of both blood and mixed abattoir material (MAM). Every site is different. The plan was to cover most of the variations so renderers can pick out what may apply to their particular site. To minimise the budget, the plan was to visit only five (5) sites. This included two bovine dry-rendering plants, one ovine dry-rendering plant, one bovine wet-rendering plant and a mixed-species plant, all of which also processed blood separately from other raw material. Rendering plants associated with an abattoir were contacted by AMPC and those who responded were followed up with a questionnaire (see Appendix A). The rendering plants chosen by AMPC were those who then fitted the initial need to cover the five major types of process after reviewing the questionnaire responses. Further questions were left until the site

The budget allowed for a 2-3 day visit to each site to gather overall data not included in the survey and also to take samples of the major environmental rendering plant and blood processing discharges. In particular, the project was to look at not just the value of the lost product, but the total cost to the company of losing the material and it was to include some suggestions of how material may be recovered. An important consideration is how much of the overall abattoir waste liquid effluent was due to just the rendering plant in terms of COD, TN, TP and TDS. There could be some positives from the load in the effluent, e.g. the fertiliser value of the nitrogen and phosphorus, and the biogas that could be harnessed from degradation of the COD. All the above considerations are known in qualitative terms but this project aimed to quantify this for the industry so the data is available to immediately respond to external pressures.

It must be recognised that most of the effluent flows needed for such a project are not measured and in a budget of a 2-3 day site visit could not be measured. However, many of these flows can be calculated with sufficient accuracy for such a high-level, industry overview based on the five sites. Flowrates are important as in the past a number of abattoir studies have just focussed on which are the highest concentration of the various parameters whereas the important thing is what the discharge load is. The opportunity exists in future to look at aspects that warrant a more in-depth investigation depending on rendering industry needs and an individual sites wishes. It should also be appreciated that waste from all abattoirs creates this environmental discharge, even if it is processed at a stand alone renderer, so abattoirs that send MAM and blood off site for processing still are part of that environmental impact and should work to minimise that environmental load.

No analyses were carried out on the abattoir effluent. The project only used what historical data there was.

3.2 Sample collection

Five rendering sites were selected by AMPC to take part in the project. The criteria for selection included:

- two dry-rendering plants that process bovine raw material;
- one dry-rendering plant that processes ovine raw material;
- one dry-rendering plant that processes mixed species raw material;
- one continuous bovine wet-rendering plant.

The sites also operated blood processing systems that used either batch-dryers, a ring dryer or a cascading rotary dryer. Some of the sites brought in raw material from sources outside the associated abattoir. Processing of outside material was not a consideration when selecting sites for involvement in the project but has been noted as an important distinction between sites.

The five sites are identified by code in this report. The characteristics of the each of the coded sites are shown below in Table 3.2.

Table 3.2: Key to site characteristics and codes

Site code	Species processed	Outside raw material	Rendering system	Blood drying system
A	Mixed	Yes	Continuous dry	Cascading rotary dryer
B	Ovine	Yes	Continuous dry	Cascading rotary dryer
C	Bovine	No	Continuous dry	Ring Dryer
D	Bovine	Yes, blood only	Continuous dry	Batch dryers
E	Bovine	No	Continuous wet	Cascading rotary dryer

The selected sites were visited to sample effluent streams and to estimate flowrates of streams. Before visits were conducted the sites were asked to complete a questionnaire about production in 2010/2011 and 2011/2012. The questionnaire is shown in Appendix 1 and responses are summarised in Appendix B. Where data reported on the questionnaire was incomplete or unclear, additional data was collected and verified during site visits.

3.2.1 Effluent streams from rendering operations

Figures 3.2.1.1 and 3.2.1.2 represent steps in dry- and wet-rendering processes and identify the effluent streams. Figure 3.2.1.3 represents steps in production of blood meal and identifies effluent streams from the process.

Figure 3.2.1.1: Dry rendering process and effluent streams

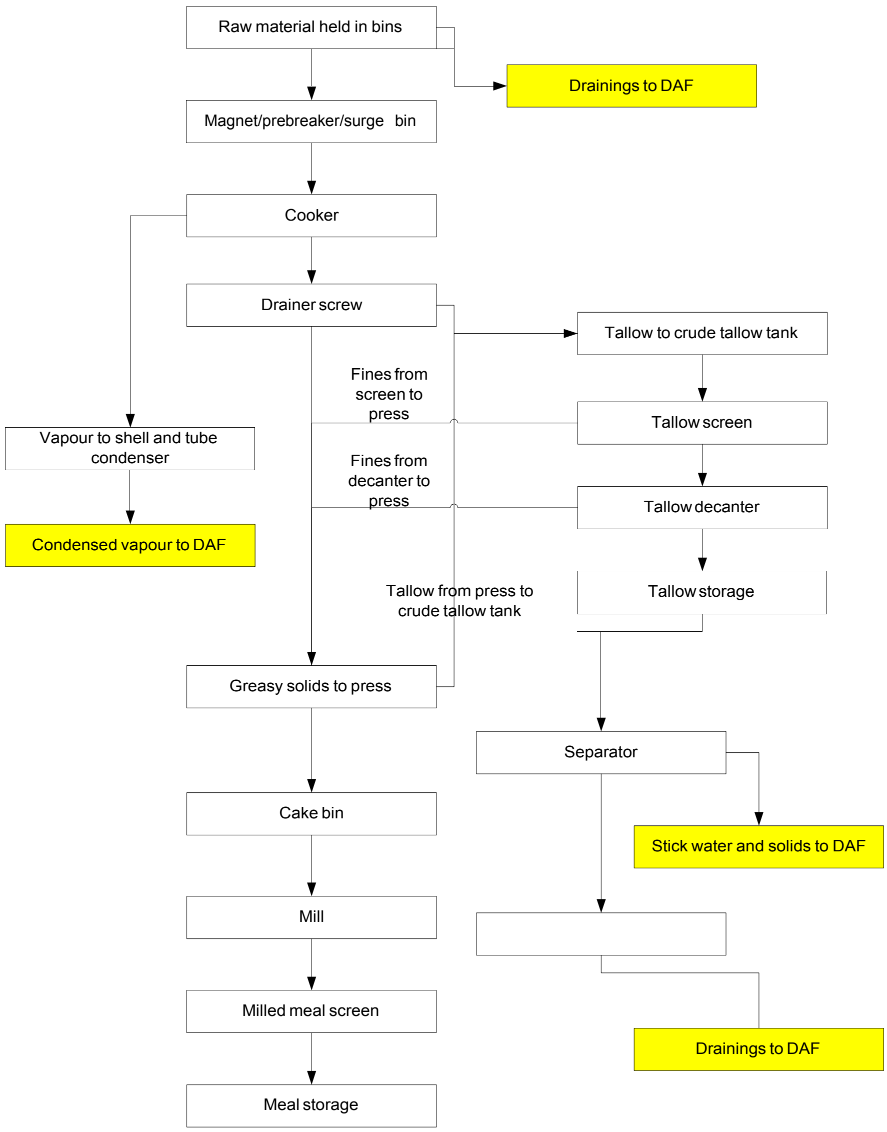


Figure 3.2.1.2: Wet rendering process and effluent streams

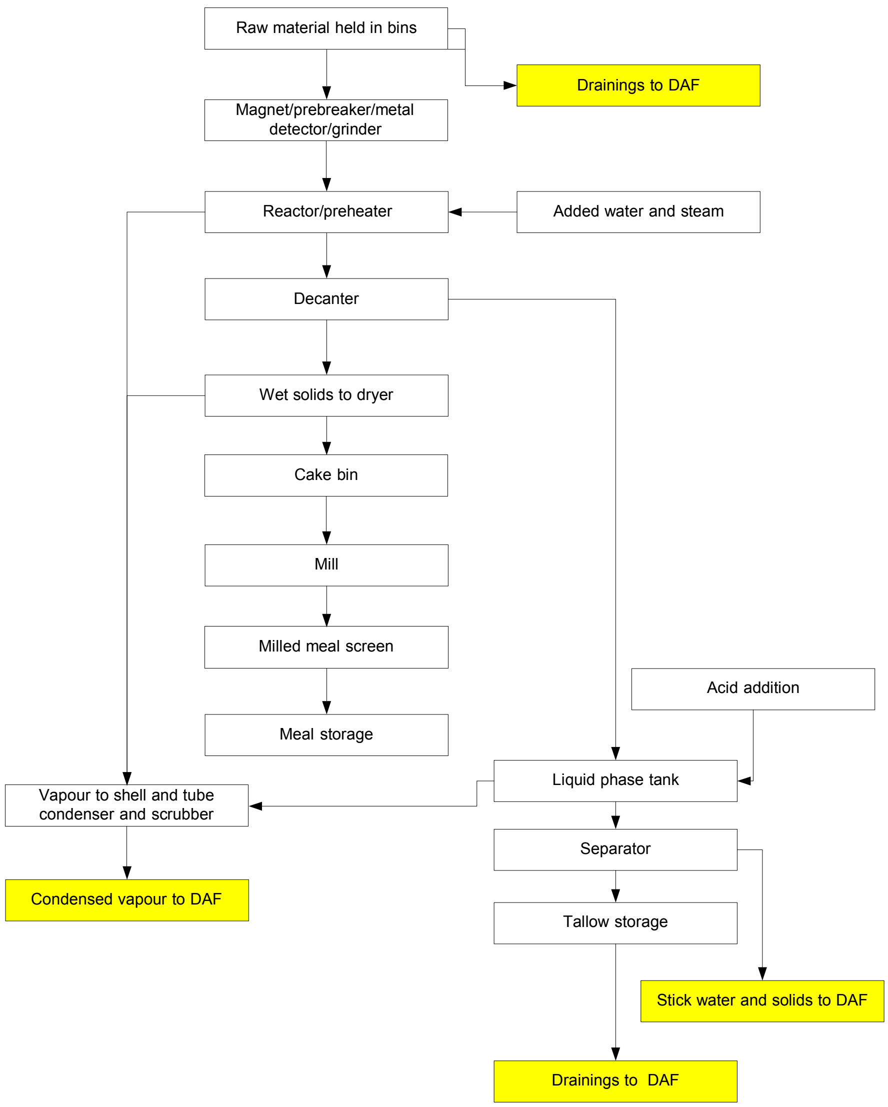
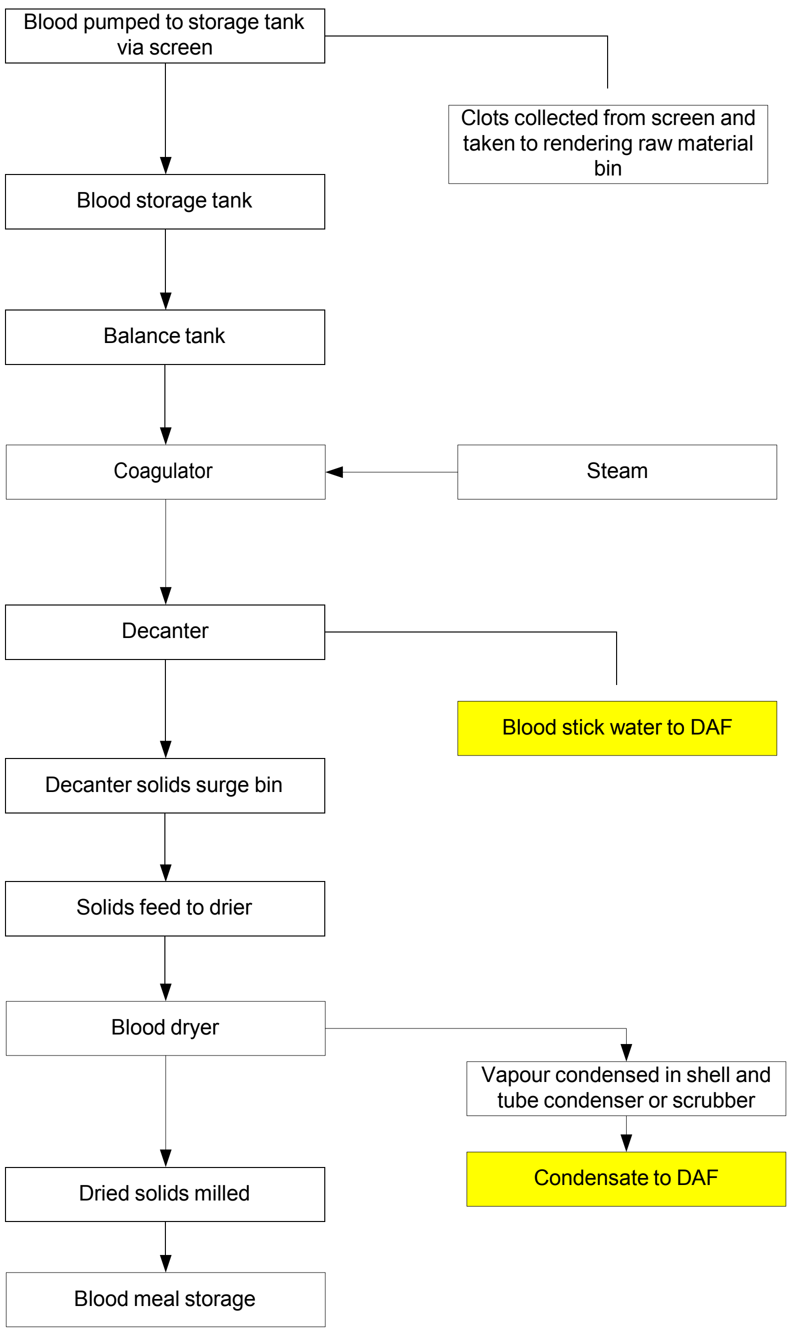


Figure 3.2.1.3: Blood processing and effluent streams



There were differences between the sites in the way in which effluent streams were contained and managed. This affected the accessibility of the streams and the number of streams that could be included in the sampling program. The methods of sampling of the different streams at the five sites are described below

3.2.1.1 Drainings from raw material

In general, samples were collected from raw material bin drains and flowrates were estimated by timing the collection of measured volumes.

At site A, raw material was in two raw material bins and was blended on a concrete apron. Drainings from the apron and raw material bin drainings were collected in concrete floor drains. All drainings from raw material were combined in a tank. Samples (5) were taken from the drainings storage tank and were combined into a composite sample. The volume of drainings collected during a day's production was estimated from the dimensions of the storage tank and the depth of drainings in the tank.

At site B, drainings were from a single raw material bin. The drainings from the raw material bin were collected in a floor drain and piped to an open sump. Samples were collected from the discharge into the sump on two days. Two composite samples consisting of three sub-samples from the discharge into the sump were collected. The flowrate of the drainings was estimated by timing the collection of a measured volume from the discharge into the sump on four occasions.

At site C, drainings were from a single raw material bin. The drainings were collected in a sump in the floor under the raw material. The drainings were pumped from the sump. Three samples of drainings were collected from the discharge of the sump-pump and were combined into a single composite sample. The flowrate of drainings from the raw material bin was estimated by timed collection of a measured volume from the outlet of the sump-pump on three occasions.

At site D there were two raw material bins each with a drainage point. In addition there were drain points in the discharge screws from the bins. Samples were collected from the two raw material bin drains, the combined drainings from the two bin discharge screws and from the transfer screw to the cooker surge bin. Separate samples were collected when the bin screws and discharge screws were on and off. The samples from the different sources were analysed separately. Flowrates from the two bin drains, combined bin discharge drains and the transfer screw drain were estimated separately by timing the collection of a weighed amount of drainings on two occasions each.

At site E there was one raw material bin with a single drain point. There was a discharge belt from the raw material bin. The belt was washed when it was on and the wash water was drained to a single point. Samples were taken from the drain point from the raw material bin and the raw material-belt wash on two days. The samples from each day were composites of three sub-samples. The flowrate of drainings from the bin and raw material-belt washings was estimated by timed collection of a measured volume on three occasions on each of two days.

3.2.1.2 Tallow wash/separator discharge/liquid phase separation

At site A, the separator was not operating during the site visit. Tallow was water washed and settled. Samples of wash water drained off the bottom of the settling tank were collected. The flowrate of water added to the tallow wash and settling tank was estimated by timed collection of a measured volume and the total amount of water used to wash tallow was estimated from the fixed interval and time of addition of water to the tank.

At site B, two samples of water separated from tallow were collected while tallow was processed through the separator. The flowrate of separated water was estimated by timed collection of a measured volume on four occasions. The flowrate of tallow through the separator was estimated from the daily production and hours of operations. The total volume of water, sludge and tallow discharged from the separator during the cleaning cycle was collected. The volume was estimated from the dimensions of the collection vessel and samples of the combined material discharged during the cleaning cycle were taken on two occasions. The time and sequence of cleaning were noted.

At site C, 2 samples of water separated from tallow were collected while tallow was processed through the separator. It was not possible to measure the flowrate of water separated from tallow. The rate of addition of water to tallow before the separator was estimated by applying a portable ultrasonic flow meter at two locations on the pipe-line that delivered water to the tallow. The tallow flowrate to the separator was estimated from the volume of tallow production and hours of operation. There was no access to material discharged from the separator during the cleaning cycle.

At site D, 2 samples of water separated from tallow were collected while tallow was processed through the separator. It was not possible to measure the flowrate of water separated from tallow. The rate of addition of water to the tallow was estimated from an in-line flow meter on the water line to the tallow inlet to the separator. The flowrate of tallow was estimated from the production of tallow as indicated by the read out of loads cells on the tallow storage tanks and hours of production. There was no access to material discharged from the separator during the cleaning cycle.

At site E, wet-rendered liquid phase was separated into finished tallow and stickwater. Stickwater from the liquid-phase separator was diverted to a storage tank in order to obtain access to the stickwater. The stickwater flowed through the tank and did not accumulate. Four samples of stickwater were collected from the discharge from the storage tank. The flowrate of stickwater was estimated on four occasions by timed collection of a measured volume of stickwater as it flowed from the storage tank. The estimated flowrate was verified by reference to an in-line flow meter on the stickwater drain line. The material discharged from the liquid-phase separator during the cleaning cycle was collected in tubs. Samples of the discharged material were collected from the mixed material in the tubs. The volume of material discharged during the cleaning cycle was estimated from the dimensions of the tubs. The flowrate and total volume of material discharged from the separator during cleaning was estimated from the timing of the cleaning sequence. Tallow production rate was estimated from the total day's production and hours of operation.

3.2.1.3 Condensate cooking and drying vapours

At site A, condensed vapours from the cooker were sampled from a tap in the outlet drain from the condenser. Samples were collected on two days. The flowrate of condensate was estimated from a flow meter on the outlet drain from the condenser.

At sites B, C, and D, samples of condensate were collected from the outlet drain from the condenser. The flowrate of condensate was estimated by timed collection of a measured weight or volume of condensate on three to five occasions.

At site E, vapours from the dryer, reactor vessel and liquid phase tank were combined and were treated through a condenser, scrubber and discharge stack. There were effluent flows from each treatment. Samples were collected from the three sources and combined as a single condensate sample. There was no access to the full flow of the streams and flowrates from the condensate sources were not estimated.

3.2.1.4 Other measurements

At site E, water added to the reactor vessel was estimated by timed collection of a weighed amount of water on two occasions. Water added to the reactor in the form of condensation of direct steam injection was estimated from the temperature increase in the reactor and the steam pressure in the injection line.

3.2.2 Effluent streams from blood processing

3.2.2.1 Blood samples

Samples of ovine and bovine whole blood were collected from animals at the time of slaughter at sites A, C, D, and E. Samples were collected in bottles that contained known amounts of 10% citrate solution.

Samples of blood as received at the blood processing plant were collected at all sites. Samples were collected in bottles that contained known amounts of 10% citrate solution.

3.2.2.2 Volume of blood processed

At site A, blood delivered to the processing plant was weighed over a weighbridge on arrival.

At site A, drainings from raw material were accumulated during the day. The drainings were blended with the blood before the blood was coagulated. The volume of drainings was estimated from the dimension of the holding tank and the depth of drainings in the tank before processing started.

At site B, blood received from an outside source was weighed over a weighbridge on arrival. The rate of blood processing was estimated by timed collection of a measured volume delivered to the coagulator feed tank.

At sites C and D, blood processing rate and blood quantity were not measured but were estimated from kill numbers.

At site E, one day’s production of blood was accumulated in tanks before it was processed. The volume of blood was estimated from the depth of blood in the tanks and the dimensions of the tanks

3.2.2.3 Steam addition

The amount of steam added to the coagulated blood was estimated from the temperature differential through the coagulator and the pressure of steam injected into the coagulator.

3.2.2.4 Blood stickwater

Samples of stickwater from the coagulated blood decanter were collected at all sites. Where possible, the flowrate of stickwater production was estimated

At site A the flowrate of stickwater was not available.

At sites B, C, D and E the flowrate of stickwater was estimated by timed collection of a measured volume or weight of stickwater on two occasions.

3.2.2.5 Dewatered blood solids

Samples of dewatered wet blood solids before drying were collected at all sites.

3.2.2.6 Blood vapour condensate

Samples of condensate from the blood dryer were collected at sites A, and B.

At site C, vapour from the ring dryer was condensed in a water scrubber and samples were collected from the scrubber overflow drain.

At site D, vapour from blood drying was not condensed.

At site E samples of condensate from the blood dryer combined with water from a scrubber were collected

At sites A and B, flowrates of condensate from blood drying were estimated by timed collection of a measured volume of condensate from the condenser drain. Flowrates of condensate were not available at sites C, D and E.

4 Results

4.1 Potential product losses from rendering

From the results of analyses of total solids, organic nitrogen and oil and grease shown in Appendices C to G and the volume of effluent streams shown in Appendices H to E, equivalent amounts of meat and bone meal, tallow and blood meal in effluent can be estimated.

The fat-free total solids in effluent streams have been converted to equivalent meat and bone meal by assuming that meat and bone meal is 85% fat-free solids (i.e. typical meat meal analysis of 4% moisture and 11% fat). Fat- free solids of the various streams are the difference between total solids and oil and grease shown in appendices C to G.

The equivalent protein content of effluent streams has been estimated by multiplying the organic nitrogen content of effluent streams shown in Appendices C to G by 6.25 (the typical nitrogen content of animal proteins). The equivalent protein content of the effluent streams is part of the fat-free solids and ratio of equivalent protein to equivalent meat and bone meal is an indication of the potential protein content of the equivalent meat and bone meal in effluent streams.

The oil and grease in effluent streams shown in Appendices C to G has been converted to an equivalent amount of tallow by assuming that the equivalent meat and bone meal produced from the fat-free solids in a stream is 11% fat and by subtracting this amount of fat from the oil and grease component of effluent stream

4.1.1 Raw material drainings

The equivalent amount of meat and bone meal, protein and tallow in raw material drainings is shown below in Table 4.1.1.1.

Table 4.1.1.1: Equivalent meat and bone meal and tallow in raw material drainings

Site	HSCW mean of 2010/2011 and 2011/2012 (t/yr)	Effluent volume (m^3/yr)	Equivalent MBM (t/yr)	Equivalent protein (t/yr)	Equivalent tallow (t/yr)
A	66,248	1,207	163	66	-12
B	13,853 plus 6,615 tonnes of outside raw material	1,187	163	55	-14
C	54,476	3,744	272	68	-20
D	52,589	16,678	866	439	170
E	32,426	4,082	80	27	-6
E Belt washings	32,426	10,990	117	16	-5

At all sites except D, equivalent tallow in the effluent stream is a negative figure because the amount of oil and grease in the effluent stream was less than 11% of the equivalent meat and bone meal in the stream.

At site A, all raw material drainings were blended with blood. The blend was coagulated and dried.

At site A the annual effluent volume is extrapolated over 286 days from one day's collection of all drainings from raw material.

At site B the volume of drainings is based on the mean of four estimates of flowrate for 2,394 hours operation.

At site C, the volume of drainings is based on the mean of three estimates of flowrate for 5,200 hours operation.

At site D the flowrate of drainings from four sources (two raw material bins, combined drainage from two bin discharge screws and drainage from one transfer screw) were estimated. Volumes of drainings were estimated for 4,335 hours of operation. Analyses of drainings from each source were used to estimate the combined equivalent meat and bone meal, protein and tallow in the raw material drainings.

At site E the volume of drainings is based on the mean of four estimates of flowrates for 4,080 hours operation. In addition the volume of raw material belt washings was based on the mean of three estimates of flowrates for 4,080 hours operation

4.1.2 Separator

The equivalent amount of meat and bone meal, protein and tallow in water separated from tallow and discharged from tallow purifying centrifuges is shown in Table 4.1.2.1. The equivalent amount of meat and bone meal, protein and tallow in discharges from tallow purifying separators during cleaning cycles is shown in Table 4.1.2.2. Tables 4.1.2.1 & 4.1.2.2 also show the equivalent amount of meat and bone meal, protein and tallow in stickwater and cleaning cycle discharges from the liquid phase separator at the wet-rendering plant: site E.

Table 4.1.2.1: Equivalent meat and bone meal and tallow in water phase from tallow purifying centrifuges and wet-rendering liquid phase centrifuge

Site	HSCW mean of 2010/2011 and 2011/2012 (t/yr)	Effluent volume (m^3/yr)	Equivalent MBM (t/yr)	Equivalent protein (t/yr)	Equivalent tallow (t/yr)
A (water wash and settling)	66,248	1,336	79	N/A	112
B	13,853 plus 6,615 tonnes of outside raw material	111	2	0.2	1
C	54,476	45,800	155	29.0	27
D	52,589	367	11	3.0	2
Wet-rendering stickwater					
E	32,426	25,845	375	229.0	34

Table 4.1.2.2: Equivalent meat and bone meal and tallow in discharges from tallow purifying centrifuges and wet-rendering stickwater centrifuge during cleaning cycles

Site	HSCW mean of 2010/2011 and 2011/2012 (t/yr)	Effluent volume (m^3/yr)	Equivalent MBM (t/yr)	Equivalent protein (t/yr)	Equivalent tallow (t/yr)
B	13,853 plus 6,615 tonnes of outside raw material	873	23	1	6
Wet-rendering separator cleaning cycle					
E	32,426	5,141	132*	66	141

*At site E the fat-free solids in material discharged from the liquid phase centrifuge was about 20%w/v. This result is unusually high and has not been used to estimate the equivalent amount of meat and bone meal in the discharge. The equivalent meat and bone meal in the discharge has been estimated from the organic nitrogen.

At site A the tallow purifying centrifuge was not operating and the data in Table 4.1.2.1 refers to the equivalent meat and bone meal, tallow and protein in a sample of wash water drained from the settling tank. The volume of effluent is the volume of wash water added to the tallow.

At site B no water was added to the tallow. Crude tallow was drained before it was purified in the centrifuge and steam was injected into the tallow prior to the centrifuge. Consequently the amount of water discharged from the centrifuge is very small.

At site, D a small amount of water was added to the tallow prior to the centrifuge.

At site D there was no direct measurement of the water discharged from the centrifuge. The flowrate of water added to the tallow was measured with a portable ultrasonic flow meter. The flowrate was measured at two locations on the water line but the results could not be verified. Based on the readings of the ultrasonic flow meter and production of tallow on the day of the site visit, the amount of water added to the tallow was about 4 times the volume of the tallow.

4.1.3 Condensate

The equivalent amount of meat and bone meal, protein and tallow in condensed cooking vapours is shown below in Table 4.1.3.

Table 4.1.3: Equivalent meat and bone meal and tallow in condensate

Site	HSCW mean of 2010/2011 and 2011/2012 (t/yr)	Effluent volume (m^3/yr)	Equivalent MBM (t/yr)	Equivalent protein (t/yr)	Equivalent tallow (t/yr)
A	66,248	29,387	41	2.0	N/A
B	13,853 plus 6,615 tonnes of outside raw material	7,097	1	0.5	0.4
C	54,476	15,695	4	1.0	0.6
D	52,589	24,393	13	2.0	-1.0
E	32,426	6,199	1	0.5	Neg

4.2 Potential losses from blood processing

4.2.1 Blood stickwater

The equivalent amount of blood meal and protein in blood stickwater are shown below in Table 4.2.1

Table 4.2.1 Equivalent blood meal in stickwater from coagulated blood

Site	HSCW mean of 2010/2011 and 2011/2012 (t/yr)	Estimated whole blood volume (t/yr)	Estimated blood volume received at rendering plant (t/yr)	Stickwater volume (m^3/yr)	Equivalent blood meal in stickwater (t/yr)	Equivalent protein in stickwater (t/yr)
A	66,248	4,220	9,634*	8,228	120	25
B	13,853 plus 1,044 tonnes of outside blood		1,586**	792	10	2
C	54,476	2,837	4,184	3,611	85	62
D	52,589		5,000***	4,914	194	142
E	32,426	1,362	1,719	2,604	19	5

*Includes 1,207 m^3 of raw material drainings

**Includes 1,546 tonnes of blood brought in from outside sources

***Includes approximately 2,000 tonnes of blood brought in from outside sources

4.2.2 Blood vapour condensate

The equivalent amount of blood meal and protein in condensed vapour from blood drying are shown below in Table 4.2.2.

Table 4.2.2: Equivalent blood meal in blood vapour condensate

Site	HSCW mean of 2010/2011 and 2011/2012 (t/yr)	Blood meal production mean of 2010/2011 and 2011/2012 (t/yr)	Effluent volume (condensate) (m^3/yr)	Equivalent blood meal (t/yr)	Equivalent protein (t/yr)
A	66,248	1,266	1,760	1.0	1.0
B	13,853 plus 1,044 tonnes of outside blood	383	589	0.2	0.3

5 Discussion

5.1 Background

5.1.1 General site survey

The overall philosophy was to take specific samples of each rendering plant stream and either measure or calculate its flowrate. This was then linked via the t HSCW for that day to the t HSCW for the full year 2010/11 to estimate what load on the environment was caused by each separate rendering plant stream. This was related to the overall site load i.e. the abattoir plus rendering plant. In the past, samples have been taken of rendering plant streams to decide which were the major load on the environment without regard to the flowrate. Where possible, actual flowrates were measured and this is described elsewhere in the report. You cannot improve what you do not measure. Unless there is some assessment of the overall rendering plant load on the environment, it is not known whether it is cost effective to try and reduce the load. It is not known what % of the total site load is due to the rendering plant and what is due to the abattoir. Should effort be put into the abattoir and/or the rendering plant to minimise the environmental load.

However, some “condensate” flows could not be measured at some sites due to the following reasons

- Condensate was not actually condensed but was just evaporated
- Condensate was recycled through a scrubber tank where there was an automatic potable water makeup valve and overflow bleed off.

5.1.2 Rendering plant effluent streams

The project plan was to produce a report that would enable any site to follow and produce their own specific set of loads on the environment from their rendering plant. The following rendering streams should be considered and compared to the overall abattoir trade waste. Those streams that then constitute the greatest contribution to load on the environment can then be look at in more detail (load being tonnes/year, that is, not just concentration but also volume).

- Abattoir wastewater
- Rendering plant wastewater
- Cooker condensate (dry rendering)
- Raw material bin drainage
- Tallow processing losses
- Belt drainage
- MAM stickwater (wet rendering)
- MBM condensate
- Blood stickwater
- Blood dryer condensate

5.1.2.1 Abattoir wastewater

Some sites do not measure their wastewater flowrate. If this is the case then it can be estimated as a % of the potable water flowrate plus the addition of the volume of blood stickwater and the water in the MAM. Some potable water is lost due to evaporation and some lost as it is used by amenities (showers, toilets, laundry) and perhaps animal drinking troughs. Amenities were shown to use 1.5% of potable water in one MLA study and troughs to use 0.2%. A figure of 5% loss of potable water overall may be reasonable. It was found that most sites do not analyse their discharge to waste treatment only analysing the final treated effluent prior to sewer, or irrigation, or reuse. It is worthwhile analysing the combined wastewater going to a treatment plant. It was very variable between sites and so there is no "average" wastewater. At least weekly grab samples should be taken over a period of a few months and analysed by a NATA laboratory used to handling abattoir wastewater. Prior to collecting any of these wastewater streams, and estimate of the expected flow should be calculated so the appropriate sized containers are used.

5.1.2.2 Rendering plant wastewater

The rendering plant wastewater effluent was not measured at any site visited. This report estimated this flow from the summation of individual streams listed below.

5.1.2.3 Cooker condensate (dry rendering)

Cooker condensate from dry rendering may be measured physically but if there is no suitable drainage point then it can be calculated from the weight of MBM, its average moisture content and assuming the moisture in MAM to be 50 to 55%. A sample should be analysed. It may look clear and it has been described as clean as distilled water. However, Appendix M & N show that condensate has a high COD load and is high in NH_3-N. The COD is due to the volatile organic acids, shown in Appendix T.

5.1.2.4 Raw material bin drainage

This needs to be physically measured using a container and stopwatch. It is very variable and is highly polluting. While three sites were 2%, 4% and 7% of HSCW, two sites were 13% and 34% of HSCW. One of the lower discharge sites processed the drainage with the blood. Some sites in Australia operate with no raw material bin drainage. The COD in the raw material bin drainage was 0.2% to 0.8% of the HSCW for four of the sites but 3.6% for the high volume site so the drainage is not a low concentration because it is high volume.

5.1.2.5 Tallow processing losses

There are two streams which may need to be considered, the tallow separator water and the separator cleaning cycle discharge. They may not be accessible for measurement but they are important as they are high in O+G, so high in COD and it is advisable to minimise the O+G going to anaerobic digestion.

5.1.2.6 Belt drainage

Some sites do not have any belt drainage but it is a simple exercise to collect it in a container and physically measure.

5.1.2.7 MAM stickwater (wet rendering)

This can be calculated from the tallow and MBM produced using an assumed MAM moisture content, say 52%. If water is added to fluidise the wet MAM then this needs to be measured. Then following a similar calculation to that show in Appendix Y, the amount of steam needed to heat up the wet MAM can be calculated. A sample of wet MBM prior to the dryer needs to be analysed for moisture content. A simple mass balance of wet MAM plus added water plus steam less wet MBM and tallow gives MAM stickwater.

5.1.2.8 MBM condensate

Depending on the type of dryer installed, the vapour from the MBM dryer may go to atmosphere or will be recovered directly or indirectly and will then go to wastewater. It can be seen in Appendix M and N that there is a small amount of COD coming from volatile organic acids and ammonia nitrogen. If condensate does go to wastewater then the quantity can be calculated based on the weight of MBM produced and the analyses of wet and dry MBM.

5.1.2.9 Blood stickwater

Blood stickwater volume can be measured physically. It can also be calculated. Appendix Y explains how to calculate the steam that is injected into the blood to coagulate the protein solids. Some sites collect all their blood into one or more receivers prior to processing. In this case, the actual blood volume can be calculated. Alternatively, the quantity of blood may be calculated by referencing the theoretical yield in Appendix U and then adjusting the volume by analysing the blood solids compared to the theoretical blood solids as shown in Appendix Y. The wet blood solids and stickwater need to be analysed for solids content. A mass balance can then be done as shown in Appendix Y to calculate the quantity of wet blood solids and blood stickwater.

5.1.2.10 Blood dryer condensate

Depending on the type of dryer installed, the vapour from the MBM dryer may go to atmosphere or will be recovered directly or indirectly and will then go to wastewater. The quantity of condensate can be calculated from the moisture contents of wet and dry blood solids and the quantity of dry blood solids.

5.2 Environmental impact

5.2.1 COD

It is not just the value of lost product which is important. The basis of the project was to look at the positive and negative impacts on the environment of the effluent streams from processing both blood and mixed abattoir material (MAM). It was explained earlier why chemical oxygen demand (COD), nitrogen (TN), phosphate (TP), and dissolved salts (TDS) are all important.

COD is converted by microorganisms in an aqueous environment to mainly methane and carbon dioxide anaerobically, and mainly carbon dioxide aerobically. If it occurs in a creek or other waterway then living things that require oxygen will die. It is usually more economic to metabolise COD anaerobically but anaerobic digestion cannot reduce the COD sufficiently to meet environmental discharge standards so digestion is usually followed by aerobic processing which converts carbonaceous COD to carbon dioxide and water molecules. Aerobic processes need dissolved oxygen.

Overall, Appendix Z shows that the rendering plant contributes between 14% and 40% of the COD in the combined abattoir/rendering plant wastewater which is substantial compared to the 5% to 23% flowrate contribution and is worthwhile targeting for reduction.

Appendix W shows a comparison for all the sites of the theoretical amount of biogas that would be generated from the COD discharged from their rendering plants. Calculations have been done to show the size of anaerobic digester, and the carbon tax that may need to be paid if this biogas is discharged to atmosphere if the site exceeds the 25,000 t/yr threshold. This may be offset by the value of the biogas if it replaces natural gas and the biogas the discharge will not count towards the 25,000 t/yr threshold if it is simply flared. MLA has issued a number of reports regarding the effect of the carbon tax and it is in a state of flux at present with the recent change of government and the upcoming senate election.

Appendix W also calculates the amount of electricity required to provide the dissolved oxygen from the air, and using individual sites' electricity costs, what the cost of the electricity would be to provide that air. Any other site may substitute their COD load to determine their site values. Assumptions are given in Appendix W generally taken from the government NGER regulations. It can be seen from Appendix X that actual performance of the anaerobic digester at site C exceeds the NGER figures both in the % removal of COD (93% compared to 80%) and the amount of biogas generated (0.333 kg CH_4/kg COD compared to 0.25 kg CH_4/kg COD).

The value of the biogas is usually given in terms of the equivalent value of natural gas it can replace. During this project values the various sites quoted costs of $4.50 to $15.90/GJ. Just recently (The Age newspaper, 2014 04 09) a review of future world prices over the next decade was quoted at US$4 to US$6/BThU, equivalent to A$3.55 to A$5.33/GJ due to the long term oversupply of LNG. With Australia being one of the two largest exporters of LNG in the world, the implication of this is that natural gas and so biogas will not have an increased value in the medium term future.

The "emissions from wastewater treatment" i.e. the methane released by the waste treatment plant in tonnes CO_2-e, given in Appendix W and X were calculated using the NGER wastewater (industrial) calculator Excel spreadsheet provided by the Department of Climate Change and Energy Efficiency which is used to report into OSCAR. The site A example is shown in Appendix ZA. It may be that the "emissions from wastewater treatment" is zero as a rendering plant may be included at no extra cost if the emissions are calculated from inserting tonnes HSCW into the "tonnes of commodity produced" ie an abattoirs with or without attached rendering plants are treated the same by the NGER.

5.2.2 Nitrogen

The nitrogen in the rendering plant wastewater is present as NH_3-N, organic nitrogen (mainly protein) and a few mg/L of NO_x-N. During anaerobic digestion, the organic nitrogen is mainly converted to NH_3-N, but unless this process is followed by a nitrification/denitrification designed system, no N will be lost to atmosphere and will still be present in the final treated effluent as NO_2/NO_3-N and NH_3-N. If this effluent goes to sewer there will be charges and maybe maximum limits whereas if it is irrigated then it will be beneficial to the soil. Generally, the hydraulic limit will be reached before the nitrogen limit for irrigating land. There are substantial quantities of protein nitrogen present in the rendering plant effluent, Appendix M and N, which is discussed elsewhere.

5.2.3 Phosphate

There is generally very little removal of TP during wastewater treatment unless a special system has been installed. Phosphorus is essential to life. Isaac Asimov (Asimov on Chemistry, 1974) said "life can multiply until all the phosphorus is gone, and then there is an inexorable halt". Today's mines will be exhausted by the end of the 21st century. The future reserves are estimated to last 200 to 400 years. Phosphorus scarcity is as important as climate change. Sweden and Germany aim to recover at least 60% of phosphorus compounds by 2015 (www.tcetoday.com,

Feb. 2014, page 29). Australia soil is depleted in P. There are a number of ways of recovering P from wastewater. However, while concentrations are higher in rendering plant effluent than in domestic sewage treatment plants, overall tonnage is lower. Appendix N shows that concentrations are 43, 60, 58, 18 and 99mg/L TP at the 5 sites A-E but tonnages are not worth recovering. The best way of using this TP is by irrigation of treated effluent. If the effluent goes to sewer then the municipal authority may recover TP or recycle it by irrigation. TP in water going to waterways is a major cause of algal blooms and eutrophication.

5.2.4 Dissolved salts

The concentration of dissolved salts are unchanged on their passage through the waste treatment plant. The major source of TDS in the rendering plant wastewater is from raw material bin drainage. The TDS of the abattoir wastewater was not measured by site D but clearly rendering wastewater TDS concentration would be substantially lower if there was no raw material bin drainage. Site A includes raw material bin drainage in the blood that is processed. Site E is wet rendering and its major source of TDS is the MBM stickwater. The volume of water from the other four dry rendering plants is similar to the MBM stickwater but as it is condensate it is very low in TDS.

Table. 5.2.4 TDS comparison between sites

site		A	B	C	D	E
Rendering %abattoir plus rendering	%	3.5	12.1	25.8		19.2
Rendering concentration inc. bin drainage	mg/L	1,510	2,660	1,010	2,490	1,400
Rendering concentration without bin drainage	mg/L	1,510	840	780	810	1,200

5.2.5 Blood stickwater

Blood stickwater represents only 0.3-1.8% of the wastewater flowrate of the overall abattoir but for rendering plants C & D which are doing a poor job at coagulating/recovering protein, blood stickwater represents large loads of COD, TN, and TP going to wastewater.

Site D had the highest COD of 50,667 mg/L average. It had the lowest estimated blood solids going to processing of 9.7% solids, compared to the other sites of 13.3%, 14.0%, 14.5% and 15.1%. Pilkington (“Continuous blood coagulation and dewatering”) stated that solids in blood generally ranged from 10% to 15% and at about 9% to 10% solids it is not possible to coagulate blood.

Sites C & D had 2.3% and 3.8% solids in blood stickwater compared to 1.4%, 1.2% and 0.7% for sites A, B, and E respectively. Pilkington stated that blood stickwater generally ranged from 0.75% to 2%.

5.3 Potential product losses from rendering

The fat-free solids, oil and grease and organic nitrogen in effluent are derived from raw materials or processing steps. They could contribute to meat and bone meal or tallow if they are retained within the raw material or processes or if they are recovered from effluent streams. The amount of potential product in effluent streams depends on the volume of effluent and the concentration of solids and oil and grease. There were wide variations in both volume and composition of effluent streams at the five sites. The variations between the dry-rendering sites were due to both the way in which equipment was operated and the type of equipment. For example the excessive amount of potential product in effluent from tallow purifying at site C was due to the amount of water introduced to the centrifuge with the tallow. The excessive potential product in raw material drainings at site D was due to the use of multiple blow lines used to transport raw material to the rendering plant.

The amounts of meat and bone meal and tallow equivalent to the fat-free solids and oil and grease in the effluent streams are discussed below. Benchmarks for potential product in effluent streams are suggested. The value of potential product is also suggested. Values of meat and bone meal and tallow are based on the mean monthly price of 50% protein meat and bone meal and 2% FFA tallow reported in the MLA Co-products Market Analysis Report in 2011, 2012 and 2013. The mean prices are:

- 50% protein meat and bone meal $582 per tonne
- 2% FFA tallow $881 per tonne

In some cases, the equivalent amount of protein in effluent streams was considerably less than 50% of the fat free solids and the solids, if recovered, would not produce 50% protein meat and bone meal. In these cases an alternative value has been suggested based on the equivalent protein in the effluent streams and assuming that the protein would be 50% of the meat and bone meal

5.3.1 Raw material drainings and benchmarks

Table 4.1.1.1 shows the equivalent amount of meat and bone meal, protein and tallow in raw material drainings. It is inevitable that a certain amount of water is added to raw material, for example in the gut washing process. It is conventional practice to drain off added water to reduce the cost of evaporating extra water in the rendering process.

At each site there was a substantial loss of solids in the raw material drainings. At site D the fat-free solids in raw material drainings was equivalent to about 866 tonnes per year of meat and bone meal and 440 tonnes of protein or 51% protein in the meat and bone meal. There was also the equivalent of 170 tonnes per year of tallow in the drainings. At this site, raw material was from five sources and was transported by blow line to the rendering plant. A large volume of water was added to material in the blow pots to keep the raw material moving. The amount of water drained from raw material bins and screws was estimated to be 16,678 m^3/yr. The added water was approximately 50% of the estimated raw material weight.

The drain screens on raw material screws at site D were sprayed with hot water to keep the screen holes clear. The drainage from these screens was relatively high in oil and grease but the solids content of drainings from site D were not higher than at other sites. The high amount of equivalent meat and bone meal in the drainings was due to the volume of water rather than the composition of the drainings although the hot-water sprays on drains from the screws contributed to the high equivalent amount of tallow in the drainings.

The fat-free solids in drainings at sites A and B were higher than at other sites at about 11.5%. At site B, sheep heads and hocks were treated in a caustic bath to hydrolyse wool before that were added to the raw material bin. This may have resulted in additional solids in the drainings.

Table 5.3.1 shows the volume of raw material drainings as a proportion of the estimated raw material. The average volume of drainings was 17.1% of raw material. If site D is discounted as an unusual case, the average volume of raw material drainings was 8.6% of raw material. This could be considered a benchmark for the volume of raw material drainings. Discounting site D, the average solids content of drainings was 80,462 mg/L, the average organic nitrogen content 5,045 mg/L and the average oil and grease was 2,877 mg/L. The equivalent amount of meat and bone meal and tallow in the benchmark drainings is:

- Mean amount of raw material 29,690 m^3/yr
- Mean amount of drainings 2,554 m^3/yr
- Equivalent amount of meat and bone meal based on fat-free solids 233 tonnes
- Equivalent amount of protein 54 tonnes
- Equivalent amount of tallow -18 tonnes

Table 5.3.1: Raw material drainings compared with raw material quantity

Site	Estimated raw material (t/yr)	Volume of drainings (m^3/yr)	Drainings as a percentage of raw material %
A	48,467	1,207	2.5
B	14,382	1,187	8.25
C	31,645	3744	11.8
D	38,944	16,678	42.8
E	24,268	4,082	16.8

5.3.2 Value of potential product in raw material drainings

The potential values of the equivalent amount of meat and bone meal and tallow in raw material drainings is shown in Table 5.3.2.

Table 5.3.2: Value of equivalent meat and bone meal and tallow in raw material drainings

Site	Value of MBM assuming fat-free solids are 85% of MBM ($/yr)	Value of MBM assuming protein is 50% of MBM ($/yr)	Value of tallow ($/yr)
A	94,961	77,208	-10,500
B	95,010	63,988	-12,578
C	158,554	79,534	-17,660
D	504,302	511,878	150,224
E	46,368	31,211	-4,988

5.3.3 Tallow purifying water

Tallow purifying centrifuges at three sites were evaluated in terms of effluent discharged from the centrifuges. The centrifuge at site A was not operational at the time of the site visit and at site E the centrifuge separated wet-rendered liquid phase and the performance is not comparable with purifying dry-rendered tallow.

At two sites (B and D), very little water was added to the tallow prior to the centrifuge and at site C an excessive amount of water was added.

At sites B and D the volume of water discharged from the centrifuge was estimated to be 111 and 367 m^3/yr. The fat-free solids in the water discharge were 14,030 and 26,000 mg/L and oil and grease was 8,800 and 8,000 mg/L. The equivalent amount of meat and bone meal in the water discharge was 1.8 and 11 tonnes per year and the equivalent amount of tallow was 0.8 tonnes and 1.7 tonnes per year.

At site C the flowrate of water discharged from the tallow purifying centrifuge could not be measured but the flowrate of water added to the tallow was estimated with an ultrasonic flow meter. The estimated volume of water added to the tallow and assumed to be discharged from the centrifuge was 45,800 m^3/yr. The fat-free solids content of water separated from tallow at site C was 2,880 mg/L, less than 20% of the fat-free solids content in centrifuge water at sites B and D. The oil and grease was 970 mg/L, about 11 to 12% of the oil and grease content of centrifuge water at sites B and D at. The equivalent amount of meat and bone meal and tallow in the centrifuge water at site C was 155 t/yr and 27 t/yr (see Table 4.1.2.1).

Tallow purifying centrifuges have programmed cleaning cycles to flush out solids that collect at the edge of the bowl. During the cleaning cycle, tallow flow to the separator stops, water is introduced to displace tallow in the bowl and the bowl opens to discharge solids. The quantity and composition of material discharged during the cleaning cycle was assessed at site B. The cleaning cycle discharge was not accessible at sites C and D. The total volume of material discharged during the cleaning cycle at site B was estimated to be 873 m^3/yr. The equivalent amount of product in the discharge was 22 t/yr of meat and bone meal; 1 t/yr of protein and 6 t/yr of tallow.

In view of the large differences in the amount of water added to tallow prior to the centrifuge and the volume of water discharged from centrifuges at the three dry-rendering sites, no benchmarks for meat meal and tallow in water separated from tallow are suggested.

5.3.4 Value of potential products in tallow purifying water and cleaning cycle discharge

The potential values of the equivalent amounts of meat and bone meal and tallow in water separated from tallow in purifying centrifuges is shown below in Table 5.3.4.1

Table 5.3.4.1: Value of equivalent meat and bone meal and tallow in water separated from tallow by centrifuge

Site	Value of MBM assuming fat-free solids are 85% of MBM ($/yr)	Value of MBM assuming protein is 50% of MBM ($/yr)	Value of tallow ($/yr)
B	1,071	224	686
C	90,315	30,681	24,100
D	6,533	2,797	1,498

The potential values of the equivalent amount of meat meal and tallow discharged in effluent from tallow purifying centrifuges during the cleaning cycle is shown in Table 5.3.4.2.

Table 5.3.4.2: Value of equivalent meat and bone meal and tallow in the discharge from the tallow purifying centrifuge during the cleaning cycle

Site	Value of MBM assuming fat-free solids are 85% of MBM ($/yr)	Value of MBM assuming protein is 50% of MBM ($/yr)	Value of tallow ($/yr)
B	12,582	1,404	5,100

5.3.5 Wet-rendering liquid phase separation

At site E the wet-rendered liquid phase is separated to produce stickwater and purified tallow. The potential value of the equivalent amounts of meat and bone meal, and tallow in the stickwater and in the material discharged during the centrifuge cleaning cycles are shown in Table 5.3.5

Table 5.3.5: Value of equivalent meat and bone meal and tallow in stickwater and cleaning cycle discharges at wet-rendering plant

Effluent	Value of MBM assuming fat-free solids are 85% of MBM ($/yr)	Value of MBM assuming protein is 50% of MBM ($/yr)	Value of tallow ($/yr)
Stickwater	218,106	266,710	30,283
Cleaning cycle discharge		76,596	123,824

5.3.6 Condensate and benchmarks

The volume of condensate from the dry-rendering sites should equate to the difference between raw material (including undrained added water) and the product output. Condensate volumes were calculated on this basis and were also estimated from measurements of the flowrate of condensate to drain. At site C, the amount of condensate estimated from flowrates was 14,973 m^3/yr and 15,695 m^3/yr based on the difference between raw material and finished product. At site D the amount of condensate estimated from flowrates was 24,298 m^3/yr and 24,393 m^3/yr based on the difference between raw material and finished product.

The estimated volumes of condensate and raw material are shown in Table 5.3.6.1. The equivalent amounts of meat and bone meal and tallow in condensate are shown in Table 4.1.3. The value of the meat and bone meal and tallow is shown in Table 5.3.6.2.

Table 5.3.6.1: Raw material and estimated volume of dry-rendering condensate

Site	Raw material (t/yr)	Condensate (m^3/yr)	Condensate as % of raw material
A	48,467	26,896	55.5
B	14,382	7,097	49.3
C	31,645	15,695	49.6
D	38,944	24,393	62.6
Mean	33,359	18,520	55.5

Table 5.3.6.2 Value of equivalent meat and bone meal and tallow in condensate

Site	Value of MBM assuming fat-free solids are 85% of MBM ($/yr)	Value of MBM assuming protein is 50% of MBM ($/yr)	Value of tallow ($/yr)
A	23,940	2,965	Not assessed
B	656	1,173	369
C	2,595	1,730	579
D	7,515	4,033	-924

The condensate from site E included added water from a water scrubber. The flowrate could not be assessed. The expected amount of condensate has been estimated but there are no analyses of the condensate, only the mixed condensate and scrubber water. Thus the equivalent meat meal and tallow in condensate or condensate plus scrubber water are not available.

The volume of condensate depends on the raw material composition. At site D there was a high proportion of water in the raw material because of the large amount of water added in the blow lines. At site A, the total solids content of condensate was 1,300 mg/l which is higher than at other sites. However the organic nitrogen in the condensate was low and the equivalent meat meal based on the protein content of the condensate was in-line with the other site.

The average value of the equivalent meat meal and tallow in condensate using the value of meat meal based on protein in the condensate is $2,481 per year.

The total solids in condensate was from 205 mg/L to 1,300 mg/L. The total solids of 1,300 mg/L was more than twice the other readings. The high reading may have been caused by fouling in the condenser or carry over from the cooker trash vessel.

It is suggested that the total solids in condensate should be less than 400 mg/L and oil and grease less than 70mg/L.

5.4 Potential product losses from blood meal production

Production of blood meal involves heat coagulation of blood by steam injection. Free water containing soluble protein and other solutes is separated from coagulated solids by decanter (horizontal bowl) centrifuge. The protein and solids in stickwater represent an equivalent amount of blood meal which could be considered a loss of product. The equivalent amount of blood meal is about 104% of the solids content of stickwater assuming the finished blood meal is 96% solids or about 117% of the protein content of the stickwater assuming the protein content of the finished blood meal is 85%.

The equivalent amount of blood meal in stickwater is related to the amount of stickwater and the composition of the stickwater. The amount of stickwater is affected by the amount of added water in the blood. The composition of the stickwater is probably affected by the efficiency of coagulation and centrifugation of the coagulated blood.

The amounts of blood meal equivalent to the solids content and protein content in stickwater are discussed below. Benchmarks for equivalent amounts of blood meal in stickwater are suggested. The value of potential product in stickwater is also suggested. Values of blood meal are based on the mean monthly price of blood meal reported in the MLA Co-products Market Analysis Report in 2011, 2012 and 2013. The mean price is $911 per tonne.

The equivalent amount and value of product in condensed vapour from blood drying processes has also been estimated

5.4.1 Blood stickwater and benchmarks

Table 5.4.1.1 shows the solids content of blood as received at the processing plant. From the solids content of blood as received, the amount of added water has been estimated assuming a solids content of 19% in the whole blood as drained from slaughtered animals.

Table 5.4.1.2 below shows the solids content and protein content of stickwater and the equivalent amount and value of blood meal in stickwater

Table 5.4.1.1: Added water in blood

Site	Volume of whole blood (m^3/yr)	Solids content of blood received for processing (%w/v)	Added water (% of whole blood)
A	4,220	13.3	43
B		13.5	37
C	2,837	14.5	31
D	2,571	9.2	106
E	1,362	9.5	100

Table 5.4.1.2 Equivalent blood meal in stickwater

Site	Volume of stickwater (m^3/yr)	Total solids in stickwater (mg/L)	Equivalent blood meal if solids are 96% of blood (tonnes)	Equivalent blood meal if protein is 85% of blood meal (tonnes)	Value of equivalent blood meal based on solids ($/yr)	Value of equivalent blood meal based on protein ($/yr)
A	8,228	14,000	120	30	109,312	29,678
B	792	12,000	10	2.5	9,019	2,510
C	3,611	22,500	85	73	77,100	72,754
D	4,914	38,000	195	167	177,201	165,608
E	2,604	6,866	19	6	16,966	5,806

At site A, raw material drainings are added to the blood before coagulation. This increases the volume of stickwater and the equivalent amount of blood meal in stickwater. By adding drainings to blood, the volume of stickwater increased by 1,056 m^3/yr and the equivalent blood meal in stickwater increased by about 5 tonnes per year. However the solids in the raw material drainings appear to have contributed an additional 139 tonnes of blood meal per year worth

$126,629. This contribution to blood meal is based on the measured solids content of stickwater of 1.4%. This solids content was not confirmed by analysis of samples collected during processing of the blood and drainings blend.

At site D, the blood as received in the rendering plant includes 106% added water. In addition the solids content of the stickwater is relatively high at 38,000 mg/l. The high solids content of the stickwater indicates inefficient coagulation and separation of solids and stickwater.

The solids content of blood stickwater from site D was also determined after the samples were centrifuged at the analytical laboratory. The solids content after centrifugation was 1.5% w/w compared with 3.8% w/w before centrifugation. The high solids content in stickwater at site D is in part due to the capacity of the decanter.

The total solids in blood stickwater is minimised by avoiding added water in raw blood, achieving efficient coagulation and by using high-capacity decanter. The highest total solids in blood as received at the processing site was 14% indicating added water of about 35%. It is suggested that solids of 14 % in blood as received could be a benchmark. However higher solids content and less addition of water to blood are probably possible.

As an indicator of the efficiency of coagulation the solids content of stickwater should be measured. One site achieved solids in stickwater of less than 1%. This is an unusually low solids content of blood stickwater. At other sites the solids content of blood stickwater was 1.2 to 3.8%. It is suggested that solids in stickwater of 1.2% is achievable and could be considered to be a benchmark.

The solids content of samples of blood stickwater from sites B and E were 1.2% and 0.7% respectively. Both sites aged blood before processing. The other sites did not age blood. At site B, blood was aged for up to 48 hours. At site E, blood was aged for up to 12 hours. Ageing blood is known to improve coagulation efficiency but is probably not the only factor involved in the low stick-water solids at these sites.

The solids content of stickwater samples from two sites were measured after centrifugation at the analytical laboratory. At one site the solids were reduced from an average of 3.8% to 1.5%. At the other site the solids in stickwater was reduced from an average of 0.69% to 0.61%. It is suggested that a reduction of 12% of the solids content of blood stickwater after centrifugation could be a useful benchmark to indication the efficiency of blood decanters.

Using these benchmarks, the equivalent blood meal in stickwater is 8.5 tonnes worth $7,766 per 1,000 tonnes of blood processed and production of 137 tonnes of blood produced i.e. the equivalent amount of blood meal in stickwater is about 6% of the value of total blood production.

5.4.2 Blood condensate

Samples of condensate from blood drying were available from sites A and B. At sites C and E condensate was mixed with scrubber water and blood drying vapours were not condensed at site D.

From the calculated volume of stickwater at sites A and D, the equivalent amount of blood meal in condensate was 1 tonne and 0.2 tonne per year with a value of $911 and $182 per year.

5.5 Reduction and recovery of potential product in effluent streams

The equivalent amounts of meat and bone meal and tallow in effluent streams has been estimated from the fat-free solids, organic nitrogen and oil and grease content of samples of effluents. What is not clear is whether solids, organic nitrogen and oil and grease in effluents could be recovered and added to product without affecting quality. For example the organic nitrogen in streams may contribute biogenic amines to meat meal and oil and grease in streams may contribute free fatty acids to tallow. The loss of solids and oil and grease in effluent streams should be prevented as far as possible before considering wether product can be recovered from streams

5.5.1 Raw material drainings

In the case of raw material drainings there were substantial amounts of equivalent meat and bone meal in the effluent (see Table 5.3.2). From the example of site D, addition of water to blow lines results in large amounts of potential product in drainings. The value of product in drainings at site D was about $550,000 per year higher than at other sites with comparable meat production. Site D had the particular problem of transporting raw material over relatively long distances from several sources. To reduce the amount of added water, material from some of these sources could be pumped conveyed by screw or by truck.

If added water is controlled such that drainings from raw material are at the benchmark of about 8.6% of raw material, the value of meat and bone meal and the negative value of tallow in raw material drainings is about $30,000 per 10,000 tonnes of raw material, less than 1% of the product value

At site A the raw materials were blended with blood. This appears to convert an equivalent amount of meat and bone meal in the drainings of 163 tonnes per year to a gain of 139 tonnes of blood meal. However, the estimated amount of blood meal recovered from the drainings is based on the measured blood stickwater solids content of 14,000 mg/L. The samples of stickwater were not taken when the blood and drainings blend was coagulated. The solids in blood stickwater could be higher when the blood and drainings blend is coagulated.

The extra cost of processing drainings in conjunction with blood has not been assessed.

Combining raw material drainings with blood appears to be a successful approach to recovering

value from drainings. Success depends on the solids content of the drainings being substantially higher than the solids content of the stickwater. The value of blood meal recovered from drainings should be verified by measuring the solids content of stickwater when the drainings are blended with blood.

Value from raw material drainings could be recovered by anaerobic digestion in a covered pond. The mean COD of samples of drainings from the five sites was 85,000mg/L. The total COD in the benchmark drainings of 8.6% from 10,000 tonnes of raw material is 73 tonnes which could convert to 26 tonnes of methane with a calorific value of 1,359 GJ. This is equivalent to $8,872 worth of natural gas using a price of natural gas of $6.36 per GJ

5.5.2 Effluent from tallow centrifugation

At site C there was a substantial amount of equivalent meat and bone meal and tallow in water separated from tallow. It is assumed that the quantity of water separated from tallow and the equivalent meat and bone meal and tallow can be greatly reduced my reducing the added water from about 4 times the volume of the tallow to about 10% of the volume of tallow.

At other sites the value of equivalent meat and bone meal and tallow in water separated from tallow were small (see Table 5.3.4.1) and it is not suggested that there are opportunities to recover the potential product in these streams.

5.5.3 Stickwater from low-temperature rendering

There is a substantial amount of equivalent meat meal and tallow in stickwater from low-temperature rendering (see table 5.3.5). The potential loss of product in stickwater is an acknowledged disadvantage of wet-rendering systems. The common method of preventing product losses in stickwater is to concentrate stickwater by waste-heat evaporation and by adding the concentrate back to defatted solids prior to drying.

This solution is used at wet-rendering plants that use contact dryers such as disc dryers and at plants that have dry-rendering system in addition to wet-rendering and where concentrated stickwater can be added to material in the dry-rendering systems. It is not a practical solution at wet-rendering plants that use direct-fired cascading rotary dryers such as site E. In addition, at rendering plants that are on-site at abattoirs there is competition for the use of waste heat from the rendering plant and most of the waste heat is used to produce hot water for the abattoir.

At some wet-rendering plants that use direct-fired cascading rotary dryers the stickwater in combination with other effluent is treated in flocculent-assisted floatation tanks. Dewatered float from these systems has been returned to the rendering process but currently this is not the usual practice because of concerns about the effect of the dewatered float on product quality.

At this stage, no practical options for recovering product from stickwater at plants that use direct-fired cascading rotary dryers are suggested.

Value could be recovered from the stickwater by collection of biogas from the anaerobic digestion of the stickwater. At site E anaerobic digestion of stickwater would produce about 13,400 GJ of methane per year, the equivalent of about $85,000 worth of natural gas.

5.5.4 Blood stickwater

There was a wide variation in the amount and value of equivalent blood meal in the blood processing stickwater (see Table 5.4.1.2). If the volume of stickwater is controlled by minimising dilution of blood with added water and the solids and organic nitrogen content of blood stickwater are controlled by efficient coagulation and centrifugation of coagulated blood, the equivalent blood meal in stickwater could be limited to about 6% of the quantity of blood meal produced.

No practical options for recovering product from blood stickwater are suggested.

Value could be recovered from blood stickwater by collection of biogas from the anaerobic digestion of the stickwater. Using the suggested benchmarks, about 91GJ of methane per year, the equivalent of about $578 worth of natural gas could be produced per 1,000 tonnes of blood processed

Conclusions

6

6.1

It was possible to identify the load on the environment exerted by each separate major stream produced by each rendering plant in terms of COD, nitrogen and phosphorus.

The effluent from the wet rendering plant was 1.87m^3 /tHSCW compared to an average of 1.01m^3 /tHSCW for the four dry rendering plants.

The COD discharged to waste by the rendering plants was very variable from 13.7t/ 1,000tHSCW to 59.9t/tHSCW. While there is a very high load coming from wet rendering plant cooker stickwater of 22t/1,000tHSCW compared to 0.7t/1,000tHSCW from dry rendering cooker condensate, the raw material bin drainage and tallow stickwater are major variable contributors.

The wet rendering plant discharged 17% more total nitrogen than any of the dry rendering plants mainly dur to the fact that it discharged 1.0t TN/1,000tHSCW in the stickwater from the cooker compared to an average of 0.16t/1,000tHSCW as condensate from the cooker for the four dry rendering plants. Raw material bin drainage was a major variable contributor of TN.

The wet rendering plant discharged almost 4 times the TP of the four dry rendering plants 0.19t TP/1,000t HSCW compared to an average of 0.05t TP/1,000tHSCW. This was due mainly to the 0.1t TP/1,000tHSCW in the cooker stickwater. Raw material bin drainage was also a major variable contributor.

The O&G varied from two plants averaging 3.8t/1,000tHSCW and two averaging 1.3t/1,000tHSCW. The cause of the high discharges were totally different and even the two better performing plants had O&G loss in different streams.

The wet rendering plant discharged no more TDS than one of the dry rendering plants but the wet rendering had its discharge caused by the 1.5t/1,000tHSCW from the stickwater whereas dry-rendering plant's was from raw material bin drainage. The first is inevitable whereas the latter can be substantially reduced. TDS from blood stickwater averaged 0.52t/1,000tHSCW+/- 50% for all plants. Blood processing adds an average of 439mg/L to the TDS of the rendering plant waste or about 35mg/L to the abattoir waste which is not critical to disposal by irrigation.

6.2

Raw material drainings, water discharged from tallow purifying centrifuges, stickwater from low temperature rendering and blood stickwater all contained solids and oils and grease equivalent to substantial amounts of meat and bone meal and tallow.

6.3

The equivalent amount of protein meals and tallow in condensates from dry rendering, drying of low temperature rendered solids and drying coagulated blood were small.

6.4

The equivalent amount of products in water discharged from tallow purifying centrifuges and blood stickwater can be reduced to low levels by using appropriate processing conditions.

6.5

The equivalent amount of product in drainings from raw material can be reduced by avoiding the addition of water to raw material but the equivalent amount of product in drainings is likely to be substantial in all cases. Solids in drainings can be recovered as blood meal by mixing the drainings with blood prior to coagulation but the value of the recovered blood meal may not exceed the processing costs, depending on the solids content of the drainings and the blood stickwater.

6.6

The equivalent amount of product in stickwater from wet-rendering can and is recovered by waste-heat evaporation. However, this method of recovery of product is not suitable at all plants and other satisfactory methods of recovery have not been identified.

6.7

Biogas can be recovered from rendering plant affluent streams in covered anaerobic ponds. The value of the biogas is about 25% of the value of the equivalent amounts of product in the streams so product recovery may be the better option

6.8

If rendering plants managed their effluent streams then the only effluent streams containing possible recoverable product are raw material bin drainings and wet-rendered stickwater. In general, there is no need for extra equipment to reduce losses. The raw material bin drainings can be recovered by admixture with blood and the wet-rendered stickwater can, and is recovered using waste heat evaporation unless a cascading rotary dryer are installed. Some with cascading rotary dryers already use chemical flocculation for solids recovery.

6.9

Without calculations and analysis, such as provided by this report, a rendering plant does not know the size of the losses that are occurring so there is no incentive to reduce them.

Appendix A. Site Questionnaire

We will need the following data four weeks before our site visit.

1. How many head were processed in 2010/2011
2. How many head were processed in 2011/2012
3. How many tonnes HSCW were produced in 2010/11
4. How many tonnes HSCW were produced in 2011/12
5. How many tonnes raw material were processed in the rendering plant in 2010/2011
6. How many tonnes raw material were processed in the rendering plant in 2011/2012
7. How many tonnes tallow was produced in 2010/2011
8. How many tonnes tallow was produced in 2011/2012
9. How many tonnes meat/bone meal was produced in 2010/2011
10. How many tonnes meat/bone meal was produced in 2011/2012
11. What was % moisture in meat/bone meal in 2010/2011
12. What was % moisture in meat/bone meal in 2011/2012
13. What other analyses are done on meat/bone meal
14. How many tonnes raw blood were processed in 2010/2011
15. How many tonnes raw blood were processed in 2011/2012
16. How many tonnes blood meal were produced in 2010/2011
17. How many tonnes blood meal were produced in 2011/2012
18. What was % moisture in blood meal in 2010/2011
19. What was % moisture in blood meal in 2011/2012
20. What other analyses are done on blood meal
21. What analyses are done on blood
22. Which of the following materials are sent to the rendering plant

brains,

hearts
tripe,
lungs
hocks,
trachaea,
runners,

23. Indicate if the raw material rendering plant is

wet or
dry

24. How many continuous cookers
25. How many batch cookers

27. Are the vapours from the cookers condensed directly into water or indirectly through a heat exchanger
28. Are the vapours from the dryers condensed directly into water or indirectly through a heat exchanger

29. What temperature is the blood heated to
30. Are the vapours from the blood dryer(s) condensed directly into water or indirectly through a heat exchanger

31. How many hours/day does the rendering plant operate
32. How many days/week does the rendering plant operate
33. How many weeks/year does the rendering plant operate

Please note We need to collect samples of material below in a bucket **so we need to be able to fit a bucket under the sample point or into a tank/vessel**

2.18.1 blood directly from animals.

2.18.2 from the blood tank,

2.18.3 of the hot blood stickwater,

2.18.4 of the condensate from the cooker(s) or dryer(s)

2.18.5 of tallow separator water phase

2.18.6 of tallow

2.18.7 of stickwater from wet rendering

2.18.8 of defatted wet solids from wet rendering

2.18.9 of dry meat/bone meal

2.18.10 of wet blood meal (blood decanter solids)

2.18.11 of dry blood meal

2.18.12 drainage from raw materials bin

The items underlined are most important and often need pipework

Appendix B. Questionnaire data

species				mixed	ovine	bovine	bovine	bovine
Site				A	B	C	D	E
Head processed	2010/11	beef		152,593		208,767	136,866	102,124
Head processed	2010/11	sheep/veal		1,258,973			86,949	
Head processed	2011/12	beef		161,149		214,663	140,430	
Head processed	2011/12	sheep/veal		1,376,857			150,369	
HSCW	2010/11	beef	tonnes	40,156		53,531	38,617	32,426
HSCW	2010/11	sheep/veal	tonnes	23,392			9,897	
HSCW	2011/12	beef	tonnes	42,012		55,421	39,310	
HSCW	2011/12	sheep/veal	tonnes	26,937			17,354	
MAM processed	2010/11		tonnes	58,495		31,645	37,457	18,402
MAM processed	2011/12		tonnes	48,561		30,815	42,590	
Tallow produced	2010/11		tonnes	10,000		8,340	11,852	7,206
Tallow produced	2011/12		tonnes	9,000		8,181	12,684	9,167
Meat/bone meal produced	2010/11		tonnes	14,000		7,166	7,126	4,729
Meat/bone meal produced	2011/12		tonnes	12,000		6,918	8,951	5,830
%moisture in final meat/bone meal	2010/11		%	3.5%		6.2%	3.5%	4.4%
%moisture in final meat/bone meal	2011/12		%	3.5%		6.0%	3.8%	4.2%
meat/bone meal other analyses	2010/11	protein	%				55.0%	
meat/bone meal other analyses	2011/12	protein	%				55.0%	
meat/bone meal other analyses	2010/11		%				9.0%	
meat/bone meal other analyses	2011/12		%				9.0%	
Raw blood processed	2010/11		tonnes	10,215		4,184	5,000	1,719
Raw blood processed	2011/12		tonnes	9,265		4,241	4,250	
Blood meal produced	2010/11		tonnes	1,328		579	413	278
Blood meal produced	2011/12		tonnes	1,204		587	358	290
%moisture in blood meal	2010/11		%	5.0%		6.5%		6.5%
%moisture in blood meal	2011/12		%	5.0%		7.1%		5.7%

blood meal other analyses	2010/11		%					
blood meal other analyses	2011/12		%					
blood coagulation temperature average			^{0}C	90-93	90-95	88-98	90	
rendering plant operating hours			start up			0500	0700	06:00
rendering plant operating hours			shut down			0000	2300	06:00
rendering plant operating hours			hrs	20	16	20	16	24
rendering plant operating days/week			start up	Mon			Mon	Mon
rendering plant operating days/week			shut down	Sat noon			Fri	Fri
rendering plant operating days/week			days	5.5	5	5	5	5
rendering plant operating weeks/year			weeks	52	51	52	51	51
rendering plant operating days/year			days	286	255	260	255	255
rendering plant operating hrs/year			hrs	5,720	4,080	5,200	4,080	
blood plant operating hours			start up			0630		21:45
blood plant operating hours			shut down			1630		0:45
blood plant operating hours			hrs		14	10		3
blood plant operating days/week			start up					Mon
blood plant operating days/week			shut down					Fri
blood plant operating days/week			days		5			5
blood plant operating weeks/year			weeks					51
blood plant operating days/year			days					255
blood plant operating hrs/year			hrs					
sewer charges (if applicable)			$/kg COD					
sewer charges (if applicable)			$/kg BOD					
sewer charges (if applicable)			$/kL					
sewer charges (if applicable)			$/kg TN					
sewer charges (if applicable)			$/kg TP					
sewer charges (if applicable)			$/kg TDS					
Electricity charge		peak	$/kWh	$0.075	$0.054910	$0.0593	12.259	
Electricity charge		off peak	$/kWh	$0.055	$0.054958	$0.0263	9.280	

		average	$/kWh		$0.033109	$0.1900		
Electricity charge								
Boiler fuel		coal	$/t				N/A	
Boiler fuel		gas	$/GJ	$5.67	$4.50	$15.29	N/A	
Boiler fuel		other	$/				$8-50	
Does MAM contain the following			Y/N					
brains				brains	brains	brains	Y	
hearts							N	
tripe							N	
lungs							N	
hocks				hocks	hocks	hocks	Y	
trachaea				trachaea	trachaea	trachaea	Y	
runners							Y	
Batch or continuous cookers?				continuous	continuous	continuous	continuous	continuous
How many cookers?				1	1	1	1	1
Cooker type								
Cooker temperature			^0C	130	125	120-135	120-130	low
Do vapours from cookers condense directly into water or indirectly?			Y/N	directly	indirectly	indirectly	indirect	
Do vapours from MAM dryers condense directly into water or indirectly?			Y/N	directly	indirectly			
Do vapours from blood dryers condense directly into water or indirectly?			Y/N	directly	N/A			

Appendix C. Site A. Laboratory analyses

	TS	ash	TS organic	COD	NH3 -N	Org - N	Kj-N	TP	O+G
SITE A	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
tallow separator water	36,000	830	35,170	160,000	17	283	300	210	51,000
blood stickwater	14,000	6,700	7,300	11,000	660	440	1,100	240	
blood stickwater	14,000	6,000	8,000	9,600	330	610	940	160	
cooker condensate	1,300	280	1,020	1,500	310	10	320	0.62	
cooker condensate	190	45	145	2,100	310	20	330	0.12	
whole blood (sheep)	144,100	8,050	136,050	211,460	425	19,695	20,120	68	<100
whole blood (cattle)	211,100	7,820	203,280	177,930	515	28,545	29,060	61	<100
blood as received	105,000	7,940	97,060	122,050	1,230	13,300	14,530	246	<200
blood as received	132,900	6,820	126,080	155,580	548	16,212	16,760	89	
blood condensate	580	91	489	2,600	760	140	900	2.8	
saveall effluent	19,000	3,600	15,400	37,000	290	550	840	190	
raw material drainage	120,000	13,000	107,000	120,000	1,200	8,800	10,000	520	5,000
abattoir trade waste	12,000	9,000	3,000	4,500	98	212	310	70	130
tallow manual wash water	140,000								90,000
	TS	ash	TS organic	COD	NH_3 -N	Org - N	Kj-N	TP	
	%w/w as is	%w/w DW	%w/w DW		%w/w DW	%w/w DW	%w/w DW	%w/w DW	
blood wet solids	38.7%	2.48%	97.52%		1.50%	14.50%	16.0%	0.10%	
blood meal	94.2%	2.43%	97.57%		0.14%	13.86%	14.0%	0.11%	

Appendix D. Site B. Laboratory analyses

	TS	ash	TS organic	COD	NH3 -N	Org - N	Kj-N	TP	O+G
SITE B	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
tallow separator water 1	15,000	840	14,160	30,000	10	100	110	58	5,600
tallow separator water 2	34,000	2,500	31,500	74,000	10	510	520	260	12,000
separator cleaning cycle	20,000	1,400	18,600	42,000	10	260	270	170	7,800
separator cleaning cycle 2nd stage	59,000	920	58,080	63,000	10	130	140	100	13,000
blood stickwater 1	13,000	7,000	6,000	7,700	260	490	750	250	40
blood stickwater2	11,000	6,300	4,700	6,000	240	380	620	230	40
blood stickwater (centrifuged)				6,300	240	340	580		
cooker condensate 1	240	20	220	1,500	420	20	440	0.78	94
cooker condensate 2	170	20	150	1,500	410	10	420	0.026	46
blood as received (sheep) 2	130,510	7,410	123,101	171,470	538	18,209	18,747	173	<100
blood as received (sheep) 1	140,660	8,425	132,236	191,770	1,117	19,184	20,300	203	<100
blood condensate	320	20	300	825	270	80	350	2.29	40
raw material drainage	120,000	18,000	102,000	170,000	290	7,410	7,700	190	3,100
	TS	**ash**	**TS organic**	**COD**	**NH_3 -N**	**Org - N**	**Kj-N**	**TP**	
	%w/w as is	**%w/w DW**	**%w/w DW**		**%w/w DW**	**%w/w DW**	**%w/w DW**	**%w/w DW**	
blood wet solids average	33.35%	2.37%	97.65%		0.75%	13.76%	14.50%	0.11%	
blood meal average	96.50%	2.56%	97.45%		0.20%	14.30%	14.50%	0.09%	

Appendix E. Site C. Laboratory analyses

	TS	ash	TS organic	COD	NH3 -N	Org - N	Kj-N	TP	O+G
SITE C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
cooker condensate 10:55	470	120	350	2,000	370	10	380	0.004	98
cooker condensate 14:45	150	87	63	2,000	460	10	470	0.004	41
blood vapour scrubber overflow 10:20	11,000	2,300	8,700	4,900	73	457	530	87	<100
Blood vapour scrubber overflow 14:20	11,000	2,200	8,800	4,600	73	457	530	77	<100
anaerobic digester inlet 07:45	3,000	1,000	2,000	4,200	31	109	140	38	<300
anaerobic digester inlet 10:45	3,600	930	2,670	6,900	22	138	160	43	370
anaerobic digester inlet 13:30	3,500	690	2,810	4,200	38	232	270	30	830
anaerobic digester inlet 15:30	4,500	1,000	3,500	7,700	49	241	290	51	500
anaerobic digester outlet	1,100	830	270	390	98	22	120	36	40
whole blood	221,860	7,105	214,755	303,390	436	31,029	31,465	213	<100
blood stickwater 10:00	19,000	6,600	12,400	25,000	120	2,280	2,400	110	40
blood stickwater 14:10	26,000	6,600	19,400	35,000	150	3,250	3,400	110	40
raw material drainage 11:15	56,000	4,300	51,700	44,000	580	2,920	3,500	470	1,200
raw material drainage 14:55	73,000	4,700	68,300	65,000	610	3,190	3,800	440	4,100
blood as received 10:40	140,000	7,300	132,700	200,000	450	20,550	21,000	170	40
blood as received 14:30	150,000	7,400	142,600	220,000	590	22,410	23,000	150	40
tallow separator water 1	5,200	460	4,740	11,000	5.6	114	120	52	1,600
tallow separator water 11:30	2,500	310	2,190	4,200	5.6	89	95	35	340
blood stickwater 10:00 centrif				12,000	110	850	960		
blood stickwater 14:10 centrif				11,000	120	830	950		
	TS	ash	TS organic	COD	NH_3 -N	Org - N	Kj-N	TP	O+G
	%w/w as is	%w/w DW	%w/w DW		%w/w DW	%w/w DW	%w/w DW	%w/w DW	%w/w
blood wet solids 10:15	45.8%	1.7%	44.1%		0.4%	14.6%	15.0%	0.1%	0.2%
blood wet solids 14:30	43.8%	1.7%	42.1%		0.4%	14.7%	15.0%	0.1%	0.2%
blood meal	96.4%	1.8%	94.6%		0.3%	13.7%	14.0%	0.1%	0.2%
blood meal 14:30	89.6%	1.7%	87.9%		0.2%	13.8%	14.0%	0.1%	0.1%

Appendix F. Site D. Laboratory analyses

	TS	ash	TS organic	COD	NH3 -N	Org - N	Kj-N	TP	O+G
SITE D	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
raw material drainage 1	31,000	3,400	27,600	38,000	220	2,280	2,500	320	1,600
raw material drainage 2	53,000	3,800	49,200	67,000	210	5,690	5,900	400	1,700
raw material drainage 3	44,000	3,700	40,300	56,000	210	5,090	5,300	380	780
raw material drainage 4	18,000	3,000	15,000	50,000	190	1,910	2,100	270	380
raw material drainage 5	38,000	4,400	33,600	51,000	390	4,910	5,300	380	180
raw material drainage 6	8,000	1,600	6,400	50,000	84	746	830	120	130
raw material screw drain 1	29,000	3,100	25,900	83,000	200	2,300	2,500	200	14,000
raw material screw drain 3	43,000	590	42,410	150,000	25	565	590	45	28,000
whole blood A (beef)	149,358	7,623	141,735	237,339	501	19,148	19,649	61	706
whole blood B (beef)	192,137	7,906	184,231	301,282	531	24,433	24,964	55	539
whole blood C (veal)	215,728	8,427	207,301	304,175	460	30,257	30,716	61	545
whole blood D (veal)	218,837	8,348	210,490	297,791	456	28,564	29,021	73	553
blood stickwater 1	62,000	6,700	55,300	90,000	110	8,190	8,300	90	500
blood stickwater 2	15,000	4,900	10,100	14,000	140	1,260	1,400	150	500
blood stickwater 3	37,000	6,500	30,500	48,000	73	4,427	4,500	130	500
cooker condensate 1	200	90	110	880	250	10	260	0.29	<20
cooker condensate 2	740	150	590	1,300	200	20	220	0	30
blood as received	92,000	4,300	87,700	170,000	310	15,690	16,000	67	5,700
tallow separator water 1	3,600	690	2,910	6,700	8	142	150	79	1,200
tallow separator water 2	34,000	3,000	31,000	70,000	45	1,155	1,200	360	8,000
blood stickwater 1 centrifuged	18,000	6,200	11,800	21,000	56	1,644	1,700	130	<200
blood stickwater 2 centrifuged	8,500	4,500	4,000	5,700	130	360	490	140	<200
blood stickwater 3 centrifuged	19,000	6,500	12,500	22,000	66	1,534	1,600	150	<200

	TS	ash	TS organic	COD	NH_3 -N	Org - N	Kj-N	TP	O+G
	%w/w as is	%w/w DW	%w/w DW		%w/w DW	%w/w DW	%w/w DW	%w/w DW	%w/w DW
blood wet solids 1	42.2%	1.58%			1.10%		15.0%	0.05%	<0.25%
blood wet solids 2	42.4%	1.61%			1.50%		15.0%	0.05%	<0.25%
blood meal	98.6%	1.70%			0.20%		14.0%	0.20%	1.8%
MBM dry solids	97.6%	32.90%			0.10%		8.1%	5.80%	3.8%

Appendix G. Site E. Laboratory analyses

SITE E	TS mg/L	ash mg/L	TS organic mg/L	COD mg/L	NH3 -N mg/L	Org - N mg/L	Kj-N mg/L	TP mg/L	O+G mg/L
blood as received tank 1	92,205	3,311	88,894	170,355	1,602	17,629	19,231	52	339
blood as received tank 2	97,066	3,718	93,348	180,081	1,381	15,619	16,999	46	<500
whole blood 1	179,764	7,645	172,120	277,366	435	27,486	27,920	55	<500
whole blood 2	196,359	7,584	188,776	296,418	470	30,625	31,095	56	<500
blood stickwater 1	7,200	4,200	3,000	10,000	800	300	1,100	56	<200
blood stickwater 2	6,900	4,100	2,800	10,000	790	310	1,100	56	<200
blood stickwater 3	6,500	3,800	2,700	10,000	790	310	1,100	57	<200
MAM stickwater 1	13,000	1,600	11,400	28,000	81	1,219	1,300	55	3,000
MAM stickwater 2	17,000	2,000	15,000	29,000	76	1,224	1,300	170	4,000
MAM stickwater 3	15,000	1,900	13,100	26,000	69	1,131	1,200	150	2,000
MAM stickwater 4	16,000	2,100	13,900	28,000	100	1,200	1,300	150	2,700
separator cleaning cycle	260,000	390	259,610	150,000	52	2,048	2,100	82	54,000
waste to treatment	12,000	820	11,180	24,000	76	354	430	69	3,200
final fond	270	180	90	120	20	11	31	5.8	<10
dryer dondensate	160	5	155	250	87	23	110	<0.016	12
raw material drainage composite	25,000	2,900	22,100	28,000	530	1,870	2,400	270	850
raw material belt drainage composite	9,700	340	9,360	4,300	28	232	260	34	670
scrubber condensate	68	25	43	37	14	8	22	0.014	<10
stack drainage composite	68	30	38	310	92	18	110	0.008	19
blood dryer condensate	62	20	42	410	170	10	180	0.026	<10
blood stickwater 1 centrifuged	6,200	3,800	2,400	9,200	800	200	1,000	55	<20
blood stickwater 2 centrifuged	6,000	3,700	2,300	8,800	780	210	990	54	<20
MAM stickwater 1 centrifuged	8,100	2,200	5,900	9,700	69	651	720	120	1,000
MAM stickwater 4	7,500	2,000	5,500	9,800	95	595	690	120	880

centrifuged									
	TS	**ash**	**TS organic**	**COD**	**NH_3 -N**	**Org - N**	**Kj-N**	**TP**	**O+G**
	%w/w as is	**%w/w DW**	**%w/w DW**		**%w/w DW**	**%w/w DW**	**%w/w DW**	**%w/w DW**	**%w/w DW**
blood wet solids	44.50%	1.14%			0.500%		15.0%	0.0380%	<0.2%
blood meal	94.20%	1.31%			0.260%		14.0%	0.0380%	<0.1%
MBM dry solids 1	95.00%	39.00%			0.088%		7.5%	5.0%	1.2%
MBM dry solids 2	96.30%	40.20%			0.100%		7.8%	4.7%	1.3%
MBM wet solids 1	41.20%	25.10%			1.2%		9.2%	4.8%	4.0%
MBM wet solids 2	40.50%	28.20%			1.4%		10.0%	5.2%	1.9%

Appendix H. Site A. Waste stream discharges from the abattoir and rendering plant

SITE A mixed species dry rendering			COD	TN	TP	TDS	NH_3-N	O+G
Effluent flows	**2010/11**		**t/yr**	**t/yr**	**t/yr**	**t/yr**	**t/yr**	**t/yr**
Abattoir trade waste goes to sewer	459,530	m^3/yr	894.2	53.3	11.7	1,809.8	13.0	
(rendering plant effluent treated on site)								
Rendering plant								
cooker condensate	26,896	m^3/yr	48.4	8.7	0.010	4.4	8.3	
blood stickwater (blood over weighbridge)	8,228	m^3/yr	84.8	8.4	1.6	52.3	4.1	
blood meal dryer condensate	1,760	m^3/yr	4.6	1.6	0.005	1.0	1.3	
tallow washwater leave out as it is an anomaly	1,336	m^3/yr						
subtotal	38,221	m^3/yr	137.7	18.7	1.7	57.6	13.7	
washwater + storm water	3,822	m^3/yr	13.8	1.9	0.2	5.8	1.4	
Rendering plant TOTAL	42,043	m^3/yr	151.5	20.6	1.8	63.4	15.1	8.4
rendering % abattoir & rendering	***8.4%***		***14%***	***28%***	***13%***	***3%***	***54%***	

Appendix I. Site B. Waste stream discharges from the abattoir and rendering plant

SITE B ovine dry rendering			**COD**	**TN**	**TP**	**TDS**	**NH_3-N**	**O+G**
Effluent flows	**2010/11**		**t/yr**	**t/yr**	**t/yr**	**t/yr**	**t/yr**	**t/yr**
Abattoir trade waste to sewer	228,270	m^3/yr	1,027.2	39.9	7.7	258.7	unknown	
Rendering plant								
cooker condensate	7,097	m^3/yr	10.6	3.1	0.003	0.14	2.9	0.50
blood stickwater	792	m^3/yr	5.4	0.54	0.19	5.3	0.20	0.03
blood meal dryer condensate	589	m^3/yr	0.5	0.21	0.001	0.01	0.16	0.02
tallow separator water	984	m^3/yr	56.9	0.3	0.2	1.6	0.01	10.6
raw material bin drainage	1,187	m^3/yr	201.9	9.1	0.2	21.4	0.3	3.7
subtotal	10,649	m^3/yr	275.4	13.2	0.6	28.4	3.7	14.8
washwater + storm water	1,065	m^3/yr	27.5	1.3	0.1	2.8	0.4	1.5
Rendering plant TOTAL	11,714	m^3/yr	302.9	14.6	0.7	31.2	4.0	16.3
rendering % abattoir & rendering	***5.1%***		**29%**	**36%**	**9%**	**12%**	***?***	***?***

Appendix J. Site C. Waste stream discharges from the abattoir and rendering plant

SITE C bovine dry rendering			**COD**	**TN**	**TP**	**TDS**	**NH_3-N**	**O+G**
Effluent flows	**2010/11**		**t/yr**	**t/yr**	**t/yr**	**t/yr**	**t/yr**	**t/yr**
Abattoir & rendering waste to on site treatment	319,154	m^3/yr	1,835.1	68.6	12.9	288.8	11.2	159.6
Rendering plant:								
cooker condensate	15,695	m^3/yr	31.4	6.7	0.0001	1.6	6.5	1.1
blood stickwater (via industry average blood yield)	3,611	m^3/yr	108.3	10.5	0.40	23.8	0.49	0.14
blood meal dryer scrubber overflow	629	m^3/yr						
tallow separator water	46,800	m^3/yr	355.7	5.0	2.0	28.8	0.3	45.4
raw material bin drainage	3,744	m^3/yr	204.0	13.7	1.7	16.8	2.2	9.9
subtotal	70,478	m^3/yr	699.4	35.8	4.1	71.1	9.5	56.6
washwater + storm water	6,985	m3/yr	69.9	3.6	0.4	7.1	0.9	5.7
Rendering plant TOTAL	76,834	m3/yr	769.4	39.4	4.6	78.2	10.4	62.2
rendering % abattoir & rendering	***24%***		***42%***	***57%***	***35%***	***27%***	***93%***	***39%***

Appendix K. Site D. Waste stream discharges from the abattoir and rendering plant

SITE D bovine dry rendering			COD	TN	TP	TDS	NH3-N	O+G
Effluent flows			**t/yr**	**t/yr**	**t/yr**	**t/yr**	**t/yr**	**t/yr**
Abattoir & rendering waste to on site treatment	814,564	m^3/yr	6,693	210	30	unknown	23	683
Rendering plant								
cooker condensate	24,393	m^3/yr	26.6	5.9	0.00	2.9	5.5	0.6
blood stickwater	4,914	m^3/yr	249.0	23.3	0.61	29.6	0.5	2.5
blood dryer condensate	0	m^3/yr	0.0	0.0	0.00	0.0	0.0	0.0
tallow separator water	367	m^3/yr	25.7	0.4	0.13	1.1	0.02	2.9
raw material bin drainage	16,678	m^3/yr	1,747.3	68.1	0.12	81.6	5.1	166.5
subtotal	46,353	m^3/yr	2,048.6	97.6	0.9	115.3	11.1	172.5
washwater + storm water	4,635	m3/yr	204.9	9.8	0.09	11.5	1.1	17.2
Rendering plant TOTAL	50,988	m3/yr	2,253.5	107.4	1.0	126.8	12.2	189.7
rendering % abattoir & rendering	***6.3%***		***33.7%***	***51.0%***	***3.2%***	***?***	***52.4%***	***27.8%***

Appendix L. Site E. Waste stream discharges from the abattoir and rendering plant

SITE E bovine wet rendering			COD	TN	TP	TDS	NH3-N	O+G
Effluent flows			**t/yr**	**t/yr**	**t/yr**	**t/yr**	**t/yr**	**t/yr**
Abattoir & rendering waste to on site treatment	539,975	m^3/yr	12,959.4	232.2	37.3	442.8	41.0	1,727.9
Rendering plant								
MAM stickwater	25,845	m^3/yr	717.2	33.0	3.4	49.1	2.1	75.6
blood stickwater	2,604	m^3/yr	26.04	2.86	0.15	10.50	2.07	0.52
blood dryer condensate	306	m^3/yr	0.126	0.055	0.00001	0.006	0.052	0.003
MAM dryer condensate	6,199	m^3/yr	1.550	0.682	0.00010	0.031	0.539	0.074
tallow sepatator water	5,141	m^3/yr	771.1	10.8	0.4	2.0	0.3	277.6
raw material bin drainage	4,082	m^3/yr	114.3	22.6	1.1	11.8	2.2	3.5
raw material belt washings	10,990	m^3/yr	47.3	2.9	0.4	3.7	0.3	7.4
subtotal	55,167	m^3/yr	1,677.6	72.8	5.4	77.2	7.5	364.6
washwater + storm water	5,517	m^3/yr	167.8	7.3	0.5	7.7	0.8	36.5
Rendering plant TOTAL	60,684	m^3/yr	1,845.4	80.1	6.0	84.9	8.3	401.1
rendering % abattoir & rendering	***11.2%***		***14.2%***	***34.5%***	***16.1%***	***19.2%***	***20.1%***	***23.2%***

Appendix M. Comparison of actual site emissions to the environment (Flow, COD, TN)

2010/11 ACTUAL	A	B	C	D	E
species	mixed	ovine	bovine	bovine	bovine
rendering	dry	dry	dry	dry	wet
t HSCW	68,949	11,060	53,531	48,514	32,426
Flowrate	m^3/yr	m^3/yr	m^3/yr	m^3/yr	m^3/yr
cooker condensate or MAM stickwater	26,896	7,097	15,695	24,393	25,845
MAM dryer condensate					6,199
blood stickwater	8,228	792	3,611	4,914	2,604
blood meal dryer condensate	1,760	589	629	0	306
tallow separator water	1,336	984	46,800	367	5,141
raw material bin drainage		1,187	3,744	16,678	4,082
raw material belt washings					10,990
subtotal	38,221	10,649	70,478	46,353	55,167
washwater/storm water	3,822	1,065	3,524	2,318	5,517
total rendering plant	42,043	11,714	74,002	48,670	60,684
abattoir		228,270	319,154	814,564	539,975
COD	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr
cooker condensate or MAM stickwater	48.40	10.60	31.40	26.60	717.20
MAM dryer condensate					1.55
blood stickwater	84.40	5.40	108.30	249.00	26.04
blood meal dryer condensate	4.60	0.50		0.00	0.13
tallow separator water		56.90	355.70	5.70	771.10
raw material bin drainage		201.90	204.00	1,747.30	114.30
raw material belt washings					47.30
subtotal	137.70	275.40	699.40	2,048.60	1,677.60
washwater/storm water	13.80	27.50	35.00	102.40	167.80
total rendering plant	151.50	302.90	734.40	2,151.00	1,845.40
abattoir	894.20	1,027.20	1,835.10	6,693.00	12,959.40
TN	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr
cooker condensate or MAM stickwater	8.70	3.10	6.70	5.90	33.00
MAM dryer condensate					0.68
blood stickwater	8.40	0.54	10.50	2.30	2.86
blood meal dryer condensate		0.21		0.00	0.06
tallow separator water	1.60	0.30	5.00	0.40	10.80
raw material bin drainage		9.10	13.70	68.10	22.60
raw material belt washings					2.90
subtotal	18.70	13.20	35.80	97.60	72.80
washwater/storm water	1.90	1.30	1.80	4.90	7.30
total rendering plant	20.60	14.60	37.60	102.50	80.10
abattoir	53.30	39.90	68.60	210.00	232.20

Appendix N. Comparison of actual site emissions to the environment (NH_3-N, TP, TDS)

2010/11 ACTUAL	A	B	C	D	E
species	mixed	ovine	bovine	bovine	bovine
rendering	dry	dry	dry	dry	wet
t HSCW	68,949	11,060	53,531	48,514	32,426
NH_3-N	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr
cooker condensate or MAM stickwater	8.30	2.90	6.50	5.50	2.10
MAM dryer condensate					0.54
blood stickwater	4.10	0.20	0.49	0.50	2.07
blood meal dryer condensate	1.30	0.16		0.00	0.05
tallow separator water		0.01	0.30	0.02	0.30
raw material bin drainage		0.30	2.20	5.10	2.20
raw material belt washings					0.30
subtotal	13.70	3.70	9.50	11.10	7.50
washwater/storm water	1.40	0.40	0.50	0.60	0.80
total rendering plant	5.10	4.00	10.00	11.70	8.30
abattoir	13.00		11.20	23.00	41.00
TP	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr
cooker condensate or MAM stickwater	0.01	0.00	0.00	0.00	3.40
MAM dryer condensate					0.00
blood stickwater	1.60	0.19	0.40	0.61	0.15
blood meal dryer condensate	0.01	0.00		0.00	0.00
tallow separator water		0.20	2.00	0.13	0.40
raw material bin drainage		0.20	1.70	0.12	1.10
raw material belt washings					0.40
subtotal	1.70	0.60	4.10	0.90	5.40
washwater/storm water	0.20	0.10	0.20	0.04	0.50
total rendering plant	1.80	0.70	4.30	0.90	6.00
abattoir	11.90		2.90	30.00	37.30
TDS	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr
cooker condensate or MAM stickwater	4.40	0.14	1.60	2.90	49.10
MAM dryer condensate					0.03
blood stickwater	52.30	5.30	23.80	29.60	10.50
blood meal dryer condensate	1.00	0.01		0.00	0.01
tallow separator water		1.60	28.80	1.10	2.00
raw material bin drainage		21.40	16.80	81.60	11.80
raw material belt washings					3.70
subtotal	57.60	8.40	71.10	115.30	77.20
washwater/storm water	5.80	2.80	3.60	5.80	7.70
total rendering plant	63.40	31.20	74.60	121.10	84.90
abattoir	1,809.80	258.70	288.80		442.80

Appendix O. Comparison of actual site emissions to the environment (O+G)

2010/11 ACTUAL	A	B	C	D	E
species	mixed	ovine	bovine	bovine	bovine
rendering	dry	dry	dry	dry	wet
t HSCW	68,949	11,060	53,531	48,514	32,426
O+G	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr
cooker condensate or MAM stickwater		0.50	1.10	0.60	75.60
MAM dryer condensate					0.07
blood stickwater		0.03	0.14	2.50	0.52
blood meal dryer condensate		0.02		0.00	0.00
tallow separator water		10.60	45.40	2.90	27.60
raw material bin drainage		3.70	9.90	166.50	3.50
raw material belt washings					7.40
subtotal		14.80	56.60	172.50	114.70
washwater/storm water		1.50	2.80	8.60	11.47
total rendering plant	8.40	16.30	59.40	181.10	126.17
abattoir				683.00	1,727.90

Appendix P. Comparison of "standardised" environment emissions (Flow, COD, TN)

50,000t HSCW basis	A	B	C	D	E
	mixed	ovine	bovine	bovine	bovine
2010/11	dry	dry	dry	dry	wet
t HSCW	50,000	50,000	50,000	50,000	50,000
Flowrate	m^3/yr	m^3/yr	m^3/yr	m^3/yr	m^3/yr
cooker condensate or MAM stickwater	19,504	32,084	14,660	25,140	39,852
MAM dryer condensate					9,559
blood stickwater	5,967	3,580	3,373	5,065	4,015
blood meal dryer condensate	1,276	2,663	588		472
tallow separator water	969	4,448	43,713	378	7,927
raw material bin drainage		5,366	3,497	17,189	6,294
raw material belt washings					16,946
subtotal	27,717	48,142	65,829	47,773	85,066
washwater/storm water	2,772	4,815	3,292	2,389	8,507
total rendering plant	30,488	52,957	69,121	50,161	93,573
abattoir		1,031,962	298,102	839,514	832,627
COD	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr
cooker condensate or MAM stickwater	35.10	47.92	29.33	27.41	1,105.90
MAM dryer condensate					2.39
blood stickwater	61.20	24.41	101.16	256.63	40.15
blood meal dryer condensate	3.34	2.26	0.00		0.19
tallow separator water	unknown	257.23	332.24	5.87	1,189.01
raw material bin drainage	unknown	912.75	190.54	1,800.82	176.25
raw material belt washings					72.94
subtotal	99.86	1,245.03	653.27	2,111.35	2,586.81
washwater/storm water	10.01	124.32	32.69	105.54	258.74
total rendering plant	109.86	1,369.35	685.96	2,216.89	2,845.56
abattoir	648.45	4,643.76	1,714.05	6,898.01	19,983.04
TN	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr
cooker condensate or MAM stickwater	6.31	14.01	6.26	6.08	50.89
MAM dryer condensate					1.05
blood stickwater	6.09	2.44	9.81	2.37	4.41
blood meal dryer condensate		0.95			0.08
tallow separator water	1.16	1.36	4.67	0.41	16.65
raw material bin drainage		41.14	12.80	70.19	34.85
raw material belt washings					4.47
subtotal	13.56	59.67	33.44	100.59	112.26
washwater/storm water	1.38	5.88	1.68	5.05	11.26
total rendering plant	14.94	66.00	35.12	105.64	123.51
abattoir	38.65	180.38	64.08	216.43	358.05

Appendix Q. Comparison of "standardised" environment emissions (NH_3-N, TP, TDS)

50,000t HSCW basis	A	B	C	D	E
	mixed	ovine	bovine	bovine	bovine
2010/11	dry	dry	dry	dry	wet
t HSCW	50,000	50,000	50,000	50,000	50,000
NH_3-N	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr
cooker condensate or MAM stickwater	6.02	13.11	6.07	5.67	3.24
MAM dryer condensate					0.83
blood stickwater	2.97	0.90	0.46	0.52	3.19
blood meal dryer condensate	0.94	0.72			0.08
tallow separator water		0.05	0.28	0.02	0.46
raw material bin drainage		1.36	2.05	5.26	3.39
raw material belt washings					0.46
subtotal	9.93	16.73	8.87	11.44	11.56
washwater/storm water	1.02	1.81	0.47	0.62	1.23
total rendering plant	3.70	18.08	9.34	12.06	12.80
abattoir	9.43		10.46	23.70	63.22
TP	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr
cooker condensate or MAM stickwater	0.01	0.01	0.00		5.24
MAM dryer condensate					0.00
blood stickwater	1.16	0.86	0.37	0.63	0.23
blood meal dryer condensate	0.00	0.00	0.00		0.00
tallow separator water		0.90	1.87	0.13	0.62
raw material bin drainage		0.90	1.59	0.12	1.70
raw material belt washings					0.62
subtotal	1.23	2.71	3.83	0.93	8.33
washwater/storm water	0.15	0.45	0.19	0.04	0.77
total rendering plant	1.31	3.16	4.02	0.93	9.25
abattoir	8.63		2.71	30.92	57.52
TDS	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr
cooker condensate or MAM stickwater	3.19	0.63	1.49	2.99	75.71
MAM dryer condensate					0.05
blood stickwater	37.93	23.96	22.23	30.51	16.19
blood meal dryer condensate	0.73	0.05	0.00		0.01
tallow separaotr water		7.23	26.90	1.13	3.08
raw material bin drainage		96.75	15.69	84.10	18.20
raw material belt washings					5.71
subtotal	41.77	37.97	66.41	118.83	119.04
washwater/storm water	4.21	12.66	3.36	5.98	11.87
total rendering plant	45.98	141.05	69.68	124.81	130.91
abattoir	1,312.42	1,169.53	269.75		682.79

Appendix R. Comparison of "standardised" environment emissions (O+G)

50,000t HSCW basis	**A**	**B**	**C**	**D**	**E**
	mixed	**ovine**	**bovine**	**bovine**	**bovine**
2010/11	**dry**	**dry**	**dry**	**dry**	**wet**
t HSCW	50,000	50,000	50,000	50,000	50,000
O+G	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr	tonnes/yr
cooker condensate or MAM stickwater		2.26	1.03	0.62	116.57
MAM dryer condensate					0.11
blood stickwater		0.14	0.13	2.58	0.80
blood meal dryer condensate		0.09		0.00	0.00
tallow separator water		47.92	42.41	2.99	42.56
raw material bin drainage		16.73	9.25	171.60	5.40
raw material belt washings					11.41
subtotal		66.91	52.87	177.78	176.85
washwater/storm water		6.78	2.62	8.86	17.69
total rendering plant		73.69	55.48	186.65	194.54
abattoir				703.92	2,664.37

Appendix S. Reduction in pollutants by centrifugation of stickwaters

	C	A	B	D	E	E
	bovine	mixed	bovine	bovine	bovine	bovine
	dry	dry	dry	dry	wet	wet
	%	%	%	%	%	%
	blood stickwater	blood stickwater	blood stickwater	blood stickwater	blood stickwater	MAM stickwater
TS				60.1%	11.2%	48.9%
ash				5.0%	7.0%	0.0%
TS organic				70.5%	17.1%	57.3%
COD	61.7%		8.0%	68.0%	10.0%	64.9%
NH3 -N	14.8%		4.0%	22.0%	0.4%	0.0%
Org - N	69.6%		21.8%	74.5%	33.2%	47.8%
Kj-N	67.1%		15.3%	73.3%	9.5%	44.7%
TP				0.0%	3.3%	8.6%
O+G				60.0%	90.0%	67.9%
COD mg/L[1]	30,000	9,600	6,850	50,667	10,000	28,000

Notes:

1. COD of stickwater before centrifugation

Clearly it is effective in removing COD and TN when COD is high

Appendix T. Analysis of cooker condensate at SITE C

	sample 1	sample 2
	mg/L	mg/L
Acetic Acid	460	550
Propionic Acid	150	250
Butyric Acid	63	110
iso-Butyric Acid	8	14
iso-Valeric Acid	17	25
Valeric Acid	17	32
VFA as acetic	580	850
TVA	720	990
COD by analysis		2,000
COD by calculation		1,307

Appendix U. Blood yield figures

Blood yield % HSCW				calculated
SPECIES	**Liquid blood**	**Dried blood solids**	**kg HSCW**	**% solids in blood**
cattle(1)	6.3%	1.2%	<200	19.0%
cattle(2)	5.3%	1.0%	200-300	18.9%
cattle(3)	4.2%	0.8%	>300	19.0%
veal	7.4%	1.4%	60	18.9%
lamb	6.9%	1.3%	21	18.8%
sheep	7.4%	1.4%	21	18.9%

Appendix V. Blood analyses from all sites

		TS	**ash**	**TS organic**	**COD**	**NH3 -N**	**Org - N**	**Kj-N**	**TP**	**O+G**
		mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
A	ovine	144,100	8,050	136,050	211,460	425	19,695	20,120	68	100
C	ovine	223,300	7,105	216,195	303,390	436	31,029	31,465	213	100
A	bovine	211,100	7,820	203,280	177,930	515	28,545	29,060	61	100
B	bovine	130,510	7,410	123,101	171,470	538	18,209	18,747	173	100
B	bovine	140,660	8,425	132,236	191,770	1,117	19,184	20,300	203	100
D	bovine	140,000	7,000	133,000	220,000	460	17,540	18,000	56	650
D	bovine	180,000	7,300	172,700	280,000	490	22,510	23,000	51	500
D	veal	200,000	7,700	192,300	280,000	420	27,580	28,000	56	500
D	veal	200,000	7,500	192,500	270,000	410	25,590	26,000	65	500
E	bovine	150,000	6,300	143,700	230,000	360	22,640	23,000	45	500
E	bovine	160,000	6,100	153,900	240,000	380	24,620	25,000	45	500
	average	**170,879**	**7,337**	**163,542**	**234,184**	**505**	**23,376**	**23,881**	**94**	**332**

Appendix W. Environmental emissions from rendering plant effluents

SITE		A	B	D	E
COD to waste (2011/12)	t/yr	152	303	2,253	1,845
volume of lagoon (anaerobic)	m^3	2,442	4,881	36,317	29,740
area of lagoon (anaerobic) @3m depth	m^2	814	1,627	12,106	9,913
COD to aerobic if 80% anaerobic removal	t/yr	30	61	451	369
Electricity used to remove 75% of COD going to aerobic treatment	kWh/yr	18,940	37,861	281,685	230,670
Electricity cost assuming charges below	$/yr	$2,020	$5,848	$53,157	$26,673
Elec (only aerobic treatment)	kWh/yr	94,698	189,304	1,408,425	1,153,349
Elec cost (only aerobic treatment)	$/yr	$10,101	$29,240	$265,784	$133,366
Biogas generated from COD removed	m^3/t COD	500	500	500	500
government default value abattoir effluent flow	kL/t HSCW	13.7	13.7	13.7	13.7
government default value abattoir effluent COD	kg COD/kL	6.1	6.1	6.1	6.1
COD/BOD		2.6	2.6	2.6	2.6
fraction removed by anaerobic ponds		0.8	0.8	0.8	0.8
aerator oxygen production	kg O_2/kWh	1.6	1.6	1.6	1.6
General anaerobic lagoon loadings	kgCOD/m^3/day	0.17	0.17	0.17	0.17
Natural gas	GJ/t	44.4	44.4	44.4	44.4
Natural gas (scope1 equivalent)	kg CO_2/GJ	51.2	51.2	51.2	51.2
Scope 1	kg CO_2/yr	25,000	25,000	25,000	25,000
Carbon cost	$/t	$24.15	$24.15	$24.15	$24.15
Electricity cost peak	$/kWh	$0.13	$0.27028	$0.29078	$0.161312
Electricity cost shoulder	$/kWh		$0.17134	$0.21608	
Electricity cost off peak	$/kWh	$0.06	$0.08954	$0.12241	$0.074108
Electricity peak period	hrs/day	16	5	5	11.43
Electricity shoulder period	hrs/day		8	8	
Electricity off peak period	hrs/day	8	11	11	12.57

Appendix W. Environmental emissions from rendering plant effluents

(continued)

SITE		A	B	D	E
Natural gas[1]	\$/GJ	\$5.67	\$4.50	\$4.50	\$4.50
CO_2 generated from burning natural gas	t CO_2 / 10^3GJ	51.29	51.29	51.29	51.29
methane	GJ/m^3	0.0377	0.0377	0.0377	0.0377
methane	m^3/t	1,400	1400	1400	1400
methane	GJ/t	52.78	52.78	52.78	52.78
biogas at 65% methane	GJ/t	34.31	34.307	34.307	34.307
methane produced from BOD removed	kg CH_4/kg BOD	0.65	0.65	0.65	0.65
methane produced from COD removed	kg CH_4/kg COD	0.25	0.25	0.25	0.25
emissions from wastewater treatment	t CO_2-e	642	1,284	9,120	7,824
cost if plant was exceeding 25,000kg/yr limit	\$	\$15,515	\$31,016	\$220,243	\$188,952
methane effect compared to carbon dioxide		21	21	21	21
CO_2 emission is equivalent to	t/yr	31	61	434	373
biogas from 80%removal of COD	m^3/yr	60,607	121,155	901,392	738,143
biogas from 80%removal of COD	t/yr	43	87	644	527
calorific value of biogas	GJ/yr	1,485	2,969	22,089	18,088
equivalent amount of natural gas	t/yr	33	67	497	407
Value of natural gas replaced	\$	\$9,446	\$13,360	\$99,399	\$81,397
Scope 1 emission reduction	t CO_2-e	76	152	1,131	926
natural gas replacement scope 1 saving	\$	\$1,836	\$3,671	\$27,312	\$22,366
Total saving if biogas replaced natural gas	\$	\$11,282	\$17,031	\$126,711	\$103,763
methane produced from 80% COD removed	t/yr	30	61	451	369
biogas produced from 80% COD removed	t/yr	47	93	693	568

Note 1. Range reported \$4.50 to \$15.90/GJ

Appendix X. Comparison of actual and theoretical emissions from site C

C	theoretical	actual	
COD to waste (2011/12)	1,835	1,835	t/yr
volume of lagoon (anaerobic)	29,575		m^3
area of lagoon (anaerobic) @3m depth	9,858		m^2
COD to aerobic if 80% anaerobic removal	367		t/yr
Elec use to remove 75% of COD to aerobic	229,392	438,000	kWh/yr
Electricity cost assuming charges quoted below	35,081		$/yr
Elec (only aerobic treatment)	1,146,960		kWh/yr
Elec cost (only aerobic treatment)	175,407		$/yr
Biogas generated from COD removed	500		m^3 /t COD
government default value abattoir effluent flow	13.7		kL/t HSCW
government default value abattoir effluent COD	6.1		kg COD/kL
COD/BOD	2.6		
fraction removed by anaerobic ponds[1]	0.8	0.93	
aerator oxygen production	1.6		kg O_2 /kWh
General anaerobic lagoon loadings (min & max)	0.17		kgCOD/m^3/day
Natural gas	44.4		GJ/t
Natural gas (scope1 equivalent)	51.2		kg CO_2 /GJ
Scope 1	25,000		kg CO_2 /yr
Carbon cost	$24.15		$/t
Electricity cost peak	$0.26875		$/kWh
Electricity cost shoulder	$0.16981		$/kWh
Electricity cost off peak	$0.08801		$/kWh
Electricity peak period	5		hrs/day
Electricity shoulder period	8		hrs/day
Electricity off peak period	11		hrs/day

Notes

1. This site does better than the government NGER figure of 80% COD removal

Appendix X. Comparison of actual and theoretical emissions from site C

(continued)

C	theoretical	actual	
Natural gas[1]	$6.36		$/GJ
carbon dioxide generated from burning natural gas	51.29		t CO_2 / 10^3GJ
methane	0.0377		GJ/m^3
methane	1,400		m^3/t
methane	53		GJ/t
biogas at 65% methane	34		GJ/t
methane produced from BOD removed	0.65		kg CH_4/kg BOD
methane produced from COD removed[2]	0.25	0.333	kg CH_4/kg COD
emissions released from wastewater handling	7,780		t CO_2-e
cost if plant was exceeding 25,000kg/yr limit	$187,887		$
methane effect compared to carbon dioxide	21		
CO2 emission is equivalent to	163,380		t/yr methane
biogas from 80%removal of COD	734,055	797,160	m^3/yr
biogas from 80%removal of COD	524	569	t/yr
calorific value of biogas	17,988	19,534	GJ/yr
equivalent amount of natural gas	405	440	t/yr
Value of natural gas replaced	$114,404	$124,239	$
Scope 1 emission reduction	921		t CO_2-e
natural gas replacement scope 1 saving	$22,242		$
Total saving if biogas replaced natural gas	$136,646		$
methane produced from 80% COD removed	367		t/yr
biogas produced from 80% COD removed	565		t/yr

Note

1. Range reported $4.50 to $15.90
2. This site produces more biogas from the COD than the government NGER figure of 0.25

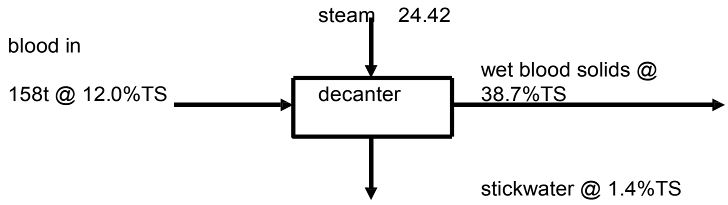
Appendix Y. Steam injected to coagulate blood

theoretical blood volume	tonnes /day	100	19.0% solids	from Appendix U	
actual blood volume	tonnes /day	158	12.0% solids	analysed	
specific heat water	kJ/kg/degC	4.18			
blood temperature	degC	20			
coagulation temperature	degC	97			
steam pressure	kPa	580			
latent heat of saturated steam	kJ/kg	2,097	at	550	kPa
latent heat of saturated steam	kJ/kg	2,087	at	600	kPa
latent heat of saturated steam	kJ/kg	2,067	at	700	kPa
latent heat of saturated steam	kJ/kg	2,048	at	800	kPa
direct steam injected to coagulate blood	tonnes /day	24.42			

To calculate the volume of blood stickwater, the quantity of steam directly injected into the blood to cause coagulation needs to be calculated as in the above example.

1. Calculate the quantity of blood from HSCW using Appendix U
2. Analyse the dry solids in the blood to be processed
3. Calculate the actual tonnes of blood processed using the ratio of the analysed solids compared to the theoretical solids
4. Measure the temperature of the blood to be processed (ambient or chilled)
5. Measure the temperature of the blood stickwater as discharged
6. From the boiler steam pressure estimate the latent heat of steam from above table
7. Direct steam injected =

[actual blood volume x specific heat x (coagulation temp-blood temp)]/latent heat



Appendix Z. % comparison of emissions to the environment (flow, COD, NH_3-N, TN)

Rendering % Abattoir	A	B	C	D	E
Flowrate					
cooker condensate or MAM stickwater	5.9%	3.1%	4.9%	3.0%	4.8%
MBM dryer condensate					1.1%
blood stickwater	1.8%	0.3%	1.1%	0.6%	0.5%
blood meal dryer condensate	0.4%	0.3%	0.2%	0.0%	0.1%
tallow separator water		0.4%	14.7%	0.0%	1.0%
raw material bin drainage	0.0%	0.5%	1.2%	2.0%	0.8%
raw material belt washings					2.0%
total	8.4%	5.1%	23.2%	6.0%	11.2%
COD					
cooker condensate or MAM stickwater	5.4%	1.0%	1.7%	0.4%	5.5%
MBM dryer condensate					0.0%
blood stickwater	9.5%	0.5%	5.9%	3.7%	0.2%
blood meal dryer condensate	0.5%	0.0%		0.0%	0.0%
tallow separator water		5.5%	19.4%	0.4%	6.0%
raw material bin drainage	0.0%	19.7%	11.1%	26.1%	0.9%
raw material belt washings					0.4%
total	14.5%	29.5%	40.0%	32.1%	14.2%
TN					
cooker condensate or MAM stickwater	16.4%	7.6%	9.7%	2.8%	14.2%
MBM dryer condensate					0.3%
blood stickwater	15.7%	1.4%	15.3%	11.1%	1.2%
blood meal dryer condensate	3.0%	0.5%		0.0%	0.0%
tallow separator water		0.8%	7.3%	0.2%	4.6%
raw material bin drainage	0.0%	22.9%	19.9%	32.4%	9.8%
raw material belt washings					1.2%
total	27.9%	36.5%	54.8%	48.7%	
NH_3-N					
cooker condensate or MAM stickwater	64.2%		58.3%	23.5%	5.1%
MBM dryer condensate					1.3%
blood stickwater	31.4%		4.4%	2.3%	5.0%
blood meal dryer condensate	10.3%			0.0%	0.1%
tallow separator water			2.3%	0.1%	0.7%
raw material bin drainage	0.0%		19.9%	21.8%	5.3%
raw material belt washings					0.7%
total	53.8%		89.2%	50.0%	20.1%

Appendix Z. % comparison of emissions to the environment (TP, TDS, O+G)

Rendering % Abattoir	A	B	C	D	E
TP					
cooker condensate or MAM stickwater	0.1%	0.0%	0.0%	0.0%	9.1%
MBM dryer condensate					0.0%
blood stickwater	14.1%	2.5%	3.1%	2.0%	0.4%
blood meal dryer condensate	0.0%	0.0%		0.0%	0.0%
tallow separator water		2.3%	15.7%	0.4%	1.1%
raw material bin drainage	0.0%	2.9%	13.2%	0.4%	3.0%
raw material belt washings					1.0%
total	13.5%	8.5%	33.6%	3.1%	16.1%
TDS					
cooker condensate or MAM stickwater	0.2%	0.1%	0.6%		11.1%
MBM dryer condensate					0.0%
blood stickwater	2.9%	2.0%	8.3%		2.4%
blood meal dryer condensate	0.1%	0.0%			0.0%
tallow seoarator water		0.6%	10.0%		0.5%
raw material bin drainage	0.0%	8.3%	5.8%		2.7%
raw material belt washings					0.8%
total	3.4%	12.1%	25.8%		19.2%
O+G					
cooker condensate or MAM stickwater			0.7%	0.1%	4.4%
MBM dryer condensate					0.0%
blood stickwater			0.1%	0.4%	0.0%
blood meal dryer condensate				0.0%	0.0%
tallow separator water			28.4%	0.4%	16.1%
raw material bin drainage			6.2%	24.4%	0.2%
raw material belt washings					0.4%
total			37.2%	26.5%	23.2%

Appendix ZA. NGER wastewater (industrial) calculator example

NGER wastewater (industrial) calculator version 1.0 | Industrial plant 1

Australian Government
Department of Climate Change and Energy Efficiency

Emissions released from wastewater handling (industrial)

NGER (Measurement) Determination 2008 as amended Part 5.4 (methane)

CLICK HERE for NGER (Measurement) Determination 2008 as amended

$E_j = [CH_4^* - \gamma(Q_{cap} + Q_{flared} + Q_{tr})] =$		**642.43**	(CH_4 released by plant in tonnes CO_2-e)	
(CH_4 released by the plant measured in tonnes CO_2-e)				
CH_{4gen} (CH_4 generated by the plant, expressed as CO_2-e tonnes)				
$CH_{4gen} = [(COD_{wi} - COD_{sl} - COD_{eff}) \times (F_{wan} \times EF_{wij})] + [(COD_{sl} - COD_{trl} - COD_{tro}) \times F_{slan} \times EF_{slij}] =$	Total	Wastewater	Sludge	
	642.43	642.43	0.00	
$\gamma(Q_{cap} + Q_{flared} + Q_{tr})$		0.00	methane (CH_4) captured in tonnes CO_2-e	
CH_4^* (CH_4 in biogas released, in CO_2-e tonnes)		642.43	see Determination subsections 5.42 (2, 3)	

Follow instructions, strictly from top to bottom, to input Industrial plant 1 data.

AFTER data has been inputted in this worksheet for the [illegible] worksheet to report into [illegible].

Select method (1 or 2 or 3) from drop-down list. See NGER (Measurement) Determination 2008 as amended Part 5.4, links are included in this spreadsheet.	**1**

Enter Prodi, Wgen,i, CODcon,i. For Method 1 only, default values can be selected from the table at the bottom of this sheet.

Note: chemical oxygen demand (COD) can be derived from biological oxygen demand (BOD), EXCEPT for CODw,i and CODsl under Method 1.
$COD = 2.6 \times BOD_5$.

Commodity	$Prod_i$ (tonnes of commodity produced)	$W_{gen,i}$ (wastewater generation rate) (kL/tonne)	$COD_{con,i}$ (COD concentration) (kg/kL)	$COD_{W,i}$ (COD in wastewater) (tonnes)
Dairy product (ANZSIC code 113)				0.00
Pulp, paper and paperboard (ANZSIC code 1510)				0.00
Meat and poultry (ANZSIC codes 1111 and 1112)	1,813	13.70	6.10	151.52
Organic chemicals (ANZSIC codes 18 and 19)				0.00
Raw sugar (ANZSIC code 1181)				0.00
Beer (ANZSIC code 1212)				0.00
Wine and other alcoholic beverage (ANZSIC code 1214)				0.00
Fruit and vegetable (ANZSIC code 1140)				0.00
$COD_{w,i}$ (tonnes COD in wastewater entering plant)	151.52			
F_{sl} (Fraction of COD removed as sludge)	0.00			
COD_{sl} (tonnes COD sludge removed)	0.00			
COD_{trl} (tonnes COD sludge transferred to landfill)	0.00			
COD_{tro} (tonnes COD sludge transferred not landfill)	0.00			
Q_{cap} (m^3 CH_4 in sludge biogas for combustion)	0.00			
Q_{flared} (m^3 CH_4 in sludge biogas flared)	0.00			
Q_{tr} (m^3 CH_4 in sludge biogas transferred elsewhere)	0.00			
F_{wan} (Fraction of wastewater COD treated anaerobically)	anaerobic digester/reactor	0.8		
F_{slan} (Fraction sludge COD treated anaerobically)	0.00	0		
EF_{wij} (tonnes CO_2-e / tonne COD)	5.30			
EF_{slij} (tonnes CO_2-e / tonne sludge COD)	5.30			
γ ($6.784 \times 10^{-4} \times 21$) ($m^3$ CH_4 ===> tonnes CO_2-e)	0.0142464			

CLICK HERE for NGER (Measurement) Determination 2008 as amended

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