final report

Project code: P.PIP.0306

Prepared by: Tamara Emms

National Centre for Engineering in Agriculture,
University of Southern Queensland

Date published: January 2012

PUBLISHED BY
Meat & Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Wastewater Audit – Churchill Abattoir 2011

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government and contributions from the Australian Meat Processor Corporation to support the research and development detailed in this publication.

Executive summary

An audit was conducted on various effluent streams generated by the meat processing activity at Churchill Abattoir (CA). A primary aim of the project was to determine the composition of these effluent streams and secondly, gain an accurate measurement of the total volume of effluent generated. A total of seven sampling locations were identified prior to commencement of sampling of which six were individual effluent streams and one from combined effluents. Water samples were collected on six occasions between 6 May 2011 and 28 July 2011 and were analysed for the following parameters:

> pH, electrical conductivity (EC), total suspended solids (TSS), Total Kjeldahl Nitrogen (TKN), total nitrogen (TN), total phosphorus (TP), fats, oils and greases (FOGs), chemical oxygen demand (COD) and volatile acids as acetic acid (VA).

In an effort to improve wastewater treatment processes CA is planning to install a dissolved air floatation (DAF) unit. The analysis of individual streams will enable the identification of target streams for load reduction on current wastewater treatment infrastructure which forms an important precursor to the commissioning of any DAF unit. Parameters of particular interest in relation to location and commissioning of the DAF unit were COD, VA and FOGs. It is proposed to potentially divert those effluent streams with high concentrations of these parameters to the DAF unit in attempt to reduce organic loading on the current wastewater treatment infrastructure.

Of the seven sampling locations, six were found to have a maximum COD content between 10000-20000 mg/L with only the effluent from the cattle holding yards having a lower COD content, with a maximum of 2580 mg/L. The waste streams with a maximum COD content of more than 20000 mg/L were the ‘alley’, ‘manhole’ and ‘render’. However, the mean values for these effluent streams are 13103, 9532 and 12385 mg/L, respectively. These results demonstrate the variability of the COD content in these waste streams. The remaining effluent streams showed less variability in COD content. Both the ‘alley’ and ‘render’ samples were relatively consistent returning a COD content of 10000 mg/L or higher over the six sampling periods.

In relation to VA content of the various effluent streams, the ‘alley’ and ‘manhole’ samples had the highest maximum VA concentration of 1370 and 1510 mg/L, respectively. The maximum concentration of VA for both the ‘raw materials’ and ‘saveall’ effluent streams was just below 1000 mg/L. However, the average VA concentration in the ‘alley’ effluent stream was 1007 mg/L with consistent data over the sampling period. The result of 1510 mg/L for the ‘manhole’ sample on 6 May 2011 is far greater than the other sampling periods for that effluent stream with an average concentration of 96 mg/L when result removed. Therefore the effluent streams with the highest VA concentrations in decreasing order are the ‘alley’, ‘saveall’ and ‘raw materials’, with values of 1370, 973 and 839 mg/L, respectively.

The ‘alley’, ‘paunch separator’, ‘render’ and ‘saveall’ effluent streams had an average TSS content of 4712, 5140, 5990 and 6543mg/L, respectively. When compared to influent to anaerobic ponds monitoring results between the years 2000 and 2009, the TSS content of the effluent streams appears to have remained consistent with an average of 4000-5000 mg/L.

A number of studies have inferred that FOG content of the effluent streams is potentially inhibitory to the biological processes, particularly to the anaerobic portion of the current wastewater treatment infrastructure. Currently, a fatty crust forms on the surface of the

onsite anaerobic ponds and although this provides an effective cover to maintain anaerobic conditions, this crust is causing problems with the use of synthetic covers on the ponds. The results show that there is variation in FOG content both between and within individual effluent streams. The 'alley', 'render' and 'saveall' had the most consistent FOG contents with averages of 1007, 595 and 708 mg/L, respectively. However the 'paunch separator' effluent stream average result was the highest. The results from samples taken on 6 May 2011 have an FOG content of 3400 mg/L, where the other results were approximately 44 mg/L.

The results of the audit provide data to make an informed decision as to the placement of a DAF unit and the effluent streams that will most effectively utilise the primary effluent treatment measure. The information from the audit will identify where improvements of the primary effluent treatment program can be made and is crucial in maximising the functional operation of secondary effluent treatment using anaerobic ponds. The relevant parameters to this study whose loading is known to be reduced by DAF treatment are OLR, COD and FOG. From the data it can be determined that of these parameters the 'alley', 'render', 'manhole' and 'paunch separator' effluent streams have average concentrations that are commonly the highest. The 'alley' and 'manhole' effluent streams were high across the three parameters and would be the primary effluent streams to be diverted. The combined organic and hydraulic loading of these primary effluent streams diverted to the DAF unit must be determined before addition of the 'render' and 'paunch separator' effluent streams is considered.

Diversion of these effluent streams through a DAF unit for primary treatment will result in the current anaerobic ponds receiving for primary treatment the 'raw materials', 'cattleyards' and 'saveall' effluent streams in addition to the DAF-treated effluent streams. The initial impact of a reduced organic loading rate on the current anaerobic ponds treatment efficiency will need to be monitored. There may be a transition period where the treatment efficiency (i.e. COD removal rate) and biogas production is adversely impacted by changes in influent composition.

Based on calculated OLR for the individual effluent streams, it is recommended that the 'alley', 'paunch separator' and 'render' be diverted to the DAF for primary treatment before combining in the 'saveall' for secondary treatment in the ponds. However, if the primary role of the DAF is to reduce the FOG content of the effluent and become concentrated in sludge generated, the 'paunch separator' effluent stream should be replaced by the 'raw material' effluent stream.

Key Recommendations:

- The 'alley', 'render' and 'raw material' effluent streams be diverted to the DAF for primary treatment to reduce both OLR and FOG content;
- The 'paunch separator' effluent stream not be diverted to the DAF for primary treatment for although the OLR is relatively high, the solids content may cause an increase in DAF sludge requiring management;
- Monitoring of effluent compostion from the 'saveall' for the parameters adopted in this report and pond treatment efficiency to determine the impact of the installation of the DAF;
- Monitoring of key parameters (i.e. OLR, COD, FOG) of the influent and effluent of the DAF to ensure a minimum 85% reduction is achieved

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Churchill Abattoir Pty. Ltd. (CA) is a medium-sized red meat abattoir, processing around 3000 cattle a week. Approximately 0.8ML of wastewater is generated each working day, and while the wastewater characteristics are unknown, traces of blood, fat and manure are known to exist in the wastewater. Prior to 2001 when the abattoir was state owned, there was no wastewater treatment system in place.

In 2000, three ponds - one anaerobic (10ML), one facultative (10ML) and one aerobic (12ML) - were constructed for the on-site treatment of wastewater. These ponds, based on slaughterhouse industry standards, were designed to last 15 years of operation. Water treated by these ponds was, and still is, irrigated onto crops. However, the ponds failed after only five years of operation due to significant sludge accumulation. This, coupled with secondary problems of greenhouse gas (GHG) and odour emissions led to the construction of five smaller anaerobic ponds, each approximately 2.2ML in volume. The intention was to cover these ponds to reduce GHG emissions by capturing methane gas to generate electricity and reduce odour emissions while retaining a high level of wastewater treatment. The first cover was installed on Pond A during September 2010 and was employed for 10 weeks before decommissioned to remove the build-up of crust that accumulated on the surface of the pond.

1.1 Purpose of the Study

It was decided in early 2011 that the installation of a dissolved air flotation (DAF) unit would be required to reduce the fat, oil and grease (FOG) component of the wastewater. The commissioning of a DAF unit should provide many advantages to CA. DAF units significantly reduce the biochemical oxygen demand (BOD), chemical oxygen demand (COD) and total suspended solids (TSS) characteristics of the generated wastewater (Mittal 2006). By reducing these characteristics before discharge of effluent into the anaerobic ponds, the hydraulic retention time required for removal of nutrients in an equivalent volume of wastewater should be reduced (Torkian *et al.* 2003). Also, by reducing the amount of solids entering the anaerobic ponds, the rate of sludge accumulation should also be reduced, extending pond life and reducing overall maintenance cost (Saqqar & Pescod 1995). Further benefits of DAF installation include in particular the enhanced retention of high quality tallow for sale and further profit generation.

A wastewater audit was conducted at CA in order to determine the location for DAF installation whereby optimal benefit is returned. Over a three month period, the audit identified effluent streams of importance for both the treatment efficiency of current effluent treatment and the proposed installation of the DAF.

The effluent streams that were sampled derived from various activities within the abattoir operations. A high level of variation was expected between the individual streams but there is uncertainty as to whether the combined effluent stream composition is consistent despite this. Consequently, the main purpose of this study was to determine the impact of any variation within individual effluent stream composition on the combined effluent stream that is currently treated onsite using anaerobic ponds. This has implications on the potential for overloading and failure of these ponds resulting in reduced treatment efficiencies and release of noxious odours.

1.2 Description of Effluent Streams

The following section provides a description of the primary effluent streams at CA. In this study, these locations are named after their respective location or waste source and include the 'cattle yards', 'paunch separator', 'saveall', 'render', 'alley', 'raw materials', 'manhole' and 'gut wash' (later separated into 'clear' and 'tripe wash' – not all data presented (Figure 1).

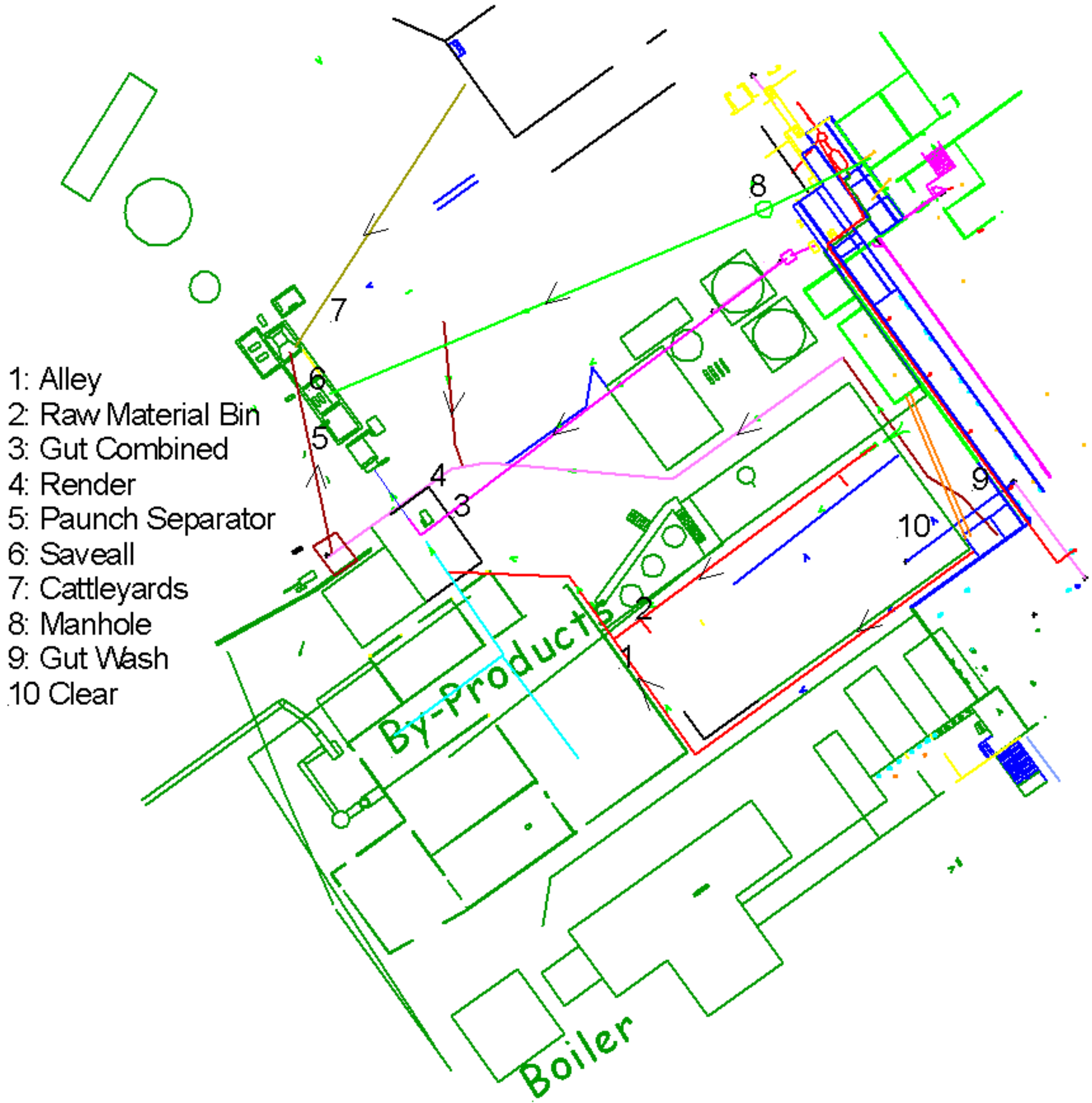

Figure 1: Sample locations at Churchill abattoir

1.2.1 The Alley

The sample for this stream was collected from a drain located in an alley way near the hide packing area of the site (Figure 2). The source of this stream is primarily from wash water within the kill-floor area including de-heading the carcass, the splitting saw, trimmers and final wash of the carcass. Although this stream is potentially relatively dilute because of the high volumes of water used within the kill-floor area, the stream could potentially contain high levels of solids material including fats. The volume of this stream generated per day is

430kL/day with an average COD content of 13103 mg/L and organic loading rate (OLR) of 5634 kg/day.

Figure 2: Sampling location (circled) from the 'alley' effluent stream

The photo above illustrates the potential contaminants that may be in the drain that can impact on results and provide inaccurate results (circled above). Material such as this may have contributed to the large spike in COD content observed in the sample collected from this location on 21 July 2011.

1.2.2 Raw Material

The sample from this stream was collected at a drain located at the end of the 'hogger' prior to solid waste material entering the rendering plant (Figure 3). The liquid portion is run-off from the material sent for rendering including shredded gut and fat, shredded carcass offcuts such as heads, hooves and offal. Consequently, it is anticipated that this stream will have a high solids and organic component including fats, flesh and bone. The volume of this stream generated per day is 40kL/day with an average COD content of 8817 mg/L and organic loading rate (OLR) of 353 kg/day.

Figure 3: Sampling location of 'raw material' effluent stream

The sample was collected upstream from where this effluent stream combines with 'the alley' effluent stream (circled above). As can be seen in the photo above, this effluent stream is high in blood and gross pollutants, primarily fats and proteins.

1.2.3 Gut Combined

The sample for this stream was collected at a location adjacent to the large tallow storage tanks behind an area of the site known as 'by-products' (Figure 4). The source of this stream is derived from the removal of paunch material from the gut and the tripe washing activity within the abattoir. Consequently, it is expected that this stream will have a high solids and organics loading including fats and proteins. The volume of this stream generated per day is 50 kL/day with an average COD content of 6460 mg/L and organic loading rate (OLR) of 323 kg/day (*NOTE: These calculations based on 1 sample due to changes to location and effluent streams sampled*).

Figure 4: Sample location for 'gut combined' effluent stream

This waste stream was later separated into 'tripe/clear' and 'gut wash' effluent streams with 2 samples collected on 21/7/11 and 28/7/11. As a result, there is not enough data for effluent generated from the gut and tripe washing activities and will not be included further in this report.

1.2.4 'Paunch separator'

The sample for this stream was collected from the base of the pipe before combining with other effluent streams in the 'saveall' (

Figure 5). The primary input to this effluent stream is from the coarse separation of paunch material with solids collected and removed after dewatering. As a result of the input, it is expected that this effluent stream will be a major contributor to COD content and likely TSS concentration. The volume of this stream generated per day is 230 kL/day with an average COD content of 9820 mg/L and organic loading rate (OLR) of 2259 kg/day.

Figure 5: Sample location of paunch separator effluent stream

Approximately 15m^3 of solid fraction from this effluent stream is generated each day and transported offsite up to 3 times a week for composting at a facility located nearby in Ipswich, QLD.

1.2.5 Manhole

The sample from this stream was collected at a location between the 'knocking box' and cattle holding yards (

Figure 6). The inputs into this stream are varied ranging from water from the Woolworths meat processing area, the 'knocking box' and from de-hiding and horn removal activities. Due to the variety of inputs into this stream, the composition is expected to have a relatively high degree of variability. The volume of this stream generated per day is 25 kL/day with an average COD content of 9532 mg/L and organic loading rate (OLR) of 238 kg/day.

Figure 6: Sample location of 'manhole' effluent stream

1.2.6 Cattleyards

The sample for this stream was collected from the end of the pipe before combining with all effluent streams in the 'saveall' (

Figure 7). The input for this effluent stream is wash water containing urine, faeces and dirt from the cattle. As such, this effluent stream is expected to contribute significantly to TSS concentration in particular, as well as COD, nitrogen and phosphorus content. Cattle yard input stream from the grey-coloured pipe to the left of the photo (circled below). The volume of this stream generated per day is 500 kL/day with an average COD content of 1596 mg/L and organic loading rate (OLR) of 798 kg/day.

Figure 7: Sample location of 'cattle yards' effluent stream

1.2.7 Render

The location of the sampling point for this effluent stream is upstream from the 'paunch separator' and 'saveall' sample locations, located at the rear of the rendering plant (Figure 8). The inputs to this effluent stream include 'stick water' and other water by-products from the rendering process. Due to the nature of the rendering process, it is expected that this effluent stream will contribute to the COD and FOGs content in particular. The volume of this stream generated per day is 16 kL/day with an average COD content of 12385 mg/L and organic loading rate (OLR) of 421 kg/day.

Figure 8: Sample location of 'render' effluent stream

The picture on the left is the actual sampling location where the red colour of the effluent stream can be seen. The photo on the right shows the location (circled above) of the effluent stream in relation to the abattoir with pipework associated with the rendering plant visible to the right of the photo.

1.2.8 'Saveall'

The location of the sampling point for this effluent stream was from the area of the collection pit that is aerated to ensure complete mixing of all effluent streams that input into this area (

Figure 9, circled in red below). The inputs to this effluent stream are a combination of all the effluent that is pumped for treatment via current wastewater infrastructure. As this effluent stream is a combination of all effluent generated onsite, it is expected that the composition has the potential to vary significantly as the composition is dependent on the consistency of input effluent streams. The volume of this stream generated per day is 1300 kL/day with an average COD content of 10810 mg/L and organic loading rate (OLR) of 14053 kg/day.

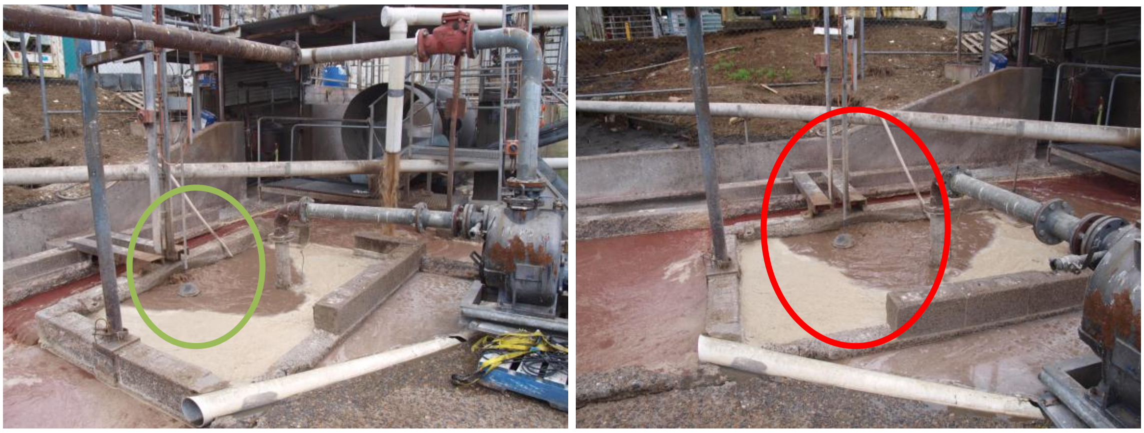

Figure 9: Sample location for 'saveall' effluent stream

In these photos a number of effluent streams can be seen with the sample for the 'saveall' collected from the aerated area (i.e. brown coloured material) to the left of the central pit (circled in green above), away from the surface scum material.

1.3 Wastewater Treatment Infrastructure

Historically, all effluent streams generated have been combined in the 'saveall' prior to being pumped for treatment and this remains the current practice. The original wastewater treatment infrastructure commissioned in 2000 included the construction of large ponds for biological treatment including both anaerobic and aerobic technologies. The effluent from the 'saveall' was firstly pumped to a large anaerobic lagoon with a volume of approximately 10 ML. The primary treated effluent would then be pumped to a facultative anaerobic lagoon with a volume of 10ML. Final polishing then occurred via a large aerobic basin of 12ML before storage in onsite dams to be used for irrigation purposes.

The treatment system was not efficient and prone to failure with the release of noxious odours and as previously mentioned, the lagoons became overloaded within 5 years of commissioning rather than the expected 15 year life span. Anaerobic lagoons for the treatment of red meat processing facilities do not have standard specifications for the design relating to potential inefficiencies in treatment and biogas generation and capture. This leads to an anaerobic treatment system that will be prone to failure as important parameters such as organic loading rate and retention time do not appear to be considered.

In 2010, five small anaerobic ponds with an approximate volume of 2ML were constructed to replace the overloaded anaerobic treatment pond. The configuration of these ponds is illustrate below (Figure 10) with the primary flow of effluent from the abattoir split between two lagoons (A and B). These are further connected to another three lagoons that are two-way connected (C, D and E). There are valves on all incoming lines and connections between lagoons which enables control over where the effluent goes. For example, lagoons can be isolated from the system for maintenance purposes.

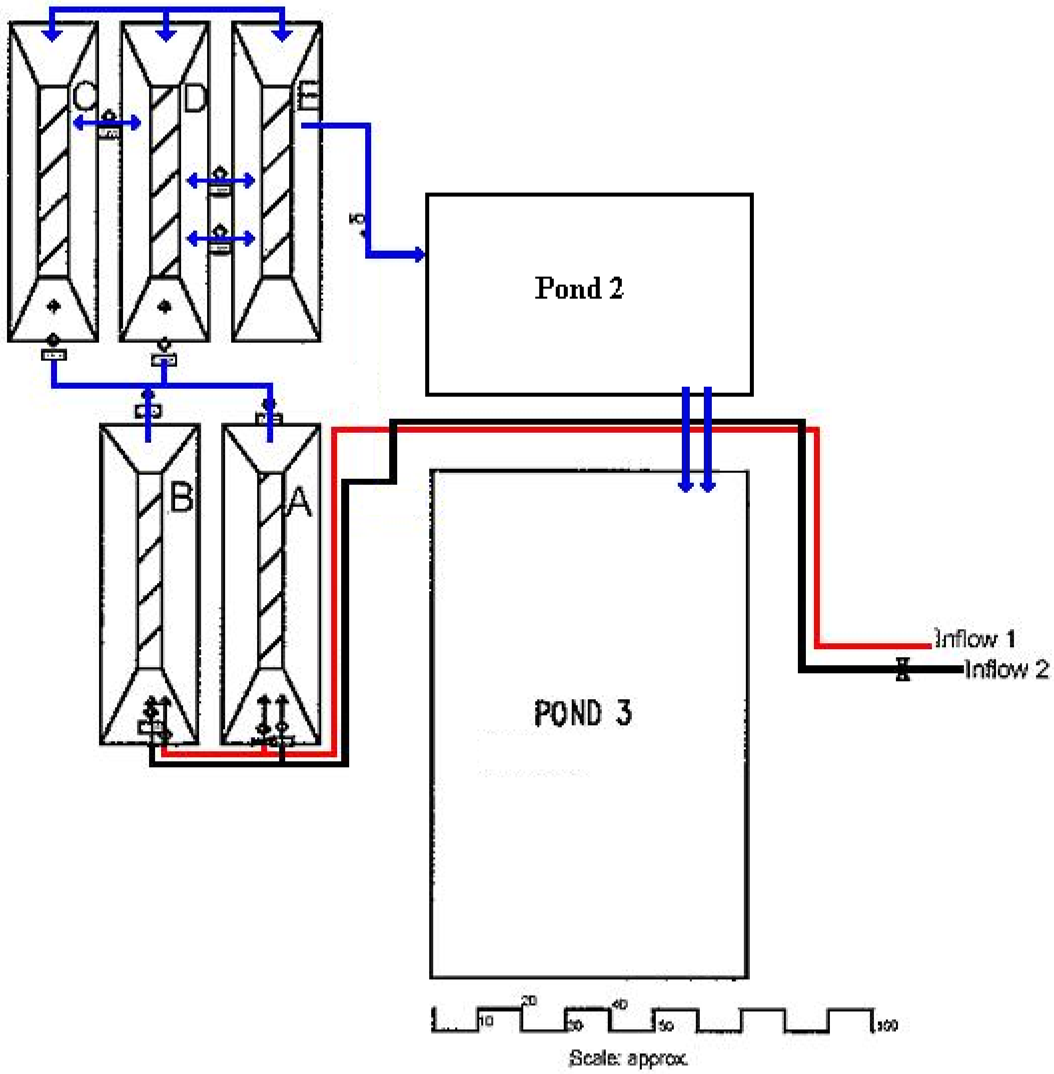

Figure 10: Churchill abattoir wastewater treatment pond configuration

In 2010, a project was initiated to cover these smaller anaerobic ponds in order to capture the biogas and limit odours generated by the anaerobic lagoons. Instead of burying the cover as had been done traditionally, a raft was constructed and a cover of HDPE was attached. This was done to allow recovery of the cover for the purpose of maintenance. The actual design of the framework and of the covering of the rafts are a work in progress and the development of the various cover framework designs, construction and cover material used is being documented as part of an AMPC/MLA funded project A.ENV.0107.

2. METHODOLOGY

Wastewater samples were collected from ten locations around CA. A description of each of the locations is given in Section 1.2. These locations were chosen as they represent major sources of wastewater within the abattoir and contribute to the majority of pollution and effluent.

Samples were collected from waste streams using a 2m long metal pole with a metal bucket attached which was allowed to swivel. This bucket was rinsed periodically between sampling, particularly when significant matter (usually fats) had accumulated from the previous sample.

Samples were characterised in terms of flow and volume. Analysis of the following parameters were conducted by Australian Laboratory Services (ALS), a National Association of Testing Authorities (NATA) accredited laboratory:

> pH, electrical conductivity (EC), total suspended solids (TSS), chemical oxygen demand (COD), fats, oils and greases (FOG), total Kjeldahl nitrogen (TKN), total nitrogen (TN), total phosphorus (TP) and volatile acids as acetic acid (VA).

Sample bottles specific to the analysis required were provided by Australian Laboratory Services (ALS) and transported on ice. Each sample was analysed by ALS using the following methods EP026: COD, EP020: FOG, EP045: VFA, EA025: TSS, EK061G: TKN and EK067G: TP, and for some initial samples EA005P pH and EA010P: EC. Dalian Zerogo RV-100F fixed ultrasonic flow meters were used to determine flow rates through pipes.

3. RESULTS

A summary of the data can be found in Appendix 1. Results for the combined gut wash are not included as this effluent stream was only sampled once (6/5/2011). The operator of the abattoir decided to split this effluent into two effluent streams, namely 'gut wash' and 'clear/tripe'. Consequently, these results are not presented in this report and the contribution of this effluent stream in total volume generated is approximately 100kL which in a total 0.8ML effluent generated is considered minimal.

The 'saveall' is the final combination of all the effluent streams generated by the abattoir before being pumped to the ponds for treatment. AMPC/MLA funded project A.ENV.0107 has been characterising the anaerobic pond influent and effluent composition to determine treatment efficiency using similar sampling parameters. The waste audit results will be subsequently discussed relative to the 'savell' results provided by the project A.ENV.0107. A summary of the average results for parameters sampled in both the raw effluent streams and ponds influent and effluent characterisation are provided in Appendix 2.

3.1 pH

Samples were collected for analysis from individual effluent streams on three (3) occasions with a minimum of 6.0 and maximum of 8.0 ('alley' and 'cattleyards', 14/7/11, respectively), with an average of 6.5 (refer

Figure 11). From these results it was determined that the pH of effluent streams generated was consistent and further measurement was not continued.

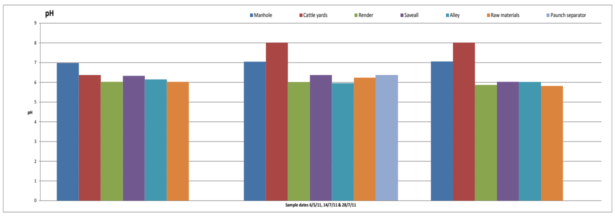

Figure 11: pH of effluent streams sampled 6/5/11, 21/7/11 and 28/7/11

3.2 Electrical Conductivity (EC)

Samples were collected for analysis from individual effluent streams on three (3) occasions with the range across all waste streams with a minimum of 774 and maximum of 5600 µS/cm ('manhole' 14/7/11 and 'alley' 6/5/11, respectively) (refer

Figure 12) with an average of 2403 mg/L.

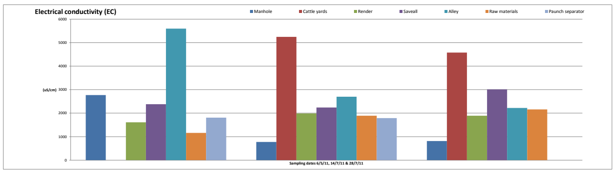

Figure 12: Electrical conductivity (EC) results for effluent streams sampled 6/5/11, 21/7/11 and 28/7/11

3.3 Total Suspended Solids (TSS)

Samples were collected for analysis from individual effluent streams on six occasions with a minimum value of 186 and maximum of 31600 mg/L. However, the results for the 'alley' sample on 6 May 2011 were substantially greater than results from five other samples for this effluent stream. Omitting this result, the range changed to 186 to 9820 mg/L ('manhole' and 'render' 21/7/11, respectively) with an average for all streams of 4590 mg/L. From the results it can be determined that the 'alley', 'render', 'paunch separator' and 'saveall' have consistently high TSS content with an average over the sampling period of 4712, 5990, 5140 and 6543 mg/L, respectively (see

Figure 13).

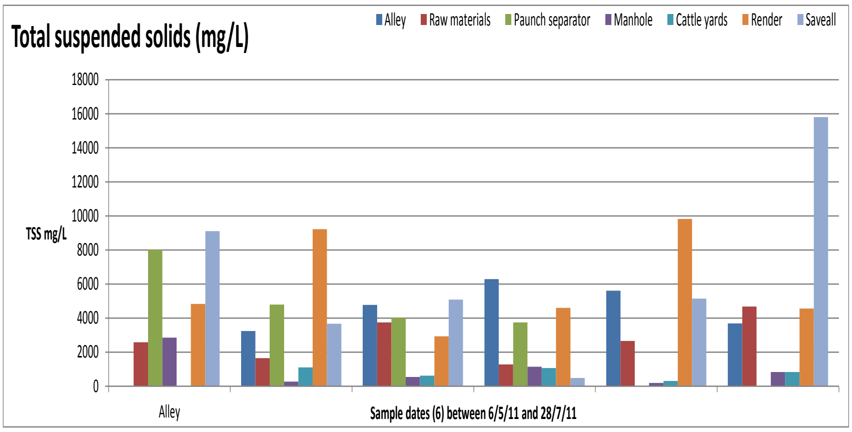

Figure 13: Results for total suspended solids (TSS) from individual effluent streams

Results of water composition monitoring have been provided by CA between the years 2000 and 2009 taken approximately on a quarterly basis. As a comparison to results obtained during the current effluent composition, data has been provided below (refer

Figure 14). Over the period the minimum value was 407 and maximum value of 21000 mg/L with an average value of 4527 mg/L.

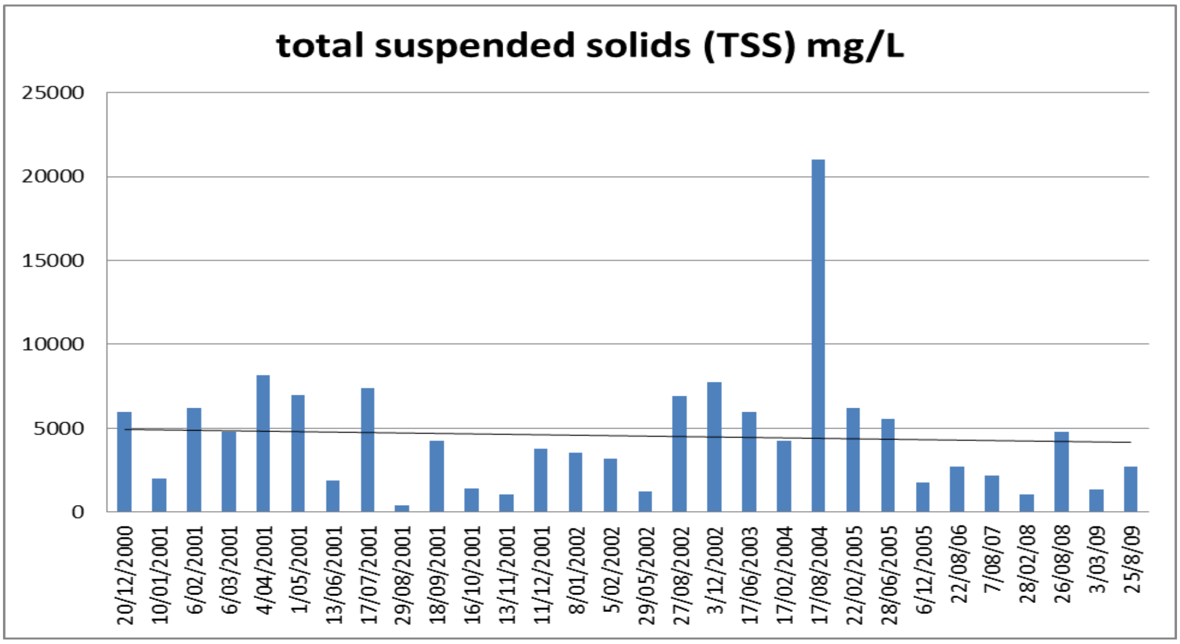

Figure 14: Historical sampling results for TSS between 2000 and 2009

A spike occurred during sample period 17 August 2004 with a TSS content of 21000 mg/L, With these data points omitted the average TSS content over the period 2000 to 2009 becomes 3893 mg/L. By comparison the TSS content currently entering the wastewater treatment infrastructure is relatively consistent averaging around 4000-5000 mg/L.

3.4 Total Kjeldahl Nitrogen (TKN) and Total Nitrogen (TN)

Samples were collected for analysis from individual effluent streams on six occasions with a minimum of 30 and maximum of 2300 mg/L ('paunch separator' 14/7/11 and 'manhole' 6/5/11, respectively) with an average of 557 mg/L.

Figure 15 below illustrates the variability of the TKN content within and across the individual effluent streams. When the results of TKN are compared with that for total nitrogen (data not provided), it was determined that a large proportion of the nitrogen in the effluent streams comprised of nitrogen in a reduced state (i.e. NH^{4+}/NH_3) or organic nitrogen species. Oxidised forms of nitrogen (i.e. NO_3^-/NO_2^-) were either not detected or at low concentrations.

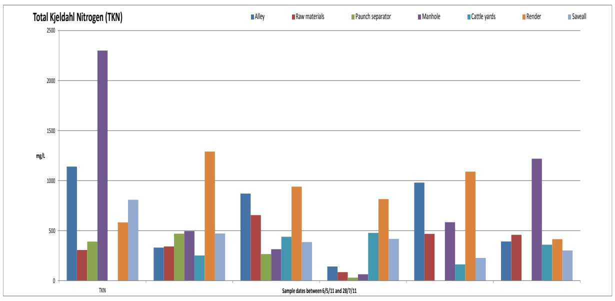

Figure 15: TKN results for individual effluent streams

As noted above, a significant proportion of the nitrogen species in the 'saveall' effluent stream are comprised of non-oxidised forms. From the pond influent results, the TKN results are comparable to those of the 'saveall'.

The average TKN content of the influent entering pond A and B was 443 mg/L and TKN 451mg/L, respectively. However, the influent entering pond A and B has an ammonia-as-nitrogen (NH3-N) content of 160mg/L and 183 mg/L, respectively. From these results it can be determined that a degree of oxidation and conversion of reduced nitrogen species during the transportation of the effluent to the treatment ponds. Alternatively, in addition to oxidation the more volatile ammonia ions may be have been released during the turbulence created during pumping. As a result, the nitrogen species in the effluent entering the ponds will be in the bioavailable oxidised forms of nitrate/nitrite.

3.5 Total Phosphorus (TP)

Samples were collected for analysis from individual effluent streams on 6 occasions with a minimum of 1.1 and maximum of 138.0 mg/L ('manhole' 14/7/11 and 'alley' 21/7/11, respectively) (
Figure **16**) with an average of 66.2 mg/L. The TP for the effluent streams was variable within and between the sample results. A portion of that variability is likely attributable to the different times samples were collected which is affected by the processes within the abattoir at that time.

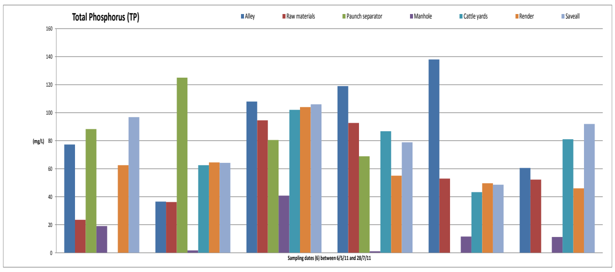

Figure 16: Total phosphorus (TP) of individual effluent streams

3.6 Fats, Oils and Greases (FOGs)

Samples were collected for analysis from individual effluent streams on 6 occasions with a minimum of 5 and maximum of 3400 mg/L ('manhole' 6/5/11 and 'paunch separator' 6/5/11, respectively) with an average of 558 mg/L. The result for the paunch separator sample collected on 6 May 2011 is approximately 10-fold higher than for the other samples collected. Of the results for samples taken on 6 May 2011, 4 of the 5 results are substantially higher than for results obtained throughout the remainder of the sampling period. This difference is clearly illustrated in Figure 17.

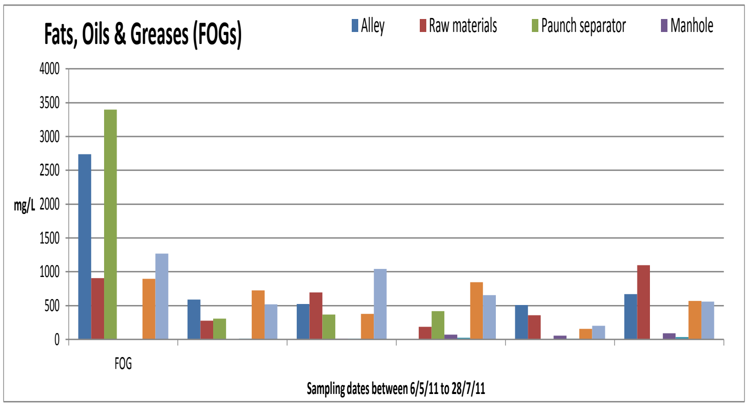

Figure 17: Fats, Oils and Greases (FOGs) content of the individual effluent streams

Historical sampling results shown in Figures 18 and 19 are provided for comparison purposes with current FOG content of the 'saveall'.

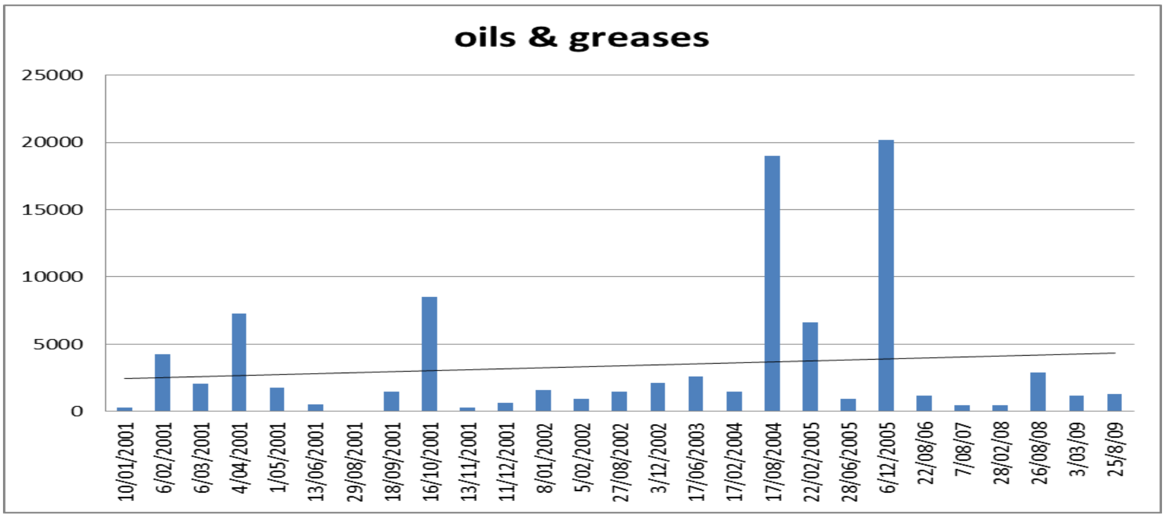

Figure 18: Historical results of FOG content of 'saveall' effluent stream

Results for sample period 17/8/2004 and 6/12/2005 appear to be outliers as they are substantially higher than results for the rest of the sampling periods. When these are removed the average O&G content becomes 2096 mg/L which is higher relative to current results for FOGs (

Figure 19). The removal of the outliers changes the trend of the FOG content over time from being a slow increase over time to a general reduction over that same time. In the more recent sampling conducted, the FOG content of the samples taken at the 'saveall' on average was 708 mg/L, with influent to pond A and B 425 mg/L and 575 mg/L, respectively. Comparison of historical and current results, the FOG content of the effluent currently entering the onsite wastewater treatment infrastructure is generally within the range of 1000-1500 mg/L.

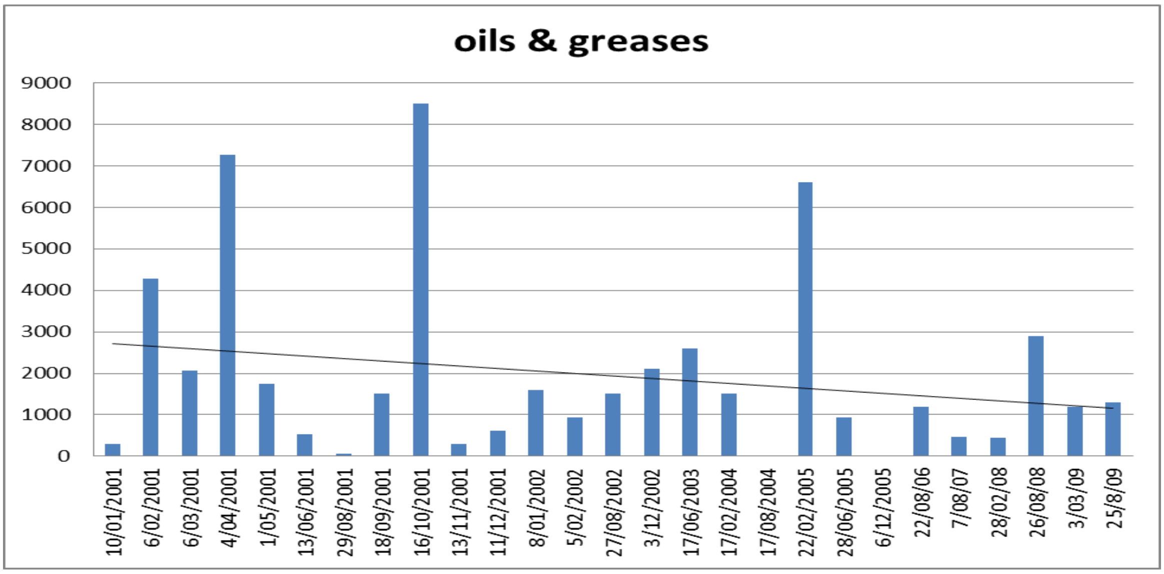

Figure 19: Historical effluent sampling results with certain samples omitted (see text above)

The current results show on average a lower FOG content than the average between 2000 and 2009 and this decreasing trend may be indicative of improvements over time within the meat processing facility.

3.7 Chemical Oxygen Demand (COD)

Samples were collected for analysis from individual effluent streams on 6 occasions with a minimum of 909 and maximum of 20600 mg/L ('cattle yards' and 'alley' 21/7/11, respectively) with an average of 13103 mg/L. The average COD content for all effluent streams excluding the cattle yards, was approximately 10000-12000 mg/L. The two effluent streams with consistently high COD content were the 'alley' and 'render' with an average of 13103 and 12385 mg/L, respectively. However, both effluent streams experienced a number of increases during the sampling period with COD content reaching over 20000 mg/L (Figure 20).

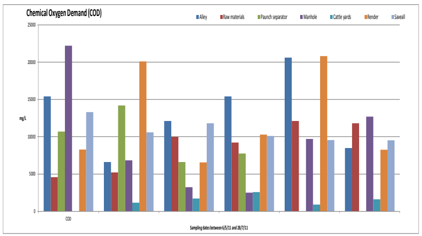

Figure 20: Chemical Oxygen Demand (COD) results for individual effluent streams

3.8 Volatile Acids (VA) as Acetic Acid

Samples were collected for analysis from individual effluent streams on six occasions with a minimum of 40 and maximum of 1510 mg/L ('manhole' 13/5/11 and 'manhole' 6/5/11, respectively) with an average of 541 mg/L. The result for the 'manhole' sample collected on 6 May 2011 is higher than the other results for this effluent stream obtained during the sampling period. However, even when this result is omitted the average VA content across the effluent streams is 514 mg/L. The effect of the result is only noticeable within the 'manhole' effluent stream results. The 'alley' consistently had the highest VA content as compared to the other effluent streams as illustrated in

Figure 21 below.

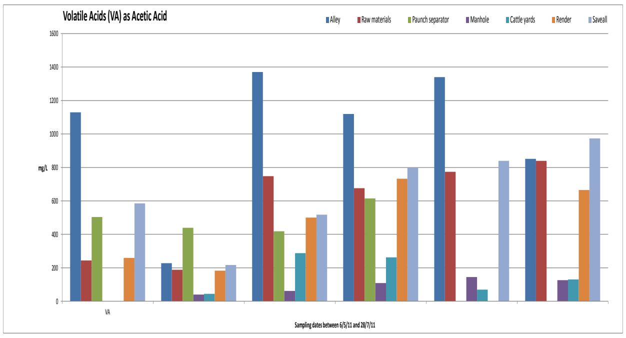

Figure 21: Volatile Acid (VA) as Acetic Acid results for individual effluent streams

4. DISCUSSION & RECOMMENDATIONS

The results obtained indicate that there is variation within and between the various effluent streams sampled. There are a number of factors that can cause variation including:

- Difference in the time samples were collected relative to abattoir processes;
- Effluent sample size relative to total volume of effluent generated per day; or
- The inherent variability of industrial effluents from manufacturing activities.

The results obtained will enable a more informed decision as to the optimal location of the DAF unit with respect to reducing organic loading to current onsite wastewater infrastructure. Additionally, those effluent streams with higher FOG content to ensure sufficient FOG content in the subsequent DAF sludge for further processing.

The organic loading rate (OLR) of each effluent stream has been calculated. Table 1 provides the OLR (i.e. kg of COD/m^3/day) for each stream with no pre-treatment.

Effluent stream	Volume / day (kL)	Avg COD (mg/L)	OLR (kg / m^3/d)
Alley	430	13103	5634
Raw material	40	8817	353
Gut combined	*50*		-
Paunch separator	230	9820	2259
Saveall	1300	10810	14053
Cattleyards	500	1596	798
Manhole	25	9532	238
Gut wash / tripe	*60*		-
Clear	*21*		-
Render	34	12385	421

Table 1: Total volume (kL) of each effluent stream generated each day, COD and OLR data.
Note: effluent streams italicised included for total volume of effluent generated per day purposes only

From this table, the current OLR from the 'saveall' is 14053 kg COD/m^3/day with the sum of the various individual effluent streams having an OLR of 9703 kg/COD/m^3/day. It is expected that there is 'COD loss'. Not all waste streams and volumes were analysed which contributes to COD loss along with other factors which can give rise to variation as previously mentioned above. The difference indicates that other effluent streams not included in this study contribute to the 'saveall' OLR.

At this stage, the 'alley', 'paunch separator' and 'render' effluent streams should be diverted to the DAF to lower OLR. Working on an average 85[1]% efficiency OLR removal rate by the DAF, the OLR for these effluent streams would be 845, 339 and 63 kg of COD/m^3/day. Diversion of these effluent streams for primary treatment through the DAF would result in a cumulative OLR reduction from 8314 to 1247 kg of COD/m^3/day.

[1] Reduction rates calculated as per minimum regulatory requirements for similar DAF installation in NSW.

It is anticipated that once the above effluent streams are diverted for primary treatment through the DAF, the OLR to the current wastewater treatment infrastructure will potentially be significantly reduced. During this transition period as the biomass acclimate to the reduced loading, there is likely to be adverse impacts, particularly on biogas production and methane yield. The treatment efficiency of current wastewater infrastructure and biogas production should be monitored during this period to ensure the system adapts and is able to continue effectively treating the effluent streams generated by the abattoir.

With respect to reduction of the FOG content, it is recommended that the 'alley', 'render' and 'raw material' effluent streams (combined FOG content of 2190 mg/L) be diverted to the DAF for pre-treatment. Calculating on a 85% DAF reduction efficiency, diversion of these effluent streams would result in a combined FOG content on average 328 mg/L going to the 'saveall'. However, the cumulative result for the individual effluent streams compared to results obtained for the 'saveall' do not correlate as per OLR results above i.e. individual effluent stream FOG results do not equate to results for the 'saveall'. Due to the variability of the individual effluent stream FOG content, the impact of this reduction on the ponds cannot be readily determined.

The current pond configuration has FOG reduction rates of 77% for pond A and 75% for pond B. However, it is proposed to treat effluent streams with higher FOG content through the DAF in order to recover the FOGs for feedstock manufacture. Additionally, reduction of FOG content of final effluent pumped to the ponds for treatment should reduce the issue of a fatty crust forming which are currently interfering with treatment efficiency and biogas capture.

From the results of this study, the following is recommended:

i. The 'alley', 'render' and 'raw material' effluent streams be diverted to the DAF for primary treatment to reduce both OLR and FOG content;
ii. The 'paunch separator' effluent stream not be diverted to the DAF for primary treatment for although the OLR is relatively high, the solids content may cause an increase in DAF sludge requiring management;
iii. Monitoring of effluent compostion from the 'saveall' for the parameters adopted in this report and pond treatment efficiency to determine the impact of the installation of the DAF; and
iv. Monitoring of key parameters (i.e. OLR, COD, FOG) of the influent and effluent of the DAF to ensure a minimum 85% reduction is achieved.

5. ACKNOWLEDGEMENTS

The project team would like to thank Mike Spence and the staff at Churchill abattoir for the help and technical assistance throughout the project.

6. APPENDIX 1 – Summary of effluent sampling results

	Date	Alley	Raw materials	Paunch separator	Manhole	Cattle yards	Render	Saveall
pH	6/5/11	6.15	6.03	-	6.98	6.37	6.03	6.33
	14/7/11	5.96	6.24	6.36	7.05	8.01	6.01	6.37
	28/7/11	6.02	5.82	-	7.06	8.01	5.87	6.03
	Mean	6.04	6.03	6.36	7.03	7.46	5.97	6.24
	MIN	5.96	5.82	6.36	6.98	6.37	5.87	6.03
	MAX	6.15	6.24	6.36	7.06	8.01	6.03	6.37
ALL	MIN	5.82						
	MAX	8.01						
	Mean	6.46						
	Date	**Alley**	**Raw materials**	**Paunch separator**	**Manhole**	**Cattle yards**	**Render**	**Saveall**
EC	6/5/11	5600	1160	1810	2770	-	1610	2380
	14/7/11	2700	1890	1790	774	5250	1990	2240
	28/7/11	2220	2160	-	812	4580	1890	3010
	Mean	3507	1737	1800	1452	4915	1830	2543
	MIN	2220	1160	1790	774	4580	1610	2240
	MAX	5600	2160	1810	2770	5250	1990	3010
ALL	MIN	774						
	MAX	5600						
	Mean	2455						
	Date	**Alley**	**Raw materials**	**Paunch separator**	**Manhole**	**Cattle yards**	**Render**	**Saveall**
TSS	6/5/11	-	2580	8020	2840	-	4820	9100
	13/5/11	3240	1640	4780	272	1090	9220	3660
	6/7/11	4760	3740	4020	533	620	2930	5080
	14/7/11	6280	1270	3740	1140	1050	4590	478
	21/7/11	5600	2660	-	186	300	9820	5140
	28/7/11	3680	4680	-	832	820	4560	15800
	Mean	4712	2762	5140	967	776	5990	6543
	MIN	3240	1270	3740	186	300	2930	478
	MAX	6280	4680	8020	2840	1090	9820	15800
ALL	MIN	186						
	MAX	15800						
	Mean	3831						
	Date	**Alley**	**Raw materials**	**Paunch separator**	**Manhole**	**Cattle yards**	**Render**	**Saveall**
TKN	6/5/11	1140	306	390	2300		583	809
	13/5/11	330	342	470	495	252	1290	472
	6/7/11	870	655	266	315	439	940	385
	14/7/11	142	84.5	30.4	63.8	478	815	418
	21/7/11	980	468	-	585	162	1090	227
	28/7/11	392	458	-	1220	360	415	302
	Mean	642	386	289	830	338	856	436
	MIN	142	85	30	64	162	415	227
	MAX	1140	655	470	2300	478	1290	809
ALL	MIN	30						
	MAX	2300						
	Mean	557						

	Date	Alley	Raw materials	Paunch separator	Manhole	Cattle yards	Render	Saveall
TN	6/5/11	1140	307	390	2300	-	584	809
	13/5/11	331	342	471	496	252	1290	472
	14/7/11	142	84.5	30.7	64.3	478	816	418
	21/7/11	980	468	-	586	162	1090	227
	28/7/11	392	458	-	1220	360	415	302
	Mean	597	332	297	933	313	839	446
	MIN	142	85	31	64	162	415	227
	MAX	1140	468	471	2300	478	1290	809
ALL	MIN	31						
	MAX	2300						
	Mean	559						
	Date	**Alley**	**Raw materials**	**Paunch separator**	**Manhole**	**Cattle yards**	**Render**	**Saveall**
TP	6/5/11	77.3	23.5	88.3	19.1	-	62.5	96.8
	13/5/11	36.5	36.2	125	1.74	62.5	64.5	64.2
	6/7/11	108	94.5	80.5	40.8	102	104	106
	14/7/11	119	92.7	68.9	1.06	86.8	55	78.8
	21/7/11	138	53	-	11.6	43.3	49.6	48.6
	28/7/11	60.5	52.2	-	11.3	81	46	92
	Mean	89.9	58.7	90.7	14.3	75.1	63.6	81.1
	MIN	36.5	23.5	68.9	1.1	43.3	46.0	48.6
	MAX	138.0	94.5	125.0	40.8	102.0	104.0	106.0
ALL	MIN	1.1						
	MAX	138.0						
	Mean	66.2						
	Date	**Alley**	**Raw materials**	**Paunch separator**	**Manhole**	**Cattle yards**	**Render**	**Saveall**
FOG	6/5/11	2740	909	3400	5	-	897	1270
	13/5/11	591	279	309	6	9	726	518
	6/7/11	524	696	370	10	11	377	1040
	14/7/11	-	185	420	72	24	845	656
	21/7/11	508	356	-	58	13	155	201
	28/7/11	672	1100	-	93	38	568	561
	Mean	1007	588	1125	41	19	595	708
	MIN	508	185	309	5	9	155	201
	MAX	2740	1100	3400	93	38	897	1270
ALL	MIN	5						
	MAX	3400						
	Mean	558						
	Date	**Alley**	**Raw materials**	**Paunch separator**	**Manhole**	**Cattle yards**	**Render**	**Saveall**
COD	6/5/11	15400	4580	10700	22200	-	8280	13300
	13/5/11	6620	5220	14200	6840	1150	20100	10600
	6/7/11	12100	9980	6620	3240	1720	6570	11800
	14/7/11	15400	9220	7760	2500	2580	10300	10100
	21/7/11	20600	12100	-	9710	909	20800	9540
	28/7/11	8500	11800	-	12700	1620	8260	9520
	Mean	13103	8817	9820	9532	1596	12385	10810
	MIN	6620	4580	6620	2500	909	6570	9520

	MAX	20600	12100	14200	22200	2580	20800	13300
ALL	MIN	909						
	MAX	20600						
	Mean	13103						
	Date	**Alley**	**Raw materials**	**Paunch separator**	**Manhole**	**Cattle yards**	**Render**	**Saveall**
VA	6/5/11	1130	244	503	1510	-	259	585
	13/5/11	228	188	439	40	44	183	217
	6/7/11	1370	748	419	62	288	500	518
	14/7/11	1120	676	615	109	263	732	798
	21/7/11	1340	774	-	145	70	-	839
	28/7/11	851	839	-	126	131	665	973
	Mean	1007	578	494	332	159	468	655
	MIN	228	188	419	40	44	183	217
	MAX	1370	839	615	1510	288	732	973
ALL	MIN	40						
	MAX	1510						
	Mean	541						

Note:

- Denotes sample not taken

7. APPENDIX 2 – Summary of Results for Raw Effluent and Pond Influent/Effluent Characterisation

Parameter	Alley	Raw materials	Paunch separator	Manhole	Cattle yards	Render	Saveall	*Pond A (influent)*	Pond A (effluent)	*Pond B (influent)*	Pond B (effluent)
pH	6.04	6.03	6.36	7.03	7.46	5.97	6.24	*7.33*	7.32	*7.27*	7.32
EC	3507	1737	1800	1452	4915	1830	2543	*3065*	3842	*3504*	3832
TSS	4712	2762	5140	967	776	5990	6543	*2799*	1723	*2773*	1218
TKN	642	386	289	830	338	856	436	*443*	369	*451*	378
NH3-N								*160*	253	*183*	274
TN	597	332	297	933	313	839	446				
FOG	1007	588	1125	41	19	595	708	*425*	171	*575*	106
COD	13103	8817	9820	9532	1596	12385	10810	*6104*	3180	*6534*	2849
VA	1007	578	494	96	159	468	655		559		379