final report

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An assesment of dry paunch dumping in red meat processing plants

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EXECUTIVE SUMMARY

This report presents the results of Stage 1 and 2 of Project PRENV.008, 'An Assessment of Dry Paunch Dumping in Red Meat Processing Plants' commissioned by AMPC.

The wet processing of paunch contents has been identified as a major contributor to the overall nutrient load in wastewater at meat processing plants. Wet processing entails the dumping of the paunch contents into the waste stream in conjunction with the wash water used to clean the paunch before further processing. In the Meat Research Corporation Report M.445 (MRC, 1995), the manure and paunch contents were clearly identified as the major source of phosphorus in wastewater and were ranked second and third for COD and nitrogen contributions to wastewater, respectively. In an overall sense, the paunch contents were ranked as the second most significant waste source in an abattoir. A recommendation of that report was that the paunches are dry dumped, with the contents kept separate from the wash water.

The overall aim of this project was to determine the wastewater load generated in an abattoir performing dry dumping of paunch contents and compare the results with that generated by the traditional wet processing method. Options for treating this stream were also to be evaluated. The dry dump process involves dumping paunch contents without the addition of water, followed by either no further washing (very dry dumping – Stage 1), or an umbrella wash of the empty paunch ("dry dumping" – Stage 2). AMH Dinmore routinely uses the latter process.

The Australian Meat Holdings' (AMH) Dinmore meat processing plant site was identified as a suitable location for the project, due to their use of the dry-dump process and willingness to be involved in the research project. Permission was obtained from Meat and Livestock Australia (MLA) and AMH to access this site. After a tour of the facility, three waste streams from the paunch processing area were identified. These were the umbrella wash (after static screening), dry dump liquid (after screening through a Contrashear rotary drum screen), and the liquid from a Spirac screw press.

Data collection was performed in two stages. Stage 1 was performed over a two week period in March/April 2000, during which four days were spent at the meat processing plant taking samples from the three streams on an hourly basis. A total of 74 samples were collected during this time and were analysed for suspended solids (TSS), both total and soluble COD (TCOD & SCOD), ammonia, total Kjeldahl nitrogen (TKN), total phosphorus (TP) and ortho-phosphate. The flowrate of each stream was measured at the time of sampling, except for the umbrella wash that could not be measured due to the physical installation.

Stage 2 was performed in December 2000, over two consecutive days. A total of 33 samples were collected and analysed for the same parameters as measured in Stage 1. A combined sample of the dry dump and screw press streams was taken as they were found to be not significantly different in Stage 1

The results from this study revealed that the load from the dry dump and screw press waste streams was approximately 58 – 64 kg N and 51 – 53 kg P each day. These

streams therefore represent only 4% of the nitrogen load but 16 - 21% of the phosphorus load emitted from the Dinmore plant. The contribution to the overall load from the umbrella wash is small, as the concentration of this stream is approximately 25% or less of the dry dump streams and nutrient load is only approx. 15% of the combined dry dump and screw press stream.

Water consumption for paunch processing, excluding the umbrella wash and the tripe processing machine (*la parmentiere*), was approx. 65 - 85 kL/day or 2% of the total effluent flow from the meat processing plant, which equates to approx. 22 – 28 litres per paunch. Including the umbrella wash this is approx. 42 – 48L per paunch. This is significantly less than that typically encountered in the wet dump process, which ranged from 240 – 390 L per paunch in the MIRINZ study conducted in 1996. The recently completed Offal.com project, also based at AMH Dinmore, estimated total water consumption during dry dumping, mountain chain washing and tripe processing of 94 litres (The Fifth Quarter, April 2001).

The study has identified that the wastewater generated in this process contributes 16 - 21% of the phosphorus load on the wastewater treatment plant. This is a significant contribution from such a low volume stream, which represents only 2% of the total daily flow. The fraction of the total P load generated by paunch processing has reduced from nearly 50% when the Dinmore plant used the conventional wet dump process to 16%.. Nitrogen load from this stream only accounts for 3% of the total N load.

During stage 2 a significant fraction of cattle processed were grain fed. The data show that this increased pollutant concentrations in the dry dumped waste streams by between 30 to 185%. TSS (185%), TCOD (154%) and TN (185%) increased by the greatest amount, whereas TP was increased only 40%. This suggests that separate capture of grain-fed paunch streams will be of even greater benefit than for grass-fed paunches.

The dry dump waste streams are suitable for segregation and separate treatment. Total Phosphorus (TP) and Total Nitrogen (TN) concentrations in the dry dump and screw press streams are of the order of 600 – 900 mg/L and 650 – 1,100 mg/L, respectively. This compares to typical values in raw meat processing wastewater of 30 – 50 mg TP/L and 160 – 300 mg TN/L.

The most appropriate treatment processes, in order of ease of implementation, are:

- Use the separated streams to moisten composting operations where the fine solids and nutrients are adsorbed in the solids. This would be cost-effective, create no sludge and maximise beneficial reuse of nutrients. The only issue may be that of excess liquid. Also the microbial load of the dumped streams would probably require them to be added to composting only in the early stages of the heap, otherwise they may survive the process.
- Chemical precipitation (eg. alum) to remove the solids and phosphorus as well as some organic nitrogen and COD. The sludge could then be potentially disposed of to the compost heap.
- Struvite crystallisation may be an option, but there is insufficient ammonium nitrogen form to make it feasible without adding a separate stream. Struvite precipitation would generate a potentially valuable fertiliser by-product, although

the technology has not been applied to meat processing wastewater treatment at full scale.

A small equalisation tank of less than 100kL would be required in all cases.

ABBREVIATIONS

Alum	Aluminium sulphate
AMH	Australian Meat Holdings Pty Ltd
COD	Chemical Oxygen Demand
CSIRO	Commonwealth Scientific and Industrial Research Organisation
FIA	Flow Injection Analyser
kL	Kilolitre
kL/d	Kilolitre per day
mg/L	milligrams per litre
MLA	Meat and Livestock Australia
ML	megalitre
ML/d	megalitre per day
MIRINZ	Meat Industry Research Institute of New Zealand
MRC	Meat Research Corporation
N	nitrogen
P	phosphorus
ppm	parts per million (equivalent to mg/L)
SBR	Sequencing Batch Reactor
SCOD	Soluble Chemical Oxygen Demand
SD	Standard Deviation
TCOD	Total Chemical Oxygen Demand
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
VFA	Volatile Fatty Acid

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1 INTRODUCTION

1.1 Aims

The aims of this project were to:

- Determine the wastewater load generated in an meat processing plant performing dry dumping of paunch contents.
- Compare this to the wastewater load generated by the traditional wet processing method.
- Evaluate the options for handling this stream.

1.2 Background

The paunch, or rumen, is an organ specific to ruminant animals. Cellulose and other plant polysaccharides are digested inside the paunch through the activity of special microbial populations. Cows, sheep and goats are ruminants and in the case of meat processing, are the principal sources of red meat in Australia.

The wet processing of paunch contents has been identified as a major contributor to the overall nutrient load (load is defined as kg of pollutant generated per day) in wastewater at meat processing plants. The nominal weight of the paunch is about 73 kg with the contents consisting of 29 kg water and 25 kg paunch solids. Wet processing entails the dumping of the paunch contents into the waste stream in conjunction with the wash water used to clean the paunch before further processing.

In Meat Research Corporation (MRC) Report M.445 (1995), the manure and paunch contents were clearly identified as the major source of phosphorus in meat processing plant wastewater and were ranked second and third for COD and nitrogen contributions respectively. In an overall sense, the paunch contents were ranked as the second most significant wastewater stream in an meat processing plant. A recommendation of that report was that the paunches are dry dumped, with the contents kept separate from the wash water. Typically, dry dumping is assumed to mean the dumping of contents without added water, followed by an umbrella wash of the emptied paunch.

In the book, "Abattoir Waste Water and Odour Management" (CSIRO, 1993), a similar recommendation is made to again minimise this load on the wastewater treatment plant. It is noted that the dry-dumped contents are then eminently suitable for composting with other waste materials or, in some instances, may be spread directly on suitable land.

In the MRC Report M.445, involving a study of 5 Australian meat processing plants, it was identified that manure and paunch contents contributed 36% of the phosphorus load and 12% each of the COD and nitrogen load discharged in the raw wastewater. MIRINZ (1996) found over 50% of the phosphorus load, 30 – 50% COD load and 20% nitrogen load came from the wet paunch processing of beef cattle.

The MIRINZ report also compared wet versus dry dumping of paunches in four meat plants and found that the dry-dump process used 3 - 7% of the water consumed in the wet dump process. This resulted in approximately a four-fold reduction in nutrient loads in the effluent, although the concentrations in the final waste streams actually increased due to the reduced water use. This offers benefits in terms of capture and treatment separate from the main wastewater.

The benefits of dry dumping paunches are considered to be:
1. Reduced potable water consumption through elimination of wet-paunch processing resulting in lower town water charges and/or reduced wastewater treatment costs.
2. Reduced wastewater generation.
3. Deferred capital expenditure by extending the life span of the wastewater treatment plant.
4. Potentially reduced nutrient loading (COD, nitrogen and phosphorus) to the wastewater treatment plant, as the paunch contents are no longer mixed into this stream, but segregated and handled separately.
5. Lower operational costs of wastewater treatment plants due to reduced organic load. There will be less power consumption due to lower aeration demand and less volume to be pumped.
6. Less sludge accumulation in lagoons due to reduced pollutant loads that will result in less frequent de-sludging of lagoons.
7. Increased irrigation area life since phosphorus accumulation in soils of an irrigation area defines the sustainable life of the area.
8. Potential simplification of the operation of the wastewater treatment plant based on the reduced nutrient load.

1.3 Methodology

The data collection work was performed in two stages:

Stage 1 of the project had the following aims:

- To evaluate the change in wastewater characteristics in a "very dry-dump" paunch installation as compared to a wet-dump process.
- To investigate the benefit of dry-dumping paunches.
- To evaluate the benefits of separating the paunch waste stream from the main waste stream.

Stage 2 was a repeat of Stage 1 with the express aim of determining if seasonal changes had also resulted in a change to the wastewater or loading. It was also an attempt to close the mass balance around the paunch process area. In Stage 2, a dry dump process incorporating an umbrella wash of the emptied paunch was used.

This report covers both Stages 1 and 2 of the work. The sampling method and analyses performed on the samples are described in Section 3, with the results tabulated in Section 4 and Appendix C. The results are discussed in Section 5 with the recommendations outlined in Section 6.

2 THE SITE

2.1 Site Selection

The first stage of this project entailed identifying an appropriate site for performing the data collection exercise.

The proposal targeted Australian Meat Holding's meat processing plant at Dinmore near Brisbane to be utilised in this project. This site was appropriate for this study for a number of reasons:

- Proximity to laboratories.
- Use of wet and dry dumping methods.
- Company interest in enhancing wastewater treatment.
- Previous successful collaboration with AMH (Dinmore was the site for the Offalcom project studying the food safety implications of dry dumping)

An initial site meeting was held at AMH on the 24th March 2000 with the General Manager Jim Yates, Environmental Officer Greg Brennan, Mike Johns from MLA and Paul Lant and Justin Doyle from AWMTech P/L. After permission was granted to access the site, the paunch processing room on the kill floor and the screenings area on the floor below were evaluated. During this evaluation, three streams were identified which could be sampled and which would represent the characteristics of the paunch process waste streams. These were the umbrella wash stream (after screening), the dry dump liquid stream (after the contra-shear), and the liquid stream from the screw press. The possibility of sampling the stream from the tripe processing machine (*la parmentiere*) was investigated, but this was not possible because of lack of direct access to the effluent for sample collection.

Prior to the commencement of Stage 2 a meeting was held with Wally Scofield (AMH), Mike Johns (MLA), Paul Lant and Justin Doyle (AWMTech P/L) on the 21st September. At this meeting we were informed by Wally that the method of paunch processing had changed from that used during the Stage 1 evaluation.

The description of the two AMH paunch processes follows.

2.2 AMH Dinmore Dry Dump Process Descriptions

Stage 1 – Dry Dump Process

After removal of the paunch from the animal on the kill floor, the paunch is transferred to the gut room where it is cut open and the contents dumped down a chute (dry dump). No water is applied to the paunch in this step. The operator makes a decision at the time of dumping the paunch contents, which if "too dry" are placed over the umbrella wash *after* dry dumping to rinse the contents before further processing. During Stage 1 approximately a quarter of paunches received further washing. The paunch then enters the tripe washing machines (*la parmentieres*), where it is given a hot scalding. The process flowsheet is shown in Figure 1.

Stage 2 – Semi-Dry Dump Process

For Stage 2 however, *ALL* paunches were being rinsed in the umbrella wash after dry dumping and prior to the tripe washing stage. This is shown in Figure 2.

The umbrella wash stream leaves the kill floor and falls to the ground floor into the offal area. The wash liquid passes over a static screen, before entering the green waste system and transfer to the ponds.

The dry dump paunch contents also passes to the lower level into the offal area. The stream passes through a contra-shear for screening with the liquid stream entering into the green waste system (separate discharge to the umbrella wash) and transfer to the ponds. The solids screened from the contra-shear are further dewatered via a screw press. The solids are transferred to a truck for land disposal and the liquid stream enters the same green waste discharge as the original liquid stream for transfer to the ponds.

It is the three waste streams identified as the dry dump, umbrella wash and screw press that were collected for the intensive sampling study. For Stage 2 the streams designated dry dump and screw press were collected as a single sample to reflect their common source and characteristics.

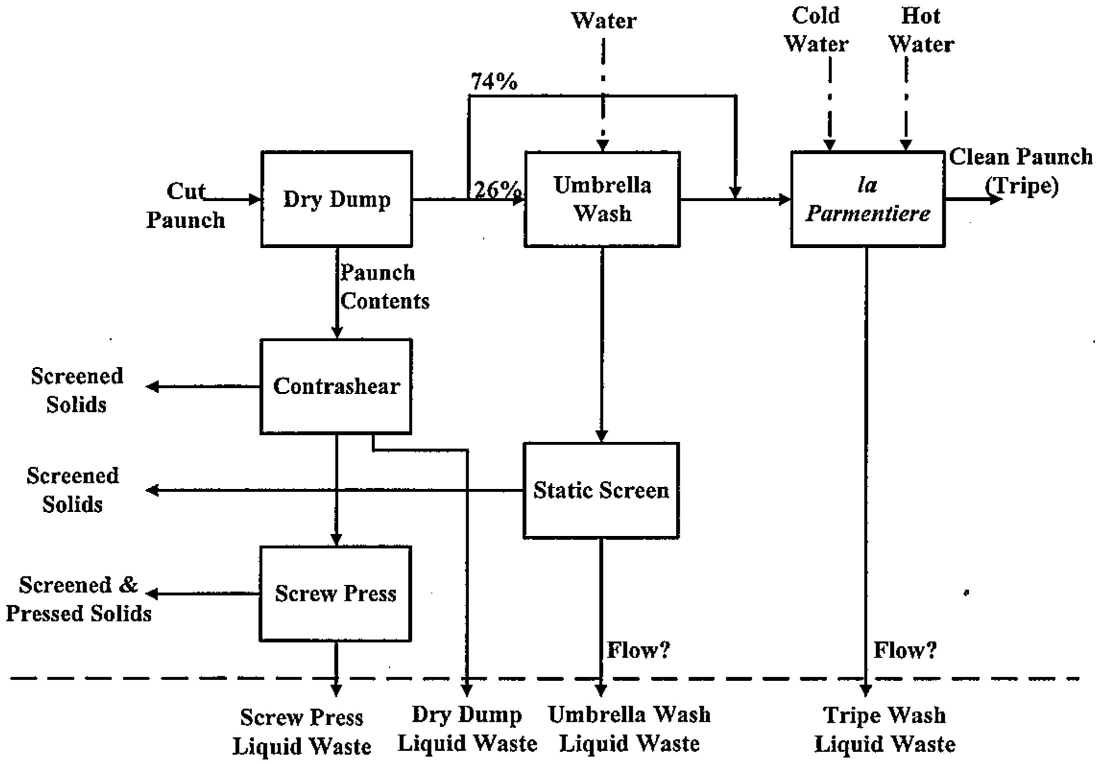

Figure 1. Paunch dry dump processing flowsheet – Stage 1

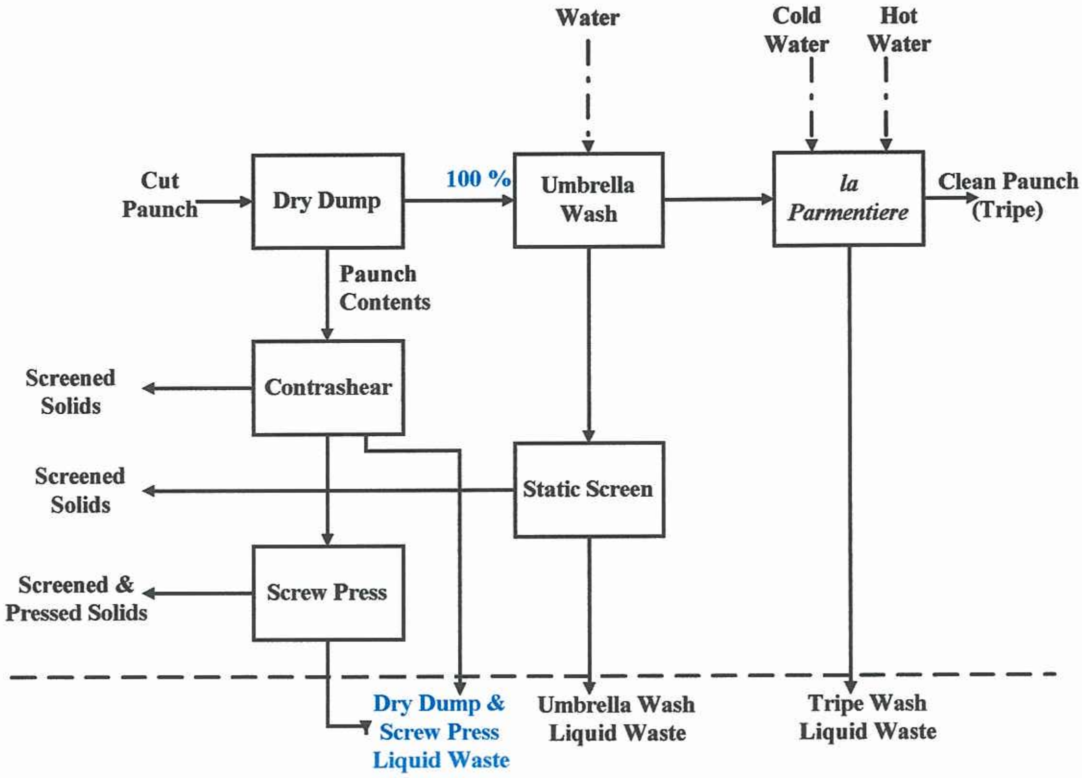

Figure 2. Paunch processing flowsheet – Stage 2

3 METHOD

A series of intensive sampling studies were performed to evaluate the characteristics of the wastewater generated as well as the volume of water used. The data collection was performed in two stages. Both exercises are described in detail here.

3.1 Sampling – Stage 1

Samples were taken on four separate days, over a two-week period. On each day of sampling, grab samples were taken from the three wastewater streams hourly where possible. This is shown in Figure 3. At times there was no flow from some of the streams and these times have been identified accordingly. Approximately 1L of each waste stream was collected and taken back to the on-site laboratory for preservation. An unfiltered sample (approx. 70 mL) was set aside for TCOD, TKN, TP and TSS analysis and a filtered sample (approx. 70 mL) was set aside for SCOD, ammonia and ortho-phosphate measurements.

3.2 Sampling – Stage 2

Samples were taken on two consecutive days, in December 2000. On each day of sampling, grab samples were taken from two wastewater streams hourly where possible. This is shown in Figure 4. At times there was no flow from one of the streams and these times have been identified accordingly. Approximately 1L of each waste stream was collected and taken back to the on-site laboratory for preservation. An unfiltered sample (approx. 70 mL) was set aside for TCOD, TKN, TP and TSS analysis and a filtered sample (approx. 70 mL) was set aside for SCOD, ammonia and ortho-phosphate measurements.

3.3 Flow Measurement

The liquid stream from the contra-shear and screw press flowed relatively continuously, although the flowrate varied considerably. It was possible to use a bucket and stopwatch to estimate the flow at the time of sampling. This flow measurement was made three times and the average result recorded. Flow measurement from the umbrella wash stream was not possible due to its intermittent operation and design constraints that meant that collecting the flow was not possible. However, a design and operation figure of 20L per paunch was used for the load calculations. This was obtained from one of the offal area supervisors at AMH, Wally Scofield.

3.4 Analyses

Liquid samples were analysed for TSS, TCOD, SCOD, TKN, TP, ammonia and ortho-phosphate. The pH of the sample was also measured at the time of sampling. All analyses were performed to the APHA Standard Method as outlined in Table 1 below. The unfiltered samples were sonicated before the TCOD, TKN or TP analyses were performed, to break up the larger particles and aid the digestion step.

Table 1. Analytical Method and Reference

Test	APHA Standard Method
SCOD	5220 D. Closed Reflux, Colorimetric
TCOD	5220 D. Closed Reflux, Colorimetric
TSS	2540 D. TSS Dried @ 103 – 105°C
TKN	4500-N_{org} D. Block Digestion and Flow Injection Analysis
TP	4500-P H. Manual Digestion and Flow Injection Analysis for TP
Ammonia	4500-NH_3 H. Flow Injection Analysis
Ortho-P	4500-P G. Flow Injection Analysis for Ortho-phosphate

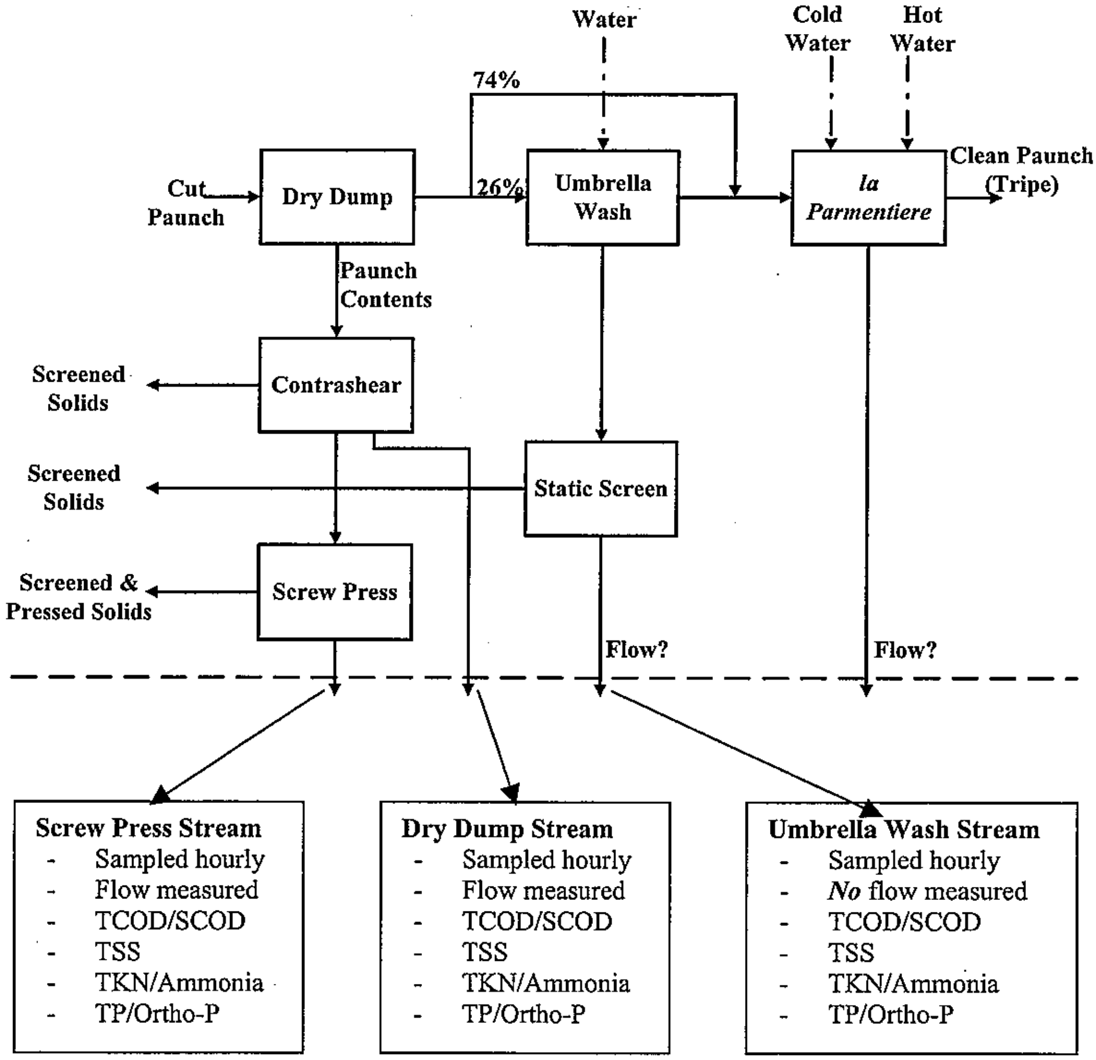

Figure 3. Sample and analysis summary – Stage 1.

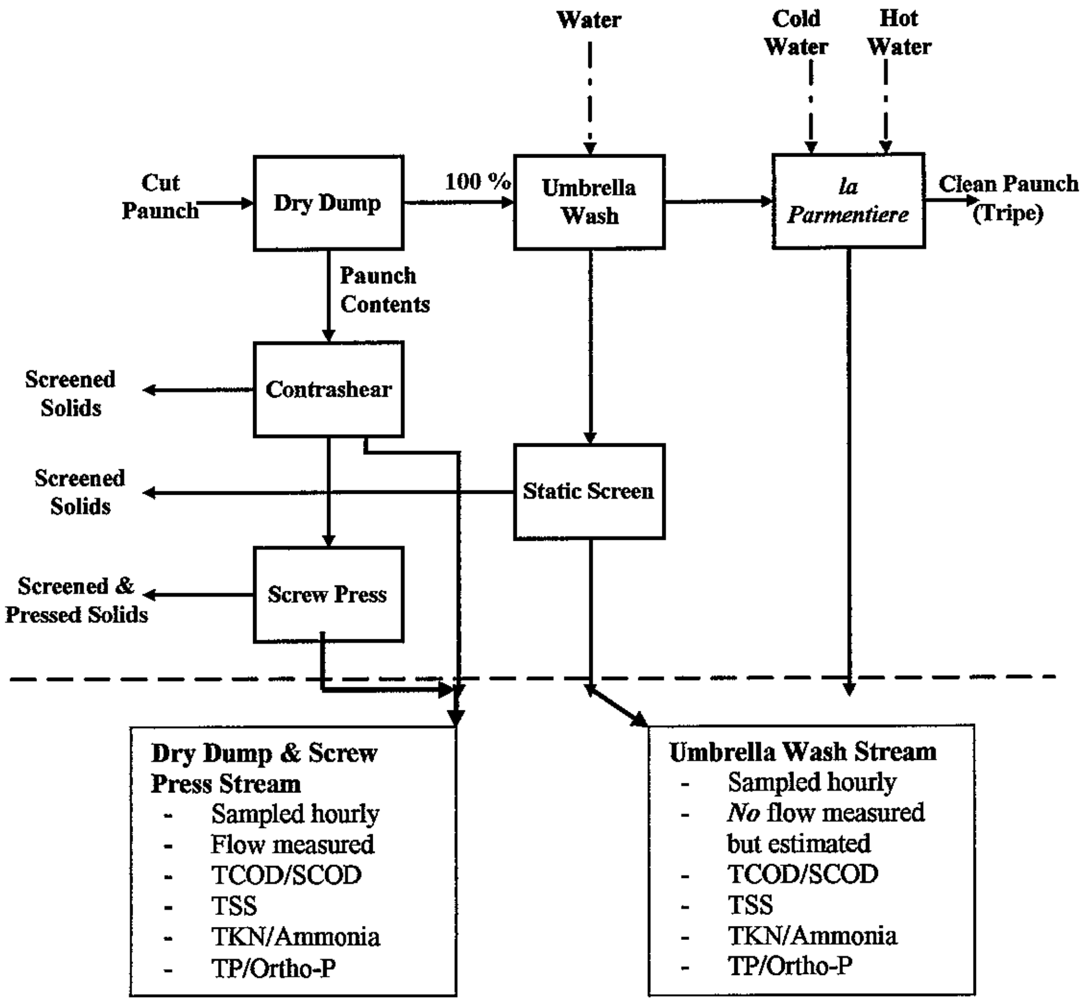

Figure 4. Sample and analysis summary – Stage 2.

3.5 Limitations

Sample collection in an operational plant is often restricted by practical limitations. In this study, there were several practical complications that limited the study:

- Flow sampling, particularly the umbrella wash was difficult and this is reflected in the variability of the results.
- Inaccessibility of wastewater from the tripe processing machine, which meant that effluent flow and analyses could not be determined. This may be a significant source of phosphorus as the 1995 MRC study estimate of P generated during paunch processing included tripe processing.
- In Stage 2 there were periods when the screw press stream was being pumped away to a holding tank. At these times it was not possible to acquire a sample from this stream.

4 RESULTS

4.1 Stage 1 – Dry Dump Paunch Processing

MRC Report M.445 (1996) recommended paunches be dry-dumped and that the contents be kept separate from the wash wastewater, as a result of the finding that the manure and paunch streams were clearly the major source of phosphorus in wastewater. They were ranked second and third for COD and nitrogen respectively. The report also found 36% of the P load and 12% each for the COD and nitrogen load were contributed by the manure and paunch streams.

MIRINZ bulletin No. 33 evaluated a similar dry dump process to what is currently in use at AMH Dinmore in which the paunch contents were dumped and then each paunch washed thoroughly (but using a hand held spray in the MIRINZ study). They found that 10% TSS, 14% of the TKN and 11% of the TP in the paunch material remained in the paunch sac after dry dumping, which was then washed out during the spray wash. This is a similar approach to the Dinmore process where the paunches are first dry dumped and then washed over the umbrella wash. In Stage 1 only a quarter of the paunches were washed in the umbrella wash however, in Stage 2, ALL paunches were washed prior to the *la parmentiere.*

The following results, shown in Tables 2, 3, 4 and 5 and Figures 5, 6 and 7, summarise the data obtained during the Stage 1 study.

Table 2. Stage 1 Umbrella Wash Results and Statistical Representation

	TSS (mg/L)	TCOD (mg/L)	SCOD (mg/L)	TKN (mg/L)	NH_4-N (mg/L)	TP (mg/L)	Ortho-P (mg/L)
Mean	2,738	4,428	474	110	8	71	44
Minimum	1,000	1,540	30	46	3	27	17
Maximum	9,150	14,675	1,303	220	17	150	95
50 Percentile	2,113	3,335	440	87	7	65	39
90 Percentile	5,200	7,685	779	188	13	106	68
Geometric mean	2,292	3,743	377	99	8	66	40

By way of explanation, the mean is the average of all the individual results, the minimum is the lowest value in the set of results and the maximum is the highest value in the set of results. The 50 percentile is that value which 50% of the results in a set of data is equal to or less than and the 90 percentile is that value which 90% of the results in a set of data is equal to or less than. Thus the higher the percentile, the closer the value becomes to the maximum. The geometric mean is often found to be a better estimate of the average in highly variable data sets typical of effluent characterisation.

For discussion purposes, the mean value has been used throughout the report and is highlighted in the tables to clearly identify this.

The umbrella wash stream is typically weaker than the dry dump/screw press streams by approx. 75 – 90% the concentration of the other streams. This finding is consistent with other dry dump installations (MIRINZ). As mentioned earlier, the flow could not be measured from the umbrella wash but for the purpose of calculating nutrient loads from this stream we have used the design figure of 20L per paunch. Table 2 shows the characteristics of the umbrella wash which are significantly weaker than the dry dump and screw press characteristics which are shown in Tables 3 and 4 respectively.

Table 3. Stage 1 Dry Dump Stream Results and Statistical Representation

	Flow (L/min)	TSS (mg/L)	TCOD (mg/L)	SCOD (mg/L)	TKN (mg/L)	NH_4-N (mg/L)	TP (mg/L)	Ortho-P (mg/L)
Mean	50	12,922	19,576	2,254	666	47	595	325
Minimum	15	1,525	8,690	720	252	15	308	146
Maximum	98	24,800	34,390	5,892	1,128	114	1,197	750
50 Percentile	43	12,475	18,698	2,467	671	41	562	282
90 Percentile	84	20,725	28,303	3,397	1,004	77	879	580
Geometric mean	44	11,261	18,170	1,987	618	43	557	295

The complete results of the sample analyses are shown in Appendix C.

Table 4. Stage 1 Screw Press Stream Results and Statistical Representation

	Flow (L/min)	TSS (mg/L)	TCOD (mg/L)	SCOD (mg/L)	TKN (mg/L)	NH_4-N (mg/L)	TP (mg/L)	Ortho-P (mg/L)
Mean	34	10,980	18,713	2,544	635	52	611	345
Minimum	10	3,925	8,845	905	355	20	300	145
Maximum	58	17,567	29,235	4,536	938	97	1,028	603
50 Percentile	36	10,463	17,468	2,569	671	43	550	322
90 Percentile	46	15,663	25,595	3,815	829	73	877	527
Geometric mean	31	10,391	17,785	2,306	615	48	582	318

The contribution to the overall load from the umbrella wash is small, as the concentration of this stream is approximately 10 - 25% (depending on the parameter) that of the other streams. Using the design figure of 20 L/paunch for Stage 1 we find that the umbrella wash contributes 7 kg nitrogen, 4 kg phosphorus and 266 kg COD per day. This ranges from 9% (P) to 17% (COD) of the load from the dry/screw press stream.

Table 5. Results – Calculated Nutrient Loadings in Dry Dump Waste Streams for Stage 1

Date	COD Load (kg/day)	N Load (kg/day)	P Load (kg/day)
30th March	1564	52	44
4th April	1301	45	45
6th April	1491	53	45
13th April	1974	59	45
Ave Stage 1	1768	58	51

The figures in Table 5 were calculated from the average nutrient concentration for the sample day, times the average flowrate on the same day, extrapolated over a 16.5 hr processing day. No sample could be obtained from the *la parmentiere* stream that meant the mass balance around the system could not be closed. An estimate of the umbrella wash flow was used for calculating the nutrient loads.

The total load on the wastewater treatment plant is estimated to be 1500 kg N and 250 kg P per day. Table 5 shows that the paunch area generated 58 kg N and 51 kg P at this stage. The paunch stream therefore represents only 4 % of the nitrogen load but 23% of the phosphorus load.

Water consumption for this area, excluding the umbrella wash and *la parmentiere*, was approx. 85 kL/day for Stage 1, which equates to nearly 28L per paunch. This excludes the contribution from the umbrella wash, which is specified as 20L per paunch by the operators at AMH, which yields a total of 48L per paunch, again excluding the tripe processing water.

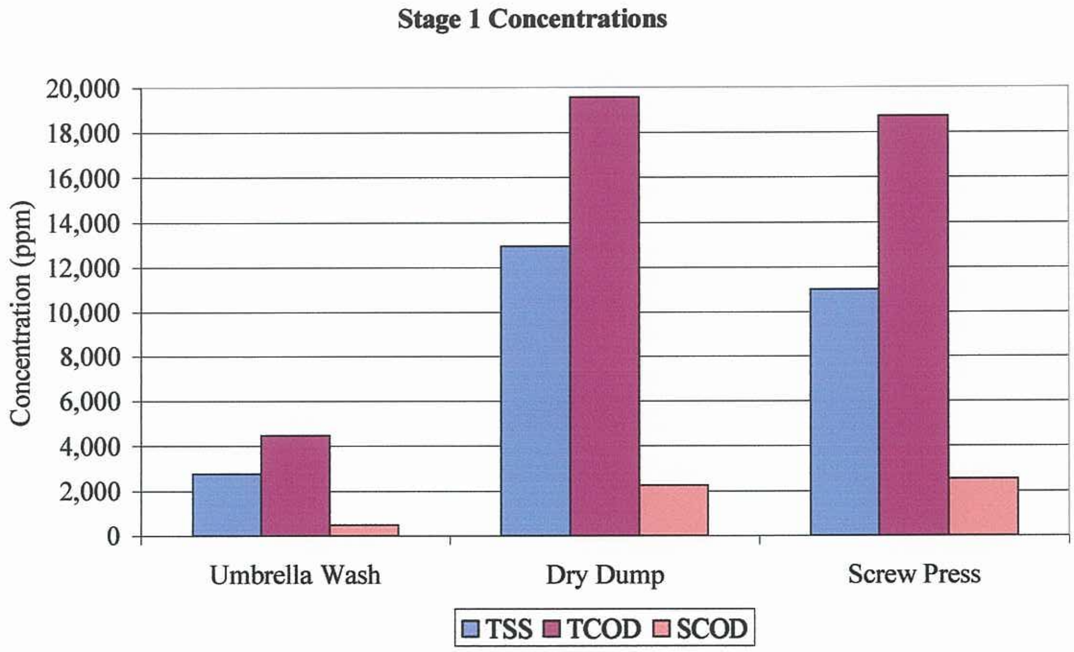

Figure 5. Stage 1 Suspended Solids and COD Average Concentrations.

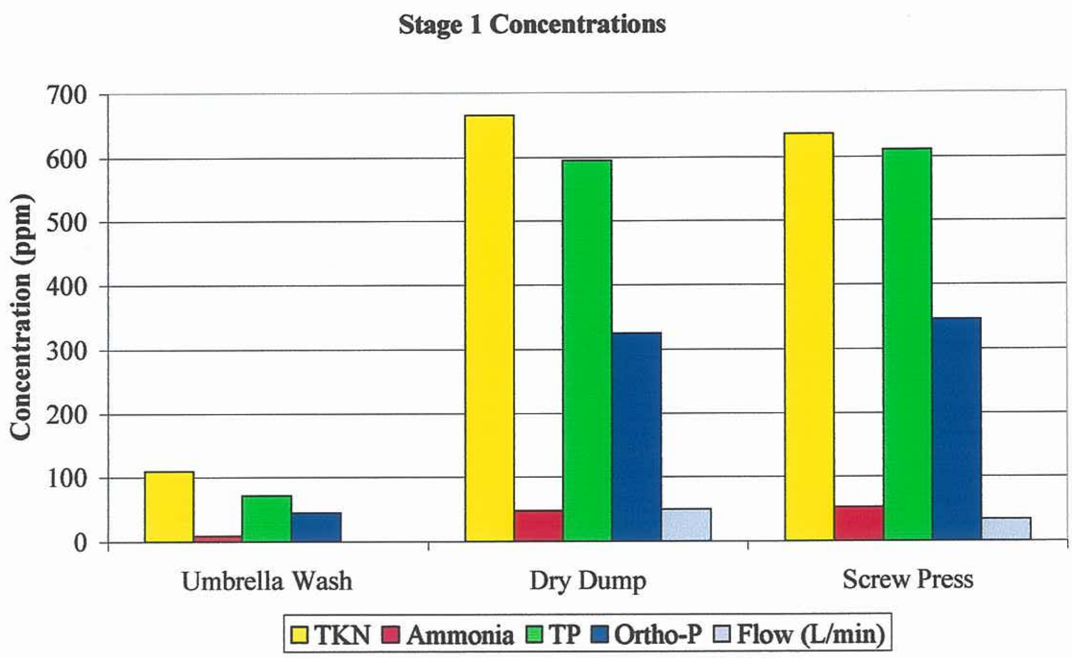

Figure 6. Stage 1 Nitrogen, Phosphorus Average Concentrations and Flow.

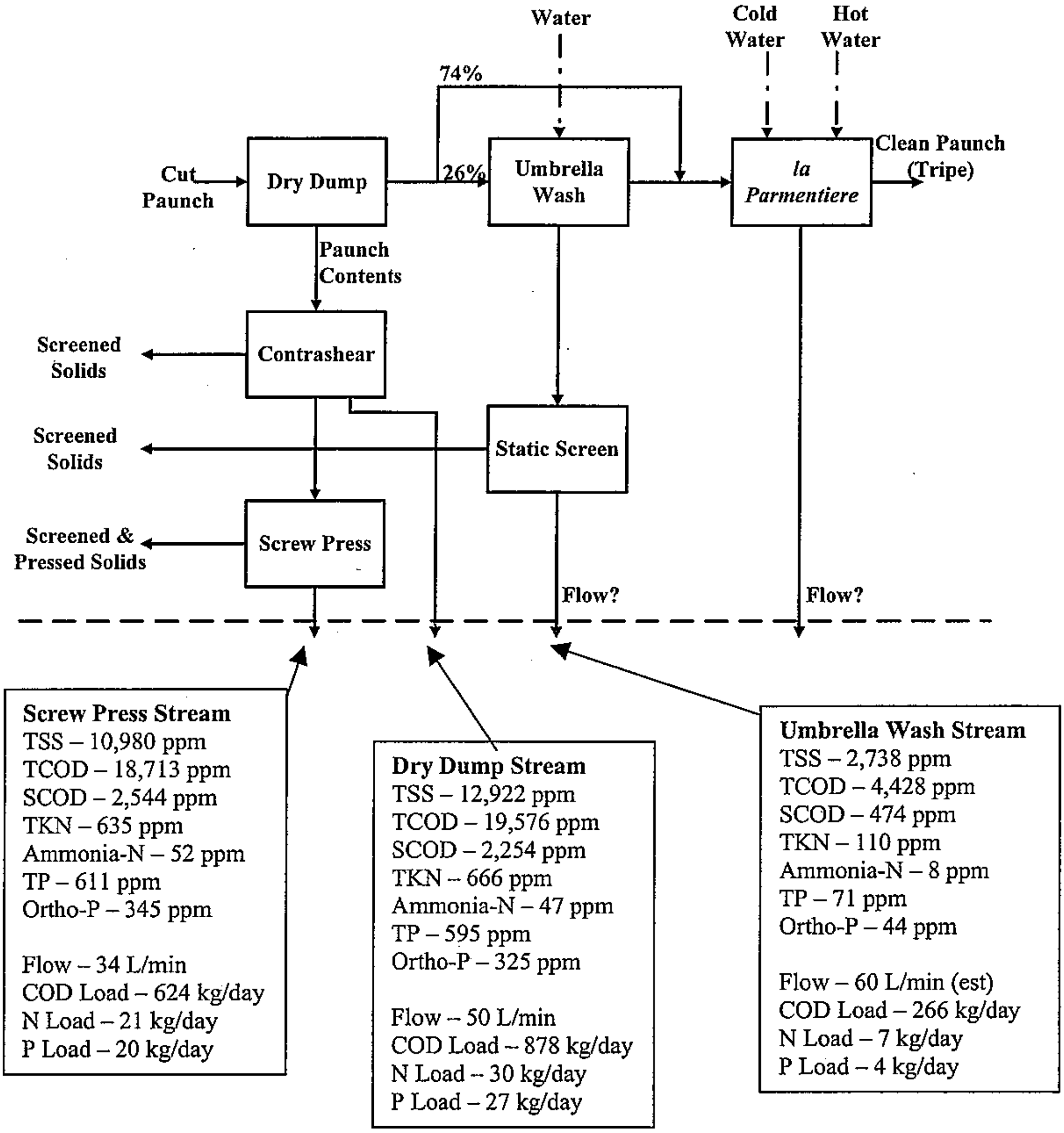

Figure 7. Summary of results – Stage 1

4.2 Stage 2 – Semi-Dry Dump Paunch Processing

In Stage 2, a change in the processing of paunches was investigated that saw all paunches being washed with the umbrella wash after dumping the contents. Again a flowrate for the umbrella wash was estimated based on design and operator input. Due to the process change it was thought to be less important to obtain a sample from the *la parmentiere*, which was still unable to be sampled due to its installation and construction. A discussion of this phase of the project follows with the results shown in Tables 6, 7 and 8 and Figures 8, 9 and 10.

Table 6. Stage 2 Umbrella Wash Results and Statistical Representation

	TSS (mg/L)	TCOD (mg/L)	SCOD (mg/L)	TKN (mg/L)	NH_4-N (mg/L)	TP (mg/L)	Ortho-P (mg/L)
Mean	4,313	1,334	763	237	8	153	107
Minimum	1,220	368	132	39	2	54	42
Maximum	9,920	2,970	2,120	598	26	466	304
50 Percentile	3,520	1,113	532	168	5	110	83
90 Percentile	8,408	2,465	1,619	528	17	246	179
Geometric mean	3,673	1,114	567	183	7	128	93

Water consumption for this area, excluding the umbrella wash and *la parmentiere*, was approx. 67 kL/day, which equates to nearly 22L per paunch for Stage 2. This excludes the contribution from the umbrella wash, which is specified as 20L per paunch by the operators at AMH, which yields a total of 42L per paunch, again excluding the tripe processing water.

Using the design figure of 20 L/paunch we find that the umbrella wash contributes 14 kg nitrogen, 9 kg phosphorus and 80 kg COD per day. This ranges from 5% (COD) to 22% (N) of the load from the dry/screw press stream. Table 6 shows the characteristics of the umbrella wash which are significantly weaker than the dry dump and screw press characteristics which are shown in Table 7.

Table 7. Stage 2 Dry Dump/Screw Press Stream Results and Statistical Representation

	Flow (L/min)	TSS (mg/L)	TCOD (mg/L)	SCOD (mg/L)	TKN (mg/L)	NH_4-N (mg/L)	TP (mg/L)	Ortho-P (mg/L)
Mean	67	22,065	30,123	5,103	1,158	65	943	681
Minimum	33	6,100	7,185	1,085	291	16	438	305
Maximum	90	65,160	62,920	11,435	3,295	161	1905	1,274
50 Percentile	59	14,480	23,310	5,038	805	56	792	596
90 Percentile	86	39,400	55,425	8,355	2,166	125	1,384	890
Geometric mean	57	17,742	25,382	4,225	911	52	886	650

As the waste stream from the *la parmentiere* could not be sampled in Stage 1, the overall mass balance from the paunch processing system was incomplete, although an estimate of the umbrella wash flow enabled a more complete picture. This was overcome partially in Stage 2 due to the change to washing all paunches in the umbrella, which should flush out most of the residual paunch material after dumping.

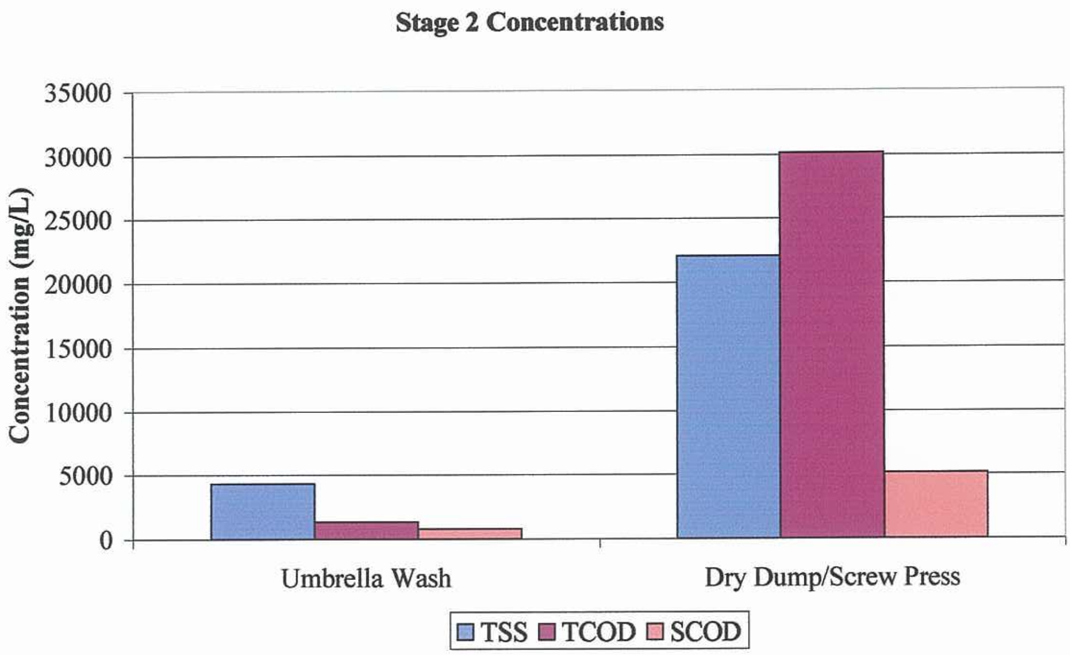

Figure 8. Stage 2 Suspended Solids and COD Average Concentrations.

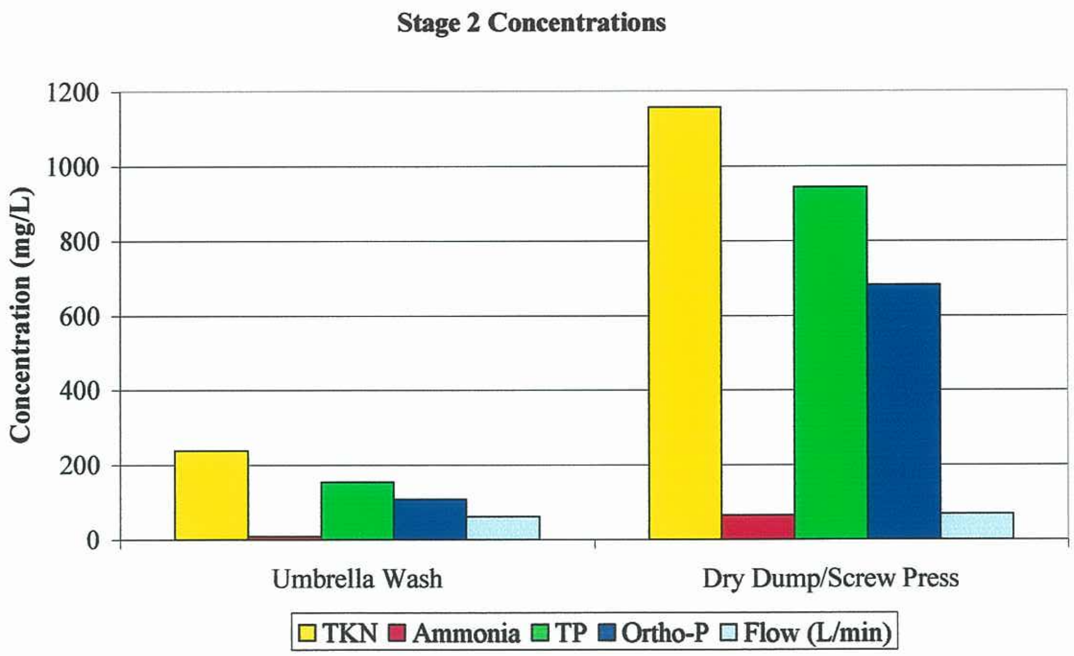

Figure 9. Stage 2 Nitrogen, Phosphorus Average Concentrations and Flow.

Table 8. Results – Calculated Nutrient Loadings for Stage 2

Date	COD Load (kg/day)	N Load (kg/day)	P Load (kg/day)
19th December	1501	64	56
20th December	2064	94	68
Ave Stage 2	1783	78	62

The figures in Table 8 were calculated from the average nutrient concentration for the sample day, times the average flowrate on the same day, extrapolated over a 16.5 hr processing day. No sample could be obtained from the *la parmentiere* stream. An estimate of the umbrella wash flow was used for calculating the nutrient loads.
The total load on the wastewater treatment plant is estimated to be 1500 kg N and 250 kg P per day. Table 8 shows that the paunch area generated 78 kg N and 62 kg P in this stage. The paunch stream therefore represents only 5 % of the nitrogen load but a considerable 25% of the phosphorus load.

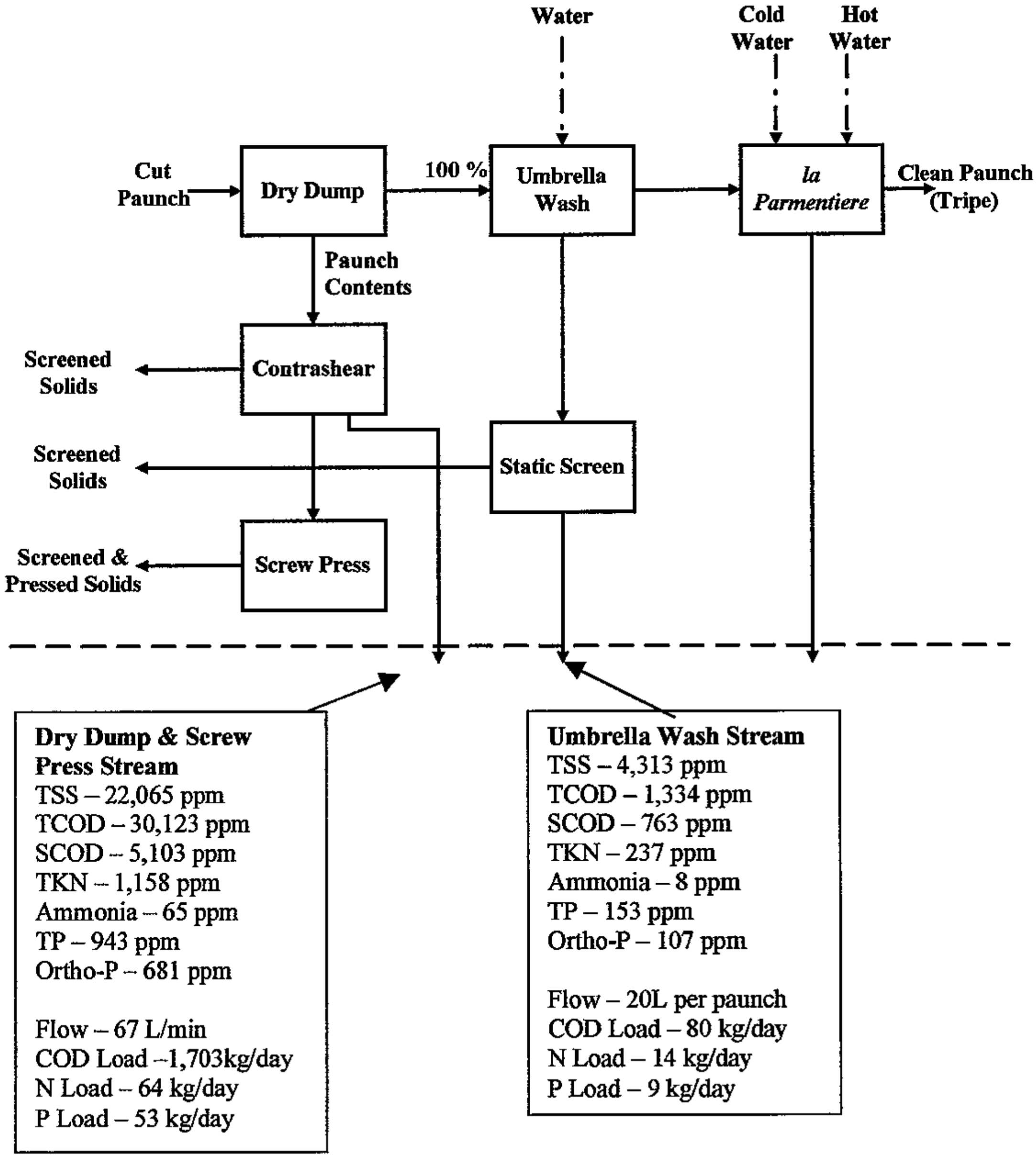

Figure 10. Summary of results – Stage 2

- **Grain-fed cattle generate higher pollutant loads.**

In Stage 2 approx. 70% of samples collected were grain-fed. No samples collected during Stage 1 appeared to be from grain-fed cattle. The visual change in paunch material was dramatic with the grass-fed variety appearing very yellow/green with grass material. Grain-fed paunch material appeared grey/brown in colour and contained, not surprisingly, grain like material.

The results described previously show a significant increase in concentrations from Stage 1 to Stage 2. This is most certainly due to the source of paunch material, which in the case of Stage 2 was mostly grains. To further evaluate this the data collected during Stage 2 was analysed as two distinct categories, those being grass-fed and grain-fed. This is shown in Table 9.

Table 9. Grain-Fed vs. Grass-Fed Paunch Material in Stage 2 (Averages)

	TSS (mg/L)	TCOD (mg/L)	SCOD (mg/L)	TKN (mg/L)	Ammonia -N (mg/L)	TP (mg/L)	Ortho-P (mg/L)
Grain	27,608	37,166	5,884	1,453	74	1,029	732
Grass	9,869	14,628	3,385	510	46	753	568
% change	180	154	73.8	185	60.9	36.6	28.9

The concentration of pollutants from grass-fed samples collected for Stage 2 for the dry-dump/screw press stream are very similar to those collected in Stage 1. The overall increase in concentrations and nutrient load from Stage 1 to 2 is therefore due to the large number of grain-fed cattle being processed at the time of sampling in Stage 2.

This data clearly shows a significant increase in nutrient concentrations for grain-fed cattle. Increased concentrations range from 30% for ortho-P to nearly 200% for TKN. This is due primarily to the increase in suspended solids in the samples which impacts on the TCOD, TKN and TP and to a lesser extent ortho-P and ammonia. The increase in solids may be a result of a higher percentage of the solids from grain-fed cattle passing through the screens as opposed to grass-fed cattle or as a result of the feed composition. The gross solids size was visually greater in grass-fed paunch material than grain-fed paunch material.

This significant difference in paunch material and therefore nutrient load generated by grass-fed versus grain-fed cattle may be due to the elapsed time from last feeding, with grain-fed cattle being "fuller" at the time of slaughter than grass-fed cattle. It may also be due to the composition of the feed, with grains being more concentrated in these nutrient than grass.

- **Water usage**

Water usage per paunch, including the umbrella wash water but excluding the tripe processing water accounted for approximately 48L per paunch for Stage 1 and 42L per paunch for Stage 2. This was based on a 16 & ½ hr shift processing 3000 cattle each day for both Stage 1 and Stage 2. This is significantly less than that typically encountered in the wet dump process, which ranged from 240 – 390 L per paunch (MIRINZ).

- **Nutrient loads per paunch**

A wastewater audit was performed on the old processing plant at Dinmore in 1994, which was utilising wet dump processing, and is reported in MRC Report M.479/M.480. In that report the paunch, offal and tripe processing area contributed 119 g N/paunch and 13 g P/paunch. At that time the plant was processing 1065 head of cattle each day. Under the new dry dump operation investigated in this study, the paunch processing area contributed 19 g N/ paunch and 17 g P/paunch in Stage 1 and 26 g N/paunch and 21 g P/paunch in Stage 2.

The nitrogen load/head has decreased significantly from the wet dump process but the phosphorus load/head has actually increased. Overall totals of nitrogen and phosphorus requiring treatment has increased from 680 kg N & 130 kg P in 1994 to 1500 kg N & 250 kg P in 2000, which represents an approx. two-fold increase whilst the head of cattle processed has increased by nearly 3 times.

It is interesting to note that in 1994 the paunch, offal and tripe processing area accounted for nearly 50% of the P load on the wastewater treatment plant but the new paunch processing area now only contributes 20 - 25%. This may be due to the design of the new plant and the segregation of the paunch, tripe and offal waste streams as well as the dry dump process method. The remaining unknown in this area is the nutrient load released in the tripe processing step. It is possible that the remaining 25% of the P load is liberated at this stage, however this could not be determined in this study.

- **Form of Nutrients**

The major form of nitrogen in the paunch streams is organic nitrogen, represented as TKN. In most samples the ammonia nitrogen fraction of the TKN was very low at less than 6%. However in the case of phosphorus, the predominate form was ortho-P or the soluble form, which accounted for approx. 75% of the total P. A low fraction indicates that the nutrients are associated with the suspended solids. This is ideal for further treatment as the majority of the nutrients could be removed with a simple solids removal step. In this case however, we see a combination that complicates matters.

4.3 Treatment Alternatives

In terms of wastewater management at the meat processing plant, it would be of significant benefit to the wastewater treatment plant if the two concentrated waste streams from the paunch (ie. the dry dump and screw press streams) were not treated as part of the main system. In this case, the N and P loads to the wastewater treatment plant would be reduced by 3% and 20% respectively. These two streams account for only 66 - 85kL each day (approx. 2% of the total flow), which could be segregated and treated separately or alternatively trucked off site.

- **Physical**

Further clarification of this stream as part of a separate treatment process, to remove the majority of the suspended material, would significantly reduce the load on the next step. Suitable clarification could be by sedimentation, flotation, centrifugation or filtration. The solids removed by this step would be suitable for composting as they are predominately grass and/or grain material. Analysis showed that the soluble components of these streams represent small fractions of the totals. In the case of COD, the soluble component is only approx. 15% of the TCOD, ammonia was less than 6% of the TKN and ortho-phosphate the highest fraction at 55 - 75% of the TP.

- **Chemical (Precipitation)**

Alternatively, chemical P removal with aluminium sulphate ($Al_2(SO_4)_3.18H_2O$) typically requires 1.5 – 3 moles alum per mole P precipitated. At the concentration of P encountered in this study of approx. 335 - 681 mg/L, this would require 7200 – 28,800 mg/L alum, for chemical treatment only. The figure would be less if only partial chemical removal is required.

- **Chemical (Crystallisation)**

Another treatment option investigated elsewhere has been the production of struvite crystals. Struvite or magnesium ammonium phosphate ($MgNH_4PO_4$) or MAP is formed by the precipitation of ammonia, ortho-phosphate and magnesium in a 1:1:1 molar ratio. The wastewater characteristics encountered in this study shows that ammonia is limiting the reaction. Without addition of extra ammonia (eg. urea), approx. one-third of the P will be removed and all the ammonia as struvite. Magnesium will need to be added at the rate of 90 - 180 mg/L Mg. If additional ammonia was added, and also magnesium, then near complete P removal could be achieved.

The process of struvite production is performed in a single reactor, with a suitable mixing system and pH control. The process is typically operated semi- continuously and shut down only for harvesting the crystals. Struvite has potential as an excellent slow release fertiliser, with commercial applications.

As the waste streams in this case are ammonia deficient we investigated the potential for some of the organic nitrogen to be converted to ammonia in a simple batch experiment. In this case a sample of the dry dump/screw press liquid was left un-preserved in an ambient environment for 20 days. This sort of environment is suitable for the breakdown of organic nitrogen to ammonia. At the end of this time the sample was analysed with the following results shown in Table 10.

Table 10. Wastewater characteristics of aged sample

Sample	TSS (mg/L)	TCOD (mg/L)	TKN (mg/L)	Ammonia-N (mg/L)	TP (mg/L)	PO4-P (mg/L)
Day 0	14,680	24,380	856	85	812	568
Day 20	15,040	25,860	922	191	891	575

The major change over the incubation period was the doubling of the ammonia concentration. Although the ammonia concentration had increased significantly, there was still an insufficient amount to precipitate all the phosphorus. More ammonia may be liberated if the stream is subjected to an acid treatment or other partial digestion, but this would need to be evaluated further.

- **Biological**

Further treatment for removal of the soluble components could be performed by sequencing batch reactor (SBR), with chemical addition (eg. Alum) for more P removal if required. This wastewater has a very high soluble COD, as well as an equally very high ortho-P concentration. The COD requirement for bio-P removal is approx. 7.5 – 10.5 mg COD (as VFA) per mg P removed. In this case the combined wastewater has a SCOD to P ratio of approx. 7.5 mg SCOD/mg P. This falls short of the COD required for complete P removal. For the worst case scenario, which requires 10.5 mg COD/mg P, only two-thirds of the P will be removed. Chemical addition to further reduce the P would be required in this case. Biological treatment would be the least likely avenue for treatment due to its complexity and additional cost compared to the other alternatives.

6 RECOMMENDATIONS FOR FUTURE WORK

This project has presented results that demonstrate the eminent suitability of dry-dumping paunches from both an environmental and financial viewpoint. The financial benefit is in reduced water consumption and environmentally, in identifying a significant source of phosphorus and to a lesser extent nitrogen and COD.

Further benefits may be made in a suitable side-stream treatment of the dry dump/ screw press stream. It is our recommendation to investigate further the options for treating this high strength wastewater, including construction and operation of small pilot scale plants to evaluate the performance of suitable options. Obvious candidates are struvite crystallisation, gross solids removal systems and chemical precipitation.

A small side-stream treatment system has the potential to reduce the load on the main wastewater treatment plant by 20% in terms of P.

An earlier MRC study (1994) accounted for nearly 50% of the P load as emanating from the paunch area. This current study has identified approx. 25%. It is possible that the tripe processing machine leads to a significant P release. This could not be evaluated in this study but should be reviewed. The main disadvantage of this tripe process is the very large water consumption (approx 5% total) which does not lend itself to segregation. However, it would be important to know if they are responsible for the additional 25%.

There is also a significant difference in paunch material and therefore nutrient load generated by grass-fed versus grain-fed cattle. This may be due to the elapsed time from last feeding with grain-fed cattle being "fuller" at the time of slaughter than grass-fed cattle or due to the composition of the grain feed.

A more extensive evaluation of paunch material from grain-fed vs. grass-fed cattle would be beneficial.

7 CONCLUSIONS

This study has investigated the dry dump paunch processing method as used at AMH Dinmore, Brisbane.

A limitation of the Stage 1 study was the inability to perform a complete mass balance over the paunch process due to difficulties of measuring flows, and the inaccessibility of the *la parmentiere*. Based on this finding, Stage 2 was modified to address this problem so as to enable completion of the mass balance. Stage 2 did close in on the mass balance however there is still an unknown, that being the nutrient load from the tripe washing process. Despite this, both stages of work provided some very interesting conclusions.

The study identified that the wastewater generated in this process contributed approx. 25% of the phosphorus load on the wastewater treatment plant. This is a significant contribution from such a small stream, which represents only 2% of the total daily flow. The fraction of the total P load generated by paunch processing has reduced from nearly 50% when the Dinmore plant used the conventional wet dump process to approx. 25%, although this excludes any contribution from the tripe processing. The actual P loading on the plant also increased from 130 kg/day to 250kg/day from the change from wet to dry dumping. This represents a minor reduction in the phosphorus load from this area from 65 kg/day to 51 - 62 kg/day even though the head of cattle processed each day has increased from just over 1000/day to approx. 3000/day. Nitrogen load from this stream only accounts for 3% of the total N load.

This stream is eminently suitable for segregation and separate treatment, most appropriately by a two-stage process employing first a solids clarification step and then either struvite precipitation, chemical phosphorus removal or conventional activated sludge treatment for phosphorus removal. A small equalisation tank of less than 100kL would be required. Chemical and activated sludge treatment will have the disadvantage of large quantities of sludge requiring disposal.

Limited information on other dry dump installations exists, but MIRINZ bulletin No. 33 also evaluated the two processes and their results were consistent with the findings.

8 REFERENCES

CSIRO (1993). Abattoir Waste Water and Odour Management. CSIRO, Australia

MRC (1995). Identification of Nutrient Source Reduction Opportunities and Treatment Options for Australian Abattoirs and Rendering Plants. M.445. MRC, Australia.

Harrison M. (1994). Australia Meat Holdings Dinmore and Beef City Waste Water Nutrient Audit. M.479/M.480. MRC, Australia.

MIRINZ (1996). Bulletin No. 33 – Beef Paunch Processing. MIRINZ, New Zealand.

APHA (1998). Standard Methods for the Examination of Water and Wastewater. 20^{th} Edition.

APPENDIX A

MLA CONTRACT PRENV.008

AN ASSESSMENT OF DRY PAUNCH DUMPING IN RED MEAT PROCESSING PLANTS

VARIATION AGREEMENT - PRENV.008
"An Assessment of Dry Paunch Dumping in Red Meat Processing Plants"

THIS AGREEMENT IS MADE ON 8 January ~~2000~~ 2001

PARTIES

MEAT AND LIVESTOCK AUSTRALIA LIMITED, ABN 39 081 678 364 of Level 1, 165 Walker Street, North Sydney, New South Wales (**MLA**)

AWMTECH PTY LIMITED, ABN 93 085 246 699 of PO Box 6306, St Lucia, Queensland (**Consultant**)

RECITALS

A. The parties are parties to an agreement for PRENV.008 "An assessment of dry paunch dumping in red meat processing plants." dated 27 June 2000 (**Agreement**).

B. The parties have agreed to amend the Agreement on the terms of this agreement.

AGREEMENTS

From the date of this agreement the Agreement is amended as follows:

(a) Under **SCHEDULE 1. Services** Objectives, "30 June 2000" is replaced with "28 February 2001".

(b) Under **SCHEDULE 4. Timetable**, is replaced with the following:

4. Timetable

Start Date:	4 February 2000
End Date:	28 February 2001

Milestone	Date	Achievement Criteria
1. Agree with MLA on plant to be approached. *	11.02.00	Letter of agreement from MLA
2. Conclude discussions with abattoir and agree on experimental plan. *	03.03.00	Letter of acceptance from abattoir.
3. Conclude data collection (Stage 1). *	31.03.00	Successful completion of sampling and sample analysis.
4. Submit interim report. *	14.05.00	Letter of acceptance from MLA.
5. Go / No go milestone based on interim report. *	12.05.00	Decision made by MLA whether to progress to stage 2.
6. Commence stage 2 data collection and performance benchmarking.	15.11.00	First samples taken and successfully analysed.
7. Conclude stage 2 data collection.	31.01.01	Successful completion of sampling and sample analysis.
8. Final report completed.	28.02.01	Final report received and accepted by MLA.

* Indicates milestones already completed.

(c) Under **SCHEDULE 5. Fees and Payment**, is replaced with the following:

Professional Fees	Out-of-Pocket Expenses	Payment Date
$18,530		Within 7 days of signing the agreement.
$12,350		28 February 2001, subject to completion of milestone 8.

EXECUTED AS AN AGREEMENT

Signed for and on behalf of
Meat & Livestock Australia Limited
in the presence of:

....
COLIN PITT
General Manager
Processing & Product Innovation

....
Signature of witness

DUNCAN FERGUSON
Name of witness (print)

Signed for and on behalf of
AWMTech (ABN 93 085 246 699)
in the presence of:

....
Signature of authorised person

....
Signature of witness

DIRECTOR
Office held by authorised person

PAUL LANT
Name of witness (print)

JUSTIN DOYLE
Name of authorised person (print)

CONSULTANCY AGREEMENT

BETWEEN

MEAT & LIVESTOCK AUSTRALIA
ACN 081 678 364

AND

AWMTech PTY LTD
ACN 085 246 699

PRENV.008

"An Assessment of Dry Paunch Dumping in Red Meat Processing Plants"

CONSULTANCY AGREEMENT

THIS AGREEMENT IS MADE ON **199**

PARTIES

MEAT AND LIVESTOCK AUSTRALIA LIMITED ACN 081 678 364 of Level 1, 165 Walker Street, North Sydney, New South Wales **(MLA)**

AWMTech PTY LTD ACN 085 246 699 of PO Box 6306, St Lucia 4067 **(Consultant)**

BACKGROUND

MLA has agreed to engage the Consultant to provide the Services and the Consultant has agreed to accept the engagement on the terms of this agreement.

AGREEMENTS

1. DEFINITIONS AND INTERPRETATION

1.1 Definitions

1.1.1 Where commencing with a capital letter:

Contract Material means all material brought into existence for the purpose of providing the Services;

Intellectual Property means all patents, trade marks, designs and plant breeder's rights (whether registered or not), copyright, know-how, trade secrets and EL rights subsisting in the Contract Material or arising out of the provision of the Services;

MLA Material means all material provided by MLA to the Consultant for the purpose of this agreement;

Nominated Persons means the persons named in the schedule and such other persons approved in writing by MLA to perform the work in respect of the Services on behalf of the Consultant;

Proposal means the proposal from the Consultant to MLA referred to in the schedule;

Services means the services to be provided by the Consultant specified in the schedule; and

Year 2000 Compliant means that the operation, performance and functionality of all software and goods are not and will not be affected by dates prior to, during and after the year 2000 and that, in particular:

(a) date-based functionality behaves consistently for dates prior to, during and after the year 2000;

(b) no date interrupts or will cause any interruption in operation; and

(c) all leap years are recognised.

1.1.2 Where a word or phrase is given a defined meaning another part of speech or other grammatical form in respect of that word or phrase has a corresponding meaning.

1.2 Presumptions of interpretation

Unless the context otherwise requires a word which denotes:

(a) the singular denotes the plural and vice versa; and

(b) a person includes an individual, a body corporate and a government.

1.3 The Proposal

If there is any inconsistency between the provisions of this agreement and those of the Proposal, the provisions of this agreement prevail.

1.4 Successors and assigns

A person includes the trustee, executor, administrator, successor in title and assign of that person. This clause must not be construed as permitting a party to assign any right under this agreement.

2. APPOINTMENT OF THE CONSULTANT

2.1 Appointment

MLA appoints the Consultant to provide the Services in accordance with the Proposal and the timetable set out in the schedule on the terms set out in this agreement, and the Consultant accepts the appointment.

2.2 Nominated Persons

The Consultant:

(a) must, subject to the terms of this agreement, cause only the Nominated Persons to perform the work in respect of the Services on behalf of the Consultant;

(b) undertakes that the Nominated Persons will during the term of this agreement perform this work to the best of their skill and ability; and

(c) must provide each Nominated Person with a copy of this agreement and take all reasonable steps to explain it to them.

3. OBLIGATIONS OF THE CONSULTANT

3.1 Liaison

The Consultant must:

(a) liaise with MLA in providing the Services; and

(b) if requested by MLA, provide reasonable details of the Consultant's proposed course of action and strategies,

for the purpose of enabling MLA to review the performance of the Consultant's obligations under this agreement.

3.2 Directions

The Consultant must comply with all reasonable and lawful directions of MLA from time to time concerning the Services.

3.3 Comply with all laws

The Consultant must comply with all relevant laws and regulations when performing the Consultant's obligations under this agreement.

3.4 Insurance

3.4.1 The Consultant must at all times maintain:

(a) adequate workers' compensation insurance as required by law for its employees;

(b) professional indemnity insurance cover of at least $2 million;

(c) public liability insurance cover of at least $5 million;

3.4.2 Each insurance policy obtained by the Consultant under clause 3.4.1 must note MLA as a named insured under the policy.

3.4.3 The Consultant must, on request by MLA, produce evidence of the currency of the insurance policies referred to in this clause 3.4.

4. FEES AND EXPENSES

4.1 Fees

MLA must pay the Consultant for providing the Services the fee specified in the schedule, provided that Services to which each payment relates are completed to the reasonable satisfaction of MLA.

4.2 Expenses

MLA must reimburse the Consultant for all reasonable travel and telecommunication expenses incurred by the Consultant in providing the Services provided that the Consultant:

(a) obtains MLA's prior written consent before incurring any travel or accommodation expenses not specified in the Proposal; and

(b) gives MLA:

(i) details of the expenses incurred, together with evidence acceptable to MLA on reasonable grounds of the incurring of those expenses, including receipts for expenses over $20; and

(ii) all assistance reasonably required by MLA to verify the expenses incurred.

4.3 Payment

MLA must, subject to this clause 4, pay the fees and expenses referred to in clauses 4.1 and 4.2 in the following manner:

(a) the Consultant must after the end of each period specified in the schedule provide to MLA an invoice setting out details of:

(i) the Services provided, time worked and fees payable; and

(ii) expenses incurred,

in that period; and

(b) MLA must pay the invoice within 1 month of receipt of it.

5. CONFIDENTIALITY

5.1 Consultant to maintain

The Consultant must not during or after the term of this agreement:

(a) except in the proper course of performance of this agreement, disclose to any person without the previous consent in writing of MLA the terms of this agreement or any MLA Material or Contract Material; or

(b) use or attempt to use any MLA Material or Contract Material in any manner which may cause injury or loss to MLA or in any manner other than that contemplated by this agreement.

5.2 Third party disclosure

The Consultant must take all such reasonable precautions as are necessary to maintain the confidentiality of the MLA Material and the Contract Material and must:

(a) prevent its disclosure directly or indirectly to any person other than in accordance with this agreement; and

(b) prior to disclosure to any person of any MLA Material or Contract Material in accordance with this agreement, obtain a written undertaking of confidentiality from that person in the same terms as this clause 5.

6. INTELLECTUAL PROPERTY

6.1 Assignment

6.1.1 The Consultant assigns all Intellectual Property to MLA as and when it is created, whether existing as at the date of this agreement or created afterwards.

6.1.2 Where the Consultant engages an agent or contractor to provide any of the Services, the Consultant must ensure that the agent or contractor assigns to MLA all Intellectual Property as and when it is created, whether existing as at the date of this agreement or created afterwards.

6.2 Licence to the Consultant

MLA grants the Consultant a royalty free licence to use the Intellectual Property and the intellectual property rights in the MLA Material for the purpose of enabling the Consultant to provide the Services.

7. WARRANTY

The Consultant warrants that:

(a) the provision of the Services will not infringe any other person's intellectual property rights and that MLA will be entitled to use the Contract Material without the consent of any other person;

(b) it, its officers and employees, the Nominated Persons and all agents and contractors have the necessary experience, skill and ability to properly provide the Services on the terms contained in this agreement;

(c) the Services will be provided in a professional manner and conform to a standard of competence equal to that normally employed by consultants of good standing for services of a magnitude and nature similar to the Services; and

(d) all software and goods provided by it as part of the Services will, without any modification, be Year 2000 Compliant.

8. MATERIAL

8.1 MLA Material

The MLA Material remains the property of MLA and, on termination of this agreement, the Consultant must immediately return the MLA Material and all copies of it to MLA.

8.2 Contract Material

On termination of this agreement, the Consultant must immediately deliver the Contract Material and all copies of it to the MLA.

8.3 Safekeeping

The Consultant is responsible for the safekeeping and maintenance of the MLA Material and the Contract Material and must ensure that the MLA Material and the Contract Material are used, copied, supplied or reproduced only for the purposes of this agreement.

9. RELATIONSHIP OF THE PARTIES

9.1 No partnership

Nothing contained in this agreement creates an agency, partnership, joint venture or employment relationship between MLA and the Consultant or any of their respective employees, agents or contractors.

9.2 No holding out

Neither the Consultant nor any person acting on behalf of the Consultant may hold itself out as being entitled to contract or accept payment in the name of or on account of MLA.

9.3 Exclusion

MLA's only liability is as expressly stated in this agreement. To the extent permitted by law, all other liability is excluded.

10. SUBCONTRACTORS

10.1 Consent

The Consultant must not without the prior written consent of MLA engage agents or contractors to assist the Consultant in providing the Services.

10.2 Terms

If the Consultant engages an agent or a contractor to assist the Consultant in providing the Services the terms of engagement must be approved by MLA and must contain terms requiring the agent or contractor to:

(a) undertake obligations of confidentiality in terms substantially the same as the terms of clause 5;

(b) assign to MLA the intellectual property in any materials created under the engagement; and

(c) maintain such insurance in such amounts as MLA may specify.

11. CONFLICT OF INTEREST

The Consultant must not, during the term of this agreement:

(a) act as a consultant to any person who carries on or is involved in any capacity in an activity or business; or

(b) carry on or be involved in any capacity in an activity or business,

which is competitive with or detrimental to any business or activity carried on by MLA or in which MLA is involved.

12. INDEMNITY

The Consultant indemnifies MLA against all damages, losses, costs and expenses incurred by MLA arising out of:

(a) any breach by the Consultant of this agreement; or

(b) any act or omission of the Consultant, its employees, the Nominated Persons and all agents and contractors in connection with this agreement.

13. TERMINATION

13.1 Notice

MLA may, on 1 month's notice to the Consultant, terminate this agreement.

13.2 Default

If the Consultant:

(a) goes into liquidation, has a receiver or receiver and manager appointed to it or any part of its assets, enters into a scheme of arrangement with creditors or suffers any other form of external administration;

(b) fails, within 7 days after receipt of notice, to remedy any breach of its obligations under this agreement which is capable of remedy; or

(c) breaches any provision of this agreement which is not capable of remedy,

MLA may, by notice to the Consultant, terminate this agreement and recover from the Consultant all damages, losses, costs and expenses suffered by MLA.

14. DISPUTE RESOLUTION

14.1 Dealing with disputes

14.1.1 The parties must, without delay and in good faith, attempt to resolve any dispute which arises out of or in connection with this agreement prior to commencing any proceedings.

14.1.2 If a party requires resolution of a dispute it must do so in accordance with the provisions of this clause 14 and the parties acknowledge that compliance with these provisions is a condition precedent to any entitlement to claim relief or remedy whether by way of proceedings in a court of law or otherwise in respect of such disputes.

14.2 Resolution by management

14.2.1 If a party requires resolution of a dispute it must immediately submit full details of the dispute to the chief executive officer of the other party.

14.2.2 If the dispute is not resolved within 1 month of submission of the dispute to them, or such other time as they agree, the provisions of clause 14.3 will apply.

14.3 Conciliation

14.3.1 Disputes must be submitted to conciliation in accordance with and subject to the Institute of Arbitrators Australia Rules for the Conduct of Commercial Conciliations.

14.3.2 A party may not commence proceedings in respect of the dispute unless the dispute is not settled by conciliation within 1 month of submission to conciliation, or such other time as the parties agree.

15. GOODS AND SERVICES TAX (GST)

15.1 If any GST is payable for the supply of goods or services under this agreement, payment for those goods or services must be:

(a) increased in accordance with the GST payable less

(b) any decrease in the cost to the Supplier of supplying the goods or services resulting from the abolition or variation of any taxes, duties or statutory charges in conjunction with the imposition of GST.

15.2 If GST is payable, the Supplier warrants that, at all relevant times from 1 July 2000, it is or will be registered under GST law and must provide each party receiving the goods or services (Recipient) with:

(a) on request, evidence of registration; and

(b) a tax invoice (as defined under GST law) or, prior to 1 July 2000, any other document required by the Recipient to claim any available tax credit for GST payments.

16. MISCELLANEOUS

16.1 Notices

16.1.1 A notice under this agreement must be in writing and may be given to the addressee by:

(a) delivering it to the address of the addressee;

(b) sending it by pre-paid registered post to the address of the addressee; or

(c) sending it by facsimile to the facsimile number of the addressee,

and the notice will be deemed to have been received by the addressee on receipt.

16.1.2 A facsimile is deemed to have been received on production of a transmission report by the machine from which the facsimile was sent which indicates that the facsimile was sent in its entirety to the facsimile number of the addressee.

16.2 Amendment

This agreement may only be varied by the written agreement of the parties.

16.3 Assignment

The Consultant may only assign a right under this agreement with the prior written consent of MLA.

16.4 Entire agreement

16.4.1 This agreement embodies the entire understanding and agreement between the parties as to its subject matter.

16.4.2 All previous negotiations, understandings, representations, warranties, memoranda or commitments in relation to, or in any way affecting, the subject matter of this agreement are merged in and superseded by this agreement.

16.5 Further assurance

Each party must promptly execute all documents and do all things that the other party from time to time reasonably requests to effect, perfect or complete this agreement and all transactions incidental to it.

16.6 Governing law and jurisdiction

16.6.1 This agreement is governed by and must be construed in accordance with the laws of New South Wales.

16.6.2 Each party:

(a) irrevocably and unconditionally submits to the non-exclusive jurisdiction of the courts of New South Wales and all courts which have jurisdiction to hear appeals from those courts; and

(b) waives any right to object to proceedings being brought in those courts for any reason.

16.7 Legal costs

The parties must each pay their own legal and other expenses relating directly or indirectly to the negotiation, preparation and execution of this agreement and all documents incidental to it.

Schedule

1. Consultant

Company Name: AWMTech Pty Ltd
ACN (if applicable): 085 246 699
Street Address: Ground Floor, Ritchie Building, Research Road, St Lucia QLD 4072

Postal Address: PO Box 6306 ,
St Lucia , Queensland

Admin. Contact Name (including title): Mr Justin Doyle
Position: Senior Engineer
Telephone: 07 3365 7519
Facsimile: 07 3365 4726
E-mail: Justin@cheque.uq.edu.au

2. Services

Background/Description:

The wet processing of paunch contents has been identified as a major contributor to the overall nutrient load in wastewater at meat processing plants. In previous research undertaken by the MRC in 1995 paunch contents were ranked as the second most significant waste source in an abattoir. A recommendation of that report was that the paunches be dry dumped, with the contents kept separate from the washings wastewater.

The project will be undertaken to generate new data from a dry-dumping installation. Data will be compared with information from previous research work undertaken to demonstrate the benefits of dry dumping paunch contents via a reduction in the volumes and nutrient concentrations of the wastewater produced.

Potential Industry Benefit

This project will demonstrate the benefits of dry-dumping paunch contents, which are considered to be:

1. Reduced potable water consumption through elimination of wet-paunch processing resulting in lower town water charges and/or reduced purification costs.
2. Reduced wastewater generation as a result of 1.
3. Reduced nutrient loading (COD, nitrogen and phosphorus) to the wastewater treatment plant as the paunch contents are no longer mixed into this stream.
4. Lower operational costs of wastewater treatment plants due to reduced organic load ie. less power consumption due to lower aeration demand and less volume to be pumped.
5. Less sludge accumulation in lagoons due to reduced pollutant load which will result in less frequent desludging of lagoons.
6. Less land required for irrigation (if land application of effluent used) due to reduced nutrient levels in effluent.
7. Potential simplification of the operation of the wastewater treatment plant due to reduced nutrient load.

Objectives:

By 30 June 2000 to have obtained and assessed detailed information on dry dumping paunch contents to assist meat processors in evaluating the technology.

Approach/Methodology:

1. Site Selection
A meat processing plant in Queensland will be utilised in this project. This plant dry-dumps the paunch contents and we have an existing relationship with this site, having been involved in other projects with this particular plant, both related to MRC projects (MRC.478) and other direct consulting.

2. Data Collection Exercise
A series of studies will be performed to evaluate the characteristics of the wastewater generated as well as the volume of water used. Data collection will be undertaken in two stages to account for possible seasonable fluctuations in wastewater characteristics.

Stage 1
Due to the high solids content of the wastewater, the use of an auto-sampler will not be suitable. Subsequently, composite samples of the wastewater from the paunch processing area will need to be taken manually. Wastewater samples will be taken hourly during a complete shift in the paunch processing area, estimated to be 8 hours duration. Water consumption will be recorded from a water meter in the processing area (if installed) or otherwise estimated by timed measurement using a suitable container of known volume at the time of sampling. The number of carcasses processed will also be recorded to provide a basis for the data evaluation. Samples will be analysed for the following, with the method of analysis also indicated.

Pollutant	Analytical Method
Total COD	Merck - Acid digestion and oxidation
Soluble COD	Merck - Acid digestion and oxidation
Oil and Grease	Std Methods1 - Solvent extraction
Total suspended solids	Std Methods1 - Filtration
Total Kjeldahl Nitrogen	Std Methods1 - Digestion + FIA
Ammonia nitrogen	Flow Injection Analysis (FIA)
Total Phosphorus	Std Methods1 - Digestion + FIA
Ortho-Phosphate	FIA

At the time of sampling, the sample will be preserved by the suitable method, described below, to halt biological activity and to stabilise the sample prior to analysis in our laboratory.

Pollutant	Preservation Method
Total COD	Add H2SO4 to pH < 2 and cool to 4°C
Soluble COD	0.45mm filter sample and cool to 4°C
Oil and Grease	Add H2SO4 to pH < 2 and cool to 4°C
Total suspended solids	Cool to 4°C
Total Kjeldahl Nitrogen	Add H2SO4 to pH < 2 and cool to 4°C
Ammonia nitrogen	0.45mm filter sample and cool 4°C
Total Phosphorous	Add H2SO4 to pH < 2 and cool to 4°C
Ortho-Phosphate	0.45mm filter sample and cool to 4°C

Sampling will be performed twice a week for one complete paunch process shift and on one day during this period, samples will be taken for a double shift. This will generate sufficient data for preparation of the interim report.

Stage 2
Stage 2 will be a repetition of Stage 1, in a different season, to determine if seasonal and/or process changes have affected the characteristics of the wastewater.

3. Data Analysis and Discussion
The data generated by the study will be analysed to evaluate the change in wastewater characteristics in a dry dump paunch installation as compared to a wet-dump process. The data will be compared to previous data obtained at the plant when it was using a wet-dump process, as well as in relation to the hot carcass weight (HCW). The data will also be compared to other available data eg. MIRINZ bulletin No.33.

A discussion of the benefits of dry dumping paunch contents will be made as well as an evaluation of technologies that could be utilised to treat the "new" dry dump waste stream, such as struvite crystalisation.

4. Report Preparation

- Executive summary
- Project background and literature review
- Methodology of the project
- Results of all analyses
- Discussion of results including the benchmarking of wet versus dry dumping of paunch contents
- Clearer description of the benefits of wet versus dry paunch processing
- Recommendations for further work, with possible alternatives for treating the wastewater stream generated by the dry paunch processing eg. Struvite crystalisation.

<u>Dissemination Strategy</u>:

A final report, with executive summary, will be prepared and submitted to Meat and Livestock Australia at the end of the project. This will summarise all the findings of the study and benchmark the dry-dumping of paunch contents. An electronic version of the report will also be made available to the MLA, most likely in an Adobe Acrobat (*.pdf) format that can be placed on the MLA website (http://www.mla.com.au) for easy access within Australia and around the world. An interim report will also be provided at the mid-point of the project.

A brief article will also be written that will be suitable for inclusion in Envirofacts.

A half-day workshop will be organised in conjunction with MLA at the completion of the final report. Invitations to the workshop will be sent to all relevant parties around Australia, identified with the help of the MLA. This workshop will include a Power Point presentation of the results of the project, with an opportunity for discussion and possible plant visit to view the method of dry-dumping.

3. Nominated Persons

Admin. Contact Name (including title):	Mr Justin Doyle
Position:	Senior Engineer
Telephone:	07 3365 7519
Facsimile:	07 3365 4726
E-mail:	Justin@cheque.uq.edu

Admin. Contact Name (including title):	Dr Paul Lant
Position:	Senior Lecturer – Advanced Wastewater Management Centre
Telephone:	07 3365 4728
Facsimile:	07 3365 4726
E-mail:	paull@cheque.uq.edu.au

Admin. Contact Name (including title):	Mike Harrison
Position:	Senior Engineer
Telephone:	Principle Investigator
Facsimile:	
E-mail:	07 3365 4726

4. Timetable

Start Date[1]: 04 February 2000
End Date: 31 July 2000

	MILESTONES	DUE DATE	ACHIEVEMENT CRITERIA
01	Agree on plant to be approached with MLA	11 Februar 2000	Letter of agreement from MLA
02	Conclude discussions with abattoir and agree experimental plan.	3 March 2000	Letter of aceptance from abattoir
03	Conclude data collection (Stage 1)	31 March 2000	Successful completion of sampling and sample analysis.
04	Submit interim report	14 April 2000	Letter of acceptance from MLA
05	Go/No Go Milestone based on interim report	12 May 2000	Decision made to MLA whether to progress to stage two.
06	Commence data collection and performance benchmarking (Stage 2)	5 June 2000	First samples taken and analysed successfully
07	Conclude data collection (Stage 2)	30 June 2000	Successful completion of sampling and sample analysis
08	Final Report completed and received by MLA	31 July 2000	Final report accepted by MLA

[1] When estimating the Start Date, please note the minimum turn-around-time on contracts from submission of proposals and contract execution is 3 weeks.

5. Fees and Payment

DATE	FEES	CAPITAL	OVERSEAS TRAVEL	OTHER EXPENSES	TOTAL	PAY ON MILE-STONE
24 April 2000	$18,530				$18,530	
30 June 2000	$12,350				$12,350	
Total	$30,880				$30,880	

EXECUTED AS AN AGREEMENT

Signed for and on behalf of
Meat & Livestock Australia Limited in
the presence of:

	.... Signature of authorised person
.... Signature of witness	General Manager .... Office held by authorised person
Michael Johns .... Name of witness (print)	Colin Pitt .... Name of authorised person (print)

Signed for and on behalf of
AWMTech Pty Ltd
in the presence of:

	.... Signature of authorised person 6/3/00
.... 6/3/00 Signature of witness	Director. .... Office held by authorised person
JUSTIN DOYLE .... Name of witness (print)	PAUL ANDREW LANT. .... Name of authorised person (print)

APPENDIX B

LETTER OF ACCEPTANCES FROM MLA AND AMH

MEAT & LIVESTOCK

AUSTRALIA

10 May 2000

Dr Paul Lant,
AWMTech Pty Ltd.,
PO Box 6303
St Lucia, QLD 4067

Re: PRENV.008 Dry Paunch Dumping Project

Dear Paul,

Thanks for your report received by email on 9th May 2000. This letter serves as a Letter of Agreement from MLA for the project to be based at the Australia Meat Holdings Pty Limited Dinmore abattoir as agreed between myself, Mr Jim Yates (General Manager, AMH Dinmore) and yourselves. We note the Letter of Agreement (dated 4 April 2000) from Mr. Yates received by Dr Johns formalising AMH's agreement to the project. A copy is attached for your information.

We look forward to the results of the project with great interest. We remind you that it is your responsibility to ensure that your personnel are fully protected against Q Fever and that they honour all necessary OH&S and environmental requirements pertaining to the AMH Dinmore site.

We wish you all the best in your work.

Yours sincerely

Assoc. professor Mike Johns
Project Leader, Environment, MLA.

Meat & Livestock Australia Limited ACN 081678364. Level 1, 165 Walker Street, North Sydney NSW 2060
Locked Bag 991, North Sydney, 2059 Telephone +61 2 9463 9333 Fax +61 2 9463 9393 www.mla.com.au

AUSTRALIA MEAT HOLDINGS PTY LIMITED
Incorporated in Queensland
A.C.N. 011 062 338

Dinmore:

4 April 2000

Mr Mike Johns
PO Box 73
BALD HILLS QLD 4036

Dear Mike

Following your request for a project at Australia Meat Holdings Dinmore, for an assessment of Dry Paunch Dumping, Proposal No. S111 84-4, I confirm that the project can proceed and any information related to the project can be publicised.

Can you please organise for a copy of the findings to be sent to myself.

Regards

Jim Yates
General Manager

I:\jim\letter\mjohns

173 Riverview Road Dinmore Queensland 4303 Postal Address: P.O. Box 121 Booval 4304
Tel: (07) 3810 2152 Fax: (07) 3282 4203

APPENDIX C

RESULTS OF DATA COLLECTION STAGE 1 & 2

MLA Paunch Project Results

Day 1 30th March 2000

Umbrella Wash

Time	Flow (L/min)	pH	TSS	TCOD	SCOD	TKN	Ammonia	TP	Ortho-P
10:15 AM		7.57	2113	3090	785	72	10	60	47
11:15 AM		Not in Operation							
12:15 PM		Not in Operation							
2:15 PM		7.28	3650	5650	385	188	11	83	52
Ave		7.43	2882	4370	585	130	11	72	50
% Dry + Screw Conc			*23%*	*22%*	*27%*	*19%*	*19%*	*10%*	*11%*

Dry Paunch Dump

Time	Flow (L/min)	pH	TSS	TCOD	SCOD	TKN	Ammonia	TP	Ortho-P
10:15 AM	23	7.97	9425	13600	1060	381	40	711	425
11:15 AM	15	7.91	13275	20330	2495	735	82	979	750
12:15 PM	31	7.56	10775	14770	1630	499	31	340	168
2:15 PM	60	7.41	16350	27215	2605	986	60	583	310
Ave	32.3	7.71	12456	18979	1948	650	53	653	413

Screw Press Liquor from Dry Dump

Time	Flow (L/min)	pH	TSS	TCOD	SCOD	TKN	Ammonia	TP	Ortho-P
10:15 AM	26	8.12	7050	11065	1080	355	35	1028	516
11:15 AM	33	7.92	12675	22185	1845	809	75	891	534
12:15 PM	38	7.92	17400	28185	3215	848	56	540	363
2:15 PM	53	7.66	11375	22045	3240	794	70	549	390
Ave	37.5	7.91	12125	20870	2345	702	59	752	451

MLA Paunch Project Results

Day 2 4th April 2000

Umbrella Wash

Time	Flow (L/min)	pH	TSS	TCOD	SCOD	TKN	Ammonia	TP	Ortho-P
7:50 AM	Not in Operation					80	7	55	36
8:50 AM		7.73	1875	2625	250	85	7	66	39
9:50 AM	Not in Operation								
10:50 AM		7.74	1813	2685	30	86	5	87	31
11:50 AM		7.81	5463	7685	440	198	10	96	48
3:00 PM	Not in Operation								
4:00 PM		7.27	1088	2000	175	64	5	32	22
5:00 PM		7.58	1250	2450	405	93	6	61	30
6:00 PM		7.85	1000	1540	150	46	5	48	30
7:00 PM		8.24	1525	2215	160	72	3	54	39
Ave		7.75	2002	3029	230	91	6	62	34
% Dry + Screw Conc			*20%*	*18%*	*13%*	*15%*	*14%*	*10%*	*11%*

Dry Paunch Dump

Time	Flow (L/min)	pH	TSS	TCOD	SCOD	TKN	Ammonia	TP	Ortho-P
7:50 AM	35		14725	21360	2540	599	57	776	554
8:50 AM	27	8.12	17400	23660	1350	913	52	737	210
9:50 AM	25		24525	29390		1128		1197	
10:50 AM	41	8.03	8025	13495	800	404	35	511	237
11:50 AM	38	7.66	11300	17210	1420	526	42	419	161
3:00 PM	60	8.07	6225	9080	1445	283	21	625	365
4:00 PM	50	7.95	10400	18020	1525	630	33	675	232
5:00 PM		Not in Operation							
6:00 PM	72	7.94	6250	11120	1300	368	36	519	300
7:00 PM	82	7.97	1525	12960	1415	711	25	337	268
Ave	48	7.96	11153	17366	1474	618	38	644	291

Screw Press Liquor from Dry Dump

Time	Flow (L/min)	pH	TSS	TCOD	SCOD	TKN	Ammonia	TP	Ortho-P
7:50 AM	12		8125	13060	1045	440	41	646	231
8:50 AM	30	8.42	13850	23480	2855	885	97	852	603
9:50 AM	48		9300	13530	1540	513	43	796	425
10:50 AM	43	8.04	7925	15725	1350	515	42	669	284
11:50 AM	36	7.87	9450	15845	905	520	38	477	175
3:00 PM	10	7.59	14850	22825	3080	671	36	987	492
4:00 PM	30	7.69	6575	15345	4015	605	64	618	322
5:00 PM		Not in Operation							
6:00 PM	27	7.92	3925	8845	1905	359	35	394	255
7:00 PM	36	8.26	7025	10965	1040	452	20	436	279
Ave	30	7.97	9003	15513	1971	551	46	653	341

MLA Paunch Project Results

Day 3 6th April 2000

Umbrella Wash

Time	Flow (L/min)	pH	TSS	TCOD	SCOD	TKN	Ammonia	TP	Ortho-P
9:30 AM		6.87	1350	2345	550	70	7	43	39
10:30 AM		7.27	9150	14675	1303	220	17	112	94
11:30 AM		7.22	1310	1820	304	48	5	27	17
12:30 PM		7.4	1500	2905	492	59	5	65	42
1:30 PM		Not in Operation							
Ave		7.19	3328	5436	662	99	9	62	48
% Dry + Screw Conc			*26%*	*28%*	*23%*	*13%*	*17%*	*10%*	*16%*

Dry Paunch Dump

Time	Flow (L/min)	pH	TSS	TCOD	SCOD	TKN	Ammonia	TP	Ortho-P
9:30 AM	98	7.19	9667	14315	2467	433	31	546	274
10:30 AM	26	7.36	16400	24845	2618	831	51	660	299
11:30 AM	20	7.29	14025	26205	4554	1021	81	555	321
12:30 PM	52	7.64	18700	26330	2638	803	49	913	597
1:30 PM	63	7.03	12100	9570	2060	731	37	440	187
Ave		7.30	14178	20253	2867	764	50	623	336

Screw Press Liquor from Dry Dump

Time	Flow (L/min)	pH	TSS	TCOD	SCOD	TKN	Ammonia	TP	Ortho-P
9:30 AM	43	7.61	8625	15015		460		528	
10:30 AM	21	7.44	12350	20045	2354	676	37	447	211
11:30 AM	36	7.48	9400	18405	3418	680	57	500	242
12:30 PM	19	7.43	17567	29235	3675	938	69	863	459
1:30 PM	21	7.19	11567	9905	2118	785	36	550	158
Ave		7.43	11902	18521	2891	708	50	578	268

MLA Paunch Project Results

Day 4   13th April 2000

Umbrella Wash

Time	Flow	pH	TSS	TCOD	SCOD	TKN	Ammonia	TP	Ortho-P
9:40 AM		7.58	2480	4915	779	166	13	83	59
10:40 AM		7.48	5200	8130	620	187	11	150	95
11:40 AM		7.52	4113	5765	641	111	9	59	34
12:40 PM		Not in Operation							
1:40 PM		7.51	3013	5820	644	111	9	87	50
2:40 PM		7.67	2663	4690	673	133	13	106	68
3:40 PM		7.53	1963	3545	365	87	5	43	18
4:40 PM		7.69	2825	5110	521	133	10	79	44
Ave		*7.57*	*3180*	*5425*	*606*	*133*	*10*	*87*	*53*
% Dry + Screw Conc			*24%*	*25%*	*20%*	*20%*	*18%*	*17%*	*16%*

Dry Paunch Dump

Time	Flow (L/min)	pH	TSS	TCOD	SCOD	TKN	Ammonia	TP	Ortho-P
9:40 AM	86	7.61	5820	13270	720	447	58	354	282
10:40 AM	41	7.63	22300	31850	5892	867	42	712	328
11:40 AM	39	7.61	24800	34390	2730	875	70	568	345
12:40 PM	37	7.51	16175	27055	2737	1021	114	844	657
1:40 PM	62	7.44	12850	19375	3028	570	40	449	216
2:40 PM	90	7.81	4988	8690	1132	252	15	308	254
3:40 PM	44	7.16	19150	25310	3643	778	40	342	146
4:40 PM	82	7.57	8800	15555	2537	514	41	360	230
Ave	*60*	*7.54*	*14360*	*21937*	*2802*	*666*	*53*	*492*	*307*

Screw Press Liquor from Dry Dump

Time	Flow (L/min)	pH	TSS	TCOD	SCOD	TKN	Ammonia	TP	Ortho-P
9:40 AM	41	7.63	8000	16530	3337	526	65	419	298
10:40 AM	35	7.84	14800	24595	2345	703	89	685	534
11:40 AM	33	7.73	16475	25100	4536	673	62	503	288
12:40 PM	38	7.85	12167	23090	3490	737	67	749	496
1:40 PM	41	7.62	14114	26090	2835	670	67	582	427
2:40 PM	42	7.86	9550	16225	2659	577	31	500	345
3:40 PM	27	7.33	12200	23310	3909	754	43	365	162
4:40 PM	58	7.55	9150	15890	1815	573	27	300	145
Ave	*39*	*7.68*	*12057*	*21354*	*3116*	*652*	*56*	*513*	*337*

Umbrella Wash Results

Sample	Date	Time	TP	PO4-P	% Ortho-P	TKN	NH3-N	% NH4-N	TSS	TCOD	SCOD	SCOD/TCOD	P Load	N Load	COD Load
			mg/L	mg/L	%	mg/L	mg/L	%	mg/L	mg/L	mg/L	%	kg/day	kg/day	kg/day
	19-Dec	8:30am	68	54.0	79%	131	5.4	4%	2600	648	479	74%	4	8	39
	19-Dec	9:30am	90	67.3	75%	69	4.3	6%	1760	439	161	37%	5	4	26
Grain	19-Dec	10:30am	466	304.4	65%	598	16.4	3%	9920	2970	1505	51%	28	36	178
Grain	19-Dec	11:30am	76	59.4	78%	145	4.9	3%	3040	1001	411	41%	5	9	60
Grain	19-Dec	12:45pm	110	95.6	87%	170	4.6	3%	3520	1113	338	30%	7	10	67
Grain	19-Dec	1:45pm	239	171.5	72%	445	16.8	4%	7160	2482	1695	68%	14	27	149
Grain	19-Dec	2:45pm	88	69.5	79%	139	4.2	3%	2740	791	348	44%	5	8	47
Grain	19-Dec	3:45pm	86	72.9	85%	168	4.3	3%	3360	1026	311	30%	5	10	62
	20-Dec	8:45am	93	71.2	76%	79	4.6	6%	1800	583	532	91%	6	5	35
	20-Dec	9:45am	54	42.0	77%	39	2.4	6%	1220	368	132	36%	3	2	22
Grain	20-Dec	10:45am	226	157.0	70%	584	25.6	4%	9240	2440	2120	87%	14	35	146
Grain	20-Dec	11:45am	133	83.0	62%	209	4.7	2%	4280	1345	626	47%	8	13	81
Grain	20-Dec	12:45pm	159	93.3	59%	168	5.1	3%	3760	1129	599	53%	10	10	68
Grain	20-Dec	1:45pm	149	98.8	66%	290	9.2	3%	4280	1491	1026	69%	9	17	89
Grain	20-Dec	2:45pm	252	184.2	73%	341	11.4	3%	6680	2242	1183	53%	15	20	135
	20-Dec	3:45pm	158	90.6	57%	212	11.3	5%	3640	1269	740	58%	9	13	76
		Ave	**153**	**107**	**73%**	**237**	**8**	**4%**	**4313**	**1334**	**763**	**54%**	**9**	**14**	**80**
		SD	**104**	**67**	**9%**	**172**	**6**	**1%**	**2597**	**793**	**585**	**19%**	**6**	**10**	**48**
		50%ile	**110**	**83**	**75%**	**168**	**5**	**3%**	**3520**	**1113**	**532**	**51%**	**7**	**10**	**67**
		90%ile	**246**	**179**	**83%**	**528**	**17**	**6%**	**8408**	**2465**	**1619**	**82%**	**15**	**32**	**148**
		min	**54**	**42**	**59%**	**39**	**2**	**2%**	**1220**	**368**	**132**	**30%**	**3**	**2**	**22**
		max	**466**	**304**	**87%**	**598**	**26**	**6%**	**9920**	**2970**	**2120**	**91%**	**28**	**36**	**178**
		geomean	**128**	**93**	**73%**	**183**	**7**	**4%**	**3673**	**1114**	**567**	**51%**	**8**	**11**	**67**
Grain Ave			**156**	**109**	**73%**	**240**	**9**	**4%**	**4391**	**1320**	**782**	**56%**			
Grass Ave			**108**	**80**	**77%**	**199**	**6**	**3%**	**3460**	**1103**	**562**	**48%**			
% Diff Grain			**1.45**	**1.36**		**1.20**	**1.46**		**1.27**	**1.20**	**1.39**				

Loads calculation based on: 20L per paunch and 3000 paunches per day.

Dry Dump/Scew Press

Sample	Date	Time	Flow L/min	TP mg/L	PO4-P mg/L	% Ortho-P	TKN mg/L	NH3-N mg/L	% NH4-N	TSS mg/L	TCOD mg/L	SCOD mg/L	SCOD/TCOD %	P Load kg/day	N Load kg/day	COD Load kg/day
	19-Dec	8:30am	74	772	584.8	76%	504	60.7	12%	10367	13415	2880	21%	57	37	983
*	19-Dec	9:30am	38	694	563.8	81%	291	16.5	6%	6100	7185	1085	15%	26	11	270
Grain*	19-Dec	10:30am	60	1362	934.2	69%	1746	109.7	6%	28533	37605	6510	17%	81	104	2234
Grain	19-Dec	11:30am	58	438	305.4	70%	552	27.6	5%	11800	20220	2670	13%	25	32	1161
Grain*	19-Dec	12:45pm	43	741	574.4	77%	546	18.8	3%	12200	17095	1580	9%	32	23	728
Grain	19-Dec	1:45pm	45	1162	836.2	72%	2009	116.5	6%	42920	62920	8120	13%	52	90	2803
Grain	19-Dec	2:45pm	90	713	568.3	80%	576	23.7	4%	11640	19915	2250	11%	64	51	1774
Grain	19-Dec	3:45pm	65	656	587.6	90%	754	31.3	4%	14280	22240	2820	13%	42	49	1431
	20-Dec	8:45am	90	731	516.8	71%	535	39.9	7%	10760	16155	4960	31%	65	48	1439
	20-Dec	9:45am	55	752	605.2	80%	364	27.4	8%	7440	12005	2885	24%	41	20	654
Grain	20-Dec	10:45am	82	1004	679.6	68%	2323	161.3	7%	34240	47930	8590	18%	82	189	3891
Grain	20-Dec	11:45am	72	1063	812.1	76%	1393	75.2	5%	23840	43640	5900	14%	76	99	3111
Grain	20-Dec	12:45pm	39	1406	846.7	60%	1647	65.5	4%	35880	41135	7795	19%	54	64	1588
Grain*	20-Dec	1:45pm	33	1905	1274.2	67%	3295	133.5	4%	65160	62920	11435	18%	62	108	2056
Grain*	20-Dec	2:45pm	40	874	636.8	73%	1140	51.5	5%	23200	33210	7055	21%	35	45	1315
*	20-Dec	3:45pm	75	812	568.3	70%	856	85.3	10%	14680	24380	5115	21%	60	64	1810
	20-Dec	3:45pm		891	575.2	65%	922	191.0	21%	15040	25860	6420	25%	Left for 20 days before filtering		
		Ave	**67.0**	**943**	**681**	**74%**	**1158**	**65**	**6%**	**22065**	**30123**	**5103**	**17%**	**53**	**64**	**1703**
		SD	**17.8**	**366**	**220**	**7%**	**849**	**45**	**2%**	**15995**	**17576**	**2975**	**5%**	**18**	**45**	**953**
		50%ile	**59**	**792**	**596**	**72%**	**805**	**56**	**6%**	**14480**	**23310**	**5038**	**18%**	**55**	**50**	**1514**
		90%ile	**86**	**1384**	**890**	**81%**	**2166**	**125**	**9%**	**39400**	**55425**	**8355**	**23%**	**78**	**106**	**2957**
		min	**33**	**438**	**305**	**60%**	**291**	**16**	**3%**	**6100**	**7185**	**1085**	**9%**	**25**	**11**	**270**
		max	**90**	**1905**	**1274**	**90%**	**3295**	**161**	**12%**	**65160**	**62920**	**11435**	**31%**	**82**	**189**	**3891**
		geomean	**57**	**886**	**650**	**73%**	**911**	**52**	**6%**	**17742**	**25382**	**4225**	**17%**	**50**	**51**	**1433**
Grain Ave			57	1029	732	73%	1453	74	5%	27608	37166	5884	15%			
Grass Ave			66	753	568	76%	510	46	9%	9869	14628	3385	22%			
% Diff Grain				1.37	1.29		2.85	1.61		2.80	2.54	1.74				

APPENDIX D

GLOSSARY

Chemical Oxygen Demand (COD)	a measure of the quantity of oxidisable (combinable with oxygen) components present in water. It is determined by measuring the amount of oxygen gas absorbed during a particular laboratory analytical test (COD test), in which components of a water sample are broken down by an inorganic chemical (an oxidising agent) under specified conditions during a certain number of hours.
Dry dump	emptying of paunch contents without the addition of water
Geometric mean	a measure of central tendency used to measure the average rate of change or growth for some quantity, calculated by taking the *n*th root of the product of *n* values representing change
La Parmentiere	machine used to wash and process the paunch
Load	defined as the kg pollutant generated per day
Maximum	the largest number in a set of observations
Mean	a central tendency measure representing the arithmetic average of a set of observations
Minimum	the smallest number in a set of observations
Paunch (or rumen)	an organ specific to ruminant animals
pH	measure of the acidity of a solution
Screw Press	machine used to de-water a high solids content liquid stream
Sludge	undefined mixture of microorganisms and suspended solids
Suspended Solids	matter in wastewater that is in suspension
Total Kjeldahl Nitrogen	is a determination of organic nitrogen and ammonia
Total suspended solids	the amount of volatile and fixed suspended solids in wastewater
Umbrella wash	equipment used to wash the inside of the paunch involving the injection of water

Volatile suspended solids	the amount of volatile suspended solids in wastewater
50 Percentile	the value for which 50% of the numbers in a set of observations are less than
90 Percentile	the value for which 90% of the numbers in a set of observations are less than