final report

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Best Practice Wastewater Management for Beef Processing & Tanning
A High Level Roadmap

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Abstract

This project aimed to provide a high level review of wastewater management at the Northern Cooperative Meat Company site located at Casino, NSW. The abattoir's water usage was better than the industry norm and wastewater quality was within typical values found in the meat processing industry. Nitrogen was found to be the primary issue in terms of long-term sustainability of effluent irrigation.

Technologies considered for removing nitrogen were Dissolved Air Flotation, Struvite Precipitation, Ammonia Strippers, High Rate Algal Ponds, Anaerobic Co-treatment of Tannery & Abattoir Effluents, and certain combinations of some of the above. None of the technologies on their own provided a sustainable solution.

In line with the current industry position in Australia, it was difficult to define a clear roadmap for sustainability, primarily due to the high cost of some options and the emerging technologies viewed as having great potential but currently unproven.

An interim roadmap was developed including reviewing how to target low volume but high concentration wastewater streams, attempting to be involved in struvite R&D, optimising an existing tannery DAF, commissioning further effluent irrigation, and keeping a watching brief on new technologies such as Anammox.

Executive summary

The sustainable management of wastewaters from meat processing and tanning is a challenge across both industries to the point where it has been a contributor to the closure of several tanneries and meat processing plants over the past decade or more. Downstream (end-of-pipe) solutions to wastewater management have involved considerable expense.

It is possible to reduce the cost and complexity of wastewater management systems (or any required upgrading of those systems) by improving upstream management such as source reduction, wastewater reuse or recycling, stream segregation and/or recovery of wastes (e.g. energy, organics, nutrients).

This project attempted a holistic approach to the meat processing and tanning facilities at the Northern Cooperative Meat Company's (NCMC's) Casino site, to review and compare several options in the areas of source reduction, separation of waste steams, reuse / recycling of wastewaters, recovery of wastes (solids, nutrients and energy), and end-of-pipe treatments. The review entailed a high level assessment of the relative viability of several options to provide a cost effective integrated solution(s) for the site.

The abattoir wastewater characteristics are typical of Australian abattoirs, with organic and solids concentrations approaching the high end of the industry norms and nutrient values (TKN and TP) typical of industry norms. The treated tannery wastewater characteristics are very similar to the raw abattoir wastewater, especially for COD, BOD and TSS but with elevated TDS. The tannery wastewater is very high in nitrogen, relatively low in phosphorus & has a high pH.

When irrigation loadings were calculated it was found that the tannery effluent is the major contributor of TDS, organics and solids loadings, while the abattoir is the major contributor to nitrogen loadings. Within the abattoir the major sources of nitrogen are kill floors and rendering operations. The review indicated that nitrogen was the primary issue in terms of long term sustainability of effluent irrigation.

Seven wastewater treatment options were considered which are expected to reduce nutrient loadings to irrigation. These options and conclusions for each are:

Option 1: Dissolved Air Flotation (DAF) treatment of the slaughter, boning room & rendering streams. It was considered that targeting further upstream might be a better spend for the limited available capital and therefore, the investigation of Option 1 was put on hold, particularly as the DAF was only expected to provide minor improvement in nitrogen removal .

Option 2: Co-treatment of paunch waste (PW) liquor and tannery effluent via struvite (magnesium ammonium phosphate or MAP) precipitation. It was found that while common in Australian municipal effluent treatment, struvite precipitation is not established in the Australian meat processing industry. Discussions with consultants revealed that there is work afoot to develop struvite precipitation in our industry but with a lag time of a year or more before the technology is

likely to be proven. For this reason Option 2 was put on hold while the necessary R&D work is conducted.

Option 3: Co-treatment of paunch waste (PW) liquor and tannery effluent via ammonia stripping and struvite (magnesium ammonium phosphate or MAP) precipitation. For the same reasons as for Option 2, Option 3 was not explored further. Once the success of struvite precipitation is proven in our industry, Option 3 may be worth considering.
Option 4: Treatment of Anaerobic Dam effluent via Hi-rate Algal Ponds (HRAP). Due to the large land area required and an estimated capital cost of over $2 million, Option 4 was not explored in any further. After a better look at upstream treatments, Option 4 may be worth further investigation, perhaps targeting low volume streams.

Option 5: Air stripping and recovery of ammonia from anaerobic ponds. There was insufficient time to explore in great detail but it does warrants investigation at some stage in the future, subject to an assessment of costs and benefits compared with any other options available at that point in time.

Option 6: Treatment of tannery effluent in existing anaerobic dams. While considered technically possible to achieve nitrogen removal, there are several aspects that could present significant challenges. These include residual chromium from the tannery accumulating in pond sludge making waste disposal expensive, and conversion of sulphur in tannery effluent into hydrogen sulphide, creating safety issues and extreme odours. The potential for significant odours and the possible associated community complaints left Option 6 as non-viable at this stage.

Option 7: Co-treatment of tannery and abattoir effluent in the Anaerobic Dams followed by ammonia stripping and recovery. For the same reasons as Option 6, Option 7 is considered non-viable at this stage.

Further studies may be undertaken to assess the establishment of a High Rate Anaerobic Treatment (HRAT) plant located close to the abattoir which would effectively replace the anaerobic pond system. This option would provide increased efficiency in the anaerobic process but provide minimal benefit to remove the major nutrients such as nitrogen or phosphorus from the wastewater streams. As the existing anaerobic ponds are operating reasonably well then this option is not considered high priority at this stage.

Many operators of anaerobic ponds and dams are moving to cover the dams with a synthetic cover to enable methane gas capture and utilisation by providing a supplementary fuel to the boilers. By covering the anaerobic dams the level of greenhouse gas production (GHG) from the dams can be effectively reduced. However, as there would be no improvement in nutrient removal or wastewater volumes generated, this option is not considered a high priority at this stage.

New technologies for treatment of abattoir wastewater are being developed and the University of Queensland's Advanced Water Management Centre has trialled, albeit only at laboratory scale, a novel treatment scheme comprising high rate aerobic biological treatment followed by anaerobic digestion and Anammox for nitrogen removal. Technologies such as these are as yet, insufficiently tested enough to consider in a current roadmap.

Even with a scope specifying consideration of upstream treatments, the consultant employed had considerable focus on downstream treatments such as algal ponds, anaerobic ponds and applying other technologies even further downstream. Some upstream options considered were not well developed in Australia and require some development work to prove their viability in the meat processing industry. It is suggested that the above observations are an indication of the meat processing industry's general historical focus on downstream treatments rather than a widespread focus on upstream nutrient removal.

While the meat industry has in recent years been moving upstream with regards to reduction in water use, the industry seems to be in the early stages of the upstream approach to nutrient removal. With the number of emerging industry projects with an upstream focus, it seems that there is still much work to do before meat processors are able to map out a clear roadmap for wastewater sustainability.

Although it is currently difficult to map a clear roadmap for sustainability at NCMC, the following interim roadmap has been developed;

- Identify low volume, high concentration streams for targeted treatment (eg raw material bin drains & stickwater streams are prime candidates) – technologies to be determined through further consultant engagement
- Participate in Uni of Qld struvite project (e.g. tannery wastewaters and paunch filtrate are prime candidates).
- Optimise the existing DAF at the tannery.
- Conduct a detailed review of wastewater nutrient concentrations and capacity of irrigation areas to accept the nutrients – the aim is to quantify the deficiency in the amount of irrigation area. This will allow an accurate comparison of the cost of opening up more irrigation areas versus the cost of implementing nutrient reduction technologies (once they are known)
- Meanwhile commission further irrigation – this has commenced & comprises spray irrigation. This allows some decommissioning of older channel irrigation areas and brings the site further into compliance with the New Sales Wales EPA Guidelines for The Use of Effluent By Irrigation
- Keep a watching brief on other developments such as Anammox treatment.

Targeted upstream nutrient removal should continue to be developed as a major focus for the meat processing industry. It is therefore recommended that industry bodies continue to take up projects in these areas, including the emerging projects related to struvite precipitation and targeting rendering wastewater streams.

Contents

1 Background

1.1 The Wastewater Predicament for Industry

The sustainable management of wastewaters from meat processing and tanning is a challenge across both industries to the point where it has been a contributor to the closure of several tanneries and meat processing plants over the past decade or more. Downstream (end-of-pipe) solutions to wastewater management have involved considerable expense.

This is true for the recent growth in the use covered anaerobic lagoons (CALs) in the Australian meat processing industry. CALs involve considerable expense and present major challenges in operation and maintenance.

It is possible to reduce the cost and complexity of wastewater management systems (or any required upgrading of those systems) by improving upstream management such as source reduction, wastewater reuse or recycling, stream segregation and/or recovery of wastes (eg energy, organics, nutrients).

Increasing energy costs, the introduction of the carbon tax and the associated grant funding that has become available, now provide great incentives to explore alternate options in the areas of energy recovery and associated upstream management strategies. At the same time increasing water costs provide incentive to invest in reducing water usage rather than investing in the treatment of the resulting extra wastewaters.

1.2 NCMC's Challenge

NCMC's Casino site comprises an integrated meat processing plant (including abattoir, boning room and high temperature rendering) along with a tannery. The company has previously invested time and expense into the design and planning work for a major wastewater treatment system upgrade involving Sequenced Batch Reactors (SBRs) to co-treat the tanning & meat processing wastes. Due to the large capital and operating costs associated with the proposed system it was necessary to consider alternate approaches to reduce the cost burden and where possible, to maximise the benefits of recovering valuable wastes before they are mixed in downstream treatment systems.

2 Project objectives

This project attempted to take a holistic approach to the meat processing and tanning facilities at NCMC to review and compare several options in the areas of source reduction, separation of waste streams, reuse / recycling of wastewaters, recovery of wastes (solids, nutrients and energy), and end-of-pipe treatments.

The review entailed a high level assessment of the relative viability of several options to provide a cost effective integrated solution(s) for the site. In essence, the review was intended to provide a high level roadmap for the site to enhance its capability in relation to wastewater management and the recovery of associated wastes. The roadmap and the findings leading to its development should be applicable to other players in the industry, thus providing potential to increase the entire industry's capability.

3 Methodology

3.1 Overview

To conduct the review a consultancy firm was engaged. GHD were selected due to their experience in the meat processing and tanning industries, and their reputation being held in high regard within industry.

GHD's brief was to conduct a high level review considering the various upstream wastes generated by the site. This required knowledge of the individual streams generated. Therefore, NCMC signed on to participate in an industry-funded waste characterisation study undertaken by the Advanced Water Management Centre (AWMC) operating out of the University of Queensland. Unfortunately, the AWMC data was not available in time to be included in GHD's review and GHD supplemented NCMC's existing in-house knowledge with generic data based on GHD's previous experience in the industry.

3.2 Process

3.2.1 Stage 1 – Initial High level Review

This stage involved GHD undertaking the following steps:

a) Review of existing site and operational data including quantity and quality of waste streams as well as the equipment and operations utilised on site.

b) Review downstream wastewater treatments, effluent irrigation practices and key characteristics of the effluent irrigation areas

c) Visit site to understand operations and identify sub-optimal treatment operations.

d) Assess the capacity of the effluent irrigation area to receive the quantity and quality of wastewater produced by the plant.

e) Issue a report identifying potential **key** improvements along with estimates of resulting wastewater stream qualities and quantities, and how each potential option measures up both in terms of achieving sustainability and in terms of cost.

3.2.2 Stage 2 – Workshop to Assess Merits of Options

This stage involved a workshop with GHD to discuss the relative merits of options identified in the report. This led to a set of preferred options that warranted further exploration.

3.2.3 Stage 3 – Exploring Options in More Detail

This stage involved further exploration of preferred options identified in Stage 2. This was conducted in-house by liaising with suppliers of relevant equipment and some smaller interaction with consultants. This work was conducted in house.

4 Results and Discussion

4.1 High Level Assessment of Operations

4.1.1 Facility Description

The facility consists of two kill floors, one for large beef cattle and one for smaller cattle (veal), typically operating 5 days per week (nominally 6am to 4pm). The abattoir processes a mix of grain and grass fed cattle. The boning room operates on 2 shifts, dayshift & afternoon shift followed by a cleaning shift typically from 11pm to 5am. Boxed meat is stored in chillers or freezers prior to transport off site to domestic and overseas markets.

The abattoir includes a high temperature rendering cooker that processes all non-edible offal, fat and bone from the slaughter floor along with fleshings (flesh removed from hides) from the tannery. The rendering facility can also receive miscellaneous fat and bone wastes from local butchers in the region. Blood waste from the company's smaller pig processing plant also located in the region, is cooked in batch cookers, separate to the fats & bones. The plant produces tallow (3 grades), blood meal, and meat and bone meal (MBM). Off-gases from rendering are condensed and then deodorised in an LPG-fired after-burner.

NCMC also operates a tannery (since 1972) which processes all the hides generated at the abattoir and also processes external hides on a contract basis. The tannery operates 5 to 6 days per week. All the hides processed are "green", that is, no salted hides are processed. The tannery product is wet-blue hides, with no finishing operations. Since the tannery "lags" the abattoir, significant water is used for 6 days per week. Peak flows are Thursday and Friday each week.

Hot water and steam for the abattoir is provided by a biomass fired boiler. The boiler operates about 20 hours per day, 5 days per week and typically, a few hours on Saturday mornings. Waste heat from the rendering operations is used to preheat potable water for use in processing. An ammonia refrigeration system is on site to provide cooling for chillers and freezers.

Apart from some reuse of reclaimed process waters, the plant water is primarily supplied as potable water by the local municipal council. Electricity is supplied entirely from the retail market.

After primary treatment to remove solids, followed by anaerobic pond treatment, wastewater from the abattoir is utilised via furrow irrigation on a property owned by NCMC. Treated tannery wastewater is also utilised via spray irrigation on the same property.

4.1.2 The Water / Wastewater Circuit

A simplified diagram, showing the water and wastewater circuits within the complex, is depicted in Figure 1.

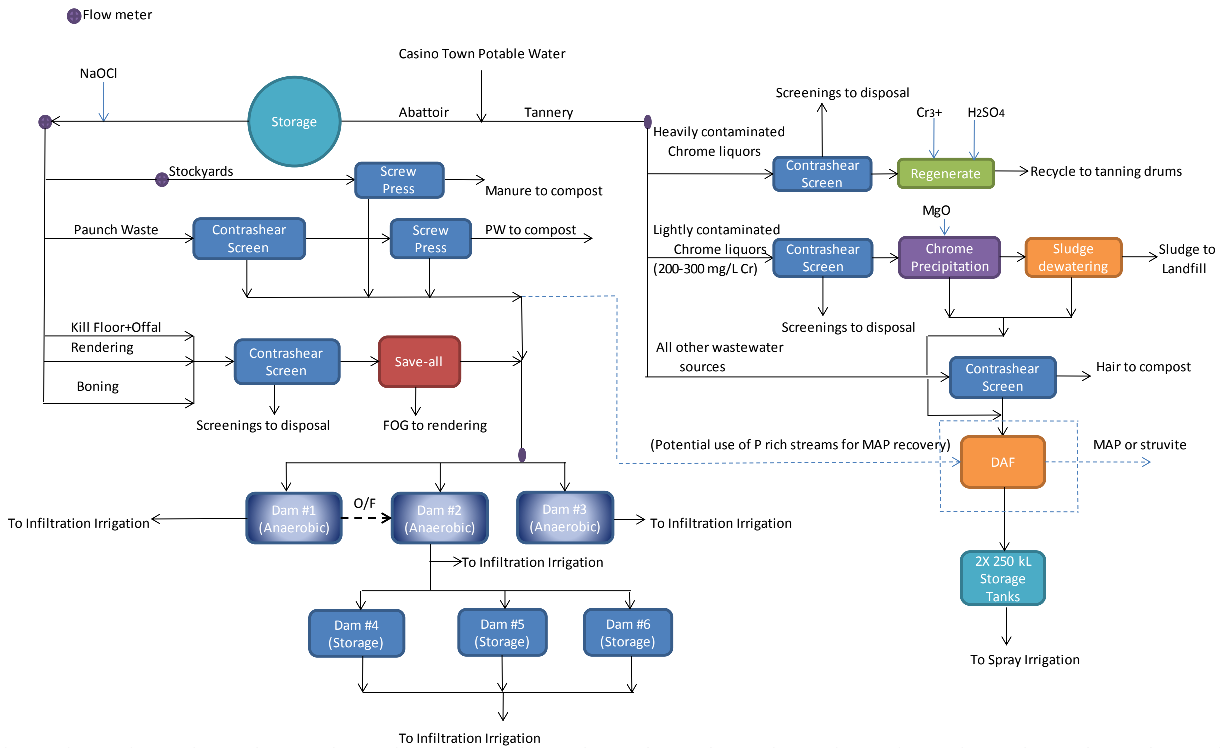


Figure 1 NCMC Water Circuit PFD

Paunch wastewaters are screened to separate partly digested grass and grain from the wastewater stream, with the dewatered paunch sent to composting. A separate screen can be used to separate manure solids from the stockyards wastewaters.

The two “green” streams, from dewatering, are piped individually to the pump station that pumps the total abattoir wastewater stream to the Anaerobic Dams. The abattoir’s “red” streams are screened in a common rotary screen followed by a save-all to remove floating fats & oils which are sent to rendering.

The green and red streams are then combined in a pump well for transfer to biological treatment in three anaerobic dams operating in parallel.

Tannery wastewater is separated into three individual streams. The high concentration chrome liquor stream is regenerated and recycled back to the tanning drums. The low concentration chrome liquors (200 to 300 mg/L Cr) are screened and then treated to precipitate the chromium (tri-valent), using magnesium oxide. The chrome screenings and sludge are disposed to landfill. All other wastewater, with little or no chrome, is screened and then combined with the filtrate from the chrome precipitation step prior to spray irrigation on the company farm. A DAF has been installed to improve wastewater quality. The management of sludge from the unit has presented difficulties.

4.1.3 Effluent & Its Reuse By Irrigation

A key element of the site's sustainability management is the utilisation of treated effluent for irrigation. This makes use of the water and the nutrients within it, to grow pasture for cattle grazing (and recently, some cropping).

The quality and quantity of the abattoir's and tannery's wastewaters were reviewed in conjunction with a review of the site's effluent irrigation systems. The abattoir wastewater characteristics are typical of Australian abattoirs, with organic and solids concentrations approaching the high end of the industry norms and nutrient values (TKN and TP) typical of industry norms. The treated tannery wastewater characteristics are very similar to the raw abattoir wastewater, especially for COD, BOD and TSS but with elevated TDS. The tannery wastewater is very high in nitrogen, relatively low in phosphorus & has a high pH.

When irrigation loadings were calculated it was found that the tannery effluent is the major contributor of TDS, organics and solids loadings, while the abattoir is the major contributor to nitrogen loadings. Within the abattoir the major sources of nitrogen are kill floors and rendering operations.

The review indicated that nitrogen was the primary issue in terms of long term sustainability of effluent irrigation.

4.2 Initiatives & Technologies for Sustainability

4.2.1 Options Proposed for Consideration

Consideration was given to seven wastewater treatment options, all are expected to reduce nutrient loadings to irrigation. The options were:

- Option 1: Dissolved Air Flotation (DAF) treatment of the slaughter, boning room & rendering streams.
- Option 2: Co-treatment of paunch waste (PW) liquor and tannery effluent via struvite (magnesium ammonium phosphate or MAP) precipitation.
- Option 3: Co-treatment of paunch waste (PW) liquor and tannery effluent via ammonia stripping and struvite (magnesium ammonium phosphate or MAP) precipitation.
- Option 4: Treatment of Anaerobic Dam effluent via Hi-rate Algal Ponds (HRAP).
- Option 5: Air stripping and recovery of ammonia from Anaerobic dam.
- Option 6: Treatment of tannery effluent in existing Anaerobic Dams.
- Option 7: Co-treatment of tannery and abattoir effluent in the Anaerobic Dams followed by ammonia stripping and recovery.

4.2.2 Option 1 - DAF of Abattoir Red Streams

Dissolved Air Flotation is a technology commonly applied to abattoir effluent. The high level review showed the overall impact of DAF pre-treatment (Option 1) of the abattoir red streams when combined with the contaminant loading from the tannery stream. This is shown in the following table.

Impact on Irrigation from Option 1

Parameter	Current total loading to Irrigation (tpa)	New total loading to Irrigation with Option 1 (tpa)	Load reduction (tpa)	Load reduction (% removal)
COD	1609	1548	61	4%
BOD	681	671	11	2%
TSS	645	620	25	4%
O&G	39	35.7	2	6%
TKN	244	236	8	3%
TP	19	19	0.3	2%

As shown in the table, implementation of Option 1 will only reduce TKN and TP loadings to irrigation by 8.2 and 0.3 tpa respectively, both low percentages (< 4%) of the total loadings. However, a benefit of this option is increased recovery of fat and organics that can go back to rendering. The high level review estimated that an additional 136 tonnes p.a could be recovered for rendering. At $300 per tonne for tallow this is worth about $40,000 per annum. At $800 per tonne this is over $108,000. Whilst use of a chemical DAF would increase contaminant recovery rates, this would increase the costs associated with recovery and there is the potential that these chemicals could affect tallow quality.

Following the high level review, this option was explored in more detail by liaising with DAF suppliers. Six suppliers were approached, most visiting the site to assist them in understanding the current treatment systems and the available areas for a potential DAF installation. Due to the cost being near or over $1 million NCMC wanted an adequate performance guarantee before deciding to invest. Unfortunately, no supplier could provide a performance guarantee that assured NCMC of better performance than the Saveall system currently used to treat the red streams.

Some suppliers provided proposals for a decanter to either treat the DAF float or to individually target rendering streams. The same issue existed with a lack of adequate performance guarantees. However, the notion of targeting lower volume but high concentration streams seemed to make sense and has become a focus for NCMC since this project. It was considered that targeting further upstream might be a better spend for the limited available capital and therefore, the investigation of Option 1 was put on hold, particularly as the DAF was only expected to provide minor improvement in nitrogen removal .

4.2.3 Option 2 – Struvite Precipitation from Paunch Liquor & Tannery Effluent

Struvite precipitation is used in several locations in Australia to remove nitrogen and phosphorus from effluents, mainly in municipal treatment plants. The high level review showed the overall impact of Option 2, assuming that the tannery DAF is fully operational. This is shown in the following table.

Impact on Irrigation from Option 2

Parameter	Current total loading to Irrigation (tpa)	New total loading to Irrigation with Option 2 (tpa)	Load reduction (tpa)	Load reduction (% removal)
COD	1,609	645	964	60%
BOD	681	381	300	44%
TSS	645	84	561	87%
O&G	39	34	4.1	11%
TKN	244	186	65	26%
TP	19	1.3	18	93%

Implementation of Option 2 is expected to significantly reduce the loadings of COD, BOD, TSS, TKN and TP on irrigation. As shown, TKN and TP loading reductions of 65 and 18 tpa are anticipated. A number of commercial suppliers of struvite precipitation reactors are available, with fluid bed crystallisers the most common. The struvite (also known as MAP) is generated as large crystals or pellets that are readily dewatered on screens. Struvite is a valuable fertiliser and current prices are about $700/tonne.

The major proportion of nitrogen removal is expected to occur across the DAF with very little P removal in the DAF. Struvite removes only the nitrogen that is in the form of ammonia, in this case expected to be approximately 26 kg ammonia-N/d being removed. TKN removal is however, expected to be 259 kg/d across the combined DAF + struvite process. This comprises the 26 kg/d (10%) removed as ammonia, with the remaining 233 kg/d (90%) being particulate organic nitrogen removed across the DAF. The resultant struvite production is estimated as 456 kg/d as dry struvite crystal.

Following the high level review, this option was explored in more detail by searching for companies with experience in precipitating struvite from meat processing wastewaters. It was found that while common in Australian municipal effluent treatment, struvite precipitation is not established in the Australian meat processing industry. Discussions with consultants revealed that there is work afoot to develop struvite precipitation in our industry but with a lag time of a year or more before the technology is likely to be proven. For this reason Option 2 was put on hold while the necessary R&D work is conducted. NCMC became aware of the project involving struvite removal, proposed by the Advanced Water Management Centre at the University of Queensland. Since then, NCMC has expressed a strong interest in partaking in the project as a relevant industry site.

4.2.4 Option 3 – Option 2 Supplemented With Ammonia Stripping

In this process the combined tannery effluent and paunch waste liquid stream would be first treated using an existing tannery DAF to remove solids and particulate COD and BOD. The wastewater is then sent to the ammonia stripping column where the pH is raised to 9.5 with caustic and the required amount of ammonia is stripped from the wastewater to ensure that after struvite precipitation, ammonia levels are very low. The stripped ammonia is then removed as ammonium sulphate in an adsorption column using sulphuric acid as the adsorbent. Ammonium sulphate is worth approximately $450/t. The ammonia-lean stream is then sent to the struvite precipitation circuit where MAP is precipitated and removed from the wastewater.

The overall impact of ammonia recovery and struvite precipitation on contaminant loadings to irrigation is shown in the following table

Impact on Irrigation from Option 3

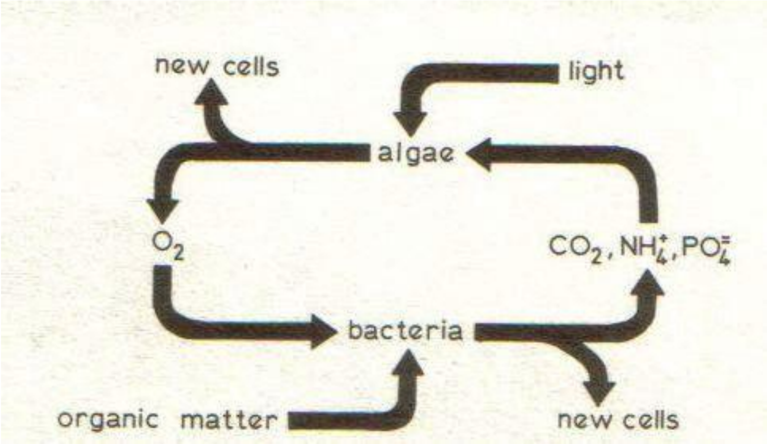
Parameter (tpa)	Current total loading to Irrigation	New total loading to Irrigation with Option 3	Load reduction	Load reduction (% removal)
COD	1,609.2	644.9	964.3	60%
BOD	681.3	381.3	300.0	44%
TSS	644.8	84.0	560.7	87%
O&G	37.8	33.6	4.1	11%
TKN	243.8	154.4	89.5	37%
TP	19.2	1.3	17.8	93%

As can be seen, the only difference to Option 2 is the lower TKN loadings to irrigation due to ammonia recovery.

For the same reasons as explained in Section 4.2.4 for Option 2, Option 3 was not explored in greater detail. Once the success of struvite precipitation is proven in our industry, Option 3 may be worth considering.

4.2.5 Option 4 – High Rate Algal Ponds

The use of HRAPs, to treat the anaerobic dam effluent, is considered a potentially viable treatment option to consider. HRAPs are effective in reducing nitrogen in wastewaters, due to stripping and assimilation of ammonia (and to a lesser extent TP) which is required for algal growth. Algal ponds are very shallow (0.3 to 1.5 m) to provide the light penetration required for algal growth. There is a symbiotic relationship between bacteria and algae in algal ponds as is shown in the following diagram.



Source: “Sewage Treatment in Hot Climates”, D Mara, Published by J Wiley and Sons, 1976

Algal Pond Biochemistry

This option is based on installing a new HRAP and a new settling pond adjacent to the existing anaerobic dams. Preliminary estimates of the HRAP surface area required are 66 ha and the settling pond surface area is 17 ha. It is possible that the three storage dams could be used as the site(s) for these algal ponds. The costs for new HRAPs have been estimated at $15/m3. The HRAP is equipped with baffles to provide “race-track” flow configuration and mixers to ensure no stratification in the pond. The expected performance of the HRAP and settling pond is shown in the following table;

Expected Impact on Irrigation from Option 4

Parameter	Current total loading to Irrigation (tpa)	New total loading to Irrigation with Option 4 (tpa)	Load reduction (tpa)	Load reduction (% removal)
COD	1,609	1,422	188	12%
BOD	681	632	49	7%
O&G	38	34	1	10%
TSS	645	644	4	0%
TKN	244	124	120	49%
TP	19	16	4	18%

Option 4 provides a very significant reduction in nitrogen loading to the irrigation system. However, due to the large land area required and an estimated capital cost of over $2 million, Option 4 was not explored in any more detail. After a better look at upstream treatments, Option 4 may be worth further investigation, possibly targeting low volume wastewater streams.

4.2.6 Option 5 – Ammonia Recovery of Anaerobic Dam Effluent

This option is based on air stripping ammonia from the anaerobic dam effluent and recovering it as ammonium sulphate. Unfortunately this option is not suitable to treat the raw abattoir wastewater as the ammonia concentrations are too low and most of the nitrogen is organic. This option is based on the same ammonia recovery system as described in Option 3.

It is expected that approximately 100 tpa of ammonia (as nitrogen) is recovered from the anaerobic dam effluent via the stripping system. This is expected to produce about 387 tpa of dry ammonium sulphate.

The expected overall impact of the anaerobic dam effluent ammonia recovery system on contaminant loadings to irrigation is shown in the following table;

Impact on Irrigation from Option 5

Parameter	Current total loading to Irrigation (tpa)	New total loading to Irrigation with Option 3 (tpa)	Load reduction (tpa)	Load reduction (% removal)
COD	1,609	1,609	0.0	0%
BOD	681	681	0.0	0%
TSS	644	645	0.0	0%
O&G	39	38	0.0	0%
TKN	244	144	100	41%
TP	19	19	0.0	0%

The Option 5 system targets the reduction of the nitrogen loading to irrigation, and by a significant amount (about 100 tpa). The need to raise the pH will increase the TDS of the wastewater. Caustic is probably the best for this, but will increase the sodium concentration to levels that may increase the sodium absorption ratio too much. To alleviate this, lime or magnesium could be used to raise the pH, but this may cause problems with scaling of the stripper. Some preliminary testing of this would need to be conducted to confirm the best way forward.

There was insufficient time to further explore Option 5 but it does probably warrant some investigation at some stage subject to an assessment of costs and benefits compared with any other options available at that point in time.

4.2.7 Option 6 – Co-treating of Abattoir & Tannery Effluent Anaerobically

This option is based on the premise that the tannery effluent will be pre-treated using the existing new DAF at the tannery. The treatment performance of the DAF is assumed to be the same as outlined for Option 1. The combined stream chromium concentration is well below the USEPA estimated inhibitory value (50 mg/L) for anaerobic lagoons. Other chemicals used in the plant need to be checked also for any toxic effects.

In addition, co-treatment using DAF pre-treated tannery effluent only increases loadings to the anaerobic dams by relatively small amounts (compared to the existing treatment of abattoir effluent) and it is expected that this should have little impact on anaerobic dam biological performance. The overall impact on loadings to irrigation is shown in the following table;

Impact on Irrigation from Option 6

Parameter	Current total loading to Irrigation (tpa)	New total loading to Irrigation with Option 6 (tpa)	Load reduction (tpa)	Load reduction (% removal)
COD	1,609	411	1,198	74%
BOD	681	82	600	88%
TSS	645	115	530	82%
O&G	38	11	27	70%
TKN	244	198	46	19%
TP	19.2	18.2	1.0	5%

As shown in **Error! Reference source not found.** this option provides a significant reduction in COD, BOD, TSS and TKN loadings to irrigation.

Following the high level review, this option was explored in more detail by considering the approach internally and seeking advice from an environmental consultant, experienced in wastewater treatment & design. While considered technically possible to achieve nitrogen removal, there are several aspects that could present significant challenges. These include;

a) residual chromium from the tannery accumulating in pond sludge, making waste disposal expensive

b) conversion of sulphur in tannery effluent into hydrogen sulphide, creating safety issues and extreme odours

The potential for significant odours and the possible associated community complaints left Option 6 as unviable at this stage.

4.2.8 Option 7 – Co-treating of Abattoir & Tannery Effluent Anaerobically Followed by Ammonia Stripping

This option is the same as Option 6, but with air stripping and recovery of ammonia from the dam effluents, as per Option 5. Thus the only difference between Options 6 and 7 is the higher ammonia removals achieved by the stripping and recovery process, as shown in the following table;

Impact on Irrigation from Option 7

Parameter	Current total loading to Irrigation (tpa)	New total loading to Irrigation with Option 7 (tpa)	Load reduction (tpa)	Load reduction (% removal)
COD	1,609	411	1,198	74%
BOD	681	82	600	88%
TSS	645	115	530	82%
O&G	38	11	27	70%
TKN	244	102	142	52%
TP	19.2	18.2	1.0	5%
Cr	7.0	3.0	4.2	61%

For the same reasons as Option 6, Option 7 is considered unviable at this stage.

4.3 Other Alternatives Considered

4.3.1 High Rate anaerobic Treatment

Further studies may be undertaken to assess the establishment of a High Rate Anaerobic Treatment (HRAT) plant located close to the abattoir which would effectively replace the anaerobic dam system. This option would provide increased efficiency in the anaerobic process but provide minimal benefit to remove the major nutrients such as nitrogen or phosphorus from the wastewater streams. As the existing anaerobic dams are operating reasonably well then this option is not considered high priority at this stage.

4.3.2 Covered Anaerobic Dams

Many operators of anaerobic ponds and dams are moving to cover the dams with a synthetic cover to enable methane gas capture and utilisation by providing a supplementary fuel to the boilers. By covering the anaerobic dams the level of greenhouse gas production (GHG) from the dams can be effectively reduced. However for the NCMC system the gas would require capture and piping back to the abattoir's boiler or combustion at the pond in a gas engine to provide electricity for the grid or power requirements at the pond area. As there would be no improvement in nutrient removal or wastewater volumes generated, this option is not considered a high priority at this stage.

4.3.3 Novel new technologies

New technologies for treatment of abattoir wastewater are being developed and the University of Queensland's Advanced Water Management Centre has trialled, albeit only at laboratory scale, a novel treatment scheme comprising high rate aerobic biological treatment followed by anaerobic digestion and Anammox for nitrogen removal. Technologies such as these may well prove economically feasible for abattoirs in the future but are as yet, insufficiently tested enough to consider in a current roadmap.

4.4 Comparison of Options

4.4.1 Comparison Summary

A brief summary of the costs (+/- 50%) and nutrient removals of the seven treatment options considered to reduce contaminant loadings to irrigation are summarised in the following table.

Summary of Treatment Options

Option	Description	Cost Estimate ($ 1000)		Nutrient Removed	
		CAPEX	OPEX	TN (tpa)	TP (tpa)
1	DAF pre-treatment of kill floor, boning room, rendering	650[a]	20	8.2	0.3
2	Struvite precipitation from co-treatment of paunch waste liquor and Tannery effluent.	700	-65[b]	58.1	17.8
3	Struvite precipitation and ammonia recovery from Paunch Waste liquor and Tannery effluent.	1,350	-71[c]	89	17.8
4	High Rate Algal Ponds	1,950	40[d]	120	4
5	Ammonia Recovery from anaerobic dam effluent	1,300	-41[e]	100	0
6	Co-treatment of Abattoir and Tannery Effluent in Anaerobic Dams	<100	<5	46	1
7	Co-treatment of Abattoir and Tannery Effluent in Anaerobic Dams with ammonia stripping and recovery of AD effluents	1,400	-35[e]	142	1

Notes:
a Based upon GHD data recently obtained for a similar sized DAF unit.
b Operating revenues include sales of MAP produced.
c Operating revenues include sales of ammonium sulphate and MAP produced.
D Includes estimates of electrical power costs to operate the mixers.
E Operating revenues include sales from ammonium sulphate.

A table summary of the main advantages and disadvantages is shown in the following table.

Comparison of Advantages and Disadvantages

Option	Description	Advantages	Disadvantages
1	DAF pre-treatment of kill floor, boning room, rendering	• Partial removal and recovery of O & G to rendering. • Moderate CAPEX • Moderate OPEX	• Minor reduction of COD, BOD, TSS and O& G to irrigation. • Minor reduction of N & P to irrigation
2	Struvite precipitation from co-treatment of paunch waste liquor and Tannery effluent.	• Moderate CAPEX • Generates revenue stream which can offset OPEX costs • High reduction in COD, TSS to irrigation • Moderate reduction in BOD and O & G • Moderate reduction in N to irrigation • High reduction in P to irrigation • DAF currently installed at tannery	
3	Struvite precipitation and ammonia recovery from Paunch Waste liquor and Tannery effluent.	• High reduction in COD, TSS to irrigation • Moderate reduction in BOD, N and O&G to irrigation • Very high reduction in P to irrigation • Generates revenue stream which can offset OPEX costs	• High CAPEX • Complex equipment
4	High Rate Algal Ponds	• Good reduction in N • Good reduction in P	• High CAPEX • Moderate OPEX • Requires new power supply to HRAP site(s)
5	Ammonia Recovery from anaerobic dam effluent	• Good reduction in N	• High CAPEX • Moderate OPEX
6	Co-treatment of Abattoir and Tannery Effluent	• Low CAPEX and OPEX • Good removal rates of COD, BOD, TSS and O&G.	• Moderate removal of N • Minor removal of P • Toxic risk to anaerobic dam

Option	Description	Advantages	Disadvantages
	in Anaerobic Dams		operation from chemicals
7	Co-treatment of Abattoir and Tannery Effluent in Anaerobic Dams followed by air stripping and recovery of ammonia	• Good COD, BOD, TSS, O&G and N removal	• High CAPEX • Minor P removal • Toxic risk to AD operation from chemicals

4.5 Discussion of Treatment Options

The high level review found that no Option on its own provided the complete sustainability solution. It was suggested that a combination of Options 3 & 4 may be a feasible solution, although clearly there is much work required to prove the success of struvite precipitation in the meat processing industry.

GHD advised that overall, given the strength of the wastewater, the most feasible solution is likely to be one that combines pre-treatment, anaerobic treatment and some form of post treatment (stripping, algae or activated sludge).

5 Conclusions and recommendations

5.1 Conclusions

5.1.1 Options for the Northern Cooperative Meat Company

The following conclusions have been drawn as a result of this study:

- NCMC have already undertaken significant improvements in wastewater recycling leading to significant volume reductions per head of cattle, bettering industry average.
- When irrigation loadings were calculated it was found that the tannery effluent is the major contributor of TDS, organics and solids loadings, while the abattoir is the major contributor to nitrogen loadings. Within the abattoir the major sources of nitrogen are kill floors and rendering operations.
- High nitrogen-loadings were the primary issue in terms of long term sustainability of effluent irrigation.
- A number of treatment options have been identified which are capable of reducing nitrogen and phosphorus however the most feasible solution is likely to involve a combination of struvite precipitation, co-anaerobic treatment of tannery and abattoir effluents and possibly air stripping and ammonia recovery of the AD effluents.
- A High Rate Anaerobic Treatment (HRAT) plant would provide increased efficiency in the anaerobic process but provide minimal benefit to remove the major nutrients and as such, is not considered high priority at this stage.
- Covering anaerobic ponds to capture & utilise methane gas would reduce greenhouse gas emissions. As there would be no improvement in nutrient removal or wastewater volumes generated, this option is not considered a high priority at this stage.
- New technologies for treatment of abattoir wastewater are being developed and the University of Queensland's Advanced Water Management Centre has trialled, albeit only at laboratory scale, a novel treatment scheme comprising high rate aerobic biological treatment followed by anaerobic digestion and Anammox for nitrogen removal. Technologies such as these are as yet, insufficiently tested enough to consider in a current roadmap.
- Wastewater sustainability relies on a balance between the nutrients in the wastewater and the amount of suitable land available to irrigate the wastewater. Finding more suitable land for irrigation is a method of assisting the move to long term sustainability. NCMC has identified various areas of its existing farmland where further irrigation is being commissioned.

5.1.2 The Wider Meat Industry Position

This review utilised a large, well known consultant with considerable experience in the meat processing industry. Even with a scope specifying consideration of upstream treatments, the work had considerable focus on downstream treatments such as algal ponds, anaerobic ponds and applying other technologies even further downstream.

Some upstream options considered were not well developed in Australia and require some developmental work to prove their viability in the meat processing industry.

It is suggested that the above observations are an indication of the meat processing industry's traditional adoption of downstream treatments rather than a focus on upstream nutrient removal.

While the meat industry has in recent years been moving upstream with regards to reduction in water use, the industry seems to be in the early stages of the upstream approach to nutrient removal. With the number of emerging industry projects with an upstream focus, it seems that there is still much work to do before meat processors are able to map out a clear roadmap for wastewater sustainability.

5.2 Recommendations

5.2.1 NCMC Wastewater Roadmap

Although it is currently difficult to define a clear pathway for the sustainable treatment of wastewater, NCMC has developed the following interim roadmap;

- Identify low volume, high concentration streams for targeted treatment (e.g. raw material & stick-water streams are prime candidates) – technologies to be determined through further consultant engagement
- Participate in Uni of Qld struvite project (e.g. tannery wastewaters and paunch filtrate are prime candidates).
- Optimise the existing DAF at the tannery.
- Conduct a detailed review of wastewater nutrient concentrations and capacity of irrigation areas to accept the nutrients – the aim is to quantify the deficiency in the amount of irrigation area. This will allow an accurate comparison of the cost of opening up more irrigation areas versus the cost of implementing nutrient reduction technologies (once they are known)
- Meanwhile commission further irrigation – this has commenced & comprises spray irrigation. This allows some decommissioning of older channel irrigation areas and brings the site further into compliance with the New Sales Wales EPA Guidelines for The Use of Effluent By Irrigation
- Keep a watching brief on other developments such as Anammox treatment.

5.2.2 Further Industry Work

Targeted upstream nutrient removal should continue to be developed as a major focus for the meat processing industry. It is recommended that industry bodies continue to work up projects in these areas, including the emerging projects related to struvite precipitation and targeting rendering wastewater streams.

6 Reference list

Environmental Guidelines: Use of Effluent by Irrigation, NSW Department of Environment & Conservation (now EPA), October 2004