# final report

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# Abattoir DAF Sludge Capture, Benchmarking & Sludge Processing (protein capture) Project

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# Abstract

This report assesses the efficiency and value of an effective dissolved air flotation (DAF) system. One key abattoir industry issue is managing high volume, wet waste streams containing large quantities of suspended solids. Effective DAF technology can extract suspended solids from the wet stream at a very low cost-per-unit solids removed, whilst operating in a reliable manner. This study demonstrates that suspended solids in the Churchill Abattoir red stream could be removed at levels of up to 99% for a chemical cost of approximately $250 per mega-litre (see Test 1, Table 1.1, 1.2.) plus other minor on-costs. Effluence deployed its trans-locatable DAF to Churchill Abattoir with MLA/AMPC assistance to demonstrate the ease of deployment, operation and delivery of outcomes.

The removal of suspended solids from the wet waste stream means that pond management costs could decline, offsetting DAF capital and operational costs. The study also explores the cost of beneficial re-use options for the captured sludge as the captured sludge may attract disposal charges. Further, the study explores the re-use of DAF sludge, which is often re-processed for tallow extraction, thereby generating offsetting income in addition to the relatively low cost of operation.

Photo 1: Effluence Pty Ltd's DAF being hosted on the Churchill Abattoir site in Ipswich, Queensland, January, 2012

Photo 2: Effluence Pty Ltd's DAF wastewater cleaning results, progressing from right to left where the right hand container is the original influent and the lefthand containers are the clarified water where the reddish colour is dissolved blood, Churchill Abattoir, 2012

Photo 3.  Sludge on the surface of the Effluence DAF, about to be captured, Churchill Abattoir, 2012

# Executive Summary

It is proposed that effective Dissolved Air Flotation (DAF) operations can capture and convert suspended volatile solids in the industry's red waste stream into an opportunity for a value added by-product. The volatile suspended solids component (VSS), or organic component of total suspended solids (TSS), is the dominant proportion of the total suspended solids.

Effluence has provided its DAF and expertise with MLA/AMPC support to demonstrate the feasibility of cost-effectively extracting suspended solids (TSS and VSS) from the industry red waste stream. Based on results in this report, effective DAF operations can remove up to 99% of suspended solids at a chemical cost of $250 per mega-litre of wastewater (Test 1, Table 1.1, Table 1.2) plus other operational costs. The results of this trial represent the results for the waste stream at the trial site but also indicate the potential that effective DAF operations can deliver. The cost of DAF operations may be offset by a consequential decline in the cost of pond operations in terms of minimising crust accumulation by the reduction of VSS.

The project objectives were, given the mobile nature of the Effluence DAF, to:

1. trial efficient installation,
2. 'tune' the DAF to the waste stream, and
3. demonstrate efficient capture of fats, oil, greases and meat particulates.

Effluence 's experience is that DAF's need to be 'tuned' to each unique waste stream for efficient operations. The DAF was 'tuned' to find the optimal sludge removal option whilst meeting cost and environmental objectives. Optimisation is never perfect and, given our imperfect knowledge of these complex processes, the results demonstrated a $250/ML chemical cost for a 88% to 99% reduction in suspended solids and a 97% reduction in fats, oils and greases (Tests 1 and 6, Tables 1.1 to 1.4). This result is considered operationally feasible and hence can be repeated during normal operations. Capture of fats and oils in high percentages between 80% and 100% was also demonstrated, depending on the sample and chemical strength used. Sludge was considered to comprise fats, water and meat solids. The reduction in VSS also reduces the greenhouse gas emission potential from waste treatment ponds. GHG emission potential remains, as it is carried by the sludge, subject to how the DAF sludge (and VSS) are subsequently treated. On-going operational experience will allow the chosen 'best' optimal approach to be continuously refined.

The report examines options for the re-use of the captured sludge to add value and reduce negative externalities (environmental impacts for example). Options are compared in a simple cost-benefit analysis. The report has examined four options for reuse, ruling out one at the Churchill Abattoir (CA) site (reuse in render – discussed later). The remaining three options have varying levels of feasibility.

The re-sale of untreated sludge except at a price of zero dollars for compost has not attracted any interest. The re-use of sludge to create low quality tallow seems a feasible method to create value and further offset the cost of the DAF technology. By adding the pond management cost savings with the sales revenue from tallow, it is feasible that an effective DAF may add value to the processor. Finally it is feasible that an anaerobic

digester (AD) may add value by absorbing all the VSS at little cost whilst offering more competitively priced energy that also reduces GHG emissions.

The industry can benefit from this work. Volatile suspended solids management has a significant and growing cost if it is to be managed ‘in situ’ in the wastewater stream. The management process also uses energy whilst the solids will attract an increasing carbon price. Removing the suspended solids from the water stream in a low cost manner removes the costs and creates the possibility of value creation.

An effective DAF solution is available to the industry as an immediately implementable option, subject to a investigative test period on each waste stream as explained previously. The technology is useable with any water based waste stream containing suspended solids subject to the stream being trialled first.

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# 1 Introduction

*In this section we outline how this project to demonstrate effective Dissolved Air Flotation began, and why it is significant to the meat industry.*

This is the Final Report in the Sludge Capture, Benchmarking and Processing Project (‘the Project’), with an emphasis on “demonstrating the ease of installation, effective Dissolved Air Flotation (DAF) unit performance, and potential sludge re-use options as well as the costs, benefits and implications of effective DAF operations”.

This project came about to solve two issues:

1. DAF Operations

   The type, efficiency, and mechanism of DAF’s are many and varied. The Effluence DAF is compact and transportable. The trial DAF had been installed previously and run successfully but had not been widely publicised due to factors beyond Effluence’s control. The key concept was to demonstrate efficient DAF operations and review alternate, economically viable uses of DAF sludge.

2. Churchill Abattoir (CA).

   CA had mixed success with DAF operations, a legacy of the previous owners. Additionally there was a reluctance to use chemicals due to a perceived operational cost, chemical fate (i.e., what happens to the chemicals), tallow recovery, tallow quality and cooking systems. Additionally, carbon tax pressures were seen as a potential threat with significant ‘fat’ losses to the treatment ponds. CA was also seeking a DAF solution that minimised chemical use or could be used without chemicals.

An additional benefit was that CA ha d an industry funded project in progress to investigate anaerobic lagoon treatment systems. The DAF Project was seen as an adjunct to this lagoon project (MLA/AMPC project A.ENV.0107).

The Effluence DAF was transported by truck, from its warehouse, and plumbed into the site. The setup time was largely due to the implementation of infrastructure support and services. The DAF had previously been removed from its former host in 36 hours and then installed at Ipswich within 2 weeks. Infrastructure was adapted to support the DAF after its arrival. The DAF captures sludge from the red waste stream of the Churchill Abattoir (CA). Currently the DAF is being used to capture all processing wastes including the ‘green’ stream as this is mixed with some fat laden wastewater from tripe processing.

This report has reviewed a range of options for processing the sludge in order to create a saleable product at a maximum, net sale value. The sludge refers to the suspended solids in the CA red stream. These suspended solids comprise largely volatile solids (that is organic matter perishable by ignition in the absence of water). These volatile solids, if left untreated, would breakdown anaerobically, creating odourless methane and other, sometimes noxious, gases.

The project demonstrates that effective DAF operations sit at the heart of the industry waste management process. That process must focus on the volume of dry volatile solids in the industry's water-based waste stream. Effective DAF operations, by definition, in a commercial environment, need to be financially competitive as a means of capturing these suspended solids. In addition, in a environment of strong and increasing regulation,, where industry needs to control and reduce its footprint, effective DAF operations must convert an environmental management challenge into a commercial opportunity wherever possible.

Volatile solids, being the dominant component of suspended solids in most industry waste streams, because of its organic nature, can breakdown through an anaerobic process. Uncontrolled or inefficient anaerobic processes can result in fugitive GHG and other noxious gas emissions. Removing the suspended solids, including the volatile solid component, eliminates or reduces this problem in anaerobic ponds.

This report has sought to estimate, as much as possible, the cost, benefits and implications of effective DAF operations in order to provide the industry with a benchmark for performance.

# 2 Background

*This section briefly explains why Churchill Abattoir, MLA/AMPC and Effluence had a convergence of interest in demonstrating the capacity of an effective DAF to deliver good outcomes.*

The Effluence DAF was hosted by Churchill Abattoir (CA) to demonstrate its capacity to remove sludge (suspended solids) from the site's 'red stream' wastewater discharge. CA had recently covered their anaerobic lagoons and the 'fat' build-up on the ponds formed a crust that interfered with methane capture. Traditionally a crust had been used as an odour control mechanism but this approach 'wastes' the tallow and is now counted as a GHG emission source. If the VSS can be captured and create an income stream then reduction in pond management issues makes DAF operations more cost-effective. DAF performance measures are difficult to source from the literature or are only available from manufacturers' brochures, this is also why MLA/AMPC have supported the trial, in an effort provide a data point and to identify potential industry performance and profitability parameters.

The Effluence DAF, based on its performance at Rockdale Beef, was offered an opportunity to demonstrate and document the cost of operating an effective DAF. The results of the DAF process are measured in terms of wastewater treatment outcomes (percentage reduction in volatile solids) graphed against cost per mega-litre of processed wastewater. The project could provide a documented benchmark for industry performance in terms of the cost of waste removal per unit percentage of solid reduction.

In addition the project also explores the re-use options for sludge extracted by the DAF. The DAF, whilst cost effective, still has capital and operational costs per kilogram of dry volatile sludge removed. The wet sludge (50% moisture) itself has useful properties comprising fats and meat/other solids. If the sludge could be re-used, and the added value was sufficiently high, the value of the sludge could offset or even exceed the cost of its extraction, adding value to the operation of the abattoir.

# 3 Project Objectives

*This section outlines the prime goal of the project to provide an estimate of the cost and performance of effective DAF operations.*

This project demonstrates a mobile, add on, modular, low cost, low energy system for converting meat industry waste to saleable products. The trial objectives were:

1. Trial the capture of fats, oils, greases and meat by-products from wastewater.
2. Demonstrate the efficient installation of the DAF unit.
3. 'Tune' the DAF unit to the particular characteristics of the host wastewater stream.
4. Further refine the DAF unit to produce the optimal sludge whilst meeting host wastewater objectives.
5. In addition:
    a. Trial a small footprint, mobile DAF solution;
    b. Demonstrate the quality of the treated water;
    c. Determine and demonstrate the percentage reduction in organic and nutrient loading in the processed waste water stream; and
    d. Benchmark the reduction/elimination of greenhouse gas emission liability.
    e. Estimate the cost of wastewater treatment per unit of wastewater with the mobile DAF.
6. Demonstrate a method of sludge capture, storage, transport and handling to assist full-scale production.
7. Demonstrate the trial processing outcomes by provision of trial derived product of a test industrial process for the on-going manufacture of stockfeed from sludge;
8. Outline the business case for use of sludge from the Effluence DAF to create a new stockfeed product

The final report emphasizes the costs and benefits of effective DAF operations. The report provides costs and benefits for the capture of sludge and guidance on the manner in which sludge processing can be adopted in order to further increase profitability. Work is on-going with respect to sludge processing.

# 4 Methodology

*This section discusses how we implemented the trial of the DAF at Churchill Abattoir.*

The Effluence Dissolved Air Flotation (DAF) unit was moved from its warehouse and craned into the CA site in late 2011. The unit is skid-mounted to allow quick assembly. It became operationally capable in early 2012 as varied infrastructure works on the host site were completed to allow the system to integrate into the site (This was a CA operational decision as the DAF was ready within 2 weeks of delivery).

Effluence is firmly of the view that DAFs need to be 'tuned' to each waste stream. Each waste stream is unique, and effective DAF operations require the DAF's physio-chemical parameters to be adjusted through practice, trial and error to the requirements of the host waste stream. The DAF tuning process commenced in February/March and continued as opportunity permitted through to May.

Once the physio-chemical operating parameters of the DAF were established such that it could reliably produce sludge as required the testing process was commenced to optimise the system. Eight samples have been analysed in this report comprising influent, sludge and clarified water. The samples were tested at two laboratories (ALS and SGS), one of which was also used by CA. Chemical dosages were recorded for each test sample. Chemical and other parameters were varied to seek the maximum steady state capture rate of solid matter at the lowest possible cost in chemicals per megalitre (ML). Parameters were also 'dialled down' to reduce the solids capture rate and measure the relationship between chemical cost/ML and the percentage reduction in solid waste.

During this period sludge was also tested, informally (through cooking and by the host site) and formally (by laboratories) to determine the proportions of fat, meat/solids and water. The aim of the process was to identify the most valuable re-use options for the sludge in order from least valuable to the most valuable. Equipment suppliers, potential users and other stakeholders were contacted to discuss re-use options.

# 5 Results and Direction

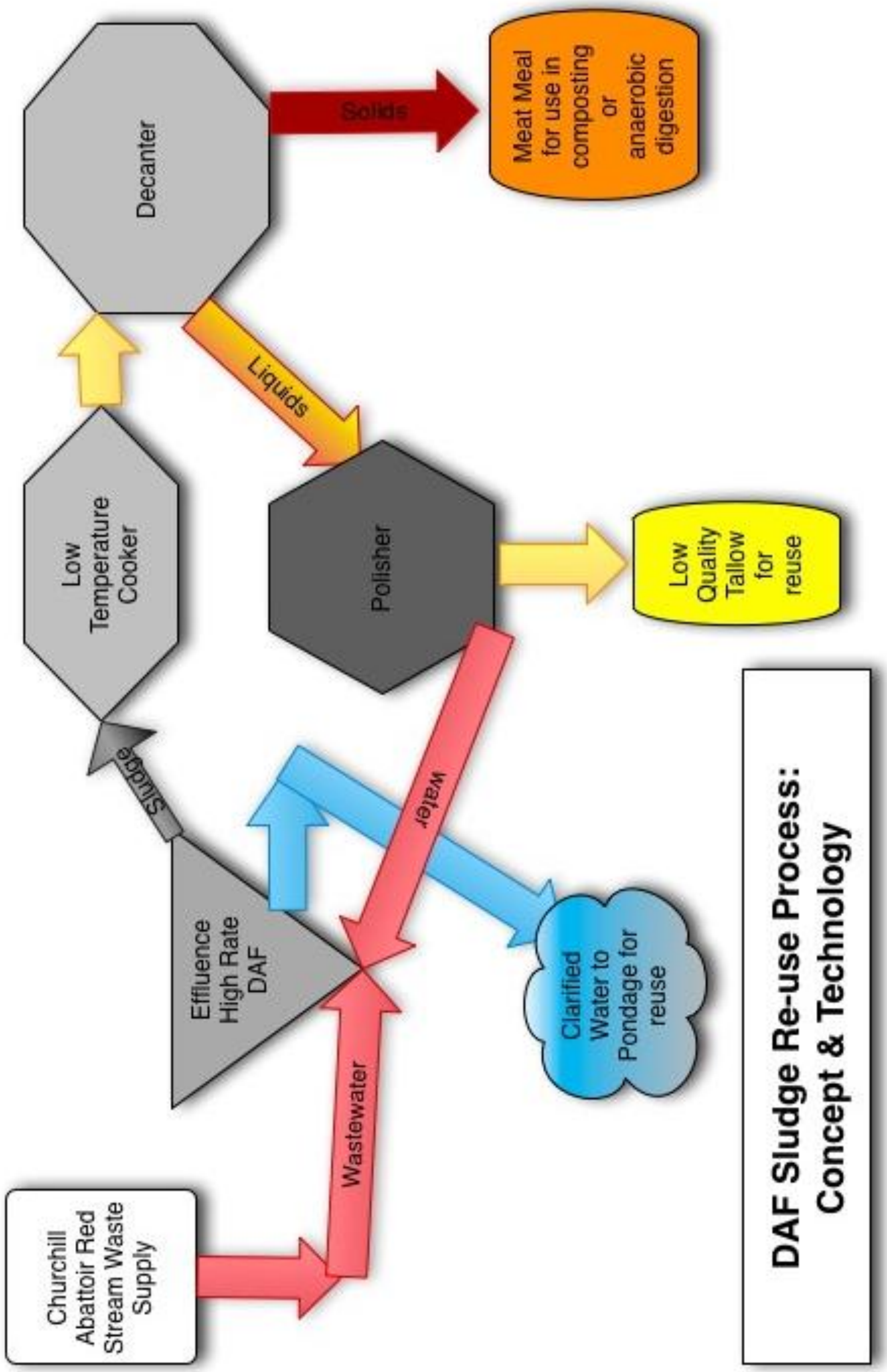
*In this section we report on the capture rate for VSS in the Churchill wastewater stream. We then outline and cost the options for processing the sludge into value added product culminating in Table 11. that summarises the choices.*

In Diagram 1 below we have mapped our present concept for processing the red waste stream. The red waste stream is processed by the Effluence DAF and split into sludge containing up to 98% of the suspended solids and clarified water. The clarified water is sent to the treatment ponds. The sludge is sent for further processing.

The processing concept or technology package in Diagram 1 is common, particularly in the US (pers. comm.). It is not the end of the process but like all manufacturing is a strong first leap forward which needs to be followed by ongoing and continuous improvement (technically known as ‘tweaking’).

The sludge can be sent to a low temperature cooker. The sludge comprises fat, water, meat and blood. The low temperature cooker then ensures that all the fat content is cooked to the same level and the meat is also slightly cooked. Blood dissipates throughout the other elements of meat, fat and water. Once the sludge has been cooked it is then sent through a decanter that separates the meat (solids) from the liquid stream (fat and water). The liquid stream is sent through a polisher that separates fat from water. The water is then returned to the inlet valve of the DAF. The fats, which have now been cooked, are converted to low quality tallow, available for sale and re-use. The meat/solid is now suitable for re-use in some other process but more likely to be used for compost or soil conditioner.

Diagram 1. DAF Sludge Re-use Process: Concept and Key Technology



## 5.1 Results from the Sludge Capture Process

### 5.1.1 Sludge capture results

The results from the sludge capture process have been shown in Tables 1.1 to 1.4.

Table 1.1 Overall Data

| Parameter | Unit | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 | Test 6 | Test 7 | Test 8 |
|---|---|---|---|---|---|---|---|---|---|
| Chemical Cost/ML | $ | $241.42 | $396.16 | $340.46 | $284.76 | $219.75 | $252.55 | | $155.97 |
| Chemical Dosing Index | | 60 | 86.67 | 78.33 | 70 | 50 | 60 | | 23.33 |
| Inflow COD | mg/l | 19,200 | 6,990 | 10,200 | 6,790 | 11,700 | 9,810 | 12,000 | 6,650 |
| Outflow COD | mg/l | 873 | 1,580 | 956 | 1,840 | 4,990 | 3,330 | 5,040 | 6,500 |
| % Reduction in COD | % | 95 | 77 | 91 | 73 | 57 | 66 | 58 | 2 |
| Inflow BOD | mg/l | | | 19,900 | 11,100 | 11,700 | 2,920 | | 1,930 |
| Outflow BOD | mg/l | | | 490 | 1,010 | 4,990 | 1,450 | 1,690 | 1,860 |
| % Reduction in BOD | % | | | 98 | 91 | 57 | 50 | | 4 |
| Inflow TSS | mg/l | 3,900 | 367 | 3,970 | 2,350 | 4,200 | 3,230 | 3,590 | 1,630 |
| Outflow TSS | mg/l | 34 | 87 | 131 | 136 | 136 | 376 | 1,020 | 1,550 |
| % Reduction in TSS | % | 99 | 76 | 97 | 94 | 97 | 88 | 72 | 5 |
| Inflow O&G | mg/l | 752 | 757 | 539 | 351 | 794 | 725 | 139 | 183 |
| Outflow O&G | mg/l | 6 | 5 | | | | 23 | 89 | 79 |
| % Reduction in O&G | % | 99 | 99 | | | | 97 | 36 | 57 |

(NB: the highlighted empty boxes indicate incomplete data due to laboratory failure)

Each test has a unique number from 1 to 8. Table 1.1 shows the chemical cost per ML plus reductions in the parameters tested. Table 1.1 also shows the 'strength' of the chemicals as measured by the dosing rate and a calculated "Dosing Index"; the higher dosing rate implies that more chemicals are used as the dosing pump has been set to a higher level. The precise type and formulation of chemicals is proprietary information from which the Dosing Index was calculated. The test results do not capture all variables for all tests but provide an indication of the performance in each situation.

Tables 1.2 to 1.4 show the effect of the DAF on the following variables:

1. Chemical Cost and TSS % Reduction
2. Chemical Oxygen Demand (COD),
3. Biological Oxygen Demand (BOD), and
4. Suspended Solids (SS or TSS) and Oil and Grease

Table 1.2. Chemical Cost and % TSS Reduction from Least Chemical Cost to Highest Chemical Cost*

| Test No. | Chemical Cost | Chemical Dosing Index | Reduction in TSS |
|---|---|---|---|
| Units | $/ML | | % Reduction |
| 8 | $155.97 | 23.33 | 5 |
| 5 | $219.75 | 50 | 79 |
| 1 | $241.42 | 60 | 99 |
| 6 | $252.55 | 60 | 88 |
| 4 | $284.76 | 70 | 94 |
| 3 | $340.46 | 78.33 | 97 |
| 2 | $396.16 | 86.67 | 76 |
| 7 | NR | NR | 72 |

*NR refers to not reliable

Table 1.3. COD and BOD % Reduction from Least Chemical Cost to Highest Chemical Cost

| Test No. | Inflow COD | Outflow COD | % Reduction in COD | Inflow BOD | Outflow BOD | % Reduction in BOD |
|---|---|---|---|---|---|---|
| Units | mg/l | mg/l | % | mg/l | mg/l | % |
| 8 | 6,650 | 6,500 | 2 | 1,930 | 1,860 | 4 |
| 5 | 11,700 | 4,990 | 57 | 11,700 | 4,990 | 57 |
| 1 | 19,200 | 873 | 95 | NR | NR | 0 |
| 6 | 9,810 | 3,330 | 66 | 2,920 | 1,450 | 50 |
| 4 | 6,790 | 1,840 | 73 | 11,100 | 1,010 | 91 |
| 3 | 10,200 | 956 | 91 | 19,900 | 490 | 98 |
| 2 | 6,990 | 1,580 | 77 | NR | NR | 0 |
| 7 | 12,000 | 5,040 | 58 | NR | 1,690 | 0 |

Table 1.4. Per Centage reduction in TSS and O&G from Least Chemical Cost to Highest Chemical Cost.

| Test No. | Inflow TSS | Outflow TSS | % Reduction in TSS | Inflow O&G | Outflow O&G | % Reduction in O&G |
|---|---|---|---|---|---|---|
| Units | mg/l | mg/l | % | mg/l | mg/l | % |
| 8 | 1,630 | 1,550 | 5 | 862 | 183 | 79 |
| 5 | 4,200 | 900 | 79 | 794 | NR | NR |
| 1 | 3,900 | 34 | 99 | 752 | 6 | 99 |
| 6 | 3,230 | 376 | 88 | 725 | 23 | 97 |
| 4 | 2,350 | 136 | 94 | 351 | NR | NR |
| 7 | 3,590 | 1,020 | 72 | 1,290 | 139 | 89 |
| 3 | 3,970 | 131 | 97 | 539 | NR | NR |
| 2 | 367 | 87 | 76 | 767 | 5 | 99 |

Results broadly move in line from lowest chemical dosage rate (and hence lowest cost) to highest chemical dosage rate and highest cost. In each test from 1 to 8 the application of the chemical dose, along with the DAF's physical operation, serves to cause a significant reduction in the volume of suspended solids.

In Graph 1 we have plotted the test results for the chemical cost per megalitre of wastewater processed by the DAF versus percentage reduction in total suspended solids (the improvement in wastewater quality) achieved in the wastewater as it leaves the DAF. The data underlying Graph 1 is presented in Table 1.1. There is a response line from the lowest cost to the highest cost as the percentage reduction proceeds from lower reductions to higher reductions. Graph 1 and Table 1.1 illustrate that the DAF achieves reductions in suspended solids in the order of 80% to 99%, with costs ranging from $219 per megalitre to as high as nearly $400 per megalitre. Whilst there is a slight trend in the results from the high reductions costing more there are also some results that had high reductions at more modest cost levels. Test 6 and Test 1 stand out with reductions of 88% and 99% respectively but similar chemical costs ranging from $252 to $241 per megalitre.

The test results indicate the value of iterative experimentation as a means of isolating the best performance rather than relying on simple assumptions that more reductions will require higher costs.

This relationship indicates some attention also needs to be shown to the outliers. The results show some significant outliers such as Tests 2, 3 and 7, which may be the result of errors. However, the results presented are taken from continuous flow operations where the physical properties remained constant and thus represent steady state flow. Steady state flow was achieved for the period of the sample but can vary with production activities.

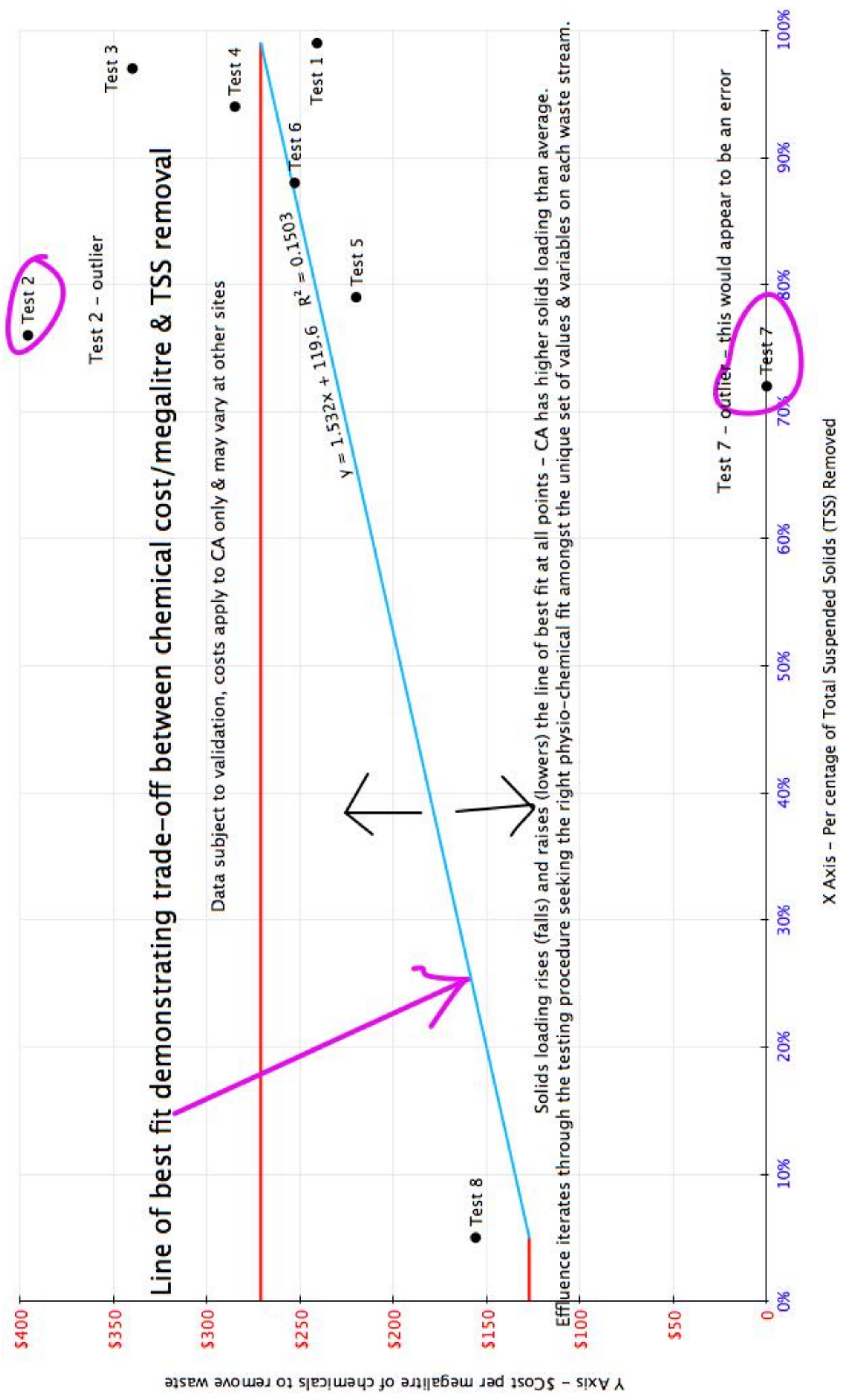
To represent a complete data set that achieves a 95% degree of confidence is prohibitively expensive using 3rd party laboratories. The samples were taken as representative of the inputs and outputs; however, the nature of the concentration of solids can vary rapidly resulting in fluctuations in individual samples. The deduction from this is to try and ensure a consistent feed to the DAF and a suggested option is to use a balancing tank with or without a stirrer; this also minimises the effect of varying production activities.

In Graph 2 we plotted the same results for fats and oils. The response curve is steeper as more fats and oils are removed but the removal rate is consistently high even for the lower doses of chemicals.

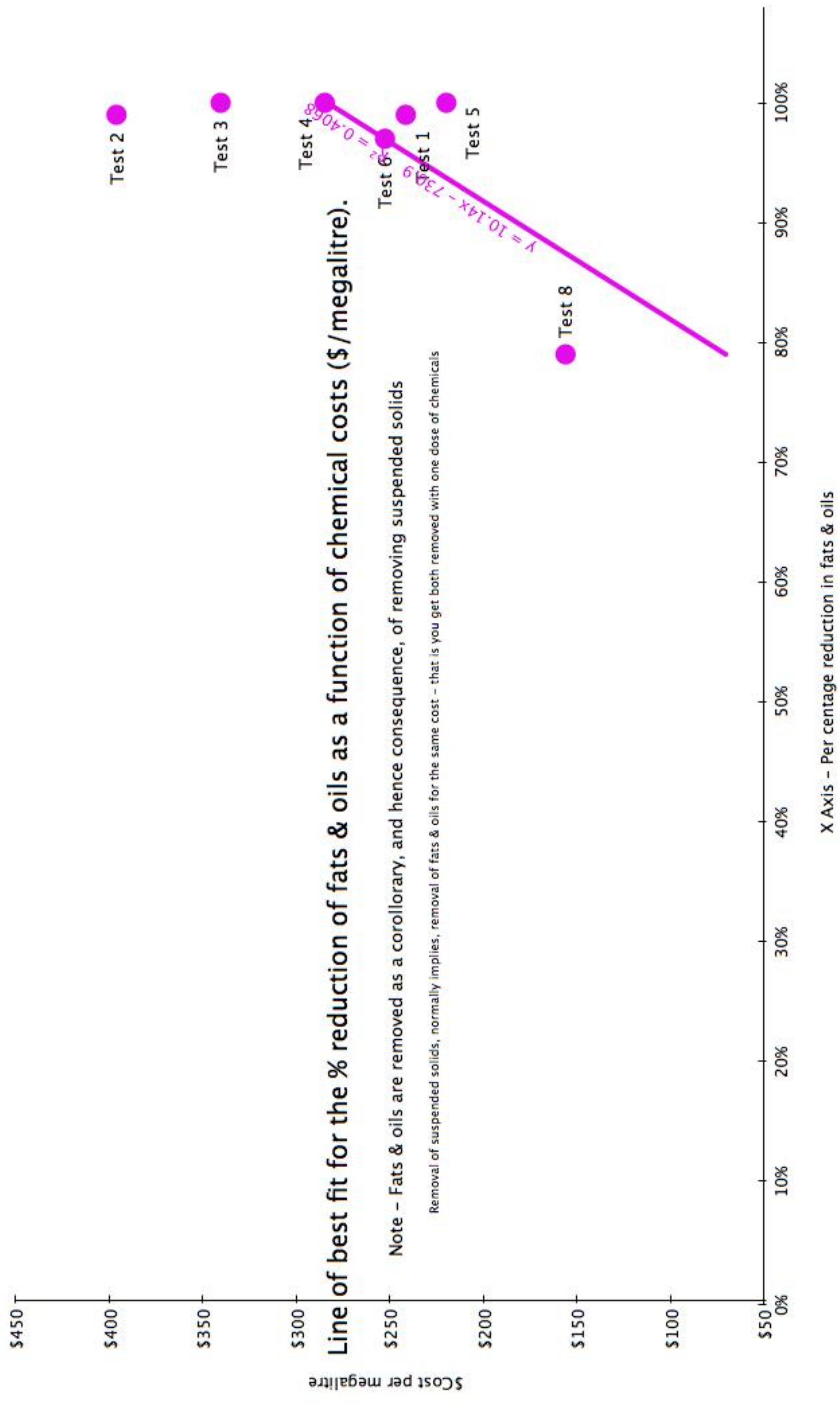
Tests 6, 1, 4 and 5 provided a suitable benchmark for operational implementation of the DAF. At approximately $250/ml the cost of chemical use is not too expensive yet the results range from suspended solids removal in the high eighties to the high nineties. It is this combination of reasonable cost and high percentage reduction that makes the DAF in this trial effective and sets a benchmark for other DAFs to achieve.

The test results beg the question of the optimal level of suspended solid discharge to ponds. Ponds are required to receive the DAF discharge water; there is a point where ponds require a level of suspended solid discharge to operate effectively. Yard wash down water and other solids are not treated in the DAF. However, an exceptional feature of this DAF is the ability to 'dial' the results up or down to achieve greater or lesser reductions in VSS that are sent to the ponds. The health of the pond ecosystem and the inflow rate of suspended solid matter is addressed in the report by the University of Southern Queensland (USQ) in MLA (2012) A.Env.0107 Using Covered Anaerobic Ponds to Treat Abattoir Wastewater, Reduce Greenhouse Gases and Generate Bioenergy. Additional doctoral research will be undertaken on pond management and optimisation in the near future.

Graph 1. Test results plotted as chemical cost/megalitre versus percentage reduction in suspended solids



Graph 2. Test results plotted as chemical cost/megalitre versus percentage reduction in fats, oils and greases



### 5.1.2 DAF Operating Costs

The cost of the DAF in capital terms is approximately $400,000 with infrastructure and differing options altering the final price. The operating costs of the DAF have been calculated in Table 1.6. The DAF is ‘tuned’ to each waste stream. The costs of processing vary with every waste stream and hence the estimates here must be considered indicative costs only as established at the CA site. For example if the waste stream has a heavy concentration of suspended solids the DAF may have slower processing rates and higher chemical cost than a waste stream with higher flow rates but lower loadings.

We have calculated an annual cost of approximately $148,000 to operate the DAF at CA. This cost, as Table 6 reveals, also includes a labour component. The labour is used for one hour to turn on the machine, and one hour to close the machine down, at the end of the day. Further, labour is needed to provide an hourly visual check of the machine during operations. The visual check supplements the remote sensing equipment. The labour time is three hours per working day. The calculations are undertaken on a 52 week year and a five day working week. They are not indicative of CA’s working cycle but used as a reference for companies to perform their own estimates.

The operating costs of the DAF should be considered in the context of the existing pond management system. CA operates an example of the lowest cost pond management system in the industry. This allows the waste solid to stabilise in ponds at very slow rates but with minimal input. In some cases, ponds are aerobically treated, requiring electricity to keep them functioning. In the case of CA, at the lower cost end of the spectrum, the DAF adds value despite its operating cost by reducing the cost of pond management to a very low level. This is achieved because the cost to remove volatile solids (the crust and pond sludge) is the expensive part of pond management.

## 5.2 Managing DAF Sludges

The critical issue is the trade-off between different options for managing volatile solids. The choice of volatile solid management (VSM) should be based on which option provides the greatest value added to the host entity (given specific regulatory and external factors).

There are five options:

Option 0: Business As Usual (BAU) – continue using the pond system;

Option 1: Capture the sludge and resell immediately;

Option 2: Capture the sludge and re-process into higher value added feedstock;

Option 3: Capture the sludge and re-process in the render plant; and

Option 4: Capture the sludge and process in a digester.

The four re-use options for DAF sludge have been examined by testing sludge supplies, visiting equipment suppliers and operators both in Australia and overseas and talking to other stakeholders from universities and research facilities. The results have been summarised in Table 11.

### 5.2.1 Options for Re-using DAF Sludge: an assessment framework.

We began the re-use process with the results of previous work that suggested the sludge could be re-used as a feedstock. Converting Churchill sludge into viable products is a multi-step process, requiring the calibration of the production process in pursuit of the most cost-effective production opportunities on a risk-adjusted basis. Each of these options is being reviewed according to the following framework.

1. Capture an adequate quantity of sludge for testing purposes in each option;
2. Identify a viable product or products for the given feedstock;
3. Test the qualities of the sludge for product conversion in a simulated or actual conversion process;
4. Evaluate the product quality from the testing process against potential market opportunities;
5. Evaluate the regulatory requirements to sell the product;
6. Evaluate the capital, and operating cost of the production process relative to the expected revenue stream;
7. Develop a financing plan to assess the bankable and non-bankable risks for a production facility. Bankable risk can be funded by loans but non-bankable risk will need private capital and/or government grants depending on the nature of the non-bankable risk.

The above framework provides the structure to Table 1 where we compare each re-use option (including Business As Usual (BAU) – Option 0) with Options 1 to 4.

### 5.2.2 DAF sludge options

Option 0 is the continuation of the existing pond system at CA. It represents the cheapest option presently available in the industry for the disposal of wet waste. The wastewater is pumped into ponds that have minimal intervention. In other sites such ponds require constant energy inputs to maintain aerobic conditions. This latter intervention is costly in terms of energy use amongst other costs. Whilst the CA pond system is at the cheaper end of the existing waste treatment spectrum it is not clear that the option is ‘free’. The capital cost of the ponds is a definite consideration but could be considered a ‘sunk cost’ borne in previous years. The key cost faced by the CA business is maintaining these ponds in the face of continuing inflow of dry volatile solids. The flow of water is less of a concern than the volatile solids carried therein. We estimate that the annual operational cost of such ponds could be in the order of $200,000 per year as businesses seek to control the behaviour of the volatile solids. These costs will vary from site to site and the $200,000 does not reflect an analysis of CA in particular but the general requirement observed in the industry for such low maintenance ponds to require ongoing management and operational input.

In particular the cost of regularly removing pond sludge and crust is reputed to be the most expensive part of pond management. This suggests that the key factor in ponds is the overloading by incoming VSS. Other costs included in here could be costs such as work programs, labour and the opportunity cost of management time, opportunity costs from the non-use of the buffer zone and the pond area itself and perhaps most expensive the inability to expand production because of limitations on the ability to manage increased flows of volatile solids. The figure could also include the 'insurance' risk of such ponds whereby they must be managed to prevent the occurrence of unwanted environmental events with regulatory and environmental consequences. In consequence we feel it is reasonable to attribute some estimated annual cost, in the order of $200,000 per annum to the lowest cost volatile solids management system available. An additional substantial cost can be a cost attributed to GHG emissions and the subsequent 'Carbon Tax' if the 25,000 t CO2 (equiv) is exceeded due to pond methane losses (a minimum of $575,000 annually).

Any 'improvement' in the volatile solid management system (VSM) must compete financially with the BAU (Option 0 case) by reducing the total cost of the BAU baseline. This is where this project began.

The Effluence DAF offers the ability to extract volatile solids at a price competitive with Option 0. We have brought these options together to explore the costs and benefits of effective DAF operations. Effective DAF operations create a range of new possibilities, which were not previously feasible, as the issue of industry waste management now focuses on managing volatile solids ex-water. In Table 1.11 we have provided a framework for comparing all options on a level playing field across seven criteria.

Option 3, the re-use of the DAF sludge in the CA render plant, has been ruled out. The risk is that the sludge may contaminate the existing render plant product and lower its value; tallow quality is affected by a range of issues such as fat degradation, contamination with paunch, chemicals and other material. Thus, contamination is a catch-all phrase to include the potential to lower tallow quality by increasing Free Fatty Acid (FFA) levels, and processing issues when polymer is used where the polymer may clog decanters and polishers. As a result this relatively simple option for re-use within the existing cooker system is not possible.

Option 1 is also a relatively simple opportunity. This proposes the re-sale of the DAF sludge via tanker to a customer. The sludge has properties that could appeal to some customers. As yet no buyer has been located. The 'highest bid' has come from the local composter who is willing to take the sludge for free along with paunch waste. This represents a simple removal from site that through aerobic composting also minimises the GHG emissions from anaerobic ponds although GHG emission reporting is not negated by composting.

Option 1 would remove the load of volatile solids from the ponds, and hence reduce pond financial, regulatory, direct carbon and environmental costs, and possibly reduce the insurance premium attracted by such environmental and commercial risks. The constraint on plant expansion could, however, be lifted subject to planning approvals. It could be expected that the annual costs of pond management would reduce dramatically in such an instance, representing direct savings to the host. The DAF operation, however, is not free and its costs (capital, operational) must be set against the diminished cost of managing the ponds. Option 1 does open the possibility that, if the DAF sludge could be sold, the DAF operations could be offset with revenue (Tables 1.6 to 1.11 for the cost and revenue estimates). This is where Option 2 seeks a new path.

In Option 2 the DAF sludge is re-processed separately. The sludge is effectively cooked and separated into fat, solids and water. The fat can be sold as second grade tallow (i.e., higher FFA than good quality tallow), the solids can be sent for composting and the water can be recycled through the DAF, and eventually to the pond as clarified water. This is a standard industry process and is well known and understood. Its costs and opportunities would be understood in each company although cooking efficiency and techniques can vary considerably. The key questions are the value of the fats, how much is present, how much can be captured, cost of production per tonne of tallow and the sale price of the resulting product. The implementation of this option requires additional capital and operational cost on top of the cost represented by the DAF in Table 1.9, Option 1 and 2. We have provided estimates of the cost but there will be wide variations around this. Option 2 offers the chance of capturing a revenue stream from the sale of a familiar and well-priced product, low quality tallow. This revenue could offset all costs and make a profit or fall short and only reduce the cost of operations. In addition we began this project with the prospect that we could capture the solid stream and re-process it for re-sale rather than composting. Regulatory frameworks require that this solid be treated in such a manner as to render it harmless from the perspective of contamination. This process would also appear to remove the solid of its value as an industry input. This sub-option remains a possibility for further exploration but we have assumed it's not feasible for Option 2 to avoid overstating the value proposition of Option 2. This option attracts all the gains of Option 1 but adds the prospect of higher revenue but at higher cost. It is our observation that most sites would probably find Option 2 more financially attractive than Option 1, and that most sites would have the ability to evaluate this option for themselves once they had clear information on how much fat could be re-captured from their waste stream. However each site would need to be analysed separately, not the least to establish the cost of truly effective DAF operations.

In Option 4 we have considered the preferred Effluence option of removing the sludge for digestion and conversion to biogas and fertiliser. In Option 2 the fats are resold to create some revenue to offset the costs of the DAF, cooking and separators. In Option 4 the DAF, cookers and separators supply feedstock to a digester that adds value to the remaining solid stream that would otherwise have been given away for composting. Composting aerobically converts organic matter to, at best, a soil conditioner, capable of improving soil quality. Composted materials add considerable value to soils but have a low market value and hence a limited ability to absorb waste production. This is more a market (farmer) factor and is influenced by perceptions of the availability of inorganic fertilisers, ease of use, and transport costs. Sufficient information on the beneficial properties of compost in cropping is available in the literature.

Anaerobic conversion in a controlled vessel converts the same organic material to biogas for energy generation and a digestate capable of increasing crop output. In short anaerobic conversion has the theoretical ability to add value relative to the composting process. In Option 4 the digester potentially adds value to Option 2 by converting the solid fraction to higher value added and hence more saleable commodities. This offsets further the cost of the DAF and cookers. In addition the digester can absorb the full range of wet organic wastes created by the abattoir, not processed by the DAF in the red stream, and hence add further value. This combination of paunch, cattle wash, render and ex-red stream waste, as well as its attendant water supply, could provide a significant feedstock for the digester.

Conversion of this biomass to energy in particular then offers the digester a chance to sell electricity and heat back to any co-located abattoir. This green energy would probably be sold at prices and terms that undercut the existing outsourced energy suppliers (through avoided transmission and carbon costs, as well as the benefits of proximity) creating another mechanism by which the site could gain increased value. Option 4 adds value over Option 2 by simply absorbing, at a minimum, the waste stream into the digester, avoiding the need for the host site to own its own DAF, cookers or separators yet removing the volatile solids, at an agreed level, from the site. Theoretically, under Option 4, it is feasible for the site to reduce its volatile solids to an environmentally insignificant level (that level is yet to be determined) and the attendant management costs without the need for any significant capital investment or operational cost, even at a site like CA that has ‘low cost’ waste treatment. Option 4 is beyond the scope of this report and is to be investigated in late 2012.

Table 1.11 summarises the findings from the report. Table 1.11 builds on the prior Tables 1.6 to 1.10. Table 1.11 summarises the review framework for comparing different options. Table 1.10 seeks to track the changes in value added as we move from Option 0 to Option 4. Table 1.10 is based on the costings provided in Table 1.9. Table 1.9, using very wide margins for error, assumed to be at least plus or minus 40%, sought to calculate the net value added by each option. Table 1.9 draws some of its costing from Tables 1.6, 1.7, and 1.8 to fill out as complete a picture as possible of the costs and revenues of each option. Table 1.10 seeks to interpret the costings in Table 1.9 to give a sense of the full range of value creation (or destruction) of moving from option zero to through to option 4. Table 1.5 below provides an overview of the tables from 1.6 to 1.11.

Table 1. 5. A Summary Listing of Tables 1.6 to 1.11

| | |
|---|---|
| Table 1.6 | DAF Annual Operating Costs |
| Table 1.7 | Cooking and separation plant – capital costs |
| Table 1.8 | Cooking and separation plant annual operating costs |
| Table 1.9 | The costs of different options |
| Table 1.10 | Tracking cost, benefits, net benefits, and value enhancements by option |
| Table 1.11 | Framework for reviewing sludge options |

Table 1. 6. DAF Annual Operating Cost

| DAF Annual Operating Costs | Notes | Units | Cost ($) | Processing Volume | Annual Volume | Annual Operating Cost | $/ML |
|---|---|---|---|---|---|---|---|
| Chemicals | Note 1 | $/ml | $ 250.00 | MLs/annum | 208 | $ 52,000 | $ 250 |
| Electricity | Note 2 | 14cts/kwh | $ 0.14 | kwh/annum | 96,200 | $ 13,468 | $ 65 |
| Labour Oversight | Note 3 | $80/hr | $ 80.00 | hours/annum | 780 | $ 62,400 | $ 300 |
| Maintenance | Note 4 | $200/hr | $ 200.00 | hours/annum | 52 | $ 10,400 | $ 50 |
| Replacement parts | Note 5 | $10,000/yr | $ 10,000.00 | $/annum | $ 10,000 | $ 10,000 | $ 48 |
| | | | | Total Operating Cost | | $ 148,268 | $ 713 |

**Notes**

Note 1 Assuming the plant works ten hours per working day,that there are 5 working days per week and 52 working weeks per year

Note 2 Assuming the plant uses 20 KWs in total when operating for ten hours per day, 5 days per week for 52 weeks per year

Note 3 Assuming one hour at start up and one hour at closing and a walk by visit each hour for the remaining 8 hours of a ten hour operating schedue for a daily useage rate of 3 hours per working day, 5 days/week, 52 weeks/yr.

Note 4 Maintenance is assumed to be one hour per week for a five day working week, 52 weeks per year.

Note 5 Replacement parts are budgetted at $10,000 per year.

Table 1. 7.  Cooking and Separation Plant – Capital Costs

| Cooking and Separation Plant - Capital Costs | Capacity | Daily Volume | Cost to Purchase | Daily Use | Units | Capital Cost |
|---|---|---|---|---|---|---|
| Heated Storage Tank - Sludge | One days supply | 10 tonnes | $30k | 10 | tonnes | $ 30,000 |
| Cooker | 10 horsepower | HP=7500 watts/hr | $20k to buy, $25k to ins | 7500 | kwhs | $ 60,000 |
| Decanter/Separator(polisher) | 10 Kw | Operates for 2 hours day | $60k reconditione | 20 | kwhs | $ 60,000 |
| Heated Storage Tank - Tallow | One days supply | 2.5 tonnes | $10k | 2.5 | tonnes | $ 10,000 |
| Concrete, power, shed | Entire plant | Entire system | $100k | Complete processing unit | | $ 100,000 |
| | | | | Construction, plans, approvals | | $ 140,000 |
| | | | | | Contingency | $ 100,000 |
| | | | | | Total Cost | $ 500,000 |

Table 1. 8. Cooking and Separation Plant Annual Operating costs

**Cooker & Separation Plant Annual Operating Costs**

| Operating Cost Components | Notes | Units | Cost ($) | Processing Volume | Annual Volume | Annual Operating Cost | $/tonne |
|---|---|---|---|---|---|---|---|
| Other expenses (contingency) | Note 1 | $/tonne | $ 50.00 | tonnes/annum | 2600 | $ 130,000 | $ 50 |
| Electricity | Note 2 | 14cts/kwh | $ 0.14 | kwh/annum | 258,700 | $ 36,218 | $ 14 |
| Labour Oversight | Note 3 | $80/hr | $ 80.00 | hours/annum | 260 | $ 20,800 | $ 8 |
| Maintenance | Note 4 | $200/hr | $ 200.00 | hours/annum | 104 | $ 20,800 | $ 8 |
| Replacement parts | Note 5 | 20000 per yea | $ 20,000 | $/annum | $ 20,000 | $ 20,000 | $ 8 |
| | | | | | Total Operating Cost | $ 227,818 | $ 88 |

**Notes**

Note 1 $/tonne of sludge processed, 10 tonnes per working day over ten hour period, output 2.5 tonnes/fat

Note 2 Assumes storage tanks are heated with 'free' waste heat

Note 3 Same team looks after the DAF

Note 4 Same maintenance people inspect the DAF

Note 5 Machines need maintenance at year 3 depending on load

Table 1. 9. The cost of different options

| Estimating the cost of different sludge processing options - Note 9 | Description | Option 0<br>Business As Usual | Option 1<br>Direct Re-sale in industry | Option 2<br>Reprocessing as industry feedstock | Option 3<br>Re-use in the Churchill rendering plant | Option 4<br>Processing as a digester feedstock | NOTES |
|---|---|---|---|---|---|---|---|
| Cost Breakdown | Descriptions of key equipment | Pond system, screening | DAF captured sludge sold direct | DAF sludge reworked as feedstock | DAF sludge reused in render plant | Sludge used in digester | Brief Explanation of Table Components |
| Estimated Capital Cost - land cost, construction cost - assume land is zero) | *Ponds* | $ - | $ - | $ - | $ - | $ - | 1 |
| Estimated Capital Cost | *Infrastructure* | $ - | $ - | $ - | $ - | $ - | 1 |
| Estimated Capital Cost | *DAF* | $ - | $ 400,000 | $ 400,000 | $ 400,000 | $ 400,000 | |
| Estimated Capital Cost - collecting sludge and storing till disposa, sale or reuse | *Pumping+Storage* | $ - | $ 20,000 | $ 40,000 | $ 20,000 | $ 40,000 | |
| Estimated Capital Cost for 'technology package' for cooking sludge, separating fat, water & solids | *Technology Package* | $ - | $ - | $ 460,000 | $ - | $ 460,000 | |
| Estimated Capital Cost - pumpimg system to move sludge to the render plant | *Render plant pump* | $ - | $ - | $ - | Not Feasible | $ - | |
| Estimated Capital Cost - pumping system and digester plant | *Digester* | $ - | $ - | $ - | Not Feasible | to be determin | 7 |
| Total Estimated capital Cost | *Complete System* | $ - | $ 420,000 | $ 900,000 | Not Feasible | to be determined | |
| Estimated Operating Cost - ponds used for aerobic or anaerobic treatment (ponds used for storage only are relatively cheap) | *Ponds-Note 2* | $ 200,000 | $ 20,000 | $ 20,000 | Not Feasible | $ 20,000 | 2 |
| Estimated Operating Cost | *Infrastructure* | $ - | $ - | $ - | Not Feasible | $ - | |
| Estimated Operating Cost | *DAF* | $ - | $ 148,268 | $ 148,268 | Not Feasible | $ 148,268 | |
| Estimated Operating Cost - collecting sludge, heating and storing till disposal, sale or reuse | *Pumping+Storage* | $ - | $ 5,000 | $ - | Not Feasible | $ - | |
| Estimated Operating Cost for 'technology package' for cooking sludge, separating fat, water & solids | *Technology Package* | $ - | $ - | $ 227,000 | Not Feasible | $ 227,000 | |
| Estimated Operating Cost - pumpimg system to move sludge to the render plant | *Render plant pump* | $ - | $ - | $ - | Not Feasible | $ - | |
| Estimated Operating Cost - pumping system and digester plant | *Digester* | $ - | $ - | $ - | Not Feasible | to be determin | 7 |
| Estimated Operating Cost | *$/annum - Note 6* | $ 200,000 | $ 173,268 | $ 395,268 | Not Feasible | to be determined | |
| Environmental Assessment, Management & Regulation, Carbon Tax etc | *Note 3* | Unknown | Unknown | Unknown | Unknown | Unknown | 3 |
| Financial costs such as depreciation, return on capital | | Not estimated | Not estimated | Not estimated | Not estimated | Not estimated | 12 |
| Estimated Annual Revenue | *Note 4* | $ - | $ - | $ 260,000 | Not Feasible | Future research | 2 |
| Profit | *Note 5* | $ (200,000) | $ (173,268) | $ (135,268) | Not Feasible | Future research | 8, 10, 11 |

*Notes Table 1.9*

Note 1. The assumption is that the ponds have been built and the costs are hereby already 'sunk'

Note 2. Aerobic & anaerobic ponds are not free as they require maintenance, management, regulatory compliance, rates, as well as 'insurance' and buffer zones and hence land is not utilised or accessible.

Note 3. These costs have not been estimated but would be substantial even if they only included compliance requirements. Removal of the volatile solid from the water streams for re-use should reduce costs considerably.

Note 4. Included where feasible - In Option 2 tallow is sold for $400 per tonne, solids are given to composting for free

Note 5. Allows the waste treatment system to be seen in its full context as a 'profit' centre for the business

Note 6. Conservative estimates have been used.

Note 7. Pumping from the DAF to the digester may require heated pipes.

Note 8. Digester costs, revenues & profitability are being determined in a separate feasibilty study.

Note 9. All costs are highly qualified estimates in the range of 40% plus or minus

Note 10. Buiilding a digester option alters the approach for Option 2 and hence may increase profitability for both projects.

Note 11. The digester adds value to CA directly if it can offset the Net cost of Option 2 including finance costs. This is the bottom line.

Note 12. Estimating finance costs such as foregone return on capital, depreciation etc adds to the 'losses'.

Table 1.10. Tracking Costs, Benefits, Net Benefits & Value Enhancements by Option

| **Tracking Costs, Benefits, Net Benefits and Value Enhancements across all options** | Description | **Option 0** **Business As Usual (BAU)** | **Option 1** **Direct Re-sale in industry** | **Option 2** **Reprocessing as industry feedstock** | **Option 3** **Re-use in the Churchill rendering plant** | **Option 4** **Processing as a digester feedstock - note 4** |
|---|---|---|---|---|---|---|
| | | Pond system, screening | DAF captured sludge sold direct | DAF sludge reworked as feedstock | DAF sludge reused in render plant | Sludge used in digester |
| 1. Estimate the cost of the different options – TP, digester, CA system change; annualised capital, operating | *$/annum* | *$/annum* | *$/annum* | *$/annum* | *$/annum* | *$/annum* |
| Estimated Capital Cost | *Note 1* | Sunk cost | $ 420,000 | $ 900,000 | Not Feasible | $ - |
| Estimated Operating Cost | *Note 2* | $ 200,000 | $ 173,268 | $ 395,268 | Not Feasible | $ - |
| Estimated Annual Revenue | | $ - | $ - | $ 260,000 | Not Feasible | $ - |
| Profit | | $ (200,000) | $ (173,268) | $ (135,268) | Not Feasible | Note 5 |
| Profit Probability Distribution (the chance of good management increasing the profitability relative to BAU) | *Note 6* | None | reasonable | Highly likely | Not Feasible | Highly likely |
| Technology Package - additional technology beyond BAU | *Equipment* | As normal - Screening, ponds | Screening, DAF, storage tank | Screening, DAF, Storage tanks (2) cooking, separation system | Not Feasible | Screening, DAF, Storage tanks (2) cooking, separation system, digester |
| 2. Estimate the value of the clarified water, meat solids (onsite and offsite) and low quality tallow (existing and biodiesel); | *$/annum* | $ - | $ - | $ 260,000 | Not Feasible | Lower energy cost - values to be determined |
| 3. An improvement in the CA risk profile ('a reduced insurance premium if you like') against BAU; | *$/annum* | 0 | Big reduction | Big reduction | Not Feasible | Risk Elimination |
| 4. A reduction in the greenhouse gas and other emissions from the site; | *$/annum* | 0 | Big reduction | Big reduction | Not Feasible | Waste emission elimination, Energy emission reduction |
| 5. Removal of waste volume may remove development constraints or 'closure threats' on the site; | *$/annum* | 0 | Big reduction | Big reduction | Not Feasible | Risk Elimination |
| 6. Allows the clients of CA to 'green their value chain' and hence value CA services at a higher rate; and | *$/annum* | 0 | Improved | Improved | Not Feasible | Strong Improvement |
| 7. A reduction in the need for environmental management at the site. | *$/annum* | increasing | Reduction | Reduction | Not Feasible | Strong reduction |
| 8. Potential value of multiplier effects; | *$/annum* | zero/negative | Positive - adds value via composter only, reduced site costs, potential for sludge resale | Positive via new production equals new value added in addition to composter | Not Feasible | More positive than other options - new products, costs should be eliminated, value added to site through reduced input costs to CA |

*Notes to Table 10*

Note 1. Estimated capital cost is zero for BAU since the cost is considered 'sunk'. However, future expansion, improvements and maintenance must be considered as significantly above zero. Other options are costed based on the price paid at commissioning.

Note 2. Labour, energy, tax, regulation, foregone revenue on sunk capital cost, management, opportunity cost of site in revenue terms attributed to the pond component, site and buffer maintenance attributed to the pond component (not plant related emissions).

Note 3. Not feasible due to potential contamination of the existing render plant product.

Note 4. The digester option is considered from the perspective of the net benefits received by CA rather than from the perspective of the digester business itself. In other words the co-location of the digester brings benefits to CA through reduce energy costs from a competitive energy pricing arrangement.

Note 5. The co-location of a digester leads to lower energy supply costs, massively reduced pond 'costs', disappearance of the DAF plus separators across the boundary to the Digester and hence reduces CA's cost against its business as usual scenario.

Note 6. Profit probability distribution - this is the idea that profit is not guaranteed but subject to risk. We have chosen the most likely profit outcome given conservative assumptions. In the hands of good management the profit is likely to be higher than stated.

Table 1.11. Framework for reviewing sludge options

| Review Framework for processing DAF Sludge | Units of measure | Option 0 Business As Usual | Option 1 Direct re-sale in industry | Option 2 Reprocessing as industry feedstock | Option 3 Re-use in the Churchill rendering plant | Option 4 Processing as a digester feedstock |
|---|---|---|---|---|---|---|
| 1. Capture an adequate quantity of sludge for testing purposes in each option; | | Disposal to ponds | Completed | Completed | Not feasible | To be tested |
| 2. Identify a viable product or products for the given feedstock; | | None as yet | Search ongoing, Composting only reuse available as yet | Cook sludge to separate tallow, solid & water | Not feasible due to risk of contamination | Fertiliser & biogas |
| 3. Test the qualities of the sludge for product conversion in a simulated or actual conversion process; | | Ultra slow composting process | Composter will accept the waste | Sludge has been cooked, and is amenable to this. | Not feasible | Tested in benchtop test & micro-digester trial |
| 4. Evaluate the product quality from the testing process against potential market opportunities; | | No market opportunities | Fat content presently precludes other uses except composting | Tallow should be saleable, biodiesel to be investigated, cooking the solids to be investigated, solids can be composted/digested | Not feasible | Micro-digester trial tested biogas production and fertiliser qualities |
| 5. Evaluate the regulatory requirements to sell the product; | | No sales opportunities, severe & increasing regulatory risk, operational risk | Fat content is an operational issue until removed, regulatory concerns not triggered | Cooking solids for food industry precluded by regulations, tallow feasible as low quality product | Not feasible | Feasibility study to be conducted |
| 6. Evaluate the capital, and operating cost of the production process relative to the expected revenue stream; | | $200k/yr cost, assuming zero capital costs because of pond cost is already 'sunk'. | No revenue in composting, DAF operating costs $142k, pond costs reduced | Feasible on tallow sales alone depending on tallow price | Not feasible | Feasibility study to be conducted |
| 7. Develop a financing plan to assess the bankable and non-bankable risks for an Effluence funded production facility. Bankable risk can be funded by loans but non-bankable risk will need private capital and/or government grants. | | Not feasible | Possible with work | Possible | Not feasible | Feasibility study to be conducted |

# 6 Discussion and Conclusion

In this section we discuss the implications of being able to effectively remove the VSS component from the waste stream.

The key issue in solid waste management for the meat industry has been to cost-effectively remove the dry volatile solids from the wet waste stream. If this could be achieved the industry would then be able to find the means to cost-effectively process this resource whilst mitigating its negative environmental and financial effects. It is our view that this study has demonstrated the feasibility and implications of removing volatile solids (VS). The removal of VS as an issue could negate one potential limiting element to expand the business.

## 6.1 Project Objectives

The project had a series of objectives. These are listed below. Each objective is discussed separately.

1. Trial the capture of fats, oils, greases and meat by-products from wastewater.

*As the photos, site visits, operational use and testing reveal the DAF captures up to 98% of the suspended solids. In this sense the DAF is exceptional because of this ability alone.*

2. Demonstrate the efficient installation of the DAF unit.

*As was demonstrated by the installation, the inherent design characteristics, and the portable nature of the system meant that it could be installed over a period of days rather than weeks.*

3. 'Tune' the DAF unit to the particular characteristics of the host wastewater stream.

*The DAF has gone through many operational iterations some of which were captured by the testing process, reported on by this document. These iterations have continually sought to refine the performance of the DAF in order to gain additional performance benefits and add as much value as possible to the required commercial objectives.*

4. Further refine the DAF unit to produce the optimal sludge whilst meeting host wastewater objectives.

*Once the DAFs performance had been demonstrated the host site needed to work out its preferred objectives for the technology. In this instance maximum removal of the VSS became the goal. Effluence could then further refine the DAF process to minimise the cost per megalitre, match the system automation to the host requirements and work with the host to find a solution for the accumulation of sludge.*

5. In addition:

    a. Trial a small footprint, mobile DAF solution;

    b. Demonstrate the quality of the treated water;

c. Demonstrate an 85% reduction in organic and nutrient loading in the processed waste water stream; and

d. Benchmark the reduction/elimination of greenhouse gas emission liability.

e. Estimate the cost of wastewater treatment per unit of wastewater with the mobile DAF.

*Element 5a. has been demonstrated by the presence of the DAF onsite with its very small footprint. Testing of the wastewater has demonstrated 5b, 5c and 5d. of the above elements. Point d. is resolved by the capture of the VSS component. In a carbon pricing environment re-use of the VSS that avoids release of the methane component to the atmosphere or any other high carbon emission use meets the requirements for reducing or eliminating greenhouse gases. In essence the VSS, once captured, is now capable of being managed to avoid emissions. Cost of wastewater treatment has been estimated based the chemical cost per megalitre of wastewater.*

6. Demonstrate a method of sludge capture, storage, transport and handling to assist full-scale production.

*Our efforts to add value to the sludge as an industry feedstock through cooking and processing have had mixed success. The sludge can be cooked and some fat re-processed into tallow. This part of the process needs further 'tweaking' in order to make it more commercially valuable, though technically all the sludge can be cooked and made more amenable to reuse.*

7. Demonstrate the trial processing outcomes by provision of trial derived product of a test industrial process for the on-going manufacture of stockfeed from sludge;

*The result here is poor. Through onsite and offsite, in-house testing and cooking we have determined that the sludge can be cooked. We do not believe that the sludge can be cooked to make stockfeed due to the requirements of the regulatory process. Under the regulatory process the sludge would need to be cooked at such high temperatures as to reduce its value in a stockfeed system. Further work will be conducted in future studies in a private capacity.*

8. Outline the business case for use of sludge from the Effluence DAF to create a new stockfeed product

*Since the testing process revealed that the sludge could not be used to create a new stockfeed product as we had hoped we have provided Table 1.11 as an analysis of various re-use options. In Table 1.11. We have provided an analysis of the possible pathways by which the sludge could be re-used.*

## 6.2 Cost-effectiveness of the DAF

The Effluence DAF represents a cost-effective opportunity to remove VSS at an estimated operating cost of $148,000 per year. This is expensive if it's higher than the cost of an existing system and cheap if it allows the business to reduce its waste management costs. At CA, Effluence has had the chance to deploy its DAF technology, in a very competitive environment, as CA's waste management costs are very low. What we have learnt is that whilst the waste management costs are low the costs of the DAF are probably slightly lower if not significantly lower than the cost of operating ponds with a full load of volatile solids. This would be an exceptional outcome for the DAF and sets a benchmark for the industry. Whilst the DAF costs money to operate, its operation should remove most if not all the operating costs of the ponds. Use of a DAF would allow CA to increase throughput if the opportunity presented, based on waste management capacity alone, excluding any other considerations.

There is room for debate when comparing pond costs with the DAF. This study would tend to indicate that if significant inputs like energy are applied to a pond then the DAF as described here should be the more economical option. It is also possible that operating the DAF is cheaper than simply operating ponds without aerobic interventions due the cost of pond sludge and crust removal.

The DAF option also creates the potential for more product sales through the re-processing of captured waste. This potential source of revenue makes it highly probable that the DAF combined with waste re-use such as tallow production may add value even where a site has a low cost option such as that at CA.

## 6.3 Re-use options for captured sludge

We have the following options presently available, once sludge has been captured by the DAF. These options include:

Option 0: Business As Usual (BAU) – continue using the pond system;

Option 1: Capture the sludge and resell immediately;

Option 2: Capture the sludge and re-process into higher value added feedstock;

Option 3: Capture the sludge and re-process in the render plant; and

Option 4: Capture the sludge and process in a digester.

The options were each examined in Table 1.11. The following provides a short summary.

Option 0 is business as usual which means the use of ponds either with or without various forms of aeration. It is well-known, which is a major advantage for any technology, but it does not appear to be cheaper than the DAF in even its lowest cost version. We have not been commissioned to provide the full accounting costs of non-aerated ponds, but as the lowest cost option we feel that the costs of sludge disposal alone are likely to be a significant proportion of the annual DAF cost. The addition of other costs such as restrictions on expansion, management and staff time, carbon emission issues, environmental and regulatory challenges etc would tend to make the un-aerated pond of at least equivalent cost, if not higher cost, than a DAF. Ponds that are aerated, or use more sophisticated systems for managing what amounts to advanced aeration can cost much more than our benchmark and lowest cost, un-aerated pond, hence making the effective DAF, on balance of probabilities, a cheaper option by logical definition. Ponds tend to be overloaded rather than optimised for their ability to process large volumes of mild waste water containing dissolved solids for polishing and some gas production.

Option 1 involved extracting the sludge by DAF and then using the raw sludge as an input in a existing process or sale. This process is simple but the likely re-use options would appear to be limited. Some DAF users may wish to render the sludge (see Option 3 below), others may try composting. The composting process has been considered uneconomic by waste industry veterans for twenty years for all industries including meat production because the volume of supply drives down market prices to uneconomic levels. If the option of immediate reuse is available its convenient but all operators should consider the option of adding value as a benchmark just in case this latter step is more lucrative.

Option 2, involves processing the DAF sludge to manufacture a feedstock to industry. This option requires more expenditure in terms of capital and operating expense but can create, some tallow, for example, which may offset the cost of operation. The net value of such steps should be estimated first. The process of reuse may result in further reduction in the sludge volume and stabilisation of the contents. This is an ‘in-house’ work in progress as the opportunity to explore the options is only new.

Option 3 involves re-use in the render plant of the DAF sludge. If possible it is very convenient but it is also a possibility that the sludge may detract value in the render plant by lowering the quality of the existing product. Once again a cost-benefit analysis must be performed to clarify the likely and the desired outcome.

Option 4 involves re-use of the DAF sludge in a digester system to recover energy and create soil conditioner or fertiliser. The digester process requires more capital and operating cost but can absorb all the available organic matter. Potentially the digester can generate returns from the sale of energy and fertiliser to offset the costs and perhaps add value to make a profit as well. Once again this needs to be studied.

## 6.4 Concluding Remarks

The cost-effective capture of significant quantities of VSS, at a cost that can be borne by industry, has been successfully documented. The system has demonstrated that it can operationally extract 85% or more of the VSS as required, subject to appropriate ‘tuning’. Since effective capture of sludge is somewhat novel the next part of the project was to explore potential re-use options for the sludge.

We began the project with a clear view as to how captured fats/meat solids could be converted to new value added product. This option failed, since it appears that regulatory barriers may prevent the solid being reused at its proper value. This means that Option 2, as discussed on page 24 and outlined in Tables 1.9 to 1.11, at this point, has less value than we might otherwise have expected. However, this process of examining re-use options is only the initial steps on a longer journey. We expect that with continued ‘tweaking’ we will find re-use options for part of the sludge at least.

Option 3, passing the sludge through an existing render plant, is ruled out at CA but maybe feasible in other locations. Option 4 is a feasible outcome for the CA site. The presence of a digester could absorb the entire organic waste stream from CA with minimal capital or operational cost on their part. Even if such costs were incurred the savings on the pond management system would be useful. A co-located digester also offers the opportunity of some competitively priced green energy that would add further value.

Even without Option 4 the DAF appears to open up opportunities to re-direct VSS towards a value added use rather than subtracting value through increased costs and environmental and carbon degradation. As environmental, carbon and energy costs rise the DAF could add further value as a hedge against rising prices. Effective DAF operations offer the following benefits versus a baseline of business as usual.

1. Potentially lower net costs versus BAU;
2. Potential for new revenue streams to evolve;
3. An improvement in the CA risk profile (‘a reduced insurance premium if you like’), expansion opportunities and freeing up of some of the buffer zone;
4. A reduction in the greenhouse gas and other emissions from the site subject to Carbon capture technologies (eg; methane production);
5. Removal of waste volume may remove development constraints or ‘closure threats’ on the site;
6. Allows the clients of CA to ‘green their value chain’ and hence value CA services at a higher rate; and
7. A reduction in the need for environmental management at the site.
8. Potential value of multiplier effects as digester type businesses co-locate.
9. Reduction in odour producing material from the anaerobic ponds

Future research opportunities may examine:

1. The significance of keeping the waste stream inside the food safety envelope to maintain value, and avoid regulatory overburden;
2. The maximum capacity of ponds to absorb volatile solids and yet maintain year round fitness for purpose;
3. The costs of waste ponding systems should be clearly elaborated in the face of electricity price rises driven by rising transmission costs;
4. Opportunities for adding value to waste volatile solids should be examined;
5. The cost of a digester system to the industry as a waste solution.

# 7 End Notes & References

### Explanation of Suspended Solids

Suspended solids often known as Total Suspended Solids (TSS) comprise volatile suspended organic solids (VSS) and suspended inorganic solids.

In layman's terms the non-suspended component is known as dissolved solids.

The VSS refers to the fraction of total suspended solids (TSS) that can be destroyed by burning off in an ignition test. The burnt fraction is taken as a proxy for the 'organic' proportion of the total solids where organic matter is material likely to be actively involved in bacterial breakdown and reduction in an anaerobic environment such as a treatment pond that lacks oxygen.

The definition of volatile versus non-volatile organic solids can be further understood at this link - http://www.norweco.com/html/lab/test_methods/2540efp.htm

### References

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