Dairy Production Systems, Branford Farm

Manure Treatment Process

Final Report

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1 EXECUTIVE SUMMARY

In July 2005 the Farm Pilot Project Coordination, Inc (FPPC) granted QED Environmental Services LLC (QED) partial funding for a pilot plant (PP) at the Dairy Production Systems (DPS) dairy near Branford, Florida USA. Using this funding as a project base, in 2006 there was an extensive upgrade performed at the DPS farm from the barn to the manure handling system. This report concentrates on the performance of the QED Tangential Flow Separator (QTFS) and the Activated Sludge Biological system (ASBS). FPPC funding provided assistance with the QTFS portion of the project only however, the TFS works in conjunction with the biological system so the total system consideration for this report is the QTFS and the ASBS. DPS provided substantial support to the project (both financial and managerial) and have been a committed partner in the project.

The system was designed as a PP to be proved on 100,000gpd. The QTFS was commissioned at 100,000gpd however, to the benefit of DPS, the system capacity has been increased to 220,000gpd. It is planned to in increase the flow through the QTFS in upcoming months to 300,000gpd.

The QTFS system was operational in batch mode in July 2006. The barn flush system was completed on April 20th 2007 and at this time the full system including the ASBS had been commissioned. It has been operational on a 24/7 basis since this point. ASBS's usually take several months to reach optimum performance.

The treatment cost per unit volume of the QTFS is below the design criteria, averaging $1.02 per 1000 gallons. This equates to a cost per hundred weight (CWT) of $0.16 based on production of 500,000CWT. These economics are what DPS had planned for and meets the project success criteria.

Despite doubling the incoming nutrient concentrations the total system was able to achieve a peak performance of 87% Total Phosphorous (TP) reduction and 88% TN reduction, exceeding the project success criteria for 100,000 gpd. The system now treats some 220,000gpd. The total system is achieving averaged reductions of 68% Total Phosphorous (TP), 61% TN, 68% Total Solids (TS) and significant odor reductions. It is predicted the ASBS would also significantly reduce pathogens with an up to 10°F temperature increase across the system due to biological activity. The system is designed to work as a multi-step process thereby dampening effects of changes in concentration. As a result emphasis in the report is on total system reductions not individual components.

The concentration of infeed nutrients is close to double what system was designed for. A number of possible causes and solutions are discussed. Incoming concentration of Total Nitrogen (TN) in particular decreases performance of the biological system. Biological activity is adversely affected by higher ammonia concentrations. Higher TN and BOD will also increase the demand for air. Without increasing aeration the amount of ammonia conversion (TN reduction) is restricted.

The project has been a great success. Project success criteria were met or exceeded. The plant is now treating over double the pilot flow rate and nutrient input concentrations are double what was designed for and as a result removal averages are lower than peak criteria. It also should be noted that with the variations in incoming concentration, sampling needs to be careful to account for the eight day retention in the biological system; otherwise the output may not match up with the input. This lag effect has on occasion given the results phenomena of higher in TN out of the biological system that the input at a given moment in time.

A series of recommendations are provided to decrease the incoming TN concentration and increase ASBS performance to achieve the system average TN reduction design criteria of 75% removal for the higher flow rate.

This report was prepared in conjunction with and the support of DPS. We also wish to Thank FPPC for the generous support given to the project which had a big part in the overall success.

2 INTRODUCTION

2.1 General

In July 2005 the Farm Pilot Project Coordination, Inc (FPPC) granted QED Environmental Services LLC (QED) partial funding (43%) for a pilot plant (PP) at the Dairy Production Systems (DPS) dairy in Florida USA.

The FPPC is a US government funded entity established to select and fund technologies that have the potential to significantly reduce the pollution of farmlands and waterways from the discharge of effluents from concentrated animal farming operations (CAFO's). The FPPC has awarded a number of grants over the past several years with the QED funding allocation being one of three allocated in the July 2005 funding round.

The objective of the FPPC funding is for the funding recipient to demonstrate the viability of their technology in a real farm application. As a result the documentation and verification of the treatment process and treatment results is of key importance to the project. Other key criteria for the project includes the farmers commitment to the long term viability of the treatment system and that the technology provides a complete solution for the wastes produced, i.e. by products from the treatment process having a commercial value to end product users. Further information with regard to the objectives of the project is provided in section 3 of this document.

QED selected DPS for the project, as DPS demonstrated a very strong commitment to ensuring the success of the project and has a demonstrated track record of being a leader in the dairy industry, assessing, adopting and implementing new technologies to improve the long term viability of the dairying industry.

The key objective of the contract is to demonstrate the viability of the QED multi stage separation technology as a low cost sustainable technology for the removal of nutrients from dairy farming effluent. Specifically the aim of the plant was to remove 75% P & N.

2.2 Description of clients overall facility

The DPS - Branford dairy is permitted by Florida Department of Environmental Protection (FDEP) to milk 2,050 cows on a 3 milking per day, 7 day per week basis. The farm occupies 593 owned acres and an additional 103 adjacent rented acres and borders on the Sante Fe River. As such nutrients leaching into the river are closely monitored with 11 bores along the riverbanks sampling the quality of water seeping into the river.

2.3 Site details

The farm is located in the Suwannee Basin, some 150 miles (2.5 hours drive) from Orlando. See Appendix 1 for farm locality map.

The DPS - Branford site address is as follows:

DPS – Branford Farm
2780 NW CR 138
Branford, FL 32008

2.4 Client Details

2.4.1 Client contacts

Client	Farm Pilot Project Coordination, Inc. Suite 3220 101 E. Kennedy Blvd. Tampa, FL 33602-5178	
Key client contact	Robert E. Monley General Manager Address (as above)	
	Phone	813 222 8200
	Fax	813 221 8811
	email	bmonley@fppcinc.org
Client contact	Lauren Seigel Operations Associate	
	Direct	(800) 829 8212
	email	lseigel@fppcinc.org
Key farmer contact	David Sumrall President and Chief Executive Officer 23343 NW CR 236 High Springs, FL 32643	
	Phone	386 454 7977
	Cell	352 490 1696
	Fax	386 454 7966
	email	DPSumrall@DPSDairy.com
Farm's external engineer	Stephen C. Swann Vice President Applied Technology and Management Inc., 411 Pablo Ave, Jacksonville Beach, FL, 32250-5540	
	Phone	904 249 8009
	Fax	904 249 8007
	Email	sswann@appliedtm.com

2.4.2 Stakeholders/Project Supporters

The stakeholders in the project include:

i)	FPPC	overall program coordinator
ii)	DPS	farmer
iii)	FDACS	Florida Department of Agriculture and Consumer Services – (part funder of the project)

iv)	Suwannee Alliance	coordinator of agricultural activities in Suwannee basin
v)	Cowpeat	Contracted with DPS to take our solids for use in a composting operation with purpose of marketing to solids to the nursery industry.
vi)	Agpro	Contracted with DPS to supply the run down screen (RDS) for the project. Appointed by DPS as the "project manager' for overall coordination of the various upgrades on the farm.

2.5 Description of farm upgrade

There was an extensive upgrade performed at the farm. The upgrade affected both the effluent treatment system and other parts of the farming operation such as the barns.

The upgrade in the effluent treatment system included:

- new sand separator,
- new RDS,
- the TFS system,
- new aerobic biological system, and
- composting operation.

2.6 Description of where this contract fits into clients operation

The PP is installed in the strip of land between the two concrete lined lagoons, see sketch No 5920-001 for site location plan (contained in Appendix 1).

Whilst the objective of the PP was to prove the viability of the QED technology to economically treat the effluent, the plant is now used as part of the normal farm operations to effectively treat the effluent stream on a long term basis.

The key new equipment components include:

- Passive sand separation lane
- Agitated pump pit
- Double inclined VRDS supply pump for effluent,
- QTFS,
- Sludge tank,
- Mono sludge pump,
- Lime dosing system,
- Ferric dosing system,
- Polymer dosing system,
- Feed effluent monitoring points (flow, TSS, P, N),
- Treated effluent monitoring points (TSS, P, N),
- All pipe work required from the RDS to the TEHP,
- Foundations and concrete pad for above plant,
- Electrical systems,
- Trickle filter,
- New aerobic biological system.

3 PROJECT OBJECTIVES, SUCCESS CRITERIA AND MONITORING

3.1 Client contract objectives

The key client criteria for the contract was to demonstrate the economic viability of removing substantial quantities of nutrients (primarily P, N) from the effluent. This was achieved by:

- supplying a fit for purpose, cost (capital) effective system,
- providing a system that has an appropriate operating cost, including:

  vii) minimum chemical usage to achieved desired water quality,
  viii) has low energy consumption,
  ix) has minimum number of operating items of equipment, there by reducing maintenance costs, and
  x) has low as practical requirement for farm labor intervention.

- providing a robust system that requires minimum technical support,
- ensuring that the system consistently removes agreed quantity of nutrients from the effluent,
- ensuring that the solids produced are in a form ready for composting (15-20% dry matter) and in-turn commercial sale, there by providing a revenue stream to offset operating cost,
- providing sampling points to monitor effluent, and
- provide substantive reports to document the performance of the system.

3.2 Project success criteria

The primary project success criteria was treating the effluent stream to reduce the quantity of P, N in the waste stream by a minimum of 75% on average and this needs to be achieved for less than $1.20/1000 gallons of treated effluent for the QTFS portion.

In recognition of a doubling of input concentrations the need for the system to meet this for an average case has been removed (as this would require doubling the systems air requirements).

3.3 Monitoring

Following installation of the system, completed in June 2006, the system was run in batch mode. The construction of the flush system was delayed over six months till late April 2007. As a result sampling and continuous operation of the system did not begin until after April 2007.

Based on the above dairy project build delays, the sample plan was adjusted according to fit within project budget restrictions and client contractual objectives. It was necessary to simplify the sampling plan to focus on simply the TFS and the biological system.

Sampling has been undertaken every week by the plant operator with the following information taken (in conjunction with site operator):

- flow rate (treated),
- ferric usage,
- polymer usage for flocculation,
- grab sample of raw (lagoon 1),
- grab sample of TFS treated (irrigation pipe from lagoon 2), and
- grab sample of the biological treated.

Grab samples were analyzed for pH, Total Solids (TS), Total P (TP) and Total N (TN). This analysis was undertaken by an independent laboratory. Biological systems were also analyzed for alkalinity.

Grab sample sites were specifically taken at the following points;

1. Incoming pipe to the QTFS, sample port in-pipe (Raw)
2. Overflow pipe from the TFS, sample port in-pipe (QTFS treated)
3. Overflow pipe from biological system, open spigot (final treated)

Of note during this study the overflow from the QTFS sludge tank was directed back to the round lagoon (pre-QTFS) and as such was not routinely monitored.

3.4 Assisting in finishing Aprile Dairy Project

In development of the DPS project, QED reviewed equipment used at Aprile Dairy, assisted in evaluating liquid lime in manure treatment and determining effectiveness of chemical treatment and potential to re-use the treated water for flushing.

The Aprile Dairy project was testing lime, a metal coagulant and polymers with a unique configuration of mobile hardware. The use of the novel hardware was quickly discounted (as it did not perform for more than 12 hours continuously without issues). Instead the evaluation of lime was done on the current DPS system in addition jar testing utilizing lime was also undertaken to backup results.

4 PROJECT DESCRIPTION

4.1 Overview

The project involves the supply of a complete effluent treatment system (ETS) required to treat a minimum of 100,000 gpd of effluent and to reduce the level of P and N in the effluent by 75%. The contractual obligation is to treat 100,000gpd, however, the farm currently uses 300,000gpd, so the intention was to design the main vessel to have a capacity of up to 300,000gpd to accommodate a higher flow rate if necessary.

The objective of this project is to incorporate the lessons learned from the first generation plant installed at McArthur farms (Lake Okeechobee, Florida) and to demonstrate the economic viability of significantly reducing the levels of nutrients in dairy effluent streams.

A key design parameter for the TFS capacity is the settling velocity of the feed fluid. The settling velocity is a function of the contaminants contained in the fluid which can be further modified by chemical additions to increase the settling rate. Feeds that have a high settling velocity can achieve high feed rates while feeds with low settling velocities require low feed rates. However, the settling velocity can be increased by the use of more chemicals hence the capacity of the TFS is influenced by the rate of chemical addition. When the feed rate is varied to the TFS system at DPS, it has a resultant upflow velocity increase. If this resultant upflow velocity now exceeds the settling velocity of the fluid, more chemicals are now required to maintain the TFS separation performance. While rules of thumb can be applied to give a general performance capacity, actual settling velocities and chemical additions required are a site specific function.

The TFS was optimized with regard to the feed inlet location, feed pipe diameter, cone length, cone diameter, TFS length to diameter ratio and inner cone dimensions; all designs were to allow for maximum variability in variation in flow and composition. Design capacity was for between 100,000 gpd and 300,000 gpd with the following ranges in criteria;

Upflow velocity:	4’2” ft/hr to 12’3” ft/hr
Residence time:	minimum 1.2 hrs
Solids loading (feed)	0.04 lb/gal
Solids loading (TFS)	170 lb/hr to 500 lb/hr

4.2 Scope of work

The scope of work was in three key parts, namely:

i) plant supply,
ii) plant commissioning and system optimization, and
iii) system performance monitoring and reporting.

4.3 Schedule and Milestones

The build and commissioning program for the PP at the DPS farm took approximately 5 months.

The project milestones for the project, all of which were met, include:

		Weeks post contract award
i)	complete effluent stream analysis	3
ii)	define P reduction and other project criteria	5
iii)	define all key plant required for PP	7
iv)	complete civil works	10
v)	install PP	15
vi)	commission PP	25
vii)	submit project report	after 12 months of operation

System operation was started on July 1 2006, on schedule. However, unfortunately the flush system for the barns was not commissioned until April 2007 which significantly delayed system monitoring and necessitated a change in the monitoring.

4.4 Project expenditure

The total project expenditure was approximately $684,000 for the QTFS portion. External to this budget QED also undertook design work of the ASBS to compliment the QTFS system. The QTFS for this study was run with the purpose of conditioning the water for the ASBS. Hence whilst the FPPC only contributed to the QTFS protion of the project the ASBS is included in the assessment as the QTFS was not run as an isolated component but instead as part of a system. For the balance of this report the "system" is in reference to the QTFS and the ASBS.

4.5 Comprehensive Nutrient Management Plan

The site permit is presented in Appendix 2.
The site CNMP is presented in Appendix 3.

4.6 Process Flow

The effluent flow from the barn through treatment to the field is summarized below:

i) effluent washed from the milking pallor and barns via an open spoon drain to the sand separator and in turn flowing to the collection sump,
ii) effluent pumped from the sump to the RDS,
iii) solids from the RDS dumped onto concrete lay down area,
iv) effluent from RDS flows by gravity to the pumping pond,
v) Effluent is pumped out of the pumping pond to the mixing chamber attached to the QED tangential flow separator (QTFS), where ferric and polymer are added,
vi) The effluent flows by gravity out of the bottom of the mixing chamber into the QTFS,
vii) The QTFS is a highly efficient physical chemical manure treatment system. System detail is provided in Appendix 4.
viii) supernatant (treated effluent) from QTFS flows to the aerobic biological system,

ix) The ASBS is designed to encourage biological growth to allow for nitrification/ denitrification. The system includes three distinct treatment zones and "CAFO designed" fine bubble aeration.

x) liquid flows through the biological system cells and overflows a collection weir to the concrete square lagoon,

xi) solids from RDS is to be used as feed stock for the Cowpeat composting operation,

xii) sludge from the QTFS is stored in a sludge tank prior to being pumped to the RDS for dewatering,

xiii) compost from composting operating removed from site and sold to commercial composting operations, and

xiv) treated effluent from concrete square lagoon is pumped onto the fields for land irrigation.

Refer to attached figures for the main elements of the system.

Plate 1. Passive Channel Sand Separator

Plate 2. Dual Inclined Separation Screens

Plate 3. Return of thickened sludge from TFS mixing the course solids

Plate 5. Coarse solids with darker portion where sludge has also been mixed in.

Plate 6. QTFS System

Plate 7. Biological Trickle Filter

Plate 8. Bank mounted AIA Taeration system. System has air vents and water intake/out-take vents.

Plate 9. The lagoon filled and overflow structure in operation

5 BASELINE CHARACTERISTICS OF INCOMING FLUID

The nature of the raw water and required quality of the treated water was based on existing data and is presented in Table 1 below. The actual water quality that was eventually being treated was some double the estimated concentration (refer to Table 1).

Nitrogen feed levels in the design were 371ppm, actual concentrations have averaged 616ppm. This has a significant impact on the performance of the biological system. Higher ammonia levels typically impede biological activity. In addition the concentration of TN has a direct relationship with the demand for oxygen. As a result doubling the TN concentration will likely require double the amount of aeration to achieve the same reductions. At the time of this report the amount of aeration had not been increased to meet the increased oxygen demand. BOD was not measured but given higher solids loading is also likely to be elevated. Higher concentrations of BOD will also have a significant slowing effect on biological removal of TN as BOD is preferentially digested by the nitrifying bacteria.

The P concentration has more than doubled from the design criteria of 28ppm to the actual of 79. This puts pressure on the total treatment system to achieve the P reductions required as generally a more concentrated infeed will require more chemistry to treat (higher operating cost).

Table 1
Dairy Production Systems
Feed water and treated water quality

Characteristic	Unit	Feed		
		Raw	After RDS DESIGN	ACTUAL
Flow	Gallons/day	100,000	NA	NA
	kL/hr		NA	
Phosphorous (P)	ppm		28	79
Nitrogen (N)	ppm		371	616

In summary doubling input concentrations will decrease removal rates for N (unless air and retention times are increased) and also make removal of P more expensive through increased chemical demand.

At the time of system design the input of N and P of the final barn setup was not known. As a result the system was designed to historical known nutrient levels with a safety margin.

6 RESULTS

6.1 Results Summary

Results to date are provided in Appendix 5 and the lab reports in Appendix 6. A summary of the results is as follows:

6.1.1 Infeed Volume

The system easily met the requirement to treat 100,000gpd.

During the bulk of the period of this assessment the TFS was run at approximately 85 gpm which equates to 120,000 gpd. The ASBS was run at a slightly lower volume, approximately 100,000 gpd (direct feed from QTFS) with the balance of QTFS treated water going directly for irrigation pumpage.

At the request of DPS we have recently increased the flow rate through the QTFS from 100,000gpd to 220,000gpd. The QTFS throughput should be able to be increased to 300,000 gallons with associated increase in chemical consumption. The biological system has been commissioned on 100,000gpd which is what its basic design parameters were based on.

6.1.2 Infeed Nutrient Concentration

A distinct concern for the systems performance is the input concentrations of TN, TP and TS are much higher than was used for the system design. In addition rapid changes in concentration, up to 100% change within 24 hours, have been occurring. This creates problems for the biological system which is designed to receive consistent concentrations.

The systems design was based on historical barn data with an added a safety factor. Thus the concentrations used for design were, after screening, a maximum input TN concentration of 371ppm, TP of 28ppm and a TSS of 4800ppm.

The reality is the system is receiving, post screening, an average input TN of 616ppm, a TP 79ppm and a TS of >8000.

6.1.3 Total Nitrogen Reduction

Complete system TN reduction (physical-chemical and biological combined) was able to achieve a peak reduction of TN of 88% (meeting plant criteria). After flush system installed the current average reduction is 61% which is considered excellent given the doubling of incoming TN concentration.

6.1.4 Total Phosphorous Reduction

The peak TP total system reduction is 87% (meeting plant criteria). After flush system installed the current average reduction is 68% which is considered excellent given the doubling of incoming TP concentration.

6.1.5 Total Solids Reduction

Complete system TS reduction (physical-chemical and biological combined) after flush system installed currently averages ~68%

6.1.6 Pathogen Reduction

The biological system results in a 10°F increase in temperature due to biological activity. Such a large temperature differential indicates high rates of biological activity. A standard of functioning biological systems should result in significant pathogen reductions. This has not been examined at DPS to date but is considered highly likely is occurring in the ASBS.

6.2 Total System Economics

The breakdown of the QTFS system economics at the time of this report production is provided in Table 2 below. Of note the dose rate is constant so the total volume of additives is directly proportional to treatment flow rate. Hence if treating less volume then the volume of coagulants will reduce accordingly in the same proportions.

Plant operations	**flow**	**220,000**	**gallons per day**					
	sludge	**10**	**% of feed**					
			per day		density	$/gall	$/tonne	$/annum
	dose rate		Gallons	Lbs				
Lime	500	Ppm	0	0	1.23		160	0
ferric sulphate	180	Ppm	39.6	497.376	1.57	1.13	258	23,419
Polymer TFS	20	Ppm	4.4			14.65		23,528
Polymer dewatering	200	Ppm	4.4			12		19,272
	kW					$/kWhr		
Power	8					0.08		5,606
	hrs/day					$/hr		
labor operations	1.5					10		5,475
labor maintenance	0.5					10		1,825
	% of capital							
spares	0.50%							2,500
							Total	$81,625 Per annum
								$1.02 Per 1000 gallons treated

As presented in the above table dose rates during the study period were as follows;
Ferric sulphate 180ppm
Flocculation Polymer 20ppm
Dewatering Polymer 200ppm

Currently the QTFS operational costs are $1.02 per 1000 gallons, which is below the allowed costing in the design. The ASBS is currently utilizing 50HP of aeration, which is made up of 20HP fine bubble and 30HP course bubble. Additionally there is

15 HP of mixing and pumping. The cost data for the ASBS (electrical) has not been compiled for this report as it is outside the scope of the FPPC study.

It is estimated that the Branford Farm will produce approximately 50 million pounds of milk for 2007 (500,000CWT). Using the TFS cost's of $1.02 per 1000 gallons treated, this equates to a **cost of treatment per hundred weight (CWT) of $0.16** based on production of 500,000CWT. These economics are what DPS had planned for and meets the project success criteria.

The capital costs of the project (~$680,000) will be costed as a depreciating asset. The economics of the asset and lifecycle of the asset are pending the compost program which is yet to produce product for market.

6.3 Results Discussion

Despite doubling the incoming nutrient concentrations the total system was able to achieve a peak performance of 87% Total Phosphorous (TP) reduction and 88% TN reduction, <u>exceeding the project success criteria</u>. The total system is currently achieving averaged reductions of 68% Total Phosphorous (TP), 61% TN, 68% Total Solids (TS) and significant odor reductions. It is predicted the ASBS would also significantly reduce pathogens with an up to 10°F temperature increase across the system due to biological activity. Flow rate of the TFS is 220,000gpd, over double the pilot rate.

The reduction for TN and TP needs to be discussed in the context of near doubling of the input TN concentrations as this will significantly affect performance in the negative. The concentration of infeed nutrients is close to double what system was designed for. There are a number of possible causes though it is considered likely it is simply a reflection of a greater number of cows in the barns for longer periods of time. Initial system design was done on the only data available at the time.. It is predictable that the removal of TN will be lower under higher incoming concentrations of TN. In wastewater treatment it is an accepted scientific principle that higher ammonia concentrations are more difficult to treat (as it slows down biological activity) and require more oxygen to treat. Additionally large fluctuations in concentration are notoriously problematic for waste water treatment plant.

Project success criteria were met or exceeded. However, the nutrient removal averages are currently below the design criteria due to a doubling of input concentration.

With regard to TN it is noteworthy that throughout this study QED discovered all three commercial labs QED utilized had problems accurately determining TKN. Hence samples required extensive reanalysis. Several sample results upon re-analysis were over 100% different which is very disturbing. As a result QED had samples analyzed several times. All labs used for this work are accredited professional laboratories. The lab we eventually settled on we believe has corrected all issues with TN analyses and as a result we now have faith in the TN results. It is important to note for future projects though that high TN results are not without laboratory error.

In addition, spot sampling (not recorded) also has shown that it is possible to observe a reverse effect of TN across the treatment system (e.g., increasing TN concentration from the QTFS to the end of the biological system). This phenomenon is caused by the eight day retention in the biological system. If a high concentration of waste water comes through prior to the sampling event this will show up at the end of the treatment system and not in the other stages that are more an instantaneous sampling event.

6.4 Steps to improve the systems

Removing more N in response to higher input concentrations is work that is currently being undertaken. Several immediate items are being done to assist in this area as listed below:

General

- Undertake a water audit of the site. Once completed and water usage is minimized, ensure that daily water usage is as consistent as possible. This will cut down on the large changes in concentration. DPS is currently undertaking this work.

- Recycle flush water from the square concrete lagoon not the round lagoon. By recycling water directly from the round lagoon it was possible for water to get more concentrated prior to being treated. This appears to have been happening. By moving the feed to the treated lagoon, whilst this will result in more liquid being treated, it will reduce concentrations in the feed lagoon by stopping untreated liquid going round and round and concentrating up. This change was already actioned by DPS and COMPLETED BY DPS AUGUST 2.

- Continue to foster ownership of the system with the plant operators. DPS and QED are working to make sure this approach is taken.

- Work with the labs and consistently cross check lab results.

QTFS

- Improve the dewatering of sludge for the QTFS. For some time there was an issue with the dewatering polymer pump which resulted in more sludge escaping back to the round lagoon. This will have been more of an issue for phosphorous removal than for Nitrogen removal. This pump has been replaced in late July and performance is being monitored.

- From extensive testing undertaken between QED and CIBA chemicals it was determined that there is a more effective polymer to aid dewatering of sludge. A change of polymer was recommended to DPS in July 2007. This is to be installed on August 2 for observation. It should be noted that the sludge dewatering is not always going to be perfect (always some will get through) but the more efficient it is made the better the total results will be, particularly for TP. COMPLETED BY QED AUGUST 2.

- Need to experiment with the output of sludge onto the screens to optimize the removal of sludge in the solids. Of note by using the screens to dewater the sludge it was possible to negate the need for a screwpress, thus saving DPS on project equipment required.

- Experiments with increasing the dose rates of the QTFS could be undertaken but this will increase chemical cost and may not affect N reduction much.

Currently not recommended. Currently the TFS is run with a minimum dose rate designed to condition the water for optimum biological treatment.

- The use of lime as a coagulant was trialed but it was found to be marginally effective. For now its use has been discontinued.

- Several times in the last six months the run down screen has been down for greater than 12 hours (e.g., week of 8/20 screen was down for greater than 24 hours). When the screen is down not only is their lower quality water going into the system downstream, there is also a build up of sludge in the TFS (only discharges when screens run) and this has repercussions for the entire treatment system with regard water quality. DPS is currently addressing this.

<u>Biological System</u>

If the TN is going to be higher consistently then the direct result is the need for more aeration. The initial modeling predicted the need for nearly double the aeration that was installed and it appears that more aeration is needed. <u>Of course this is a direct power consumption issue so there needs to be steps to maximize aeration and minimize power consumption.</u> Steps under consideration include:

- The surface aerators are a course bubble aerator and so are not all that efficient at oxygen transfer (e.g. use quite a lot of HP for limited oxygen transfer). The below surface aerator offers far greater oxygen transfer as it is very fine bubble (some four times the oxygen transfer per horse power). DPS is considering increasing fine bubble aeration.

- Take two of the surface aerators out of the activated sludge system and putting them in the concrete square lagoon to aerate this basin prior to discharge.

- Adding surface aeration to the round lagoon.

- Consider taking 50% of the recycle of activated sludge back to the round lagoon to increase potential for denitrification in that lagoon.

6.5 Aprile Project Discussion

6.5.1 Introduction

QED agreed to take over the aims of the Aprile Dairy project work (formerly in Riverview) at the DPS – Branford location as some of the project aims were similar. The Aprile Dairy project was testing lime, alum salts and polymers with a unique configuration of mobile hardware. The Aprile Dairy has since closed.

The unique mobile hardware was examined by QED and its use at DPS was discounted as it did not perform for more than a few hours straight without major problems. After a review of the available equipment none of the equipment was deemed to have salvage value to QED. From what QED understands the University of Florida (Gainesville) has taken possession of the second hand equipment.

6.5.2 Project Aims

The major aims of Aprile were;

i) to remove nutrients with addition of lime and a metal salt,
ii) to allow for recycling of flushwater through raising the pH higher than 9.5 with aim to kill pathogens.

6.5.3 Procedure

Discussions with Chemical Lime and University of Florida indicated that they had no issue with what variety of metal salt is used so we have kept the use of ferric sulfate in preference to aluminum salts (in order to make sure the compost product is not contaminated). The procedure over-view was to run the TFS system with and without lime dosing and take samples. In addition jar testing was performed.

6.5.4 Results

The first aim of nutrient removal is achievable at the DPS dairy with reference to Total Phosphorous. We have been working with CIBA Chemicals in this regard (please see CIBA report, Appendix 7). However, this work indicated that lime was ineffective at removing P at low dose concentrations and ferric sulfate worked more efficiently on its own. Composite sampling running the system on the addition of lime were run. The results indicated minimal difference in P reduction (Aug 2, 2007, 32ppm P and 33ppm P respectively) with and without lime addition respectively.

The second project aim of raising the pH was quickly deemed unpractical due to economics. The manure is well buffered which translates to a heavy lime demand. Allowing for optimum conditions (thorough mixing and 15 minute retention time with step dosing) it took an addition of greater than 10,000ppm of liquid lime to raise the pH above 9.5. This is cost prohibitive compared to ferric sulphate dosing.

The Aprile project is being further reported on by a separate external group.

7 CONCLUSION

7.1 Client contract objectives

The key criteria for the contract were to demonstrate the economic viability of removing substantial quantities of nutrients from the effluent. The breakdown of these criteria with project status is setout below.

- supplying a fit for purpose, cost (capital) effective system.
  Outcome - ACHIEVED

- providing a system that has an appropriate operating cost, including:

i) minimum chemical usage to achieved desired water quality,
ii) has low energy consumption,
iii) has minimum number of operating items of equipment, there by reducing maintenance costs, and
iv) has low as practical requirement for farm labor intervention.
Outcome - ACHIEVIED

- providing a robust system that requires minimum technical support.
  Outcome - ACHIEVED

- ensure that the system consistently removes agreed quantity of nutrients from the effluent.
  Outcome - ACHIEVED

- ensure that the solids produced are in a form ready for composting (15-20% dry matter) and in-turn commercial sale, thereby providing a revenue stream to offset operating cost.
  Outcome - ACHIEVED

- providing sampling points to monitor effluent
  Outcome - ACHIEVED

- provide substantive reports to document the performance of the system.
  Outcome – ACHIEVED

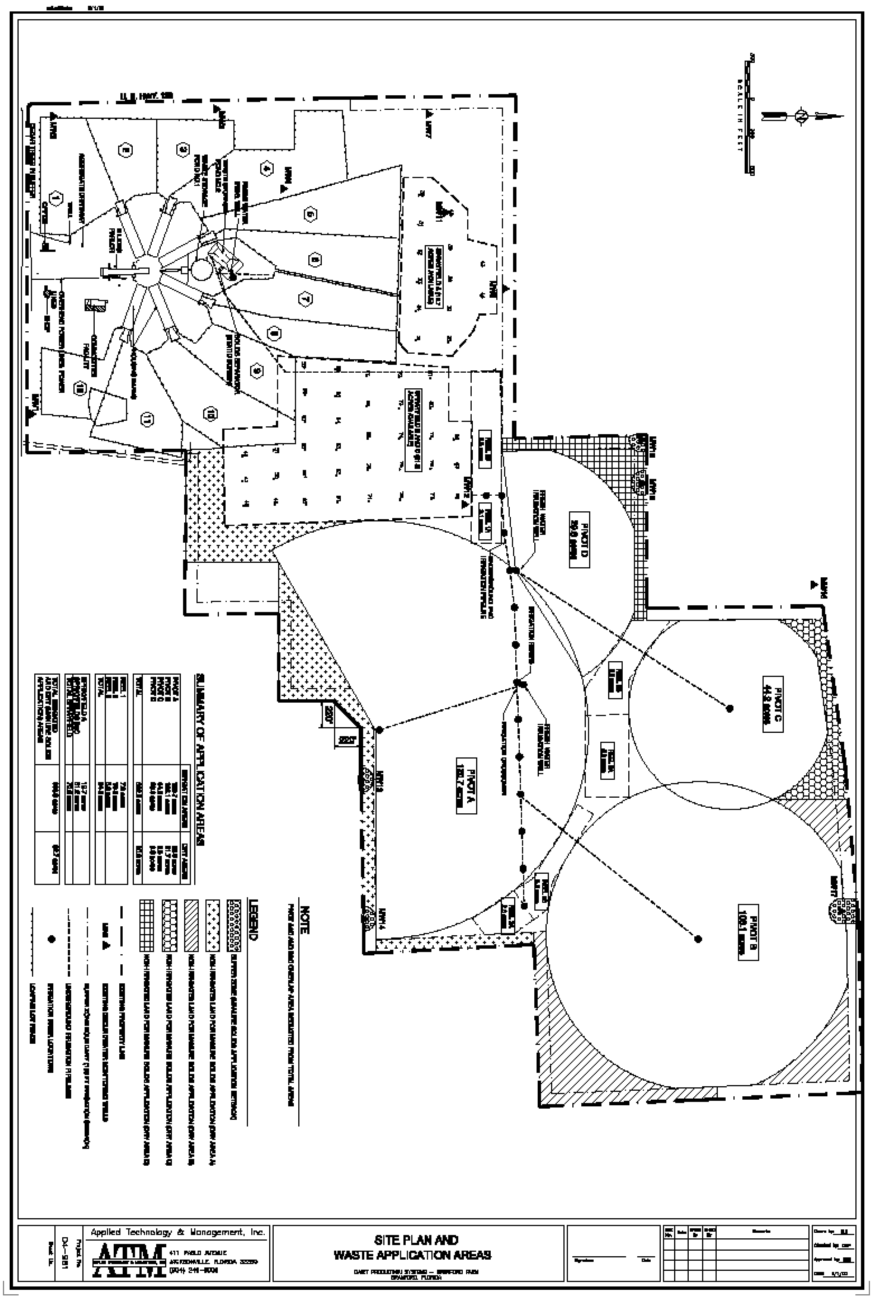
7.2 Project success criteria

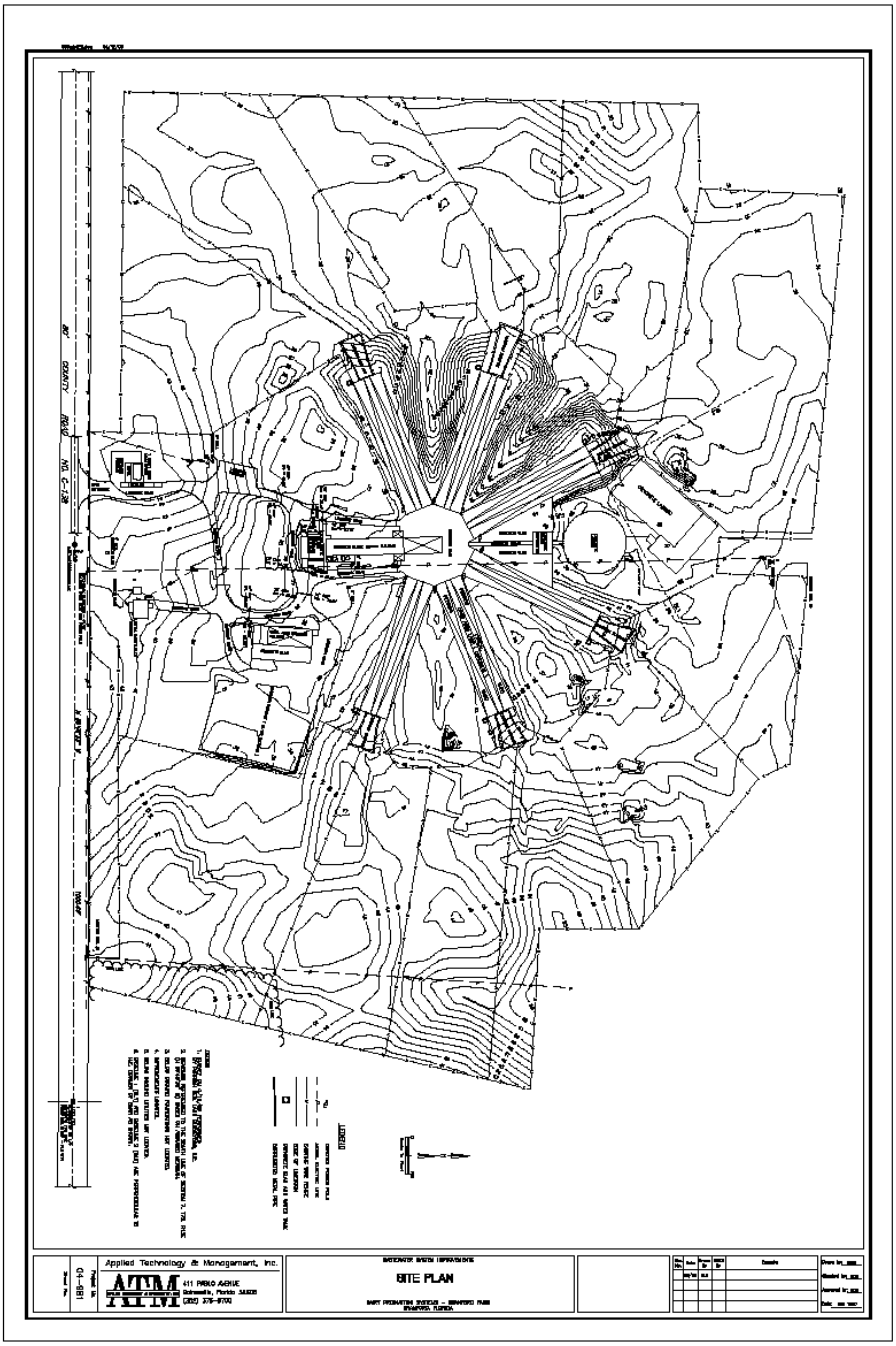
The project success criteria was treating the effluent stream to reduce the quantity of P, N in the waste stream by a minimum of 75% on average for less than $1.20/1000 gallons of treated effluent for the QTFS portion of the operations.

ACHIEVED - PEAK REDUCTION RATES >75%. PLANT IS ABLE TO REDUCE N & P BY >>75%. QTFS OPERATIONS COST ~$1.02 PER 1000 GALLONS WHICH WAS BELOW DESIGN CRITERIA AND SO COST CRITERIA WERE MET. SYSTEM ABLE TO TREAT HIGHER FLOW RATES.

INPUT NUTRIENT CONCENTRATIONS ARE DOUBLE BASELINE INDICATIONS, AS A RESULT THE SYSTEM NUTRIENT REDUCTION AVERAGES ARE 68% P AND 61% N REDUCTION RESPECTIVELY.

APPENDIX 1. SITE PLAN AND WASTE WATER IRRIGATION AREAS.





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SITE PLAN
04-881

APPENDIX 2. SITE PERMIT

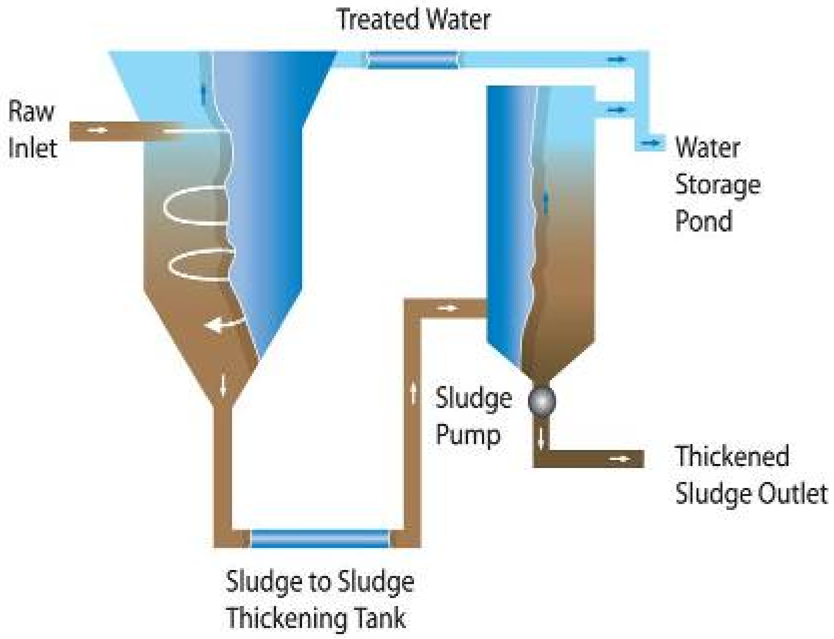
APPENDIX 3. CNMP

APPENDIX 4. THE QTFS

The QTFS is the core of the plant for the effective removal of solids and nutrients. The QTFS is robust as it has no internal moving parts, efficient as it uses very little energy and compact and therefore has minimum space and foundation requirements.

The fluid is introduced to the QTFS tangentially so as to cause a controlled rotation of the fluid mass within the vessel, which produces a controlled shear effect in an annulus flow path. This action produces a slight differential in velocity across the body of the fluid, which in turn causes a gentle and well distributed shear across the whole of the fluid body. The internal of the QTFS is equivalent to a well distributed and uniform mixing zone which allows excellent particle-to-particle contact and is ideal for natural or chemically assisted coagulation and flocculation - leading to superior solids separation.

The Tangential Flow Separator

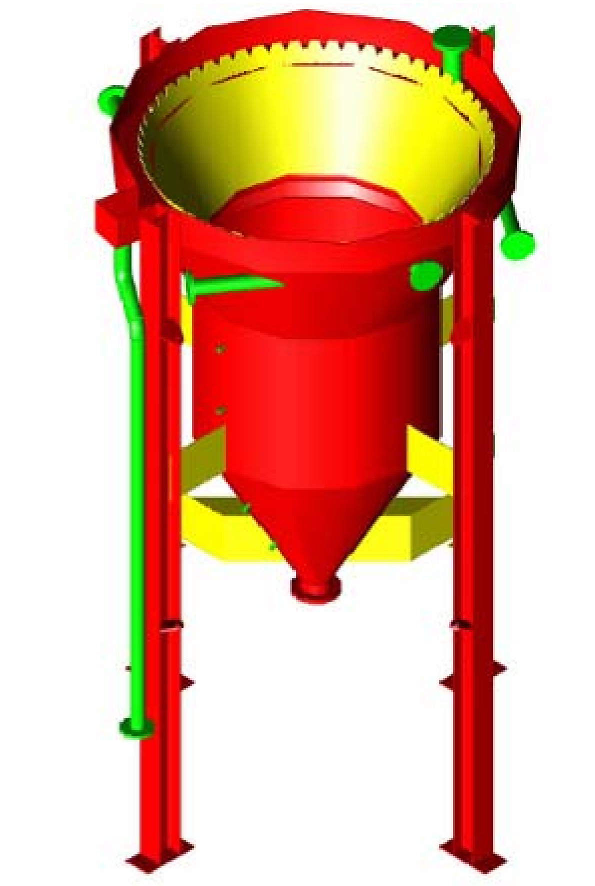


The treated water, which is referred to as supernatant, passes through the intricate static internals of the QTFS, rising upward over a control weir. It then passes through a down pipe and inturn flowing to the treated water lagoon. The flow path within the QTFS ensures the optimum period for the chemical additives to react with the solids and nutrients, so that the desired quality of the supernatant can be achieved.

The internal arrangement of the QTFS not only achieves the optimum shear conditions for mixing but also for the settling of solids and solids collection. Solids accumulate at the lower cone and are constantly, but gently, moved in a circular direction, which overcomes bridging and slip resistance moving the solids to a central well. The steep sided central well of the QTFS allows for the accumulation of the solids and preliminary compaction to improve solids density before the solids are drawn from the QTFS.

The solids are continuously drawn from the bottom outlet of the QTFS and transferred to the sludge tank. The retention time of the sludge within the sludge tank is approximately 6 hours, allowing further sludge and supernatant separation and compaction, i.e. increase of sludge density prior to sludge dewatering. The supernatant from the top of the sludge tank is discharged to the treated water lagoon.

QTFS Key Features



The QTFS has a number of features and benefits over the traditional clarifiers and reaction-clarifiers. Each of these features is particularly important for a low semi-skilled operator interface and in turn keeping the operations cost of the treatment system to a minimum. The features include:

i) low energy requirement, with entire mixing force provided by QTFS feed pump,
ii) compact design, providing a small footprint and allowing a completed QTFS to be transported to the farm as a single unit. This reduces assembly and erection time on the farm and thereby reduces capital cost of the plant,
iii) use of hydrostatic head of QTFS allows treated water to flow back to the treated water lagoon thereby reducing the need for pumps and in turn lowering operating costs,
iv) no internal moving parts that need to be serviced, and

v) use of hydrostatic head to transfer sludge from QTFS to sludge tank, thereby reducing number of pumps and operating cost.

QTFS AND COMPLIANCE WITH STANDARDS 629 AND 591

The utilization of the QTFS to treat waste streams produced by CAFOs, directly addresses the objectives of the Conservation Practice Standard 629 and amendment standard 591 for the treatment of agricultural wastes.

In particular the objectives that are addressed by the technology from Standard 629 and amendment 591 include:

i) To improve ground and surface water quality by reducing the nutrient content, organic strength and or pathogen levels of agricultural waste.

The QTFS removes significant quantities of nutrients from the waste stream and consolidates the nutrients into a form that can be readily transported for reuse. The nutrients are contained within the system and are thus prevented them from infiltrating the surface or ground water.

The QTFS system eliminates the storage of significant quantities of untreated wastewater for extended periods in waste lagoons. Lagoon are subject to the risk of being breached and infiltrating the ground water system. Additionally, severe weather events can also breach the lagoons causing contamination of surrounding surface waters. This was evidenced during hurricane Floyd, where breached hog waste lagoons impacted severely on the surrounding environment.

Treated water that is returned to irrigation lagoons has significantly less nutrients than the untreated waste water.

ii) *To improve air quality by reducing odors and gaseous emissions:*

One of the main issues for agricultural waste is the removal of volatile odor compounds such as phenol, p-cresol, skatoles and indoles which are produced by the action of anaerobic bacteria on the waste. Treating the waste prior to the onset of anaerobic activity results in a lower consumption of the chemicals required to remove odor compounds and produces a higher quality effluent.

Currently some farms store the waste streams for extended periods (up to 70 days) in pits and covered with water which creates anaerobic conditions and promotes the formation of the odor producing compounds mentioned.

The QTFS system treats the waste as it is produced, well in advance of septicity thus greatly reducing odor emissions and due to lower chemical consumption has a lower operating cost. In addition the QTFS can be used to dose lime which by raising the pH eliminates the production of H2S gas and other odor compounds associated with acidic environments.

iii) *To produce value added by products*

The agricultural sector has long viewed animal waste as a potential resource. The QTFS system concentrates up the nutrients within the waste stream making their reuse more beneficial and cost effective. The solids containing the nutrient are reduced to <5% of the original volume of waste water. This helps to overcome barriers of transport costs as highlighted in amendment 591.

As described in section 12 herein, the potential value added by-products that stem from a QTFS installation include:

- waste to biodiesel,
- waste to LNG,
- waste to fertiliser,
- waste to gas, and
- waste to energy.

iv) *To facilitate desirable waste handling, storage or land application alternatives:*

The QTFS treatment process removes nutrients and Volatile Organic compounds thereby the resultant fluid is more applicable to land application.

APPENDIX 5. RESULTS

APPENDIX 6. LABORATORY SHEETS

APPENDIX 7 CIBA REPORT