Final Report

Nutrient Removal from Dairy Wastewater Using Lime

Riverview, Florida
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(Note: Appendix B is not available on the internet.)
Executive Summary

Chemical Lime Company received a grant to design, construct, operate and monitor a demonstration project that would reduce nutrients in the wastewater from dairy farms. Dewatering of the flush water would be accomplished by use of a “T-Rex” mechanical screen. Lime would be added to raise the pH so that ammonia nitrogen could be stripped from the wastewater. Alum would then be added to precipitate the phosphorous. Solids would be transported off site for use as a soil amendment or fertilizer, and the treated wastewater would be recycled as flush water. On larger installations, the ammonia could be captured and also exported from the farm for use as fertilizer.

The demonstration project was to be conducted at Aprile Riverview Dairy Farm, Riverview, FL. In addition to the initial requirement of removing at least 75% of the nutrients from the waste stream, the system was also designed to be mobile and capable of being moved from farm to farm across public highways. The unit could then be used to clean out existing lagoons and storage ponds and thereby lower the cost of the system to all users in the future. An additional requirement that was imposed during the design process was that the system should be capable of unattended operation.

Difficulties were encountered almost immediately when startup of the system was attempted. The mechanical screen failed to consistently extrude dewatered solids. The pump used to agitate the collection tank and to pump wastewater to the mechanical screen suffered clogging problems, and it was not capable of adequately agitating the contents of the collection tank. It was replaced with a Houle chopper pump in spring 2004. In December 2003, consideration was given to replacing the T-Rex mechanical screen so that the demonstration project could continue, but it was decided to continue efforts to make the T-Rex operational.

In September 2004, Hurricane Frances demolished the feeding barn, recycle flush lines, and potable water lines, resulting in even more debris in the collection tank or sump. The storms and power outages had an adverse impact on the electrical equipment and control systems and on the outcome of the demonstration project.

Changing the screen to a smaller size opening may have had a dramatic effect on the machine in this application. When a T-Rex had been observed in operation in operation at another dairy farm with a 0.030 inch screen, only the coarse solids were being removed. If 0.010 inches was used, more small solids would be removed and mixed with the coarse solids. It would probably be much more difficult to compress water from the mixture. Thus, a “plug” would not form and be extruded from the T-Rex. Further testing would have to be done to verify this.

In spring 2006 it was apparent that the dairy farm was going to be sold to a housing development. Arrangements were made to remove the equipment from the site and to continue testing of the use of lime and metal salts at a Dairy Production Systems farm near Branford, FL.
Section 1. Background

Historically, nutrients were conserved and recycled on individual farms. Animals were raised as an integral part of the farm. Manure and other animal wastes were valued for their nutrient content and typically recycled directly to the land. However, as larger animal operations emerged in the swine, poultry and dairy industries, the quantities of nutrients produced by the livestock generally exceeded the recommended agronomic application rates on the available land. Historically, anaerobic lagoons were commonly used for stabilization and storage of livestock wastes and wastewaters. Some nutrient removal was obtained by settling of solids and volatilization of ammonia. However, their use has declined because of issues with odors, groundwater contamination, overflow, and dike failures during heavy rainfall events such as tropical weather events. In many cases, anaerobic lagoons were replaced by lined storage ponds which prevented groundwater contamination but exacerbated the problems with odors and minimized nutrient losses. As the size of livestock operations increased, the quantities of nutrients in the waste or wastewater increased, and available cropland became limiting.

Dairy farms in Florida have traditionally used flushing systems in milking parlors, feeding barns, and free stall barns. When the farms utilized grazing systems, the only wastewater was from the milking parlor. However, as the dairy farms transitioned from grazing systems to complete confinement free stall barns, the number of cows per farm increased dramatically. It became increasingly difficult to apply the nutrients in the wastewater to available cropland at agronomic rates to prevent environmental problems from excess nutrients. Thus, the farms became land limited.

A need exists for waste and wastewater management systems on livestock production enterprises which will capture, process and export nutrients from the farming business. Land area requirements would be minimized, odors and other gaseous emissions could be controlled, surface and groundwater pollution problems could be eliminated, and the nutrients could be converted into value added products and exported from the farm. Although technologies exist for accomplishing these goals, it has been difficult to implement them on livestock production enterprises in a manner which is economically viable and reliable.

Section 2. Introduction

Objectives

The primary objective of this project was to demonstrate the feasibility of an innovative waste treatment technology that is capable of capturing a minimum of 75% of nutrients from the feeding barn flush water for off farm applications. The system should also result in pathogen reduction, be relatively low in capital and operating costs, be able to process 16,000 gallons of wastewater (flushed from feeding barn) in three hours, be mobile, and be capable of unattended automatic operation. A secondary objective was to demonstrate the use of an innovative mechanical screen design for removing solids from dairy farm wastewaters.
Brief Project Description

Chemical Lime Company (CLC) received a grant from Farm Pilot Project Coordination, Inc. (FPPC) to design, construct, operate and monitor a demonstration project that would utilize an innovative technology system to reduce nutrients in the wastewater from dairy farms. As previously mentioned, the technology implemented would strive for at least seventy-five percent reduction in “on farm” nutrients from a feeding barn dairy flush system. The approach involved processes that are common in municipal and industrial wastewater treatment in addressing ammonia nitrogen and phosphorus. Dewatering of the flush water would be accomplished by use of a “T-Rex” separator (Waste Tec, Inc., P.O. Box 4196, Ormond Beach, FL 32175). Lime would be added to raise the pH so that ammonia nitrogen could be stripped from the wastewater. Alum would then be added to precipitate the phosphorous. Solids would be transported off site for use as a soil amendment or fertilizer, and the treated wastewater would be recycled as flush water. On larger installations, the ammonia could be captured and also exported from the farm for use as fertilizer.

Project Site and Farm Description

The dairy waste management system utilized for this project was at a privately owned farm (Figure 1). The farm was owned and operated by Aprile Farms, Inc (11513 Balm Riverview Rd, Riverview, FL 33569). Aprile Farms had been in the dairy business since 1943 with several farms in South Hillsborough County, Florida.

Figure 1. Location of Aprile Riverview Dairy Farm, approximately 10 miles southeast of Tampa, FL.
An aerial view of Aprile Riverview Dairy Farm showing major components of the waste management system prior to the demonstration project is shown in Figure 2. The farm was approximately 60 acres in size with a milking parlor and a feeding barn (Figure 3) for approximately 500 to 600 cows. The facility utilized a flush system in the feeding barn requiring approximately 16,000 gallons per day of water. The normal flushing procedure was one flush per day, during daylight shift, utilizing two 8,000 gallon storage tanks, one for each side of the feeding barn. Only the alleys along the feed bunks were flushed. Solids were scraped from the concrete area outside of the feeding barn to a solids storage area for export from the farm. Prior to this demonstration project, the wastewater generated in the feeding barn flowed into Lagoon or Pond 2. Wastewater from the milking parlor flowed into Lagoon or Pond 1, and Lagoon 1 overflowed by gravity into Lagoon 2. Wastewater from Lagoon 2 was pumped alternately to evaporation ponds or lagoons on the farm (Figure 4). Solids and nutrients were reportedly removed from the evaporation ponds periodically to export from the farm. There was a small pump in Lagoon 1 which could pump effluent back to the flush water tanks for recycling.

Figure 2. Aerial view of Aprile Riverview Dairy Farm showing major components of the waste management system prior to the demonstration project.
Figure 3. Feeding barn at Aprile Riverview Dairy Farm with one of the flush water tanks and the milking parlor in the background.

Figure 4. Evaporation ponds or lagoons at Aprile Riverview Dairy Farm, Riverview, FL.
Section 3. Methodology

On December 30, 2002, FPPC reached agreement with Chemical Lime Company (P.O. Box 985004, Fort Worth, TX 76185-5004) to conduct the demonstration project at Aprile Riverview Dairy Farm. In addition to the initial requirement of removing at least 75% of the nutrients from the waste stream, the system was also to be mobile and capable of being moved from farm to farm across public highways. The unit could then be used to clean out existing lagoons and storage ponds and thereby lower the cost of the system to all users in the future. Hi-Tech Solutions, Inc. (2086 E. Edgewood Drive, Lakeland, FL 33803-3640) was retained by Chemical Lime Company for design and construction of the system. An additional requirement that was imposed during the design process was that the system should be capable of unattended operation.

Conceptual Description of Process

A conceptual description of the nutrient removal system at Aprile Riverview Dairy Farm using lime, alum, and mechanical solids separation is shown in Figure 5. Flush water from the feeding barn would be collected in a below ground concrete tank (collection tank or sump). When the wastewater reached a preset level in the collection tank, a pump would automatically be turned on to agitate the wastewater and keep solids in suspension. When the wastewater level reached a higher level, an electrically actuated valve would direct the wastewater to a mechanical screen to remove large solids. In addition to the chemical nutrient removal processes, an important goal in this project was to test an innovative mechanical screen, the T-Rex. These solids would be stored on a concrete slab with a retaining wall for subsequent removal from the site. Phosphorus and some nitrogen would be removed from the farm site in the solids.

The effluent from the screen would flow by gravity to an agitated tank where lime would be added to raise the pH. pH and lime addition would be automatically controlled by a dual pH analyzer/controller. The wastewater would then flow by gravity to a second tank where ammonia would be stripped from the wastewater by an aeration system. In larger systems, the ammonia could be captured and sold offsite as a fertilizer or source of plant nutrients. However, in this demonstration project there would not be enough ammonia produced to economically justify the use of an ammonia recovery system. After ammonia removal, the wastewater would be treated with alum and passed through an inline static mixer. The quantity of alum which would be added would be controlled by the dual pH analyzer/controller. The addition of alum would result in precipitation of phosphorus and lowering of pH of the wastewater. It would then be pumped back to the flush tanks for recycling. Some of the phosphorus which was precipitated by the alum could then be removed by the mechanical screen in the next cycle. Some of the treated wastewater would be temporarily stored in a small tank constructed in the corner of the collection tank or sump for use in flushing the system (and lime pump and pipes) at the end of the treatment cycle. Any excess treated water would be discharged into Lagoon 2 and later pumped to the evaporation lagoons. The collection tank or sump also had a rectangular weir overflow so that excess flush water or storm water in the feeding barn area would pass through the collection tank or sump.
to Lagoon 2. Dilution water would be added to the system from rainfall on the paved feeding barn area. Thus, there would not be an accumulation of lime and alum in the waste stream.

Figure 5. Conceptual layout of nutrient removal system at Aprile Riverview Dairy Farm using lime, alum, and mechanical solids separation.

Modifications to Existing Waste Management System for Demonstration Project

A flow diagram of the demonstration project system is shown in Figure 6. Although the system was designed by Hi-Tech Solutions, input was received from numerous other people, including the people who owned and operated the dairy farm. An aerial view of Aprile Riverview Dairy Farm showing components of the demonstration treatment system (collection tank or sump, concrete area and retaining wall, location of trailer mounted screen and treatment system) is shown in Figure 7.

A below ground collection tank or sump was constructed at the end of the feeding barn with a rectangular weir overflow to Lagoon or Pond 2 (Figure 8). The dimensions of the tank were approximately 20 ft wide, 36 ft long, and the bottom sloped from 2 ft deep at one end to 6.5 ft deep at the pump intake. The approximate working
volume was 20,000 gal. A small triangular tank was constructed in the corner of the collection tank for storage of treated water used for flushing the lime slurry lines and pump at the end of a treatment cycle. The Gorman-Rupp T Series, 10 hp, semi-open impeller, self-priming centrifugal pump was mounted on a concrete pad near the deep end of the collection tank. This pump was used to mix the contents of the collection tank by recirculating the contents of the tank and also to pump the wastewater to the T-Rex mechanical screen.

Fences were reconfigured on the farm, and a concrete roadway, solids storage area, and runoff retaining wall were placed next to Lagoon 1. The trailer mounted mechanical screen and treatment unit were placed on the concrete next to the fence along Lagoon 1. Animals were not fenced away from the solids storage area or the trailer mounted screen and chemical treatment unit.

The pipe from the collection tank pump to the trailer mounted screen and treatment unit was placed underground to prevent damage from farm equipment. A return line was also placed alongside it from the trailer back to the collection tank or sump for excess flow to the mechanical screen from the pump. A pipe was also placed underground from the recycle pump on the trailer mounted treatment unit to the two recycle flush tanks for the feed barn. Plastic pipe was used wherever possible. Rigid connections were made between the trailer and other parts of the system.

Electrical service was placed underground from the service pole to the trailer. Most if not all electrical equipment was 3-phase power. Electrical power was supplied to all equipment through hard wiring. There were no provisions for quickly disconnecting any of the electrical equipment prior to transport to another site.
Figure 6. Aprile Riverview Dairy Farm Waste Treatment Flow Diagram.
Figure 7. Aerial view of demonstration project showing locations of collection tank or sump, concrete area and retaining wall, trailer mounted screen and treatment system.

Figure 8. Wastewater collection sump at Aprile Riverview Dairy Farm.
T-Rex Mechanical Screen for Dewatering and Solids Separation

The T-Rex mechanical screen (Waste Tec, Inc., P.O. Box 4196, Ormond Beach, FL 32175) was an innovative technology for screening solids from wastewater. Prior to selection for use in the demonstration project, it was observed in operation at a dairy farm north of Green Cove Springs, FL. It was successfully dewatering and extruding solids from dairy farm flushed wastewater. The location of the major components in a picture of the T-Rex is shown in Figure 9.

After the wastewater enters the upper end of the machine, the fluid moves upward through an inverted, stainless steel wedge wire screen (36 in. long, 18 in. wide, 0.010 in. openings). The wedge wire screen is cleaned by a hydraulically operated Teflon wiper on an adjustable timer. The screened effluent exits the machine. Excess wastewater that does not pass through the wedge wire screen is by-passed and goes back to the collection tank or sump. The by-pass flow can be regulated by a valve. The screened solids fall downward by gravity through an opening or throat to a cylinder with a reciprocating hydraulic piston. The piston forces water out of the particulate solids. This water bypasses the piston and moves upward through the wedge-wire screen or by-passes the screen back to the collection tank or sump. The solids are compressed against a knife valve. As the piston nears the end of its forward stroke, the knife valve opens and dewatered solids are forced out of the cylinder. The knife valve closes when the piston reaches the forward end of its stroke. The piston then moves backward to let more screened solids fall in front of the piston, and then the cycle is repeated. The forward motion of the piston and the knife valve are controlled by adjustable timers.

Some of the critical parameters in the successful operation of the machine include timing of the piston and knife valve, influent flow rate, size of the wedge wire screen, and size distribution of the solids in the wastewater. The T-Rex machine was delivered with a hydraulic system powered by a 5 hp electric motor which powered the main piston, the knife valve, and the screen wiper.
Figure 9. Picture showing the location of the major components in the T-Rex mechanical screen.

**Trailer Mounted Screen and Chemical Treatment Unit**

The T-Rex mechanical screen, the chemical storage tanks (lime slurry and alum), the chemical metering pumps, dual pH control system, chemical reaction and aeration tanks (ammonia stripping), mechanical stirrers, in-line mixer, centrifugal blower, recycle flush water pump, electrical power panel, and the electrical control system were all mounted on a semi-trailer unit. Locations of the equipment on the trailer are shown in Figure 10).
Figure 10. Trailer mounted mechanical screen and chemical treatment system.
Operation and Monitoring

The completed system had a high degree of complexity. A detailed description of operating procedures as supplied by the designer and fabricator is given in Appendix A. The mechanical catalog and procedures manual with drawings and descriptions of all equipment in the system is included as Appendix B. The proposed monitoring and evaluation plan submitted by the University of Florida is in Appendix C. It includes a list of sampling locations and test parameters, as well as recordkeeping requirements.

Construction and Startup of the Treatment System

Final design and construction began in January 2003. This included construction of the below ground concrete collection tank. The concrete roadway and pads for the trailer mounted treatment unit and for screened solids storage were also completed. Fabrication and assembly of the trailer mounted T-Rex mechanical screen and chemical treatment system were conducted by the equipment supplier at another site. Transport to the project site at Aprile Riverview Dairy Farm was carried out in the spring of 2003. Initial startup of the system was originally scheduled for June 2003, however, it was delayed because of weather and a delay in providing electrical power to the site.

Difficulties were encountered almost immediately when startup of the system was attempted. The mechanical screen failed to consistently extrude dewatered solids. The pump used to agitate the collection tank and to pump wastewater to the mechanical screen suffered clogging problems, and it was not capable of adequately agitating the contents of the collection tank. Both settled and floating solids continued to accumulate in the collection tank.

In December 2003, consideration was given to replacing the T-Rex mechanical screen so that the demonstration project could continue. A rotary vibrating screen (Sweco), a sloping wedge wire screen (Vincent), and a screw press (Vincent) were considered, but it was decided to continue efforts to make the T-Rex operational. In spring 2004, the Gorman-Rupp pump was replaced with a Houle chopper pump. After several days of work, the solids accumulation in the collection pit was broken up and pumped into Lagoon or Pond 2.

Attempts to operate the T-Rex and the chemical nutrient removal system continued. The T-Rex did not consistently operate satisfactorily. The lime control system appeared to be working properly. However, the alum control system did not operate properly despite claims by the designer and fabricator of the system that it had been tested and operated properly. It was discovered that the check valves for the alum metering pump were not present. Since it was a diaphragm pump, the check valves were essential for the pump to operate. It is not known whether the check valves had been removed from the system or whether they had not been installed during fabrication of the system.
Check valves were installed on the alum metering pump, and then other problems were found. The pH sensor was not working properly, and it had been installed in a “T” approximately 18 inches away from the wastewater flow. Thus, the response to changes in pH would have been very slow, if at all.

In spring 2006 it was apparent that the dairy farm was going to be sold to a housing development. Arrangements were made to remove the equipment from the site and to continue testing of the use of lime and metal salts at another project at Dairy Production Systems near Branford, FL.

Section 4. Findings and Observations

Annual rainfall in the Tampa Bay watershed in both 2003 and 2004 exceeded the 90th percentile. Hence, electrical storms and power outages were common in the area. Also, Hurricane Frances hit the area in September, 2004, and demolished the feeding barn, recycle flush lines, and potable water lines. It also resulted in even more debris in the collection tank or sump. The storms and power outages had an adverse impact on the electrical equipment and control systems and on the outcome of the demonstration project.

The agitation system and pumping system for the collection tank was not adequate and had to be replaced. This was due in part to the inability to run the system regularly as planned. If the collection tank had been emptied several times a week, then floating and settled solids would not have accumulated in the tank. Although the electrician modified the controls so that the pump could be run independently, the farm workers did not regularly perform this simple task. Another complicating factor seemed to the spilled hay from the feed bunk which contributed to clogging problems in the pump. Broken pieces of concrete, pieces of wood, etc. were a constant contaminant into the collection pit. Because the shallow end of the collection tank had a 2 foot depth, it was not possible get a wheeled loader or scraper into the collection tank for sand and debris removal. Since cows were washed and milked prior to entering the feeding barn, there was not an excessive quantity of sand which was flushed into the collection pit. However, sand did accumulate over time.

The as-built system contained numerous flow meters, electrically actuated valves, float switches, a dual pH analyzer/controller, metering pumps, etc. It was a very complex system deployed in an extremely harsh environment. As previously mentioned, it was designed to operate independently of daily management. If any one of the components would fail, then the entire system would fail. This made reliable operation almost impossible. There was no protection provided from the sun and rain, such as a shed or pole barn structure, and this eventually took its toll on the equipment.

The control system was not programmable, so it was very difficult to operate the system manually without the electrician who did the original installation.
A T-Rex mechanical screen had been observed in operation at a dairy farm in northern Florida. It was successfully screening and dewatering solids from dairy farm wastewater. The unit which was supplied to the demonstration was a different machine, and it had been used previously in another application. However, there was no reason to expect that it should not have operated satisfactorily in the demonstration project. A hydraulic line inside of the piston cylinder ruptured and had to be replaced. Also, the screen wiper bracket broke and had to be welded back in place. These were not easy tasks, but repairs on hydraulically operated equipment should be expected.

During efforts to make the system operable, it was discovered that the 0.030 inch screen in the T-Rex had been replaced with a 0.010 inch screen during fabrication so that it would remove a larger quantity of solids from the waste stream. Also, the control system in the original T-Rex had been replaced after the equipment had been delivered to the demonstration project site, and it was found that the piston and the knife valve were not properly synchronized. This was essential for the screen to operate properly. This problem was subsequently corrected.

Changing the screen to a smaller size opening may have had a dramatic effect on the machine in this application. When a T-Rex had been observed in operation at another dairy farm with a 0.030 inch screen, only the coarse solids were being removed. If 0.010 inches was used, more small solids would be removed and mixed with the coarse solids. It would probably be much more difficult to compress water from the mixture. Thus, a “plug” would not form and be extruded from the T-Rex. Further testing would have to be done to verify this. An attempt was made to locate the original screen that was in the machine, but the supplier could not locate it.

Rate of flow through the 0.010 inch screen in the T-Rex was much lower than expected. The flow rate could be increased by closing the valve on the bypass to put more pressure on the screen. However, this also increased the concentration of solids in the screen effluent going to the chemical treatment system.

Consideration was given to replacing the T-Rex, however, a decision was made to continue efforts at getting the T-Rex to operate properly. Although other solids removal equipment, such as rotary vibrating, sloping wedge wire, and screw press, might remove fewer solids or be more expensive, they would probably be more likely to function unattended.

Two other problems were encountered. First, water was found in the T-Rex hydraulic system, but no source of the problem was ever identified. Second, oil was found in the centrifugal air blower, but no source of the problem was ever identified.
This project may have been successful in the use of lime and alum for removal of nutrients from dairy farm wastewater if the mechanical screen or solids removal equipment would have performed satisfactorily. However, modifications had been made to the mechanical screen after it had been observed to be working successfully while screening dairy farm wastewater at another dairy farm. Replacing the electrical control system for the piston, knife valve and screen wiper after the machine had been delivered to the demonstration project site may not have resulted in improved machine performance.

The change to a smaller screen opening was purportedly made so that more solids could be removed from the wastewater and so that the system could be used for cleaning out old lagoons and storage ponds. This undoubtedly resulted in a change in the dewatering characteristics of the screened solids. When the piston failed to squeeze water out of the solids, a plug could not form and liquid slurry flowed through the knife valve when it was opened.

The particle size of the solids in old lagoons is very small, often described as being the size of silt or clay, because the solids have been undergoing decomposition for long periods of time. It is unclear whether the T-Rex mechanical screen could have removed many solids from the sludge in old lagoons.

As previously mentioned, a decision was made to design a system which would operate unattended, reportedly because of a belated reluctance by the farm owner/operator to devote employee time to operating the system. Automation of any system may save labor costs, but it also has a higher initial cost and compromises reliability. This automated system was not reliable at this farm site. Maintenance and repair of the system components had to be done by others at considerable expense. The failure of any component in the system resulted in system shutdown. Also, the control system was not programmable, which made manual operation very difficult.

Results of the work conducted at Dairy Production Systems (DPS), Branford, FL, are included in Appendix E. A sample of wastewater from DPS was sent to Ciba Specialty Chemicals Corporation for evaluation. They evaluated the effect of lime, ferric sulfate, and several of their proprietary polymers on the removal of phosphorus from the wastewater. Ciba concluded that lime was not beneficial in removing phosphorus from the wastewater. They did not evaluate the effect of lime on removal of nitrogen. QED used lime in their system at DPS and concluded that it was not effective when used in conjunction with ferric sulfate in removing phosphorus. Through further testing, they also concluded that the quantities of lime (10,000 ppm) required to raise the pH above 9.5 were too expensive.

The demonstration nutrient removal system at Aprile Riverview Dairy Farm used lime to raise the pH sufficiently to strip ammonia from the wastewater through aeration.
Since it was not possible to run the system consistently, the ammonia removal associated with varying lime dosages could not be evaluated. The QED system at DPS does not use aeration in their chemical nutrient removal system.

Past results from laboratory studies using lime to treat dairy farm wastewater have shown varying degrees of success, with some of the results being very promising. The inconsistency of the laboratory results indicates that we may not understand all of the chemistry involved in the use of lime, particularly in field studies. A need still exists to further research and demonstration on the role of lime in treating livestock wastewaters.

Although the demonstration system did not achieve sustained operation, it is likely that a clarifier between the recycle pump and the flush tanks would greatly improve the appearance and quality of the recycle flush water. It would also provide another place where solids and nutrients could be removed from the system. Then the T-Rex could be modified with a larger opening wedge wire screen with a higher likelihood of successful operation.

Section 6. Recommendations and Lessons Learned

It is apparent that not everyone involved in the project, including suppliers, was familiar with the characteristics of dairy farm wastewater. It contains settleable, suspended, and floating solids. Also, it contains a wide range of particle sizes, including hay and grass which can cause clogging problems in pumps and pipes. Foreign material (pieces of concrete and wood, wire, cans, etc.) may also be present. Dairy farm wastewater can also present some very corrosive conditions. Communication between members of the team could have been better in relation to the waste characteristics.

Safety could have been improved. The area around the collection tank or sump was particularly worrisome. There were no guardrails, and footing was particularly hazardous. The area around the collection tank where the pump and piping was located should have been on a concrete pad. Safety standards may be an important part of the approved designs by FPPC.

Adequate and clear usage of signage was noticeably absent. Animals were not fenced away from the trailer mounted treatment system. Damage to the electrical conduits occurred and presented an electrical hazard to both animals and workers. The area surrounding the trailer mounted treatment system was always covered with manure. This was not only a nuisance, but it also presented a safety hazard because of slippery conditions.

Daily operation of the system was problematic because the trailer mounted treatment unit and the collection tank were not in close proximity. This was a problem for people attempting to operate the system because they could not see what was
happening at both locations. The area was not maintained or mowed. This hindered visual access and added the potential for insects, snakes, etc.

Layout and access to the demonstration site for project personnel and for visitors was only possible through areas where cows also had access. This made biosecurity and safety additional issues.

Although the equipment in this demonstration project probably suffered from electrical surges and outages, much of the damage was due to environmental exposure. Even though most of the equipment was supposedly in weatherproof enclosures, moisture still affected the equipment and made it nonfunctional. Deterioration from exposure to the sun was also obvious, not to discount the effects of a hurricane.

The treatment system was placed on a semi trailer so that it could be transported and utilized at other locations. However, the electrical lines and pipes were not fabricated so that they could be easily disconnected. Therefore, considerable expense would be involved in reconnecting the trailer at another site. Most of the equipment was three phase electrical which would limit its use in many locations.

Since many of the technologies that are being evaluated for possible application on livestock operations involve people that are not familiar with agriculture, everyone in the project should maintain channels of communication with technical expertise on farm waste characteristics and farm management. More attention should be given to removal of foreign material from the waste stream. This is a common deficiency in many modern livestock waste handling systems.

More attention should be given to safety and biosecurity on all demonstration projects, particularly on privately owned farms, for farm workers, demonstration project personnel, and for visitors.

Animals should always be fenced away from the demonstration project sites, and easy access to the project sites should be provided without having to pass through animal confinement areas.

Demonstration project sites should include hard surfaces for working areas and personnel, and the surrounding areas should be mowed and well maintained.

Although it will be an additional cost, protection from the sun and rain should be provided for critical equipment, particularly electrical equipment such as control panels, flow meters, pH sensors, etc. It will also provide protection for project personnel and make their work more productive and safe.

Automation, reliability and cost should be carefully evaluated in future projects. Consideration should be given to delegating the management of waste management
systems to an independent contractor if the farm owner/operator cannot devote the necessary management and labor to its operation. This is particularly true if the system is very complex and difficult to understand.

The use of lime in treating livestock farm wastewaters should not be removed from consideration in future research and demonstration projects. It may be effective under other circumstances.

The mechanical aspects of proposed technologies should be scrutinized. Although the chemical reaction processes in many projects appear sound, the implementation through mechanical means can be problematic.

It is important that the farmer understand and agree to their responsibilities for a project to be successful.

Adequate local project management is critical to ensuring success of unique pilot technologies.
Section 7. Appendices
Appendix A. Operating Procedures and Instructions for Demonstration Waste Treatment System
Waste Treatment System at Aprile Farm

The experimental dairy waste treatment system proposed for installation at the Aprile farm will be designed on treatment every day for a period of one about two hours.

Treatment Every Day
This scenario starts with running the daily flushes for both sides of the feeding barn discharging into a tank. The estimated volume of the tank would be around 25-30,000 gallons. This would be large enough to hold the capacity of two flushes, rain, and waste from the cows. The hydraulic fluid level in the T-Rex, lime solution level, and alum solution level must be checked every Monday morning before starting the equipment. HiTech is to be notified if anything is below an established minimum level. There will be a separate electrical system (a single line) to power the system. The only piece of equipment that will run continually is the agitator in the lime storage tank. The system will start, run, and stop automatically. There will be an override switch that can shut the entire system down.

Requirements for Aprile Personnel

Daily
Step 1. Open the flush valve on South Feeding Barn Flush Tank.
Step 2. After the water flow has diminished to a trickle, close the flush valve on the South Feeding Barn Flush Tank. Step 3. Open the flush valve on the North Feeding Barn Flush Tank. Step 4. After the water flow has diminished to a trickle, close the flush valve on the North Feeding Barn Flush Tank.
Step five. Check pH at sample port 4b after the system starts

Weekly
Check the hydraulic system of the T-Rex.
Record the readings of the flow meter totalizers. FQI 101 Overflow from T-Rex Feed Sump 2001-B. FQI 102 Feed to the T-Rex Separator 1501. FQI 103 Overflow from the T-Rex, Water Treatment Tank, and T-Rex cylinder drain. FQI 104 Return water to the flush tanks.

System Operation
Lime Storage agitator runs 24 hours per day.

Treatment mode
The flush valves will be opened and the flush water and manure will flow into the T-Rex feed sump. As the level in the North flush tank drops, LS-204 will close LV-204 to allow treated water into the flush tanks.
The T-Rex will start from a high level switch (LSH-202) in the T-Rex feed sump (2001-A).
This switch will: Open Valve LCV-202 Close Valve LCV-201 Start the T-Rex system Start a loop minute timer
The T-Rex will be run for a preset period of time on a recycle loop to permit the system to
stabilize before the rest of the system starts. After the loop has timed out, the following equipment starts.

! Open 6" butterfly valve V-003  
! Close 6" ball valve V-004  
! Open ¾” lime feed valve V-014  
! Start lime system feed pump 1003  
! Start mixer 1802-A  
! Start mixer 1802-B  
! Start Aeration Blower 1101  
! Open water return pump discharge 3“ butterfly valve V-008  
! Start water return pump 1002  
! Open Alum feed valve V-020  
! Start Alum system

The system will continue to operate with the treated water going to the flush tanks until LS204 is activated. LS-204 will open the return valve L-204 to send the water to T-Rex feed Sump 2001-B. The system will continue to operate with the feed from the T-Rex from Feed sump 2001-A until the low-level switch LSL - 201 is reached. Switch LSL - 201 will open Valve LCV - 201 from Feed Sump 2001-B and close valve LCV - 202. This shifts the system into a wash mode. If LSH-203 is not made then the system will skip the wash mode and go to the shut down mode.

**Wash Mode**  
The wash mode will run for 5 minutes. At the start of the wash mode the following changes to the equipment will occur.

! Shut down the ¾” lime feed valve V - 014  
! Open lime ¾” wash valve V- 015

The clean pH water is pumped through the system for 5 minutes, then the system will shut down by the following equipment changes.

**Shutdown Mode**  
! Shut off the T-Rex  
! Shut off valve FV - 004  
! Shut off lime wash valve V - 015  
! Shut off the lime feed pump 1003  
! Shut off Treated Water Return Pump  
! Shut off Treated Water Return Pump valve FV - 008  
! Shut off Alum Feed Pump 1004  
! Shut off Alum Feed Pump valve V - 020  
! Shut off Aeration Blower
General Operation Principles

The flow will be regulated to 200 gallons per minute by manually adjusting valve V-002. The excess will be returned to the T-Rex Feed Tank.

When valve FV-041 opens, it will start the lime feed system, agitators (1802A, 1802B), the Treated Water Return Pump 1003, the aeration system and the alum system.

The lime addition will be controlled by a pH sensor (AC-601) installed in tank 1003B. The pH point of control is 10.5.

The alum system will inject alum into the discharge line of the treated water return pump just in front of the in-line mixer. The amount of alum will be controlled to a pH of 7.5 by a pH sensor downstream of the in-line mixer.

The Water Treatment Tank serves as the reaction tank with the lime to reach the desired pH of 10.5. The lime slurry reacts in tank 2002-A with the soluble phosphorus to form insoluble calcium phosphate and then increases the pH to the set point in section 2002-B. The high pH water overflows into an aeration chamber 2002-C. In the aeration chamber, air is used to strip out the gaseous ammonia that was freed by the pH change. The air bubbles are liberated from the liquid as the water flows into the pump tank 2002-D before the water is pumped out with the Treated Water Return Pump 1003.

The level in the lime treatment feed tank 2002 is maintained by a V-Notch Weir in the suction pipe of the Treated Water Return Pump. Overflow from the lime treatment feed tank 2002-A goes back to the T-Rex feed tank.

The treated water return pump will pump the water to the two Flush tanks at the same time. When the tanks are filled, a level switch will open the overflow valve F-104 and divert the water to the overflow section 2001-B.

The system continues to run until the low level switch in the T-Rex feed tank 2001-A is reached. When the low level is reached the valves in the T-Rex feed line is switched to feed from 2001-B.

After the system has run for 5 minutes, the system will shut down with the exception of the lime slurry mixer, which will run continuously.

Advantages of the daily running of the system during the pilot project test:

1. The Flush Tanks will be refilled with the treated water.
2 The precipitated solids in the treated water will be removed in the next cycle.
3 The circuit will become a closed system with only the daily waste from the feeding barn entering and the daily removal of the solid waste and excess water.
4 The ratio of ammonia to solids will remain relatively stable without unknown amounts of input from the contaminated waste of Lagoon 1.
5 This will result in a stable system for sampling and analysis purposes.
6 The one day / in the ground tank is less expensive
7 The actual run time for the equipment will be slightly shorter.
8 The system will be easier to operate. No changes in procedures for partial mixing of solids and liquid.
9 A daily routine will insure better acceptance by farm personnel.
10 Stable system is easier to sell to the dairy industry.
11 The accuracy and repeatability of the samples will be far better.
12 The flushing and cleaning of the system will be easier.
13 The present colloidal suspension of the manure in the flush tanks will be reduced or eliminated when using treated water for flushing.
14 The removal of the suspension will result in the elimination of the majority of pathogens in the flush tank and reduced spread of diseases to the dairy cows.

Disadvantages of not running once a day:
1 The flushes will segregate in the T-Rex Feed Tank. This will force us to run the T-Rex Feed Pump for several minutes before starting the T-Rex to partially mix the solids and water.
2 Unable to get representative samples.
3 Sand, even though there is very little, will settle to the bottom of the T-Rex Feed Tank and will have to be cleaned out periodically.

Troubleshooting

During normal operation of the treatment system, problems or malfunctions could occur.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Main pump will not prime</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pH of flush water too high or too low</td>
</tr>
<tr>
<td></td>
<td>Water return pump not pumping</td>
</tr>
<tr>
<td></td>
<td>No solids being produced by the T-Rex</td>
</tr>
<tr>
<td></td>
<td>Treatment tank overflowing</td>
</tr>
<tr>
<td></td>
<td>System runs for extended period of time (more than 2.5 hrs)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Procedure</th>
<th>For all problems listed above, shut system off using</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>main switch on trailer and contact HiTech</td>
</tr>
<tr>
<td></td>
<td>Solutions as soon as possible.</td>
</tr>
<tr>
<td>Problem</td>
<td>System does not start after flush</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Procedure</td>
<td>Check that main switch on the trailer is set to “Auto.” If system still does not operate, contact HiTech Solutions</td>
</tr>
</tbody>
</table>
Appendix B. Catalog and Bill of Material, Hi-Tech Solutions
Appendix C. Monitoring and Evaluation Plan for Aprile Riverview Dairy Farm
Project Title: Monitoring and Evaluation of Demonstration Wastewater Treatment System Using Lime at Aprile Riverview Dairy Farm

Principal Investigator: Dr. Roger A. Nordstedt
Agricultural and Biological Engineering Department
University of Florida
P.O. Box 110570
Gainesville, FL  32611-0570
Telephone: (352) 392-1864 Ext 103
Fax: (352) 392-4092
E-mail: roger@agen.ufl.edu

Submitted to: John Elliott
Chemical Lime, Inc.
3201 Willow Oak Road
Charlotte, NC  28209

Goal: Monitor nutrient concentrations in the demonstration waste management system at the Aprile Riverview Dairy Farm, Riverview, Florida, that includes new and innovative technologies to determine efficacy of the system and to identify potential improvements in the design and operation of the system.

Objectives:
1. Identify sample collection points and monitor performance of the waste management system at Aprile Riverview Dairy Farm for approximately 15 months.
2. Outline record keeping requirements for tracking the flows of water and nutrients in the system.
3. Evaluate performance of the system through analysis of the monitoring data and site visits, and identify potential improvements in system design or operation.
4. Summarize findings of the study in quarterly and final reports.

Deliverables:
1. Quarterly progress reports that will include results of sample analyses and summaries of site visits. (Results of certified laboratory analyses will be provided to the contractor as they become available for inclusion with monthly progress reports.)
2. A final report that will include results of sample analyses, an evaluation and summary of the results, and recommendations for potential improvements in the design and operation of the system.

Discussion:
Samples will be collected by University of Florida, Chemical Lime Corporation, or Hi Tech Solutions personnel for laboratory analysis. Data will be summarized and integrated with information obtained in site visits to formulate recommendations for changes in design and/or operation to improve performance of the demonstration waste management system.
**Timetable:**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Quarter 2003</td>
<td>Identify sampling points and record keeping requirements during construction of the system</td>
</tr>
<tr>
<td>Second Quarter 2003</td>
<td>Begin sampling program and conduct site visits through Compile laboratory data from sampling activities</td>
</tr>
<tr>
<td>Second Quarter 2004</td>
<td>Submit quarterly reports</td>
</tr>
<tr>
<td>Third Quarter 2004</td>
<td>Prepare and submit final report</td>
</tr>
</tbody>
</table>

**Budget:**

<table>
<thead>
<tr>
<th>OE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel</td>
<td>$1,299</td>
</tr>
<tr>
<td>Report preparation</td>
<td>1,000</td>
</tr>
<tr>
<td>Laboratory -- UF</td>
<td>4,800</td>
</tr>
<tr>
<td>Laboratory -- commercial (106 samples @ $123 each)</td>
<td>13,038</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>$20,137</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OPS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Part-time student labor (5 hours/week for 72 weeks @ $8/hour)</td>
<td>2,880</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$23,017</strong></td>
</tr>
</tbody>
</table>

**GRANT OVERHEAD (5%)**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Project Cost</td>
<td>$24,168</td>
</tr>
</tbody>
</table>

**Budget Summary:**

Travel has been estimated as follows: (1) 15 trips to Riverview for site visits, sampling, and system testing, (2) one trip to present results of the study at a meeting for dairymen and regulatory personnel (date and place to be determined). Mileage expenses have been estimated at $0.29/mile (280 miles round trip).

Miscellaneous report preparation expenses have been included at $1,000.

Laboratory testing of samples has been included for both the UF Agricultural Waste Management Laboratory (AWML) and a commercial testing laboratory. Samples collected during preliminary testing and evaluation of alternative operating procedures, flow rates, and chemical variations will be performed at the UF laboratory. Regular monitoring samples will be sent to a certified commercial testing laboratory for inclusion in reports and for verification of system performance (10 sampling events for performance (100 samples), 1 sampling event for storage pond cleanup (6 composite samples)).

Part-time student labor has been budgeted to assist with laboratory work, data analysis and report preparation.

Grant overhead is a requirement of the University of Florida, and rates are established by the Division of Sponsored Research.
Sampling Points (10 minimum): (See Attachment 1 and Drawing 1378-F-101)

Sampling Frequency:
Phase one (cleanout of Lagoon #2) is anticipated to take approximately 7 to 14 days. Composite samples of slurry from Lagoon #2 will be sent to a certified laboratory for analysis (6 samples).
During startup and initial testing (one month), samples will be collected as needed and analyzed for necessary parameters at the UF AWML. During the duration of the demonstration, other samples will also be sent to the UF AWML when chemical feed rates and operational parameters are changed and evaluated.
Samples will be collected (composites) and sent to a certified commercial laboratory on a monthly basis for the first five months and bimonthly for the remainder of the 15 month monitoring period (10 sampling events, 100 samples total).

Additional Instrumentation and Data:
The pump(s) or generator will be equipped with clock(s) so that total run time and volume can be estimated.
Pumping rates will be determined with portable flow meters as appropriate.
Quantity of screened solids and scraped solids removed from the solids storage area will be determined by estimating volume and by bulk density measurements.
Rain gauge (11 inch capacity plastic) with a tipping bucket and data logger as backup (available from another project).
Additional field measurements, such as DO, pH, temperature, etc., may be made during the course of the study.
Staff gauges for measuring surface water levels will be placed in Lagoon #2 and in each of the two evaporation lagoons. A staff gauge will not be necessary in Lagoon #1. It will remain at a constant level because of an overflow structure.

Record keeping requirements (minimum):
Number of loads of screened solids removed from the screened solids storage area.
Number of loads of scraped solids from feeding barn removed from the solids storage area.
Numbers of cows and residence times in the waste collection area (feeding barn) shall be recorded daily by the farmer or operator.
Feed consumption and composition (N, P, K) from farm records (quarterly).
Milk production (exported from the farm)/Generator or pump run times/
Rainfall will be recorded daily from rain gauge and from a data logger.
Surface water levels in Lagoon #2 will be recorded daily, and water levels in the two evaporation lagoons will be recorded weekly.
Chemicals added in the system for waste treatment (lime, alum, etc.). Record date, time and quantity.
## Attachment 1 -- Sampling Points and Parameters

<table>
<thead>
<tr>
<th>Sampling Point</th>
<th>Location and Description</th>
<th>Type</th>
<th>Parameters*</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Influent to treatment system (T-Rex screen)</td>
<td>Liquid</td>
<td>pH, TS, TVS, TKN, NH3-N, NOX, TP, RP, TK</td>
</tr>
<tr>
<td>B</td>
<td>Effluent from mechanical screen</td>
<td>Liquid</td>
<td>pH, TS, TVS, TSS, TKN, NH3-N, NOX, TP, RP, TK</td>
</tr>
<tr>
<td>C</td>
<td>Influent to ammonia removal unit</td>
<td>Liquid</td>
<td>pH, TS, TVS, TSS, TKN, NH3-N, NOX, TP, RP, TK</td>
</tr>
<tr>
<td>D</td>
<td>Effluent from ammonia removal unit</td>
<td>Liquid</td>
<td>pH, TS, TVS, TSS, TKN, NH3-N, NOX, TP, RP, TK</td>
</tr>
<tr>
<td>E</td>
<td>Effluent from acidification or flocculant addition</td>
<td>Liquid</td>
<td>pH, TS, TVS, TSS, TKN, NH3-N, NOX, TP, RP, TK, FC</td>
</tr>
<tr>
<td>F</td>
<td>Effluent from Lagoon #2 to evaporation lagoons</td>
<td>Liquid</td>
<td>pH, TS, TVS, TSS, TKN, NH3-N, NOX, TP, TK, FC</td>
</tr>
<tr>
<td>G</td>
<td>Scraped solids from feeding barn --fresh **</td>
<td>Solid</td>
<td>pH, TS, TVS, TKN, NH3-N, NOX, TP, TK</td>
</tr>
<tr>
<td>H</td>
<td>Scraped solids from feeding barn -- exported **</td>
<td>Solid</td>
<td>pH, TS, TVS, TKN, NH3-N, NOX, TP, TK</td>
</tr>
<tr>
<td>I</td>
<td>Screened solids from T-Rex – fresh</td>
<td>Solid</td>
<td>pH, TS, TVS, TKN, NH3-N, NOX, TP, TK</td>
</tr>
<tr>
<td>J</td>
<td>Screened solids from T-Rex – exported</td>
<td>Solid</td>
<td>pH, TS, TVS, TKN, NH3-N, NOX, TP, TK</td>
</tr>
</tbody>
</table>

*TS = Total Solids  
TVS = Total Volatile Solids  
TSS = Total Suspended Solids  
TKN = Total Kjeldahl Nitrogen  
NH3-N = Ammonia Nitrogen  
NOX = NO3-N + NO2-N  
TP = Total Phosphorus  
RP = Reactive Phosphorus (Orthophosphorus)  
TK = Total Potassium  
FC = Fecal Coliform  

** When applicable

The list of parameters may be expanded or shortened as the project progresses to obtain more information or to expedite sampling.
Appendix D.  Properties of Lime Slurry Used in Chemical Nutrient Removal System
LIME SLURRY
Manufactured From Fresh Burned Quicklime
Which Meets ANSI/NSF Standard 60

TYPICAL ANALYSIS

CHEMICAL (Solids):

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>% BY WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium Hydroxide, Ca(OH)$_2$</td>
<td>90.0%</td>
</tr>
<tr>
<td>Calcium Carbonate, CaCO$_3$</td>
<td>2.2</td>
</tr>
<tr>
<td>Magnesium Oxide, MgO</td>
<td>1.1</td>
</tr>
<tr>
<td>Silicon Dioxide, SiO$_2$</td>
<td>0.7</td>
</tr>
<tr>
<td>Aluminum Oxide, Al$_2$O$_3$</td>
<td>0.3</td>
</tr>
<tr>
<td>Iron Oxide, Fe$_2$O$_3$</td>
<td>0.2</td>
</tr>
<tr>
<td>Sulfur, S</td>
<td>0.03</td>
</tr>
<tr>
<td>Inert Ingredients</td>
<td>1.5</td>
</tr>
</tbody>
</table>

PHYSICAL PROPERTIES:

Solids Content - Ca(OH)$_2$ 35 - 38

Gradation:

- Retained on #6 mesh 0.0%
- Retained on #10 0.1
- Retained on #30 1.5

Bulk Density 10.3 lbs/gal

Viscosity 500 to 1,000 centipoise (Brookfield)

2/3/97
limeslur.doc

Chemical Lime Company
P.O. Box 1137, Mulberry, Florida 33860
Phone: (800) 695-5657 Fax: (941) 425-0686
Material Safety Data Sheet

May be used to comply with
OSHA's Hazard Communication Standard
29 CFR 1910.1200. Standard must be
consulted for specific requirements.

IDENTITY
Hydrated Lime Slurry
Ca(OH)₂ (Calcium hydroxide slurry)

Section I

Manufacturer's Name and Address
Chemical Lime Company
3724 Hulen Street
Fort Worth, Texas 76107

Emergency Telephone Number
Chemtrec 800-424-9300

Information Phone Number
817-732-8164

Data Prepared
6/1/2001

Section II - Hazardous ingredients/Identity Information

Hazardous Components CAS Common Name OSHA PEL ACGIH TLV Other Limits % (optional)
Calcium hydroxide 1305-62-0 Hydrated Lime 5 mg/m³ 5 mg/m³ 7340 mg/kg 20-55%
Magnesium hydroxide 1309-42-8 Brucite N.A. N.A. <5%
Silicon dioxide 14808-60-7 Quartz 0.1 mg/m³ 0.1 mg/m³ 4 mg/m³ <2%

Section III - Physical/Chemical Characteristics

Boiling Point 100 °C Melting Point dec. 580 °C Specific Gravity 1.3 - 1.5 g/cc N.A.
Vapor Pressure (mm Hg) N.A. Vapor Density N.A. Evaporation Rate N.A.
Solubility in Water Material is a stable suspension of calcium hydroxide in water. pH=12.4@25°C
Appearance and Odor White low viscosity liquid, odorless

Section IV - Fire and Explosion Hazard Data

Flash Point N.A. Flammable Limits LEL/UEL N.A. N.A.
Extinguishing Media Not Combustible -- Use extinguishing agent for surrounding fire

Special Firefighting Procedures/Unusual Fire and Explosion Hazards
Avoid skin contact or inhalation of dust if material becomes dry.

Section V - Reactivity Data

Stability
Conditions to Avoid (stability-related)
Stable
Material is stable

Incompatibility (Materials to Avoid)

Aluminum: May react to form hydrogen gas.

Hazardous Polymerization/Hazardous Decomposition of Byproducts
Will not occur (none)

Section VI - Health Hazard Data

Route(s) of Entry: Inhalation, Ingestion

Health Hazards (Acute and Chronic)

Avoid skin and eye contact as irritation will occur. Inhalation of mist or dried dust can cause coughing, sneezing, or breathing problems.

Carcinogenicity:
OSHA?
SID:
NTP?
IARC Monographs?
SiO₂

Respirable crystalline silica from occupational sources is classified by IARC as a Group I Carcinogen.
California Proposition 65: Silica is on the Governor's Proposition 65 list. Components used in this product may contain trace amounts of inherent naturally occurring elements (such as, but not limited to arsenic, cadmium) that are on the Governor's Proposition 65 list.
Section VI - Health Hazard Data (continued)

Signs and Symptoms of Exposure
Skin or eye irritation; coughing or breathing problems.

Medical Conditions Generally Aggravated by Exposure
Respiratory problems, asthma, dermatitis or skin or eye sensitivity.

Emergency and First Aid Procedure
Flush contaminated area with excess water. If eye contact, rinse eye with warm water for 30 minutes and seek medical attention immediately.

Section VII - Precautions for Safe Handling and Use

Steps to be Taken in Case Material is Released or Spilled
Protect skin and eyes from contact and avoid inhalation of mist. Collect by mop other suitable method. Place in steel container.

Waste Disposal Method
Add water to dilute and flush to sewer. Consult local, state, or federal regulations.

Precautions to be Taken in Handling and Storage
Store in tightly closed containers and keep away from acids or other incompatible substances. Do not store or ship in aluminum containers.

Other Precautions
Avoid eye contact and breathing dust if material becomes dry.

NFPA Rating: HEALTH: 1 FLAMMABILITY: 0 REACTIVITY: 0
WHMIS Rating: D2A, E

Section VIII - Control Measures
Respiratory Protection (Specify Type)
Dust masks meeting the NIOSH N95 rating are sufficient for casual exposure to mist or dust. (42 CFR)

Ventilation
Local Exhaust Special Do not dispose of dust with combustible materials.
N.A. N.A. Other

Mechanical (General)
N.A.

Protective Gloves
Clean dry rubber gloves Full clothing to cover arms and legs, safety glasses or face shield.

Other Protective Clothing or Equipment

Work/Hygienic Practices
Eye wash and shower station should be readily available.

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kdi phd
Appendix E. Plans and Results from Demonstration at DPS, Branford, FL
The following is an excerpt from the final report (September 2007) which QED submitted to FPPC on the work at Dairy Production Systems, Branford, FL, which was related to the use of lime and metal salts:

**Aprile Project Discussion**

**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.

**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 flush water through raising the pH higher than 9.5 with aim to kill pathogens.

**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.

**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.
SUMMARY

In support of this treatment opportunity, test work was undertaken in the Suffolk laboratory to determine the most suitable products for this application.

The test work indicated the following.

The sample as received had a 'typical' dairy farm odor and pH of 7.3. In addition, its orthophosphate was measured at 132.5ppm.

Using the doses of ferric sulfate, lime and Zetag 8846FS supplied in the information and then removing all of the flocculated solids, residual orthophosphate was reduced to 14.9ppm or by almost 90%.

Testing indicated that removing the lime dosing had very little effect on orthophosphate removal and so this was removed from the treatment bundle.

Further testing indicated that the amount of iron could be reduced by 50% to be replaced by 5ppm of Zetag 7127 and this, along with an active dose of Zetag 8844FS of 30ppm reduced orthophosphate levels to 30.6ppm. This represented a reduction of in excess of 75% over the untreated material.

1.0 INTRODUCTION

QED Environmental Solutions is currently in the process of treating dairy farm waste using its tangential flow treatment system at DPS in Florida. The chemical treatment currently involves applying ferric sulfate in association with a lime slurry to coagulate the solids which are then flocculate using Zetag 8846FS. The ferric sulfate dose varies in the range of 200 to 700ppm, depending upon the feed strength but it becomes uneconomical above 500ppm and accounts for up to 60% of the total treatment cost. In addition, QED is currently unsure as to whether or not the lime is having any beneficial effects.
Consequently, a request was received that an evaluation of the current treatment be undertaken along with consideration for more cost effective alternatives.

This report details the findings of these alternative treatments.

2.0 EXPERIMENTAL AND RESULTS

Characterization of Samples

The sample as received was characterized in the laboratory, in accordance with standard procedures and the obtained results are presented below in Table 1.

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>RESULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Type pH Physical Characteristics</td>
<td>Liquid Dairy Farm Waste 7.3 Green/Brown Color, Dairy Farm Odor 0.31% 132.5ppm</td>
</tr>
<tr>
<td>Dry Solids Orthophosphate</td>
<td></td>
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</tbody>
</table>

Sample aliquots of 200ml were taken. The ferric sulfate was applied as a 10% solution, the lime as a 20% slurry and Zetag 7127 as a 2.5% (as received) solution. All polymers under consideration were diluted to 0.1% active solutions and all shear was induced at 500rpm. Following treatment, the conditioned solids were allowed to sink before supernatant was decanted for residual orthophosphate testing using Hach Spectrometry.

The results of this test work are displayed in Table 2.
| 280 280 280 | 440 ----------- | -----5 10 -5 | Zetag 8846FS | 30 30 | 14.9 15.1 |
| 280 280 210 | 10 -5 10 -5     | 10 5 10 15 20 | Zetag 8844FS | 30 30 | 13.2 11.9 |
| 210 210 175  |                |               | Zetag 8844FS | 30 30 | 9.8 18.1  |
| 175 175 140  |                |               | Zetag 8844FS | 30 30 | 15.5 13.6 |
| 140 140 105  |                |               | Zetag 8844FS | 30 30 | 26.1 22.0 |
| 105 105      |                |               | Zetag 8844FS | 30 30 | 19.4 32.0 |

This information is also included graphically – see Figure 1
3.0 DISCUSSION

Considering these results, it is clear that the ferric sulfate dose is by far the greatest contributing factor in the removal of orthophosphate. Reductions in ferric
sulfate alone are directly linked to increases in residual phosphate levels. In addition, while *Zetag 7127* is an effective coagulant of solids, its impact upon residual phosphate is marginal at best.

However, it was discovered that reductions in ferric sulfate dose could be made to approximately 50% of their current levels while maintaining phosphate removal at above 75%. This was achieved through the addition of 5ppm of *Zetag 7127*.

It was further discovered that the lime that is currently being applied has no beneficial effect to the treatment process, apart from its nutritional value in the final fertilizer product.

Furthermore, switching from *Zetag 8846FS* to *Zetag 8844FS* generates a more granular floc that settles readily and should be more suited to the tangential flow separator.

### 4.0 CONCLUSIONS

A 50% reduction in ferric sulfate dose, along with 5ppm of *Zetag 7127*, generates supernatant containing 30.6ppm of residual phosphate. This represents a 75% reduction over the untreated material. *Zetag 7127* alone has only marginal effect on residual phosphate, although does remove solids.

The lime slurry that is currently part of the treatment process appears to have little beneficial value.

Switching flocculants from *Zetag 8846FS* to *Zetag 8844FS* should improve fines capture, floc structure and the operation of the tangential flow separator.

Martin Riley  
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