NC STATE UNIVERSITY

January 2006

Cost and Returns Analysis of Manure Management Systems Evaluated in 2005 under the North Carolina Attorney General Agreements with Smithfield Foods, Premium Standard Farms, and Front Line Farmers

TECHNOLOGY REPORT: ENVIRONMENTAL TECHNOLOGIES, LLC CLOSED-LOOP SYSTEM

Prepared as Part of the Full Economic Assessment of Alternative Swine Waste Management Systems Under the Agreement Between the North Carolina Attorney General and Smithfield Foods

Prepared for:
C. M. (Mike) Williams
Animal and Poultry Waste Management Center
North Carolina State University
Campus Box 7609
Room 134 Scott Hall
2711 Founder's Drive
Raleigh, NC 27695-7608

Prepared by:
Task 1 Team
Department of Agricultural and Resource Economics
North Carolina State University

Technical Point of Contact:
Dr. Kelly Zering (Task 1 Team Leader)
North Carolina State University
Department of Agricultural
and Resource Economics
3313 Nelson Hall
Campus Box 8109
Raleigh, NC 27695-8109
Tel: 919-515-6089
Fax: 919-515-6268
Email: kelly_zering@ncsu.edu

Administrative Point of Contact:
Dr. Michael Wohlgenant
(Project Coordinator)
North Carolina State University
Department of Agricultural
and Resource Economics
3310 Nelson Hall
Campus Box 8109
Raleigh, NC 27695-8109
Tel: 919-515-4673
Fax: 919-515-6268
Email:michael_wohlgenant@ncsu.edu

Table of Contents

Summary of Results

Retrofit Cost per 1,000 pounds Steady State Live Weight per year: $136.70
Standardized Feeder-to-Finish Farm with 4,320 head (Tables CL.42- CL.54)
10-Year Amortization, Pit-Recharge, N limited Irrigation onto Forage

Includes:	Manure Evacuation:	$ 1.86 / 1,000 lbs. SSLW / Yr.
	Equalization Tank:	$ 8.31 / 1,000 lbs. SSLW / Yr.
	Solids Separator and Building:	$ 18.14 / 1,000 lbs. SSLW / Yr.
	Sanitizing/Disinfecting Unit Process:	$ 4.56 / 1,000 lbs. SSLW / Yr.
	Flocculation Unit Process: (settling tanks and polymer tank)	$ 52.17 / 1,000 lbs. SSLW / Yr.
	Control System:	$ 6.73 / 1,000 lbs. SSLW / Yr.
	Building and Non-Allocated Costs:	$ 30.26 / 1,000 lbs. SSLW / Yr.
	Increased Land Application Cost:	$ 14.67 / 1,000 lbs. SSLW / Yr.
Excludes:	Norweco System:	$ 15.24 / 1,000 lbs. SSLW / Yr.
Range:	Across Farm Sizes and Types (Pit-Recharge):	$124.69 To 463.82 / 1,000 lbs. SSLW / Yr.
	Across Farm Sizes and Types (Flush):	$143.46 To 887.90 / 1,000 lbs. SSLW / Yr.

Confidence in Estimates:

Medium-Low to Medium

Based on evaluation over a 5-month period with 6 sampling events and intensive sampling over a 2-week period, real commercial setting data for treatment effects, polymer and sanitizer use and prices, and construction expense

Costs by Category:

Direct Construction:	$ 57.00 / 1,000 lbs. SSLW / Yr.
Contractor Overhead	$ 21.58 / 1,000 lbs. SSLW / Yr.
Total Operating:	$ 43.45 / 1,000 lbs. SSLW / Yr.
Increased Land Application Cost:	$ 14.67 / 1,000 lbs. SSLW / Yr.

Sensitivity Analysis

Effect of Expected Economic Life, Interest Rate, and Overhead Rate on Predicted Annualized Construction and Overhead Cost ($ / 1,000 lbs. SSLW)

		Overhead Rate	
Capital Recovery Factor (CRF)		20 %	43.1 %
Low-Cost Projection (15-year economic life, 6 % interest rate)	0.1030	$50.04	$58.03
Baseline Cost Projection (10-year economic life, 8 % interest rate)	0.1490	$67.01	**$78.58***
High-Cost Projection (7-year economic life, 10 % interest rate)	0.2054	$87.79	$103.73

* This predicted cost was estimated using the assumptions that are applied throughout the report—10-year economic life, 8 % interest rate, and 43.1 % overhead rate.

Effect of Electricity Price on Predicted Annual Operating Cost ($ / 1,000 lbs. SSLW)

Electricity Price ($ / kWh)	Predicted Annual Operating Cost ($ / 1,000 lbs. SSLW)
Low-Cost Electricity ($0.06 / kWh)	$42.82
Baseline Cost of Electricity ($0.08 / kWh)	**$43.45***
High-Cost Electricity ($0.10 / kWh)	$44.09

* This predicted cost was estimated using the assumption that is applied throughout the report--$0.08 / kWh.

The sensitivity of predicted costs and returns to a few critical assumptions is illustrated above by recalculating **annualized construction and overhead cost** with lower and higher values for amortization rate (cost recovery factor) and for overhead rate. The number in bold face, $78.58, is the predicted 2004 annual construction and overhead cost for the Environmental Technologies closed-loop system on a 4,320-head feeder to finish farm with pit-recharge and nitrogen-limited land application to forage. Numbers are recalculated using two overhead rates: 20% and 43.1%, and three combinations of interest rate and maximum expected economic life: 15 year life and 6% interest rate, 10 year life and 8% interest rate, and 7 year life and 10% interest rate. The range of selected parameter values has a significant effect on the predicted annual construction and overhead costs.

Similarly, predicted **annual operating costs** of the Environmental Technologies closed-loop system are recalculated using higher and lower prices for electricity. The 25% increase or decrease in electricity price has a small effect (plus or minus $0.64 per 1,000 pounds SSLW per year or about 1.5%) on the predicted annual operating cost reflecting a relatively small amount of electricity usage for this system. The majority of operating expenses are comprised of polymer costs.

Note that the sensitivity analysis is not intended to propose alternative costs and returns estimates. It is solely intended to illustrate the sensitivity of the results to changes in parameter values.

Break-even Analysis on By-product Prices

Breakeven analysis is conducted for systems that produce potentially marketable by-products in order to determine the by-product price required to cover the cost of the system. The Environmental Technologies closed-loop system produces two streams of potentially marketable by-products: separated solids and settled solids. Separated solids contain about 22.8% dry matter, while settled solids (collected from the bottom of the settling tanks) contain about 2.6% dry matter (Creamer). These two distinct streams of solids can be combined to form a single marketable by-product. At Chuck Stokes Farm, both the separated and settled solids were being composted. Because there were no cost invoices or physical performance data provided for the closed-loop composting unit, this process was not included in the costs and returns report. Instead, the separated solids were assumed to be land applied with a spreader, while the settled solids were assumed to be pumped into the existing lagoon and eventually land applied along with liquid effluent. This section will provide a breakeven analysis of the solids produced and collected at a 4,320-head finishing facility.

Based on the performance data for the closed-loop system as operated on Chuck Stokes Farm, 499,091 pounds (249.55 dry tons) of dry weight solids are modeled to be collected using the solids separator. An additional 425,777 pounds (212.89 dry tons) of dry weight solids are modeled to be collected from the bottom of the settling tank. In total, 924,868 pounds (462.4 dry tons) of dry weight solids are modeled to be collected by using the closed-loop system on a 4,320-head feeder-to-finish farm.

Break-even Analysis on Separated Solids (per dry ton of separated solids produced)

Cost to be Recovered	**($ / 1,000 lbs. SSLW)**	**Breakeven Price @ 0.43 dry tons of separated solids / 1,000 lbs. SSLW per year**
		($ / dry ton)
Predicted cost of solids separator and building	$18.14	$42.19
Predicted cost of closed-loop system (less land application)	$122.03	$283.79

The first line in the above table shows the break-even price for a dry ton of separated solids that is necessary to offset the annualized cost of the solids separator unit process. The second line in the table shows the break-even price for a dry ton of separated solids that is necessary to cover the annualized cost of the entire closed-loop system (excluding

land application). These breakeven prices are contingent on the assumption that 0.43 dry tons of separated solids are collected per year for every 1,000 pounds of SSLW.

Break-even Analysis on Settled Solids (per dry ton of settled solids produced)

Cost to be Recovered	**($ / 1,000 lbs. SSLW)**	**Breakeven Price @ 0.37 annual dry tons of settled solids / 1,000 lbs. SSLW**
		($ / dry ton)
Predicted cost of flocculation unit process (settling tanks + polymer tank)	$52.17	$142.93
Predicted cost of closed-loop system (less land application)	$122.03	$334.33

The first line in the above table shows the break-even price for a dry ton of settled solids that is necessary to offset the annualized cost of the flocculation unit process (settling tanks and polymer tank). The second line in the table shows the break-even price for a dry ton of settled solids that is necessary to cover the annualized cost of the entire closed-loop system (excluding land application). These breakeven prices are contingent on the assumption that 0.37 dry tons of settled solids are collected per year for every 1,000 pounds of SSLW. These costs to be recovered do not include any dewatering or drying costs that might be necessary in order to utilize settled solids.

The technology providers are in the process of agreeing to a contract with Vermicycle Organics Management Services, LLC. Over the course of a 7-year contract, it is stipulated that the technology providers would receive $0.07 / pound for all worm castings produced in the first three years and $0.04 / pound for all worm castings produced in the last four years. This contract would include pick-up and transportation of solids from the farm site (Chuck Stokes Farm) to the vermicomposting site by Vermicycle Organics (Stokes). Before any break-even analyses can be performed based on this agreement, some performance verification data would be necessary for the vermicomposting operation. Specifically, it would be necessary to determine the amount of worm castings that could be produced from one dry ton of closed-loop solids (mixture of separated and settled solids). Also, it would be necessary to determine whether the solids would need to be mixed with a bulking agent (e.g., cotton gin trash, wood chips, etc.) prior to being collected and transported by Vermicycle Organics. The cost of any additional treatment and handling that would not be paid by Vermicycle Organics would also have to be determined and subtracted from the potential revenue stream. Finally, while the Vermicycle Organics contract represents an indication of potential revenue for this farm for 7 years, a careful market analysis is required to determine the demand (quantity demanded at various prices) for swine manure solids as inputs to vermicomposting in eastern North Carolina. Given the current small number of vermicompost marketers, some assurance of a continued market for swine manure solids such as a bonded contract over the 10-year amortization period would be required to

justify a long term investment contingent on sales of the solids. A contingent outlet for the solids in the event of contract failure would also be required.

Based on cost and performance data provided by the technology providers and Vermicycle Organics, a hypothetical breakeven analysis can be conducted for the vermicomposting operation. It is important to note that this facility has not been constructed yet. As such, there are no actual cost invoices for the vermicomposting facility. Likewise, there has not yet been any performance verification of this solids treatment system.

The proposed worm castings production rate has been estimated at 1.5 pounds of castings / finishing head / day for a feeder-finish operation (Lloyd). This assumed production rate will generate 5,508 pounds of castings per day at a 3,672-head farm (like Chuck Stokes Farm). Assuming 340 production days per year, the annual amount of worm castings produced will be 1,872,720 pounds. At a price of $0.07 per pound, the castings will generate $131,090 in revenue given these assumptions. At a price of $0.04 per pound, the castings will generate $74,909 in revenue per year. Based on the stipulations of the contract ($0.07 / lb. of castings in years 1-3, and $0.04 / lb. of castings in years 4-7), a total revenue of $692,906 will be generated from by-product worm castings. An average annual revenue of $98,987 will be generated from worm castings given the assumptions in this scenario (Lloyd).

The proposed construction cost of the vermicomposting facility is given as $184,800 (Lloyd). Amortized over the 7-year length of the contract at an 8% interest rate, the facility will have an annualized cost of $35,495. Proposed operating costs (including maintenance, property taxes, electricity, and labor) and contract fees for the facility are given as $19,258 (Lloyd). Given these cost assumptions, the total proposed annualized cost of the vermicomposting operation is $54,753. Over the course of the 7-year contract, the 3,672-head finishing farm in this example will have annual net revenue of $44,234. In numbers provided by the technology provider team (Lloyd), annual net revenues of $61,706 were calculated (using different amortization assumptions). The avoided cost of land applying solids would also be considered in the economic analysis of an actual vermicomposting site that was using separated swine solids as a feedstock.

Important assumptions about vermicomposting on the Chuck Stokes farm that remain to be proven include costs, castings production rate, income, and market demand.

1. Introduction and Farm Description

The Environmental Technologies closed-loop system is located on Chuck Stokes Farm near Ayden, North Carolina. This technology treats the manure produced from three finishing houses, each with a capacity of 1,224 head. In total, the closed-loop system treated the flushed manure from 3,672-head (495,720 pounds of SSLW) capacity of finishing pigs. The houses at Chuck Stokes Farm use a flush system for manure removal.

2. Technology Description

Flushed manure from the houses is diverted to an equalization (buffering) tank as the first step of the closed-loop process. From the equalization tank, manure is pumped to an inclined-screen solids separator. Separated solids are collected in a spreader and eventually composted on-farm. Composted solids are currently being land applied, but the technology providers have reached an agreement to have the separated solid used as a feedstock at a vermicomposting facility. Liquid effluent from the solids separation process is injected with a sanitizer/disinfectant (trichloromelamine, or TCM) and a polymer flocculant (a proprietary polymer formulation developed by Environmental Technologies, LLC) before being pumped into a settling tank. While in the settling tank, flocculated solids fall to the bottom of the tank over a retention time of 3-4 hours. The settled solids at the bottom of the tank will be composted along with solids collected from the inclined-screen separator. Most of the liquid fraction of the settling tank effluent is sent to the houses for re-use as flush water. When the flush tanks are full, the excess settling tank effluent is pumped to a tertiary treatment system (Norweco system). The Norweco system is housed in a septic tank and provides filtration and aeration. The treated Norweco water is blended with well water to produce potable water for the finishing houses. The evaluation of the Norweco system could not be conducted due to operating difficulties. Because potable water is still not being produced, it is uncertain whether the system can operate in a closed-loop fashion. If the amount of well water necessary to dilute the treated Norweco water exceeds the amount of water removed from the system in the form of separated solids, settled solids, and evaporation, then the system will not be able to operate in a closed-loop fashion. This is still unknown, as the ratio of well water to treated Norweco water has yet to be determined (Creamer). The timing and volume of system flows is controlled using a programmable logic controller (PLC). The sanitizer, polymer, and settling tanks are housed in a building that was constructed as part of the closed-loop system.

The unit processes associated with the closed-loop system as constructed and operated at Chuck Stokes Farm are:

1.) manure evacuation modifications
2.) equalization tank
3.) inclined-screen separator
4.) sanitizing tank
5.) polymer tank

6.) settling tank (return to barns)
7.) Norweco system (excluded from final cost estimate)
8.) control system
9.) tank building
10.) land application of liquid (settled solids and excess precipitation)
11.) land application of solids

The composting unit at Chuck Stokes Farm was not included as part of this costs and returns report due to a lack of performance data and cost invoices for this unit process.

3. Mass Balances and Performance Data (Tables CL.1-CL.3)

Evaluation and performance verification of the closed-loop system began in March, 2005 and concluded in July, 2005. A total of 6 sampling events occurred during this time period. An intensive two-week sampling period was conducted from July 18 through July 31. During these two weeks, the mass balances and system flows were measured. Table CL.1 reports the flow volumes as wastewater travels through the closed-loop system. An average of 14,865 gallons / day was flushed from the houses. A total of 9,600 gallons / day was returned to the houses as flush water. A standard 3,672-head feeder-finish facility with a flush system is estimated to discharge 28,479 gallons of wastewater per day, while using 20,033 gallons of recycled flush water. Although the closed-loop system was receiving manure from barns with a capacity of 3,672 head, the flow volumes indicate that the system was treating a manure volume equal to the standard volume that would be produced by about 2,000 finishing head. Table CL.2 reports the nutrient and dry matter content of the wastewater stream at different stages of the closed-loop system. No data were available for the Norweco system. Table CL.3 reports the mass balance of nutrients and total solids for the closed-loop system. Total nitrogen was reduced by 41% and P was reduced by 44% by the closed-loop system at Chuck Stokes Farm as measured by comparing the mass balance of nutrients exiting the barns to the mass balance of nutrients entering the barns in flush water. Total solids were reduced by 60% with the closed-loop technology (Creamer).

4. Costs of the Environmental Technologies Closed-Loop System as Constructed at Chuck Stokes Farm

4.1. Invoiced Construction Costs at Chuck Stokes Farm (Tables CL.4-CL.12)

Reported cost estimates (Tables CL.4-CL.12) were based on cost invoices provided by Kurt Creamer. The invoiced costs for the closed-loop system as constructed at Chuck Stokes Farm were separated into unit processes by Mr. Creamer. Table CL.4 reports the costs associated with manure evacuation modifications. Equalization tank cost invoices are reported in Table CL.5. Table CL.6 reports the costs associated with the solids

separator and building. Tables CL.7, CL.8, and CL.9 list the invoiced costs of the sanitization, polymer, and settling tanks, respectively. Invoiced costs for the Norweco system are reported in Table CL.10, while Table CL.11 lists the miscellaneous invoiced costs of the closed-loop system. Table CL.12 summarizes the invoiced construction costs of the closed-loop system technology as demonstrated at Chuck Stokes Farm. Total invoiced cost of the system was $159,500 (Table CL.12). The solids separator accounted for the largest percentage of this total invoiced cost, with a unit process cost of $27,485 (see Table CL.6), or 17.2% of the closed-loop system's total invoiced construction cost. The settling tank (16.4%) and Norweco system (15.0%) also accounted for significant portions of the technology's total invoiced cost.

4.2. Modified Construction Costs at Chuck Stokes Farm (Tables CL.13-CL.14)

Tables CL.13 and CL.14 describe cost modifications that were made to the invoiced costs listed in Tables CL.4-CL.12. These modifications were made in order to remove research-related or unnecessary expenses from the technology's invoiced costs. Determining which, if any, costs to modify was based on the discretion of the economics team after discussions with the technology providers and examination of the cost invoices received from Kurt Creamer. The biggest change to the invoiced costs for this technology was the removal of the Norweco system unit process. This unit process was eliminated from the system after the decision was made to treat the solids at a vermicomposting facility. The vermiculture worms require a substantial amount of water for moistening their skin (Lloyd). It was decided by the technology providers that the liquid entering the Norweco system at Chuck Stokes Farm would instead by used to provide moisture to the worms. Table CL.13 lists all of the costs that were modified as well as the reason for the change. In Table CL.14, a revised invoiced cost summary is shown. The total modified invoiced costs for the closed-loop technology decreased to $129,882; a $29,618 reduction (~ 19%) from the total reported in Table CL.12.

5. Cost Modeling (Tables CL.15-CL.82)

5.1. Introduction

Original invoice costs were reported detailing the construction costs of the closed-loop system technology as it was built on Chuck Stokes Farm. These costs are reported by unit process in Tables CL.4-CL.11 and summarized in total in Table CL.12. Modified construction costs were also determined based on communication between the principal investigator and the economic modeling team. The modified costs are reported in Table CL.13 and total modified construction costs are summarized in Table CL.14. In the next step, the economic modeling team examined the data reported in Tables CL.4-CL.12 for missing components and outdated prices. The resulting complete estimate of construction cost is intended to approximate adjusted invoiced cost that can be compared to those for other technologies analyzed under the Agreement. These approximated

invoiced costs are summarized in Tables CL.16-CL.28. In the next step, estimates of costs that would occur on standard (representative) North Carolina farms were calculated. Necessary modeling assumptions used in the cost standardization process are described in Section 5.2 and in Table CL.15. These costs are presented in Tables CL.29-CL.41 for a 4,320-head feeder-to-finish facility using a flush system of manure removal. Tables CL.42-CL.54 present the costs associated with a standard North Carolina feeder-to-finish operation with a head capacity of 4,320 using a pit-recharge system of manure removal. A representative NC 8,800-head feeder-to-finish facility with a flush system for manure removal is reported in Tables CL.55-CL.67. The final standard NC farm described in these cost tables is a 4,000-sow farrow-to-wean operation using a flush system of manure removal. Tables CL.68-CL.80 list the costs associated with using the closed-loop system technology at this representative facility.

5.2. Standardized Modeling Assumptions (Table CL.15)

Table CL.15 lists some assumptions that were used in constructing the cost models for the closed-loop system technology. These assumptions were based on data provided by the principal investigator, as well as standard economic assumptions seen in all Task 1 costs and returns reports (as described in the Combined Appendices Final Report).

The equalization tank was sized using a 2-hour hydraulic retention time. It was assumed that 100% of the manure flushed from the houses would enter the equalization tank and that the tank would be sized and priced using the standard steel tank assumptions (see Appendix E in the Combined Appendices Report). The inclined-screen separator was assumed to remove 28.62% of total solids produced at the houses. Separated solids had an assumed dry matter content of 22.8%. These assumptions were based on performance data collected at Chuck Stokes Farm. Prices and injection rates are reported for both the sanitizer/disinfectant (TCM) and the polymer in Table CL.15. Prices were provided by the principal investigator, while injection rates were based on performance verification and system operation at Chuck Stokes Farm. A 3-hour hydraulic retention time was assumed for sizing the settling tanks based on operating conditions at Chuck Stokes Farm. Due to a lack of performance or cost data on the vermicomposting facility, separated solids were assumed to be land applied using a spreader. Settled solids from the settling tanks were assumed to be returned to the existing lagoon and eventually land applied as liquid effluent (Creamer). The effluent from the Norweco system is assumed to be land applied. If a vermicomposting facility is constructed, the liquid originally intended as Norweco system influent will be used to moisten the worms.

5.3. Estimated Adjusted Invoice Costs for Environmental Technologies Closed-Loop System at Chuck Stokes Farm (Tables CL.16-CL.28)

Table CL.16 lists the assumptions (3,672-head finishing facility with flush system) for the cost estimate calculation and also summarizes annualized costs by land application scenario (nitrogen-based application to forages, nitrogen-based application to row crops, phosphorus-based application to forages, and phosphorus-based application to row

crops).[1] Annualized costs for the whole farm and per 1,000 lbs. of SSLW (incremental cost) are reported. Table CL.16 presents annualized incremental costs (excluding the Norweco system) for each of the four land application scenarios that range from $102.40 (nitrogen-based application to row crops) to $138.62 (phosphorus-based application to forages). Phosphorus-based land application is more costly than nitrogen-based application and application to forages is more costly than application to row crops with the closed-loop system technology as modeled at Chuck Stokes Farm. Tables CL.17-CL.25 summarize costs associated with individual unit processes of the closed-loop system technology. Costs are reported for the following unit processes: manure evacuation (CL.17), equalization tank (CL.18), solids separator and solids building (CL.19), sanitization tank (CL.20), polymer tank (CL.21), settling tanks (CL.22), Norweco system (CL.23), control system (CL.24), tank building/overall system (non-allocated) costs (CL.25). Table CL.25 also reports the total costs associated with the unit processes listed above, **excluding the Norweco system**. Total construction costs (excluding the Norweco system) are predicted as $185,862, while annual operating costs (excluding the Norweco system) are estimated as $14,156. The total annualized cost (excluding the Norweco system) of the closed-loop system technology before land application is estimated to be $46,019 for the 3,672-head feeder-to-finish facility at Chuck Stokes Farm. Tables CL.26 (lagoon effluent) and CL.27 (solids) report land application costs associated with the closed-loop system technology. Used in conjunction with the numbers reported at the end of Table CL.25, the total annualized and incremental cost estimates are calculated and reported in Table CL.16 for each of the four scenarios of land application. Table CL.28 details the mass balance of nutrients associated with the closed-loop system technology. The mass balance estimates are used to derive the land application costs in Tables CL.26 and CL.27.

5.4. Standardized Costs for Environmental Technologies Closed-Loop System at a 4,320-Head Feeder-to-Finish Farm with Flush System (Tables CL.29-CL.41)

Tables CL.29 to CL.41 provide estimates of the cost of constructing and operating the closed-loop system technology on a standard (representative) North Carolina farm. The representative farm reported in this section is a 4,320-head feeder-to-finish facility using a flush system for manure removal. Table CL.29 provides total annualized and per unit ($ / 1,000 lbs. SSLW) costs (excluding the Norweco system) for retrofitting the farm with standardized closed-loop system technology. The standardized incremental costs range from $155.46 (nitrogen-based application to row crops) to $191.43 (phosphorus-based application to forages), with an average incremental cost of $165.59 per 1,000 lbs. SSLW per year across the four land application scenarios. In the standardized closed-loop system model, forages are more costly than row crops to land apply and phosphorus-based land application is more costly than nitrogen-based land application. Tables CL.30-CL.38 report standardized costs for the same unit processes (in the same order) as seen in Tables CL.17-CL.25. Within certain unit processes (e.g., manure evacuation modifications), there are differences in individual components between the actual and standardized models. In these cases, the technology as it was constructed at Chuck

[1] For more on land application, see Appendix B in the Combined Appendices Report.

Stokes Farm was not indicative of how it would be constructed on a representative NC farm. Table CL.38 also summarizes the predicted total costs (excluding the Norweco system) associated with the standardized closed-loop system technology for a 4,320-head finishing facility with a flush system. Total construction costs (excluding the Norweco system) are estimated at $335,859, while total annual operating costs (excluding the Norweco system) are predicted as $30,940. Total annualized costs (excluding the Norweco system) before land application are estimated at $84,346 for this representative farm size and type. Tables CL.39 (lagoon effluent) and CL.40 (solids) summarize the land application costs predicted for this model for each of four scenarios. Table CL.41 provides an estimated mass balance of nutrients for this representative NC farm size and type.

5.5. Standardized Costs for Environmental Technologies Closed-Loop System at a 4,320-Head Feeder-to-Finish Farm with Pit-Recharge System (Tables CL.42-CL.54)

Tables CL.42- CL.54 provide estimates of the cost of constructing and operating the closed-loop system technology on a standard (representative) North Carolina 4,320-head feeder-to-finish facility using a pit-recharge system for manure removal. The only difference between the standard farm chosen to calculate the numbers in Tables CL.42-CL.54 versus the one chosen to estimate the numbers in Tables CL.29-CL.41 is the type of manure removal system used. Table CL.42 provides total annualized and per unit ($ / 1,000 lbs. SSLW) costs (excluding the Norweco system) for the standardized closed-loop system technology. The standardized incremental costs of retrofitting the farm with the closed-loop system technology range from $132.87 (nitrogen-based application to row crops) to $168.84 (phosphorus-based application to forages), with an average incremental cost across the four scenarios of $143.00 per 1,000 lbs. SSLW per year. Forages are more costly than row crops for land application and phosphorus-based applications are more costly than nitrogen-based applications. The use of the pit-recharge system of manure removal decreases average incremental cost estimates by about 13.6% for a 4,320-head finishing facility as compared to using a flush system on the same facility (corresponding to a 15% reduction in daily discharge volume from the barns). Tables CL.43-CL.51 list the costs of individual unit processes in this standardized model. The set of unit processes and components are identical to those in Tables CL.30-CL.38, while some of the costs change between the two sets of tables. Table CL.51 also summarizes the total costs (excluding the Norweco system) associated with the standardized closed-loop system technology for a 4,320-head finishing facility with a pit-recharge system. Total construction costs (excluding the Norweco system) are estimated at $280,368, while total annual operating costs (excluding the Norweco system) are reported as $25,343. Total annualized costs (excluding the Norweco system) before land application are estimated at $71,168 for this representative farm size and type. Tables CL.52 (lagoon effluent) and CL.53 (solids) summarize the land application costs associated with this standardized model for each of four scenarios. Table CL.54 provides an estimated mass balance of nutrients for the representative farm modeled in these tables.

5.6. Standardized Costs for Environmental Technologies Closed-Loop System at an 8,800-Head Feeder-to-Finish Farm (Tables CL.55-CL.67)

Tables CL.55- CL.67 provide estimates of the cost of constructing and operating the closed-loop system technology on a standard (representative) North Carolina 8,800-head feeder-to-finish facility using a flush system for manure removal. Table CL.55 provides total annualized and per unit ($ / 1,000 lbs. SSLW) costs (excluding the Norweco system) for retrofitting a farm with the standardized closed-loop system technology. The standardized incremental costs for the 8,800-head finishing facility range from $141.29 (nitrogen-based application to row crops) to $177.28 (phosphorus-based application to forages), with an average incremental cost of $151.48 per 1,000 lbs. SSLW per year across the four scenarios. This average incremental cost is about 9% less than that of a standardized 4,320-head finishing facility with a flush system. Based on this finding, the model suggests that economies of scale are present for the closed-loop system technology when moving from one medium-sized farm to another. The next sections show that more significant economies of scale are predicted when moving from small farms to large farms (or, to a lesser degree, small farms to medium farms). Tables CL.56-CL.64 list the costs of individual unit processes in this standardized model. The set of unit processes and components are identical to those in Tables CL.30-CL.38 and CL.43-CL.51 although some of the costs change between the sets of tables. Table CL.64 also summarizes the total costs (excluding the Norweco system) associated with the standardized closed-loop system technology for an 8,800-head finishing facility. Total construction costs (excluding the Norweco system) are estimated at $621,478, while total operating costs (excluding the Norweco system) are reported as $59,923. Total annualized costs (excluding the Norweco system) before land application are estimated at $160,140 for this representative farm size and type. While these total construction costs are higher than in the standardized 4,320-head model, the costs per unit are lower. That is because the 8,800-head facility contains 1,188,000 pounds of steady-state live weight (SSLW) as compared to the 583,200 pounds of SSLW housed in the 4,320-head facility. Tables CL.65 (lagoon effluent) and CL.66 (solids) summarize the land application costs associated with this standardized model for each of four scenarios. Table CL.67 provides predicted mass balance of nutrients for the representative farm modeled in this section.

5.7. Standardized Costs for Environmental Technologies Closed-Loop System at a 4,000-Sow Farrow-to-Wean Farm (Tables CL.68-CL.80)

Tables CL.68- CL.80 provide estimates of the cost of constructing and operating the closed-loop system technology on a standard (representative) North Carolina 4,000-sow farrow-to-wean operation using a flush system for manure removal. This representative farm contains 1,732,000 pounds of SSLW: the largest of any standard farm modeled for the closed-loop system technology. Table CL.68 provides total annualized and per unit ($ / 1,000 lbs. SSLW) costs (excluding the Norweco system) for the standardized closed-loop system technology. The standardized incremental costs range from $199.90 (phosphorus-based application to row crops) to $217.11 (phosphorus-based application to forages), with an average incremental cost of $204.96 per 1,000 lbs. SSLW per year

across the four scenarios of land application. Land application to forages was modeled to be more costly than application to row crops for this size and type of operation. Tables CL.69-CL.77 provide details of the costs of individual unit processes in this standardized model. Table CL.77 also summarizes the total costs (excluding the Norweco system) of the standardized closed-loop system technology for a 4,000-sow farrow-to-wean operation. Total construction costs (excluding the Norweco system) are estimated at $1,279,678, while total annual operating costs (excluding the Norweco system) are reported as $137,668. Total annualized costs (excluding the Norweco system) before land application are estimated at $342,937 for this representative farm size and type. Tables CL.78 (lagoon effluent) and CL.79 (solids) summarize the land application costs associated with this standardized model for each of four scenarios. Table CL.80 provides an estimated mass balance of nutrients for the 4,000-sow farrow-to-wean operation modeled for the closed-loop system technology.

5.8. Extrapolation to Other Farm Types and Sizes (Tables CL.81-CL.82)

Table CL.81 summarizes the per unit incremental costs ($ / 1,000 lbs. SSLW) of retrofitting the closed-loop system technology onto each of the 25 size of farm / type of operation combinations. This table uses the representative farm size for a permitted North Carolina farm within a size / type combination. Incremental costs are shown for both pit-recharge and flush systems and Table CL.81's costs assume nitrogen-based land application to forages. Table CL.82 is analogous to Table CL.81, but uses representative farm sizes for Smithfield Foods/Premium Standard Farms (SF/PSF) owned farms only. Incremental costs are again shown for both pit-recharge and flush systems. As in Table CL.81, the costs in Table CL.82 assume that a nitrogen-based land application to forages is chosen. All incremental costs in Tables CL.81 and CL.82 exclude the Norweco system unit process. Tables CL.81 and CL.82 illustrate that predicted incremental costs decrease as the size of the farm increases. These economies of scale are present across all five types of operations, and are the most significant when moving from the smallest size category (0-500,000 lbs. SSLW) to the next smallest size category (500,000-1,000,000 lbs. SSLW). It is also apparent in Tables CL.81 and CL.82 that retrofits of farms with flush systems of manure removal are predicted to be more costly than those with pit-recharge systems for any size of farm/type of operation category (due to a higher daily volume of wastewater leaving the barns).

6. Summary

The Environmental Technologies Closed-Loop System technology was installed on the Chuck Stokes farm and treated an average of 14,865 gallons per day of effluent from three flush finishing barns during a two-week intensive monitoring period. Performance evaluation occurred between March and July, 2005. The system included an inclined screen solids separator that was reported to separate 28.6% of total solids with a 22.8% dry matter content. Liquid effluent from the separator was treated with a sanitizer and a polymer flocculant and allowed to settle in tanks. In addition, the solids stream from the

settling tanks was reported to contain 24.4% of total solids with a 2.6% dry matter content. Liquid from the settling tanks is used to refill the flush tanks. An additional unit process was designed to further treat some of the liquid effluent from the separation tanks and return it to the barns as drinking water for the pigs. This unit process was not demonstrated during the evaluation period so no data were available. A vermicomposting unit was planned to treat separated solids from the inclined screen and from the settling tank. No cost invoices or performance data for the vermicomposting unit were received so it was excluded from this analysis. Solids from the inclined screen were assumed to be land applied. Settled solids were assumed to be returned to the lagoon for eventual land application as a liquid. Monitoring data indicates that total nitrogen was reduced by 41% and P was reduced by 44% by the closed-loop system as measured by comparing the mass balance of nutrients exiting the barns to the mass balance of nutrients entering the barns in flush water. The initial investment (excluding the Norweco system) predicted for installation of the Environmental Technologies system on a standardized 4,320-head flush type finishing farm is $335,859. The annual operating costs (excluding the Norweco system) for the system are predicted to be $30,040 and total annualized cost of the system (excluding the Norweco system) is predicted at $159.30 per 1,000 pounds Steady State Live Weight per year over a 10-year amortization period. A considerable range of predicted costs ($116 to $814 per 1,000 pounds SSLW per year) occurs across different sizes and types of farms reflecting economies of size and scale in construction of the system and reflecting differences in barn effluent volume per 1,000 pounds SSLW across different types of farms.

References

Creamer, Kurt. “Evaluating the Performance of a “Closed-Loop” Swine Waste Treatment System.” November, 2005.

Creamer, Kurt. Animal and Poultry Waste Management Center. North Carolina State University. Personal Communication with and/or data submitted by. March-December, 2005.

Lloyd, Don. Environmental Technologies, L.L.C. Additional Documentation Regarding Vermiculture. January 10, 2006.

Stokes, Chuck. Personal communication (via e-mail forwarded by Dr. C.M. Williams). December, 2005.

Tables CL.1 through CL.3: Performance Data and Mass Balance Tables for the Environmental Technologies Closed-Loop System as Constructed and Demonstrated at Chuck Stokes Farm

Table CL.1. Summary of Wastewater Flow* through the Environmental Technologies Closed-Loop System (Creamer)

Description	Volume (gallons per day)
Volume pumped from houses to equalization tank	14,865
Volume pumped from equalization tank to solids separator	14,865
Volume exiting in separated solids	418
Volume pumped from solids separator to settling tanks	14,447
Volume pumped from settling tanks to lagoon as settled solids	2,924
Volume pumped from settling tanks to flush tanks	9,600
Volume pumped from settling tanks to Norweco system	1,923
Volume pumped from Norweco system to barns for use as drinking water (proposed)	1,923
Volume to be land-applied	2,924

* This summary was based on system flow data collected from 7/18-7/31 at Chuck Stokes Farm.

Table CL.2. Nutrient Content of the Wastewater Stream at Various Sampling Points for the Environmental Technologies Closed-Loop System (Creamer)

Sampling Point	Total Nitrogen (ppm)	P (ppm)	DM %
House effluent	3,100	1,600	No data
Separated solids	10,300	6,000	22.8%
Separated liquid	2,800	1,400	2.2%
Settled solids	2,300	800	2.6%
Settling tank effluent	2,400	900	1.4%

Note: These nutrient analyses are based on the average of 6 sampling events taken between the dates of 3/05 and 8/05 at Chuck Stokes Farm.

Table CL.3. Mass Balance of Nutrients for the Environmental Technologies Closed-Loop System (Creamer)

Sampling Point	Total Nitrogen (lbs. / day)	P (lbs. / day)	Total Solids (lbs. / day, dry weight)
House effluent	321	124	2,781
Separated solids	36	21	796
Separated liquid	285	103	1,985
Settled solids	57	20	639
Settling tank effluent	228	83	1,346
Norweco system	38	14	225
Barn influent	190	69	1,121
% reduction for total system	**40.8%**	**44.4%**	**59.7%**

Note: These mass balances were measured during the week of July 18-July 24, 2005.

Tables CL.4 through CL.12: Invoiced Construction Costs of the Environmental Technologies Closed-Loop System

Table CL.4. Invoiced Manure Evacuation Modifications Costs for the Environmental Technologies Closed-Loop System (Creamer)

Component	Invoiced Cost
Electronic sensor and mechanical floats	$965.18
Ball valves	$72.00
Piping and fittings	$158.56
Air-actuating valves	$1,950.00
Labor (electrical and plumbing)	$3,900.00
Excavation and driveway	$2,500.00
Total Invoiced Cost of Manure Evacuation Modifications	**$9,545.74**

Table CL.5. Invoiced Equalization Tank Costs for the Environmental Technologies Closed-Loop System (Creamer)

Component	Invoiced Cost
Tank (2,900 gallons)	$3,150.00
Tank installation	$1,100.00
Electrical	$2,000.00
Excavation and driveway	$1,100.00
Sensor	$1,850.00
Plumbing	$900.00
Total Invoiced Cost of Equalization Tank	**$10,100.00**

Table CL.6. Invoiced Solids Separator and Solids Building Costs for the Environmental Technologies Closed-Loop System (Creamer)

Component	Invoiced Cost
Pump (3-HP)	$4,800.00
Separator stand	$4,200.00
Separator (1/2-HP)	$7,000.00
Auger (3-HP)	$3,660.00
Hopper for auger	$540.00
Holding tank (250-gallon)	$85.00
Solids building (labor and materials)	$3,450.00
Plumbing (labor and materials)	$2,000.00
Electrical	$500.00
Excavation and driveway	$1,250.00
Total Invoiced Cost of Solids Separator and Solids Building	**$27,485.00**

Table CL.7. Invoiced Sanitization Tank Costs for the Environmental Technologies Closed-Loop System (Creamer)

Component	Invoiced Cost
Static mixer	$145.00
Injection quill	$57.75
250-gallon PVC tanks	$80.00
Variable speed pump (1/8-HP)	$865.00
Mixers	$450.00
Chlorine sensor	$1,200.00
Electrical	$500.00
Plumbing	$1,300.00
Total Invoiced Cost of Sanitization Tank	**$4,597.75**

Table CL.8. Invoiced Polymer Tank Costs for the Environmental Technologies Closed-Loop System (Creamer)

Component	Invoiced Cost
Static mixer	$145.00
Injection quills	$115.50
250-gallon PVC tanks	$80.00
Manual set pump (1/8-HP)	$645.00
Mixers	$450.00
Total Invoiced Cost of Polymer Tank	**$1,435.50**

Table CL.9. Invoiced Settling Tank Costs for the Environmental Technologies Closed-Loop System (Creamer)

Component	Invoiced Cost
Interior hopper tanks (2-2,700-gallon tanks)	$6,200.00
Pump (1-HP)	$1,011.00
Flow sensor	$2,975.86
Flow control valves	$3,343.06
Check valves	$78.00
Air-actuating valves	$5,750.00
Piping and fittings	$1,123.89
Filling and lowering sensors	$2,700.00
Pump	$1,169.00
Ball valves	$59.60
Electrical	$500.00
Plumbing	$1,300.00
Total Invoiced Cost of Settling Tank	**$26,210.41**

Table CL.10. Invoiced Norweco System (Tertiary Treatment) Costs for the Environmental Technologies Closed-Loop System (Creamer)

Component	Invoiced Cost
Norweco tank	$3,000.00
Tank inside hopper (2,700-gallons)	$3,150.00
Flow control valve	$1,671.53
Flow sensors	$1,487.93
Pumps	$2,877.00
Air-actuating valves	$950.00
Aerators (2-1/8-HP)	$750.00
Bio-kinetic filters	$1,650.00
Pump tank (1,000-gallons)	$1,200.00
Dissolved solids sensor and gauge	$310.00
Solenoid valves	$1,800.00
Piping and fittings	$331.56
Filling and lowering sensors	$1,850.00
Electrical	$400.00
Plumbing	$300.00
Excavating and driveway	$2,200.00
Total Invoiced Cost of Norweco System	**$23,928.02**

Table CL.11. Invoiced Miscellaneous and Total System Costs for the Environmental Technologies Closed-Loop System (Creamer)

Component	Invoiced Cost
Control panel	$16,000.00
Battery back-up	$525.00
Computer (programmable software)	$1,200.00
Building that houses system	$16,200.00
Electrical (total system)	$9,983.00
Excavation and driveway (total system)	$7,750.00
Plumbing (total system)	$4,100.00
Air compressor (3-HP)	$340.00
Air distribution valve	$65.00
Air line	$35.00
Total Invoiced Miscellaneous and Total System Costs	**$56,198.00**

Table CL.12. Summary of Invoiced Construction Costs for the Environmental Technologies Closed-Loop System

Unit Process	Invoiced Cost	% of Total Invoiced Cost
Manure evacuation modifications	$9,545.74	5.99%
Equalization tank	$10,100.00	6.33%
Solids separator and solids building	$27,485.00	17.23%
Sanitization tank	$4,597.75	2.88%
Polymer tank	$1,435.50	0.90%
Settling tank	$26,210.41	16.43%
Norweco system	$23,928.02	15.00%
Control panel	$17,725.00	11.11%
Building	$16,200.00	10.16%
Total system costs	$22,273.00	13.97%
Total Invoiced Cost of Closed-Loop System	**$159,500.42**	**100.00%**

Tables CL.13 through CL.14: Modified Invoiced Construction Costs of the Environmental Technologies Closed-Loop System

Table CL.13. Summary of Modified Costs for the Environmental Technologies Closed-Loop System (Creamer)

Unit Process	System Component	Invoiced Cost	Modified Cost	Reason for Modification
Norweco system	Entire unit process	$23,928.02	$0.00	Implementation of vermiculture treatment of solids will remove the need for the Norweco system
Solids separator	Separator stand	$4,200.00	$0.00	Unnecessary component
Sanitization tank	Static mixer	$145.00	$0.00	Unnecessary component
Polymer tank	Static mixer	$145.00	$0.00	Unnecessary component
Control panel	Programmable software	$1,200.00	$0.00	Research-related expense

Table CL.14. Summary of Modified Invoiced Construction Costs for the Environmental Technologies Closed-Loop System

Unit Process	Invoiced Cost	% of Total Invoiced Cost
Manure evacuation modifications	$9,545.74	7.35%
Equalization tank	$10,100.00	7.78%
Solids separator and solids building	$23,285.00	17.93%
Sanitization tank	$4,452.75	3.43%
Polymer tank	$1,290.50	0.99%
Settling tank	$26,210.41	20.18%
Norweco system	$0.00	0.00%
Control panel	$16,525.00	12.72%
Building	$16,200.00	12.47%
Total system costs	$22,273.00	17.15%
Total Modified Invoiced Cost of Closed-Loop System	**$129,882.40**	**100.00%**

Tables CL.15: Modeling Assumptions for Standardized Cost Models

Table CL.15. Modeling and Operating Assumptions for Standardized Cost Models

Equalization tank volume	modeled using standard sized and priced steel tanks, and a 2-hour retention time
Separator efficiency*	28.62% of total solids removed
Dry matter content of separated solids	22.8% (77.2% moisture content)
Cost of sanitizer (TCM)**	$0.66 / ounce
Rate of sanitizer (TCM) use*	201 ounces / 1,000,000 gallons of treated wastewater
Cost of polymer**	$5.45 / gallon
Rate of polymer use*	310 gallons / 1,000,000 gallons of treated wastewater
Settling tank retention time	3 hours

* Based on performance data from Chuck Stokes Farm (Creamer)

** Based on cost invoice data provided by Kurt Creamer

Tables CL.16 through CL.28: Costs and Returns Estimates Based on Actual Cost and Performance Data for Environmental Technologies Closed-Loop On-Farm System: 3,672-Head Feeder to Finish Operation with Flush System

Table CL.16. Environmental Technologies Closed-Loop System Assumptions and Total Annualized Costs: Actual Costs and Performance Data

Number of Animals	**3,672**		
Type of Operation	**Feeder-Finish**		
Barn Cleaning System	**Flush**		
Annualized Cost ($ / Year)			
Total Annualized Cost		Forages	Row Crops
	If Nitrogen-Based Application	**$ 52,544.17**	**$ 50,763.02**
	If Phosphorus-Based Application	**$ 68,716.83**	**$ 51,338.38**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 106.00**	**$ 102.40**
	If Phosphorus-Based Application	**$ 138.62**	**$ 103.56**

Note: Actual daily volume discharged from barns is 14,865 gallons / day including recharge liquid (as compared to 28,479 gallons / day of volume that is predicted to be discharged from a farm of this type and size with a flush system).
SSLW equals 495,720 pounds.

Table CL.17. Environmental Technologies Closed-Loop System Manure Evacuation Modifications Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Sensor and Mechanical Floats	$ 965.18	$ 143.84
Ball Valves	$ 72.00	$ 10.73
Piping and Fittings	$ 158.56	$ 23.63
Air-Actuating Valves	$ 1,950.00	$ 240.42
Labor (plumbing and electrical)	$ 3,900.00	$ 581.22
Excavation and Driveway	$ 2,500.00	$ 372.57
Contractor & Engineering Services & Overhead	$ 4,114.21	$ 613.14
Total Construction Cost	$ 13,659.95	$ 1,985.55
Maintenance Cost		$ 140.91
Property Taxes		$ 48.49
Total Operating Cost		$ 189.41
TOTAL ANNUALIZED COST OF MANURE EVACUATION MODIFICATIONS		**$ 2,174.95**

Table CL.18. Environmental Technologies Closed-Loop System Equalization Tank Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Tank	$ 3,150.00	$ 469.44
Tank installation	$ 1,100.00	$ 163.93
Sensor	$ 1,850.00	$ 228.09
Electrical	$ 2,000.00	$ 246.58
Plumbing	$ 900.00	$ 134.13
Excavation and Driveway	$ 1,100.00	$ 163.93
Contractor & Engineering Services & Overhead	$ 4,353.10	$ 648.74
Total Construction Cost	$ 14,453.10	$ 2,054.84
Maintenance Cost		$ 180.00
Property Taxes		$ 51.31
Total Operating Cost		$ 231.31
TOTAL ANNUALIZED COST OF EQUALIZATION TANK		**$ 2,286.15**

Table CL.19. Environmental Technologies Closed-Loop System Solids Separator and Solids Building Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Pump	$ 4,800.00	$ 1,862.56
Separator	$ 7,000.00	$ 2,716.23
Auger	$ 3,660.00	$ 1,318.88
Hopper for Auger	$ 540.00	$ 80.48
Holding Tank	$ 85.00	$ 12.67
Solids Building	$ 3,450.00	$ 425.35
Plumbing	$ 2,000.00	$ 298.06
Electrical	$ 500.00	$ 74.51
Excavation and Driveway	$ 1,250.00	$ 186.29
Contractor & Engineering Services & Overhead	$ 10,035.84	$ 1,495.64
Total Construction Cost	$ 33,320.84	$ 8,470.66
Electric Power Cost		$ 574.75
Maintenance Cost		$ 893.70
Property Taxes		$ 118.29
Total Operating Cost		$ 1,586.73
TOTAL ANNUALIZED COST OF SOLIDS SEPARATOR AND SOLIDS BUILDING		**$ 10,057.40**

Table CL.20. Environmental Technologies Closed-Loop System Sanitization Tank Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Injection Quill	$ 57.75	$ 8.61
PVC Tanks	$ 80.00	$ 9.86
Variable Speed Pump (1/8-HP)	$ 865.00	$ 335.65
Chlorine Sensor	$ 1,200.00	$ 178.84
Mixers	$ 450.00	$ 67.06
Plumbing	$ 1,300.00	$ 193.74
Electrical	$ 500.00	$ 74.51
Contractor & Engineering Services & Overhead	$ 1,919.14	$ 286.01
Total Construction Cost	$ 6,371.89	$ 1,154.28
TCM Cost		$ 702.00
Electric Power Cost		$ 5.37
Maintenance Cost		$ 128.51
Property Taxes		$ 22.62
Total Operating Cost		$ 858.50
TOTAL ANNUALIZED COST OF SANITIZATION TANK		**$ 2,012.77**

Table CL.21. Environmental Technologies Closed-Loop System Polymer Tank Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Injection Quills	$ 115.50	$ 14.24
PVC Tanks	$ 80.00	$ 9.86
Manual Set Pump (1/8-HP)	$ 645.00	$ 250.28
Mixers	$ 450.00	$ 67.06
Contractor & Engineering Services & Overhead	$ 556.21	$ 82.89
Total Construction Cost	$ 1,846.71	$ 424.34
Polymer Cost		$ 8,914.29
Electric Power Cost		$ 5.37
Maintenance Cost		$ 58.66
Property Taxes		$ 6.56
Total Operating Cost		$ 8,984.87
TOTAL ANNUALIZED COST OF POLYMER TANK		**$ 9,409.21**

Table CL.22. Environmental Technologies Closed-Loop System Settling Tank Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Interior Hopper Tanks	$ 6,200.00	$ 923.98
Pump (1-HP)	$ 1,011.00	$ 392.30
Flow Sensors	$ 2,975.86	$ 443.49
Flow Control Valves	$ 3,343.06	$ 498.21
Check Valves	$ 78.00	$ 11.62
Air-Actuating Valves	$ 5,750.00	$ 856.92
Piping and Fittings	$ 1,123.89	$ 138.57
Filling and Lowering Sensors	$ 2,700.00	$ 402.38
Pump	$ 1,169.00	$ 453.61
Ball Valves	$ 59.60	$ 8.88
Electrical	$ 500.00	$ 74.51
Plumbing	$ 1,300.00	$ 193.74
Contractor & Engineering Services & Overhead	$ 11,296.69	$ 1,683.54
Total Construction Cost	$ 37,507.10	$ 6,081.76
Electric Power Cost		$ 193.34
Maintenance Cost		$ 589.61
Property Taxes		$ 133.15
Total Operating Cost		$ 916.10
TOTAL ANNUALIZED COST OF SETTLING TANK		**$ 6,997.87**

Table CL.23. Environmental Technologies Closed-Loop System Norweco System (Tertiary Treatment) Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Norweco Tank	$ 3,000.00	$ 447.09
Hopper Tank	$ 3,150.00	$ 469.44
Flow Control Valves	$ 1,671.53	$ 249.11
Flow Sensors	$ 1,487.93	$ 221.75
Pumps	$ 1,802.00	$ 699.24
Air-Actuating Valves	$ 950.00	$ 141.58
Aerators	$ 750.00	$ 291.03
Bio-kinetic Filters	$ 1,650.00	$ 245.90
Pump Tank	$ 1,200.00	$ 178.84
Piping and Fittings	$ 331.56	$ 40.88
Dissolved Solids Sensor and Gauge	$ 310.00	$ 46.20
Solenoid Valves	$ 1,800.00	$ 268.25
Filling and Lowering Sensors	$ 1,850.00	$ 275.70
Electrical	$ 400.00	$ 59.61
Plumbing	$ 300.00	$ 44.71
Excavation and Driveway	$ 2,200.00	$ 327.86
Contractor & Engineering Services & Overhead	$ 8,901.45	$ 1,326.58
Total Construction Cost	$ 31,754.47	$ 5,333.76
Electric Power Cost		$ 1,075.03
Maintenance Cost		$ 489.62
Property Taxes		$ 112.73
Total Operating Cost		$ 1,677.38
TOTAL ANNUALIZED COST OF NORWECO SYSTEM		**$ 7,011.13**

Table CL.24. Environmental Technologies Closed-Loop System Control System Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Control Panel	$ 16,000.00	$ 2,384.47
Battery Back-up	$ 525.00	$ 64.73
Contractor & Engineering Services & Overhead	$ 7,122.28	$ 1,061.43
Total Construction Cost	$ 23,647.28	$ 3,510.63
Maintenance Cost		$ 330.50
Property Taxes		$ 83.95
Total Operating Cost		$ 414.45
TOTAL ANNUALIZED COST OF CONTROL SYSTEM		**$ 3,925.08**

Table CL.25. Environmental Technologies Closed-Loop System Building and Non-Allocated System Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Building that Houses Technology	$ 16,200.00	$ 2,414.28
Non-Allocated Electrical	$ 9,983.00	$ 1,487.76
Non-Allocated Excavation and Driveway	$ 7,750.00	$ 1,154.98
Non-Allocated Plumbing	$ 4,100.00	$ 505.49
Air Compressor	$ 340.00	$ 131.93
Air Distribution Valve and Air Line	$ 100.00	$ 14.90
Contractor & Engineering Services & Overhead	$ 16,581.86	$ 2,471.19
Total Construction Cost	$ 55,054.86	$ 8,180.53
Maintenance Cost		$ 779.66
Property Taxes		$ 195.44
Total Operating Cost		$ 975.10
TOTAL ANNUALIZED COST OF BUILDING AND NON-ALLOCATED (TOTAL SYSTEM) INVOICES		**$ 9,155.64**

TOTAL CONSTRUCTION COST OF CLOSED-LOOP SYSTEM TECHNOLOGY (EXCLUDING NORWECO SYSTEM)	**$ 185,861.71**
TOTAL OPERATING COST OF CLOSED-LOOP SYSTEM TECHNOLOGY (EXCLUDING NORWECO SYSTEM)	**$ 14,156.47**
TOTAL ANNUALIZED COSTS OF CLOSED-LOOP SYSTEM TECHNOLOGY WITHOUT LAND APPLICATION (EXCLUDING NORWECO SYSTEM)	**$ 46,019.07**

Table CL.26. Environmental Technologies Closed-Loop System Predicted Liquid Application Costs for Four Land Application Scenarios: Actual Costs and Performance Data

Annual Cost of Applying Lagoon Effluent	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 10,111.04	$ 7,970.58
If Phosphorus-Based Application	$ 13,691.49	$ 8,816.42
Acres Needed For Assimilation	**Forages**	**Row Crops**
If Nitrogen-Based Application	39.23	127.14
If Phosphorus-Based Application	61.33	167.64
Opportunity Cost of Land	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 2,353.62	
If Phosphorus-Based Application	$ 3,679.67	
Irrigation Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 7,757.42	$ 10,661.95
If Phosphorus-Based Application	$ 8,151.23	$ 12,440.53
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application		$ (2,691.36)
If Phosphorus-Based Application		$ (3,624.11)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ -	
If Phosphorus-Based Application	$ 1,860.60	

Note: 3,636,751 gallons / year of effluent land applied at Chuck Stokes Farm

Table CL.27. Environmental Technologies Closed-Loop System Predicted Solids Application Costs for Four Land Application Scenarios: Actual Costs and Performance Data

Annual Cost of Applying Solids		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	8,939.23	$	6,840.15
If Phosphorus-Based Application	$	24,387.73	$	7,507.70
Acres Needed For Application		**Forages**		**Row Crops**
If Nitrogen-Based Application		17.22		55.81
If Phosphorus-Based Application		85.18		227.56
Opportunity Cost of Land		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	1,033.18		
If Phosphorus-Based Application	$	5,110.59		
Application Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	7,469.87	$	8,066.27
If Phosphorus-Based Application	$	8,514.68	$	10,630.84
Savings From Not Having To Buy Fertilizer		**Forages**		**Row Crops**
If Nitrogen-Based Application			$	(1,226.11)
If Phosphorus-Based Application			$	(3,123.14)
Extra Fertilizer Purchase Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	436.18		
If Phosphorus-Based Application	$	10,762.46		

Note: 1,275,046 lbs. / year of solids land applied at Chuck Stokes Farm

Table CL.28. Summary and Mass Balance of Generated and Land Applied Nutrients: Actual Costs and Performance Data

Nutrient Balance	**Nitrogen (lbs/ year)**	**Phosphorus (lbs / year)**	**Potassium (lbs / year)**
Generated At Barn	74,321.28	21,297.60	36,536.40
Removed in Separated Solids	8,331.42	3,606.75	3,653.64
Land Applied in Liquid Effluent	22,775.16	3,036.69	21,256.81

Source: Creamer

Tables CL.29 through CL.41: Costs and Returns Estimates Based on Standardized Cost and Performance Data for Environmental Technologies Closed-Loop System: 4,320-Head Feeder to Finish Operation with Flush System

Table CL.29. Environmental Technologies Closed-Loop System Assumptions and Total Annualized Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Number of Animals	**4,320**		
Type of Operation	**Feeder-Finish**		
Barn Cleaning System	**Flush**		
Annualized Cost ($ / Year)			
Total Annualized Cost		Forages	Row Crops
	If Nitrogen-Based Application	**$ 92,901.39**	**$ 90,665.91**
	If Phosphorus-Based Application	**$ 111,643.54**	**$ 91,082.78**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 159.30**	**$ 155.46**
	If Phosphorus-Based Application	**$ 191.43**	**$ 156.18**

Note: Daily volume discharged from barns is 33,505 gallons / day including recharge liquid SSLW equals 583,200 pounds.

Table CL.30. Environmental Technologies Closed-Loop System Manure Evacuation Modifications Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Manure Evacuation	$ 9,110.00	$ 1,357.66
Contractor & Engineering Services & Overhead	$ 3,926.41	$ 585.15
Total Construction Cost	$ 13,036.41	$ 1,942.81
Maintenance Cost		$ 182.20
Property Taxes		$ 46.28
Total Operating Cost		$ 228.48
TOTAL ANNUALIZED COST OF MANURE EVACUATION MODIFICATIONS		**$ 2,171.29**

Table CL.31. Environmental Technologies Closed-Loop System Equalization Tank Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Tank	$ 13,118.75	$ 1,955.08
Tank installation	$ 2,479.34	$ 369.49
Sensor	$ 1,850.00	$ 228.09
Electrical	$ 4,507.88	$ 555.78
Plumbing	$ 2,479.34	$ 369.49
Excavation and Driveway	$ 2,028.55	$ 302.31
Contractor & Engineering Services & Overhead	$ 11,405.92	$ 1,699.82
Total Construction Cost	$ 37,869.77	$ 5,480.07
Maintenance Cost		$ 488.71
Property Taxes		$ 134.44
Total Operating Cost		$ 623.14
TOTAL ANNUALIZED COST OF EQUALIZATION TANK		**$ 6,103.21**

Table CL.32. Environmental Technologies Closed-Loop System Solids Separator and Solids Building Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Pump	$ 4,800.00	$ 1,862.56
Separator	$ 7,000.00	$ 2,716.23
Auger	$ 3,660.00	$ 1,318.88
Hopper for Auger	$ 540.00	$ 80.48
Holding Tank	$ 85.00	$ 12.67
Solids Building	$ 3,450.00	$ 425.35
Plumbing	$ 2,000.00	$ 298.06
Electrical	$ 500.00	$ 74.51
Excavation and Driveway	$ 1,250.00	$ 186.29
Contractor & Engineering Services & Overhead	$ 10,035.84	$ 1,495.64
Total Construction Cost	$ 33,320.84	$ 8,470.66
Electric Power Cost		$ 1,295.44
Maintenance Cost		$ 893.70
Property Taxes		$ 118.29
Total Operating Cost		$ 2,307.43
TOTAL ANNUALIZED COST OF SOLIDS SEPARATOR AND SOLIDS BUILDING		**$ 10,778.10**

Table CL.33. Environmental Technologies Closed-Loop System Sanitization Tank Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Injection Quill	$ 57.75	$ 8.61
PVC Tanks	$ 80.00	$ 9.86
Variable Speed Pump (1/8-HP)	$ 865.00	$ 335.65
Chlorine Sensor	$ 1,200.00	$ 178.84
Mixers	$ 450.00	$ 67.06
Plumbing	$ 1,300.00	$ 193.74
Electrical	$ 500.00	$ 74.51
Contractor & Engineering Services & Overhead	$ 1,919.14	$ 286.01
Total Construction Cost	$ 6,371.89	$ 1,154.28
TCM Cost		$ 1,593.20
Electric Power Cost		$ 12.19
Maintenance Cost		$ 128.51
Property Taxes		$ 22.62
Total Operating Cost		$ 1,756.52
TOTAL ANNUALIZED COST OF SANITIZATION TANK		**$ 2,910.80**

Table CL.34. Environmental Technologies Closed-Loop System Polymer Tank Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Injection Quills	$ 115.50	$ 14.24
PVC Tanks	$ 80.00	$ 9.86
Manual Set Pump (1/8-HP)	$ 645.00	$ 250.28
Mixers	$ 450.00	$ 67.06
Contractor & Engineering Services & Overhead	$ 556.21	$ 82.89
Total Construction Cost	$ 1,846.71	$ 424.34
Polymer Cost		$ 20,231.17
Electric Power Cost		$ 12.19
Maintenance Cost		$ 58.66
Property Taxes		$ 6.56
Total Operating Cost		$ 20,308.57
TOTAL ANNUALIZED COST OF POLYMER TANK		**$ 20,732.91**

Table CL.35. Environmental Technologies Closed-Loop System Settling Tank Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Interior Hopper Tanks	$ 15,500.00	$ 2,309.96
Pump (1-HP)	$ 1,011.00	$ 392.30
Flow Sensors	$ 7,439.65	$ 1,108.73
Flow Control Valves	$ 8,357.65	$ 1,245.54
Check Valves	$ 195.00	$ 29.06
Air-Actuating Valves	$ 14,375.00	$ 2,142.30
Piping and Fittings	$ 2,809.73	$ 346.41
Filling and Lowering Sensors	$ 6,750.00	$ 1,005.95
Pump	$ 2,338.00	$ 907.22
Ball Valves	$ 149.00	$ 22.21
Electrical	$ 1,250.00	$ 186.29
Plumbing	$ 3,250.00	$ 484.35
Contractor & Engineering Services & Overhead	$ 27,336.19	$ 4,073.90
Total Construction Cost	$ 90,761.21	$ 14,254.20
Electric Power Cost		$ 438.79
Maintenance Cost		$ 1,368.97
Property Taxes		$ 322.20
Total Operating Cost		$ 2,129.97
TOTAL ANNUALIZED COST OF SETTLING TANK		**$ 16,384.17**

Table CL.36. Environmental Technologies Closed-Loop System Norweco System (Tertiary Treatment) Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Norweco Tank	$ 5,026.90	$ 749.16
Hopper Tank	$ 5,278.24	$ 786.61
Flow Control Valves	$ 1,671.53	$ 249.11
Flow Sensors	$ 1,487.93	$ 221.75
Pumps	$ 1,802.00	$ 699.24
Air-Actuating Valves	$ 950.00	$ 141.58
Aerators	$ 1,500.00	$ 582.05
Bio-kinetic Filters	$ 1,650.00	$ 245.90
Pump Tank	$ 1,200.00	$ 178.84
Piping and Fittings	$ 331.56	$ 40.88
Dissolved Solids Sensor and Gauge	$ 310.00	$ 46.20
Solenoid Valves	$ 1,800.00	$ 268.25
Filling and Lowering Sensors	$ 1,850.00	$ 275.70
Electrical	$ 670.25	$ 99.89
Plumbing	$ 502.69	$ 74.92
Excavation and Driveway	$ 3,686.39	$ 549.38
Contractor & Engineering Services & Overhead	$ 10,896.16	$ 1,623.85
Total Construction Cost	$ 40,936.91	$ 6,881.46
Electric Power Cost		$ 1,242.31
Maintenance Cost		$ 619.68
Property Taxes		$ 145.33
Total Operating Cost		$ 2,007.32
TOTAL ANNUALIZED COST OF NORWECO SYSTEM		**$ 8,888.79**

Table CL.37. Environmental Technologies Closed-Loop System Control System Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Control Panel	$ 16,000.00	$ 2,384.47
Battery Back-up	$ 525.00	$ 64.73
Contractor & Engineering Services & Overhead	$ 7,122.28	$ 1,061.43
Total Construction Cost	$ 23,647.28	$ 3,510.63
Maintenance Cost		$ 330.50
Property Taxes		$ 83.95
Total Operating Cost		$ 414.45
TOTAL ANNUALIZED COST OF CONTROL SYSTEM		**$ 3,925.08**

Table CL.38. Environmental Technologies Closed-Loop System Building and Non-Allocated System Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Building that Houses Technology	$ 40,500.00	$ 6,035.69
Non-Allocated Electrical	$ 22,501.10	$ 3,353.33
Non-Allocated Excavation and Driveway	$ 17,468.05	$ 2,603.25
Non-Allocated Plumbing	$ 9,241.16	$ 1,139.35
Air Compressor	$ 340.00	$ 131.93
Air Distribution Valve and Air Line	$ 100.00	$ 14.90
Contractor & Engineering Services & Overhead	$ 38,854.78	$ 5,790.51
Total Construction Cost	$ 129,005.09	$ 19,068.97
Maintenance Cost		$ 1,813.21
Property Taxes		$ 457.97
Total Operating Cost		$ 2,271.17
TOTAL ANNUALIZED COST OF BUILDING AND NON-ALLOCATED (TOTAL SYSTEM) INVOICES		**$ 21,340.14**

TOTAL CONSTRUCTION COST OF CLOSED-LOOP SYSTEM TECHNOLOGY (EXCLUDING NORWECO SYSTEM)	**$ 335,859.18**
TOTAL OPERATING COST OF CLOSED-LOOP SYSTEM TECHNOLOGY (EXCLUDING NORWECO SYSTEM)	**$ 30,039.73**
TOTAL ANNUALIZED COSTS OF CLOSED-LOOP SYSTEM TECHNOLOGY WITHOUT LAND APPLICATION (EXCLUDING NORWECO SYSTEM)	**$ 84,345.69**

Table CL.39. Environmental Technologies Closed-Loop System Predicted Liquid Application Costs for Four Land Application Scenarios: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Annual Cost of Applying Lagoon Effluent	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 10,744.25	$ 8,469.29
If Phosphorus-Based Application	$ 14,961.57	$ 9,462.71
Acres Needed For Assimilation	**Forages**	**Row Crops**
If Nitrogen-Based Application	45.13	146.28
If Phosphorus-Based Application	70.56	192.88
Opportunity Cost of Land	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 2,707.94	
If Phosphorus-Based Application	$ 4,233.62	
Irrigation Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 8,036.31	$ 11,565.82
If Phosphorus-Based Application	$ 8,587.24	$ 13,632.40
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application		$ (3,096.54)
If Phosphorus-Based Application		$ (4,169.70)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ -	
If Phosphorus-Based Application	$ 2,140.71	

Note: 4,184,246 gallons / year of effluent modeled to be land applied

Table CL.40. Environmental Technologies Closed-Loop System Predicted Solids Application Costs for Four Land Application Scenarios: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Annual Cost of Applying Solids		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	11,354.63	$	8,821.45
If Phosphorus-Based Application	$	29,421.37	$	9,389.35
Acres Needed For Application		**Forages**		**Row Crops**
If Nitrogen-Based Application		20.26		65.66
If Phosphorus-Based Application		100.21		267.72
Opportunity Cost of Land		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	1,215.50		
If Phosphorus-Based Application	$	6,012.46		
Application Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	9,625.98	$	10,263.94
If Phosphorus-Based Application	$	10,747.18	$	13,063.63
Savings From Not Having To Buy Fertilizer		**Forages**		**Row Crops**
If Nitrogen-Based Application			$	(1,442.49)
If Phosphorus-Based Application			$	(3,674.28)
Extra Fertilizer Purchase Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	513.15		
If Phosphorus-Based Application	$	12,661.72		

Note: 2,188,996 lbs. / year of solids modeled to be land applied

Table CL.41. Summary and Mass Balance of Generated and Land Applied Nutrients: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Nutrient Balance	**Nitrogen (lbs/ year)**	**Phosphorus (lbs / year)**	**Potassium (lbs / year)**
Generated At Barn	87,436.80	25,056.00	42,984.00
Removed in Separated Solids	9,801.67	4,243.23	4,298.40
Land Applied in Liquid Effluent	26,203.84	3,493.85	24,456.92

Tables CL.42 through CL.54: Costs and Returns Estimates Based on Standardized Cost and Performance Data for Environmental Technologies Closed-Loop System: 4,320-Head Feeder to Finish Operation with Pit-Recharge System

Table CL.42. Environmental Technologies Closed-Loop System Assumptions and Total Annualized Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Number of Animals	**4,320**		
Type of Operation	**Feeder-Finish**		
Barn Cleaning System	**Pit-Recharge**		
Annualized Cost ($ / Year)			
Total Annualized Cost		Forages	Row Crops
	If Nitrogen-Based Application	**$ 79,723.96**	**$ 77,488.48**
	If Phosphorus-Based Application	**$ 98,466.11**	**$ 77,905.35**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 136.70**	**$ 132.87**
	If Phosphorus-Based Application	**$ 168.84**	**$ 133.58**

Note: Daily volume discharged from barns is 28,361 gallons / day including recharge liquid
SSLW equals 583,200 pounds.

Table CL.43. Environmental Technologies Closed-Loop System Manure Evacuation Modifications Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Manure Evacuation	$ 4,555.00	$ 678.83
Contractor & Engineering Services & Overhead	$ 1,963.21	$ 292.58
Total Construction Cost	$ 6,518.21	$ 971.40
Maintenance Cost		$ 91.10
Property Taxes		$ 23.14
Total Operating Cost		$ 114.24
TOTAL ANNUALIZED COST OF MANURE EVACUATION MODIFICATIONS		**$ 1,085.64**

Table CL.44. Environmental Technologies Closed-Loop System Equalization Tank Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Tank	$ 9,500.00	$ 1,415.78
Tank installation	$ 2,098.70	$ 312.77
Sensor	$ 1,850.00	$ 228.09
Electrical	$ 3,815.81	$ 470.45
Plumbing	$ 2,098.70	$ 312.77
Excavation and Driveway	$ 1,717.11	$ 255.90
Contractor & Engineering Services & Overhead	$ 9,085.62	$ 1,354.02
Total Construction Cost	$ 30,165.94	$ 4,349.78
Maintenance Cost		$ 387.26
Property Taxes		$ 107.09
Total Operating Cost		$ 494.35
TOTAL ANNUALIZED COST OF EQUALIZATION TANK		**$ 4,844.14**

Table CL.45. Environmental Technologies Closed-Loop System Solids Separator and Solids Building Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Pump	$ 4,800.00	$ 1,862.56
Separator	$ 7,000.00	$ 2,716.23
Auger	$ 3,660.00	$ 1,318.88
Hopper for Auger	$ 540.00	$ 80.48
Holding Tank	$ 85.00	$ 12.67
Solids Building	$ 3,450.00	$ 425.35
Plumbing	$ 2,000.00	$ 298.06
Electrical	$ 500.00	$ 74.51
Excavation and Driveway	$ 1,250.00	$ 186.29
Contractor & Engineering Services & Overhead	$ 10,035.84	$ 1,495.64
Total Construction Cost	$ 33,320.84	$ 8,470.66
Electric Power Cost		$ 1,096.56
Maintenance Cost		$ 893.70
Property Taxes		$ 118.29
Total Operating Cost		$ 2,108.55
TOTAL ANNUALIZED COST OF SOLIDS SEPARATOR AND SOLIDS BUILDING		**$ 10,579.21**

Table CL.46. Environmental Technologies Closed-Loop System Sanitization Tank Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Injection Quill	$ 57.75	$ 8.61
PVC Tanks	$ 80.00	$ 9.86
Variable Speed Pump (1/8-HP)	$ 865.00	$ 335.65
Chlorine Sensor	$ 1,200.00	$ 178.84
Mixers	$ 450.00	$ 67.06
Plumbing	$ 1,300.00	$ 193.74
Electrical	$ 500.00	$ 74.51
Contractor & Engineering Services & Overhead	$ 1,919.14	$ 286.01
Total Construction Cost	$ 6,371.89	$ 1,154.28
TCM Cost		$ 1,343.20
Electric Power Cost		$ 10.28
Maintenance Cost		$ 128.51
Property Taxes		$ 22.62
Total Operating Cost		$ 1,504.64
TOTAL ANNUALIZED COST OF SANITIZATION TANK		**$ 2,658.92**

Table CL.47. Environmental Technologies Closed-Loop System Polymer Tank Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Injection Quills	$ 115.50	$ 14.24
PVC Tanks	$ 80.00	$ 9.86
Manual Set Pump (1/8-HP)	$ 645.00	$ 250.28
Mixers	$ 450.00	$ 67.06
Contractor & Engineering Services & Overhead	$ 556.21	$ 82.89
Total Construction Cost	$ 1,846.71	$ 424.34
Polymer Cost		$ 17,057.03
Electric Power Cost		$ 10.28
Maintenance Cost		$ 58.66
Property Taxes		$ 6.56
Total Operating Cost		$ 17,132.52
TOTAL ANNUALIZED COST OF POLYMER TANK		**$ 17,556.86**

Table CL.48. Environmental Technologies Closed-Loop System Settling Tank Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Interior Hopper Tanks	$ 12,400.00	$ 1,847.97
Pump (1-HP)	$ 1,011.00	$ 392.30
Flow Sensors	$ 5,951.72	$ 886.98
Flow Control Valves	$ 6,686.12	$ 996.43
Check Valves	$ 156.00	$ 23.25
Air-Actuating Valves	$ 11,500.00	$ 1,713.84
Piping and Fittings	$ 2,247.78	$ 277.13
Filling and Lowering Sensors	$ 5,400.00	$ 804.76
Pump	$ 1,169.00	$ 453.61
Ball Valves	$ 119.20	$ 17.76
Electrical	$ 1,000.00	$ 149.03
Plumbing	$ 2,600.00	$ 387.48
Contractor & Engineering Services & Overhead	$ 21,653.79	$ 3,227.05
Total Construction Cost	$ 71,894.61	$ 11,177.59
Electric Power Cost		$ 369.95
Maintenance Cost		$ 1,070.22
Property Taxes		$ 255.23
Total Operating Cost		$ 1,695.39
TOTAL ANNUALIZED COST OF SETTLING TANK		**$ 12,872.98**

Table CL.49. Environmental Technologies Closed-Loop System Norweco System (Tertiary Treatment) Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Norweco Tank	$ 5,026.90	$ 749.16
Hopper Tank	$ 5,278.24	$ 786.61
Flow Control Valves	$ 1,671.53	$ 249.11
Flow Sensors	$ 1,487.93	$ 221.75
Pumps	$ 1,802.00	$ 699.24
Air-Actuating Valves	$ 950.00	$ 141.58
Aerators	$ 1,500.00	$ 582.05
Bio-kinetic Filters	$ 1,650.00	$ 245.90
Pump Tank	$ 1,200.00	$ 178.84
Piping and Fittings	$ 331.56	$ 40.88
Dissolved Solids Sensor and Gauge	$ 310.00	$ 46.20
Solenoid Valves	$ 1,800.00	$ 268.25
Filling and Lowering Sensors	$ 1,850.00	$ 275.70
Electrical	$ 670.25	$ 99.89
Plumbing	$ 502.69	$ 74.92
Excavation and Driveway	$ 3,686.39	$ 549.38
Contractor & Engineering Services & Overhead	$ 10,896.16	$ 1,623.85
Total Construction Cost	$ 40,936.91	$ 6,881.46
Electric Power Cost		$ 1,242.31
Maintenance Cost		$ 619.68
Property Taxes		$ 145.33
Total Operating Cost		$ 2,007.32
TOTAL ANNUALIZED COST OF NORWECO SYSTEM		**$ 8,888.79**

Table CL.50. Environmental Technologies Closed-Loop System Control System Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Control Panel	$ 16,000.00	$ 2,384.47
Battery Back-up	$ 525.00	$ 64.73
Contractor & Engineering Services & Overhead	$ 7,122.28	$ 1,061.43
Total Construction Cost	$ 23,647.28	$ 3,510.63
Maintenance Cost		$ 330.50
Property Taxes		$ 83.95
Total Operating Cost		$ 414.45
TOTAL ANNUALIZED COST OF CONTROL SYSTEM		**$ 3,925.08**

Table CL.51. Environmental Technologies Closed-Loop System Building and Non-Allocated System Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Building that Houses Technology	$ 32,400.00	$ 4,828.56
Non-Allocated Electrical	$ 19,046.62	$ 2,838.51
Non-Allocated Excavation and Driveway	$ 14,786.27	$ 2,203.59
Non-Allocated Plumbing	$ 7,822.41	$ 964.43
Air Compressor	$ 340.00	$ 131.93
Air Distribution Valve and Air Line	$ 100.00	$ 14.90
Contractor & Engineering Services & Overhead	$ 32,107.48	$ 4,784.96
Total Construction Cost	$ 106,602.78	$ 15,766.88
Maintenance Cost		$ 1,500.11
Property Taxes		$ 378.44
Total Operating Cost		$ 1,878.55
TOTAL ANNUALIZED COST OF BUILDING AND NON-ALLOCATED (TOTAL SYSTEM) INVOICES		**$ 17,645.43**

TOTAL CONSTRUCTION COST OF CLOSED-LOOP SYSTEM TECHNOLOGY (EXCLUDING NORWECO SYSTEM)	**$ 280,368.23**
TOTAL OPERATING COST OF CLOSED-LOOP SYSTEM TECHNOLOGY (EXCLUDING NORWECO SYSTEM)	**$ 25,342.69**
TOTAL ANNUALIZED COSTS OF CLOSED-LOOP SYSTEM TECHNOLOGY WITHOUT LAND APPLICATION (EXCLUDING NORWECO SYSTEM)	**$ 71,168.26**

Table CL.52. Environmental Technologies Closed-Loop System Predicted Liquid Application Costs for Four Land Application Scenarios: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Annual Cost of Applying Lagoon Effluent	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 10,744.25	$ 8,469.29
If Phosphorus-Based Application	$ 14,961.57	$ 9,462.71
Acres Needed For Assimilation	**Forages**	**Row Crops**
If Nitrogen-Based Application	45.13	146.28
If Phosphorus-Based Application	70.56	192.88
Opportunity Cost of Land	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 2,707.94	
If Phosphorus-Based Application	$ 4,233.62	
Irrigation Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 8,036.31	$ 11,565.82
If Phosphorus-Based Application	$ 8,587.24	$ 13,632.40
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application		$ (3,096.54)
If Phosphorus-Based Application		$ (4,169.70)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ -	
If Phosphorus-Based Application	$ 2,140.71	

Note: 4,184,246 gallons / year of effluent modeled to be land applied

Table CL.53. Environmental Technologies Closed-Loop System Predicted Solids Application Costs for Four Land Application Scenarios: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Annual Cost of Applying Solids		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	11,354.63	$	8,821.45
If Phosphorus-Based Application	$	29,421.37	$	9,389.35
Acres Needed For Application		**Forages**		**Row Crops**
If Nitrogen-Based Application		20.26		65.66
If Phosphorus-Based Application		100.21		267.72
Opportunity Cost of Land		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	1,215.50		
If Phosphorus-Based Application	$	6,012.46		
Application Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	9,625.98	$	10,263.94
If Phosphorus-Based Application	$	10,747.18	$	13,063.63
Savings From Not Having To Buy Fertilizer		**Forages**		**Row Crops**
If Nitrogen-Based Application			$	(1,442.49)
If Phosphorus-Based Application			$	(3,674.28)
Extra Fertilizer Purchase Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	513.15		
If Phosphorus-Based Application	$	12,661.72		

Note: 2,188,996 lbs. / year of solids modeled to be land applied

Table CL.54. Summary and Mass Balance of Generated and Land Applied Nutrients: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Nutrient Balance	**Nitrogen (lbs/ year)**	**Phosphorus (lbs / year)**	**Potassium (lbs / year)**
Generated At Barn	87,436.80	25,056.00	42,984.00
Removed in Separated Solids	9,801.67	4,243.23	4,298.40
Land Applied in Liquid Effluent	26,203.84	3,493.85	24,456.92

Tables CL.55 through CL.67: Costs and Returns Estimates Based on Standardized Cost and Performance Data for Environmental Technologies Closed-Loop System: 8,800-Head Feeder to Finish Operation with Flush System

Table CL.55. Environmental Technologies Closed-Loop System Assumptions and Total Annualized Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Number of Animals	**8,800**		
Type of Operation	**Feeder-Finish**		
Barn Cleaning System	**Flush**		
Annualized Cost ($ / Year)			
Total Annualized Cost		Forages	Row Crops
	If Nitrogen-Based Application	**$ 173,094.46**	**$ 167,857.46**
	If Phosphorus-Based Application	**$ 210,605.86**	**$ 168,259.16**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 145.70**	**$ 141.29**
	If Phosphorus-Based Application	**$ 177.28**	**$ 141.63**

Note: Daily volume discharged from barns is 68,251 gallons / day including recharge liquid
SSLW equals 1,188,000 pounds.

Table CL.56. Environmental Technologies Closed-Loop System Manure Evacuation Modifications Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Manure Evacuation	$ 18,220.00	$ 2,715.32
Contractor & Engineering Services & Overhead	$ 7,852.82	$ 1,170.30
Total Construction Cost	$ 26,072.82	$ 3,885.62
Maintenance Cost		$ 364.40
Property Taxes		$ 92.56
Total Operating Cost		$ 456.96
TOTAL ANNUALIZED COST OF MANURE EVACUATION MODIFICATIONS		**$ 4,342.58**

Table CL.57. Environmental Technologies Closed-Loop System Equalization Tank Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Tank	$ 13,118.75	$ 1,955.08
Tank installation	$ 5,050.50	$ 752.67
Sensor	$ 1,850.00	$ 228.09
Electrical	$ 9,182.72	$ 1,132.15
Plumbing	$ 5,050.50	$ 752.67
Excavation and Driveway	$ 4,132.23	$ 615.82
Contractor & Engineering Services & Overhead	$ 16,543.80	$ 2,465.51
Total Construction Cost	$ 54,928.50	$ 7,902.00
Maintenance Cost		$ 685.05
Property Taxes		$ 195.00
Total Operating Cost		$ 880.05
TOTAL ANNUALIZED COST OF EQUALIZATION TANK		**$ 8,782.05**

Table CL.58. Environmental Technologies Closed-Loop System Solids Separator and Solids Building Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Pump	$ 9,600.00	$ 3,725.12
Separator	$ 14,000.00	$ 5,432.47
Auger	$ 7,320.00	$ 2,637.75
Hopper for Auger	$ 1,080.00	$ 160.95
Holding Tank	$ 170.00	$ 25.34
Solids Building	$ 6,900.00	$ 850.71
Plumbing	$ 4,000.00	$ 596.12
Electrical	$ 1,000.00	$ 149.03
Excavation and Driveway	$ 2,500.00	$ 372.57
Contractor & Engineering Services & Overhead	$ 20,071.67	$ 2,991.27
Total Construction Cost	$ 66,641.67	$ 16,941.33
Electric Power Cost		$ 2,638.86
Maintenance Cost		$ 1,787.40
Property Taxes		$ 236.58
Total Operating Cost		$ 4,662.84
TOTAL ANNUALIZED COST OF SOLIDS SEPARATOR AND SOLIDS BUILDING		**$ 21,604.17**

Table CL.59. Environmental Technologies Closed-Loop System Sanitization Tank Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Injection Quill	$ 57.75	$ 8.61
PVC Tanks	$ 80.00	$ 9.86
Variable Speed Pump (1/8-HP)	$ 865.00	$ 335.65
Chlorine Sensor	$ 1,200.00	$ 178.84
Mixers	$ 450.00	$ 67.06
Plumbing	$ 1,300.00	$ 193.74
Electrical	$ 500.00	$ 74.51
Contractor & Engineering Services & Overhead	$ 1,919.14	$ 286.01
Total Construction Cost	$ 6,371.89	$ 1,154.28
TCM Cost		$ 3,245.42
Electric Power Cost		$ 24.83
Maintenance Cost		$ 128.51
Property Taxes		$ 22.62
Total Operating Cost		$ 3,421.37
TOTAL ANNUALIZED COST OF SANITIZATION TANK		**$ 4,575.65**

Table CL.60. Environmental Technologies Closed-Loop System Polymer Tank Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Injection Quills	$ 115.50	$ 14.24
PVC Tanks	$ 80.00	$ 9.86
Manual Set Pump (1/8-HP)	$ 645.00	$ 250.28
Mixers	$ 450.00	$ 67.06
Contractor & Engineering Services & Overhead	$ 556.21	$ 82.89
Total Construction Cost	$ 1,846.71	$ 424.34
Polymer Cost		$ 41,211.63
Electric Power Cost		$ 24.83
Maintenance Cost		$ 58.66
Property Taxes		$ 6.56
Total Operating Cost		$ 41,301.68
TOTAL ANNUALIZED COST OF POLYMER TANK		**$ 41,726.02**

Table CL.61. Environmental Technologies Closed-Loop System Settling Tank Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Interior Hopper Tanks	$ 31,000.00	$ 4,619.91
Pump (1-HP)	$ 1,011.00	$ 392.30
Flow Sensors	$ 14,879.30	$ 2,217.45
Flow Control Valves	$ 16,715.30	$ 2,491.07
Check Valves	$ 390.00	$ 58.12
Air-Actuating Valves	$ 28,750.00	$ 4,284.60
Piping and Fittings	$ 5,619.45	$ 692.83
Filling and Lowering Sensors	$ 13,500.00	$ 2,011.90
Pump	$ 3,507.00	$ 1,360.83
Ball Valves	$ 298.00	$ 44.41
Electrical	$ 2,500.00	$ 372.57
Plumbing	$ 6,500.00	$ 968.69
Contractor & Engineering Services & Overhead	$ 53,732.79	$ 8,007.77
Total Construction Cost	$ 178,402.84	$ 27,522.47
Electric Power Cost		$ 893.84
Maintenance Cost		$ 2,628.94
Property Taxes		$ 633.33
Total Operating Cost		$ 4,156.11
TOTAL ANNUALIZED COST OF SETTLING TANK		**$ 31,678.58**

Table CL.62. Environmental Technologies Closed-Loop System Norweco System (Tertiary Treatment) Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Norweco Tank	$ 10,239.98	$ 1,526.06
Hopper Tank	$ 10,751.98	$ 1,602.36
Flow Control Valves	$ 1,671.53	$ 249.11
Flow Sensors	$ 1,487.93	$ 221.75
Pumps	$ 1,802.00	$ 699.24
Air-Actuating Valves	$ 950.00	$ 141.58
Aerators	$ 2,625.00	$ 1,018.59
Bio-kinetic Filters	$ 1,650.00	$ 245.90
Pump Tank	$ 1,200.00	$ 178.84
Piping and Fittings	$ 331.56	$ 40.88
Dissolved Solids Sensor and Gauge	$ 310.00	$ 46.20
Solenoid Valves	$ 1,800.00	$ 268.25
Filling and Lowering Sensors	$ 1,850.00	$ 275.70
Electrical	$ 1,365.33	$ 203.47
Plumbing	$ 1,024.00	$ 152.61
Excavation and Driveway	$ 7,509.32	$ 1,119.11
Contractor & Engineering Services & Overhead	$ 16,026.44	$ 2,388.41
Total Construction Cost	$ 63,403.19	$ 10,498.48
Electric Power Cost		$ 1,511.89
Maintenance Cost		$ 914.00
Property Taxes		$ 225.08
Total Operating Cost		$ 2,650.96
TOTAL ANNUALIZED COST OF NORWECO SYSTEM		**$ 13,149.45**

Table CL.63. Environmental Technologies Closed-Loop System Control System Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Control Panel	$ 18,500.00	$ 2,757.05
Battery Back-up	$ 525.00	$ 64.73
Contractor & Engineering Services & Overhead	$ 8,199.78	$ 1,222.01
Total Construction Cost	$ 27,224.78	$ 4,043.78
Maintenance Cost		$ 380.50
Property Taxes		$ 96.65
Total Operating Cost		$ 477.15
TOTAL ANNUALIZED COST OF CONTROL SYSTEM		**$ 4,520.93**

Table CL.64. Environmental Technologies Closed-Loop System Building and Non-Allocated System Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Building that Houses Technology	$ 81,000.00	$ 12,071.39
Non-Allocated Electrical	$ 45,835.57	$ 6,830.85
Non-Allocated Excavation and Driveway	$ 35,583.06	$ 5,302.92
Non-Allocated Plumbing	$ 18,824.59	$ 2,320.90
Air Compressor	$ 340.00	$ 131.93
Air Distribution Valve and Air Line	$ 100.00	$ 14.90
Contractor & Engineering Services & Overhead	$ 78,305.46	$ 11,669.82
Total Construction Cost	$ 259,988.68	$ 38,342.72
Maintenance Cost		$ 3,643.86
Property Taxes		$ 922.96
Total Operating Cost		$ 4,566.82
TOTAL ANNUALIZED COST OF BUILDING AND NON-ALLOCATED (TOTAL SYSTEM) INVOICES		**$ 42,909.55**

TOTAL CONSTRUCTION COST OF CLOSED-LOOP SYSTEM TECHNOLOGY (EXCLUDING NORWECO SYSTEM)	**$ 621,477.88**
TOTAL OPERATING COST OF CLOSED-LOOP SYSTEM TECHNOLOGY (EXCLUDING NORWECO SYSTEM)	**$ 59,922.98**
TOTAL ANNUALIZED COSTS OF CLOSED-LOOP SYSTEM TECHNOLOGY WITHOUT LAND APPLICATION (EXCLUDING NORWECO SYSTEM)	**$ 160,139.52**

Table CL.65. Environmental Technologies Closed-Loop System Predicted Liquid Application Costs for Four Land Application Scenarios: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Annual Cost of Applying Lagoon Effluent	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 15,668.27	$ 12,347.38
If Phosphorus-Based Application	$ 24,838.00	$ 14,488.41
Acres Needed For Assimilation	**Forages**	**Row Crops**
If Nitrogen-Based Application	91.05	295.11
If Phosphorus-Based Application	142.36	389.14
Opportunity Cost of Land	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 5,463.27	
If Phosphorus-Based Application	$ 8,541.32	
Irrigation Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 10,205.00	$ 18,594.63
If Phosphorus-Based Application	$ 11,977.80	$ 22,900.77
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application		$ (6,247.26)
If Phosphorus-Based Application		$ (8,412.36)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ -	
If Phosphorus-Based Application	$ 4,318.87	

Note: 8,441,713 gallons / year of effluent modeled to be land applied

Table CL.66. Environmental Technologies Closed-Loop System Predicted Solids Application Costs for Four Land Application Scenarios: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Annual Cost of Applying Solids		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	17,857.03	$	12,580.59
If Phosphorus-Based Application	$	54,466.38	$	13,408.59
Acres Needed For Application		**Forages**		**Row Crops**
If Nitrogen-Based Application		41.27		133.75
If Phosphorus-Based Application		204.13		545.35
Opportunity Cost of Land		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	2,476.02		
If Phosphorus-Based Application	$	12,247.61		
Application Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	14,335.70	$	15,518.99
If Phosphorus-Based Application	$	16,426.38	$	20,893.24
Savings From Not Having To Buy Fertilizer		**Forages**		**Row Crops**
If Nitrogen-Based Application			$	(2,938.40)
If Phosphorus-Based Application			$	(7,484.65)
Extra Fertilizer Purchase Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	1,045.31		
If Phosphorus-Based Application	$	25,792.39		

Note: 4,459,066 lbs. / year of solids modeled to be land applied

Table CL.67. Summary and Mass Balance of Generated and Land Applied Nutrients: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Nutrient Balance	**Nitrogen (lbs/ year)**	**Phosphorus (lbs / year)**	**Potassium (lbs / year)**
Generated At Barn	178,112.00	51,040.00	87,560.00
Removed in Separated Solids	19,966.36	8,643.62	8,756.00
Land Applied in Liquid Effluent	52,866.22	7,048.83	49,341.81

Tables CL.68 through CL.80: Costs and Returns Estimates Based on Standardized Cost and Performance Data for Environmental Technologies Closed-Loop System: 4,000-Sow Farrow to Wean Operation with Flush System

Table CL.68. Environmental Technologies Closed-Loop System Assumptions and Total Annualized Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Number of Animals	**4,000**
Type of Operation	**Farrow-Wean**
Barn Cleaning System	**Flush**

Annualized Cost ($ / Year)			
Total Annualized Cost		Forages	Row Crops
	If Nitrogen-Based Application	**$ 350,468.03**	**$ 347,241.60**
	If Phosphorus-Based Application	**$ 376,030.30**	**$ 346,232.51**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 202.35**	**$ 200.49**
	If Phosphorus-Based Application	**$ 217.11**	**$ 199.90**

Note: Daily volume discharged from barns is 158,582 gallons / day including recharge liquid
SSLW equals 1,732,000 pounds.

Table CL.69. Environmental Technologies Closed-Loop System Manure Evacuation Modifications Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Component	Total Cost	Annualized Cost
Manure Evacuation	$ 12,754.00	$ 1,900.72
Contractor & Engineering Services & Overhead	$ 5,496.97	$ 819.21
Total Construction Cost	$ 18,250.97	$ 2,719.93
Maintenance Cost		$ 255.08
Property Taxes		$ 64.79
Total Operating Cost		$ 319.87
TOTAL ANNUALIZED COST OF MANURE EVACUATION MODIFICATIONS		**$ 3,039.80**

Table CL.70. Environmental Technologies Closed-Loop System Equalization Tank Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Component	Total Cost	Annualized Cost
Tank	$ 16,406.25	$ 2,445.02
Tank installation	$ 11,734.96	$ 1,748.85
Sensor	$ 1,850.00	$ 228.09
Electrical	$ 21,336.28	$ 2,630.57
Plumbing	$ 11,734.96	$ 1,748.85
Excavation and Driveway	$ 9,601.33	$ 1,430.88
Contractor & Engineering Services & Overhead	$ 31,318.09	$ 4,667.32
Total Construction Cost	$ 103,981.86	$ 14,899.58
Maintenance Cost		$ 1,261.25
Property Taxes		$ 369.14
Total Operating Cost		$ 1,630.38
TOTAL ANNUALIZED COST OF EQUALIZATION TANK		**$ 16,529.97**

Table CL.71. Environmental Technologies Closed-Loop System Solids Separator and Solids Building Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Component	Total Cost	Annualized Cost
Pump	$ 19,200.00	$ 7,450.24
Separator	$ 28,000.00	$ 10,864.94
Auger	$ 14,640.00	$ 5,275.50
Hopper for Auger	$ 2,160.00	$ 321.90
Holding Tank	$ 340.00	$ 50.67
Solids Building	$ 13,800.00	$ 1,701.42
Plumbing	$ 8,000.00	$ 1,192.24
Electrical	$ 2,000.00	$ 298.06
Excavation and Driveway	$ 5,000.00	$ 745.15
Contractor & Engineering Services & Overhead	$ 40,143.34	$ 5,982.54
Total Construction Cost	$ 133,283.34	$ 33,882.66
Electric Power Cost		$ 6,131.46
Maintenance Cost		$ 3,574.80
Property Taxes		$ 473.16
Total Operating Cost		$ 10,179.42
TOTAL ANNUALIZED COST OF SOLIDS SEPARATOR AND SOLIDS BUILDING		**$ 44,062.08**

Table CL.72. Environmental Technologies Closed-Loop System Sanitization Tank Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Component	Total Cost	Annualized Cost
Injection Quill	$ 57.75	$ 8.61
PVC Tanks	$ 80.00	$ 9.86
Variable Speed Pump (1/8-HP)	$ 865.00	$ 335.65
Chlorine Sensor	$ 1,200.00	$ 178.84
Mixers	$ 450.00	$ 67.06
Plumbing	$ 1,300.00	$ 193.74
Electrical	$ 500.00	$ 74.51
Contractor & Engineering Services & Overhead	$ 1,919.14	$ 286.01
Total Construction Cost	$ 6,371.89	$ 1,154.28
TCM Cost		$ 7,665.57
Electric Power Cost		$ 58.65
Maintenance Cost		$ 128.51
Property Taxes		$ 22.62
Total Operating Cost		$ 7,875.34
TOTAL ANNUALIZED COST OF SANITIZATION TANK		**$ 9,029.62**

Table CL.73. Environmental Technologies Closed-Loop System Polymer Tank Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Component	Total Cost	Annualized Cost
Injection Quills	$ 115.50	$ 14.24
PVC Tanks	$ 80.00	$ 9.86
Manual Set Pump (1/8-HP)	$ 645.00	$ 250.28
Mixers	$ 450.00	$ 67.06
Contractor & Engineering Services & Overhead	$ 556.21	$ 82.89
Total Construction Cost	$ 1,846.71	$ 424.34
Polymer Cost		$ 97,340.63
Electric Power Cost		$ 58.65
Maintenance Cost		$ 58.66
Property Taxes		$ 6.56
Total Operating Cost		$ 97,464.49
TOTAL ANNUALIZED COST OF POLYMER TANK		**$ 97,888.83**

Table CL.74. Environmental Technologies Closed-Loop System Settling Tank Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Component	Total Cost	Annualized Cost
Interior Hopper Tanks	$ 68,200.00	$ 10,163.81
Pump (1-HP)	$ 2,022.00	$ 784.60
Flow Sensors	$ 32,734.46	$ 4,878.40
Flow Control Valves	$ 36,773.66	$ 5,480.36
Check Valves	$ 858.00	$ 127.87
Air-Actuating Valves	$ 63,250.00	$ 9,426.12
Piping and Fittings	$ 12,362.79	$ 1,524.22
Filling and Lowering Sensors	$ 29,700.00	$ 4,426.18
Pump	$ 7,014.00	$ 2,721.67
Ball Valves	$ 655.60	$ 97.70
Electrical	$ 5,500.00	$ 819.66
Plumbing	$ 14,300.00	$ 2,131.12
Contractor & Engineering Services & Overhead	$ 117,822.69	$ 17,559.06
Total Construction Cost	$ 391,193.20	$ 60,140.76
Electric Power Cost		$ 2,111.22
Maintenance Cost		$ 5,738.49
Property Taxes		$ 1,388.74
Total Operating Cost		$ 9,238.45
TOTAL ANNUALIZED COST OF SETTLING TANK		**$ 69,379.21**

Table CL.75. Environmental Technologies Closed-Loop System Norweco System (Tertiary Treatment) Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Component	Total Cost	Annualized Cost
Norweco Tank	$ 16,517.47	$ 2,461.59
Hopper Tank	$ 17,343.35	$ 2,584.67
Flow Control Valves	$ 1,671.53	$ 249.11
Flow Sensors	$ 1,487.93	$ 221.75
Pumps	$ 1,802.00	$ 699.24
Air-Actuating Valves	$ 950.00	$ 141.58
Aerators	$ 4,500.00	$ 1,746.15
Bio-kinetic Filters	$ 1,650.00	$ 245.90
Pump Tank	$ 1,200.00	$ 178.84
Piping and Fittings	$ 331.56	$ 40.88
Dissolved Solids Sensor and Gauge	$ 310.00	$ 46.20
Solenoid Valves	$ 1,800.00	$ 268.25
Filling and Lowering Sensors	$ 1,850.00	$ 275.70
Electrical	$ 2,202.33	$ 328.21
Plumbing	$ 1,651.75	$ 246.16
Excavation and Driveway	$ 12,112.81	$ 1,805.17
Contractor & Engineering Services & Overhead	$ 23,820.47	$ 3,549.95
Total Construction Cost	$ 91,201.20	$ 15,089.34
Electric Power Cost		$ 1,940.49
Maintenance Cost		$ 1,294.42
Property Taxes		$ 323.76
Total Operating Cost		$ 3,558.67
TOTAL ANNUALIZED COST OF NORWECO SYSTEM		**$ 18,648.01**

Table CL.76. Environmental Technologies Closed-Loop System Control System Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Component	Total Cost	Annualized Cost
Control Panel	$ 24,500.00	$ 3,651.22
Battery Back-up	$ 525.00	$ 64.73
Contractor & Engineering Services & Overhead	$ 10,785.78	$ 1,607.40
Total Construction Cost	$ 35,810.78	$ 5,323.35
Maintenance Cost		$ 500.50
Property Taxes		$ 127.13
Total Operating Cost		$ 627.63
TOTAL ANNUALIZED COST OF CONTROL SYSTEM		**$ 5,950.98**

Table CL.77. Environmental Technologies Closed-Loop System Building and Non-Allocated System Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Component	Total Cost	Annualized Cost
Building that Houses Technology	$ 178,200.00	$ 26,557.05
Non-Allocated Electrical	$ 106,500.05	$ 15,871.65
Non-Allocated Excavation and Driveway	$ 82,678.09	$ 12,321.47
Non-Allocated Plumbing	$ 43,739.38	$ 5,392.67
Air Compressor	$ 340.00	$ 131.93
Air Distribution Valve and Air Line	$ 100.00	$ 14.90
Contractor & Engineering Services & Overhead	$ 177,381.29	$ 26,435.04
Total Construction Cost	$ 588,938.82	$ 86,724.73
Maintenance Cost		$ 8,241.35
Property Taxes		$ 2,090.73
Total Operating Cost		$ 10,332.08
TOTAL ANNUALIZED COST OF BUILDING AND NON-ALLOCATED (TOTAL SYSTEM) INVOICES		**$ 97,056.81**

TOTAL CONSTRUCTION COST OF CLOSED-LOOP SYSTEM TECHNOLOGY (EXCLUDING NORWECO SYSTEM)	**$ 1,279,677.56**
TOTAL OPERATING COST OF CLOSED-LOOP SYSTEM TECHNOLOGY (EXCLUDING NORWECO SYSTEM)	**$ 137,667.67**
TOTAL ANNUALIZED COSTS OF CLOSED-LOOP SYSTEM TECHNOLOGY WITHOUT LAND APPLICATION (EXCLUDING NORWECO SYSTEM)	**$ 342,937.29**

Table CL.78. Environmental Technologies Closed-Loop System Predicted Liquid Application Costs for Four Land Application Scenarios: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Annual Cost of Applying Lagoon Effluent	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 19,656.85	$ 15,488.72
If Phosphorus-Based Application	$ 32,838.14	$ 18,559.35
Acres Needed For Assimilation	**Forages**	**Row Crops**
If Nitrogen-Based Application	128.25	415.67
If Phosphorus-Based Application	200.51	548.11
Opportunity Cost of Land	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 7,695.15	
If Phosphorus-Based Application	$ 12,030.67	
Irrigation Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 11,961.70	$ 24,288.14
If Phosphorus-Based Application	$ 14,724.23	$ 30,408.36
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application		$ (8,799.42)
If Phosphorus-Based Application		$ (11,849.02)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ -	
If Phosphorus-Based Application	$ 6,083.24	

Note: 11,890,364 gallons / year of effluent modeled to be land applied

Table CL.79. Environmental Technologies Closed-Loop System Predicted Solids Application Costs for Four Land Application Scenarios: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Annual Cost of Applying Solids		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	12,401.00	$	9,379.21
If Phosphorus-Based Application	$	39,707.49	$	9,905.69
Acres Needed For Application		**Forages**		**Row Crops**
If Nitrogen-Based Application		27.11		87.86
If Phosphorus-Based Application		148.14		395.76
Opportunity Cost of Land		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	1,626.47		
If Phosphorus-Based Application	$	8,888.16		
Application Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	10,477.52	$	11,309.42
If Phosphorus-Based Application	$	12,131.73	$	15,483.17
Savings From Not Having To Buy Fertilizer		**Forages**		**Row Crops**
If Nitrogen-Based Application			$	(1,930.21)
If Phosphorus-Based Application			$	(5,577.48)
Extra Fertilizer Purchase Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	297.00		
If Phosphorus-Based Application	$	18,687.61		

Note: 2,547,732 lbs. / year of solids modeled to be land applied

Table CL.80. Summary and Mass Balance of Generated and Land Applied Nutrients: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Nutrient Balance	**Nitrogen (lbs/ year)**	**Phosphorus (lbs / year)**	**Potassium (lbs / year)**
Generated At Barn	117,000.00	37,040.00	77,000.00
Removed in Separated Solids	13,115.70	6,272.72	7,700.00
Land Applied in Liquid Effluent	74,463.40	9,928.45	69,499.18

Tables CL.81 and CL.82: Predicted Costs of Retrofitting Various Representative Farm Sizes and Farm Types with the Environmental Technologies Closed-Loop System: DWQ Permitted Farms and SF/PSF Owned Farms

Table CL.81. Predicted Costs* ($ / 1,000 Pounds of Steady-State Live Weight (SSLW) per Year) of Retrofitting DWQ Permitted Representative Farm Type / Farm Size Combinations: Environmental Technologies Closed-Loop System

	Farm Size (1,000 pounds SSLW)				
	0-500	**500-1000**	**1000-1500**	**1500-2000**	**> 2000**
Farm Type					
Farrow-wean					
Rep. # of sows	752	1,540	2,400	4,000	6,000
Pit-recharge system	$223.56	$204.68	$185.49	$179.38	$179.15
Flush system	$251.85	$224.35	$206.51	$202.35	$196.51
Farrow-feeder					
Rep. # of sows	500	1,200	2,000	3,600	5,500
Pit-recharge system	$238.11	$214.78	$188.47	$186.82	$180.12
Flush system	$320.70	$282.95	$271.31	$262.84	$256.93
Farrow-finish					
Rep. # of sows	150	500	1,000	1,200	2,000
Pit-recharge system	$223.43	$150.77	$140.99	$144.72	$136.43
Flush system	$297.16	$202.00	$186.11	$181.09	$176.81
Wean-feeder					
Rep. head capacity	3,840	20,000	N/A	N/A	N/A
Pit-recharge system	$306.34	$157.49	N/A	N/A	N/A
Flush system	$727.93	$602.16	N/A	N/A	N/A
Feeder-finish					
Rep. head capacity	2,448	5,280	8,800	12,240	17,136
Pit-recharge system	$175.20	$132.24	$125.09	$116.90	$116.45
Flush system	$187.21	$150.98	$145.70	$134.90	$135.22

* These predicted costs exclude the Norweco system unit process.

Table CL.82. Predicted Costs* ($ / 1,000 Pounds of Steady-State Live Weight (SSLW) per Year) of Retrofitting Smithfield Foods/Premium Standard Farms Representative Farm Type / Farm Size Combinations: Environmental Technologies Closed-Loop System

	Farm Size (1,000 pounds SSLW)				
	0-500	**500-1000**	**1000-1500**	**1500-2000**	**> 2000**
Farm Type					
Farrow-wean					
Rep. # of sows	650	1,700	2,400	4,000	7,000
Pit-recharge system	$243.37	$201.96	$185.49	$179.38	$175.84
Flush system	$255.37	$219.96	$206.51	$202.35	$196.94
Farrow-feeder					
Rep. # of sows	675	1,200	2,000	3,419	5,500
Pit-recharge system	$231.85	$214.78	$188.47	$183.29	$180.12
Flush system	$292.09	$282.95	$271.31	$263.85	$256.93
Farrow-finish					
Rep. # of sows	N/A	500	1,000	1,200	2,000
Pit-recharge system	N/A	$150.77	$140.99	$144.72	$136.43
Flush system	N/A	$202.00	$186.11	$181.09	$176.81
Wean-feeder					
Rep. head capacity	2,808	N/A	N/A	N/A	N/A
Pit-recharge system	$389.75	N/A	N/A	N/A	N/A
Flush system	$813.83	N/A	N/A	N/A	N/A
Feeder-finish					
Rep. head capacity	1,240	5,100	8,800	12,246	17,136
Pit-recharge system	$252.86	$134.71	$125.09	$116.87	$116.45
Flush system	$265.49	$153.76	$145.70	$134.87	$135.22

* These predicted costs exclude the Norweco system unit process.