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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: ISSUES RENEW (ISSUES VESTAL)

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

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Summary of Results

Retrofit Cost per 1,000 pounds Steady State Live Weight per year: $125.93
Standardized Feeder-to-Finish Farm with 4,320 head (Tables IR.37- IR.46)
10-Year Amortization, Pit-Recharge, N limited Irrigation onto Forage

Includes:	Manure Evacuation and Lift Station:	$ 7.28 / 1,000 lbs. SSLW / Yr.
	Equalization Tank:	$ 8.55 / 1,000 lbs. SSLW / Yr.
	Clarifier/Thickener:	$ 27.29 / 1,000 lbs. SSLW / Yr.
	Mesophilic Digester:	$ 31.57 / 1,000 lbs. SSLW / Yr.
	Flare:	$ 1.23 / 1,000 lbs. SSLW / Yr.
	Aerobic Digester:	$ 49.57 / 1,000 lbs. SSLW / Yr.
	Control System:	$ 3.05 / 1,000 lbs. SSLW / Yr.
	Decreased Land Application Cost:	$ -2.61 / 1,000 lbs. SSLW / Yr.

Excludes: Micro-turbine
Water Re-use System

Range:	Across Farm Sizes and Types (Pit-Recharge):	$78.69 To 620.03 / 1,000 lbs. SSLW / Yr.
	Across Farm Sizes and Types (Flush):	$87.70 To 766.25 / 1,000 lbs. SSLW / Yr.

Confidence in Estimates:
Low-Medium
Full farm-scale system with evaluations extending over a 16-month period. Cost invoices incomplete as technology provider provided some construction inputs. Flow and performance data sampled over short periods as operation of the technology varied over time.

Costs by Category:

Direct Construction:	$ 71.04 / 1,000 lbs. SSLW / Yr.
Contractor Overhead	$ 24.91 / 1,000 lbs. SSLW / Yr.
Total Operating:	$ 32.59 / 1,000 lbs. SSLW / Yr.
Decreased Land Application Cost:	$ -2.61 / 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	$62.95	$72.17
Baseline Cost Projection (10-year economic life, 8 % interest rate)	0.1490	$82.60	**$95.95***
High-Cost Projection (7-year economic life, 10 % interest rate)	0.2054	$106.48	$124.88

* 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)	$27.11
Baseline Cost of Electricity ($0.08 / kWh)	**$32.59***
High-Cost Electricity ($0.10 / kWh)	$38.08

* 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, $95.95, is the predicted 2004 annual construction and overhead cost for the ISSUES RENEW technology 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 ISSUES RENEW technology are recalculated using higher and lower prices for electricity. The 25% increase or decrease in electricity price has a significant effect (plus or minus $5.48 per 1,000 pounds SSLW per year) on the predicted annual cost reflecting significant electricity use by the blower in the aerobic digester.

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 ISSUES RENEW technology, as modeled and tested, has no marketable by-products. However, this technology was intended to use a 30-kW micro-turbine to generate electricity as a by-product. Due to ongoing negotiations and contractual delays with the local utility provider, no electricity was actually produced at Vestal Farm. Biogas was produced and collected, however, and based on this data it is possible to calculate hypothetical break-even prices.

Table IR.4 reports the amount of biogas (and methane) produced and collected by the ISSUES RENEW technology for the month of August, 2004. For the 20 days in which biogas data is available, the mesophilic digester produced a daily average of 41,879 cubic feet of biogas. Assuming this biogas contained 70% methane, the average daily amount of methane produced by the mesophilic digester at Vestal Farm was 29,315 cubic feet. Using a conversion rate of 600 BTU's per cubic foot of methane (Hansen), the Vestal Farm digester produced about 17,589,000 BTU's per day, or 6,420,000,000 BTU's per year. Converting to kilowatt-hours (3,413 BTU's = 1 kWh), the ISSUES RENEW digester as operated at Vestal Farm produced about 1,880,000 kWh per year. Dave Townsend has cited a conversion rate of 1,000 BTU's per cubic foot of methane for Premium Standard Farms projects (assuming that biogas is 70% methane).

Because of a lack of performance verification or operating data for the micro-turbine, it is unknown how efficiently electricity could be produced. The percentage of biogas that would be available for electricity generation (vs. the percentage needed to fuel the heat exchanger and heat the digester influent) is also unknown due to a lack of performance verification or data. Due to the capacity of the 30-kW micro-turbine, a maximum of 262,980 kWh per year of electricity (30 kW * 24 hours / day * 365.25 days /year) could be generated. This assumes 100% efficiency for the micro-turbine (20-40% is a more reasonable assumption).

Table IR.21 reports the annualized cost of the micro-turbine/heating system to be $50,230.90. Using this cost, and an annual electricity generation rate of 262,980 kWh / year, the break-even price of a kWh of electricity is calculated as $0.19. This price can be interpreted as the price per kWh needed to offset the entire micro-turbine and heating system (including heat exchanger). The break-even price to simply offset the 30-kW micro-turbine would be less than $0.19 and depend on the cost of the micro-turbine (the economics team did not receive an itemized cost for the micro-turbine, only a cost for the combined micro-turbine plus heating system). Once the micro-turbine is demonstrated,

and physical performance data is available, a breakeven analysis can be conducted that reflects the actual performance of the micro-turbine.

The ISSUES RENEW technology also has the potential for a second by-product. If the water re-use system is used, by-product water can be provided as drinking water for the animals. This would result in a cost savings on fresh water used at the farm. Due to the lack of performance data on the water re-use system, the economics team is unable to conduct a break-even analysis for this unit process.

1. Introduction and Farm Description

The Innovative Sustainable Systems Utilizing Economical Solutions (ISSUES) technology was a three-component program in which separate systems were constructed and tested at each of three farm sites. The economic analyses for the ISSUES systems will be reported in three separate documents. The economic analysis reported in this document is for the Recycling of Existing Nutrients, Energy, and Water (RENEW) component of the ISSUES technology.

The ISSUES RENEW technology was constructed and operated on the Vestal 1 & 2 Farm in Duplin County, North Carolina. This farm is owned and operated by Murphy Farms, LLC. Vestal 1 and Vestal 2 each contain four 1,224-head capacity, feeder-to-finish barns with natural ventilation and flush systems for manure removal. A combined total of 9,792 finishing head (8 barns * 1,224 head / house) are housed at the two Vestal sites (Bull, et al).

2. Technology Description (As Proposed)

Flushed manure from the eight individual barns was diverted to either of two lift stations (each lift station handled the flushed manure from four barns) and subsequently pumped to a 10,000-gallon equalization tank at a sampled rate of 75,398 gallons per day. From the equalization tank, the wastewater stream traveled to a clarifier ("concentrator") in order to be thickened. Any excess wastewater from the equalization tank (about 4,100 gallons per day at the Vestal sites) was diverted to the polishing/storage basin. Six batches of wastewater per day were sent from the equalization tank to the clarifier. The thickened sludge from the bottom of the clarifier was pumped to an in-ground mesophilic digester. The digester was both lined and covered with a 40-millimeter HDPE synthetic material and was operated at around 95°F (Dugba(b)). Supernatant from the clarifier was sent to the existing lagoon, which was converted to a polishing/storage basin. Biogas captured from the mesophilic digestion of volatile solids was intended to fuel a 30-kW micro-turbine generator to produce electricity. The waste heat from this generator could then be used to heat the mesophilic digester. Because of contractual delays with the local utility company, the performance verification of the micro-turbine was not conducted for the RENEW technology. All biogas produced by the digester was either flared or used to heat the digester influent. Effluent from the polishing/storage basin was pumped to an aerobic digester at a rate of 75,398 gallons per day. A fine bubble aeration system was used in combination with an Air-Jammer ™ (aerator and mixer unit) to provide dissolved oxygen in the aerobic digester. A 20-HP blower was used to produce the fine bubbles and the Air-Jammer™ unit was equipped with a 15-HP motor. The aerobic digester was lined with a 40-millimeter HDPE synthetic material. After 8-10 days of retention time in the aerobic digester, approximately 12,522 gallons per day of nitrified water was returned to the polishing/storage basin and eventually land applied. Approximately 52,877 gallons per day of nitrified water from the aerobic digester was returned to the barns for flushing.

The remaining nitrified water (about 10,000 gallons per day) was intended to be fed into the water re-use system. The water re-use system used a Fuzzy™ filter, sand filters, and a reverse osmosis unit to disinfect and clean the nitrified water influent. Upon being treated, the water re-use system effluent could be used as drinking water by the animals. The water re-use component of the RENEW technology was an add-on system. For the standardized economic analyses, this component will not be included due to a lack of performance verification data. It was included at the Vestal site only for developmental and demonstrational purposes and was not funded through the AG/SF/PSF/FF Agreement (Dugba(b)). In the standardized models, the 10,000 gallons per day that were diverted to the water re-use system will instead by sent to the polishing/storage basin and land applied.

The unit processes that were identified by the economics team for the ISSUES RENEW technology were:

1.) modifications to waste evacuation and lift station
2.) equalization tank
3.) clarifier or "concentrator"
4.) mesophilic digester
5.) micro-turbine generator and flare
6.) polishing/storage basin
7.) aerobic digester (fine bubble diffusion and Air-Jammer™)
8.) water re-use system (Fuzzy™ filter, sand filter, reverse osmosis unit)
9.) land application of liquid effluent

3. Mass Balances and Performance Data (Tables IR.1-IR.4)

The ISSUES RENEW site evaluation at Vestal Farm began in August, 2003 and concluded in November, 2004. Flow monitoring was also conducted in February, 2005. Table IR. 1 lists the flow volumes associated with the ISSUES RENEW technology as it was operated at Vestal Farms. Of the wastewater volume flushed from the houses (76,840 gallons per day), 95% was sent to the clarifier with the remaining volume overflowing to the polishing/storage basin. Of the 72,748 gallons sent daily to the clarifier, 46.8% is next sent to the mesophilic digester with the remaining volume being pumped from the clarifier to the polishing/storage basin. The necessary volume to flush the houses (53,839 gallons per day) was sent daily from the polishing/storage basin to the aerobic digester (to replace the volume used for that day's flushing). The remaining volume (22,300 gallons per day) remained in the polishing/storage basin and was eventually land applied (or sent to the water re-use system) (Worley-Davis).

Table IR.2 lists the nutrient concentration (TKN, P, and K) of the wastewater stream at various sampling points throughout the ISSUES RENEW technology. Table IR.3. lists the mass balance of nutrients (TKN and P) for this technology. TKN is reduced by 74.5% and P is reduced by 86.6% by the ISSUES RENEW technology (Bull, et. al).

Table IR.4 lists the biogas and methane production for August, 2004 at Vestal Farm. It is assumed that the biogas produced at Vestal contains 70% methane content. For the 20 days in which biogas data is available, the ISSUES RENEW technology produced and captured an average of 41,879 cubic feet per day of biogas (29,315 cubic feet of methane). Assuming a volatile solids loading rate of 5,520 pounds per day (Dugba(b)), the average methane production rate for the mesophilic digester at Vestal Farm was 5.31 cubic feet of methane per pound of volatile solid loaded.

4. Costs of the ISSUES RENEW Technology as Constructed at Vestal Farm

4.1. Invoiced Construction Costs at Vestal Farm (Tables IR.5-IR.12)

Reported cost estimates (Tables IR.5-IR.12) were based on cost invoices provided by Cavanaugh and Associates. The invoiced costs for the ISSUES RENEW technology as constructed at Vestal Farm were separated into unit processes by Cavanaugh. Because some in-house work was performed by Murphy-Brown (e.g., excavation for the mesophilic and aerobic digesters), the costs invoices provided by Cavanaugh do not represent the total cost of the ISSUES RENEW system.

Table IR.5 reports the costs associated with the equalization tank. Clarifier/thickener construction costs are reported in Table IR.6. Table IR.7 reports the costs associated with the construction of the mesophilic digester at Vestal Farm. Table IR.8 lists the invoiced costs of the micro-turbine/heating system, while Table IR.9 reports the construction costs for the aerobic digester. Invoiced construction costs for the water re-use system are listed in Table IR.10. Finally, miscellaneous invoices associated with the ISSUES RENEW technology are reported in Table IR.11. Table IR.12 summarizes the invoiced construction costs of the ISSUE RENEW technology as demonstrated at Vestal Farm. Total invoiced cost of the ISSUES RENEW system was $560,060 (Table IR.12). The micro-turbine/heating system accounted for the largest percentage of this total invoiced cost, with a unit process cost of $198,015 (see Table IR.8), or 35.4% of the ISSUE RENEW technology's total invoiced construction cost.

4.2. Modified Construction Costs at Vestal Farm (Tables IR.13-IR.14)

Tables IR.13 and IR.14 describe cost modifications that were made to the invoiced costs listed in Tables IR.5-IR.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 meetings with the technology providers and examination of the cost invoices received from Cavanaugh. Table IR.13 lists the costs that were modified as well as the reason for the change. In Table IR.14, a revised invoiced cost summary is shown. The total

modified invoiced costs for the ISSUES RENEW technology decreased to $465,130; a $94,930 reduction (~ 17%) from the total reported in Table IR.12.

5. Cost Modeling (Tables IR.15-IR.68)

5.1. Introduction

Original invoice costs were reported detailing the construction costs of the ISSUES RENEW technology as it was built on the Vestal Farm. These costs are reported by unit process in Tables IR.5-IR.11 and summarized in total in Table IR.12. Modified construction costs were also determined based on meetings between the technology providers and the economic modeling team. The modified costs are reported in Table IR.13 and total modified construction costs are summarized in Table IR.14. In the next step, the economic modeling team examined the data reported in Tables IR.5-IR.11 for missing components and outdated prices. Specifically, for the ISSUES RENEW technology, excavation and liner costs were included for the mesophilic and aerobic digesters. 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 IR.16-IR.26. 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 IR.15. These costs are presented in Tables IR.27-IR.36 for a 4,320-head feeder-to-finish facility using a flush system of manure removal. Tables IR.37-IR.46 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 waste removal. A representative NC 8,800-head feeder-to-finish facility with a flush system for manure removal is reported in Tables IR.47-IR.56. 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 IR.57-IR.66 list the costs associated with using the ISSUES RENEW technology at this representative facility.

5.2. Standardized Modeling Assumptions (Table IR.15)

Table IR.15 lists some assumptions that were used in constructing the cost models for the ISSUES RENEW technology. These assumptions were based on design equations found in the permit application and meetings that the economics team had with the principal investigators and technology providers.

Both the equalization tank and clarifier were designed using 3-hour hydraulic retention times. The equalization tank was sized using the function for steel tanks as described in Appendix E of the Combined Appendices Report. The clarifier used at Vestal Farm had a capacity of 10,000 gallons per batch, or 80,000 gallons per day. For representative

farms that had a wastewater discharge volume of greater than 80,000 gallons per day, multiple clarifiers were added to the economic model.

The mesophilic digester was designed using a 25-day hydraulic retention time. It was assumed that 46.8% of the daily flush volume was sent to the mesophilic digester (see Table IR.1 and Section 3). The digester was modeled to be a square with a depth of 15 feet. The aerobic digester was designed using a 10-day hydraulic retention time. It was assumed that the volume of wastewater entering the aerobic digester each day was equal to the average wastewater discharge from the barns less the volume of manure, urine, and excess water produced at the barns. In other words, the daily amount of wastewater entering the aerobic digester was assumed to be equal to the amount of liquid that would be returned to the barns to fill the flush tanks. The aerobic digester was also modeled to be constructed as a square with a depth of 15 feet. In the standardized models (Tables IR.26-IR.61), the blower (20-HP at Vestal Farm) was assumed to be operated continuously (24 hours per day), while the Air-Jammer was assumed to not be operated at all. The Air-Jammer was shown to be unnecessary at Vestal Farm, as the blower was capable of supplying the required amount of oxygen to the aerobic digester (Dugba(a)). In the actual model (Tables IR.16-IR.26), the Air-Jammer was assumed to be operated for 4 hours per day to reflect operating conditions at Vestal Farm.

The actual costs and returns model (Tables IR.16-IR.26) includes the micro-turbine and water re-use system since invoiced costs were provided for these unit processes. The standardized costs and returns models do not include these unit processes, however. Because the micro-turbine was never operated, there was no performance verification or data for it. In the standardized models, it was assumed that the biogas was used to heat the mesophilic digester influent. Any remaining biogas was assumed to be flared. The water re-use component of the ISSUES RENEW project was considered an add-on unit process. It was not included as part of the standardized ISSUES RENEW model which was used to calculate the costs reported in Tables IR.27 to IR.66.

There are no costs associated with the polishing/storage basin in either the actual or standardized costs and returns models. The polishing/storage basin makes use of the existing lagoon that is present on all permitted North Carolina farms. It also uses previously existing pumps and piping for return of flush water to the barns. Because of its use of existing structures and equipment, there is no incremental cost associated with the polishing/storage basin unit process.

5.3. Estimated Adjusted Invoice Costs for ISSUES RENEW Technology at Vestal Farm (Tables IR.16-IR.26)

Table IR.16 lists the assumptions (9,792-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 IR.16 presents annualized incremental costs for each of the four land application scenarios that range from $149.06 (phosphorus-based application to row crops) to $155.99 (nitrogen-based application to forages). Nitrogen-based land application is more costly than phosphorus-based application and application to forages is more costly than application to row crops with the ISSUES RENEW technology as modeled at Vestal Farm. Tables IR.17-IR.24 summarize costs associated with individual unit processes of the ISSUES RENEW technology. Costs are reported for the following unit processes: manure evacuation and lift station (IR.17), equalization tank (IR.18), clarifier/thickener (IR.19), mesophilic digester (IR.20), micro-turbine/heating system (IR.21), aerobic digester (IR.22), water re-use system (IR.23), and control system (IR.24). Table IR.24 also reports the total costs associated with the unit processes listed above. Total construction costs are predicted as $902,472, while annual operating costs are estimated as $59,136. The total annualized cost of the ISSUES RENEW technology before land application is estimated to be $213,238 for the 9,792-head feeder-to-finish facility at Vestal Farm. Table IR.25 (lagoon effluent) reports land application costs associated with the ISSUES RENEW technology. Used in conjunction with the numbers reported at the end of Table IR.24, the total annualized and incremental cost estimates are calculated and reported in Table IR.16 for each of the four scenarios of land application. Table IR.26 details the mass balance of nutrients associated with the ISSUES RENEW technology. The mass balance estimates are used to derive additional land application costs in Table IR.25.

5.4. Standardized Costs for ISSUES RENEW Technology at a 4,320-Head Feeder-to-Finish Farm with Flush System (Tables IR.27-IR.36)

Tables IR.27 to IR.36 provide estimates of the cost of constructing and operating the ISSUES RENEW 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 waste removal. Table IR.27 provides total annualized and per unit ($ / 1,000 lbs. SSLW) costs for retrofitting the farm with standardized ISSUES RENEW technology (flare instead of micro-turbine and no water re-use system). The standardized incremental costs range from $123.69 (phosphorus-based application to row crops) to $134.60 (nitrogen-based application to forages), with an average incremental cost of $130.53 per 1,000 lbs. SSLW per year across the four land application scenarios. In the standardized ISSUES RENEW model, forages are more costly than row crops to land apply and nitrogen-based land application is more costly than phosphorus-based land application. Tables IR.28-IR.34 report standardized costs for the following unit processes: manure evacuation and lift station (IR.28), equalization tank (IR.29), clarifier/thickener (IR.30), mesophilic digester (IR.31), flare (IR.32), aerobic digester (IR.33), and control system (IR.34). Within certain unit processes (e.g., manure evacuation), there are differences in individual components between the actual and standardized models. In these cases, the technology as it was constructed at Vestal was not indicative of how it would be constructed on a representative NC farm. Table IR.34

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

also summarizes the predicted total costs associated with the standardized ISSUES RENEW technology for a 4,320-head finishing facility with a flush system. Total construction costs are estimated at $353,487, while total annual operating costs are predicted as $19,607. Total annualized costs before land application are estimated at $80,020 for this representative farm size and type. Table IR.35 (lagoon effluent) summarizes the land application costs predicted for this model for each of four scenarios. Table IR.36 provides an estimated mass balance of nutrients for this representative NC farm size and type.

5.5. Standardized Costs for ISSUES RENEW Technology at a 4,320-Head Feeder-to-Finish Farm with Pit-Recharge System (Tables IR.37-IR.46)

Tables IR.37- IR.46 provide estimates of the cost of constructing and operating the ISSUES RENEW 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 IR.37-IR.46 versus the one chosen to estimate the numbers in Tables IR.27-IR.36 is the type of manure removal system used. Table IR.37 provides total annualized and per unit ($ / 1,000 lbs. SSLW) costs for the standardized ISSUES RENEW technology. The standardized incremental costs of retrofitting the farm with the ISSUES RENEW system range from $115.02 (phosphorus-based application to row crops) to $125.93 (nitrogen-based application to forages), with an average incremental cost across the four scenarios of $121.86 per 1,000 lbs. SSLW per year. Forages are more costly than row crops for land application and nitrogen-based applications are more costly than phosphorus-based applications. The use of the pit-recharge system of manure removal decreases average incremental cost estimates by about 7% for a 4,320-head finishing facility as compared to using a flush system on the same facility. Tables IR.38-IR.44 list the costs of individual unit processes in this standardized model. The set of unit processes and components are identical to those in Tables IR.28-IR.34, while some of the costs change between the two sets of tables. Table IR.44 also summarizes the total costs associated with the standardized ISSUES RENEW technology for a 4,320-head finishing facility with a pit-recharge system. Total construction costs are estimated at $323,569, while total annual operating costs are reported as $19,009. Total annualized costs before land application are estimated at $74,963 for this representative farm size and type. Table IR.45 (lagoon effluent) summarizes the land application costs associated with this standardized model for each of four scenarios. Table IR.46 provides an estimated mass balance of nutrients for the representative farm modeled in these tables.

5.6. Standardized Costs for ISSUES RENEW Technology at an 8,800-Head Feeder-to-Finish Farm (Tables IR.47-IR.56)

Tables IR.47- IR.56 provide estimates of the cost of constructing and operating the ISSUES RENEW technology on a standard (representative) North Carolina 8,800-head feeder-to-finish facility using a flush system for manure removal. Table IR.47 provides

total annualized and per unit ($ / 1,000 lbs. SSLW) costs for retrofitting a farm with the standardized ISSUES RENEW technology. The standardized incremental costs for the 8,800-head finishing facility range from $85.45 (phosphorus-based application to row crops) to $95.45 (nitrogen-based application to forages), with an average incremental cost of $91.89 per 1,000 lbs. SSLW per year across the four scenarios. This average incremental cost is about 30% 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 ISSUES RENEW 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). The clarifier/thickener contributes most significantly to the economies of scale, while the mesophilic digester and aerobic digester also demonstrate some economies of scale. Tables IR.48-IR.54 list the costs of individual unit processes in this standardized model. The set of unit processes and components are identical to those in Tables IR.28-IR.34 and IR.38-IR.44 although some of the costs change between the sets of tables. Table IR.54 also summarizes the total costs associated with the standardized ISSUES RENEW technology for an 8,800-head finishing facility. Total construction costs are estimated at $541,460, while total operating costs are reported as $24,167. Total annualized costs before land application are estimated at $117,830 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. Table IR.55 (lagoon effluent) summarizes the land application costs associated with this standardized model for each of four scenarios. Table IR.56 provides predicted mass balance of nutrients for the representative farm modeled here.

5.7. Standardized Costs for ISSUES RENEW Technology at a 4,000-Sow Farrow-to-Wean Farm (Tables IR.57-IR.66)

Tables IR.57- IR.66 provide estimates of the cost of constructing and operating the ISSUES RENEW 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 ISSUES RENEW technology. Table IR.57 provides total annualized and per unit ($ / 1,000 lbs. SSLW) costs for the standardized ISSUES RENEW technology. The standardized incremental costs range from $87.90 (phosphorus-based application to row crops) to $97.58 (nitrogen-based application to forages), with an average incremental cost of $94.05 per 1,000 lbs. SSLW per year across the four scenarios of land application. Nitrogen-based applications were modeled to be more costly than phosphorus-based applications and applications to forages were modeled to be more costly than applications to row crops. Tables IR.58-IR.64 provide details of the costs of individual unit processes in this standardized model. Table IR.64 also summarizes the total costs of the standardized ISSUES RENEW technology for a 4,000-sow farrow-to-wean operation. Total construction costs are estimated at $903,045, while total annual operating costs are

reported as $31,481. Total annualized costs before land application are estimated at $174,920 for this representative farm size and type. Table IR.65 (lagoon effluent) summarizes the land application costs associated with this standardized model for each of four scenarios. Table IR.66 provides an estimated mass balance of nutrients for the 4,000-sow farrow-to-wean operation modeled for the ISSUES RENEW technology.

5.8. Extrapolation to Other Farm Types and Sizes (Tables IR.67-IR.68)

Table IR.67 summarizes the per unit incremental costs ($ / 1,000 lbs. SSLW) of retrofitting the ISSUES RENEW 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 IR.67's costs assume nitrogen-based land application to forages. Table IR.68 is analogous to Table IR.67, 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 IR.67, the costs in Table IR.68 assume that a nitrogen-based land application to forages is chosen. Tables IR.67 and IR.68 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 IR.67 and IR.68 that retrofits of farms with flush systems of manure removal are predicted to be more costly than those with pit-recharge systems for all size of farm/type of operation categories.

6. Summary

The ISSUES RENEW technology was installed on the Vestal 1 and 2 Farms. Based on a one-day sample, it treated 75,398 gallons per day of effluent from eight flush type finishing barns each with1,224-head capacity. Performance evaluation occurred between August, 2003 and November, 2004. The system includes an equalization tank and lift station, a concentrator tank, a covered mesophilic digester with heated influent, a polishing and storage pond (formerly a lagoon), and an aeration pond. The system also included a water re-use system and a microturbine electricity generator that were excluded from this analysis. A variety of operating protocols were tested during that period. Samples of effluent flow, biogas production (20 days), and nutrient concentrations were provided to the cost and returns team and used to model the system. The effluent from the aeration pond had 75% less TKN and 86% less P than the barn effluent (Table IR.3.). The initial investment predicted for installation of the RENEW system on a standardized 4,320-head flush type finishing farm is $353,487. The annual operating costs for the system are predicted at $19,607 and total annualized cost of the system is predicted at $134.60 per 1,000 pounds Steady State Live Weight per year over a 10-year amortization period. A considerable range of predicted costs ($79 to $766 per 1,000 pounds SSLW per year) occurs across different sizes and types of farms reflecting

predicted economies of size and scale in construction of the system and reflecting differences in COD loading per 1,000 pounds SSLW across different types of farms.

References

Bull, Leonard S. “Innovative Sustainable Systems Utilizing Economical Solutions (ISSUES) Final Report.” August, 2005.

Cavanaugh and Associates. Data provided and/or personal communication with Jason Wilson. January-March, 2005.

(Dugba(a)) Dugba, Prince. Environmental Engineer. Smithfield Foods. Personal Communication. March-December, 2005.

(Dugba(b)) Dugba, Prince. “Innovative Permit Application for the RENEW System for Vestal Farms.” October 4, 2002.

Hansen, R.W. “Methane Generation from Livestock Wastes.” October, 2004. Available at: http://www/ext.colostate.edu/pubs/farmmgt/05002.html

Worley-Davis, Lynn. North Carolina State University. Animal and Poultry Waste Management Center. Data provided and/or personal communication. March-October, 2005.

Tables IR.1 through IR.4: Performance Data and Mass Balance Tables for the ISSUES RENEW Technology as Constructed and Demonstrated at Vestal Farm

Table IR.1. Summary of Wastewater Flow* through the ISSUES RENEW Technology (Worley-Davis)

Description	Volume (gallons per day)
Volume pumped from Vestal 1 and Vestal 2 houses to equalization tank	76,840
Volume pumped from equalization tank to clarifier/thickener	72,748
Volume discharged from the equalization tank to polishing/storage basin	4,092
Volume pumped from the clarifier/thickener to mesophilic digester	34,050
Volume discharged from the clarifier/thickener to polishing/storage basin	38,698
Volume pumped from polishing/storage basin to aerobic digester	53,839
Volume pumped as flush water from aerobic digester to Vestal 1	30,780
Volume pumped as flush water from aerobic digester to Vestal 2	23,760
Volume to be land applied or sent to water-reuse system	22,300

* This summary was based on system flow data collected on 2/2/05 at Vestal Farm

Table IR.2. Nutrient Content of the Wastewater Stream at Various Sampling Points for the ISSUES RENEW Technology (Bull, et. al)

Sampling Point	TKN (ppm)	P (ppm)	K (ppm)	DM %
House effluent	959	244	782	1.4%
Clarifier (liquid)	889	53	No data	0.58%
Clarifier (solid)	1,159	158	No data	0.82%
Mesophilic digester effluent	835	120	565	0.31%
Polishing/storage basin	464	52	538	0.20%
Aerobic digester influent	459	47	539	0.16%
Aerobic digester effluent	346	46	546	0.15%

Note: These nutrient analyses are based on the average of 15 sampling events taken between the dates of 8/03 and 11/04 at Vestal Farm.

Table IR.3. Mass Balance of Nutrients for the ISSUE RENEW Technology (Bull, et. al)

Sampling Point	TKN (lbs. / day)	P (lbs. / day)
House effluent	621.3	158.0
Mesophilic digester influent	331.8	45.3
Mesophilic digester effluent	239.1	34.4
% reduction in mesophilic digester	27.9%	24.1%
Aerobic digester influent	207.8	21.3
Aerobic digester effluent	158.7	21.1
% reduction in aerobic digester	23.6%	0.94%
% total reduction for technology*	**74.5%**	**86.6%**

* This % reduction does not include the water re-use component of the ISSUE RENEW technology. It represents the percent reduction in nutrient content from the house effluent to the house influent (as pumped from the aerobic digester) or, alternatively, the percent reduction in nutrient content from the house effluent to land applied liquid from the aerobic digester.

Table IR.4. Biogas Production at Vestal Farm for the Month of August, 2004 (Bull, et. al)

Date	Biogas Production ($ft.^3$)	Methane Production* ($ft.^3$)	Methane Production Rate** ($ft.^3$ / lb. VS loaded)
8/6/04	21,693.60	15,185.52	2.75
8/7/04	25,740.00	18,018.00	3.26
8/8/04	39,906.72	27,934.70	5.06
8/9/04	42,744.96	29,921.47	5.42
8/11/04	39,656.16	27,759.31	5.03
8/14/04	43,606.08	30,524.26	5.53
8/16/04	44,953.92	31,467.74	5.70
8/17/04	43,784.64	30,649.25	5.55
8/18/04	43,421.76	30,395.23	5.51
8/19/04	43,797.60	30,658.32	5.55
8/20/04	44,763.84	31,334.69	5.68
8/21/04	46,680.48	32,676.34	5.92
8/22/04	47,204.64	33,043.25	5.99
8/23/04	46,012.32	32,208.62	5.83
8/24/04	46,166.40	32,316.48	5.85
8/25/04	46,229.76	32,360.79	5.86
8/26/04	46,657.44	32,660.21	5.92
8/27/04	45,489.60	31,842.72	5.77
8/28/04	41,914.08	29,339.86	5.32
8/29/04	37,149.12	26,004.38	4.71
Total	**837,573.12**	**586,301.18**	**5.31**
Average	**41,878.66**	**29,315.06**	**5.31**

* Assuming the biogas at Vestal Farm contains 70% methane

** Based on 6,900 lbs. / day of total solids (TS) containing 80% volatile solids (VS) (or 5,520 lbs. / day of VS) being loaded into the mesophilic digester (Dugba(b))

Tables IR.5 through IR.12: Invoiced Cost Tables for the ISSUES RENEW Technology as Constructed at Vestal Farm

Table IR.5. Invoiced Equalization Tank Costs for the ISSUES RENEW Technology (Cavanaugh)

Component	Invoiced Cost
Tank cleaning	$2,468.25
Submersible pumps (2)	$1,485.00
Valve and actuator	$447.38
Impeller pump (5-HP)	$1,300.00
Motor (5-HP)	$674.55
Plumbing (labor and materials)	$5,256.46
Electrical (labor and materials)	$4,412.66
Industrial maintenance	$10,234.26
Total Invoiced Costs of Equalization Tank	**$26,278.56**

Table IR.6. Invoiced Clarifier/Thickener Costs for the ISSUES RENEW Technology (Cavanaugh)

Component	Invoiced Cost
Solids concentrator	$56,900.00
Concrete pad	$3,625.00
Submersible pump	$625.00
Centrifugal pump	$645.00
Plumbing (labor and materials)	$5,256.46
Electrical (labor and materials)	$4,412.66
Industrial maintenance	$10,234.26
Total Invoiced Costs of Clarifier/Thickener	**$81,698.36**

Table IR.7. Invoiced Mesophilic Digester Costs for the ISSUES RENEW Technology (Cavanaugh)

Component	Invoiced Cost
Cover (40-mil. HDPE)	$29,462.00
Gas flowmeter (with accumulator)	$2,964.00
Controls	$1,822.45
Wetwell (5-ft. diameter)	$889.00
Start-up service	$6,000.00
Pumps (5)	$4,578.72
Plumbing (labor and materials)	$5,256.46
Electrical (labor and materials)	$4,412.66
Industrial maintenance	$10,234.26
Total Invoiced Costs of Mesophilic Digester	**$65,619.55**

Table IR.8. Invoiced Micro-Turbine/Heating System Costs for the ISSUES RENEW Technology (Cavanaugh)

Component	Invoiced Cost
Micro-turbine system (including heat exchanger and flare)	$182,500.00
Carports	$4,209.00
Regulator and solenoid valve	$1,071.75
Industrial maintenance	$10,234.26
Total Invoiced Costs of Micro-Turbine/Heating System	**$198,015.01**

Table IR.9. Invoiced Aerobic Digester Costs for the ISSUES RENEW Technology (Cavanaugh)

Component	Invoiced Cost
Fine bubble diffusion system (blower and Air-Jammer)	$44,100.00
Submersible pumps (2)	$1,485.00
Regenerative blower	$664.65
Submersible sewage pumps (2)	$1,192.65
Plumbing (labor and materials)	$5,256.46
Electrical (labor and materials)	$4,412.66
Industrial maintenance	$10,234.26
Total Invoiced Costs of Aerobic Digester	**$67,345.68**

Table IR.10. Invoiced Water Re-Use System Costs for the ISSUES RENEW Technology (Cavanaugh)

Component	Invoiced Cost
Reverse osmosis (RO) unit	$23,200.00
Ultra-Violet disinfection units	$12,230.00
Sand filter	$8,890.00
Ultrafilter membrane system	$8,910.00
Pumps (8)	$2,844.74
Plumbing (labor and materials)	$5,256.46
Electrical (labor and materials)	$4,412.66
Industrial maintenance	$10,234.26
Freight	$1,800.00
Concrete pad	$380.00
Valve and actuator	$447.37
Compressor, regulators, pressure hose	$1,345.67
Timer	$80.50
Solenoid valve	$200.50
450-lb. drum	$378.10
Chemical metering pump	$798.75
2-1,000 gallon tanks	$748.00
Total Invoiced Costs of Water Re-Use System	**$82,157.01**

Table IR.11. Invoiced Miscellaneous Costs for the ISSUES RENEW Technology (Cavanaugh)

Component	Invoiced Cost
Lab/control system	$14,939.23
Lab supplies	$2,836.60
Elmer Environmental	$18,190.92
Brown's Services (repairs and retrofit)	$1,861.38
HDPE pipe	$310.00
Solid waste removal	$759.64
Relays and sockets	$48.25
Total Miscellaneous Invoiced Costs	**$38,946.02**

Table IR.12. Summary of Invoiced Costs for the ISSUES RENEW Technology

Unit Process	Invoiced Cost	% of Total Invoiced Cost
Equalization tank	$26,278.56	4.69%
Clarifier/thickener	$81,698.36	14.59%
Mesophilic digester	$65,619.55	11.72%
Micro-turbine/heating system	$198,015.01	35.36%
Aerobic digester	$67,345.68	12.02%
Water re-use system	$82,157.01	14.67%
Lab/control system	$17,775.83	3.17%
Consulting fees	$18,190.92	3.25%
Miscellaneous invoices	$2,979.27	0.53%
Total Invoiced Costs	**$560,060.19**	**100.00%**

Table IR.13 through IR.14: Modified Invoiced Construction Costs for the ISSUES RENEW Technology as Constructed at Vestal Farm

Table IR.13. Summary of Modified Costs for the ISSUES RENEW Technology

Unit Process	System Component	Invoiced Cost	Modified Cost	Reason for Modification
Equalization tank	Tank cleaning	$2,468.25	$0.00	Replaced by maintenance cost assumption in the model
All unit processes	Industrial maintenance	$61,405.56	$0.00	Replaced by maintenance cost assumption in the model
Water re-use	Freight	$1,800.00	$0.00	Replaced by overhead/engineering services in the model
Miscellaneous	Lab/lab supplies/control system	$17,775.83	$7,469.62	Cost of lab/lab supplies research-related
Miscellaneous	Consulting fees (Elmer Environmental)	$18,190.92	$0.00	Replaced by overhead/engineering services in the model
Miscellaneous	Solid waste removal	$759.64	$0.00	Replaced by sludge removal assumption in the model

Table IR.14. Summary of Modified Invoiced Construction Costs for the ISSUES RENEW Technology

Unit Process	Invoiced Cost	% of Total Invoiced Cost
Equalization tank	$13,576.05	2.92%
Clarifier/thickener	$71,464.10	15.36%
Mesophilic digester	$55,385.29	11.91%
Micro-turbine/heating system	$187,780.75	40.37%
Aerobic digester	$57,111.42	12.28%
Water re-use system	$70,122.75	15.07%
Lab/control system	$7,469.62	1.61%
Consulting fees	$0.00	0.00%
Miscellaneous invoices	$2,219.63	0.48%
Total Modified Invoiced Costs	**$465,129.61**	**100.00%**

Tables IR.15: Modeling Assumptions for Standardized Cost Models

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

Equalization tank volume	modeled to hold 1/8 of the daily flush volume from the houses (3-hour retention time)
Clarifier volume	10,000 gallons
Retention time in clarifier	3 hours (8 batches per day)
% of wastewater volume pumped from clarifier to mesophilic digester*	46.80%
% of wastewater volume pumped from clarifier to storage basin*	53.20%
Mesophilic digester hydraulic retention time**	25 days
Mesophilic digester depth	15 feet
Mesophilic digester liner cost	$0.72 / square foot
Mesophilic digester cover cost	$0.87 / square foot
Aerobic digester hydraulic retention time**	10 days
Aerobic digester depth	15 feet
Aerobic digester liner cost	$0.77 / square foot
Blower operating time per day	24 hours
Air-Jammer operating time per day	0 hours***
Blower HP****	modeled using COD production rates and loading rates into the aerobic digester

* Based on recorded flow volumes at Vestal Farm (Worley-Davis)

** Based on specifications found in the permit application (Dugba(b))

*** It was found that the Air-Jammer was not needed to supply oxygen in the aerobic digester (the blower was sufficient) (Dugba(a)), so the Air-Jammer was not operated in the standardized costs and returns model. In the actual costs and returns model, the Air-Jammer is assumed to be operated for 4 hours per day.

**** A 20-HP blower was used in the aerobic digester at Vestal Farm and sufficiently aerated the wastewater stream produced by 9,792 finishing head.

Tables IR.16 through IR.26: Costs and Returns Estimates Based on Actual Cost and Performance Data for ISSUES RENEW On-Farm System: 9,792-Head Feeder to Finish Operation with Flush System

Table IR.16. ISSUES RENEW Technology Assumptions and Predicted Total Annualized Costs: Actual Costs and Performance Data

Number of Animals	**9,792**		
Type of Operation	**Feeder-Finish**		
Barn Cleaning System	**Flush System**		
Annualized Cost ($ / Year)			
Total Annualized Cost		Forages	Row Crops
	If Nitrogen-Based Application	**$ 206,210.56**	**$ 204,722.90**
	If Phosphorus-Based Application	**$ 200,601.84**	**$ 197,048.44**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 155.99**	**$ 154.87**
	If Phosphorus-Based Application	**$ 151.75**	**$ 149.06**

Note: Daily volume discharged from barns is 75,398 gallons / day including recharge liquid.
SSLW equals 1,321,920 pounds.

Table IR.17. ISSUES RENEW Technology Manure Evacuation and Lift Station Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Retrofit and Hardware	$ 1,861.38	$ 277.40
Plumbing (labor and materials)	$ 4,380.38	$ 652.81
Electrical (labor and materials)	$ 3,677.22	$ 548.01
Pump	$ 645.00	$ 250.28
Piping	$ 310.00	$ 46.20
Contractor & Engineering Services & Overhead	$ 4,686.68	$ 698.45
Total Construction Cost	$ 13,699.28	$ 2,195.75
Electric Power Cost		$ 613.18
Maintenance Cost		$ 236.83
Property Taxes		$ 48.63
Total Operating Costs		$ 898.64
TOTAL ANNUALIZED COST OF MANURE EVACUATION AND LIFT STATION		**$ 3,094.39**

Table IR.18. ISSUES RENEW Technology Equalization Tank Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Tank	$ 13,118.75	$ 1,955.08
Submersible Pumps	$ 1,485.00	$ 576.23
Impeller Pump and Motor	$ 1,974.55	$ 766.19
Plumbing (labor and materials)	$ 4,380.38	$ 652.81
Electrical (labor and materials)	$ 3,677.22	$ 548.01
Valve and Actuator	$ 447.38	$ 66.67
Contractor & Engineering Services & Overhead	$ 10,810.89	$ 1,611.14
Total Construction Cost	$ 35,894.16	$ 6,176.14
Electric Power Cost		$ 384.42
Maintenance Cost		$ 605.45
Property Taxes		$ 127.42
Total Operating Cost		$ 1,117.30
TOTAL ANNUALIZED COST OF EQUALIZATION TANK		**$ 7,293.44**

Table IR.19. ISSUES RENEW Technology Clarifier Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Solids Concentrator	$ 56,900.00	$ 8,479.78
Concrete Pad	$ 3,625.00	$ 540.23
Pump (centrifugal)	$ 645.00	$ 250.28
Pump (submersible)	$ 625.00	$ 242.52
Plumbing (labor and materials)	$ 4,380.38	$ 652.81
Electrical (labor and materials)	$ 3,677.22	$ 548.01
Contractor & Engineering Services & Overhead	$ 30,106.47	$ 4,486.75
Total Construction Cost	$ 99,959.07	$ 15,200.38
Electric Power Cost		$ 344.41
Maintenance Cost		$ 1,435.15
Property Taxes		$ 354.85
Total Operating Cost		$ 2,134.41
TOTAL ANNUALIZED COST OF CLARIFIER		**$ 17,334.80**

Table IR.20. ISSUES RENEW Technology Mesophilic Digester Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Excavation	$ 25,094.00	$ 3,739.75
Liner (40-mil. HDPE)	$ 56,447.00	$ 8,412.27
Cover (40-mil. HDPE)	$ 54,462.00	$ 8,116.44
Gas Flowmeter	$ 2,964.00	$ 441.72
Plumbing (labor and materials)	$ 4,380.38	$ 652.81
Electrical (labor and materials)	$ 3,677.22	$ 548.01
Pumps	$ 4,578.72	$ 1,776.70
Controls	$ 1,822.45	$ 271.60
Wetwell	$ 889.00	$ 132.49
Start-up Service	$ 6,000.00	$ 894.18
Mixing Pole	$ 200.00	$ 29.81
Contractor & Engineering Services & Overhead	$ 69,181.87	$ 10,310.14
Total Construction Cost	$ 229,696.63	$ 35,325.90
Electric Power Cost		$ 458.85
Maintenance Cost		$ 2,721.78
Property Taxes		$ 815.42
Total Operating Cost		$ 3,996.05
TOTAL ANNUALIZED COST OF MESOPHILIC DIGESTER		**$ 39,321.96**

Table IR.21. ISSUES RENEW Technology Micro-turbine/Heating System Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Micro-turbine (micro-turbine and heat exchanger)	$ 182,500.00	$ 27,197.88
Carports	$ 4,209.00	$ 627.27
Regulator and Solenoid Valve	$ 1,071.75	$ 159.72
Contractor & Engineering Services & Overhead	$ 80,933.50	$ 12,061.48
Total Construction Cost	$ 268,714.25	$ 40,046.35
Maintenance Cost		$ 9,230.62
Property Taxes		$ 953.94
Total Operating Cost		$ 10,184.55
TOTAL ANNUALIZED COST OF MICRO-TURBINE/HEATING SYSTEM		**$ 50,230.90**

Table IR.22. ISSUES RENEW Aerobic Digester Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Excavation	$ 14,056.00	$ 2,094.76
Liner (40-mil. HDPE)	$ 34,601.00	$ 5,156.57
Fine Bubble Diffusion System (blower and Air-Jammer)	$ 44,100.00	$ 17,112.28
Plumbing (labor and materials)	$ 4,380.38	$ 652.81
Electrical (labor and materials)	$ 3,677.22	$ 548.01
Pumps	$ 1,192.65	$ 462.79
Regenerative Blower	$ 664.65	$ 257.91
Contractor & Engineering Services & Overhead	$ 44,251.59	$ 6,594.79
Total Construction Cost	$ 146,923.49	$ 32,879.91
Electric Power Cost		$ 13,792.92
Maintenance Cost		$ 3,151.04
Property Taxes		$ 521.58
Total Operating Cost		$ 17,465.54
TOTAL ANNUALIZED COST OF AEROBIC DIGESTER		**$ 50,345.45**

Table IR.23. ISSUES RENEW Technology Water Re-use System Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Reverse Osmosis (RO) Unit	$ 23,200.00	$ 9,002.38
Ultra-violet Disinfection Units	$ 12,230.00	$ 1,822.63
Sand Filter	$ 8,890.00	$ 1,324.87
Pumps	$ 2,844.74	$ 1,103.85
Compressor, Regulators, and Pressure Hose	$ 1,345.67	$ 200.54
Plumbing (labor and materials)	$ 4,380.38	$ 652.81
Electrical (labor and materials)	$ 3,677.22	$ 548.01
Solenoid Valve	$ 200.50	$ 29.88
450-lb. Drum	$ 378.10	$ 56.35
2-1,000 Gallon Tanks	$ 748.00	$ 111.47
Valve and Actuator	$ 447.38	$ 66.67
Timer	$ 80.50	$ 31.24
Concrete Pad	$ 380.00	$ 56.63
Ultra-filter Membrane System	$ 8,910.00	$ 1,327.85
Contractor & Engineering Services & Overhead	$ 29,184.08	$ 4,349.29
Total Construction Cost	$ 96,896.56	$ 20,684.48
Electric Power Cost		$ 3,070.34
Polymer Cost		$ 17,600.00
Maintenance Cost		$ 2,138.01
Property Taxes		$ 343.98
Total Operating Cost		$ 23,152.33
TOTAL ANNUALIZED COST OF WATER RE-USE SYSTEM		**$ 43,836.82**

Table IR.24. ISSUES RENEW Technology Control System Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Control System	$ 7,469.62	$ 1,113.19
Contractor & Engineering Services & Overhead	$ 3,219.40	$ 479.79
Total Construction Cost	$ 10,689.02	$ 1,592.98
Maintenance Cost		$ 149.39
Property Taxes		$ 37.95
Total Operating Cost		$ 187.34
TOTAL ANNUALIZED COST CONTROL SYSTEM		**$ 1,780.32**

TOTAL CONSTRUCTION COST OF ISSUES RENEW TECHNOLOGY	**$ 902,472.47**
TOTAL OPERATING COST OF ISSUES RENEW TECHNOLOGY	**$ 59,136.17**
TOTAL ANNUALIZED COST OF ISSUES RENEW TECHNOLOGY WITHOUT LAND APPLICATION	**$ 213,238.07**

Table IR.25. ISSUES RENEW Technology 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	$	11,386.10	$	6,363.92
If Phosphorus-Based Application	$	15,090.17	$	1,571.45
Acres Needed For Assimilation		**Forages**		**Row Crops**
If Nitrogen-Based Application		31.48		102.03
If Phosphorus-Based Application		50.21		134.15
Opportunity Cost of Land		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	1,888.78		-
If Phosphorus-Based Application	$	3,012.68		-
Irrigation Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	9,497.32	$	10,125.88
If Phosphorus-Based Application	$	8,923.57	$	11,353.94
Savings From Not Having To Buy Fertilizer		**Forages**		**Row Crops**
If Nitrogen-Based Application		-	$	(3,761.96)
If Phosphorus-Based Application		-	$	(9,782.48)
Extra Fertilizer Purchase Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application		-		-
If Phosphorus-Based Application	$	3,153.92		-

Note: 6,326,231 gallons / year of effluent land applied at Vestal Farm.

Table IR.26. 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	198,190.08	56,793.60	97,430.40
Nutrients Entering Mesophilic Digester	105,714.59	16,294.08	No data
Nutrients Exiting Mesophilic Digester	76,188.50	12,380.24	No data
Nutrients Entering Aerobic Digester	66,204.76	7,652.23	No data
Nutrients Exiting Aerobic Digester	50,553.96	7,580.30	No data
Nutrients Entering Water Re-use System	10,552.44	1,402.93	No data
Land Applied as Lagoon Effllluent	18,277.11	2,429.91	28,841.92

* Nutrient mass balances were not available for potassium

Tables IR.27 through IR.36: Costs and Returns Estimates Based on Standardized Cost and Performance Data for ISSUES RENEW Technology: 4,320-Head Feeder to Finish Operation with Flush System

Table IR.27. ISSUES RENEW Technology 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 System**		
Annualized Cost ($ / Year)			
Total Annualized Cost		Forages	Row Crops
	If Nitrogen-Based Application	**$ 78,497.73**	**$ 76,737.11**
	If Phosphorus-Based Application	**$ 77,126.37**	**$ 72,138.03**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 134.60**	**$ 131.58**
	If Phosphorus-Based Application	**$ 132.25**	**$ 123.69**

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

Table IR.28. ISSUES RENEW Technology Manure Evacuation and Lift Station Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush)

Component	Total Cost	Annualized Cost
Waste Evacuation	$ 9,100.00	$ 1,357.66
Concrete Lift Station	$ 604.90	$ 90.15
Switches and Brackets	$ 126.50	$ 18.85
Pump	$ 1,734.20	$ 672.93
Piping	$ 145.67	$ 21.71
Lift Station Accessories	$ 7,715.73	$ 1,149.87
Contractor & Engineering Services & Overhead	$ 8,377.35	$ 1,248.47
Total Construction Cost	$ 27,814.35	$ 4,559.64
Electric Power Cost		$ 272.48
Maintenance Cost		$ 440.77
Property Taxes		$ 98.74
Total Operating Cost		$ 811.99
TOTAL ANNUALIZED COST OF MANURE EVACUATION AND LIFT STATION		**$ 5,371.62**

Table IR.29. ISSUES RENEW Technology Equalization Tank Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush)

Component	Total Cost	Annualized Cost
Tank	$ 9,500.00	$ 1,415.78
Submersible Pumps	$ 1,485.00	$ 576.23
Impeller Pump and Motor	$ 1,974.55	$ 766.19
Plumbing (labor and materials)	$ 1,932.52	$ 288.00
Electrical (labor and materials)	$ 1,622.30	$ 241.77
Valve and Actuator	$ 447.38	$ 66.67
Contractor & Engineering Services & Overhead	$ 7,310.51	$ 1,089.48
Total Construction Cost	$ 24,272.26	$ 4,444.13
Electric Power Cost		$ 170.83
Maintenance Cost		$ 443.02
Property Taxes		$ 86.17
Total Operating Cost		$ 700.02
TOTAL ANNUALIZED COST OF EQUALIZATION TANK		**$ 5,144.14**

Table IR.30. ISSUES RENEW Technology Clarifier Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush)

Component	Total Cost	Annualized Cost
Solids Concentrator	$ 56,900.00	$ 8,479.78
Concrete Pad	$ 3,625.00	$ 540.23
Pump (centrifugal)	$ 645.00	$ 250.28
Pump (submersible)	$ 625.00	$ 242.52
Plumbing (labor and materials)	$ 1,932.52	$ 288.00
Electrical (labor and materials)	$ 1,622.30	$ 241.77
Contractor & Engineering Services & Overhead	$ 28,165.77	$ 4,197.53
Total Construction Cost	$ 93,515.60	$ 14,240.12
Electric Power Cost		$ 153.05
Maintenance Cost		$ 1,345.10
Property Taxes		$ 331.98
Total Operating Cost		$ 1,830.12
TOTAL ANNUALIZED COST OF CLARIFIER		**$ 16,070.24**

Table IR.31. ISSUES RENEW Technology Mesophilic Digester Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush)

Component	Total Cost	Annualized Cost
Excavation	$ 6,367.22	$ 948.90
Liner (40-mil. HDPE)	$ 13,914.70	$ 2,073.70
Cover (40-mil. HDPE)	$ 5,633.57	$ 839.57
Gas Flowmeter	$ 2,964.00	$ 441.72
Heat Exchanger	$ 36,204.50	$ 5,395.54
Plumbing (labor and materials)	$ 1,932.52	$ 288.00
Electrical (labor and materials)	$ 1,622.30	$ 241.77
Pumps	$ 4,578.72	$ 1,776.70
Controls	$ 1,822.45	$ 271.60
Wetwell	$ 889.00	$ 132.49
Start-up Service	$ 6,000.00	$ 894.18
Mixing Pole	$ 200.00	$ 29.81
Contractor & Engineering Services & Overhead	$ 35,397.59	$ 5,275.29
Total Construction Cost	$ 117,526.58	$ 18,609.26
Electric Power Cost		$ 203.90
Maintenance Cost		$ 1,528.60
Property Taxes		$ 417.22
Total Operating Cost		$ 2,149.72
TOTAL ANNUALIZED COST OF MESOPHILIC DIGESTER		**$ 20,758.98**

Table IR.32. ISSUES RENEW Technology Flare Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush)

Component	Total Cost	Annualized Cost
Flare	$ 3,000.00	$ 447.09
Contractor & Engineering Services & Overhead	$ 1,293.00	$ 192.70
Total Construction Cost	$ 4,293.00	$ 639.78
Maintenance Cost		$ 60.00
Property Taxes		$ 15.24
Total Operating Cost		$ 75.24
TOTAL ANNUALIZED COST OF FLARE		**$ 715.02**

Table IR.33. ISSUES RENEW Aerobic Digester Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush)

Component	Total Cost	Annualized Cost
Excavation	$ 11,968.21	$ 1,783.62
Liner (40-mil. HDPE)	$ 15,837.59	$ 2,360.27
Fine Bubble Diffusion System (blower and Air-Jammer)	$ 19,455.74	$ 7,549.48
Plumbing (labor and materials)	$ 1,932.52	$ 288.00
Electrical (labor and materials)	$ 1,622.30	$ 241.77
Pumps	$ 1,192.65	$ 462.79
Regenerative Blower	$ 664.65	$ 257.91
Contractor & Engineering Services & Overhead	$ 22,702.35	$ 3,383.32
Total Construction Cost	$ 75,376.02	$ 16,327.15
Electric Power Cost		$ 12,131.40
Maintenance Cost		$ 1,453.50
Property Taxes		$ 267.58
Total Operating Cost		$ 13,852.48
TOTAL ANNUALIZED COST OF AEROBIC DIGESTER		**$ 30,179.63**

Table IR.34. ISSUES RENEW Technology Control System Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush)

Component	Total Cost	Annualized Cost
Control System	$ 7,469.62	$ 1,113.19
Contractor & Engineering Services & Overhead	$ 3,219.40	$ 479.79
Total Construction Cost	$ 10,689.02	$ 1,592.98
Maintenance Cost		$ 149.39
Property Taxes		$ 37.95
Total Operating Cost		$ 187.34
TOTAL ANNUALIZED COST OF CONTROL SYSTEM		**$ 1,780.32**

TOTAL CONSTRUCTION COST OF ISSUES RENEW TECHNOLOGY	**$**	**353,486.82**
TOTAL OPERATING COST OF ISSUES RENEW TECHNOLOGY	**$**	**19,606.90**
TOTAL ANNUALIZED COST OF ISSUES RENEW TECHNOLOGY WITHOUT LAND APPLICATION	**$**	**80,019.96**

Table IR.35. ISSUES RENEW Technology Predicted Liquid Application Costs for Four Land Application Scenarios: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush)

Annual Cost of Applying Lagoon Effluent	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 10,383.42	$ 6,050.14
If Phosphorus-Based Application	$ 12,553.96	$ 2,595.51
Acres Needed For Assimilation	**Forages**	**Row Crops**
If Nitrogen-Based Application	22.13	71.72
If Phosphorus-Based Application	35.30	94.30
Opportunity Cost of Land	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 1,327.71	-
If Phosphorus-Based Application	$ 2,117.75	-
Irrigation Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 9,055.71	$ 8,694.59
If Phosphorus-Based Application	$ 8,219.18	$ 9,472.06
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	$ (2,644.45)
If Phosphorus-Based Application	-	$ (6,876.55)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	-
If Phosphorus-Based Application	$ 2,217.03	-

Note: 4,446,995 gallons / year of effluent modeled to be land applied.

Table IR.36. Summary and Mass Balance of Generated and Land Applied Nutrients: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush)

Nutrient Balance	**Nitrogen (lbs/ year)**	**Phosphorus (lbs / year)**	**Potassium* (lbs / year)**
Generated At Barn	87,436.80	25,056.00	42,984.00
Nutrients Entering Mesophilic Digester	46,638.79	7,188.57	No data
Nutrients Exiting Mesophilic Digester	33,612.58	5,461.87	No data
Nutrients Entering Aerobic Digester	29,207.98	3,375.98	No data
Nutrients Exiting Aerobic Digester	22,303.22	3,344.25	No data
Nutrients Entering Water Re-use System	0	0	0
Land Applied in Lagoon Effluent	12,847.81	1,708.09	20,274.30

* Nutrient mass balance data were not available for potassium

Tables IR.37 through IR.46: Costs and Returns Estimates Based on Standardized Cost and Performance Data for ISSUES RENEW Technology: 4,320-Head Feeder to Finish Operation with Pit-Recharge System

Table IR.37. ISSUES RENEW Technology Assumptions and Total Annualized Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge)

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	**$ 73,441.25**	**$ 71,680.63**
	If Phosphorus-Based Application	**$ 72,069.88**	**$ 67,081.54**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 125.93**	**$ 122.91**
	If Phosphorus-Based Application	**$ 123.58**	**$ 115.02**

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

Table IR.38. ISSUES RENEW Technology Manure Evacuation and Lift Station Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge)

Component	Total Cost	Annualized Cost
Waste Evacuation	$ 4,555.00	$ 678.83
Concrete Lift Station	$ 604.90	$ 90.15
Switches and Brackets	$ 126.50	$ 18.85
Pump	$ 1,734.20	$ 672.93
Piping	$ 145.67	$ 21.71
Lift Station Accessories	$ 7,715.73	$ 1,149.87
Contractor & Engineering Services & Overhead	$ 6,414.14	$ 955.90
Total Construction Cost	$ 21,296.14	$ 3,588.23
Electric Power Cost		$ 230.65
Maintenance Cost		$ 349.67
Property Taxes		$ 75.60
Total Operating Cost		$ 655.91
TOTAL ANNUALIZED COST OF MANURE EVACUATION AND LIFT STATION		**$ 4,244.15**

Table IR.39. ISSUES RENEW Technology Equalization Tank Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge)

Component	Total Cost	Annualized Cost
Tank	$ 9,500.00	$ 1,415.78
Submersible Pumps	$ 1,485.00	$ 576.23
Impeller Pump and Motor	$ 1,974.55	$ 766.19
Plumbing (labor and materials)	$ 1,635.83	$ 243.79
Electrical (labor and materials)	$ 1,373.24	$ 204.65
Valve and Actuator	$ 447.38	$ 66.67
Contractor & Engineering Services & Overhead	$ 7,075.29	$ 1,054.43
Total Construction Cost	$ 23,491.29	$ 4,327.74
Electric Power Cost		$ 144.60
Maintenance Cost		$ 432.11
Property Taxes		$ 83.39
Total Operating Cost		$ 660.10
TOTAL ANNUALIZED COST OF EQUALIZATION TANK		**$ 4,987.84**

Table IR.40. ISSUES RENEW Technology Clarifier Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge)

Component	Total Cost	Annualized Cost
Solids Concentrator	$ 56,900.00	$ 8,479.78
Concrete Pad	$ 3,625.00	$ 540.23
Pump (centrifugal)	$ 645.00	$ 250.28
Pump (submersible)	$ 625.00	$ 242.52
Plumbing (labor and materials)	$ 1,635.83	$ 243.79
Electrical (labor and materials)	$ 1,373.24	$ 204.65
Contractor & Engineering Services & Overhead	$ 27,930.55	$ 4,162.48
Total Construction Cost	$ 92,734.62	$ 14,123.73
Electric Power Cost		$ 129.55
Maintenance Cost		$ 1,334.18
Property Taxes		$ 329.21
Total Operating Cost		$ 1,792.94
TOTAL ANNUALIZED COST OF CLARIFIER		**$ 15,916.67**

Table IR.41. ISSUES RENEW Technology Mesophilic Digester Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge)

Component	Total Cost	Annualized Cost
Excavation	$ 5,398.94	$ 804.60
Liner (40-mil. HDPE)	$ 12,046.73	$ 1,795.32
Cover (40-mil. HDPE)	$ 4,777.03	$ 711.92
Gas Flowmeter	$ 2,964.00	$ 441.72
Heat Exchanger System	$ 30,646.21	$ 4,567.19
Plumbing (labor and materials)	$ 1,635.83	$ 243.79
Electrical (labor and materials)	$ 1,373.24	$ 204.65
Pumps	$ 4,578.72	$ 1,776.70
Controls	$ 1,822.45	$ 271.60
Wetwell	$ 889.00	$ 132.49
Start-up Service	$ 6,000.00	$ 894.18
Mixing Pole	$ 200.00	$ 29.81
Contractor & Engineering Services & Overhead	$ 31,175.16	$ 4,646.02
Total Construction Cost	$ 103,507.31	$ 16,519.97
Electric Power Cost		$ 172.60
Maintenance Cost		$ 1,352.03
Property Taxes		$ 367.45
Total Operating Cost		$ 1,892.07
TOTAL ANNUALIZED COST OF MESOPHILIC DIGESTER		**$ 18,412.05**

Table IR.42. ISSUES RENEW Technology Flare Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge)

Component	Total Cost	Annualized Cost
Flare	$ 3,000.00	$ 447.09
Contractor & Engineering Services & Overhead	$ 1,293.00	$ 192.70
Total Construction Cost	$ 4,293.00	$ 639.78
Maintenance Cost		$ 60.00
Property Taxes		$ 15.24
Total Operating Cost		$ 75.24
TOTAL ANNUALIZED COST OF FLARE		**$ 715.02**

Table IR.43. ISSUES RENEW Aerobic Digester Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge)

Component	Total Cost	Annualized Cost
Excavation	$ 9,399.66	$ 1,400.83
Liner (40-mil. HDPE)	$ 13,488.47	$ 2,010.18
Fine Bubble Diffusion System (blower and Air-Jammer)	$ 19,455.74	$ 7,549.48
Plumbing (labor and materials)	$ 1,635.83	$ 243.79
Electrical (labor and materials)	$ 1,373.24	$ 204.65
Pumps	$ 1,192.65	$ 462.79
Regenerative Blower	$ 664.65	$ 257.91
Contractor & Engineering Services & Overhead	$ 20,347.62	$ 3,032.39
Total Construction Cost	$ 67,557.86	$ 15,162.02
Electric Power Cost		$ 12,109.98
Maintenance Cost		$ 1,395.60
Property Taxes		$ 239.83
Total Operating Cost		$ 13,745.41
TOTAL ANNUALIZED COST OF AEROBIC DIGESTER		**$ 28,907.43**

Table IR.44. ISSUES RENEW Technology Control System Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge)

Component	Total Cost	Annualized Cost
Control System	$ 7,469.62	$ 1,113.19
Contractor & Engineering Services & Overhead	$ 3,219.40	$ 479.79
Total Construction Cost	$ 10,689.02	$ 1,592.98
Maintenance Cost		$ 149.39
Property Taxes		$ 37.95
Total Operating Cost		$ 187.34
TOTAL ANNUALIZED COST OF CONTROL SYSTEM		**$ 1,780.32**

TOTAL CONSTRUCTION COST OF ISSUES RENEW TECHNOLOGY	**$**	**323,569.24**
TOTAL OPERATING COST OF ISSUES RENEW TECHNOLOGY	**$**	**19,009.02**
TOTAL ANNUALIZED COST OF ISSUES RENEW TECHNOLOGY WITHOUT LAND APPLICATION	**$**	**74,963.48**

Table IR.45. ISSUES RENEW Technology Predicted Liquid Application Costs for Four Land Application Scenarios: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge)

Annual Cost of Applying Lagoon Effluent		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	10,383.42	$	6,050.14
If Phosphorus-Based Application	$	12,553.96	$	2,595.51
Acres Needed For Assimilation		**Forages**		**Row Crops**
If Nitrogen-Based Application		22.13		71.72
If Phosphorus-Based Application		35.30		94.30
Opportunity Cost of Land		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	1,327.71		-
If Phosphorus-Based Application	$	2,117.75		-
Irrigation Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	9,055.71	$	8,694.59
If Phosphorus-Based Application	$	8,219.18	$	9,472.06
Savings From Not Having To Buy Fertilizer		**Forages**		**Row Crops**
If Nitrogen-Based Application		-	$	(2,644.45)
If Phosphorus-Based Application		-	$	(6,876.55)
Extra Fertilizer Purchase Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application		-		-
If Phosphorus-Based Application	$	2,217.03		-

Note: 4,446,995 gallons / year of effluent modeled to be land applied.

Table IR.46. Summary and Mass Balance of Generated and Land Applied Nutrients: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge)

Nutrient Balance	**Nitrogen (lbs/ year)**	**Phosphorus (lbs / year)**	**Potassium* (lbs / year)**
Generated At Barn	87,436.80	25,056.00	42,984.00
Nutrients Entering Mesophilic Digester	46,638.79	7,188.57	No data
Nutrients Exiting Mesophilic Digester	33,612.58	5,461.87	No data
Nutrients Entering Aerobic Digester	29,207.98	3,375.98	No data
Nutrients Exiting Aerobic Digester	22,303.22	3,344.25	No data
Nutrients Entering Water Re-use System	0	0	0
Land Applied in Lagoon Effluent	12,847.81	1,708.09	20,274.30

* Nutrient mass balance data were not available for potassium

Tables IR.47 through IR.56: Costs and Returns Estimates Based on Standardized Cost and Performance Data for ISSUES RENEW Technology: 8,800-Head Feeder to Finish Operation with Flush System

Table IR.47. ISSUES RENEW Technology Assumptions and Total Annualized Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush)

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	**$ 113,395.74**	**$ 110,762.17**
	If Phosphorus-Based Application	**$ 110,995.20**	**$ 101,515.32**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 95.45**	**$ 93.23**
	If Phosphorus-Based Application	**$ 93.43**	**$ 85.45**

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

Table IR.48. ISSUES RENEW Technology Manure Evacuation and Lift Station Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush)

Component	Total Cost	Annualized Cost
Waste Evacuation	$ 18,220.00	$ 2,715.32
Concrete Lift Station	$ 1,209.80	$ 180.30
Switches and Brackets	$ 253.00	$ 37.70
Pump	$ 3,468.40	$ 1,345.86
Piping	$ 291.34	$ 43.42
Lift Station Accessories	$ 15,431.46	$ 2,299.74
Contractor & Engineering Services & Overhead	$ 16,754.69	$ 2,496.94
Total Construction Cost	$ 55,628.69	$ 9,119.28
Electric Power Cost		$ 555.05
Maintenance Cost		$ 881.53
Property Taxes		$ 197.48
Total Operating Cost		$ 1,634.06
TOTAL ANNUALIZED COST OF MANURE EVACUATION AND LIFT STATION		**$ 10,753.34**

Table IR.49. ISSUES RENEW Technology Equalization Tank Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush)

Component	Total Cost	Annualized Cost
Tank	$ 13,118.00	$ 1,955.08
Submersible Pumps	$ 1,485.00	$ 576.23
Impeller Pump and Motor	$ 1,974.55	$ 766.19
Plumbing (labor and materials)	$ 3,936.62	$ 586.67
Electrical (labor and materials)	$ 3,304.69	$ 492.50
Valve and Actuator	$ 447.38	$ 66.67
Contractor & Engineering Services & Overhead	$ 10,459.07	$ 1,558.71
Total Construction Cost	$ 34,726.05	$ 6,002.05
Electric Power Cost		$ 347.98
Maintenance Cost		$ 589.13
Property Taxes		$ 123.28
Total Operating Cost		$ 1,060.39
TOTAL ANNUALIZED COST OF EQUALIZATION TANK		**$ 7,062.44**

Table IR.50. ISSUES RENEW Technology Clarifier Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush)

Component	Total Cost	Annualized Cost
Solids Concentrator	$ 56,900.00	$ 8,479.78
Concrete Pad	$ 3,625.00	$ 540.23
Pump (centrifugal)	$ 645.00	$ 250.28
Pump (submersible)	$ 625.00	$ 242.52
Plumbing (labor and materials)	$ 3,936.62	$ 586.67
Electrical (labor and materials)	$ 3,304.69	$ 492.50
Contractor & Engineering Services & Overhead	$ 29,754.65	$ 4,434.32
Total Construction Cost	$ 98,790.95	$ 15,026.30
Electric Power Cost		$ 311.76
Maintenance Cost		$ 1,418.83
Property Taxes		$ 350.71
Total Operating Cost		$ 2,081.29
TOTAL ANNUALIZED COST OF CLARIFIER		**$ 17,107.59**

Table IR.51. ISSUES RENEW Technology Mesophilic Digester Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush)

Component	Total Cost	Annualized Cost
Excavation	$ 12,820.73	$ 1,910.67
Liner (40-mil. HDPE)	$ 19,111.01	$ 2,848.10
Cover (40-mil. HDPE)	$ 11,340.04	$ 1,690.00
Gas Flowmeter	$ 2,964.00	$ 441.72
Heat Exchanger System	$ 73,749.91	$ 10,990.91
Plumbing (labor and materials)	$ 3,936.62	$ 586.67
Electrical (labor and materials)	$ 3,304.69	$ 492.50
Pumps	$ 4,578.72	$ 1,776.70
Controls	$ 1,822.45	$ 271.60
Wetwell	$ 889.00	$ 132.49
Start-up Service	$ 6,000.00	$ 894.18
Mixing Pole	$ 200.00	$ 29.81
Contractor & Engineering Services & Overhead	$ 60,649.10	$ 9,038.50
Total Construction Cost	$ 201,366.28	$ 31,103.85
Electric Power Cost		$ 415.36
Maintenance Cost		$ 2,571.29
Property Taxes		$ 714.85
Total Operating Cost		$ 3,701.50
TOTAL ANNUALIZED COST OF MESOPHILIC DIGESTER		**$ 34,805.34**

Table IR.52. ISSUES RENEW Technology Flare Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush)

Component	Total Cost	Annualized Cost
Flare	$ 3,000.00	$ 447.09
Contractor & Engineering Services & Overhead	$ 1,293.00	$ 192.70
Total Construction Cost	$ 4,293.00	$ 639.78
Maintenance Cost		$ 60.00
Property Taxes		$ 15.24
Total Operating Cost		$ 75.24
TOTAL ANNUALIZED COST OF FLARE		**$ 715.02**

Table IR.53. ISSUES RENEW Aerobic Digester Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush)

Component	Total Cost	Annualized Cost
Excavation	$ 23,846.72	$ 3,553.86
Liner (40-mil. HDPE)	$ 22,437.48	$ 3,343.85
Fine Bubble Diffusion System (blower and Air-Jammer)	$ 39,623.07	$ 15,378.57
Plumbing (labor and materials)	$ 3,936.62	$ 586.67
Electrical (labor and materials)	$ 3,304.69	$ 492.50
Pumps	$ 1,192.65	$ 462.79
Regenerative Blower	$ 664.65	$ 257.91
Contractor & Engineering Services & Overhead	$ 40,951.41	$ 6,102.97
Total Construction Cost	$ 135,966.27	$ 30,179.11
Electric Power Cost		$ 12,276.07
Maintenance Cost		$ 2,668.04
Property Taxes		$ 482.68
Total Operating Cost		$ 15,426.80
TOTAL ANNUALIZED COST OF AEROBIC DIGESTER		**$ 45,605.91**

Table IR.54. ISSUES RENEW Technology Control System Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush)

Component	Total Cost	Annualized Cost
Control System	$ 7,469.62	$ 1,113.19
Contractor & Engineering Services & Overhead	$ 3,219.40	$ 479.79
Total Construction Cost	$ 10,689.02	$ 1,592.98
Maintenance Cost		$ 149.39
Property Taxes		$ 37.95
Total Operating Cost		$ 187.34
TOTAL ANNUALIZED COST OF CONTROL SYSTEM		**$ 1,780.32**

TOTAL CONSTRUCTION COST OF ISSUES RENEW TECHNOLOGY	**$**	**541,460.27**
TOTAL OPERATING COST OF ISSUES RENEW TECHNOLOGY	**$**	**24,166.61**
TOTAL ANNUALIZED COST OF ISSUES RENEW TECHNOLOGY WITHOUT LAND APPLICATION	**$**	**117,829.96**

Table IR.55. ISSUES RENEW Technology Predicted Liquid Application Costs for Four Land Application Scenarios: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush)

Annual Cost of Applying Lagoon Effluent		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	12,800.42	$	6,806.51
If Phosphorus-Based Application	$	18,667.56	$	127.00
Acres Needed For Assimilation		**Forages**		**Row Crops**
If Nitrogen-Based Application		44.67		144.78
If Phosphorus-Based Application		71.25		190.35
Opportunity Cost of Land		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	2,680.19		-
If Phosphorus-Based Application	$	4,275.00		-
Irrigation Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	10,120.23	$	12,144.75
If Phosphorus-Based Application	$	9,917.14	$	14,008.37
Savings From Not Having To Buy Fertilizer		**Forages**		**Row Crops**
If Nitrogen-Based Application		-	$	(5,338.24)
If Phosphorus-Based Application		-	$	(13,881.38)
Extra Fertilizer Purchase Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application		-		-
If Phosphorus-Based Application	$	4,475.42		-

Note: 8,976,943 gallons / year of effluent modeled to be land applied.

Table IR.56. Summary and Mass Balance of Generated and Land Applied Nutrients: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush)

Nutrient Balance	**Nitrogen (lbs/ year)**	**Phosphorus (lbs / year)**	**Potassium* (lbs / year)**
Generated At Barn	178,112.00	51,040.00	87,560.00
Nutrients Entering Mesophilic Digester	95,004.94	14,643.38	No data
Nutrients Exiting Mesophilic Digester	68,470.06	11,126.04	No data
Nutrients Entering Aerobic Digester	59,497.74	6,877.00	No data
Nutrients Exiting Aerobic Digester	45,432.48	6,812.36	No data
Nutrients Entering Water Re-use System	0	0	0
Land Applied in Lagoon Effluent	25,935.28	3,448.04	40,926.78

* Nutrient mass balance data were not available for potassium

Tables IR.57 through IR.66: Costs and Returns Estimates Based on Standardized Cost and Performance Data for ISSUES RENEW Technology: 4,000-Sow Farrow to Wean Operation with Flush System

Table IR.57. ISSUES RENEW Technology Assumptions and Total Annualized Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush)

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	**$ 169,002.12**	**$ 165,926.77**
	If Phosphorus-Based Application	**$ 164,423.88**	**$ 152,247.42**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 97.58**	**$ 95.80**
	If Phosphorus-Based Application	**$ 94.93**	**$ 87.90**

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

Table IR.58. ISSUES RENEW Technology Manure Evacuation and Lift Station Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush)

Component	Total Cost	Annualized Cost
Waste Evacuation	$ 12,754.00	$ 1,900.72
Concrete Lift Station	$ 1,209.80	$ 180.30
Switches and Brackets	$ 253.00	$ 37.70
Pump	$ 3,468.40	$ 1,345.86
Piping	$ 291.34	$ 43.42
Lift Station Accessories	$ 15,431.46	$ 2,299.74
Contractor & Engineering Services & Overhead	$ 14,398.85	$ 2,145.85
Total Construction Cost	$ 47,806.85	$ 7,953.59
Electric Power Cost		$ 1,289.67
Maintenance Cost		$ 772.21
Property Taxes		$ 169.71
Total Operating Cost		$ 2,231.60
TOTAL ANNUALIZED COST OF MANURE EVACUATION AND LIFT STATION		**$ 10,185.19**

Table IR.59. ISSUES RENEW Technology Equalization Tank Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush)

Component	Total Cost	Annualized Cost
Tank	$ 14,332.50	$ 2,135.97
Submersible Pumps	$ 1,485.00	$ 576.23
Impeller Pump and Motor	$ 1,974.55	$ 766.19
Plumbing (labor and materials)	$ 9,146.82	$ 1,363.15
Electrical (labor and materials)	$ 7,678.53	$ 1,144.33
Valve and Actuator	$ 447.38	$ 66.67
Contractor & Engineering Services & Overhead	$ 15,112.92	$ 2,252.27
Total Construction Cost	$ 50,177.69	$ 8,304.80
Electric Power Cost		$ 808.54
Maintenance Cost		$ 805.08
Property Taxes		$ 178.13
Total Operating Cost		$ 1,791.76
TOTAL ANNUALIZED COST OF EQUALIZATION TANK		**$ 10,096.56**

Table IR.60. ISSUES RENEW Technology Clarifier Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush)

Component	Total Cost	Annualized Cost
Solids Concentrator	$ 113,800.00	$ 16,959.56
Concrete Pad	$ 7,250.00	$ 1,080.46
Pump (centrifugal)	$ 1,290.00	$ 500.56
Pump (submersible)	$ 1,250.00	$ 485.04
Plumbing (labor and materials)	$ 9,146.82	$ 1,363.15
Electrical (labor and materials)	$ 7,678.53	$ 1,144.33
Contractor & Engineering Services & Overhead	$ 60,519.02	$ 9,019.12
Total Construction Cost	$ 200,934.36	$ 30,552.22
Electric Power Cost		$ 724.38
Maintenance Cost		$ 2,884.51
Property Taxes		$ 713.32
Total Operating Cost		$ 4,322.20
TOTAL ANNUALIZED COST OF CLARIFIER		**$ 34,874.42**

Table IR.61. ISSUES RENEW Technology Mesophilic Digester Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush)

Component	Total Cost	Annualized Cost
Excavation	$ 28,899.89	$ 4,306.94
Liner (40-mil. HDPE)	$ 22,092.20	$ 3,292.39
Cover (40-mil. HDPE)	$ 25,528.82	$ 3,804.55
Gas Flowmeter	$ 2,964.00	$ 441.72
Heat Exchanger System	$ 171,359.70	$ 25,537.65
Plumbing (labor and materials)	$ 9,146.82	$ 1,363.15
Electrical (labor and materials)	$ 7,678.53	$ 1,144.33
Pumps	$ 4,578.72	$ 1,776.70
Controls	$ 1,822.45	$ 271.60
Wetwell	$ 889.00	$ 132.49
Start-up Service	$ 6,000.00	$ 894.18
Mixing Pole	$ 200.00	$ 29.81
Contractor & Engineering Services & Overhead	$ 121,180.01	$ 18,059.40
Total Construction Cost	$ 402,340.13	$ 61,054.88
Electric Power Cost		$ 965.09
Maintenance Cost		$ 5,058.57
Property Taxes		$ 1,428.31
Total Operating Cost		$ 7,451.96
TOTAL ANNUALIZED COST OF MESOPHILIC DIGESTER		**$ 68,506.84**

Table IR.62. ISSUES RENEW Technology Flare Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush)

Component	Total Cost	Annualized Cost
Flare	$ 3,000.00	$ 447.09
Contractor & Engineering Services & Overhead	$ 1,293.00	$ 192.70
Total Construction Cost	$ 4,293.00	$ 639.78
Maintenance Cost		$ 60.00
Property Taxes		$ 15.24
Total Operating Cost		$ 75.24
TOTAL ANNUALIZED COST OF FLARE		**$ 715.02**

Table IR.63. ISSUES RENEW Aerobic Digester Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush)

Component	Total Cost	Annualized Cost
Excavation	$ 59,813.27	$ 8,913.94
Liner (40-mil. HDPE)	$ 30,880.17	$ 4,602.06
Fine Bubble Diffusion System (blower and Air-Jammer)	$ 21,164.47	$ 8,212.52
Plumbing (labor and materials)	$ 9,146.82	$ 1,363.15
Electrical (labor and materials)	$ 7,678.53	$ 1,144.33
Pumps	$ 1,192.65	$ 462.79
Regenerative Blower	$ 664.65	$ 257.91
Contractor & Engineering Services & Overhead	$ 56,262.98	$ 8,384.84
Total Construction Cost	$ 186,803.54	$ 33,341.53
Electric Power Cost		$ 12,652.20
Maintenance Cost		$ 2,105.20
Property Taxes		$ 663.15
Total Operating Cost		$ 15,420.55
TOTAL ANNUALIZED COST OF AEROBIC DIGESTER		**$ 48,762.08**

Table IR.64. ISSUES RENEW Technology Control System Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush)

Component	Total Cost	Annualized Cost
Control System	$ 7,469.62	$ 1,113.19
Contractor & Engineering Services & Overhead	$ 3,219.40	$ 479.79
Total Construction Cost	$ 10,689.02	$ 1,592.98
Maintenance Cost		$ 149.39
Property Taxes		$ 37.95
Total Operating Cost		$ 187.34
TOTAL ANNUALIZED COST OF CONTROL SYSTEM		**$ 1,780.32**

TOTAL CONSTRUCTION COST OF ISSUES RENEW TECHNOLOGY	**$**	**903,044.59**
TOTAL OPERATING COST OF ISSUES RENEW TECHNOLOGY	**$**	**31,480.65**
TOTAL ANNUALIZED COST OF ISSUES RENEW TECHNOLOGY WITHOUT LAND APPLICATION	**$**	**174,920.43**

Table IR.65. ISSUES RENEW Technology Predicted Liquid Application Costs for Four Land Application Scenarios: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush)

Annual Cost of Applying Lagoon Effluent	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 14,228.57	$ 7,189.74
If Phosphorus-Based Application	$ 24,575.85	$ (1,883.42)
Acres Needed For Assimilation	**Forages**	**Row Crops**
If Nitrogen-Based Application	51.40	166.60
If Phosphorus-Based Application	96.80	258.62
Opportunity Cost of Land	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 3,084.13	-
If Phosphorus-Based Application	$ 5,808.06	-
Irrigation Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 11,144.44	$ 13,393.13
If Phosphorus-Based Application	$ 11,123.80	$ 17,232.12
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	$ (6,203.38)
If Phosphorus-Based Application	-	$ (19,115.54)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	-
If Phosphorus-Based Application	$ 7,643.98	-

Note: 12,196,173 gallons / year of effluent modeled to be land applied.

Table IR.66. Summary and Mass Balance of Generated and Land Applied Nutrients: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush)

Nutrient Balance	**Nitrogen (lbs/ year)**	**Phosphorus (lbs / year)**	**Potassium* (lbs / year)**
Generated At Barn	117,000.00	37,040.00	77,000.00
Nutrients Entering Mesophilic Digester	62,407.80	10,626.78	No data
Nutrients Exiting Mesophilic Digester	44,977.30	8,074.22	No data
Nutrients Entering Aerobic Digester	39,083.48	4,990.68	No data
Nutrients Exiting Aerobic Digester	29,844.14	4,943.77	No data
Nutrients Entering Water Re-use System	0	0	0
Land Applied in Lagoon Effluent	29,844.14	4,684.55	55,603.57

* Nutrient mass balance data were not available for potassium

Tables IR.67 and IR.68: Predicted Costs of Retrofitting Various Representative Farm Sizes and Farm Types with the ISSUES RENEW Technology: DWQ Permitted Farms and SF/PSF Owned Farms

Table IR.67. Predicted Costs ($ / 1,000 Pounds of Steady-State Live Weight (SSLW) per Year) of Retrofitting DWQ Permitted Representative Farm Type / Farm Size Combinations: ISSUES RENEW Technology

	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	$199.16	$126.39	$114.11	$90.54	$83.21
Flush system	$209.10	$133.68	$121.07	$97.58	$90.13
Farrow-feeder					
Rep. # of sows	500	1,200	2,000	3,600	5,500
Pit-recharge system	$238.52	$136.45	$122.34	$94.82	$92.14
Flush system	$267.05	$162.02	$147.04	$127.02	$126.13
Farrow-finish					
Rep. # of sows	150	500	1,000	1,200	2,000
Pit-recharge system	$270.71	$119.00	$96.10	$87.81	$82.61
Flush system	$288.22	$135.72	$111.29	$102.78	$97.53
Wean-feeder					
Rep. head capacity	3,840	20,000	N/A	N/A	N/A
Pit-recharge system	$468.68	$144.32	N/A	N/A	N/A
Flush system	$616.48	$304.22	N/A	N/A	N/A
Feeder-finish					
Rep. head capacity	2,448	5,280	8,800	12,240	17,136
Pit-recharge system	$187.07	$110.88	$86.97	$83.60	$79.56
Flush system	$196.03	$119.46	$95.45	$101.16	$87.70

Table IR.68. 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: ISSUES RENEW Technology

	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	$222.22	$119.30	$114.11	$90.54	$78.69
Flush system	$230.61	$126.41	$121.07	$97.58	$90.29
Farrow-feeder					
Rep. # of sows	675	1,200	2,000	3,419	5,500
Pit-recharge system	$194.26	$136.45	$122.34	$96.67	$92.14
Flush system	$220.48	$162.02	$147.04	$129.84	$126.13
Farrow-finish					
Rep. # of sows	N/A	500	1,000	1,200	2,000
Pit-recharge system	N/A	$119.00	$96.10	$87.81	$82.61
Flush system	N/A	$135.72	$111.29	$102.78	$97.53
Wean-feeder					
Rep. head capacity	2,808	N/A	N/A	N/A	N/A
Pit-recharge system	$620.03	N/A	N/A	N/A	N/A
Flush system	$766.25	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	$327.06	$113.37	$86.97	$83.58	$79.56
Flush system	$337.20	$122.06	$95.45	$101.13	$87.70